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Tentative Lower Cretaceous Calcareous Nannoplankton Zonation

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ABSTRACT

Nine nannoplankton zones ranging from Upper Tithonian to Lower Cenomanian are described from continuous sections in southeastern France and from the DSDP Leg 1 cores of Sites 4, 4A and 5A from the Blake Bahama Basin (West Atlantic). The nannofossil zones are correlated with cephalopod, foraminifera and calpionellid zonations and their relationships to the classical Lower Cretaceous stages are presented. The zonal system proposed here is correlated and compared with the nannofossil zonations proposed by WORSLEY (1971) and MANIVIT (1971).

Four nannofossil genera (*Calcicalathina*, *Cretaturbella*, *Cruciellipsis*, *Polycostella*) and six species (*Bipodorhabdus roeglii*, *Cretaturbella rothii*, *Microrhabdulus bollii*, *Polycostella beckmannii*, *Polycostella senaria*, *Rucinolithus wisei*) are described as new.

1. Introduction

All classic Lower Cretaceous stages in Europe have been defined by macropaleontological data. Until recently the biostratigraphic subdivision has been based primarily on cephalopods, although other macrofossils, such as brachiopods, echinoderms, pelecypods and plants have provided further valuable biostratigraphic information. Within the past three decades the introduction of micropaleontological methods, particularly the study of foraminifera, calpionellids, ostracods, pollen, spores, and calcareous nannoplankton has provided valuable additional data for a further refinement of Lower Cretaceous biostratigraphic subdivision and correlation. A summary of the state of Lower Cretaceous biostratigraphy until the early sixties has been given at the *Colloque sur le Crétacé inférieur* in Lyon 1963 (published in: Mémoires du B. R. G. M. *34*, 1965).

A first subdivision of Lower Cretaceous strata by means of nannofossils was introduced by BRONNIMANN (1955). He described three nannoconid assemblages, ranging from Neocomian to Albian. STRADNER (1963) added a tentative range chart of 21 calcareous nannofossil species. NOËL (1965), REINHARDT (1966), STOVER (1966), MANIVIT (1966, 1969), FORCHHEIMER (1968), STRADNER, ADAMIKER and MARESCH (1968), ČEPEK (1970), HOFFMANN (1970), and REINHARDT (1970a, 1970b, 1971) gave further taxonomic descriptions and biostratigraphic implications. In 1969 ČEPEK and HAY proposed a zonation of Upper Cretaceous strata in Alabama and Kansas. Two nannofossil zonations were proposed in 1971, one by MANIVIT, based on Aptian to Danian sections in France, another by WORSLEY, based on seven samples of the DSDP Leg 1, Sites 4, 4A and 5A.

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2. Purpose and methods of study

The stratigraphic distribution of calcareous nannoplankton in the Lower Cretaceous has been less studied than that in any younger interval of the geologic column. Most of the publications mentioned in the introduction are concerned primarily with problems of taxonomy, and no continuous sections which can be correlated with other fossil groups have yet been studied in detail. The purpose of this paper, therefore, is to establish a stratigraphic subdivision of the Lower Cretaceous by means of nannofossils and to correlate it with other biostratigraphic zonations.

It is based on the following studies:

1. Development of a preparation method which allows the identification of the same nannofossil specimen in the light and the scanning electron microscope in order to avoid uncertainties of taxonomic nature.
2. Taxonomic investigation of selected, well preserved samples with the aid of the scanning electron microscope.
3. Light microscope study of continuous sections of known biostratigraphic extent.
4. Establishment of levels of distinct changes in nannofossil assemblages.
5. Correlation of such changes with biozonations based on other fossil groups and with the classical stages.

The biostratigraphic subdivision proposed here is restricted to a selected number of species which are easily and with certainty recognizable by means of the light microscope only. The taxonomic position of the species has, however, been determined by the scanning electron microscope, applying the preparation method described by THIERSTEIN, FRANZ and ROTH (1971) which allows the identification of the same specimen in both the light and the scanning electron microscope. This method utilizes only a thin coating of conductive material on the specimen. Consequently specimens often become charged when exposed to the electron beam of the scanning electron microscope and the quality of the micrographs may, therefore, suffer.

The study with the light microscope of the nannofossils of samples from well-investigated and published sections in southeastern France has produced reliable biostratigraphic information and has allowed correlations with cephalopod, calpionellid and foraminifera biostratigraphic zones. Because of superior nannofossil preservation, most of the scanning electron microscope investigations have been carried out on samples of DSDP Leg 1 although several samples of satisfactory preservation from southeastern France were also studied.

3. Typification

In accordance with the recommendations drawn up by members of the *Round Table on Calcareous Nannoplankton* at the II Planktonic Conference 1970, the holotypes and paratypes of the species described are scanning electron microscope photographic negatives. They are deposited at the Naturhistorisches Museum Basel and identified by the author's negative numbers [listed here in square brackets] and by the Basle Museum type collection numbers. The light microscope slides with the orientated holotypes and paratypes are also deposited in the Basle Museum and identified by the same Basle Museum type collection numbers.

4. Relation to previous zonations and rational for revision

Relations between the zonations proposed by WORSLEY (1971) and MANIVIT (1971) and the zonation described here are shown in Figure 1.

Following FARINACCI (1964) *Nannoconus steinmanni* KAMPTNER 1931 is here considered to be a synonym of *Nannoconus colomi* (DE LAPPARENT 1931). Therefore the name of WORSLEY'S *Nannoconus steinmanni* Zone is changed to *Nannoconus colomi* Zone. The base of the here described *Nannoconus colomi* Zone (defined by the first occurrence of *Nannoconus colomi* [DE LAPPARENT 1931]) coincides with the base of WORSLEY'S *Nannoconus steinmanni* Zone (defined by the first appearance of *Nannoconus steinmanni* KAMPTNER 1931). The assemblage and the type level of WORSLEY'S *Nannoconus steinmanni* Zone moreover belong to the here proposed *Microrhabdulus bollii* Zone. The guide fossil of WORSLEY'S overlying zone, *Diadorhombus rectus* WORSLEY 1971 is extremely rare in the sections of southeastern France and thus could not be used as a zonal marker. *Ellipsochiastus quadriserratus* WORSLEY 1971 could not be identified in the samples studied. *Watznaueria diaphanae* WORSLEY 1971 could not be distinguished from *Watznaueria barnesae* (BLACK 1959) in land sections because of frequent overgrowth. Therefore the *Calcicalathina oblongata* Zone and the *Microrhabdulus bollii* Zone are proposed here for the interval from WORSLEY'S *Diadorhombus rectus*

Stages	Thierstein this paper	Manivit 1971 ms	Worsley 1971	Čepek and Hay 1969
Cenomanian	Eiffellithus turriseiffeli	Staurolithites orbiculofenestrus	Staurolithites orbiculofenestrus	Staurolithites orbiculofenestrus
Albian		Staurolithites matalosus		
		Corollithion rhombicum		
	Prediscosphaera cretacea	Hayesites albiensis	Staurolithites matalosus	
Aptian	Parhabdolithus angustus	Parhabdolithus angustus		
	Chiastozygus litterarius	Prediscosphaera columnata	Watznaueria diaphanae	
Barremian	Micrantholithus hoschulzi			
	Microrhabdulus bollii			
Hauterivian	Calcicalathina oblongata		Ellipsochiastus quadriserratus	
Valanginian			Diadorhombus rectus	
	Cretarhabdus crenulatus		Nannoconus steinmanni	
Berriasian	Nannoconus colomi			

Fig. 1. Correlation of Lower Cretaceous calcareous nannoplankton zones.

Zone to *Watznaueria diaphanae* Zone. The first occurrence of the guide fossil *Staurolithites matalosus* (STOVER 1966) of WORSLEY'S next overlying zone is not clear in detail. Small specimens of this species appear rarely already in the Lower Aptian, but typical specimens become abundant only in the Lower Albian. *Staurolithites matalosus* (STOVER 1966) therefore is a much less significant zonal marker than the index species used here.

The name species of MANIVIT'S *Prediscosphaera columnata* Zone (MANIVIT 1971) has not been found in Lower Aptian sections studied by the author. The definition of the lower limit of MANIVIT'S *Parhabdolithus angustus* Zone is emended here to include the first occurrence of *Lithastrinus floralis* STRADNER 1962. The guide fossils *Hayesites albiensis* MANIVIT 1971 and *Corollithion rhombicum* (STRADNER and ADAMIKER 1968) of MANIVIT'S two overlying zones have been recorded until now in the Albian of the western Atlantic only. *Staurolithites matalosus* (STOVER 1966) occurs rarely from the Lower Aptian and becomes abundant in the Upper Albian. The first occurrence of *Podorhabdus orbiculofenestrus* (GARTNER 1968) (which defines the base of ČEPEK and HAY'S [1969] proposed *Staurolithites orbiculofenestrus* Zone) is found to lie in southeastern France and in the West Atlantic in the Lower Albian, between the much more striking first occurrences of *Prediscosphaera cretacea* (ARKHANGELSKY 1912) and *Eiffellithus turriseiffeli* (DEFLANDRE 1954). These latter are used here for the basal definitions of two easily recognizable new zones.

5. Material studied

Sections in southern France

(detailed range charts and sample numbers will be given in a further publication now in preparation):

Broyon (Ardèche)
Berrias (Ardèche)
Lacisterne (Hérault)
Ginestous-la-Garenne (Hérault)
Ginestous-les-Oliviers (Hérault)

For geographic localization, lithology, cephalopod and calpionellid content, and zonation of these sections, see LE HÉGARAT and REMANE 1968.

Orpierre (Hautes-Alpes)
La Charce (Drôme)
Ferme Raton, près Rosans (Hautes-Alpes)
Sisteron (Basses-Alpes)
Route d'Angles (Basses-Alpes)
Lesches-en-Diois (Drôme)
Col de Palluel (Hautes-Alpes)

For geographic localization, lithology, cephalopod and foraminifera content, and zonation of these sections, see MOULLADE (1966).

La Bédoule, Station de Cassis (Bouches-du-Rhône)
Gargas (Vaucluse)

For geographic localization, lithology, fossil content, and zonation of these sections, see FABRE-TAXY, MOULLADE and THOMEL (1965), MOULLADE (1965), and OERTLI (1958).

The biostratigraphic extent of the studied sections and correlation of the standard Lower Cretaceous cephalopod zonation proposed by the *Colloque sur le Crétacé inférieur* in Lyon 1963, the foraminifera zonation proposed by GUILLAUME, BOLLI and BECKMANN (1969), and the cephalopod, calpionellid and foraminifera zonations established in the sections studied in this paper, with the calcareous nannofossil zonation proposed here, are given on Figures 2 and 3.

Samples of the Blake Bahama Basin (West Atlantic) DSDP Leg 1, Sites 4, 4A and 5A

The sample numbers which identify the relative position of the samples in the holes, consist of a series of numbered and lettered entries separated by hyphens in the following sequence: (cruise-leg number) – (drill-hole [site] designation, consisting of site number plus a letter, if more than one hole) – (core run number) – (core-section number). This series is followed by the interval below the top of each core section in centimeters.

1–4–3–1, 15 cm (depth: 134 m below sea floor)
1–4–3–2, 25 cm (depth: 135 m below sea floor)
1–4–4–1, 11 cm (depth: 191 m below sea floor)
1–4–4–1, 110 cm (depth: 192 m below sea floor)
1–4–5, core catcher (depth: 251 m below sea floor)
1–4A–2–1, 120 cm (depth: 115 m below sea floor)

1–5A–4–1, 10cm (depth: 184,8 m below sea floor)
1–5A–4–1, 35cm (depth: 185,1 m below sea floor)
1–5A–6, core catcher (depth: 236 m below sea floor)

Location of sites, lithology, paleontology and further description of these samples are given, in: EWING, M., et al. (1969): *Initial Reports of the Deep Sea Drilling Project*, Vol. 1.

6. Zonation

The nannofossil assemblages from the Berriasian to the Cenomanian are subject to continuous changes in number and evolutionary state of species. Of a total of about 170 different species recorded from the Lower Cretaceous of southeastern France and the western Atlantic, about half have their first or last occurrences within that interval in an apparently consistent and unchanging succession. The taxonomic positions of 46 of these species have been clarified and only these are included in the tentative zonation proposed here. The remaining 40 or so species are either too rare, have interruptions in their ranges or have dubious taxonomic status. Zonal limits defined here are based on significant changes in number and abundance of nannofossil species within reasonably small intervals of rock strata. These changes may be represented by the first or last occurrences of one or more species and may take place within a minimum of 5 m of rock strata (e.g. limit between the *Prediscosphaera cretacea* Zone and the *Eiffellithus turriseiffeli* Zone in the section of the Col de Palluel) or may extend to as much as 40 m (e.g. limit between the *Microrhabdulus bollii* Zone and the *Micrantholithus hoschulzi* Zone in the section of the Route d'Angles). In order to arrive at a subdivision which is as independent as possible of local paleoenvironmental influences, all limits are based on as many significant alternations of the assemblage as possible. Defining zonal boundaries in this less restricted way should also allow recognition of limits in areas of differing paleoecology. While numerous first occurrences have been identified in the intervals Upper Tithonian to Lower Hauterivian and Lower Aptian to Upper Albian, no significant first occurrences have as yet been found between the Upper Hauterivian and the Upper Barremian. Here nannofossil assemblages become progressively more impoverished. The succession of species extinctions is variable, therefore the zonal limits defined by the extinctions of two species may encompass as much as 40 m of rock strata in the sections studied. Further investigations under way of taxonomically still doubtful species and the study of the nannofossil stratigraphy of other areas may show which species are the most consistent markers. Zonal limits may then be defined more closely, some additional zones may be introduced and the establishment of datum levels may become justified.

The nine nannofossil zones proposed here cover the interval from the Upper Tithonian to the Lower Cenomanian. This interval represents about 35 million years (HURLEY 1966). The average time interval covered by the nannofossil zones is, therefore, about four million years.

Nannoconus colomi Zone

Description:

The base of this zone is marked by the first appearance of *Nannoconus colomi* (DE LAPPARENT) which becomes immediately abundant. The top of this zone is below the first appearance of *Cretarhabdus crenulatus* BRAMLETTE and MARTINI emend. Abundant species at the base of this zone are: *Cyclagelosphaera margareli* NOËL, *Cretaturbella rothii* n.sp., *Diazomatholithus lehmani* NOËL, *Watznaueria barnesae* (BLACK), and *Parhabdolithus embergeri* (NOËL). Common species are: *Watznaueria britannica* (STRADNER), *Polycostella beckmannii* n.sp., *Stephanolithion laffittei* NOËL and *Watznaueria communis* REINHARDT. *Polycostella beckmannii* n.sp. has its last occurrence near the base of this zone. Within this zone *Polycostella senaria* n.sp. appears, becomes immediately abundant, and then extincts. The following species have their first appearances within this zone: *Cretarhabdus surirellus* (DEFLANDRE), *Cretarhabdus conicus* BRAMLETTE and MARTINI, *Rucinolithus wisei* n.sp., *Staurolithites compactus* (BUKRY), *Nannoconus truitti* BRONNIMANN, *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT), *Parhabdolithus asper* (STRADNER), *Cruciellipsis cuvillieri* (MANIVIT), *Parhabdolithus splendens* (DEFLANDRE), *Glaukolithus diplogrammus* (DEFLANDRE), *Bipodorhabdus roeglii* n.sp., *Micrantholithus obtusus* STRADNER, and *Micrantholithus hoschulzi* (REINHARDT). Remarks:

The definition of the lower limit of this zone is the same as that of WORSLEY's *Nannoconus steinmanni* Zone, due to the fact that *Nannoconus colomi* (DE LAPPARENT) and *Nannoconus steinmanni* KAMPTNER are synonyms. The type assemblage of WORSLEY's *Nannoconus steinmanni* Zone (DSDP Leg 1–4–4–1, 80cm) is similar to that of the lower *Microrhabdulus bollii* Zone (defined below) and therefore is younger.

