SPANISH JOURNAL OF PALAEONTOLOGY

Early Aptian corals from Peñascal (Bilbao, N Spain)

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Löser, H., Mendicoa, J. & Fernández-Mendiola, P.Á. 2020. Early Aptian corals from Peñascal (Bilbao, N Spain). [Corales del Aptiense inferior de Peñascal (Bilbao, N de España)]. *Spanish Journal of Palaeontology*, 35 (2), 209-228.

Manuscript received 24 February 2020
Manuscript accepted 22 July 2020

https://doi.org/10.7203/sjp.35.2.18484

ABSTRACT

From two horizons in the lower Aptian Peñascal limestone Formation south of Bilbao 22 coral species are reported. The corals belong to the scleractinian families Actinastraeidae, Eugyridae, Haplaraeidae, Latomeandridae, and Solenocoeniidae, and the octocorallian family Helioporidae. The stratigraphic distribution of the species lies between the Berriasian to Cenomanian, but most species have a distribution between the Barremian and Albian. The faunas show most palaeobiogeographical relationship to faunas from the Hauterivian to Albian of the European Boreal, the Western Atlantic and the Western Tethys.

Keywords: Scleractinia, Octocorallia, fossil, taxonomy, Cretaceous, Aptian.

RESUMEN

Se describen 22 especies de corales pertenecientes a dos horizontes de la Formación calizas de Peñascal del Aptiense inferior en el sur de Bilbao. Los corales pertenecen a las familias Actinastraeidae, Eugyridae, Haplaraeidae, Latomeandridae, y Solenocoeniidae del orden Scleractinia, y a la familia Helioporidae del orden Helioporacea. La distribución estratigráfica de las especies abarca un rango desde Berriasiense hasta Albiense. La fauna revela correlaciones paleobiogeográficas con faunas del Hauteriviense al Albiense del Boreal Europeo, Atlántico occidental y del oeste del Tethys.

Palabras claves: Scleractinia, Octocorallia, fósil, taxonomía, Cretácico, Aptiense.

1. INTRODUCTION

Although the early Aptian is one of the periods with the most abundant co-existing coral genera and species in the Cretaceous (Löser, 2016), little data is reported from northern Spain. There are some reports from Aragón (mainly around Teruel) and from Cataluña (Ulldecona; Löser *et al*., 2005). From the Basque country, material is only reported from the Peñacerrada diapir (Sachs, 2002). Here, another two stratigraphic intervals containing coral faunas in the vicinity of Bilbao are described.

2. STUDY AREA

2.1. Geological setting

The investigation was carried out in the Peñascal quarry (Fig. 1). This lies in the southern outskirts of Bilbao city, just SW of the Supersur highway. The Peñascal quarry lies in the Basque-Cantabrian Basin, and belongs to the Basque Arch, the western prolongation of the north Pyrenean Zone, encompassing the Basque Paleozoic Massifs and their westerly adjunct Mesozoic and Cenozoic sedimentary cover (Rat, 1959). More precisely, the quarry lies in the northern margin of the Bilbao Anticlinorium, with a NW-SE running axis-trend. The quarry outcrops occur south of Arnotegi fault. Several faults of this Arnotegi system reveal synsedimentary activity and were responsible for the diversity and partitioning of sedimentary settings during the Aptian. Deposition occurred as the result of extensional rifting movements related to the opening of the Bay of Biscay (Boillot, 1984; Olivet, 1996; Le Pichon, *et al*., 1971; Sibuet, *et al*., 2004; García-Mondejar, *et al*., 2018). Later in the Alpine-Pyrenean orogeny, those units were folded and fractured to its present situation and structure following compressive movements at the boundary of the Iberian and European tectonic plates.

2.2. Stratigraphy and sedimentology

Two coral horizons have been investigated. They stand respectively at the base and upper part of the Peñascal limestones. Biostratigraphic data indicate that the corals belong to the *Dufrenoyia furcata* Zone of the early Aptian, based on orbitolinid and ammonite correlation (Fernández-Mendiola *et al*., 2017).

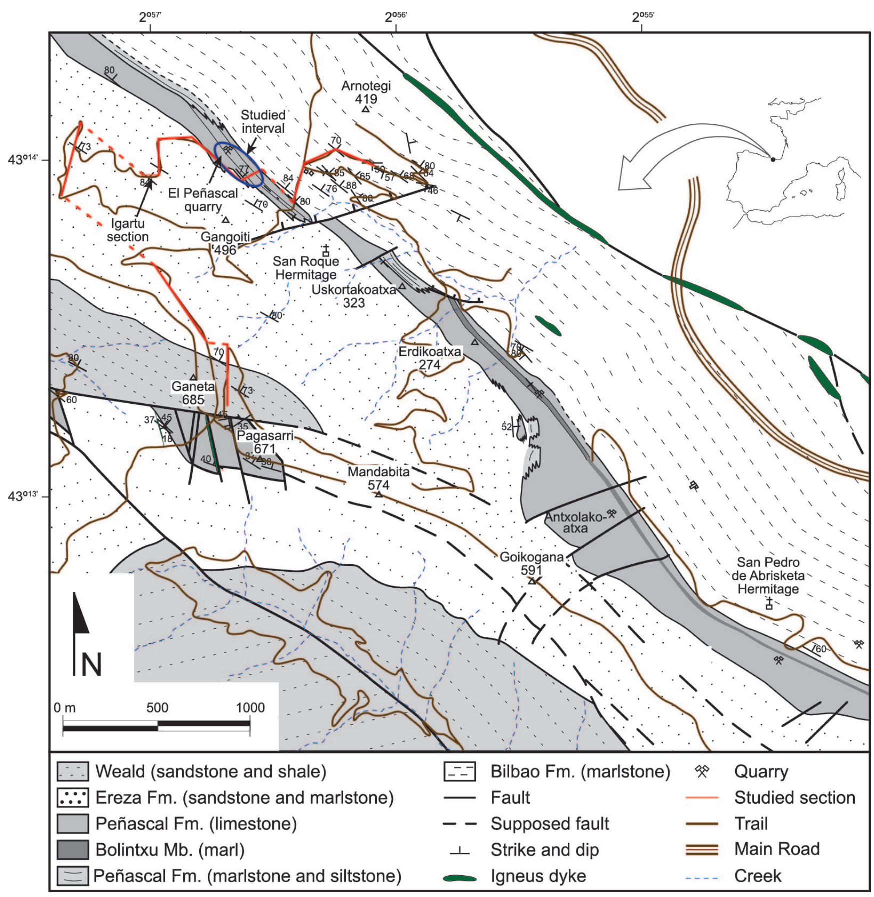


Figure 1. Geological map of the area south of Bilbao (Spain), with location in the studied area at the Peñascal quarry, along the Peñascal limestone Formation oriented NW-SE. Mb = Member; Fm = Formation. The Peñascal quarry forms part of the S-N Igartu section (in red) from the Pagasarri Mountain (671 m) to the Arnotegi area, described in Fernández-Mendiola *et al*. (2017).

The first horizon is located from metre 12 to 15 of the Peñascal quarry section (Fig. 2). Corals occur within a 3 metre-thick unit of wavy, slightly argillaceous limestone that forms the base of the Peñascal Formation. This unit is transitional between the underlying marlstones of the Ereza Formation and the overlying micritic limestones of the Peñascal Formation. The underlying marls contain echinoderms, local burrow structures and scattered plants debris. They have been interpreted as estuarine siliciclastic deposits (García-Garmilla, 1987; Fernández-Mendiola *et al*., 2017). The marls gradually evolve to marly limestones and wavy limestones. The latter are fine-grained packstones to wackestones with corals. The succession records a marine transgresion from coastal environments to a mixed carbonate-siliciclastic marine shelf. Corals growth forms are massive and colonies reach sizes up to 20 centimetres. The coral facies are replaced upward by micritic limestones with requieniid rudists. This vertical evolution reveals a shallowing upward trend and the rudist-dominated carbonate muddy environment reflects siliciclastic-free restricted settings.

The second horizon occurs from metre 140 to 163 of the section (Fig. 2). The succession is divided into three sub-units. Sub-unit 1 (metres 15 to 40) consists of requieniid limestones with occasional miliolid foraminifera and several packages of wavy limestones with marly partings. Two paleokarst horizons occur at metres 20 and 38 respectively suggesting periods of subaerial exposure of the carbonate platform. The sub-unit is interpreted as an inner carbonate platform with occasional phases of turbid water responsible for the argillaceous sedimentary imprint. Sub-unit 1 shows absence of coral facies.

The second sub-unit spans from metre 40 to 110. It consists of limestones dominated by requieniids punctuated with several horizons of scattered massive and/or ramose corals (*Latohelia*) that occur together with rudists. In this second sub-unit, three paleokarst horizons are recognised at metres 57, 80 and 89. These facies associations of rudists and corals reveal more open-water conditions in the shallow-water carbonate platform with respect to sub-unit 1.

