Festschrift zum 60. Geburtstag von Erik Flügel				Redaktion: Baba Senowbari-Daryan & Albert Daurer
Abh. Geol. B.-A.	ISSN 0378-0864 ISBN 3-900312-90-7	Band **50**	S. 295–317	Wien, 6. April 1994

Cretaceous (Albian–Turonian) Calcareous Algae from Egypt and Jordan – Systematics, Stratigraphy and Paleogeography

By JOCHEN KUSS*)

With 1 Text-Figure, 1 Table and 5 Plates

Ägypten
Jordanien
Kreide
Kalkalgen
Systematik
Stratigraphie
Paläogeographie

Contents

Oberkretazische (Alb–Turon) Kalkalgen aus Ägypten und Jordanien – Systematik, Stratigraphie und Paläogeographie

Zusammenfassung

Im folgenden Artikel werden Kalkalgen aus Alb–Turon-Kalken Ägyptens und Jordaniens systematisch beschrieben und in Hinblick auf ihre paläogeographischen und stratigraphischen Verbreitungen abgehandelt. Zahlreiche mittelkretazische Kalke der Region sind durch hochdiverse Grünalgenfloren gekennzeichnet, wogegen Rotalgen nur untergeordnet vorkommen. Neben den jüngst dargestellten kretazischen Mikrofloren der Region (KUSS & CONRAD, 1991) werden hier weitere 12 Grünalgen-Arten (darunter 10 Vertreteter der Dasycladales mit *Acroporella hamata* n.sp., *Acicularia magnapora* n.sp. und *Likanella sinaica* n.sp.) und zwei Rotalgen-Arten beschrieben und mit äquivalenten Formen verschiedener tethyaler Vorkommen verglichen. Die biostratigraphische und paläogeographische Bedeutung dieser Algen wird im Zusammenhang diskutiert.

Abstract

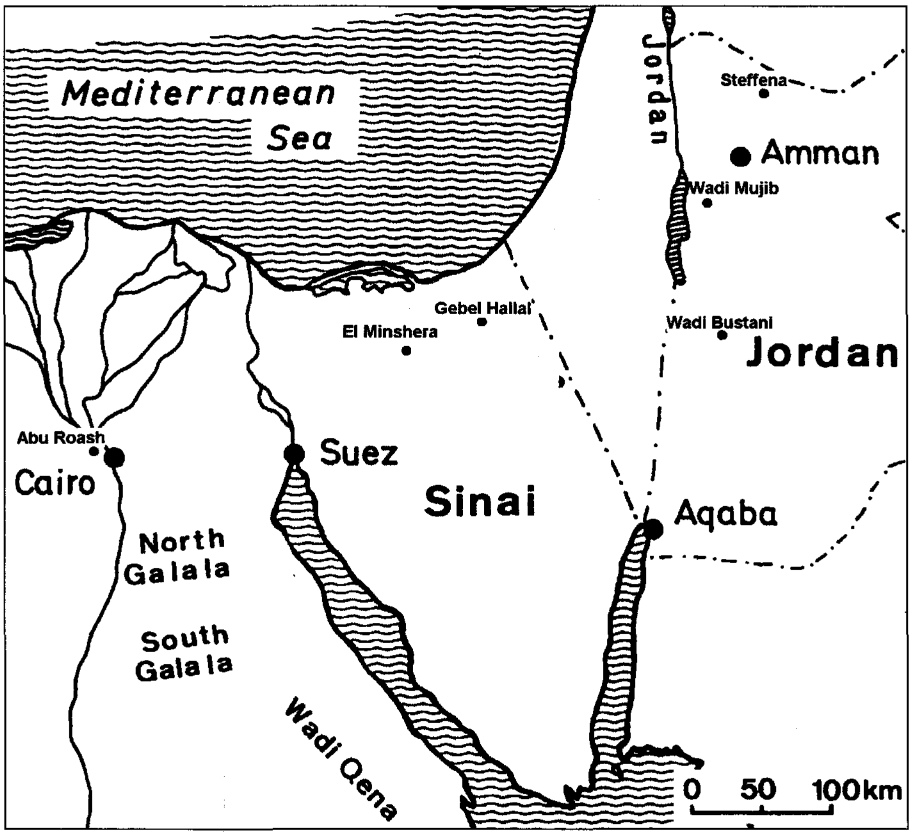
The present work deals with the systematic description, paleogeography, and stratigraphic value of calcareous algae from Albian–Turonian limestones of Egypt and Jordan. Here, many Mid Cretaceous limestones are characterized by highly diversified green algal floras, while red algae are of subordinate value. Besides the recently reported Cretaceous microfloras from the region (KUSS & CONRAD, 1991) additional 12 species of green algae (among them 10 dasycladaleans with *Acroporella hamata* n.sp., *Acicularia magnapora* n.sp. and *Likanella sinaica* n.sp.) and two species of red algae are described and compared with those from several Tethyan occurrences.
The biostratigraphic and paleogeographic importance of the described algae is discussed.

1. Introduction

Besides foraminiferids, benthic algae may be frequent constituents within the shallow marine Cretaceous limestone sequences of the Middle East, as mentioned by several authors: ELLIOTT (1968), BASSON & EDGELL (1970), RADOIČIĆ (1975) and KUSS (1986). The scope of presently continuing studies on north-east African limestones is to document the microfaunal/floral composition of Cretaceous carbonates with respect to biostratigraphy and paleogeography. KUSS & CONRAD (1991) gave a first summarized description of the microfloral content of the Mid Creta-

*) Author's Address: Prof. Dr. JOCHEN KUSS, Universität Bremen, FB 5, P.O.Box 330440, D-28334 Bremen.

Text-Fig. 1.
Location map of the studied sections in Egypt, Sinai andJordan where the algae-bearing limestone samples were taken. The sections of the here new desribed taxa were drawn in Text-Figs.2 and 3.

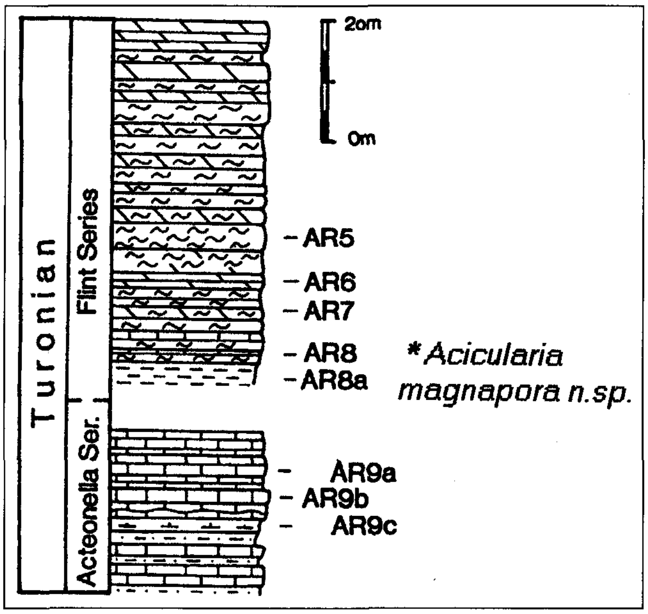


ceous carbonates of Egypt and Jordan. The calcareous algae described here are based on newly collected samples from limestones of different localities in Jordan, northern Sinai and one locality close to the city of Cairo (Text-Fig. 1).

The Mid Cretaceous sediments from the southern parts of Egypt, Sinai and Jordan are mainly composed of nearshore silt-/sandstones with intercalated carbonates; they grade into thicker carbonate units intercalated with marls and shales further north, exposed in localities of northern Egypt, the central Sinai and northwestern Jordan, where the described algae were collected. The stratigraphic subdivision of the Cretaceous sequences in that region was recently summarized by KUSS & MALCHUS (1989), KUSS (1992a, b) and POWELL (1988). These articles also refer to sedimentologic interpretations of the varied rock suites; two of them (Text-Figs. 2,3) were drawn with respect to the stratigraphic occurrences of the new algal species described here.

The green algae represent the most important group (with respect to frequency and diversity) of Mid Cretaceous calcareous algae from the Middle East. Within that group, the dasycladaleans are by far the most significant, followed by the udoteaceans. Red algae – mainly gymnocodiaceans and corallinaceans – are only of subordinate importance; the same is true for solenoporaceans, cyanobacteria and microproblematica.

This general distribution pattern of prevailing green algae and subordinate red algae contrasts with descriptions of microfloral distributions from several different Mid Cretaceous localities, e.g. from Iran (DELOFFRE et al., 1977) or the Northern Calcareous Alps (MOUSSAVIAN, 1988; SCHLAGINTWEIT, 1991b), where the red algae reach much higher frequencies and diversities.



Text-Fig. 2.
The late Turonian succession of Hassana Dome/Abu Roash (see Text-Fig.1) close to the city of Cairo.
Within the listed samples the stratigraphic occurrence of *Acicularia magnapora* n.sp. is indicated.
Subdivision after JUX (1954) and HATABA & AMMAR (1990).

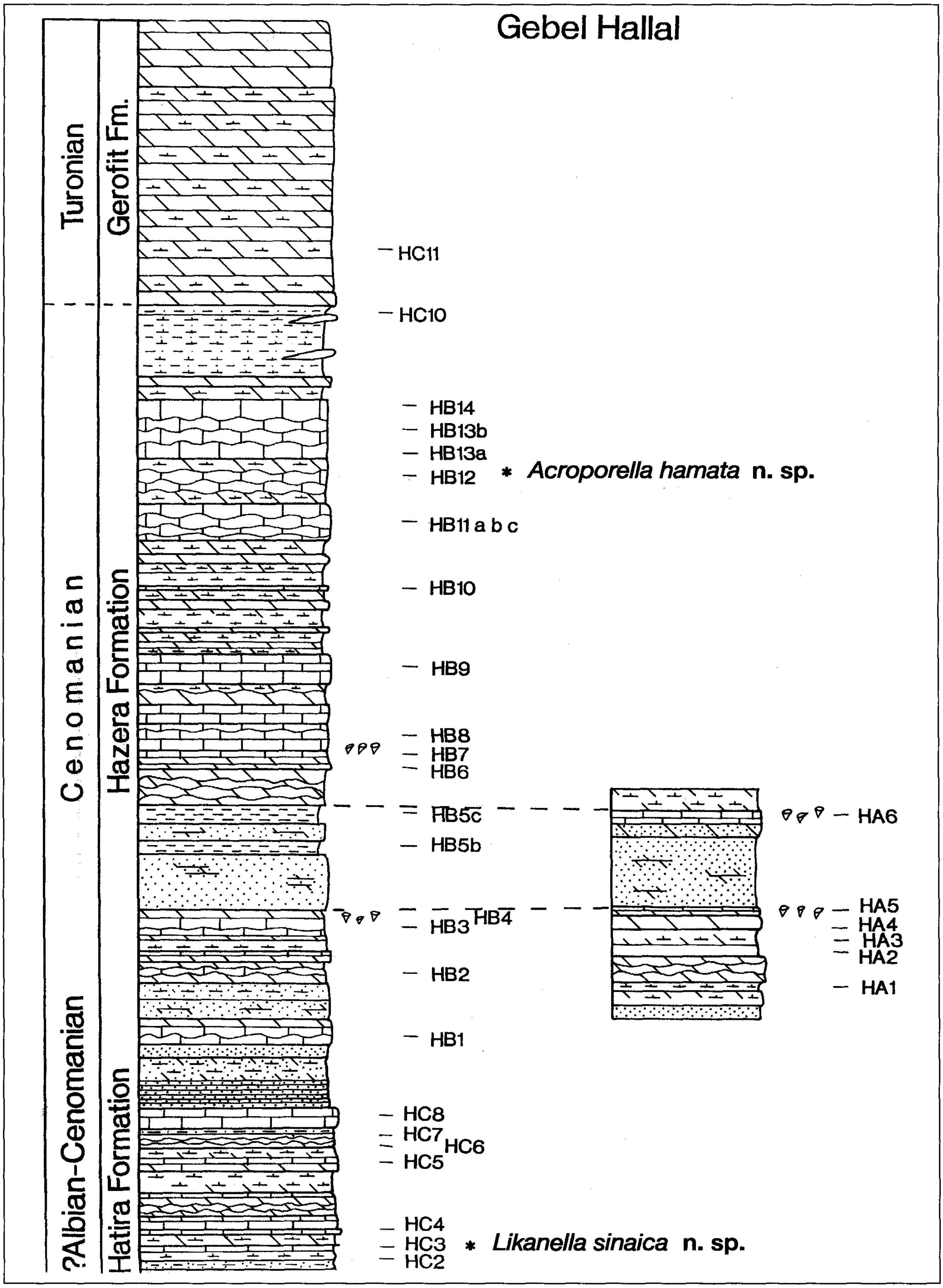
2. Systematic Description

Systematic classification of the udoteaceans (including the abbreviations proposed here) follows the revision of BASSOULLET et al. (1983).

