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Lower Cretaceous Calcareous Nannoplankton Biostratigraphy

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25 Figures and 6 Plates

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By HANS R. THIERSTEIN *)

Contents

Zusammenfassung

Kalkige Nannofossilien werden erst seit wenigen Jahren zur biostratigraphischen Gliederung jurassischer bis rezenter Sedimente angewendet. Die untere Kreide war bis vor kurzem das am wenigsten untersuchte Intervall. Drei Zonierungsvorschläge wurden erst kürzlich publiziert: WORSLEY (1971) definierte 7 Zonen (Tithonian — Cenomanian), basiert auf 7 untersuchten Bohrproben aus dem West-Atlantik (Deep Sea Drilling Project, Leg 1, Sites 4 und 5 A). MANIVIT (1971) schlug eine Nannoplankton-Zonierung für das Intervall Aptian — Danian Südfrankreichs vor. Der Autor (1971) beschrieb 9 Zonen, die sich vom obersten Jura bis ins untere Cenomanian erstrecken; diese Unterteilung beruhte auf der Untersuchung von 9 Proben aus drei Bohrungen in West-Atlantik (Deep Sea Drilling Project, Leg 1, Sites 4, 4 A und 5 A) sowie auf ca. 300 Proben aus Profilen in Südostfrankreich, in denen die Ammoniten-, Calpionellen- und Foraminiferenstratigraphie bereits bekannt war. Diese Zonierung weicht in wesentlichen Teilen von den beiden früher vorgeschlagenen ab.

WORSLEY's (1971) Zonengliederung konnte nicht übernommen werden, weil seine Interpretation der stratigraphischen Abfolge der Proben aus dem West-Atlantik, nach Vergleichen mit den datierten Profilen aus Südostfrankreich, revidiert werden mußte, und weil seine Zonenleitfossilien in Frankreich nicht oder nur äußerst spärlich auftreten. Die Abweichungen von der von MANIVIT (1971) vorgeschlagenen Zonierung beruhen auf der unterschiedlichen Interpretation der stratigraphischen Verbreitung einzelner Arten und der wesentlich geringeren Häufigkeit ihrer leitenden Arten. Beide Vorschläge wurden vom Autor (1971) ausführlich diskutiert.

Die vorliegende Arbeit stellt den Zonierungsvorschlag von THIERSTEIN (1971), in dem unter anderem 4 neue Nannofossil-Genera und 6 neue -Arten beschrieben wurden, sowie die Untersuchung von Bohrproben aus dem Süd-Atlantik (ROTH & THIERSTEIN 1972, im Druck), welche die Beschreibung eines neuen Nannofossil-Genus und 6 neuer -Arten einschließt, in einen größeren Zusammenhang. Sie paßt die bereits vorgeschlagene Zonierung an die Ergebnisse der Untersuchung weiterer Profile aus der Schweiz, dem Atlantik, Venezuela, Trinidad und England an und dokumentiert sie ausführlich.

Die stratigraphische Verbreitung von 83 Nannoplankton-Arten, die Nannoplankton-Zonengrenzen, sowie 9 Datumsflächen werden mit

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der Ammoniten-, Calpionellen- und Foraminiferen-Biostratigraphie sowie mit den klassischen Stufen korreliert. Die systematische Beschreibung basiert auf Untersuchungen derselben Objekte im Raster-Elektronenmikroskop und im Lichtmikroskop, nach der von THIERSTEIN, FRANZ & ROTH (1972) beschriebenen Methode. Drei neue Arten *(Flabellites biforaminis, Micula infracretacea, Tubodiscus verenae)*, zwei neue Gattungen *(Flabellites, Tubodiscus)* und zwei neue Familien *(Cretarhabdaceae, Lithastrinaceae)* werden definiert.
Folgende paläoökologische Einflüsse konnten festgestellt werden: 1. Vorwiegend aus Mergeln bestehende Profile zeigen zahlen- und artenmäßig reichere Nannofloren als kalkreiche Profile. 2. Bei Häufigkeitszunahme eingeschalteter harter Kalkbänke nimmt die relative Häufigkeit von Nannoconiden zu und die von Coccolithen ab. 3. Nannofloren der Unterkreide Englands (boreale Provinz) setzen sich zum Teil aus anderen Arten zusammen als jene der Tethys. Ein gegenseitiger Austausch scheint sich vom Aptian an zu vollziehen. 4. In Flachwasserablagerungen treten Arten der Gattungen *Watznaueria* REINHARDT und *Cyclagelosphaera* NOEL relativ häufiger auf.

Abstract

The calcareous nannoplankton is studied in fourteen sections from southeastern France, three sections in Switzerland, two sections in Great Britain, numerous samples from the West and Central Atlantic, from Venezuela and Trinidad. Nine nannoplankton zones and nine biostratigraphic datum levels are described and correlated with the ammonite, calpionellid and foraminifera biostratigraphy and with the classical Lower Cretaceous stages. Paleoecologic implications are made. Systematic descriptions, references and stratigraphic extent of 83 species are presented. Two new families *(Cretarhabdaceae, Lithastrinaceae)*, two new genera *(Flabellites, Tubodiscus)*, and three new species *(Flabellites biforaminis, Micula infracretacea, Tubodiscus verenae)* are described.

Résumé

Les Nannofossiles calcaires des localités et coupes types du Crétacé inférieur et de nombreuses autres coupes dans le Sud-est de la France, en Suisse, en Angleterre, de l'Atlantique de l'Ouest et du Sud, du Venézuéla et de l'île de la Trinité sont étudiés. Neuf zones de Nannofossiles et neuf „datum levels" sont définis et corrélés avec les zones d'Ammonites, de Calpionelles et de Foraminifères. Des indications paléoécologiques sont présentées. On donne les descriptions systématiques, les références et les répartitions stratigraphiques de 83 espèces de Nannofossiles. Deux nouvelles familles *(Cretarhabdaceae, Lithastrinaceae)*, deux nouveaux genres *(Flabellites, Tubodiscus)*, et trois nouvelles espèces *(Flabellites biforaminis, Micula infracretacea, Tubodiscus verenae)* sont décrits.

1. Introduction

1.1. Scope of present study

Calcareous nannofossils have been recorded from sediments of Lower Jurassic to Recent age. Until recently the Lower Cretaceous received relatively little attention. The purpose of this study is to establish a biostratigraphic subdivision by means of nannofossils and to compare it with other biostratigraphic zonations and the classical stages. In order to accomplish this, the author carried out SEM examinations of 22 selected, well preserved samples for detailed investigation of morphology and taxonomy, and light microscopy of about 750 Lower Cretaceous samples. About 300 of these were collected by the author in the type localities of the Lower Cretaceous stages in southeastern France and Switzerland, and other well-dated sections. 300 additional samples collected from the Helvetic and Ultrahelvetic Nappes in Switzerland turned out to contain no or very poorly preserved nannofossils. The remainder of the samples included 93 from the Atlantic Ocean (DSDP Leg 1 and Leg 14), 24 from Venezuela and Trinidad, and 18 from Great Britain. Levels of distinct change in the Lower Cretaceous nannofossil assemblages were identified, and from these zones and datum levels are proposed. Finally, the nannoplankton zones and datum levels are correlated with other biostratigraphic zonations and classical stages.

1.2. Stages and boundaries in the Lower Cretaceous

The classical areas of Lower Cretaceous stratigraphy are the southern Jura mountains, and the Subalpine Chains and adjacent areas in southeastern France. In these areas continuous marine sedimentation of limestones and marls took place from the Upper Jurassic to the Cenomanian.

Most of the Lower Cretaceous stages were originally defined lithologically, but in the later part of the 19th century many of them were redefined using the biostratigraphic succession of cephalopods. Today, the Berriasian, Barremian, and Albian Stages are based on satisfactory stratotypes; the Valanginian, Hauterivian and Aptian Stages are to be provided with parastratotypes (see proposals prepared at the Colloque sur le Crétacé inférieur, Lyon 1963 [1965, p. 832]).

Tithonian

This stage was introduced by OPPEL (1865) but no stratotype has ever been designated. It has been used by many authors with different meanings. No decision was reached by the Colloque du Jurassique (Luxembourg, 1962) on possible correlation of the Tithonian with the Kimmeridgian and Portlandian Stages. The most continuous and intensively studied sections of the Upper Tithonian are situated in southeastern France (Aizy, Chomérac) and Czechoslovakia (Štramberk). The uppermost Tithonian as used in this paper is considered to be the *Berriasella jacobi* Ammonite Zone and the Calpionellid Zone B inf. (LE HÉGARAT & REMANE 1968).

Berriasian

Originally described informally as base of the Neocomian (PICTET 1867), this stage was later formally defined by COQUAND (1871). The type section in Berrias (Ardèche) has recently been investigated by BUSNARDO, LE HÉGARAT & MAGNÉ (1965), and LE HÉGARAT & REMANE (1968).

Valanginian

This stage was defined by DESOR (1853) in the vicinity of Neuchâtel (Switzerland). HAEFELI, MAYNC, OERTLI & RUTSCH (1965) described the informal lithologic units and the paleontology of the type section in Valangin and the adjacent area. The type section consists of shallow water sediments which have partly been deposited under brackish conditions (HAEFELI, 1966, p. 676), and lack cephalopods. Recently STEINHAUSER & CHAROLLAIS (1971) suggested that the lower part of the type Valanginian most probably corresponds to the upper part of the type Berriasian.

Hauterivian

RENEVIER (1874) defined this stage to include several formations in the vicinity of Neuchâtel. Only isolated outcrops of the originally included formations exist. A "type locality" has been designated by BURRI (1961) near Hauterive, but no satisfactory type section has been described. All Hauterivian sediments in the type region are littoral or neritic and only one bed contains cephalopods (HAEFELI, MAYNC, OERTLI & RUTSCH 1965, p. 68). As was the case with the Valanginian, selection of a parastratotype in southeastern France was proposed by the Colloque sur le Crétacé inférieur (Lyon 1963).

Barremian

The original exclusively biostratigraphical definition of this stage by COQUAND (1862) included the Barremian and the Upper Hauterivian as they are presently understood. KILIAN (1895) described the ammonites of the Route d'Angles section. This locality has often been considered as the stratotype, but was formally designated as such only in 1963. Lithology and paleontology of the type section have recently been described by BUSNARDO (1965), GUILLAUME & SIGAL (1965), BOUCHÉ (1965), and MOULLADE (1966).

Aptian

This stage was introduced by D'ORBIGNY (1840, 1842) for sediments of the "Upper Neocomian". The two classical type localities of La Bédoule (Bouches-du-Rhône) and Gargas (Vaucluse) have led to the common usage of the terms Bédoulian and Gargasian. BREISTROFFER (1947) defined a third substage, the Clansayésian, for sediments between the Gargasian and the Lower Albian. The Colloque sur le Crétacé inférieur (Lyon 1963) proposed that the Lower Aptian encompass the Bédoulian, that the Upper Aptian include the Gargasian and Clansayésian, and that parastratotypes for the latter two substages be selected. The Aptian type sections have been described recently by OERTLI (1958), FABRE-TAXY, MOULLADE & THOMEL (1965), and MOULLADE (1965 a, 1965 b).

Albian

This stage was proposed by D'ORBIGNY (1842) to replace the term Gault which was only defined lithologically. Recent investigations of the stratotypes in the region of the Aube River have been published by CASEY (1961), LARCHER, et al. (1965), and MANIVIT (1971). Following the proposals of the Colloque sur le Crétacé inférieur, the Vraconnian Substage is considered here to be synchronous with the uppermost ammonite zone (*Stoliczkaia dispar* Zone) of the Upper Albian.

Jurassic-Cretaceous boundary

Whether the chronostratigraphic boundary between these systems should be placed at the Tithonian/Berriasian limit, within the Berriasian, or at the Berriasian/Valanginian limit, is still under discussion. The Commission of Stratigraphy of the International Union of Geological Sciences will conduct an international symposium on the Jurassic-Cretaceous boundary (Lyon - Neuchâtel) in 1973. For the present, the proposal of the Colloque sur le Crétacé inférieur (Lyon 1963) is accepted and the lower boundary of the Cretaceous system is considered to be the base of the Berriasian.

Lower Cretaceous-Upper Cretaceous boundary

This boundary coincides with the chronostratigraphic limit Albian (including Vraconnian) /Cenomanian.

1.3. Lower Cretaceous biostratigraphy

Until recently, subdivisions of the classic Lower Cretaceous sections and stages in Europe have been based primarily on cephalopods, although other macrofossils, such as brachiopods, echinoderms, pelecypods and plants have proved valuable for local and regional correlations. Since the introduction of micropaleontological methods, in particular foraminifera and ostracoda, the biostratigraphic subdivision and correlation of Lower Cretaceous sections has progressed further.

The Tithonian-Berriasian interval has been subdivided by means of calpionellids (ALLEMANN, CATALANO, FARÈS & REMANE 1971). Correlation of the stratotypes of the Valanginian and Hauterivian stages, almost devoid of macrofauna, must rely principally on ostracoda and foraminifera (HAEFELI, MAYNC, OERTLI & RUTSCH 1965, STEINHAUSER & CHAROLLAIS 1971). Foraminiferal zonations of Lower Cretaceous sections have been proposed recently by MOULLADE (1966), and GUILLAUME, BOLLI & BECKMANN (1969).

A summary of the status of Lower Cretaceous biostratigraphy up to 1963 was presented at the Colloque sur le Crétacé inférieur (Lyon 1963, published 1965).

1.4. Biostratigraphic applications of Lower Cretaceous nannoplankton

The newest method of biostratigraphic subdivision of Lower Cretaceous sediments is the application of calcareous nannofossils. It was initiated by BRONNIMANN (1955). He distinguished 10 species and 3 assemblages of Nannoconus, which had proved useful for zoning Lower Cretaceous limestones in Cuba. Two attempts towards further refinement followed: TREJO (1960) correlated 6 zones, based on nannoconids with the classical stages, and STRADNER (1963) described 3 associations, characterized by nannoconids and coccoliths. Subsequently, Cretaceous nannofossil assemblages from short stratigraphic intervals have been described by BOUCHÉ (1965), DEFLANDRE & DEFLANDRE-RIGAUD (1967), FARINACCI (1964), FORCHHEIMER (1968, 1970), HOFFMANN (1970 b), LYULYEVA (1967 a, 1967 b, 1967 c, 1968), MANIVIT (1965, 1966, 1968), MANIVIT, CHAROLLAIS & STEINHAUSER (1969), NOEL (1965), REINHARDT (1964, 1965, 1967), STRADNER, ADAMIKER & MARESCH (1968) and others. Valuable biostratigraphic information of the Upper Cretaceous has been presented by ČEPEK (1970), ČEPEK & HAY (1969), GARTNER (1968), REINHARDT (1966 a), and STOVER (1966). A Cretaceous nannofossil zonation covering the upper part of the Lower Cretaceous has been proposed by MANIVIT (1971).

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

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

Two zonations for the interval Tithonian - Cenomanian have been suggested recently by WORSLEY (1971) and THIERSTEIN (1971). The tentative zonation proposed by THIERSTEIN (1971) is supplemented and documented in detail in this paper. Reasons for revision of previous zonations were given in THIERSTEIN (1971, p. 461). Correlation of existing Lower Cretaceous nannofossil zonations is given in Fig. 1.

In addition, a number of datum levels are defined by using first and last occurrences of abundant species or genera which are considered to be relatively independent of paleoecologic influences and are supposed to be consistent time markers in a wider area.

1.5. Methods of investigation

A total of 756 samples from Lower Cretaceous sections were prepared for LM investigation using the conventional preparation methods. Taxonomic studies of the nannofossils were carried out with the SEM, using 22 samples: 8 from the West Atlantic (DSDP Leg 1), 9 from the Central Atlantic (DSDP Leg 14), and 5 samples from southeastern France. These were prepared using the method described by THIERSTEIN, FRANZ & ROTH (1972) which permits study of the same specimens in both the SEM and LM. Because this technique utilizes only a thin coating of conductive material, specimens may become charged when exposed to the electron beam of the SEM, with consequent loss of quality in the micrographs.

SEM studies have been carried out on Cambridge II A and Cambridge S 4 scanning electron microscopes, and LM studies on a Zeiss photomicroscope using Agfa Copex Pan film.

1.6. Concept of Taxonomy

Along with the developments in the study of fossil coccoliths, rapid advances have been made in the study of living marine flagellates. In particular, the discovery of two phases in the life history of *Coccolithus pelagicus* (WALLICH 1877) SCHILLER 1930, which is the non-motile phase of the motile *Crystallolithus hyalinus* GAARDER & MARKALI, 1956, and the presence of a haptonema in the *Crystallolithus hyalinus* phase (PARKE & ADAMS 1960), have necessitated complete reassessment of the criteria used for the classification of the coccolithophorids. Consequently CHRISTENSEN (1962, p. 72) placed the coccolithoporids under a new class *Haptophyceae* CHRISTENSEN 1962 which he subdivided into two new orders: *Isochrysidales* CHRISTENSEN 1962 (motile phase without an obvious haptonema) and *Prymnesiales* CHRISTENSEN 1962 (motile phase with an obvious haptonema). This subdivision has been assumed with reservations by PARKE & DIXON (1964) who included, among others, the families *Syracosphaeraceae* LEMMERMANN 1908, *Coccolithaceae* POCHE 1913 emend. KAMPTNER 1928, *Braarudosphaeraceae* DEFLANDRE 1947 and *Thoracosphaeraceae* SCHILLER 1930 in the order *Prymnesiales* CHRISTENSEN 1962. Recently PARKE (1971) reported that the "Apistonema" phase in the life history of forms placed in the genera *Cricosphaera* BRAARUD 1960, *Pleurochrysis* PRINGSHEIM 1955 and *Hymenomonas* STEIN 1878, can produce two types of motile cells both, covered by scales and bearing two flagella, but one has a clearly discernible haptonema while the other apparently lacks a haptonema altogether (PRINGSHEIM 1955, VON STOSCH 1955, PARKE 1961, RAYNS 1962, VALKANOV 1962, LEADBEATER 1970).

As many questions on classification of living coccolithophorids are still unanswered, no systematic units of higher than family rank are adopted here for subdivision of the fossil calcareous nannoplankton.

Many studies of Mesozoic calcareous nannofossils were mainly based on LM investigations: BRAMLETTE & MARTINI (1964), BRONNIMANN (1955), CARATINI (1963), DEFLANDRE (1950, 1953, 1963), DEFLANDRE & FERT (1954), GÓRKA (1957), KAMPTNER (1931, 1938), MANIVIT (1965, 1966), NOEL (1957, 1959), STOVER (1966), STRADNER (1961, 1962, 1963), VEKSHINA (1959), WORSLEY (1971). A great number of species were described and classified using rather simple systematic criteria. With the application of the EM, classification of calcarous nannofossils was adapted to the much more detailed information on the microstructures of these minute calcite skeletons. Thus, many species originally defined by light microscopy have been redefined using the EM, especially by: BUKRY (1969), GARTNER (1968), NOEL (1965, 1969, 1970), REINHARDT & GÓRKA (1967), STRADNER, ADAMIKER & MARESCH (1968), and THIERSTEIN (1971). A number of species have been differentiated from others using differences in ultrastructure; some of these are hardly recognizable in the LM.

The most important concepts of classification of Mesozoic coccoliths were introduced by REINHARDT (1964, 1965, 1966, 1967), and NOEL (1965) A detailed discussion and synopsis of these suggestions is given in PERCH-NIELSEN (1968). Since then a great number of publications on Mesozoic nannofossils have appeared, and different concepts of specific, generic and suprageneric criteria were used. A synopsis of Mesozoic nannofossil genera and species has been presented by REINHARDT (1970 a, 1970 b, 1971). An excellent review of mesozoic genera with a tentative key has been given by NOEL (1971).

In the following work, only species identifiable in both, the EM and LM, are used. The terms approved by the Round Table on Calcareous Nannoplankton (Rome 1970) are applied in the morphologic descriptions of nannofossils. Families are distinguished on the basis of shield construction and of number of cycles. Genera are distinguished on the basis of the architecture of the central area, of other pecularities of shield construction, or of geometric shape. Species are distinguished by the number of elements in the shields and the central area, and their geometric properties.

The taxonomic value of a criterion (e. g. shape, pecularities in shield construction) is not the same in each family; its importance depends directly on the possibilities for useful differentiation within a group of forms.

1.7. Typification

The scanning electron microscope photographic negatives and the light microscope slides with the types are deposited at the Naturhistorisches Museum Basel (Switzerland). They are identified by the autor's negative numbers [listed here in square brackets] and by the Basel Museum type collection numbers (A 938—A 960).

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2. Description of zones

The zones are described in stratigraphic order from older to younger. The reference section given for each zone includes usually two independent localities, one for the lower limit and one for a typical nannofossil assemblage. For location of the sections see Fig. 2.

2.1. Nannoconus colomi Zone

Definition: Interval from the first occurrence of *Nannoconus colomi* (DE LAPPARENT) to the first occurrence of *Cretarhabdus crenulatus* BRAMLETTE & MARTINI emend. THIERSTEIN.

Author: WORSLEY (1971), modified by THIERSTEIN (1971).

Important species:

First occurrences: *Nannoconus colomi* (DE LAPPARENT), *Nannoconus bronnimanni* TREJO, *Lithraphidites carniolensis* DEFLANDRE, *Stephanolithion laffittei* NOEL, *Polycostella senaria* THIERSTEIN, *Parhabdolithus asper* (STRADNER), *Rucinolithus wisei* THIERSTEIN, *Cruciellipsis chiasta* (WORSLEY), *Cruciellipsis cuvillieri* (MANIVIT), and *Micrantholithus hoschulzi* (REINHARDT).

Last occurrences: *Polycostella beckmannii* THIERSTEIN and *Polycostella senaria* THIERSTEIN.

Remarks: The assemblage of this zone consists of abundant *Polycostella beckmannii* THIERSTEIN, *Cretaturbella rothii* THIERSTEIN, *Parhabdolithus embergeri* (NOEL), *Watznaueria barnesae* (BLACK), *Cyclagelosphaera margereli* NOEL, *Diazomatolithus lehmani* NOEL, *Watznaueria britannica* (STRADNER), and *Biscutum constans* (GÓRKA). The following species have their first occurrence in this zone, but are very scarce: *Nannoconus bermudezi* BRONNIMANN, *Nannoconus truitti* BRONNIMANN, *Braarudosphaera bigelowi* (GRAN & BRAARUD), *Watznaueria biporta* BUKRY, *Cretarhabdus surirellus* (DEFLANDRE), *Cretarhabdus conicus* BRAMLETTE & MARTINI, *Nannoconus globulus* BRONNIMANN, *Nannoconus minutus* BRONNIMANN, *Vagalapilla compacta* BUKRY, *Zygodiscus elegans* GARTNER emend. BUKRY, *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT), *Markalius circumradiatus* (STOVER), *Biscutum supracretaceum* (REINHARDT), and *Micrantholithus obtusus* STRADNER. Rare *Watznaueria communis* REINHARDT and *Discorhabdus rotatorius* (BUKRY) continue into this zone.

Only a few samples of Lower Tithonian age have been studied and no Upper Tithonian section with marly beds has been found yet; many of the first occurrences within the *Nannoconus colomi* Zone may be due to facies change.

The base of this zone seems to coincide with the first occurrence of all nannoconids and approximates the base of the *Calpionella* Zone = B Zone of REMANE 1964 (see ALLEMANN, CATALANO, FARÈS & REMANE 1971). The base of the *Nannoconus colomi* Zone lies slightly below the first occurrence of *Berriasella grandis* MAZENOT, guide fossil of the lowermost Cretaceous ammonite zone.

Reference section: Typical assemblage: Broyon, layers BR 26 to BR 35, alternating marly limestones and marls (see Fig. 3); this section is dated by its calpionellid and cephalopod assemblages (see LE HÉGARAT & REMANE 1968).

Geographic distribution: Southeastern France (Broyon, Chomérac; Massif des Bauges [MANIVIT, CHAROLLAIS & STEINHAUSER 1969]), Switzerland (Montsalvens), Algeria (NOEL 1965).

Age: Uppermost Tithonian to Upper Berriasian.

2.2. Cretarhabdus crenulatus Zone

Definition: Interval from the first occurrence of *Cretarhabdus crenulatus* BRAMLETTE & MARTINI emend. THIERSTEIN to the first occurrence of *Calcicalathina oblongata* (WORSLEY).

Author: THIERSTEIN (1971).

Important species:

First occurrences: Common: *Cretarhabdus crenulatus* BRAMLETTE & MARTINI emend. THIERSTEIN, *Vagalapilla stradneri* (ROOD, HAY & BARNARD); rare: *Bipodorhabdus roeglii* THIERSTEIN, *Reinhardtites fenestratus* (WORSLEY), and *Tubodiscus verenae* n. sp.

Remarks: *Cretaturbella rothii* THIERSTEIN becomes rare near the base of this zone, otherwise the assemblage is the same as in the *Nannoconus colomi* Zone.

The first *Cretarhabdus crenulatus* BRAMLETTE & MARTINI emend. THIERSTEIN appear in the *Berriasella paramimouna* Ammonite Subzone and in the D_1 Calpionellid Subzone of the Lacisterne section (see LE HÉGARAT & REMANE 1968). The base of the *Cretarhabdus crenulatus* Zone is slightly lower than indicated by THIERSTEIN (1971).

In southeastern France and Switzerland the limit Berriasian/Valanginian coincides closely with the first occurrences of *Vagalapilla stradneri* (ROOD, HAY & BARNARD) and *Bipodorhabdus roeglii* THIERSTEIN. *Vagalapilla stradneri* (ROOD, HAY & BARNARD) has been described from the Oxfordian of Great Britain, but reached the Tethys during the Early Valanginian.

R e f e r e n c e s e c t i o n : Lower limit: Lacisterne, layers LC 3414 to LC 3418 (see Fig. 5); typical assemblage: Ginestous-les Oliviers, layers LO 3443 to LO 3458 (see Fig. 6), alternating marly limestones and marls; both sections are dated by calpionellids and ammonites (see LE HÉGARAT & REMANE 1968).

G e o g r a p h i c d i s t r i b u t i o n : Southeastern France (Lacisterne, Berrias, Ginestous-la Garenne, Ginestous-les Oliviers, Orpierre; Massif des Bauges, Massif des Bornes [MANIVIT, CHAROLLAIS & STEINHAUSER 1969]), Switzerland (Montsalvens).

A g e : Upper Berriasian to Lower Valanginian.

2.3. Calcicalathina oblongata Zone

D e f i n i t i o n : Interval from the first occurrence of *Calcicalathina oblongata* (WORSLEY) to the first occurrence of *Lithraphidites bollii* (THIERSTEIN).
Author: THIERSTEIN (1971).

I m p o r t a n t s p e c i e s :
First occurrences: Common: *Calcicalathina oblongata* (WORSLEY); rare: *Zygodiscus diplogrammus* (DEFLANDRE & FERT), and *Parhabdolithus splendens* (DEFLANDRE).
Last occurrence: *Rucinolithus wisei* THIERSTEIN.

R e m a r k s : This zone is characterized by other scarce species: First occurrences of *Micula infracretacea* n. sp., *Podorhabdus dietzmanni* (REINHARDT), *Diadorhombus rectus* WORSLEY, *Discorhabdus biradiatus* (WORSLEY), *Nannoconus bucheri* BRONNIMANN, and *Nannoconus wassalli* BRONNIMANN. *Diadorhombus rectus* WORSLEY and *Tubodiscus verenae* n. sp. have not been recognized above this zone. The base of the zone lies in the upper part of the *Kilianella roubaudiana* Ammonite Zone (see Fig. 8).
The limit Lower/Upper Valanginian (section of Orpierre) is not characterized by distinct changes in the nannofossil assemblages, it nevertheless coincides with the first occurrences of scarce *Zygodiscus diplogrammus* (DEFLANDRE & FERT), *Parhabdolithus splendens* (DEFLANDRE) and *Micula infracretacea* n. sp.
The limit Valanginian/Hauterivian cannot be recognized by means of nannofossils.

R e f e r e n c e s e c t i o n s : Lower limit: Orpierre, unnamed formation with *Kilianella roubaudiana* (D'ORBIGNY), 15—25 m below formation a (see Fig. 8); typical assemblage: La Charce, formations b—d (see Fig. 9), alternating marls and limestones; the sections are dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 4 and Fig. 5).

G e o g r a p h i c d i s t r i b u t i o n : Southeastern France (Orpierre, La Charce), Switzerland (Valangin, Hauterive, Montsalvens), Atlantic.

A g e : Lower Valanginian — Lower Hauterivian.

2.4. Lithraphidites bollii Zone

D e f i n i t i o n : Interval from the first occurrence of *Lithraphidites bollii* (THIERSTEIN) to the last occurrence of *Calcicalathina oblongata* (WORSLEY).
Author: THIERSTEIN (1971).

I m p o r t a n t s p e c i e s :
First occurrence: *Lithraphidites bollii* (THIERSTEIN).
Last occurrences: *Discorhabdus biradiatus* (WORSLEY), *Cruciellipsis cuvillieri* (DEFLANDRE ex MANIVIT), *Bipodorhabdus roeglii* THIERSTEIN, *Lithraphidites bollii* (THIERSTEIN), and *Calcicalathina oblongata* (WORSLEY).

R e m a r k s : Very rare specimens of *Nannoconus kamptneri* BRONNIMANN and *Tegumentum stradneri* THIERSTEIN have their first occurrence near the top of this zone. In southeastern France only one specimen of *Hayesites bulbus* THIERSTEIN has been observed near the top, together with the last *Lithraphidites bollii* (THIERSTEIN).
The base of this zone lies within the *Holcostephanus jeannoti-Leopoldina castellanensis* Ammonite Subzone and slightly above the base of the *Dorothia ouachensis-Haplophragmoides vocontianus* Foraminifera Zone (MOULLADE 1966).
The limit Lower/Upper Hauterivian lies a few meters below the extinctions of *Discorhabdus biradiatus* (WORSLEY), *Cruciellipsis cuvillieri* (DEFLANDRE ex MANIVIT) and *Bipodorhabdus roeglii* THIERSTEIN. The Hauterivian/Barremian limit cannot be characterized by means of nannofossils.

R e f e r e n c e s e c t i o n s : Lower limit: La Charce, formation e (see Fig. 10), alternating limestones and marls; the section is dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 8). Typical assemblage: DSDP Leg 1—4—4—1, 110 cm to 11 cm (see Fig. 17), alternating light grey nannoplankton chalk and dark grey nannoplankton marls.

G e o g r a p h i c d i s t r i b u t i o n : Southeastern France (La Charce, Route d'Angles, Ferme Raton, Sisteron, Montclus), Switzerland (Montsalvens), Atlantic.

A g e : Lower Hauterivian to Lower Barremian.

2.5. Micrantholithus hoschulzi Zone

D e f i n i t i o n : Interval from the last occurrence of *Calcicalathina oblongata* (WORSLEY) to the last occurrence of *Nannoconus colomi* (DE LAPPARENT) and/or the first occurrences of *Chiastozygus litterarius* (GÓRKA) and/or *Rucinolithus irregularis* THIERSTEIN.
Author: THIERSTEIN (1971), modified in this paper.

I m p o r t a n t s p e c i e s :
Last occurrence: *Nannoconus colomi* (DE LAPPARENT).

R e m a r k s : The assemblage is the same as at the top of the underlying *Lithraphidites bollii* Zone, minus *Calcicalathina oblongata* (WORSLEY). Very rare *Nannoconus bermudezi* BRONNIMANN and *Nannoconus kamptneri* BRONNIMANN have their last occurrence within this zone. Its base lies below the top of the *Emericeras emerici* Ammonite Zone, within the *Pulchellia compressissima* Ammonite Subzone, and at the base of the *Clavihedbergella* aff. *simplex* Foraminifera Zone (MOULLADE 1966), i. e. in the upper part of the Lower Barremian.

R e f e r e n c e s e c t i o n : Lower limit: Route d'Angles, formations 5—6 (see Fig. 11), typical assemblage: Route d'Angles, formations 7—13 (see Fig. 11), alternating limestones and marls. The section is dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 11).

G e o g r a p h i c d i s t r i b u t i o n : Southeastern France (Route d'Angles, La Charce, Sisteron, Montclus), Trinidad.

A g e : Lower Barremian to Upper Barremian.

2.6. Chiastozygus litterarius Zone

D e f i n i t i o n : Interval from the last occurrence of *Nannoconus colomi* (DE LAPPARENT) and/or the first occurrences of *Chiastozygus litterarius* (GÓRKA) and/or *Rucinolithus irregularis* THIERSTEIN to the first occurrences of *Parhabdolithus angustus* (STRADNER) and/or *Lithastrinus floralis* STRADNER.
Author: THIERSTEIN (1971), modified in this paper.

I m p o r t a n t s p e c i e s :
First occurrences: *Chiastozygus litterarius* (GÓRKA), *Rucinolithus irregularis* THIERSTEIN, *Podorhabdus decorus* (DEFLANDRE) and *Lithastrinus septentrionalis* STRADNER.

Last occurrences: *Nannoconus colomi* (DE LAPPARENT), *Micrantholithus hoschulzi* (REINHARDT), *Micrantholithus obtusus* STRADNER, *Cretaturbella rothii* THIERSTEIN, and *Nannoconus bronnimanni* TREJO.

Remarks: *Tegumentum stradneri* THIERSTEIN becomes common and *Parhabdolithus infinitus* (WORSLEY) has its first occurrence within this zone in southeastern France. The latter species, however, has been recognized in the *Lithraphidites bollii* Zone in the West Atlantic (DSDP Leg 1, Sites 4 and 5 A), and in the *Chiastozygus litterarius* Zone in the eastern Atlantic (DSDP Leg 14, Site 135). The last occurrence of *Nannoconus colomi* (DE LAPPARENT) would be the most convenient index of the top of this zone, but Lower Aptian sediments very often contain reworked nannofossils (La Charce III, West Atlantic, Central Atlantic, Spain), so that the base of the *Chiastozygus litterarius* Zone is better recognized by the first occurrence of either *Chiastozygus litterarius* (GÓRKA) (Montclus, La Charce III, Central Atlantic), or *Rucinolithus irregularis* THIERSTEIN (Route d'Angles). These three events all range between the uppermost *Silesites seranonis* and the lower *Puzosia matheroni* Ammonite Zones, and between the uppermost *Lenticulina eichenbergi* and the lowermost *Hedbergella sigali without Lenticulina eichenbergi* Foraminifera Zones (MOULLADE 1966) i. e. at the limit Barremian/Aptian.

Reference section: Lower limit: Route d'Angles, formations 14—15 (see Fig. 11), alternating limestones and marls. Typical assemblage: Lesches-en-Diois, formation 1 (see Fig. 15), alternating dark marls and thin limestones; both sections are dated by foraminifera and ammonites (see MOULLADE 1966, Figs. 11 and 16).

Geographic distribution: Southeastern France (Route d'Angles, Lesches-en-Diois, La Charce, Sisteron, Montclus, La Bédoule-Station de Cassis), Central Atlantic, Trinidad.

Age: Lower Aptian.

2.7. Parhabdolithus angustus Zone

Definition: Interval from the first occurrences of *Parhabdolithus angustus* (STRADNER) and/or *Lithastrinus floralis* STRADNER, to the first occurrence of *Prediscosphaera cretacea* (ARKHANGELSKY).
Author: MANIVIT (1971), modified in this paper.

Important species:
First occurrences: *Parhabdolithus angustus* (STRADNER), *Lithastrinus floralis* STRADNER, *Flabellites biforaminis* n. sp., *Corollithion achylosum* (STOVER), *Tranolithus gabalus* STOVER, and *Cretarhabdus loriei* GARTNER.
Last occurrences: *Nannoconus wassalli* BRONNIMANN, *Micula infracretacea* n. sp., *Cyclagelosphaera margereli* NOEL, *Nannoconus bucheri* BRONNIMANN, and *Nannoconus globulus* BRONNIMANN.

Remarks: Within this zone rare *Braarudosphaera africana* STRADNER, *Corollithion rhombicum* (STRADNER & ADAMIKER), *Corollithion ellipticum* BUKRY, and *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH) have their first occurrence, and rare specimens of *Lithastrinus septentrionalis* STRADNER occur for the last time.
The base of the *Parhabdolithus angustus* Zone approximates the limit Lower/Upper Aptian.