The third sub-unit spans from metre 110 to 163, and consists of alternating massive and wavy limestone intervals. Corals in this sub-unit are overall more abundant than rudists except for the beds spanning from 116 to 120 m, which are requieniid-dominant. At metre 145 rudists recover and coexist with corals. Except for those two intervals, coral dominance suggests more open-water conditions than sub-unit 2. The succession indicates a transgressive trend from base to top of the Peñascal limestone.

We have sampled the upper part of the Peñascal limestones from metre 140 to 163, coral horizon-2 in Figure 2, for thin section and taxonomic analyses. Massive coral-head type forms alternate vertically with ramose

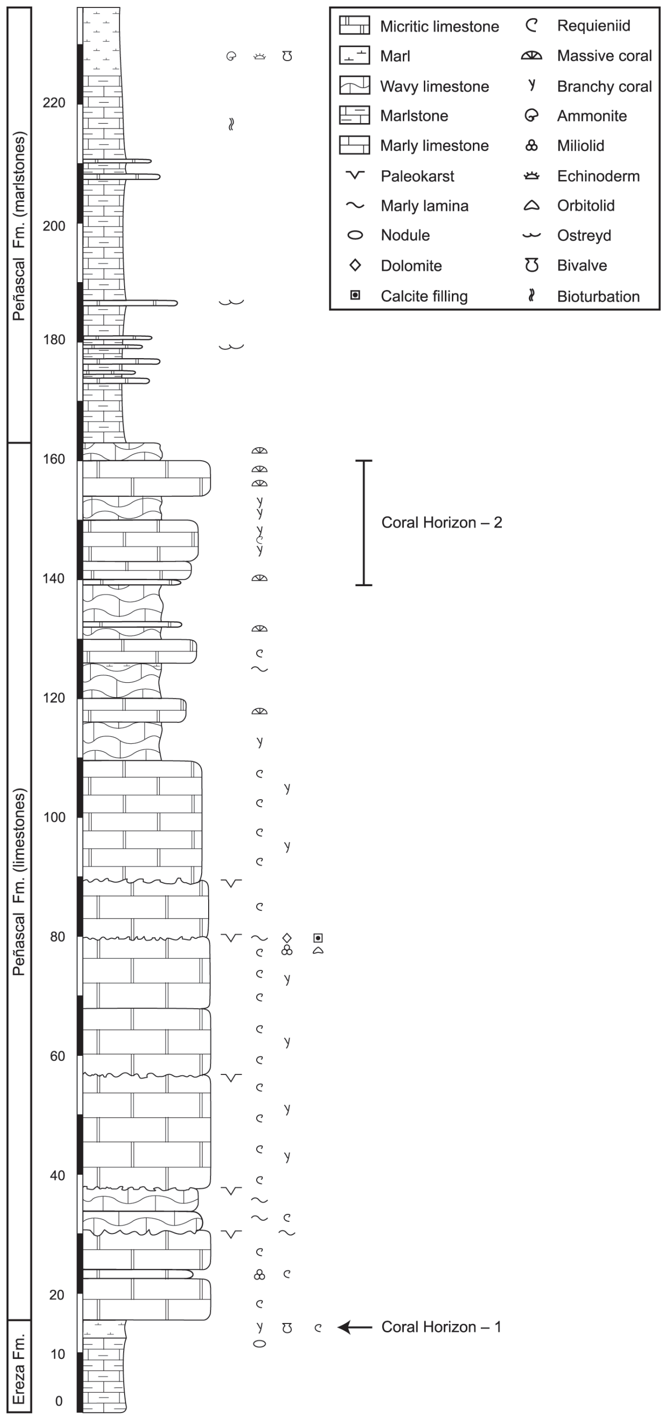


Figure 2. Stratigraphic section of the Peñascal quarry with indication of the two Members: a lower limestone unit from metre 16 to 163 and an upper marlstone Member from metre 163 to 225. The Peñascal Formation is underlain by the siliciclastic Ereza Formation. The two studied coral horizons stand respectively at the transition between the Ereza and Peñascal Formations, and at the upper part of the Peñascal Formation limestones.

corals, both in massive micritic limestones and in wavy argillaceous marly-micritic limestones. The marls tend to occur in isolated partings less than one centimetre-thick, and correspond to periods of increased turbid waters on the sea-floor. From metre 163 up the drowning of the carbonate platform is marked by the end of the Peñascal limestones and the encroachment of the overlying Bilbao marlstones. Those marlstones were sedimented in outer slope environments dominated by settling of silts and muds and inhabited by oysters, bivalves, echinoderms and ammonites.

3. MATERIAL AND METHODS

About 30 corals were collected from horizon 1 and about 50 from horizon 2. Finally six specimens from horizon 1 and 31 specimens from horizon 2 could be assigned to a species. The corals from horizon 1 are strongly recrystallized and therefore poorly preserved. Corals from horizon 2 are partly better preserved. Coral specimens were cut and polished. Thin sections in both transversal and longitudinal orientation were prepared where possible. Thin sections were scanned by passing light through them using a flatbed scanner with an optical resolution of 6,400 dpi. Scanned images were then transferred to grey scale bit maps. Their quality was amended by histogram contrast manipulation (contrast stretching) where possible.

Corallite dimensions were systematically measured using the PaleoTax/Measure (http://www.paleotax.de/measure). For each type of measurement (calicular diameter and distance, width and distance of calicular row), in one thin section, the following values were obtained:

n: number of measurements
min–max: lowest and highest measured values
μ: arithmetic mean (average)
s: standard deviation
v: coefficient of variation according to K Pearson
μ ± s: first interval

The obtained values were compared against those for specimens in worldwide fossil coral collections, and an associated image database (ca. 26,900 specimens, ca. 15,200 illustrated, located in the Estación Regional de Noroeste (ERNO), Sonora, Mexico). Data storage and processing were carried out using the PaleoTax database program (Löser, 2004).

The material is kept at the Museo de Ciencias Naturales de Álava. Since final collection numbers are not provided before publication, here the field numbers are given. These numbers are also valid for the thin sections.

4. SYSTEMATIC DESCRIPTION

The preliminary classification system introduced in Löser (2016) is used here. This system does not apply suborders, but superfamilies that group families together. Contrary to the former classification system based on suborders, superfamilies may constitute monophyletic groups. The basic characteristic for the distinction of superfamilies is the relative size of the trabeculae (in the ratio of the trabeculae to the septa). Further distinction is made based on the presence or absence of synapticulae and the septal perforation. Detailed description of superfamilies, families and genera are given in Löser (2016) and are not repeated here. Since the species within a genus are entirely distinguished on the basis of morphometric data (dimensions of the corallite, number and/or density of septa), descriptions of species are not given.

The distribution data are almost entirely based on well-examined material. Material only mentioned in the literature and material not available or insufficiently described and illustrated in the literature was not taken into account. To obtain better insight into the distribution patterns of the coral fauna of the Peñascal area, much unpublished material was included.

The abbreviations used in the synonymy lists follow Matthews (1973):

*: Earliest valid publication of the species name.

?: The assignation of this description to the species is doubtful (so marked quotations are not reflected in the stratigraphic and palaeobiogeographic distribution).

p: The described material belongs only in part to the species concerned.

v: the specimen was observed by the first author.

Abbreviations of measurements are: c, calicular diameter (outer diameter); ccd, distance between calicular centres; cl, calicular diameter (lumen, calicular pit); clmax, large lumen; clmin, small lumen; cmax, larger outer calicular diameter; cmin, smaller outer calicular diameter; crd, distance of calicular series; crw, width of calicular series; septa, number of septa in the adult corallite; sd, density of septa.

Phylum CNIDARIA Milne Edwards, 1857

Class ANTHOZOA Ehrenberg, 1834

Order SCLERACTINIA Bourne, 1900

Superfamily **Actinastraeoidea** Alloiteau, 1952

Family **Actinastraeidae** Alloiteau, 1952

Genus *Stelidioseris* Tomes, 1893

The genus was revised by Löser (2012).

Stelidioseris icaunensis (Orbigny, 1850)
(Figs 3a-c)

Material: 140312; 2 thin sections.

Synonymy:
*v 1850 *Prionastraea icaunensis*; Orbigny, (2), p. 93.

v 1871 *Astrocoenia Kunthi*; Bölsche, p. 56, Pl. 12, Fig. 7.

v 1897 *Astrocoenia urgoniensis*; Koby, p. 58, Pl. 15, Figs. 5-8.

v 1924 *Astrocoenia hexamera* n.sp.; Fritzsche, p. 318, Pl. 3, Fig. 7.

v 1933 *Astrocoenia budaensis* n.sp.; Wells, p. 78, Pl. 6, Fig. 3.

