STROMATOLITES AND CALCAREOUS ALGAE OF MÜNDER FORMATION (TITHONIAN-BERRIASIAN) FROM NW GERMANY

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Abstract. The *Tithonian* stromatolites of Münder Formation, from Thüste locality (Hils Syncline), NW Germany were intensively investigated in the last years, as an account of their special environment of formation (Jahnke & Ritzkowski 1980, Dragastan & Richter 2001, Arp et al. 2008).

Descriptions and interpretations of this paper are focused on the stromatolites of the lowermost Katzberg Member (uppermost Tithonian). The stromatolites developed in a lagoon with various energy environments, between coastal sabkha (supra-tidal salt flat) facies and intertidal to subtidal facies, including serpulid-reef banks and oolitic bars, that functioned as a "barrier island" (Dragastan & Richter 2001). Two kinds of stromatolite bioherms were described: *Type 1* formed in intertidal and *Type 2* formed in intertidal to supratidal environments. Serpulid reef-banks are more or less the equivalent of oolitic bars, being composed of a mass of tiny tubes up to 60 % of *Serpula coacervata* (BLUMENBACH 1803) SCHÖNFELD 1979, during successive growth stages.

In several slabs, the stromatolite bioherms contain diverse morphologies and populations characterized by three growth phases or stages:

- *growth phase 1*, the basal part composed of small (0. 250-0.500 mm in diameter), spheroidal to ellipsoidal microbial oncolites with serpulid-tubes nuclei and few, 2 up to 3 microbial laminae, reduced in thickness. *Chlorellopsis coloniata* REIS is rarely present, as biofilms; in our opinion it is a green alga; however its origin and taxonomy are still under debate.

The initial substratum for the stromatolite bioherms were the serpulid-reef banks and biostroms. The tubes of serpulids were selectively transported according to their sizes; in most of the cases, they represented nuclei for microbial oncoids. On the other hand it is interesting to specify that very few (pyritized) ooids were found in the stromatolite bioherms, fact which is an indication that oolities were not in direct "connection" with the stromatolites and did not serve as substratum.

Biomats occur as mm-sized deposits, while oncolites are found also over large areas on the channels floor.

- *growth phase 2* contains microbial macrooncoids (up to 2 cm in diameter) in the lower part, with serpulid-tubes nuclei fixed by the substratum and growing up to form microbial mounds or knolls.

To the upper part, the microbial mounds are consisting of up to 10 laminae, thinner in the lower part and thicker to the top of this phase. During this phase the green algae contributed also to building the edifice of stromatolites: *Chlorellopsis coloniata* REIS (rarely) and *Brachydactylus reisi* DRAGASTAN & RICHTER (frequently). Sometimes, between the knolls appear vertical "cracking - pockets" filled up with reworked materials (mat debris, intraclasts) and small depressions filled with few coprolites of gastropods, ostracods, bivalves fragments and caddisfly pupal larvae of Trichoptera. This phase ends with a clear erosional surface with partly oxidized framboidal pyrites (bacterial in origin), which point out to anoxic conditions. Some channels are distributed towards the top of growth phase 2 and document a transition zone between the growth phases 2 and 3.

- *growth phase 3* begins with basal domal laterally linked stromatolites, which landwards of the lagoon pass into a tabular stromatolitic structure composed more or less by horizontal, parallel microbial laminae. To the top of this final phase the stromatolites present only planar wavy, pustular microbial laminae crossed by upward cracks filled with coarsely crystalline calcite, rarely ostracods, irregular fenestral fabrics, *Brachydactylus* sp. (green algae), *Pseudorothpletzella"* sp. (possible blue-green algae) and frequently caddisfly cases.

The uppermost Tithonian stromatolites of Thüste are built mainly by microbial organisms, but also with the contribution of green algae such as *Chlorellopsis coloniata*, *Brachydactylus reisi*, *Brachydactylus.*sp. and possibly the alga *Pseudorothpletzella* sp. in a lagoon with intertidal to supratidal environments under warm climate and phases with two seasonal periods. The growth phases 1 and 2 indicate an intertidal depositional facies while growth phase 3 corresponds to supratidal facies. The facies model for Thüste stromatolites can be compared with the Recent facies model of the coastal sabkha (supratidal salt flat) from the Trucial Coast (Abu Dhabi), Arabian - Persian Gulf.

The *Berriasian* deposits of Borberg Member, Münder Formation contain marlstone, micritic limestone, bindstone, oncoids with serpulid-tubes nuclei, calcareous algae, serpulids and ostracods. The calcareous algae were described from Deister area, near Springe. Thalli fixed in some cases on serpulid tubes, have hemisphaeroidal, sphaeroidal or planar shapes and belong to cyanophycean and chlorophycean algae.

The following taxa are re-described and described: *Springerella bifurcata* DRAGASTAN & RICHTER 2001, *S. fuchtbaueri* DRAGASTAN & RICHTER 2001, *S.westphalica* nov. sp., *Deisterella germanica* nov. gen. nov. sp. (Chlorophyta) and *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985 (Cyanophyta).

The calcareous algal assemblage of Borberg Member corresponds to lacustrine-brackish marine environments. The eulittoral freshwater-oligohaline *Theriosynoecum ostracods association* with calcareous algae in lithofacies 4 included species of genus *Springerella* and *Rivularia lissaviensis;* sublittoral-miohaline *Mantelliana* ostracods association contains only *Deisterella germanica* nov. gen.nov. sp., in lithofacies 5, sensu Arp & Mennerich (2008).

Keywords: Stromatolites, calcareous algae, new taxa, Tithonian-Berriasian, depositional facies, NW Germany.

INTRODUCTION

The term **stromatolite** introduced by Kalkowsky (1908) has now a full recognition as reffering to deposits of organo-sedimentary nature and including the interpretation of their genesis - i.e. more or less a combination between biological and environmental factors responsible for morphologies and lamination types.

Supratidal and intertidal ranges with ephemeral pools influenced by water supplies induced a special mineralogy and chemistry in various environmental climates (Horodyski & Van der Haar 1975).

In 1987 Burne & Moore introduced a new category of

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organo-sedimentary deposits, **microbialite**, related mainly to microbial carbonate formations. Episodic sedimentation in relation to periodical microbial growth will produce a good lamination, characteristic for fine-grained, well laminated stromatolites (Riding 1991). Fine-grained agglutinated stromatolites are dominantly prokaryotic (bacterial and cyanophycean) in origin, being characteristic for the shallow flat environment composed of domal and planar-flat, sometimes crinkled laminae. Microbial mats appear in a variety of morphologies as determined by the dominant species of cyanophycean and the specific environmental factors. Classical mat types can be found in the intertidal zone of Abu Dhabi, Persian Gulf, where the tidal conditions provide different environmental deposits (Golubić 1992). Microbial laminae show irregular pores or fenestrae and radial convex upward cracks filled with coarsely crystalline calcite or gypsum (?) in case of Thüste stromatolites (Arp et al. 2008). Sometimes, the mineral incorporation obliterates the biological structure (Golubić 1983), but not completely, the initial structures are still preserved by the evaporative intertidal environments.

Organisms contributing to the deposition of microbial mats can be assigned to moderate halophiles, e.g. cyanobacteria, bacteria and to extremely halophilic taxa, e.g. green algae and halobacteria (Gerdes et al. 2000). The microbial carbonate formations can be related to the following main calcareous microbialite types: stromatolites and oncolites, both found in marine, freshwater as well as lagoonal brackish environments.

Near the Jurassic–Cretaceous boundary a large Purbeck inland sea extended from Dorset (England), Netherlands and to northwestern Germany, covering the area of the so-called Lower Saxony Basin. The Purbeck facies contained marlstones, limestone deposits (oolites, serpulid-reef banks) and stromatolite intercalations. Two locations and subunits from the Münder Formation were re-studied by us: the first one is Katzberg Member, uppermost Tithonian in age from Thüste, a quarry of Schütte Company and the second one is Borberg Member, Berriasian in age, from Deister area, near Springe (Fig.1 A and B).

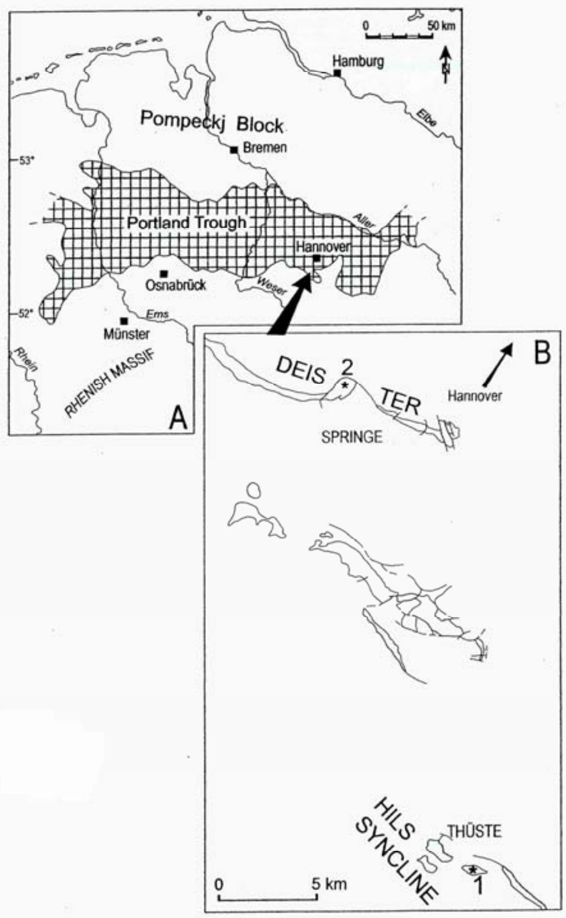

Fig.1 - A. Paleogeographic map showing the distribution of Late Jurassic to Early Cretaceous deposits (Purbeck facies) of the Portland Trough, NW Germany (from Betz et al. 1987).; B. Sketch map with the studied area located southeast of Hannover: 1. Thüste stromatolites, 2. Deister calcareous algae, near Springe.

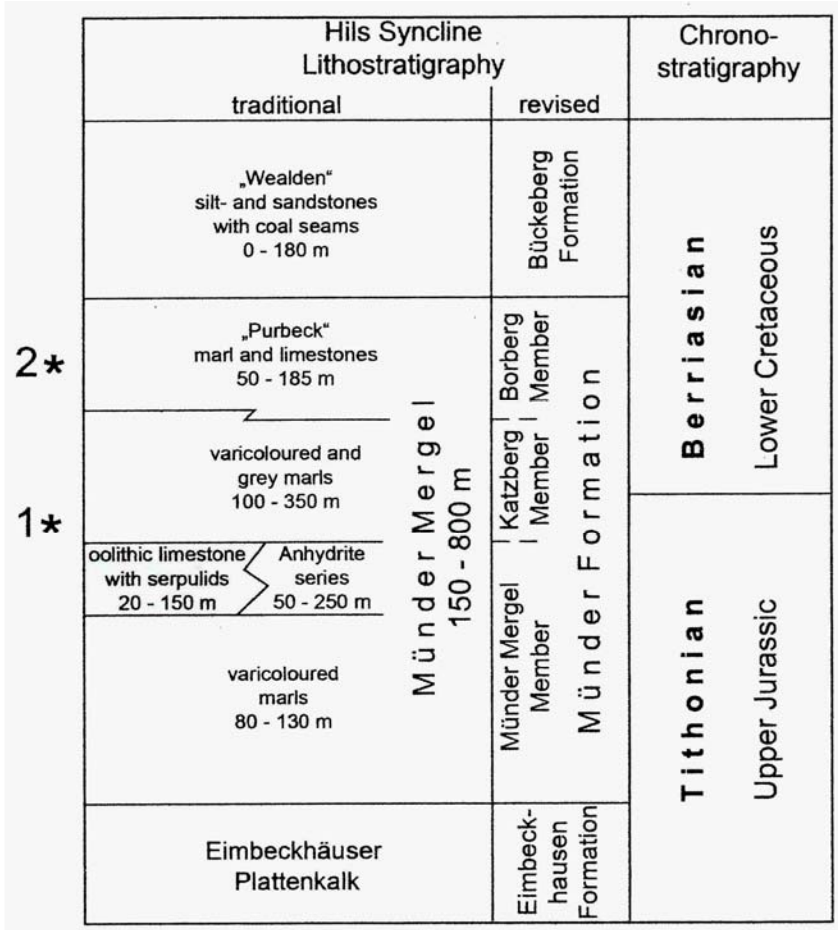

Fig.2 - Lithostratigraphy of Münder Formation (Hils Syncline) with data for (1) after Wolfart (1956), Casey et al. (1975), Waldeck (1975), Harms (1964), Jordan (1994), Gramann et al. (1997) & Deutsche Stratigraphische Kommission (2002) and chronostratigraphy (2) after Remane et al. (2000), Arp et al. (2008),* 1. Thüste stromatolites, *2. Deister calcareous algae.

The goal of this study is to contribute with new data on the role of prokaryotic (bacteria and cyanophycean) and eukaryotic (chlorophycean) organisms to the genesis of Thüste stromatolites and to describe the calcareous algae from Deister area, including some palaeoenvironmental considerations.

GEOLOGICAL SETTING

Uppermost Jurassic (Tithonian) to lowermost Cretaceous (Berriasian) sequences containing serpulids, algae and sometimes, ooids are typical of the final carbonate facies of the E-W striking Portland Trough in northwestern Germany (Fig. 1). On the southern coast of the trough the two investigated areas Thüste (1) and Deister, near Springe (2) belong to the NW-SE striking Hils Bay. The configuration of this bay was predestinated by a halotectonic depression formed during the Late Jurassic to Early Cretaceous (Jordan 1994). The sequences of the so-called **Münder Mergel** correspond to the environmental change from the marine **Eimbeckhausen Formation** to the nonmarine **Bückeburg Formation** (Fig. 2). The marl dominated sequence shows variable thicknesses, between 150 and 800 m due to synsedimentary salt tectonics (lithostratigraphy adapted from Arp et al. 2008).

The first description of the serpulids-rich limestones from the southern coast of the Portland Trough was published by Blumenbach (1803). Later on the environmental facies including salinity was discussed several times due to faunal and floral assemblages and to the distribution of salt minerals (e.g. Huckriede 1967, Gramann et al. 1997). In the last years facies models for the serpulid-algal outcrops of the Hils and Deister were described by Jahnke & Ritzkowski (1980), Ten Hove & Van den Hurk (1993), Dragastan & Richter (2001) and Arp et al. (2008). The localities of our study represent the algal dominated facies of the Münder Formation of the coastal zone of the Portland Trough situated southwest-south to Hannover (Fig.1).

The **Münder Formation** (Fig. 2) was divided into three subunits: in the lower part, the **Münder Mergel Member** with marls, oolites and serpulids, in the middle part the **Katzberg Member** with marlstones and stromatolites (uppermost Tithonian) followed by the upper **Borberg Member** (Berriasian) equivalent of Purbeck facies composed of marlstones and micritic limestones, also with serpulids.