Reference sections: Lower limit: Lesches-en-Diois, base of formation m (see Fig. 15), alternating dark marls and thin limestones; the section is dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 16); typical assemblage: Gargas, formations 3—4 (= localities B, C, D, E, F in MOULLADE 1965), blue grey marls; the section is dated by cephalopods (MOULLADE 1965) and ostracods (OERTLI 1958).

Geographic distribution: Southeastern France (Lesches-en-Diois, Gargas), Great Britain (Copt Point), Atlantic.

Age: Upper Aptian — Lower Albian.

2.8. Prediscosphaera cretacea Zone

Definition: Interval from the first occurrence of *Prediscosphaera cretacea* (ARKHANGELSKY) to the first occurrence of *Eiffellithus turriseiffeli* (DEFLANDRE & FERT).
Author: THIERSTEIN (1971), modified in this paper.

Important species:
First occurrences: *Prediscosphaera cretacea* (ARKHANGELSKY), *Vagalapilla matalosa* (STOVER), *Eiffellithus trabeculatus* (GÓRKA), *Cretarhabdus coronadventis* REINHARDT, *Broinsonia signata* (NOEL), *Tranolithus exiguus* STOVER, *Tranolithus orionatus* (REINHARDT), *Broinsonia lata* (NOEL), *Podorhabdus orbiculofenestrus* (GARTNER), and *Prediscosphaera spinosa* (BRAMLETTE & MARTINI).

Remarks: The base of this zone was originally defined by the first occurrences of *Prediscosphaera cretacea* (ARKHANGELSKY) and *Cribrospherella ehrenbergi* (ARKHANGELSKY). Comparison with other sections, examination of further samples from the Col de Palluel section, and re-preparation of the samples initially investigated, showed that the rare *Cribrosphaerella ehrenbergi* (ARKHANGELSKY) originally mentioned (THIERSTEIN 1971) were introduced in these samples by contamination. *Cribrosphaerella ehrenbergi* (ARKHANGELSKY) has its first occurrence at the base of the *Eiffellithus turriseiffeli* Zone in the sections of Col de Palluel, of Copt Point, and in the samples from the West Atlantic.
Prediscosphaera cretacea (ARKHANGELSKY) has been found in the lowermost sample of the Col de Palluel section, but not in the uppermost sample of the Lesches-en-Diois section. Its precise lower limit, therefore, has not yet been discovered, but must lie within the Lower Albian, i. e. in the upper part of the *Leymeriella tardefurcata — Hypacanthoplites trivialis* Ammonite Zone and in the upper part of the *Pleurostomella subnodosa — Ticinella bejaouaensis* Foraminifera Subzone (see MOULLADE 1966). The zone covers the upper part of the Lower and the Middle Albian.
In the section of Copt Point (Folkestone, Great Britain) the base of the *Prediscosphaera cretacea* Zone lies within the Lower Gault, i. e. the *Anahoplites intermedius* Ammonite Subzone. Its anomalous base in Great Britain is probably due to the scarce nannoflora in lower samples.

Reference section: Assemblage: Col de Palluel, formations p and q (see Fig. 16), dark marls with sandy and glauconitic beds. The section is dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 18).

Geographic distribution: Southern France (Col de Palluel; Coupe de l'Aube and Côtes de Moeslains [MANIVIT 1971]), Switzerland (Montsalvens), Great Britain (Copt Point), West Atlantic, Kansas (ČEPEK and HAY 1969).

Age: Lower Albian to Middle Albian.

2.9. Eiffellithus turriseiffeli Zone

Definition: The base of this zone is characterized by the first occurrence of *Eiffellithus turriseiffeli* (DEFLANDRE & FERT), which is abundant up to the Lower Cenomanian.
Author: THIERSTEIN (1971).

Important species:
First occurrences: *Eiffellithus turriseiffeli* (DEFLANDRE & FERT), *Cribrosphaerella ehrenbergi* (ARKHANGELSKY), *Corollithion signum* STRADNER, *Broinsonia enormis* (SHUMENKO), and *Scapholithus fossilis* DEFLANDRE & FERT.
Last occurrences: *Rucinolithus irregularis* THIERSTEIN, *Parhabdolithus infinitus* (WORSLEY), *Diazomatolithus lehmani* NOEL, and *Braarudosphaera africana* STRADNER.

Remarks: The base of this zone coincides with the limit Middle Albian/Upper Albian, i. e. the base of the *Pervinquieria inflata* Ammonite Zone, and the base of the *"Globigerinelloides" breggiensis* Foraminifera Zone, i. e. the base of the *Ticinella praeticinensis* Foraminifera Subzone (MOULLADE 1966). The limit Upper Albian/Vraconnian lies above the last occurrences of *Parhabdolithus infinitus* (WORSLEY) and *Rucinolithus irregularis* THIERSTEIN, and below the first occurrence of *Broinsonia enormis* (SHUMENKO). The limit Albian (including Vraconnian)/Cenomanian could not be recognized by means of nannofossils in southeastern France and Great Britain. In Switzerland (Montsalvens) and in the Atlantic *Lithraphidites alatus* THIERSTEIN has its first occurrence in the Lower Cenomanian.
The top of this zone is not defined because of conflicting first occurrences of younger species indicated by ČEPEK & HAY (1969), ČEPEK (1970) and MANIVIT (1971).

Reference section: Lower limit and assemblage: Col de Palluel, formations r1—r3 (see Fig. 16), blue-grey marls; the section is dated by ammonites and foraminifera (see MOULLADE 1966, Fig. 18).

Geographic distribution: Southeastern France (Col de Palluel; Coupe de l'Aube, Côtes de Moeslains, Wissant [MANIVIT 1971]), Switzerland (Montsalvens), Great Britain (Copt Point, Barrington), West and Central Atlantic, Kansas (ČEPEK & HAY 1969).

Age: Upper Albian to Cenomanian.

3. Sections and material studied

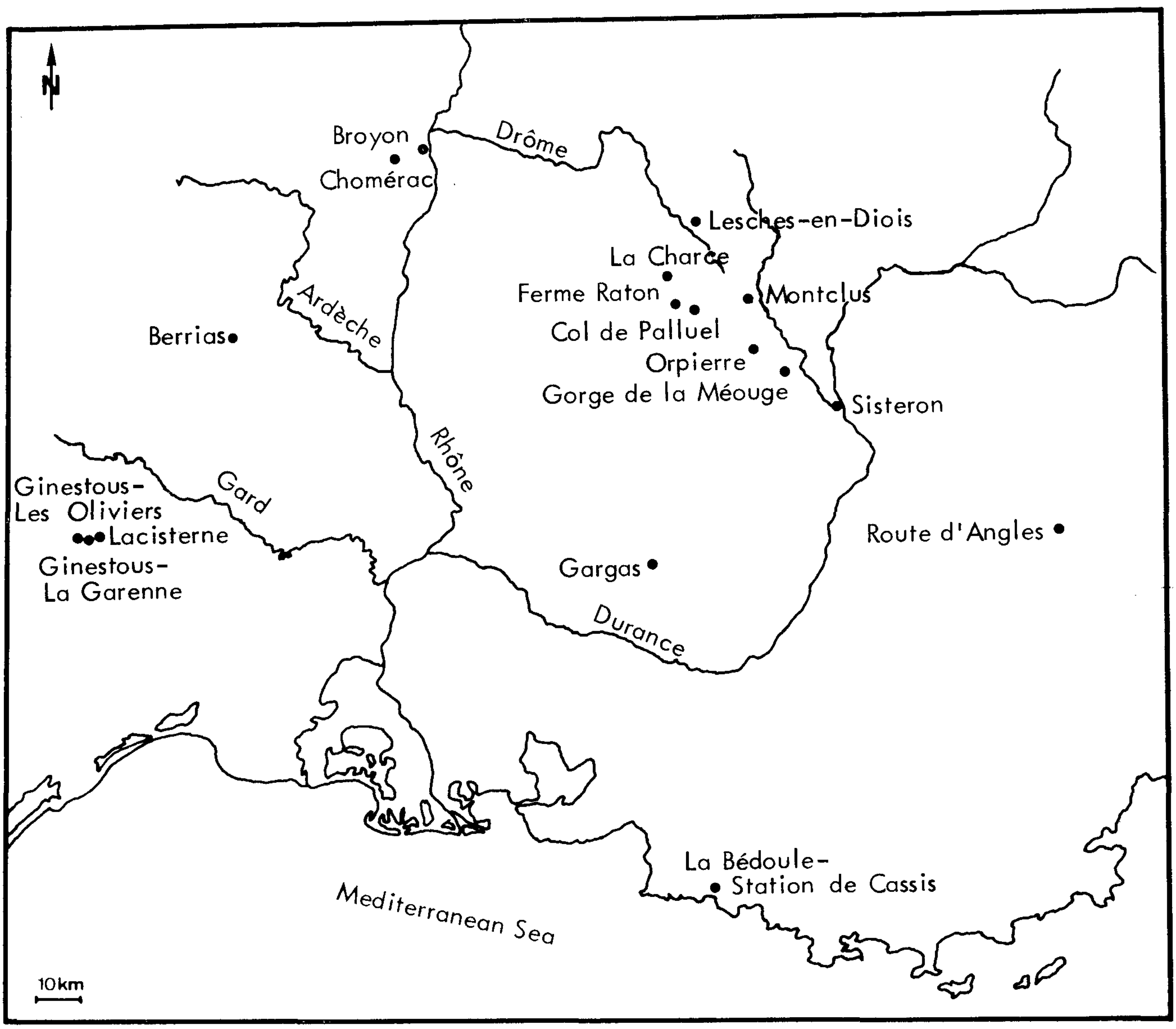


Fig. 2. Geographic location of sections and samples studied in southeastern France.

The lithology indicated in the range charts and text is adapted from the cited publications. Most of the units mentioned as "formations" are members or beds, in the sence of the principles of stratigraphic classification and terminology of the ISSC (1961).

In all range charts the species are arranged in order of their known first occurrences.

3.1. Southeastern France

The sections are arranged in stratigraphic order from older to younger. Their location is indicated on Fig. 2.

3.1.1. Broyon (Ardèche)

Figure 3

For geographic location, lithology, and paleontology of this section, see LE HÉGARAT & REMANE (1968). The nannofloras of the following samples have been studied:

Sample	Layer	Ammonite Zone	Calpionellid Subzone	Substage
Th 70/360	BR 34	*B. privasensis*	B. sup.	Upper Berriasian
Th 70/359	BR 33	*N. subalpinus*	B. sup.	Upper Berriasian
Th 70/358	BR 32	*B. grandis*	B. sup.	Lower Berriasian
Th 70/356	BR 31	*B. grandis*	B. sup.	Lower Berriasian
Th 70/355	BR 29	*B. grandis*	B. sup.	Lower Berriasian
Th 70/354	BR 27	*B. grandis*	B. sup.	Lower Berriasian
Th 70/353	BR 10	*Subplanites*	B. sup.	Lower Tithonian
Th 70/352	BR 6	*Subplanites*	B. sup.	Lower Tithonian
Th 70/351a	BR 4	*Subplanites*	B. sup.	Lower Tithonian

In this section, the base of the *Nannoconus colomi* Zone lies within the Upper Tithonian. Samples Th 70/354—360 belong to the *Nannoconus colomi* Zone and contain moderately well preserved nannofloras.

3.1.2. Ginestous-la Garenne (Hérault)

Figure 4

LE HÉGARAT & REMANE (1968) gave the location and described the lithology, ammonites and calpionellids of this section. The following samples have been collected and their nannofloras studied:

Sample Th 70/	Layer	Ammonite Subzone	Calpionellid Subzone	Substage
315	LG 4043	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
314	LG 4040	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
313	LG 4035	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
312	LG 4031	*B. callisto*	D 3	Upper Berriasian
311	LG 4029	*B. callisto*	D 3	Upper Berriasian
310	LG 4028	*B. callisto*	D 2	Upper Berriasian
308	LG 4025	*B. dalmasi*	C	Upper Berriasian

The nannofloras are of average preservation and abundance. Samples Th 70/309 and Th 70/310 belong to the *Nannoconus colomi* Zone, and sample Th 70/311 contains the first *Cretarhabdus crenulatus* BRAMLETTE & MARTINI 1964 emend. THIERSTEIN 1971.

3.1.3. Lacisterne (Hérault)

Figure 5

The geographic location, lithology, and the calpionellids and cephalopods of this section have been described by LE HÉGARAT & REMANE (1968). 6 of 7 samples collected by the author contain nannofloras of poor to moderately good preservation.

Sample Th 70/	Layer	Ammonite Subzone	Calpionellid Subzone	Substage
306	LC 3442	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
305	LC 3441a	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
304	LC 3438	*B. callisto*	D 3	Upper Berriasian
303	LC 3429	?	D 2	Upper Berriasian
302	LC 3428	?	D 1	Upper Berriasian
301	LC 3416	?	D 1	Upper Berriasian

No samples have been studied from the interval between samples Th 70/301 and 302, because no outcrops of marly beds could be found.

All samples from this section belong to the *Cretarhabdus crenulatus* Zone.

3.1.4. Ginestous-les Oliviers (Hérault)

Figure 6

For geographic location, lithology, and detailed ammonite and calpionellid range charts see LE HÉGARAT & REMANE (1968). The nannofloras of the 5 following samples have been investigated (see Fig. 6).

Sample Th 70/	Layer	Ammonite Subzone	Calpionellid Subzone	Substage
320	LO 3457	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
319	LO 3455	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
318	LO 3451	*B. callisto*	D 3	Upper Berriasian
317	LO 3448	*B. callisto*	D 3	Upper Berriasian
316	LO 3443	*B. callisto*	D 3	Upper Berriasian

All samples from this section belong to the *Cretarhabdus crenulatus* Zone and contain nannofloras of average preservation and abundance.

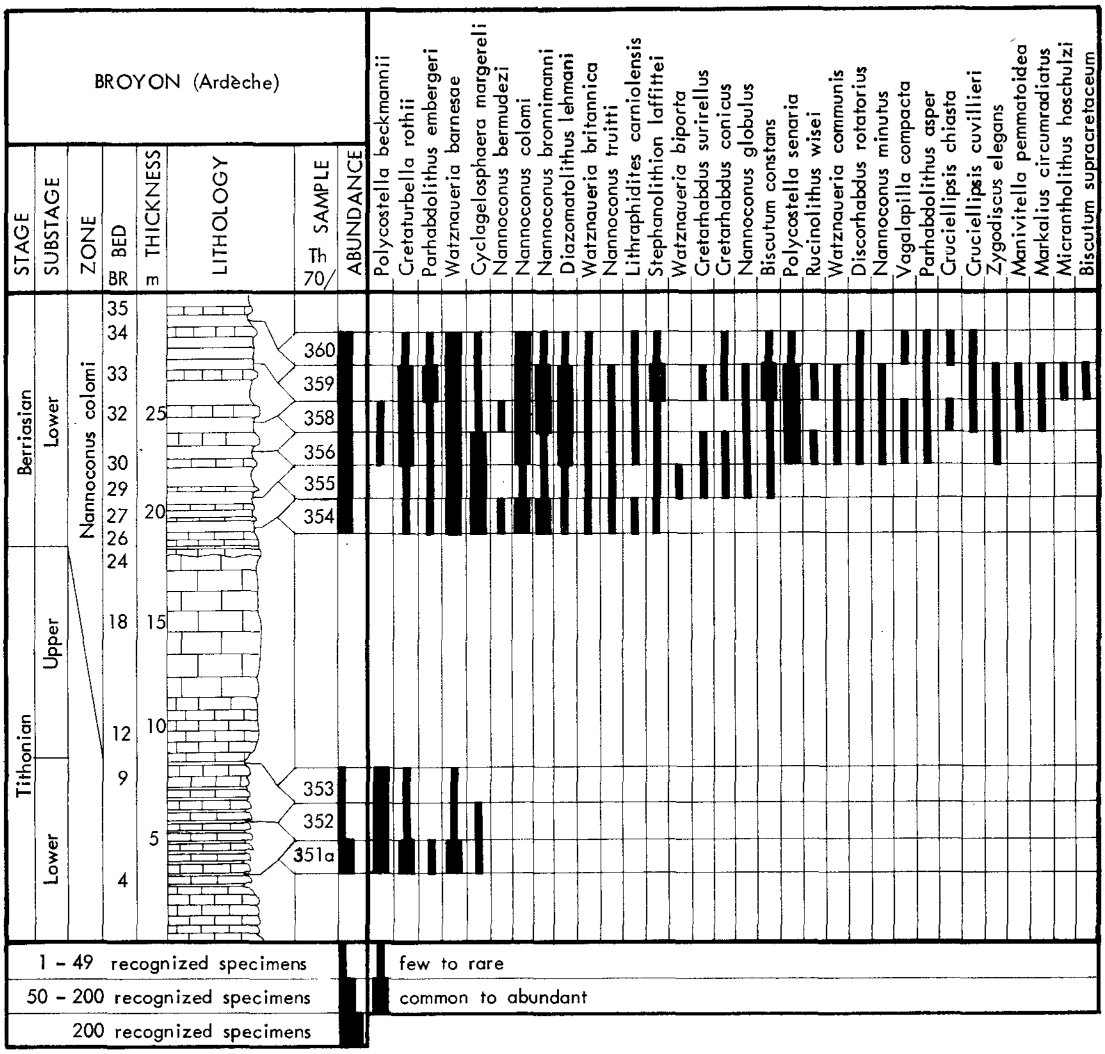


Fig. 3. Distribution of calcareous nannofossils in the section of Broyon (Ardèche).

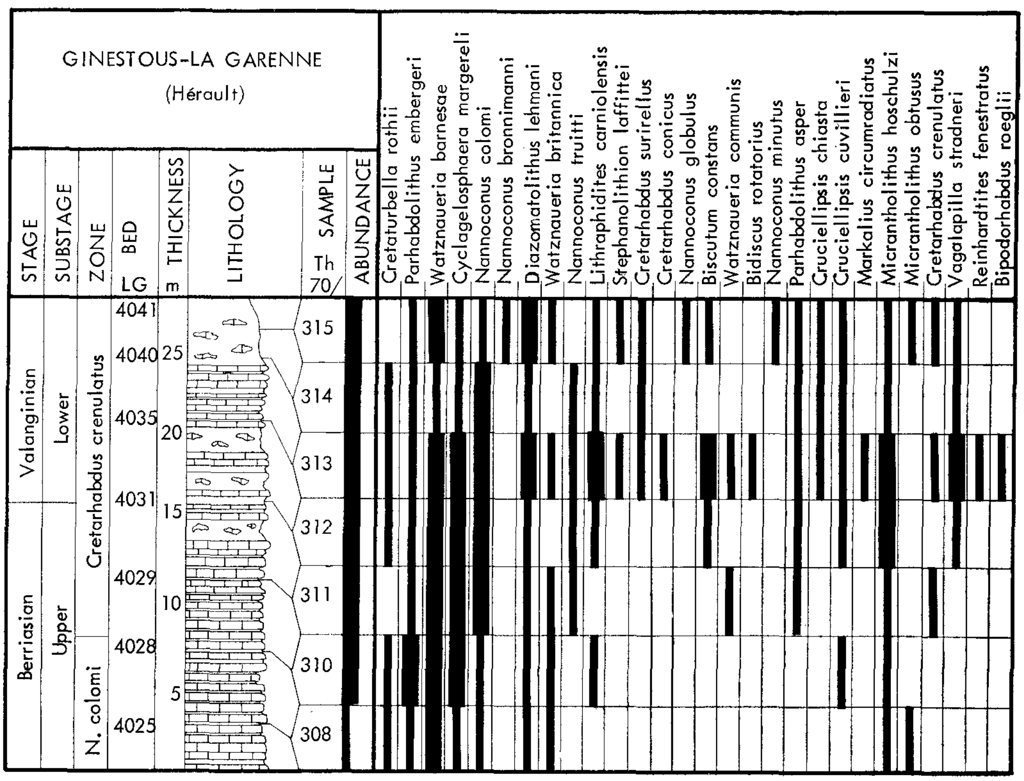


Fig. 4. Distribution of calcareous nannofossils in the section of Ginestous-La Garenne (Hérault).

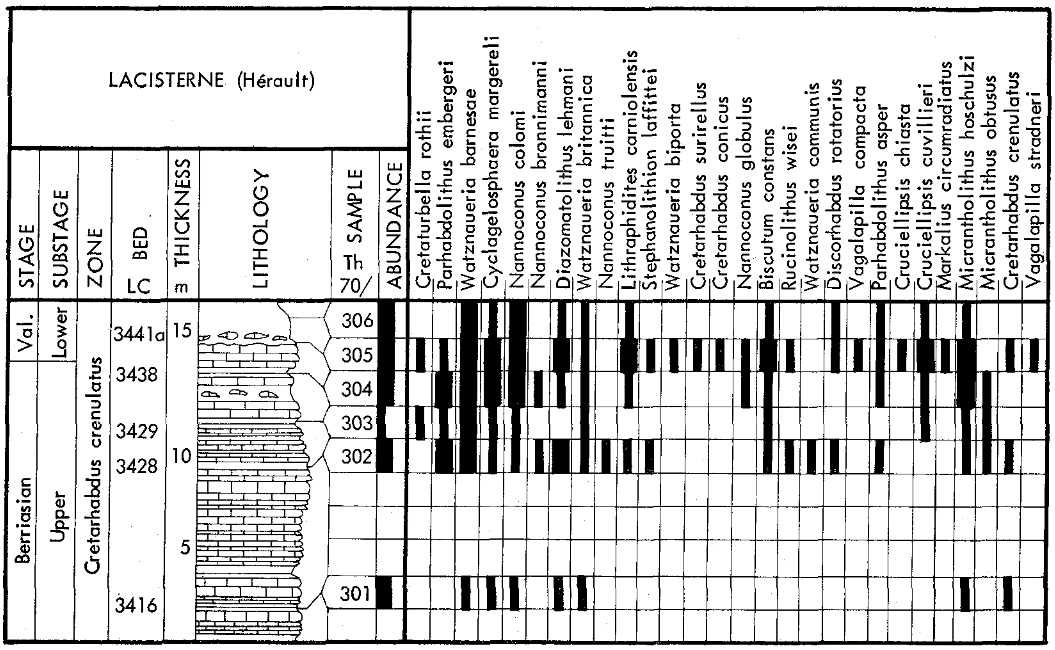


Fig. 5. Distribution of calcareous nannofossils in the section of Lacisterne (Hérault).

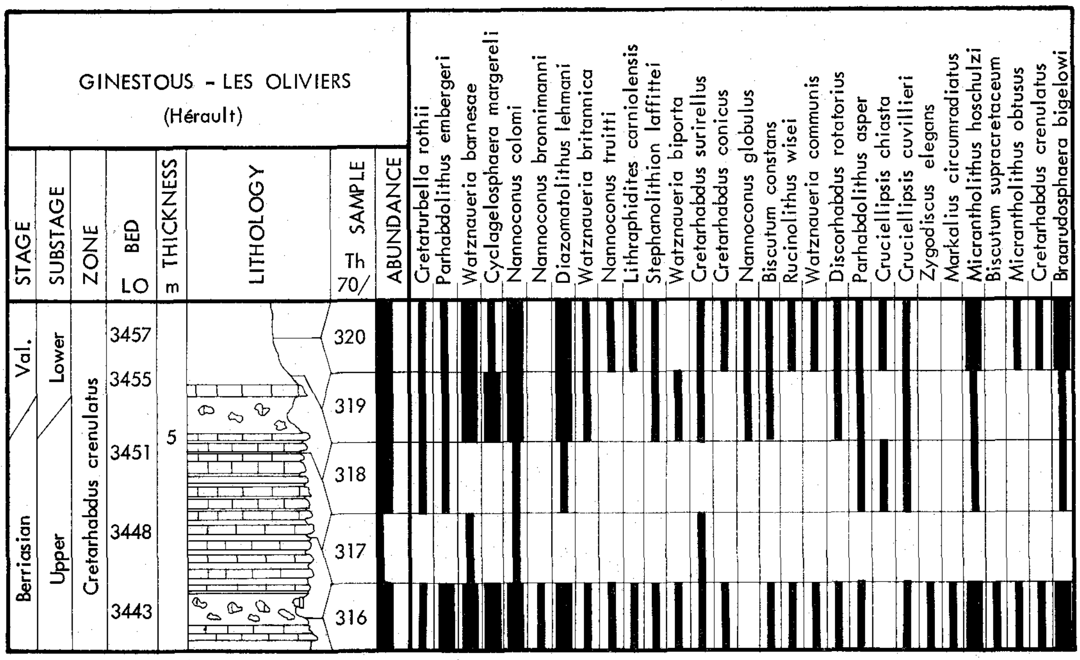


Fig. 6. Distribution of calcareous nannofossils in the section of Ginestous-Les Oliviers (Hérault).

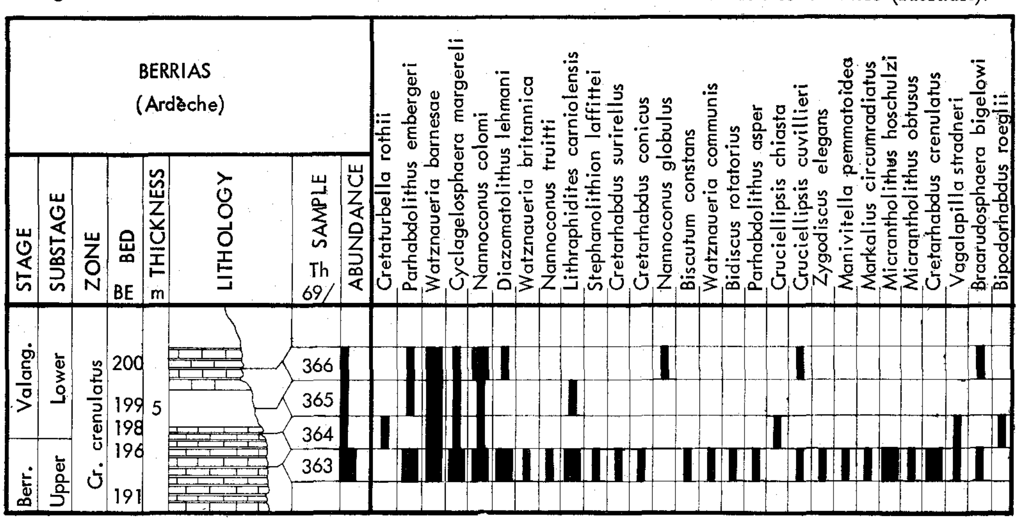


Fig. 7. Distribution of calcareous nannofossils in the upper part of the Berriasian type section at Berrias (Ardèche).

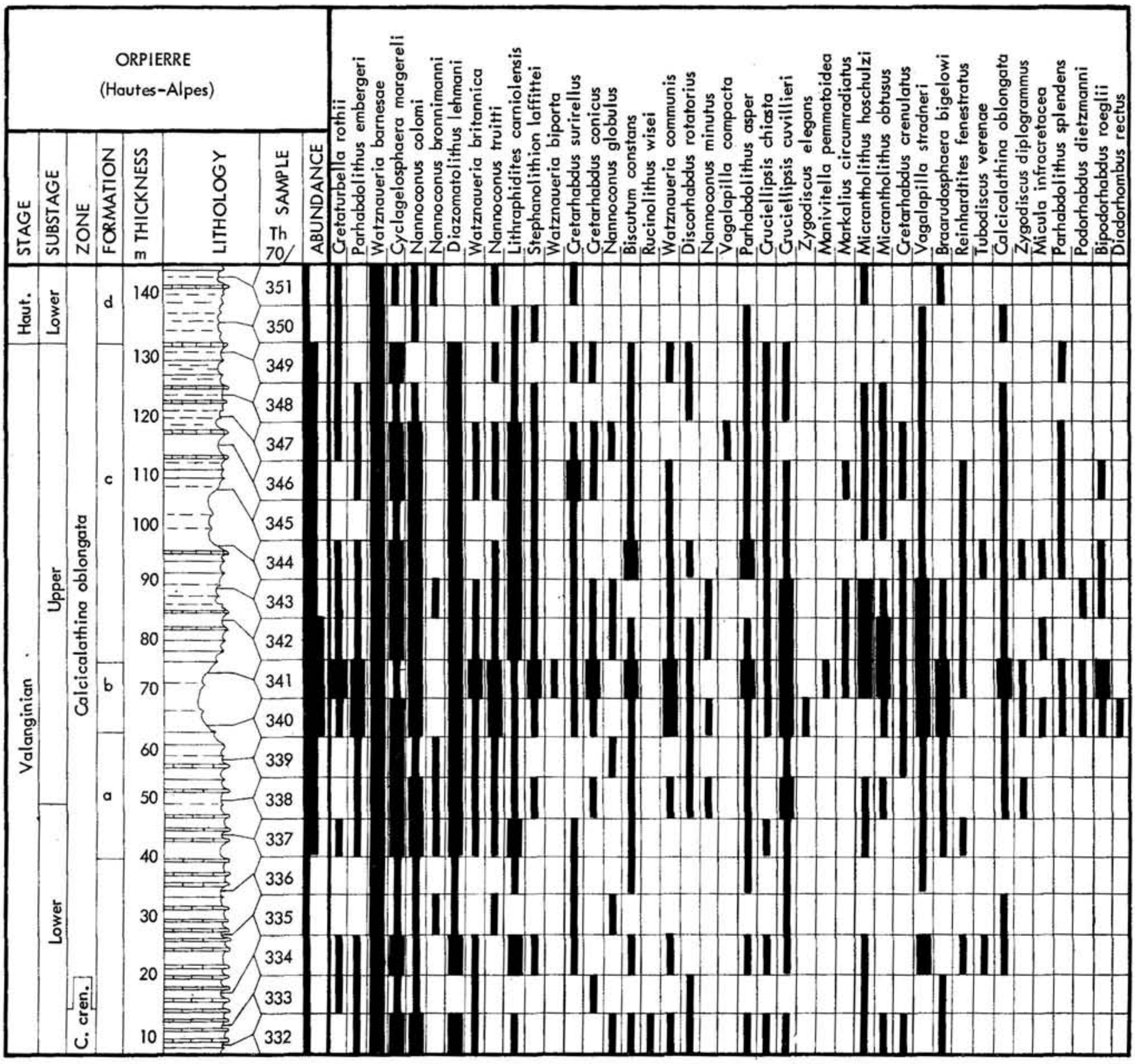


Fig. 8. Distribution of calcareous nannofossils in the section of Orpierre (Hautes-Alpes).

3.1.5. Berrias (Ardèche)

Figure 7

For geographic location, lithology and paleontology of this, the type section of the Berriasian Stage see Busnardo, le Hégarat amd Magné (1965), and le Hégarat & Remane (1968). The section lacks marly beds from the Tithonian (bed BE 142) up to the uppermost Berriasian (bed BE 191). A total of 11 samples from this section have been studied, but only the 4 uppermost showed satisfactory nannofloras, these all belong to the *Cretarhabdus crenulatus* Zone.

Sample	Layer	Ammonite Subzone	Calpionellid Subzone	Substage
Th 69/				
366	BE 200	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
365	BE 199	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
364	BE 198	*T. pertransiens* + *K. pexiptycha*	D 3	Lower Valanginian
363	BE 193	*B. callisto*	D 2	Upper Berriasian

Thin sections of layer BE 145 (= *B. grandis* Ammonite Zone, and B. sup. Calpionellid Zone) contain *Nannoconus colomi* (de Lapparent, 1931).

3.1.6. Orpierre (Hautes-Alpes)

Figure 8

For geographic location, lithology, and ammonite and foraminiferal contents of this section, see Moullade (1966).

From the 150 m of alternating grey marls and grey to yellow limestones, 21 samples have been studied. A striking reciprocal relation between nannofossil abundance and frequency of limy beds is observed.

The limit between the *Cretarhabdus crenulatus* Zone and the *Calcicalathina oblongata* Zone lies below sample Th 70/334, about 30 m below the Lower/Upper Valanginian limit. The *Calcicalathina oblongata* Zone extends into the Lower Hauterivian. The Valanginian/Hauterivian limit cannot be recognized by any change in the nannofossil assemblages.

3.1.7. La Charce I (Drôme)

Figure 9

The location, lithology, and ammonites and foraminifera found in this section have been described by MOULLADE (1966). La Charce I includes the lower part of a continuously exposed section of 240 m (La Charce I and La Charce II) ranging from Upper Valanginian to Upper Hauterivian.

The lower part (0—50 m) of the La Charce I section is very marly and shows a rich and well preserved nannoflora, whereas in the upper part (50—120 m) the abundance of the nannofossils decreases. La Charce I covers the Upper Valanginian to Lower Hauterivian interval. The limit between the two stages cannot be distinguished by any nannofossil event. All 20 samples from this section belong to the *Calcicalathina oblongata* Zone.

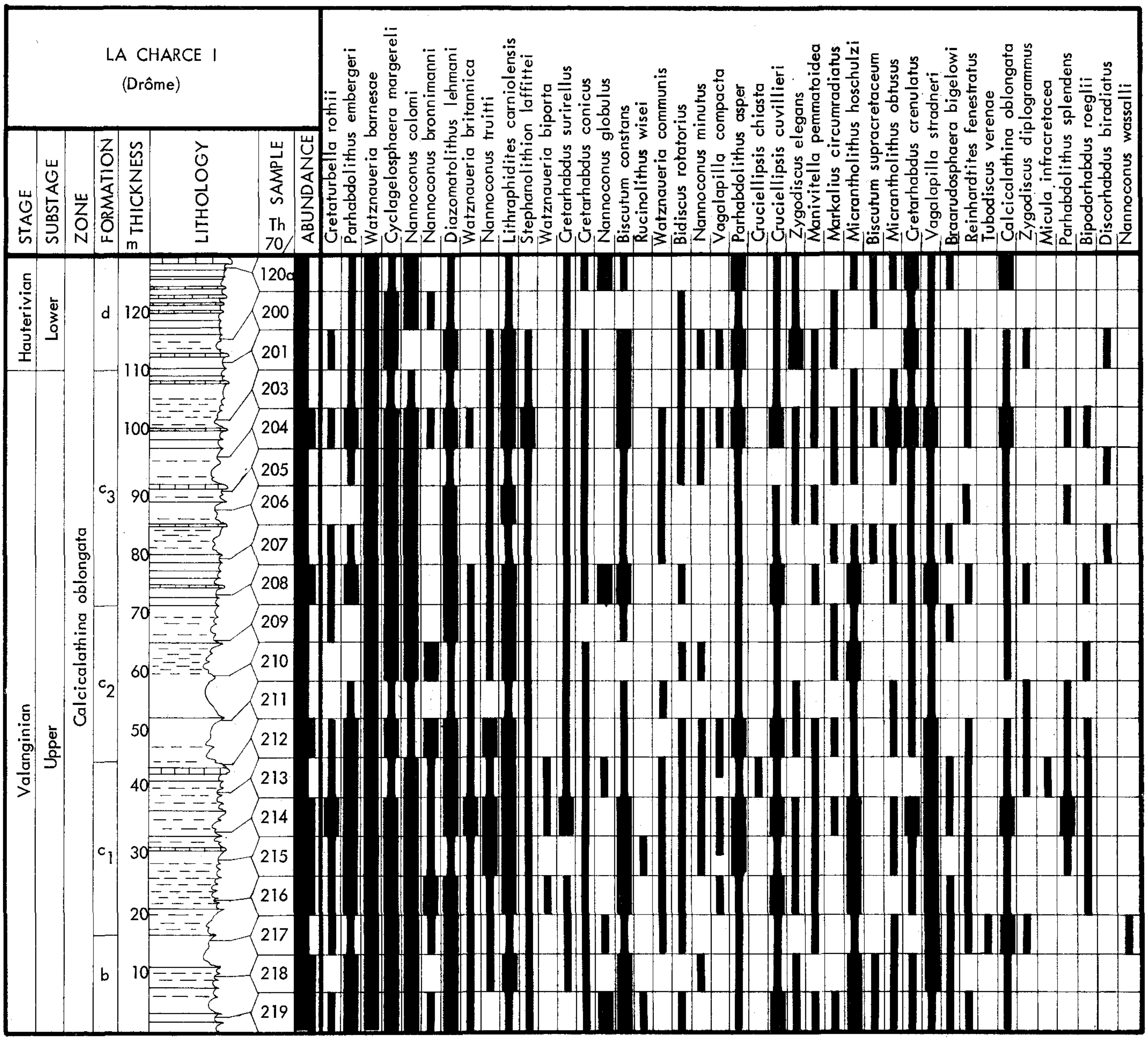


Fig. 9. Distribution of calcareous nannofossils in the Valanginian section of La Charce (Drôme).

