

Description of the Serpukhovian rugose and tabulate corals from Idmarrach and Tirhela Formations (Adarouch, Morocco)

Descripción de los corales rugosos y tabulados del Serpukhoviense de las formaciones Idmarrach y Tirhela (Adarouch, Marruecos)

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RESUMEN

Se describen los corales rugosos y tabulados de las formaciones Idmarrach y Tirhela, que se localizan en el área de Adarouch, en la Meseta central de Marruecos. Se han identificado 32 especies de corales rugosos pertenecientes a 19 géneros y una especie de coral tabulado. Las asociaciones de edad Serpukhoviense de las formaciones estudiadas están compuestas en su mayoría por especies que tienen su máximo desarrollo en el Viséense superior. Sin embargo, la mayoría de los taxones identificados en Adarouch han sido mencionados previamente en rocas del Serpukhoviense de otras regiones del Paleotethys occidental y las cuencas epicontinentales del norte de África.

Las asociaciones de corales están dominadas por corales coloniales pertenecientes a la familia Lithostrotonidae y por corales solitarios pertenecientes a la familia Aulophyllidae. Son también frecuentes los representantes de las familias Axophyllidae, Cyathaxoniidae, Cyathopsidae, Palaeosmiliidae, Stereophrentidae y Zaphrentoididae. El medio de desarrollo de los corales estudiados fue una plataforma carbonatada interna a media con importantes aportes de terrígenos finos.

ABSTRACT

The Serpukhovian coral assemblages from the Idmarrach and Tirhela formations in Central Morocco are described. 32 rugose species belonging to 19 genera and 1 tabulate species have been identified. The Serpukhovian assemblages are composed mostly of species that have their greater abundance in the upper Viséan. However, most recorded taxa in Adarouch have been already mentioned in Serpukhovian rocks from other regions in the Palaeotethys and in North African epicontinental basins.

The coral assemblage is dominated by colonial corals belonging to the family Lithostrotonidae and solitary corals belonging to the family Aulophyllidae. In addition, representatives of the families Axophyllidae, Cyathaxoniidae, Cyathopsidae, Palaeosmiliidae, Stereophrentidae and Zaphrentoididae are also present in the assemblages. The environment where the corals lived was mostly an inner to middle carbonate platform with a minor but significant input of terrigenous sediments.

1. Introduction

The Carboniferous rocks from Adarouch (central Morocco) range in age from the middle Viséan up to the Bashkirian (CÓZAR *et al.*, 2008, 2011) (Fig. 1). The presence of rugose and tabulate corals in the Adarouch area has been known for a long time. TERMIER & TERMIER (1950) described *Dibunophyllum vaughani* from the Tizra Hills. TERMIER *et al.* (1975) dated Carboniferous rocks from Adarouch as Viséan to Serpukhovian, and provided a list of some corals. BERKHLI (1999) defined the Oued Amhares Formation at the base, the Tizra and Mouarhaz formations in the middle and the Akerchi Formation at the top (Fig. 1). He also described the Idmarrach and Tirlhela formations as lateral equivalents to the Akerchi Formation. The rugose and tabulate coral assemblages of those formations and their biostratigraphic, palaeoecologic and palaeobiogeographic implications have been partly described in previous papers (SAID *et al.*, 2007, 2010, 2011; SAID & RODRÍGUEZ, 2008; RODRÍGUEZ *et al.*, *in press*, HERBIG & ARETZ, 2015). The aim of this paper is the taxonomic description of the Serpukhovian corals occurring in the lower part of the Idmarrach and Tirlhela formations.

The Tirlhela and Idmarrach formations, located in the tectonic block east of Akerchi scarp, in the Adarouch area (Fig. 1) include Serpukhovian and Bashkirian rocks (CÓZAR *et al.*, 2011). The Akerchi Formation is a lateral equivalent to the lower part of those formations and contains also Serpukhovian sandy limestones that yielded few corals, apart from the biostrome near the base, of latest Viséan age (CÓZAR *et al.*, 2008; SAID *et al.*, 2010). The Idmarrach Formation is mainly composed of shales interbedded with limestones in its lower part and well-bedded limestones in its upper part. The Tirlhela Formation is composed mainly of limestones and it is equivalent to the upper part of the Idmarrach Formation. The upper part of the Tirlhela Formation (Bashkirian) has red sandstones, shales, limestones and conglomerates (Fig. 2).

The coral assemblages from the Idmarrach Formation (Idmarrach-1 and -2 sections) were listed in SAID *et al.* (2007). New sampling campaigns have been undertaken since then, providing additional specimens from the Idmarrach-2 section and many specimens from a new section (Idmarrach-3), as well as from two isolated outcrops (Idmarrach-4 and Tirlhela-1) and from the main section of Tirlhela (Tirlhela-2) (Fig. 2). The coral assemblages from the lower beds of both Idmarrach and Tirlhela formations comprise many species that have their acme in the upper Viséan and less commonly have been recorded in the Serpukhovian. This fact and the previous data on those formations (BERKHLI, 1999; BERKHLI & VACHARD, 2001, 2002) induced

SAID *et al.* (2007) to identify the assemblages as upper Viséan. However, CÓZAR *et al.* (2011) established that the lower beds of Idmarrach and Tirlhela formations are Serpukhovian in age, based on a diverse assemblage of foraminifers, including *Insolentitheca horrida*, *Eostaffellina "protvae"*, *Eostaffella pseudostruvei*, *Loeblichia minima*, *Bradyina cribrostomata* and others. The lower Bashkirian age of the upper units in the Tirlhela and Idmarrach formations is established by the presence of the conodont *Declinognathodus noduliferus* (Idmarrach), first recorded from unit 8, and a rich and diverse foraminiferal assemblage including *Eostaffellina protvae*, *Seminovella elegantula* and *Novella?* from Tirlhela (CÓZAR *et al.*, 2011).

The Serpukhovian rugose coral assemblages have been studied in detail in order to check for possible differences with upper Viséan populations from the western Palaeotethys.

2. Methodology

More than 300 coral specimens have been collected in the Serpukhovian interval of the studied sections, 25 specimens from Idmarrach-1, 120 specimens from Idmarrach-2, 70 specimens from Idmarrach-3, 15 specimens from Idmarrach-4, 5 specimens not precisely located in a section from the Idmarrach area, 10 specimens from Tirlhela-1 and 60 specimens from Tirlhela-2. The sampling was not exhaustive; when the identification of the taxa was possible in the field, only 3-4 specimens of each species were collected from a single outcrop, irrespective of its abundance. The difficulties for sampling due to the presence of most colonial specimens in flat bedding surfaces led to collecting in most cases incomplete colonies, despite the fact that most colonies were in growth position in some biostromes.

The specimens have been studied by means of about 400 thin sections and 50 polished surfaces. When several specimens of a single species have been identified, only the best preserved have been sectioned. Usually, one transverse (in the base of the calice) and one longitudinal section have been prepared in solitary corals and two transverse and two longitudinal sections have been made in colonial corals. Additional thin sections in lower levels of the specimens have been undertaken only in the cases of doubtful identifications.

All specimens are housed in the Paleontology Department of the Complutense University (DPM), Sergio Rodríguez Collection (SRG).

3. Systematic descriptions

No exhaustive descriptions have been included here because most of the taxa are well known in the Mississippian Palaeotethys and they have been repeatedly described (HILL, 1938-41;

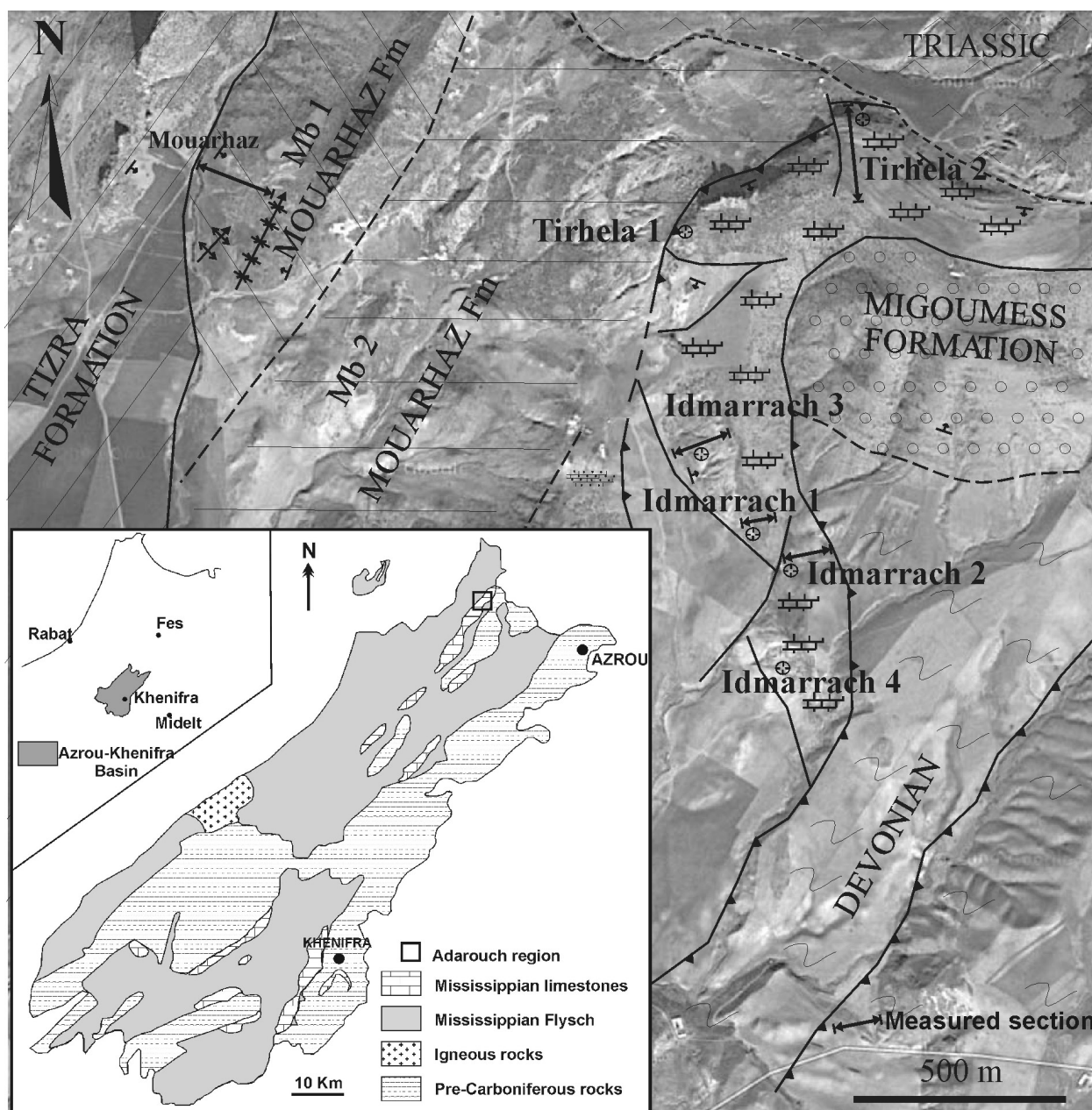


Figure 1. Location of the Adarouch area (encased box) in the Moroccan Meseta. The photogeological map shows the location of the studied stratigraphic sections. Modified from CÓZAR *et al.* (2011).

— Localización del área de Adarouch (recuadro pequeño) en la meseta marroquí. El mapa fotogeológico muestra la localización de las secciones estratigráficas estudiadas. Modificado de CÓZAR *et al.* (2011).

SEMENOFF-TIAN-CHANSKY, 1974, 1985; KHOA, 1977; POTY, 1981; RODRÍGUEZ *et al.*, 2001, 2002, 2004; SAID & RODRÍGUEZ, 2008; ARETZ, 2010a, etc.). Emphasis has been placed on those features that allow the identification of the specimens and those that are not usual in each species. For the same reason, synonymies are not provided, but references to articles with complete synonymies are provided.

The total Serpukhovian coral assemblage comprises 33 species (32 rugosans and 1 tabulate) (Table I). The morphological terminology is based on that proposed by HILL (1956, 1981), with

some additions by POTY (1981) and RODRÍGUEZ (1984). The microstructural descriptions are based on the terminology proposed by SEMENOFF-TIAN-CHANSKY (1974) and some modifications by RODRÍGUEZ (1984). The taxonomic classification follows that of HILL (1981) with some variations following recently published papers.

Class ANTHOZOA Ehrenberg, 1834
Subclass RUGOSA Milne-Edwards & Haime, 1850
Order STAURIIDA Verrill, 1865
Family Cyathaxoniidae Milne-Edwards & Haime, 1850



Figure 2. Distribution of corals in the Idmarrach and Tihela composite sections (adapted from CÓZAR *et al.*, 2011). All species recorded in the Idmarrach and Tihela formations are shown in the diagram, but only the Serpukhovian species are described in this paper. The Bashkirian species are described in RODRÍGUEZ *et al.* (2015)
 — Distribución de los corales en las secciones de Idmarrach y Tihela (adaptado de CÓZAR *et al.*, 2011). Se indica la distribución de todas las especies registradas en las formaciones Idmarrach y Tihela, pero en este artículo sólo las especies serpukhovianenses se describen. Las especies del Bashkiriense se describieron en RODRÍGUEZ *et al.* (2015).

Table I. Species occurrence in the Idmarrach and Tirhela formations. X = Occurrence in Serpukhovian rocks.

— Distribución de las especies de corales en las formaciones Idmarrach y Tirhela. X = registro en rocas del Serpukhovense

Species	IDM1	IDM2	IDM3	IDM4	TIR1	TIR2
<i>Haplolasma lamelliferum</i>			X			X
<i>Aulophyllum fungites</i>		X	X			X
<i>Clisiophyllum garwoodi</i>		X	X			
<i>Clisiophyllum keyserlingi</i>		X	X			X
<i>Clisiophyllum</i> sp.		X				
<i>Dibunophyllum bipartitum</i>	X	X	X	X	X	X
<i>Dibunophyllum linnense</i>		X				
<i>Arachnolasma sinense</i>		X	X			
<i>Arachnolasma cylindrica</i>		X	X			X
<i>Arachnolasma</i> sp. aff. <i>dibunoides</i>			X			
<i>Koninckophyllum interruptum</i>		X				
<i>Koninckophyllum magnificum</i>		X	X	X	X	X
<i>Palaesmia murchisoni</i>		X	X			X
<i>Palastraea regia</i>		X				
<i>Aulokoninckophyllum carinatum</i>		X	X			X
<i>Lithostrotion decipiens</i>	X	X	X	X	X	
<i>Lithostrotion vorticale</i>		X			X	X
<i>Lithostrotion maccoyanum</i>		X				
<i>Siphonodendron martini</i>	X	X				X
<i>Siphonodendron pauciradiale</i>		X				
<i>Siphonodendron irregulare</i>		X	X	X		X
<i>Siphonodendron intermedium?</i>		X	X			X
<i>Diphyphyllum lateseptatum</i>		X	X	X		
<i>Diphyphyllum furcatum</i>		X		X		
<i>Diphyphyllum fasciculatum</i>		X	X	X		X
<i>Solenodendron</i> cf. <i>hibernicum</i>					X	
<i>Axophyllum kirsopianum</i>		X				X
<i>Gangamophyllum</i> sp.						X
<i>Cyathaxonia cornu</i>			X			
<i>Zaphrentites</i> sp.		X				
<i>Zaphrufimia</i> sp.			X			
Gen. et sp. indet.						X
<i>Multithecopora</i> sp.				X		

Genus *Cyathaxonia* Michelin, 1847Type species. *Cyathaxonia cornu* Michelin, 1847

Diagnosis (After HILL, 1981). Small, ceratoid to cylindroid solitary coral. Strong axial column developed independently of the septa but attached to them. Majors long. Minors long and contratingent. Dissepiments absent. Outer wall arched or festooned. Tabulae complete and downturned towards the periphery.