The described Rodophyceae belong to two different systematic groups: While the classification of the gymnocodiaceans is based on MU (1990), the description of the one coralline alga follows BARATTOLO & RE (1984).

The used systematic classification of the dasycladaleans is based on the subdivision given by BERGER & KAEVER (1992); in contrast to the classification proposed by DELOFFRE (1988), the former authors introduced the new family Triploporellaceae, including the euspondyl/cladospore dasycladaleans, while the euspondyl/choristopore forms remain in the family Dasycladaceans. The here described taxa are from three families: the Triploporellaceae (*Acroporella*, *Cylindroporella*, *Heteroporella*, *Trinocladus*), the Dasycladaceae (*Likanella*) and the Acetabulariaceae (*Acicularia*). All abbrevations used for description follow BASSOULLET et al. (1978).

Short synonymy lists referring especially to occurrences in neighbouring areas were added to most descriptions.



Text-Fig. 3.
The Albian-Turonian succession of Gebel Hallal (northern Sinai; see Text-Fig.1).
The column is drawn with respect to sample-horizons and occurrences of the new species *Acroporella hamata* n.sp. and *Likanella sinaica* n.sp.

2.1. Udoteaceans

Genus: *Boueina* TOULA, 1883

The main criteria for subdivision of the similar genera *Boueina*, *Halimeda* and *Arabicodium*, based on the arrangement of filaments and utricel structures were given by ELLIOTT (1982) and BASSOULLET et al. (1983).

Boueina pygmaea (PIA, 1936)

(Pl. 3; Figs. 5, 8–11)

1936 *Boueina pygmaea* – PIA, p. 12–13, Pl. 5; Figs. 1–9, Cenomanian–Turonian of Libya.
1960 *Boueina pygmaea* – ELLIOTT, p. 224, upper Cretaceous of Iraq and Oman.
1975 *Boueina pygmaea* – RADOICIC, p. 149, 152, Cenomanian–Turonian of Libya.
1986 *Boueina pygmaea* – KUSS, p. 231, Fig. 5f–i, Cenomanian–Turonian and Campanian–Maastrichtian of Egypt.

The broken chips of the cylindrical, segmented thalli show strong calcification of the medullary and cortical zones. The interwoven tubular filaments of the narrow medullary zone diverge to the cortical zone; towards the periphery they ramify into smaller threads, curving and diverging in all directions.

Dimensions: D = 0.48–0.8 mm;
dtm = 0.026–0.055 mm.

Boueina pygmaea occurs in algal packstones of Cenomanian limestones from Gebel El Minshera/ northern Sinai (Text-Fig. 1) together with fragments of ?*Permocalculus* sp. (see below).

Boueina cf. *hochstetteri* TOULA, 1883

(Pl. 3; Figs. 1–4)

1922 *Boueina hochstetteri* – RAINERI, p. 72, Fig. 13, Cenomanian–Tronian of Libya
1963 *Boueina hochstetteri* var. *moncharmonti* – DE CASTRO, p. 114–115, Pl. 6–8, Aptian of southern Italy
1969 *Boueina hochstetteri* – ELLIOTT, p. 327–328, Pl. 61; Figs. 1–2, Valanginian–Hauterivian of Iraq.

The elongated, segmented thallus has thick calcified cortical layers, while the medullary zone is less calcified. Internal threads are larger and more regularly spaced in comparison to *B. pygmaea*. Threads are clearly dichotomizing towards the cortical zone.

Dimensions: L = 6 mm;
D = 0.98–1.7 mm;
dtm = 0.04–0.08 mm.

Comparisons with *Boueina hochstetteri* var. *moncharmonti* collected from the type-locality (DE CASTRO, 1963) document the close relationships with the here described *B.* cf. *hochstetteri*, concerning size and arrangement of threads; the first is interpreted as an intermediate form between *B. hochstetteri* and *B. pygmaea* (BASSOULET et al., 1983).

Boueina cf. *hochstetteri* was found in bioclastic wackestones, composed of echinids together with few specimens of *Cylindroporella sugdeni* and miliolid foraminiferids; these samples are from Cenomanian limestones of Wadi Kufranji, a section south of Wadi Bustani/Jordan (Text-Fig. 1). Moreover, this species occurs in Cenomanian limestones of Gebel Hallal/Sinai (Text-Figs. 1,3).

2.2. Red Algae

Class: Rhodophyceae RUPRECHT, 1851
Family: Gymnocodiaceae ELLIOTT, 1955
Genus: *Permocalculus* ELLIOTT, 1955

ROUX & DELOFFRE (1990) recently started a taxonomic revision of that extinct rhodophycean family, mainly based on comparisons of the internal structures of the four genera. Based on ELLIOTT (1956) the external morphologies of the Cretaceous *Permocalculus* species were compared by SCHLAGINTWEIT (1991a), while MU (1990) stressed the importance of reproductive structures for classification.

Besides the occurrences of *P. irenae*, *P. budaensis* and *Permocalculus* sp., described by KUSS & CONRAD (1991) from Albian–Tronian limestones of Egypt and Jordan, the following species was recognized in Cenomanian strata of the Sinai.

?*Permocalculus* sp.

(Pl. 3; Figs. 6,7)

The elongated, irregularly finger-shaped ("forme de doigt") thalli are strongly calcified; internally they show well preserved threads arranged in central (medullary) and peripheral (cortical) zones, running longitudinally along the axis. The lateral filaments are in a nearly perpendicular position to those of the medullary zone, with somewhat thinner diameters. Only few are bifurcating towards the outer surface. No cross-partitions were found in either type of filaments.

Spherical and oval sporangia are arranged in rows within the inner third of the cortical areas. They are filled with dark micrite; some of them hold small tubes, running towards the external parts of the thallus (Pl. 3; Fig. 7).

Dimensions: L = 1.3–2–9 mm;
D = 1.1–1.65 mm;
$d_{fil.}$ = 0.023–0.35 mm;
$d_{sp.}$ = 0.09–0.17 mm.

The systematic assignment of the described specimens to the gymnocodiaceans is mainly supported by their sporangial cavities, a characteristic which is most indicative for the red algal affinities (MU, 1990). However, the red algal nature of the gymnocodiaceans in general needs further confirmations, such as the proof of cross partitions within the filaments, or septal plugs as mentioned by MU (1990). Nevertheless, the described specimens of ?*Permocalculus* show features of the soft tissues, which are rarely preserved in the fossil record. They may be due to quick lithification (forming a "diagenetic umbrella") of the algal material, which is also indicated by the co-occurring well-preserved chips of *Boueina pygmaea*.

?*Permocalculus* sp. was found in algal packstones together with many fragments of *Boueina pygmaea*. A Cenomanian age of the limestones from Gebel El Minshera/northern Sinai (Text-Fig. 1) is proved by foraminiferids and oysters.

Family: indet.
Genus: *Marinella* PFENDER, 1939

Marinella lugeoni PFENDER, 1939

(Pl. 1; Figs. 1–4)

1959 *Lithophyllum* (?) *shebae* – ELLIOTT – p. 220–222, Pl. 1, Fig. 7, Lower Cretaceous (Barremian–Aptian) of Southern Arabia.

1967 *Lithophyllum* (?) cf. *L. shebae* – BISMUTH et al., Pl. 12, Fig. 7; Pl. 13, Fig. 20; early Cenomanian–Coniacian of Tunisia.
1968 *Marinella lugeoni* PFENDER – BOUROULLEC & DELOFFRE, p. 218–219, Pl. 1, Figs. 7–9; early Cretaceous of southern France.
1974 *Lithophyllum* (?) *shebae* – SAINT-MARC, p. 271–272, Pl. 16, Figs. 8–9; Aptian–Turonian of Liban.

The hemispheric to nearly spheric thalli – with protuberance-like ramifications – form small nodules. Closely packed cellular threads of filaments form rounded, digitate masses. The tubular filaments show constrictions but without distinct cross-partitions. A differentiation in hypo- and perithallus is not possible; reproductive organs are not visible.

The close relationships of this taxon with different species of *Marinella* PFENDER (based on its morphologic features and biometric values) was mentioned by POIGNANT (1968) and discussed in detail by BARATTOLO & RE (1984); the latter redescribed the genus *Marinella* and compared the systematic position of *M. yugoslavica* and *M. lugeoni* with *Lithophyllum* (?) *shebae* – a form which was mentioned from different Middle East-localities, and which is closely related to *M. lugeoni*. Several authors discussed the systematic position of *M. lugeoni* within different groups of calcareous algae. While PFENDER (1939) considered *Marinella* as a bluegreen alga, JOHNSON (1969) ascribed it to the solenoporaceans, later followed by DRAGASTAN (1980) and BARATTOLO & RE (1984). However, MASSE (1979) again favoured its cyanophycean-affinities.

Many globular masses of these red algal thalli contribute to pelsparitic grain-/rudstones together with benthic foraminiferids of the genus *Cuneolina*; they occur in massive limestones at the base of the Turonian Wadi As Sir Limestone Formation of Wadi Mujib/Jordan (Text-Fig. 1). *M. lugeoni* was also found in Cenomanian and Turonian limestones of Gebel El Minshera/Sinai and Abu Roash (Text-Fig. 1).

2.3. Dasycladaleans

Family: Triploporellaceae (PIA, 1920) BERGER & KAEVER, 1992
Tribe: Cylindroporelleae PAL, 1976
Genus: *Cylindroporella* JOHNSON, 1954

JOHNSON's original diagnosis of that genus was summarized by DELOFFRE (1988) with the following few characteristics:

"... Thallus cylindrical; two types of primary ramifications: sterile and fertile, possibly secondary ramifications..."

From the at least 14 mesozoic species of *Cylindroporella*, five were described from Cretaceous carbonates of the Middle East (incl. Turkey):

◇ *C. barnesii* JOHNSON, 1954
Valanginian–Late Aptian of Irak (ELLIOTT, 1968)
Aptian–Late Albian of Lebanon (SAINT-MARC, 1970)
Late Albian–Late Cenomanian of Libya (BISMUTH et al., 1981)
Late Albian of Egypt (KUSS & CONRAD, 1991)

◇ *C. cruciformis* GRANIER & BRUN, 1991:
Valanginian of Abu Dhabi (GRANIER & BRUN, 1991)

◇ *C. parva* RADOIČIĆ, 1983
Upper Cenomanian–Turonian of Libya (RADOIČIĆ, 1983)
Upper Cenomanian of Egypt (KUSS & CONRAD, 1991)

◇ *C. sugdeni* ELLIOTT, 1957
Early Cretaceous of Oman (ELLIOTT, 1954)
Upper Aptian of Lebanon (BASSON & EDGEL, 1971)
Aptian–Albian of Israel (RAVIV & LORCH, 1992)
Aptian of Sinai (KUSS & CONRAD, 1991)
? Coniacian–Maastrichtian of central Saudi Arabia (OKLA, 1991)

◇ *C. taurica* CONRAD & VAROL
Albian of central Turkey (CONRAD & VAROL, 1990).