3.1.8. La Charce II (Drôme)

Figure 10

This section is the upward continuation of the La Charce I section. The locality, lithology, ammonites and foraminifera have been described by MOULLADE (1966).

In addition to MOULLADE's description of the section, the author observed penecontemporaneous slumping at 38 m and at 55 to 58 m.

The 27 samples from this section contained well preserved, medium abundant to rich nannofloras. The samples up to Th 70/133 a represent the upper part of the *Calcicalathina oblongata* Zone and belong to the Lower Hauterivian. Sample Th 70/134 contains the first *Lithraphidites bollii* (THIERSTEIN) and marks the base of the *Lithraphidites bollii* Zone. The limit between the Lower and the Upper Hauterivian lies within the *Lithraphidites bollii* Zone and is not marked by any event in the nannoflora. Sample Th 70/131 a comes from the upper slumped bed; its rich nannoflora is the same as in the beds below and above.

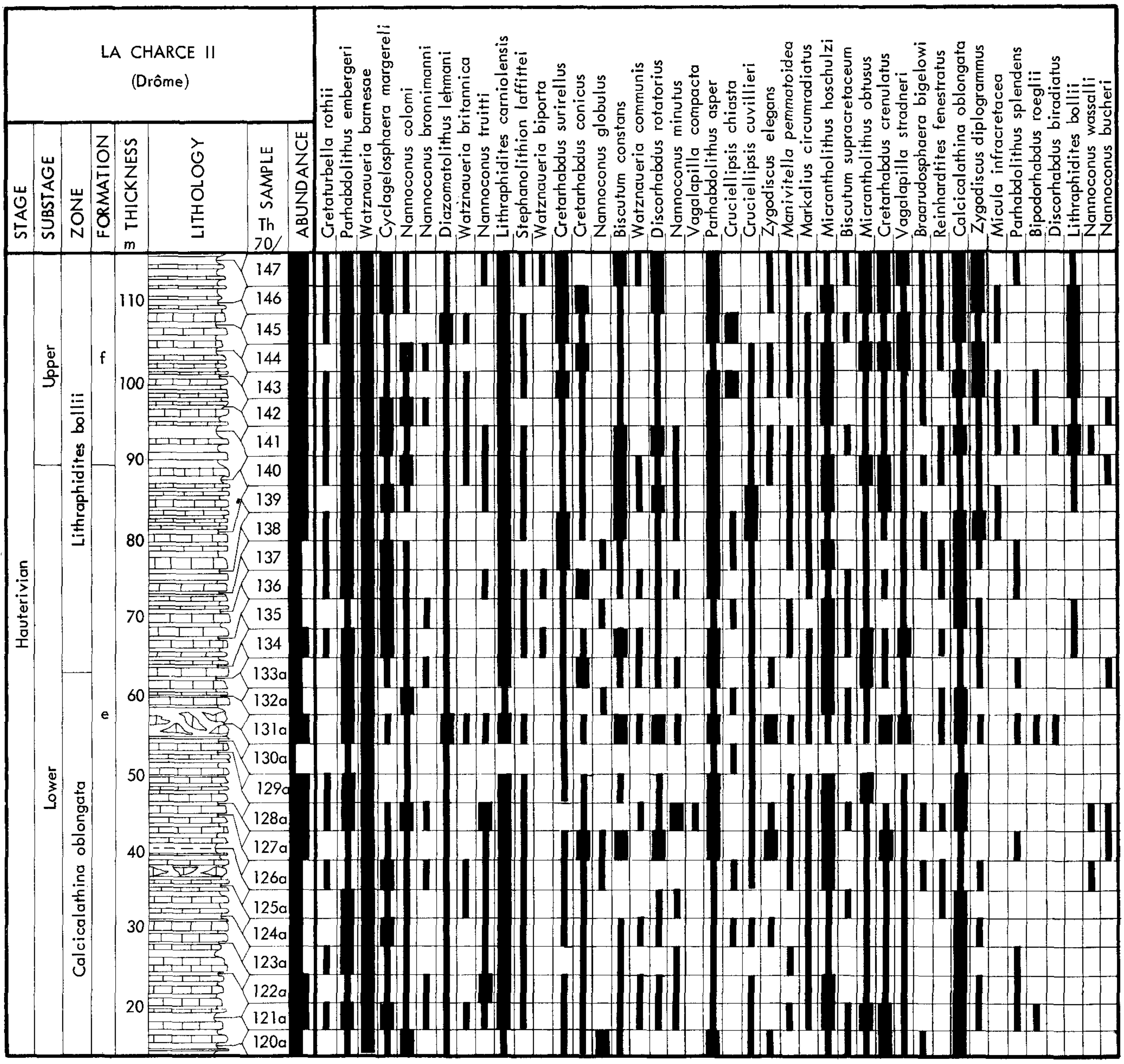


Fig. 10. Distribution of calcareous nannofossils in the Hauterivian section of La Charce (Drôme).

3.1.9. Route d'Angles (Basses Alpes)

Figure 11

For geographic location, lithology and paleontology of this, the type section of the Barremian Stage, see Busnardo (1965, lithology and marcofauna), Bouché (1965, nannoconids), Guillaume & Sigal (1965, foraminifera), and Moullade (1966, lithology, ammonites, foraminifera).

Of a total of 88 marly samples collected in this 120 m thick section, the nannofloras of only 21 were studied in detail. The section shows a predominance of limestone layers over intercalated marly beds. The nannofloras from this section are always poorly preserved and sparse. The samples from formations 1—5 (see Fig. 11) belong to the *Lithraphidites bollii* Zone, and include the limit Upper Hauterivian/Lower Barremian. Formations 6—14 represent the *Micrantholithus hoschulzi* Zone and range from Lower to Upper Barremian.

Neither the limit Upper Hauterivian/Lower Barremian nor the limit Lower/Upper Barremian are characterized by changes in the nannofossil assemblages. The highest occurrence of *Nannoconus colomi* (de Lapparent) in sample Th 69/318 and the lowest occurrence of *Rucinolithus irregularis* Thierstein in sample Th 69/320 lies just above the limit Upper Barremian/Lower Aptian. No *Nannoconus colomi* (de Lapparent) have been observed in the samples Th 69/320—327, all taken from marly layers between the limestone beds of formation 16. Bouché (1965) indicated that *Nannoconus colomi* (de Lapparent) and *Nannoconus steinmanni* Kamptner (considered here as a synonym of *Nannoconus colomi* [de Lapparent]) were present up to formation 16, but supposed them to be reworked. The striking disappearance of *Nannoconus colomi* (de Lapparent) at the limit Barremian/Aptian, however, has been observed by the author in the sections at Montclus (Hautes-Alpes) between formations k and l (see Moullade, 1966, Fig. 13), and at Sisteron (Basses-Alpes) between formations j and l (see Moullade, 1966, Fig. 12). No *Nannoconus colomi* (de Lapparent) have been recognized in the Lower Aptian samples from La Bédoule and Station de Cassis. The limit Barremian/Aptian, therefore, coincides with the top of the *Micrantholithus hoschulzi* Zone.

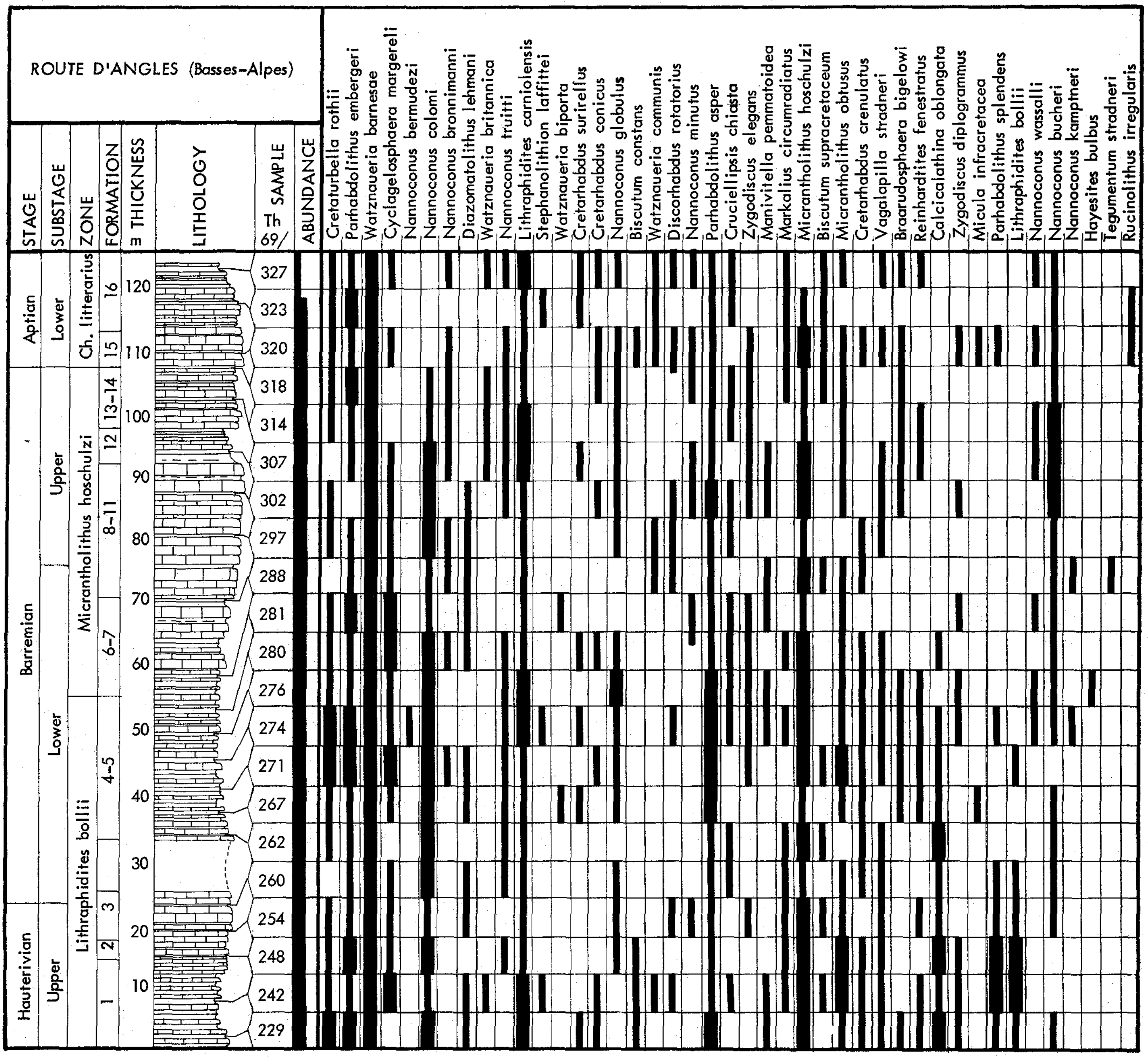


Fig. 11. Distribution of calcareous nannofossils in the type section of the Barremian Stage near Angles (Basses-Alpes).

3.1.10. La Charce III (Drôme)

Figure 12

Moullade (1966) described the geographic location, lithology and ammonites and foraminifera from this section. The lowermost two samples Th 70/164 and 165 contain rare specimens of the name species of the *Lithraphidites bollii* Zone and range within the Lower Barremian. The 17 samples covering formations i—j 3 belong to the *Micrantholithus hoschulzi* Zone and include the upper part of the Lower Barremian to the Upper Barremian. Recognition of *Chiastozygus litterarius* (Górka) in sample Th 70/160 and *Rucinolithus irregularis* Thierstein in sample Th 70/163 indicate the presence of the *Chiastozygus litterarius* Zone which covers the Lower Aptian. The limit Barremian/Aptian indicated between formations k and l by Moullade (1966) is based on lithologic criteria and is not supported by ammonites or foraminifera, thus it rather lies within formation j 3.

Slumping phenomena (formations j 1, k, l) seem to have affected the composition of the corresponding nannoflora in formations k and l: They contain reworked *Nannoconus colomi* (de Lapparent).

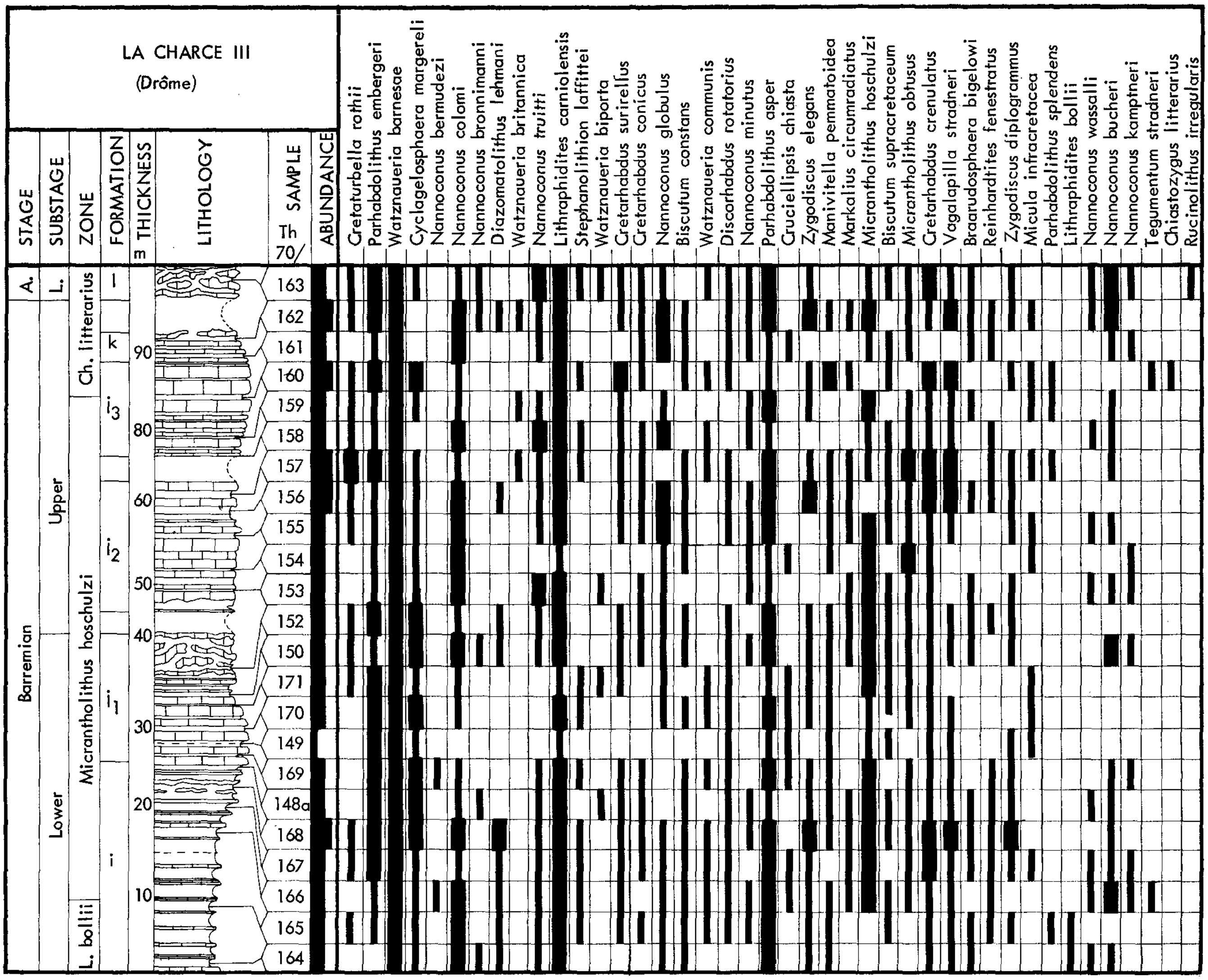


Fig. 12. Distribution of calcareous nannofossils in the Barremian section of La Charce (Drôme).

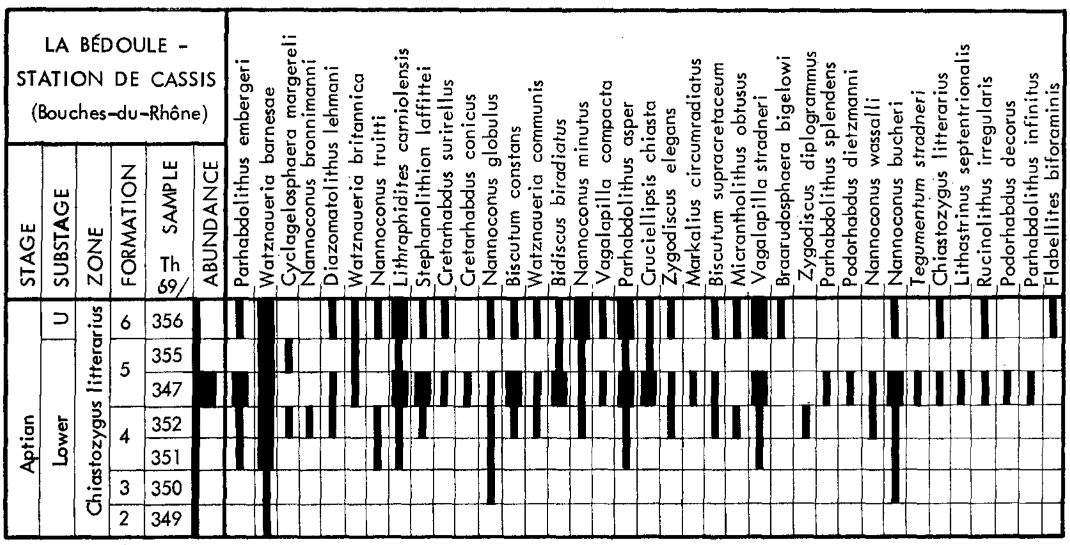


Fig. 13. Distribution of calcareous nannofossils in the type section of the Lower Aptian Substage at La Bédoule Station de Cassis (Bouches-du-Rhône).

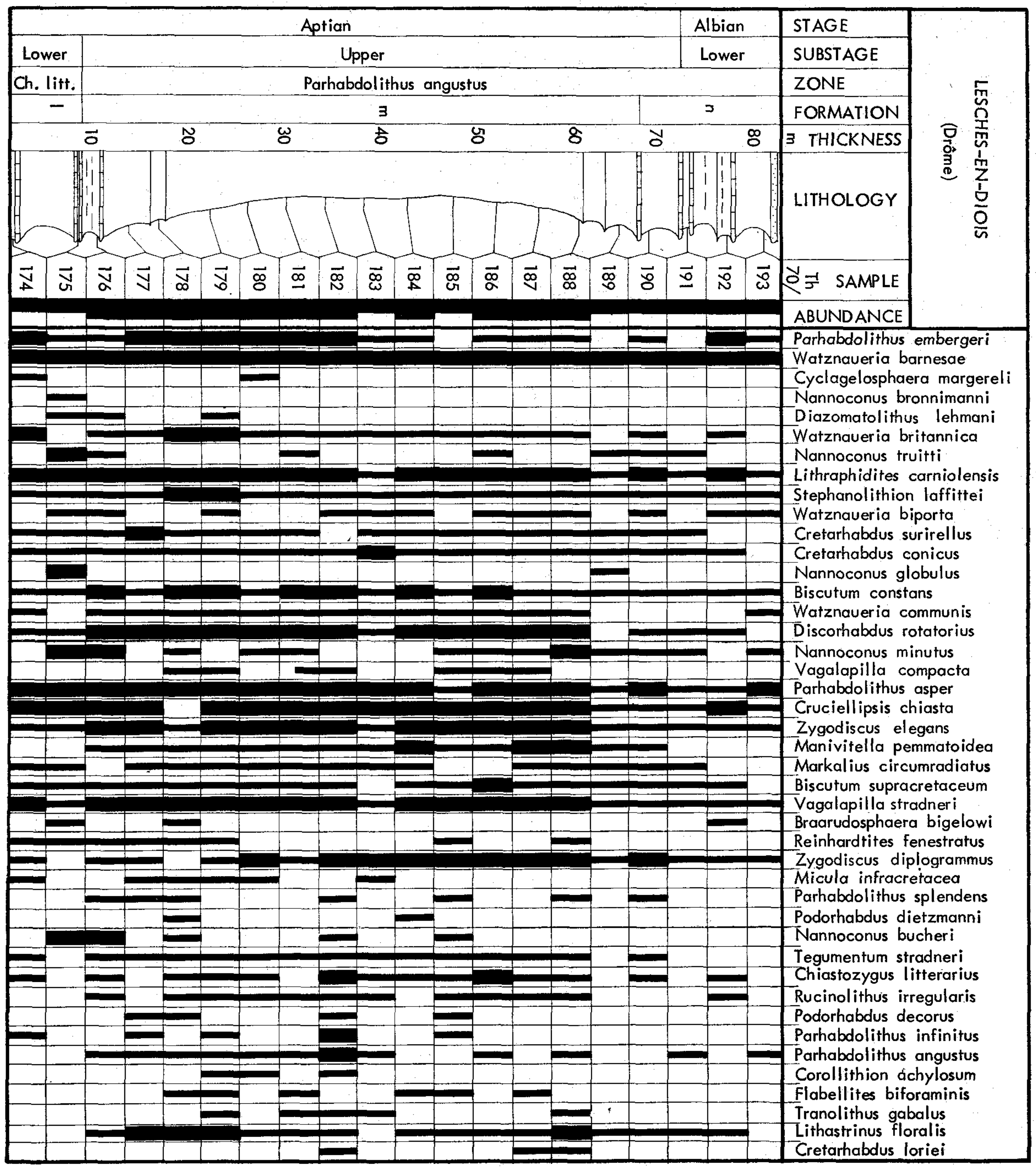


Fig. 15. Distribution of Calcareous nannofossils in the section of Lesches-en-Diois (Drôme).

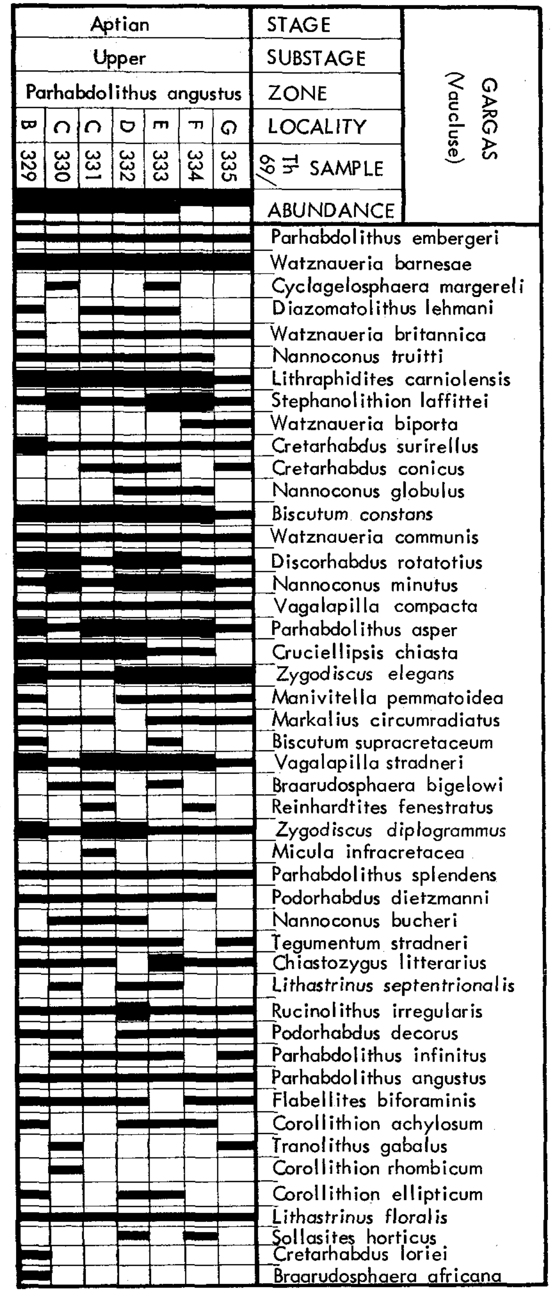


Fig. 14. Distribution of calcareous nannofossils in the type section of the lower part of the Upper Aptian Substage at Gargas (Vaucluse).

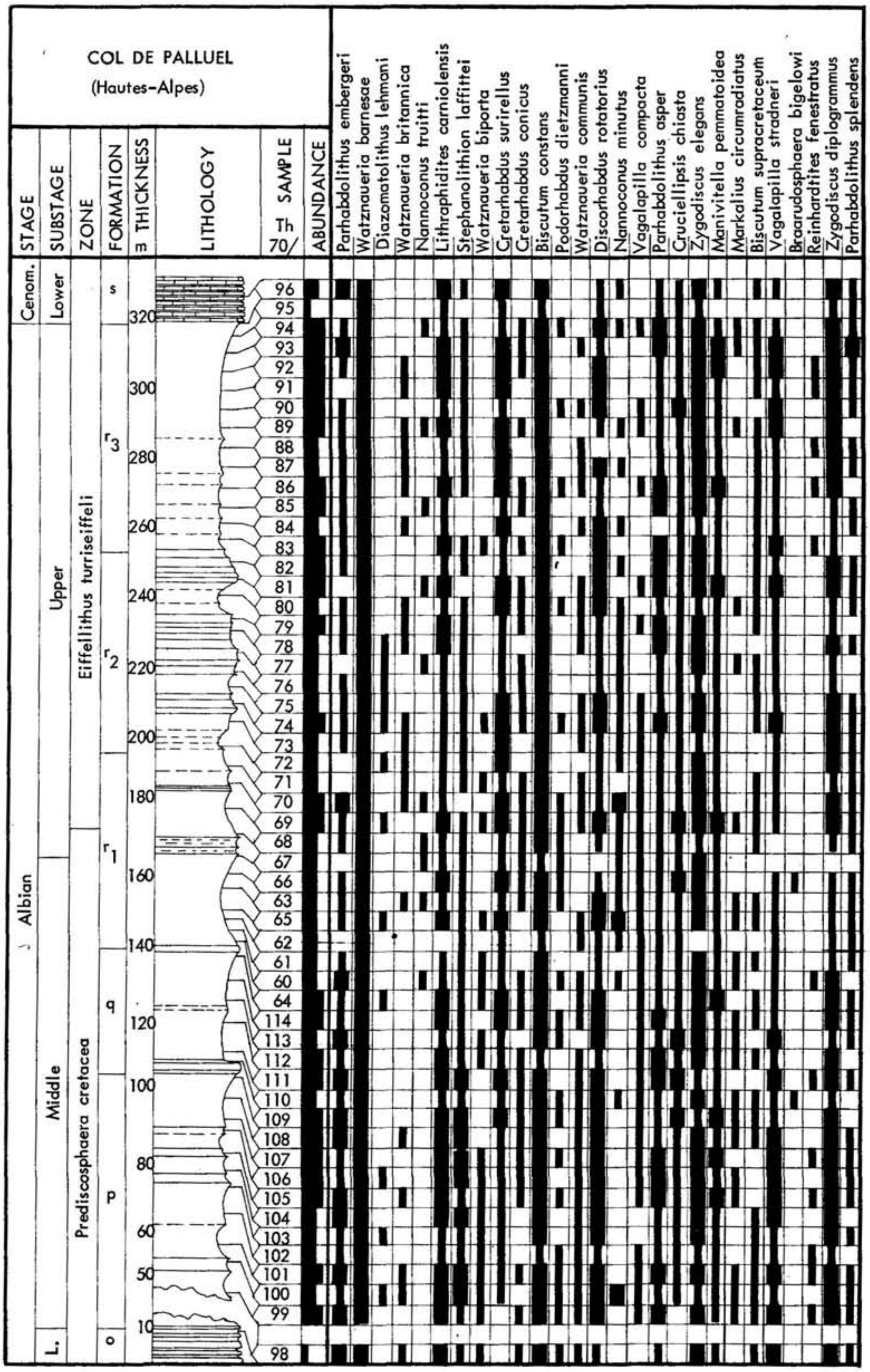
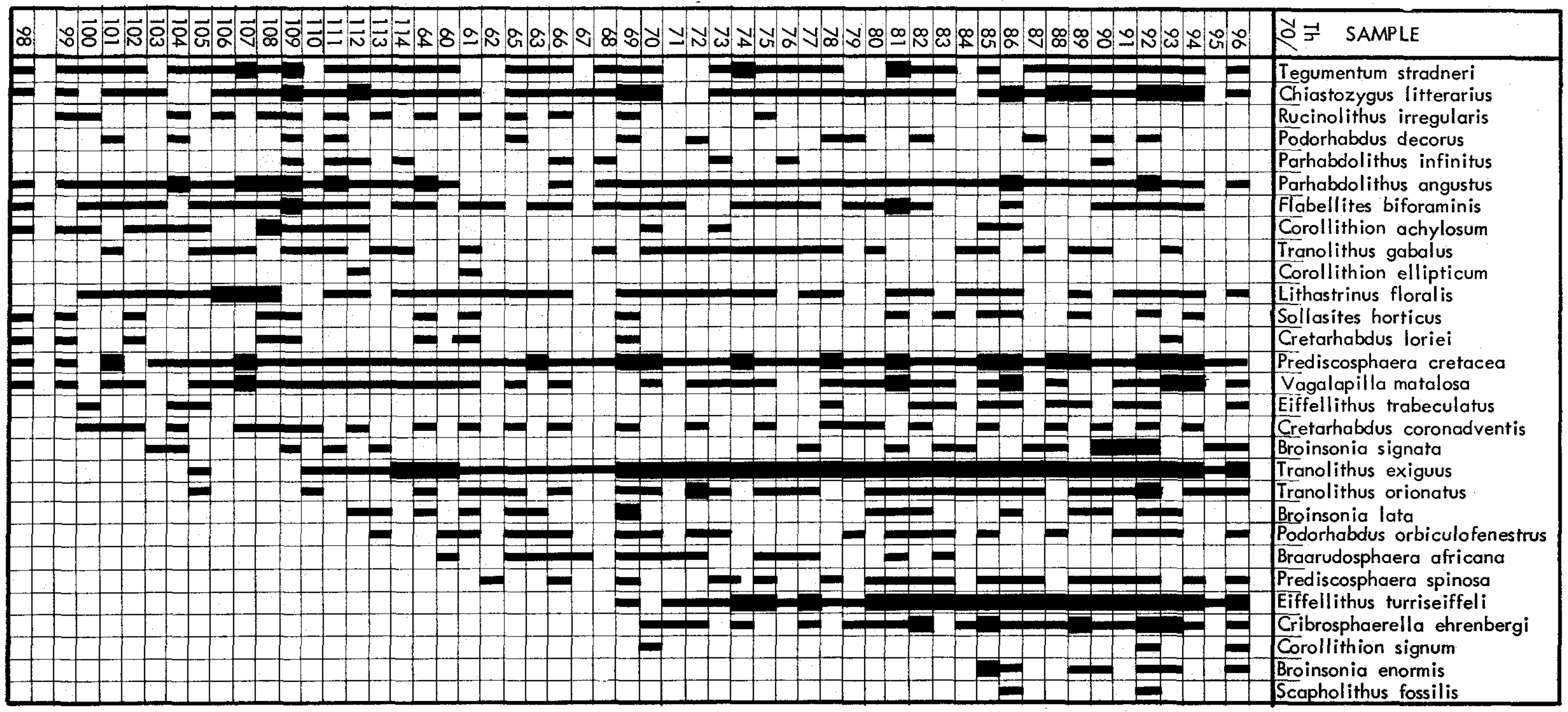


Fig. 16. Distribution of calcareous nannofossils in the section of the Col de Palluel (Hautes-Alpes).


70/Th SAMPLE
98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 64 60 61 62 65 63 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
Tegumentum stradneri
Chiastozygus litterarius
Rucinolithus irregularis
Podorhabdus decorus
Parhabdolithus infinitus
Parhabdolithus angustus
Flabellites biforaminis
Corollithion achylosum
Tranolithus gabalus
Corollithion ellipticum
Lithastrinus floralis
Sollasites horticus
Cretarhabdus loriei
Prediscosphaera cretacea
Vagalapilla matalosa
Eiffellithus trabeculatus
Cretarhabdus coronadventis
Broinsonia signata
Tranolithus exiguus
Tranolithus orionatus
Broinsonia lata
Podorhabdus orbiculofenestrus
Braarudosphaera africana
Prediscosphaera spinosa
Eiffellithus turriseiffeli
Cribrosphaerella ehrenbergi
Corollithion signum
Broinsonia enormis
Scapholithus fossilis

3.1.11. La Bédoule-Station de Cassis (Bouches-du-Rhône)

Figure 13

For geographic location, lithology and macrofossils of this, the type section of the Bédoulian Substage (Lower Aptian) see FABRE-TAXY, MOULLADE & THOMEL (1965, p. 173 ff). Of 13 samples collected by the author, 6 were barren. Sample Th 69/347 showed an abundant nannoflora. The remaining samples contained poorly preserved specimens.

Sample	Locality	Formation	Substage
Th 69/356	S (La Bédoule)	6	Gargasian (Upper Aptian)
Th 69/355	R (La Bédoule)	5	Bédoulian (Lower Aptian)
Th 69/347	H (St. de Cassis)	5	Bédoulian (Lower Aptian)
Th 69/352	Q (La Bédoule)	4	Bédoulian (Lower Aptian)
Th 69/351	N (La Bédoule)	4	Bédoulian (Lower Aptian)
Th 69/350	M (La Bédoule)	3	Bédoulian (Lower Aptian)
Th 69/349	L (La Bédoule)	2	Bédoulian (Lower Aptian)

All samples belong to the *Chiastozygus litterarius* Zone. The very poor nannoflora of sample Th 69/356 belonging to the Upper Aptian did not show any differences from Th 69/347.

3.1.12. Gargas (Vaucluse)

Figure 14

The type locality of the Upper Aptian has recently been subject of two investigations: OERTLI (1958, ostracods), and MOULLADE (1965, lithology, ammonites, foraminifera).

Of a total of 11 samples (Lower Aptian — Albian) collected, 7 showed a moderate to abundant nannoflora.

Sample	Locality	Formation	Substage	Nannoflora
Th 69/335	G	4	Upper Aptian	mediocre
Th 69/334	F	4	Upper Aptian	mediocre
Th 69/333	E	4	Upper Aptian	abundandt
Th 69/332	D	4	Upper Aptian	abundandt
Th 69/331	C	4	Upper Aptian	abundandt
Th 69/330	B	3	Upper Aptian	abundandt
Th 69/329	B	3	Upper Aptian	abundandt

The samples from locality A (formation 1), and H (formations 6, 7, 8) were barren.

Samples Th 69/329—335 belong to the *Parhabdolithus angustus* Zone and are dated as Upper Aptian by macrofossils.

3.1.13. Lesches-en-Diois (Drôme)

Figure 15

For geographic location, lithology, foraminifera and ammonites of this section see MOULLADE (1966). The 80 m of marls range from the Lower Aptian to the Lower Albian and are dated by ammonites and foraminifera (MOULLADE, 1966, Fig. 16). Of the 20 samples most showed an abundant and well preserved nannoflora. The limit Lower/Upper Aptian closely approximates the base of the *Parhabdolithus angustus* Zone which extends into the Lower Albian.

3.1.14. Col de Palluel (Hautes-Alpes)

Figure 16

The marly section, 320 m thick, has been described by MOULLADE (1966), who dated it by ammonites and foraminifera. Most of the 54 samples from this section contain rich, well preserved nannofloras. The lowermost formation o (see MOULLADE, 1966, Fig. 18) belongs to the Lower Albian and contains rare specimens of the name fossil of the *Prediscosphaera cretacea* Zone.

The limit Middle Albian/Upper Albian s. s. approximates the base of the *Eiffellithus turriseiffeli* Zone. The nannoflora of sample Th 70/96 from formation s (= Lower Cenomanian) did not show any changes from those of the lower samples. The latest events below the Albian/Cenomanian boundary are the first occurrences of *Broinsonia enormis* (SHUMENKO) and *Scapholithus fossilis* DEFLANDRE. *Lithraphidites alatus* THIERSTEIN which has its first occurrence within the Lower Cenomanian in the section of Montsalvens (Switzerland) and in the Atlantic, could not be found here.