We suggest to change the name of Münder Mergel Member because it has the same name with the whole Formation, which is in contradiction with IGS rules becoming invalid.

Locality 1 - Stromatolitic horizon of Katzberg Member, old quarry of Schütte Company, ESE of Thüste village; MTB 3923 Salzhemmendorf, H 576565, R 3545100. The new quarry directly to the west shows the oolitic limestones with serpulids of the upper Münder Mergel Member (see Fig. 2).

Locality 2 - Purbeck limestones of Borberg Member; three quarries in the Deister Mountains, north of Springe; MTB 3723 Springe; a. H 5789800, R 3538160; b. H 5790210, R 3538480; c. H 5790370, R 3538070 (Dragastan & Richter 2001).

DESCRIPTION OF THÜSTE STROMATOLITES

The stromatolites samples from Richter Collection (quarry of Schütte Co.) consist of vertical polished slabs and oriented thin sections. The dimensions of stromatolites bioherms are variable between 10 up to 30 cm in width and 10 up to 20 cm in high, as vertical thickness. The position of vertical thin sections is shown in Figure 3.

Two kinds of stromatolite bioherms were defined: **Type 1,** compact-flat, wavy on the surface formed by 4 growth phases (Fig. 4) and **Type 2**, largeer, bulbous and with protuberances which contain 3 growth phases (Fig. 5). The different morphologies of the stromatolite bioherms were controlled by the physical environment and the corresponding biological (microbial and algal) responses to that environment.

The first type bioherms with a distinctive inner structure correspond to a shallow intertidal facies (intertidal algal flat) accumulated in the lagoon, but disposed seaward on the serpulid - reef banks and oolitic bars, possibly on both sides of the barrier (serpulids and oolites). The second type formed landwards from the lagoon, in shallow intertidal up to supratidal facies.

The ***first type*** stromatolite bioherms are composed of a basal growth phase (1) with oncoids and serpulid nuclei followed by phase (2) with columnar, simple or laterally branched structure; a minor discontinuity to the top of this phase indicates a subaerial exposure with reworked mats. This discontinuity was followed by growth phase (3), which contains columnar to domal inner structures; the final growth phase (4) shows a structure containing only domal to planar, wavy microbial laminae (Fig. 4).

The ***second type*** of stromatolite bioherms contains 3 growth phases and it is described below, in the subchapter on internal structure of stromatolites, because it is more widespread in the lagoon than the first type disposed towards the seaward part of the lagoon.

The substratum of stromatolite bioherms is not so easy to define, because of its transitional facies from the oolites to serpulid-reef banks and from these to marlstone beds (Fig. 6). Depending on shore line profiles, the substratum of Thüste stromatolites was represented by either the serpulid-reef banks, or in most of the cases by the marlstone facies. The marlstone facies contains small lenses of serpulid biostroms and is positioned on the top of the serpulid-reef banks.

The stromatolite bioherms frequently contain in their basal part tiny tubes of *Serpula coacervata* (BLUMENBACH 1803) SCHÖNFELD 1979. The organisms of genus *Serpula* are not cemented to its substrate, but they are not mobile either, partially burying themselves in carbonatic muds or in sandy sediments. The species of genus *Serpula* are suspension deposit feeders.

The serpulid - reef banks contain a mass of up to 60 % entire or fragmentary, sometimes, telescopate tubes of *Serpula coacervata* (after Ten Hove & Hurk 1993); they are not fully equivalent to the oolitic bar. The serpulid-reef banks with variable thickness from 1.0 up to 6.0 m (Schönfeld 1979) were formed exclusively by tubes of *Serpula* disposed more or less in a micritic matrix, parallel to the bedding plane. Ooids occur extremely rarely in the stromatolite bioherms, suggesting that there was no direct relation between oolites and the substratum of stromatolites. In exchange, mat debris, (marly-limestone) intraclasts, serpulid tubes, rarely ostracod shells, were all stored to the basal part of the stromatolites and (partly) contributed to the initial growth phase 1.

Internal structure of stromatolites.

Studied in several slabs and in oriented thin sections, the stromatolitic bioherms showed diverse morphologies and populations, characteristic for three or four growth phases or stages, in relationship with the specific depositional environments. Here we describe in detail ***type 2*** of stromatolite bioherms (Fig. 5 and Plates 1-7), which is relatively more extended in the lagoon, landwards:

G*rowth phase 1* (3.0-5.0 cm) in the basal part, consists of different particles (mat debris, marly-limestone intraclasts with diameters between 1. 0 mm up to 5.0 mm, and rarely ostracod shells and serpulid tubes).

The main components of this growth phase are spheroidal to ellipsoidal microbial oncolites (with diameters from 0.25-0.50 up to 3.0 mm) with only serpulid tubes nuclei and 2 up to 5 microbial laminae, variable in thickness from 0.090 mm up to 0.15 mm. The spaces between oncoids are filled up with mat-debris, small intraclasts, rare ostracod shells and pyritized minicrusts. To the upper part of this phase fine, vertical or irregular cracks were formed during the lithification processes. The oncolites, radial calcitic ooids and shells represent, in this case, mobile built-ups.

Rarely, biofilm-like *Chlorellopsis coloniata* REIS is present; this form, considered a green alga after Freytet (2000) and confirmed also in our opinion, is still under debate as far as origin and taxonomy are concerned. This species is not very abundant at this level, which contains small spheres of sparry calcite, 0.10-0.15 mm in diameter (Pl. 8, Figs. 1- 4).

The boundary between growth phases 1 and 2 corresponds to an easily-noticeable irregular plane; the oncoids of the two stages are also different in sizes.

G*rowth phase 2* (4.0-5.0 cm) contains in the lower part microbial macrooncoids sensu Richter (1983a, 1983b) with diameters up to 3.0 - 4.0 cm. The macrooncoids have spheroidal or ellipsoidal shape, sometimes more elongated on the vertical plane, when they incorporate 2 or 3 serpulid-nuclei. The macrooncoids present concentrical microbial laminae. The variable number of microbial laminae have different thicknesses, from 0. 050 to 0. 20 mm.

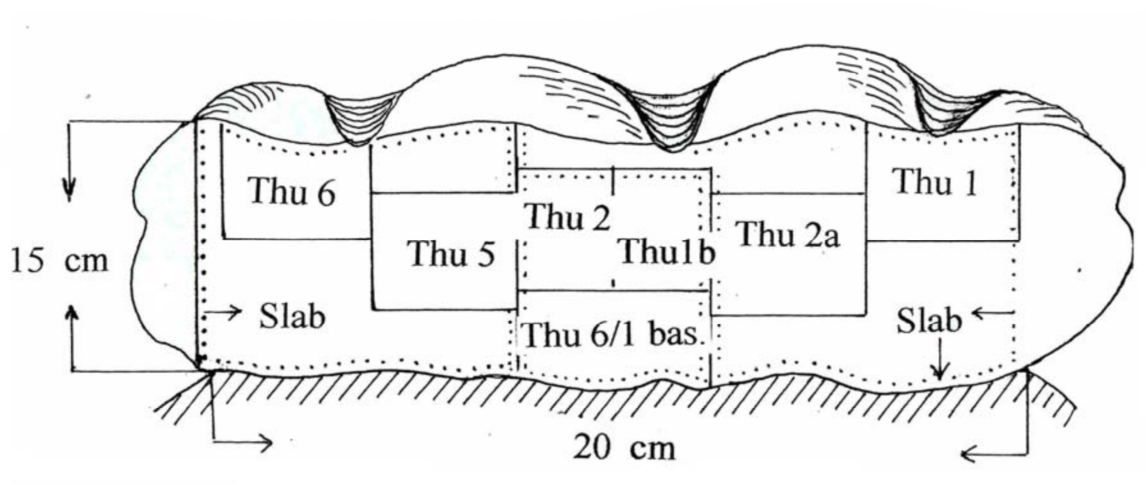

Fig.3 - Location of the oriented thin sections within the studied stromatolite bioherms Type 2 from Thüste (not to scale).

Fig.4 - Stromatolite bioherms Type 1: compact, flat, wavy at the surface, with 4 growth phases. Accumulated on the intertidal algal flat (intertidal facies) disposed seawards from the lagoon on serpulid-reef banks and oolitic bars, Thüste quarry, Collection Prof. Dr. Detlev K. Richter, scale bar 2 cm.

Given their large sizes and the moderately high level of hydrodynamism, the macrooncoids were fixed to the substratum during the growth phase 1. After fastening on the substratum, the macrooncoids were covered by microbial laminae which continue to grow and to built mounds or knolls (Fig. 6). To the upper part of this phase, the microbial mounds (= knolls) contain up to 10 microbial laminae, parallel and wavy, thinner in the lower part (7 laminae) and thicker to the top (3 or 4 laminae) - (Pl. 2 Fig. 1, Pl. 3, Fig. 1, Pl. 5, Fig. 1).

Additional to this phase contributed the green algae *Chlorellopsis coloniata* REIS, rarely (Pl. 8 Fig.1 - 4) and *Brachydactylus reisi* DRAGASTAN & RICHTER, frequently (Pl. 8, Figs. 5 -7), being disposed on the top of the layer, between the knolls.

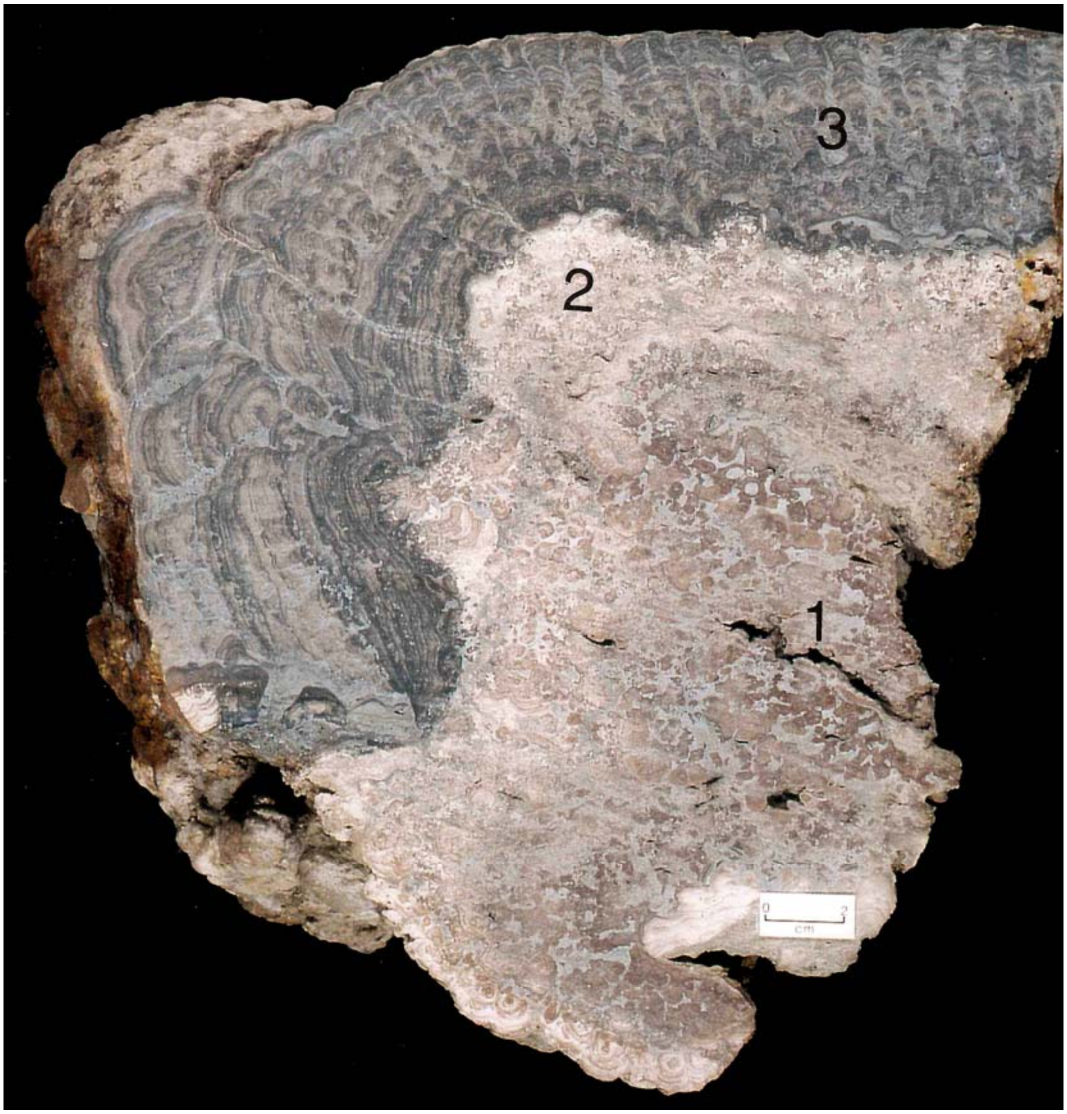

Fig.5 - Stromatolite bioherms Type 2: bulbous and with protuberances, with 3 growth phases. Accumulated in the lagoon between coastal sabkha and oolites, serpulid banks to marlstone with serpulid biostromes, Thüste quarry, Collection Prof. Dr. Detlev K. Richter, scale bar 2 cm.

The alga *Brachydactylus reisi* is represented by nodular thalli with small protuberances crossed by fascicles of tubes, dichotomic branched, minidigitated, sometimes incompletely filled with calcite after gypsum crystals. The *Brachydactylus* thalli were not affected by gypsum especially to the top of this phase; some parts of the thalli remained unchanged. It cannot be excluded that the genera *Chlorellopsis* and *Brachydactylus* belong to the group of halophilic algae.

There are small depressions between the knolls that contain coprolites of gastropods (Pl. 12, Fig. 5), ostracods, fragmented bivalve shells, caddisfly, and pupal larvae of Trichoptera (Pl. 11, Figs. 5–6, Pl.12, Fig. 4).

Channels can be observed at the top of this phase or between phases 2 and 3 (Pl.1, Fig. 1, Pl. 2, Fig. 1, Pl. 3, Fig. 1). These channels are filled with mat - clasts, oncoids and ostracod shells that indicate a “reworking” event, which might have been followed by a hiatus in trapping and binding of microbial mats. The phase ends with an erosional surface that is crossed by channel–fills; on its top a mm-thick pyritized lamina follows, bacterial in origin, which is also an indicator for the presence of anoxic conditions.

Growth phase 3 (5.0 cm-7.0 cm) starts with basal, domal laterally-linked microbialites, which in some parts (inwards) of the lagoon passed into planar structures and wavy microbial laminae (Pl. 3 Fig.1, Pl. 7, Fig.1 to the top of photo).

The domal structures contain up to 10 undulatory laminae showing couplets between the thicker laminae. These may be possibly formed by coccoids and thinner laminae. The latter ones are produced by filamentous cyanophyceans. This kind of couplet-laminae could be an indicator for trapping and binding processes under warm climate conditions, perhaps during two seasonal periods.