Cylindroporella sugdeni ELLIOTT, 1957
(Pl. 5; Figs. 1–3, 7, 8)

The articulated thallus of *C. sugdeni* consists of thick cylindrical segments, with a large central stem, surrounded by six large sporangia, alternating with primary branches. The measured biometric values: D = 0.8–0.95 mm; d = 0.21–0.26 mm; ds = 0.18–0.26 mm are clearly larger, compared with those of the type species *C. barnesii* JOHNSON, 1954 and also with *C. kochanskyae* RADOIČIĆ, 1970.

New findings from Gebel Hallal/northern Sinai (Text-Figs. 1,3) confirm the already described late Early Cretaceous occurrences of that species (KUSS & SCHLAGINTWEIT, 1988; KUSS & CONRAD, 1991); *C. sugdeni* is here associated with *C.* cf. *kochanskyae*, together with shallow marine foraminiferids of ?Albian–Early Cenomanian age.

Moreover, *C. sugdeni* also occurs in massive-white limestones of Listib-Steffena/Jordan (Text-Fig. 1), directly underlying massive rudist-bearing beds. These bioturbated wackestones hold additionally very few remains of *Halimeda* sp., ostracods, small benthic foraminiferids of the genus Gavelinella, scattered individuals of *Bolivinopsis* sp., *Lituola* sp. and quinqueloculinids. Due to the microfacies characteristics and the micropaleontologic content, a restricted marine environment of deposition (?lagoonal) is assumed. Only few biostratigraphic data are available for that section; due to lithostratigraphic correlations and the few foraminiferids, the algal limestones are of Turonian age. In consideration of the stratigraphic uncertainties, this is the first report of *C. sugdeni* from upper Cretaceous strata; the Senonian occurrence of central Saudi Arabia (OKLA, 1991) is doubtful, as the here described alga does not belong to *C. sugdeni*.

Cylindroporella cf. *kochanskyae* RADOIČIĆ, 1970
(Pl. 5; Figs. 9–13)

Within the elongated cylindrical calcareous body (D = 0.3–0.35 mm), the central stem occupies a fourth of the outer diameter (d = 0.06–0.08 mm). Each whorl is composed of a equal number of alternating large, spherical fertile blisters (∅ = 0.08–0.1 mm) and primary branches, which show a regular arrangement in vertical sections (Pl. 5; Text-Fig. 13, 14). In contrast to *C. parva* the branches do not alternate in the successive whorls.

C. cf. *kochanskyae* occurs in bioclastic wackestones together with *C. sugdeni*, *Permocalculus* sp., quinqueloculine foraminiferids and *Cuneolina* sp.; bioclasts are mainly composed of mollusc- and echinid-debris. The stratigraphic position of these *Cylindroporella*-bearing limestones from Gebel Hallal/Sinai (Text-Figs. 1,3, samples HC5 and 6) is ?Late Albian–Early Cenomanian.

Cylindroporella taurica CONRAD & VAROL, 1990

(Pl. 5; Figs. 4–6)

The simple, cylindrical thallus has a cylindrical stipe and large primary blisters. Two types of first order ramifications run perpendicular or slightly oblique to the axis: While the R1A-branches are funnel-like, uncompressed and (uncalcified) open at tips, the R1B-branches are pear-shaped or sub-spherical and closed at tips. The dimensions (D = 0.55–0.86 mm; d = 0.11–0.15 mm; l = 0.22–0.28 mm) and numbers of ramifications (R1A+R1B) = 16–18 correlate well with those given in the original description; spacing of verticils and thallus-length could not be measured, as no longitudinal sections were found.

C. taurica is characterized by a thin sheat of microcrystalline calcite, which displays a special type of calcification, discussed in detail by CONRAD & VAROL (1990).

This species occurs within fossiliferous, partly washed-out foraminiferal wackestones of ?late Albian–Cenomanian age (Gebel Hallal/Sinai, Egypt – Text-Figs. 1,3, samples HC3,10). Among the diverse microfaunas *Cuneolina* sp., *Valvulammina* sp., *Nummoloculina* sp. and plenty small, quinqueloculine miliolids occur. Few anomuran coprolithes, *Likanella sinaica* n.sp. and frequent miroproblematica of *Thaumatoporella parvovesiculifera* were found.

Genus: *Heteroporella* (CROS & LEMOINE, 1966) OTT, 1968

The following characteristics typify the genus, based on OTT (1968) and DELOFFRE (1988):

"... Cylindrical thallus with two kinds of sterile and fertile branches in alternating, independent whorls ... "

Heteroporella lepina PRATURLON, 1966

(Pl. 2; Figs. 8–10)

1966 *Heteroporella lepina* – PRATURLON, p. 202–205, Pl. 51–52 (Turonian of Italy).
1978 *Heteroporella lepina* – BASSOULLET et al., p. 130, Pl. 14, Figs. 6–8 (complete synonymy).
1981 *Heteroporella lepina* – BISMUTH et al., Pl. 5, Fig. 3.3–4, (late Albian–late Cenomanian of Tunisia).

The morphologic characteristics and biometric values of *H. lepina* (the type-species of the genus) were described in detail by PRATURLON (1966) and are well comparable with the Egyptian specimens. The primaries are narrow, compared to other species of the genus *Heteroporella*.

The typical yellowish colours of the calcareous envelopes of the thalli are additional characteristics, which are due to interlocking crystals (CONRAD & VAROL, 1990).

Descriptions of *H. lepina* range from Albian–Turonian limestones of different tethyan occurrences, where this species is common to extremely abundant in different suitable facies: *H. lepina* characterizes near-reef regions of the outer shelf (PRATURLON, 1966), but occurs also within lagoonal areas (LAUVERJAT & POIGNANT, 1977). The Egyptian specimens occur in limestones, indicating a shallow subtidal (?lagoonal) environment of deposition; these wackestones hold bioclasts (mainly echinids and rudists), many fragments of *Cuneolina* sp., and small miliolids.

H. lepina was found in middle Turonian limestones of the "Acteonella Series" (JUX, 1954; HATABA & AMMAR, 1990), directly underlying the beautifully exposed massive, rudist-bearing limestones of the Abu Roash outcrop near Cairo (Text-Fig. 1).

Tribe: Triploporelleae (PIA, 1920) BASSOULLET et al., 1978
Genus: *Acroporella* (PRATURLON, 1964) PRATURLON & RADOIČIĆ, 1974

PRATURLON & RADOIČIĆ (1974) revised the diagnosis of that genus, with type-species *A. radiocicae*:

"... Cylindrical, unsegmented thallus, with whorls of long primary branches, distally ramified in clusters of button-like secondary twigs ... "

Acroporella assurbanipali ELLIOTT, 1968

(Pl. 1; Figs. 9–10)

1960 *Macroporella* sp. – ELLIOTT, p. 222, lower Cretaceous of Iraq.
1968 *Acroporella assurbanipali* – ELLIOTT, Pl. 75, Figs. 1–3, Aptian of Iran.
1987 *Acroporella assurbanipali* – SIMMONS & HART, Hauterivian–Valanginian of Oman.

The cylindrical, tubular and strongly calcified thallus shows successive, nearly horizontal verticils. Primary branches start with thin pores at the stem and swell to flask-shaped cavities.

Dimensions: D = 1.14–1.42 mm;
d = 0.53–0.75 mm;
w = 12;
$p_{max.}$ = 0.16 mm correlate with those given by ELLIOTT (1968).

Acroporella assurbanipali was found in algal/foraminiferal wackestones of Cenomanian limestones from Jordan (Um Dananir/Steffena and Wadi Salihi; for both localities see Text-Fig. 1). These carbonates hold a rich microfauna of *Biconcava benthori*, *Cuneolina* sp., *Pseudorhapidionina dubia*, *Orbitolina* sp., *Praealveolina* cretacea, *Trocholina* sp., quinqueloculine and agglutinated foraminiferids; among the algae, *Halimeda* sp., *Cylindroporella sugdeni* and *Neomeris* sp. are frequent constituents.

Acroporella hamata n.sp.

(Pl. 1; Figs. 5–8,11; Pl. 5; Figs. 14–16; Text-Figs. 4,5)

Derivatio nominis: Hamatus (lat.) = hooked with barbs, because of the hooked structures at the primaries.

Locus typicus: Gebel Hallal – Sinai/Egypt (Text-Figs. 1,2)

Holotype: Longitudinal section of thin-section $HB12_5$, figured in Pl. 1; Fig. 6, illustrating the euspondyle arrangement of the branches, and the hooked appendices at the primaries.

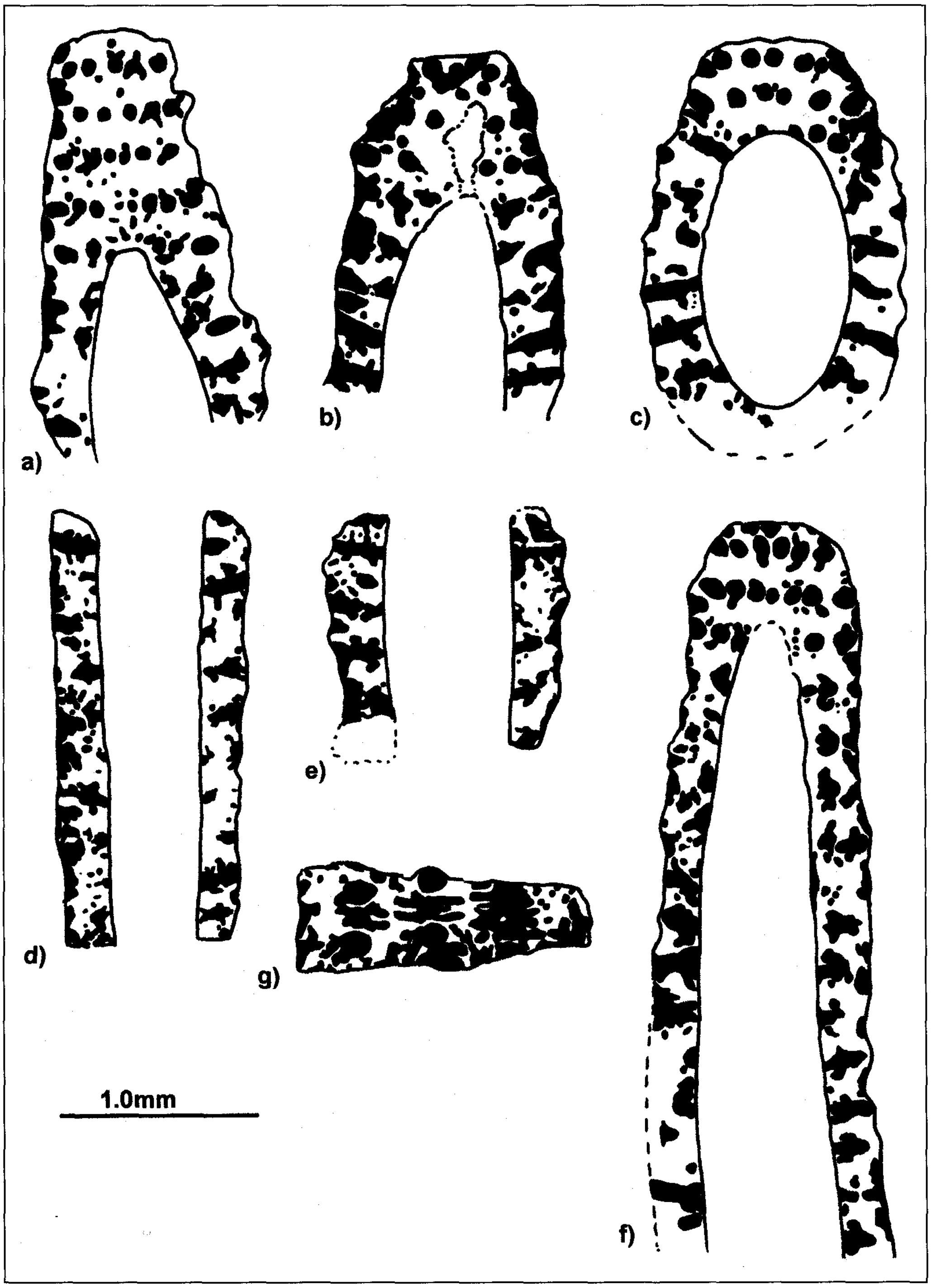
Paratypes: Specimens of Fig. 7 with a nearly transverse section ($HB12_4$) and Fig. 11 (both Pl. 1) with a tangential thallus-section ($HB12_3$), showing three parallel rows of globular primaries with small appendices, attaching and surrounding the primaries.