Cyathaxonia cornu Michelin, 1847

Figure 3a

Material. One single specimen, IDM3/1-51; one transverse thin section.

Location, horizon and age. Idmarrach-3 section, lower Serpukhovian.

Diagnosis (Modified from POTY, 1981). *Cyathaxonia* with a diameter smaller than 6 mm. Axial column circular in transverse section. Majors may be carinate. Tabulae complete and slightly downturned towards the periphery. Microstructure composed only of mesoplasm, mainly fibrous.

Description. Small, ceratoid, partly eroded corallite, 6.1 mm in diameter, 21 majors; contratingent minors. Moderately thin majors, thicker near the columella; thinner minors. Small cardinal fossula. Columella 1/5 of the corallite diameter.

Remarks. All features of the specimen fit with those typical for this well-known species.

Family Zaphrentoididae Schindewolf, 1938
Subfamily Hapsiphyllinae Grabau, 1928

Genus *Zaphrentites* Hudson, 1941

Type species. *Zaphrentis parallela* Carruthers, 1910

Diagnosis (Modified from HILL, 1981). Slightly curved, solitary corals in which axial margins of majors commonly unite around conspicuous cardinal fossula located on concave side; cardinal septum normally elongate in early stages, shortened at maturity; counter septum normally approximately equal in length to neighbouring majors but may be slightly longer and thicker; septa pinnately arranged in cardinal quadrants, radially arranged in counter quadrants, commonly withdrawn abaxially at maturity, withdrawal normally beginning in cardinal quadrants; minors very short or absent; alar pseudofossulae commonly well developed in early stages but may be inconspicuous at maturity; tabulae complete or incomplete, commonly large domes subhorizontal or gently concave in axial area, steeply depressed at periphery and in fossula; dissepiments absent; septal microstructure showing inner, thin middle line composed of microtrabeculae, flanked by wide outer fibrous layers.

Zaphrentites sp.
Figure 3b

Material. One single specimen, IDM2/1-27; one transverse thin section.

Location, horizon and age. Idmarrach-2 section, unit 1, marls interbedded with biostromal limestones, upper Serpukhovian.

Description. Small fragment of corallite, 7.6 mm diameter, 23 majors, minors present as pegs on epithecal wall. Slightly shortened cardinal septum. Cardinal fossula not well marked. Most septa reaching the axis of the corallite.

Remarks. The oblique section in an incomplete corallite prevents species identification.

Family Stereophrentidae Fomichev, 1953

Genus *Zaphrufimia* Fedorowski, 2012

Diagnosis (After FEDOROWSKI, 2012): Stereophrentinae with cardinal protoseptum on concave side of corallite and with ufimioid differentiation of majors in maturity; biform-like tabulae may appear in some septal loculi late in ontogeny.

Zaphrufimia sp.
Figure 3c

Material. One single specimen, IDM3/1-50; three transverse thin sections.

Location, horizon and age. Idmarrach-3 section, lower Serpukhovian.

Description. Small corallite, 15 mm long and 8.9 mm in diameter; 26 majors, minors thin and short. Rhopaloid septa almost reaching the axis. Shortened cardinal septum located in a narrow triangular fossula, open to the axis of the corallite. Counter-lateral and alar septa are slightly longer and thicker and more rhopaloid than other septa. Counter septum is somewhat shorter than counter-laterals. No dissepiments.

Remarks. All features of the specimen fit well with the genus *Zaphrufimia*. They are comparable to the type specimen of the type species, but is slightly larger in size and the number of septa is also higher. In spite of the strong similarities, the presence of only one specimen prevents species identification.

Family Cyathopsidae Dybowski, 1873

Genus *Haplolasma* Semenoff-Tian-Chansky, 1974
Type species. *Caninia subibicina* McCoy, 1851

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). Solitary coral. Majors long but withdrawn from the axis with a large free zone in the central part of the tabularium. Minors short (less than half of majors). Small cardinal fossula with a shorter cardinal septum. Dissepimentarium of various widths, made of small simple and V-shaped dissepiments.

Haplolasma lamelliferum Semenoff-Tian-Chansky, 1974
Figures 3d, e

Material. Three specimens, IDM3/1-12; TIR2/1-2, 15; three transverse and one longitudinal thin sections.

Location, horizon and age. Tirhela-2 section, basal beds, upper Serpukhovian.

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). *Haplolasma* close to *H. subibicinum* (McCoy, 1851) in its macrostructure, but clearly different in its microstructure; it shows a thick lamellar stereoplasm.

Description. Single corallites with 62 to 66 majors for corallite, 30 to 35 mm in diameter and a very wide tabularium 24 to 26 mm (4/5 corallite diameter); relatively narrow dissepimentarium partly not preserved, composed of 7 to 8 rows of concentric to slightly angulate dissepiments; narrow cardinal fossula with short cardinal septum; minors extend across dissepimentarium; 6 low mesa-shaped tabulae in longitudinal section per 5 mm height.

Remarks. The studied specimens differ from the holotype by a wider tabularium and more strongly dilated majors. Differs from *H. parvicarinatum* Semenoff-Tian-Chansky, 1974 by a larger corallite, narrower tabularium and majors more strongly dilated in the tabularium.

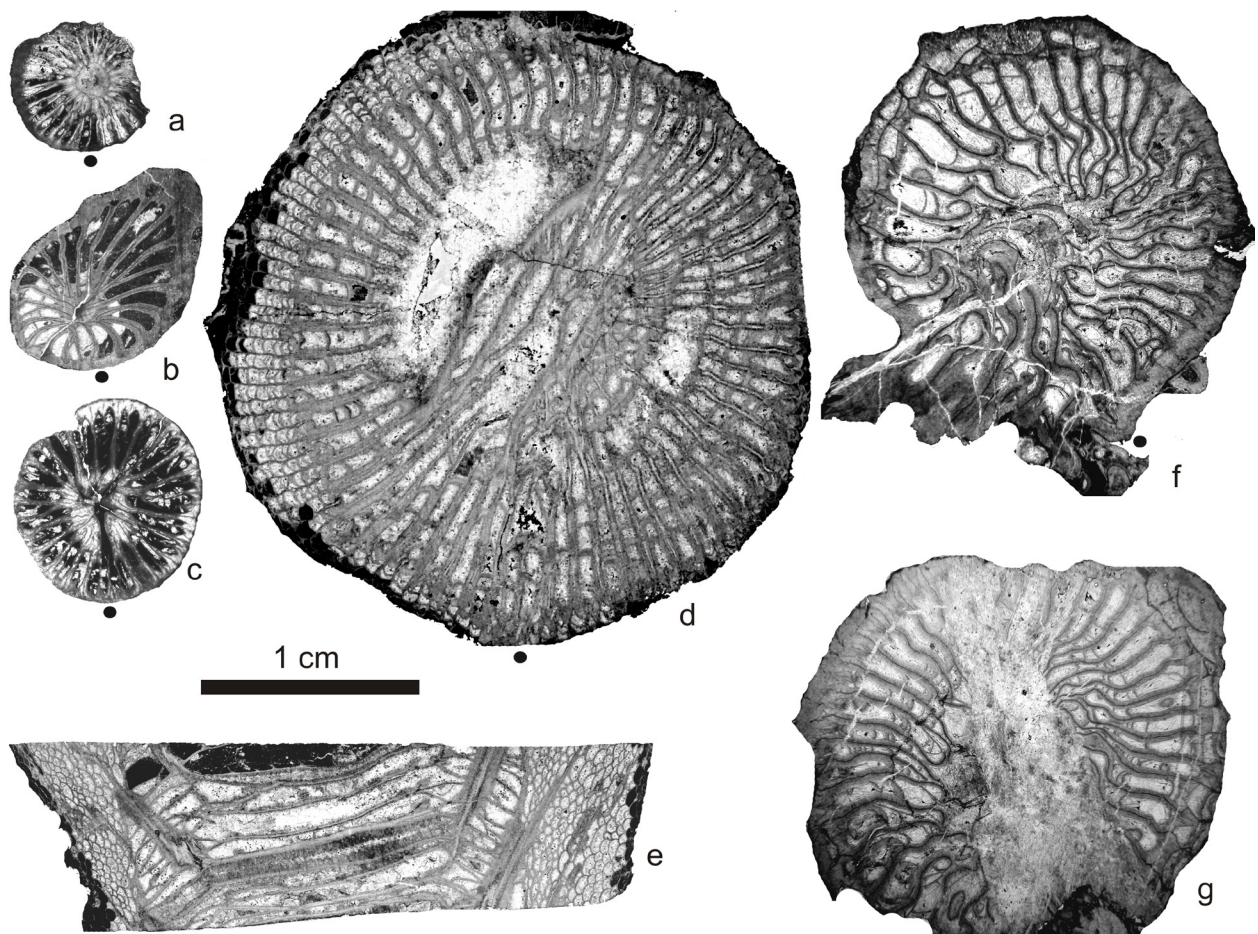


Figure 3. Solitary undisseptimented corals and Cyathopsidae. a. *Cyathaxonia cornu* Michelin, 1847, specimen IDM3/1-51, transverse section. b. *Zaphrentites* sp., specimen IDM2/1-27, transverse section. c. *Zaphrufimia* sp., specimen IDM3/1-50, transverse section. d-e. *Haplolasma lamelliferum* Semenoff-Tian-Chansky, 1974, specimen TIR2/1-15, d: transverse section. e: longitudinal section. f-g: Gen. et sp. indet., specimen IDM2/1-34, transverse sections. Scale bar 1 cm, same for all pictures. Black dots indicate the location of the cardinal septum.

— Corales solitarios sin disepimientos y Cyathópsidos a. *Cyathaxonia cornu* Michelin, 1847, ejemplar IDM3/1-51, sección transversal. b. *Zaphrentites* sp., ejemplar IDM2/1-27, sección transversal. c. *Zaphrufimia* sp., ejemplar IDM3/1-50, sección transversal. d-e. *Haplolasma lamelliferum* Semenoff-Tian-Chansky, 1974, ejemplar TIR2/1-15, d: sección transversal. e: sección longitudinal. f-g: Gen. et sp. indet., ejemplar IDM2/1-34, secciones transversales. Escala 1 cm, la misma para todas las figuras. Los puntos negros indican la posición del septo cardinal.

Genus et species indet.

Figure 3f, g

Material. One single specimen, IDM2/1-34; two transverse thin sections.

Location, horizon and age. Idmarrach-2 section, unit 1, marls interbedded with biostromal limestones, upper Serpukhovian.

Description. Fragmentary corallite. Maximum diameter 23 mm, showing 38? majors, not completely seen because of recrystallisation. A lower section being 20 mm in diameter shows 36 majors (Fig. 3f). Thick wall partly eroded. One single row of dissepiments occurs near the wall in the counter quadrants. The outline of the coral is irregular due to a talon developed in the cardinal quadrants (Fig. 3f). The septa are thick, more

marked in the area of the talon. The deformity produced by the attachment provokes irregularity in the septal development, but a slightly shortened cardinal septum, located in a very irregular cavity open to the axis of the corallite (fossula?) can be identified. Most septa are long, almost reaching the axis. Minors are only pegs at the wall. The largest section (Fig. 3g) is crossed by a vein that impedes detailed observation of the cardinal and counter septa. The septa are still irregular in spite of the fact that the talon is not present. Minors are inserted in a thick peripheral stereozone. One to two rows of transeptal dissepiments occur in one of the counter quadrants (Fig. 3g).

Remarks. The general septal structure, the presence of a fossula reaching the axis of the corallite and the presence of sporadic dissepiments

allows to include it in the Cyathopsidae. However, the fragmentary condition, the irregularity produced by an attachment structure and the recrystallization produced by a vein crossing the upper part of the corallite impede more detailed identification.

Family Aulophyllidae Dybowski, 1873
Subfamily Aulophyllinae Dybowski, 1873

Genus *Aulophyllum* Milne-Edwards & Haime, 1850

Type species. *Clisiophyllum prolapsum* McCoy, 1849

Diagnosis (After POTY 1981). Sub-cylindrical solitary coral with a complex axial structure. Majors long but not connected to the axial structure, often thickened in the cardinal parts of the tabularium. Minors half as long as the majors. Cardinal septum slightly shorter, except in juvenile stages. Axial structure dense forming a well-defined column with a circular shape and cuspidate towards the cardinal fossula, made of densely packed radial lamellae and axial tabulae with no median plate. Cardinal fossula in the convex side of the corallite. Dissepimentarium wide, made of small simple dissepiments. Tabulae incomplete and depressed in the outer part of the tabularium. Axial tabulae densely packed, downturned toward the axis and towards the outer part of the axial column.

Aulophyllum fungites (Fleming, 1828)
Figures 4a-c

Material. Ten specimens, IDM2/1-33, 34, 52; IDM2/3-1, 4; IDM3/1-1, 4, 8a; TIR2/1-1, 12; fifteen transverse and eight longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, units 1 and 3; Idmarrach section 3, limestone debris; Tirhela-2 section, basal beds. lower and upper Serpukhovian and lower Bashkirian.

Diagnosis. Same as for the genus.

Description. Solitary corals being 25 to 40 mm in diameter in adult stage and showing 60 to 80 majors. Tabularium and axial structure diameters vary from 20 to 32 mm and from 10 to 15 mm, respectively. Narrow dissepimentarium composed of 4 to 8 rows of regular dissepiments. Conspicuous thickening of the septa in the tabularium, mostly in cardinal quadrants (Fig. 4b). Typically aulophylloid axial structure. Periaxial tabulae sparse and declined to the dissepimentarium. Young stages show less development of the dissepimentarium and axial structure with more irregular distribution of the tabellae and radial lamellae (Fig. 4a).

Remarks. Specimens typical of *Aulophyllum fungites*, which show similar variability in alar diameter, tabularium diameter, axial structure and number of septa to the specimens from

Western Europe (SMITH, 1913) and Sahara basins (SEMENOFF-TIAN-CHANSKY, 1974) although they can have a narrower dissepimentarium, slightly larger number of septa for same diameters and less differentiation in the thickness of the septa in cardinal and counter quadrants. This species has a long stratigraphical range. It has been recorded from the upper Viséan to the upper Serpukhovian (SMITH 1913, SEMENOFF-TIAN-CHANSKY, 1974; POTY, 1981); in Adarouch its distribution is even longer, because it has also been recorded in the lower Bashkirian (RODRÍGUEZ *et al.*, 2015). Complete synonymy in RODRÍGUEZ *et al.* (2001).

Subfamily Clisiophyllinae Nicholson, 1889

Genus *Clisiophyllum* Dana, 1846

Type species. *Clisiophyllum keyserlingi* McCoy, 1849

Diagnosis (Modified from SEMENOFF-TIAN-CHANSKY, 1974; HILL, 1981; POTY, 1981). Solitary corals with numerous radially arranged, long majors reaching or closely approaching axial column, minors generally well developed, rarely penetrating outer tabularium, cardinal septum shortened in late stages, in open cardinal fossula. Axial structure consists of median lamella and numerous radial or spirally arranged septal lamellae in axial column formed by continuous series of steeply elevated, linked axial tabellae. Tabularium weakly biform where penetrated by minors, tabulae incomplete, tabellae generally convex, less steeply elevated and fewer than those in axial column. Dissepimentarium regular, with small, concentric and, less commonly, herringbone dissepiments. Septa composed mainly of fibrous mesoplasm. Fibrous stereoplasm may sporadically occur.

Clisiophyllum keyserlingi McCoy, 1849
Figures 4i-k

Material. Six specimens, IDM2/3-15, 19; IDM3/1-5a, IDM0-6; TIR2/1-3, 17; eight transverse and six longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 3; Idmarrach-3 section, limestone debris, Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis. (After SEMENOFF-TIAN-CHANSKY, 1974): Large curved *Clisiophyllum*, with axial structure that may reach half of the corallite diameter and having regular radial lamellae and tabellae. The septa are composed of fibrous mesoplasm and being mesoplasm only developed sporadically.

