

SYLVIA FORCHHEIMER

SCANNING ELECTRON MICROSCOPE
STUDIES OF CRETACEOUS COCCOLITHS
FROM THE KÖPINGSBERG
BOREHOLE NO. 1, SE SWEDEN

WITH 27 PLATES AND 12 FIGURES

РЕЗЮМЕ



STOCKHOLM 1972

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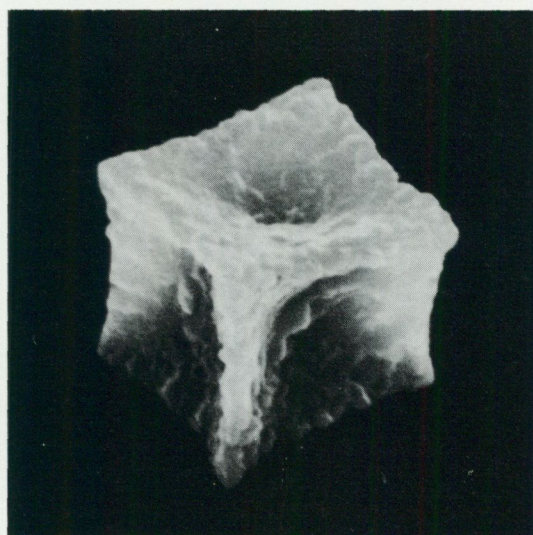
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ABSTRACT

Cretaceous coccoliths from the lowest part of a continuously cored well in Köpingsberg 1, Scania, SE Sweden, have been studied mainly under the scanning electron microscope (SEM) but also under the light microscope.

Comparisons with species previously published and illustrated with light microscope photomicrographs or drawings could be made only in a few cases. The quantitative occurrence of coccoliths (including some of the coccoliths not described here due to their accordance to earlier descriptions in the literature) is presented. Of the forms occurring in the Lower Cretaceous of the Köpingsberg 1 core, *Ahmuellerella octoradiata* (GÓRKA, 1957), *Kamptnerius punctatus* STRADNER, 1963 and *Micula staurophora* (GARDET, 1955) have hitherto been reported as being guide fossils of the Upper Cretaceous. The genera *Marthasterites* and *Lucianorhabdus*, and *Deflandrius spinosus* BRAMLETTE et MARTINI, 1964 have also been reported only from Upper Cretaceous, and (in the case of *Marthasterites*) from younger deposits.

The stratigraphy of the core has previously been established by means of the foraminifera. The samples studied here belong to the Hauterivian – Cenomanian.

The coccoliths are relatively well preserved. About 6 800 specimens have been counted and examined. 50 species belonging to the families Arkhangelskiellaceae, Coccolithaceae, Deflandriaceae, Eiffellithaceae, Podorhabdaceae, Polycyclolithaceae and Zygodiscaceae are described. One new family *Polycyclolithaceae* n. fam., and two new genera *Repagulum* n. gen., and *Margolatus* n. gen. are erected. In connection with some forms taxonomic problems are discussed. Three genera are emended, and 20 new species are proposed i. e.: *Broinsonia dempta* n. sp., *Broinsonia lacunosa* n. sp., *Cretarhabdus biseriatus* n. sp., *Cretarhabdus octoperforatus* n. sp., *Helicolithus stillatus* n. sp., *Kamptnerius pertusus* n. sp., *Lithastrinus septenarius* n. sp., *Lucianorhabdus arcuatus* n. sp., *Lucianorhabdus quadrifidus* n. sp., *Margolatus manivitae* n. sp., *Markalius sulcatus* n. sp., *Marthasterites duplex* n. sp., *Micula cubiformis* n. sp., *Polycyclolithus orbiculatus* n. sp., *Tranolithus skoglundii* n. sp., *Vagalapilla alata* n. sp., *Vagalapilla coroniformis* n. sp., *Vagalapilla partita* n. sp., *Vagalapilla solida* n. sp., and *Zygodiscus inclinatus* n. sp.

ZUSAMMENFASSUNG

Coccolithen der Kreide des unteren Teils der Kernbohrung Köpingsberg 1, SO Schweden, wurden hauptsächlich mit dem Scanning Elektronen-Mikroskop (SEM) aber auch mit dem Lichtmikroskop untersucht.

Vergleiche mit früher veröffentlichten, nur mit lichtmikroskopischen Bildern oder Zeichnungen belegten Formen, werden nur in einigen Fällen gezogen. Die quantitative Verbreitung der untersuchten Coccolithen wird gezeigt.

Von den Formen die in der unteren Kreide der Kernbohrung Köpingsberg 1 auftreten, sind bisher die Arten *Ahmuellerella octoradiata* (GÓRKA), *Kamptnerius punctatus* STRADNER, 1963 und *Micula staurophora* (GARDET) als Leitfossilien der oberen Kreide, besonders des Turon bis zum Maastricht betrachtet worden. Auch die Gattungen *Marthasterites* und *Lucianorhabdus* sowie die Art *Deflandrius spinosus* BRAMLETTE et MARTINI, 1964 sind nur von der oberen Kreide bekannt, im Falle *Marthasterites* auch aus noch jüngeren Ablagerungen.

Die Stratigraphie des Kernes ist bereits mit Hilfe von Foraminiferen aufgestellt worden. Die hier studierten Proben gehören demnach zum Hauterive-Cenoman.

Die Coccolithen sind verhältnismässig gut erhalten und über 6800 Exemplare wurden näher untersucht. Die 50 Arten gehören zu den Familien Arkhangelskiellaceae, Coccolithaceae, Deflandriaceae, Eiffellithaceae, Podorhabdaceae, Polycyclolithaceae und Zygodiscaceae. Eine neue Familie *Polycyclolithaceae* n. fam. und zwei neue Gattungen *Repagulum* n. gen. und *Margolatus* n. gen. werden aufgestellt.