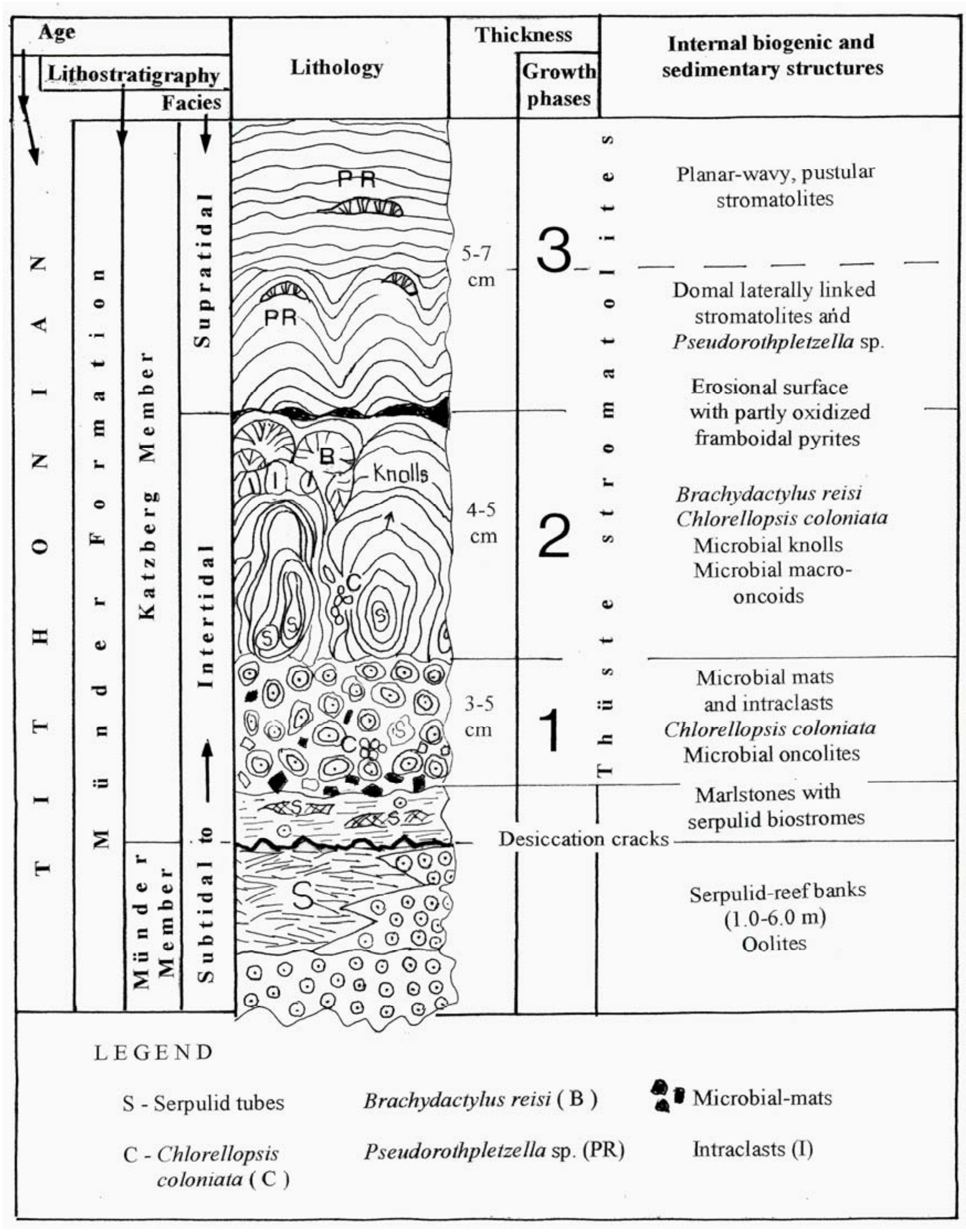

Fig.6 - Substratum, biogenic and sedimentary structures of stromatolite bioherms Type 2 and the evolution of growth phases (1 - 3), based on vertical slabs, Thüste quarry of Schütte Co. (not to scale).

On the top of the domal microbialites a possible cyanophycean thin algal crust occurs, similar as inner morphology is concerned with the thallus-crust of the genus *Pseudorothpletzella* SCHLAGINTWEIT & GAWLICK 2007 described here under the name of *Pseudorothpletzella* sp. (Pl. 11, Figs. 3, 5, Pl. 12, Fig. 3). Between the domal structures, in small depression also the alga *Brachydactylus* sp. (Pl. 11, Figs. 3 - 4) was noticed, with small thalli and only one or two fan-haped fascicles crossed by dichotomously branched tubes that differ from those of species *B. reisi* DRAGASTAN & RICHTER. Also, in the domal linked depressions ostracods shells, caddisfly pupal larvae (Pl. 11, Figs. 5 - 6), mat clasts and microbial peloids are present. Towards the margin of this stromatolitic bioherm, between the growth phase 2 and the basal part of growth phase 3 vertical, irregular channels can be observed (Pl. 1, Fig. 1, Pl. 2, Fig. 2). The channels are filled with microbial mat-clasts, intraclasts with algal fragments, oncoids and rarely radial calcitic ooid-clasts. To the top of this final phase, the stromatolites present only planar, wavy, pustular microbial laminae crossed by upward cracks, irregular fenestral fabric and rare ostracod shells (Pl. 2, Fig. 1, Pl. 7, Fig. 1).

This top planar layer consists of microbial fine-grained agglutinated sediments and it is well laminated.

The phase contains a variable number (from 14 up to 20) of laminae. Here, two types of laminae were noticed: thicker – with thicknesses of 0.15 up to 0.60 mm, and thinner – with thicknesses between 0.025 mm up to 0.10 mm.

As conclusion to this general presentation we can state the following:

1. The uppermost Tithonian stromatolites of Thüste, Katzberg Member of Münder Formation were mainly built by the microbial organisms, with the contribution of green algae *Chlorellopsis coloniata* REIS, rarely found in growth phases 1 and 2, *Brachydactylus reisi* DRAGASTAN & RICHTER, frequently found in growth phase 2 and *Brachydactylus* sp., rarely found in growth phase 3. The cyanophycean (?) thalli crusts of *Pseudorhotpletzella* sp. were rarely encountered in growth phases 2 and 3.(Pl. 11, Figs. 3, 5, Pl. 12, Fig. 3). In-between the domal link depressions coprolites of gastropods (Pl.12, Fig.5), caddishfly pupal larvae (Pl.11, Figs. 3, 5 - 6, Pl.12, Fig. 4), ostracods and bivalves shells, microbial mats occur. All the components contributed in small amounts to building the edifice of the stromatolitic bioherms.

2. Two types of stromatolitic bioherms are described: *first type (*1) massive, compact with a flat, wavy surface composed of 4 growth phases with microbial columnar and domal inner structure formed in the intertidal environments on the serpulid-reef banks and oolites. They are disposed towards the seaward edges of the lagoon or possibly to both edges of serpulid and oolites deposits which functioned as an island barrier; *second type* (2), larger, bulbous with protuberances containing three growth phases, with microbial oncoids (1), microbial macrooncoids and green algae (2), and domal to planar, wavy, pustular (3), inner structure.

This type of bioherms, disposed inwards or landwards of the lagoon, has developed in intertidal to supratidal environments.

3. The stromatolitic bioherms present internally a variety of morphologies controlled by the physical environment (water movements and current actions) including a characteristic biological content.

4. The internal morphologies of the stromatolitic bioherms showed that the organo-sedimentary associations from growth phases 1, 2, 3 and 4 contain microbial, green and blue-green algae, the latter ones as halophilic biota. The growth phases 1, 2, 3 and 4 from the first type (1) bioherm developed in a moderately high-energy environment, only on the intertidal algal-flat including both sides of the „island barrier" with columnar, simple or branched structures; to the top, this continued exclusively with the domal stuctures.

The growth phases 1, 2, 3 from the second type (2) bioherm developed in a moderately low-energy environment, inward or landward of the lagoon is represented by domal or knolls structure, which correspond to the intertidal environment and planar, wavy, pustular structure to the supratidal environment.

5. The growth phase 2 and the basal part of phase 3 were crossed by channel systems filled with reworked materials from the offshore-sea bottom and from the seaward edges of the lagoon.

6. Between the growth phases 2 and 3, an erosional surface was outlines, as discontinuity or hiatus corresponding to the lack of accretionary processes. This surface, which was impregnated with framboidal pyrites of bacterial origin during an anoxic event, is probably a marker for a transitional phase from intertidal to supratidal environments.

7. The marlstone with serpulid biostroms, the serpulid-reef banks and oolites were accumulated in intertidal to subtidal environments.

8. The presence of two types of microbial laminae in the stromatolitic bioherms – some thicker (possibly coccoidal in origin) and others thinner (possible cyanofilamentous in origin), could be an indicator for the fact that the microbialites and the associated populations evolved in a lagoon environment (of the tidal flat), under warm climate and perhaps during two-seasonal periods.

9. The facies model of Thüste stromatolites including the serpulid-reef banks and oolites which functioned like an island barrier and associated deposits can be compared with the Recent facies model of the Trucial Coast (Abu Dhabi) from the Arabian/Persian Gulf (Fig. 7).

In the case of Thüste stromatolites, the coastal sabkha corresponds to supratidal salt-flat, including gypsum and anhydrite deposits (early diagenetic minerals, like widespread pyrites and dolomites) and to the lagoon with stromatolites disposed between the sabkha flat and the oolites-serpulid-reef banks up to marlstones with serpulid biostroms comparable with a barrier island, the last deposits being accumulated in intertidal to subtidal environments. The Thüste stromatolite bioherms were formed in the lagoon, in intertidal and supratidal enviroments.

10. The serpulid-reef banks, the oolites and marlstones with serpulid biostroms functioned, more or less, like a barrier island; associate deposits were accumulated, corresponding to intertidal and subtidal environments.

11. In the case of environmental interpretations of the Thüste stromatolites, the algae and bacteria are more sensitive than the assemblages of minerals, because of the direct contact of the organisms with the waters of the Portland Basin, whereas the minerals, e.g. sulphates, pyrite, or dolomite have crystallized under diagenetic conditions – after sedimentation and lithification.

CALCAREOUS ALGAE OF DEISTER AREA, NEAR SPRINGE

The Berriasian deposits of the Borberg Member contain marlstones, micritic limestones, bindstones, oncoids with serpulid-tubes nuclei, calcareous algae, serpulids and ostracods. The deposits are also known as Purbeck limestones and marls; their thicknesses vary between 50 m and 185 m (Fig. 2). The **Borberg Member** defined by Wolfart in Waldeck (1975) contains marls intercalated with micritic limestones.

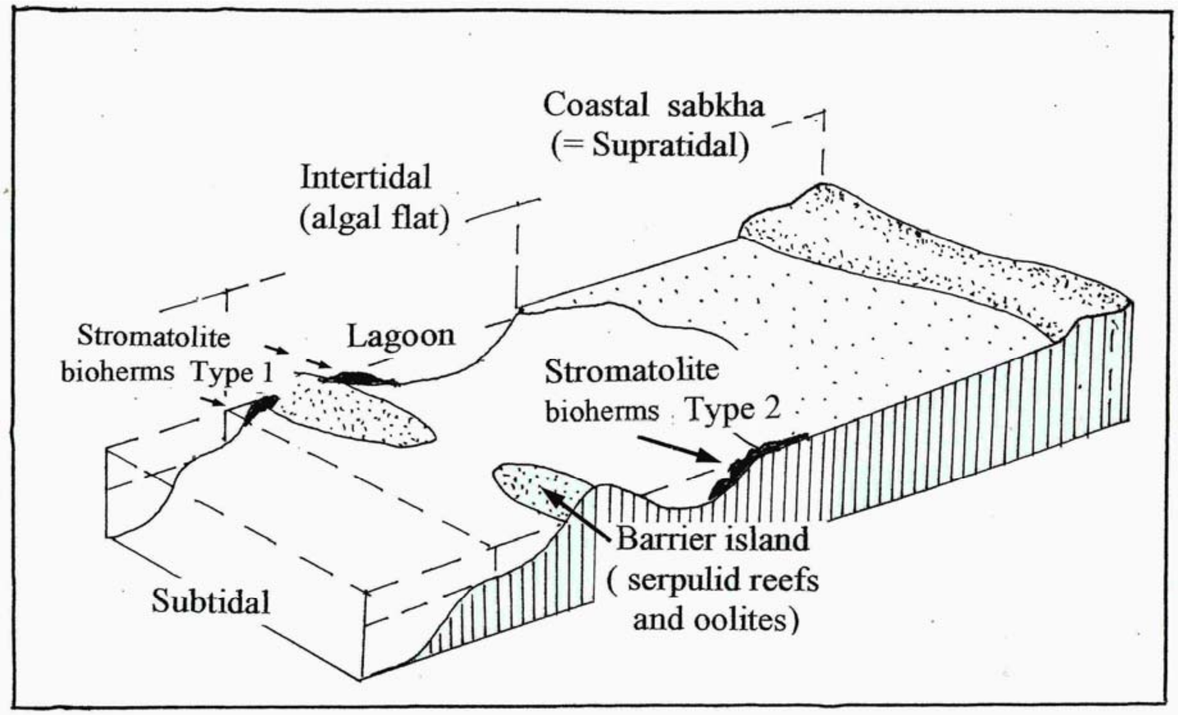

Fig.7 - Adapted Recent facies model of coastal sabkha (supratidal salt flat), lagoon and barrier island (intertidal to subtidal facies) from the Trucial Coast, Abu Dhabi (after Purser 1985, in Einsele 2000) reconsidered in the case of Thüste stromatolites.

Arp & Mennerich (2008) investigated a typical section for this subunit, which contains six characteristic lithofacies types (Lithos 1-6), as follows: **lithofacies 1** includes marlstones and limestones with grey nodules, laminated fabric and ostracods, considered as massive limestones; **lithofacies 2** with bedded marlstones, mud cracks, stem and oogonia of charophycean and ostracods; **lithofacies 3** with dark-grey marlstones, ostracods, charophyceans and gastropods; **lithofacies 4,** also consisting of massive limestones, which contain calcareous algae (cyanophyceans and chlorophyceans, based on our data)**,** ostracods, bivalves, gastropods and rare oncoids; **lithofacies 5** composed by grey, micritic limestones with ostracods, gastropods and calcareous algae (chlorophyceans) and **lithofacies 6** with grey, clayely marlstones with ostracods, miliolids and authigenic aggregates of pyrite.

The calcareous algae of the Deister area include the following cyanophyceans: *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985, *Rivularia* sp. and chlorophyceans: *Springerella bifurcata* DRAGASTAN & RICHTER 2001, *S. fuchtbaueri* DRAGASTAN & RICHTER 2001, *S. westphalica* nov. sp. and *Deisterella germanica* nov.gen. nov.sp.

The eulittoral freshwater-oligohaline association (*Theriosynoecum* ostracod association) from **lithofacies 4** contains the following algae: species of genus *Springerella, Rivularia lissaviensis, Rivularia* sp. In the sublittoral-miohaline association (*Mantelliana* ostracod association) from **lithofacies 5** only the alga *Deisterella germanica* nov. gen. nov. sp. was found.

