

Large dasycladalean algae from Upper Jurassic limestone deposits of the Apuseni Mountains (Romania) – habitat and depositional environment

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ABSTRACT

Three species of dasycladalean algae are described: *Petrascula piai* Bachmayer, 1944, *P. bursiformis* (Etallon, 1859) and *Steinmanniporella kapelensis* (Sokač & Nikler, 1973). Two of them, *Petrascula piai* and *Steinmanniporella kapelensis*, are relatively seldom reported and consequently poorly known algae. They were found at two locations in the Apuseni Mountains: Sânduleşti quarry (Trascău Mountains) and Şerbota Hill (near Aştileu, Pădurea Craiului Mountains). The two species of *Petrascula* were essentially identified from sections of the stalk. Their study provides, especially for *P. piai*, useful supplementary data related to the morphology of the laterals and the structure of the stalk. Regarding *Steinmanniporella kapelensis*, Sânduleşti is only the second locality (after the type locality) where this alga is known to occur as numerous well preserved specimens. Microfacies and sedimentological data suggest that these algae were restricted to micro-environments within the external part of the carbonate platforms.

KEY WORDS

Calcareous algae,
Dasycladales,
paleoenvironment,
Upper Jurassic,
Apuseni Mountains,
Romania.

RÉSUMÉ

Grandes algues dasycladales des calcaires du Jurassique supérieur des monts Apuseni (Roumanie) – habitat et milieu de dépôt.

Trois espèces d'algues dasycladales sont présentées : *Petrascula piai* Bachmayer, 1944, *P. bursiformis* (Etallon, 1859) et *Steinmanniporella kapelensis* (Sokač & Nikler, 1973). Deux d'entre elles, *Petrascula piai* et *Steinmanniporella kapelensis*, sont rarement citées dans la littérature et, par conséquent, relativement peu connues. Elles ont été trouvées dans deux localités des monts Apuseni : la carrière de Sânduleşti (monts de Trascău) et la colline de Şerbota (près d'Aştileu, monts de Pădurea Craiului). Les deux espèces de *Petrascula* ont été essentiellement

MOTS CLÉS
Algues calcaires,
Dasycladales,
paléoenvironnement,
Jurassique supérieur,
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identifiées par des sections de la tige. Leur étude, spécialement celle de *P. piai*, apporte des données supplémentaires sur la morphologie des rameaux latéraux et la structure de la tige. Concernant *Steinmanniporella kapelensis*, Sândulești est la seconde localité (outre la localité-type) où cette algue est représentée par de nombreux exemplaires bien conservés. L'étude des microfaciès et des données sédimentologiques suggère que ces algues se développaient essentiellement dans des micro-environnements caractéristiques de la partie externe des plates-formes carbonatées.

INTRODUCTION AND GEOLOGICAL SETTING

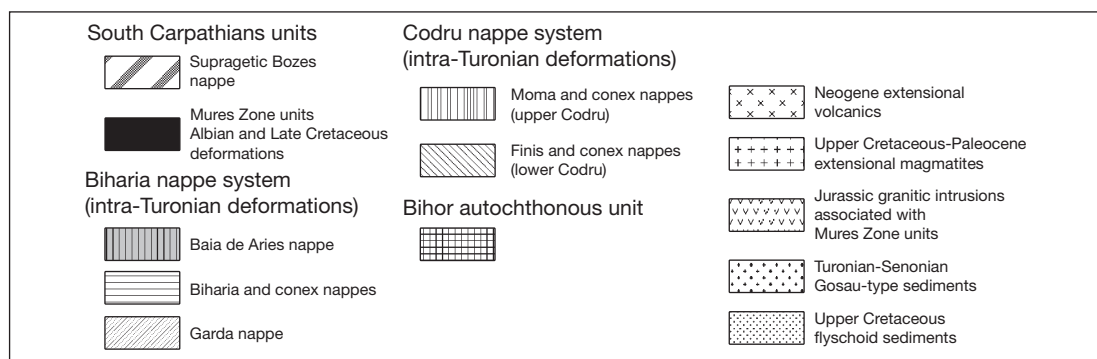
The dasycladalean algae presented here were collected from two different regions of the Apuseni Mountains: Șerbota Hill (near Aștileu, northern part of Pădurea Craiului Mountains), and Sândulești quarry (the northern end of Trascău Mountains) (Fig. 1).

Two main facies associations have been distinguished within the Upper Jurassic succession of the Aștileu area (Fig. 2): 1) distal shelf (offshore) facies, identified in the lower part of the succession; and 2) shallow-water, external carbonate platform facies (bioclastic shoals), in the upper part.

1) The distal-shelf facies are represented by peloidal-bioclastic packstone/wackestone with stromatolites and peloidal-bioclastic packstone/grainstone (Fig. 2). Within these facies, rare ammonites, small foraminifers (including small miliolids), hemipelagic

foraminifers (*Lenticulina* sp.), sponge spicules and echinoderm fragments are also present (Fig. 4A).

2) The distal-shelf facies gradually pass upwards into shallow-water bioclastic shoal deposits (Fig. 2). Intercalations of grainy limestones with diverse microfossils increase along this transition. The more representative shallow-water facies consist of intraclastic-bioclastic grainstone/packstone, ooid-bioclastic grainstone and ooid-pisoid-bioclastic grainstone (Fig. 4B-D). The clasts are sand-size and subangular to subrounded in shape, pointing to a relatively high-energy depositional environment. The clasts consist of reefal intraclasts and bioclasts, ooids, oncoids, and peloids. The bioclasts are represented by fragments of corals, echinoderms, molluscs, bryozoans, foraminifers, dasycladalean algae and rivulariacean-type cyanobacteria. This composition is consistent with their external platform bioclastic shoal environment.



Caption of the Figure 1.

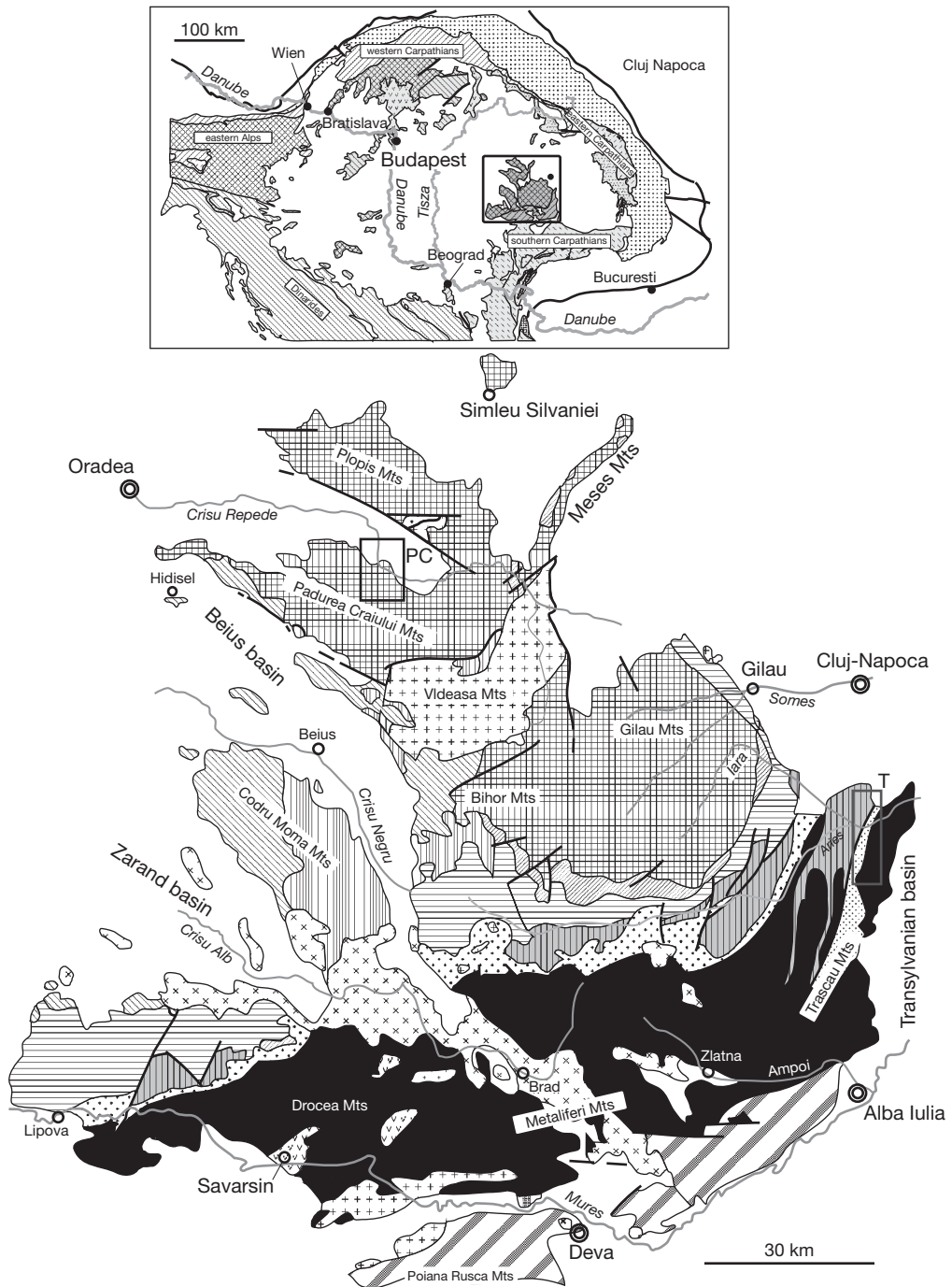


FIG. 1. — Location of the sections studied within the Carpathian area and in relation to the tectonic outline of the Apuseni Mountains, based on Balintoni (2001). Abbreviations: **PC**, Pădurea Craiului; **T**, Trascau Mountain.