In Zusammenhang mit einigen Formen werden taxionomische Fragen diskutiert.

Drei Gattungen werden revidiert und folgende 20 neue Arten vorgeschlagen: *Broinsonia dempta* n. sp., *Broinsonia lacunosa* n. sp., *Cretarhabdus biseriatus* n. sp., *Cretarhabdus octoperforatus* n. sp., *Helicolithus stillatus* n. sp., *Kamptnerius pertusus* n. sp., *Lithastrinus septenarius* n. sp., *Lucianorhabdus arcuatus* n. sp., *Lucianorhabdus quadrifidus* n. sp., *Margolatus manivitae* n. gen., n. sp., *Markalius sulcatus* n. sp., *Marthasterites duplex* n. sp., *Micula cubiformis* n. sp., *Polycyclolithus orbiculatus* n. sp., *Tranolithus skoglundii* n. sp., *Vagalapilla alata* n. sp., *Vagalapilla coroniformis* n. sp., *Vagalapilla partita* n. sp., *Vagalapilla solida* n. sp. und *Zygodiscus inclinatus* n. sp.

РЕЗЮМЕ

В данной статье описаны кокколиты с интервала 752,6 м — 1004,4 м в опорном размере скважины Шепингсберг 1 (Köpingsberg 1) в юго-восточной Швеции.

Кокколиты были исследованы главным образом при помощи сканинг — электронного микроскопа.

Благодаря тому получено новые данные по их морфологии, таксономии и распространению в нижнемеловых и сеноманских отложениях.

Некоторые виды, выступающие в нижней мелу этой скважины считались до сих пор „ведущими“ для верхнемеловых отложений. Этот опорный разрез содержащий также фораминиферы исследовался раньше Норлингом (1968). Проведенный им предварительный биостратиграфический анализ описан в отчете (Андерегг и и., 1968).

Изученные в этой работе образцы принадлежат к Гаутерив-Сенومانу. На основе исследования около 6800 кокколитов определено тоже их количественное распространение.

В результате проведенных исследований установлено 7 семей и 26 родов. Предложены одна новая семья, *Polycyclolithaceae* fam. n. и два новых рода: *Repagulum* gen. n. и *Margolatus* gen. n.

Описано 50 видов, в том числе 20 новых: *Broinsonia dempta* sp. n., *Broinsonia lacunosa* sp. n., *Cretarhabdus biseriatus* sp. n., *Cretarhabdus octoperforatus* sp. n., *Helicolithus stillatus* sp. n., *Kamptnerius pertusus* sp. n., *Lithastrinus septenarius* sp. n., *Lucianorhabdus arcuatus* n. sp., *Lucianorhabdus quadrifidus* n. sp., *Margolatus manivitae* sp. n., *Markalius sulcatus* sp. n., *Marthasterites duplex* sp. n., *Micula cubiformis* sp. n., *Polycyclolithus orbiculatus* sp. n., *Tranolithus skoglundii* sp. n., *Vagalapilla alata* sp. n., *Vagalapilla coroniformis* sp. n., *Vagalapilla partita* sp. n., *Vagalapilla solida* sp. n., и *Zygodiscus inclinatus* sp. n.

ACKNOWLEDGEMENTS

The investigation of the core from K pingsberg Borehole No. 1 has been carried out at the request of the Geological Survey of Sweden (S.G.U.).

The study of coccoliths, being extremely small objects, requires access to intricate and expensive technical equipment. For the invaluable opportunity of unlimited use of the scanning electron microscope (SEM), laboratory facilities and help from technical staff I wish to express my sincere thanks to Mr. K. A. Lindbergson, the Director General of S.G.U., Dr. E. Fromm, the Head of the Department of Research and Applied Geology, S.G.U. and Dr. A. Danielsson, the Chief of the Chemical Laboratory, S.G.U.

For arousing my initial interest and providing me with the necessary knowledge and investigation routine I thank my teachers Prof. I. Hessland, the University of Stockholm, and the late Dr. Fritz Brotzen.

As appears from the conclusion drawn on a basis of these studies, there have been certain contradictions in regard to the stratigraphic analysis. For patient and self-sacrificing support throughout many difficulties I am deeply indebted to Dr. R. Skoglund, the Head of the Section for Stratigraphy and Palaeontology, S.G.U.

At this point I also wish to thank Dr. E. Norling, S.G.U. for his kind readiness to recheck and extend his investigations of foraminifera with the purpose of confirming the stratigraphic determination of the material. On his recommendation the important problem of contamination was repeatedly discussed and thoroughly penetrated, which contributed to the certainty of results and conclusions.

For untiring help, encouragement and useful criticism I am very much indebted to Dr. G. Kjellstr m, S.G.U. His investigations of the material in regard to dinoflagellates and discussion of the stratigraphic problems also in cooperation with Dr. W. A. S. Sarjeant, Department of Geology, the University of Nottingham, have contributed essentially to the clarification of the problems.

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Of course the confusing results observed right at the very beginning of the investigation have been discussed with a number of well known experts in the coccolith field. By grants secured by the Geological Survey of Sweden and economical support from the Swedish Natural Science Research Council (Statens naturvetenskapliga forskningsr d), Stockholm, I have been able to visit the IX Northern Geological Congress in Lyngby, Copenhagen (det IX Nordiska Geologiska Vinterm tet), the University of Cambridge and the II Planktonic Conference in Rome. On these occasions I have received good advice and useful criticism from Dr. W. W. Hay (Department of Geology, the University of Illinois), Dr. Denise No l (Museum National d'Histoire Naturelle) and Dr. Helen Manivit (Universit  de Paris). To them I wish to express my sincere thanks.