Description. Large corallites having 60 to 70 majors in 30 to 40 mm in diameter and 20 to 28 mm in tabularium diameter. Narrow, mainly eroded dissepimentarium composed of regular and less frequently by herringbone dissepiments. They occur first at 15 to 20 mm in diameter. Septa thickened in the tabularium, mostly in the cardinal

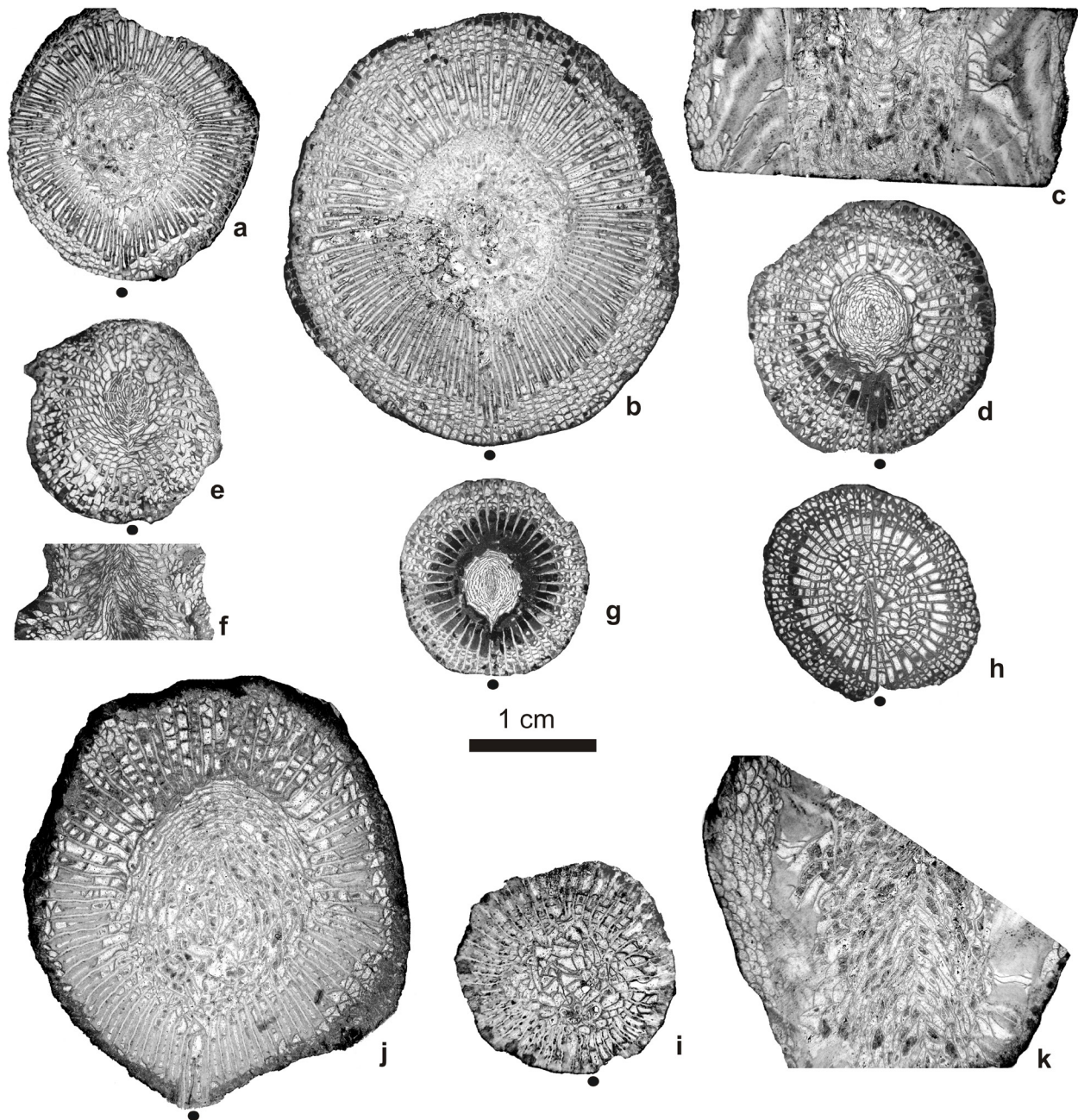


Figure 4. Aulophyllinae and Clisiophyllinae. a-c: *Aulophyllum fungites* (Fleming, 1828), a: specimen TIR2/1-12, transverse section, early adult stage. b-c: specimen IDM3/1-8, b: transverse section, adult stage, c: longitudinal section. d-g: *Clisiophyllum garwoodi* (Salée, 1913), d: specimen IDM2/1-53, transverse section. e-f: specimen IDM3/1-6, e: transverse section, f: longitudinal section. g: specimen IDM3/1-36, transverse section at the base of the calice. h: *Clisiophyllum* sp. specimen IDM2/1-56, transverse section. i-k: *Clisiophyllum keyserlingi* (McCoy, 1849), i: specimen TIR2/1-17, transverse section, young stage, j-k: specimen TIR2/1-3, j: transverse section. k: longitudinal section. Scale bar 1 cm, same for all pictures. Black dots indicate the location of the cardinal septum.

— Aulophyllinae y Clisiophyllinae. a-c: *Aulophyllum fungites* (Fleming, 1828), a: ejemplar TIR2/1-12, sección transversal, estadio adulto temprano. b-c: ejemplar IDM3/1-8, b: sección transversal, estado adulto, c: sección longitudinal. d-g: *Clisiophyllum garwoodi* (Salée, 1913), d: ejemplar IDM2/1-53, sección transversal. e-f: ejemplar IDM3/1-6, e: sección transversal, f: sección longitudinal. g: ejemplar IDM3/1-36, sección transversal en la base del cáliz. h: *Clisiophyllum* sp. ejemplar IDM2/1-56, sección transversal. i-k: *Clisiophyllum keyserlingi* (McCoy, 1849), i: ejemplar TIR2/1-17, sección transversal, estadio juvenil, j-k: ejemplar TIR2/1-3, j: sección transversal. k: sección longitudinal. Escala 1 cm, la misma para todas las figuras. Los puntos negros indican la posición del septo cardinal.

quadrants. Cardinal septum shortened in a narrow fossula. Very wide clisiophyllid axial structure ($\frac{1}{2}$ corallite diameter), comprising numerous septal lamellae and tabellae and inconspicuous median plate (Fig. 4j). Its boundaries are not well marked; axial tabellae are conical, densely packed and strongly declined to the periphery (Fig. 4k). Periaxial tabellae are less declined to the dissepimentarium and sparsely arranged.

Remarks. All features of the studied specimens allow their identification as *C. keyserlingi*. No differences have been found with populations from Britain (HILL, 1940) or Belgium (ПОТЪ, 1981).

Clisiophyllum garwoodi (Salée, 1913)
Figures 4d-g

Material. Ten specimens, IDM2/1-28, 53; IDM3/1-6, 17, 36, 46, 49; IDM0-1, 2, 4; twelve transverse and eight longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 1; Idmarrach-3 section, limestone debris, lower and upper Serpukhovian.

Diagnosis (After ПОТЪ, 1981). Small *Clisiophyllum*, 9.7 mm in diameter (maximum 14.3 mm) and having 31 (maximum 41) majors. Minors shorter than the dissepimentarium width, very short in some cases. Axial structure 1/3-1/4 as wide as the diameter of the corallite, dense, symmetrical or poorly developed with few radial lamellae. Wide dissepimentarium.

Description. Ceratoid to trochoid corallites. Majors range from 37 to 43 for corallites 15.1 to 20.0 mm; tabularium range 10.6 to 13 mm. Compact clisiophyllid axial structure and short median plate (Fig. 4d); short cardinal septum in small fossula; minors extend across dissepimentarium and can form pegs on inner dissepimentarium wall; relatively narrow dissepimentarium with regular dissepiments (4 to 8 rows). Periaxial tabellae cystose, incomplete and declined to the dissepimentarium.

Remarks. Typical representatives of the species in all features, except that some of them are somewhat larger than the holotype. The largest specimens show high similarity with the populations from SW Spain (RODRÍGUEZ et al., 2001), which are slightly larger than the Belgium specimens described by ПОТЪ (1981).

Clisiophyllum sp.
Figure 4h

Material. One single specimen, IDM2/1-56; two transverse thin sections.

Location, horizon and age. Idmarrach-2 section, unit 1, upper Serpukhovian.

Description. Fragmentary corallite, 16 mm in diameter and 44 majors. 4 to 5 rows of regular dissepiments. Long septa slightly thickened in the tabularium that reach the axial structure, which shows lower density of elements than typical

representatives of the genus, with 4 to 6 rows of concentric tabellae and nearly half of septal lamellae continuous with majors (21 out of 44); septa thickened in outer tabularium. The cardinal septum in inconspicuous cardinal fossula is connected to long blade-like median plate. Minors cross dissepimentarium and protrude slightly into outer tabularium. External border of the axial structure not well marked.

Remarks. The specimen is clearly different to other species of *Clisiophyllum* such as *C. garwoodi* and *C. keyserlingi* in having a lower number and thicker radial lamellae and a long cardinal septum joined to the median plate in adult stage. Further considerations are not possible (one fragmentary specimen). Consequently, it is left in open nomenclature.

Subfamily Dibunophyllinae Wang, 1950

Genus *Dibunophyllum* Thomson & Nicholson, 1876

Type species. *Dibunophyllum bipartitum* Thomson & Nicholson, 1876

Diagnosis (After HILL, 1940). Large, simple rugose coral, whose variable axial structure is typically one-third as wide as the corallum, and consists of a long median plate, a few (usually four to eight) septal lamellae on either side, and numerous tabellae, sloping steeply down at its periphery; less typically the lamellae may become curved, the median plate disappears, and the bilaterally radiate arrangement lost. Minors are degenerate; the width of the dissepimentarium is about two-thirds the length of the majors, which is two-thirds the radius of the corallite; the dissepiments are frequently inosculating. Tabulae are incomplete and bracket-shaped; the tabellae are of two series, the plates of the outer series being fewer and less steeply declined than those of the inner series. The septa are not curved about the small fossula.

Dibunophyllum bipartitum (McCoy, 1849)
Figures 5a-f

Material. Thirty-two specimens, IDM1/1-1, 15a; IDM2/1-9a, 15, 19, 22, 26; IDM2/2- 7, 8, 9, 10, 12, 15, 16, 17, 23, 27, 29; IDM3/1-3, 10, 16, 18, 20, 37, 44, 61; IDM4-6; IDM/0-2; TIR1/1-3; TIR2/1-13, 51, 52; forty-five transverse and twenty-four longitudinal thin sections.

Location, horizon and age. Idmarrach-1 and -2 sections, unit 1, basal biostromes, unit 2, Idmarrach-3 section, limestone debris, Idmarrach-4 isolated outcrop, Tihela-1 isolated outcrop, Tihela-2 section, basal beds, lower and upper Serpukhovian and lower Bashkirian.

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). Solitary, large corals with a variable axial structure that reach 1/3 of the diameter. It is composed of a median lamella, a small number of radial lamellae and tabulae inclined to the

periphery. The lamellae are usually anastomosed or winding. The dissepimentarium is wide, with short minors and angulate to inosculate, occasionally regular dissepiments. In rare cases the minors are long, reaching the inner border of the dissepimentarium. The septa are commonly thick in the tabularium, mainly in the cardinal quadrants. The tabulae are incomplete, tent-shaped and divided in two series: axial and periaxial. The wall is lamellar with fibrous intercalations. The septa show a thin, irregular mesoplasm. The stereoplasm only occurs in the outer parts of the septa, and on some dissepiments or tabulae.

Description. Large solitary corals, trochoid to ceratoid. The alar diameter in adult stages varies from 19 to 33 mm. The tabularium diameter varies from 12 to 16 mm. Majors range from 44 to 56 in adult stages. They are thin in the dissepimentarium and somewhat thickened in the tabularium. The cardinal septum may be shorter than other majors and is located in a small fossula (Figs. 5a, e). Minors are short and irregular or absent. The dissepimentarium is wide, composed of up to 15 rows of angulate to herringbone dissepiments (Fig. 5a). The inner two or three rows of dissepiments are composed of regular dissepiments. In longitudinal section they are long and declined to the tabularium. The axial structure is large, 8 to 9 mm in diameter, and complex. The median plate is long and thin. There are from 10 to 25 sinuous radial lamellae (Fig. 5a). The border of the axial structure is well marked in longitudinal section by a change in the density and in the declination of the tabellae (Fig. 5b).

Remarks. There is no difference between the Serpukhovian specimens from Adarouch and those described in northern areas of the western Palaeotethys (POTY, 1981; RODRÍGUEZ *et al.*, 2001) or in the Serpukhovian from Saharan basins (SEMENOFF-TIAN-CHANSKY, 1974; ARETZ, 2011; RODRÍGUEZ *et al.*, 2013a).

Dibunophyllum linnense Hill, 1940
Figures 5g, h

Material. Three specimens, IDM2/2-8, 9, 12; four transverse and two longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 2, upper Serpukhovian.

Diagnosis (After HILL, 1940). *Dibunophyllum* with an axial column which is more than one-third as wide as the corallum, but which is constructed like that of *Dibunophyllum bipartitum konincki* (Edwards & Haime, 1851); the outer tabularium is narrow and the septa in it are typically dilated, whereas those in the dissepimentarium are never dilated. The minors are almost entirely degenerate.

Description. Fragmentary and eroded specimens lacking apex and part of the dissepimentarium. Trochoid corals, 28 to 33 mm in diameter and 64 to 66 majors. Septa are thin in the dissepimentarium and thick in the tabularium, mostly in the cardinal quadrants (Figs. 5g, h).

Minors are irregular, some of them are absent, substituted by crowded dissepiments, some other are thin and reach the tabularium. The cardinal septum is shortened in a narrow but deep fossula (Fig. 5g). The dissepimentarium is composed mainly of angulate to herringbone dissepiments, but regular dissepiments are also present. The axial structure is large, up to 12 mm in diameter, showing an inconspicuous median plate and 20 to 25 radial lamellae.

Remarks. This species can be distinguished from *D. bipartitum* by the larger number of majors, narrow and regular dissepimentarium, wider axial structure, and greater number of septal lamellae. The specimens from Idmarrach show identical measurements, thickenings, septal structure and dissepimentarium as the types from Scotland. The only difference is a higher number of radial lamellae in the axial structure.

Genus *Arachnolasma* Grabau, 1922

Type species. *Lophophyllum sinense* Yabe & Hayasaka, 1920

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). Solitary coral with well-developed dissepimentarium. Axial structure having a small diameter (about 1/5 of the alar diameter), composed of a thick median lamella and a low number of radial lamellae. The axial tabulae are more-or-less well differentiated from the rest of the tabularium and strongly declined from the median lamella to the periphery. Septa with two phases of secretion, with the stereoplasm fibrous or lamellar in different species.