Dragastan & Richter (2001) described some calcareous green algae (Chlorophyta) from Deister area, near Springe: genus *Springerella* with two new species, *S. bifurcata* and *S. fuchtbaueri*.

The thalli of the algae, in most of the cases, were fixed on the serpulid tubes; they show various hemispherical or spheroidal shapes, when they completely surround one serpulid tube nucleus, or ellipsoidal shapes, when they include two serpulid-tubes nuclei (Pl. 10, Fig. 2), in case of *Springerella* species, and flat-planar crustose thalli, when they are fixed only on one, "upper" surface of the serpulid tubes, in case of *Rivularia lissaviensis* (Pl. 9, Fig. 5, Pl. 10, Fig. 1).

In this paper, the following taxa are redescribed or described: *Springerella bifurcata* DRAGASTAN & RICHTER 2001, *S. fuchtbaueri* DRAGASTAN & RICHTER 2001, *S. westphalica* nov. sp., *Deisterella germanica* nov. gen. nov.sp. (Chlorophyta), *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985 and *Rivularia* sp. (Cyanophyta).

The calcareous algal assemblage from Deister area corresponds to lacustrine-freshwater-brackish environments.

PALEOALGOLOGICAL DESCRIPTION OF THÜSTE STROMATOLITES

Phylum CHLOROPHYTA
Genus ***Chlorellopsis*** REIS 1923
Chlorellopsis coloniata REIS 1923
Pl.8, Figs. 1-4

1923 *Chlorellopsis coloniata* n.gen.n.sp. Reis, p.107, Pl. III, Figs. 1-2, 9, Pl. IV,
Figs. 3, 6,Pl. V, Figs. 2 - 6 and Text - Fig 1, p. 105.
1995 Problematicum *Chlorellopsis*, Arp, p. 83, Pl.17/ 6.
1997 *Ch. coloniata*, Freytet, p.13, Pl.1, Figs. a - c.

1999 *Ch. coloniata*, Freytet et al., p.121, p.126, Figs. 8 e - f.

2000 *Ch. coloniata*, Freytet, p.11, Pl. I, Fig. c.

2001 *Ch. coloniata*, Freytet et al., p.161, Pl. III, Figs. a - b.

2001 *Ch.coloniata*, Dragastan & Richter, p.314, Figs 12/ 1-2.

2007 *Ch. coloniata*, Leggitt et al., p. 673 (mentioned without description).

2008 *Ch.coloniata*, Arp et al., p. 1224 (mentioned without description).

Paratypes: Pl. 8, Figs. 1-4, Collection MMPP (Microfacies, Micropaleobotany, Paleobotany & Palynology), Laboratory of Paleontology, University of Bucharest, No. 1187, 1188, 1189, Uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Description: Thalli irregular, sometimes included in nodular microbial mats or in ellipsoidal oncoids with superficial laminae formed by microbial peloids (Pl. 8, Fig. 4). Thalli contain spherical cells, variable in diameter between 0.10 mm and 0.15 mm, preserved in coarsely crystalline calcite.

The spherical cells are surrounded by a micritic layer which is, in its turn surrounded by sparry polygonal or hexagonal networks, muff-like. The polygonal or hexagonal sparry network is an important character, which confers to this taxon an algal origin. The Recent genus *Chlorella* also presents a hexagonal network disposition around the spherical-ball cells; thus this feature of the fossil genus is very similar with that of this Recent taxon.

This species was not so frequently found in growth phases 1 and 2 of the Thüste stromatolites.

Dimensions in mm: size of thallus: 1.0-4.0; diameter of spherical-ball cells: 0.10-0.150.

Remarks: in spite of its disputed origin, *Chlorellopsis coloniata* REIS is a frequent algal component of brackish and freshwater environments, mainly associated with stromatolite built-ups. A discussion and interpretation of *Ch. coloniata* was presented in detail at page 11 by Freytet (2000) showing that: *Chlorellopsis* are never free in the sediments, they are always associated with stromatolitic built-ups.

An argument in favour of the algal origin remains the hexagonal or polygonal outline (Pl. 8, Figs. 1-3) surrounded the spheric cells, like in the Recent genus *Chlorella.*

The systematic position of this taxon is and remains controversial:

- Reis (1923) concluded that this genus belongs to Chlorophyta, Order Protococcales, being compared with the marine genus *Halosphaera* and with freshwater genera *Eremosphaera* and *Chlorella*;
- Nathan (1925) concluded that *Chlorellopsi*s is an alga;
- Bradley (1929) considered this taxon as a potential index for algal remains;
- Bolten (1977) considered also that this taxon is an alga;
- Stapf (1988) proposed for *Chlorellopsis* an algal origin;
- Bertrand-Sarfati et al. (1994) and Arp (1995) assigned the genus *Chlorellopsis* to insect eggs or arthropods, but without arguments;
- Lundquist (1994) considers that these thalli with spheres represent endogonaceous fungal spores;
- Freytet (1997) shows that a precise attribution of *Chlorellopsis* remains open; in 2000, the same author preferred the hypothesis of an algal origin;
- Dragastan & Richter (2001) also assigned genus *Chlorellopsis* to the green algae.

Stratigraphic range: Permian (?), Lower Triassic, Upper Jurassic (uppermost Tithonian of Thüste stromatolites), Eocene and Oligo-Miocene.

Genus ***Brachydactylus*** REIS 1923
Brachydactylus reisi DRAGASTAN & RICHTER 2001
Pl. 8, Figs. 5 – 7

2001 *Brachydactylus reisi* n.sp. Dragastan & Richter, p.314, Fig.12.1 and Fig.13.1-6.

Holotype in 2001, Pl. 8, Fig. 5, Collection MMPP – Bucharest, No. 1138.

Paratypes: Pl.8, Figs. 6 - 7, Collection MMPP – Bucharest, No. 1190 - 1191, uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münster Formation.

Description: Nodular thalli with small protuberances (see Holotype) sometimes covered by microbial laminae. Thalli composed of small fan-shaped bundles crossed by dichotomously branched tubes. To the distal ends, the tubes appear short and minidigitate as structure. In the transverse section, the fan-shaped bundles contain up to four fascicles, all together round in shape and looking like a cauliflower (Pl. 8, Figs. 6- 7). Some bundles preserved completely the inner structure, showing the radially disposed minidigitate tubes, the dichotomously branched remaining unaffected by the formation of post-diagenetic gypsum crystals (Pl.8, Fig. 7).

In vertical section (Pl. 8, Fig. 6) the fan-shaped bundles are disposed bilaterally and present dichotomously branched tubes, which can be seen only to the distal ends of the fascicles. However, in some parts of the thalli-bundles, the terminal traces of the tubes can be observed (Pl. 8, Fig.7).

Dimensions in mm: diameter of nodular thallus: 2.0 - 3.0, diameter of the isolate protuberance: 1.0 -1.5, width of fan-shaped bundles: 0.50 - 0.65, heigth of the fan-shaped bundles: 0.35 - 0.50, proximal diameter of dichotomously branched tubes: 0.040 - 0.060, distal diameter of dichotomously branched tubes: 0.010 - 0.030.

Remarks: *Brachydactylus reisi* DRAGASTAN & RICHTER 2001 was compared with, but differs from the Miocene *Brachydactylus radialis* REIS 1923, by the shape of the thallus – nodular with protuberances, by the disposition of the dichotomously tubes into fan-shaped bundles with fascicles of tubes and also by a lesser number of bundles in comparison with the Reis species, which presents a more compact inner thallus structure and has a different shape of the bundles.The *Brachydactylus reisi* was frequently identified in growth phase 2 of the Thüste stromatolites.

Stratigraphic range: uppermost Tithonian, Katzberg Member, Münder Formation.

Brachydactylus sp.
Pl.11, Figs. 3-4

Material: Two specimens, Collection MMPP-Bucharest, No. 1205-1206, uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Description: Thallus very small, fan-shaped, corresponding to one bundle crossed by dichotomously-branched tubes. The tubes are short and have a larger diameter in the base, before branching and smaller in the distal parts of the tubes.

Dimensions in mm: heigth of thallus: 0.30-0.40, width of thallus: 0.40-0.50, proximal diameter of tubes before branching: 0.030-0.040 and distal diameter of dichotomously branched tubes: 0.015-0.025.

Remarks: This alga occurs rarely, only in the growth phase 3 of Thüste stromatolites bioherms Type 2. When comparing with species *Brachydactylus radialis* Reis and *B. reisi* Dragastan & Richter, this alga shows a very small incipient thallus with only one or two bundles crossed by dichotomously branched tubes. The alga grew on the top of microbial domal structures, between the laminae (Pl. 11, Fig. 3), but also in the middle of the "depressions" formed between the domal structures (Pl.11, Fig. 4).

Stratigraphic range: uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

PALEOALGOLOGICAL DESCRIPTION OF DEISTER AREA

Genus ***Springerella*** Dragastan & Richter 2001
Springerella bifurcata Dragastan & Richter 2001
Pl. 9, Figs. 1 - 4, Pl.10, Figs. 2 – 3

2001 *Springerella bifurcata* nov. gen.nov. sp. Dragastan & Richter, p.313, Fig.10.1-3, Fig.11.1-4.

Paratypes: Pl. 9, Figs.1 – 4, Pl.10, Fig. 2–3, Collection MMPP- Bucharest, No. 1192, 1193, 1194, 1194 a, Berriasian, Borberg Member, Münder Formation.

Description: Nodular, spheroidal, ellipsoidal to hemispherical thallus. The morphology of the thalli is influenced by the shape of the nuclei and by the substratum. If the alga is attached on a single serpulid-tube nucleus, the shape is spheroidal (Pl. 9, Fig. 2) while when it is attached on two serpulid-tubes nuclei the thallus become ellipsoidal (Pl. 10, Fig. 2). Sometimes the thalli present also hemispherical shapes (Pl. 9, Fig. 1).

In vertical-longitudinal sections, the thalli are composed of long Y- shaped, open, dichotomously branched tubes having a strongly calcified swelling in the area of branching, and occasionally a swelling along the tubes between the branched areas (Pl. 9, Figs. 1-2). The swellings are ovoidal to ellipsoidal in shape, between the dichotomies of the tubes. The angle of divergence between the Y- branched tubes is variable, from 30° to 40° (Pl. 9, Figs. 3-4, Pl. 10, Fig. 3).

In transverse sections, the tubes are disposed in a regular quadrangular or polygonal network, grouped into 6 up to 8 tubes (Pl. 9, Figs. 1, 3 see in the lower part of the photo) and 4, in a broken thallus (Pl. 10, Fig. 2). The tubes show a petaloid, more or less regular disposition in transverse section of the broken thallus fragment (Pl. 9, Fig. 4 in the upper part of the photo). Also, in transverse section the swellings have a circular shape with large diameter; their appearance is similar to white sparitic spots (Pl. 9, Fig. 3 arrows).

Dimensions in mm: maximum diameter of thallus: 3.5-4.0, normal diameter of thallus: 2.20-3.0, diameter of tubes in the branching area: 0.075-0.080, diameter of tube after the dichotomously branching area: 0.030-0.045, diameter of occasional swellings along the tubes: 0.040-0.050.

Remarks: This species can be compared with *Sarfatigirella fallacia* Freytet & Verrechia, 1998 from the Campanian (Late Cretaceous). The difference consists of the smaller diameter of its erect "filaments" (= tubes) that are not undulose. The common features consist in the presence of the swellings, but they are not distributed in the branching area. The marine species *Mitcheldeania americana* (Johnson 1961) Dragastan 1985 from the Late Jurassic of Family Avrainvilleaceae Dragastan et al. 1999 non 1997, differs from *Springerella bifurcata* by the presence of siphons, dichotomously branched after an angle of divergence of less than 10° and by the presence of many swellings along the siphons The marine species of genus *Pseudomitcheldeania* Schlagintweit 1990, *P. dragastani* Schlagintweit 1990 from the Upper Aptian , *P. akrokorinthiaca* Dragastan & Richter 1999 from the Tithonian of Acrocorinth (Greece) and *P*.sp. from the Valanginian of Ghilcoş Massif, Transylvanian Carbonate Platform (Dragastan et al. 1997) differ from *S. bifurcata* by the presence of many swellings along the siphons, variable in shape. All these marine species belong to the Family Avrainvillaceae Dragastan et al. 1999, Class Bryopsidophyceae, Chlorophyta.

Stratigraphic range: Berriasian of Dreister area, lithofacies 4, eulittoral, freshwater-oligohaline, *Theriosynoecum* ostracods association.

Springerella fuchtbaueri Dragastan & Richter 2001

Pl.10, Figs. 4-5

2001 *Springerella bifurcata* nov.sp. Dragastan & Richter, p. 313, Fig. 11. 5 - 7.

2008 undescribed porostromate alga attached to a charophyte stem fragment, Arp & Mennerich, p. 23, Fig. 4 C, lithofacies 4.

Paratypes: Pl.10, Figs. 4 - 5, Collection MMPP-Bucharest, No. 1199, 1200, Berriasian, Borberg Member, Deister area, near Springe.

Description: Thallus small, hemispheroidal to spheroidal crossed by claviform, dichotomously branched and strongly calcified tubes, with larger diameter to the distal part (Pl.10, Figs. 4-5). Thalli attached in many cases on the serpulid-tubes; sometimes, together also with thalli of *Springerella bifurcata.*

Dimensions in mm: heigth of thallus: 0.30 - 0.70, width of thallus: 0.40-0.90, diameter of tubes in the proximal parts: 0.020-0.040, diameter of tubes in the distal parts: 0.050-0.090.

Remarks: The new material of *Springerella fuchtbaueri* shows the claviform shape of tubes, but without swellings. The claviform shape of the tubes remains a characteristic feature of this species.

Stratigraphic range: Berriasian of Deister area, lithofacies 4, eulittoral, freshwater -oligohaline, *Theriosynoecum* ostracods association.

Springerella westphalica nov.sp.
Pl. 10, Figs. 6 – 8

Derivatio nominis: "westphalica" from Westphalia, the German historical part (land) of NW Germany.

Holotype: Pl.10, Fig. 6, Collection MMPP-Bucharest, No. 1201**,** Berriasian of Borberg Member, Deister area, near Springe.

Isotypes: Pl. 10, Figs. 7 - 8, Collection MMPP - Bucharest, No. 1202, 1203**,** Berriasian of Borberg Member, Deister area, near Springe.

Dimensions in mm: height of thallus: 1.50 - 2.0, width of thallus: 2.0-3.0 when they have lobes (diameter of lobe 1.0); proximal diameter of tubes before branching: 0.030-0.040, distal diameter of tubes: 0.035-0.047, diameter of tubes in transverse section: 0.040-0.050, diameter of swellings: 0.060-0.090.

Description: Thalli hemispheroidal or spheroidal in shape, sometimes with lobes, not very compact in the inner structure, crossed by very laxly disposed dichotomously branched tubes. The tubes have a large angle of divergence; their opening varies from 30 up to 40°.