For close penetration of the taxonomic problems I am much indebted to Prof. Mauritz Black, the University of Cambridge, Dr. Katharina Perch-Nielsen, the University of Copenhagen, and Prof. H. Stradner, Geologische Bundesanstalt, Vienna.

For every geologist and especially micropalaeontologist it is a well known fact that investigations of this extent include a lot of details which have to be worked out

skillfully and carefully. For preparation of hundreds of suspensions and slides I wish to thank Miss Berit Henriksson, Miss Raija Lentz and Mrs. Basia Horn, S.G.U.

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INTRODUCTION

Coccoliths (calcareous nannofossils) were discovered by Ehrenberg (1836), who studied and illustrated specimens found in samples of chalk. He considered them to be of inorganic origin and called them "Morpholite der Kreide" (Cretaceous morpholiths).

HUXLEY (1858) found a great number of oval and rounded bodies in Atlantic deposits. After comparing the "morpholiths" with these minute objects he was doubtful about their inorganic origin. Due to the fact that they looked somewhat like cells of the green alga *Protococcus* he called them "coccoliths."

The organic origin of the coccoliths was definitely proved in 1861, when SORBY (1860) and WALLICH (1860, 1861) found that the minute bodies are not separate individuals, but parts of cells with a diameter a few times greater than that of the individual coccoliths. SORBY found that they formed the walls of small spheres, and were not "flat discs" as described by EHRENBURG but concave on one side and convex on the other. He thought that they were derived from decomposed foraminifera.

The true origin of the coccoliths was explained by WALLICH (1861) who some years later (1865) found the living organisms floating on the surface of the sea. He called them "coccospheres". MURRAY (1891) regarded the coccospheres as a remnant of a pelagic alga.

Studies of recent as well as fossil coccoliths were also carried out by GÜMBEL (1870) and SCHWARZ (1894). LOHMAN (1902) made the first taxonomic study of recent calcareous nannofossils and Arkhangelsky (1912) described Cretaceous coccoliths. SCHILLER (1930), KAMPTNER and DEFLANDRE made an important contribution to the knowledge of recent coccoliths and the latter two also studied fossil coccoliths.

At about the middle of this century the investigation of coccoliths increased rapidly due on the introduction of the new microscopes TEM (transmission electron microscope) and SEM (scanning electron microscope), and especially in oil geology there are hopes that the coccoliths will be suitable stratigraphic indicators.

It is mainly the minute size of the coccoliths, their worldwide distribution and their great abundance that are promising features in their biostratigraphical application.

The purpose of this paper is to present the coccolith flora occurring in the K opingsberg Borehole No. 1, Scania, SE Sweden (Fig. 1).

As hitherto only a few investigations have been presented on Lower Cretaceous coccoliths (Fig. 2), it was especially interesting to start the study of the lowest part of the 1 004.4 m long core with a stratigraphic range from the Hauterivian to the Lower Maastrichtian. Samples from the Hauterivian – Cenomanian (Fig. 11) have been studied mainly at intervals of 5 m. A quantitative study in which about 6 800 specimens have been counted was carried out by means of the Stereoscan at a magnification of 2 000 x (Fig. 11).

Although the main problem has been to identify coccoliths previously studied under the light microscope, some descriptions have been emended. Comparisons with light microscope micrographs and drawings published in the literature have been made only in cases of unambiguous identification. In order to avoid mistakes it would be necessary to study the holotype material, previously investigated only by means of the light microscope, also under the scanning electron microscope (SEM).

Investigations by means of the transmission electron microscope have been carried out by NO EL (1965), REINHARDT et G ORKA (1967) and PERCH-NIELSEN (1968) on samples studied by DEFLANDRE (1954) and G ORKA (1957) under the light microscope. However, PERCH-NIELSEN (personal communication) had difficulty in identifying some species reported by G ORKA (1957).

STRADNER et al (1968) in their study on Albian coccoliths by means of the transmission electron microscope, described specimens as *Zycolithus litterarius* (G ORKA) and the identification of this species was based on the descriptions and drawings given by G ORKA (1957). In their discussion they mentioned: "In G ORKA 1957 three different species designations were used for what is considered here as one species: *Discolithus trabalis* n. sp. (Pl. 3, Fig. 2), *D. litterarius* n. sp. (Pl. 3, Fig. 3) and *D. anceps* (Pl. 3, Fig. 4). Priority was given to that name which was first printed in text, and that was *D. litterarius* (p. 251) against *D. trabalis* and *D. anceps* (p. 252)". In this way the Maastrichtian forms published by G ORKA (1957) got a stratigraphic range from the Albian to the Maastrichtian.

Discolithus crux DEFLANDRE et FERT, 1954, a Tertiary form, raises problems of the same kind. The original description is illustrated by a drawing (Fig. 55) and an electron microscope micrograph (not a carbon replica) of an oval coccolith with a straight cross in the centre (Pl. 14, Fig. 4). Cretaceous forms showing similar characteristics have been compared to this form. As a consequence the stratigraphic range of the species is Cretaceous – Tertiary.

A number of authors have reported distribution of coccoliths from the Lower Cretaceous and the Cenomanian. Fig. 2 shows these reports in chronological order.