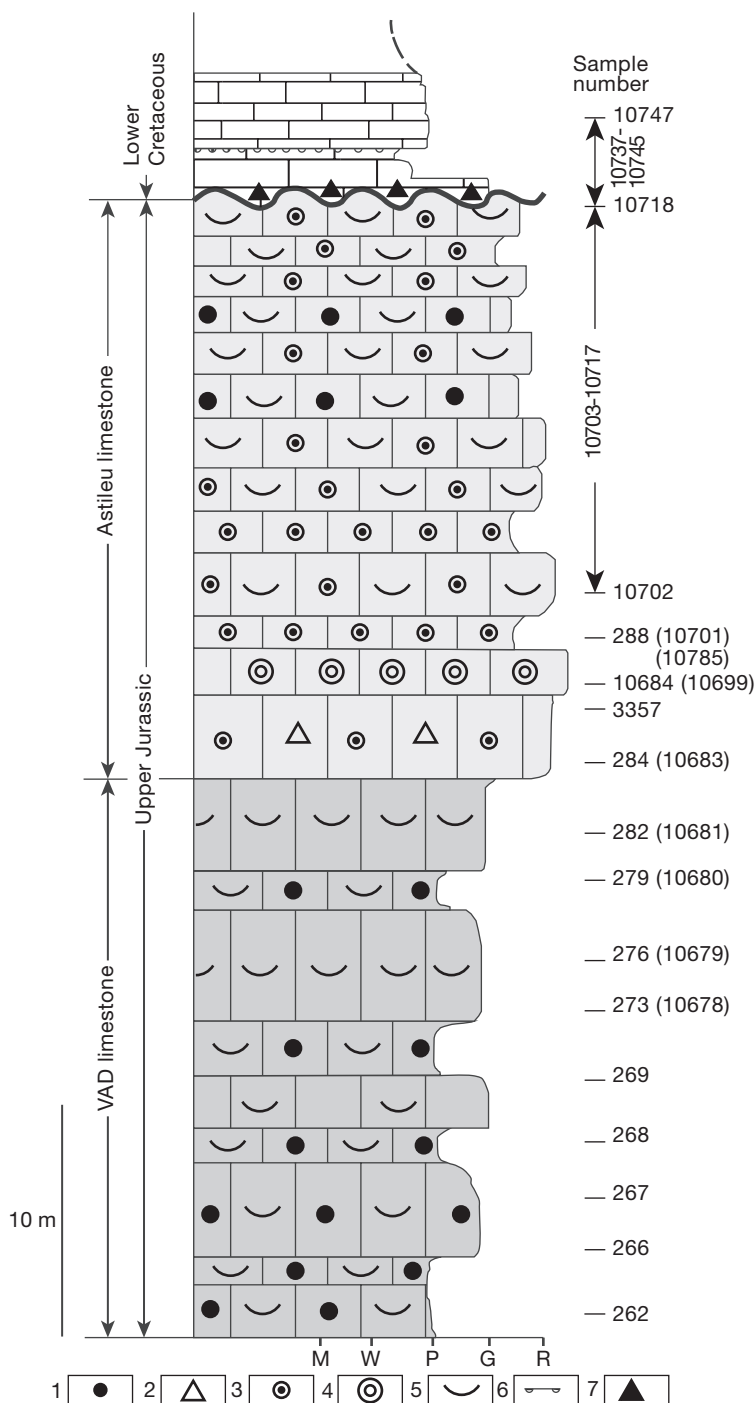


FIG. 2. — Succession of the carbonate deposits at Șerbota Hill (Aștileu, Pădurea Craiului Mountains): 1, peloids; 2, intraclasts; 3, ooids; 4, pisoids; 5, bioclasts; 6, emersion surface; 7, breccia; M, mudstone; W, wackestone; P, packstone; G, grainstone; R, rudstone.

The dasycladalean assemblage, represented by *Salpingoporella pygmaea* (Gümbel, 1891) Pia, 1925, *Salpingoporella annulata* Carozzi, 1953, *Campbelliella striata* (Carozzi, 1954) Bernier, 1974, *Neoteutloporella socialis* (Praturlon, 1963) Bassoullet *et al.*, 1978 and species of the genus *Petrascula* (*P. piai* Bachmayer, 1944 and *P. bursiformis* (Etallon, 1859) Pia, 1920), is present in the upper part of the succession. The large Dasycladales (*Petrascula* specimens) have been found in ooid-pisoid or coarse intraclastic-bioclastic grainstones together with abundant echinoderm fragments (Fig. 4B, C).

Based on sedimentological and micropaleontological data, the large dasycladaleans from the Aștileu area developed on submarine dunes, as well as in protected inter-dune areas, in the external part of the Bihor-Pădurea Craiului Upper Jurassic carbonate platform.

Two main facies have also been distinguished in the limestones from Sândulești: carbonate breccia and microbreccia consisting mainly of reef fragments, and coral-microbial bioconstructions.

1) The breccia/microbreccia levels are decimetric to metric in thickness and consist of coarse “reefal” intraclasts in a fine-grained (silt, and sand sized) carbonate matrix (Fig. 3). Microfacies include intraclastic-bioclastic rudstone/floatstone and coarse intraclastic-bioclastic grainstone/packstone (Fig. 4H). These deposits are unstructured and poorly sorted. The clasts are chaotically distributed, angular to subrounded, with dimensions ranging from gravel to boulders. They are represented mainly by coral and sponges boundstones, coral-microbialite boundstones, microbial crusts and bioclastic grainstones/packstones. In most cases, the top of the carbonate breccia/microbreccia is intensely encrusted by microbialite. Accordingly, these facies associations are interpreted as reef slope deposits in the proximity of the reef crest.

2) The reef bioconstructions are made up mostly of corals, microbialites and sponges (Fig. 4E, F). Bryozoans, encrusting microorganisms (*Trogrotella incrustans* Wernli & Fookes, 1992, *Thaumato-porella parvovesiculifera* (Raineri, 1922) Pia, 1927, *Crescentiella morronensis* (Crescenti, 1969) Senowbari-Daryan *et al.*, 2008, *Radiomura cautica* Senowbari-Daryan & Schäfer, 1979, *Koskinobullina*

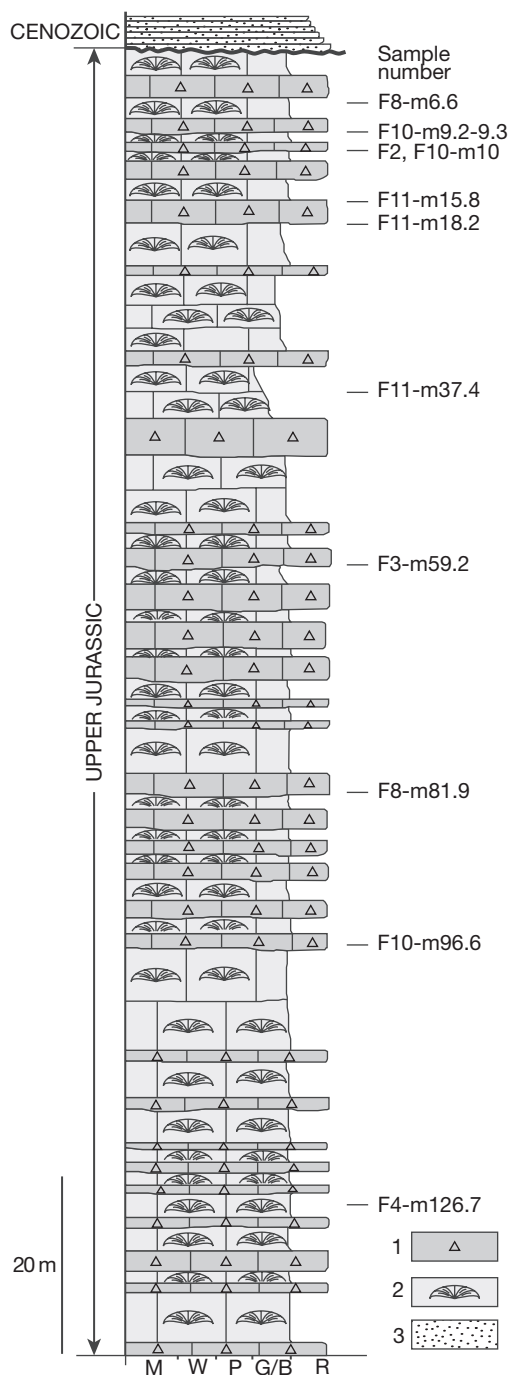


FIG. 3. — Succession of carbonate deposits in the Sândulești quarry (Trascău Mountains): 1, reef breccia (rudstone); 2, reef limestone (boundstone); 3, terrigenous deposits; M, mudstone; W, wackestone; P, packstone; G/B, grainstone/boundstone; R, rudstone.

socialis Cherchi & Schroeder, 1979, *Lithocodium aggregatum* Elliott, 1956), and annelid worms also contributed to the reef framework development. Syndepositional (radial fibrous) cement is frequently associated with the microbialites and played an important role in framework development. The intra-reefal sediment contains fragments of echinoderms, bivalves, gastropods, fish teeth (*Sphaerodus maximus* Wagner, 1863), foraminifers, and dasycladalean algae (Fig. 4G). In most cases, the sediments between the bioconstructions are wackestone/packstone with sponge spicules and packstone with *Crescentiella morronensis* and sponges. These sediments, together with the presence of microbial crusts, suggest relatively low sedimentation rates that were favorable for the nucleation and development of the bioconstructions.

Facies associations from the Săndulești area are characteristic of reef-slope environments located near the shelf margin. They demarcate the paleoslope of a carbonate platform that was developed in this region on an island-arc topography during the Upper Jurassic-Lower Cretaceous.

In the Săndulești area, the dasycladalean algae assemblage consists of: *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010, *Salpingoporella pygmaea* (Gümbel, 1891) Pia, 1925, *Clypeina sulcata* (Alth, 1882), Granier & Brun, 1991, *Petrascula piai* Bachmayer, 1944, and *Griphoporella cretacea* (Dragastan, 1967) Bucur & Schlagintweit, 2009.

ABBREVIATIONS

The following abbreviations refer to sample location in Figures captions.

As	Aștileu;
F	borehole (forage);
Sa	sample;
Sd	Săndulești.

DESCRIPTION OF THE DASYCLADALES

Large Dasycladales have been found in both areas. In Săndulești they are present in both reef and rudstone facies. In the Aștileu area they are mostly associated with the ooid-pisoid or coarse intraclastic-bioclastic grainstone with frequent echinoderm fragments.

Three species are identified: *Steinmanniporella kapelensis*, *Petrascula piai* and *Petrascula bursiformis*. *Steinmanniporella kapelensis* was found only in the Săndulești area, while the two species of *Petrascula* are present in both areas.

Petrascula piai Bachmayer, 1944 (Figs 5-8)

Petrascula piai Bachmayer, 1944: 238, figs 3-6 (emend. Bernier 1979: 845, pls 3, 4). — Bernier 1984: 478, pl. 11, figs 1, 2. — Moshammer & Schlagintweit 1999: 557, pl. 1, figs 4, 5. — Bucur & Săsăran 2005: 28, pl. 3, fig. 1.

Non *Petrascula* cf. *piai* — Okla 1991: 92, pl. 2, figs 3-5.

Montenegrella sp. — Bodeur 1992: pl. 16, figs 5, 7-9, 12.

?*Suppiluliumaella tuberifera* (Sokač & Nikler) — Dya 1992: 81, pl. 8, figs 1, 2, 6, 7.

?*Dasycladale* indet. — Carras 1995: pl. 22, fig. 2.