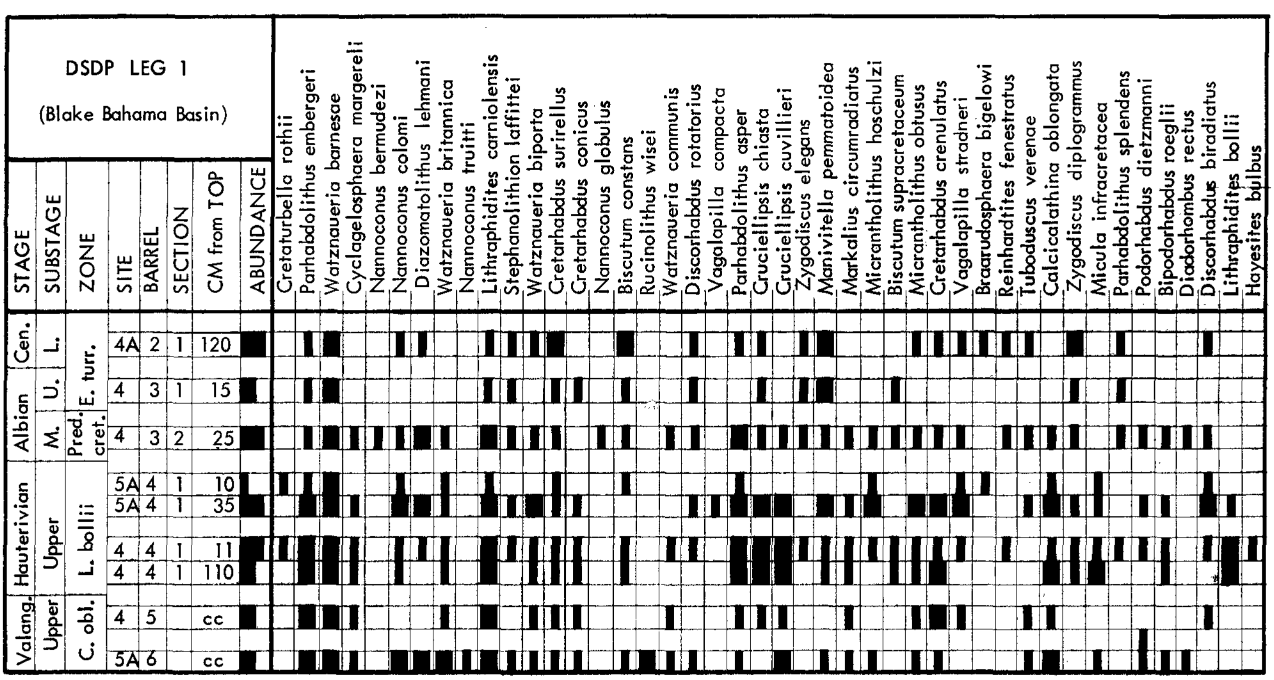


Fig. 17. Distribution of calcareous nannofossils in the Lower Cretaceous of the West Atlantic (Blake Bahama Basin).

3.1.15. Other sections and samples from Southeastern France

Samples from three additional sections (Ferme Raton, près Rosans [Hautes-Alpes], Montclus [Hautes-Alpes] and Sisteron [Basses-Alpes] described by MOULLADE (1966) have been investigated. Their nannofloras are scarce and of poor preservation and are not shown in detail here.

3.1.15.1. Ferme Raton, près Rosans (Hautes-Alpes)

Geographic location, lithology and paleontology have been published by MOULLADE (1966, Fig. 9). 140 m of alternating limestones and marls with strong predominance of limestone beds cover a stratigraphic interval from Lower Hauterivian to Lower Barremian. The 19 poorly preserved samples contained, among others, rare *Lithraphidites bollii* (THIERSTEIN) and *Calcicalathina oblongata* (WORSLEY) and belong to the *Lithraphidites bollii* Zone.

3.1.15.2. Montclus (Hautes-Alpes)

The section covers 200 m of alternating marls and limestones of Upper Hauterivian to Lower Aptian age. The base of the section (formation g 1, see MOULLADE, 1966, Fig. 13) belongs to the *Lithraphidites bollii* Zone. Formation k (uppermost Barremian) includes the last *Nannoconus colomi* (DE LAPPARENT) and the first rare *Chiastozygus litterarius* (GÓRKA). The top of the section is of Lower Aptian age and is attributed to the *Chiastozygus litterarius* Zone.

3.1.15.3 Sisteron (Basses-Alpes)

This section ranges from the Upper Hauterivian to the Lower Aptian and is 160 m thick. Alternating marls and limestones show slump bedding in several layers. Formation g (see MOULLADE, 1966, Fig. 12) contains fairly well preserved nannofloras belonging to the *Lithraphidites bollii* Zone. The upper part of the section yielded only poor nannofloras. The last *Nannoconus colomi* (DE LAPPARENT) have been observed in formation j (uppermost Barremian), and the limit Barremian/Aptian seems to coincide with the limit *Micrantholithus hoschulzi* Zone/*Chiastozygus litterarius* Zone.

3.1.15.4. Chomérac (Ardèche)

Two samples from a marly outcrop at the department road D. 2 between Chomérac and Alissas (Ardèche) contained nannofloras like those from Broyon (layers BR 26—BR 35).

3.1.15.5. Gorge de la Méouge (Hautes-Alpes)

A sample from Lower Tithonian of the Gorge de la Méouge (Hautes-Alpes) yielded a nannoflora identical to that of the Lower Tithonian marls of Broyon (Ardèche).

3.2. Atlantic Ocean

3.2.1. Blake Bahama Basin, West Atlantic (DSDP Leg 1, Sites 4, 4 A and 5 A)

Figure 17

The stratigraphic sequence of the 9 samples studied has been discussed in THIERSTEIN (1971). The enlarged species list is given on Fig. 17. Samples of Leg 1—4—3—2, 25 cm and Leg 1—4 A—2—1, 120 m contain reworked pre-Barremian nannofossils.

DSDP Leg 1																										
SITE	BARREL	SECTION	CM from TOP	Tegumentum stradneri	Chiastozygus litterarius	Rucinolithus irregularis	Podorhabdus decorus	Parhabdolithus infinitus	Parhabdolithus angustus	Flabellites biforaminis	Corollithion achylosum	Tranolithus gabalus	Lithastrinus floralis	Prediscosphaera cretacea	Vagalapilla matalosa	Hayesites albiensis	Cretarhabdus coronadventis	Tranolithus exiguus	Broinsonia lata	Podorhabdus orbiculofenestrus	Prediscosphaera spinosa	Eiffellithus turriseiffeli	Cribrosphaerella ehrenbergi	Corollithion signum	Scapholithus fossilis	Lithraphidites alatus
4A	2	1	120	▮	▮		▮		▮		▮	▮	█	█	▮		▮			▮	▮	█	▮	▮	▮	▮
4	3	1	15		▮				▮	▮		▮	▮				▮	▮	▮	▮		█				
4	3	2	25	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮	▮		▮	▮								
5A	4	1	10																							
5A	4	1	35					▮																		
4	4	1	11					▮																		
4	4	1	110					▮																		
4	5		cc																							
5A	6		cc																							

3.2.2. Central Atlantic (DSDP Leg 14, Sites 135, 136, 137 and 144)

Location of sites, lithology, paleontology and further descriptions of these samples are given in the forthcoming Initial Reports of the Deep Sea Drilling Project, Vol. XIV.

The nannofloras of 85 Cretaceous samples from the Atlantic sites of DSDP Leg 14 have been investigated by the author. Systematic descriptions, nannofossil lists and range charts are given in ROTH & THIERSTEIN (1972, in press). The following new species, described in this paper, have been recognized in Leg 14 cores:

Flabellites biforaminis n. sp.

Site 136, core 8	*Parhabdolithus angustus* Zone
Site 137, core 16	*Eiffellithus turriseiffeli* Zone
Site 137, cores 15 to 5	? *Chiastozygus cuneatus* Zone
Site 144, cores 7 to 5	*Parhabdolithus angustus* Zone

Micula infracretacea n. sp.

Site 135, core 9, section 1	*Chiastozygus litterarius* Zone
Site 136, core 8, section 2	*Parhabdolithus angustus* Zone

At Site 137 the limit between the uppermost Albian (Vraconnian) and the Cenomanian is dated by foraminifera (see BECKMANN, 1972, in press) and coincides with the first occurrence of *Lithraphidites alatus* THIERSTEIN (see ROTH & THIERSTEIN, 1972, in press).

3.3. Switzerland

Geographic location of the sections studied in detail is given on Fig. 18.

3.3.1. Valangin (Jura Mountains)

Figure 19

The geographic location, lithology, ostracod and foraminiferal assemblages of this, the type section of the Valanginian stage have been described by HAEFELI, MAYNC, OERTLI & RUTSCH (1965), by HAEFELI (1966), and by STEINHAUSER & CHAROLLAIS (1971). The 11 samples from the type section have been supplemented by 13 samples from the section at Twann-Schützenhaus (HAEFELI, 1966, p. 661), and by 8 samples from the section at Rusel (HAEFELI, 1966, p. 652). Out of these 32 samples, only 4 (Th 69/234—237) contained a poor, but identifiable nannoflora. These samples were collected in the Astieriaschicht (sample Th 69/234) of Upper Valanginian age, the Mergel- und Knollenmergel-Zone (samples Th 69/235, 236), and the Mergel- und Kalk-Zone (sample Th 69/237), both of Lower Hauterivian age. Only sample Th 69/235 contained rare specimens of the name fossil of the *Calcicalathina oblongata* Zone. In each of the four samples 90% of the specimens belong to the species *Watznaueria barnesae* (BLACK) and *Cyclagelosphaera margereli* NOEL. These species must have been ecologically favored under the reducing marine environment suggested by HAEFELI (in HAEFELI, MAYNC, OERTLI & RUTSCH, 1965, p. 67).

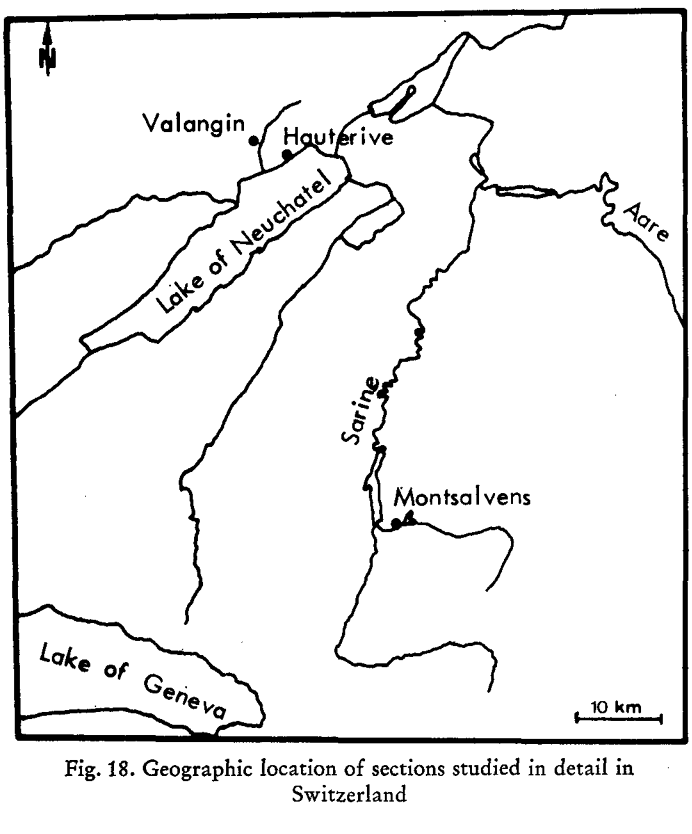


Fig. 18. Geographic location of sections studied in detail in Switzerland

3.3.2. Hauterive (Jura Mountains)

Figure 20

The type section of the Hauterivian Stage has been described by HAEFELI, MAYNC, OERTLI & RUTSCH (1965, p. 55). Lithological and paleontological data from that section have been supplemented by the same authors in the section of Le Landeron. Of 7 samples collected in the section of Hauterive, 6 contained a very poor nannoflora. The name fossil of the *Calcicalathina oblongata* Zone could be identified in samples Th 69/221—223. This interval corresponds with the samples Th 69/235, 236 from the Valangin type section. Three samples from the same formation in the section of Le Landeron (see HAEFELI, MAYNC, OERTLI & RUTSCH, 1965, p. 57) showed only few, poorly preserved, long ranging nannofossils.

3.3.3. Montsalvens (Préalpes externes)

Figure 21

The geology of Montsalvens has been studied in detail by GUILLAUME (1957). The stratigraphic position of the samples investigated here is indicated on Fig. 19. The generalized lithologic column is based on that given by GUILLAUME (1957, p. 61). The 27 samples from the interval lowermost Berriasian to Lower Cenomanian were collected from the following outcrops:

Sample Th 69/	Locality	Formation (F), Bed (B)	Description in GUILLAUME (1957)	Stage
77	Rio des Covayes	B 1—22	p. 120	Cenomanian
76	Rio des Covayes	F 4—6	p. 119	Cenomanian
75	Rio des Covayes	F 3	p. 110	Albian
74	Rio des Covayes	F 2	p. 110	Albian
73	Rio du Javrex		p. 110 + 115	Albian
72	Rio du Javrex	B 12	p. 110	Aptian
69	Rio du Javrex	B 8	p. 110	Aptian
70	Rio du Javrex	B 6	p. 110	Aptian
71	Rio du Javrex		p. 110	Barremian
65	Rio des Pelleys		p. 103	Barremian
64	Rio des Pelleys	B 10	p. 100	Barremian
63	Rio des Esserts	F 5, B 1—4	p. 94 + 100	Hauterivian
62	Rio des Esserts	F 4	p. 94	Hauterivian
61	Rio des Esserts	F 3	p. 94	Hauterivian
60	Rio des Esserts	F 2	p. 94	Hauterivian
59	Rio des Esserts	F 1	p. 94	Hauterivian
58	Route de Bataille		p. 78	Valanginian
57	Abrupt de Villarbeney	F 3	p. 81	Valanginian
56	Abrupt de Villarbeney	F 2	p. 81	Valanginian
55	Abrupt de Villarbeney	F 1	p. 81	Valanginian
54	Abrupt de Villarbeney	F 1	p. 81	Valanginian
53	Abrupt de Villarbeney	F 1	p. 81	Valanginian
52	Abrupt de Villarbeney	B 20	p. 65	Berriasian
51	Abrupt de Villarbeney	B 13	p. 65	Berriasian
50	Abrupt de Villarbeney	B 12	p. 65	Berriasian
49	Abrupt de Villarbeney	B 10	p. 65	Berriasian
48	Abrupt de Villarbeney	B 4	p. 65	Berriasian
47	Abrupt de Villarbeney	B 1	p. 65	Berriasian

All samples from Montsalvens were poorly preserved and only a few showed a satisfactory floral abundance. Therefore, zonal limits often had to be based on very few specimens or could not be identified at all. The base of the *Lithraphidites bollii* Zone would lie here in the Upper Hauterivian, whereas in southeastern France the index fossil of this zone has been recognized in Lower Hauterivian sediments. Samples Th 69/64—73 are completely or nearly barren; Lower Barremian to Lower Aptian sediments are too limy and the Upper Aptian is represented by glauconitic sandstones. The marly samples of Albian to Cenomanian age contained a fairly well preserved and abundant nannoflora, and allowed recognition of the *Prediscosphaera cretacea* Zone and the *Eiffellithus turriseiffeli* Zone. MORNOD (1949, p. 574) and GUILLAUME (1957, p. 115) investigated the foraminifera. They considered formations 2 and 3 to be Vraconnian and formation 4 to be Cenomanian, but the nannofloras suggest that formation 2, 3 and the base of formation 4 (Th 69/74—76) belong to the Middle Albian. Nannofloras of the lower *Eiffellithus turriseiffeli* Zone (= Vraconnian) have not been recognized at Montsalvens. The uppermost sample (Th 69/77) was collected in beds 1 to 22 (MORNOD, 1949, p. 574, and GUILLAUME, 1957, p. 120). It contains *Lithraphidites alatus* THIERSTEIN, a species which has its first occurrence in the Lower Cenomanian of the Atlantic and therefore indicates a Lower Cenomanian age. This is supported by the foraminifera listed by MORNOD (1949) and GUILLAUME (1957).

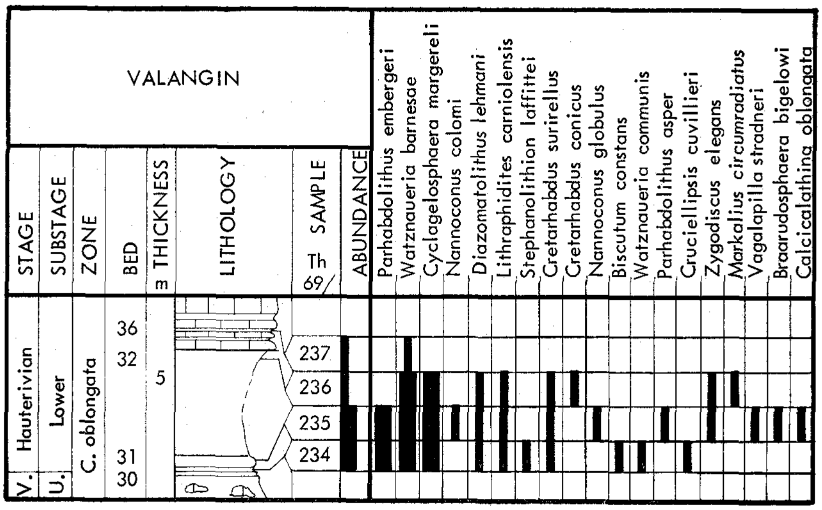


Fig. 19. Distribution of calcareous nannofossils in the upper part of the Valanginian type section at Valangin (Jura mountains).

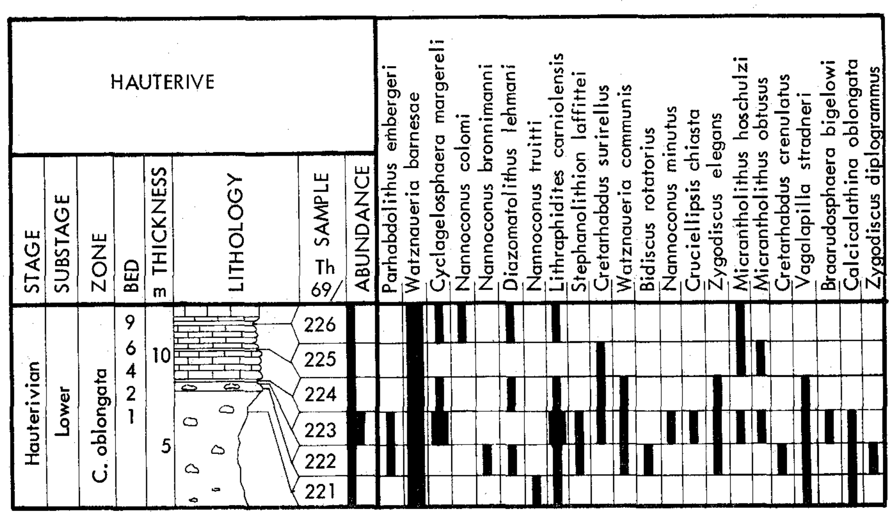


Fig. 20. Distribution of calcareous nannofossils at the type locality of the Hauterivian Stage, near Hauterive (Jura mountains).

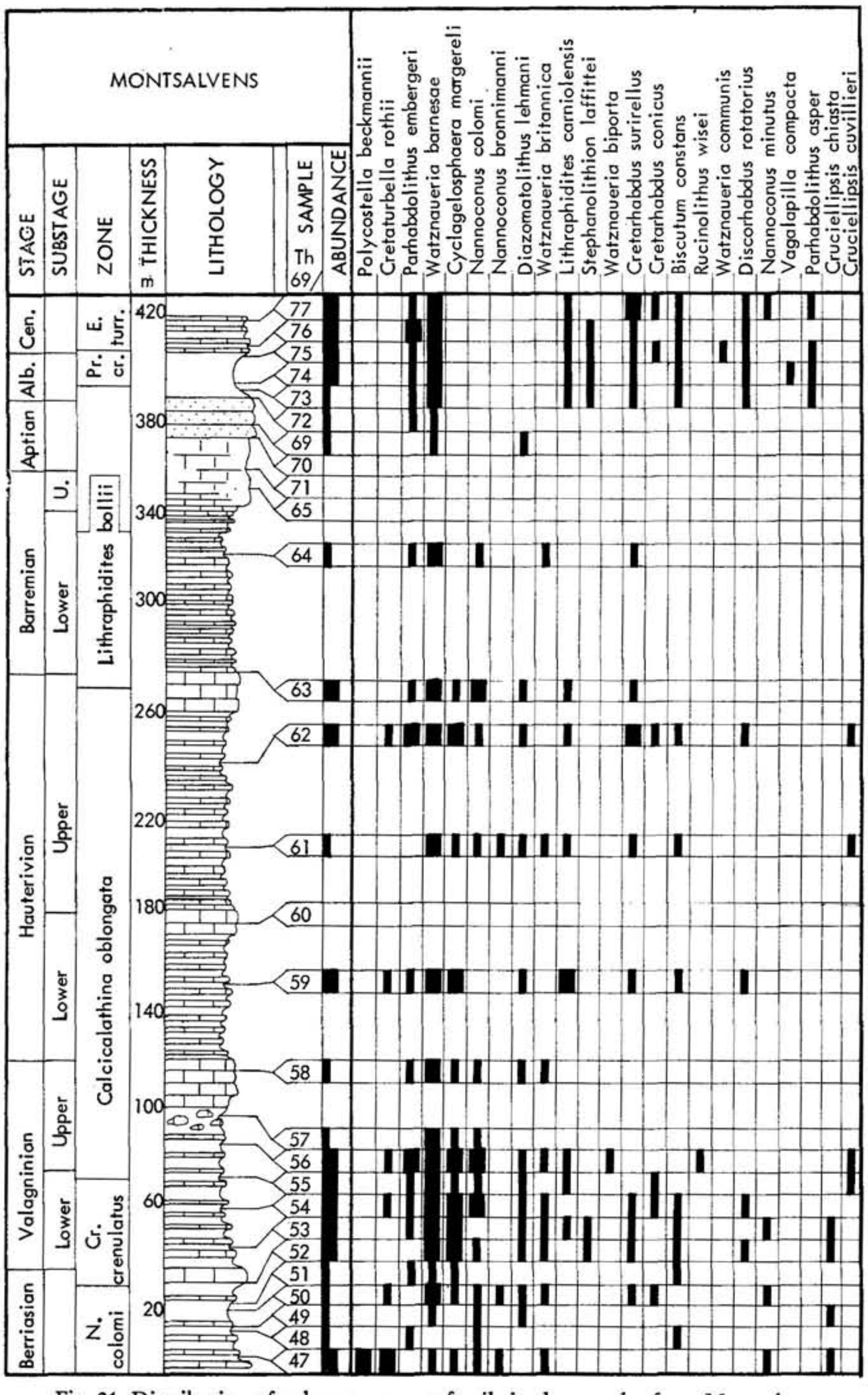
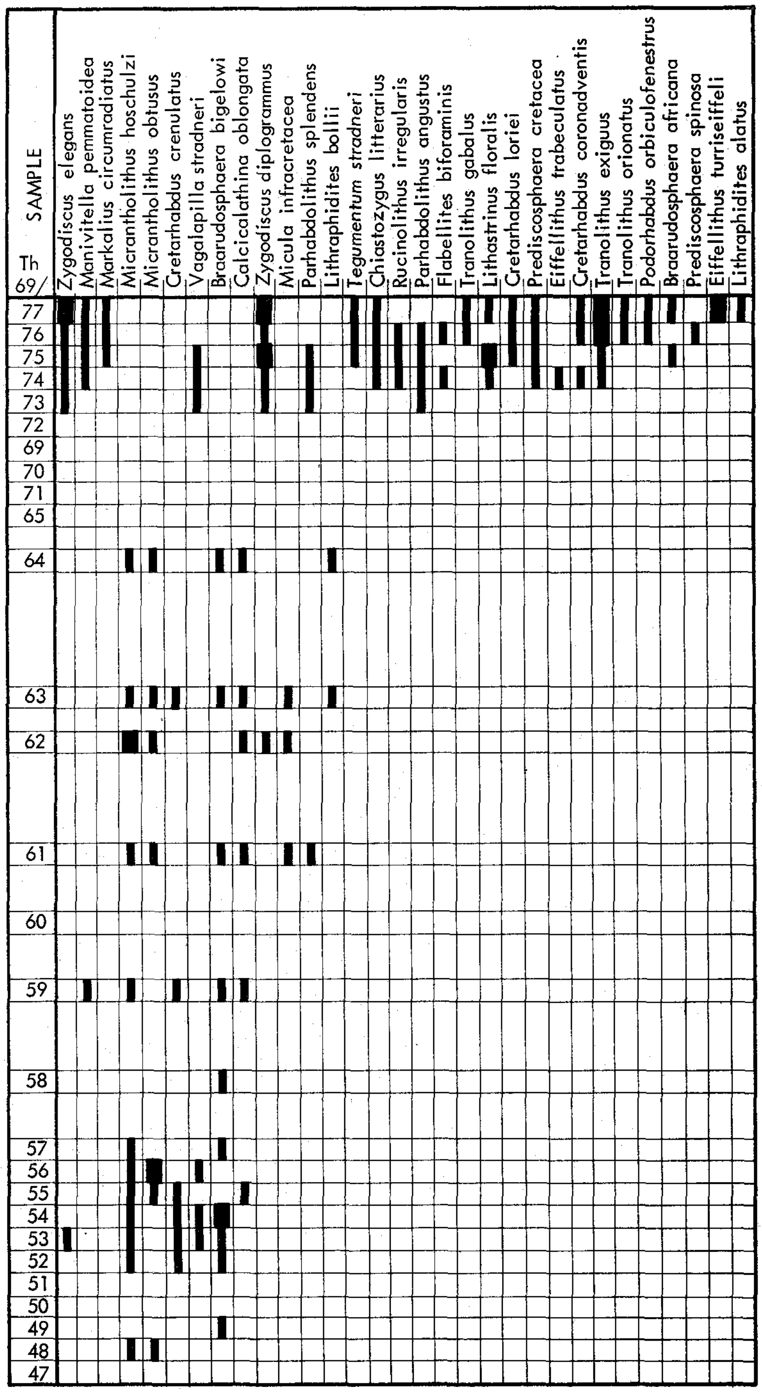


Fig. 21. Distribution of calcareous nannofossils in the samples from Montsalvens (Ultrahelvetic nappes).


Th 69/ SAMPLE
Zygodiscus elegans
Manivitella pemmatoidea
Markalius circumradiatus
Micrantholithus hoschulzi
Micrantholithus obtusus
Cretarhabdus crenulatus
Vagalapilla stradneri
Braarudosphaera bigelowi
Calcicalathina oblongata
Zygodiscus diplogrammus
Micula infracretacea
Parhabdolithus splendens
Lithraphidites bollii
Tegumentum stradneri
Chiastozygus litterarius
Rucinolithus irregularis
Parhabdolithus angustus
Flabellites biforaminis
Tranolithus gabalus
Lithastrinus floralis
Cretarhabdus loriei
Prediscosphaera cretacea
Eiffellithus trabeculatus
Cretarhabdus coronadventis
Tranolithus exiguus
Tranolithus orionatus
Podorhabdus orbiculofenestrus
Braarudosphaera africana
Prediscosphaera spinosa
Eiffellithus turriseiffeli
Lithraphidites alatus
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3.3.4. Other Sections in Switzerland

Samples of several other sections have been collected in Switzerland by the author or have kindly been put at the author's disposal by Prof. H. M. BOLLI, Zürich [HMB], Dr. A. MATTER, Bern [AM], and Prof. L. HOTTINGER, Basel [LH]. Many of these sections are completely barren of nannofossils, and the nannofloras of most of the remaining fossiliferous samples are extremely poor and all are badly preserved. The absence of nannofossils seems to be due to paleoecological factors and not to diagenesis or recrystallisation. Only the following long-ranging species have usually been recognized: *Watznaueria barnesae* (BLACK), *Biscutum constans* (GÓRKA), *Nannoconus colomi* (DE LAPPARENT), *Braarudosphaera bigelowi* (GRAN & BRAARUD), *Markalius circumradiatus* (STOVER), *Lithraphidites carniolensis* DEFLANDRE, *Parhabdolithus embergeri* NOEL, *Vagalapilla stradneri* (ROOD, HAY & BARNARD), and *Nannoconus globulus* BRONNIMANN. These sections and samples are:

Préalpes Externes	Samples	Remarks
Veveyse de Fégire	Th 69/1-11	very poor preservation
Pléiades	Th 69/15-29	scarce
Veveyse de Châtel	Th 69/30-46	very poor preservation
Médianes Plastiques		
Caux-Sonchaux	Th 69/88-100	scarce
Eastern Helvetic Nappes (Churfirsten-Alvier)		
Oehrlimergel-Valanginianmergel:		
Lüsis	Th 69/101-118	barren
Thur (Fuchsboden)	Th 69/119-125	barren
Drusbergschichten:		
Barbielergrat-Hurst	Th 69/126-141	3 samples very poor, others barren
Gault:		
Sisitz (Voralp)	Th 69/142-149	barren
Helvetic Border Chain (Central Switzerland)		
Valanginianmergel:		
Schrattenfluh	Th 69/163-175	scarce, very poor preservation
Drusbergschichten:		
Schrattenfluh	Th 69/181-187	scarce, very poor preservation

Oberhaupt (Pilatus)	[AM] (S2)	17 samples	barren
Klimsenhorn (Pilatus)	[AM] (S3)	17 samples	barren
Lopper	[AM] (S4)	13 samples	barren
Choltal	[AM] (S5)	6 samples	barren
Bürgenstock	[AM] (S6)	23 samples	barren
Chastelendossen (Pilatus)	[AM] (S7)	13 samples	3 samples very poor, others barren
Schwalmis	[AM] (S8)	14 samples	barren
Wilerhorn	[AM] (S10A)	16 samples	7 samples very poor, others barren
Arnifirst	[AM] (S10B)	15 samples	1 sample very poor, others barren
Gr. Melchtal	[AM] (S11)	17 samples	barren
Littlihorn	[AM] (S12)	4 samples	barren
Standfluh	[AM] (S14)	4 samples	barren
Schwalmern	[AM] (S15)	14 samples	1 sample very poor, others barren
Schiffli	[AM] (S16)	2 samples	barren
Jura Montains			
La Vraconne	[LH] GG 264, 266		very poor
	[HMB] 65/291-293		very poor
Cressier	[LH]	4 samples	barren
Southern Alps			
Breggia (Scaglia)	[LH]	6 samples	very poor preservation

3.4. South America

3.4.1. Venezuela

Four samples from the Serrania del Interior have been investigated. The type samples of three Lower Cretaceous foraminifera zones defined by GUILLAUME, BOLLI & BECKMANN (1969), the *Neobulimina subcretacea* Zone (sample GU 44), the *Praeglobotruncana planispira* Zone (sample GU 50), and the *Neobulimina primitiva* Zone (sample GU 59) are from the upper member of the Chimana Formation. One sample (GU 674) is from the Barranquin Formation, 10 m below the type sample of the *Choffatella decipiens* Zonule. For the geographic locations, lithologies and biostratigraphy of these sections see GUILLAUME, BOLLI & BECKMANN (1969). Samples GU 44 and GU 674 were completely barren, the remainder showed extremely scarce nannofossils with strong overgrowth:

Sample GU 50: (type sample of the *Praeglobotruncana planispira* Zone):
Watznaueria barnesae (BLACK)

Sample GU 59: (type sample of the *Neobulimina primitiva* Zone):
Braarudosphaera africana STRADNER
Watznaueria barnesae (BLACK)
Biscutum constans (GÓRKA)
Zygodiscus diplogrammus (DEFLANDRE & FERT)
Zygodiscus elegans GARTNER emend. BUKRY
Cretarhabdus surirellus (DEFLANDRE & FERT)
Eiffellithus turriseiffeli (DEFLANDRE & FERT)

This sample belongs to the *Eiffellithus turriseiffeli* Zone (Upper Albian — Lower Cenomanian).

3.4.2. Trinidad, W. I.

The Cretaceous foraminifera and biostratigraphy of Trinidad have been the subject of several publications (BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, 1966; BOLLI, 1957, 1959, KUGLER & BOLLI, 1967). The following samples were kindly made available to the author by Prof. H. M. BOLLI and Dr. H. G. KUGLER for investigation of the nannoflora:

Gautier Formation

(see BOLLI, 1957)

Rotalipora appenninica appenninica Zone:	Nannofossils
— Sample from type locality (Gautier River, for detailed location see BOLLI, 1957, p. 52)	barren
— Well Morne Diablo No. 34 of Trinidad Leaseholds Ltd. (now Texaco Trinidad Inc.)	
sample at 13.890 ½ feet from top	barren
sample at 13.928 feet from top	barren
sample at 13.948 ½ feet from top	barren
sample at 13.985 ½ feet from top	barren
sample at 13.999 feet from top	barren
Globigerina washitensis Zone:	Nannofossils
— Well Marac No. 1 of Trinidad Leaseholds Ltd. (now Texaco Trinidad Inc.)	
sample at 9.854 feet from top	barren
sample at 9.874 feet from top	barren
sample at 9.886 feet from top	barren
Rotalipora ticinensis ticinensis Zone:	Nannofossils
— Well Marac No. 1 of Trinidad Leaseholds Ltd. (now Texaco Trinidad Inc.)	
sample at 12.040 feet from top	barren
sample at 13.999 feet from top	barren

Maridale Formation

(see BARTENSTEIN, BETTENSTAEDT & BOLLI, 1966, p. 131)

Biglobigerinella barri Zone:

sample from co-type locality Pointe à Pierre (see BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Fig. 1, locality 6)

Nannofossils: *Watznaueria barnesae* (BLACK)
Lithraphidites carniolensis DEFLANDRE
Cruciellipsis chiasta (WORSLEY)
Markalius circumradiatus (STOVER)
Rucinolithus irregularis THIERSTEIN
Manivitella pemmatoidea (DEFLANDRE ex MANIVIT)

This assemblage most probably belongs to the *Chiastozygus litterarius* Zone (Lower Aptian).

Cuche Formation

Lenticulina ouachensis ouachensis Zone:

— Remanié Boulder Bed in Pointe-à-Pierre (sample K. 8187, see BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Fig. 1, locality 2)

Nannofossils: *Parhabdolithus asper* (STRADNER)
Watznaueria barnesae (BLACK)
Lithraphidites carniolensis DEFLANDRE
Nannoconus colomi (DE LAPPARENT)
Diazomatolithus lehmani NOEL
Cyclagelosphaera margereli NOEL
Micrantholithus obtusus STRADNER

This assemblage belongs to the *Micrantholithus hoschulzi* Zone (Barremian).

— Station Road (sample Rz. 180) in Pointe-à-Pierre (see BARTENSTEIN BETTENSTAEDT & BOLLI, 1957, Fig. 1, locality 1)

Nannofossils: *Parhabdolithus asper* (STRADNER)
Watznaueria barnesae (BLACK)
Lithraphidites carniolensis DEFLANDRE
Cruciellipsis chiasta (WORSLEY)
Nannoconus colomi (DE LAPPARENT)
Cretarhabdus crenulatus BRAMLETTE & MARTINI emend. THIERSTEIN
Zygodiscus diplogrammus (DEFLANDRE & FERT)
Zygodiscus elegans GARTNER emend. BUKRY
Parhabdolithus embergeri (NOEL)
Reinhardtites fenestratus (WORSLEY)
Stephanolithion laffittei NOEL
Diazomatolithus lehmani NOEL
Cyclagelosphaera margereli NOEL
Micrantholithus obtusus STRADNER
Manivitella pemmatoidea (DEFLANDRE ex MANIVIT)
Vagalapilla stradneri (ROOD, HAY & BARNARD)
Cretarhabdus surirellus (DEFLANDRE & FERT)

This assemblage belongs to the *Micrantholithus hoschulzi* Zone (Barremian).

Toco Formation

(see BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Fig. 3)

Lenticulina barri Zone:	Nannofossils
Sample H. G. K. 9423 from the type locality, Toco Bay	barren
Sample K. 2658, East of Jetty, Pointe-à Pierre	barren
Sample B. T. 517	barren

Tompire Formation

Type locality Tompire Bay (see BARTENSTEIN, BETTENSTAEDT & BOLLI, 1957, Fig. 3)	Nannofossils
Sample K. 9262 (B. T. 456)	barren
Sample K. 10927/28	barren
Sample PJ 329	barren

3.5. Great Britain

Only a few samples from the Lower Cretaceous of Great Britain have been investigated. They were collected by Dr. J. P. Beckmann while on excursion with the Eleventh European Micropaleontological Colloquium, England 1969.