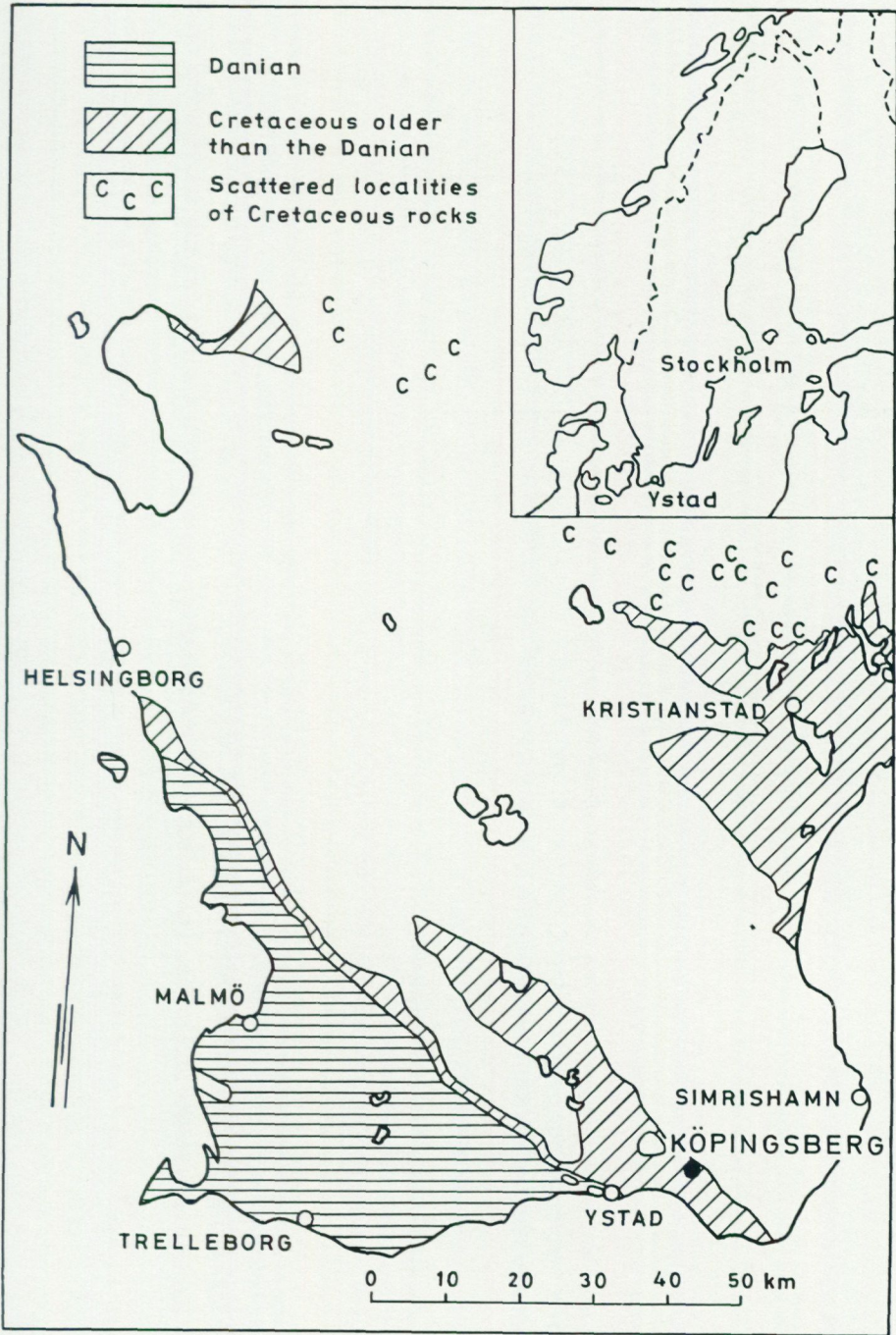


Fig. 1. Map showing the Cretaceous deposits in Scania with the location of the Köpingsberg Borehole No. 1.

AUTHOR *	DATE	STRATIGRAPHICAL RANGE	Mode of illustration	LEGEND:
Stradner	1963	L.Cretaceous – Cenomanian	6;8	1. Light microscope micrographs
Gorka	1963	Cenomanian	6;8	2. phase contrast
Caratini	1963	U.Cenomanian	6;1;8	3 polarized light
Cepek et Hay	1963	Cenomanian	6;8	4. transmission electron microscope
Manivit	1965	Albian – Aptian	1;3;8	5. scanning electron microscope
	1971	Aptian – Cenomanian	1;3;5	
Noël	1965	Hauterivian	4;8	6. morphological drawings
Reinhardt	1966	Hauterivian – Cenomanian	3;6;4;8	7. stratigraphical list
Stover	1966	Neocomanian – Cenomanian	6;1;2;3;8	8. stratigraphical tables
Trexler	1967	Cenomanian	6;8	
Forchheimer	1968	Albian – Cenomanian	6;1;2;3;5;8	
Gartner	1968	Cenomanian	6;1;2;3;4;8	
Bukry	1969	Albian	4;8	
Bramlette et Bukry	1969	Hauterivian, Albian, Cenomanian	7	* for further information see references
Shumenko	1969	Cenomanian	4;8	

Fig. 2. Index to publications on Lower Cretaceous – Cenomanian coccoliths.

MATERIAL

The samples studied are derived from the sequences between 752.6 m and 1 004.4 m (T. D. or total depth) of the K opingsberg 1 core. The boring was situated in SE Scania (Fig. 1) and was drilled in 1967 as a stratigraphic test in the exploration program of the Geological Survey of Sweden, 1967–1969.