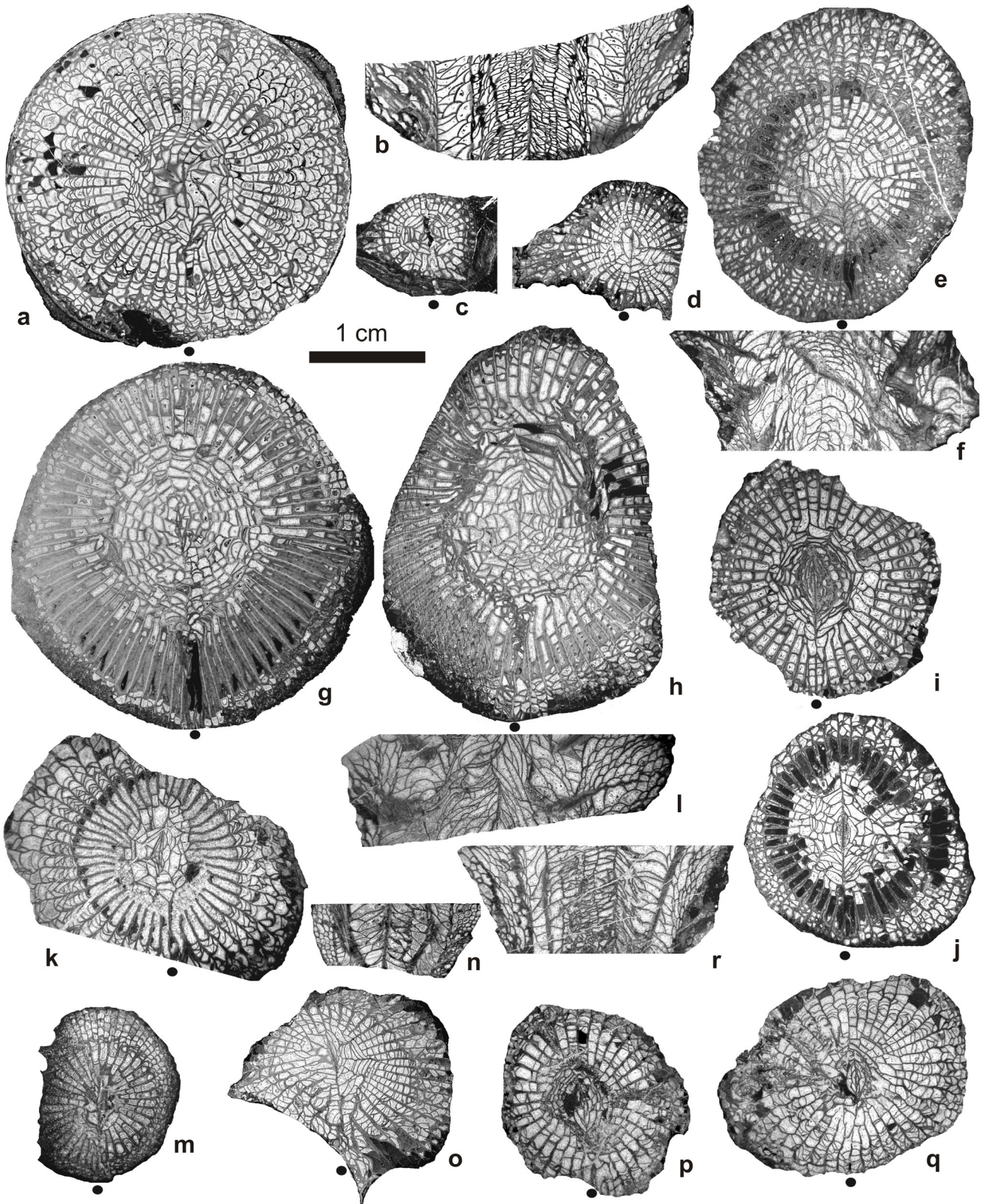
Arachnolasma sinense (Yabe & Hayasaka, 1920)
Figures 5i, j

Material. Six specimens, IDM2/2-23, 28; IDM2/3-3, IDM3/1-13, 34; TIR2/1-53; eight transverse and three longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, units 2 and 3; Idmarrach-3 section, limestone debris; Tirhela-2 section, basal beds; lower and upper Serpukhovian.

Diagnosis (After FEDOROWSKI, 1971). *Arachnolasma* with up to 28 mm in diameter and 47 to 61 septa of each order; dibunophylloid axial structure, occupying 1/5 of the corallite diameter and conspicuous also in longitudinal section. Minors short.

Description. Trochoid corals. Diameter in adult stages varies from 20 to 35 mm. Number of majors range from 40 to 55, most commonly 45. Compact axial structure composed of a relatively thick median plate, connected both with cardinal and counter septa (Figs. 5i, j), few radial lamellae and conical tabellae. Majors slightly thickened in the tabularium and some of them are in continuity with radial lamellae of the axial structure (Fig. 5j). Small cardinal fossula. Short and irregular minors; regular outer dissepiments, inner herringbone dissepiments.



Remarks. The type species for the genus, *A. sinense*, can be distinguished from the closely related species with which it co-occurs, *Dibunophyllum bipartitum*, by the presence of a stouter short median plate, usually joined to the counter septum in a smaller axial structure (typically 1/5 corallite diameter), and fewer majors. As stated by FEDOROWSKI (1971), there is a great variability in the density of elements in the axial structure. The specimens from Adarouch show similar size and number of septa as in the Chinese specimen of Yü (1933), but slightly fewer septa than the specimens described from Poland by FEDOROWSKI (1971).

Arachnolasma aff. *dibunophylloides* (Gorsky in VOLKOVA, 1941)
Figures 5k, l

Material. One single specimen, IDM3/1-35; one transverse and one longitudinal thin sections.

Location, horizon and age. Idmarrach-3 section, limestone debris, lower Serpukhovian.

Description. Trochoid coral. Diameter 28 mm, tabularium diameter 15 mm and 45 majors that are dilated in the tabularium. Minors irregular and short. Cardinal fossula inconspicuous. Longer cardinal septum connected to a thin median plate (Fig. 5k). Spider web axial structure comprising a few septal lamellae, some of them joined to septa, and tabellae, majors which mostly fail to reach axial structure, slightly twisted median plate in longitudinal section and wide dissepimentarium (1/2 corallite radius), composed of regular and herringbone dissepiments; innermost row thickened to form a dissepitheca. Axial tabellae typically conical and periaxial tabellae cystose and declined to the periphery (Fig. 5l).

Remarks. The specimen fits in most features with the types figured by BYKOVA (1966), but it is slightly smaller in dimensions and has fewer

majors (45) than in the holotype (50). The axial structure shows less radial lamellae.

Arachnolasma cylindrica Yü, 1933
Figures 5m-r

Material. Sixteen specimens, IDM0-3, 7; IDM2/1-3, 29, 37, 40; IDM2/3-6, 7, 13; IDM3/1-8b, 33, 38, 41, 42; TIR2/1-20, 37; 22 transverse and 8 longitudinal thin sections

Location, horizon and age. Idmarrach-2 section, units 1 and 3; Idmarrach-3 section, limestone debris; Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (After FEDOROWSKI, 1971). An *Arachnolasma* 22 to 25 mm in diameter and with (42 to 48) x 2 septa; minors shortened; majors mostly not separated from septal lamellae; columella long, lath-like; cardinal fossula poorly visible or lacking.

Description. Solitary corals. Diameter 15 to 22 mm, tabularium diameter 9 to 16 mm and 30 to 45 majors. Long septa reaching the axial structure; some joined to radial lamellae (Figs. 5o, p); minors short and irregular. Cardinal fossula inconspicuous. Thick and long median plate connected with cardinal and counter septa (Figs. 5m, o). Few, irregular radial lamellae and conical tabellae, but axial structure is not well marked; periaxial tabellae connected with conical axial tabellae.

Remarks. Specimens assigned to *A. cylindrica* have a more irregular axial structure with irregular septal lamellae joined to majors or median plate; counter septum and sometimes cardinal septum joined to median plate, and fewer majors than in *A. sinensis*. The specimens from Adarouch fit in all features with the types of Yü (1933); same size and number of septa, not well differentiated axial structure, periaxial tabellae in continuity with axial ones, etc. However, they differ from the Polish specimens described by FEDOROWSKI

Figure 5. Dibunophyllinae. a-f: *Dibunophyllum bipartitum* (McCoy, 1849), a-b: specimen IDM2/2-15, a: transverse section, b: longitudinal section. c: specimen IDM0/2, transverse section, young stage. d-f: specimen IDM4/6, d: transverse section, young stage e: transverse section, adult stage. f: longitudinal section. g-h: *Dibunophyllum linnense* Hill, 1940, g: specimen IDM2/2-9, transverse section. h: specimen IDM2/2-8, transverse section. i-j: *Arachnolasma sinense* (Yabe & Hayasaka, 1920), i: specimen IDM3/1-34, transverse section, j: specimen IDM3/1-13, transverse section. k-l: *Arachnolasma* aff. *dibunophylloides* (Gorsky in VOLKOVA, 1941), specimen IDM3/1-35, k: transverse section. l: longitudinal section. m-r: *Arachnolasma cylindrica* Yü, 1933, m-n: specimen TIR2/1-37, m: transverse section. n: longitudinal section. o: specimen IDM3/1-8, transverse section. p-r: specimen IDM3/1-38, p: transverse section, late young stage, q: transverse section, adult stage, r: longitudinal section. Scale bar 1 cm, same for all pictures. Black dots indicate the location of the cardinal septum.

— Dibunophyllinae. a-f: *Dibunophyllum bipartitum* (McCoy, 1849), a-b: ejemplar IDM2/2-15, a: sección transversal, b: sección longitudinal. c: ejemplar IDM0/2, sección transversal, estadio juvenil. d-f: ejemplar IDM4/6, d: sección transversal, estadio juvenil e: sección transversal, estadio adulto. f: sección longitudinal. g-h: *Dibunophyllum linnense* Hill, 1940, g: ejemplar IDM2/2-9, sección transversal. h: ejemplar IDM2/2-8, sección transversal. i-j: *Arachnolasma sinense* (Yabe & Hayasaka, 1920), i: ejemplar IDM3/1-34, sección transversal, j: ejemplar IDM3/1-13, sección transversal. k-l: *Arachnolasma* sp. cf. *dibunophylloides* (Gorsky in VOLKOVA, 1941), ejemplar IDM3/1-35, k: sección transversal. l: sección longitudinal. m-r: *Arachnolasma cylindricum* Yü, 1933, m-n: ejemplar TIR2/1-37, m: sección transversal. n: sección longitudinal. o: ejemplar IDM3/1-8, sección transversal. p-r: ejemplar IDM3/1-38, p: sección transversal, estadio juvenil tardío, q: sección transversal, estadio adulto, r: sección longitudinal. Escala 1 cm, la misma para todas las figuras. Los puntos negros indican la posición del septo cardinal.

(1971), which show a more differentiated axial structure and moderate septal thickenings that are neither present in the types, nor in the Moroccan specimens.

Genus *Koninckophyllum* Thomson & Nicholson 1876

Type species. *Koninckophyllum magnificum* Thomson & Nicholson 1876

Diagnosis (after SEMENOFF-TIAN-CHANSKY, 1974). Solitary or dendroid corals. Majors withdrawn from axis, except on the surface of some tabulae. Minors generally long. Clisiophylloid axial structure, very reduced: thin axial plate, in some cases styliform and scarce radial lamellae. Cardinal fossula present. Regular to complex, small, globose dissepiments. Tabulae declined from the axial plate, incomplete to more or less complete and horizontal if medial plate is missing. Microstructure: septa with fibrous or granulo-fibrous mesoplasm with indented borders; fibrous or lamellar stereoplasm.

Koninckophyllum magnificum (Thomson & Nicholson, 1876)

Figures 6c-g

Material. Fourteen specimens, IDM2/1-30, 31, 32, 42, 44, 45, 46; IDM3/1-9c, 11, 66, 69; IDM4-15; TIR1/1-1; TIR2/1-25b; twenty transverse and seven longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 1; Idmarrach-3 section, limestone debris and interbedded marls; Idmarrach-4 isolated outcrop; Tirhela-1 isolated outcrop; Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (After HILL, 1940). Patellate, turbinate, or trochoid *Koninckophyllum*; with a dibunophylloid or clisiophylloid axial structure in neanic stages; in ephebic stages the septal lamellae withdraw from the axis, leaving a columella in an axial space; in gerontic stages the columella may atrophy. The dissepimentarium is very wide, with fine, concentric dissepiments, and the septa may be buttressed by very small dissepiment-like plates.

Description. Solitary corals having 40 to 49 majors for corallite diameter 15 to 25 mm and tabularium diameter 10 to 15.3 mm. Majors slightly dilated in outer tabularium and withdrawn from axis. Minors thin, restricted to the dissepimentarium. Cardinal septum short located in a prominent fossula (Figs. 6c, g). Dissepimentarium composed of regular dissepiments in the peripheral parts, but some angulate dissepiments occur in the inner zones. Conical tabulae in the axial zone, reinforced with small tabellae in the periphery. Conspicuous median plate that is connected to a longer counter septum (Fig. 6c) and continuous in longitudinal section (Fig. 6f).

Remarks. Features of the specimens from Adarouch fit completely with those of the THOMPSON & NICHOLSON (1876) type and show less variability than the specimens included in this species by HILL (1938-41) in size, development of the axial structure, width of the dissepimentarium, etc.

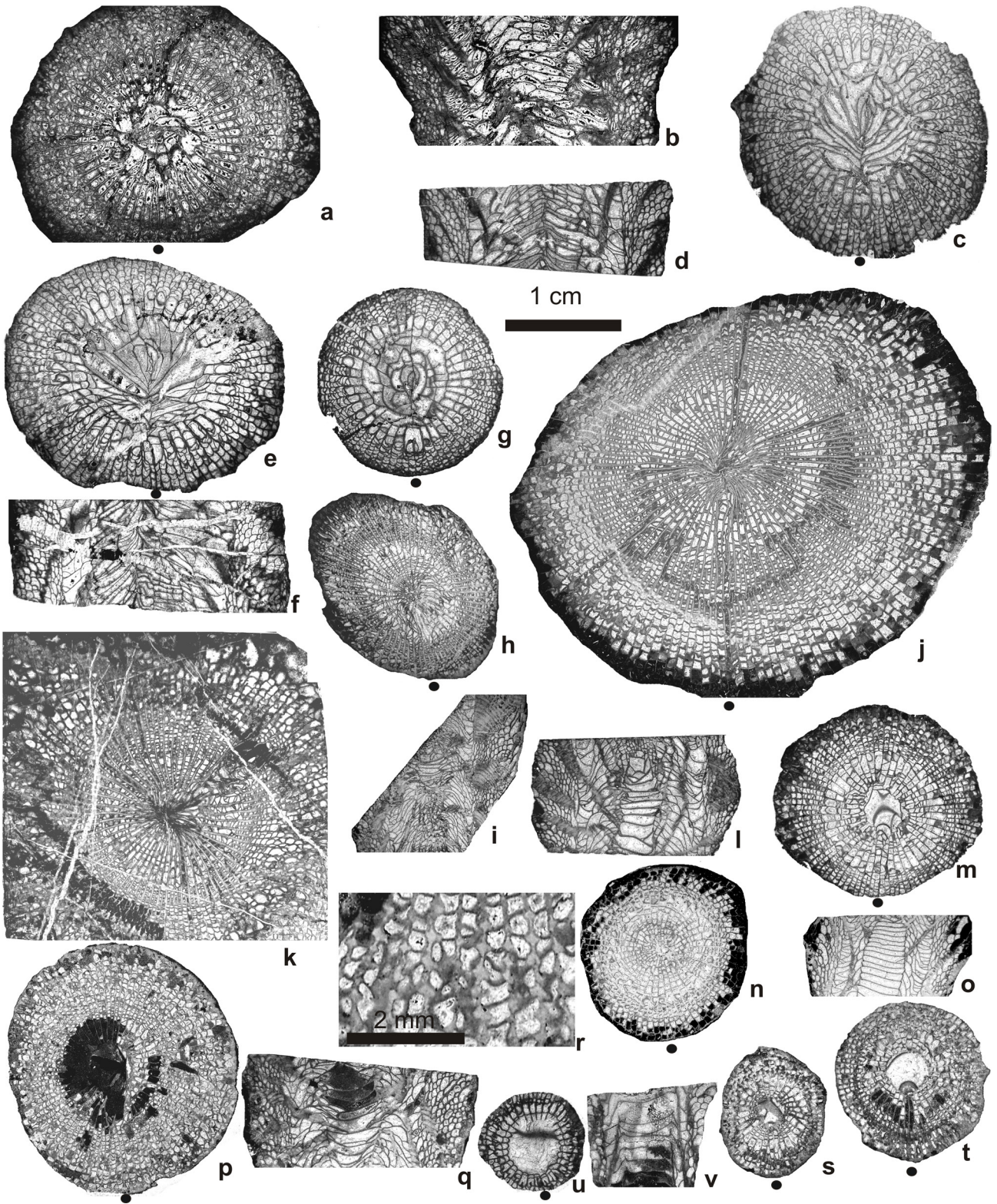
Koninckophyllum interruptum (Thomson & Nicholson, 1876)

Figures 6a, b

Material. One single specimen, IDM2/1-17; one transverse and one longitudinal thin section.