The limit between Tithonian and Berriasian is dated by cephalopods and calpionellids and lies just above layer BR 26 (LE HÉGARAT and REMANE 1968). *Polycostella senaria* n.sp. and *Rucinolithus wisei* n.sp. have their first occurrence 4m above this layer. They range within the *Berriasella grandis* Zone and the calpionellid *Bsup.* Subzone. Therefore the Jurassic-Cretaceous boundary can be fixed with the first occurrences of these two species.

Reference sections: Assemblage: Broyon, formations BR 26 to BR 35; upper limit: Lacisterne, formations LC 3428 to LC 3440; sedimentary facies: Alternations of marly limestones and marls. The sections are dated by their cephalopod and calpionellid assemblages (LE HÉGARAT and REMANE 1968).

Geographic distribution: Southeastern France (Broyon, Lacisterne; Massif des Bauges [MANIVIT, CHAROLLAIS and STEINHAUSER 1969]), Algeria (NOËL 1965).

Zonal range: Upper Tithonian to Upper Berriasian.

Cretarhabdus crenulatus Zone

Description:

The base of this zone is characterized by the first occurrence of *Cretarhabdus crenulatus* BRAMLETTE and MARTINI emend., which is common throughout this zone. The top of the zone lies below the first occurrences of *Calcicalathina oblongata* (WORSLEY) and *Staurolithites crux* (DEFLANDRE). *Micrantholithus hoschulzi* (REINHARDT) becomes abundant and *Markalius circumradiatus* (STOVER) makes its first appearance within this zone.

Remarks:

Only species with eight radial arms in the central area are included here in *Cretarhabdus crenulatus* BRAMLETTE and MARTINI (see emendation p. 476).

STAGES		CEPHALOPODS: Colloque 1963 Zones	CEPHALOPODS: Moullade 1966 Zones	CEPHALOPODS: Moullade 1966 Subzones	FORAMINIFERA: Moullade 1966 Zones	FORAMINIFERA: Moullade 1966 Subzones	FORAMINIFERA: Guillaume, Boli and Beckmann 1969 ms
CENOMANIAN			subvarians			greenhornensis	Rotalipora apenninica + Rotalipora ticinensis
ALBIAN	Upper	Stoliczkaia dispar	bergeri+dozei paronai?		apenninica sans greenhornensis	moliniensis + buxtorfi	
		Mortoniceras inflatum	inflata		breggiensis	ticinensis + delrioensis	Neobulimina primitiva
		Diploceras cristatum				praeticinensis	Praeglobotruncana planispira
	Lower	Eohoplites nitidus			planispira + infracretacea + O. aff. brotzeni	oxycona+primula	
		"Hoplites dentatus" + Lyelliceras lyelli				gyroidinaeformis	Neobulimina subcretacea
		Douvilleiceras mammillatum			subnodosa + trocoidea		
		Leymeriella tardefurcata	tardefurcata + trivialis			subnodosa + bejaouaensis	Praeglobotruncana rohri
APTIAN	Upper	Diadochoceras nodocostatum	jacobi + elegans		ferreolensis	O. aff. brotzeni sans Pleurostomaria; bejaouaensis sans O. aff. brotzeni	Praeglobotruncana infracretacea
		Cheloniceras subnodocostatum				trocoidea; algerianus; barremiana+blowi	Biglobigerinella barri
	Lower	Aconoceras nisus	guettardi	nisum	cabri		Biglobigerinella cf. barri
		Deshayesites deshayesi	matheroni	deshayesi	sigali sans eichenbergi	sigali + H. aff. planispira	Choffatella decipiens
BARREMIAN	Upper	Silesites serranonis	serranonis		eichenbergi + barremiana	eichenbergi + aptiensis	
	Lower	Nicklesia pulchella	emerici	moutoni?	sigmoicosta + sigali	C. aff. simplex; sigmoicosta + sigali sans Clavihedbergella	
HAUTERIVIAN	Upper	Pseudothurmannia angulicostata	angulicostata		hauteriviana + sigmoicosta	ouachensis + vocontianus	
		Subsaynella sayni	duvali + ligatus + balearis; villersianus + sayni + meriani				
	Lower	"Crioceras duvali"	jeannoti + castellanensis		vocontianus		
		Acanthodiscus radiatus	Lytoceras + Crioceratites				
VALANGINIAN	Upper	Lytoceras s. l. sp.	Lytoceras sans Crioceratites		hauteriviana + eichenbergi + bartensteini + busnardoi		
		Saynoceras verrucosum	verrucosum		zedlerae + busnardoi sans hauteriviana; nodosa + busnardoi		
	Lower	Kilianella roubadiana	roubadiana			D_3	
BERRIASIAN	Upper	Berriasella boissieri	boissieri	callisto; picteti	D	D_2	
				paramimouna	D	D_1	
				dalmasi; privasensis; subalpinus	C		
	Lower	Berriasella grandis	grandis		B	B sup.	
STAGES		Zones	Zones	Subzones	Zones	Subzones	
		Colloque 1963	Le Hégarat and Remane 1968				
		CEPHALOPODS	CEPHALOPODS	CEPHALOPODS	CALPIONELLIDS	CALPIONELLIDS	

Fig. 2. Correlation of Lower Cretaceous cephalopod, foraminifer and calpionellid zones with classical stages.

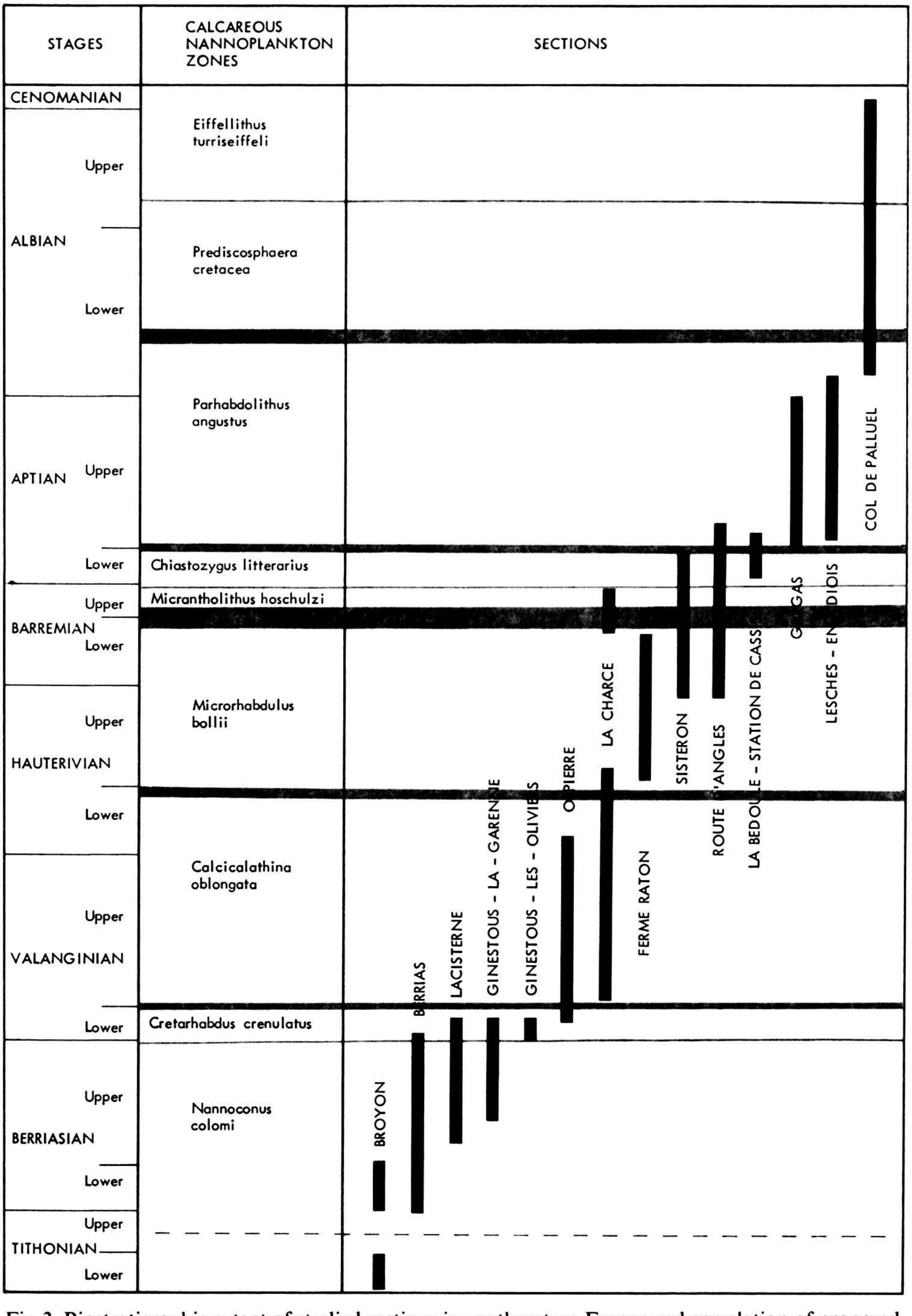

Fig. 3. Biostratigraphic extent of studied sections in southeastern France and correlation of proposed nannofossil zonation with classic Lower Cretaceous stages.

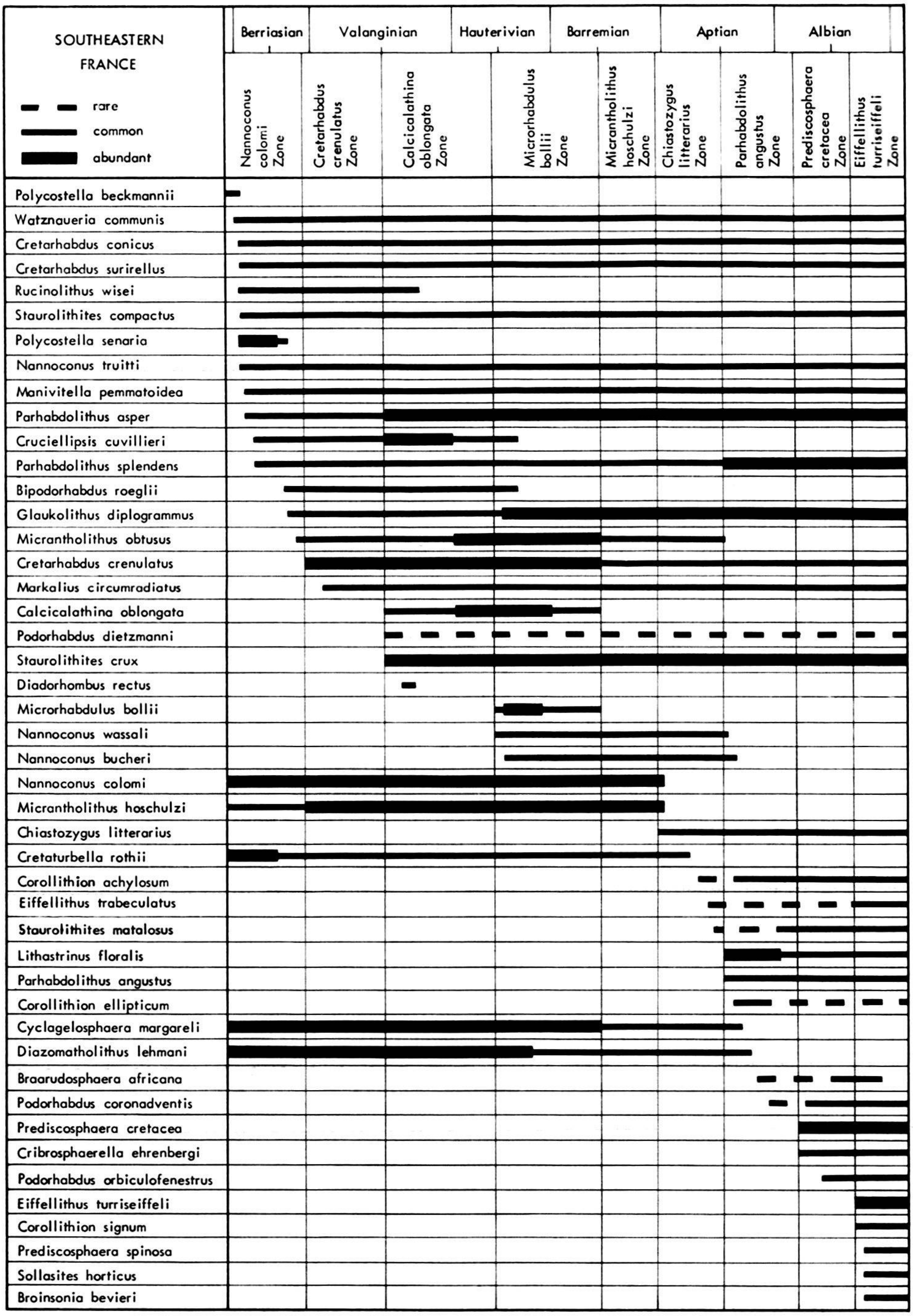

Fig. 4. Compiled distribution of calcareous nannofossils in the sections of southeastern France. Species arranged in order of biostratigraphic events.