The boring was carried out as a continuously cored well down to T. D. The sequence penetrated ranges from the Cenomanian to the Hauterivian. The stratigraphy, based upon the foraminifera, has preliminarily been established by NORLING in ANDEREGG et al (1968); and Norling (1970).

A lithological description of the cored section in the report mentioned shows that calcareous sandstone, glauconite siltstone, black shale and siltstone with intercalations of clay form the bulk of the sediments.

The coccolith flora occurring at levels 1 004.4–986.4 m, 955.2–950.6 m, 936.9 m, 924.2–888.0 m, 846.4 m and 809.4 m is relatively rich and well preserved. The coccoliths in levels between 789.9 m and 752.6 m occur less frequently (Fig. 11), and show a poor state of preservation.

METHODS

Various methods of separation of coccoliths from sediments have been previously described by KAMPTNER (1954), BLACK et BARNES (1959), STRADNER et PAPP (1961), BRAMLETTE et SULLIVAN (1961), EDWARDS (1963), COHEN (1965), NO EL (1965), MARESCH (1966), STRADNER et al (1968), PERCH-NIELSEN (1968), FORCHHEIMER (1968, 1970), BUKRY (1969), NO EL (1970) and MANIVIT (1970). Some of these methods require centrifuging.

The present author has in a previous paper (FORCHHEIMER, 1968) emphasized the importance of careful processing and has only infrequently used the centrifuge. The method described below does not involve any centrifuging. It is based on repeated filtration and sedimentation. Pl. I, Figs. 1–2 illustrate the method used.

As the coccoliths occur infrequently in the samples studied, 40 g of sample have been needed for each suspension instead of the lower amounts commonly described in the literature.

The pulverized sample was prepared with 4 percent H₂O₂, the suspension shaken in a beaker and left overnight. Afterwards, the decantant was poured out. Distilled water was added to the residue which was washed several times. During washing the water was poured off carefully into a 2 l beaker. The remaining deposit on the bottom was studied under a light microscope and the washing process was discontinued when no coccoliths were observed any longer. The suspension was allowed to settle for 12–15 hours and then decanted, and the new residue placed in a 450 ml glass filter funnel with 90–150 μ

porosity. The glass filter was coupled to a filtering flask connected to a separatory funnel by means of a rubber tube. The funnel was fastened to a stand (Pl. I, Figs. 1–2) with movable clamps. From the beginning the filtering flask and the separatory funnel were filled with distilled water. By raising and lowering the separatory funnel a stream of water moves the sediment particles up and down, cleaning the glass filter pores at each stroke. The coccoliths together with other particles of a size small enough not to hinder study pass into the filtering flask. This process is repeated several times. Pl. I, Fig. 1 shows the result immediately after some raising and lowering of the separatory funnel, and the grey colour of the water in the filtering flask indicates sediment particles. The coccoliths are concentrated in the filtering flask (Pl. I, Fig. 2) while the bigger particles stay in the glass filter funnel. After 10–12 hours of settling, the filtering flask is removed and decanted. Distilled water with wetting agent is added to the residue. Some drops of the suspension are taken for preparing sample stubs for study under the SEM and for slides for investigation under the light microscope.

The preparation method of the stubs and slides has been previously described by FORCHHEIMER (1970).

Attempts have been made to refind the same specimen after removing the stub from the stage. Pl. I, Figs. 3–6 show a part of the sample stub, photographed at various magnifications: Fig. 3 has a magnification of 16.7 x, Fig. 4 – 41.6 x, Fig. 5 – 167 x and Fig. 6 – 416 x. After placing the sample stub in a position marked on the stage the magnification is noted as well as the x–y–z coordinates, the aperture, the lens, the tilting angle and the voltage. This procedure makes it possible to refind the same specimen, in this case a coccosphere.

About 600 sample stubs have been studied under the “Cambridge Stereoscan MK II a” (SEM) made by Cambridge Instrument Co. LTD., Cambridge, England, and about 250 slides by means of light microscopes Zeiss Ultraphot II and Leitz Ortholux. For photographic work 35 mm Kodak film Panatomic X, Plus X Pan and Kodachrome II have been used. The specimens have been photographed from various angles. Some stereoscopic pairs of pictures with 6 degrees difference between exposures have been taken.

Type specimens are deposited in the Museum of the Geological Survey of Sweden, Stockholm.

TERMINOLOGY

Before 1950 descriptions of coccoliths were based entirely on light microscope observations.

The morphological characteristics that have hitherto been treated within the terminology are mainly the shape of the coccolith, structure of central area (cross, ridge, perforations) and striae of the rim.

HAY et al (1966) proposed separate lists in English for descriptions of coccoliths studied under light and electron microscopes, the latter "adapted from HALLDAL & MARKALI (1954, 1955), BLACK & BARNES (1959, 1961) and HAY & TOWE (1962)".

REINHARDT (1966) illustrated on two figures based on drawings (KAMPTNER, 1958, 1963) the terms (Latin and German) used for descriptions of coccoliths studied under the electron microscope.

BUKRY (1969) presented 27 English terms for the description of coccoliths. At the II Planktonic Conference, Round Table on Calcareous Coccoliths in Rome (1970) PERCH-NIELSEN proposed a fundamental coccolith terminology (illustrated by drawings) discussed and translated into English, French, German and Italian (in print). Some of these terms, also with translation into Russian are given on pp. 16-17.