Figure 6. *Koninckophyllum* and Palaeosmiliidae. a-b: *Koninckophyllum interruptum* Thomson & Nicholson, 1876, specimen IDM2/1-17, a: transverse section, b: longitudinal section. c-g: *Koninckophyllum magnificum* (Thomson & Nicholson, 1876), c-d: specimen IDM2/1-30, c: transverse section, d: longitudinal section. e-f: specimen IDM2/1-44, e: transverse section, f: longitudinal section. g: specimen IDM2/1-31, transverse section. h-j: *Palaeosmilia purchisoni* Milne-Edwards & Haime, 1848, h-i: specimen TIR2/1-31, h: transverse section, i: longitudinal section. j: specimen IDM3/1-2, transverse section. k: *Palaeosmilia regia* (Phillips, 1836), specimen IDM2/2-4, transverse section. l-t: *Aulokoninckophyllum carinatum* (Carruthers, 1909) l-m: specimen IDM2/1-54, l: longitudinal section, m: transverse section. n-o: specimen TIR2/1-29, n: transverse section, o: longitudinal section. p-r: specimen IDM3/1-15, p: transverse section, q: longitudinal section, r: enlarged view of 6p to show carinae in dissepimentarium. s-t: specimen IDM3/1-43, s: transverse section, young stage, t: transverse section, adult stage. u-v: *Semenoffia* sp., specimen IDM3/1-25, u: transverse section, v: longitudinal section. Scale bar 1 cm, same for all pictures except r, 2 mm. Black dots indicate the location of the cardinal septum.

— *Koninckophyllum* y Palaeosmiliidae. a-b: *Koninckophyllum interruptum* Thomson & Nicholson, 1876, ejemplar IDM2/1-17, a: sección transversal, b: sección longitudinal. c-g: *Koninckophyllum magnificum* (Thomson & Nicholson, 1876), c-d: ejemplar IDM2/1-30, c: sección transversal, d: sección longitudinal. e-f: ejemplar IDM2/1-44, e: sección transversal, f: sección longitudinal. g: ejemplar IDM2/1-31, sección transversal. h-j: *Palaeosmilia purchisoni* Milne-Edwards & Haime, 1848, h-i: ejemplar TIR2/1-31, h: sección transversal, i: sección longitudinal. j: ejemplar IDM3/1-2, sección transversal. k: *Palaeosmilia regia* (Phillips, 1836), ejemplar IDM2/2-4, sección transversal. l-t: *Aulokoninckophyllum carinatum* (Carruthers, 1909) l-m: ejemplar IDM2/1-54, l: sección longitudinal, m: sección transversal. n-o: ejemplar TIR2/1-29, n: sección transversal, o: sección longitudinal. p-r: ejemplar IDM3/1-15, p: sección transversal, q: sección longitudinal, r: detalle de 6p que muestra las carenas de los septos en el dissepimentario. s-t: ejemplar IDM3/1-43, s: sección transversal, estadio juvenil, t: sección transversal, estadio adulto. u-v: *Semenoffia* sp., ejemplar IDM3/1-25, u: sección transversal, v: sección longitudinal. Escala 1 cm, la misma para todas las figuras, excepto r, 2 mm. Los puntos negros indican la posición del septo cardinal.



Location, horizon and age. Idmarrach-2 section, unit 1, upper Serpukhovian.

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). Solitary *Koninckophyllum* with axial structure more rudimentary than *K. magnificum*. Possible presence of lonsdaleoid dissepiments. Fibrous septa composed of thick mesoplasm with undulated borders and stereoplasm only in the tabularium.

Description. Solitary trochoid coral having 55 majors in 25.6 mm of alar diameter and 14.1 mm of tabularium diameter. Majors are long, extending over $\frac{3}{4}$ of the radius and slightly thickened. Minors are irregular, reaching usually $\frac{1}{2}$ of the majors, but showing strong variation. Wide dissepimentarium ($\frac{1}{4}$ of the corallite diameter) (Fig. 6a). 15 to 20 rows of regular to angulate dissepiments in transverse section, small and globose in longitudinal section. The columella is thin, irregular and discontinuous as seen in longitudinal section (Fig. 6b). Tabulae are incomplete and convex to domed.

Remarks. Most features are identical to the types of the species. The main difference of the specimen from Idmarrach to the types from Britain is the total absence of lonsdaleoid dissepiments (HILL, 1938-41).

Family Palaeosmiliidae Hill 1940

Genus *Palaeosmilia* Milne-Edwards & Haime, 1848

Type species. *Palaeosmilia murchisoni* Milne-Edwards & Haime, 1848

Diagnosis (After RODRÍGUEZ *et al.*, 2013b). Solitary corals with numerous septa radially disposed; long minors; some majors reach the axis. The cardinal fossula is narrow and reaches the axis. Incomplete tabulae disposed in two series. An axial series composed of globose tabellae, with the axial zone slightly depressed, and a periaxial series composed of convex tabellae that may be declined to the dissepimentarium. Numerous, small, regular dissepiments that may be replaced in the periphery by transeptal and/or naotic dissepiments. The microstructure is composed of a lamellar wall and fibrous septa. The peripheral part of the septa (dissepimentarium) is trabecular, but the inner zone of the septa (tabularium) is composed of fibres with water-jet disposition.

Palaeosmilia murchisoni Milne-Edwards & Haime, 1848
Figures 6h-j

Material. Five specimens, IDM2/4-1; IDM3/1-2; TIR2/1-11, 14, 31; six transverse and two longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 4; Idmarrach-3 section, limestone debris; Tirhela-2 section, basal and top beds, lower and upper Serpukhovian and lower Bashkirian.

Diagnosis (After SEMENOFF-TIAN-CHANSKY, 1974). Solitary, turbinate to cylindrical, more or less curved *Palaeosmilia* that may reach large size (10 cm in diameter). A large number of septa reach the axis. Narrow fossula reaches the axis, where it gets wider. Long minors that reach $\frac{1}{2}$ to $\frac{2}{3}$ of the radius of the coral. Axial tabulae incomplete forming a central dome with a depressed axial zone. Lamellar wall and completely fibrous septa without discontinuity between the mesoplasm and stereoplasm. The septa may be trabecular, at least in part. Stereoplasmatic thickenings occur on thick dissepiments.

Description. Large solitary corallites having 61 to 87 majors in 34 to 59 mm in diameter. Long majors, that reach the axis; trabecular in the dissepimentarium and water-jet to fibronormal in the tabularium (Fig. 6h, i). The trabecular structure in the dissepimentarium is shown by the irregular to zig-zag trajectory of the septa, whereas they are straight in the tabularium. The trabeculae are clearly seen in longitudinal section (Fig. 6i). Long minors that penetrate in the tabularium. Long cardinal septum located in a narrow fossula that also reach the axis (Fig. 6j). Domed tabulae, which show a small depression at the axis (Fig. 6i).

Remarks. All corallites can be easily identified as *P. murchisoni*. No specimens from Adarouch can be related to the forma *stutchburyi* (with common lonsdaleoid dissepiments). A detailed synonymy can be found in SEMENOFF-TIAN-CHANSKY (1974).

Genus *Palaeosmilia* McCoy, 1851

Type species. *Astraea carbonaria* McCoy, 1849

Diagnosis (After HILL, 1981). Cerioid, astreoid or aphroid *Palaeosmilia*.

Palaeosmilia regia (Phillips, 1836)

Figure 6k

Material. One single specimen, IDM2/4-4; one transverse section.

Location, horizon and age. Idmarrach-2 section, unit 4, upper Serpukhovian.

Diagnosis. Colonial coral with numerous septa radially disposed; long minors; some majors may reach the axis. The cardinal fossula is narrow and reaches the axis. Incomplete tabulae disposed in two series. An axial series composed of globose tabellae, with the axial zone slightly depressed, and a periaxial series composed of convex tabellae that may be declined to the dissepimentarium. Numerous, small, regular dissepiments that may be replaced in the periphery by transeptal and/or naotic dissepiments. The peripheral part of the septa (dissepimentarium) is trabecular, but the inner zone of the septa (tabularium) is composed of fibres with water-jet disposition.

Description. Fragment of a colony with wide dissepimentarium and absence of corallite wall. Majors 55 for corallite 46 mm; tabularium 16 mm. The trabecular microstructure of septa in

the dissepimentarium is marked by their irregular trajectory, which contrast with the straight trajectory in the tabularium, where they are fibrous (Fig. 6k).

Genus *Aulokoninckophyllum* Sando, 1976

Type species. *Campophyllum carinatum* Carruthers, 1909

Diagnosis (Modified from SANDO, 1976). Solitary or pseudofasciculate aulate corals in which aulos is poorly defined and formed mainly by union of the axial ends of majors and partly by tabulae. Majors long, carinate; carinae of zig-zag type. Cardinal fossula ordinarily present. Dissepimentarium regular. Tabulae in aulos ordinarily flat, horizontal; tabulae in tabularium complete or incomplete, sloping downward toward periphery of corallite. Increase seemingly lateral or peripheral. Septal microstructure trabecular.

Aulokoninckophyllum carinatum (Carruthers, 1909)

Figures 6l-t

Material. Twelve specimens, IDM2/1-54, 55; IDM3/1- 15, 22, 39, 40, 47, 63b, 64; TIR2/1-29, 36, 38; twenty-two transverse and ten longitudinal sections.

Location, horizon and age. Idmarrach-2 section, basal beds, Idmarrach-3 section limestone debris and interbedded marls and Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (Modified from SANDO, 1976). Solitary (conical to cylindrical) or pseudofasciculate *Aulokoninckophyllum* with mature corallites 10 to 28 mm in diameter, 24 to 54 ordinarily strongly carinate majors and an equal number of long minors (one-half to two-thirds length of majors), a poorly formed aulos 3 to 5 mm in diameter, tabulae numbering about 6 to 16 in 5 mm in the aulos and about 7 to 10 in 5 mm in the tabularium, and a dissepimentarium 2 to 10 mm wide composed of 4 to 16 rows of regular dissepiments. Cardinal fossula weakly to strongly developed. Increase seemingly lateral or peripheral. Septal microstructure trabecular in the dissepimentarium, water-jet fibrous in the tabularium.

Description. Solitary corals showing long carinate majors (34 to 50) for corallite diameter 14.2 to 21.8 mm and tabularium 10.3 to 14.2 mm. Most specimens have long minors which cross the dissepimentarium or extend into the outer tabularium where they are thickened along with majors (Fig. 6t). They are typically $\frac{1}{2}$ to $\frac{3}{5}$ length of majors. Wide koninckophyllid dissepimentarium (Fig. 6p). Width of aulos is variable in the specimens from Adarouch. Tabulae are flat in the axial aulos and declined to the dissepimentarium in the periphery (Figs. 6l, o).

Remarks. The specimens from Adarouch are comparable with material recorded in Algeria (SEMENOFF-TIAN-CHANSKY, 1974). This species

shows a high variability as already stated by SANDO (1976). The specimens from Tirhela show septa that are longer on the tabular floors producing the effect of a very narrow aulos when cut at that level. The development of the carinae is very variable and some specimens do not show that feature.

Genus *Semenoffia* Poty, 1981

Type species. *Aulokoninckophyllum amarensis* Semenoff-Tian-Chansky, 1974

Diagnosis (After POTY, 1981). Solitary corals having an aulos composed of the deflection or the bifurcation of the inner border of the majors, in which the tabulae may be peripherally upright. Major and minors sometimes carinate. Narrow dissepimentarium (one-third of the corallite radius), composed of regular dissepiments, in some instances herringbone or transeptal. Cardinal septum short. Cardinal fossula present, open to the aulos. Axial tabellae sparse. Periaxial tabellae slightly divided and declined to the dissepimentarium.

Semenoffia sp.

Figures 6u-v

Material. Two specimens, IDM3/1- 25, 27; two transverse and one longitudinal thin sections.

Location, horizon and age. Idmarrach-3 section, flank beds of buildup, lower Serpukhovian.

Description. Two small corallites having 22 to 33 majors in 6.5 to 9 mm diameter. Wide aulos (3.5 to 4.5 mm). Minors short, penetrating slightly in the tabularium (Fig. 6u). Narrow dissepimentarium, composed of regular dissepiments that in longitudinal section are large and globose (Fig. 6v). Tabulae flat to slightly concave in the aulos, very steeply declined to the dissepimentarium with biform inner border.

Remarks. It differs from *S. viseensis* Poty, 1981 by a greater number of septa and wider aulos but the coral diameter is smaller. It differs from the type species *S. amarensis* (Semenoff-Tian-Chansky, 1974) by its smaller dimensions, and fewer septa (51 in the holotype), but it shows in common a narrow dissepimentarium, and widely spaced horizontal tabulae and minors which extend into the outer tabularium.

Family Lithostrotionidae D'Orbigny, 1852

Subfamily Lithostrotioninae D'Orbigny, 1852

Genus *Lithostrotion* Fleming, 1828

Type species. *Lithostrotion striatum* FLEMING, 1828 = *Lithostrotion vorticale* (PARKINSON, 1808).

Diagnosis (After POTY, 1981), Cerioid colonial coral. Majors long, extending to the axis and commonly connected to the columella. Minors extending to the inner edge of the dissepimentarium or slightly entering the tabularium. Columella lath-like, connected to the counter septum. Dissepimentarium of various

widths, made of simple interseptal dissepiments and occasional lonsdaleoid dissepiments. Tabulae incomplete. Axial tabulae conical and peripheral tabulae horizontal or declined towards the dissepimentarium. Increase lateral and non-parricidal.

Remarks. Detailed analysis of the family as well as details of the different genera and species and complete synonymies can be found in NUDDS (1980), POTY (1981), RODRÍGUEZ *et al.* (2001) and BAMBER *et al.* (*in press*).

Lithostrotion decipiens (McCoy, 1849)
Figures 7a-f

Material. Sixteen specimens, IDM1/1-6, 7; IDM2/1-5, 16, 48; IDM2/2-2, 3; IDM2/3-10, 11, 12; IDM3/1-5c, 7, 9d, 32; IDM4- 1, 5; TIR1/1-6; twenty-five transverse and twenty-two longitudinal thin sections.

Location, horizon and age. Idmarrach-1 section, basal beds; Idmarrach-2 section, units 1, 2, 3; Idmarrach-3, limestone debris; Idmarrach-4, isolated outcrop; Tirlhela-1 isolated outcrop; lower and upper Serpukhovian and lower Bashkirian.

Diagnosis (After POTY, 1981). Medium-sized *Lithostrotion*, maximum 3 mm in tabularium diameter and a having maximum of 18 majors.

Description. The colonies belonging to this species from Idmarrach and Tirlhela formations have a mean of the tabularium diameter that varies from 2 to 3.3 mm, the mean of the corallite diagonals varies from 4 to 7 mm and the mean of the majors number varies from 14 to 18.

Remarks. Terrigenous inputs provoked changes in the growth of colonies that can locally develop a pseudophaceloid habit (Fig. 7a).