Stratum typicum: Upper Cenomanian Hazera Formation.

Material: 85 specimens in 14 thin-sections from three samples.

Diagnosis: Cylindrical, unsegmented thalli with tubular-slighty ovoid, elongated and slightly outwards widening primary branches, regularly bent towards the axial stem with low angles (up to 5°); distally arranged secondaries are only poorly visible, due to the outwards decreasing calcification. Phloiophorous branches show

Text-Fig. 4.
Different sections of *Acroporella hamata* n.sp., drawn from thin-sections HB121-12 to illustrate the arrangement of branches and appendices respectively.
Scale = 1 mm



an euspondyle arrangement in alternating whorls. The primaries have one, two or three rows of hooked appendices; they are irregularly arranged, often bent towards the axial cell, best visible in longitudinal sections. Small secondaries are weakly developed, no reproductive cells are discernable.

Dimensions: L = 2.1–4.7 mm;
D = 0.96–1.31 mm (mean = 1.05 mm);
d = 0.48–0.76 mm (mean = 0.62 mm);
p_{length} = 0.14–0.26 mm;
$p_{diam.}$ = 0.04–0.07 mm;
$p_{app.}$ = 0.008–0.019 mm;
w = 36–40.

Description: The most striking characteristic of this new species of *Acroporella* are the hooked appendices of the primaries, attached with small processes. They start their irregular, curved growth from different positions of the branches. These characteristic features are often diagenetically overprinted, due to strong calcification of the thalli. The hooked appendices are best visible in a tangential section of Text-Fig. 4d and Pl. 1; Fig. 11: Here the small processes run parallel and oblique, surrounding the primaries. One, two or three rows of appendices per branch occur. The primary branches of the juvenile stages of *A. hamata* n.sp. are simple, tubular elongated, without discernable processes (Pl. 5; Fig. 16).

Occurrences: *Acroporella hamata* n.sp. was found in neritic carbonate sediments of shallow shelf areas. It occurs together with a diverse microfauna, among them orbitolinids (with *Orbitolina texana*), involutinids (with *Trocholina* sp.) and different species of the genus *Praealveolina*, *Biconcava bentori*, *Pseudorhipidionina dubia*, *Cuneolina* sp. and

Broeckina sp. Green algae are represented by both genera *Cylindroporella* and *Halimeda*.

Comparisons: Four species of *Acroporella* were described from Cretaceous strata, which clearly differ from *A. hamata* n.sp. by their biometric values, the smaller number of branches per whorl, the general arrangement of branches and the missing of the small appendices at the primaries:

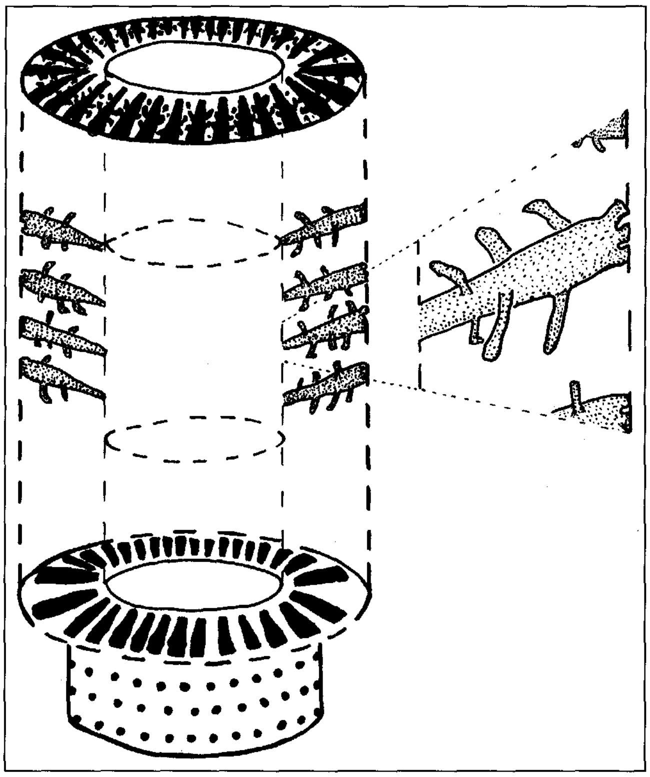
- *A. radiocicae* PRATURLON, 1964 from Hauterivian–Aptian carbonates of Italy and the Dinarids, has a metaspondyl arrangement of branches, which are more steeply bent towards the stem; branches have nearly unchanged diameters from proximal to distal positions. All biometric values are smaller than in *A. hamata* n.sp.
- *A. assurbanipali* ELLIOTT, 1968 from lower Cretaceous strata of Iraq, Iran and Oman; the specimens from Cenomanian limestones of Jordan (see above) show similar biometric values to *A. hamata* n.sp., but are different according to the arrangement of the branches.
- *A. chiapasis* DELOFFRE, FOURCADE & MICHAUD, 1985 from Maastrichtian carbonates of Mexico shows a marked inclination of the primaries towards the main axis; there are bunches of small secondary branches. Moreover the smaller dimensions and lesser numbers of branches per verticil are clearly different from *A. hamata* n.sp.
- *A.? nissovensis* BAKALOVA, 1971 from Hauterivian–Aptian limestones of Bulgaria, Spain, France and Switzerland has much smaller dimensions, a lesser number of branches, which have nearly constant diameters.

Remarks: In his first description of the genus *Acroporella*, PRATURLON (1964) discussed in detail the acrophorous branches of the genus and the type-species – a character which he later dropped in the emended diagnosis (PRATURLON & RADOICIC, 1974). Although the hooked appendices of *A. hamata* n.sp. clearly differ from acrophorous branches, the first-side similarities between both should be mentioned.

A schematic reconstruction of the thallus and the phloiophorous branches is given in Text-Fig. 4. The short, hooked appendices of one primary were drawn with higher magnification, to illustrate their characteristic arrangement.

An interpretation of the hooked appendices as being due to early diagenetic borings of microendolithic organisms, could be excluded for three reasons: they are widening towards the attachment-processes at the primaries, indicating, that they started from the primaries. Furthermore they often show regular arrangements, best visible in longitudinal sections of e.g. Text-Fig. 4f. Moreover, all the cooccuring organisms with primary aragonitic shells (like *Cylindroporella* sp., *Halimeda* sp., *Trocholina* sp. or gastropods) should yield similar traces of borings – but they do not.

Discussions concerning the biological function of these appendices have been speculative up to now; it could be excluded that they are comparable to secondaries, or that they correspond to reproductive structures.



Text-Fig. 5.
Schematic reconstruction of *Acroporella hamata* n.sp., with respect to thallus, arrangement of branches and appendices.

Genus: *Trinocladus* RAINERI, 1922

The diagnosis of the genus *Trinocladus* (with its type-species *T. tripolitanus*) was revised by ELLIOTT (1972).

Trinocladus tripolitanus RAINERI, 1922

(Pl. 2; Figs. 11–15)

T. tripolitanus is a frequent constituent of Cenomanian–Turonian strata of Northern Africa and the Middle East. A short synonymy-list (including a summary of its indicative characteristics) was recently given by KUSS & CONRAD (1991: p. 876).

Besides the already described Egyptian and Jordan findings, well preserved specimens of *T. tripolitanus* were proved from monotypic accumulations within algal wacke-/packstones together with *Praealveolina* sp. and fragments of rudists in Cenomanian limestones of Wadi Bustani, Ras en Naqb and Wadi Mujib (all central Jordan – Text-Fig. 1).

Family: Dasycladaceae KUTZING, 1843
Tribe: Coniporelleae BASSOULLET et al., 1978
Genus: *Likanella* MILANOVIC, 1865 (syn. *Johnsonia* KORDE, 1965)

The original diagnosis of that genus (MILANOVIC, 1965) was revised by SCHINDLER & CONRAD (in press):

"... The long branches which at the top are open and non-ramified have separate calcareous walls ... the laterals of Praturlonella arise from a single verticil even if they are distally arranged in horizontal rows (cortical bands). With Likanella instead, each article (segment) consists of three verticils ..."

Likanella hammudai RADOIČIĆ, 1975

(Pl. 4; Figs. 1–13)

1975 *Likanella hammudai* – RADOIČIĆ, p. 151, Pl. 1, 2, Turonian–lowermost Senonian of Libya.

1990 *Falsolikanella hammudai* – SCHLAGINTWEIT, p. 258, Pl. 1; Figs. 1–8, Coniacian of the Alps.
1991 *Praturlonella hammudai* – KUSS & CONRAD, p. 874, Fig. 3.1–3.4, upper Cenomanian of Egypt.

Based on specific comparisons with *P. jordanica* and *P. danilovae*, KUSS & CONRAD (1991) discussed the taxonomic position of *Likanella hammudai*, without knowledge of the results of SCHLAGINTWEIT (1990); he placed *L. hammudai* to the genus *Falsolikanella*, following the criteria given by GRANIER (1988: "vestibule" arrangement of the branches) although he mentioned a possible synonymy of *Likanella* with *Praturlonella*.

The *Likanella*-type arrangement is identified on the stipe, also visible by the well-preserved specimens of *Likanella hammudai* RADOIČIĆ, 1975, illustrated in ENSSLIN & SCHLAGINTWEIT (in press) from the Coniacian of Morocco. Based on this new data, the original combination *Likanella hammudai* is correct, and the proposed nov. comb. *Praturlonella hammudai* (KUSS & CONRAD, 1991) has to be rejected (see also discussion in SCHINDLER & CONRAD, in press).

The newly studied material from Sinai holds sections of isolated and complete verticils of *L. hammudai* in both, autochthonous (Pl. 4; Figs. 1–4) and allochthonous (Pl. 4; Figs. 5–13) positions. The almost cylindrical thallus is weakly calcified, with increasing calcification towards the central cavities. The primary branches show a phloiophorous arrangement in single and spaced whorls; reproductive organs were not recognized. The funnel-shaped branches are rapidly widening towards their distal ends; in tangential sections they display an ovoid-globular, bulbous shape.

Dimensions: D = 1.36–1.8 mm;
d = 0.6–1 mm; the respective d/D-ratios are fairly constant with 44 %–55 %;
p = 0.25–0.3 mm;
w = 22–46 (possibly more); contiguous verticils have distances from 0.25–0.8 mm.

L. hammudai occurs in micritic wackestones (Pl. 4; Figs. 1–4), together with *Thaumatoporella parvovesiculifera*, *Cuneolina* sp., *Pyrgo* sp., *Trochamminoides* sp., *Cyclogyra* sp. and many small quinqueloculine foraminiferids. Reworked fragments of *L. hammudai* were also found in the overlying crossbedded, well-sorted grain-/rudstones (Pl. 4; Figs. 5–13), composed of bioclastic cortoids (mainly of molluscs and echinids), few ooids and algal remains of *Halimeda* sp. and *Neomeris* sp.; foraminiferids are here restricted to few larger forms of *Chrysalidina* sp. and *Orbitolina* sp.