REMARKS

Petrascula piai was firstly described by Bachmayer (1944) from Jurassic limestones at Dörfless (Austria). The species was based on four fragments partly detached from the matrix, with two head fragments and two stalk fragments. No specimen was illustrated in thin section. Bachmayer's description (translated from the German) is as follows: "This form is characterized by a sharp difference between head and stalk. The head is almost spherical. Head and stalk were found separately. However, it is likely that the fragments illustrated in figs. 5 and 6 belong to the same species. The head consists of densely arranged secondary veriticated branches, so that little space is left for the calcareous deposit. Within the skeleton, the secondary pore fillings were joined by calcite recrystallisation, and made a rigid sphere. The outer ends of the pore fillings give the exterior very regular, hemispherical papillae-like prominences, and very probably the pores were closed to the exterior. In addition, tertiary verticillar branches could not be recognized. Within the stalk the primary verticillar branches are set at a distance from each other, in very well defined verticils. They are set obliquely to the upper part. The branch number in a verticil ranges from 16 to 20. The division of primary ver-

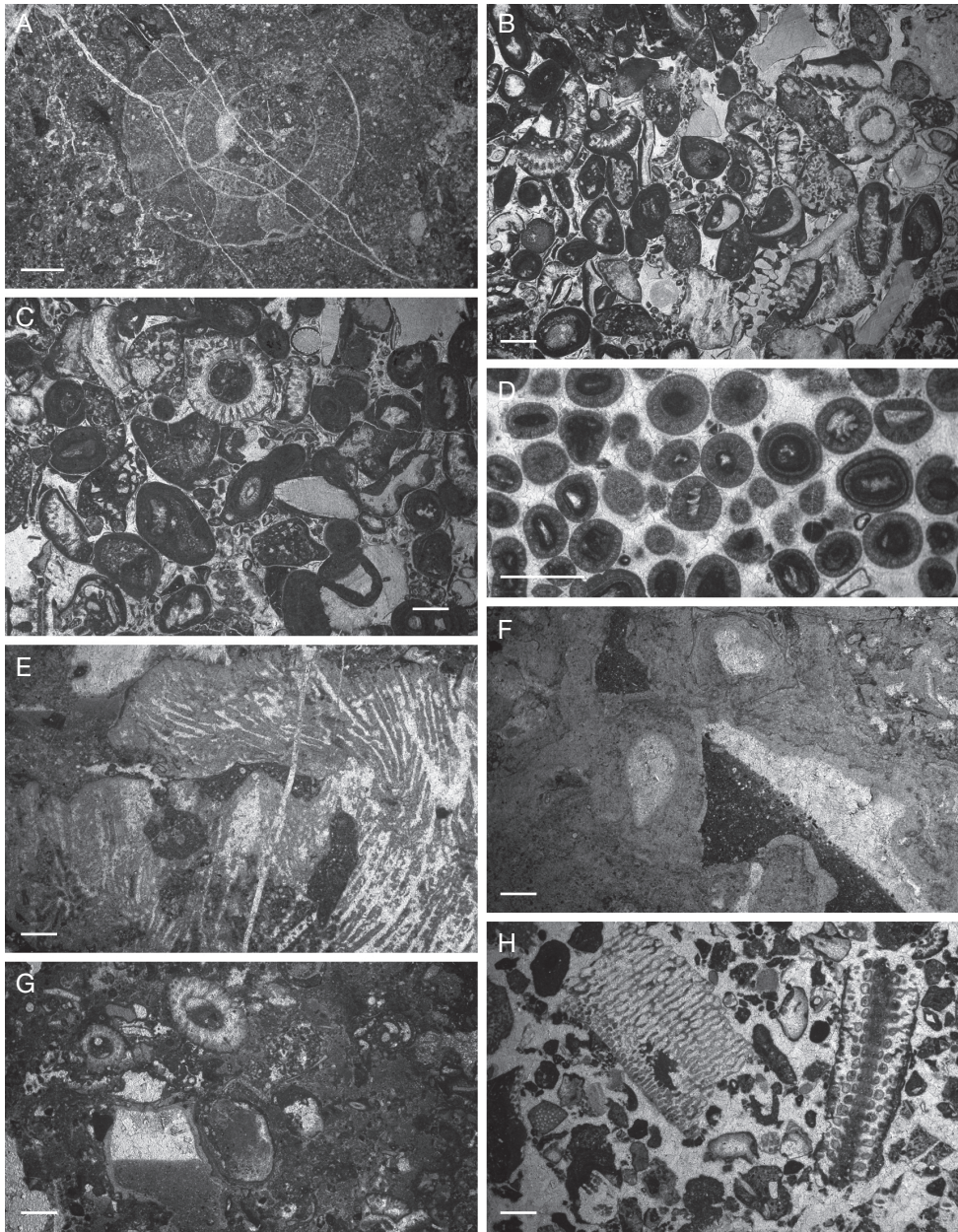


FIG. 4. — Main microfacies in the limestones from Aștileu and Sândulești: **A**, wackestone/packstone with sponge spicules and juvenile ammonites (Sa 270 As); **B**, intraclastic-bioclastic grainstone with dasycladalean algae and echinoderm fragments (Sa 10684 As); **C**, pisoid-bioclast grainstone with dasycladalean algae (Sa 10684 As); **D**, ooid grainstone with bioclastic cores to the ooids (frequently small dasycladalean algae; Sa 10685 As); **E**, coral-microbial boundstone (Sa F11-m 18.2 Sd); **F**, microbialites and internal sediment from bioconstructions (Sa F8-m 81.9 Sd); **G**, internal sediment from bioconstructions: bioclastic packstone with dasycladalean algae (Sa F10-m 9.2 Sd); **H**, intraclastic-bioclastic grainstone/rudstone with coral fragments and dasycladalean algae (Sa F10-m 96.6 Sd). Scale bars: 1 mm.

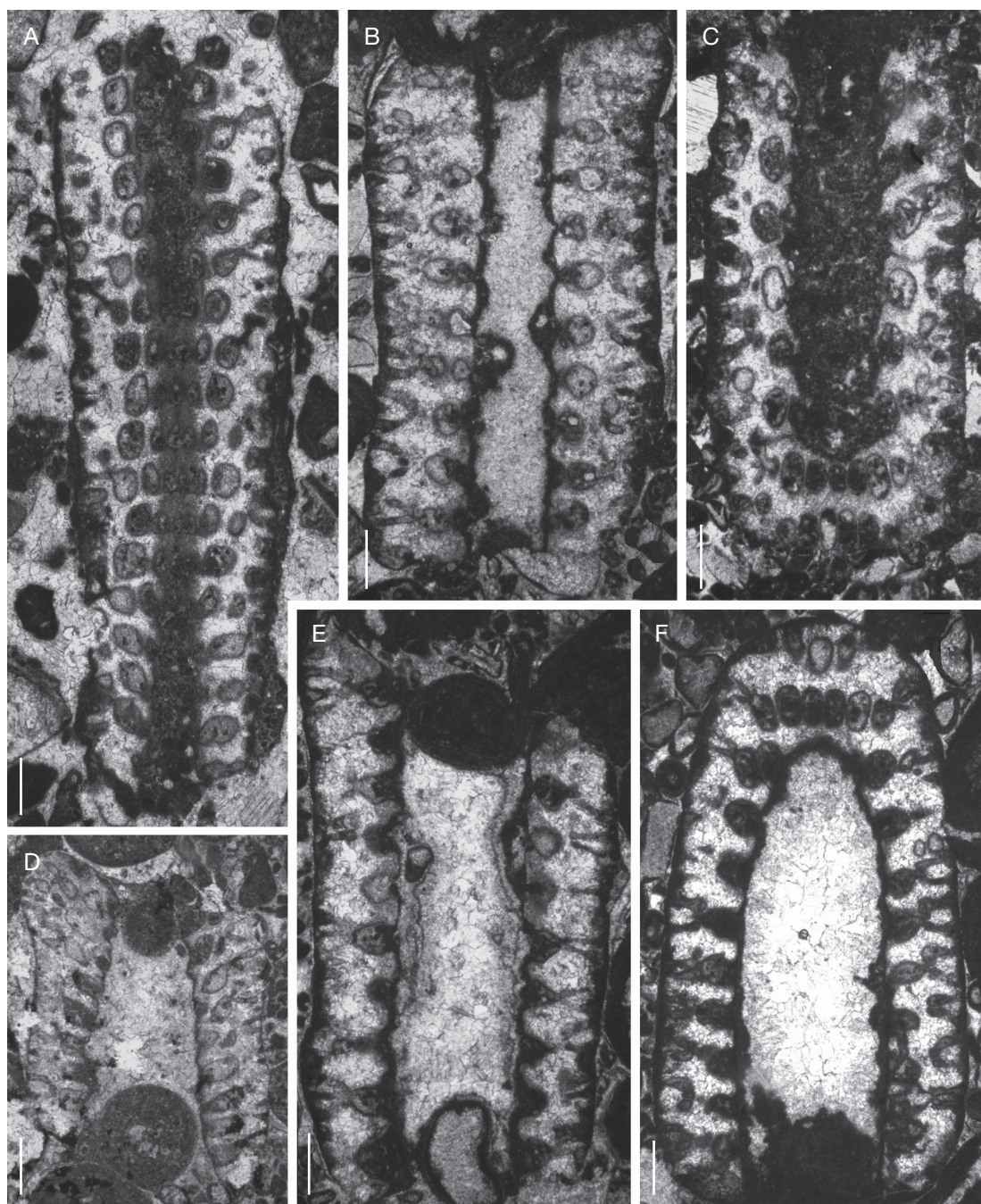


FIG. 5. — *Petrascula piai* Bachmayer, 1944, longitudinal (A, B, D, E) and longitudinal-oblique (C, F) sections through the cylindrical stalk; the upper part in D shows a small portion of the transition from stalk to head. A, Sa F10-m 96.6 Sd; B, E, Sa 10684 As; C, Sa 3357 As; D, Sa 10684a As; F, Sa 10684c As. Scale bars: 0.5 mm.