Dimensions: (140312). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	25	1.80-2.33	2.05	0.17	8.5	1.87-2.22
clmax	25	2.54-3.45	2.99	0.28	9.5	2.71-3.28
ccd	25	2.38-3.97	3.25	0.43	13.4	2.81-3.69
septa	24					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the Formation, in the cutting of the quarry (140312).

Other occurrence: Worldwide from the Hauterivian to Campanian.

Stelidioseris major (Morycowa, 1971)
(Figs 6a-b)

Material: 140301; 1 thin section.

Synonymy:
v* 1971 *Actinastraea pseudominima major* n. subsp.; Morycowa, p. 37, Text-fig. 13, 14, Pl. 1, Fig. 3, Pl. 2, Fig. 1.

v 1994 *Diplocoenia nicolaui* n. sp.; Reig Oriol, p. 21, Pl. 1, Fig. 2, Pl. 3, Figs. 6, 7.

v 2013c *Stelidioseris major* (Morycowa, 1971); Löser, Figs. 2gh.

Dimensions: (140301). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	20	1.39-2.30	1.83	0.27	15.1	1.55-2.11
clmax	20	1.80-2.86	2.31	0.37	16.1	1.94-2.69
ccd	25	2.08-3.43	2.83	0.33	11.8	2.50-3.17
septa	24					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140301).

Other occurrence: Hauterivian of the European Boreal (France), Aptian to early Albian of the Central Tethys (Greece, Romania), Western Tethys (Spain), and the Western Atlantic (Mexico, USA).

Superfamily **Cyclolitoidea** Milne Edwards & Haime, 1849

Family **Latomeandridae** Fromentel, 1861

Genus *Astraeofungia* Alloiteau, 1952

The genus is well known. A description and topotypical material was illustrated in Löser (2016).

Astraeofungia diversisepta (Hackemesser, 1936)
(Figs 3d-f)

Material: 140310; 2 thin sections.

Synonymy:
v* 1936 *Thamnastraea diversisepta* n. sp.; Hackemesser, p. 48, Pl. 6, Fig. 5.

Dimensions: (140310). See table below:

	n	min-max	µ	s	cv	µ±s
ccd	12	5.06-7.92	6.33	0.91	14.4	5.41-7.24
septa	8	20-30	24.1	3.18	13.1	21-27

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140310).

Other occurrences: Lower Valanginian to lower Cenomanian of the European Boreal (Czech Republic, Germany), Central (Greece) and Western Tethys (Spain), and Western Atlantic (Mexico).

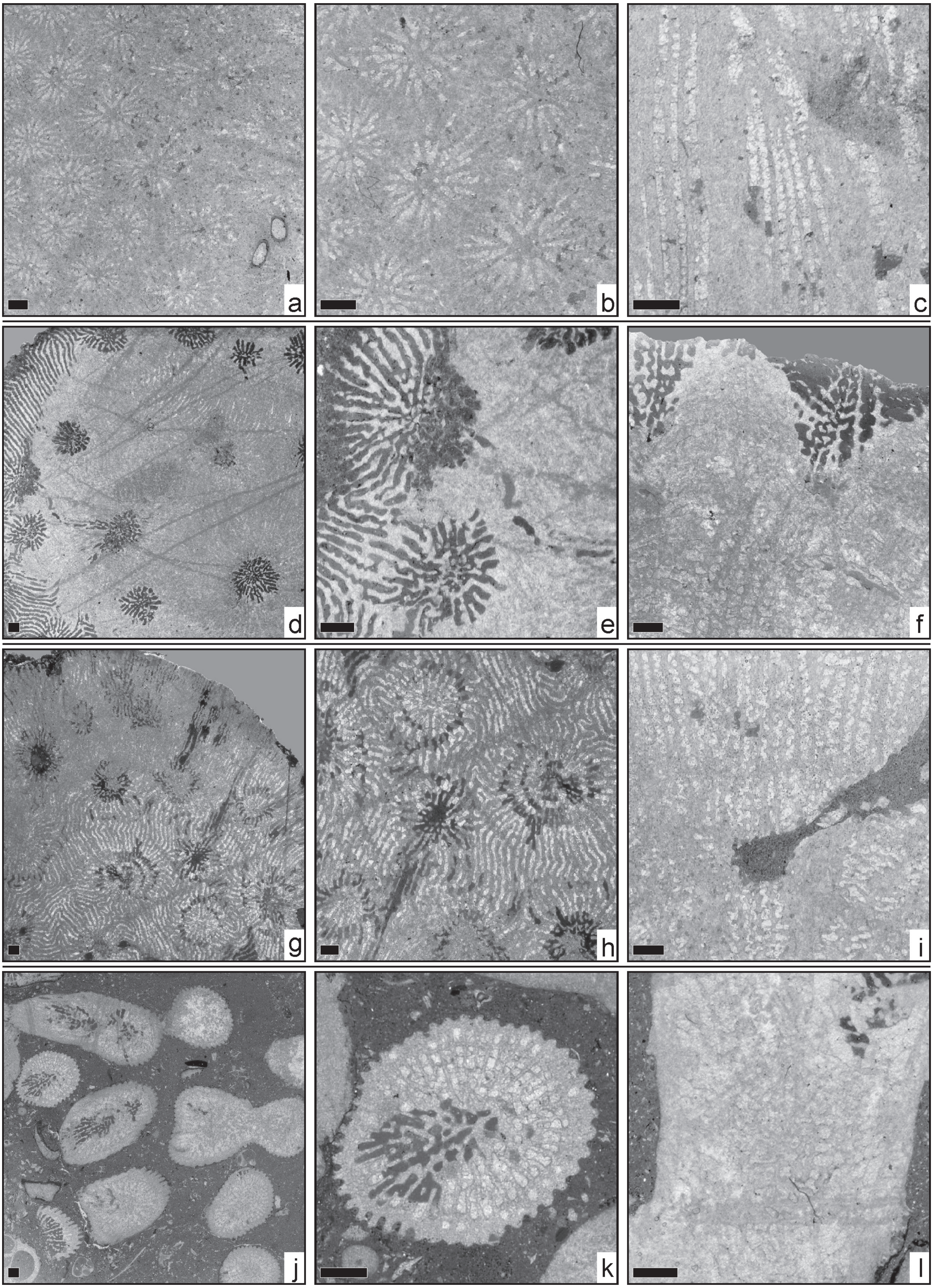
Genus *Dimorphastrea* Orbigny, 1850

A description of the genus and illustrations of type material were provided in Löser (2016).

Dimorphastrea sp.
(Figs 3g-i)

Material: 140311; 2 thin sections.

Synonymy:
v 2013 *Dimorphastrea* sp.; Löser, Vilas & Arias, p. 203, Figs. 4i-j.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Dimensions: (140311). See table below:

	n	min-max	µ	s	cv	µ±s
crd	6	6.07-8.12	7.33	0.82	11.2	6.51-8.16
cdw	4	5.19-6.95	6.31	0.78	12.4	5.53-7.10
septa	10	30-49	38.90	6.26	16.0	33-45

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140311).

Other occurrences: Hauterivian to early Cenomanian of the European Boreal (France, Germany) and the Western Tethys (Spain).

Genus *Latohelia* Löser, 1987

Latohelia is a phaceloid coral with a small corallite diameter. It was recently (Löser, 2014, 2016) illustrated and described. Formerly, Lower Cretaceous corals of this type were assigned to the genus *Calamophylliopsis*. This genus differs greatly from *Latohelia* in having a much larger corallite diameter, compact septa that are fused in the centre of the corallite and very irregular pennulae (Löser, 2016, 219) and very probably does not occur in the Cretaceous.

Latohelia ruizi (Bataller, 1947)
(Figs 3j-l)

Material: 140308, 7250; 5 thin sections.

Synonymy:
v* 1947 *Dendrosmilia Ruizi* Bataller 1943; Bataller, p. 45, Text-fig. without number

Dimensions: (7250). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	6	3.98-4.83	4.52	0.30	6.8	4.21-4.83
clmax	4	5.01-6.05	5.69	0.46	8.2	5.22-6.15
septa	5	38-52	42.20	5.63	13.3	37-48

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, between 10 and 1.5 m below the top of the formation.

Other Occurrence: The species is only known from the early Aptian of the type locality (Bilbao, Mina Abandonada) and the study area. The type locality probably refers to an iron mine within the limestones of the same Peñascal Formation that lies below the city of Bilbao.

Genus *Thalamocaeniopsis* Alloiteau, 1954

The genus was described and illustrated in Löser (2016). It is well defined but rarely recognised in the literature because its first description and illustration were poor. The genus shows a cerioid corallite arrangement and has polygonal corallites. The septa are perforated at the inner margin only, they bear pennulae and their symmetry is irregular. The genus is not rare; about 15 species reaching from the middle Jurassic to the Cenomanian are known.