Both horizons with *L. hammudai* are from one massive limestone-unit of the upper Cenomanian Hazera Formation from Gebel Hallal/Sinai (Text-Figs. 1,3; sample HC9).

Likanella sinaica n.sp.

(Pl. 2; Figs. 1–7)

Derivatio nominis: *sinaica* (geogr.), according to its occurrence in Cretaceous limestones of the Sinai-Peninsula.

Holotype: Specimen figured in Pl. 2; Fig. 1 (thin-section $HC3b_5$), transverse section with large central cavity and distally widening branches, with outwards decreasing calcification.

Paratypes: Specimens of Figs. 4 and 7 (both Pl. 1) with a longitudinal and a tangential section, illustrating the euspondyl arrangement of branches in different verticils.

Locus typicus: Gebel Hallal/Sinai, Egypt (Text-Figs. 1,3).

Stratum typicum: ?late Albian–Cenomanian.

Material: 45 individuals in 9 thin-sections of one sample.

Diagnosis: A new euspondyl species of the genus *Likanella* with thick, ploiophorous primary branches, arranged in circular whorls; no secondaries are visible. 18–26 branches per verticil. The inclination of the primaries rapidly increases towards the central stem (Pl. 2; Fig. 4) – further distally they are nearly horizontal. Calcification decreases towards the distal thallus-regions.

Dimensions: D = 1.3–1.8 mm;
d = 0.66–0.9 mm;
d/D = 41–50 %;
p_1 = 0.14–0.18 mm;
h = 0.2–0.35 mm.

Description: Cylindrical thallus with phloiophorous branches, massive calcification near the stem and around the branches – outwards decreasing. Thick branches are funnel-shaped and obliquely arranged to the thallus; their distal ends are only weakly calcified. The branches show a ring-like calcification near the stipe, best visible in tangential sections of successive verticils (Pl. 2; Fig. 7); the globular-ovoid shapes of branches in transverse sections are well documented. No reproductive organs were found.

Occurrences: The new species was found exclusively in neritic carbonate sediments of shallow shelf areas. It occurs within highly fossiliferous, partly washed-out foraminiferal wackestones. Among the diverse microfauna *Cuneolina* sp., *Valvulammina* sp., *Nummoloculina* sp., *Orbitolina* sp. and plenty small, quinqueloculine miliolids are very frequent. Few anomuran coprolithes, *Cylindroporella taurica* and *Thaumatoporella parvovesiculifera* were found.

Comparisons: *Likanella hammudai* RADOIČIĆ has smaller dimensions. *Praturlonella danilovae* (RADOIČIĆ, 1968) BARATTOLO, 1978 differs from *L. sinaica* n.sp. by its different shape of subsequent cortical bands and the less number of branches. *P. jordanica* KUSS & CONRAD, 1991 has smaller dimensions; the number of primaries is much higher. The Paleocene *P. salernitana* BARATTOLO, 1978 differs from all the Cretaceous species of *Praturlonella* by its characteristic swellings and narrowings of the thallus.

Remarks: The here described specimens of *L. sinaica* n. sp. were strongly affected by extracellular micritization processes. Due to early diagenetic removal of the original aragonitic sheaths, endolithic microbial mats created dark encrustations of the thalli. The algae also acted as substrate for encrustations of the problematic ?green alga *Thaumatoporella parvovesiculifera* (Pl. 2; Figs. 1, 2, 5 and 6) creating dark bulbous globules.

Family: Acetabulariaceae (ENDLICHER) HAUCK, 1885
Tribe: Acetabularieae DECAISNE, 1842

The Acetabularieae are characterized by a stalked thallus, which carries one fertile whorl (or more) at the top of the main axis (Fig. 6a). The fragile primary thalli-structures are seldom completely preserved in the fossil record, whereas relics of the fertile bodies often occur in algal-bearing sediments. BERGER & KAEVER (1992) gave a summarized description of the recent species and fossil genera of that tribe.

Genus: *Acicularia* D'ARCHIAC, 1843

Acicularia magnapora n.sp.

(Pl. 3; Figs. 12–16; Text-Fig. 6)

Derivatio nominis: Magna (lat. =) large, pora (lat. =) pores; because of the large dimensions of the sporangial cavities of that species.

Locus typicus: Abu Roash/Hassana Dome, close to the Cairo-Alexandria road, west of the city of Cairo.

Holotype: One spicule-like fertile branch of Pl. 3; Fig. 14 (thin-section AR82).

Stratum typicum: Late Turonian "Flint Series" (JUX, 1954).

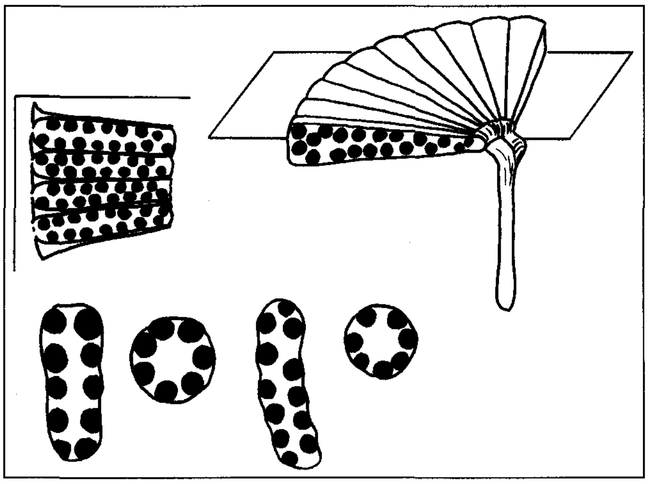
Material: 53 specimens in five thin-sections of one sample.

Diagnosis: Isolated spicule-like bodies of fertile whorls with large, globular sporangial cavities, regularly arranged. These laterals are round (in sections perpendicular to the main axis) or slightly ovoid/elongated; spherical sporangial cavities are concentrically arranged around the periphery (Text-Fig. 3a, b).

Dimensions: Diameter of spicules = 0.32–0.48 mm; length of spicules = 0.8–1.2 mm; number of sporangial cavities = approx. 50–60 per body. Diameter of the sporangial cavities = 0.1–0.14 mm.

Description: The isolated spicules of the new species occur in circular or elliptical sections of ampullaceous bodies. Their microcrystalline appearences are due to diagenetic alteration. Dark, micritic circular sporangial cavities are arranged along the periphery; due to thin-sectioning, they may also appear internally (inside the calcareous bodies). In transverse-circular sections 7–8 cavities were found (Pl. 3; Fig. 12), in longitudinal sections up to 8 cavities occur measured in more than 50 specimens.

Occurrences: *A. magnapora* n.sp. occurs in bioclastic packstones, mainly composed of rudist and echinid fragments (additionally bryozoans and serpulids are frequent), together with *Neomeris cretacea*, *Halimeda* sp.,



Text-Fig. 6.
Different sections of *Acicularia magnapora* n.sp.
a) Schematic reconstruction of a stalked thallus, showing the corona-like arangement of the branches and appendices.
b) Cross-section of four spicule-like branches along the plane indicted in Text-Fig. 7a.
c) Longitudinal and transverse sections of branches drawn from thin-section AR8.

small specimens of *Permocalculus* sp., *Marinella lugeoni*, *Cuneolina* sp. and quinqueloculine miliolids. While the latter microfossils are widespread within Turonian limestones from different localities in Sinai and Jordan, *A. macropora* n.sp. is restricted to the basal limestones of the upper Turonian "Flint-Series" (JUX, 1954; HATABA & AMMAR, 1990), directly overlying the massive rudist-bearing limestones of the Abu Roash-outcrops near Cairo.

Comparisons: *Acicularia magnapora* n.sp. differs from all Cretaceous species of *Acicularia* by its larger dimensions and the extremely thick sporangial cavities. The known Cretaceous *Acicularia*-species are listed – their main characteristics are summarized in comparison to *A. magnapora* n.sp.

- *Acicularia*? *endoi* PRATURLON, 1964 (Oxfordian–Aptian), diameters are smaller.
- *Acicularia*? *comanchense* JOHNSON, 1968 (Lower Cretaceous), outer diameters and sporangial cavities are smaller; cysts are more numerous.
- *Acicularia*? *intermedia* DRAGASTAN, 1967 (Barremian–Aptian) with much smaller dimesions.
- *Acicularia*? *sphaerica* BADVE & NAYAK, 1983 (upper Cretaceous – "post-Cenomanian"), smaller dimensions of spicules and sporangial cavities (D = 0.24–0.28 mm; d_{cyst} = 0.04–0.07 mm).
- *Acicularia longata* CAROZZI, 1947 (late Jurassic), recently described from RAVIV & LORCH (1992) from Oxfordian–Aptian strata of Israel, with smaller dimensions.
- *Russoella radiocicae* BARATTOLO, 1984 (late Albian); sporangial cavities are arranged in equatorial planes of the calcareous bodies. The parataxon Russoella was established for isolated reproductive organs of unknown systematic position.

3. Paleogeographic Value of the Algae Described Here

The distribution of benthic microbiota was influenced by numerous factors of the paleoenvironment, the adaptation of the benthics to different environments, climatic or morphological barriers, transgressions etc. Nevertheless, e.g. BASSOULLET et al.(1985) found obvious similarities in associations of Cretaceous benthic foraminiferids within the Tethyan realm, also applicable to benthic algae. It should be mentioned, however, that paleogeographic comparisons of Cretaceous algae in the northeast African region are hampered by the interrupted knowledge and modern descriptions.

The described algae are from several localities of the northern edge of the African-Arabian Craton, which was part of a broad extended shelf-system along the southern tethyan shores. During Mid Cretaceous times, immigration of benthic microbiota from neighbouring shelf-areas (including those of microplates further north) into these shallow epeiric seas of Northeast Africa was favoured by relatively short distances in between: The Mid Cretaceous plate configuration of the Tethyan region was recently updated by DERCOURT et al. (1993). The here figured maps illustrate the paleobiogeographic relationships within the southern Tethyan area, especially between the northern African/Arabian realm and the neighbouring microplates of Italy, external Dinarids/Hellenids and Turkey, an area which CONRAD et al. (in press) described as "Southern Mesogean Province". With exception of *Acicularia magnapora* n.sp., *Acroporella assurbanipali*, *A. hamata* n.sp., *Praturlonella*

Tabelle 1.
Summarized stratigraphic distribution of the currently known calcareous algae from Cretaceous strata of Egypt and Jordan.

	Aptian	Albian	Cenom.	Turon.	Coniac.	Sant./ Camp.	Maastr.
Acicularia magnapora n.sp.				■			
Acroporella assurbanipali			■				
Acroporella hamata n.sp.			■				
Arabicodium sp.		■					
Boueina cf. *hochstetteri*			■				
Boueina pygmaea			■				
Clypeina sp.			■				
Cylindroporella aff. *barnesii*		■					
C. aff. *kochanskyae*			■				
C. parva			■				
C. taurica		■	■				
C. sugdeni		■	■	■			
Dissocladella undulata					■		
Halimeda sp.		■	■				
Heteroporella lepina				■			
Likanella. hammudai			■				
L. sinaica n.sp.			■				
Marinella lugeoni	■	■	■	■			
Neomeris sp.		■	■	■	■		
Neomeris cretacea		■	■				
?Permocalculus sp.			■				
P. budaensis			■	■			
P. irenae		■	■				
Parachaetetes asvapatii							■
P. cf. *hadhramautensis*		■					
Praturlonella jordanica			■				
Pseudochaetetes sp.			■				
Pseudolithothamnium sp.							■
Salpingoporella sp.			■				
S. dinarica		■	■				
S. hasi			■				
S. aff. *hispanica*			■				
S. cf. *milanovici*			■				
S. ubaiydhi			■				
Suppiluliumaella aff. *schroederi*			■				
Terquemella sp.	■	■	■	■			
Trinocladus tripolitanus			■				

jordanica, *Likanella hammudai*, *L. sinaica* n.sp. and *Salpingoporella dinarica* all taxa listed in Tab. 1 are also known from the so called "North Mesogean Province".