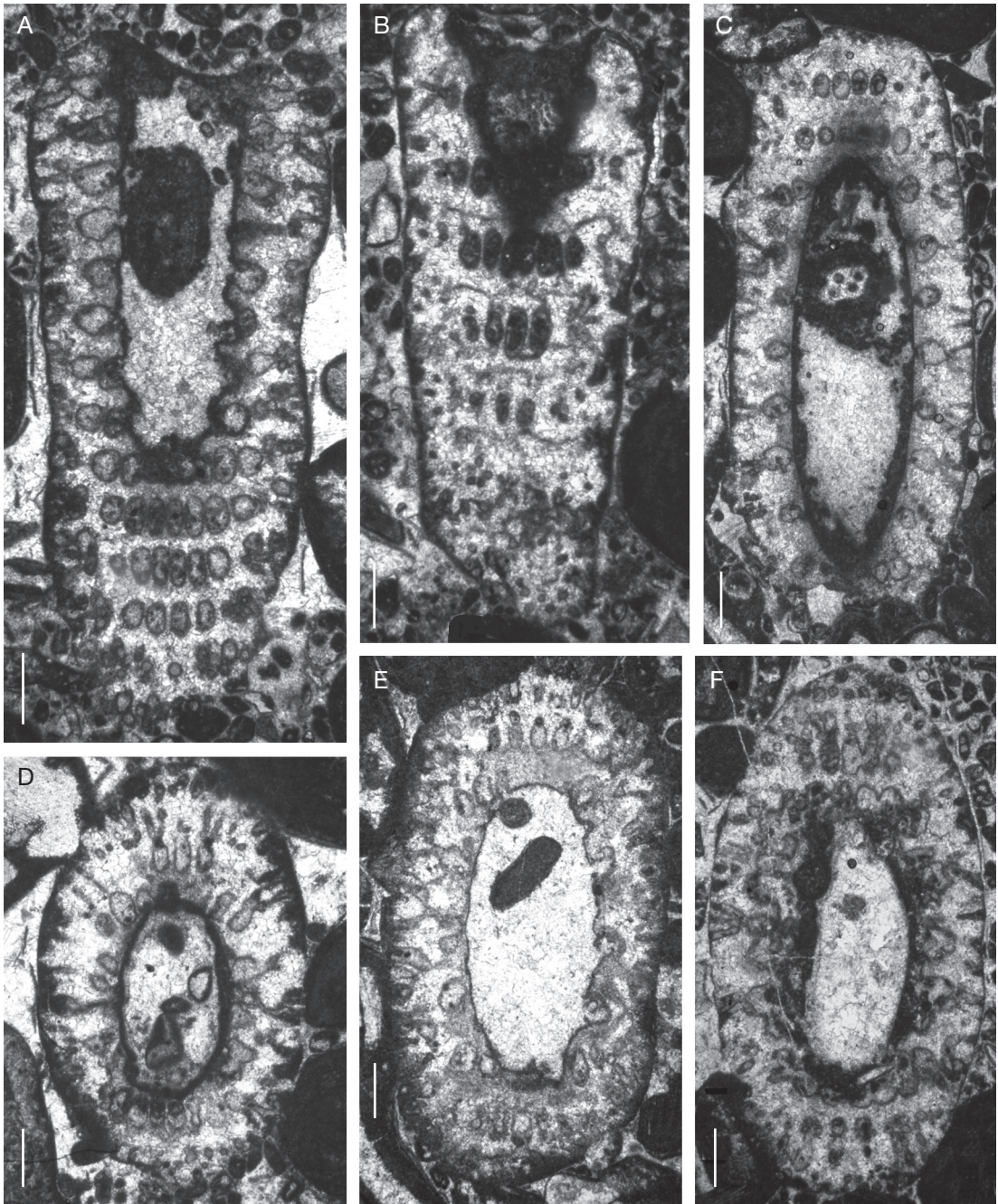


FIG. 6. — *Petrascula piai* Bachmayer, 1944, longitudinal-oblique (A), oblique-tangential (B) and oblique (C-F) sections. A-E, Sa 10684 As; F, Sa 10684a As. Scale bars: 0.5 mm.

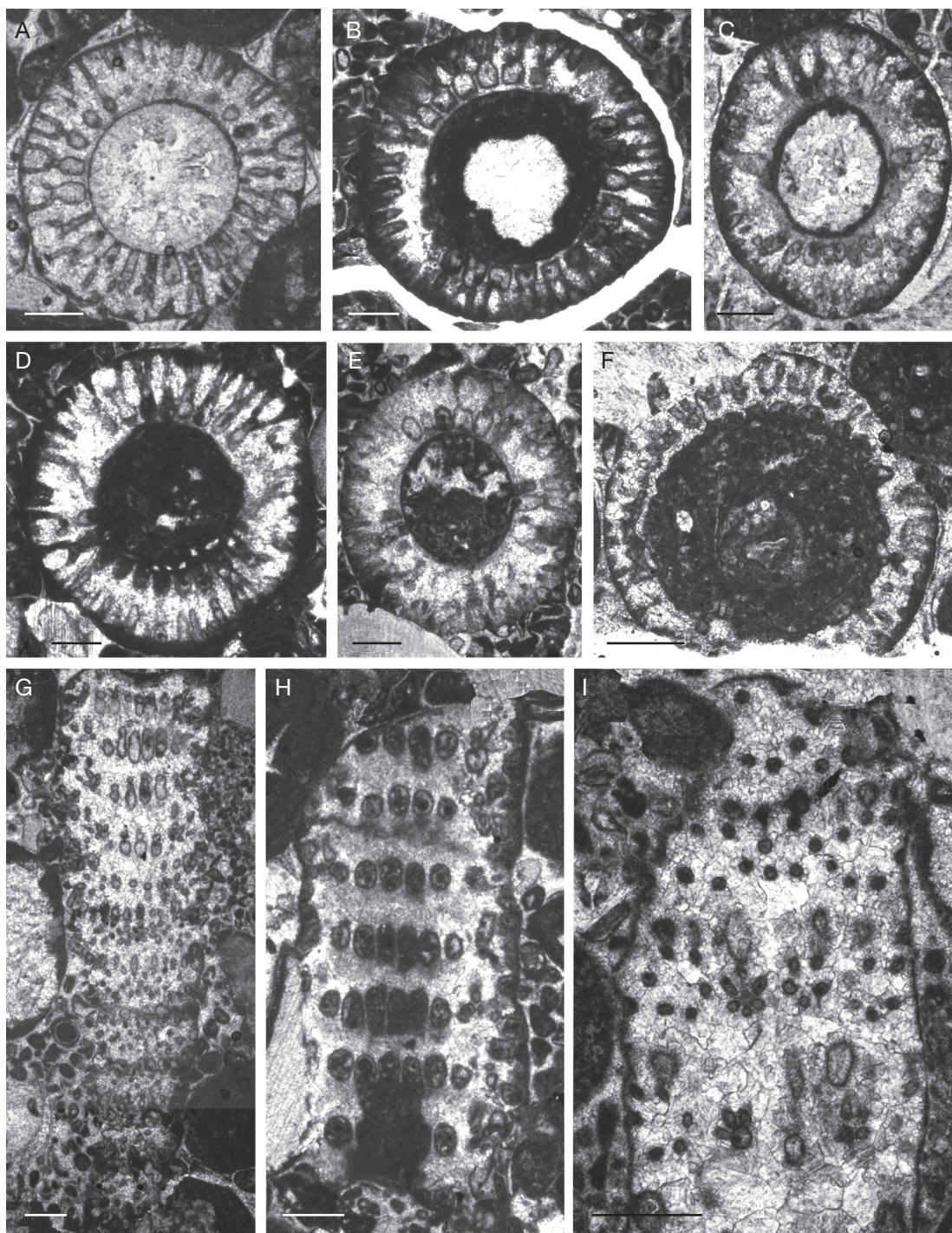


FIG. 7. — *Petrascula piai* Bachmayer, 1944: **A-F**, transverse sections (**F**, probably at the transition between stalk and head); **G-I**, tangential sections. **A, C, F-I**, Sa 10684 As; **B, D, E**, Sa 3357 As. Scale bars: 0.5 mm.

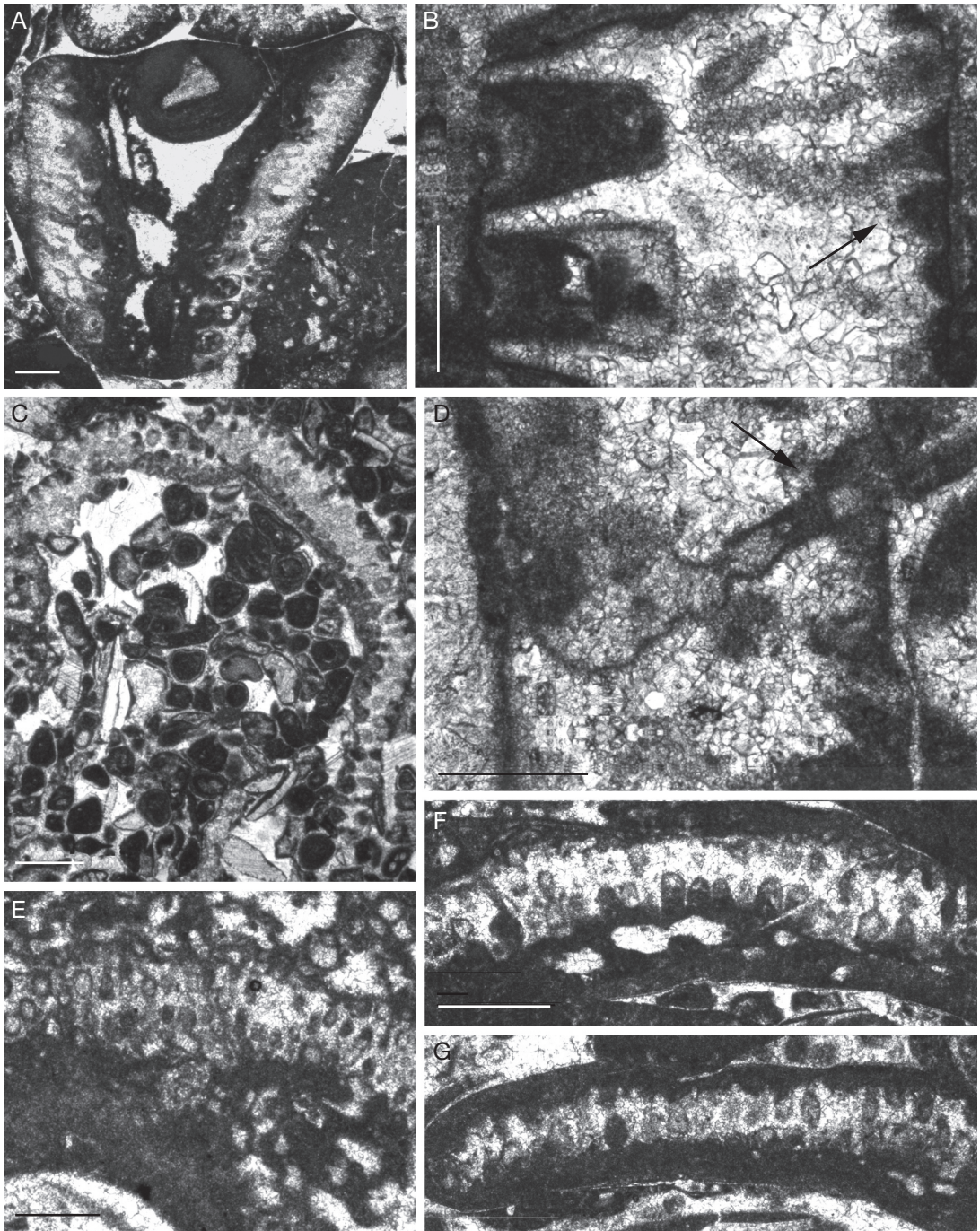


FIG. 8. — *Petrascula piai* Bachmayer, 1944: **A**, fragment in longitudinal-oblique section showing the transition from stalk to head; **B**, **D**, close-up view of laterals in transverse (**B**) and longitudinal-oblique (**D**) sections; arrows point to the third order laterals; **C**, **E**–**G**, fragments of the head, with calcification restricted to the distal part of second order and third order laterals. **A**, **E**, **F**, Sa 10684c As; **B**, **C**, Sa 3357 As; **D**, Sa 10684a As; **G**, Sa 10684b As. Scale bars: **A**, **C**, **F**, **G**, 0.5 mm; **B**, **D**, **E**, 0.25 mm.

ticillar branches into secondaries can be observed in some places, but the number of secondary branches within a bush could not be established due to the poor preservation of the stalk.”