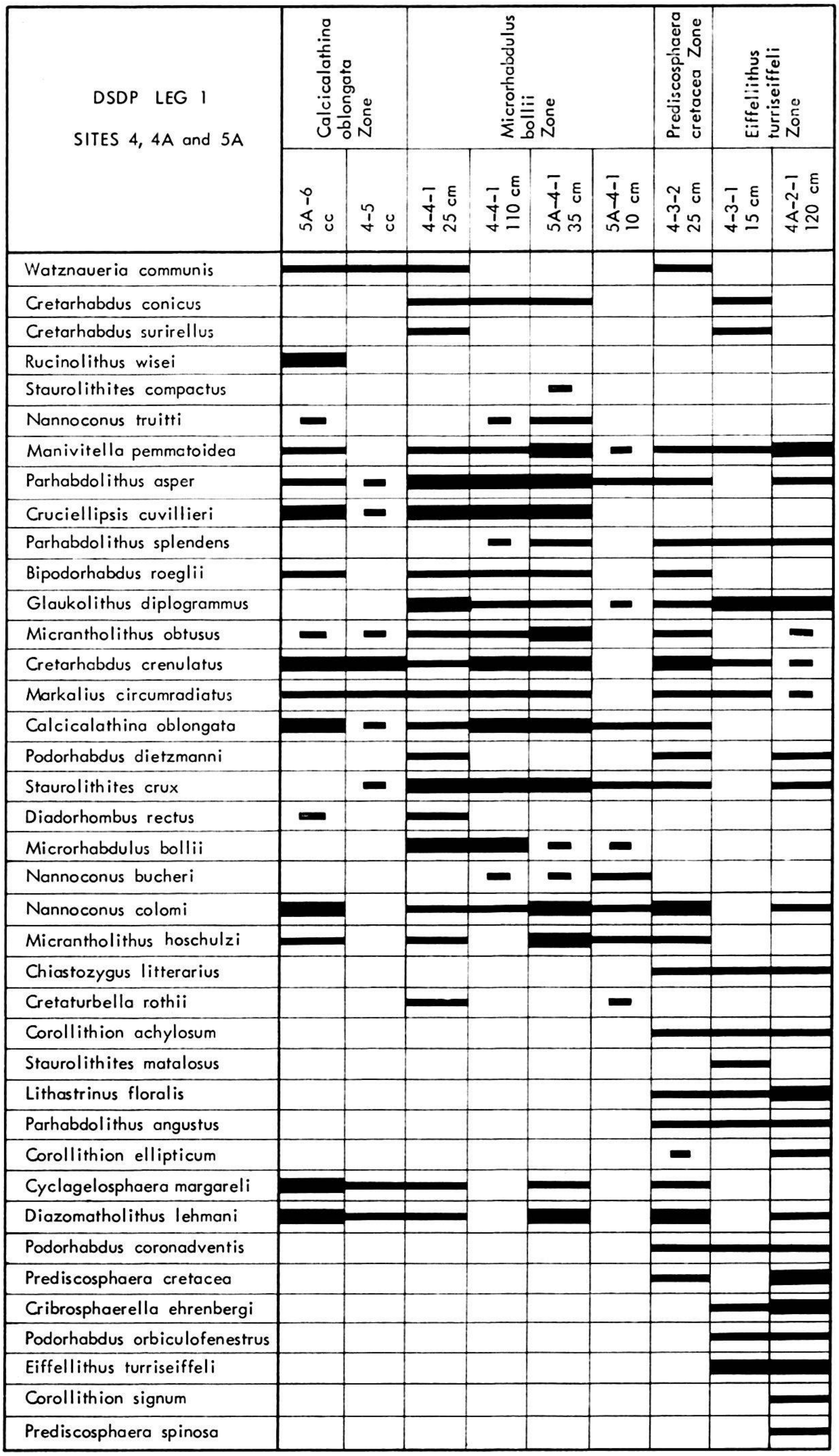

Fig. 5. Distribution of calcareous nannofossils in the Lower Cretaceous of DSDP Leg 1, Sites 4, 4A and 5A, Blake Bahama Basin (West Atlantic).

Reference section: Assemblage: Ginestous-les-Oliviers, formations LO 3443 to LO 3458; sedimentary facies: Alternations of marly limestones and marls. The section is dated by the cephalopod assemblages and the calpionellid associations (LE HÉGARAT and REMANE 1968).

Geographic distribution: Southeastern France (Lacisterne, Ginestous-les-Oliviers, Berrias, Orpierre; Massif des Bauges and Massif des Bornes [MANIVIT, CHAROLLAIS and STEINHAUSER 1969]).

Zonal range: Upper Berriasian to Lower Valanginian.

Calcicalathina oblongata Zone

Description:

The base of this concurrent-range-zone is characterized by the first occurrences of *Calcicalathina oblongata* (WORSLEY) and *Staurolithites crux* (DEFLANDRE), the latter becoming abundant, as well as *Cruciellipsis cuvillieri* (MANIVIT) and *Parhabdolithus asper* (STRADNER). The top of the zone lies below the first occurrences of *Microrhabdulus bollii* n. sp. and *Nannoconus wassali* BRONNIMANN. Except for *Rucinolithus wisei* n. sp. which disappears in the zone, the assemblage of the underlying zone persists. *Diadorhombus rectus* WORSLEY occurs very rarely at the base of this zone.

Remarks:

The type assemblage of WORSLEY's *Parhabdolithus embergeri* Zone (type level: DSDP Leg 1–4–5, core catcher) is identical to the assemblage of the *Calcicalathina oblongata* Zone with the exception that *Nannoconus colomi* (DE LAPPARENT) and *Micrantholithus hoschulzi* (REINHARDT) are missing in the first. Since both forms belong to genera whose occurrences are considered to be influenced by water depth and temperature, their absence should not be used exclusively for biostratigraphic correlation. This zone includes WORSLEY's *Diadorhombus rectus* Zone (type level: DSDP Leg 1–5A–7, core catcher), the index fossil of which is extremely rare in southeastern France. The type sample of WORSLEY's *Ellipsochiatus quadriserratus* Zone (type level: DSDP Leg 1–5A–6, core catcher) also belongs to the *Calcicalathina oblongata* Zone.

Reference sections: Lower limit: Orpierre, formations a–b; assemblage and upper limit: La Charce, formations a–e; sedimentary facies: Alternations of limestones and marls. The sections are dated by cephalopods and foraminifera (MOULLADE 1966).

Geographic distribution: Southeastern France (Orpierre, La Charce), West Atlantic.

Zonal range: Lower Valanginian to Lower Hauterivian.

Microrhabdulus bollii Zone

Description:

The base of this concurrent-range-zone is characterized by the first appearances of *Microrhabdulus bollii* n. sp., which is common, and *Nannoconus wassali* BRONNIMANN, which is rare. *Calcicalathina oblongata* (WORSLEY) and *Microrhabdulus bollii* n. sp. become rare in the upper part of the zone and both markers have their last occurrence near the top. The assemblage is otherwise the same as in the underlying zone except for the following changes: *Cruciellipsis cuvillieri* (MANIVIT) and *Bipodorhabdus roeglii*

n. sp. have their extinction in the lower part of this zone, *Glaukolithus diplogrammus* (DEFLANDRE) becomes abundant, *Nannoconus bucheri* BRONNIMANN makes its first appearance, and the frequency of *Diazomatholithus lehmani* NOËL is reduced.
Remarks:

The type sample of WORSLEY's *Nannoconus steinmanni* Zone originates from the interval between the two samples of DSDP Leg 1–4–4–1, 110cm, and DSDP Leg 1–4–4–1, 11cm, therefore all three belong to the *Microrhabdulus bollii* Zone as well as WORSLEY's type sample of his *Watznaueria diaphanae* Zone, which lies between the two samples DSDP Leg 1–5A–4–1, 35cm and DSDP Leg 1–5A–4–1, 10cm, both belonging to this zone.

Reference section: Assemblage: DSDP Leg 1–4–4–1, 110cm to 11cm; sedimentary facies: Alternating light gray nannoplankton chalk and dark gray nannoplankton marls.

Geographic distribution: Southeastern France (La Charce, Route d'Angles, Ferme Raton, Sisteron), West Atlantic.

Zonal range: Lower Hauterivian to Lower Barremian.

Micrantholithus hoschulzi Zone

Description:

The base of this inter-zone is characterized by a gradual impoverishment of the assemblage of the underlying zone: *Calcicalathina oblongata* (WORSLEY) and *Microrhabdulus bollii* n. sp. disappear and the frequencies of *Micrantholithus obtusus* STRADNER, *Cretarhabdus crenulatus* BRAMLETTE and MARTINI emend., and *Cyclagelosphaera margareli* NOËL are perceptibly reduced. The top of the zone lies below the first occurrence of *Chiastozygus litterarius* (GORKA).
Remarks:

The succession of the extinctions of *Calcicalathina oblongata* (WORSLEY) and *Microrhabdulus bollii* n. sp. is locally different, so that all the indications defining the basal limit of the zone have to be considered.

Reference section: Base, assemblage and upper limit: Route d'Angles, formations 3–16; sedimentary facies: Alternations of dark marls and gray limestones. The section is dated by cephalopods and foraminifera (MOULLADE 1966).

Geographic distribution: Southeastern France (Route d'Angles, Sisteron, Ferme Raton, La Charce).

Zonal range: Lower Barremian to Upper Barremian.

Chiastozygus litterarius Zone

Description:

The base of this zone is defined by the short overlap of *Chiastozygus litterarius* (GORKA) with abundant *Nannoconus colomi* (DE LAPPARENT) and *Micrantholithus hoschulzi* (REINHARDT), both of which disappear abruptly. The top of the zone lies below the first occurrences of *Parhabdolithus angustus* (STRADNER) and *Lithastrinus floralis* STRADNER. *Cretaturbella rothii* n. sp. has its last occurrence within this zone.
Remarks:

Very rare specimens of *Corollithion achylosum* (STOVER), *Staurolithites matalosus* (STOVER) and *Eiffellithus trabeculatus* (GORKA) have their first occurrences within this zone. The *Chiastozygus litterarius* Zone includes the *Prediscosphaera columnata* Zone of MANIVIT (1971) and the lower part of WORSLEY'S (1971) *Staurolithites matalosus* Zone, but has its base at the significant change in the nannofossil assemblage which occurs in the uppermost Barremian.

Reference section: Assemblage and upper limit: Lesches-en-Diois, formations l, m (0–25 m); sedimentary facies: Alternations of dark marls and gray marly limestones. The section is dated by cephalopods and foraminifera (MOULLADE 1966).

Geographic distribution: Southeastern France (Route d'Angles, Lesches-en-Diois, La Bédoule, Station de Cassis).

Zonal range: Upper Barremian to Lower Aptian.

Parhabdolithus angustus Zone

Description:

The first appearances of *Parhabdolithus angustus* (STRADNER) and *Lithastrinus floralis* STRADNER, the abundance of *Parhabdolithus splendens* (DEFLANDRE), and the extinctions of *Nannoconus wassali* BRONNIMANN and *Micrantholithus obtusus* STRADNER mark the base of this concurrent-range-zone. The top of the zone lies below the first appearances of *Prediscosphaera cretacea* (ARKHANGELSKY) and *Cribrosphaerella ehrenbergi* (ARKHANGELSKY). *Nannoconus bucheri* BRONNIMANN, *Cyclagelosphaera margareli* NOËL and *Diazomatholithus lehmani* NOËL have their last occurrence within this zone. The first *Corollithion ellipticum* BUKRY, *Braarudosphaera africana* STRADNER and *Podorhabdus coronadventis* (REINHARDT) appear in this zone.

Remarks:

MANIVIT'S zone definition is enlarged here to that of a concurrent-range-zone. No *Eiffellithus turriseiffeli* (DEFLANDRE) have been noted in the samples of Gargas and Lesches-en-Diois. As far as is known to the author, no *Eiffellithus turriseiffeli* (DEFLANDRE) have ever been recorded from the Upper Aptian except by MANIVIT (1971). Her range for this species is therefore considered to be the result of liberal taxonomic interpretation. The top of this zone as given by MANIVIT (first appearance of *Hayesites albiensis* MANIVIT) could not be identified with certainty in sections in southeastern France, Switzerland and in the Atlantic, therefore its definition is modified here. The *Parhabdolithus angustus* Zone lies within WORSLEY'S *Staurolithites matalosus* Zone.

Author: MANIVIT (1971), modified in this paper.

Reference section: Assemblage: Gargas, formations 3 and 4; sedimentary facies: Blue-gray marls. The section is dated by cephalopods (MOULLADE 1965) and ostracods (OERTLI 1958).

Geographic distribution: Southeastern France (Lesches-en-Diois, Gargas, Col de Palluel), South Atlantic.

Zonal range: Upper Aptian to Lower Albian.

Prediscosphaera cretacea Zone

Description:

Prediscosphaera cretacea (ARKHANGELSKY) and *Cribrosphaerella ehrenbergi* (ARKHANGELSKY) appear for the first time at the base of this concurrent-range-zone, the former becoming immediately abundant. The top of the zone is below the first appearances of *Eiffellithus turriseiffeli* (DEFLANDRE) and *Corollithion signum* STRADNER. Within this zone *Podorhabdus orbiculofenestrus* (GARTNER) has its first appearance. The rest of the assemblage is the same as in the underlying zone.

Remarks:

This zone includes the lower part of MANIVIT'S *Hayesites albiensis* Zone, the index fossil of which is quite rare in the sections studied. It also includes the lower part of ČEPEK and HAY'S (1969) *Staurolithites orbiculofenestrus* Zone, the index fossil of which also occurs rarely. The ranges of the species defining the *Prediscosphaera cretacea* Zone correspond with the range charts given by ČEPEK and HAY (1969) and MANIVIT (1971). The species used here can be recognized more easily and are more frequent than the index fossils proposed earlier. This zone also includes the top of WORSLEY'S *Staurolithites matalosus* Zone.

Reference section: Base, assemblage and upper limit: Col de Palluel, formations o, p, q, r_1; sedimentary facies: Dark marls, sandy and glauconitic at the base. The section is dated by cephalopods and foraminifera (MOULLADE 1966).

Geographic distribution: France (Col de Palluel; Coupe de l'Aube and Côtes de Moeslains [MANIVIT 1971]), West Atlantic, Kansas.

Zonal range: Lower Albian to Upper Albian.

Eiffellithus turriseiffeli Zone

Description:

The base of this concurrent-range-zone is characterized by the first occurrences of *Eiffellithus turriseiffeli* (DEFLANDRE) which becomes immediately abundant and *Corollithion signum* STRADNER. Within this zone *Prediscopshaera spinosa* (BRAMLETTE and MARTINI) and *Broinsonia bevieri* BUKRY have their first occurrence and *Braarudosphaera africana* STRADNER becomes extinct. The assemblage of this zone, originating from lower zones, consists of abundant *Glaukolithus diplogrammus* (DEFLANDRE), *Parhabdolithus asper* (STRADNER), *Watznaueria barnesae* (BLACK), *Parhabdolithus splendens* (DEFLANDRE), *Staurolithites crux* (DEFLANDRE), and *Prediscosphaera cretacea* (ARKHANGELSKY), of common *Parhabdolithus embergeri* (NOËL), *Stephanolithion laffittei* NOËL, *Cretarhabdus surirellus* (DEFLANDRE), *Creterhabdus crenulatus* BRAMLETTE and MARTINI emend., *Cretarhabdus conicus* BRAMLETTE and MARTINI, *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT), *Chiastozygus litterarius* (GORKA), *Lithastrinus floralis* STRADNER, *Parhabdolithus angustus* (STRADNER), *Staurolithites matalosus* (STOVER), *Cribrosphaerella ehrenbergi* (ARKHANGELSKY), and *Eiffellithus trabeculatus* (GORKA), and of rare *Nannoconus truitti* BRONNIMANN, *Watznaueria communis* REINHARDT, *Watznaueria britannica* (STRADNER), *Staurolithites compactus* (BUKRY), *Markalius circumradiatus* (STOVER), *Corollithion achylosum* (STOVER), *Podorhabdus coronadventis* (REINHARDT), *Podorhabdus dietzmanni* (REINHARDT) and *Podorhabdus orbiculofenestrus* (GARTNER). This assemblage persists up to the lowermost Cenomanian (occurrence of the foraminifera *Rotalipora greenhornensis* [MORROW] and *Schackoina cenomana* [SCHACKO] as listed by MOULLADE [1966]).

Remarks:

Only the lower limit and the assemblage of this zone are defined. The upper limit is still unclear, because of variable succession of first occurrences of younger species indicated by ČEPEK and HAY (1969), ČEPEK (1970), and MANIVIT (1971).

The *Eiffellithus turriseiffeli* Zone includes the top of MANIVIT'S *Hayesites albiensis* Zone and her *Corollithion rhombicum* Zone, the guide fossils of which have not been recorded with certainty in southeastern France, and her *Staurolithites matalosus* Zone, the guide fossil of which has its first occurrence in the *Chiastozygus litterarius* Zone already. It also includes ČEPEK and HAY'S *Staurolithites orbiculofenestrus* Zone, the guide fossil of which has its first occurrence only a little below that of *Eiffellithus turriseiffeli* (DEFLANDRE), but the latter being much more characteristic.