Thalamocaeniopsis collignoni (Alloiteau, 1958)
(Figs 4a-c)

Material: 140315, 140323; 3 thin sections.

Synonymy:
v* 1958 *Trigerastraea collignoni*; Alloiteau, p. 78, Pl. 7, Fig. 1, Pl. 14, Fig. 3, Text-fig.13.

Dimensions: (140223). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	10	3.79-6.54	5.11	0.98	19.2	4.13-6.10
clmax	10	7.42-10.6	8.92	1.03	11.6	7.88-9.96
ccd	18	4.16-8.60	6.57	1.34	20.4	5.23-7.92
septa	5	63-84	70.8	7.91	11.1	63-79

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140323).

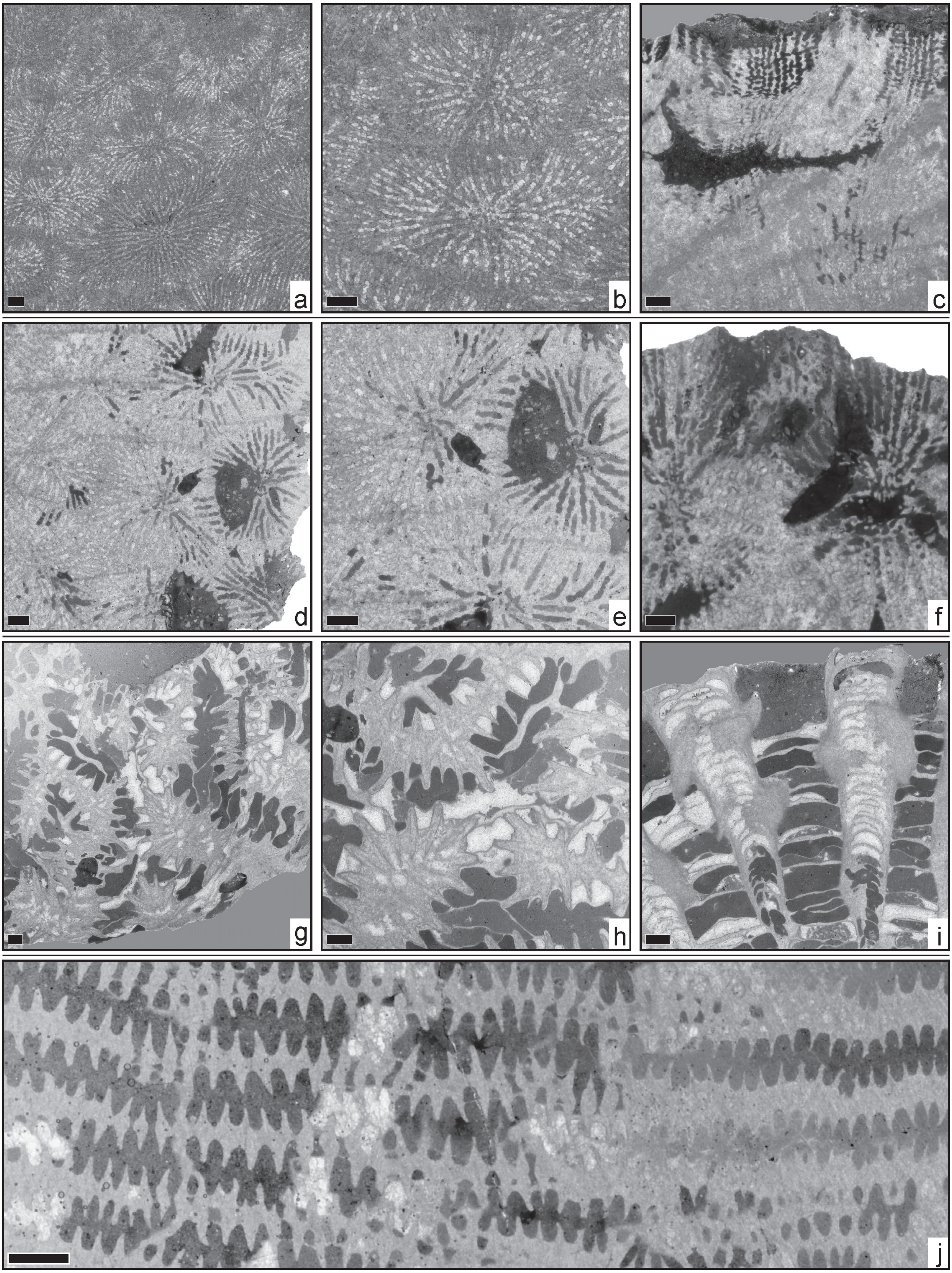
Other occurrences: Only known from the Middle Jurassic of Madagascar and the early Cenomanian of Cantabria (Spain).

Thalamocaeniopsis taramellii (Achiardi, 1880)
(Figs 4d-f)

Material: 140303, 140307; 2 thin sections.

Synonymy:
v* 1880 *Latimeandra taramellii*; Achiardi, p. 249, Pl. 17, Fig. 7.

Figure 3. a-c) *Stelidioseris icaunensis* (Orbigny, 1850), SLD 140312. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **(c)** Longitudinal thin section. **d-f)** *Astraeofungia diversisepta* (Hackemesser, 1936), SLD 140310. **(d)** Transversal thin section. **(e)** Transversal thin section, detail. **(f)** Longitudinal thin section. **g-i)** *Dimorphastrea* sp., SLD 140311. **(g)** Transversal thin section. **(h)** Transversal thin section, detail. **(i)** Longitudinal thin section. **j-l)** *Latohelia ruizi* (Bataller, 1947), ERNO . **(j)** Transversal thin section. **(k)** Transversal thin section, detail. **(l)** Longitudinal thin section. Scale bars = 1 mm.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v 2004 *Isastrea minima* Prever, 1909; Löser & Mohanti, p. 583, Fig. 2c.

v 2018 *Thalamocaeniopsis* sp.; Löser, Steuber & Löser, p. 44, Pl. 4, Figs. 10-11.

Dimensions: (140307). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	10	3.96-6.69	5.11	0.88	17.3	4.22-6.00
clmax	10	5.95-9.64	7.64	0.98	12.9	6.65-8.63
ccd	9	4.85-7.07	5.74	0.69	12.1	5.04-6.43
septa	3	44-46	45.0	1.0	2.2	44-46

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140303, 140307).

Other occurrences: Bathonian to Cenomanian of Eastern (India), Central (Germany, Greece, Italy), and Western Tethys (Spain).

Superfamily **Eugyroidea** Achiardi, 1875

Family **Eugyridae** Achiardi, 1875

Genus *Diplogyra* Eguchi, 1936

Diplogyra was described and illustrated in Löser (2016).

Diplogyra arasensis (Alloiteau, 1946)
(Figs 4g-i)

Material: 140332; 2 thin sections.

Synonymy:
v* 1946 *Eugyra arasensis* n. sp.; Alloiteau, p. 197, Pl. 2, Fig. 4, Text-fig. 2.

v 2013b *Diplogyra arasensis* (Alloiteau, 1946-47); Löser, p. 11, Figs. 4g-i [here detailed synonymy].

v 2016 *Diplogyra arasensis* (Alloiteau, 1946); Löser & Zell, p. 9, Figs. 4.1-3.

Dimensions: (140332). See table below:

	n	min-max	µ	s	cv	µ±s
crw	10	2.40-3.23	2.80	0.31	11.3	2.48-3.11
crd	3	3.88-3.93	3.90	0.02	0.6	3.88-3.93
sd/2.5mm	5	4-5	4.40	0.54	12.4	3.85-4.94

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140332).

Other occurrences: Hauterivian of the European Boreal (France), Aptian and Albian of the Eastern Tethys (Iran), Central Tethys (Greece), Western Tethys (Spain), and Western Atlantic (Mexico).

Genus *Eugyra* Fromentel, 1857

The genus was described and illustrated with the type and topotypical material in Löser (2016).

Eugyra sugiyamai Eguchi, 1951
(Fig. 4j)

Material: 140325; 2 thin sections.

Synonymy:
v 1926 *Eugyra digitata* Koby; Dietrich, p. 66, Pl. 9, Fig. 4.

v* 1951 *Eugyra sugiyamai* Eguchi, n. sp.; Eguchi, p. 54, Pl. 19, Figs. 1-6.

v 1964 *Eugyra pusilla rariseptata* n. subsp.; Morycowa, p. 45, Pl. 9, Fig. 1, Pl. 10, Fig. 1.

v 1964 *Myriophyllia lanckoronensis* n.sp.; Morycowa, p. 50, Text-fig. 6, Pl. 9, Fig. 3, Pl. 10, Figs. 2, 3.

Dimensions: (140325). See table below:

	n	min-max	µ	s	cv	µ±s
crw	40	0.76-1.08	0.90	0.09	10.2	0.80-0.99
crd	40	0.91-1.44	1.18	0.14	12.1	1.04-1.33
sd/5mm	5	13-16	14.4	1.14	7.9	13.3-15.5

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140325).