Bachmayer (1944) gives neither details related to the morphology of the primary and secondary laterals, nor remarks on the paleoenvironment.

In his detailed study of the species of the genus *Petrascula*, Bernier (1979) emended the diagnosis (i.e. description) given by Bachmayer (1944) based on many specimens observed in thin section. Bernier (1979) made the following remarks:

- the primary laterals are spherical to subspherical or ovoid; sometimes, the incomplete calcification around the primary laterals make them communicate in some places;
- the 4 to 5 secondary laterals seem to be vesiculiform, with a proximal filiform portion, and a distal enlarged portion.

Bernier (1979: 846) mentioned that he had the opportunity to examine Bachmayer's type material, and noted that the “original figurations are of very bad quality”. Bernier (1979) also made some remarks on the paleoenvironment and noted that “Le biotope de *P. piai* était certainement un milieu calme de plate-forme peu profonde, dans une eau relativement chaude”. However, he noted that he had not found any complete skeleton, only separated head and stalk fragments.

In the section from Șerbota Hill (near Astileu, Pădurea Craiului Mountains; Fig. 2) we identified numerous specimens referable to this species. Most of them are stalk fragments (Figs 5-7; 8A, B, D), but some rare fragments could belong to the head (Fig. 8C, E-G).

MORPHOLOGY OF THE STALK

The stalk fragments are cylindrical (Figs 5-7), with a slight enlargement in the upper part where the passage from stalk to the head begins (Figs 5D; 8A). The longitudinal and longitudinal-oblique sections (Fig. 5) allow the morphology of the laterals to be well observed. The first-order laterals are spheroidal to ovoidal in shape (Fig. 5A, B, D-F). In some longitudinal sections (Fig. 5C) the first-order subspherical laterals become subquadrangular, being higher than wide (see also the oblique sections in

Fig. 6A, B and the tangential section in Fig. 7H). This is due, most probably, to reciprocal pressure between laterals of the same verticil (e.g., Fig. 8B). This reciprocal pressure does not operate in the vertical plane because of the spaced out arrangement of the verticils along the stalk. In transverse sections (Fig. 7A-E) the shape of the first-order laterals range from sub-cylindrical to sub-quadrangular.

The relationship between the first-order and second-order laterals is visible in oblique sections (Fig. 6): each first-order lateral gives rise to a bush of secondaries. The second-order laterals have a proximal narrow tubular part and enlarge distally to the exterior (phloiophorous type). The link between the first-order and second-order laterals is made by a short narrow peduncle (Figs 7A [left side]; 8D). The number of second-order laterals in a bush originating from a first-order lateral varies from 4 to 6. This is clearly visible in tangential sections (Fig. 7G, I).

Both Bachmayer (1944) and Bernier (1979) emphasized that *P. piai* has only two orders of laterals. Bachmayer (1944) considered that *P. piai* differs from *P. bursiformis* by (translated from the German): “sharp passage from the stalk to the head, and the ending of pores with papillae, and additionally by the lack of calcified tertiary verticillar branches”. The same character (the lack of third-order laterals) was utilised by Bernier (1979) to differentiate *P. piai* from *P. bursiformis* and *P. guembeli*: “Elle se distingue aussi aisément de *P. bursiformis* et *P. guembeli* qui présentent trois ordres de ramifications dans la tige et au collet”. However, some rare specimens found in the Șerbota Hill section (Pădurea Craiului Mountains) (Fig. 2) show that *P. piai* can also have three orders of laterals (Fig. 8B, D [arrows]). The second-order laterals give rise, sometimes, to a bush of third-order phloiophorous short laterals. Very probably, the third-order of laterals was present only in some portions of the stalk. The thin calcification of the external part of the thallus, as well as the abrasion of the skeletons due to sedimentary transport, have made preservation of the third-order laterals very rare. On the other hand, it is very unlikely that the second-order laterals were closed to the exterior (as put forward by Bachmayer 1944); more probably the second-order or tertiary laterals formed an external cortex.

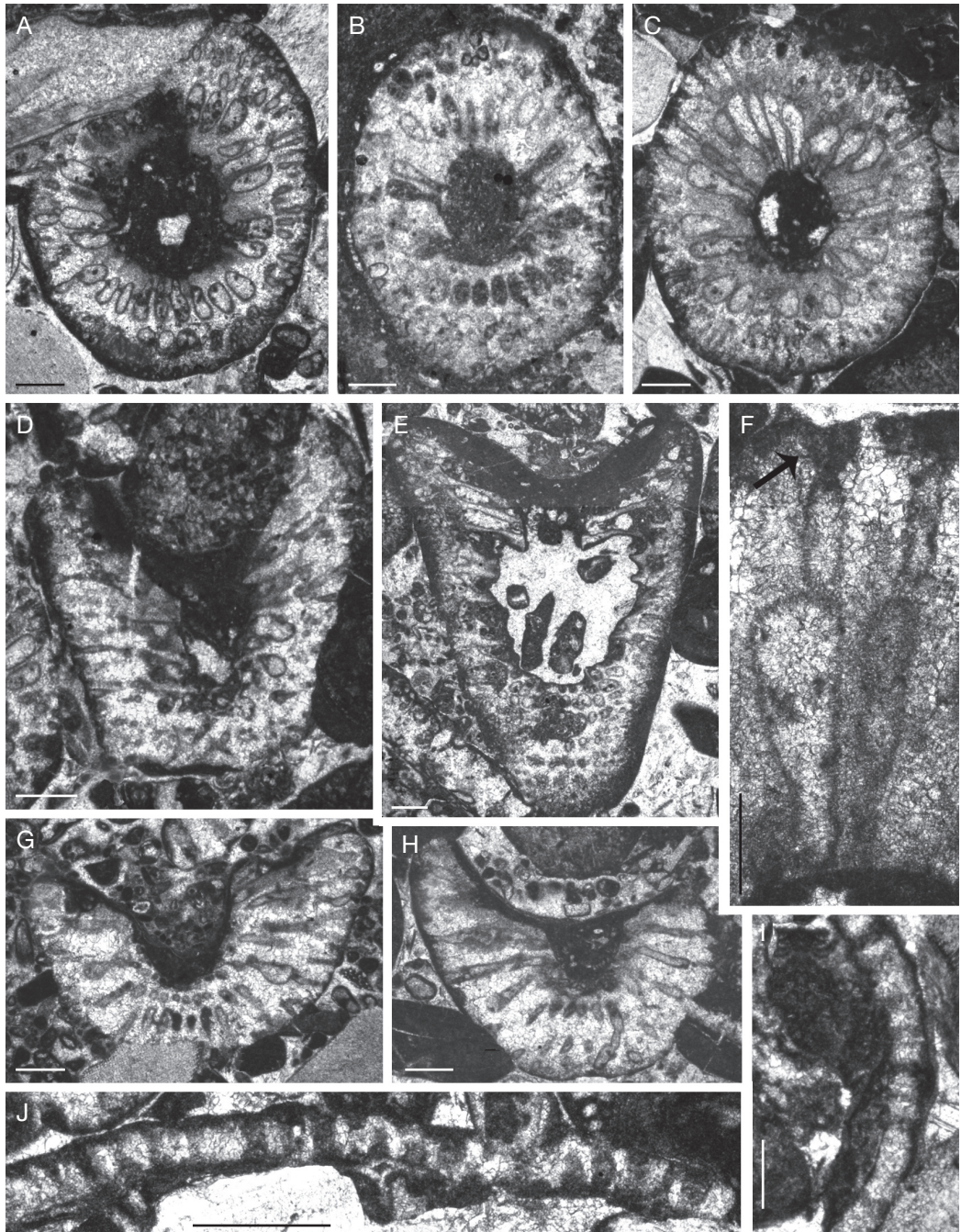


FIG. 9. — A-H, I?, J?, *Petrascula bursiformis* (Etallon, 1859) Pia, 1920, transverse (A-C) and oblique (D, E, G, H) sections through the stalk and stalk-head transition; F, close-up view of the specimen in C showing the third order laterals; I, J, probably fragments of the head. A, E, H, Sa 10684b As; B, Sa F3-m 59.2 Sa; C, D, Sa 10684a As; I, Sa 3357 As; J, Sa 10709 As; G, Sa 10.684 As. Scale bars: A-E, G-I, 0.5 mm; F, J, 0.25 mm.

TABLE 1. — General dimensions (in mm) of *Petrascula piai* Bachmayer, 1944. Abbreviations: **D**, external diameter of the thallus; **d**, internal diameter of the thallus; **d/D**, ratio between internal and external diameters; **h**, distance between two consecutive verticils; **l1**, length of the primary laterals; **l2**, length of the secondary laterals; **p1**, diameter of the primary laterals; **p2**, diameter of the secondary laterals; **p2-distal**, diameter of the secondary laterals in their distal part.