In vertical-longitudinal section (Pl. 10, Fig. 6), the thallus is composed of dichotomously branched tubes with a very open angle of divergence. The tubes present swellings, which appear like large sparry calcite spots, oval to ellipsoidal in shape. In the oblique-longitudinal section (Pl. 10, Fig. 7) the thallus is also crossed by dichotomously branched tubes.

The tubes present obvious sparitic oval to ellipsoidal swellings, located very close to each other. In transverse section (Pl.10, Fig. 8), the thallus has a round shape with some lobes; it presents the lax disposition of the tubes, with large spaces in-between. Because of the lax disposition, there are only four tubes arranged into a more or less quadrangular, or even irregular ”network” (Pl. 10, Fig. 8).

Remarks: The new species is comparable with the stock of *Springerella* species. The differences from the species of genus *Springerella* already described are represented by the lax inner structure of the thalli with lesser dichotomously branched tubes, and the large angle of divergence and the quadrangular up to irregular disposition of tubes – feature visible in transverse section. The presence of swellings along the tubes is a feature similar to that in *Springerella bifurcata*, but the distribution of the tubes with large spaces in-between and the quadrangular disposition represent the differences between these two species.

S. fuchtbaueri differs from both species by the claviform shape of the tubes with large diameters in the distal parts and by the compact disposition of the tubes along the thallus. The new species is frequently attached on serpulid-tubes.

Stratigraphic range: Berriasian of Deister area, lithofacies 4, eulittoral, freshwater-oligohaline, *Theriosynoecum* ostracods association.

Deisterella nov.gen. DRAGASTAN & RICHTER

Derivation nominis: from Deister Mountains, NW Germany.

Type species: *Deisterella germanica* nov.gen.nov.sp.

Diagnosis: Thallus hemispherical crossed by Y-shaped and V-shaped dichotomously branched tubes, which show a sparitic, elongate or passing to conical in shape swelling in area of branching,. In the lower part of the thallus spheroidal ”calcitic bodies” - considered to represent possible reproductive organs - are disposed.

Remarks: The new taxon is comparable with the marine genera *Niteckiella* Dragastan 1988 (Tithonian of Bihor and Getic Carbonate Platforms) and *Hansiella* Dragastan 1990 (Late Oxfordian-Kimmeridgian of Getic Carbonate Platform) from Family *Pseudoudoteaceae* DRAGASTAN et al. 1997, Class Bryopsidophyceae, Chlorophyta revised by Dragastan (2002).

Although these genera have different branched - V- and Y-type shaped tubes, they can be compared with the new taxon that presents similar but not identical branched tubes. It misses the fine, long, simple or bifurcate tubes present in the case of genus *Hansiella* and the more diversified inner structure with different branched tubes present in the case of genus *Niteckiella*.

The new genus is morphologically similar with genus *Hansiella*, which has a thallus crossed by Y-shaped tubes, but also by V-shaped and long, fine, simple or bifurcate tubes.

The Y- and V-shaped branched tubes and the spherical calcitic bodies – as possible reproductive organs –, provided a striking resemblance of the two genera.

The new taxon can be compared also with freshwater genera *Cladophorites* REIS 1921 (Miocene), Ries-Impact-Crater from southern Germany and *Purserella* FREYTET 1997 (Oligo-Miocene lake) from Limagne of Allier, France, based on the presence of V- and Y-shaped dichotomously branched tubes; however it differs from these genera by the absence of spheroidal calcitic bodies in the latter. Both genera are considered green algae (Chlorophyta).

Deisterella germanica nov.sp.
(Pl. 11, Figs. 1 - 2)

Derivatio nominis: ”germanica” from the Germanic ancient populations that inhabited the territory of present Germany.

Holotype: Pl. 11, Fig.1, Collection MMPP-Bucharest, No. 1204**,** Berriasian of Borberg Member, Deister area, near Springe.

Description: Thallus hemispherical attached on serpulid tubes and covered by thin microbial mats. The thallus is composed of Y- shaped dichotomously branched tubes with an angle of divergence between 30° up to 40° and of V - shaped dichotomously branched tubes with an angle of divergence between 10° up to 20°; the last ones were more frequently identified in the composition of the thallus. At the branching point, a small conical or elongate swelling is visible, similar to a white spot. In the basal part of the thallus, between the Y- shaped dichotomous tubes the spheroidal ”calcitic bodies” considered as possible reproductive organs occur (Pl. 11, Fig. 2).

Also in the basal part of the thallus, similar to the features of the transverse section, the disposition of the tubes in pentagonal or hexagonal frame can be noticed; each tube is set up to the angle of geometric disposition (Pl. 11, Fig.1, arrows).

Dimensions in mm: height of thallus: 3.0-3.50, width of thallus: 2.0-2.50, diameter of tubes in the branching area: 0.045-0.070, diameter of dichotomic tubes: in the proximal part, 0.025-0.030 while in the distal part, 0.035-0.050-(0.090), diameter of calcitic bodies: 0.10-0.12.

Remarks: *Deisterella germanica* nov.sp. differs from the marine species *Niteckiella flabelliformis* DRAGASTAN 1988, by the presence of only two types of tubes dichotomously Y- and V - shaped branched, and by the presence of spheroidal calcitic bodies. *N. flabelliformis* shows several types of tubes and does not display spheroidal calcitic bodies. As compared with the marine species *Hansiella fibrata* DRAGASTAN 1990, which also has Y- and V-shaped dichotomously branched tubes, it also shows fine, long, simple or bifurcate, parallel tubes disposed in bundles and spherical calcitic bodies as reproductive organs. The only difference in the new species is the absence of fine, long, simple or bifurcate tubes disposed in bundles.

Both marine species were found in the Tithonian (*Niteckiella flabelliformis*) of the Transylvanian, Getic and Bihor Carbonate Platforms and in the Late Oxfordian-Kimmeridgian (*Hansiella fibrata*) of the Getic Carbonate Platform.

The freshwater species *Cladophorites incrustans* (LUDWIG 1858) REIS 1921 showing hemispherical thallus crossed by V– shaped and rarely Y - shaped dichotomously branched tubes differs from the new taxon by a different disposition of the tubes in transverse section and by the absence of spheroidal calcitic bodies. In the Oligo-Miocene species *Purserella gracilis* FREYTET 1997, the differences consist of the disposition of dichotomic tubes into fascicles and the absence of calcitic bodies.

Stratigraphic range: Berriasian of Deister area, lithofacies 5, sublittoral-miohaline, *Mantelliana* ostracod association.

Genus ***Rivularia*** (ROTH 1802) AGARDH 1824

Rivularia lissaviensis (BORNEMANN 1887) DRAGASTAN 1985

Pl. 9, Fig. 5, Pl.10, Fig. 1, Pl.12, Figs.1-2

1887 *Zonotrichites lissaviensis* n. gen. n.sp., Bornemann, p.126, Pl. V, Figs.1-2, Pl. VI, Figs.1-2.

1985 *Rivularia lissaviensis* (Bornemann 1887) Dragastan 1985, p. 106-109, Text-Figs. 1-2, Pl. I, Figs. 1-3, Pl. III, Figs. 1-2, Pl. IV, Figs. 1-6, Pl. V, Figs.1-5, Pl. VI, Figs. 1-2, Pl. VII, Figs. 1-4, Pl. VIII, Figs. 1-5, see a complete list with synonymies in Dragastan 1985.

1988 *Rivularia lissaviensis* - Dragastan, p.253, Fig. 1 (comparative analyses between different species of genus Rivularia).

1992 *Rivularia lissaviensis* - Dragastan, p.98, Fig. 4, Pl. I, Figs. 1-5, Pl. II, Figs.1-3.

2008 Charophyte stem with the cyanobacterial filament - Arp & Mennerich, p. 23, Fig. 4 A.

Paratypes: Pl. 9, Fig. 5, Pl. 10, Fig.1, Pl. 12, Figs. 1-2, Collection MMPP - Bucharest No. 1195, 1196, 1197, 1198, Berriasian of Borberg Member, Deister area, near Springe.

Description: Thalli hemispherical or as planar crusts (Pl. 9, Fig. 5, Pl. 10, Fig.1, Pl. 12, Figs. 1-2) attached or not on serpulid tubes. The thalli crossed by V -shaped dichotomously branched tubes show compact inner structure. Sometimes the disposition of the branched tubes corresponds to the growth stages of the thalli, imprinting microstrata-like aspect (Pl. 10, Fig. 1). The angle of divergence varies between 6° and 10° (Dragastan 1985, 1988).

Dimensions vary in large limits, given the influence of diverse facies types (marine, brackish or freshwater) and of different types of substratum.

Remarks: Bornemann (1887) at Pl. V, Figs.1-2 figured a macrooncoid with a bivalve shells nucleus surrounded by *Rivularia lissaviensis* thallus-crusts, which finally is covered by microbial mats. The thallus which covered the charophyte stem in an oncoid structure figured by Arp & Mennerich (2008) also belongs to *Rivularia lissaviensis* (BORNEMANN) DRAGASTAN 1985.

Stratigraphic range: Berriasian of Deister area, lithofacies 4, eulittoral freshwater-oligohaline, *Theriosynoecum* ostracods association.

MICROPROBLEMATICAE

Genus *Pseudorothpletzella* SCHLAGINTWEIT & GAWLICK 2007

Pseudorothpletzella sp.

Pl. 11, Figs. 3, 5 and Pl. 12, Fig. 3

Material: Two thin sections with three specimens, Collection MMPP - Bucharest, No. 1207, 1208, 1208 a, Thüste stromatolites bioherms, uppermost Tithonian, Katzberg Member, Münder Formation.

Description: Thalli flat, undulatory, attached on microbial domal structures (Pl. 11, Figs. 3, 5). It resembles a thin encrusting ”sheet” consisting of juxtaposed tubes or cells disposed horizontally, in one plane; possibly dichotomously branched ?.

Dimensions in mm: thickness of thallus crust: 0.20 - 0.30, thickness of the juxtaposed undulatory ”sheet”: 0.075 - 0.10, diameter of cells–tubes: 0.005-0. 007, length of cells: 0.010-0.020.

Remarks: The encrusting alga with a reduced thickness of the thalli and horizontal disposition of dichotomously branched tube-cells occurs preferentially on the top of the microbial domal structures (Pl. 11, Figs. 3, 5, Pl.12, Fig. 3). This taxon was found in the growth phase 3 of the Thüste stromatolite bioherms Type 2.

Wood (1948) considered *Rothpletzella gotlandica* (WOOD 1948) as a potential alga without septation belonging to Myxophyceae (= Cyanophyceae), or possibly to the group of Siphonales from Chlorophyceae. The walls of the tubes-cells consist of microcrystalline calcite. Riding (1991) showed that these arguments are not conclusive, genus *Rothpletzella* being more probably regarded as a cyanophycean (= cyanobacterium). It is common as reefal crusts in stromatolites or oncoids, of the middle Paleozoic, and in the fore-reef stromatolites.

The new genus *Pseudorothpletzella* with new species *P. schmidi* introduced recently by Schlagintweit & Gawlick (2007) consisting of dome-shaped crusts composed of subparallel tubes or cells disposed in juxtaposed sheets is close, but not similar with the inner structure is concerned, with *P.* sp.

The taxon described here is treated as microproblematicum or incertae sedis with a possible microbial origin. The specimens found in growth phase 3 on microbial domal structures of Thüste stromatolites differ in the oval to ellipsoidal shape of the horizontal cells, and in the thin juxtaposed „sheets”. In Thüste stromatolites, this organism contributed to the binding of the microbial domal structures and is disposed on the top of these structures.

Stratigraphic range: uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Coprolite

Pl. 12, Fig. 5

Material: One thin section, Collection MMPP - Bucharest, No. 1212, uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Description: Rectangular body currently without internal channels or furrows. The furrows in this case were (probably) disposed in the external part of the body; they were removed as a result of erosion during sedimentation. It is assigned as a product of gastropods' activity.

Dimensions in mm: length of the body: 0.30-0.45, diameter of the body: 0.10-0.150.

Remarks: It was found only in growth phase 3 in Thüste stromatolite bioherms Type 2.

Stratigraphic range: uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Caddisfly pupal larvae
Pl.11, Figs. 3, 5-6, Pl. 12, Fig. 4

Material: Three thin sections, Collection MMPP - Bucharest, No. 1209, 1210, 1211, uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.

Description: The cylindrical straight, slightly tapering caddisfly cases from Thüste stromatolites appear as tubes having the walls consisting of grains of microbial peloids.

The grains are disposed more or less parallel; sometimes they show an irregular arrangement, visible in longitudinal and oblique-longitudinal sections (Pl. 11, Figs. 5-6).The peloid grains were cemented by the micritic matrix.

In transverse sections (Pl. 11, Fig. 3, Pl. 12, Fig. 4), the cases show a round disposition of the peloid grains, which is not that regular in the case of all caddisfly larvae. The cases are cut at various angles, some appear circular, others elliptical or with irregular outline in transverse section – the latter due to deformation processes during lithification in the frame of microbial domal structures.

The caddisfly larval cases are arranged in microlayers, thicker at centre and a little taper towards the edges. The caddisfly microlayers are separated from each other by a very thin carbonate "laminae" repeated several times during the growth phases.

The caddisfly was scarcely identified in growth phase 2 and more frequently in growth phase 3 in the frame of the stromatolite bioherms Type 2. The caddisfly accumulated preferentially at the top of microbial domal structures (Pl. 11, Figs. 5-6, Pl. 12, Fig. 4) and also in the small "depressions" formed between the domal structures (Pl. 11, Fig. 3).

Dimensions in mm: length of caddisfly cases: 1.0-2.0, diameter of caddisfly tubes or cases: 0.60, 0.80, 1.0 up to 1.80, length of peloidal grains: 0.30-0.50, diameter of peloidal grains: 0.10-0.15 (0.20).

Remarks: Until now, the oldest record of microbial caddisfly bioherms was reported from the Early Cretaceous Jinju Formation, Korea by Paik (2005). Also, caddisfly were described from Turonian, Upper Cretaceous amber of New Jersey by Botosaneanu (1995), by Bradley (1924,1926, 1929) and by Leggitt et al. (2007) from the Eocene Green River Formation. In the Eocene Green River Formation caddisfly dominated the microbial-carbonate mounds, 30 cm thick and 70 cm in diameter. The coated grains from the walls of caddisfly casts consist of different types of grains such as ostracods shells, ooids, peloids, quartz and rock fragments.

A study on Recent larvae from the North American caddisfly genera (Trichoptera) was performed by Wiggins (1998). This author distinguished 7 families producing caddisfly, of which only 4 families build cases made of rock fragments and peloidal grains with particular sizes, similar in shape with the caddisfly cases described from the Thüste stromatolites bioherms Type 2.

The presence of caddisfly in Thüste stromatolites bioherms Type 2, mostly in growth phase 3 is an indicator that the nearshore or landward lagoon was represented by a freshwater, lacustrine environment with a lentic character, or by a slow-moving aquatic habitat disposed near the coastline.

Until now, the discovery of caddisfly pupal larvae in the uppermost Tithonian of Thüste stromatolites represents the oldest record of this type of organic product.