3.5.1. Lower Cretaceous at Nettleton (Lincolnshire)

Three samples from this section have been investigated. Lithology, fossil lists and references are given in the Guide Book of the Eleventh European Micropaleontological Colloquium, England (London 1969), p. 16—18. Two samples are from the middle and upper part of the Lower Tealby Clay, and one sample is from the overlying Tealby Limestone. The section is dated by foraminifera (BARTENSTEIN, 1956) and ostracoda (BARTENSTEIN, 1956, KAYE, 1956) and considered Hauterivian in age.

The following nannofossils have been found in these samples:

Common to abundant:

Parhabdolithus asper (STRADNER)
Watznaueria barnesae (BLACK)
Lithraphidites carniolensis DEFLANDRE
Diazomatolithus lehmani NOEL
Vagalapilla stradneri (ROOD, HAY & BARNARD)

Few to rare:

Watznaueria communis REINHARDT
Vagalapilla compacta BUKRY
Cretarhabdus conicus BRAMLETTE & MARTINI
Cretarhabdus crenulatus BRAMLETTE & MARTINI emend. THIERSTEIN
Cruciellipsis cuvillieri (MANIVIT)
Podorhabdus dietzmanni (REINHARDT)
Zygodiscus diplogrammus (DEFLANDRE & FERT)
Zygodiscus elegans GARTNER emend. BUKRY
Corollithion ellipticum BUKRY
Parhabdolithus embergeri (NOEL)
Micrantholithus hoschulzi (REINHARDT)
Stephanolithion laffittei NOEL
Cyclagelosphaera margereli NOEL
Micrantholithus obtusus STRADNER
Manivitella pemmatoidea (DEFLANDRE ex MANIVIT)
Lithastrinus septentrionalis STRADNER
Tegumentum stradneri THIERSTEIN
Cretarhabdus surirellus (DEFLANDRE & FERT)

This assemblage lacks many of the marker species of southeastern France and the Atlantic. On the other hand it contains *Corollithion ellipticum* BUKRY, *Lithastrinus septentrionalis* STRADNER and *Tegumentum stradneri* THIERSTEIN, which in southeastern France have their first occurences between the Lower Barremian and the Upper Aptian. During the Hauterivian the nannoflora of Great Britain seems to have been completely separated from that of southeastern France and the Atlantic, by a paleogeographical or paleoecological barrier.

3.5.2. Gault Section at Copt Point, Folkestone

Figure 22

Geographic location, lithology, foraminifera and ostracod contents, ammonite zonation and references are given in the Guide Book of the Eleventh European Micropaleontological Colloquium, England (London, 1969).

The nannofloras of the following samples have been studied:

Sample	Bed	Stratigraphical distance from base of rock unit	Lithology	Ammonite Zone
BE 309	XII	24,6 m	Glauconitic, light grey clay with phosphatic nodules	*auritus-aequatorialis* sub-zone, 4 m below *dispar* zone
BE 310	XI	23,4 m	Pale grey marly clay	*auritus-aequatorialis* sub-zone
BE 306	XI	14,8 m	Pale grey marly clay with phosphatic nodules	*inflatum* zone
BE 305	X	13,9 m	Tough light grey marly clay	*inflatum* zone
BE 304	IX	10,2 m	Light grey marly clay	*cristatum* sub-zone
BE 303	VII	7,6 m	Mid-grey clay	*nitidus* sub-zone
BE 302	VI	7 m	Mottled fawn and mid-grey clay	*nitidus* sub-zone
BE 301	III	4,8 m	Fawn-grey clay	*niobe* sub-zone
BE 308	II	3,4 m	Dark-grey clay	*intermedius* sub-zone
BE 307	I	0,7 m	Dentatus nodule bed	*dentatus* zone

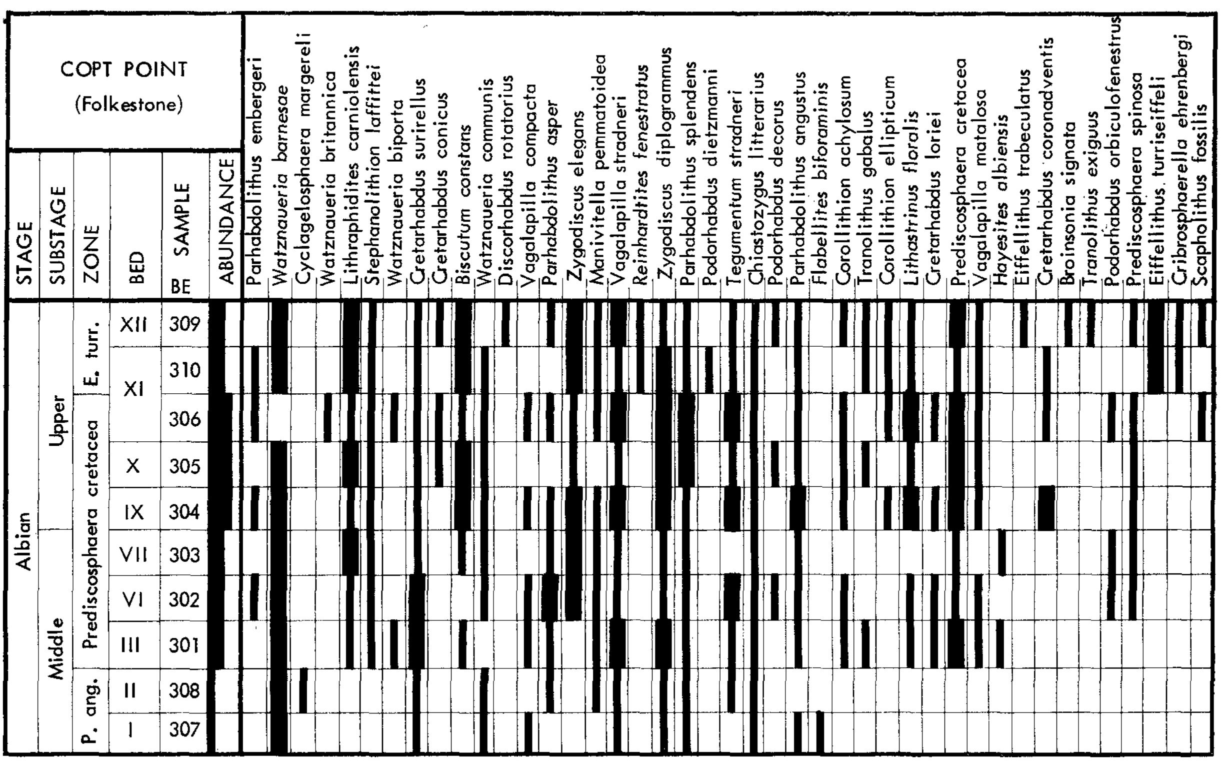

Fig. 22. Distribution of calcareous nannofossils in the Gault section at Copt Point (Folkestone).

Samples BE 309 and BE 310 have been collected in an outcrop about 1/2 mile East of Copt Point. Foraminifera of this section have been listed by KHAN (1950, 1952), and ostracoda by CHAPMAN (1898).
The *Parhabdolithus angustus* Zone, the *Prediscosphaera cretacea* Zone and the *Eiffellithus turriseiffeli* Zone are clearly identifyable in this section. The base of the *Prediscosphaera cretacea* Zone lies within the *intermedius* sub-zone (= Middle Albian).

3.5.3. Barrington Cement Works, Cambridgeshire

The section begins with upper Gault marls (sample BE 316); it includes the very marly Cambridge Greensand (BE 315), and extends into the Chalk Marl (BE 317, 318 and 319). Lithology, geographic location and references are given in the Guide Book of the Eleventh European Micropaleontological Colloquium, England 1969 (London, 1969). For descriptions of the foraminifera see BURNABY (1962).
All samples from this section show a rich, well preserved nannoflora and belong to the *Eiffellithus turriseiffeli* Zone. No event in the nannofossil assemblages has been recorded in this Upper Albian — Lower Cenomanian section, in particular no *Lithraphidites alatus* THIERSTEIN could be found.

The following species have been recognized in this section:
Common to abundant:

Watznaueria barnesae (BLACK)
Lithraphidites carniolensis DEFLANDRE
Biscutum constans (GÓRKA)
Prediscosphaera cretacea (ARKHANGELSKY)
Zygodiscus diplogrammus (DEFLANDRE & FERT)
Zygodiscus elegans GARTNER emend. BUKRY
Tranolithus exiguus STOVER
Chiastozygus litterarius (GÓRKA)
Tranolithus orionatus (REINHARDT)
Manivitella pemmatoidea (DEFLANDRE ex MANIVIT)
Broinsonia signata (NOEL)
Cretarhabdus surirellus (DEFLANDRE & FERT)
Eiffellithus turriseiffeli (DEFLANDRE & FERT)

Rare to few:

Corollithion achylosum (STOVER)
Parhabdolithus asper (STRADNER)
Parhabdolithus angustus (STRADNER)
Flabellites biforaminis n. sp.
Braarudosphaera bigelowi (GRAN & BRAARUD)
Markalius circumradiatus (STOVER)
Watznaueria communis REINHARDT
Vagalapilla compacta BUKRY
Cretarhabdus conicus BRAMLETTE & MARTINI
Cretarhabdus coronadventis REINHARDT
Podorhabdus decorus (DEFLANDRE & FERT)
Podorhabdus dietzmanni (REINHARDT)
Cribrosphaerella ehrenbergi (ARKHANGELSKY)
Corollithion ellipticum BUKRY
Parhabdolithus embergeri (NOEL)
Broinsonia enormis SHUMENKO
Lithastrinus floralis STRADNER
Scapholithus fossilis DEFLANDRE & FERT
Tranolithus gabalus STOVER
Sollasites horticus (STRADNER, ADAMIKER & MARESCH)
Stephanolithion laffittei NOEL
Broinsonia lata (NOEL)
Cyclagelosphaera margereli NOEL
Vagalapilla matalosa (STOVER)
Podorhabdus orbiculofenestrus (GARTNER)
Discorhabdus rotatorius (BUKRY)
Corollithion signum STRADNER
Prediscosphaera spinosa (BRAMLETTE & MARTINI)
Parhabdolithus splendens (DEFLANDRE)
Vagalapilla stradneri (ROOD, HAY & BARNARD)
Tegumentum stradneri THIERSTEIN
Eiffellithus trabeculatus (GÓRKA)

The assemblages are identical to the uppermost Albian assemblages of southeastern France and the Atlantic. The assemblage differs from those of the Lower Cenomanian of Montsalvens (Switzerland) and of the Atlantic in the absence of *Lithraphidites alatus* THIERSTEIN.

4. Correlation of nannofossil zonation with Lower Cretaceous stages and with ammonite, calpionellid and foraminifera biostratigraphic subdivisions

All sections studied in southeastern France have been dated by ammonites and calpionellids or by ammonites and foraminifera. References to previous biostratigraphic investigations have been given in the description of the individual sections (chapter 3).
The standard cephalopod zonation proposed by the Colloque sur le Crétacé inférieur (Lyon, 1963), the ammonite and calpionellid zonations of LE HÉGARAT & REMANE (1968), the ammonite and foraminifera zonations of MOULLADE (1966), and the foraminifera zonation of GUILLAUME, BOLLI & BECKMANN (1969) are correlated with the nannofossil zonation on Fig. 23 and Fig. 24.

The boundaries Barremian/Aptian, Lower/Upper Aptian, and Middle/Upper Albian approximate limits between nannofossil zones. The Jurassic-Cretaceous boundary, the limits Lower/Upper Berriasian, Berriasian/Valanginian, Lower/Upper Valanginian, Lower/Middle Albian, and Albian/Cenomanian (= Lower Cretaceous-Upper Cretaceous boundary) may closely coincide with events in the nannofossil assemblages (see remarks under the zone descriptions, and in the range charts). The Valanginian/Hauterivian, Hauterivian/Barremian and Aptian/Albian limits cannot be characterized by nannofossil events.

5. Biostratigraphic datum levels

Figure 25

Biostratigraphic datum levels should preferably be based on evolutionary first occurrences. A sudden appearance of a certain taxon may be due to a genetic mutation or to immigration from other areas. In the Lower Cretaceous no evolutionary first occurrences of nannofossils have so far been ascertained. Several appearances of nannofossils (for instance the different species of *Nannoconus* KAMPTNER or *Rucinolithus irregularis* THIERSTEIN and *Hayesites albiensis* MANIVIT) seem to have resulted from evolution. Because the evolving morphologic features and the infraspecific variations are not yet well enough known, evolutionary lineages have not been recognized so far. Therefore time equivalence of sudden first occurrences in the Lower Cretaceous nannoplankton can be proved only by correlation with other biostratigraphic scales in different areas.

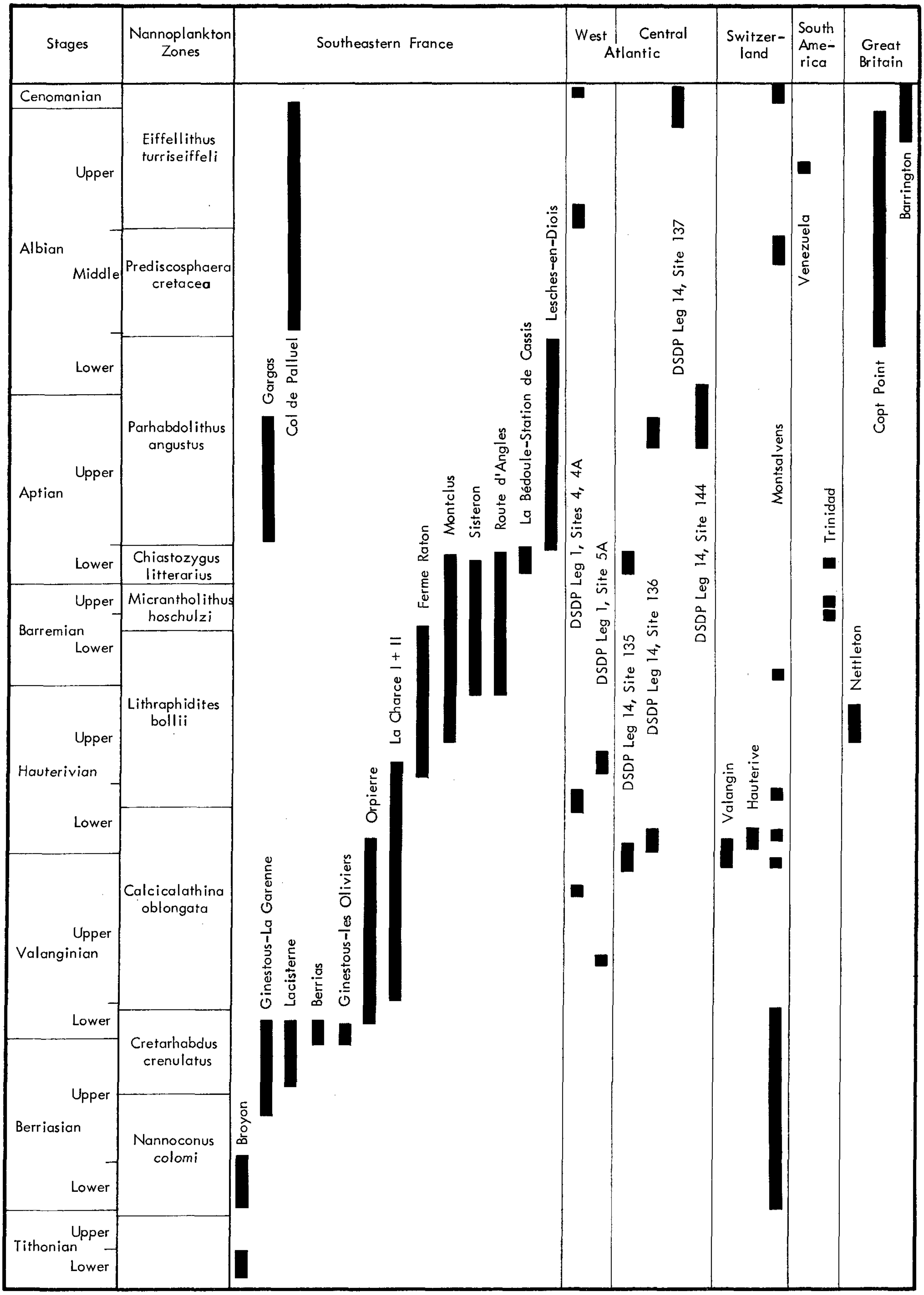

Fig. 23.
Biostratigraphic extent of the studied sections and correlation of proposed nannofossil zonation with classic Lower Cretaceous stages.

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

Fig. 24. Correlation of Lower Cretaceous cephalopod, foraminifera and calpionellid zones, described in the studied sections, with Lower Cretaceous stages.

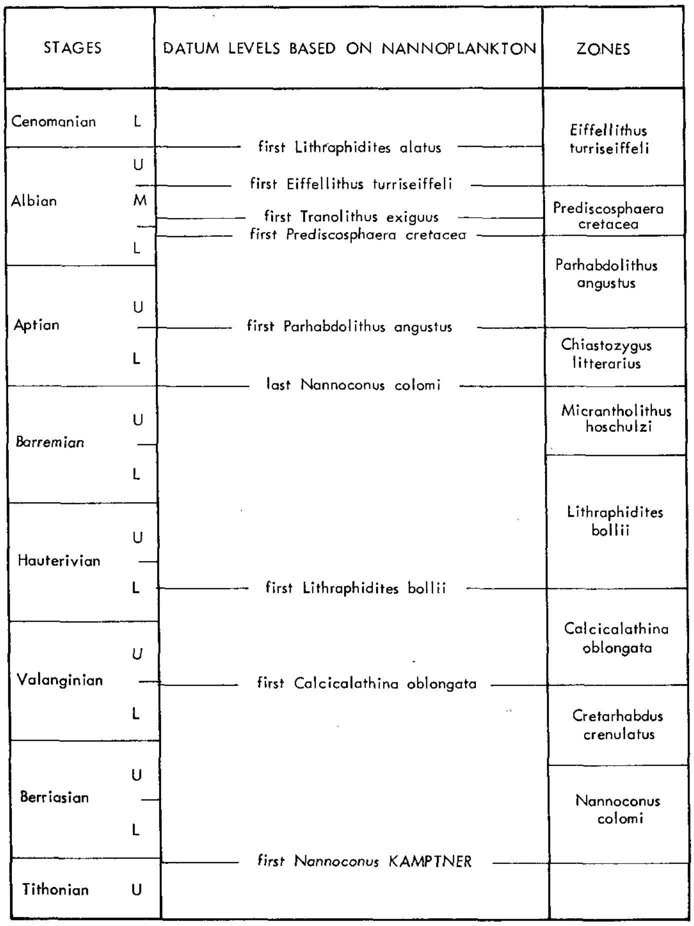

Fig. 25. Correlation of calcareous nannofossil datum levels with Lower Cretaceous stages and nannofossil zones.

The application of datum levels as completion of zonations has the following advantages:

a) No formal limits have to be defined by taxonomic criteria and changed if the concerned taxon is modified. (Zonal names are formal units and have to be formally redefined, if a taxon used for zonal definition is modified or changed.)

b) It is both objective and self-explanatory and does not require definition. (Many zones have names of taxa which are not used for definition of a limit of the zone, and limits of formal zones are often differently defined by different authors.)

c) It allows the finest and graphically clearest correlation of data of different fossil groups with even non-paleontological data in one and the same stratigraphic column.

For these reasons introduction of compiled data may give additional information and facilitate comparison between different zonal schemes. Importance and applicability of any datum depends on the area of its recognition which is indicated below.

Lithraphidites alatus datum (first occurrence)

Europe:	THIERSTEIN (this paper)
Atlantic:	THIERSTEIN (this paper) ROTH & THIERSTEIN (1972)

Eiffellithus turriseiffeli datum (first occurrence)

Europe:	STRADNER (1963), MANIVIT (1966, 1971), STOVER (1966), REINHARDT (1966)
Atlantic:	BUKRY & BRAMLETTE (1969), WORSLEY (1971), THIERSTEIN (1971), ROTH & THIERSTEIN (1972)
North America:	GARTNER (1968)
South America:	THIERSTEIN (this paper)
Pacific:	BUKRY (1971)

Tranolithus exiguus datum (first occurrence)

Europe:	MANIVIT (1971), STOVER (1966), THIERSTEIN (this paper)

Prediscophaera cretacea datum (first occurrence)

Europe:	STOVER (1966), REINHARDT (1966 a), MANIVIT (1966, 1971), THIERSTEIN (1971 and this paper)
Atlantic:	BUKRY & BRAMLETTE (1969), THIERSTEIN (1971)
West Africa:	SALES (1967)

Parhabdolithus angustus datum (first occurrence)

Europe:	MANIVIT (1971), THIERSTEIN (1971)
Atlantic:	ROTH & THIERSTEIN (1972)

Nannoconus colomi datum (extinction)

Europe:	STRADNER (1963), THIERSTEIN (1971), REINHARDT (1966 a)
Central America:	BRONNIMANN (1955)

Lithraphidites bollii datum (first occurrence)

Europe:	THIERSTEIN (1971)
Atlantic:	THIERSTEIN (1971)

Calcicalathina oblongata datum (first occurrence)

Europe:	THIERSTEIN (1971)
Atlantic:	THIERSTEIN (1971)

Nannoconus datum (first occurrence)

Europe:	KAMPTNER (1931), CITA & PASQUARÉ (1959), STRADNER (1961), CHAROLLAIS & RIGASSI-STUDER (1961), THIERSTEIN (1971)
Central America:	BRONNIMANN (1955), TREJO (1960)

6. Paleoecological observations

The influence of the paleoenvironment on Lower Cretaceous nannoplankton is difficult to evaluate. Nevertheless, some tendencies and relations of occurrence, abundance and composition of Lower Cretaceous nannofossil assemblages have been noted. These observations are not supported by extended statistical investigation, but have been recognized during examination of the numerous samples.

a) In most sections in southeastern France, the abundance and state of preservation of the nannofossils improve with the decrease in number and thickness of limy beds.

b) The frequencies of nannoconids and coccoliths are in reciprocal relation. Nannoconids are favoured in limy members, whereas coccoliths are favoured in marly members. This has also been observed by NOEL (1968), and is supported with comparing e. g. the frequency of *Parhabdolithus embergeri* (NOEL) with the frequencies of *Nannoconus truitti* BRONNIMANN and *Nannoconus minutus* BRONNIMANN in the section Lesches-en-Diois (Fig. 15), and the frequency of *Parhabdolithus embergeri* (NOEL) with the frequencies of *Nannoconus colomi* (DE LAPPARENT) and *Nannoconus minutus* BRONNIMANN in the section of La Charce III (Fig. 12).

c) Abundance of other species may vary from sample to sample without apparent relation to the lithology or to the frequency of other species.

d) Shallow water and platform conditions (sections of Hauterive [Fig. 20], Valangin [Fig. 19], and in the Helvetic Border Chain) favoured the species *Watznaueria barnesae* (BLACK) and *Cyclagelosphaera margereli* (NOEL).

e) Nannoconids and several species of coccoliths, common in the Tethyan province are not known in the Lower Cretaceous of Great Britain (boreal geoprovince). On the other hand, the following species are known to occur earlier in Great Britain than in the Tethyan province: *Lithastrinus septentrionalis* STRADNER and *Tegumentum stradneri* THIERSTEIN.

7. Systematic Paleontology

Family *Arkhangelskiellaceae* BUKRY, 1969

Definition: Elliptical coccoliths with complex shields built of two to four cycles of numerous joint elements. No stem present.

Genus *Broinsonia* BUKRY, 1969

Type species: *Broinsonia dentata* BUKRY, 1969

Synonym: *Aspidolithus* NOEL, 1969.

Definition: Elliptical coccoliths with 2-cycle distal shield, the inner cycle of constant width and 2- or 3-cycle proximal shield. Central area divided into quadrants by axial or subaxial sutures.

Remarks: *Broinsonia* BUKRY, 1969, differs from *Arkhangelskiella* VEKSHINA, 1959, by the presence of a second cycle of elements in the distal shield. *Gartnerago* BUKRY, 1969, differs from *Broinsonia* BUKRY, 1969, by having 4 cycles of elements visible on proximal side. The cycles in *Gartnerago* BUKRY, 1969, are connected in a more complex way and the sutures between the cycles are much more distinct than in *Broinsonia* BUKRY, 1969.

Broinsonia enormis (SHUMENKO, 1968) MANIVIT, 1971

1968 *Arkhangelskiella enormis* SHUMENKO, p. 33, Pl. 1, Fig. 3.
1969 *Broinsonia bevieri* BUKRY, p. 21, Pl. 1, Fig. 8—10.
1969 *Aspidolithus angustus* NOEL, p. 196, Pl. 1, Fig. 1, 2.
1970a *Arkhangelskiella enormis* SHUMENKO, 1968, REINHARDT, p. 15, Textfig. 21, 22.
1970 *Broinsonia bevieri* BUKRY, 1969, NOEL, p. 75, Pl. 23, Fig. 1, 5; Pl. 24, Fig. 1—3, 5; Pl. 25, Fig. 1—3, 5.
1971 *Broinsonia enormis* (SHUMENKO, 1968) MANIVIT, p. 105, Pl. 1, Fig. 18—20.
1972 *Broinsonia bevieri* BUKRY, 1969, ROTH & THIERSTEIN (in press), Pl. 14, Fig. 14—17, 22—29.

Remarks: REINHARDT (1970) noted the synonymy of *Arkhangelskiella enormis* SHUMENKO, 1968, with *Broinsonia bevieri* BUKRY, 1969, as evident from features recognizable on Fig. 3 (holotype) of SHUMENKO (1968). In the light microscope this species is distinguished from *Arkhangelskiella cymbiformis* VEKSHINA, 1959, and *Broinsonia orthocancellata* BUKRY, 1969, by the lack of perforations in the central area, and from *Broinsonia lata* (NOEL, 1969) by its smaller central area and its larger distal shield, which appears bright under crossed nicols.

Distribution: France, Switzerland, Atlantic.
Known range: Upper Albian — Lower Campanian.

Broinsonia lata (NOEL, 1969) NOEL, 1970

Plate 6, Figures 12—16

1969 *Aspidolithus latus* NOEL, p. 196, Textfig. 2; Pl. 2, Fig. 1, 2.
1970 *Broinsonia lata* (NOEL, 1969) NOEL, p. 76, Pl. 23, Fig. 2.
1971 *Broinsonia bevieri* BUKRY, 1969, THIERSTEIN, p. 474, Pl. 2, Fig. 1—4.
1972 *Broinsonia lata* (NOEL, 1969) NOEL, 1970, ROTH & THIERSTEIN (in press), Pl. 14, Fig. 18—21.

Hypotype: [4026] A 960.
Known range: Middle Albian — Upper Campanian.

Broinsonia signata (NOEL, 1969) NOEL, 1970

1969 *Aspidolithus signatus* NOEL, p. 197, Pl. 2, Fig. 3, 4.
1970 *Broinsonia signata* (NOEL, 1969) NOEL, p. 78, Pl. 25, Fig. 4—6.
1972 *Broinsonia signata* (NOEL, 1969) NOEL, 1970, ROTH & THIERSTEIN (in press), Pl. 13, Fig. 12—20; Pl. 14, Fig. 1—5.

Known range: Middle Albian — Lower Campanian.

Family *Eiffellithaceae* REINHARDT, 1965 emend. PERCH-NIELSEN, 1968

Definition: Elliptical coccoliths with a marginal wall of imbricated elements and a small rim. Variable structures in the central area and additional cycles of elements on the wall determine the different genera of this family.
Synonyms: *Zygolithaceae* NOEL, 1965, *Zygodiscaceae* HAY & MOHLER, 1967.

Genus *Calcicalathina* THIERSTEIN, 1971

Type species: *Schizosphaerella oblongata* WORSLEY, 1971

Definition: Central area filled with small calcite crystals, rising above distal margin of the wall.

Calcicalathina oblongata (WORSLEY, 1971) THIERSTEIN, 1971

?1969 *Crepidolithus* ? sp. indet. NOEL, Pl. 12, Fig. 2, 5.
1971 *Schizosphaerella oblongata* WORSLEY, p. 12, Pl. 2, Fig. 32, 33.
1971 *Calcicalathina oblongata* (WORSLEY, 1971) THIERSTEIN, p. 475, Pl. 4, Fig. 6—10.

Distribution: France, Switzerland, Atlantic.
Known range: Upper Valanginian — Lower Barremian.

Genus *Chiastozygus* GARTNER, 1968

Type species: *Zygodiscus? amphipons* BRAMLETTE & MARTINI, 1964

Definition: Central area spanned by a X-shaped cross.

Chiastozygus litterarius (GÓRKA, 1957) MANIVIT, 1971

1957 *Discolithus litterarius* GÓRKA, p. 274, Pl. 3, Fig. 3.
1966 *Discolithus fessus* STOVER, p. 142, Pl. 2, Fig. 17—21; Pl. 8, Fig. 16.
1967 *Zygolithus litterarius* (GÓRKA, 1957) REINHARDT & GÓRKA, p. 249, Pl. 33, Fig. 7; non Pl. 31, Fig. 18, 22.
1968 *Zygolithus litterarius* (GÓRKA, 1957) REINHARDT & GÓRKA, 1967, STRADNER, ADAMIKER & MARESCH, p. 39 (partim), Pl. 34, Fig. 2, 3.
1970b *Eiffellithus anceps* (GÓRKA, 1957) REINHARDT & GÓRKA, 1967, REINHARDT, Pl. 3, Fig. 6.
1970b *Zygostephanos litterarius* (GÓRKA, 1957) HOFFMANN, p. 177, Pl. 1, Fig. 4; Pl. 5, Fig. 4; Pl. 6, Fig. 4 B; Pl. 10, Fig. 1.

1971 *Chiastozygus litterarius* (GÓRKA, 1957) MANIVIT, p. 92, Pl. 4, Fig. 1—5.
1971 *Chiastozygus litterarius* (GÓRKA, 1957) MANIVIT, 1971, THIERSTEIN, p. 476, Pl. 2, Fig. 17—21.
1972 *Chiastozygus litterarius* (GÓRKA, 1957) MANIVIT, 1971, ROTH & THIERSTEIN (in press), Pl. 1, Fig. 1—6.

Known range: Lower Aptian — Maastrichtian.

Genus *Eiffellithus* REINHARDT, 1965, emend. REINHARDT, 1966
Type species: *Zygolithus turriseiffeli* DEFLANDRE & FERT, 1954

Definition: Central area consisting of usually eight large crystal plates around the central cross.

Eiffellithus trabeculatus (GÓRKA, 1957)
REINHARDT & GÓRKA, 1967

1957 *Discolithus trabeculatus* GÓRKA, p. 277, Pl. 3, Fig. 9.
1966 *Discolithus disgregatus* STOVER, p. 142, Pl. 2, Fig. 11, 12; Pl. 8, Fig. 12.
1967 *Eiffellithus trabeculatus* (GÓRKA, 1957) REINHARDT & GÓRKA, p. 250, Pl. 31, Fig. 19, 23; Pl. 32, Fig. 1.
1969 *Chiastozygus disgregatus* (STOVER, 1966) BUKRY, p. 49, Pl. 27, Fig. 1—4.
1970b *Eiffellithus trabeculatus* (GÓRKA, 1957) REINHARDT & GÓRKA, 1967, REINHARDT, p. 61, Textfig. 49, 50; Pl. 4, Fig. 3.
1971 *Eiffellithus anceps* (GÓRKA, 1957) REINHARDT & GÓRKA, 1967, MANIVIT, p. 91, Pl. 11, Fig. 7—9.
1972 *Eiffellithus trabeculatus* (GÓRKA, 1957) REINHARDT & GÓRKA, 1967, ROTH & THIERSTEIN (in press), Pl. 12, Fig. 7—18.

Known range: Middle Albian — Maastrichtian.

Eiffellithus turriseiffeli (DEFLANDRE & FERT, 1954)
REINHARDT, 1965

1954 *Zygolithus turriseiffeli* DEFLANDRE & FERT, p. 149, Textfig. 65; Pl. 8, Fig. 15, 16.
1970 *Eiffellithus turriseiffeli* (DEFLANDRE & FERT, 1954) REINHARDT, 1965, NOEL, p. 38, Pl. 7, Fig. 1, 6.
1970b *Eiffellithus turriseiffeli* (DEFLANDRE & FERT, 1954) REINHARDT, 1965, REINHARDT, p. 62, Textfig. 47, 48; Pl. 4, Fig. 6, 7; Pl. 5, Fig. 1, 2.
1971 *Eiffellithus turriseiffeli* (DEFLANDRE & FERT, 1954) REINHARDT, 1965, MANIVIT, p. 90, Pl. 11, Fig. 5, 6, 12, 13.
1971 *Eiffellithus turriseiffeli* (DEFLANDRE & FERT, 1954) REINHARDT, 1965, THIERSTEIN, p. 475, Pl. 7, Fig. 9—11.
1972 *Eiffellithus turriseiffeli* (DEFLANDRE & FERT, 1954) REINHARDT, 1965, ROTH & THIERSTEIN (in press), Pl. 4, Fig. 1—6, 9.

Known range: Upper Albian — Maastrichtian.

Genus *Zygodiscus* BRAMLETTE & SULLIVAN, 1961
emend. GARTNER, 1968
Type species: *Zygodiscus adamas* BRAMLETTE & SULLIVAN, 1961

Definition: Central area spanned by a crossbar in the direction of the short axis of the ellipse. The crossbar may be constructed of one or several sets of elements, and it may be surmounted by a spine or a complex stem which extends distally.
Synonyms: *Zygolithus* KAMPTNER, 1949, emend. NOEL, 1965, *Glaukolithus* REINHARDT, 1964, *Zeugrhabdotus* REINHARDT, 1965.

Remarks: *Zygodiscus* BRAMLETTE & SULLIVAN, 1961, was defined by having a crossbar of several sets of elements of different crystallographic orientation. REINHARDT defined *Glaukolithus* REINHARDT, 1964, including specimens without central process, and *Zeugrhabdotus* REINHARDT, 1965, including forms provided with a central process. Appearance of a specific detail of a form in polarized light is considered to be of secondary importance, and presence of a stem may be due to dimorphism. *Zygodiscus* BRAMLETTE & SULLIVAN, 1961, emend. GARTNER, 1968 is the best defined genus for a number of Mesozoic species.

Zygodiscus diplogrammus (DEFLANDRE & FERT, 1954)
GARTNER, 1968
Plate 3, Figure 19

1954 *Zygolithus diplogrammus* DEFLANDRE & FERT, p. 148, Pl. 10, Fig. 7.
1964 *Glaukolithus diplogrammus* (DEFLANDRE & FERT, 1954) REINHARDT p. 758.
1966 *Zygolithus ponticulus* (DEFLANDRE & FERT, 1954) STOVER, p. 148, Pl. 4, Fig. 2—5.
1966 *Zygolithus stenopous* STOVER, p. 148, Pl. 4, Fig. 6—9; Pl. 8, Fig 25.
1968 *Zygolithus diplogrammus* DEFLANDRE & FERT, 1954, STRADNER, ADAMIKER & MARESCH, p. 35, Pl. 26, Fig. 3—7; Pl. 27.
1968 *Zygodiscus diplogrammus* (DEFLANDRE & FERT, 1954) GARTNER, p. 32 (partim), Pl. 21, Fig. 2; Pl. 22, Fig. 7.
1969 *Zygodiscus compactus* BUKRY, p. 59, Pl. 34, Fig. 1—2.
1970b *Zygostephanos diplogrammus* (DEFLANDRE & FERT, 1954) HOFFMANN, p. 169, Pl. 2, Fig. 1—2; Pl. 3, Fig. 4; Pl. 6, Fig. 4 A.
1971 *Glaukolithus diplogrammus* (DEFLANDRE & FERT, 1954) REINHARDT, 1964, MANIVIT, p. 81, Pl. 13, Fig. 2—7, 12—14.
1972 *Glaukolithus diplogrammus* (DEFLANDRE & FERT, 1954) REINHARDT, 1964, ROTH & THIERSTEIN (in press), Pl. 11, Fig. 1—5.

Remarks: *Zygodiscus diplogrammus* (DEFLANDRE & FERT, 1954) is distinguished from *Zygodiscus elegans* GARTNER, 1968, emend. BUKRY, 1969, by the absence of a central process and the simple, straight crossbars under crossed nicols.
Known range: Upper Valanginian — Maastrichtian.