Sample	Specimen	D	d	d/D	l1	l2	p1	p2	p2-distal	h
F3-59.2A(4)	1	2.49	1.04	0.42	0.42	0.27	0.27	0.16		
F10-96.6B	2	2.62					0.3	0.06	0.16	0.5
3357(1)	3	2.76	1.37	0.5	0.29	0.37	0.23			
3357(2)	4	2.4								0.62
3357(3)	5	2.18	0.84	0.39	0.25	0.43	0.34	0.17	0.21	0.56
3357(3)	6	2.54	1.26	0.5	0.26	0.33	0.32	0.12		
3357(3)	7				0.33	0.34	0.22	0.08		
3357(4)	8	3.04	1.78	0.59	0.29	0.38	0.22	0.06	0.16	
3357(4)	9	2.63	1.24	0.47	0.23	0.36	0.25	0.09	0.14	0.52
3357(5)	10				0.27	0.3	0.23			0.65
3357(7)	11	2.6	1.46	0.56	0.21	0.28	0.15	0.06		
3357(7)	12	2.34	1.31	0.56	0.23	0.37	0.17	0.06	0.16	
3357(8)	13	2.7	1.24	0.46	0.27	0.38	0.2	0.11		0.55
3357(11)	14	2.32	1.15	0.5	0.33	0.2	0.17	0.07		
3357(12)	15	2.98	1.67	0.56	0.26	0.37				0.6
3357(13)	16	2.27	1.04	0.46						0.55
3357(15)	17	2.79	1.44	0.52	0.36	0.35	0.2	0.09		
3357(15)	18	2.85	1.37	0.48	0.38	0.34	0.18	0.08		
3357(17)	19	2.69	1.51	0.56	0.27	0.31	0.26	0.07		
3357(17)	20	2.45	1.31	0.53	0.27	0.28	0.23	0.09		
3357(18)	21	2	1.07	0.54	0.3	0.1	0.1	0.06	0.09	
3357(18)	22	2.66	1.27	0.48	0.34	0.37	0.2	0.07		
3357(18)	23	2.7	1.47	0.54						
3357(18)	24	2.05	1.08	0.53						0.63
3357(20)	25	2.15	1.43	0.67	0.26		0.24			
3357(24)	26	2.63	1.23	0.47	0.28	0.32	0.23	0.07		
3357(24)	27	2.8	1.4	0.5	0.37	0.34	0.17	0.07	0.15	
3357(29)	28	2.49	1.26	0.51						0.53
3357(32)	29	3.03	1.56	0.51	0.36	0.42	0.19	0.07	0.18	
10684"	30				0.25	0.35	0.25	0.08		0.57
10684B	31	2.59	1.16	0.45	0.33	0.27	0.1	0.05		
10718	32				0.32	0.26	0.16	0.08		
10684(1)	33	2.71	1.21	0.45	0.38	0.37	0.28	0.09	0.16	
10684(2)	34	2.11	0.97	0.46	0.37	0.28	0.17	0.07		
10684(3)	35	2.37	1.86	0.78	0.29	0.3	0.18	0.1		
10684(3)	36	2.48	1.3	0.52	0.28	0.32	0.17	0.07	0.12	
10684(4)	37	2.24	0.86	0.38	0.32	0.35	0.19	0.08		
10684(7)	38	2.35	1.25	0.53	0.25	0.31	0.26	0.08		0.63
10684(8)	39	2.68	1.34	0.57	0.31	0.32	0.14	0.07		
10684(11)	40	2.32	0.95	0.41	0.39	0.32	0.24	0.09		0.39
10684(13)	41	2.14	1.01	0.47	0.32	0.32	0.2	0.08	0.18	
10684(14)	42	2.44	1.09	0.45	0.3	0.3	0.2	0.08	0.19	
10684(14)	43	2.35	1.26	0.54	0.31	0.18	0.2	0.09		
10684(16)	44	2.54	1.43	0.56	0.26	0.32	0.15	0.05		
10684(17)	45	2.22	1.14	0.51	0.29	0.29	0.2	0.05		
10684(18)	46	2.22	0.84	0.38						
10684(19)	47	2.38	1.28	0.54						
10684(19)	48	2.8	1.38	0.49						
10684(19)	49	2.21	1.2	0.54						
10684(21)	50	1.95	0.95	0.49	0.24	0.24	0.16			
10684(22)	51	2.02	0.84	0.42	0.37	0.29	0.14	0.07		
10684(23)	52	2.66	1.34	0.5	0.27	0.36	0.14	0.1		
10684(25)	53				0.29	0.28	0.24	0.08		
10684(29)	54	2.13	1.12	0.53	0.36	0.27	0.13	0.07		

TABLE 1. — Continuation.

Sample	Specimen	D	d	d/D	l1	l2	p1	p2	p2-distal	h
10684(30)	55	2.11	1.54	0.73						
10684(30)	56	2.39	1.31	0.55	0.3	0.31	0.32	0.12		0.55
10684(34)	57	2.54	0.68	0.27	0.33	0.4	0.29	0.08	0.18	0.45
10684(37)	58	1.84	0.88	0.48	0.23	0.25	0.15	0.06		
10684(40)	59	1.94	0.87	0.45	0.33		0.18			0.56
10684(40)	60	2.19		0.43		0.21				
10684(40)	61	2.58	1.06	0.41	0.34	0.4	0.29	0.1		0.44
10684(41)	62	2.38	1.19	0.5	0.33	0.28	0.23	0.07		
10684(42)	63	2.55	1.2	0.47	0.35	0.38	0.19	0.07		
10684(43)	64	2.55	1.36	0.53	0.33	0.29	0.2	0.06		
10684A(2)	65	2.42	0.8	0.33	0.33	0.32	0.19	0.07		
10684A(2)	66	2.43	1.03	0.44						0.53
10684A(4)	67	2.54	1.33	0.52	0.4	0.22	0.09	0.06		
10684A(5)	68	2.38	1.26	0.53	0.31	0.27	0.16	0.06		
10684A(6)	69	2.57	1.2	0.47	0.44	0.3	0.24	0.09		
10684A(9)	70	2.88	1.34	0.46	0.39	0.41	0.33	0.08		
10684A(12)	71	2.55	1.3	0.51	0.25	0.29	0.14	0.07		
10684A(13)	72	2.89	1.31	0.45	0.37	0.23	0.09	0.06		
10684A(16)	73	2.62	1.45	0.55	0.37	0.22	0.29	0.08		
10684A(16)	74	2.3	1.42	0.62						
10684A(16)	75	2.43	1.29	0.53						
10684B(4)	76	2.07	0.84	0.41	0.32	0.26	0.15	0.07		
10684B(4)	77	2.35	0.8	0.34	0.43	0.32	0.29	0.09		
10684C(4)	78	2.37	1.14	0.48						
10684C(6)	79	2.83	1.37	0.48	0.36	0.31	0.24	0.11		0.45
Total		74	71	72	63	62	63	58	13	19
Minim		1.84	0.68	0.27	0.21	0.1	0.09	0.05	0.09	0.39
Maxim		3.04	1.86	0.78	0.44	0.43	0.34	0.17	0.21	0.65
Average		2.456	1.219	0.496	0.315	0.309	0.207	0.08	0.16	0.541
Standard deviation		0.271	0.236	0.079	0.054	0.062	0.060	0.023	0.031	0.071

A distinctive character observed in the specimens from Apuseni Mountains is the presence, in some cases, of a fissuration at the interverticillar level, visible in tangential sections (Figs 6B; 7H).

HEAD FRAGMENTS

Figure 8C, E-H illustrates fragments considered to represent calcified parts of the head of *P. piai*. The calcified parts include here, most probably, the terminal part of the second-order laterals and the third-order laterals. Lack of continuity between the head and stalk makes the attribution of these fragments to the head of *P. piai* problematic. The only specimen in which head and stalk are preserved together is a tangential-longitudinal section illustrated by Moshhammer & Schlagintweit (1999: pl. 1, fig. 4).

DIMENSIONS

Table 1 gives the dimensions of *Petrascula piai* measured on 79 specimens.

Petrascula bursiformis (Etallon, 1859) Pia, 1920 (Fig. 9)

Conodyctium bursiforme Etallon, 1859: 530.

Petrascula bursiformis (Etallon) Pia (emend. Bernier 1979: 843, pl. 2). — Bernier 1984: 477, pl. 10, figs 1-5. — Schlagintweit & Ebli 1999: 394, pl. 9, figs 1, 2. — Rasser & Fenninger 2002: 176, pl. 2, fig. 3 (reproducing the specimen illustrated by Fenninger & Holzer [1972: pl. 17, fig. 4]; following Bernier [1979: 844], this specimen does not belong to *Petrascula bursiformis*). — Schlagintweit & Gawlick 2009: fig. 2/5.

For more, see synonymy list in Bernier (1979).

TABLE 2. — General dimensions (in mm) of *Petrascula bursiformis* (Etallon, 1859) Pia, 1920. Abbreviations: see Table 1.

Sample	Specimen	D	d	d/D	l1	l2	p1	p2
F3-59.2(2)	1	2.7	0.77	0.29	0.73	0.23	0.25	0.11
F10-10.0(1)	2	2.35	0.93	0.4	0.5	0.45	0.24	0.08
F10-10.0(3)	3	2.27	0.81	0.36	0.5	0.25	0.21	0.06
10.684B	4	2.35	1	0.43	0.29	0.26	0.11	0.05
10684(40)	5	3.57			0.68	0.4	0.12	0.08
10684A(4)	6	2.43	0.78	0.2	0.62	0.35	0.17	0.06
10684A(4)	7	2.34	0.6	0.26	0.62	0.44	0.15	0.07
10684A(4)	8	3.44			0.65	0.4		
10684A(6)	9	2.62			0.5	0.29	0.15	0.07
10684A(7)	10	2.54	0.96	0.38	0.56	0.32	0.14	0.08
10684A(7)	11	2.1	0.62	0.3	0.41	0.24	0.13	0.06
10684A(10)	12	2.86	1.02	0.36	0.47	0.32	0.13	0.08
10684A(14)	13	2.79	0.75	0.27	0.77	0.23	0.36	0.08
10684A(16)	14	2.25	0.8	0.36	0.51	0.21	0.18	0.08
10684B(3)	15	3.06	1.06	0.35	0.72	0.32	0.17	0.1
10684B(3)	16	2.08	0.65	0.31	0.64	0.25	0.17	
10684B(4)	17	2.83	0.81	0.29	0.55	0.39	0.19	0.09
10684B(12)	18	4.36			0.95	0.32	0.22	0.1
10684B(13)	19	3.09			0.62		0.17	
10684B(14)	20	3	1.1	0.37	0.59	0.34	0.21	0.07
10684B(15)	21	3.69			0.76	0.37	0.23	0.1
10684B(16)	22	2.27	0.71	0.31				
10684B(16)	23	1.08	0.57	0.32	0.36	0.16	0.1	0.06
10684C(4)	24	2.84	1.05	0.37	0.62	0.39	0.17	0.09
10684C(5)	25	2.71	0.69	0.25	0.74	0.35	0.17	0.08
Total		25	19	19	24	23	23	21
Minim		1.08	0.57	0.2	0.29	0.16	0.1	0.05
Maxim		4.36	1.1	0.43	0.95	0.45	0.36	0.11
Average		2.705	0.825	0.325	0.598	0.317	0.18	0.079
Standard deviation		0.642	0.168	0.058	0.146	0.078	0.057	0.016

REMARKS

Some *Petrascula* specimens (Fig. 9) identified both in the Șerbota Hill (Aștileu) and Săndulești areas belong to *Petrascula bursiformis*. Even in transverse sections through the stalk (Fig. 9A-C) and oblique sections at the stalk-head passage level (Fig. 9D, E, G, H), the differences with respect to *Petrascula piai* are shown by the shape of the first-order laterals: longer in *P. bursiformis* and with a general club-like shape. They have a narrow proximal part, followed by a sudden and then a gradual enlargement to the distal part (Fig. 9B, C). The presence of three orders of laterals within the stalk and the stalk-head passage is also illustrated in the specimens we identified

(Fig. 9B, F). Rare fragments, somewhat similar in shape to the fragments of “*Pseudoepimastopora jurassica*” Endo, 1961 (Fig. 9I, J), could represent fragments of the head of *Petrascula bursiformis*. Bernier (1979: 848) stressed both in the text and in table 2, the pearl-string shape of the third order laterals of *P. bursiformis*. Unfortunately, in the absence of close-up views, this character is not visible in the illustration provided (Bernier 1979: pl. 2).