English	French	German
arm	bras	Arm
base	base	Basis
central area	aire centrale	Zentralfeld
central process	hampe centrale	Zentralfortsatz
central structure	structure centrale	Zentralstruktur
column	colonne	Säule
crystals	cristaux	Kristalle
cycle	cycle	Zyklus
depression	depression	Vertiefung
disc	collrette	Flansch
distal	distal	distal
element	element	Element
height	hauteur	Höhe
interray area	area interradiale	Zwischenareal
knob	bouton	Knopf
lateral	lateral	lateral
opening	ouverture	Öffnung
perforation	perforation	Perforation
proximal	proximal	proximal
ray	rayon	Strahl
ridge	arete	Grat
rim	anneau	Krantz
segment	segment	Segment
shield	disque	Scheibe
suture	suture	Sutur
wall	mur	Wand
width	largeur	Weite

Italian	Russian
braccio	рука
base	базис
area centrale	центральное поле
formazione centrale	стержень
struttura centrale	центральная структура
colonna	столбик
cristalli	хрусталы
giro	цикл
depressione	углубление
disco	диск
distale	дистальный
elemento	элемент
altezza	высота
area interradianale	межлучевая арка
bottono	бугор
laterale	латеральный
poro	отверстие
perforazione	перфорация
proximale	проксимальный
raggio	луч
cresta	кромка
anello	краевой ободок
segmento	сегмент
scudo	щиток
sutura	шов
parete	стенка
larghezza	ширина

The present author has followed the terminology proposed at the symposium with some additional terms based on HAY et al (1966), STOVER (1966) and BLACK (1967):

English

buttres: a structure supporting a high wall
 cube: a regular solid with six equal faces
 cross: two pieces placed across each other
 (straight or x-shaped)
 corner: the point of meeting of two lines or
 surfaces forming an angle
 expansion: extended surface
 flange: a part that spreads out like a rim
 point: a sharp projecting end
 protuberance: a part swelled out
 rib: edge
 wedge: a solid of five sides
 zigzag: a number of short, sharp turns

Russian

подпора
 куб
 крест
 рог
 экспансия
 внешний край
 пик
 выпуклость
 ребро
 клинообразный
 угловато-изогнутый

Some of the above terms are illustrated in Figs. 3, 4 and 5. These figures present coccolith genera (occurring in the K pingsberg 1 deposits) to which these terms are applied.

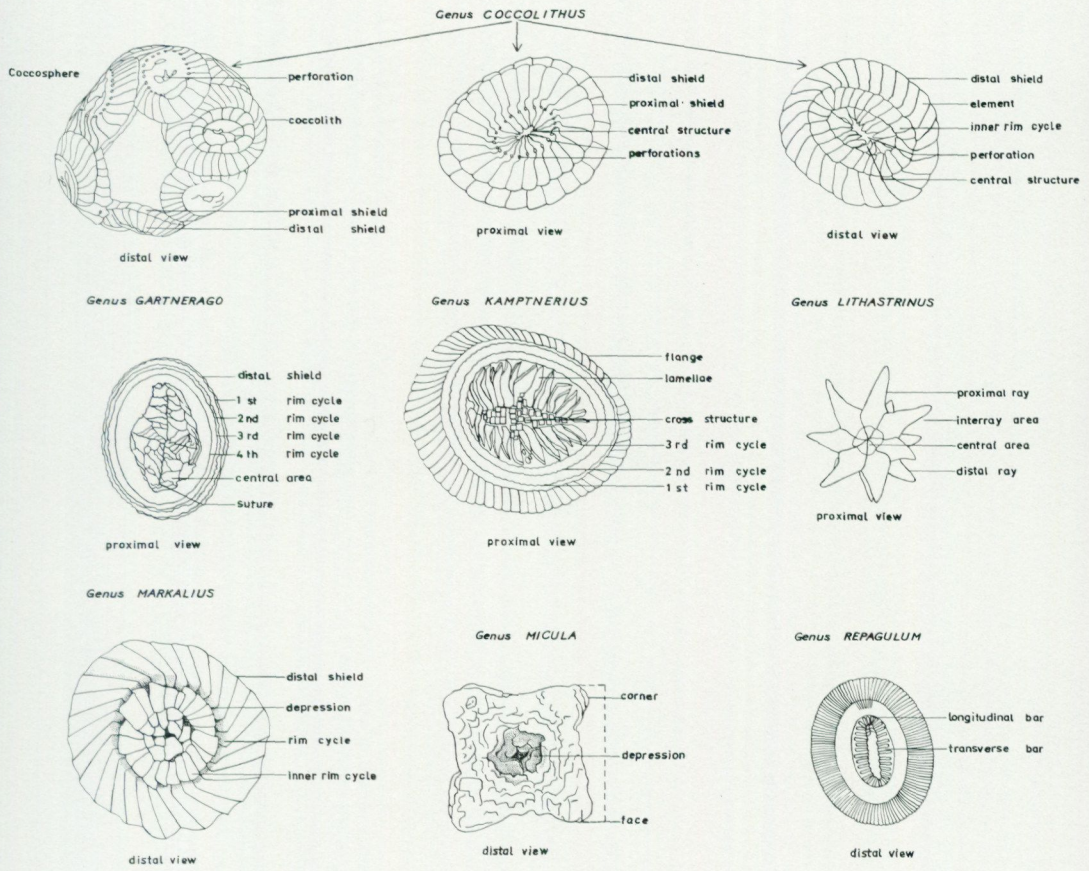


Fig. 3. Schematic drawings of coccoliths illustrating the terms mentioned on pages 16-18.