Other occurrences: Worldwide from the Hauterivian to Lower Albian.

Family **Solenocoeniidae** Roniewicz, 2008

Genus *Cryptocoenia* Orbigny, 1849

Figure 4. a-c) *Thalamocaeniopsis collignoni* (Alloiteau, 1958), SLD 140323. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **(c)** Longitudinal thin section. **d-f)** *Thalamocaeniopsis taramellii* (Achiardi, 1880), SLD 140307. **(d)** Transversal thin section. **(e)** Transversal thin section, detail. **(f)** Longitudinal thin section. **g-i)** *Diplogyra arasensis* Alloiteau, 1946, SLD 140332. **(g)** Transversal thin section. **(h)** Transversal thin section, detail. **(i)** Longitudinal thin section. **j)** *Eugyra sugiyamai* Eguchi, 1951, SLD 140325. Transversal thin section. Scale bars = 1 mm.

This very common genus was described and illustrated in Löser (2016).

Cryptocoenia annae (Volz, 1903)
(Figs 5a-c)

Material: 140306; 3 thin sections.

Synonymy:
1903 *Cyathophora Annae*; Volz, p. 26, Pl. 4, Figs. 9-13.

v 2016 *Cryptocoenia annae* (Volz, 1903); Löser & Zell, p. 14, Figs. 5.4-6 [here detailed synonymy].

Dimensions: (140327). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	20	2.12-2.82	2.46	0.16	6.7	2.30-2.63
clmax	20	2.49-3.35	2.89	0.21	7.2	2.68-3.10
septa	24					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140306).

Other occurrences: Hauterivian to early Cenomanian of the European Boreal (France), the Eastern (Iran), Central (Romania, Serbia), and Western Tethys (Spain), and the Western Atlantic (Mexico).

Cryptocoenia incerta Achiardi, 1880
(Figs 5d-f)

Material: 140223; 1 thin section.

Synonymy:
v* 1880 *Cryptocoenia* ? *incerta*; Achiardi, p. 298, Pl. 20, Fig. 4.

v 1891 *Cyathophora atempa*; Felix, p. 155, Pl. 25, Figs. 7, 8.

v 1932 *Cyathophora haysensis* Wells, n. sp.; Wells, p. 237, Pl. 30, Fig. 4, Pl. 32, Fig. 5.

v 1944 *Cyathophora hedbergi* Wells, n. sp.; Wells, p. 434, Pl. 69, Figs. 7, 8.

Dimensions: (140223). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	8	1.76-2.30	2.05	0.19	9.7	1.85-2.25
clmax	8	2.04-3.09	2.52	0.32	12.7	2.20-2.84
ccd	9	2.52-3.13	2.75	0.22	8.2	2.53-2.98
septa	6+6					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, base (140223).

Other occurrences: Worldwide from the Upper Jurassic to the middle Cenomanian.

Cryptocoenia sp. 1
(Figs 5g-i)

Material: 140217; 1 thin section.

Synonymy:
v 2018 *Cryptocoenia* sp.; Löser, Steuber & Löser, p. 50, Pl. 7, Figs. 10-12.

Dimensions: (140217). See table bellow:

	n	min-max	µ	s	cv	µ±s
clmin	15	1.38-1.87	1.55	0.14	9.3	1.41-1.70
clmax	15	1.59-2.18	1.88	0.19	10.4	1.68-2.07
ccd	20	1.60-3.05	2.32	0.37	15.9	1.95-2.69
septa	6					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, base (140217).

Other occurrences: Aptian to early Cenomanian of the Tethys (Greece, Spain).

Cryptocoenia sp. 2
(Figs 6c-d)

Material: 140203, 140204, 140224; 4 thin sections.

Dimensions: (140203). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	9	1.00-1.24	1.11	0.06	5.9	1.05-1.18
clmax	9	1.23-1.45	1.31	0.07	5.8	1.24-1.39

(140204). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	15	1.21-1.68	1.37	0.14	10.3	1.23-1.51
clmax	7	1.38-1.59	1.46	0.06	4.5	1.39-1.52

(140424). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	17	1.39-2.34	2.08	0.23	11.0	1.85-2.31
clmax	7	2.41-2.99	2.57	0.19	7.7	2.37-2.77

Remarks: Under this species, material is collected that belongs to *Cryptocoenia* or a related genus, but without any septa. Their absence can be also due to poor conservation. The three samples possess differing corallite dimensions.

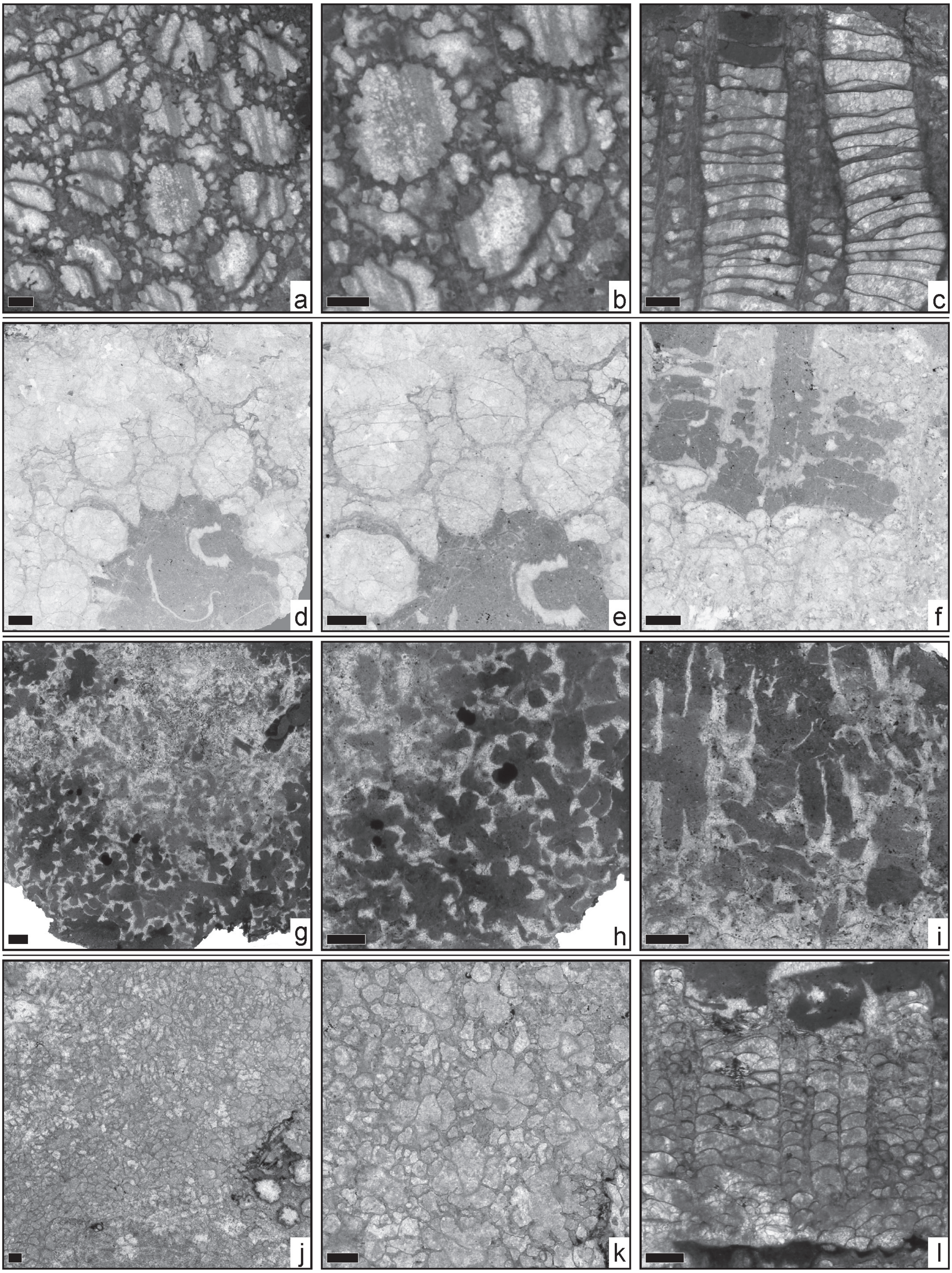

Figure 5. a-c) *Cryptocoenia annae* Volz, 1903, SLD 140327. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **(c)** Longitudinal thin section. **d-f)** *Cryptocoenia incerta* Achiardi, 1880, SLD 140223. **(d)** Transversal thin section. **(e)** Transversal thin section, detail. **(f)** Longitudinal thin section. **g-i)** *Cryptocoenia* sp., SLD 140217. **(g)** Transversal thin section. **(h)** Transversal thin section, detail. **(i)** Longitudinal thin section. **j-l)** *Holocystis nomikosi* Löser, 2006, SLD 140225. **(j)** Transversal thin section. **(k)** Transversal thin section, detail. **(l)** Longitudinal thin section. Scale bars = 1 mm.