DIMENSIONS

Table 2 gives the dimensions measured on 25 specimens of *P. bursiformis* identified in the Apuseni Mountains.

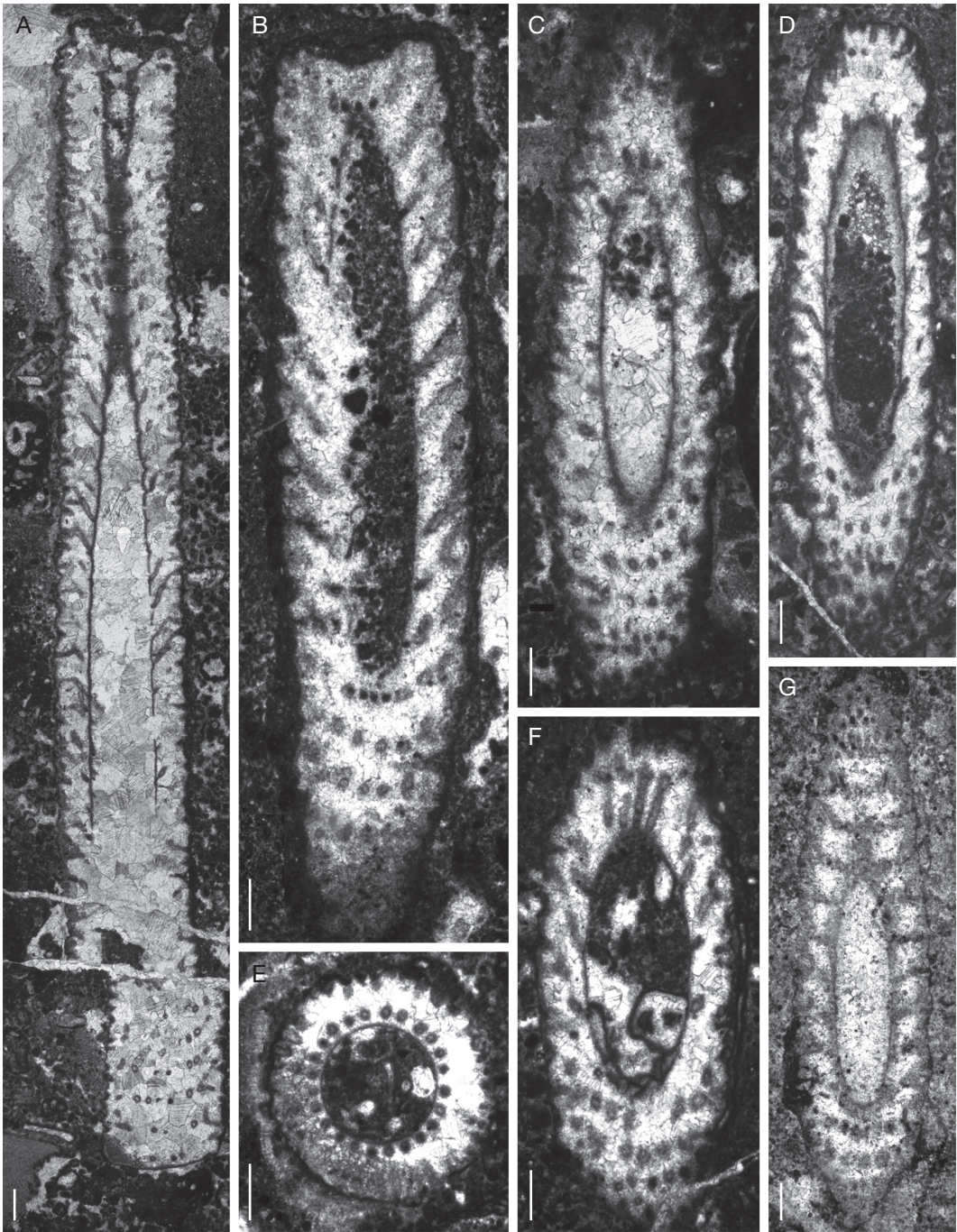


FIG. 10. — *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010, longitudinal (A), longitudinal-oblique (B-D, G), transverse (E) and oblique (F) sections. A, D, Sa F10-m 9.3 Sd; B, Sa F2-m 10 Sd; C, E, F, Sa F10-m 9.2 Sd; G, Sa F11-m 37.4 Sd. Scale bars: 0.5 mm.

Steinmanniporella kapelensis

(Sokač & Nikler, 1973)

Bucur, Granier & Schlagintweit, 2010

(Figs 10, 11)

Linoporella kapelensis Sokač & Nikler, 1973: 65, pls 1-3. — Bassoullet *et al.* 1978: 152, pl. 17, figs 6, 7 (reproducing original illustrations by Sokač & Nikler 1973). — Bucur *et al.* 2005: 110, pl. 3, figs 4, 5.

Linoporella cf. kapelensis – Schlagintweit & Ebli 1999: 393, pl. 8, fig. 4.

Steinmanniporella kapelensis – Bucur *et al.* 2010: fig. 1a (reproducing the original illustration in Sokač & Nikler 1973: pl. 1, fig. 1 – the holotype).

REMARKS

So far, this nice dasycladalean alga, described in 1973 by Sokač & Nikler, has seldom been identified in other similar deposits. In some cores from drillings in the Sândulești quarry (Fig. 3), we identified numerous quite well preserved specimens. “*Linoporella*” *kapelensis* represents the type species of the recently introduced genus *Steinmanniporella* (Bucur *et al.* 2010) as a consequence of the emendation of the genus *Linoporella* by Barattolo & Romano (2005). The genus was further emended by Radoičić *et al.* (2009).

All the characteristics given by Sokač & Nikler (1973) can be recognized in the specimens from Sândulești. The first-order laterals, tubular in shape, are inclined with respect to the axial cavity; a characteristic well seen in longitudinal and oblique sections (Fig. 10A-D, F, G). They give rise to a bush of four second-order laterals, tubular in the proximal part and enlarged distally. The oblique and transverse-oblique sections (Fig. 11A-F, H, K) show the junction between first-order and second-order laterals, and the number of the secondaries (e.g., Fig. 11D, lower part). Transverse sections (Figs 10E; 11G) show the number of first order laterals in a whorl, as well as their shape (e.g., Fig. 10E).

DIMENSIONS

The dimensions of the specimens of *S. kapelensis* from the Apuseni Mountains are given in Table 3.

ENVIRONMENTAL SIGNIFICANCE

Following Bernier (1984), Moshhammer & Schlagintweit (1999) noted that “different representatives of the genus *Petrascula* show distinct variations in their paleoenvironmental distribution. While, for example, *P. bursiformis* is typically found in very shallow and well agitated external facies, *P. piai* occurs in very shallow and quiet water settings of the inner platform”. However, Bernier (1984: 477) made the following remark on *P. bursiformis*: “Cette espèce vivait certainement dans un milieu peu profond, relativement calme (mudstones) même si on a pu la retrouver fragmentée jusque dans des grainstones, après transport”. Our specimens from the Apuseni Mountains show that both *P. bursiformis* and *P. piai* could occur in protected micro-environments in external platform settings.

The sedimentological and micropaleontological data indicate that the large dasycladaleans from the Aștileu area lived onto submarine dunes and protected inter-dune areas in the external part of the Bihor-Pădurea Craiului Upper Jurassic carbonate platform.

In ooid-pisoid and coarse intraclastic grainstone, the dasycladaleans (mainly *Petrascula piai*) are typically surrounded by a microbial cortex and/or encrusted by foraminifers and calcified cyanobacteria. These encrustations point to a comparatively low energy paleoenvironment (protected inter-dune areas) from where the algae were reworked into higher energy environments in the dunes. Other large specimens, but devoid of a microbial cortex, show abrasion due to erosion (Fig. 4B). They indicate increased wave action in the submarine dunes. Large intraclasts containing fragments of *Neoteutloporella socialis* indicate the proximity of small reefs. Smaller dasycladaleans (e.g., *Salpingoporella* sp.) frequently constitute the cores of ooids, or occur as fragments (Fig. 4C, D).

In the Sândulești area, dasycladaleans (mostly *Steinmanniporella kapelensis*) occur in intra-reefal sediments, and also in relatively low-energy deposits, being frequently reworked into the high-energy, rudstone environment where rare specimens of *Petrascula* are also found.

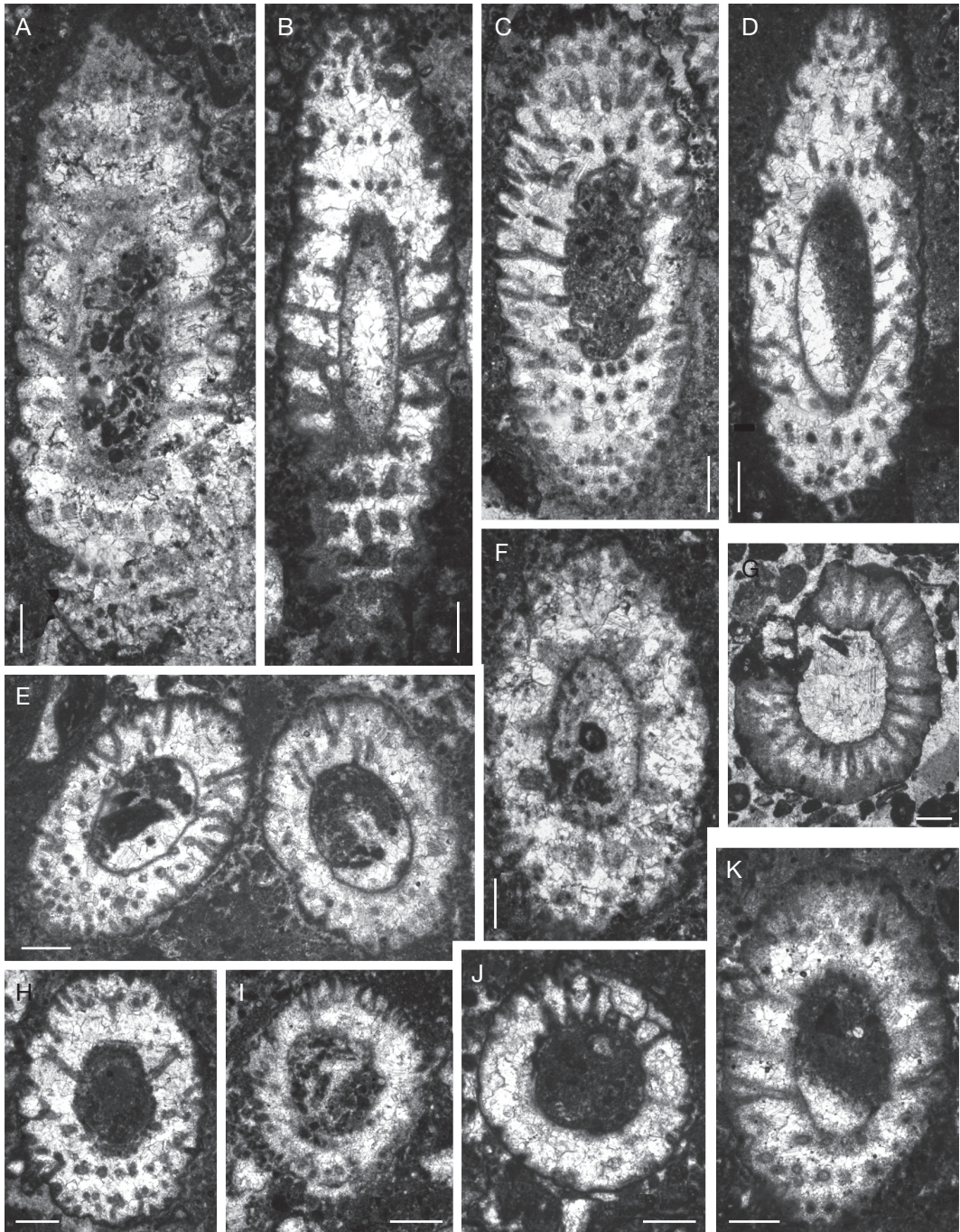


FIG. 11. — *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010, oblique (A–D, F), transverse-oblique (E, H, K), and transverse (G, I, J) sections. A, F, Sa F11-m 15.8 Sd; B, Sa F11-m 37.4 Sd; C–F, Sa F10-m 9.3 Sd; G, F4-m 126.7 Sd; H, F8-m 6.6 Sd; I, F10-m 10 Sd; J, F3-m 59.2 Sd; K, F10-m 9.2 Sd. Scale bars: 0.5 mm.