Lithostrotion vorticale (Parkinson, 1808)
Figures 7g-j

Material. Six specimens, IDM2/1-6, 36; IDM2/2-1; TIR1/1-4, 5; TIR2/1-39; twelve transverse and ten longitudinal thin sections.

Location, horizon and age. Idmarrach-1 and -2 sections, units 1 and 2; Tirlhela isolated outcrop and Tirlhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (After POTY 1981). Medium-sized *Lithostrotion*, maximum 4.1 mm in tabularium diameter and having a maximum of 24 majors.

Description. The specimens identified as *L. vorticale* in Idmarrach and Tirlhela formations show a tabularium diameter that varies from 2.5 to 4.6 mm, with a mean of 3.7 to 4.0 mm. The corallite diameter varies from 7.5 to 10.5 mm. The number of majors varies from 16 to 21, with a mean of 18 to 19. Colonies can locally develop a pseudophaceloid habit (Fig. 7h).

Remarks. The specimens identified as *L. vorticale* show a number of septa slightly lower than typical specimens of the species, but all other

features fit with those of the representatives of the species in western Palaeotethys.

Lithostrotion maccoyanum Milne-Edwards & Haime, 1851
Figure 7k

Material. One single specimen, IDM2/1-25; one transverse thin section

Location, horizon and age. Idmarrach-2 section, unit 1, basal biostromes, upper Serpukhovian.

Diagnosis (After POTY, 1981). *Lithostrotion* with very small corallites characterized by 10 to 14 septa of each cycle and a tabularium diameter lower than 2 mm.

Description. Fragmentary cerioid corallum showing four to seven-sided corallites 1.5 to 2 mm in tabularium diameter, 3 to 4 mm in corallite diameter and having 13 to 15 majors that are thin and long, reaching the axis of the corallites. Protosepta inconspicuous. One to three rows of small and regular dissepiments.

Remarks. The features of the studied colony are typical for the species. The specimen was described in the unpublished Ph. D of ISMAIL SAID (2005), but the thin section was destroyed during a move. Now the only remaining material is a small fragment of the colony and a picture taken in 2005.

Genus *Siphonodendron* McCoy, 1849

Type species. *Siphonodendron pauciradiale* (McCoy, 1844)

Diagnosis (After POTY, 1981). Fasciculate coral, with corallites having styliform columella. Majors variable in length, that may reach the columella or not. Minors more-or-less developed, reduced to the dissepimentarium or penetrating slightly in the outer tabularium. Dissepimentarium well developed, composed of regular dissepiments, absent in the very small specimens. Complete or somewhat divided, conical tabulae. They form a channel close to the dissepimentarium. Lateral, non-parricidal budding, except in some rare species, in which it may be peripheral and parricidal.

Siphonodendron martini (Milne-Edwards & Haime, 1851)
Figure 8a

Material. Four specimens, IDM1/1-8b, 15b; IDM 2/1-8, TIR2/1-27; eleven transverse and eight longitudinal thin sections.

Location, horizon and age. Idmarrach-1 and -2 sections, basal biostromes; Tirlhela-2 section, basal beds, upper Serpukhovian.

Diagnosis (Modified from SEMENOFF-TIAN-CHANSKY & NUDDS, 1979; POTY, 1981). Phaceloid corals with long majors commonly reaching columella; minors short, locally penetrating outermost tabularium; columella strongly developed, rarely discontinuous; biform

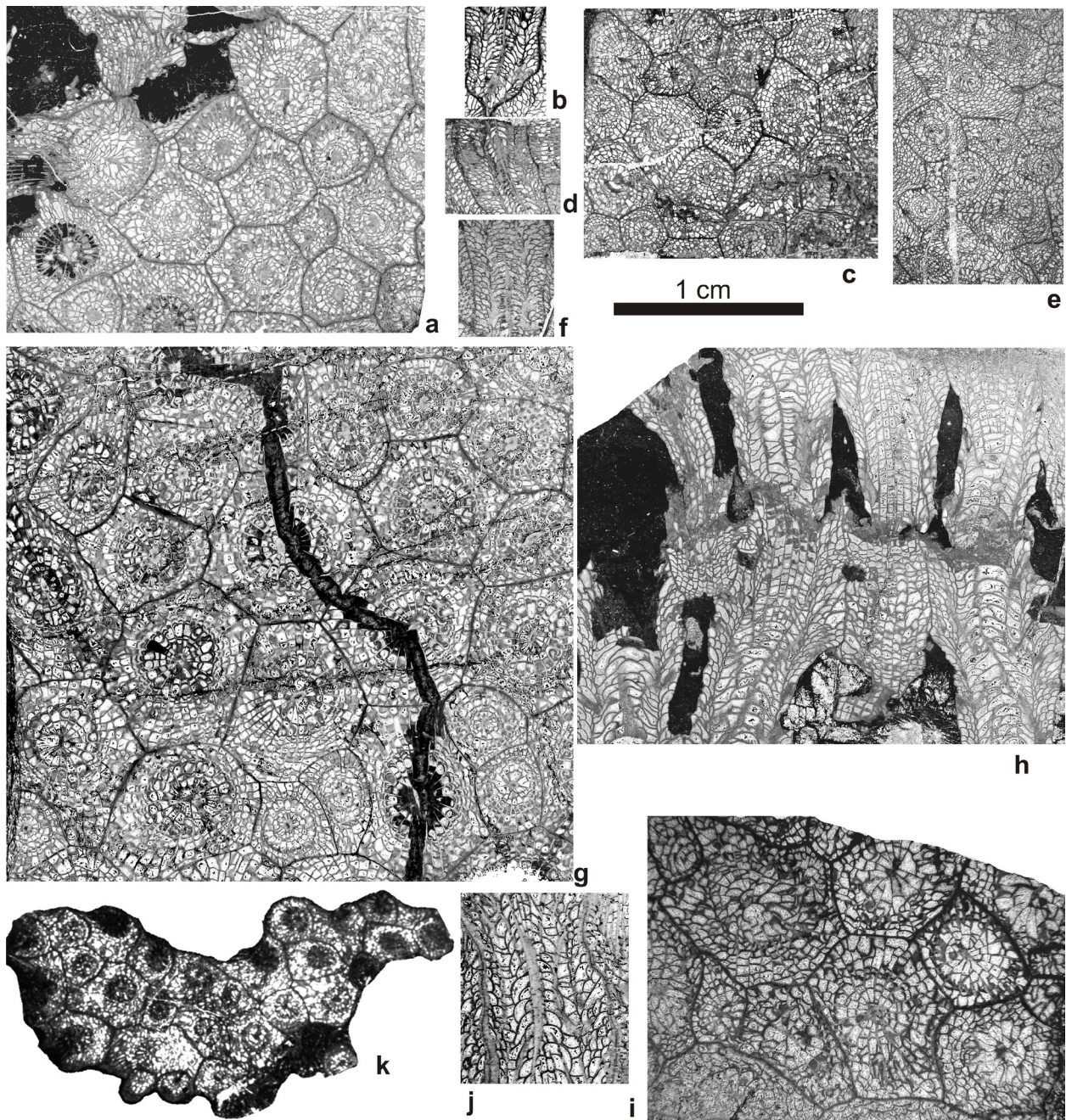


Figure 7. *Lithostrotion*. a-f: *Lithostrotion decipiens* (McCoy, 1849), a-b: specimen IDM2/1-5, a: transverse section, b: longitudinal section. c-d: specimen IDM2/2-3, c: transverse section, d: longitudinal section. e-f: IDM3/1-7, e: transverse section, f: longitudinal section. g-j: *Lithostrotion vorticale* (Parkinson, 1808), g-h: specimen IDM2/1-36, g: transverse section, h: longitudinal section. i: specimen TIR2/1-39, transverse section. j: specimen IDM2/2-1, longitudinal section. k: *Lithostrotion maccoyanum* Milne-Edwards & Haime, 1851, specimen IDM2/1-25, transverse section. Scale bar 1 cm, same for all pictures.

— *Lithostrotion*. a-f: *Lithostrotion decipiens* (McCoy, 1849), a-b: ejemplar IDM2/1-5, a: sección transversal, b: sección longitudinal. c-d: ejemplar IDM2/2-3, c: sección transversal, d: sección longitudinal. e-f: IDM3/1-7, e: sección transversal, f: sección longitudinal. g-j: *Lithostrotion vorticale* (Parkinson, 1808), g-h: ejemplar IDM2/1-36, g: sección transversal, h: sección longitudinal. i: ejemplar TIR2/1-39, sección transversal. j: ejemplar IDM2/2-1, sección longitudinal. k: *Lithostrotion maccoyanum* Milne-Edwards & Haime, 1851, ejemplar IDM2/1-25, sección transversal. Escala 1 cm, la misma para todas las figuras.

morphology locally well expressed in tabularium, tabulae complete or incomplete, gently to steeply elevated adaxially, small peripheral plates commonly developed; dissepiments small, strongly convex to globose, usually in 2 to 4 rows; 23 to 28 (commonly 23 to 25) majors at corallite diameter 6 to 9 mm.

Description. The studied specimens have a relatively wide tabularium (5.1 to 6.1 mm) for corallite diameter (7.6 to 8.1 mm), but the number of majors are low (21 to 23) for corallites of this diameter. The colonies show a high density of corallites, which in some cases share external walls. Septa are usually withdrawn from axis, but in almost all corallites some of them reach the laminar columella.

Remarks. The specimens identified as *S. martini* from Adarouch show identical size to those typical for the species, but the number of septa is just within the lower limit of it. However, the combination of both features allow their distinction from other close species, such as *S. intermedium* or *S. irregulare*.

Siphonodendron pauciradiale (McCoy, 1844)
Figures 8b, c

Material. Three colonies, IDM1/1-8a; IDM2/1- 8, 11; eight transverse and eight longitudinal thin sections.

Location, horizon and age. Idmarrach-1 and -2 sections, basal biostromes, upper Serpukhovian.

Diagnosis (After POTY 1981). Dendroid to phaceloid colonies. Corallites mean diameter 4 mm for 18 to 20 majors (maximum 22). 1 to 2 rows of dissepiments, rarely up to 4.

Description. The studied specimens are phaceloid colonies showing a tabularium that varies from 2.7 to 3.6 mm, a corallite diameter that ranges from 3.6 to 4.8 mm, number of septa that varies from 19 to 21, and typically 1 or 2 rows of regular, small and globose dissepiments. The septa are thin; many of them reach the thick columella. The axial tabulae are domical to conical and the periaxial tabulae are declined towards the periphery.

Remarks. Specimens identified as *S. pauciradiale* from Idmarrach show typical features

of that species, showing same size and number of septa as types.

Siphonodendron irregulare (Phillips, 1836)
Figures 8d-f

Material. Nine specimens, IDM2/1-2; IDM3/1-9a, 62, 63a; IDM4-3; TIR2/1- 21, 22, 23, 26; twenty-three transverse and sixteen longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, basal biostromes; Idmarrach-3 section, limestone debris; Idmarrach-4 isolated outcrop; Tirhela-2 section, basal beds, lower and upper Serpukhovian.

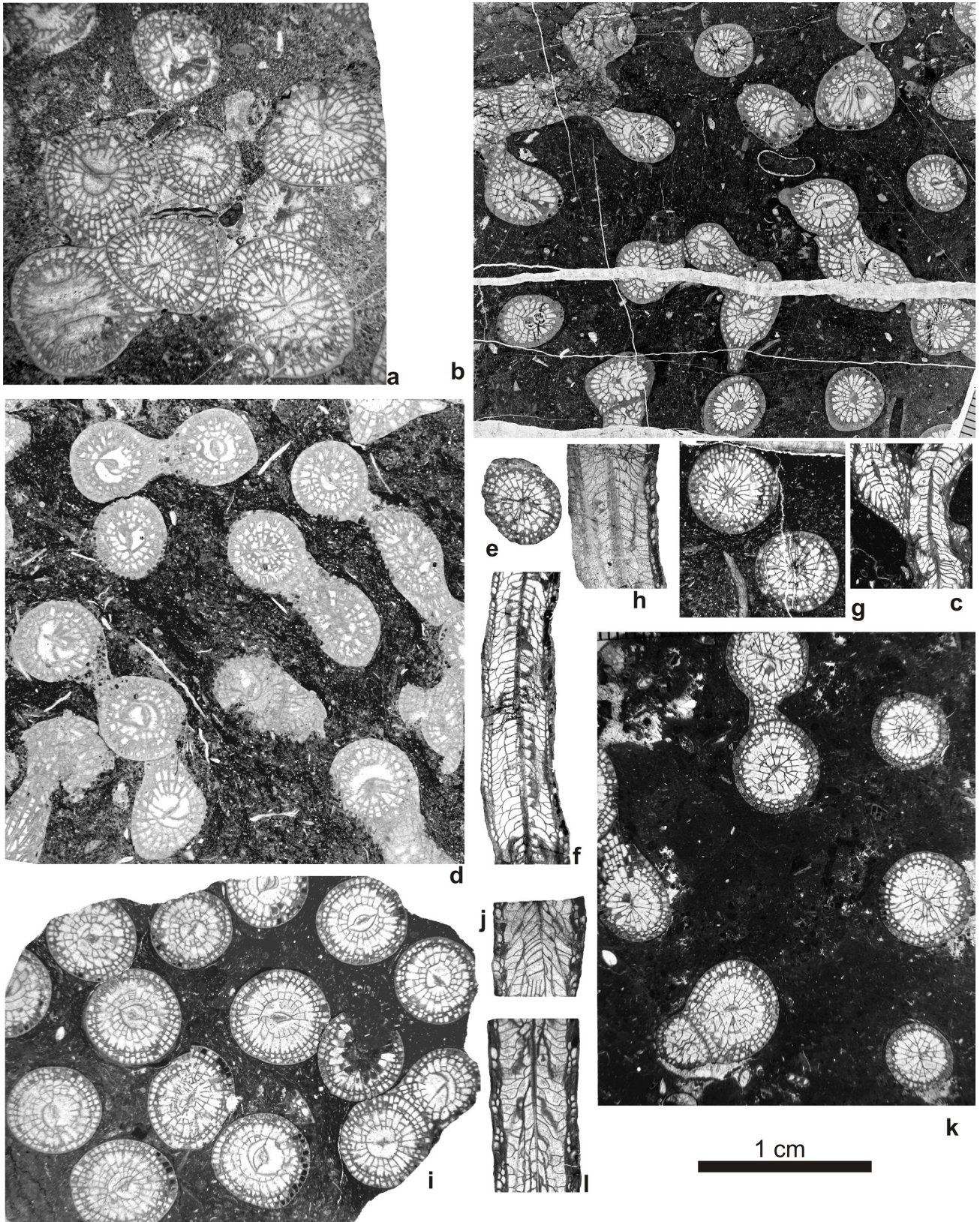
Diagnosis (Modified from POTY, 1981). Phaceloid corals with long majors usually reaching columella, less commonly strongly withdrawn abaxially; minors short, locally penetrating outermost tabularium; columella strongly developed, rarely discontinuous; biform morphology locally well expressed in tabularium, tabulae complete or incomplete, gently to steeply elevated adaxially, subhorizontal or concave where majors shortened, small peripheral plates commonly developed; dissepiments small, strongly convex to globose, usually in 1 or 2 rows, rarely up to 4 rows over short intervals; 20 to 26 (commonly 21 to 24) majors at corallite diameter 4 to 6 mm.

Description. The specimens from Adarouch show tabularium diameter varying from 3.3 to 4.5 mm, corallite diameter ranging from 4.5 to 6.0 mm and number of majors varying from 19 to 22. The columella is thick and steady, joined to cardinal and counter septa. Most other majors are short and only reach the columella on the surface of some tabulae. Minors very short. One or two rows of regular, small, globose dissepiments. Tabulae typically incomplete. Domed axial tabellae and periaxial tabellae declined towards the periphery.