Zygodiscus elegans GARTNER, 1968, emend. BUKRY, 1969
Plate 2, Figures 8—11

1968 *Zygodiscus elegans* GARTNER, p. 32, Pl. 10, Fig. 3—6; Pl. 12, Fig. 3, 4; Pl. 27, Fig. 1.
1969 *Zygodiscus elegans* GARTNER, 1968 emend. BUKRY, p. 59, Pl. 34, Fig. 6—8.
1972 *Glaukolithus elegans* (GARTNER, 1968 emend. BUKRY, 1969) THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 10, Fig. 16—20.

Remarks: *Zygodiscus elegans* GARTNER, 1969, emend. BUKRY, 1969 is distinguished from *Zygodiscus diplogrammus* (DEFLANDRE & FERT, 1954) in the EM by the presence of a circular base of the central process on the distal side, and under crossed nicols in the LM by the division of each of the two bars into three parts (see Pl. 2, Fig. 11); in contrast *Zygodiscus diplogrammus* (DEFLANDRE & FERT, 1954) shows two straight crossbars. *Zygolithus erectus* DEFLANDRE & FERT, 1954 has fewer elements in its wall and a simpler crossbar under crossed nicols (see DEFLANDRE & FERT [1954], Pl. 15, Fig. 15, 17).
Known range: Lower Berriasian — Campanian.

Genus *Parhadolithus* DEFLANDRE, 1952
Type species: *Parhabdolithus liasicus* DEFLANDRE, 1952

Definition: Elongated, elliptical coccoliths with a high wall and a long central process.

Parhabdolithus angustus (STRADNER, 1963) STRADNER,
ADAMIKER & MARESCH, 1968

1963 *Rhabdolithus angustus* STRADNER, p. 178, Pl. 5, Fig. 6.
1966 *Parhabdolithus elongatus* STOVER, p. 144, Pl. 6, Fig. 16—19; Pl. 9, Fig. 18.
1966a *Ahmuellerella angusta* (STRADNER, 1963) REINHARDT, p. 25, Pl. 22, Fig. 9—12.
1968 *Parhabdolithus angustus* (STRADNER, 1963) STRADNER, ADAMIKER & MARESCH, p. 32, Pl. 20.
1969 *Parhabdolithus angustus* (STRADNER, 1963) BUKRY, p. 53, Pl. 29, Fig. 8—11.

1971 *Parhabdolithus angustus* (STRADNER, 1963) BUKRY, 1969, MANIVIT, p. 86, Pl. 19, Fig. 1—3.
1972 *Parhabdolithus angustus* (STRADNER, 1963) STRADNER, ADAMIKER & MARESCH 1968, ROTH & THIERSTEIN (in press), Pl. 6, Fig. 14—18; Pl. 7, Fig. 1.

Known range: Upper Aptian — Campanian.

Parhabdolithus embergeri (NOEL, 1958) STRADNER, 1963

1958 *Discolithus embergeri* NOEL, p. 164, Pl. 1, Fig. 1, 7, 8.
1963 *Parhabdolithus embergeri* (NOEL, 1958), STRADNER, p. 8, Pl. 4, Fig. 1.
1969 *Parhabdolithus embergeri* (NOEL, 1958) STRADNER 1963, BUKRY & BRAMLETTE, Pl. 3, Fig. F.
1971 *Parhabdolithus embergeri* (NOEL, 1958) STRADNER, 1963, MANIVIT, p. 88, Pl. 20, Fig. 1—6.
1972 *Parhabdolithus embergeri* (NOEL, 1958) STRADNER, 1963, ROTH & THIERSTEIN (in press), Pl. 9, Fig. 1—6.

Known range: Lower Tithonian — Maastrichtian.

Parhabdolithus asper (STRADNER, 1963) MANIVIT, 1971

1963 *Discolithus asper* STRADNER, p. 11, Pl. 2, Fig. 4, 5.
?1966 *Discolithus vagus* STOVER, p. 144, Pl. 3, Fig. 10—11, Pl. 8, Fig. 20.
?1966 *Parhabdolithus granulatus* STOVER, p. 144, Pl. 6, Fig. 11—15; Pl. 9, Fig. 17.
1967 *Rhagodiscus asper* (STRADNER, 1963) REINHARDT, p. 167.
1968 *Rhagodiscus asper* (STRADNER, 1963) REINHARDT, 1967, STRADNER, ADAMIKER & MARESCH, p. 33, Pl. 24.
1971 *Rhagodiscus asper* (STRADNER, 1963) REINHARDT, 1967, REINHARDT, p. 23, Textfig. 11; Pl. 2, Fig. 4—6; Pl. 3, Fig. 1—6.
1971 *Parhabdolithus asper* (STRADNER, 1963) MANIVIT, p. 87, Pl. 23, Fig. 4—7.
1972 *Parhabdolithus asper* (STRADNER, 1963) MANIVIT, 1971, ROTH & THIERSTEIN (in press), Pl. 7, Fig. 7—17.

Remarks: *Parhabdolithus asper* (STRADNER, 1963) is distinguished from *Parhabdolithus splendens* (DEFLANDRE, 1953) by having a less elongated oval shape, circular deepenings on the distal side of the central area, and sometimes lacking a central perforation on the proximal side. If a perforation is present, it is surrounded by a narrow bright ring under crossed nicols. The base of the central process of *Parhabdolithus splendens* (DEFLANDRE, 1953) is composed of either four distinct, inclined parts or of many radial spokes.

Known range: Lower Berriasian — Upper Turonian.

Parhabdolithus infinitus (WORSLEY, 1971) THIERSTEIN, 1972

1971 *Mitosia infinitae* WORSLEY, p. 1311, Pl. 1, Fig. 48—50.
1972 *Parhabdolithus infinitus* (WORSLEY, 1971) THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 9, Fig. 7—16.

Remarks: The range of this species differs in the western Atlantic and in southeastern France. The apparent earlier first occurrence in the western Atlantic may be due to the more favorable marly facies and the better preservation of the nannofossils.

Known range: Upper Hauterivian — Cenomanian.

Parhabdolithus splendens (DEFLANDRE, 1953) NOEL, 1969

1953 *Rhabdolithus splendens* DEFLANDRE, p. 1785, Fig. 4—6.
1954 *Rhabdolithus splendens* DEFLANDRE, 1953, DEFLANDRE & FERT, p. 37, Textfig. 88, 89; Pl. 13, Fig. 1—3.
1964 *Cretarhabdus splendens* (DEFLANDRE, 1953) BRAMLETTE & MARTINI, p. 300, Pl. 3, Fig. 13—16.
1968 *Actinozygus splendens* (DEFLANDRE, 1953) GARTNER, p. 25 (partim), Pl. 5, Fig. 15, 16; Pl. 7, Fig. 1, 2; Pl. 11, Fig. 15.
1969 *Parhabdolithus splendens* (DEFLANDRE, 1953) NOEL, p. 476, Textfig. 1, 2; Pl. 1, Fig. 1—4, 7.
1967 *Rhabdolithina splendens* (DEFLANDRE, 1953) REINHARDT, p. 167.
1971 *Rhabdolithina splendens* (DEFLANDRE, 1953) REINHARDT, 1967 MANIVIT, p. 88, Pl. 19, Fig. 5—7, 9, 11, 12.
1972 *Parhabdolithus splendens* (DEFLANDRE, 1953) NOEL, 1969, ROTH & THIERSTEIN (in press), Pl. 7, Fig. 2—6.

Remarks: See *Parhabdolithus asper* (STRADNER, 1963) in this paper.

Known range: Upper Valanginian — Maastrichtian.

Genus *Reinhardtites* PERCH-NIELSEN, 1968

Type species: *Rhabdolithus anthophorus* DEFLANDRE, 1959

Definition: Central area distally covered with crystal plates and proximally differing complex structures.

Reinhardtites fenestratus (WORSLEY, 1971) THIERSTEIN, 1972

1971 *Arkhangelskiella ? fenestrata* WORSLEY, p. 1305, Pl. 1, Fig. 33 to 35.
1972 *Reinhardtites fenestratus* (WORSLEY, 1971) THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 8, Fig. 1—12.

Known range: Lower Valanginian — Upper Aptian.

Genus *Vagalapilla* BUKRY, 1969

Type species: *Vekshinella imbricata* GARTNER, 1968

Definition: Central area spanned by a cross in the axes of the ellipse.

Remarks: Relations and differences between the genera *Ephippium* VEKSHINA, 1959, *Staurolithites* CARATINI, 1963, *Vekshinella* LOEBLICH & TAPPAN, 1963, emend. GARTNER, 1968, and *Vagalapilla* BUKRY, 1969, have been discussed by BUKRY (1969, p. 55). Since the definitions of both genera, *Staurolithites* CARATINI, 1963 and *Vekshinella* LOEBLICH & TAPPAN, 1963, emend. GARTNER, 1968, differ from *Vagalapilla* BUKRY, 1969, by their shield constructions, and since the ultrastructures of the type species of both genera, *Staurolithites laffittei* CARATINI, 1963, and *Ephippium acutiferra* VEKSHINA, 1959, are not known, *Vagalapilla* BUKRY, 1969, is used here. SEM investigations of *Ephippium acutiferra* VESKHINA, 1959, and of *Staurolithites laffittei* CARATINI, 1963, may show whether *Vagalapilla* BUKRY, 1969, is a junior synonym of *Vekshinella* LOEBLICH & TAPPAN, 1963, emend. GARTNER, 1968, or *Staurolithites* CARATINI, 1963, or both.

Vagalapilla compacta BUKRY, 1969

1969 *Vagalapilla compacta compacta* BUKRY, p. 56, Pl. 31, Fig. 10, 11.
1969 *Vagalapilla compacta integra* BUKRY, p. 56, Pl. 31, Fig. 12.
1970b *Placozygus latidecussatus* HOFFMANN, p. 181, Pl. 7, Fig. 1, 2.
1971 *Staurolithites compactus* (BUKRY, 1969) THIERSTEIN, p. 485.

Known range: Lower Berriasian — Lower Santonian.

Vagalapilla matalosa (STOVER, 1966) n. comb.
Plate 3, Figures 15—18

1966 *Coccolithus matalosus* STOVER, p. 139, Pl. 1, Fig. 12—14, non Pl. 8, Fig. 6.
1969 *Staurolithites matalosus* (STOVER, 1966) ČEPEK & HAY, p. 325.
1971 *Staurolithites matalosus* (STOVER, 1966) ČEPEK & HAY, 1969, MANIVIT, p. 84, Pl. 24, Fig. 6—10.
1972 *Staurolithites matalosus* (STOVER, 1966) ČEPEK & HAY, 1969, ROTH & THIERSTEIN (in press), Pl. 13, Fig. 6—11.

Definition: The wall is composed of about 40 dextrally imbricate elements. A second cycle of irregularly shaped elements inside of the narrow proximal rim surrounds the central area which is spanned by an axial or subaxial cross with flaring, arrowhead like ends. The base of a central process is present.

Remarks: Several species, well differentiated in the EM, appear very similar in the LM, and may be identified with the help of the following micrographs:

Vagalapilla matalosa (STOVER, 1966) n. comb., this paper Pl. 3, Fig. 15—18; *Staurolithites matalosus* (STOVER, 1966) ČEPEK & HAY, 1969, ROTH & THIERSTEIN (1972), Pl. 13, Fig. 6—11.

Broinsonia signata (NOEL, 1969) NOEL, 1970, ROTH & THIERSTEIN (1972), Pl. 13, Fig. 12—20; Pl. 14, Fig. 1—5.

Broinsonia dentata BUKRY, 1969, ROTH & THIERSTEIN (1972), Pl. 14, Fig. 6—13.

Hypotypes: [1136] A 938, [4031] A 939, ROTH & THIERSTEIN (1972), Pl. 13, Fig. 7; and [1126] A 940, this paper, Pl. 3, Fig. 15—18.

Known range: Middle Albian — Lower Turonian.

Vagalapilla stradneri (ROOD, HAY & BARNARD, 1971) n. comb.

1963 *Staurolithites crux* (DEFLANDRE & FERT, 1954) CARATINI, p. 25.
1963 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, STRADNER, p. 175, Pl. 4, Fig. 6, 7.
1964 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, BRAMLETTE & MARTINI, p. 304, Pl. 4, Fig. 19, 20.
1965 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, MANIVIT, p. 191, Pl. 2, Fig. 13.
1966 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, STOVER, p. 147, Pl. 3, Fig. 17, 18, 22 A.
1966 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, STRADNER & ADAMIKER, p. 340, Pl. 3, Fig. 3, 4.
1968 *Zygolithus crux* (DEFLANDRE & FERT, 1954) BRAMLETTE & SULLIVAN, 1961, STRADNER, ADAMIKER & MARESCH, p. 36, Pl. 28—30.
1971 *Staurolithites crux* (DEFLANDRE & FERT, 1954) CARATINI, 1963, MANIVIT, p. 82, Pl. 18, Fig. 15, 16; Pl. 27, Fig. 6—8, 10, 11, 14.
1971 *Staurolithites crux* (DEFLANDRE & FERT, 1954) CARATINI, 1963, THIERSTEIN, p. 468, Pl. 6, Fig. 13, 14.
1971 *Vekshinella stradneri* ROOD, HAY & BARNARD, p. 249, Pl. 1, Fig. 2.
1972 *Staurolithites crux* (DEFLANDRE & FERT, 1954) CARATINI, 1963, ROTH & THIERSTEIN (in press).

Remarks: There has been great confusion about the ultrastructure of *Discolithus crux* DEFLANDRE & FERT, 1954. DEFLANDRE & DEFLANDRE-RIGAUD (1970, p. 3) designated Fig. 55 in DEFLANDRE & FERT (1954) as the holotype and indicated *Coccolithus crux* (DEFLANDRE & FERT, 1954) HAY & TOWE, 1962, p. 507, Pl. 2, Fig. 1 to be a hypotype. ROOD, HAY & BARNARD (1971) proposed a new specific epithet for the mesozoic species earlier assigned to *Discolithus crux* DEFLANDRE & FERT, 1954.

Known range: Upper Oxfordian — Maastrichtian.

Genus *Tegumentum* THIERSTEIN, 1972

Type species: *Tegumentum stradneri* THIERSTEIN, 1972

Definition: A band of non-imbricate tabular elements covers the marginal side of the wall. Central area with X-shaped crossbars.

Remarks: *Tegumentum* THIERSTEIN, 1972, differs from all other genera of the family *Eiffellithaceae* in possessing a unique marginal band.

Tegumentum stradneri THIERSTEIN, 1972

1968 *Zygolithus litterarius* (GÓRKA, 1957), STRADNER, ADAMIKER & MARESCH, partim, Pl. 34, Fig. 1, 4—7.
1972 *Tegumentum stradneri* THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 1, Fig. 7—15.

Remarks: In the LM this species differs from *Chiastozygus litterarius* (GÓRKA, 1957) in having a distinct marginal cycle, and spokes composed of two elongated parts of different crystallographic orientation.

Distribution: SE-France, Switzerland, Atlantic.

Known range: Lower Barremian — Maastrichtian.

Genus *Tranolithus* STOVER, 1966

Type species: *Tranolithus manifestus* STOVER, 1966

Definition: The structures of the central area are connected with the distal wall (instead of proximal rim, as in all other genera of the family) and have the same crystallographic orientation as the adjacent part of the wall.

Tranolithus exiguus STOVER, 1966

1966 *Tranolithus exiguus* STOVER, p. 146, Pl. 4, Fig. 19—21; Pl. 9, Fig. 3, 4.
1968 *Tranolithus* cf. *exiguus* STOVER, 1966, FORCHHEIMER, p. 49, Pl. 5, Fig. 2.
1970 *Tranolithus* cf. *manifestus* STOVER, 1966, NOEL, p. 44, Pl. 9, Fig. 3, 5, 7; Pl. 10, Fig. 1—4.
1971 *Tranolithus exiguus* STOVER, 1966, MANIVIT, p. 85, Pl. 26, Fig. 10—12, 18.
1972 *Tranolithus exiguus* STOVER, 1966, ROTH & THIERSTEIN (in press), Pl. 10, Fig. 6—10.

Remarks: All intermediate forms occur between *Tranolithus exiguus* STOVER, 1966, which has two small triangular elements on each side of the central field, an *Tranolithus orionatus* (REINHARDT, 1966) which has four big crystals filling most of the central area. Most intermediate forms are closer to *Tranolithus exiguus* STOVER, 1966, but typical specimens of both species have their first occurrence in the same sample (Th 70/105, Col de Palluel).

Known range: Middle Albian — Maastrichtian.

Tranolithus gabalus STOVER, 1966

1966 *Tranolithus gabalus* STOVER, p. 146, Pl. 4, Fig. 22; Pl. 9, Fig. 5.
1971 *Glaukolithus bitabulatus* WORSLEY, p. 1310, Pl. 2, Fig. 40—42.
1972 *Tranolithus gabalus* STOVER, 1966, ROTH & THIERSTEIN (in press), Pl. 10, Fig. 1—5.

Known range: Upper Aptian — Cenomanian.

Tranolithus orionatus (REINHARDT, 1966 a) REINHARDT, 1966 b

Plate IV, Figures 12—15

1966a *Discolithus orionatus* REINHARDT, p. 42, Pl. 23, Fig. 22, 31—33.
1966b *Tranolithus orionatus* (REINHARDT, 1966a) REINHARDT, p. 522.
1970 *Tranolithus orionatus* (REINHARDT, 1966a) REINHARDT, 1966b, NOEL, p. 44, Textfig. 7; Pl. 9, Fig. 4, 6; Pl. 10, Fig. 5.
1970 *Zygostephanos orionatus* (REINHARDT, 1966 a) HOFFMANN, p. 178, Pl. 1, Fig. 5; Pl. 2, Fig. 3.
1972 *Tranolithus orionatus* (REINHARDT 1966 a) REINHARDT 1966 b, ROTH & THIERSTEIN (in press), Pl. 10, Fig. 11—15.

Remarks: See above under *Tranolithus exiguus* STOVER, 1966.

Known range: Middle Albian — Maastrichtian.

Family *Podorhabdaceae* NOEL, 1965

Definition: Coccoliths with two shields, each consisting of one cycle of strongly radial non or only slightly imbricate elements. Central area varied.

Remarks: Members of this family have the characteristic „podorhabdid" appearence in the light microscope mentioned by ROOD, HAY & BARNARD (1971).

Genus *Cribrosphaerella* DEFLANDRE, 1952

Type species: *Cribrosphaera ehrenbergi* ARKHANGELSKY, 1912

Definition: Central area closed by a grid. No central process.

Remarks: A third cycle of elements may occur marginally between the two shields. The elements of the intermediate cycle are connected with and are considered to belong to those of the distal shield. This feature has been observed in specimens of the genus *Cretarhabdus* BRAMLETTE & MARTINI, 1964, also, and apparently has no taxonomic significance.

Cribrosphaerella ehrenbergi (ARKHANGELSKY, 1912) DEFLANDRE, 1952

1912 *Cribrosphaera ehrenbergi* ARKHANGELSKY, p. 142, Pl. 6, Fig. 19, 20.
1970b *Cribrosphaerella ehrenbergi* (ARKHANGELSKY, 1912) DEFLANDRE, 1952, REINHARDT, p. 52, Textfig. 24; Pl. 3, Fig. 4.
1970 *Cribrosphaera ehrenbergi* ARKHANGELSKY, 1912, NOEL, p. 70, Textfig. 17; Pl. 18, Fig. 4—7; Pl. 19, Fig. 1—4; Pl. 20, Fig. 1—4.
1971 *Cribrosphaera ehrenbergi* ARKHANGELSKY, 1912, MANIVIT, p. 101, Pl. 8, Fig. 1—13.
1972 *Cribrosphaerella ehrenbergi* (ARKHANGELSKY, 1912) DEFLANDRE, 1952, ROTH & THIERSTEIN (in press).

Known range: Upper Albian — Maastrichtian.

Genus *Podorhabdus* NOEL, 1965

Type species: *Podorhabdus grassei* NOEL, 1965

Definition: Central area with 4 radial bars supporting a central process, and with tabular and/or blocky crystals.

Podorhabdus decorus (DEFLANDRE & FERT, 1954) THIERSTEIN, 1972

1954 *Rhabdolithus decorus* DEFLANDRE & FERT, p. 159, Textfig. 87; Pl. 13, Fig. 4—6.
1964 *Cretarhabdus ? decorus* (DEFLANDRE & FERT, 1954) BRAMLETTE & MARTINI, p. 300, Pl. 3, Fig. 9—12.
1965 *Ahmuellerella granulata* REINHARDT, p. 39, Pl. 3, Fig. 2.
1966a *Cretarhabdus ? granulatus* (REINHARDT, 1965) REINHARDT, p. 27, Pl. 8, Fig. 1.
1968 *Cretarhabdus decorus* (DEFLANDRE & FERT, 1954) GARTNER, p. 22, Pl. 4, Fig. 15—16; Pl. 11, Fig. 13—14.
1969 *Podorhabdus granulatus* (REINHARDT, 1965) BUKRY, p. 37, Pl. 16, Fig. 4—6.
1972 *Podorhabdus decorus* (DEFLANDRE & FERT, 1954) THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 4, Fig. 7, 8, 10—13.

Known range: Lower Aptian — Maastrichtian.

Podorhabdus dietzmanni (REINHARDT, 1965) REINHARDT, 1967

Plate 3, Figure 20

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, BUKRY, p. 37, Pl. 16, Fig. 1—3.
1970b *Podorhabdus dietzmanni* (REINHARDT, 1965) REINHARDT, 1967, REINHARDT (partim), p. 87, Textfig. 107a.
1971 *Podorhabdus dietzmanni* (REINHARDT, 1965) REINHARDT, 1967, THIERSTEIN, p. 478, Pl. 8, Fig. 1—8.

Remarks: The differentiation from *Podorhabdus orbiculofenestrus* (GARTNER, 1968) given by THIERSTEIN (1971) is illustrated by the following scanning electron and light micrographs:

Podorhabdus dietzmanni (REINHARDT, 1965):
Distal side: THIERSTEIN (1971), Pl. 8, Fig. 1, 5.
Proximal side: this paper, Pl. 3, Fig. 20.

Podorhabdus orbiculofenestrus (GARTNER, 1968):
Distal side: ROTH & THIERSTEIN (1972), Pl. 6, Fig. 1—6.
Proximal side: THIERSTEIN (1971), Pl. 8, Fig. 14—17; and ROTH & THIERSTEIN (1972), Pl. 6, Fig. 7.

Known range: Upper Valanginian — Santonian.

Podorhabdus orbiculofenestrus (GARTNER, 1968) THIERSTEIN, 1971

1965 *Rhabdosphaera* sp., 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, REINHARDT (partim), p. 87, Textfig. 107b; Pl. 6, Fig. 4.
1971 *Podorhabdus orbiculofenestrus* (GARTNER, 1968) THIERSTEIN, p. 478, Pl. 8, Fig. 9—17.
1972 *Podorhabdus orbiculofenestrus* (GARTNER, 1968) THIERSTEIN, 1971, ROTH & THIERSTEIN (in press), Pl. 6, Fig. 1—7.

Remarks: For differentiation from *Podorhabdus dietzmanni* (REINHARDT, 1965) see THIERSTEIN (1971), p. 478, and under remarks to *Podorhabdus dietzmanni* (REINHARDT, 1965) above.

Known range: Middle Albian — Campanian.

Genus *Prediscosphaera* VEKSHINA, 1959

Type species: *Prediscosphaera decorata* VEKSHINA, 1959
(= *Prediscosphaera cretacea* [ARKHANGELSKY, 1912] GARTNER, 1968)

Definition: Two shields, the proximal smaller than the distal, always of 16 petaloid elements. Central area spanned by 4 radial bars supporting a characteristic central process.
Synonym: *Deflandrius* BRAMLETTE & MARTINI, 1964.

Prediscosphaera cretacea (ARKHANGELSKY, 1912) GARTNER, 1968

1912 *Coccolithophora cretacea* ARKHANGELSKY, p. 410, Pl. 6, Fig. 12, 13.
1964 *Deflandrius cretaceus* (ARKHANGELSKY, 1912) BRAMLETTE & MARTINI, p. 301, Pl. 2, Fig. 11—12.
1968 *Prediscosphaera cretacea* (ARKHANGELSKY, 1912) GARTNER, p. 19, Pl. 2, Fig. 10—14; Pl. 3, Fig. 8; Pl. 4, Fig. 19—24; 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.
1970 *Prediscosphaera cretacea* (ARKHANGELSKY, 1912) GARTNER, 1968, NOEL, p. 64, Textfig. 16; Pl. 15, Fig. 3—6, 9, 11; Pl. 16, Fig. 2, 3, 7, 8.
1971 *Prediscosphaera cretacea* (ARKHANGELSKY, 1912) GARTNER, 1968, MANIVIT, p. 99, Pl. 22, Fig. 1—14.
1972 *Prediscosphaera cretacea cretacea* (ARKHANGELSKY, 1912) BUKRY, 1969, ROTH & THIERSTEIN, in press, Pl. 16, Fig. 5.

Known range: Lower Albian — Maastrichtian.

Prediscosphaera spinosa (BRAMLETTE & MARTINI, 1964) GARTNER, 1968

1964 *Deflandrius spinosus* BRAMLETTE & MARTINI, p. 301, Pl. 2, Fig. 17—20.
1968 *Prediscosphaera spinosa* (BRAMLETTE & MARTINI, 1964) GARTNER, 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.
1970 *Prediscosphaera spinosa* (BRAMLETTE & MARTINI, 1964) GARTNER, 1968, NOEL, p. 66, Pl. 16, Fig. 4—6, 9, 10.
1970b *Prediscosphaera propinqua* (GÓRKA, 1957) REINHARDT, p. 93.

Remarks: *Discolithus propinquus* GÓRKA (1957) was defined by 9—12 transversal stripes on the shield. This feature casts some doubt on the claim by REINHARDT (1970b) that *Discolithus propinquus* GÓRKA (1957) is a senior synonym of *Prediscosphaera spinosa* (BRAMLETTE & MARTINI, 1964) GARTNER, 1968, which has always 16 elements in the shield.

Known range: Middle Albian — Maastrichtian.

Family *Cretarhabdaceae* new family

Definition: Elliptical coccoliths consisting of a distal shield with two cycles of inclined, non or only slightly imbricated elements, and a proximal shield with one cycle of inclined, non or slightly imbricated elements.

Remarks: The shields of most of the members of this family seem to have an elliptical crest parallel to the outer margin in the LM.

Genus *Bipodorhabdus* NOEL, 1970

Type species: *Bipodorhabdus tesselatus* NOEL, 1970

Definition: Central area spanned by one crossbar.

Bipodorhabdus roeglii THIERSTEIN, 1971

1971 *Bipodorhabdus roeglii* THIERSTEIN, p. 476, Pl. 1, Fig. 7—11.

Know range: Upper Valanginian — Upper Hauterivian.

Genus *Cretarhabdus* BRAMLETTE & MARTINI, 1964

Type species: *Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964

Definition: Central area spanned by 4 radial bars supporting a central process, the areas between the bars are filled with further ornamentation.

Remarks: *Cruciellipsis* THIERSTEIN, 1971, has only 4 crossbars, lying in the long and short axes of the ellipse.

Cretarhabdus conicus BRAMLETTE & MARTINI, 1964

1964 *Cretarhabdus conicus* BRAMLETTE & MARTINI, p. 299, Pl. 3, Fig. 5—8.
1970 *Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964, NOEL, p. 58, Textfig. 14; Pl. 17, Fig. 2, 4.
1971 *Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964, MANIVIT, p. 95, Pl. 2, Fig. 13—18.
1971 *Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964, THIERSTEIN, p. 477, Pl. 6, Fig. 7—12.

Known range: Lower Berriasian — Maastrichtian.

Cretarhabdus coronadventis REINHARDT, 1966 a

1966a *Cretarhabdus coronadventis* REINHARDT, p. 26, Pl. 23, Fig. 29, 30.
1966 *Cretarhabdus unicornis* STOVER, p. 140, Pl. 5, Fig. 15, 16; Pl. 9, Fig. 15.
1969 *Cretarhabdus unicornis* STOVER, 1966, BUKRY, p. 36, Pl. 15, Fig. 7—9.
1970 *Cretarhabdus unicornis* STOVER, 1966, NOEL, p. 59, Textfig. 15; Pl. 18, Fig. 1—3.
1970b *Podorhabdus coronadventis* (REINHARDT, 1966 a) REINHARDT, p. 86.
1971 *Cretarhabdus unicornis* STOVER, 1966, MANIVIT, p. 97, pl. 9, Fig. 13—16.
1972 *Cretarhabdus coronadventis* REINHARDT, 1966, ROTH & THIERSTEIN (in press), Pl. 5, Fig. 1—9.

Known range: Middle Albian — Campanian.

Cretarhabdus crenulatus BRAMLETTE & MARTINI, 1964 emend. THIERSTEIN, 1971

1964 *Cretarhabdus crenulatus* BRAMLETTE & MARTINI, p. 300, Pl. 2, Fig. 21—24.
1968 *Cretarhabdus conicus* BRAMLETTE & MARTINI, 1964, GARTNER (partim), Pl. 16, Fig. 14.
1968 *Cretarhabdus crenulatus* BRAMLETTE & MARTINI, 1964, GARTNER (partim), p. 22, Pl. 6, Fig. 6; Pl. 19, Fig. 11; Pl. 20, Fig. 10, 11.
1969 *Cretarhabdus crenulatus crenulatus* (BRAMLETTE & MARTINI, 1964) BUKRY, p. 35, Pl. 14, Fig. 1—6, 12.
1970 *Heterorhabdus sinuosus* NOEL, p. 48, Textfig. 9; Pl. 8, Fig. 1—4, 6.
1971 *Cretarhabdus crenulatus* BRAMLETTE & MARTINI, 1964 emend. THIERSTEIN, p. 476, Pl. 5, Fig. 10—14.
1972 *Cretarhabdus crenulatus* BRAMLETTE & MARTINI, 1964 emend. THIERSTEIN, 1971, ROTH & THIERSTEIN (in press), Pl. 5, Fig. 10—12.

Hypotypes: [6-331/9] A 941, and [6-357/1] A 942, in THIERSTEIN (1971) Pl. 5, Fig. 13, 14.

Cretarhabdus loriei GARTNER, 1968

Plate 4, Figures 1—5

1966 *Arkhangelskiella striata* STRADNER, 1963, STOVER, p. 137, Pl. 2, Fig. 3—4.
1968 *Cretarhabdus loriei* GARTNER, p. 21, Pl. 24, Fig. 9, 10.
1969 *Cretarhabdus loriei* GARTNER, 1968, BUKRY, p. 36, Pl. 15, Fig. 1—3.
1971 *Cretarhabdus loriei* GARTNER, 1968, MANIVIT, p. 96, Pl. 6, Fig. 11—14.

Known range: Upper Aptian — Campanian.

Cretarhabdus surirellus (DEFLANDRE, 1954) REINHARDT, 1970 b

1954 *Discolithus surirella* DEFLANDRE & FERT, p. 144, Textfig. 30, 31.
1957 *Tremalithus romani* GÓRKA, p. 271, Pl. 2, Fig. 5.
?1964 *Cretarhabdus crenulatus* BRAMLETTE & MARTINI, p. 300, Pl. 2, Fig. 21—24.
1968 *Cretarhabdus romani* (GÓRKA, 1957) STRADNER, ADAMIKER & MARESCH, p. 30, Pl. 15—17.
1968 *Polypodorhabdus crenulatus* (BRAMLETTE & MARTINI, 1964) PERCH-NIELSEN, p. 48, Textfig. 18; Pl. 11, Fig. 2, 3.
1968 *Polypodorhabdus actinosus* (STOVER, 1966) PERCH-NIELSEN, p. 50, Textfig. 19; Pl. 10, Fig. 1—6.
1969 *Cretarhabdus crenulatus hansmanii* BUKRY, p. 35, Pl. 14, Fig. 2, 7—9.
1970 *Stradneria crenulata* (BRAMLETTE & MARTINI 1964) NOEL (partim), p. 55, Pl. 13, Fig. 4—6.
1970b *Cretarhabdus surirellus* (DEFLANDRE & FERT, 1954) REINHARDT (partim), p. 50, Textfig. 22, Pl. 1, Fig. 8; Pl. 2, Fig. 1—6.
1971 *Cretarhabdus surirellus* (DEFLANDRE, 1954) REINHARDT, 1970, THIERSTEIN, p. 477, Pl. 6, Fig. 1—6.

Hypotypes: [6-365/2] A 943, [2420] A 944 in THIERSTEIN (1971) Pl. 6, Figs. 1, 2.
Known range: Lower Berriasian — Maastrichtian.

Genus *Cruciellipsis* THIERSTEIN, 1971

Type species: *Coccolithus cuvillieri* MANIVIT, 1966

Definition: The small central area is spanned by 4 radial bars aligned with the long and short axes of the ellipse. The base of a central process may be present. No further ornamentation in the central area.

Remarks: *Cretarhabdus* BRAMLETTE & MARTINI, 1964, has narrower shields, a wider central area and other structures in addition to the 4 bars. *Helenea* WORSLEY, 1971, is not available because SEM investigations have shown that its type species *Helenea staurolithina* WORSLEY, 1971, has a "cretarhabdid" shield construction and is synonym to *Cretarhabdus schizobrachiatus* (GARTNER, 1968) BUKRY, 1969.

Cruciellipsis chiasta (WORSLEY, 1971) THIERSTEIN, 1972

1971 *Helenea chiasta* WORSLEY, p. 1310, Pl. 1, Fig. 42—44.
1972 *Cruciellipsis chiasta* (WORSLEY, 1971) THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 6, Fig. 8—13.

Definition: The proximal shield consists of 22 to 29 slightly sinistrally imbricated and clockwise inclined elements. The wider distal shield consists of two cycles of 29 to 34 clockwise inclined, non-imbricated elements when viewed from the distal side. The small central area is spanned by a heavy axial cross constructed of small blocky crystals. Distally the central cross carries four short spurs.

Remarks: Each bar of the central cross of *Cruciellipsis cuvillieri* (MANIVIT, 1966) is symmetric and has a longitudinal suture, well visible under crossed nicols, whereas the short spurs of the central cross of *Cruciellipsis chiasta* (WORSLEY, 1971) show no suture and are often slightly rotated off the axes of the ellipse. *Cruciellipsis chiasta* (WORSLEY, 1971) differs from *Cretarhabdus schizobrachiatus* (GARTNER, 1968) by its non-flaring bars and its smaller size.
Hypotype: [4359] A 931 (ROTH & THIERSTEIN [1972], Pl. 6, Fig. 8).
Distribution: France, Switzerland, Atlantic.
Known range: Lower Berriasian — Cenomanian.

Cruciellipsis cuvillieri (MANIVIT, 1966) THIERSTEIN, 1971

1966 *Coccolithus cuvillieri* MANIVIT, p. 268, Figs. 2a, b, c; 3a, b.
1969 ?*Cruciplacolithus* sp. BUKRY & BRAMLETTE, p. 374, Pl. 3, Fig. C, D; Pl. 5, Fig. C.
1971 *Coccolithus cuvillieri* MANIVIT, 1966, WORSLEY, p. 1309, Pl. 2, Fig. 34—36.
1971 *Cruciellipsis cuvillieri* (MANIVIT, 1966) THIERSTEIN, p. 478, Pl. 5, Fig. 4—8.

Remarks: This species also shows a "cretarhabdid" shield construction, having a very small second outer cycle of elements in the distal shield.
Distribution: France, Switzerland, Atlantic, Pacific.
Known range: Lower Berriasian — Upper Hauterivian.

Genus *Flabellites* n. gen.
Type species: *Flabellites biforaminis* n. sp.

Definition: The elements of the inner cycle of the distal shield are elongated, one or two clusters of these elements often extend beyond the elliptical periphery of the coccolith.

Differentiation: *Kamptnerius* DEFLANDRE, 1959, has a much more complex proximal shield and its central area consists of elongated crystal plates instead of small blocky crystals.

Remarks: In those parts of the coccolith where the inner cycle of the distal shield is extended, the elements of the outer cycle are smaller or even fused with the elongated elements. Several specimens of the type species without asymmetric shape have been recognized (Pl. 5, Fig. 5—8). Taxonomic assignment of this genus to the family *Cretarhabdaceae* n. fam. is provisional.
The "overgrowth" of one cycle of elements seems to be primary and not due to diagenetic overcalcification or corrosion for the following reasons:

1. Elongation of the elements is not regular.
2. No overgrowth or corrosion has been recognized in the central area of the asymmetric specimens, nor was it seen in other coccoliths of the same samples.