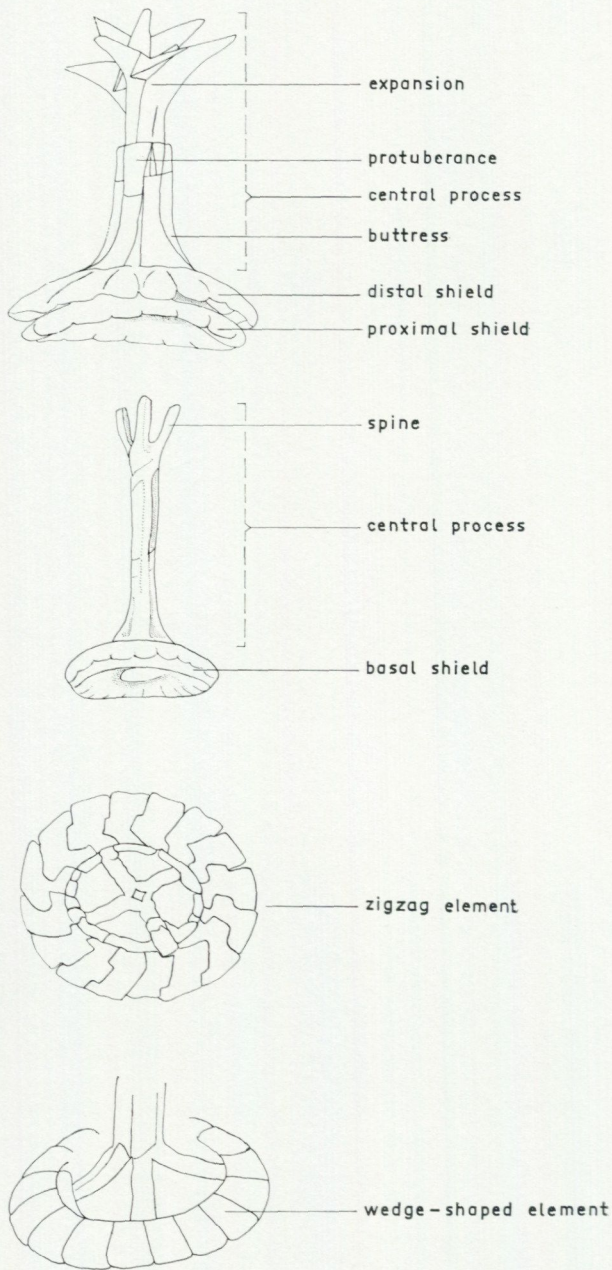
Genus DEFLANDRIUS

Fig. 4. Schematic drawings of coccoliths illustrating the terms mentioned on pages 16-18.

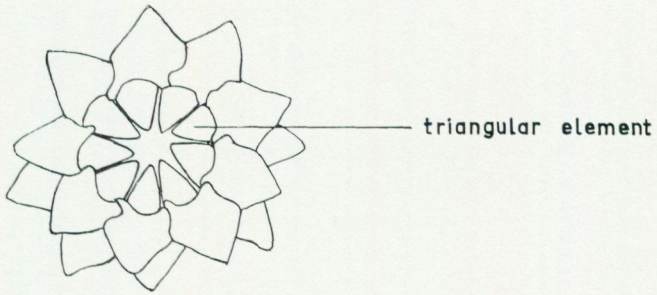
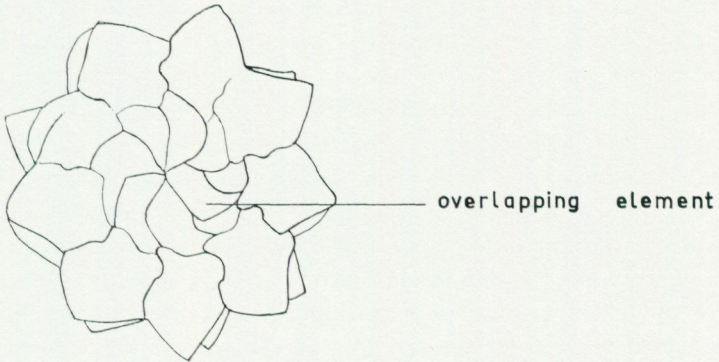
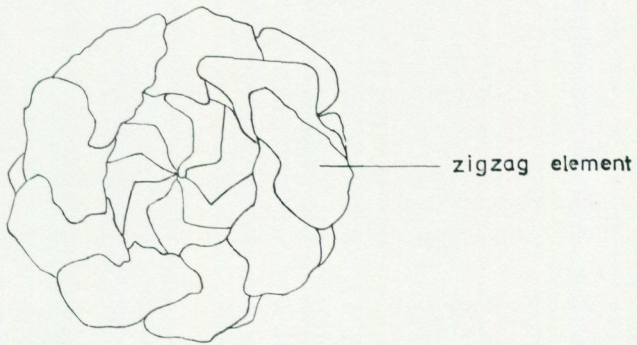
POLYCYCLOLITHUS brotzenii*POLYCYCLOLITHUS floralis**POLYCYCLOLITHUS orbiculatus n.sp*

Fig. 5. Schematic drawings of coccoliths illustrating the terms mentioned on pages 16-18.

TAXONOMY

The living species of coccoliths have been morphologically described with reference to the shape of the coccosphere, the flagellae and the aperture (LOHMAN, 1902; SCHILLER, 1930). The fossil coccoliths occurring only as isolated plates were at first classified with regard to their shape and structure as seen under the light microscope only.

DEFLANDRE (1952) studied coccoliths in polarized light and divided them into two groups: Heliolitae ("particules élémentaires de calcite rayonnante") and Ortholitae ("particules parallèles").

Since the introduction of the electron microscope in the study of coccoliths, it has been possible to observe the detailed structure of the specimens (Noël, 1965).

REINHARDT (1966) introduced a new classification of fossil coccoliths based on electron microscope studies. He distinguished four types according to the composition of the central area of the coccolith. This classification is only applicable to Cretaceous coccoliths having a very well preserved fine structure.