Reference section: Lower limit and assemblage: Col de Palluel, formations r, s; sedimentary facies: Blue-gray marls with marly, sandy limestones on top. The section is dated by cephalopods and foraminifera (MOULLADE 1966).

Geographic distribution: France (Col de Palluel; Coupe de l'Aube, Côtes de Moeslains, Wissant [MANIVIT 1971]), Atlantic, Kansas.

Zonal range: Upper Albian to Lower Cenomanian.

7. Systematic paleontology

The descriptions include five new genera, six new species, and important references to all species figured in this paper. An alphabetical list of species mentioned in this paper but already well covered in the literature is attached.

Kingdom PLANTAE
Division CHRYSOPHYTA
Class HAPTOPHYCEAE CHRISTENSEN 1962
Order PRYMNESIALES CHRISTENSEN 1962

Family Arkhangelskiellaceae BUKRY 1969

Genus *Broinsonia* BUKRY 1969

Type species: *Broinsonia dentata* BUKRY 1969

Broinsonia bevieri BUKRY 1969

Plate II, Figures 1–4

1969 *Broinsonia bevieri* BUKRY, p.21, Pl.1, Fig.8–10.
1969 *Aspidolithus angustus* NOËL, p.169, Pl.1, Fig.1, 2.

Family Zygolithaceae NOËL 1965

Genus *Calcicalathina* n. gen.

Type species: *Calcicalathina oblongata* (WORSLEY 1971) n. comb.

Description

Basket like elliptical forms with a high wall. Central area filled with calcite crystals of different orientation that rise above the distal margin of the wall. Proximal side flat or slightly concave.

Remarks

Calcicalathina n. gen. is distinguished from *Parhabdolithus* DEFLANDRE 1952 by the lack of a central process, *Crepidolithus* NOËL 1965 by its narrow wall and the presence of a central area, and all other genera by its filling of crystals.

Calcicalathina oblongata (WORSLEY 1971) n. comb

Plate IV, Figures 6–10

? 1970 *Crepidolithus ?* sp. indet. NOËL, Pl. 12, Fig. 2, 5.
1971 *Schizosphaerella oblongata* WORSLEY, p. 1312, Pl. 2, Fig. 32, 33.

Description

High distally widening wall constructed of 50–80 thin, long crystals that are inclined counterclockwise with dextral imbrication when viewed from the proximal side. On the proximal side of the wall lies a little rim composed of small, thin crystal plates. Ratio of height of filling to short axis of proximal ellipse 1 : 1 to 1 : 2.

Remarks

In the light microscope this species can be distinguished from *Parhabdolithus asper* (STRADNER 1963) by its small wall and the thickness of the central area.

Paratypes: [6-428/8] A 914, [1392] A 913

Type locality: DSDP Leg 1–5A–6, core catcher

Distribution: West Atlantic, southeastern France

Known range: Upper Valanginian – Lower Barremian

Genus *Eiffellithus* REINHARDT 1965

Type species: *Eiffellithus turriseiffeli* (DEFLANDRE 1954) REINHARDT 1965

Eiffellithus turriseiffeli (DEFLANDRE 1954) REINHARDT 1965

Plate VII, Figures 9–11

1954 *Zygolithus turriseiffeli* DEFLANDRE, in: DEFLANDRE and FERT, p. 149, Textfig. 65; Pl. 13, Fig. 15, 16.
1965 *Eiffellithus turriseiffeli* (DEFLANDRE 1954) REINHARDT, p. 36.
1970b *Eiffellithus turriseiffeli* (DEFLANDRE 1954) REINHARDT 1965, in: REINHARDT, p. 62, Textfig. 47, 48; Pl. 4, Fig. 6, 7; Pl. 5, Fig. 1, 2.

Genus *Staurolithites* CARATINI 1963

Type species: *Staurolithites laffittei* CARATINI 1963

Staurolithites crux (DEFLANDRE 1954) CARATINI 1963

Plate VI, Figures 13, 14

1954 *Discolithus crux* DEFLANDRE, in: DEFLANDRE and FERT, p. 143, Textfig. 55; Pl. 14, Fig. 4.
1963 *Staurolithites crux* (DEFLANDRE 1954) CARATINI, p. 25.
1968 *Zygolithus crux* (DEFLANDRE 1954) BRAMLETTE and SULLIVAN 1961, in STRADNER, ADAMIKER and MARESCH, p. 36, Pl. 28–30.

Genus *Chiastozygus* GARTNER 1968

Type species: *Chiastozygus amphipons* (BRAMLETTE and MARTINI 1964) GARTNER 1968

Chiastozygus litterarius (GORKA 1957) MANIVIT 1971

Plate II, Figures 17–21

1957 *Discolithus litterarius* GORKA, p. 274, Pl. 3, Fig. 3.
1967 *Zygolithus litterarius* (GORKA 1957) REINHARDT and GORKA, p. 249, Pl. 33, Fig. 7; non Pl. 31, Fig. 18, 22.
1970b *Eiffellithus anceps* (GORKA 1957) REINHARDT and GORKA 1967, in: REINHARDT, Pl. 3, Fig. 6.
1971 *Chiastozygus litterarius* (GORKA 1957) MANIVIT, manuscript p. 90, Pl. 4, Fig. 1–5.

Family Podorhabdaceae NOËL 1965

Genus *Bipodorhabdus* NOËL 1970

Type species: *Bipodorhabdus tesselatus* NOËL 1970

Bipodorhabdus roeglii n. sp.

Plate I, Figures 7–11

Description

A species of the genus *Bipodorhabdus* with two flat shields that are separated at the outer edge by a distinct groove. The distal shield consists of two cycles of which the upper one is smaller than the lower when viewed from the distal side.

Remarks

This species differs from *Bipodorhabdus tesselatus* NOËL 1970 in having the distal cycle of elements of the distal shield smaller than the proximal cycle of elements of the distal shield. The elements of the two shields are slightly inclined in opposite directions. In polarized light this species seems to have four arms arranged at an acute angle across the short axis.

Maximum diameter: 9 μm

Holotype: [6-419/3] A 906, *paratype:* [6-365/4] A 905.

Type locality: DSDP Leg 1–4–4–1, 11 cm

Distribution: West Atlantic, southeastern France

Known range: Upper Berriasian – Upper Hauterivian

Genus *Cretarhabdus* BRAMLETTE and MARTINI 1964

Type species: *Cretarhabdus conicus* BRAMLETTE and MARTINI 1964

Cretarhabdus crenulatus BRAMLETTE and MARTINI 1964 emend.

Plate V, Figures 10–14

1964 *Cretarhabdus crenulatus* BRAMLETTE and MARTINI, p. 300, Pl. 2, Fig. 21–24.
1968 *Cretarhabdus conicus* BRAMLETTE and MARTINI 1964, in: GARTNER (partim), Pl. 16, Fig. 14.
1968 *Cretarhabdus crenulatus* BRAMLETTE and MARTINI 1964, in: GARTNER (partim), p. 22, Pl. 6, Fig. 6; Pl. 19, Fig. 11; Pl. 20, Fig. 10, 11.
1969 *Cretarhabdus crenulatus crenulatus* (BRAMLETTE and MARTINI 1964) BUKRY, p. 35, Pl. 14, Fig. 1–6, 12.

Remarks

BRAMLETTE and MARTINI (1964) distinguished *Cretarhabdus crenulatus* from *Cretarhabdus conicus* by the latter having a wider perforated central area and a smaller shield. GARTNER (1968) (p. 21) pointed out that most specimens fall somewhere between the two above mentioned species. BUKRY (1969) included in *Cretarhabdus conicus* forms with two or three cycles of perforations. He subdivided specimens with one cycle of perforations into two subspecies, *Cretarhabdus crenulatus hansmanii*, including all forms with twelve perforations, and *Cretarhabdus crenulatus crenulatus* including all other forms with four to eleven and thirteen to sixteen perforations between the struts. Since in the light microscope specimens with eight struts can easily be distinguished from other specimens of the genus with more perforations in one cycle, *Cretarhabdus crenulatus* BRAMLETTE and MARTINI 1964 is thus restricted here to forms with eight struts lying parallel and diagonal to the axes of the ellipse.
Known range: Upper Berriasian – Maastrichtian

Cretarhabdus conicus BRAMLETTE and MARTINI 1964

Plate VI, Figures 7–12

1964 *Cretarhabdus conicus* BRAMLETTE and MARTINI, p. 299, Pl. 3, Fig. 5–8.
1969 *Cretarhabdus conicus* BRAMLETTE and MARTINI 1964, in: BUKRY, p. 35, Pl. 13, Fig. 7–12.

Remarks

See under *Cretarhabdus crenulatus*.
Known range: Lower Berriasian – Maastrichtian

Cretarhabdus surirellus (DEFLANDRE 1954) REINHARDT 1970b

Plate VI, Figures 1–6

1954 *Discolithus surirella* DEFLANDRE, in: DEFLANDRE and FERT, p. 144, Textfig. 30, 31.
1969 *Cretarhabdus crenulatus hansmanii* BUKRY, p. 35, Pl. 14, Fig. 2, 7–9.
1970b *Cretarhabdus surirellus* (DEFLANDRE 1954) REINHARDT (partim), p. 50, Textfig. 22; Pl. 1, Fig. 8; Pl. 2, Fig. 1–6.

Remarks

The description given by BUKRY (1969) for *Cretarhabdus crenulatus hansmanii* (p. 35), is enlarged here as far as the inclusion of all specimens of the genus *Cretarhabdus* with one cycle of perforations between the more than eight struts. In polarized light the struts of the central area extinguish in the diagonally opposite quadrants.
Known range: Lower Berriasian – Maastrichtian

Genus *Cruciellipsis* n. gen.

Type species: *Cruciellipsis cuvillieri* (MANIVIT 1966) n. comb.

Description

Two broad rings, the distal ring of greater diameter than the proximal, and both consisting of longish radial or slightly inclined elements, which may show slight sinistral imbrication or no overlap at all. The smaller diameter of the central opening is less than or equal to the breadth of the cycles. The central opening encloses an axial cross.

Remarks

The genus *Cruciellipsis* n. gen. differs from *Prediscosphaera* VEKSHINA 1959 by having more than sixteen elements in the ring, from *Cretarhabdus* BRAMLETTE and MARTINI 1964 by having only four arms in the central opening, from *Podorhabdus* NOËL 1965 by having a smaller central opening and broader rings, and from *Cruciplacolithus* HAY and MOHLER 1967 by the lack of a tube connecting the rings.

Cruciellipsis cuvillieri (MANIVIT 1966) n. comb.

Plate V, Figures 4–8

1966 *Coccolithus cuvillieri* MANIVIT, p. 268, Fig. 2, 3.
1969 *?Cruciplacolithus* sp., in: BUKRY and BRAMLETTE, p. 374, Pl. 3, Fig. C, D; Pl. 5, Fig. C.

Genus *Podorhabdus* NOËL 1965

Type species: *Podorhabdus grassei* NOËL 1965

Podorhabdus dietzmanni (REINHARDT 1965) REINHARDT 1967

Plate VIII, Figures 1–8

1965 *Ahmuellerella dietzmanni* REINHARDT, p. 30, Textfig. 1; Pl. 1, Fig. 1.
1967 *Podorhabdus dietzmanni* (REINHARDT 1965) REINHARDT, p. 169, Fig. 4.
1969 *Podorhabdus dietzmanni* (REINHARDT 1965) REINHARDT 1967, in: BUKRY, p. 37, Pl. 16, Fig. 1–3.
1970b *Podorhabdus dietzmanni* (REINHARDT 1965) REINHARDT 1967, in: REINHARDT (partim), p. 87, Textfig. 107a, non Textfig. 107b, non Pl. 6, Fig. 4.

Remarks

See diagnosis in BUKRY (1969). This species differs from *Podorhabdus orbiculofenestrus* (GARTNER 1968) in having a more elongated oval shape (excentricity 1.3–1.4), in having only one layer of small identical crystals in the central area, and in having two cycles of tabular elements in the distal shield instead of only one cycle.
Known range: Upper Valanginian – Santonian

Podorhabdus orbiculofenestrus (GARTNER 1968) n. comb.

Plate VIII, Figures 9–17

1965 *Rhabdosphaera* sp., in: BLACK, Fig. 10.
1968 *Prediscosphaera ? orbiculofenestra* GARTNER, p. 21, Pl. 25, Fig. 23–25; Pl. 26, Fig. 8.
1970b *Podorhabdus dietzmanni* (REINHARDT 1965) REINHARDT 1967, in: REINHARDT, p. 87, Textfig. 107b; Pl. 6, Fig. 4.

Remarks

This species differs from *Podorhabdus dietzmanni* (REINHARDT 1965) in having a less elongated oval shape (excentricity 1.1–1.2), in having the central area built of two layers of crystals, the proximal of small blocky crystals arranged in cycles concentric to the shield in the outer part, and around the four openings; the distal layer of irregular shaped, elongate crystals, which follow the sutures of the central area. The distal shield of *Podorhabdus orbiculofenestrus* (GARTNER 1968) consists only of one cycle of tabular

elements. The two species are very easily distinguishable in cross-polarized light: *Podorhabdus orbiculofenestrus* (GARTNER 1968) has eight bright segments along the outer margin of the central area, with the sutures along the axis of the ellipse at 45° (see Pl. 8, Fig. 12, 17), whereas the central area of *Podorhabdus dietzmanni* (REINHARDT 1965) is obscure.
Known range: Upper Albian – Campanian

Genus *Prediscosphaera* VEKSHINA 1959

Type species: *Prediscosphaera decorata* VEKSHINA 1959

Prediscosphaera cretacea (ARKHANGELSKY 1912) GARTNER 1968

Plate VII, Figure 7

1912 *Coccolithophora cretacea* ARKHANGELSKY, p. 410, Pl. 6, Fig. 12, 13.
1968 *Prediscosphaera cretacea* (ARKHANGELSKY 1912) GARTNER, p. 19, Pl. 2, Fig. 10–14; Pl. 3, Fig. 8; Pl. 4, Fig. 19–23; Pl. 6, Fig. 14, 15; Pl. 9, Fig. 1–4; Pl. 12, Fig. 1; Pl. 14, Fig. 20–22; Pl. 18, Fig. 8; Pl. 22, Fig. 1–3; Pl. 23, Fig. 4–6; Pl. 25, Fig. 12–14; Pl. 26, Fig. 2.

Family Ellipsagelosphaeraceae NOËL 1965

Genus *Markalius* BRAMLETTE and MARTINI 1964 emend. PERCH-NIELSEN 1968

Type species: *Markalius inversus* (DEFLANDRE 1954) BRAMLETTE and MARTINI 1964

Markalius circumradiatus (STOVER 1966) PERCH-NIELSEN 1968

Plate IV, Figures 1–5

1966 *Coccolithites circumradiatus* STOVER, p. 138, Pl. 5, Fig. 2–4; Pl. 9, Fig. 10.
1966 *Coccolithus deflandrei* MANIVIT, p. 268, Fig. 1 a–c.
1968 ? *Markalius circumradiatus* (STOVER 1966) PERCH-NIELSEN, p. 73, Textfig. 36, 37; Pl. 25, Fig. 2–7; Pl. 26, Fig. 1-7.