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, base (140203).

Genus *Holocystis* Lonsdale, 1849

The genus was revised in Löser (2006).

Holocystis bukowinensis Volz, 1903
(Figs 6e-f)

Material: 140341; 1 thin section.

Synonymy:
* 1903 *Holocystis bukowinensis*; Volz, p. 27 [19], Pl. 4, Fig. 14-17.

v 1995 *Holocystis calzadai* n. sp.; Reig Oriol, p. 8, Pl. 1, Fig. 1.

Dimensions: (140341). See table below:

	n	min-max	μ	s	cv	μ±s
clmin	15	1.20-1.70	1.44	0.14	9.9	1.29-1.58
clmax	15	1.30-1.76	1.56	0.14	9.1	1.41-1.70
septa	4+4					

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140341).

Other occurrences: Aptian to early Albian of Central (Greece, Poland, Romania, Serbia) and Western Tethys (Spain).

Holocystis nomikosi Löser, 2006
(Figs 5k-l)

Material: 140225, 140336; 4 thin sections.

Synonymy:
v* 2006 *Holocystis nomikosi* n. sp.; Löser, p. 295, Figs. 1j-l.

v 2016 *Holocystis nomikosi* Löser, 2006; Löser & Zell, p. 18, Figs. 6.10-12 [here detailed synonymy].

Dimensions: (140225). See table below:

	n	min-max	μ	s	cv	μ±s
clmin	30	1.71-2.00	1.86	0.08	4.7	1.77-1.95
clmax	30	1.80-2.26	2.06	0.12	6.2	1.93-2.19
ccd	30	2.11-3.16	2.63	0.27	10.6	2.35-2.91
septa	15	8-12	9.93	1.48	14.9	8-11

Remarks: The material shows slightly larger corallite dimensions compared to the holotype of the species. As in the type, only 8 to 11 septa are developed, but up to 16 are visible, partly only as costae.

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140336); Bilbao, Peñascal, base (140225).

Other occurrences: Late Barremian to Aptian of the Western Atlantic (Mexico) and the Tethys (Greece, Spain, Tanzania).

Superfamily **Haplaraeoidea** Vaughan & Wells, 1943

Family **Haplaraeidae** Vaughan & Wells, 1943

Genus *Actinaraea* Orbigny, 1849

A description and illustration of topotypical material was given in Löser (2016).

Actinaraea sp. 1
(Figs 6g-i)

Material: 140331; 2 thin sections.

Synonymy:
v 1998 *Actinaraea* sp.; Schöllhorn, p. 93, Pl. 25, Figs. 7, 8.

v 2013b *Actinaraea* cf. *robusta* Roniewicz, 1966; Löser, p. 30, Figs. 10g-i.

Dimensions: (140331). See table below:

	n	min-max	μ	s	cv	μ±s
ccd	16	4.60-7.35	5.74	0.80	14.0	4.93-6.54
septa	6	29-37	32.7	2.58	7.9	30-35

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140331).

Other occurrences: Aptian to early Albian of the Western Tethys (France, Spain).

Actinaraea sp. 2
(Figs 6j-l)

Material: 140316, 140326; 4 thin sections.

Dimensions: (140326). See table below:

	n	min-max	μ	s	cv	μ±s
ccd	15	5.60-9.25	7.47	1.22	16.3	6.25-8.69
septa	10	30-42	33.7	3.43	10.1	30-37

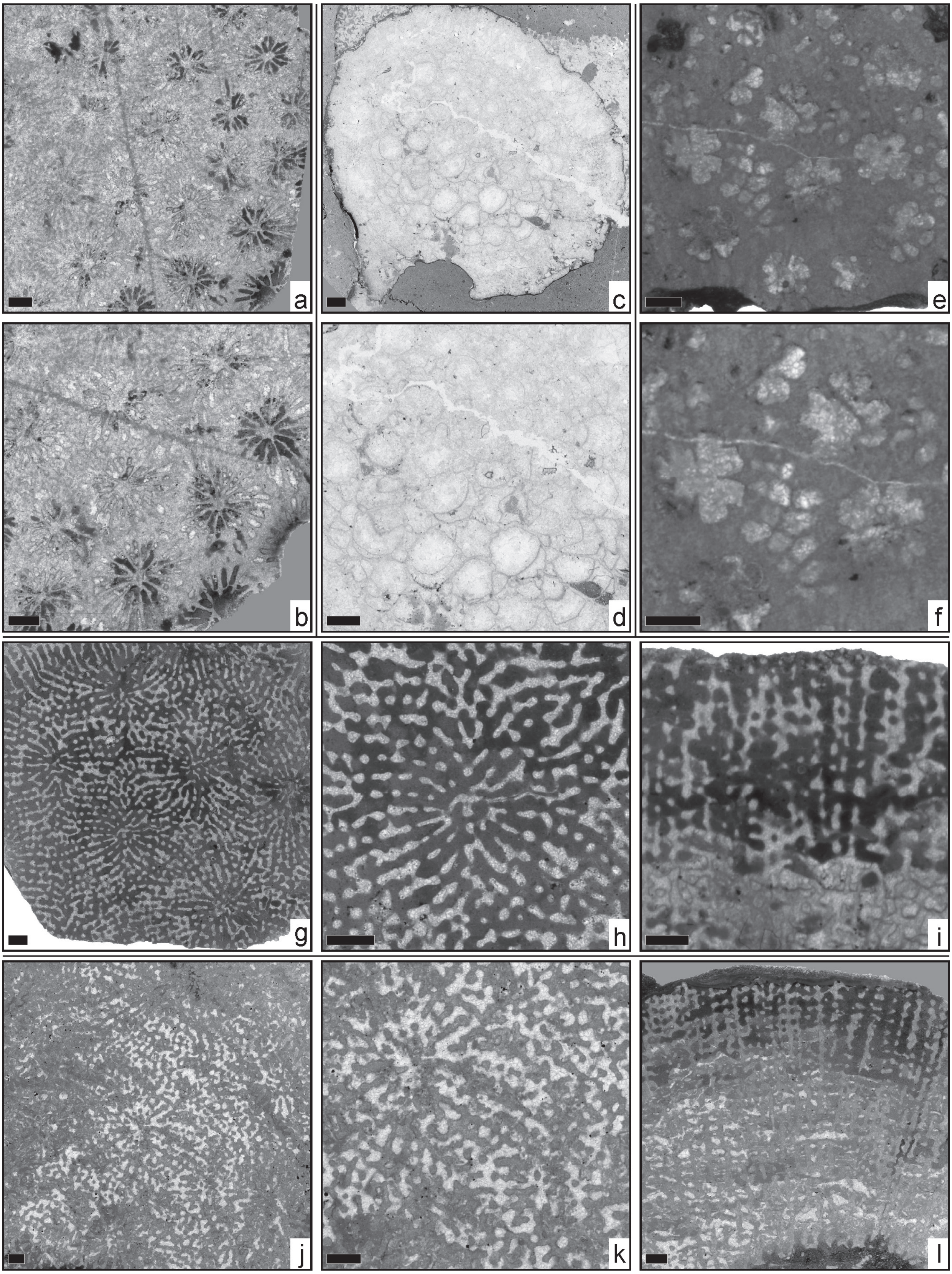

Figure 6. a-b) *Stelidioseris major* Morycowa, 1971, SLD 140301. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **c-d)** *Cryptocoenia* sp., SLD 140203. **(c)** Transversal thin section. **(d)** Transversal thin section, detail. **e-f)** *Holocystis bukowinensis* Volz, 1903, SLD 140341. **(e)** Transversal thin section. **(f)** Transversal thin section, detail. **g-i)** *Actinaraea* sp., SLD 140331. **(g)** Transversal thin section. **(h)** Transversal thin section, detail. **(i)** Longitudinal thin section. **j-l)** *Actinaraea* sp., SLD 140326. **(j)** Transversal thin section. **(k)** Transversal thin section, detail. **(l)** Longitudinal thin section. Scale bars = 1 mm.

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140316).

Other occurrences: Only known from the early Albian of the Western Atlantic (Mexico).

Actinaraea sp. 3
(Figs 7a-d)

Material: 140318; 2 thin sections.

Dimensions: (140318). See table below:

	n	min-max	µ	s	cv	µ±s
ccd	12	5.42-7.31	6.55	0.73	11.1	5.82-7.28
septa	8	38-51	44.3	5.59	12.6	39-50

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140318).

Genus *Camptodocis* Dietrich, 1926

The genus was systematically revised in Löser (2008).

Camptodocis sp.
(Figs 7e-f)

Material: 140330; 1 thin section.