TABLE 3. — General dimensions (in mm) of *Steinmanniporella kapelensis* (Sokač & Nikler, 1973) Bucur, Granier & Schlagintweit, 2010. Abbreviations: see Table 1.

Sample	Specimen	D	d	d/D	l1	l2	p1	p2	h
F3-59.2(4)	1	1.89	0.95	0.5	0.31	0.22	0.11	0.06	
F4-126.7(4)	2	2.92	1.26	0.43	0.51	0.27	0.1		
F8-6.6(4)	3	2.03	0.81	0.4	0.34	0.25	0.09	0.07	
F10-9.2	4	2.32	0.97	0.42	0.45	0.35	0.11	0.08	
F10-9.2	5	1.89	0.8	0.42					0.44
F10-9.2	6	1.91	0.97	0.51	0.45		0.09	0.06	0.31
F10-9.2	7	1.9	0.98	0.52			0.11		
F10-9.3(1)	8	2.03	0.71	0.35	0.43	0.33	0.11	0.09	0.42
F10-9.3(1)	9	2.09	0.98	0.47					
F10-9.3(1)	10	2.27	1.11	0.49					
F10-9.3(2)	11	0.71	0.84	0.49	0.38	0.23			
F10-9.3(2)	12	1.93	0.83	0.43	0.41	0.24	0.12	0.07	
F10-9.3(2)	13				0.4	0.26	0.11	0.07	0.4
F10-9.3(4)	14	2.12	0.79	0.37	0.41	0.31	0.1	0.06	0.4
F10-9.3(4)	15	2.05			0.43	0.26	0.11	0.07	0.48
F10-10.0(3)	16	1.83	0.88	0.48					
F10-10.0(4)	17	1.96	0.79	0.4	0.5	0.32			0.47
F10-10.0(4)	18	1.65	0.74	0.45	0.44	0.27	0.1	0.07	0.43
F11-15.6(4)	19	2.01	0.82	0.41					
F11-15.8(5)	20	2.31	0.89	0.39	0.48	0.31	0.11	0.07	0.52
F11-37.4(1)	21	1.61	0.51	0.32	0.39	0.26			
F11-37.4(4)	22	2	0.79	0.4					0.5
Total		21	20	19	15	14	12	11	10
Minim		0.71	0.51	0.32	0.31	0.22	0.09	0.06	0.31
Maxim		2.92	1.26	0.52	0.51	0.35	0.12	0.09	0.52
Average		1.973	0.871	0.433	0.422	0.277	0.105	0.07	0.437
Standard deviation		0.397	0.157	0.057	0.055	0.040	0.009	0.009	0.061

These two case studies provide support for previous assumptions that large dasycladaleans mainly lived onto the external parts of carbonate platform margins, such as reefal and bioclastic shoals (Bucur & Săsăran 2005 and references herein).

CONCLUSION

Specimens of the large dasycladaleans *Petrascula piai*, *P. bursiformis* and *Steinmanniporella kapelensis* occur in Upper Jurassic limestones of the Apuseni Mountains, north-west Romania. Two of these algae (*P. piai* and *S. kaplensis*) have previously only seldom been identified and consequently were poorly known. This new material allows improved descriptions and illustrations of these algae, as well as some remarks on their habitat and depositional environment.

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REFERENCES

- BACHMAYER F. 1944. — Zwei neue *Siphonaeae verticillatae* aus dem Jurakalk von Dörfles und Klatferbrunn (Nieder-Donau). *Verhandlungen der Zoologisch-Botanischen Gesellschaft in Wien*: 90, 91 (1940-41): 237-240.
- BALINTONI I. C. 2001. — Short outlook on the structure of the Apuseni Mountains, in BUCUR I. I., FILIPESCU S. & SĂSĂRAN E. (eds), *Algae and carbonate platforms in*

- the western part of Romania. *Proceedings of the 4th Regional Meeting of the International Fossil Algae Association, Regional Meeting, Cluj-Napoca, Romania, August 29-September 5, 2001, field trip-guide Book*. Cluj University Press, Cluj-Napoca: 9-17.
- BARATTOLO F. & ROMANO R. 2005. — The genus *Linoporella* Steinmann, 1899 and its type-species *Linoporella capriotica* (Oppenheim, 1889) from the Early Cretaceous of Capri. *Bollettino della Società Paleontologica Italiana* 44 (3): 237-254.
- BASSOULLET J.-P., BERNIER P., CONRAD M.-A., DELOFFRE R. & JAFFREZO M. 1978. — Les algues dasycladales du Jurassique et du Crétacé. *Geobios, mémoire spécial* 2, 330 p., 40 pls.
- BERNIER P. 1979. — Le genre *Petrascula* Gümbel 1873, algue dasycladacée: émendation, révision des espèces du genre, création de nouvelles espèces. *Geobios* 12 (6): 839-861.
- BERNIER P. 1984. — Les formations carbonatées du Kimméridgien et du Portlandien dans le Jura Méridional. Stratigraphie, micropaléontologie, sédimentologie. *Documents du Laboratoire géologique de Lyon* 92: 2 fasc., 803 p., 218 figs, 21 tables, 36 pls.
- BODEUR Y. 1992. — *Microfaciès et micro-organismes du Kimméridgien et du Tithonien au sud des Cévennes*. Université de Nantes, Nantes, 3 p., 27 pls.
- BUCUR I. I. & SĂSĂRAN E. 2005. — Relationship between algae and environment: an Early Cretaceous case study, Trascău Mountains, Romania. *Facies* 51 (1-4): 275-287.
- BUCUR I. I., HOFFMANN M. & KOŁODZIEJ B. 2005. — Upper Jurassic-lowermost Cretaceous benthic algae from Tethys and the European platform: a case study from Poland. *Revista Española de Micropaleontología* 37 (1): 105-129.
- BUCUR I. I., GRANIER B. & SCHLAGINTWEIT F. 2010. — *Steinmanniporella*, a new dasycladale genus name for "*Linoporella*" with two orders of laterals. *Facies* 56 (2): 317-321. <http://dx.doi.org/10.1007/s10347-009-0206-4>
- CARRAS N. 1995. — *La piattaforma carbonatica del Parnasso durante il Giurassico superiore-Cretacico inferiore (Stratigrafia ed evoluzione paleogeografica)*. Mesonghion, Athene, 232 p., 69 pls (in Greek, with Italian summary).
- DYA M. 1992. — *Mikropaleontologische und fazielle Untersuchungen im Oberjura zwischen Sazburg und Lofer*. Unpublished PhD thesis, Technische Universität Berlin, Berlin, 100 p., 11 pls.
- ETALLON A. 1859. — Études paléontologiques sur les terrains jurassiques du Haute Jura. Monographie de l'étage corallien. *Mémoires de la Société d'émulation du département du Doubs*, 3^e série, III (1858), 317 p.
- FENNINGER A. & HOLZER H. L. 1972. — Fazies und Paläogeographie des oberostalpinen Malm. *Mitteilungen der Geologischen Gesellschaft in Wien* 63 (1970): 52-141.
- MOSHAMMER B. & SCHLAGINTWEIT F. 1999. — The Ernstbrunn Limestone (Lower Austria): New data on biostratigraphy and applied geology. *Abhandlungen der Geologischen Bundesanstalt* 56 (2): 553-565.
- OKLA S. M. 1991. — Common Jurassic fossil algae from Tuwaiq Mountains limestone in Central Saudi Arabia. *Revista Española de Micropaleontología* 23 (2): 89-100.
- PIA J. 1920. — Die *Siphoneae verticillatae* vom Karbon bis zur Kreide. *Abhandlungen der zoologisch-botanischen Gesellschaft in Wien* 11 (2): 1-263
- RADOIČIĆ R., CONRAD M. A. & CARRAS N. 2009. — *Linoporella buseri* Radoičić, 1975, revisited. A Liassic Dasycladalean alga from the Dinarides and continental Italy. *Annales Géologiques de la Péninsule Balkanique* 70: 61-69.
- RASSER M. W. & FENNINGER A. 2002. — Jurassic/Cretaceous dasycladalean algal stratigraphy in the Northern Calcareous Alps: a critical review and a paleobiogeographic approach using similarity indices, in BUCUR I. I. & FILIPESCU S. (eds), Research advances in calcareous algae and microbial carbonates. *Proceedings of the 4th Regional Meeting of the International Fossil Algae Association, Regional Meeting, Cluj-Napoca, Romania, August 29-September 5, 2001*. Cluj University Press, Cluj-Napoca: 167-190.
- SCHLAGINTWEIT F. & EBLI O. 1999. — New results on microfacies, biostratigraphy and sedimentology of Late Jurassic-Early Cretaceous platform carbonates of the northern Calcareous Alps. Part I: Tressenstein limestone, Plassen Formation. *Abhandlungen der Geologischen Bundesanstalt* 56 (2): 379-418.
- SCHLAGINTWEIT F. & GAWLICK H. J. 2009. — *Lituola? baculiformis* n. sp., a new benthic foraminifer from the Jurassic peri-reefal carbonates of the western Tethyan domain. *Journal of Alpine Geology* 51: 39-49.
- SOKAČ B. & NIKLER L. 1973. — *Linoporella kapelensis* n. sp. (Dasycladaceae) from the Tithonian of Mt. Velika Kapela. *Geološki vjesnik* 26 (1972): 65-71.

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