Genus *Diazomatholithus* NOËL 1965

Type species: *Diazomatholithus lehmani* NOËL 1965

Diazomatholithus lehmani NOËL 1965

Plate III, Figures 11–15

1965 *Diazomatholithus lehmani* NOËL, p. 96, Textfig. 25–27, Pl. 6, Fig. 6–10.

Genus *Manivitella* n. gen.

Type species: *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT 1965) n. comb.

Description

Two closely appressed, narrow shields form an elliptical ring. The distal shield consists of one cycle of non-imbricate elements, the proximal of one or two cycles of imbricated elements.

Remarks

The morphologic term "cricolith" has been introduced by BRAARUD, DEFLANDRE, HALLDAL and KAMPTNER 1955 for heterococcoliths *with the units arranged in a simple ring (example: Hymenomonas carterae)*. KAMPTNER 1958 described a genus *Cricolithus* and designated *Coccolithus multiradiatus* KAMPTNER 1955 as type species. FORCHHEIMER 1968 used the genus *Cricolithus* KAMPTNER for elliptical forms consisting of several cycles of elements only. Since the type species *Cricolithus multiradiatus* (KAMPTNER 1955) KAMPTNER 1958 consists of one cycle of elements, that emendation would exclude the type species. Several species of different structure have been asigned to the genus *Cricolithus* KAMPTNER 1958 by KAMPTNER (1963), BIGNOT and LEZAUD (1964), COHEN (1965) and MANIVIT (1965, 1971), although no holotype or lectotype or neotype of *Cricolithus multiradiatus* (KAMPTNER 1955) KAMPTNER 1958 have been designated in the literature.

Manivitella n. gen. is distinguished from *Cyclolithella* LOEBLICH and TAPPAN 1963 (= nom. subst. pro *Cyclolithus* KAMPTNER 1948 and *Cyclolithus* DEFLANDRE 1952), and from *Loxolithus* NOËL 1965 in having two shields. The ultrastructure of the genus *Ellipticolithites* CARATINI 1963 is not known and it therefore is considered to be synonymous to *Cricolithus* KAMPTNER 1958. The type species of the genus *Apertapetra* HAY, MOHLER and WADE 1966 is synonymous with *Reticulofenestra umbilica* (LEVIN 1965) MARTINI and RITZKOWSKI 1968 (fide ROTH 1970), and the generic name is therefore unavailable.

Manivitella pemmatoidea (DEFLANDRE ex MANIVIT 1965) n. comb.

Plate V, Figures 1–3

1965 *Cricolithus pemmatoideus* DEFLANDRE, in: MANIVIT, p. 192, Pl. 2, Fig. 8.
1966 *Cyclococcolithus gronosus* STOVER, p. 140, Pl. 1, Fig. 1–3; Pl. 8, Fig. 1.
1969 *Apertapetra gronosa* (STOVER 1966) BUKRY, p. 26, Pl. 6, Fig. 6–9.

Family Stephanolithionaceae BUKRY 1969

Genus *Corollithion* STRADNER 1961 emend. REINHARDT 1970b

Type species: *Corollithion exiguum* STRADNER 1961

Corollithion achylosum (STOVER 1966) n. comb.

Plate VII, Figures 12–16

1966 *Chiphragmalithus achylosus* STOVER, p. 137, Pl. 6, Fig. 26; Pl. 7, Fig. 1–3; Pl. 9, Fig. 20.

Corollithion ellipticum BUKRY 1969

Plate VII, Figure 6

1969 *Corollithion ellipticum* BUKRY, p. 40, Pl. 18, Fig. 10, 11.

Corollithion signum STRADNER 1963

Plate VIII, Figures 18–22

1963 *Corollithion signum* STRADNER, p. 11, Pl. 1, Fig. 13, 13a.

Genus *Diadorhombus* WORSLEY 1971

Type species: *Diadorhombus rectus* WORSLEY 1971

Diadorhombus rectus WORSLEY 1971

Plate VII, Figure 8

1969 *Corollithion* sp. BUKRY and BRAMLETTE, p. 378, Pl. 5, Fig. B.
1971 *Diadorhombus rectus* WORSLEY, p. 1307, Pl. 1, Fig. 14–20.

Description

This species has a square wall of about 30 counterclockwise inclined and slightly sinistrally imbricated elements when viewed from the distal side. At the proximal end of the wall is arranged a central cross of many small elements. On the proximal side of the wall lies a rim of about 30 small blocky crystals.
Maximum diameter: 6 μm
Paratype: [6-356/9] A 917
Known range: Upper Valanginian

Genus *Lithastrinus* STRADNER 1962

Type species: *Lithastrinus grilli* STRADNER 1962

Lithastrinus floralis STRADNER 1962

Plate VII, Figures 1–5

1962 *Lithastrinus floralis* STRADNER, p. 370, Pl. 2, Fig. 6–11.

Family Microrhabdulaceae DEFLANDRE 1963

Genus *Microrhabdulus* DEFLANDRE 1959

Type species: *Microrhabdulus decoratus* DEFLANDRE 1959

Microrhabdulus bollii n. sp.

Plate III, Figures 6–10

Description

A species of the genus *Microrhabdulus* that has irregular crystals arranged along an irregular wavy median axis. All crystals have their optical orientation parallel to the median axis.

Remarks

This species is distinguished from all other species of the genus *Microrhabdulus* by the irregularity of its median suture and its shape.
Length: 8–12 μm, *thickness:* 1.5–2.0 μm
Holotype: [6-356/7] A 912, *paratype:* [1387] A 911
Type locality: DSDP Leg 1–4–4–1, 11–110 cm
Distribution: West Atlantic, southeastern France
Known range: Lower Hauterivian – Lower Barremian

Family Braarudosphaeraceae Deflandre 1947

Genus *Micrantholithus* Deflandre 1950

Type species: *Micrantholithus flos* Deflandre 1950

Micrantholithus hoschulzi (Reinhardt 1966) n. comb.

Plate I, Figures 12–15

1966 *Braarudosphaera hoschulzi* Reinhardt, p. 42, Pl. 21, Fig. 3.

Micrantholithus obtusus Stradner 1963

Plate V, Figure 9

1963 *Micrantholithus obtusus* Stradner, p. 11, Pl. 6, Fig. 11, 11a.

Genus *Rucinolithus* Stover 1966

Type species: *Rucinolithus hayi* Stover 1966

Rucinolithus wisei n. sp.

Plate IV, Figures 11–15

1971 *Lithastrinus moratus* Stover 1966, in: Worsley, p. 1309, Pl. 2, Fig. 1–3.

Description

A species of the genus *Rucinolithus* with always six sinistrally imbricated, asymmetric elements with straight edges on the distal side. Left edges of the elements on the distal side have clockwise inclination and begin off center. Viewed from proximal side the elements are asymmetric lanceolate.

Remarks

This species differs from *Rucinolithus hayi* Stover 1966 by the consistancy of the number of its elements and by their asymmetric shape.

Holotype: [6-410/4] A 915, *paratype:* [6-374/1] A 916
Type locality: DSDP Leg 1–5A–6, core catcher
Distribution: West Atlantic, southeastern France
Known range: Lower Berriasian – Upper Valanginian

Incertae sedis

Genus *Cretaturbella* n. gen.

Type species: *Cretaturbella rothii* n. sp.

Description

Elongated, truncated cone consisting of about 40 calcite plates that are dextrally inclined and arranged in a dextrally turning spindle when viewed from the narrower end of the cone. The central canal is in the median axis of the truncated cone. The spindle is enclosed by long, narrow, non-imbricate coverplates extending from one end of the truncated cone to the other, and with the sutures between the cover plates parallel to the median axis.

Cretaturbella rothii n. sp.

Plate III, Figures 1–5

1965 Particule calcaire in NOËL, Pl. 28, Fig. 7, 5.

Description

The same as for the genus.

Remarks

On many specimens the cover plates have partly or completely fallen off.

Holotype: [2448] A 910, *paratype:* [2440] A 909

Type locality: DSDP Leg 1–4–4–1, 11 cm

Distribution: West Atlantic, southeastern France

Known range: Lower Tithonian – Lower Aptian

Genus *Nannoconus* KAMPTNER 1931 emend. FARINACCI 1964

Type species: *Nannoconus colomi* (DE LAPPARENT 1931) KAMPTNER 1938

Nannoconus colomi (DE LAPPARENT 1931) KAMPTNER 1938

Plate III, Figure 16

1931 *Lagena colomi* DE LAPPARENT, p. 223.
1938 *Nannoconus colomi* (DE LAPPARENT 1931) KAMPTNER, p. 252.
1938 *Nannoconus steinmanni* KAMPTNER, p. 289, Textfig. 1–3.

Remarks

Nannoconus steinmanni KAMPTNER 1931 is considered as synonym to *Nannoconus colomi* (DE LAPPARENT 1931) because of identical ranges.

Genus *Polycostella* n. gen.

Type species: *Polycostella senaria* n. sp.

Description

Flat conical pile of radially organized elements slightly sloping towards the proximal niche and forming six to eight radial ridges on the distal side. Flat proximal side with a niche in the center.

Remarks

Hexalithus GARDET 1955 consists of six, *Micrantholithus* DEFLANDRE 1954 of five plates separated by sutures. *Brachiolithus* LOEBLICH and TAPPAN 1963 has an ortholithic structure, whereas *Polycostella* is rather heliolithic.

Polycostella beckmannii n. sp.

Plate II, Figures 5–16

Description

Generally circular shaped species of the genus *Polycostella* with six to eight ridges on the distal side.

Remarks

This species is distinguished from *Polycostella senaria* n.sp. by its always convex outer margin.

Diameter: 3.5–6 μm

Holotype: [3617] A 907, *paratype:* [3268] A 908

Type locality: Broyon (Ardèche) in southeastern France, *type level:* Lower Tithonian marls above layer BR 4 (see LE HÉGARAT and REMANE 1968)

Known range: Lower Tithonian – Lower Berriasian

Polycostella senaria n.sp.

Plate I, Figures 1–6

Description

A starlike species of the genus *Polycostella* with six ridges and concave outer margins between the ridges.

Remarks

This species differs from *Polycostella beckmannii* n.sp. by its starlike shape.

Diameter: 3–5 μm

Holotype: [2954] A 904, *paratype:* [2955] A 903

Type locality: Broyon (Ardèche) in southeastern France, *type level:* Lower Berriasian marls between layers BR 31 and BR 33 (see LE HÉGARAT and REMANE 1968)

Distribution: Southeastern France, Algeria

Known range: Berriasian

Alphabethic list of species well covered in previous literature:

Braarudosphaera africana STRADNER 1961, in: STRADNER, ADAMIKER and MARESCH 1968, p. 44, Pl. 46.

Cribrosphaerella ehrenbergi (ARKHANGELSKY 1912) DEFLANDRE 1952, in: REINHARDT 1970b, p. 52, Textfig. 24; Pl. 3, Fig. 4.

Cyclagelosphaera margareli NOËL 1965, p. 130, Textfig. 44–46; Pl. 17, Fig. 4–9; Pl. 18, Fig. 1, 2; Pl. 20, Fig. 2–4.

Eiffellithus trabeculatus (GORKA 1957) REINHARDT and GORKA 1967, p. 250, Textfig. 5; Pl. 31, Fig. 19, 23; Pl. 32, Fig. 1.

Glaukolithus diplogrammus (DEFLANDRE 1954) REINHARDT 1964, p. 758 (= *Zygolithus diplogrammus* DEFLANDRE, in: DEFLANDRE and FERT 1954, p. 148, Pl. 10, Fig. 7).

Nannoconus bucheri BRONNIMANN 1955, p. 39, Pl. 1, Fig. 1–3, 5–7; Textfig. 2k–n.

Nannoconus truitti BRONNIMANN 1955, p. 38, Pl. 2, Fig. 2–5, 7; Textfig. 2f–j.

Nannoconus wassali BRONNIMANN 1955, p. 29, Pl. 1, Fig. 4, 8, 9, 15, 17, 21; Pl. 2, Fig. 22; Textfig. 2o–s.

Parhabdolithus angustus (STRADNER 1963) STRADNER, ADAMIKER and MARESCH 1968, p. 32, Pl. 20.

Parhabdolithus asper (STRADNER 1963) MANIVIT 1971, manuscript p. 75, Pl. 23, 4–7 (= *Discolithus asper* STRADNER 1963, p. 11, Pl. 2, Fig. 4, 4a, 5, 5a).

Parhabdolithus splendens (DEFLANDRE 1953) NOËL 1969, p. 476, Pl. 1, Fig. 1–4, 7.

Podorhabdus coronadventis (REINHARDT 1966) REINHARDT 1970b, p. 86, Textfig. 16, 17 (= *Cretarhabdus coronadventis* REINHARDT 1966, p. 26, Pl. 23, Fig. 29, 30).

Prediscosphaera spinosa (BRAMLETTE and MARTINI 1964) GARTNER 1968, p. 20, Pl. 2, Fig. 15, 16; Pl. 3, Fig. 9, 10; Pl. 5, Fig. 7–9; Pl. 6, Fig. 16; Pl. 11, Fig. 17 (= *Deflandrius spinosus* BRAMLETTE and MARTINI 1964, p. 301, Pl. 2, Fig. 17–20).

Sollasites horticus (STRADNER, ADAMIKER and MARESCH 1966) ČEPEK and HAY 1969, p. 325 (= *Coccolithus horticus* STRADNER, ADAMIKER and MARESCH, in: STRADNER and ADAMIKER 1966, p. 337, Pl. 2, Fig. 4, Textfig. 1, 2).

Staurolithites compactus (BUKRY 1969) n. comb. (= *Vagalapilla compacta compacta* BUKRY 1969, p. 56, Pl. 31, Fig. 10, 11 = *Vagalapilla compacta integra* BUKRY 1969, p. 56, Pl. 31, Fig. 12).

Staurolithites matalosus (STOVER 1966) ČEPEK and HAY 1969, p. 325 (= *Coccolithus matalosus* STOVER 1966, p. 139, Pl. 2, Fig. 1, 2; Pl. 8, Fig. 10).

Watznaueria communis REINHARDT 1964, p. 756, Pl. 2, Fig. 5; Textfig. 6.

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Plate I

Fig. 1–6	*Polycostella senaria* n. sp. Broyon, layer BR 31/32, sample Th 70/358.
Fig. 1	Scanning electron micrograph of the distal side, 30° inclined, 12,000 ×.
Fig. 2	Scanning electron micrograph of the distal side, plan view, 6,500 ×, *holotype* [2954] A 904.
Fig. 3	Phase contrast, 3,200 ×, same specimen as Fig. 2.
Fig. 4	Transmitted light, 3,200 ×, same specimen as Fig. 2.
Fig. 5	Cross-polarized light, 3,200 ×, same specimen as Fig. 2.
Fig. 6	Scanning electron micrograph of the proximal side, plan view, 6,500 ×, *paratype* [2955] A 903.
Fig. 7–11	*Bipodorhabdus roeglii* n. sp. DSDP Leg 1–4–4–1, 11 cm.
Fig. 7	Scanning electron micrograph of the distal side, plan view, 5,000 ×, *paratype* [6-365/4] A 905.
Fig. 8	Scanning electron micrograph of the proximal side, plan view, 5,000 ×, *holotype* [6-419/3] A 906.
Fig. 9	Phase contrast, 3,200 ×, same specimen as Fig. 8.
Fig. 10	Cross-polarized light, 3,200 ×, same specimen as Fig. 8.
Fig. 11	Transmitted light, 3,200 ×, same specimen as Fig. 8.
Fig. 12–15	*Micrantholithus hoschulzi* (REINHARDT 1966) n. comb. DSDP Leg 1–4–3–2, 25 cm.
Fig. 12	Scanning electron micrograph, plan view, 7,000 ×.
Fig. 13	Transmitted light, 3,200 ×, same specimen as Fig. 12.
Fig. 14	Phase contrast, 3,200 ×, same specimen as Fig. 12.
Fig. 15	Cross-polarized light, 3,200 ×, same specimen as Fig. 12.