Based on paleogeographic comparisons of Cretaceous dasycladaleans and corallinaceans from North Africa (CONRAD et al., in press) the areal distribution of the herein described Mid Cretaceous dasycladaleans was drawn and correlated with those, reported from age-equivalent circum-Arabian strata (Fig. 7). The following taxa seem to be most indicative for paleogeographic correlations of the Albian–Cenomanian (I) and Turonian–Coniacian (II) strata.

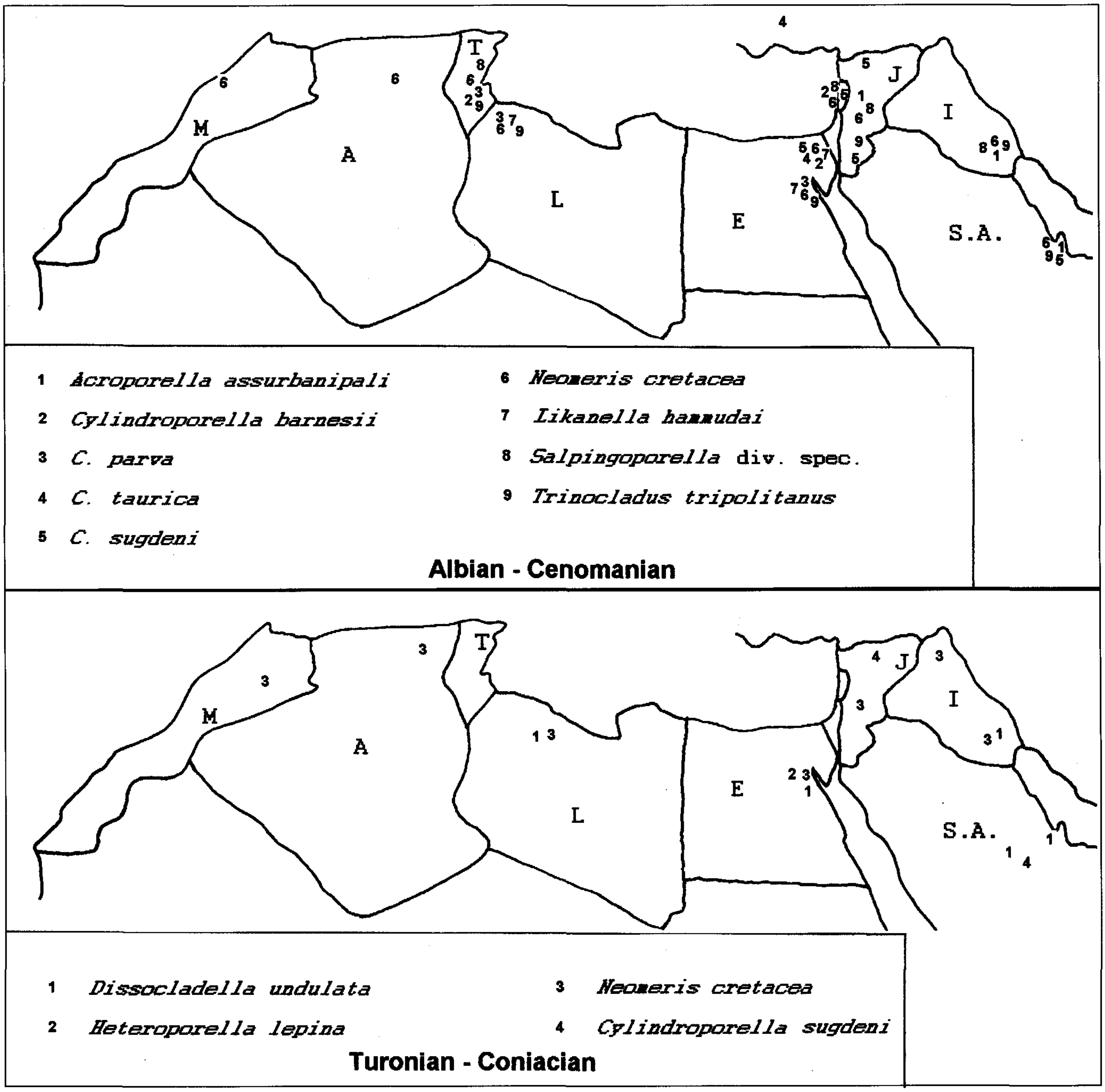
I. *Trinocladus tripolitanus*, *Cylindroporella barnesii*, *Neomeris cretacea* and *Likanella hammudai* (*Heteroporella lepina* was proved only in Turonian strata of Egypt).
II. *Disocladella undulata*, *Neomeris cretacea.*

4. Stratigraphic Importance of the Described Calcareous Algae

Cretaceous platform carbonates are often devoid of biostratigraphically useful fossils, such as ammonoids and planktic foraminiferids. As demonstrated for Jurassic and Cretaceous limestone units (BASSOULET et al., 1978) algae may be useful for the stratigraphic subdivision of limestone-dominated strata – especially in combination with larger foraminiferids (SCHROEDER & NEUMANN, 1985) and further microfossils such as e.g. anomuran coprolithes (KUSS & SENOWBARI-DARYAN, 1992).

KUSS & CONRAD (1991) gave a first summary of the stratigraphic distribution of calcareous algae in Egypt and Jordan; an extended version – including the new data – was plotted in Tab. 1. Compared with the stratigraphic compilations from BASSOULLET et al. (1978) for the Cretaceous dasycladaleans, from POIGNANT (1978) for the corallinaceans and from BASSOULLET et al. (1983) for the udoteaceans, most of the algae described herein occur within the time intervals given by the authors, with the following restrictions:

In contrast to earlier descriptions, *Acroporella assurbanipali* is not confined to Valanginian–Hauterivian strata – in accordance with SIMMONS & HART (1988) the new findings from Jordan prove a longer stratigraphic range. Occurrences of *C. sugdeni* are not confined to the Early Cretaceous; the same is true for *C. taurica*, as indicated by the new findings from Cenomanian limestones of Jordan.



Text-Figure 7.
Distribution of Albian–Cenomanian (top) and Turonian–Coniacian (below) dasycladaleans in northern Africa and circum-Arabia.
After CONRAD et al. (in press), ELLIOTT (1968), SIMMONS& HART (1987), OKLA (1991) and own observations.

In general, the stratigraphic distributions of the Egyptian/Jordan algae reflect the following trends:

Both, frequency and diversity of calcareous algae reach maxima during the Cenomanian (with a total of 32 taxa). Towards the Turonian, a conspicuous decrease of algae is obvious in the studied sections (7 taxa), a trend which continues to the Coniacian (with only two taxa). Due to the missing of suitable rocks in Santonian–Campanian times, no algae were proved from that interval in the region; a local occurrence of shallow water limestones in Campanian–Maastrichtian times again favoured suitable algal environments and thus few new taxa occur.

However, most algae of the youngest Cretaceous period are from the corallinaceans. This may be due to ecological conditions, as greater water-depths are assumed for these limestones (KUSS, 1992a).

Acknowledgements

The field work was generously funded by the German Research Foundation (DFG) in the course of two projects: Ku-642/1 and Ba-679-1,2.

I am especially obliged to M. BRINKMANN (Bremen) for the preparation of thin-sections and photographs. Thanks to Prof.Dr. J. BUCUR (Bucharest/Erlangen), who critically revised a former version of the manuscript and gave valuable comments.

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Plate 1

Figs. 1–4: ***Lithophyllum* (?) *shebae* ELLIOTT, 1959.**

Fig. 1: The large thallus acts as a nucleus of a cyanobacterian oncolithic crust.
Jordan, Muj6; ×22.

Fig. 2: Oblique-longitudinal section of a thallus with many protuberances.
Jordan, Muj 6b; ×84.

Fig. 3: Tangential thallus-section.
Jordan, Muj 6b; ×58.

Fig. 4: Detail of a longitudinal section, showing the arrangement of the filaments.
Jordan, Muj 6b; ×260.

Figs. 5-8,11: ***Acroporella hamata* n.sp.**

Fig. 5: Oblique-longitudinal section of an unsegmented thallus.
Egypt-Sinai, $HB12_6$; ×10.

Fig. 6: Holotype, longitudinal section of an euspondyle thallus with hooked appendices at the primaries.
Egypt-Sinai, $HB12a_5$; ×23.

Fig. 7: Paratype, longitudinal section, with hooked appendices.
Egypt-Sinai, $HB12_3$; ×23.

Fig. 8: Nearly transverse section.
Egypt-Sinai, $HB12_4$; ×38.

Fig. 11: Paratype, tangential thallus-section with three parallel rows of globular primaries and small appendices, attaching and surrounding the primaries.
Egypt-Sinai; $HB12_3$; ×38.

Figs. 9–10: ***Acroporella assurbanipali* ELLIOTT, 1968.**

Fig. 9: Oblique-transverse section.
Jordan, $Sal5_5$; ×17.

Fig. 10: Oblique-longitudinal section.
Jordan, $UD3_2$; ×24.

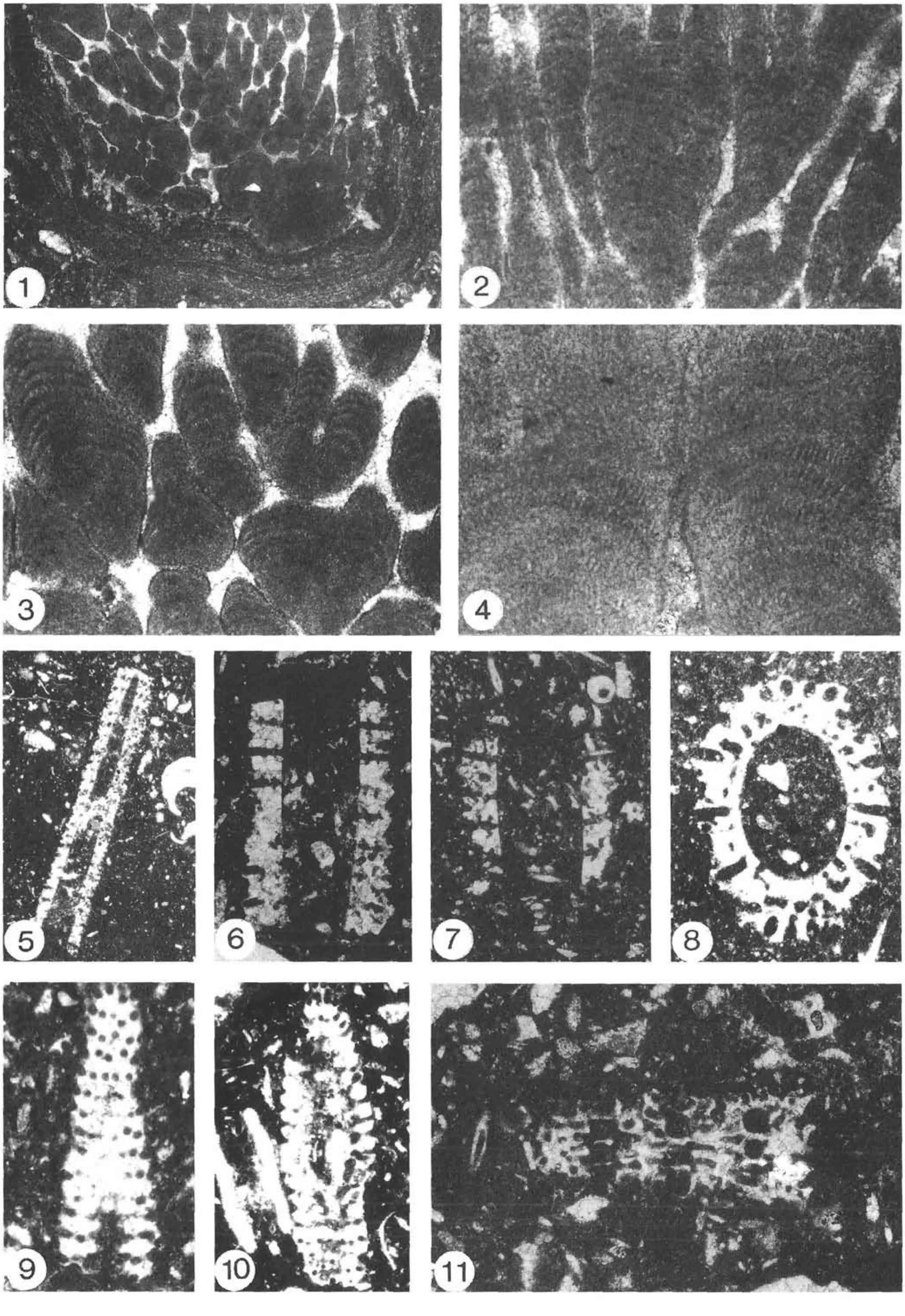
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Plate 2

Figs. 1–7: ***Likanella sinaica* n.sp.**

Fig. 1: Transverse section of the holotype, with *Thaumatoporella parvovesiculifera* inside the stipe.
Sinai, HC3b$_5$; $\times$35.