Stratigraphic range: uppermost Tithonian, Thüste, stromatolite bioherms Type 2, Katzberg Member, Münder Formation.

Algal crust
Pl. 12, Fig. 6

Material: One thin section, Thüste stromatolite bioherms Type 2, Katzberg Member, Münder Formation.

Description: Thallus as a thin crust, attached and growing on the microbial planar-wavy stromatolites from the top of growth phase 3. The crust crossed by primary tubes with large diameter before reaching the branching area (Pl. 12, Fig. 6, see arrows). After branching, the secondary tubes continue into two or three ? divergently disposed, short tubes with small diameter.

Remarks: This alga can be assigned to cyanophycean algae, if it shows only dichotomously branched tubes or to chlorophycean ones if it displays trichotomic ? branched tubes. The final assignment remains open.

Stratigraphic range: uppermost Tithonian, Thüste stromatolite bioherms Type 2, Katzberg Member, Münder Formation.

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PLATES

PLATE 1

Vertical section in the basal part of stromatolite bioherms Type 2, showing the inner structure, growth phases 1, 2, 3, channel-fills (Cf) and an erosional surface covered by a mm-thick pyritized crust, bacterial in origin, formed during an anoxic event. The black arrows point to the boundary between phases 1 and 2 and white and black arrows to the boundary between phases 2 and 3.Thüste, Schütte Company quarry, section Thü 6/1, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation. Scale bar = 2.30 mm (see the location of thin sections in Figure 3).

PLATE 2

Vertical section in the middle part of stromatolite bioherms Type 2, showing the inner structure, growth phase 2 with green alga, *Brachydactylus reisi* DRAGASTAN & RICHTER (B) and growth phase 3 with vertical cracks and irregular fenestral fabrics. The growth phases 2 and 3 are crossed by vertical channels (C) with ramifications (Cr) filled with mat clasts, *Brachydactylus* alga and microbial intraclasts.Thüste, Schütte Company quarry, section Thü 2 a, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation. Scale bar = 2.30 mm.

PLATE 3

Vertical section in the middle and upper parts on the right margin of stromatolite bioherms Type 2, showing the inner structure, growth phase 2 crossed by a narrow vertical channel (arrows and C) and phase 3 with two types - thicker (T) and thinner (t) of microbial laminae corresponding to two seasonal periods of trapping and binding processes and different fenestral fabrics. Thüste, Schütte Company quarry, section Thü 1, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation. Scale bar = 2.30 mm.

PLATE 4

Vertical section in the middle part of stromatolite bioherms Type 2, showing the inner structure, growth phase 2 with *Brachydactylus* (B) and phase 3 with voids (v), vertical cracks (c) and fenestral fabrics (f). Between these phases a clear erosional surface occurs, impregnated by pyritized minicrusts. Thüste, Schütte Company quarry, section Thü 5, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation. Scale bar = 2.30 mm.

PLATE 5

Vertical section in the middle and upper parts on the left margin of stromatolite bioherms Type 2 showing the inner structure, and growth phases 2 and 3. Between the phases 2 and 3 occur an irregular erosional surface impregnated with pyritezed crust. The growth phase 3 presents the domal (D) and after planar, wavy (P) inner structure, vertical pyritized (f) and sparry (s) cracks. Thüste, Schütte Company quarry, section Thü 6, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation. Scale bar = 2.30 mm.

PLATE 6

Vertical section in the middle part of the stromatolite bioherms Type 2, showing the inner structure, growth phase 2 with *Brachydactylus reisi* (A) and different reworked clasts (c) - microbial mats, intraclasts, or ostracod shells resulted from the erosional action of bottom currents (Ebc). The growth phase 3 shows domal (D) and planar, wavy pustular (P) growth form. Between two phases there is an erosional surface with a thin pyritized crust (Fox). Thüste, Schütte Company quarry, section Thü 1b, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member,Münder Formation. Scale bar = 2.30 mm.

PLATE 7

Vertical section in the middle part of the stromatolite bioherms Type 2, showing the inner structure, growth phase 2 with reworked material (clasts, mat debris and nodules with alga *Brachydactylus reisi* (B), a thin erosional surface impregnated with a pyritized crust (Fox). The growth phase 3 shows some reworked material in the basal part (alga *B. reisi* - Br and clasts), domal (D) and planar (P) structures. Thüste, Schütte Company quarry, section Thü 2, Collection of Prof. Dr. Detlev K. Richter, uppermost Tithonian, Katzberg Member, Münder Formation, Scale bar = 2.30 mm.

PLATE 8

Figs. 1 - 4. *Chlorellopsis coloniata* REIS 1923, 1 - 3. Thalli composed of sphaerical cells (see arrows) surrounded by a hexagonal sparry, network-like muff, similar to the hexagonal muff of the Recent genus *Chlorella* included in large nodular microbial mats. 4. the same alga disposed in the central part like a nucleus in an ellipsoidal-microbial oncoid (o) with superficial laminae.
Figs. 5- . *Brachydactylus reisi* DRAGASTAN & RICHTER 2001, 5. *Holotype* (from Dragastan & Richiter 2001), nodular thallus with protuberances consisting of small, fan-shaped bundles crossed by dichotomously branched tubes (arrows), 6 - 7. *Paratypes*, longitudinal and transverse sections showing the fan-shaped bundles and the minidigitate fascicles with tubes (arrows).
uppermost Tithonian, Thüste stromatolites, Katzberg Member, Münder Formation.
Scale bar: Figs 1, 3, 4 - 5 = 0.20 mm, Figs. 2, 6 -7. = 0.50 mm.

PLATE 9

Figs. 1 - 4. *Springerella bifurcata* DRAGASTAN & RICHTER 2001, *Paratypes,* 1. Longitudinal - oblique section in the hemispherical thallus crossed by long Y-shaped, open dichotomously branched tubes with swellings in the branched area, 2. Different sections attached on the serpulid tubes or having nuclei of serpulids, 3 - 4. longitudinal and longitudinal-oblique sections in thalli showing the types of branched tubes and the swellings with large diameters (arrows).
Fig. 5. *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985, *Paratype,* vertical-longitudinal section, in thallus crossed by V-shaped dichotomously branched tubes with compact inner structure. In Fig. 4, the thallus is attached on a serpulid tube (see arrows for the attachment area).
Berriasian of Deister area, Borberg Member, Münder Formation. Scale bar: Figs 1 - 2, 5 = 0.30 mm, Figs 3 - 4 = 0.50 mm.

PLATE 10

Fig.1. *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985, *Paratype,* longitudinal section in a nodular algal consortium composed of *Rivularia* (R) and microbial crust (m).
Figs. 2 - 3. *Springerella bifurcata* DRAGASTAN & RICHTER 2001, *Paratypes*, 2. transverse section in a thallus fixed on a nucleus of serpulid tube (S) being reincorporated in another large serpulid tube, 3. longitudinal - oblique section in hemispherical thallus showing the characteristic branching tubes.
Figs. 4-5. *Springerella fuchtbaueri* DRAGASTAN & RICHTER 2001, *Paratypes,* longitudinal sections in small, hemispherical thalli crossed by claviform dichotomously branched tubes attached on a serpulid tube (Fig. 4, arrow, F, S) and (Fig. 5 F).
Figs. 6-8. *Springerella westphalica* nov. sp., 6. *Holotype*, longitudinal section in a hemispherical thallus with lobes (W) crossed by lax dichotomously branched, very open tubes showing many swellings along the tubes (arrows), 7. *Isotype,* vertical-oblique longitudinal section in thallus (W) showing the characteristic branching tubes and swellings, 8. *Isotype*, transverse section in thallus showing the branched tubes with large spaces in-between, and the quadrangular disposition of tubes.
Fig.9. Microbial oncoid from massive limestones.
Berriasian of Deister area, Borberg Member, Münder Formation. Scale bar = 0.30 mm.

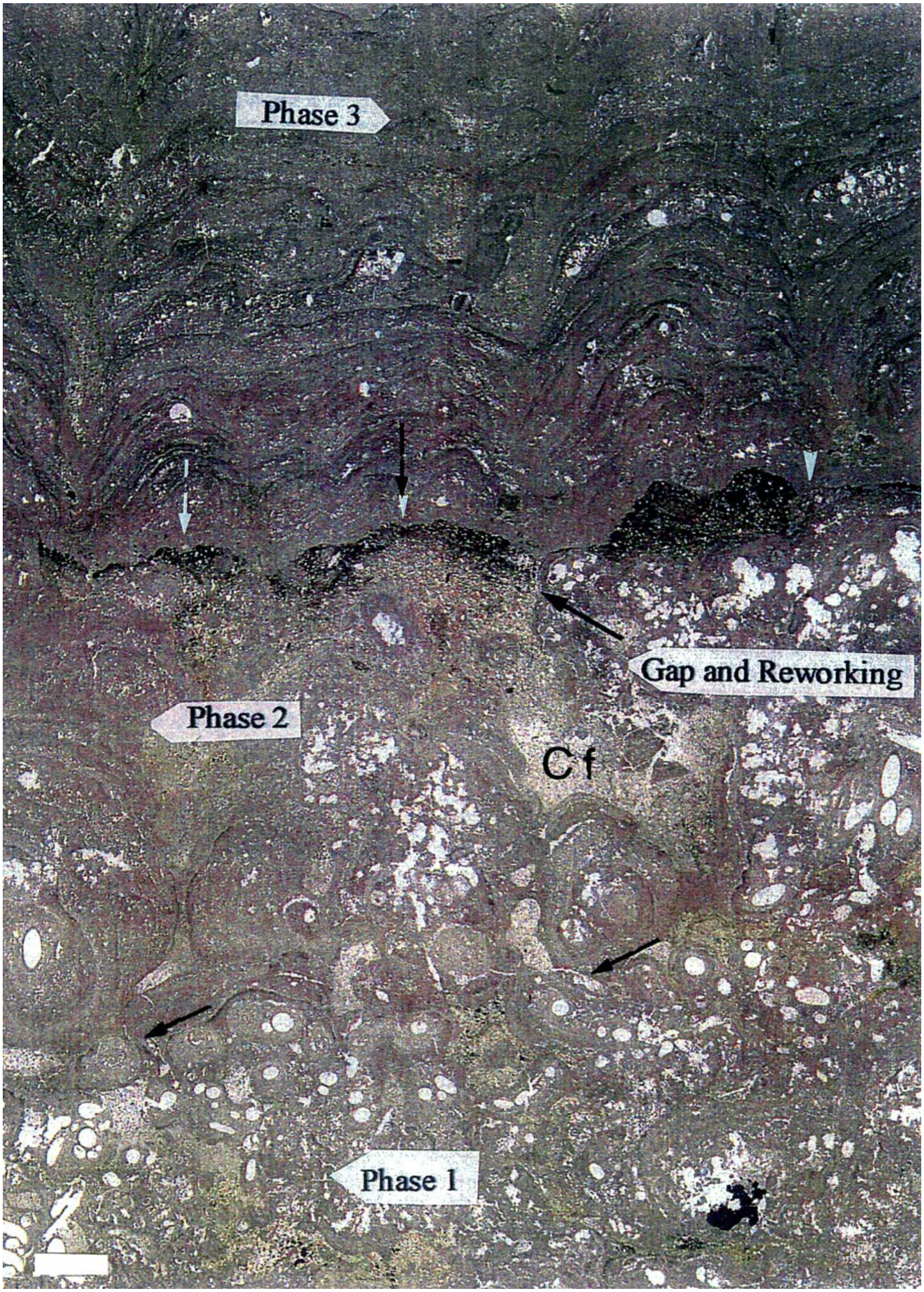
PLATE 11

Figs. 1-2. *Deisterella germanica* nov.gen.nov.sp., 1. *Holotype*, (D) vertical-longitudinal section in a hemispherical thallus, rarely consisting of Y-shaped and more frequently of V-shaped dichotomously branched tubes; in the basal part of the thallus spheroidal calcitic bodies, as possible reproductive organs (R) are present, 2. Detailed image of the same thallus showing the different types of branched tubes and reproductive organs (R).
Figs. 3-4 . *Bracydactylus* sp., Two specimens and vertical sections in small, fan-shaped thalli consisting of bundles with fascicles (b and arrows). This alga occurs only in growth phase 3 of Thüste stromatolites bioherms Type 2, mostly between the microbial laminae of the domal structure.
Figs. 3, 5. *Pseudorothpletzella* sp., Two specimens, vertical sections in the encrusting alga? represented by a thin, flat, sheet-like layer (R) consisting of tiny „tubes” or cells; they are difficult to observe if they show branching; cells disposed as juxtaposed two up to three sheets (R).
Figs. 5-6. *Caddisfly pupal larvae of Trichoptera* represented by cylindrical straight (c) or round (circular) case depending on the orientation of the sections, outlined by grains of microbial peloids grouped in tubular cases and framboidal pyrite (p). Frame of a microbial domal structure.
Figs. 1-2. Berriasian of Deister area, Borberg Member, Münder Formation, Figs. 3-6. uppermost Tithonian, growth phase 3 of Thüste stromatolites bioherms Type 2,
Katzberg Member, Münder Formation. Scale bar: Fig. 2. = 0.50 mm, Figs. 1, 3-6 = 0.30 mm.

PLATE 12

Figs. 1-2. *Rivularia lissaviensis* (BORNEMANN 1887) DRAGASTAN 1985, *Paratypes*, vertical sections in a crustose thalli attached on serpulid tubes, crossed by V-shaped dichotomously branched tubes.
Fig. 3. *Pseudorothpletzella* sp., a flat crust disposed on a microbial domal structure
consisting of cells (R) juxtaposed as two sheets.
Fig. 4. Transverse section in caddisfly (c) pupal larvae of Trichoptera formed by microbial peloids grouped in a round structure, „up” in a microbial domal laminae of growth phase 3 of Thüste stromatolites.
Fig. 5. *Coprolite* - longitudinal section in a cylindrical fecal pellet (cp) possibly produced by gastropods, and an isolate pyritized ooid (o).
Fig. 6. Algal crust (a - arrows) consisting of primary tubes, continued with secondary tubes with two or three branches.
Figs.1-2. Berriasian, Deister area, Borberg Member, Münder Formation and Figs. 3-6., growth phase 3 of Thüste stromatolites, uppermost Tithonian, Katzberg Member,
Münder Formation. Scale bar: Fig. 1 = 0.50 mm, Figs 2-6 = 0.30 mm.