Flabellites biforaminis n. sp.
Plate 5, Figures 1—12

Diagnosis: The proximal shield consists of 28—40 slightly dextrally imbricated radial elements. The wider distal shield consists of two cycles of about the same number of dextrally imbricated, and slightly counterclockwise inclined radial elements when viewed from distal side. The inner cycle may be partly enlarged. In those parts of the coccolith where the elongated elements of the inner distal cycle leave the elliptic outer margin, the elements of the original outer distal cycle are completely fused with the elongated elements of the original inner cycle.
In the granulate central field, two circular perforations in the long axis of the ellipse are separated by a bridge formed by four small calcite crystals arranged in a diagonal cross.

Remarks: Under crossed nicols, the small diagonal central cross is the most characteristic feature of this species (see Pl. 5, Fig. 4, 8, 11).
Maximum diameter: 5,8—8,5 μm.
Holotype: [5016] A 945.
Paratypes: [4999] A 946, [5024] A 947.
Distribution: France, Switzerland, Atlantic.
Known range: Upper Aptian — Upper Cenomanian.

Family *Coccolithaceae* POCHE, 1913, emend. KAMPTNER, 1928

Definition: Two shields, each consisting of one or more cycles of longish elements are connected at their inner margin, usually having "cuff-link" shape.
Synonym: *Ellipsagelosphaeraceae* NOEL, 1965.

Genus *Biscutum* BLACK, 1959
Type species: *Biscutum testudinarium* BLACK, 1959
(= *Discolithus constans* GÓRKA, 1957)

Definition: Elliptical coccoliths with 2 monocyclic shields, connected by an inner cycle of granules, filling the central area.

Biscutum constans (GÓRKA, 1957) BLACK, 1967

1957 *Discolithus constans* GÓRKA, p. 279, Pl. 4, Fig. 7.
1959 *Biscutum testudinarium* BLACK in BLACK & BARNES, p. 325, Pl. 10, Fig. 1.
1959 *Biscutum castrorum* BLACK in BLACK & BARNES, p. 326, Pl. 10, Fig. 2.
1967 *Biscutum constans* (GÓRKA, 1957) BLACK, p. 139.
1970 *Biscutum constans* (GÓRKA, 1957) BLACK, 1959, NOEL, p. 91, Pl. 33, Fig. 1—10; Pl. 34, Fig. 1.
1971 *Biscutum testudinarium* BLACK, 1959, MANIVIT, p. 113, Pl. 3, Fig. 8—12.
1972 *Biscutum constans* (GÓRKA, 1957) BLACK 1967, ROTH & THIERSTEIN (in press), Pl. 8, Fig. 13—18.

Known range: Lower Berriasian — Maastrichtian.

Biscutum supracretaceum (REINHARDT, 1965) PERCH-NIELSEN, 1968
Plate 4, Figure 11

1965 *Coccolithites supracretaceus* REINHARDT, p. 40, Pl. 2, Fig. 7, 8.
1968 *Biscutum? supracretaceum* (REINHARDT, 1965) PERCH-NIELSEN, p. 80, Pl. 23, Fig. 9—12.
1971 *Watznaueria bayacki* WORSLEY, p. 23, Pl. 1, Fig. 21—23.
1971 *„Coccolithites" supracretaceus* REINHARDT, 1965, MANIVIT, p. 137, Pl. 5, Fig. 14—18.

Known range: Upper Berriasian — Turonian.

Genus *Cyclagelosphaera* NOEL, 1965
Type species: *Cyclagelosphaera margereli* NOEL, 1965

Definition: Circular coccoliths with a 2-cycle distal shield and 1-cycle proximal shield.

Cyclagelosphaera margereli NOEL, 1965

1965 *Cyclagelosphaera margereli* NOEL, p. 130, Textfig. 44—46; Pl. 17, Fig. 4—9; Pl. 18, Fig. 1, 2; Pl. 20, Fig. 2—4.
1966 *Cyclagelosphaera margereli* NOEL, 1965, MARESCH, p. 380, Pl. 2, Fig. 5.
1969 *Cyclagelosphaera margereli* NOEL, 1965, BUKRY, p. 29, Pl. 9, Fig. 5, 6.
1971 *Cyclagelosphaera margereli* NOEL, 1965, ROOD, HAY & BARNARD, p. 270, Pl. 5, Fig. 8, 9.
1972 *Cyclagelosphaera margereli* NOEL, 1965, ROTH & THIERSTEIN (in press), Pl. 16, Fig. 19—22.

Known range: Oxfordian — Albian.

Genus *Discorhabdus* NOEL, 1965

Type species: *Rhabdolithus patulus* DEFLANDRE & FERT, 1954

Definition: Two closely appressed circular monocyclic shields surround a small central area. Central area with granules or central process.
Synonym: *Bidiscus* BUKRY, 1969.

Discorhabdus rotatorius (BUKRY, 1969) n. comb.

Plate 5, Fig. 13—16

1968 *Biscutum testudinarium* BLACK, 1959, STRADNER, ADAMIKER & MARESCH, p. 29, Pl. 11, 12.
1969 *Bidiscus rotatorius* BUKRY, p. 27, Pl. 27, Fig. 5—9.
1972 *Bidiscus rotatorius* BUKRY, 1969, ROTH & THIERSTEIN (in press), Pl. 15, Fig. 1—4.

Known range: Lower Berriasian — Campanian.

Discorhabdus biradiatus (WORSLEY, 1971) n. comb.

Plate 6, Fig. 7—11

1971 *Rucinolithus? biradiatus* WORSLEY, p. 1311, Pl. 1, Fig. 51, 52.

Definition: The slightly concave proximal shield consists of 9—11 radial elements which are slightly imbricate dextrally or non-imbricate. The distal shield is composed of 8—11 separate radial or slightly clockwise inclined bars which extend beyond the proximal shield. The bars may meet centrally, they may surround a little perforation, or they may disappear under a small central knob of many crystals.

Remarks: This species differs from all species of the genera *Hayesites* MANIVIT, 1971, and *Rucinolithus* STOVER, 1966, by having a second circular shield.

Remarks: The circular proximal shield is often hardly visible in the light microscope, but the species can be identified by its dark radial bars when viewed in phase contrast.
Maximum diameter: 3—5 μm.
Paratypes: [5034] A 948, [2413] A 949.
Distribution: Southeastern France, Atlantic.
Known range: Upper Valanginian — Upper Barremian.

Genus *Manivitella* THIERSTEIN, 1971

Type species: *Cricolithus pemmatoideus* DEFLANDRE ex MANIVIT, 1965

Definition: Elliptical to circular coccoliths consisting of two narrow shields, leaving a wide central opening.

Manivitella pemmatoidea (DEFLANDRE ex MANIVIT, 1965) THIERSTEIN, 1971

1965 *Cricolithus pemmatoideus* DEFLANDRE ex MANIVIT, p. 192, Pl. 2, Fig. 8.
1971 *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT, 1965) THIERSTEIN, p. 480, Pl. 5, Fig. 1—3.
1972 *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT, 1965) THIERSTEIN, 1971, ROTH & THIERSTEIN (in press), Pl. 11, Fig. 6—13.

Known range: Lower Berriasian — Maastrichtian.

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

Type species: *Cyclococcolithus leptoporus* MURRAY & BLACKMANN var. *inversus* DEFLANDRE & FERT, 1954

Definition: Circular coccoliths with two closely appressed monocyclic shields. Central area closed by a cycle of nummerous subradial bars.

Markalius circumradiatus (STOVER, 1966) PERCH-NIELSEN, 1968

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.
non 1968 *Markalius circumradiatus* (STOVER, 1966) PERCH-NIELSEN, p. 73, Textfig. 36, 37; Pl. 25, Fig. 2—7; Pl. 26, Fig. 1—7.
1969 *Cyclagelosphaera ? chronolitha* BUKRY, p. 29, Pl. 9, Fig. 2—4.
non 1970 *Markalius circumradiatus* (STOVER, 1966) PERCH-NIELSEN 1968, NOEL, p. 93, Pl. 36, Fig. 1—7.

Remarks: The specimens figured as *Markalius circumradiatus* (STOVER, 1966) by PERCH-NIELSEN (1968) and NOEL (1970) belong to *Cyclagelosphaera rotaclypeata* BUKRY, 1969.
Known range: Lower Berriasian — Lower Santonian.

Genus *Sollasites* BLACK, 1967 a

Type species: *Sollasites barringtonensis* BLACK 1967 a
(= *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, 1966)

Definition: Elliptical coccoliths with two monocyclic shields of imbricate radial elements. The shields are connected at their inner margin by a third cycle of subvertical elements. Central area with one crossbar in the short and several crossbars parallel or subparallel to the long axis of the ellipse.
Synonym: *Costacentrum* BUKRY, 1969.

Sollasites horticus (STRADNER, ADAMIKER & MARESCH, 1966) BLACK, 1968

1966 *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH in STRADNER & ADAMIKER, p. 337, Textfig. 1, 2; Pl. 2, Fig. 4.
1966 *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, 1966, MARESCH, p. 378, Pl. 1, Fig. 2.
1968 *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH, 1966) BLACK, p. 798, Pl. 144, Fig. 1, 2.
1968 *Coccolithus horticus* STRADNER, ADAMIKER & MARESCH, 1966, GARTNER, p. 18, Pl. 10, Fig. 2; Pl. 25, Fig. 6—8; Pl. 26, Fig. 1.
1969 *Costacentrum horticum* (STRADNER, ADAMIKER & MARESCH, 1966) BUKRY, p. 44, Pl. 21, Fig. 12; Pl. 22, Fig. 1—4.
1971 *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH, 1966) BLACK, 1968, ROOD, HAY & BARNARD, p. 264, Pl. 3, Fig. 9.
1971 *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH, 1966) ČEPEK & HAY, 1969, MANIVIT, p. 113, Pl. 24, Fig. 1—5.

Remarks: The species has been recorded as follows: Oxfordian: Great Britain (ROOD, HAY & BARNARD, 1971); Albian: Netherlands (STRADNER, ADAMIKER & MARESCH, 1968); Albian — Cenomanian: France (MANIVIT, 1971); Cenomanian: Great Britain (BLACK, 1967), Gulf Coast (GARTNER, 1968); Cenomanian — Santonian: Kansas (ČEPEK & HAY, 1969); Turonian: Austria (MARESCH, 1966); Santonian — Campanian: Texas (BUKRY, 1969). *Sollasites horticus* (STRADNER, ADAMIKER & MARESCH, 1966) has been recognized by the author from Lower Cretaceous (Valanginian) strata of Great Britain, from Aptian and Albian strata in southern France, and from Cenomanian strata of the Atlantic. It seems that the species originated in boreal regions in the Jurassic and spread to the south during the Aptian.
Known range: Oxfordian — Campanian.

Genus *Tubodiscus* n. gen.

Type species: *Tubodiscus verenae* n. sp.

Definition: Two shields are connected by a wide central tube rising distally, producing a distinct collar.

Differentiation: *Heliolithus* BRAMLETTE & SULLIVAN, 1961, consists of two truncate cones and lacks an open central area. *Cylindralithus* BRAMLETTE & MARTINI, 1964, has a perforated plate in the central area. *Diazomatolithus* NOEL, 1965, has only two cycles of elements.

Tubodiscus verenae n. sp.

Plate 2, Figures 1—7

Diagnosis: The central tube consists of about 70 slightly sinistrally imbricate tall elements. The tube ends proximally in two shields with about 70 dextrally imbricate elements with clockwise inclination. The proximal shield is wider than the distal.

Remarks: In the light microscope this species can be distinguished from *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT, 1965) by having the central tube and the shields focused at different levels, and by the fact that the heavy tube produces a bright ring which is not seen in *Manivitella pemmatoidea* (DEFLANDRE ex MANIVIT, 1965).
Maximum diameter: 8,5—10,5 μm, height: 4,5—5,5 μm.
Holotype: [6-374/5] A 950.
Paratype: [6-413/10] A 951.
Type locality: DSDP Leg 1—5 a—6, core catcher.
Distribution: SE-France, Atlantic.
Known range: Valanginian.

Genus *Watznaueria* REINHARDT, 1964

Type species: *Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, 1968

Definition: Elliptical coccoliths with 2- or 3-cycle distal shield and 1-cycle proximal shield.

Synonyms: *Colvillea* BLACK, 1964, *Maslovella* LOEBLICH & TAPPAN, 1966, *Ellipsagelosphaera* NOEL, 1965, *Actinosphaera* NOEL, 1965, *Calolithus* NOEL, 1965.

Watznaueria barnesae (BLACK, 1959)

1959 *Tremalithus barnesae* BLACK in BLACK & BARNES, p. 325, Taf. 9, Fig. 1, 2.
1968 *Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, p. 69, Textfig. 32, Pl. 22, Fig. 1—7; Pl. 23, Fig. 1, 4, 5, 16.
1971 *Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, 1968, REINHARDT, p. 32, Textfig. 31—33.

Known range: Oxfordian — Danian.

Watznaueria biporta BUKRY, 1969

Plate 6, Figure 6

1969 *Watznaueria biporta* BUKRY, p. 32, Pl. 10, Fig. 8—10.
1970 *Coccolithus bornholmensis* FORCHHEIMER, p. 12 (partim), Textfig. 5—7, 12.
1971 *Watznaueria cynthae* WORSLEY, p. 1314, Pl. 2, Fig. 23—25.

Known range: Lower Berriasian — Campanian.

Watznaueria britannica (STRADNER, 1963) REINHARDT, 1964

1963 *Coccolithus britannicus* STRADNER, p. 10, Pl. 1, Fig. 7.
1971 *Watznaueria britannica* (STRADNER, 1963) REINHARDT, 1964, REINHARDT, p. 33, Textfig. 34—36.
1971 *Watznaueria britannica* (STRADNER, 1963) REINHARDT, 1964, ROOD, HAY & BARNARD, p. 269, Pl. 5, Fig. 5.

Known range: Bathonian — Campanian.

Watznaueria communis REINHARDT, 1964

Plate 6, Fig. 17

1964 *Watznaueria communis* REINHARDT, p. 756, Pl. 2, Fig. 5, Textfig. 6.
1971 *Watznaueria communis* REINHARDT, 1964, REINHARDT, p. 34, Textfig. 38.
1971 *Watznaueria communis* REINHARDT 1964, ROOD, HAY & BARNARD, p. 268, Pl. 5, Fig. 1—4.

Known range: Oxfordian — Campanian.

Family Stephanolithionaceae BLACK, 1968

Definition: Coccoliths of various geometric shape with a distal cycle of elements forming a lower or higher cone or cylinder and a proximal cycle of small blocky crystals. Central area open or spanned by radial to subradial bars connected with the proximal cycle.
Homonym and synonym: *Stephanolithionaceae* BUKRY, 1969.

Genus *Corollithion* STRADNER, 1961

Type species: *Corollithion exiguum* STRADNER, 1961

Definition: Coccoliths having a rhomboidal, polygonal, elliptical or circular proximal shield of small blocky crystals and a distal shield of more prismatic non-imbricate elements, flaring slightly distally. Central area spanned by radial to subradial bars.
Synonyms: *Diadozygus* ROOD, HAY & BARNARD, 1971, *Truncatoscaphus* ROOD, HAY & BARNARD, 1971.

Remarks: All species of this genus have a peculiar appearance in the LM due to their shield construction. The classification based on the geometric arrangement of crossbars proposed by ROOD, HAY & BARNARD (1971) is here considered to be of lesser taxonomic importance than similarities in the shield construction.

Corollithion achylosum (STOVER, 1966) THIERSTEIN, 1971

1966 *Chiphragmalithus achylosus* STOVER, p. 137, Pl. 6, Fig. 26; Pl. 7, Fig. 1—3; Pl. 9, Fig. 20.
1968 *Zygolithus achylosus* (STOVER, 1966) STRADNER, ADAMIKER & MARESCH, p. 39 (partim), Pl. 35, Fig. 1.
1971 *Corollithion achylosum* (STOVER, 1966) THIERSTEIN, p. 480, Pl. 8, Fig. 12—16.
1971 *Corollithion signum* STRADNER, 1963, MANIVIT, p. 110 (partim), Pl. 5, Fig. 7—10.

Remarks: *Corollithion achylosum* (STOVER, 1966) differs from *Corollithion signum* STRADNER, 1963, in having an oval rather than hexagonal shape.
Known range: Upper Aptian — Campanian.

Corollithion ellipticum BUKRY, 1969

Plate 1, Figure 20

1968 *Zygolithus geometricus* (GÓRKA, 1957) STRADNER, ADAMIKER & MARESCH, p. 40, Pl. 36; Pl. 37, Fig. 1—4.
1969 *Corollithion ellipticum* BUKRY, p. 40, Pl. 18, Fig. 10—11.
1970 *Corollithion ellipticum* BUKRY, 1969, REINHARDT, p. 43, Textfig. 2; Pl. 1, Fig. 1—3.
1970b *Neococcolithes geometricus* (GÓRKA, 1957) HOFFMANN, p. 182, Pl. 2, Fig. 5, 6; Pl. 3, Fig. 6; Pl. 5, Fig. 5.
1971 *Ellipsochiastus hexserratus* WORSLEY, p. 1308, Pl. 1, Figs. 24—25.
1971 *Actinozygus geometricus* (GÓRKA, 1957) ROOD, HAY & BARNARD, p. 254, Pl. 1, Fig. 6.
1971 *Corollithion geometricum* (GÓRKA, 1957) MANIVIT, p. 91, Pl. 5, Fig. 4, 5.
1971 *Corollithion ellipticum* BUKRY, 1969, THIERSTEIN, p. 480, Pl. 7, Fig. 6.

Remarks: This species occurs in the Oxfordian of Great Britain, in all other localities it is known only from the Upper Aptian to the Maastrichtian.
Known range: Oxfordian — Maastrichtian.

Corollithion rhombicum (STRADNER & ADAMIKER, 1966) BUKRY, 1969

Plate 4, Fig. 6

1966 *Zygolithus rhombicus* STRADNER & ADAMIKER, p. 339, Textfig. 5—7, Pl. 2, Fig. 1.
1967b *Dictyolithus emendatus* LYULYEVA, p. 96, Pl. 4, Fig. 41.
1968 *Zygolithus rhombicus* STRADNER & ADAMIKER, 1966, STRADNER, ADAMIKER & MARESCH, p. 40, Pl. 37, Fig. 5—7; Pl. 38.
1969 *Dictyolithus emendatus* LYULYEVA, 1967, LYULYEVA & LIPNIK, p. 76, Pl. 3, Fig. 20.

1969 *Corollithion rhombicum* (STRADNER & ADAMIKER, 1966) BUKRY, p. 41, Pl. 19, Fig. 2—4.
1970b *Corollithion rhombicum* (STRADNER & ADAMIKER, 1966) BUKRY, 1969, REINHARDT, p. 44.
1971 *Corollithion rhombicum* (STRADNER & ADAMIKER, 1966) BUKRY, 1969, MANIVIT, p. 110, Pl. 5, Fig. 11—13.

Known range: Upper Aptian — Campanian.

Corollithion signum STRADNER, 1963

1963 *Corollithion signum* STRADNER, p. 11, Pl. 1, Fig. 13.
1968 *Zygolithus achylosus* (STOVER, 1966) STRADNER, ADAMIKER & MARESCH (partim), p. 39, Pl. 35, Fig. 5, 6.
1969 *Corollithion signum* STRADNER, 1963, BUKRY, p. 41, Pl. 19, Fig. 5—8.
1971 *Corollithion signum* STRADNER, 1963, MANIVIT (partim), p. 110, Pl. 5, Fig. 6.
1971 *Corollithion signum* STRADNER, 1963, THIERSTEIN, p. 480, Pl. 8, Fig. 18—22.

Differentiation: See differentiation under *Corollithion achylosum* (STOVER) above.
Known range: Upper Albian — Campanian.

Genus *Diadorhombus*, WORSLEY, 1971

Type species: *Diadorhombus rectus* WORSLEY, 1971

Definition: Coccoliths having a rhomboid to square shield, consisting of a distal wall of imbricate elements and a proximal rim of blocky elements connected with the structure in the central area.

Diadorhombus rectus WORSLEY, 1971

1969 *Corollithion* sp. BUKRY & BRAMLETTE, p. 378, Pl. 5, Fig. 13.
1971 *Diadorhombus rectus* WORSLEY, p. 1307, Pl. 1, Fig. 14—20.
1971 *Diadorhombus rectus* WORSLEY, 1971, THIERSTEIN, p. 481, Pl. 7, Fig. 8.

Known range: Valanginian.

Genus *Diazomatolithus* NOEL, 1965

Type species: *Diazomatolithus lehmani* NOEL, 1965

Definition: Subcircular to circular coccoliths with two cycles of elements, the elements of the smaller cycle form a ring or a very low truncated cone, those of the larger one a higher distally flaring cone.

Diazomatolithus lehmani NOEL, 1965

1965 *Diazomatolithus lehmani* NOEL, p. 96, Textfigs. 25—27, Pl. 6, Fig. 6—10.
1971 *Diazomatolithus lehmani* NOEL, 1965, THIERSTEIN, p. 479, Pl. 3, Fig. 11—15.

Known range: Oxfordian — Upper Albian.

Genus *Stephanolithion* DEFLANDRE, 1939

Type species: *Stephanolithion bigoti* DEFLANDRE, 1939

Definition: Circular or polygonal coccoliths, consisting of a cycle of small blocky elements and a second cycle of longish, imbricate elements, some of them extending outwards.

Stephanolithion laffittei NOEL, 1956

1956 *Stephanolithion laffittei* NOEL, p. 318, Pl. 2, Fig. 5.
1970 *Stephanolithion laffittei* NOEL, 1956, NOEL, p. 85, Pl. 29, Fig. 1—11; Pl. 31, Fig. 4.
1971 *Stephanolithion laffittei* NOEL, 1956, REINHARDT, . 28.
1971 *Stephanolithion laffittei* NOEL, 1956, MANIVIT, p. 108, Pl. 23, Fig. 14—18.
1972 *Stephanolithion laffittei* NOEL, 1956, ROTH & THIERSTEIN (in press), Pl. 16, Fig. 6—11.

Known range: Tithonian — Maastrichtian.

Family *Braarudosphaeraceae* DEFLANDRE, 1947

Definition: Coccoliths consisting of five connected radially arranged crystal plates.

Genus *Braarudosphaera* DEFLANDRE, 1947

Type species: *Pontosphaera bigelowi* GRAN & BRAARUD, 1935

Definition: Coccoliths with five quadrangular crystal plates.

Remarks: *Micrantholithus* DEFLANDRE, 1950 has triangular crystal plates with the marginal edges straight or concave.

Braarudosphaera africana STRADNER, 1961

1961 *Braarudosphaera africana* STRADNER, p. 82, Textfig. 44.
1968 *Braarudosphaera africana* STRADNER, 1961, STRADNER, ADAMIKER & MARESCH, p. 44, Pl. 46.
?1969 *Braarudosphaera africana* STRADNER, 1961, BUKRY, p. 62, Pl. 36, Fig. 9, 10.
1971 *Braarudosphaera africana* STRADNER, 1961, MANIVIT, p. 126.
1972 *Braarudosphaera africana* STRADNER, ROTH & THIERSTEIN (in press), Pl. 16, Fig. 18.

Known range: Upper Aptian — Upper Albian.

Braarudosphaera bigelowi (GRAN & BRAARUD, 1935) DEFLANDRE, 1947

1935 *Pontosphaera bigelowi* GRAN & BRAARUD, p. 389, Textfig. 67.
1947 *Braarudosphaera bigelowi* (GRAN & BRAARUD, 1935) DEFLANDRE, p. 439, Textfig. 1—5.
1970 *Braarudosphaera bigelowi* (GRAN & BRAARUD, 1935) DEFLANDRE, 1947, in REINHARDT, p. 21.
1971 *Braarudosphaera bigelowi* (GRAN & BRAARUD, 1935) DEFLANDRE, 1947, MANIVIT, p. 125, Pl. 3, Fig. 13—16.

Remarks: Intermediate forms between *Micrantholithus hoschulzi* (REINHARDT, 1966 a) and typical *Braarudosphaera bigelowi* (GRAN & BRAARUD, 1935) have been observed from lowermost Berriasian to Cenomanian. When their outer margin of the single elements is distinctly convex, they are here included in *Braarudosphaera bigelowi* (GRAN & BRAARUD, 1935).
Known range: Lower Berriasian — recent.

Genus *Micrantholithus* DEFLANDRE, 1950

Type species: *Micrantholithus flos* DEFLANDRE, 1950

Definition: Coccoliths with five triangular crystal plates.

Remarks: Marginal edges of the triangular elements may be straight or concave, but never convex as with *Braarudosphaera* DEFLANDRE, 1947.

Micrantholithus hoschulzi (REINHARDT, 1966 a) THIERSTEIN, 1971

1966a *Braarudosphaera hoschulzi* REINHARDT, p. 42, Pl. 21, Fig. 3.
1971 *Braarudosphaera hoschulzi* REINHARDT, 1966, WORSLEY, p. 1309.
1971 *Micrantholithus hoschulzi* (REINHARDT, 1966) THIERSTEIN, p. 482, Pl. 1, Fig. 12—15.

Known range: Upper Berriasian — Lower Aptian.

Micrantholithus obtusus STRADNER, 1963

1963 *Micrantholithus obtusus* STRADNER, p. 11, Pl. 6, Fig. 11, 11 a.
1971 *Micrantholithus obtusus* STRADNER, 1963, THIERSTEIN, p. 482, Pl. 5, Fig. 9.

Known range: Upper Berriasian — Lower Aptian.

Family *Lithastrinaceae*, n. fam.

Definition: Coccoliths with one or more cycles of 6 or more imbricate elements. Radial cross-polarized extinction lines parallel to nicols.

Genus *Hayesites* MANIVIT, 1971

Type species: *Hayesites albiensis* MANIVIT, 1971

Definition: Starlike coccoliths, consisting of a proximal cycle of 7—8 elongated radial elements meeting centrally, and one or more smaller proximal cycles of elements.

Hayesites albiensis MANIVIT, 1971

Plate 6, Figures 1—5

1971 *Hayesites albiensis* MANIVIT, p. 138, Pl. 14, Fig. 1—7.

Remarks: This species is distinguished from its evolutionary ancestor *Rucinolithus irregularis* THIERSTEIN, 1972, by having much longer and narrower radial elements.
Distribution: France, Atlantic.

Known range: Albian.

Hayesites bulbus THIERSTEIN, 1972

Plate 4, Figure 16

1972 *Hayesites bulbus* THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 2, Fig. 20—23.

Hypotype: [2425] A 952.
Distribution: Southeastern France, Atlantic.

Known range: Upper Hauterivian — Upper Aptian.

Genus *Lithastrinus* STRADNER, 1962

Type species: *Lithastrinus grilli* STRADNER, 1962

Definition: Circular coccoliths having several cycles of imbricated radial elements arranged in two partial cones joined at truncate apices and having concave basal ends. The elements of the distally flaring cycle are offset from the elements of the proximally flaring cycle when viewed along the axis of rotation.

Lithastrinus floralis STRADNER, 1962

1962 *Lithastrinus floralis* STRADNER, p. 370, Pl. 2, Fig. 6—11.
1970b *Lithastrinus floralis* STRADNER, 1962, REINHARDT, p. 71, Text-fig. 69, 70.
1971 *Lithastrinus floralis* STRADNER, 1962, THIERSTEIN p. 481, Pl. 7, Fig. 1—5.

Known range: Upper Aptian — Campanian.

Lithastrinus septentrionalis STRADNER, 1963

Plate 4, Figures 7—10

1963 *Lithastrinus septentrionalis* STRADNER, p. 177, Pl. 2, Fig. 7.
1968 *Lithastrinus tesselatus* STRADNER, ADAMIKER & MARESCH, p. 43, Textfig. 7/1, 7/2; Pl. 43, 44.
1970b *Lithastrinus septentrionalis* STRADNER, 1963, REINHARDT, p. 72, Textfig. 73, 74; Pl. 5, Fig. 6, 7; Pl. 6, Fig. 1.

Known range: Hauterivian — Albian.

Genus *Polycostella* THIERSTEIN, 1971

Type species: *Polycostella senaria* THIERSTEIN, 1971

Definition: Flat conical pile of several cycles of radially organized elements forming six to eight radial ridges or sutures.

Polycostella beckmannii THIERSTEIN, 1971

1971 *Polycostella beckmannii* THIERSTEIN, p. 483, Pl. 2, Fig. 5—16.

Distribution: Southeastern France, Switzerland.

Known range: Lower Tithonian — Lower Berriasian.

Polycostella senaria THIERSTEIN, 1971

1971 *Polycostella senaria* THIERSTEIN, p. 484, Pl. 1, Fig. 1—6.

Distribution: Southeastern France, Algeria.

Known range: Lower Berriasian — Upper Berriasian.

Genus *Rucinolithus* STOVER, 1966, emend.

Type species: *Rucinolithus hayi* STOVER, 1966

Definition: Coccoliths of one cycle of 6 or more imbricate radial crystal plates. With or without central process.

Rucinolithus irregularis THIERSTEIN, 1972

Plate 3, Figures 1—14

1972 *Rucinolithus irregularis* THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 2, Fig. 10—19.

Diagnosis: The original specific description was restricted to the proximal view. Study of additional specimens makes it possible to describe this species more precisely: A species of the genus *Rucinolithus* STOVER, 1966, with 6—11 elements of variable size, dextrally imbricated, flat or forming a low cone when viewed from the distal side. A short central process built of very small, blocky crystals may be present in the center. Very often the process has fallen off, leaving a small perforation. The proximal side shows the outward sloping elements.

Differentiation: *Rucinolithus irregularis* THIERSTEIN, 1972 seems to be the earliest species of an evolutionary lineage leading to *Hayesites albiensis* MANIVIT, 1971, as additional cycles of elements are added distally and the elements become narrower and longer. *Rucinolithus irregularis* THIERSTEIN, 1972, differs from *Rucinolithus wisei* THIERSTEIN, 1971, in having these elements sinistrally imbricate, whereas the elements of the latter show dextral imbrication.
Hypotypes: [4798] A 953, [4815] A 955, [4789] A 954.
Distribution: Southeastern France, Switzerland, Atlantic.

Known range: Lower Aptian — Upper Albian.

Rucinolithus wisei THIERSTEIN, 1971

1971 *Rucinolithus wisei* THIERSTEIN, p. 482, Pl. 4, Fig. 11—15.

Distribution: Southeastern France, Switzerland, Atlantic.

Known range: Lower Berriasian — Upper Valanginian.

Family *Microrhabdulaceae* DEFLANDRE, 1963

Definition: Rod-like calcareous nannofossils having various microstructures.

Genus *Lithraphidites* DEFLANDRE, 1963

Type species: *Lithraphidites carniolensis* DEFLANDRE 1963

Definition: Calcareous rods with central channel, a cruciform cross-section and with elements of identical optical orientation.

Lithraphidites alatus THIERSTEIN, 1972

1972 *Lithraphidites alatus* THIERSTEIN in ROTH & THIERSTEIN (in press), Pl. 3, Fig. 1—8.

Distribution: Atlantic, Switzerland.
Known range: Cenomanian.

Lithraphidites bollii (THIERSTEIN, 1971) n. comb.

1971 *Microrhabdulus bollii* THIERSTEIN, p. 481, Pl. 3, Fig. 6—10.

Remarks: The emendation of the genus *Microrhabdulus* DEFLANDRE, 1959, by DEFLANDRE, 1963, excludes *Microrhabdulus bollii* THIERSTEIN, 1971, from that genus, because its cross section is not circular.
Distribution: Southeastern France, Switzerland, Atlantic.
Known range: Lower Hauterivian — Lower Barremian.

Lithraphidites carniolensis DEFLANDRE, 1963

1963 *Lithraphidites carniolensis* DEFLANDRE, p. 3486, Textfig. 1—10.

1964 *Lithraphidites carniolensis* DEFLANDRE, 1963, STRADNER, ADAMIKER & MARESCH, p. 45, Pl. 47.
1971 *Lithraphidites carniolensis* DEFLANDERE, 1963, MANIVIT, p. 130, Pl. 16, Fig. 13—15.

Known range: Lower Berriasian — Maastrichtian.

Family *Calciosoleniaceae* KAMPTNER, 1927, emend. DEFLANDRE, 1952

Definition: Coccosphere fusiform, covered by oblique lozenge-shaped plates.

Genus *Scapholithus* DEFLANDRE & FERT, 1954

Type species: *Scapholithus fossilis* DEFLANDRE & FERT, 1954

Definition: Elongated parallelepipedic frame with the central area spanned by parallel transverse bars.

Scapholithus fossilis DEFLANDRE & FERT, 1954

1954 *Scapholithus fossilis* DEFLANDRE & FERT, p. 51, Pl. 8, Fig. 12, 16, 17.
1969 *Scapholithus fossilis* DEFLANDRE, 1954, BUKRY, p. 64, Pl. 38, Fig. 5—8.

Known range: Upper Albian — Pliocene.

Incertae sedis

Genus *Cretaturbella* THIERSTEIN, 1971

Type species: *Cretaturbella rothii* THIERSTEIN, 1971

Cretaturbella rothii THIERSTEIN, 1971

1965 *Particule calcaire* in NOEL, Pl. 28, Fig. 5, 7.
1971 *Cretaturbella rothii* THIERSTEIN, p. 483, Pl. 3, Fig. 1—5.
1972 *Cretaturbella rothii* THIERSTEIN, 1971, ROTH & THIERSTEIN (in press), Pl. 3, Fig. 9, 12—14.

Known range: Lower Tithonian — Lower Aptian.

Genus *Micula* VEKSHINA, 1959

Type species: *Micula decussata* VEKSHINA, 1959

Micula infracretacea n. sp.

Plate 1, Figures 1—19

Diagnosis: Specimens of this species are characterized by having two sets of flat crystal plates, one set piercing the other at an obtuse angle.
Remarks: In the light microscope this species has a subrectangular to suboval shape with 4—6 radial sutures. Assignment of this peculiar form to the genus *Micula* VEKSHINA, 1959, is provisional.
Maximum diameter: 5—10 μm.
Holotype: [5046] A 956.
Paratypes: [5041] A 959, [5042] A 958, [5048] A 957.
Distribution: France, Switzerland, Atlantic, Pacific.
Known range: Upper Valanginian — Upper Aptian.

Genus *Nannoconus* KAMPTNER, 1931, emend. FARINACCI, 1964

Type species: *Lagena colomi* DE LAPPARENT, 1931

Nannoconus bermudezi BRONNIMANN, 1955

1955 *Nannoconus bermudezi* BRONNIMANN, p. 37, Textfig. 2 d—e, Pl. 2, Fig. 1, 24.

Known range: Lower Berriasian — Upper Aptian.

Nannoconus bronnimanni TREJO, 1959

1959 *Nannoconus bronnimanni* TREJO, p. 130, Textfig. 1.
1960 *Nannoconus bronnimanni* TREJO, 1959, TREJO, p. 280, Textfig. 2.

Known range: Upper Tithonian — Lower Aptian.

Nannoconus bucheri BRONNIMANN, 1955

1955 *Nannoconus bucheri* BRONNIMANN, p. 39, Textfig. 2 k—n, Pl. 1, Fig. 1—3, 5—7.
1960 *Nannoconus bucheri* BRONNIMANN, TREJO, p. 297, Textfig. 10, 11; Pl. 1, Fig. 9.
1963 *Nannoconus bucheri* BRONNIMANN, STRADNER, p. 8, Pl. 3, Fig. 9.

Known range: Lower Hauterivian — Upper Aptian.