Fig. 2: Transverse section with *Thaumatoporella parvovesiculifera* inside the stipe.
Sinai, HC 3b$_5$; $\times$ 35.

Fig. 3: Oblique transverse section.
Sinai, HC3b$_5$; $\times$35.

Fig. 4: Paratype, longitudinal section.
Sinai, HC3b$_1$; $\times$21.

Fig. 5: Transverse section.
Sinai, HC 3b$_2$; $\times$21.

Fig. 6: Half-transverse section.
Sinai, HC 3b$_3$; $\times$35.

Fig. 7: Paratype, tangential section.
Sinai, HC3b$_1$; $\times$35.

Figs. 8–10: ***Heteroporella lepina* PRATURLON, 1966.**

Fig. 8: Transverse section.
Egypt, AR9c$_2$; $\times$65.

Fig. 9: Transverse section.
Egypt, AR9c$_2$; $\times$65.

Fig. 10: Tansverse section.
Egypt, AR9c$_2$; $\times$65.

Figs. 11–15: ***Trinocladus tripolitanus* RAINERI, 1922.**

Fig. 11: Bioclastic wackestones with longitudinal and transverse sections of *T. tripolitanus*.
Jordan, WBu5$_1$; $\times$17.5.

Fig. 12: Longitudinal section.
Jordan, WBu5$_1$; $\times$30.

Fig. 13: Oblique transverse section.
Jordan, WBu5$_2$; $\times$25.

Fig. 14: Transverse section.
Jordan, WBu5$_1$; $\times$40.

Fig. 15: Transverse section.
Jordan, WBu5$_3$; $\times$40.

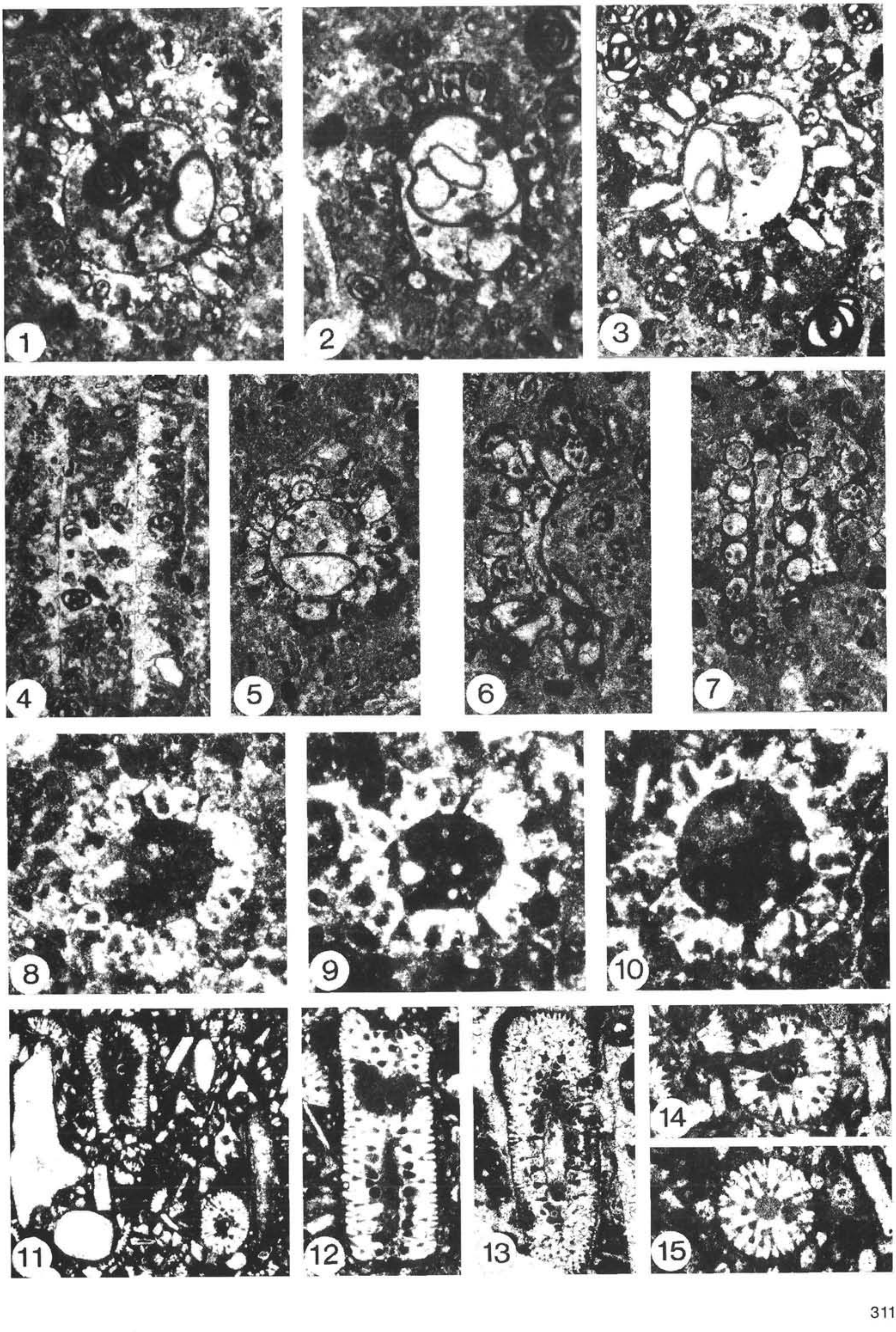
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Plate 3

Figs. 1–4: ***Boueina* cf. *hochstetteri* Toula, 1883.**
Fig. 1: Longitudinal section, showing typical segmentation.
Jordan, Kuf2a_1; ×26.
Fig. 2: Segment of a longitudinal section.
Egypt-Sinai, $HC8_1$; ×35.
Fig. 3: Longitudinal section with typical segmentation.
Egypt-Sinai, $HC8_1$; ×35.
Fig. 4: Longitudinal section.
Jordan, Kuf2a_1; ×52.

Figs. 5,8–11: ***Boueina pygmaea* Pia, 1936.**
Fig. 5: Oblique longitudinal section.
Egypt-Sinai, EM21; ×.
Fig. 8: Transverse section with internal and externally diverging threads.
Egypt-Sinai, $EM21_1$; ×38.
Fig. 9 : Several chip-like fragments.
Egypt-Sinai, EM21b; ×33.
Fig. 10: Longitudinal section.
Egypt-Sinai, EM21b; ×24.
Fig. 11: Longitudinal section.
Egypt-Sinai, EM21a; ×33.

Figs. 6,7: **?*Permocalculus* sp.**
Fig. 6: Longitudinal section, showing medullary-/cortical threads, and sporangia arranged in longitudinal rows.
Egypt-Sinai, EM21a; ×35.
Fig. 7: Longitudinal section with sporangia and small tubes.
Egypt-Sinai, EM 21b; ×33.

Figs. 12–16: ***Acicularia macropora* n.sp.**
Fig. 12: Nearly transverse section of one fertile branch.
Egypt, $AR8_1$; ×95.
Fig. 13: Transverse section of one fertile branch.
Egypt, AR8 3; ×95.
Fig. 14: Holotype, longitudinal section of a spicule-likefertile branch, showing the characteristic large sporangial cavities.
Egypt, $AR8_2$; ×70.
Fig. 15: Tangential-longitudinal section.
Egypt, $AR8_1$; ×70.
Fig. 16: Tangential-longitudinal section.
Egypt, AR_3; ×70.

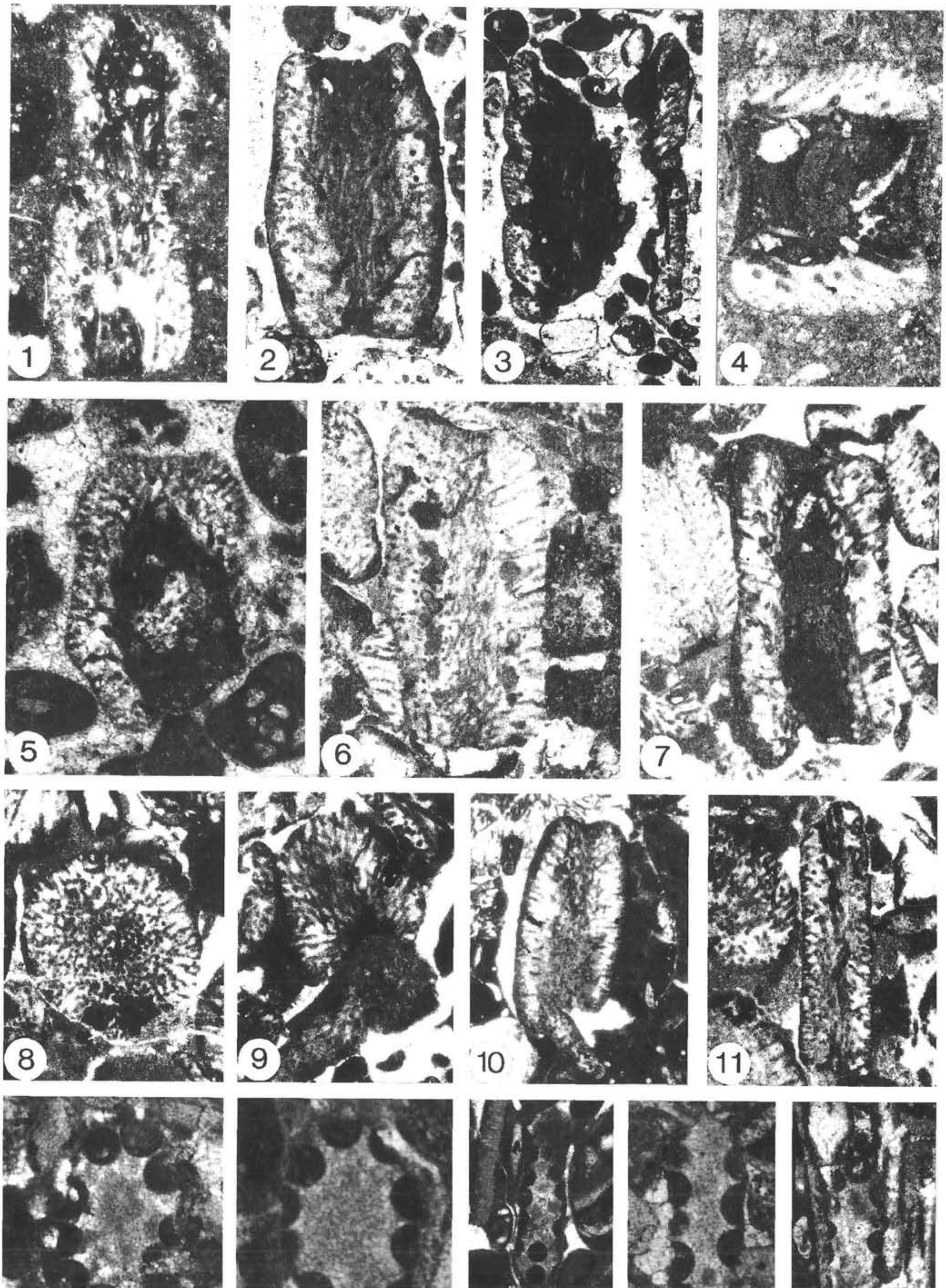
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Plate 4

Likanella hammudai RADOIČIĆ, 1975

Fig. 1: Different longitudinal, oblique and transverse sections.
Egypt-Sinai, $HC9a_1$; ×9.