Remarks. The specimens from Adarouch identified as *S. irregulare* show identical features to the populations of this species from northern Palaeotethys (Belgium, Great Britain, Spain) and can be distinguished from *S. intermedium* by slightly smaller dimensions (POTY, 1981).

Figure 8. *Siphonodendron*. a: *Siphonodendron martini* (Milne-Edwards & Haime, 1851), specimen TIR2/1-27, transverse section. b-c: *Siphonodendron pauciradiale* (McCoy, 1844), specimen IDM2/2-11, b: transverse section, c: longitudinal section, d-f: *Siphonodendron irregulare* (Phillips, 1836), d: specimen TIR2/1-21, transverse section. e-f: specimen IDM2/1-2, e: transverse section, f: longitudinal section of a single corallite. g-l: *Siphonodendron intermedium?* Poty, 1981: g-h: specimen IDM2/1-24, g: transverse section, h: longitudinal section. i-j: specimen IDM2/1-7, i: transverse section, j: longitudinal section, k-l: specimen IDM2/1-10, k: transverse section, l: longitudinal section. Scale bar 1 cm, same for all pictures.

— *Siphonodendron*. a: *Siphonodendron martini* (Milne-Edwards & Haime, 1851), ejemplar TIR2/1-27, sección transversal. b-c: *Siphonodendron pauciradiale* (McCoy, 1844), ejemplar IDM2/2-11, b: sección transversal, c: sección longitudinal, d-f: *Siphonodendron irregulare* (Phillips, 1836), d: ejemplar TIR2/1-21, sección transversal. e-f: ejemplar IDM2/1-2, e: sección transversal, f: sección longitudinal de un coralito. g-l: *Siphonodendron intermedium?* Poty, 1981: g-h: ejemplar IDM2/1-24, g: sección transversal, h: sección longitudinal. i-j: ejemplar IDM2/1-7, i: sección transversal, j: sección longitudinal, k-l: ejemplar IDM2/1-10, k: sección transversal, l: sección longitudinal. Escala 1 cm, misma para todas las figuras.



Siphonodendron intermedium? Poty, 1981
Figures 8g-l

Material. Eight colonies, IDM2/1-7, 10, 14, 24a, 50; IDM2/2-6; IDM3/1-30; TIR2/1-28; seventeen transverse and ten longitudinal thin sections.

Location, horizon and age. Idmarrach-1 and -2 sections, basal biostromes, Idmarrach-3, limestone debris, Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (After POTY, 1981). Phaceloid colonies. Corallites mean diameter 5.2 to 6.2 mm for 21 to 24 majors (maximum 26). Minors, half of the majors in length. Usually 2 rows of dissepiments.

Description. The studied specimens show a relative uniform size of corallites: tabularium (4.2 to 5.2 mm) and corallite diameter (5.1 to 6.7 mm); number of majors range from 19 to 23. They show a regular dissepimentarium composed typically of two rows of small, globose dissepiments. Majors are long, most of them reach the columella, that is styliform. Minors penetrate slightly in the tabularium. Tabulae are incomplete, composed of a series of conical to domed axial tabellae and a series of periaxial tabellae declined towards the dissepimentarium.

Remarks. The specimens from Adarouch differ from the holotype by the presence of longer majors, some of which reach the columella and a more complex tabularium. They could represent a different species or an ecological variant and for that reason are identified with a question mark.

Subfamily Diphyphyllinae Dybowski, 1873

Genus *Diphyphyllum* Lonsdale, 1845

Type species. *Diphyphyllum concinnum* Lonsdale, 1845

Diagnosis (After POTY, 1981). Fasciculate coral with corallites lacking a columella and peripheral, parricidal increase. Short majors. Minors restricted to the dissepimentarium or crossing slightly the inner border. Simple regular dissepiments. Tabulae usually divided; axial tabulae flat, horizontal and having curved borders to join the subjacent tabulae; periaxial tabulae flat, horizontal or somewhat declined to the dissepimentarium. Small cardinal fossula present.

Diphyphyllum lateseptatum (McCoy, 1849)
Figures 9a-d

Material. Five colonies, IDM1/1-8c; IDM2/1-9b, 13; IDM3/1-48; IDM4-4; eight transverse and six longitudinal thin sections

Location, horizon and age. Idmarrach-1 and -2 sections, basal biostromes; Idmarrach-3 section, limestone debris, Idmarrach-4 isolated outcrop, lower and upper Serpukhovian.

Diagnosis (After POTY, 1981). Phaceloid *Diphyphyllum*, in which corallites have a mean

of 7.2 to 9.1 mm in diameter, 24 to 30 septa as a mean and 38 septa of each cycle as a maximum.

Description. The studied specimens are fragments of phaceloid colonies, which show parricidal increase and have the following measurements: tabularium diameter, 6.3 to 8.2 mm; corallite diameter, 8.1 to 10 mm; number of septa 24 to 30. Majors reach approximately half of the radius. Minors penetrate slightly in the tabularium. One or two, more rarely three rows of small and regular dissepiments. Tabulae incomplete, composed of an axial series of domed to mesa-shaped tabellae and periaxial tabellae declined towards the dissepimentarium.

Remarks. Species can be identified as *Diphyphyllum lateseptatum* by identical measurements and morphology (increase, septa, dissepiments and tabulae) as the types.

Diphyphyllum furcatum Hill, 1940
Figures 9e, f

Material. Two fragments of colonies, IDM2/1-12, IDM4-2; four transverse and three longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, basal biostromes. Idmarrach-4 isolated outcrop, upper Serpukhovian.

Diagnosis (After POTY, 1981). Corallites 6.2 to 6.9 mm in diameter and having 23 to 25 majors (maximum 31). 2 to 4 rows of dissepiments.

Description. Moderate tabularium diameter (4.5 to 5.5 mm) for corallite diameter (6.1 to 6.7 mm); number of majors ranges from 21 to 27. Parricidal increase. Short majors and very short minors. One or two rows of small, regular dissepiments. The inner wall may be thickened to form an inner wall. Incomplete tabulae composed of an axial series of domed tabellae, that in some cases is divided in two smaller tabellae, and a series of periaxial tabellae slightly declined towards the dissepimentarium.

Remarks. Both colonies show features identifiable as *D. furcatum*.

Diphyphyllum fasciculatum (Fleming, 1828)
Figures 9g, h

Material. Eight colonies and fragments of colonies, IDM2/1-24B, 60; IDM3/1- 5b, 9b; IDM4-11, 13; TIR2/1-24, 55; seventeen transverse and eleven longitudinal thin sections.

Location, horizon and age. Idmarrach sections -2 (unit 1) and -3; Idmarrach-4 isolated outcrop; Tirhela-2 section, basal beds, lower and upper Serpukhovian.

Diagnosis (After POTY, 1981). Phaceloid *Diphyphyllum*. Corallites having 4.6 mm in diameter as a mean; number of majors is 21 as a mean (30 maximum).

Description. Colonies showing parricidal increase, tabularium diameter ranging from 3.9 to 4.0 mm, corallite diameter ranging from 5.1 to 5.4

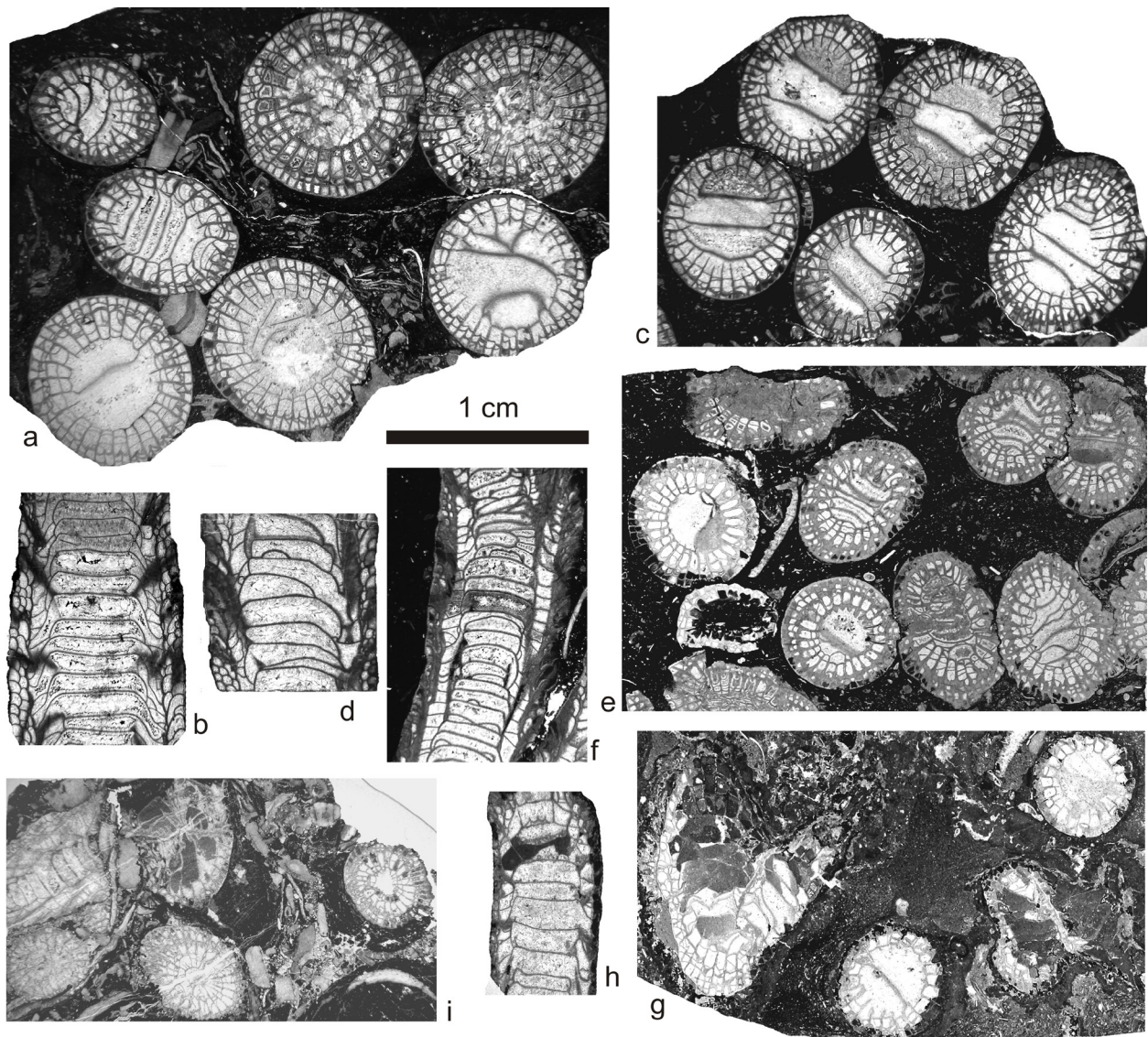


Figure 9. Diphyphyllinae. a-d: *Diphyphyllum lateseptatum* (McCoy, 1849), a-b, specimen IDM2/1-13, a: transverse section. b: longitudinal section. c-d, specimen IDM2/1-48, c: transverse section. d: longitudinal section. e-f: *Diphyphyllum furcatum* Hill, 1940, specimen IDM2/1-12, e: transverse section, f: longitudinal section. g-h: *Diphyphyllum fasciculatum* (Fleming, 1828), specimen IDM2/1-24, g: transverse section, h: longitudinal section. i: *Solenodendron cf. hibernicum* (Clarke, 1966) specimen TIR1/1-2, transverse and longitudinal sections. Scale bar 1 cm, same for all pictures.

— Diphyphyllinae. a-d: *Diphyphyllum lateseptatum* (McCoy, 1849), a-b, ejemplar IDM2/1-13, a: sección transversal. b: sección longitudinal. c-d, ejemplar IDM2/1-48, c: sección transversal. d: sección longitudinal. e-f: *Diphyphyllum furcatum* Hill, 1940, ejemplar IDM2/1-12, e: sección transversal, f: sección longitudinal. g-h: *Diphyphyllum fasciculatum* (Fleming, 1828), ejemplar IDM2/1-24, g: sección transversal, h: sección longitudinal. i: *Solenodendron cf. hibernicum* (Clarke, 1966) ejemplar TIR1/1-2, secciones transversales y longitudinales. Escala 1 cm, la misma para todas las figuras.

mm, and 20 to 21 majors. One single row of small regular dissepiments. Short majors that reach slightly more than one-third of the corallite radius. Minors just crests on the wall. Incomplete tabulae composed of a series of wide axial mesa-shaped tabulae and small periaxial tabellae declined towards the dissepimentarium.

Remarks. The specimens from Idmarrach and Tirhela formations show identical features to those from Western Europe (POTY, 1981), except

in the corallite diameter that is slightly larger than typical.

Genus *Solenodendron* Sando, 1976

Type species. *Aulina horsfieldi* Smith & Yü, 1943

Diagnosis (Modified from SANDO, 1976).

Fasciculate aulate corals in which the aulos is formed by union of deflected axial ends of majors. Major and minors carinate, carinae of zig-zag type. Dissepimentarium regular. Tabulae in aulos

ordinarily flat, horizontal; tabulae in tabularium slope downward towards periphery of corallite. Increase lateral in some species, axial (parricidal) in others. Trabecular septa in the dissepimentarium but water-jet fibrous in the tabularium.

Solenodendron cf. hibernicum (Clarke, 1966)
Figure 9i

Material. One single specimen, TIR1/1-2; two transverse and two longitudinal thin sections.

Location, horizon and age. Tirhela-1, isolated outcrop, possibly lower Serpukhovian.

Diagnosis (After SANDO, 1976). Dendroid to subphaceloid *Solenodendron* with mature corallites ordinarily 5.5 to 7 mm in diameter, 22 to 25 carinate majors and an equal number of minors, an aulos about half the width of the tabularium (2 to 3 mm), tabulae numbering about 15 in 5 mm in the aulos and about 10 in 5 mm in the tabularium, and a dissepimentarium 0.5 to 1 mm wide composed of one to three rows of regular dissepiments. Increase is parricidal, ordinarily bipartite.

Description. The specimen from Tirhela is composed of fragments of branches of a fasciculate colony concentrated in a debris bed. It shows parricidal increase, narrow aulos, moderate tabularium diameter that ranges from 5.9 to 7.0 mm, corallite diameter that varies from 7.7 to 9.2 mm, 2 rows of regular dissepiments and 23 to 24 majors. 6 flat to mesa-shaped tabulae per 5 mm.

Remarks. The studied specimen differs from the type species by its slightly larger diameter aulos (1.4 to 2.8 mm) and wider spaced and fewer flat tabulae in the aulos (6/5 mm compared with 15/5 mm height). It also has larger dimensions and more majors than in *S. furcatum* (SMITH, 1925).

Suborder LONSDALEIINA Spassky, 1974
Family Axophyllidae Milne-Edwards & Haime, 1851
Subfamily Axophyllinae Milne-Edwards & Haime, 1851

Genus *Axophyllum* Milne-Edwards & Haime, 1850

Type species. *Axophyllum expansum* Milne-Edwards & Haime, 1850

Diagnosis (After RODRÍGUEZ & SOMERVILLE, 2014). Solitary corals. Septa of two orders, thick in periphery, where they may be interrupted in adult stage by transeptal dissepiments. Axial structure composed of thickened, irregular and anastomosing radial lamellae, crossed by a median plate. Conical axial tabellae, concave or subhorizontal periaxial tabellae. Microstructure of the wall is lamellar; septa with fibrous mesoplasm and lamellar stereoplasm.

Axophyllum kirsopianum (Thomson, 1880)
Figures 10a-c

Material. Five specimens, IDM2/1-43; TIR2/1-16, 19, 30, 35; six transverse and three longitudinal thin sections.

Location, horizon and age. Idmarrach-2 section, unit 1; Tirhela 2 section, basal beds, upper Serpukhovian.