Nannoconus colomi (DE LAPPARENT, 1931) KAMPTNER, 1938

1925 „*Embryons de Lagena*" DE LAPPARENT, p. 105, Textfig. 1.
1928 ? „Embriones de *Lagena*" COLOM, p. 394, Pl. 10, Fig. 1—4.
1931 ? „Embriones de *Lagena*" COLOM, p. 544, Pl. 6, Fig. 4—5.
1931 *Lagena colomi* DE LAPPARENT, p. 223.
1931 *Nannoconus steinmanni* KAMPTNER, p. 289, Textfig. 2, 3.
1938 *Nannoconus steinmanni* KAMPTNER, 1931, KAMPTNER, p. 289, Textfig. 1—3.
1938 *Nannoconus colomi* (DE LAPPARENT, 1931) KAMPTNER, p. 252.
1945 *Nannoconus colomi* (DE LAPPARENT, 1931) KAMPTNER, 1938, COLOM, p. 129, Textfig. 2.
1948 *Nannoconus colomi* (DE LAPPARENT, 1931) KAMPTNER, 1938, COLOM, p. 252, Textfig. 7.
1955 *Nannoconus colomi* (DE LAPPARENT, 1931) COLOM, 1945, BRONNIMANN, p. 35, Textfig. 3 n—r; Pl. 2, Fig. 9, 17.
1955 *Nannoconus steinmanni* KAMPTNER, 1931, BRONNIMANN, p. 36, Textfig. 2 a—c; Pl. 1, Fig. 16; Pl. 2, Fig. 10, 15.
1964 *Nannoconus colomi* (DE LAPPARENT, 1931) KAMPTNER, 1938, FARINACCI, p. 174, Pl. 32, Fig. 1—4.
1971 *Nannoconus colomi* (DE LAPPARENT, 1931) KAMPTNER, 1938, THIERSTEIN, p. 483, Pl. 3, Fig. 16.

Known range: Upper Tithonian — Upper Barremian.

Nannoconus globulus BRONNIMANN, 1955

1955 *Nannoconus globulus* BRONNIMANN, p. 37, Textfig. 3 a—h, Pl. 2, Fig. 13, 18, 23.

Known range: Lower Berriasian — Upper Aptian.

Nannoconus kamptneri BRONNIMANN, 1955

1955 *Nannoconus kamptneri* BRONNIMANN, p. 37, Textfig. 2 i—m, Pl. 2 Fig. 14, 16, 20, 21.

Known range: Upper Hauterivian — Upper Aptian.

Nannoconus minutus BRONNIMANN, 1955

1955 *Nannoconus minutus* BRONNIMANN, p. 38, Textfig. 2 t—u, Pl. 2, Fig. 4, 6, 8, 12.

Known range: Lower Berriasian — Cenomanian.

Nannoconus truitti BRONNIMANN, 1955

1955 *Nannoconus truitti* BRONNIMANN, p. 38, Pl. 2, Fig. 2—5, 7; Textfig. 2 f—j.
1960 *Nannoconus truitti* BRONNIMANN, 1955, TREJO, p. 298, Textfig. 12, 13, Pl. 2, Fig. 6—9.
1960 *Nannoconus truitti* BRONNIMANN, 1955, DEFLANDRE et DEFLANDRE-RIGAUD, p. 177, Pl. 1, Fig. 1—6.

Known range: Lower Berriasian — Cenomanian.

Nannoconus wassalli BRONNIMANN, 1955

1955 *Nannoconus wassalli* BRONNIMANN, p. 39, Textfig. 2 o—s, Pl. 1, Fig. 4, 8, 9, 15, 17, 21; Pl. 2, Fig. 22.
1960 *Nannoconus wassalli* BRONNIMANN, TREJO, p. 295, Textfig. 9; Pl. 1, Fig. 8.

Known range: Lower Hauterivian — Upper Aptian.

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INDEX

(Rejected names enclosed within parenthesis)

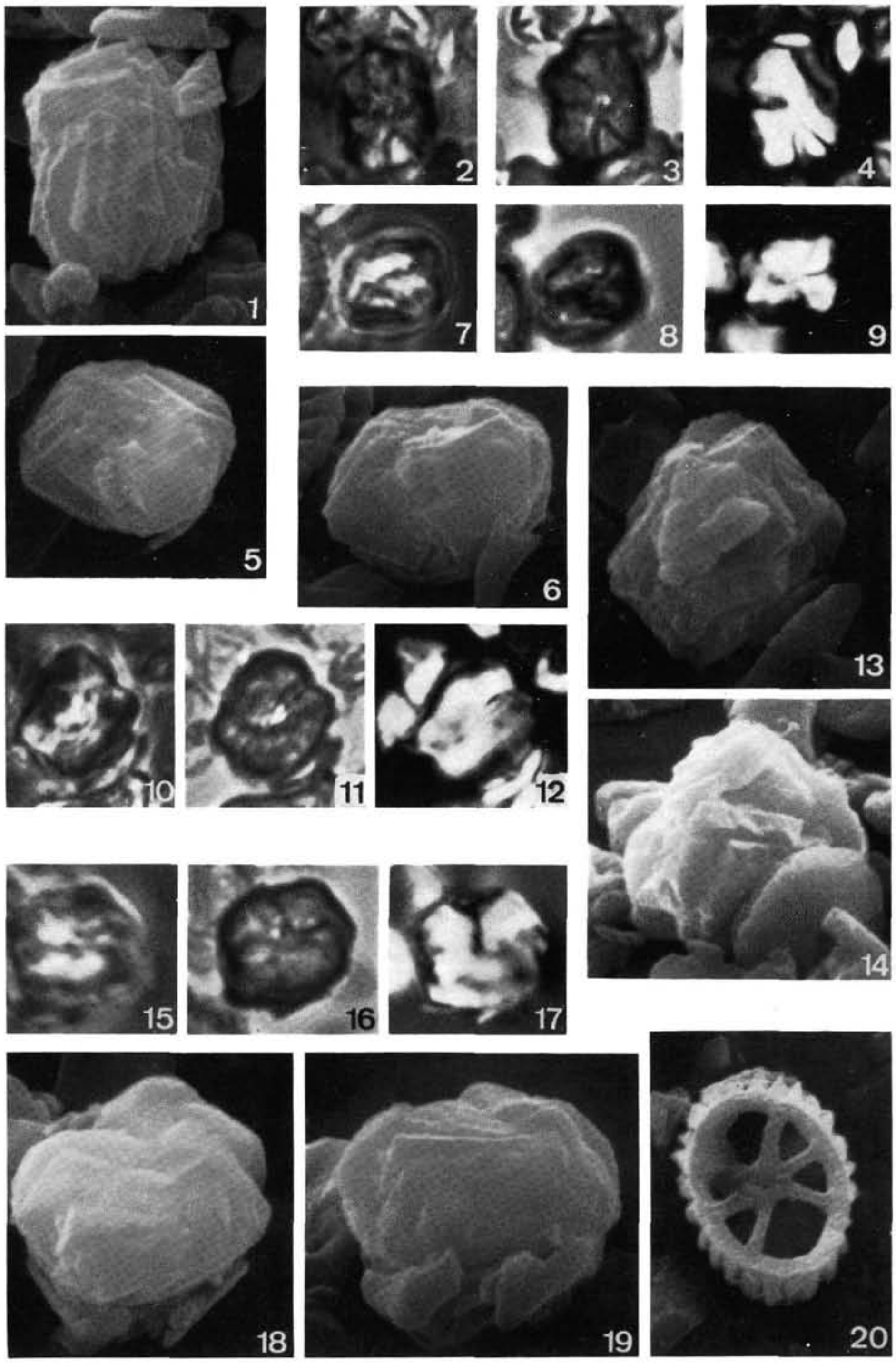

Fig. 1—19 *Micula infracretacea* n. sp.
DSDP Leg 1—4—4—1, 110 cm

Fig. 1 Scanning electron micrograph, 6000×, paratype [5042] A 958.
Fig. 2 Phase contrast, 3200×, same specimen as Fig. 1.
Fig. 3 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 4 Cross-polarized light, 3200×, same specimen as Fig. 1.
Fig. 5 Scanning electron micrograph, 6500×, holotype [5046] A 956.
Fig. 6 Scanning electron micrograph, 6500×, 45° inclined, same specimen as Fig. 5.
Fig. 7 Phase contrast, 3200×, same specimen as Fig. 5.
Fig. 8 Transmitted light, 3200×, same specimen as Fig. 5.
Fig. 9 Cross-polarized light, 3200×, same specimen as Fig. 5.
Fig. 10 Phase contrast, 3200×, same specimen as Fig. 13.
Fig. 11 Transmitted light, 3200×, same specimen as Fig. 13.
Fig. 12 Cross-polarized light, 3200×, same specimen as Fig. 13.
Fig. 13 Scanning electron micrograph, 6500×, paratype [5048] A 957.
Fig. 14 Scanning electron micrograph, 6500×, 45° inclined, same specimen as Fig. 13.
Fig. 15 Phase contrast, 3200×, same specimen as Fig. 18.
Fig. 16 Transmitted light, 3200×, same specimen as Fig. 18.
Fig. 17 Cross-polarized light, 3200×, same specimen as Fig. 18.
Fig. 18 Scanning electron micrograph, 6500×, paratype [5041] A 959.
Fig. 19 Scanning electron micrograph, 7000×, 45° inclined, same specimen as Fig. 18.

Fig. 20 *Corollithion ellipticum* Bukry, 1969
DSDP Leg 1—4—3—2, 25 cm
Scanning electron micrograph of the proximal side, 6500×.

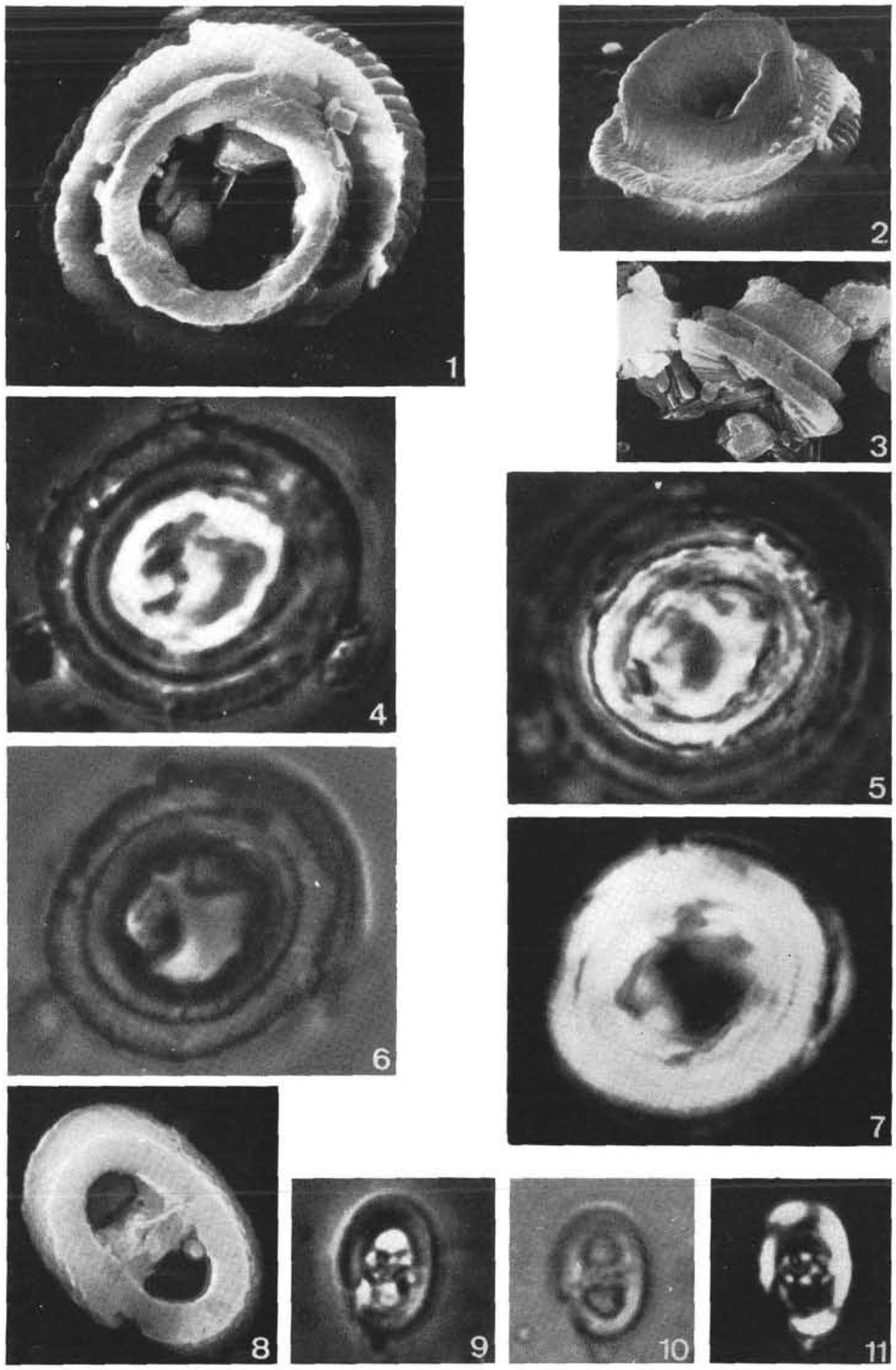

Fig. 1—7 *Tubodiscus verenae* n. sp.
DSDP Leg 1—5 A—6, core catcher

Fig. 1 Scanning electron micrograph of the distal side, 4000×, holotype [6-374/5] A 950.
Fig. 2 Scanning electron micrograph of the distal side, 60° inclined, 2800×, same specimen as Fig. 1.
Fig. 3 Scanning electron micrograph, side view, 2500×, paratype [6-413/10] A 951.
Fig. 4 Phase contrast, low focus, 3200×, same specimen as Fig. 1.
Fig. 5 Phase contrast, high focus, 3200×, same specimen as Fig. 1.
Fig. 6 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 7 Cross-polarized light, 3200×, same specimen as Fig. 1.

Fig. 8—11 *Zygodiscus elegans* GARTNER, 1968, emend. BUKRY, 1969
DSDP Leg 1—4 A—2—2, 120 cm

Fig. 8 Scanning electron micrograph of the proximal side, 7000×.
Fig. 9 Phase contrast, 3200×, same specimen as Fig. 8.
Fig. 10 Transmitted light, 3200×, same specimen as Fig. 8.
Fig. 11 Cross-polarized light, 3200×, same specimen as Fig. 8.

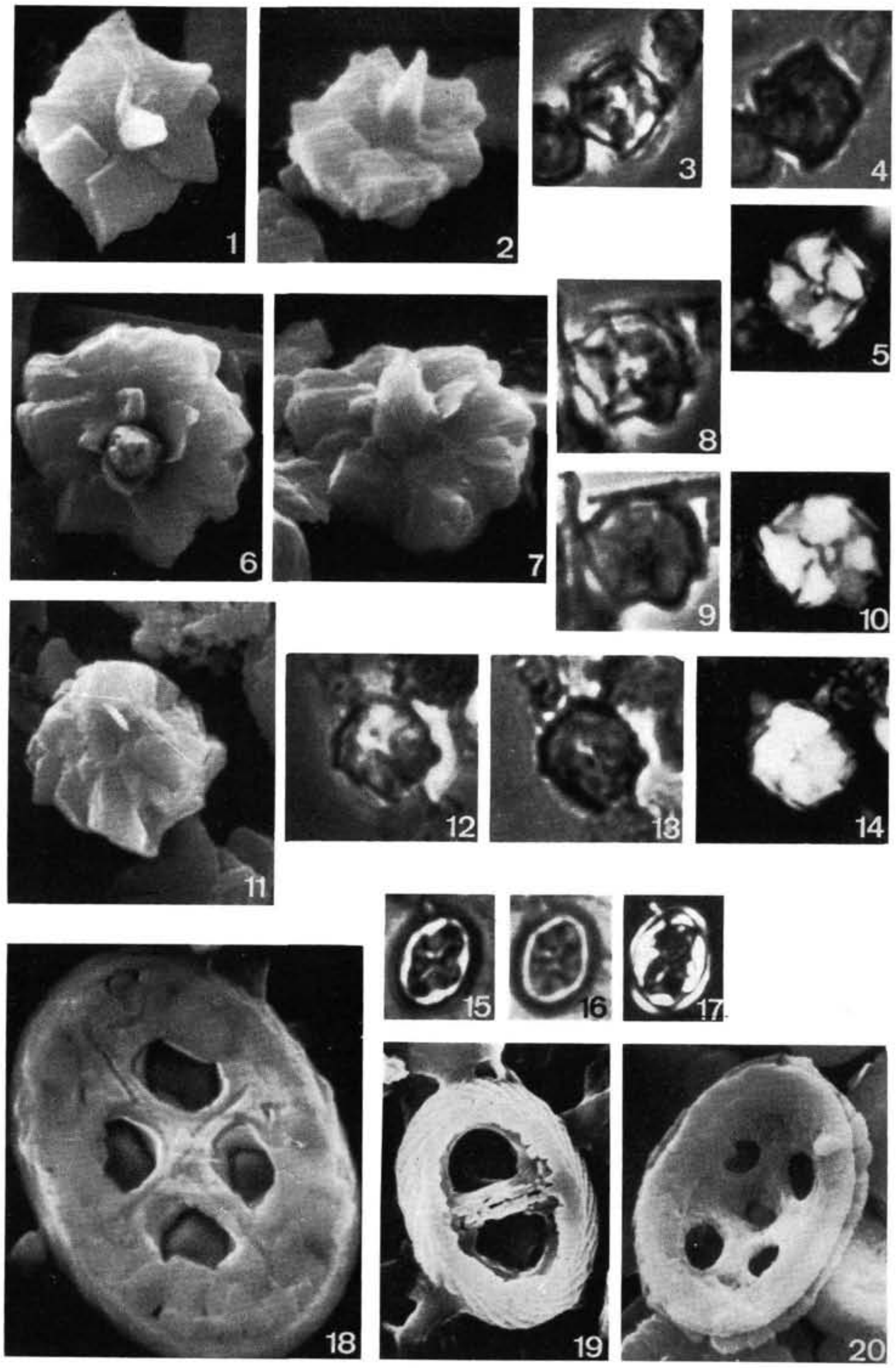

Fig. 1—14 *Rucinolithus irregularis* THIERSTEIN, 1972
Gargas, locality B, sample Th 69/329

Fig. 1 Scanning electron micrograph of the distal side, 6500×, hypotype [4789] A 954.
Fig. 2 Scanning electron micrograph of the distal side, 50° inclined, 6500×, same specimen as Fig. 1.
Fig. 3 Phase contrast, 3200×, same specimen as Fig. 1.
Fig. 4 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 5 Cross-polarized light, 3200×, same specimen as Fig. 1.
Fig. 6 Scanning electron micrograph of the distal side, 6500×, hypotype [4815] A 955.
Fig. 7 Scanning electron micrograph of the distal side, 45° inclined, 6500×, same specimen as Fig. 6.
Fig. 8 Phase contrast, 3200×, same specimen as Fig. 6.
Fig. 9 Transmitted light, 3200×, same specimen as Fig. 6.
Fig. 10 Cross-polarized light, 3200×, same specimen as Fig. 6.
Fig. 11 Scanning electron micrograph of the proximal side, 6500×, hypotype [4798] A 953.
Fig. 12 Phase contrast, 3200×, same specimen as Fig. 11.
Fig. 13 Transmitted light, 3200×, same specimen as Fig. 11.
Fig. 14 Cross-polarized light, 3200×, same specimen as Fig. 11.

Fig. 15—18 *Vagalapilla matalosa* (STOVER, 1966) n. comb.
DSDP Leg 1—4 A—2—1, 120 cm

Fig. 15 Phase contrast, 3200×, same specimen as Fig. 17.
Fig. 16 Transmitted light, 3200×, same specimen as Fig. 17.
Fig. 17 Cross-polarized light, 3200×, same specimen as Fig. 17.
Fig. 18 Scanning electron micrograph of the proximal side, 13000×, hypotype [1126] A 940.

Fig. 19 *Zygodiscus diplogrammus* (DEFLANDRE & FERT, 1954) GARTNER, 1968
DSDP Leg 1—4 A—2—1, 120 cm
Scanning electron micrograph of the proximal side, 5000×.

Fig. 20 *Podorhabdus dietzmanni* (REINHARDT, 1965) REINHARDT, 1967
DSDP Leg 14—135—9—2, 69 cm
Scanning electron micrograph of the proximal side, 6500×.

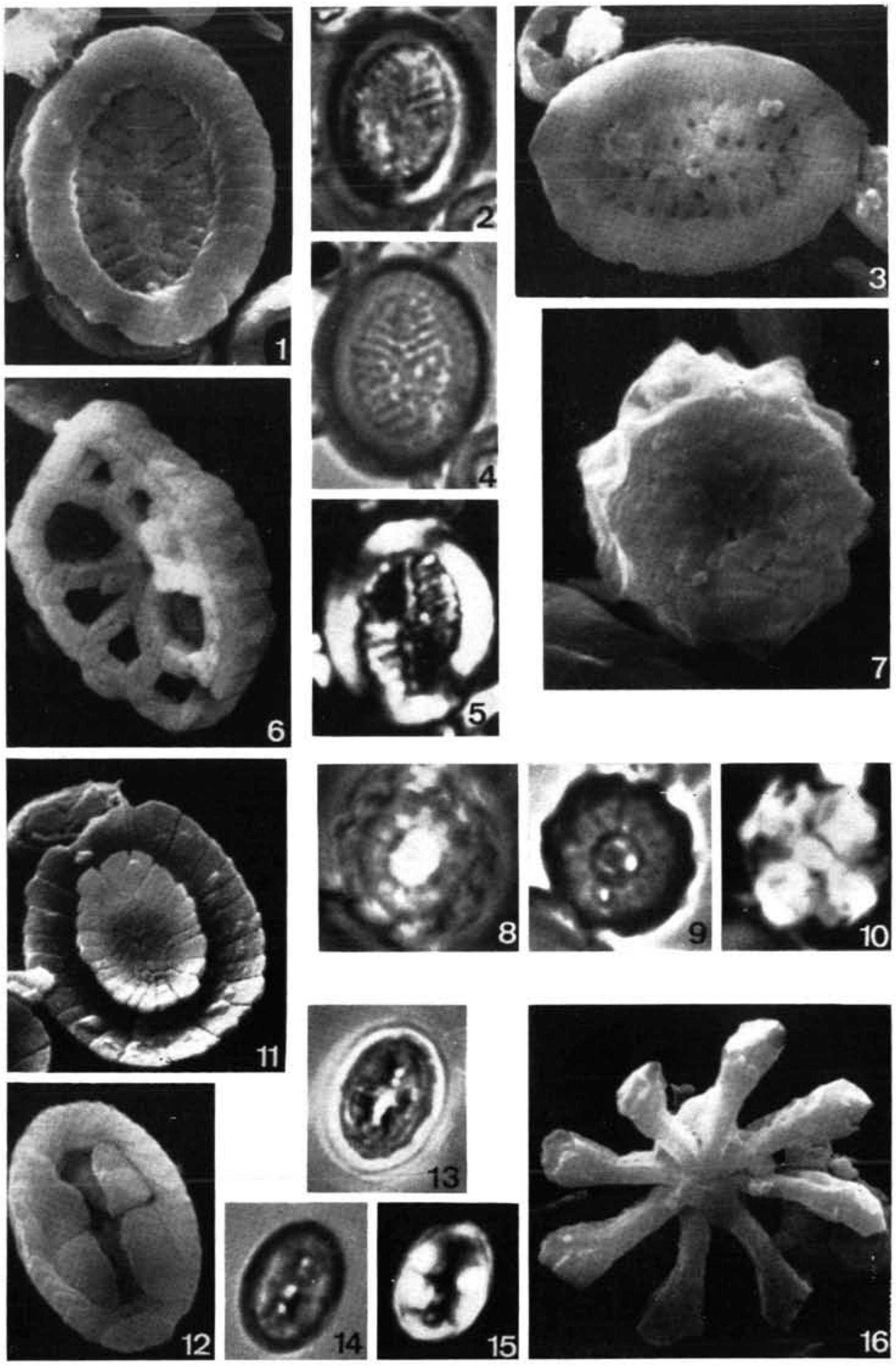

Fig. 1—5 *Cretarhabdus loriei* GARTNER, 1968
DSDP Leg 14—137—16—3, 94 cm

Fig. 1 Scanning electron micrograph of the proximal side, 4500×.
Fig. 2 Phase contrast, 3200×, same specimen as Fig. 1.
Fig. 3 Scanning electron micrograph of the distal side, 4500×.
Fig. 4 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 5 Cross-polarized light, 3200×, same specimen as Fig. 1.

Fig. 6 Corollithion rhombicum (STRADNER & ADAMIKER, 1966), BUKRY, 1969
DSDP Leg 1—4 A—2—1, 120 cm

Scanning electron micrograph of the proximal side, 13000×.

Fig. 7—10 *Lithastrinus septentrionalis* STRADNER, 1963
Gargas, locality B, sample Th 69/329

Fig. 7 Scanning electron micrograph, 6000×.
Fig. 8 Phase contrast, 3200×, same specimen as Fig. 7.
Fig. 9 Transmitted light, 3200×, same specimen as Fig. 7.
Fig. 10 Cross-polarized light, 3200×, same specimen as Fig. 7.

Fig. 11 *Biscutum supracretaceum* (REINHARDT, 1965), PERCH-NIELSEN, 1968
DSDP Leg 14—144 A—5—1, 125 cm

Scanning electron micrograph of the proximal side, 40° inclined, 6500×.

Fig. 12—15 *Tranolithus orionatus* REINHARDT, 1966 a
DSDP Leg 14—137—16—3, 94 cm

Fig. 12 Scanning electron micrograph of the distal side, 6500×.
Fig. 13 Phase contrast, 3200×, same specimen as Fig. 12.
Fig. 14 Transmitted light, 3200×, same specimen as Fig. 12.
Fig. 15 Cross-polarized light, 3200×, same specimen as Fig. 12.

Fig. 16 *Hayesites bulbus* THIERSTEIN, 1972
DSDP Leg 1—4—4—1, 11 cm

Scanning electron micrograph of the proximal side, 6500×, hypotype [2425] A 952.

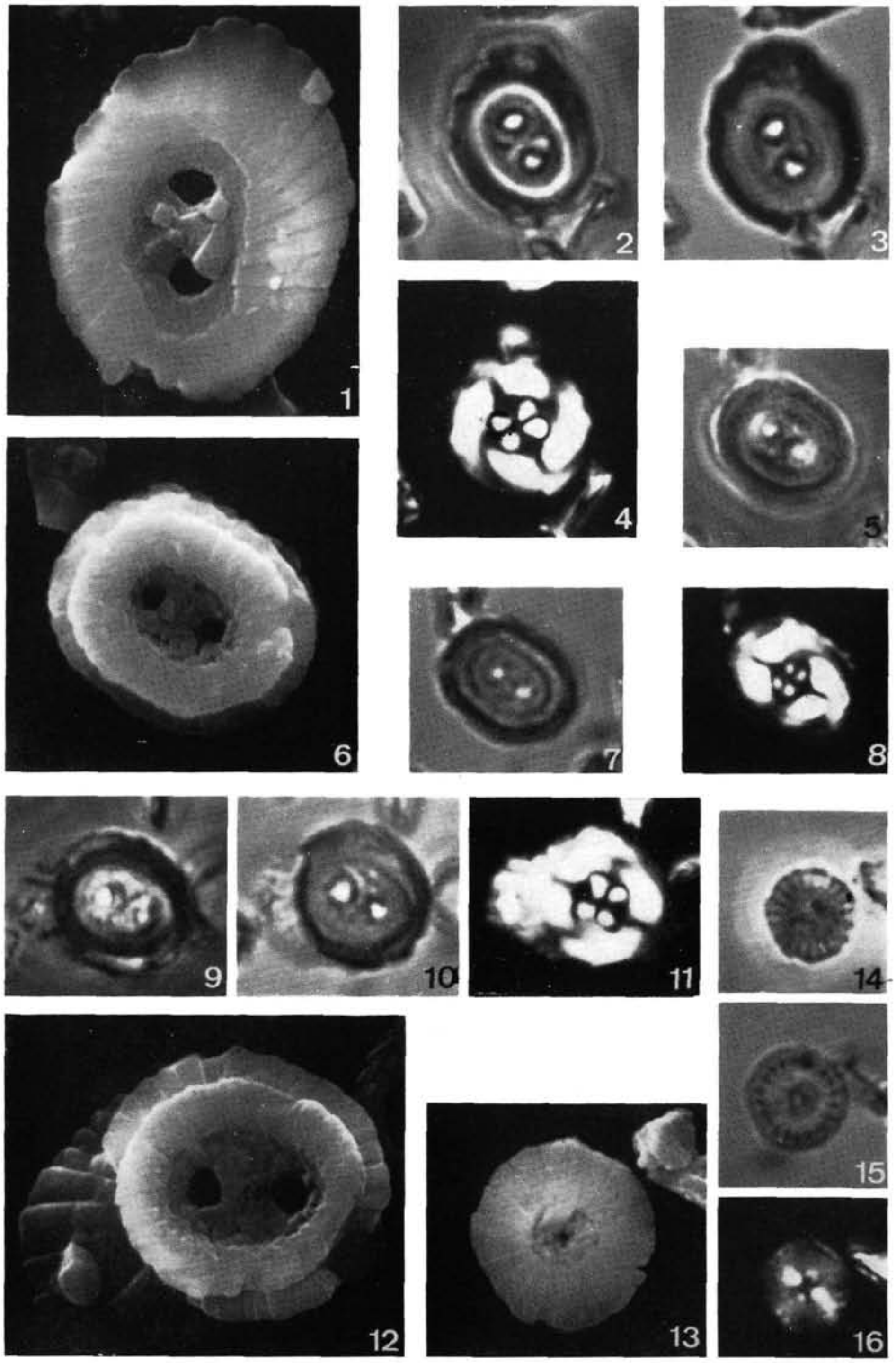

Fig. 1—12 *Flabellites biforaminis* n. sp.
DSDP Leg 14—137—16—3, 94 cm

Fig. 1 Scanning electron micrograph of the distal side, 6500×, holotype [5016] A 945.
Fig. 2 Phase contrast, 3200×, same specimen as Fig. 1.
Fig. 3 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 4 Cross-polarized light, 3200×, same specimen as Fig. 1.
Fig. 5 Phase contrast, 3200×, same specimen as Fig. 6.
Fig. 6 Scanning electron micrograph of the proximal side, 6500×, paratype [4999] A 946.
Fig. 7 Transmitted light, 3200×, same specimen as Fig. 6.
Fig. 8 Cross-polarized light, 3200×, same specimen as Fig. 6.
Fig. 9 Phase contrast, 3200×, same specimen as Fig. 12.
Fig. 10 Transmitted light, 3200×, same specimen as Fig. 12.
Fig. 11 Cross-polarized light, 3200×, same specimen as Fig. 12.
Fig. 12 Scanning electron micrograph of the proximal side, 6500×, paratype [5024] A 947.

Fig. 13—16 *Discorhabdus rotatorius* (BUKRY, 1969) n. comb.
DSDP Leg 14—137—16—3, 94 cm

Fig. 13 Scanning electron micrograph of the distal side, 6500×.
Fig. 14 Phase contrast, 3200×, same specimen as Fig. 13.
Fig. 15 Transmitted light, 3200×, same specimen as Fig. 13.
Fig. 16 Cross-polarized light, 3200×, same specimen as Fig. 13.

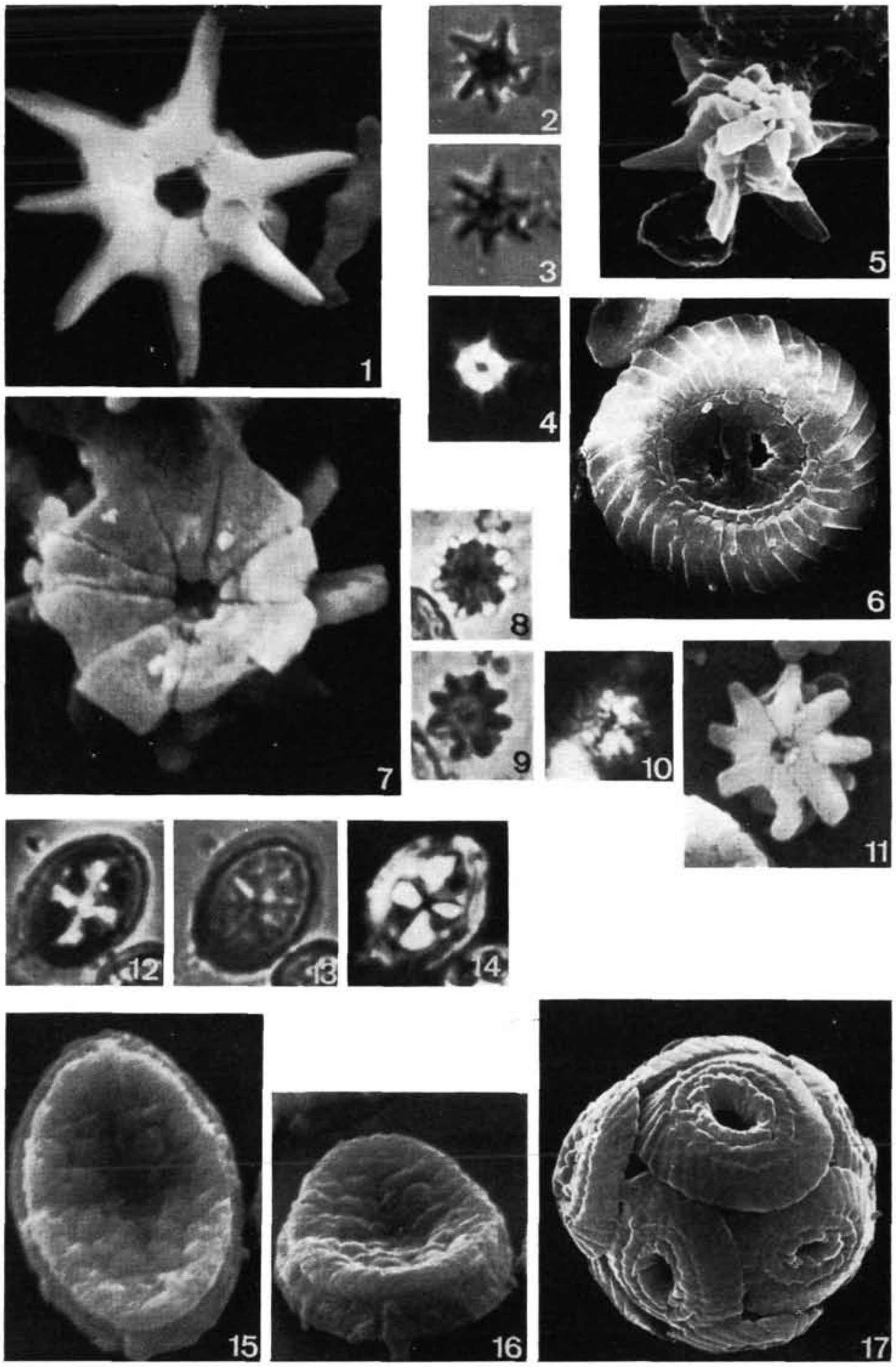

Fig. 1—5 *Hayesites albiensis* Manivit, 1971
DSDP Leg 1—4—3—2, 25 cm

Fig. 1 Scanning electron micrograph of the proximal side, 13000×.
Fig. 2 Phase contrast, 3200×, same specimen as Fig. 1.
Fig. 3 Transmitted light, 3200×, same specimen as Fig. 1.
Fig. 4 Cross-polarized light, 3200×, same specimen as Fig. 1.
Fig. 5 Scanning electron micrograph of the distal side, 10000×.

Fig. 6 *Watznaueria biporta* Bukry, 1969
DSDP Leg 1—5 A—6, core catcher

Scanning electron micrograph of a coccosphere, 4000×.

Fig. 7—11 *Discorhabdus biradiatus* (Worsley, 1971) n. comb.
DSDP Leg 1—4—4—1, 11 cm

Fig. 7 Scanning electron micrograph of the proximal side, 13000×, paratype [2413] A 949.
Fig. 8 Phase contrast, 3200×, same specimen as Fig. 11.
Fig. 9 Transmitted light, 3200×, same specimen as Fig. 11.
Fig. 10 Cross-polarized light, 3200×, same specimen as Fig. 11.
Fig. 11 Scanning electron micrograph of the distal side, 6500×, paratype [5034] A 948.

Fig. 12—16 *Broinsonia lata* (Noel, 1969) Noel, 1970
DSDP Leg 14—137—14—2, 132 cm

Fig. 12 Phase contrast, 3200×, same specimen as Fig. 15.
Fig. 13 Transmitted light, 3200×, same specimen as Fig. 15.
Fig. 14 Cross-polarized light, 3200×, same specimen as Fig. 15.
Fig. 15 Scanning electron micrograph of the proximal side, 6500×, hypotype [4026] A 960.
Fig. 16 Scanning electron micrograph of the proximal side, 50° inclined, 6500×, same specimen as Fig. 15.

Fig. 17 *Watznaueria communis* Reinhardt, 1966
DSDP Leg 1—5 A—4—1, 35 cm

Scanning electron micrograph of the distal side, 5000×.