Dimensions: (140330). See table below:

	n	min-max	µ	s	cv	µ±s
crd	14	4.79-7.25	5.95	0.68	11.5	5.26-6.64
septa	4	52-66	58.25	5.79	9.9	52.45-64.04

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140330).

Other occurrences: Aptian of the Western Atlantic (Mexico).

Superfamily **Misistelloidea** Eliášová, 1976

Plesiosmilia Group

The genus *Plesiosmilia* was long-time assigned to the Axosmiliidae family. It cannot remain in this family because *Axosmilia* is poorly defined. The so-called lectotype of its type species (*Caryophyllia extinctorium* Michelin, 1841; MNHN M00053, figured specimen, figured again in Löser, 2016) is an unsectioned, poorly preserved solitary coral. The type status of the so-called paralectotypes (MNHN M00050) is uncertain. The type of the type species of *Plesiosmilia* (*Plesiosmilia turbinata* Milaschewitsch, 1876; MB K3500) is well preserved but because it is silicified, remains without a trace of microstructures. In a certain way comparable material from the Cretaceous shows septa made of small trabeculae resulting in a median dark line, with occasionally horizontally branching trabeculae form pronounced granules at the surface of the septa that are not aligned. The *Plesiosmilia* group is further characterised by a regular septal symmetry, compact thick septa, the absence of a wall (but presence of an epitheca), a well-developed endotheca and occasionally columella. The group collects solitary and phaceloid coral genera. The informal group needs a formal name that is based on material with well-preserved fine skeletal structures.

Genus *Plesiosmilia* Milaschewitsch, 1876.

The genus was described and illustrated in Löser (2016).

Plesiosmilia fromenteli (Angelis d'Ossat, 1905)
(Figs 7g-h)

Material: 140335; 2 thin sections.

Synonymy:
v 1905 *Peplosmilia Fromenteli*; Angelis d'Ossat, p. 242, Pl. 17, Fig. 6 a-g.

v 2013a *Plesiosmilia hennigi* Dietrich, 1926; Löser, p. 104, Fig. 5.10 [here detailed synonymy as *P. hennigi*].

v 2019 *Plesiosmilia fromenteli* (Angelis d'Ossat, 1905); Löser, Heinrich & Schuster, p. 217, Figs. 340ab.

Dimensions: (140335). c = 19.8 x 20. 3 mm; septa = 48.

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140335).

Other occurrences: Berriasian to Coniacian, worldwide.

Superfamily **Thamnasterioidea** Reuss, 1864

Family **Thamnasteriidae** Reuss, 1864

Genus *Ahrdorffia* Trauth, 1911

Ahrdorffia replaces the genus *Mesomorpha* because the latter genus is preoccupied by an older name. *Ahrdorffia* was described and illustrated in Löser (2016) and Löser *et al*. (2019).

Ahrdorffia cancellata (Koby, 1898)
(Figs 7j-l)

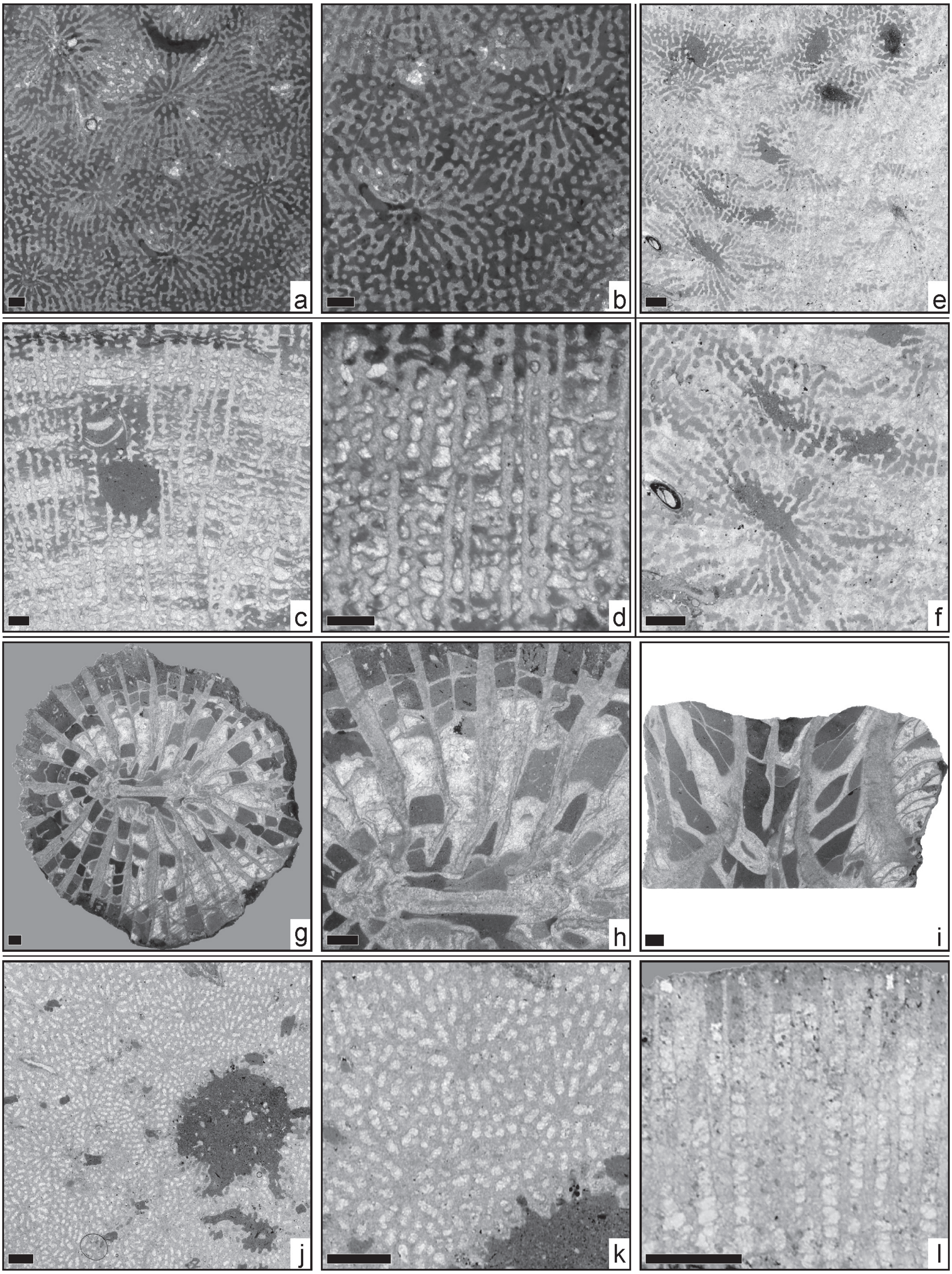

Figure 7. a-d) *Actinaraea* sp., SLD 140318. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **(c)** Longitudinal thin section. **(d)** Longitudinal thin section, detail. **e-f)** *Camptodocis* sp., SLD 140330. **(e)** Transversal thin section. **(f)** Transversal thin section, detail. **g-h)** *Plesiosmilia fromenteli* Angelis d'Ossat, 1905, ERNO L-140335. **(g)** Transversal thin section. **(h)** Transversal thin section, detail. **(i)** Longitudinal thin section. **j-l)** *Ahrdorffia cancellata* Koby, 1898, SLD 140313. **(j)** Transversal thin section. **(k)** Transversal thin section, detail. **(l)** Longitudinal thin section. Scale bars = 1 mm.

Material: 140313; 1 thin section.

Synonymy:
v* 1898 *Thamnaraea cancellata*; Koby, p. 86, Pl. 20, Figs. 7-10.

v 2013a *Mesomorpha cancellata* Koby, 1898; Löser, p. 100, Figs. 4.8-4.9 [here detailed synonymy].

Dimensions: (140313). See table below:

	n	min-max	µ	s	cv	µ±s
ccd	20	1.21-2.37	1.81	0.32	18.1	1.48-2.14
septa	5	20-21	20.8	0.44	2.1	20-21

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140313).

Other occurrences: Worldwide from the Upper Jurassic to the Coniacian.

Order HELIOPORACEA Bock, 1938

Family **Helioporidae** Moseley, 1876

Genus *Heliopora* Blainville, 1830

The genus includes *Polytremacis*. Both genera were revised in Hernández Morales & Löser (2018).

Heliopora somaliensis Gregory, 1900
Figs 8a-c

Material: 140337; 2 thin sections.

Synonymy:
*v 1900 *Heliopora somaliensis*, n.sp.; Gregory, p. 298, Pl. 2, Figs. 8 a-c.

v 1932 *Eomontipora harrisoni*, sp.n.; Gregory, p. 93, Pl. 3, Figs. 1-3.