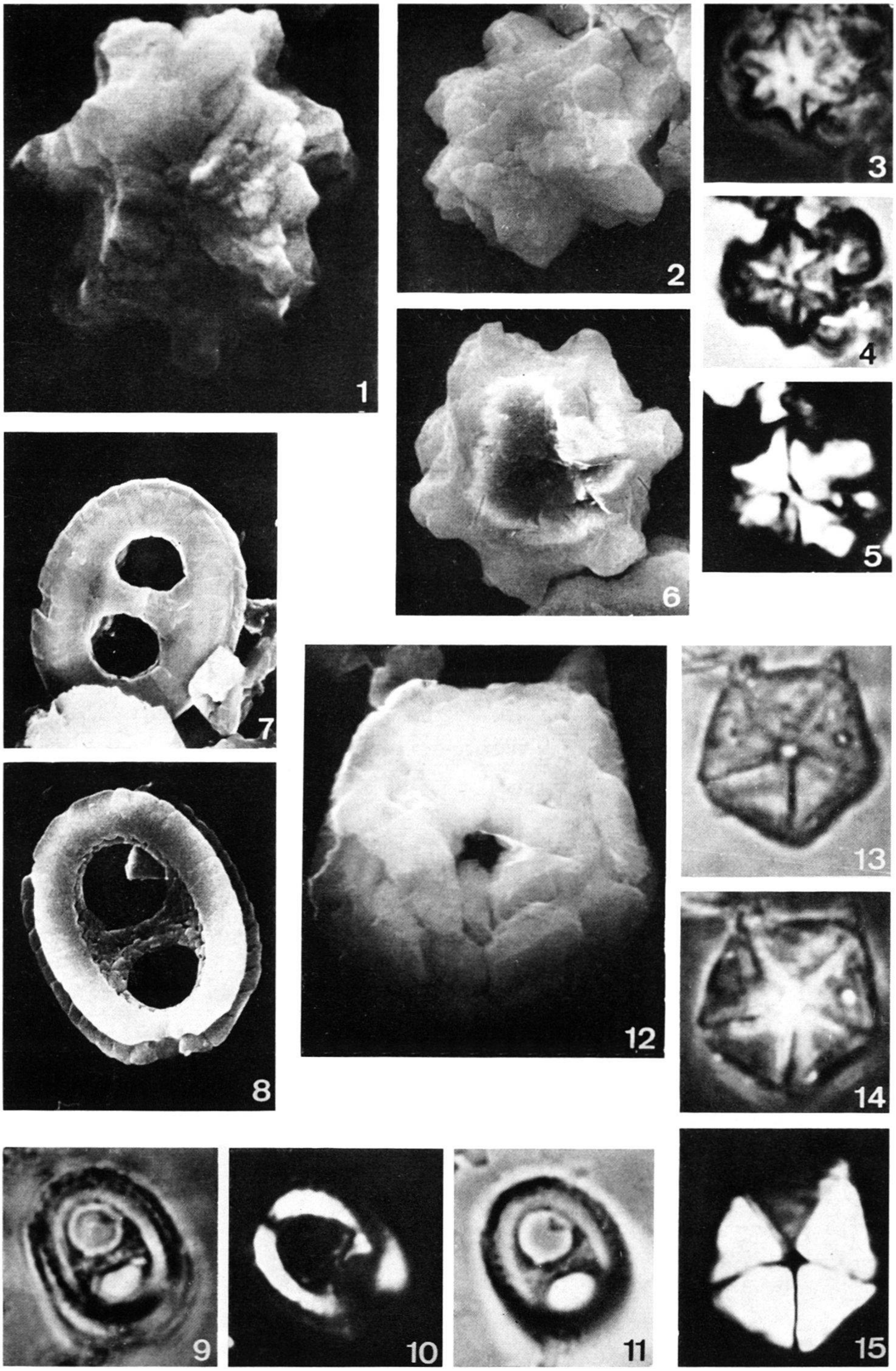
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Plate II

Fig. 1–4	*Broinsonia bevieri* BUKRY 1969 Col de Palluel, formation 3, sample Th 70/86.
Fig. 1	Scanning electron micrograph of the distal side, 6,500 ×.
Fig. 2	Phase contrast, 3,200 ×, same specimen as Fig. 1.
Fig. 3	Transmitted light, 3,200 ×, same specimen as Fig. 1.
Fig. 4	Cross-polarized light, 3,200 ×, same specimen as Fig. 1.
Fig. 5–16	*Polycostella beckmannii* n. sp. Broyon, layer BR 4, sample Th 70/351 a.
Fig. 5	Scanning electron micrograph, plan view, 6,000 ×, *holotype* [3617] A 907.
Fig. 6	Scanning electron micrograph, viewed at 45°, 6,000 ×, same specimen as Fig. 5.
Fig. 7	Phase contrast, 3,200 ×, same specimen as Fig. 5.
Fig. 8	Transmitted light, 3,200 ×, same specimen as Fig. 5.
Fig. 9	Cross-polarized light, 3,200 ×, same specimen as Fig. 5.
Fig. 10	Scanning electron micrograph, plan view, 6,500 ×, *paratype* [3268] A 908.
Fig. 11	Phase contrast, 3,200 ×, same specimen as Fig. 10.
Fig. 12	Transmitted light, 3,200 ×, same specimen as Fig. 10.
Fig. 13	Cross-polarized light, 3,200 ×, same specimen as Fig. 10.
Fig. 14	Phase contrast, 3,200 ×.
Fig. 15	Transmitted light, 3,200 ×, same specimen as Fig. 14.
Fig. 16	Cross-polarized light, 3,200 ×, same specimen as Fig. 14.
Fig. 17–21	*Chiastozygus litterarius* (GORKA 1957) MANIVIT 1971 DSDP Leg 1–4A–2–1, 120 cm.
Fig. 17	Phase contrast, 3,200 ×, same specimen as Fig. 20.
Fig. 18	Transmitted light, 3,200 ×, same specimen as Fig. 20.
Fig. 19	Cross-polarized light, 3,200 ×, same specimen as Fig. 20.
Fig. 20	Scanning electron micrograph of the proximal side, 6,500 ×.
Fig. 21	Scanning electron micrograph of the distal side, 6,500 ×.

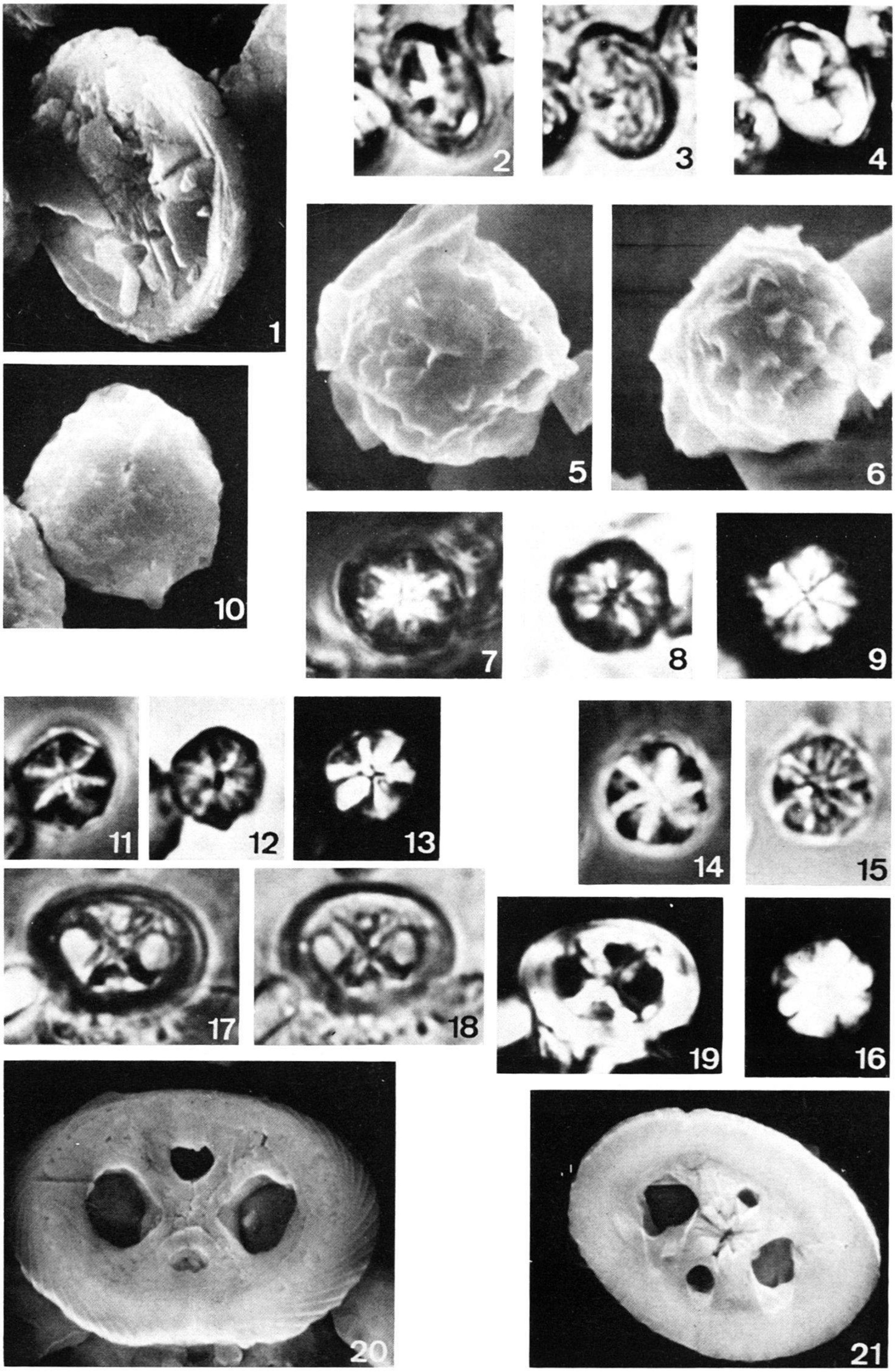
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Plate III

Fig. 1–5	*Cretaturbella rothii* n. sp.
	DSDP Leg 1–4–4–1, 11 cm.
Fig. 1	Scanning electron micrograph, 60° inclined, 9,000 ×, *paratype* [2440] A 909.
Fig. 2	Scanning electron micrograph, plan view, 7,000 ×, *holotype* [2448] A 910.
Fig. 3	Cross-polarized light, 3,200 ×, same specimen as Fig. 2.
Fig. 4	Transmitted light, 3,200 ×, same specimen as Fig. 2.
Fig. 5	Phase contrast, 3,200 ×, same specimen as Fig. 2.
Fig. 6–10	*Microrhabdulus bollii* n. sp.
Fig. 6	Scanning electron micrograph, 3,000 ×, *paratype* [1387] A 911, DSDP Leg 1–4–4–1, 110 cm.
Fig. 7	Scanning electron micrograph, 3,500 ×, *holotype* [6-356/7] A 912, DSDP Leg 1–4–4–1, 11 cm.
Fig. 8	Phase contrast, 3,200 ×, same specimen as Fig. 7.
Fig. 9	Cross-polarized light at 45°, 3,200 ×, same specimen as Fig. 7.
Fig. 10	Transmitted light, 3,200 ×, same specimen as Fig. 7.
Fig. 11–15	*Diazomatholithus lehmani* NOËL 1965
	DSDP Leg 1–5A–6, core catcher.
Fig. 11	Scanning electron micrograph, plan view, 9,000 ×.
Fig. 12	Scanning electron micrograph, 60° inclined, 9,000 ×, same specimen as Fig. 11.
Fig. 13	Phase contrast, 3,200 ×, same specimen as Fig. 11.
Fig. 14	Transmitted light, 3,200 ×, same specimen as Fig. 11.
Fig. 15	Cross-polarized light, 3,200 ×, same specimen as Fig. 11.
Fig. 16	*Nannoconus colomi* (DE LAPPARENT 1931) KAMPTNER 1938
	Scanning electron micrograph, 60° inclined, 3,500 ×, DSDP Leg 1–4–4–1, 11 cm.

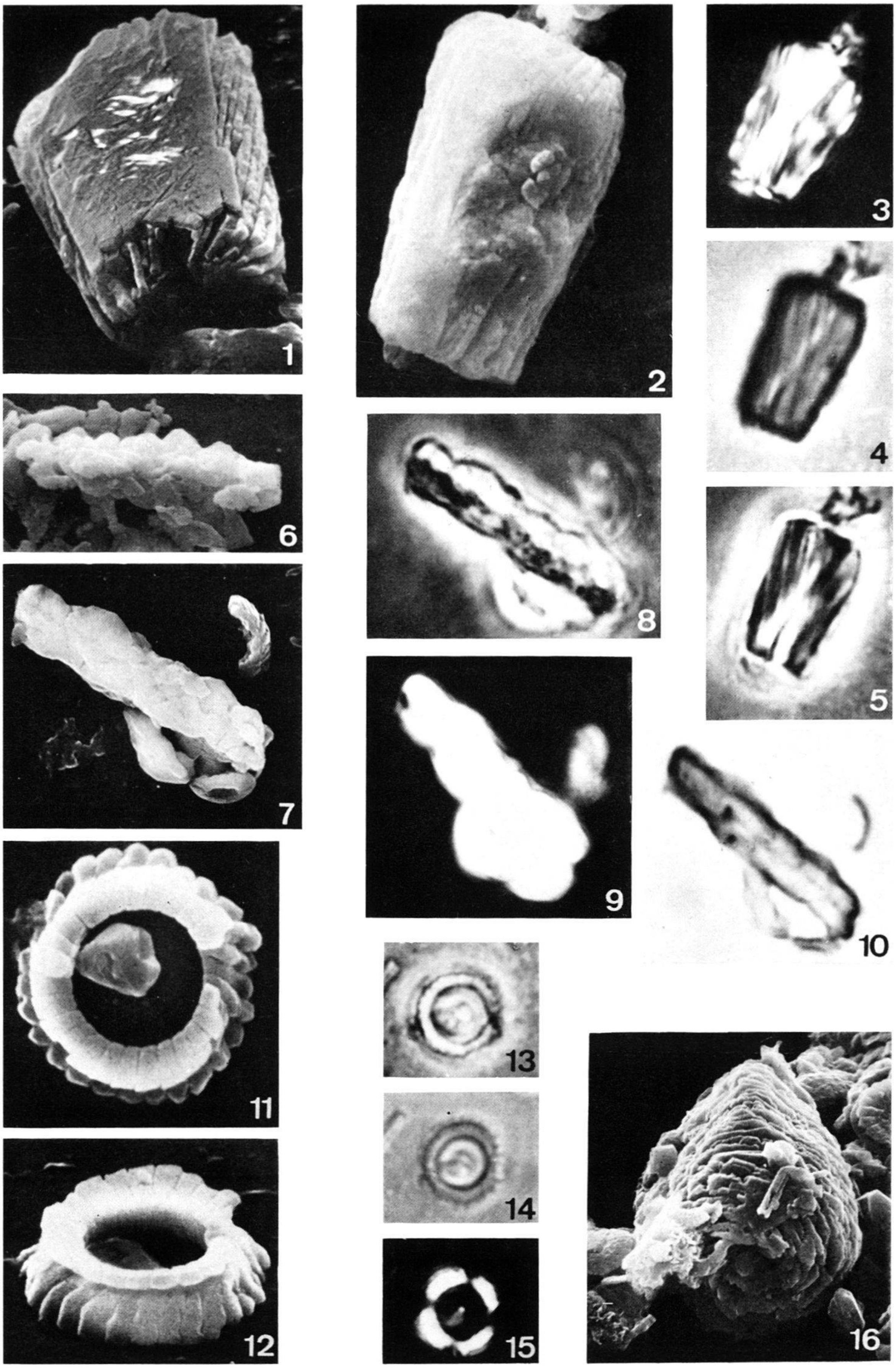
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Plate IV