PLATE 1



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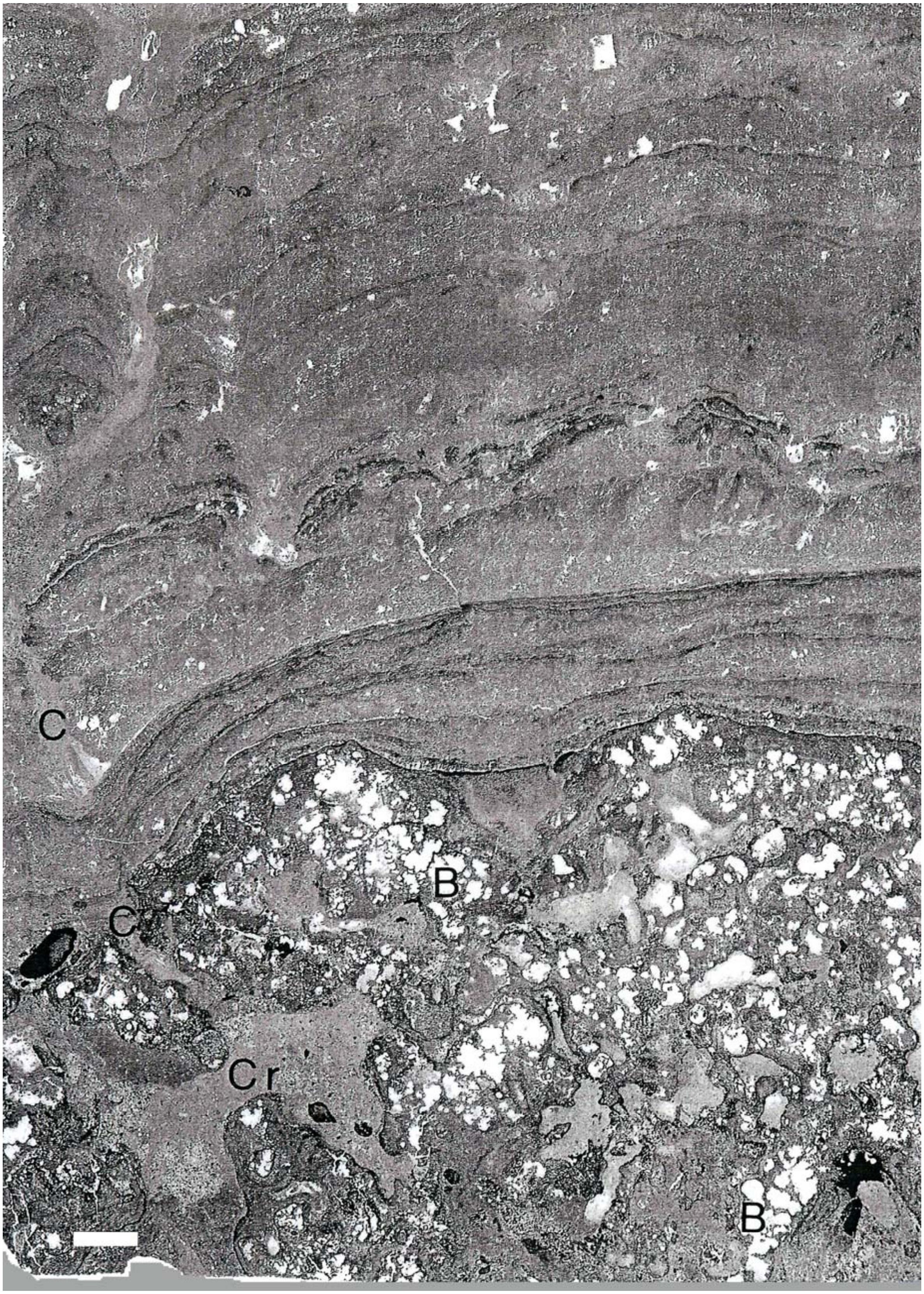
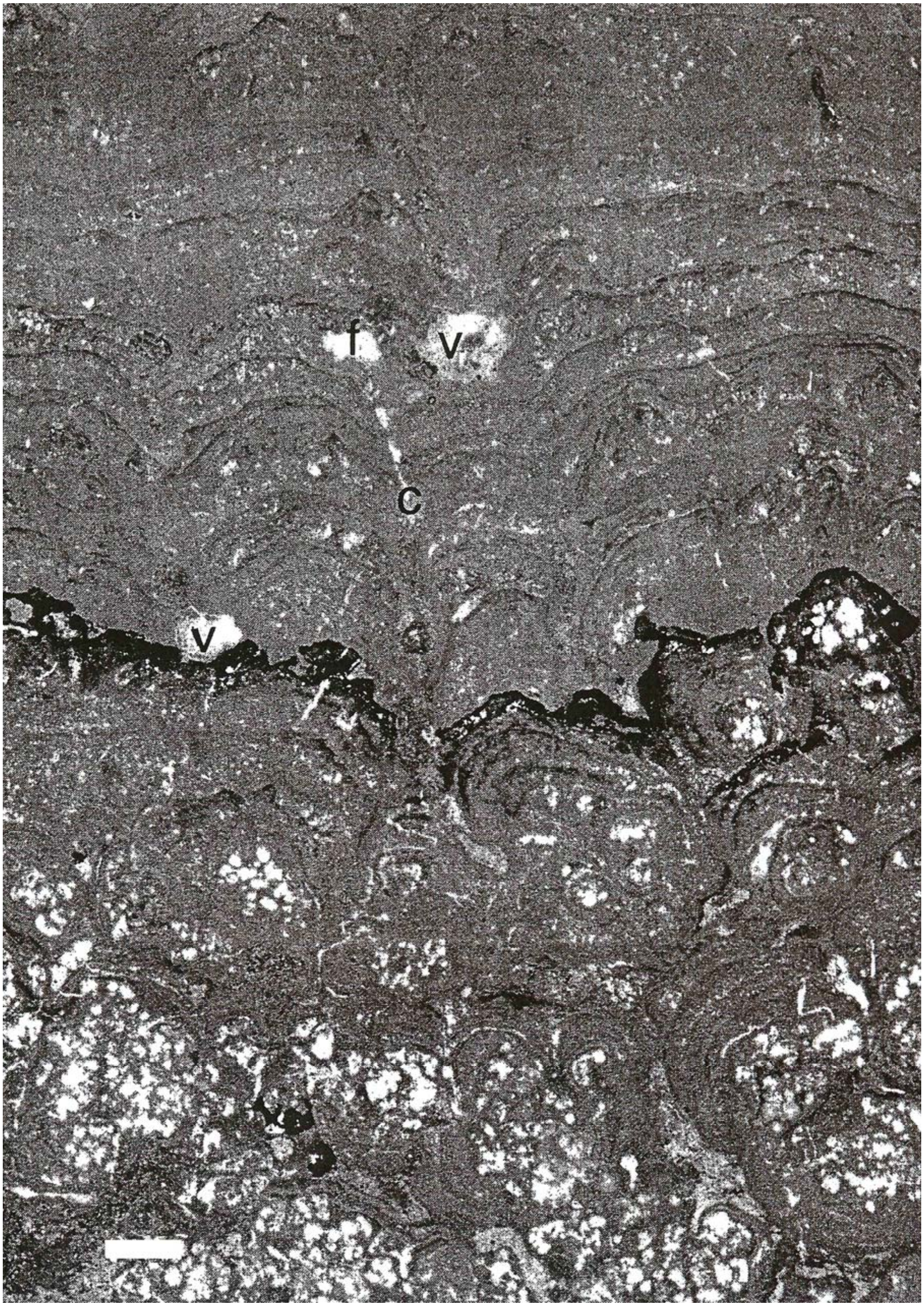


PLATE 3

PLATE 4



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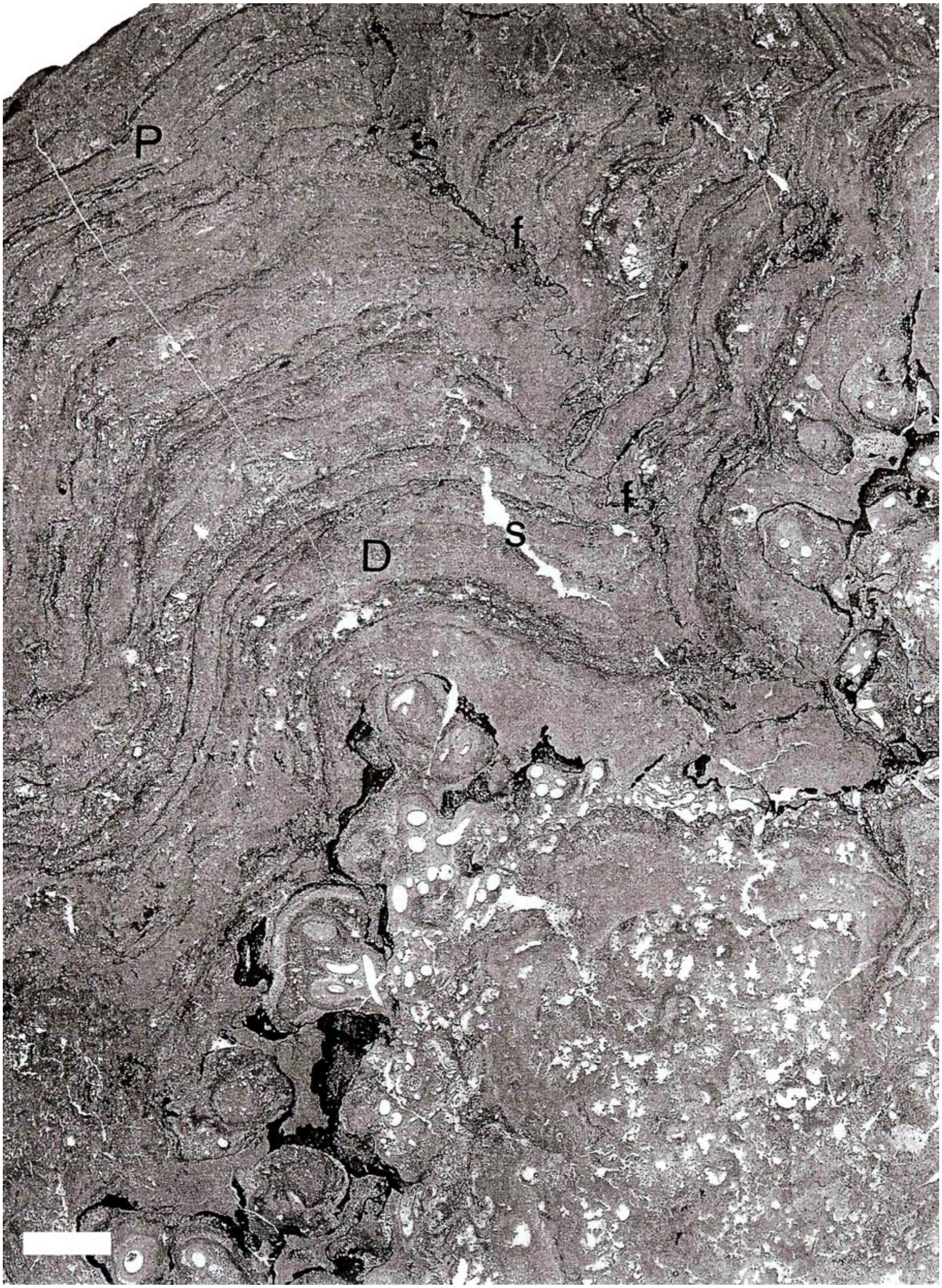
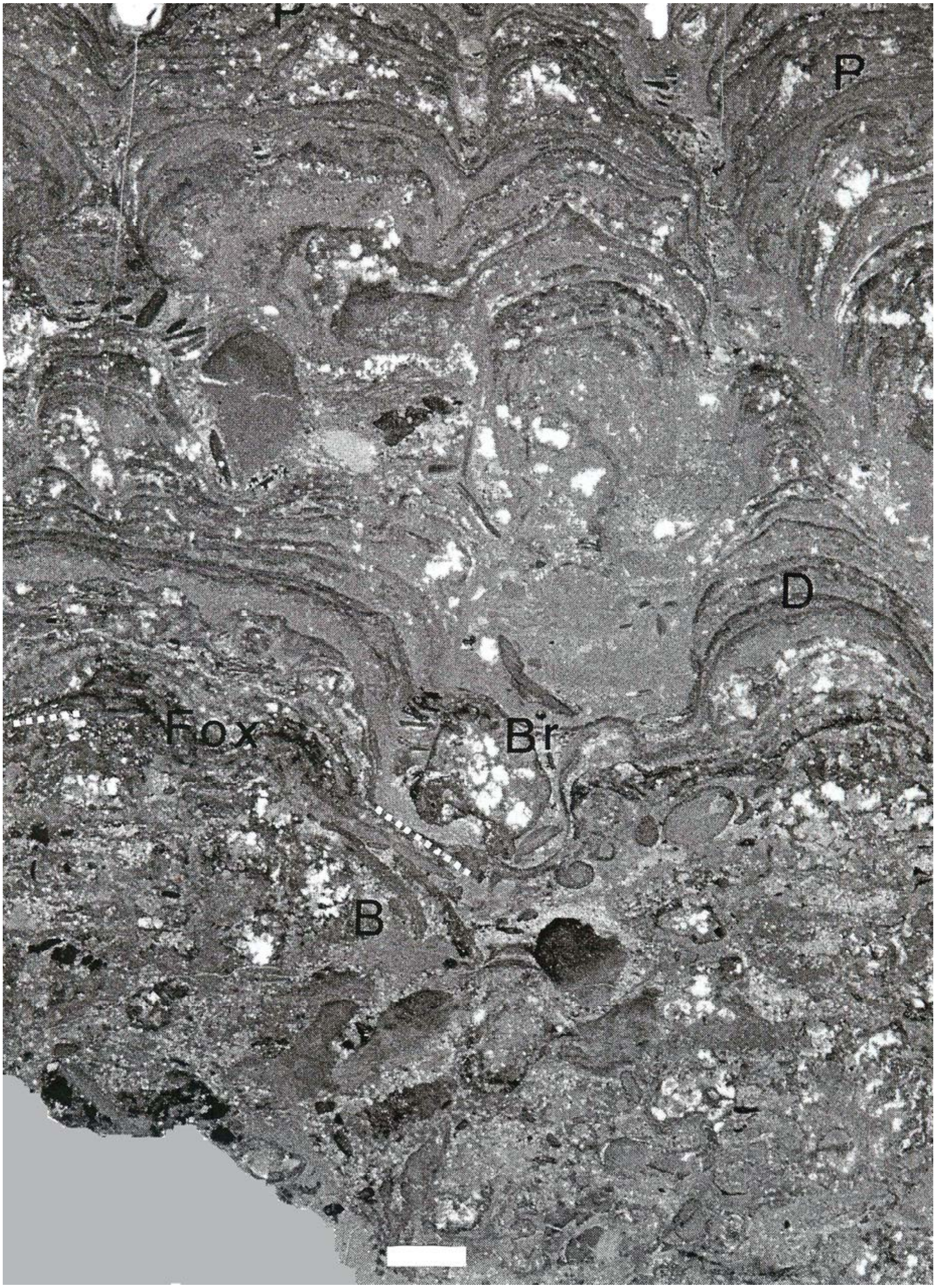