Fig. 2: Longitudinal section.
Egypt-Sinai, $HC9a_4$; ×11.

Fig. 3: Transverse sections of two individuals.
Egypt-Sinai, $HC9b_1$; ×21.

Fig. 4: Oblique transverse section.
Egypt-Sinai, $HC9b_2$; ×27.

Fig. 5: Transverse and oblique-longitudinal sections of two eroded fragments.
Egypt-Sinai, HB9b; ×22.5.

Fig. 6: Longitudinal section.
Egypt-Sinai, HB9b; ×25.

Fig. 7: Longitudinal section of an eroded and micritized individual.
Egypt-Sinai, HB9b; ×33.

Fig. 8: Oblique-transverse section.
Egypt-Sinai, $HB9_2$; ×19.5.

Fig. 9: Nearly transverse section.
Egypt-Sinai, $HB9_1$; ×36.

Fig. 10: Transverse section.
Egypt-Sinai, HB9a; ×40.

Fig. 11: Longitudinal-tangential section of a broken segment, showing the characteristic arrangement of the branches and their bulbous structures.
Egypt-Sinai, HB9b; ×35.

Fig. 12: Grainstone-facies with oblique and transverse sections.
Egypt-Sinai, HB9b; ×20.

Fig. 13: Two individuals of L. hammudai, transverse cut.
Egypt-Sinai, HB9a; ×18.

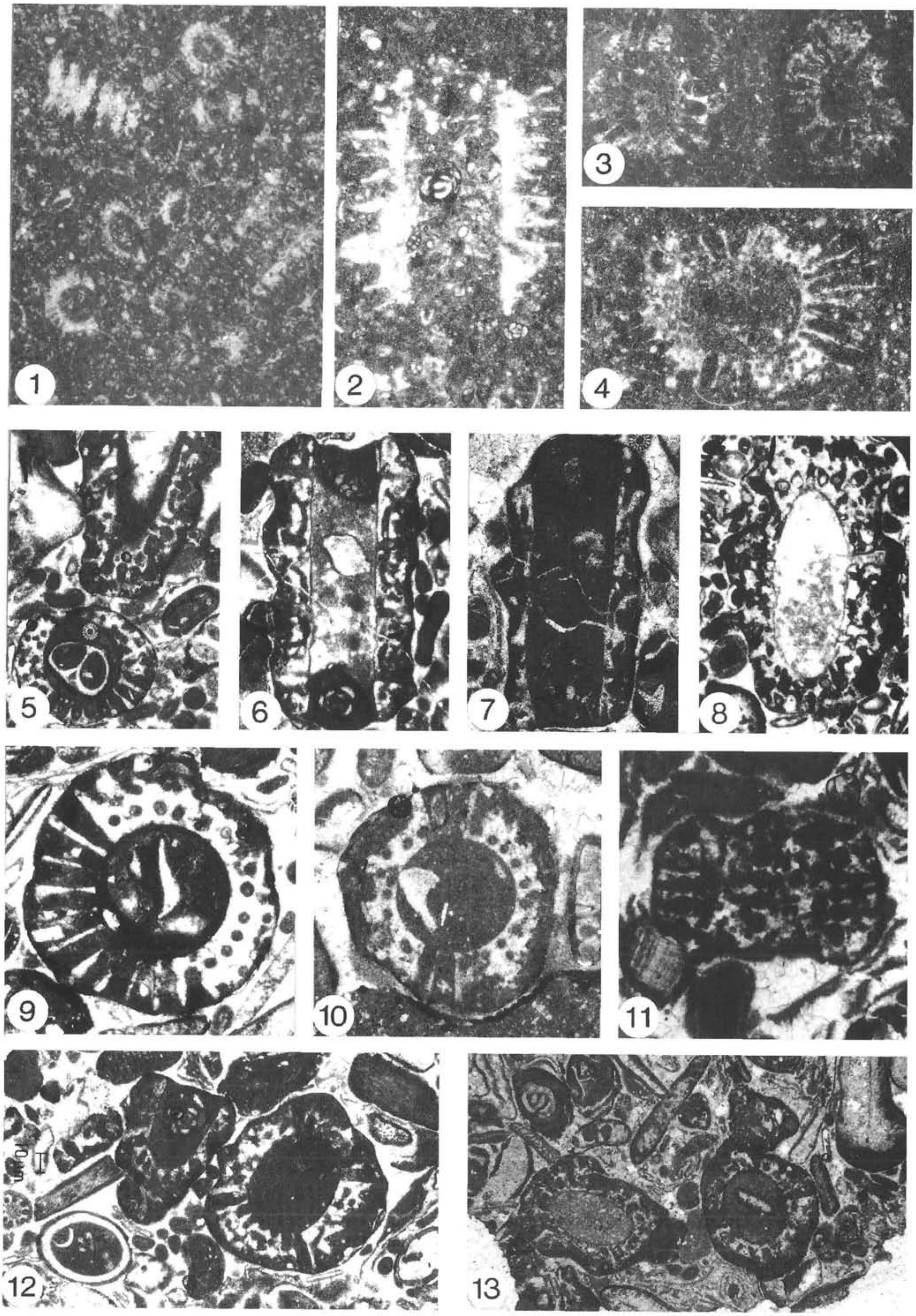
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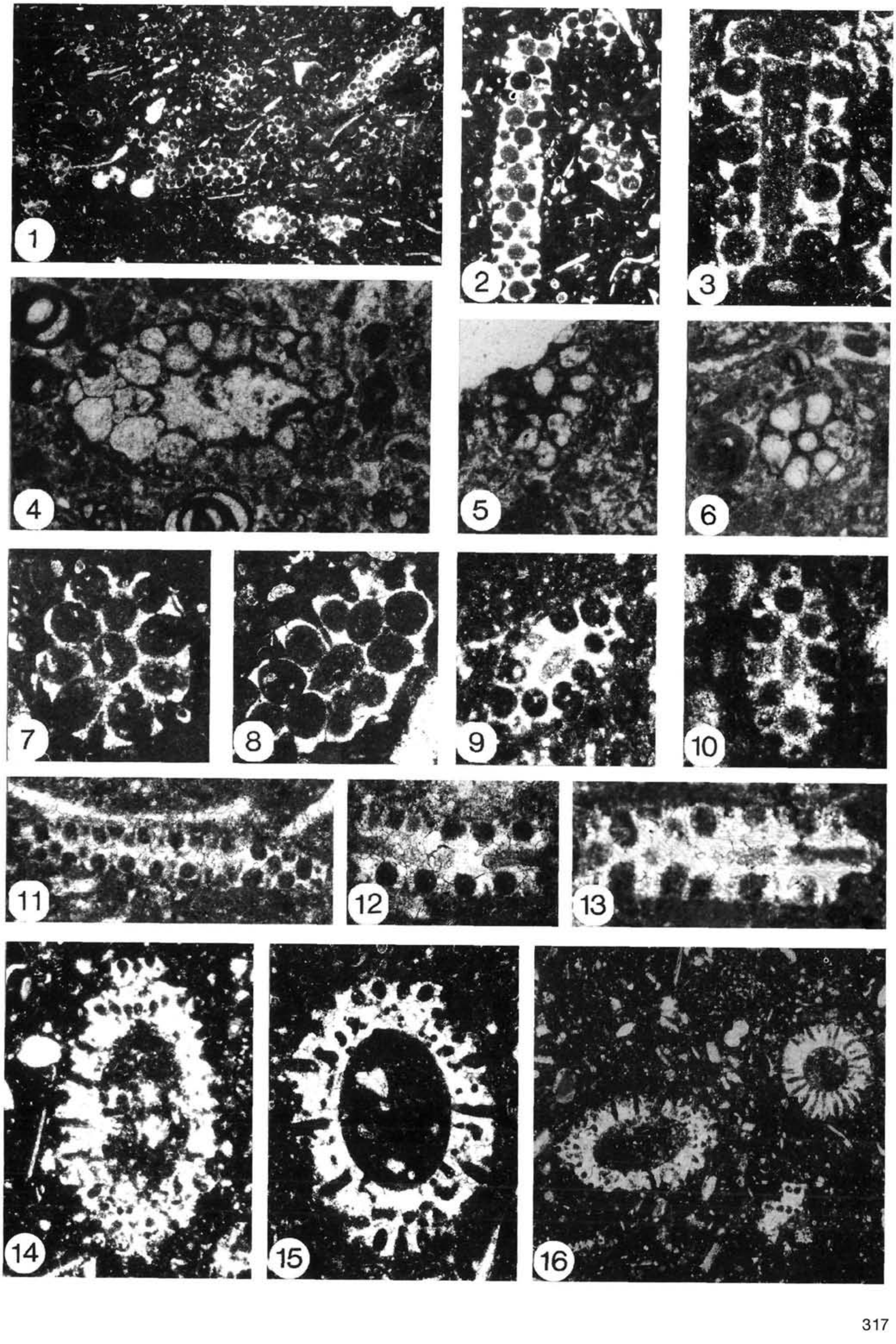
Plate 5

Figs. 1–3,7,8: ***Cylindroporella sugdeni* ELLIOTT, 1957.**
Fig. 1: Wackestone with different transverse and oblique sections.
Jordan, Lis1.
Fig. 2: Tangential-longitudinal section (left) and transverse sections.
Jordan, $Lis1_4$; ×17.
Fig. 3: Longitudinal section.
Jordan, $Lis1_1$; ×34.
Fig. 7: Transverse section.
Jordan, $Lis1_4$; ×40.
Fig. 8: Oblique-transverse section.
Jordan, $Lis1_4$; ×40.

Figs. 4–6: ***Cylindroporella taurica* CONRAD & VAROL, 1990.**
Fig. 4: Oblique-transverse section.
Egypt-Sinai, HC3b; ×.
Fig. 5: Transverse section.
Egypt-Sinai, HC10; ×.
Fig. 6: Oblique section.
Egypt-Sinai, HC10; ×.

Figs. 9–13: ***Cylindroporella* cf. *kochanskyae* RADOIČIĆ, 1970.**
Fig. 9: Oblique transverse section.
Egypt-Sinai, $HC5_2$; ×50.
Fig. 10: Transverse section.
Egypt-Sinai, $HC5_1$; ×50.
Fig. 11: Oblique longitudinal section.
Egypt-Sinai, $HC6_1$; ×36.
Fig. 12: Longitudinal section.
Egypt-Sinai, $HC6_1$; ×55.
Fig. 13: Oblique longitudinal section.
Egypt-Sinai, $HC6_1$; ×55.

Figs. 14–16: ***Acroporella hamata* n.sp.**
Fig. 14: Oblique-transverse section with appendices-bearing primaries and few secondaries.
Egypt-Sinai, $HB12_2$; ×38.
Fig. 15: Transverse section with few appendices.
Egypt-Sinai, $HB12_1$; ×38.
Fig. 16: Two transverse sections crossing a smaller (right,without appendices) and larger (left) part of the thallus.
Egypt-Sinai, HB12c; ×19.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