Fig. 1–5	*Markalius circumradiatus* (STOVER 1966) PERCH-NIELSEN 1968
Fig. 1	Scanning electron micrograph of the distal side, plan view, 6,500?, DSDP Leg 1–4A–2–1, 120cm.
Fig. 2	Transmitted light, 3,200 ×, same specimen as Fig. 1.
Fig. 3	Cross-polarized light, 3,200 ×, same specimen as Fig. 1.
Fig. 4	Phase contrast, 3,200 ×, same specimen as Fig. 1.
Fig. 5	Scanning electron micrograph of the proximal side, plan view, 5,000 ×, DSDP Leg 1–4–4–1, 11cm.
Fig. 6–10	*Calcicalathina oblongata* (WORSLEY 1971) n. comb.
Fig. 6	Scanning electron micrograph of the proximal side, 60° inclined, 9,000 ×, *paratype* [1392] A 913, DSDP Leg 1–4–4–1, 110cm.
Fig. 7	Transmitted light, 3,200 ×, same specimen as Fig. 10.
Fig. 8	Phase contrast, 3,200 ×, same specimen as Fig. 10.
Fig. 9	Cross-polarized light, 3,200 ×, same specimen as Fig. 10.
Fig. 10	Scanning electron micrograph of the distal side, plan view, 2,250 ×, *paratype* [6-428/8] A 914, DSDP Leg 1–5A–6, core catcher.
Fig. 11–15	*Rucinolithus wisei* n. sp. DSDP Leg 1–5A–6, core catcher.
Fig. 11	Scanning electron micrograph of the distal side, plan view, 6,500 ×, *holotype* [6-410/4] A 915.
Fig. 12	Cross-polarized light, 3,200 ×, same specimen as Fig. 11.
Fig. 13	Phase contrast, 3,200 ×, same specimen as Fig. 11.
Fig. 14	Transmitted light, 3,200 ×, same specimen as Fig. 11.
Fig. 15	Scanning electron micrograph of the proximal side, plan view, 5,000 ×, *paratype* [6-374/1] A 916.

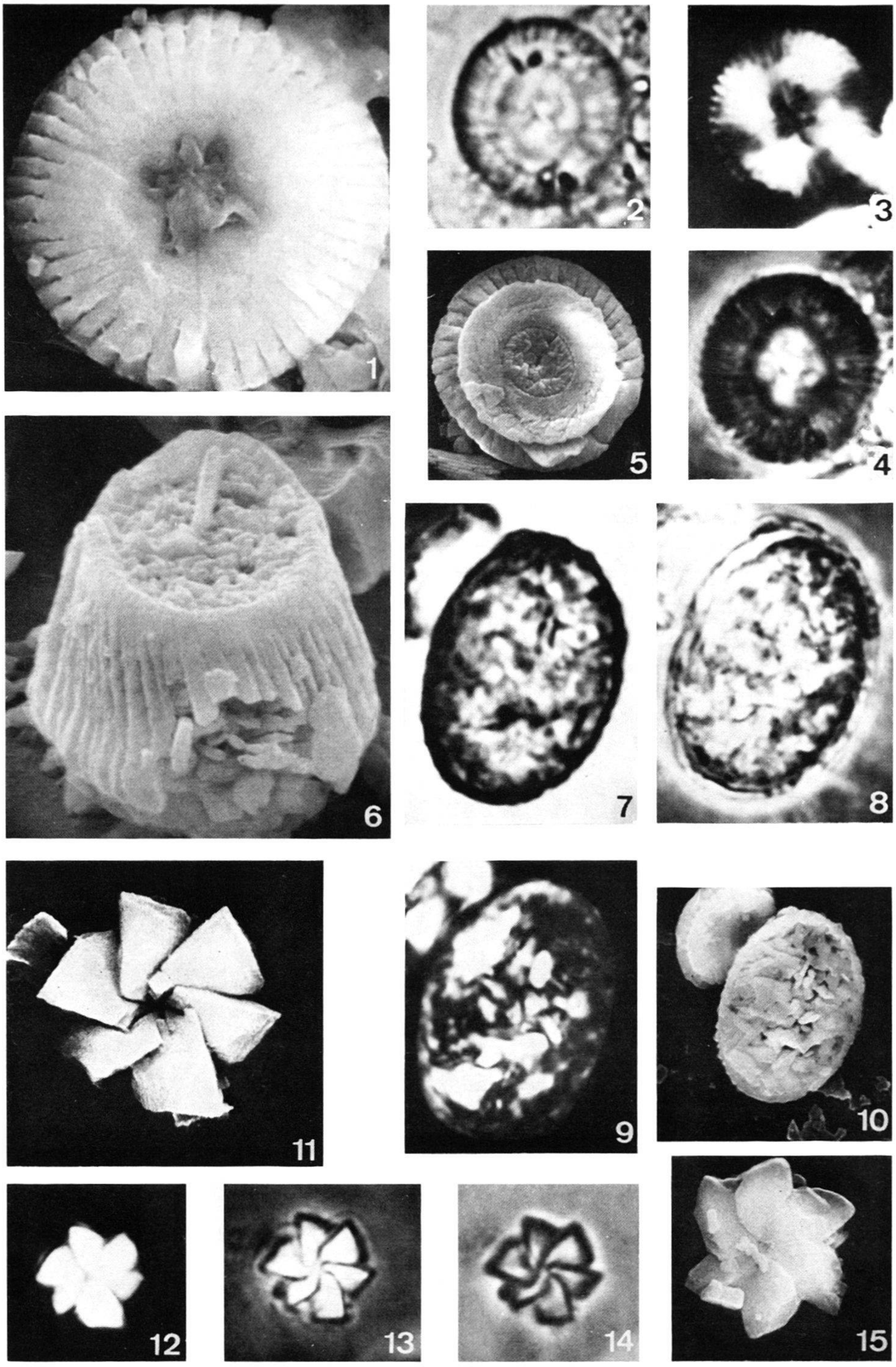

Plate V

Fig. 1–3	*Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT 1965) n.comb. DSDP Leg 1–4–3–2, 25 cm.
Fig. 1	Scanning electron micrograph of the proximal side, plan view, 2,500 ×.
Fig. 2	Transmitted light, 3,200 ×, same specimen as Fig. 1.
Fig. 3	Cross-polarized light, 3,200 ×, same specimen as Fig. 1.
Fig. 4–8	*Cruciellipsis cuvillieri* (MANIVIT 1966) n.comb.
Fig. 4	Scanning electron micrograph of the proximal side, plan view, 3,800 ×, DSDP Leg 1–4–4–1, 11 cm.
Fig. 5	Transmitted light, 3,200 ×, same specimen as Fig. 4.
Fig. 6	Phase contrast, 3,200 ×, same specimen as Fig. 4.
Fig. 7	Cross-polarized light, 3,200 ×, same specimen as Fig. 4.
Fig. 9	*Micrantholithus obtusus* STRADNER 1963 Scanning electron micrograph, 4,000 ×, DSDP Leg 1–5A–4–1, 35 cm.
Fig. 10–14	*Cretarhabdus crenulatus* BRAMLETTE and MARTINI 1964 emend. DSDP Leg 1–4–4–1, 11 cm.
Fig. 10	Phase contrast, 3,200 ×, same specimen as Fig. 13.
Fig. 11	Cross-polarized light at 45°, 3,200 ×, same specimen as Fig. 13.
Fig. 12	Transmitted light, 3,200 ×, same specimen as Fig. 13.
Fig. 13	Scanning electron micrograph of the distal side, plan view, 5,000 ×.
Fig. 14	Scanning electron micrograph of the proximal side, plan view, 5,000 ×.

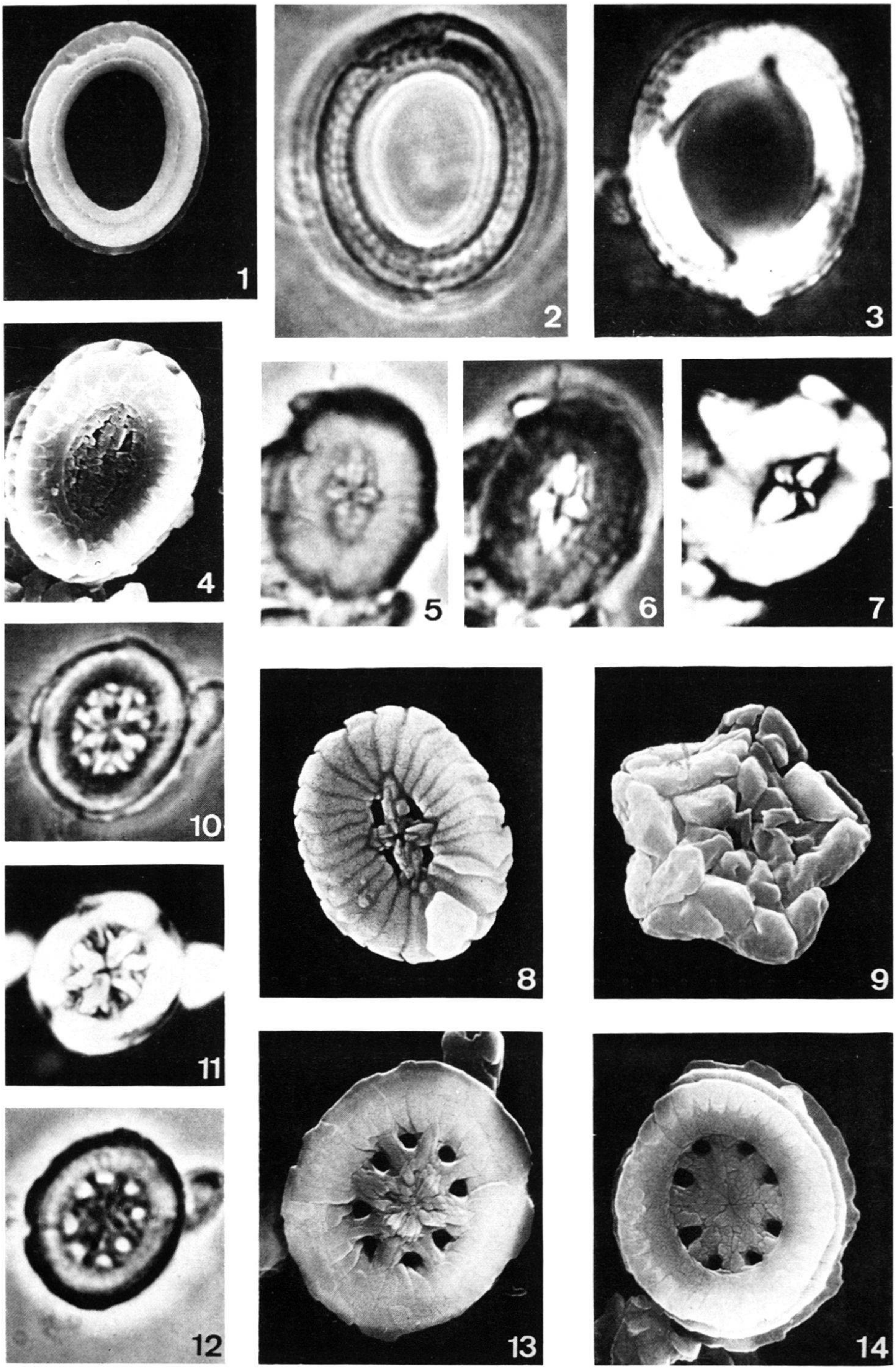
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Plate VI

Fig. 1–6	*Cretarhabdus surirellus* (DEFLANDRE 1954) REINHARDT 1970 DSDP Leg 1–4–4–1, 11 cm.
Fig. 1	Scanning electron micrograph of the proximal side, 30° inclined, 10,000 ×.
Fig. 2	Scanning electron micrograph of the distal side, plan view, 5,000 ×.
Fig. 3	Phase contrast, 3,200 ×, same specimen as Fig. 2.
Fig. 4	Cross-polarized light at 45°, 3,200 ×, same specimen as Fig. 2.
Fig. 5	Transmitted light, 3,200 ×, same specimen as Fig. 2.
Fig. 6	Cross-polarized light at 0°, 3,200 ×, same specimen as Fig. 2.
Fig. 7–12	*Cretarhabdus conicus* BRAMLETTE and MARTINI 1964
Fig. 7	Scanning electron micrograph of the proximal side, 6,000 ×, DSDP Leg 1–4–4–1, 110 cm.
Fig. 8	Scanning electron micrograph of the distal side, plan view, 6,000 ×, DSDP Leg 1–4–3–2, 25 cm.
Fig. 9	Transmitted light, 3,200 ×, same specimen as Fig. 8.
Fig. 10	Phase contrast, 3,200 ×, same specimen as Fig. 8
Fig. 11	Cross-polarized light, 3,200 ×, same specimen as Fig. 8.
Fig. 12	Scanning electron micrograph of the distal side, plan view, 5,000 ×, DSDP Leg 1–4–4–1, 11 cm.
Fig. 13–14	*Staurolithites crux* (DEFLANDRE 1954) CARATINI 1963 DSDP Leg 1–4–4–1, 11 cm.
Fig. 13	Scanning electron micrograph of the proximal side, plan view, 6,500 ×.
Fig. 14	Scanning electron micrograph of the distal side, plan view, 8,000 ×.