1932 *Polytremacis* (?) *hancockensis* Wells, n.sp.; Wells, p. 256, Pl. 35, Fig. 5.

v 1948 *Heliopora japonica* n.sp.; Eguchi, p. 363, Pl. 60, Figs. 1, 2, 5, 7.

v 2018 *Heliopora harrisoni* (Gregory, 1932); Hernández Morales & Löser, Figs. 3.1-3.3.

Dimensions: (140337). See table below:

	n	min-max	µ	s	cv	µ±s
clmin	20	0.75-1.02	0.92	0.10	10.8	0.82-1.02
clmax	20	0.80-1.13	1.00	0.09	9.4	0.91-1.10
ccd	20	1.72-3.20	2.47	0.43	17.4	2.04-2.91
septa	8	17-19	18.1	0.64	3.5	17-19

Occurrence: Early Aptian, *Furcata* Zone of Spain (País Vasco, Vizcaya) Bilbao, Peñascal, 1.5 m below top of the formation, in the cutting of the quarry (140337).

Other occurrences: Worldwide Barremian to Santonian.

5. DISCUSSION

The first horizon just on the base of the Peñascal Formation yielded only four species of the family Solenocoeniidae. One of the genera, *Cryptocoenia*, is a very common Middle Jurassic to Cenomanian coral genus and occurs almost everywhere. The other genus, *Holocystis*, is more rare. The second horizon yielded 19 species. Both horizons share only one species, *Holocystis nomikosi*.

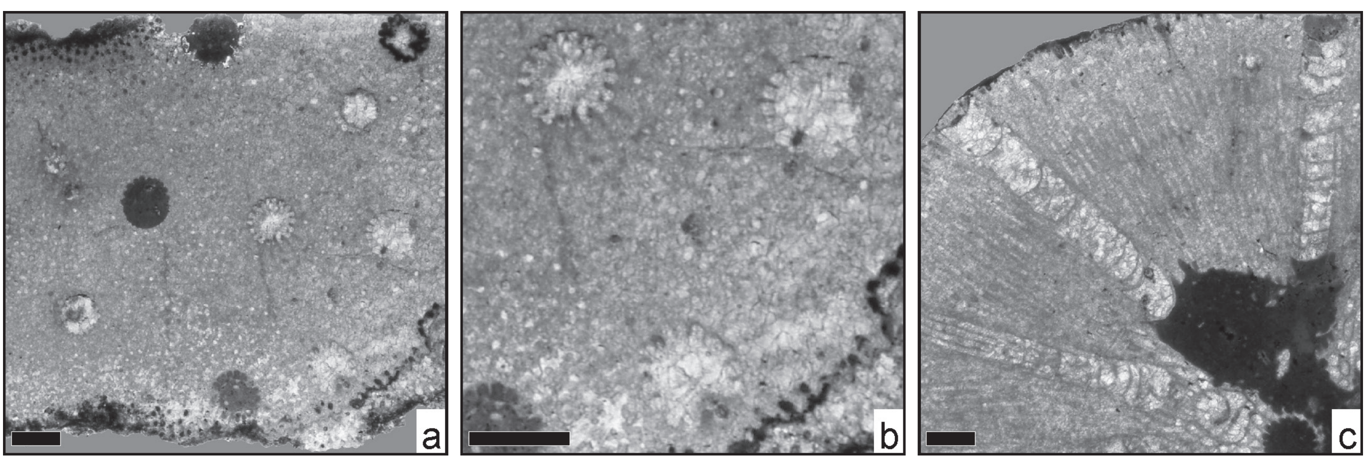

Figure 8. a-c) *Heliopora somaliensis* Gregory, 1900, SLD 140337. **(a)** Transversal thin section. **(b)** Transversal thin section, detail. **(c)** Longitudinal thin section. Scale 1 mm.

Latohelia ruizi is not restricted to the second horizon but occurs in the whole upper part of the Peñascal Formation. The difference between horizons must be found in the ecological conditions that were better for corals towards the upper part of the formation.

The early Aptian was very rich in species and genera on a global scale. When only considering the 2550 Cretaceous localities from which corals are reported in the literature, with descriptions and illustrations, about 140 coral localities have a early Aptian age (5.5%), and, when including a slightly longer time period 375 localities with corals have a range from the late Barremian to the Aptian (15%). This is also reflected in the distribution of the species found in the Peñascal Formation (Fig. 9). Most were already known from the early Aptian.

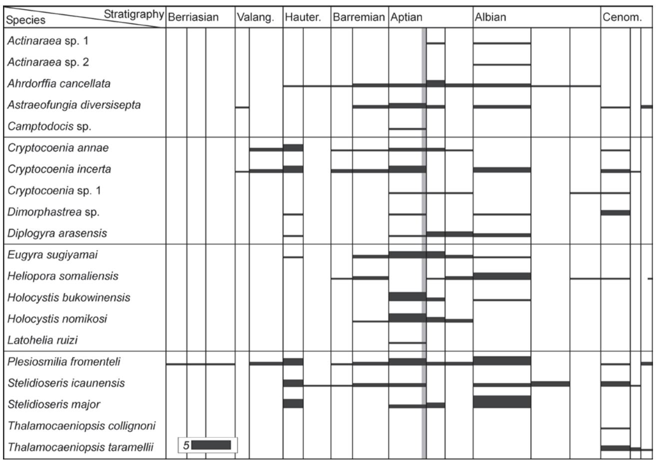

Figure 9. Stratigraphic distribution and commonness of species. The thickness of the bars indicates the number of localities in which the concerned species was found. The vertical grey bar indicates the age of the study deposits. Species outside of this bar have not been detected before in sediments of this age.

Compared to other early Aptian coral faunas, the Peñascal fauna is poor in species. When comparing the genera found in the study area to the published frequency of Hauterivian-Albian coral genera (Löser, 2016; fig. 6.3.3.4) it can be observed that the fauna is clearly dominated by very abundant to occasional genera (Table 1). The number of rare genera seems to be high but only one genus, *Actinaraea*, is well known by coral workers and more frequently reported. This is not the case for the other genera. *Camptodocis* was just recently re-activated and replaced the, so far only Late Jurassic *Actinaraeopsis* Roniewicz, 1968 (Löser, 2008). *Latohelia* was established in recent times and only up to now it was found that it should be applied to material that formerly was assigned to *Calamophylliopsis*. Finally *Thalamocaeniopsis* did not receive much attention because the original description and illustration of the taxon was so poor that it was neglected by coral workers. This means that the latter three genera are probably more common than calculated by Löser (2016) based on literature data.

Table 1. Frequency of the coral from the study area. Classification follows Löser (2016) for the time interval Hauterivian to Albian.

Frequency	Genus
Very abundant	*Cryptocoenia*, *Dimorphastrea*, *Eugyra*, *Plesiosmilia*, *Stelidioseris*
Abundant	*Astraeofungia*
Occasional	*Ahrdorffia*, *Diplogyra*, *Heliopora*, *Holocystis*
Rare	*Actinaraea*, *Camptodocis*, *Latohelia*, *Thalamocaeniopsis*

The palaeobiogeographical analysis does not show clear patterns due to the low number of species found in Peñascal (Fig. 10). Most correlations can be found into Hauterivian faunas of the Paris Basin, the Aptian and Albian of the Bisbee Basin (Northern Mexico) and east Iberia, the nearby northern Pyrenees and the Basque-Cantanbrian Basin.

No co-occurring species were found with the areas Aragón and from Cataluña, except for those mentioned in the synonymy lists. No co-occurring species were found with the Peñacerrada diapir (Sachs, 2002).

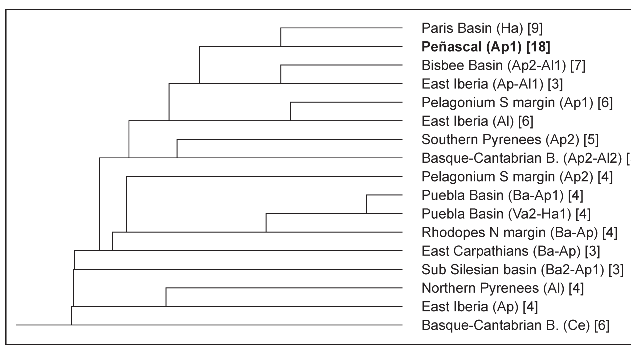

Figure 10. Correlation of provinces with joint species of the study area. Provinces with less than two joint species are suppressed and only provinces of an Early Cretaceous and Cenomanian age are shown. The correlation ratio coefficient was applied.

ACKNOWLEDGEMENTS

This research was funded by project IT-930-16 of the Basque Government. The preparation of thin sections was partly done in the Estación Regional del Noroeste (Hermosillo, Mexico) by Aimée Orcí. Alejandro Samaniego assisted in collecting morphometric data on the corals. English language correction by Proof-Reading-Services (Letchworth Garden City, England). We are grateful to Ricardo Garberoglio (Buenos-Aires) and one anonymous reviewer for their insightful comments.

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