Diagnosis (After RODRÍGUEZ & SOMERVILLE, 2014). *Axophyllum* 18 to 22 mm in diameter, 14 to 16 mm in tabularium diameter, 6 to 7 mm in axial structure diameter, having 41 to 46 septa of two orders. Majors thick and withdrawn from the axial structure. Low development of lonsdaleoid dissepiments. Inner wall composed of thickened dissepiments. Axial structure large (1/3 of the diameter) and showing thick septal lamellae. Fibrous septal mesoplasm, lamellar stereoplasm.

Description. Solitary corals ranging from 15 to 20 mm in diameter, 12 to 15 mm in tabularium diameter and 34 to 39 in septal number. Common rejuvenescences. Dissepimentarium composed of 1 or 2 rows of lonsdaleoid dissepiments plus 1 row of interseptal dissepiments. In longitudinal section the dissepiments are regularly declined to the axis. Majors moderately thick and long, mostly reaching axial structure but some are shorter. Minors occur as crests on the dissepiments. Large axial structure, approximately 1/3 of the alar diameter. Axial structure composed of short median plate, numerous radial lamellae and moderately thick, conical axial tabellae. Concave axial tabellae, slightly declined to the axis. Granulo-fibrous septal mesoplasm, lamellar wall and stereoplasmatic thickenings.

Remarks. Specimens collected show typical features of the species (axial structure size and architecture, septal thickenings, development of lonsdaleoid dissepiments, etc.). They differ in having slightly fewer majors (34 to 39) and diameter (15 to 20 mm) than the types (41 to 46 and 18 to 22 mm respectively), but similar to the variability of the species in SW Spain (RODRÍGUEZ & SOMERVILLE 2014).

Genus *Gangamophyllum* Gorsky, 1938

Type species. *Gangamophyllum boreale* Gorsky, 1938

Diagnosis (Modified from SEMENOFF-TIAN-CHANSKY, 1974). Solitary conical corals having a peripheral zone with large dissepiments sometimes lonsdaleoid. Inner wall that is reduced in adult stages. Web-like axial structure without median plate, composed of radial lamellae and axial tabellae. Large dissepiments very declined to the axis. Periaxial tabellae concave and also declined to the axis. Domical axial tabellae. Fibronormal mesoplasm, lamellar stereoplasm.

Gangamophyllum sp.
Figure 10d

Material. One single specimen, TIR2/1-32; one transverse thin section.

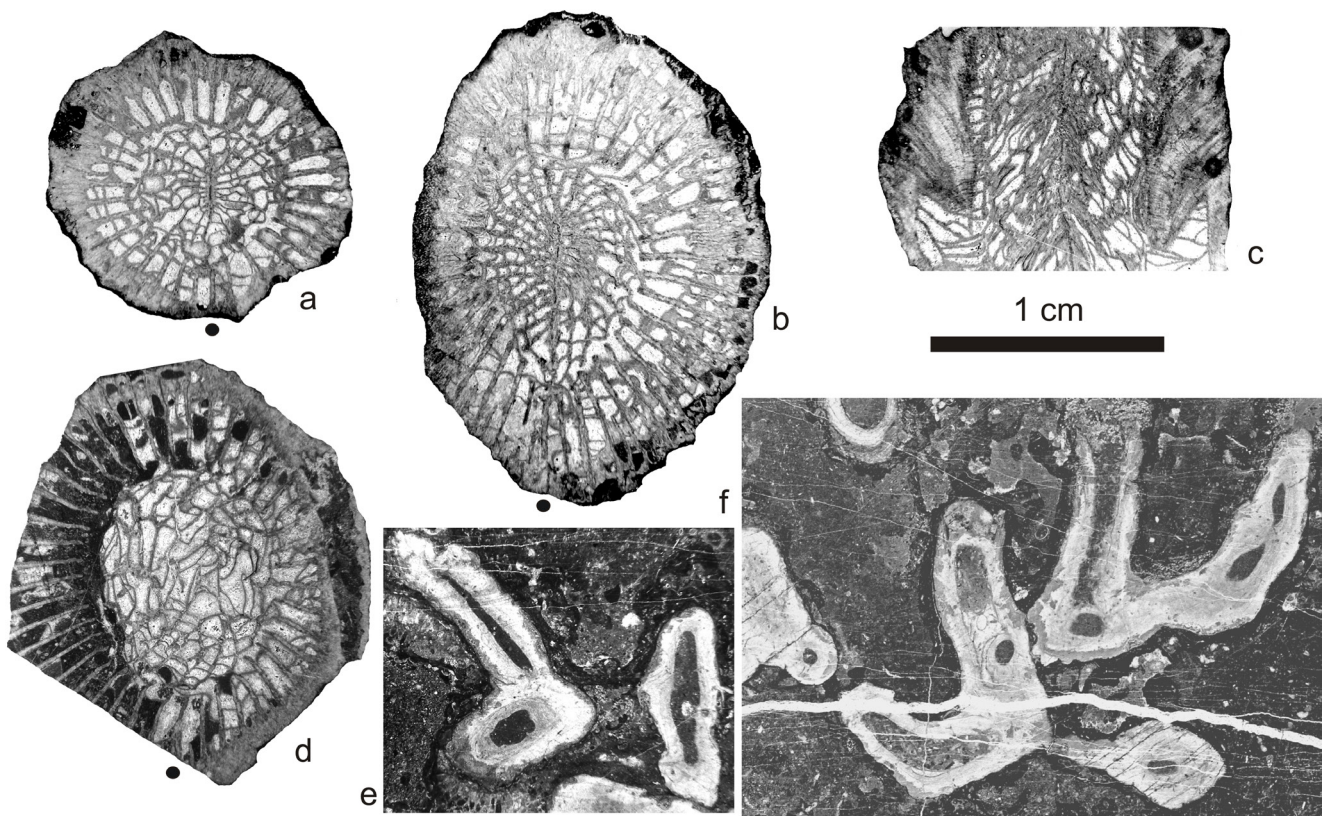


Figure 10. Axophyllidae and Syringoporidae. a-c: *Axophyllum kirsopianum* (Thomson, 1880) specimen TIR2/1-19, a: transverse section, young stage, b: transverse section, adult stage, c: longitudinal section. d: *Gangamophyllum* sp., specimen TIR2/1-32, transverse section. e-f *Multithecopora* sp., specimen IM4/1-10, sections showing transverse and longitudinal sections and buddings. Scale bar 1 cm, same for all pictures. Black dots indicate the location of the cardinal septum.

— Axophyllidae y Syringoporidae. a-c: *Axophyllum kirsopianum* (Thomson, 1880) ejemplar TIR2/1-19, a: sección transversal, estadio juvenil, b: sección transversal, estadio adulto, c: sección longitudinal. d: *Gangamophyllum* sp., ejemplar TIR2/1-32, sección transversal. e-f *Multithecopora* sp., ejemplar IM4/1-10, Lámina que muestra secciones transversales y longitudinales y gemaciones. Escala 1 cm, la misma para todas las figuras. Los puntos negros indican la posición del septo cardinal.

Location, horizon and age. Tirhela-2 section, basal beds, upper Serpukhovian.

Description. Trochoid coral, lacking the apex, the calice and part of the dissepimentarium, 17 mm in diameter. Dissepimentarium composed of some lonsdaleoid dissepiments and some interseptal dissepiments. Majors (44) are long, reaching the axial structure; thick in the border of the tabularum, thinner near the axis. Minors thin, 1/3-1/2 length of majors. Axial structure near 1/3 of alar diameter. Composed of irregular, twisted radial lamellae and domical tabellae. Periaxial tabellae declined to the axis. Granulofibrous septal mesoplasm, lamellar stereoplasm, dissepiments and tabulae.

Remarks. It is close to *G. gorskyi* Vassiljuk, 1960, but has too many septa (range of latter is 36 to 40) and has much larger dimensions than *G. mosquense* Dobrolyubova, 1952. It has similar number of majors as *G. densitabulatum*

Poty, 1981 (43) and similar size axial structure (8 to 10 mm), but slightly smaller corallite and tabularium diameters. It has same number of majors as *G. retiforme* Lin & Fan in LUO & ZHAO, 1962, but much smaller dimensions. However, the poorly developed dissepimentarium prevents identification to species level.

Subclass TABULATA Milne-Edwards & Haime, 1850

Order SYRINGOPORIDA Sokolov, 1947

Family Syringoporidae de Fromentel, 1861

Subfamily Syringoporinae de Fromentel, 1861

Genus *Multithecopora* Yoh, 1927

Type species. *Multithecopora penchiensis* Yoh, 1927

Diagnosis (After TCHUDINOVA, 1986). Colonies fasciculate, formed of cylindrical corallites with well-defined wrinkled epitheca.

Sclerenchyme of wall lamellar and so thick that lumen of corallites reduced to 1/3- 1/5 of diameter; epitheca fibrous. Connecting tubules thin, sparse; mural pores developed where corallites contact. Tabulae thin, complete, horizontal, concave, sparse, in places absent. Septal spinules well developed or lacking. Increase interstitial, more commonly lateral.

Multithecopora sp.
Figures 10e, f

Material. Two specimens, IDM2/1-70, IDM4-10; four thin sections containing transverse and longitudinal sections.

Location, horizon and age. Idmarrach-2 section, unit 1, basal biostromes; Idmarrach-4 outcrop, upper Serpukhovian.

Description. Fragments of colonies. Fasciculate coral, 2.8 to 3.5 mm in diameter, having thick wall (0.8 to 0.9 mm) and poor development of tabulae. Scarce septal spines.

Remarks. Typical features of the genus *Multithecopora*. The scarce specimens collected prevent a specific identification.

4. Discussion

Most considerations on the biostratigraphy, palaeobiogeography and palaeoecology of the coral assemblages from Idmarrach and Tirhela formations have been analysed in a complementary paper (RODRÍGUEZ *et al.*, *in press*). Consequently, only a short summary on those matters will be included here. The studied assemblages are dominated by species whose distribution in northern areas of the western Palaeotethys is mainly upper Viséan. Most species occur in the upper Viséan and do not reach the Serpukhovian in Western Europe (MITCHELL, 1989; POTY, 1981, 1985; POTY *et al.*, 2006; RODRÍGUEZ & SOMERVILLE, 2007; DENAYER *et al.*, 2011). The main reason for that is the absence of marine Serpukhovian rocks in Belgium and the scarcity in Britain, France and Spain. It is due to the reduction of marine carbonate platforms and increase of terrigenous material as a result of the collision between Laurussia and Gondwana. In the regions where marine carbonate platforms still occur, many of the species recorded in Adarouch are also present (HILL, 1938-1941).

In the north-central Palaeotethys, carbonate platforms were still preserved in the Serpukhovian and all genera and most species recorded in Adarouch have been also cited in Poland, Russia, Ukraine, Novaya Zemlya, Turkey and Kazakhstan (FEDOROWSKI, 1981; KHOA, 1977; VASSILJUK, 1960; DOBROLYUBOVA, 1952, 1958, 1970; DEGTJAREV, 1973; KACHANOV, 1965, 1975; SAYUTINA, 1973; GORSKY, 1938, 1951; DENAYER, 2012, 2014, 2015; DENAYER & HOSGÖR, 2014; BYKOVA, 1966). A similar situation is recorded in

Saharan basins (SEMENOFF-TIAN-CHANSKY 1974, 1985; ARETZ, 2011; RODRÍGUEZ *et al.*, 2013a; SOMERVILLE *et al.*, 2013).

As a consequence, the upper Viséan taxa were very conservative and most of them survived during the Serpukhovian with very little changes. Some of them have been recorded also in lower Bashkirian rocks (KOSSOVAYA, 1996; FEDOROWSKI *et al.*, 2012; RODRÍGUEZ *et al.*, 2013b).

No Serpukhovian assemblages have been described in other areas of the Azrou-Khenifra Basin, but upper Viséan assemblages from the Khenifra region, south from Adarouch, yielded similar assemblages (ARETZ & HERBIG, 2010; RODRÍGUEZ *et al.*, 2012, SOMERVILLE *et al.*, 2012; SAID *et al.*, 2013).

As a whole, the assemblages are dominated by colonial corals of the family Lithostrotionidae. By far, the most abundant corals belong to the genera *Siphonodendron* and *Diphyphyllum*. All species are closely comparable to those from northern basins with one exception. The specimens identified as *Siphonodendron intermedium?* show identical measurements to the types of this species from Belgium (POTY, 1981; DENAYER *et al.*, 2011). However, the type material shows short majors and a simple tabularium, whereas the specimens from Adarouch have a complex tabularium and long septa reaching the columella. If those differences reveal that they belong to a different species (indicative of different age) or an ecological variation is arguable without similar forms in Serpukhovian rocks from intermediate areas.

Solitary corals are also abundant, both, in the biostromes dominated by colonial corals and in interbedded marls and limestones. In this case, the dominance is provided by representatives of the family Aulophyllidae. The only peculiarity of the assemblage is the relative abundance of the species *Aulokoninckophyllum carinatum*, which is not common in northern areas of the Palaeotethys. In contrast to the abundance of axophyllids in other areas of the western Palaeotethys (SEMENOFF-TIAN-CHANSKY, 1974; POTY, 1981; RODRÍGUEZ *et al.*, 2013a, b; RODRÍGUEZ & SOMERVILLE 2014), *Axophyllum* and *Gangamophyllum* are scarce in the Adarouch outcrops.

The assemblages from Idmarrach -1 and -2 and Tirhela-2 sections occur mainly in some concentrations that may be regarded as biostromes. Depending on the section, the biostromes are dominated by colonies in growth position or reworked ones. Thus, both, autobiostrones, parabiostromes and intermediate autoparabiostromes are present (KERSHAW, 1994). Associations of gigantoproductid brachiopods and corals are common, such as described in the northern Palaeotethys areas (RODRÍGUEZ, 1992, 1996; RODRÍGUEZ *et al.*, 1994; SOMERVILLE & RODRÍGUEZ, 2007; SOMERVILLE *et al.*, 2007; ARETZ, 2010b; ARETZ *et al.*, 2010) and in Saharan basins (RODRÍGUEZ *et al.*, 2013a, b). Most solitary corals

are reworked, but transport seems to be not very long in most cases. The environment is regarded as an inner, shallow platform. On the contrary, the assemblages recorded in Idmarrach-3 occur around a microbial mound and in its flank beds. Most corals were collected in limestone debris around the mound and are reworked. Most colonies were recorded there as debris of fasciculate coral branches. The environment there is regarded as a middle platform with development of microbial mounds and debris derived from shallower areas. The assemblages from Tirhela-1 and Idmarrach-4 were collected in isolated outcrops and little palaeoenvironmental information can be inferred from them.

6. Conclusions

The Serpukhovian assemblages from Idmarrach and Tirhela formations are described. They yielded quite diverse assemblages; 25 species of rugose corals in Idmarrach sections and 17 species in Tirhela sections. A total of 32 rugose and 1 tabulate species have been recorded.

The rugose families Cyathaxoniidae, Zaphrentoididae, Stereophrentidae, Cyathopsidae, Aulophyllidae, Palaeosmiliidae, Lithostrotionidae and Axophyllidae and the tabulate family Syringoporidae are represented in the assemblages, which are dominated by colonial Lithostrotionidae and solitary Aulophyllidae.

The recorded assemblages show high similarities with those from upper Viséan and Serpukhovian strata from other regions of the western Palaeotethys.

The Idmarrach and Tirhela formations represent a mixed platform comprising shallow inner platform to middle platform. Corals recorded in shallow platforms (Idmarrach-1 and -2 and Tirhela -2 sections) occur mostly in biostromes and are in growth position or somewhat reworked. Corals recorded in Idmarrach 3 section are mostly reworked fragments and occur in limestone debris and in in marls around a microbial mound.

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