PLATE 6

PLATE 7



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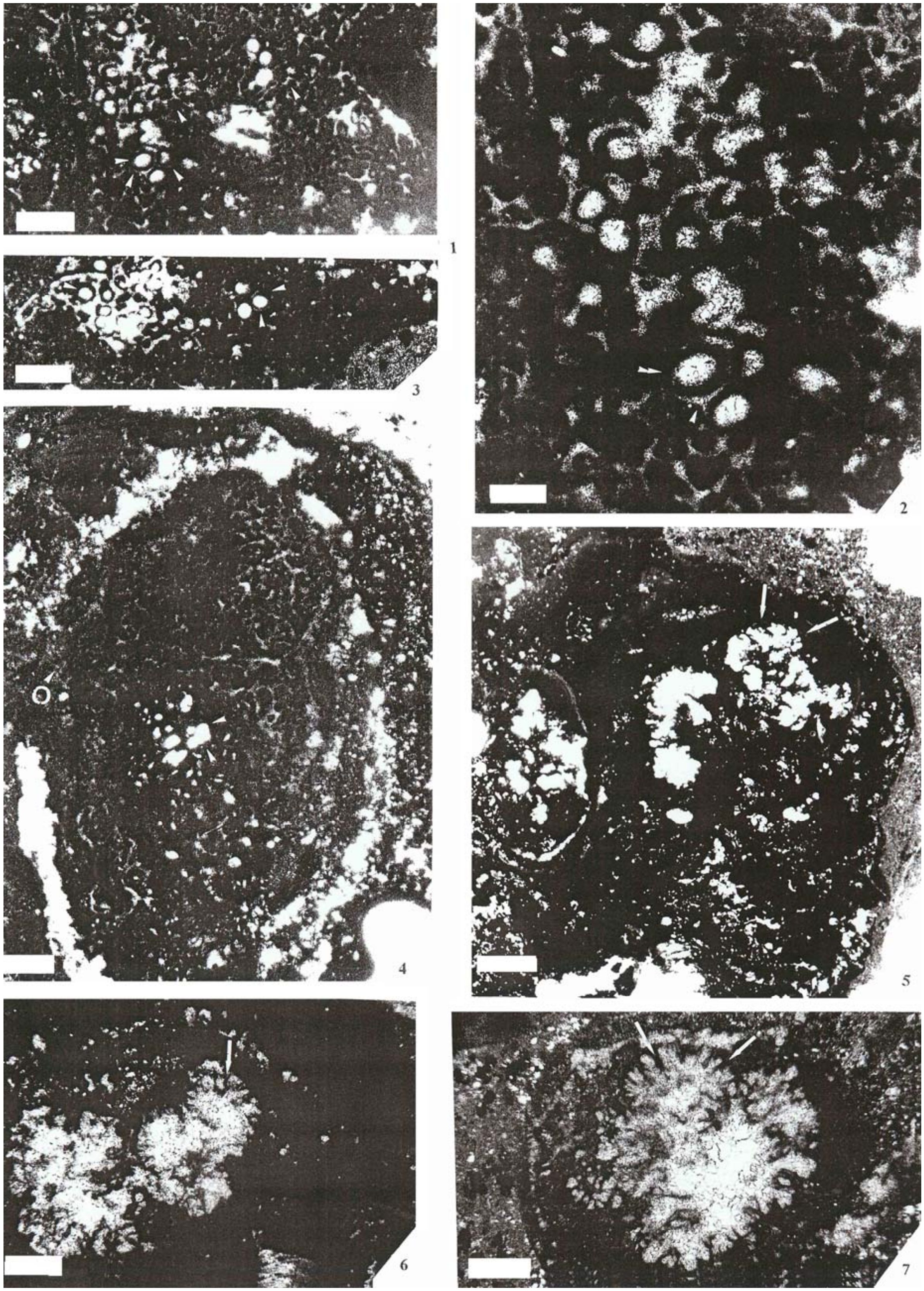

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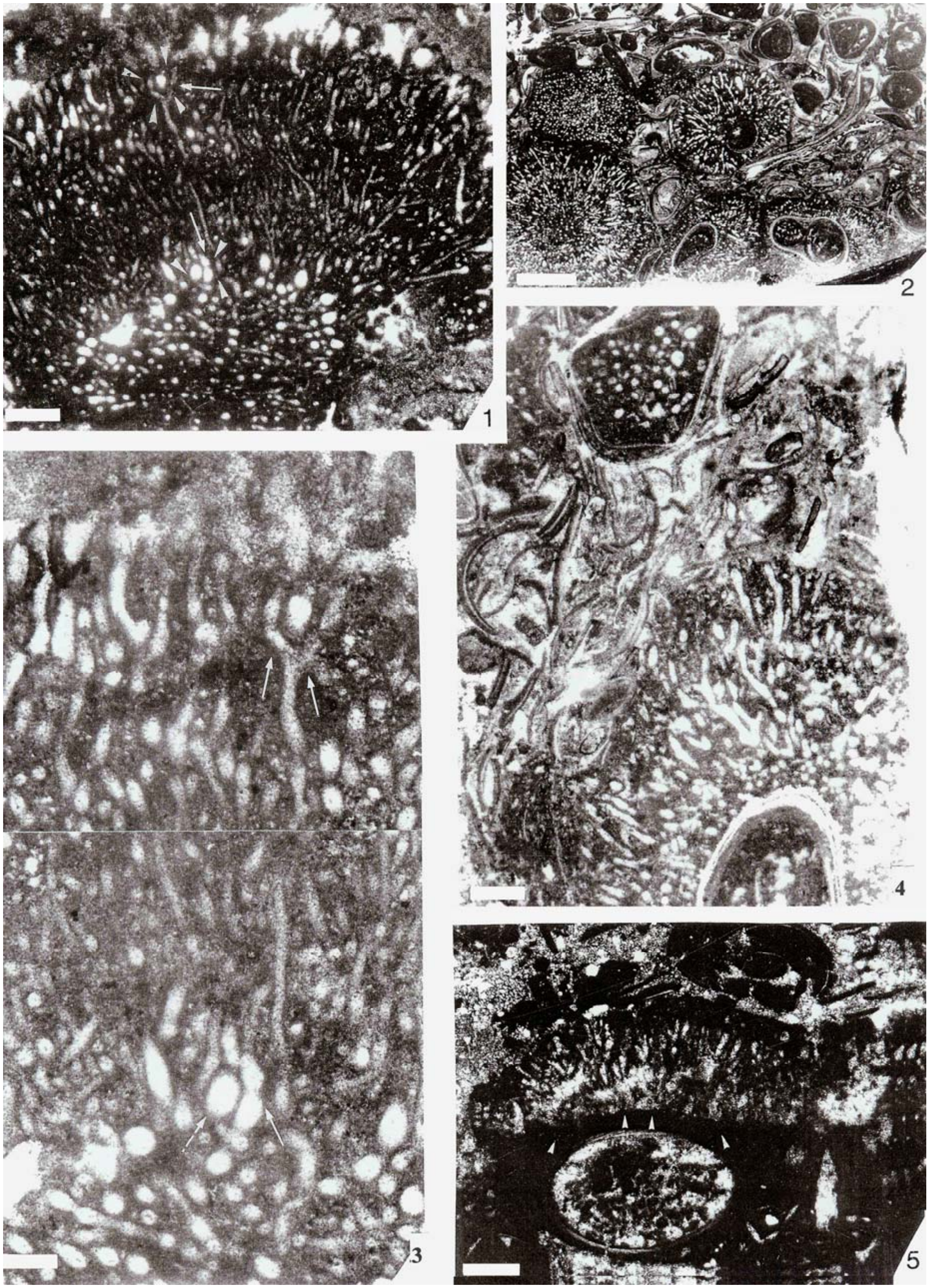

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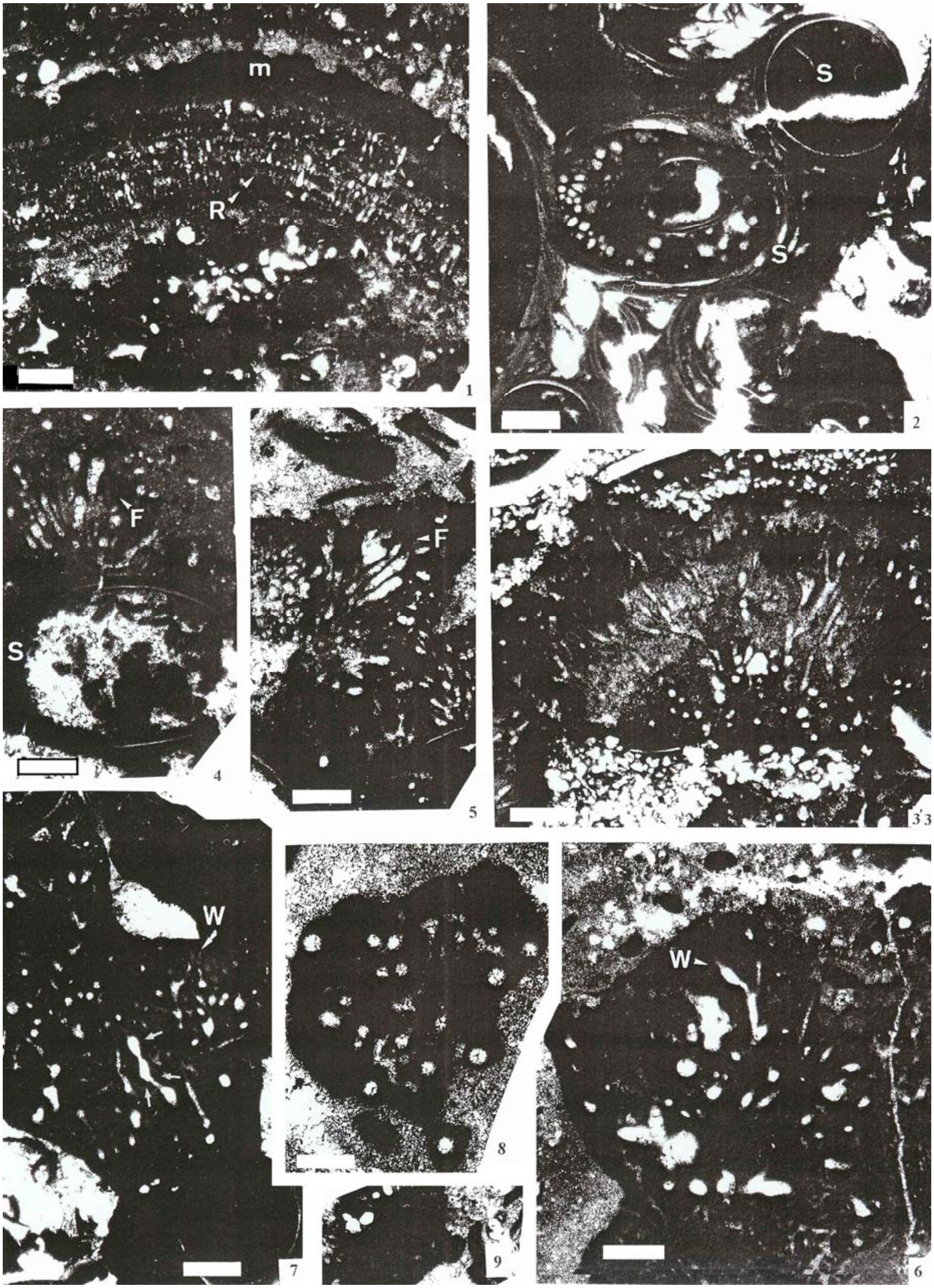

PLATE 11

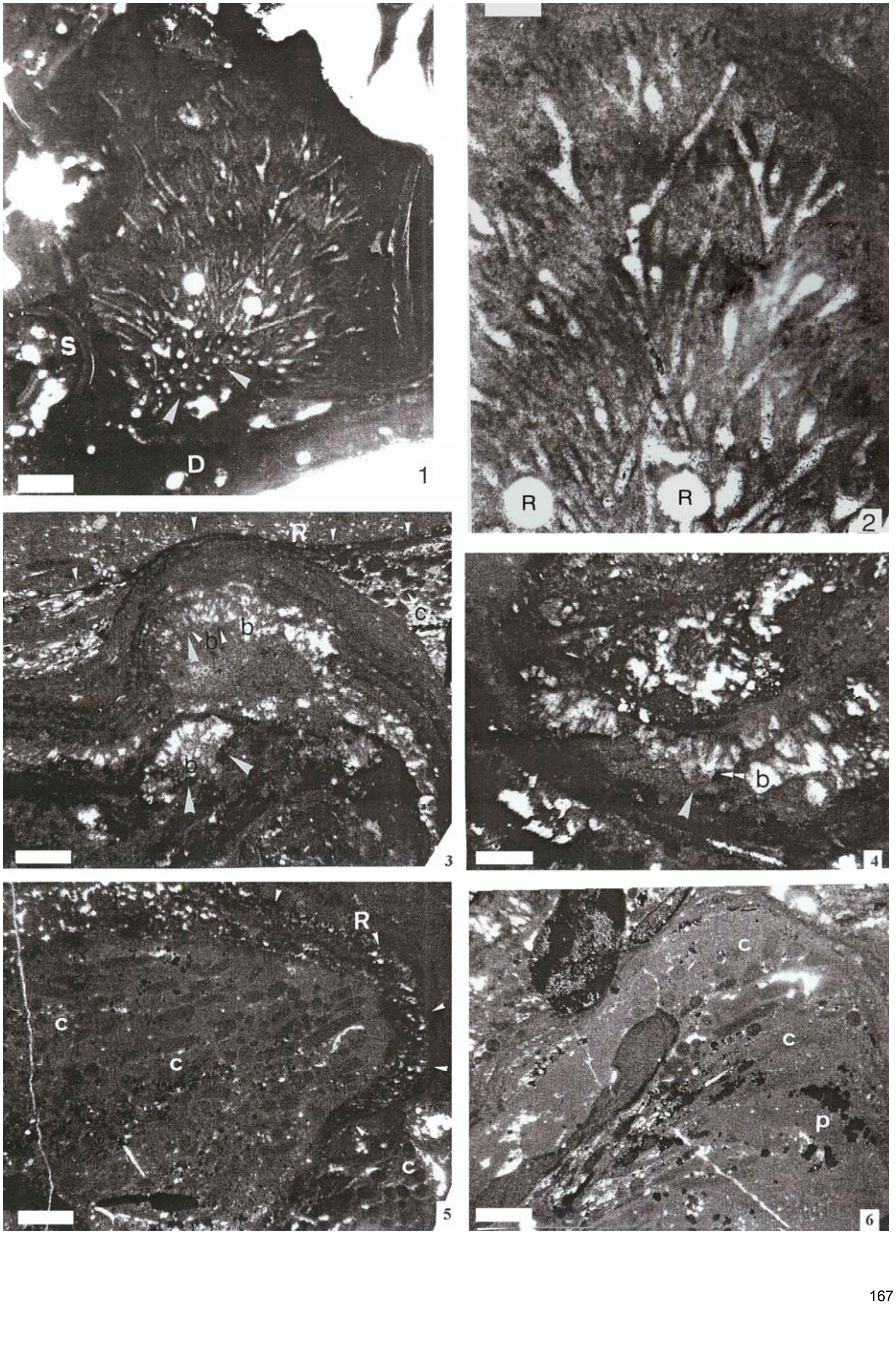

PLATE 12