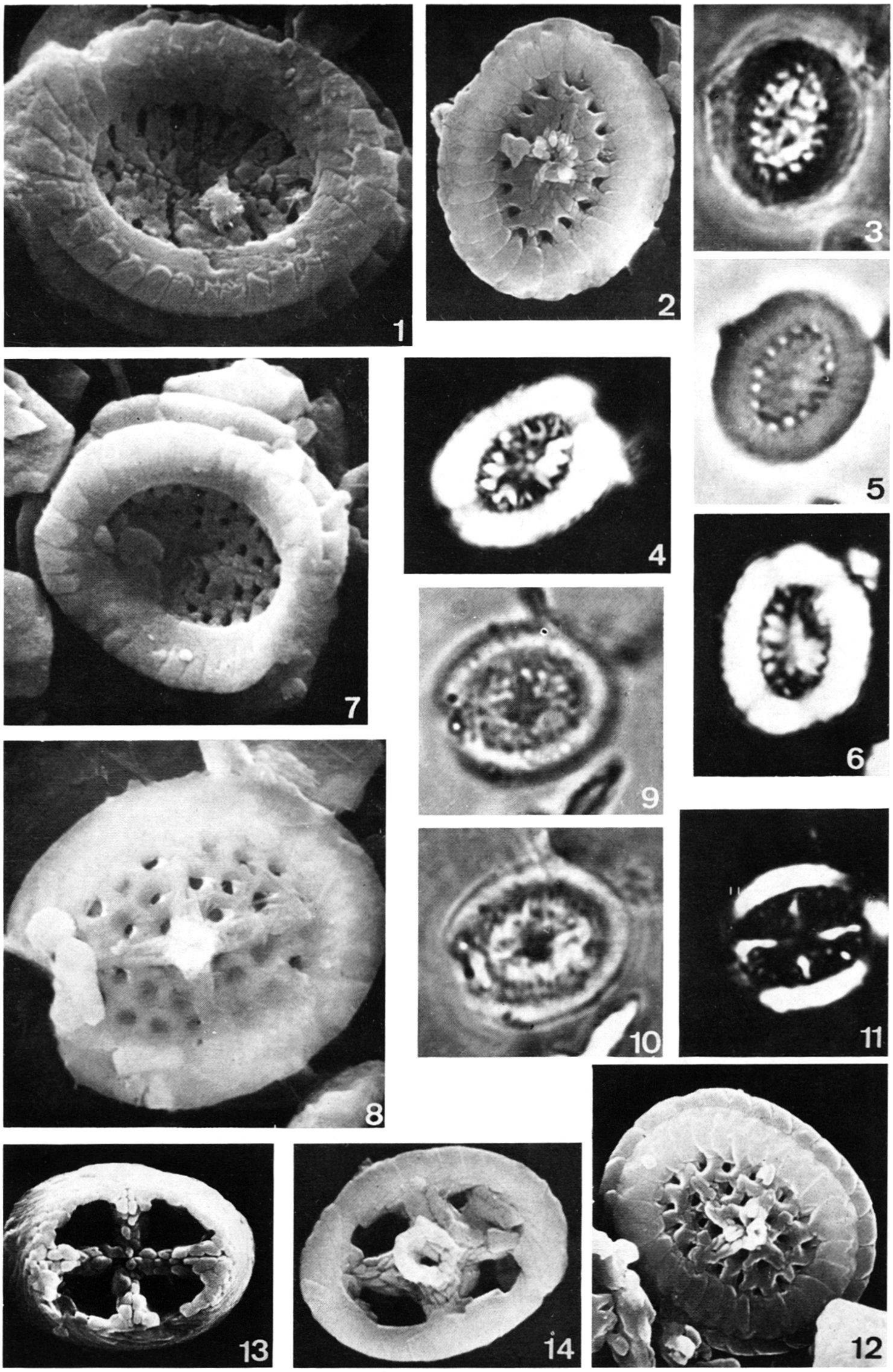
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Plate VII

Fig. 1–5	*Lithastrinus floralis* STRADNER 1962 DSDP Leg 1–4A–2–1, 120cm.
Fig. 1	Scanning electron micrograph, plan view, 9,000 ×.
Fig. 2	Phase contrast, 3,200 ×, same specimen as Fig. 1.
Fig. 3	Transmitted light, 3,200 ×, same specimen as Fig. 1.
Fig. 4	Cross-polarized light, 3,200 ×, same specimen as Fig. 1.
Fig. 5	Scanning electron micrograph, 60° inclined, 9,000 ×, same specimen as Fig. 1.
Fig. 6	*Corollithion ellipticum* BUKRY 1969 Scanning electron micrograph of the distal side, plan view, 12,000 ×, DSDP Leg 1–4A–2–1, 120cm.
Fig. 7	*Prediscosphaera cretacea* (ARKHANGELSKY 1912) GARTNER 1968 Scanning electron micrograph of the proximal side, 60° inclined, 6,000 ×, DSDP Leg 1–4A–2–1, 120cm.
Fig. 8	*Diadorhombus rectus* WORSLEY 1971 Scanning electron micrograph of the proximal side, plan view, 7,500 ×, *paratype* [6-356/9] A917, DSDP Leg 1–4–4–1, 11cm.
Fig. 9–11	*Eiffellithus turriseiffeli* (DEFLANDRE 1954) REINHARDT 1965 DSDP Leg 1–4A–2–1, 120cm.
Fig. 9	Scanning electron micrograph of the distal side, plan view, 6,500 ×.
Fig. 10	Cross-polarized light, 3,200 ×, same specimen as Fig. 9.
Fig. 11	Transmitted light, 3,200 ×, same specimen as Fig. 9.
Fig. 12–16	*Corollithion achylosum* (STOVER 1966) n.comb.
Fig. 12	Scanning electron micrograph of the proximal side, plan view, 6,500 ×, DSDP Leg 1–4–3–2, 25cm.
Fig. 13	Scanning electron micrograph of the distal side, plan view, 6,500 ×, DSDP Leg 1–4A–2–1, 120cm.
Fig. 14	Phase contrast, 3,200 ×, same specimen as Fig. 13.
Fig. 15	Transmitted light, 3,200 ×, same specimen as Fig. 13.
Fig. 16	Cross-polarized light, 3,200 ×, same specimen as Fig. 13.

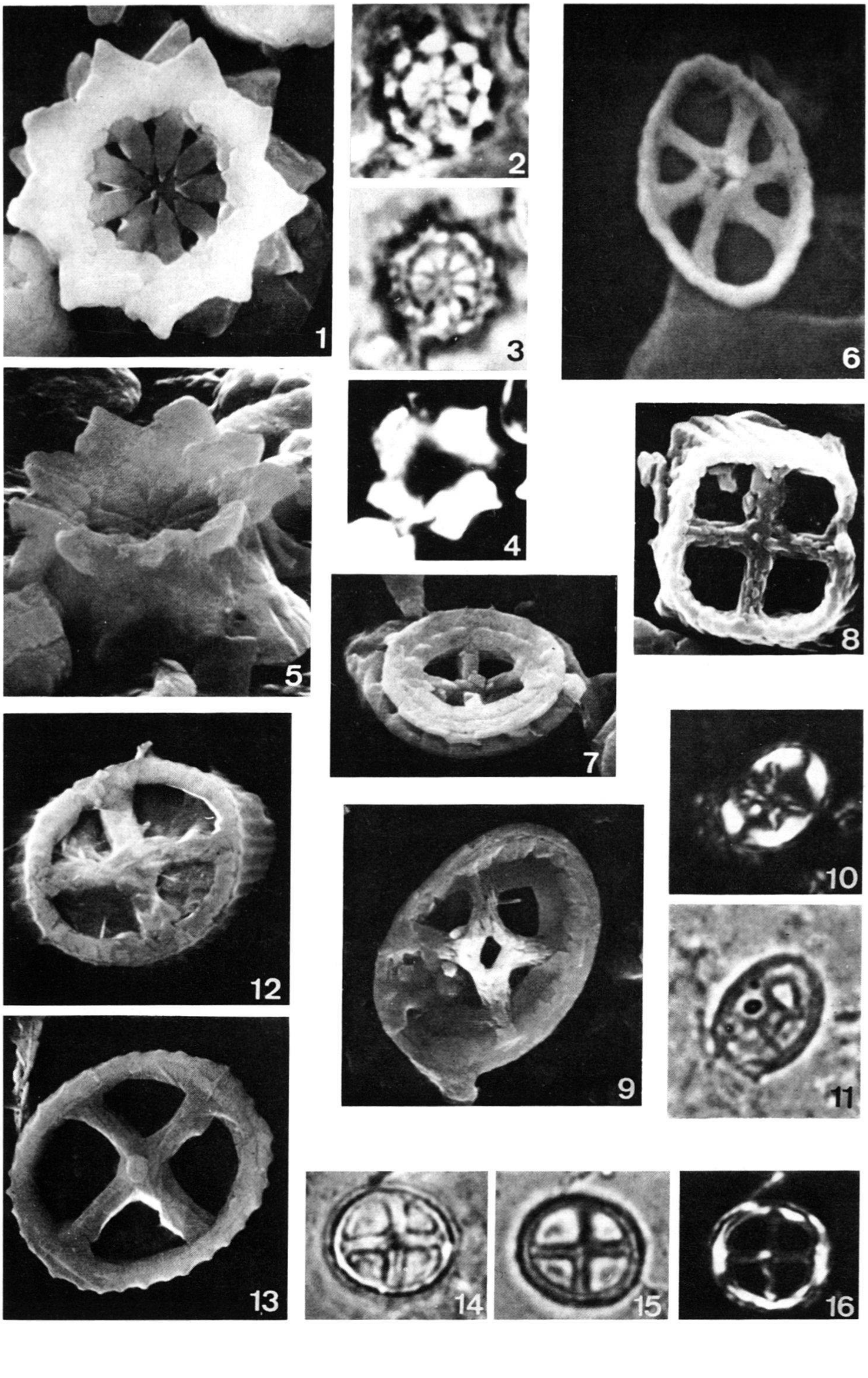
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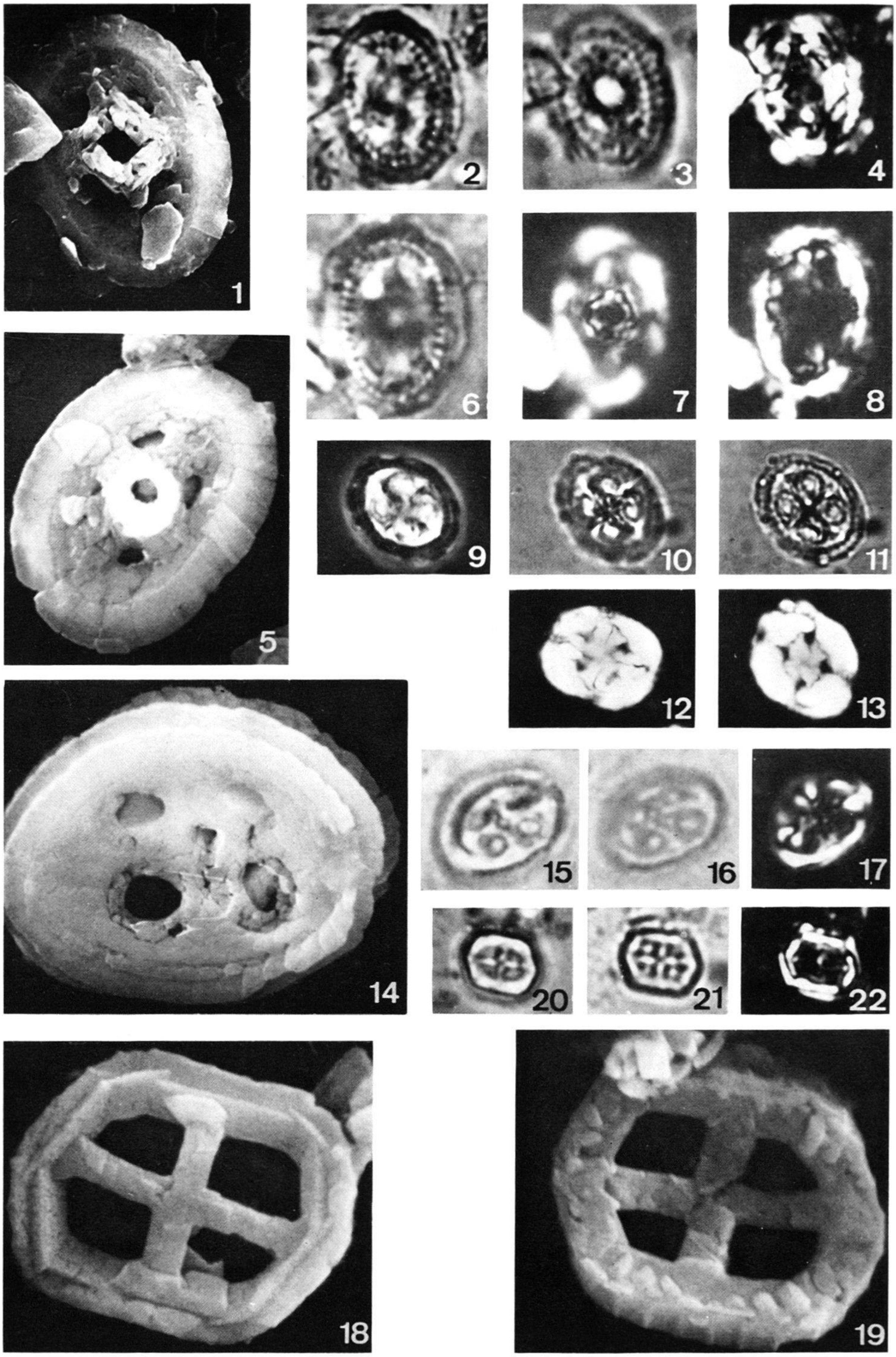
Plate VIII

Fig. 1–8	*Podorhabdus dietzmanni* (REINHARDT 1965) REINHARDT 1967
Fig. 1	Scanning electron micrograph of the distal side, plan view, 5,000 ×, DSDP Leg 1–4–4–1, 11 cm.
Fig. 2	Phase contrast, 3,200 ×, same specimen as Fig. 1.
Fig. 3	Transmitted light, 3,200 ×, same specimen as Fig. 1.
Fig. 4	Cross-polarized light, 3,200 ×, same specimen as Fig. 1.
Fig. 5	Scanning electron micrograph of the distal side, plan view, 6,000 ×, DSDP Leg 1–4A–2–1, 120 cm.
Fig. 6	Transmitted light, 3,200 ×, DSDP Leg 1–4–3–2, 25 cm.
Fig. 7	Cross-polarized light, high focus, 3,200 ×, same specimen as Fig. 6.
Fig. 8	Cross-polarized light, low focus, 3,200 ×, same specimen as Fig. 6.
Fig. 9–17	*Podorhabdus orbiculofenestrus* (GARTNER 1968) n. comb. DSDP Leg 1–4A–2–1, 120 cm.
Fig. 9	Phase contrast, 2,000 ×.
Fig. 10	Transmitted light, high focus, 2,000 ×, same specimen as Fig. 9.
Fig. 11	Transmitted light, low focus, 2,000 ×, same specimen as Fig. 9.
Fig. 12	Cross-polarized light, low focus, 2,000 ×, same specimen as Fig. 9.
Fig. 13	Cross-polarized light, high focus, 2,000 ×, same specimen as Fig. 9.
Fig. 14	Scanning electron micrograph of the proximal side, 12,000 ×.
Fig. 15	Phase contrast, 3,200 ×, same specimen as Fig. 14.
Fig. 16	Transmitted light, 3,200 ×, same specimen as Fig. 14.
Fig. 17	Cross-polarized light, 3,200 ×, same specimen as Fig. 14.
Fig. 18–22	*Corollithion signum* STRADNER 1963 DSDP Leg 1–4A–2–1, 120 cm.
Fig. 18	Scanning electron micrograph of the distal side, plan view, 12,000 ×.
Fig. 19	Scanning electron micrograph of the proximal side, plan view, 12,000 ×.
Fig. 20	Phase contrast, 3,200 ×, same specimen as Fig. 19.
Fig. 21	Transmitted light, 3,200 ×, same specimen as Fig. 19.
Fig. 22	Cross-polarized light, 3,200 ×, same specimen as Fig. 19.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