As the zoological nomenclature has been used by some authors and the botanical by others, and a combination by REINHARDT (1966), the taxonomy has been rather chaotic. The Round Table Conference on Calcareous Nannoplankton in Rome (1970) recommended following the International Code of Botanical Nomenclature. From these recommendations an extract concerning the erection of new species follows: "That when a new species is being erected the material should be studied when possible in both the light and electron microscopes. The following recommendation should be followed:

a) That the catalogue number of the holotype and the institution in which it is deposited must be given at the end of the diagnosis,

b) That a new species should not be erected on the basis of one or two specimens, . . .

a) That the holotype should be an unretouched negative,

b) That in addition to the holotype there should be a paratype showing the opposite side or another characteristic view."

According to diagnosis of a new taxon by light microscopy, the following recommendations should be followed:

"a) That the holotype should be illustrated as follows:

i) In plan view,

ii) In phase contrast and/or direct illumination,

iii) In cross polarized illumination, . . .

b) That the holotype and the paratype should never be mounted in viscous media,

c) That when possible a slide should contain only one holotype,

d) That the position of the holotype should be indicated by indelible marking on the slide."

The taxonomic problem today is how to proceed with species described by means of observations under the light microscope and often illustrated by unsatisfactory drawings and micrographs.

The priority rules should be followed but in many cases this is difficult, especially concerning forms from different stratigraphical stages (*Zycolithus litterarius* (GÓRKA) STRADNER et al, 1968, p. 39, Pl. 34 and *Discolithus litterarius* nov. spec. GÓRKA, pp. 251 and 274, Pl. 3, Fig. 3). Specimens described with a crossbar structure can belong to various species since the composition of elements in the rim cycle, the construction of the crossbars or other morphological characteristics can be different. The structure is seldom visible in light microscope micrographs or drawings.

Discolithus crux DEFLANDRE et FERT, 1954 originally described from the early Tertiary (p. 23, Pl. 14, Fig. 4; Text-Fig. 55) has been used for different forms occurring in the Cretaceous (Hauterivian – Maastrichtian) although the fine structure is not visible on the drawing or the transmission electron micrograph made without replica.

Transmission electron micrographs of coccolith replicas and scanning electron micrographs show the various differentiations among forms with crossbars which necessitates the erection not only of new species but also of new genera. The difficulty in differentiating the coccoliths when comparing the material at hand with the forms studied by light microscope very often makes them unsuitable for detailed biostratigraphical analysis.

SYSTEMATIC DESCRIPTIONS

The forms are classified by family, genus and species. The average length and the average width have been calculated on a basis of more than five specimens and only in exceptional instances on a basis of less than five specimens. The size of the central area in percent in relation to the area of the coccolith has been calculated by means of the formulas AB and A^2 respectively provided that both the areas represent an ellipse or a circle. A represents the long axis of the elliptical coccolith or the diameter of the circular coccolith; a represents the long axis or the diameter of the central area. B represents the short axis of the coccolith and b the short axis of the central area. In the circular forms is $B=A$, and $b=a$.

The table showing the vertical distribution and that showing the number of investigated coccoliths include, besides the species described in the present paper, also species neither described nor illustrated. The undescribed forms are marked with * and those only illustrated with \circ . The levels in Fig. 11 are given with an accuracy ± 0.5 cm.

Family ARKHANGELSKIELLACEAE BUKRY, 1969

Genus *Broinsonia* BUKRY, 1969

Type species: *Broinsonia dentata* BUKRY, 1969

Broinsonia dempta n. sp.

Pl. II, Figs. 5–6

DERIVATION OF NAME. – *demptus* (lat.) – lacking.

HOLOTYPE. – Specimen No.: S Kp 22 69/1.

PARATYPE. – Specimen No.: S Kp 22 69/22.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 785.4 m.

TYPE STRATUM. – Cenomanian.

DIAGNOSIS. – A species of *Broinsonia* with a central area spanned by crossbars perpendicular to each other, and dividing the central area into four empty openings. A process extends distally.

DESCRIPTION. – Elliptical coccoliths with 4 rim cycles of elements seen in distal as well as in proximal view (Pl. II, Figs. 5–6). A short central process is seen in distal view and only one perforation in the centre is observed in proximal view.

DIMENSIONS. – Average length 5.2 μ ; average width 4 μ .

REMARKS. – *Broinsonia dempta* n. sp. differs from *B. lacunosa* n. sp. in lacking perforations in the central area. It differs from *B. handfieldii* BUKRY, 1969 (Pl. 2, Figs. 9–11) in lacking the transverse ridges in the central area and in having a different form of cross. The known occurrence of *B. handfieldii* Bukry, 1969 is the Campanian from Texas.

OCCURRENCE. – Köpingsberg Borehole No. 1: Cenomanian.

Broinsonia lacunosa n. sp.

Pl. II, Fig. 1

DERIVATION OF NAME. – *lacuna* (lat.) – depression.

HOLOTYPE. – Specimen No.: S Kp 211 40a/24.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 936.9 m.

TYPE STRATUM. – Aptian.

DIAGNOSIS. – A species of *Broinsonia* with a large central area. A cross consisting of double rows of elements divides the central area into four quadrants, each with 6 perforations aligned with the crossbars.

DESCRIPTION. – The outer rim of the two cycles in distal view is composed of about 42 elements. The broad inner cycle of elements surrounding the central area shows deep depressions. The central area occupies 33 percent of the coccolith area.

DIMENSIONS. – Average length 6.8 μ ; average width 4.7 μ .

REMARKS. – *Broinsonia lacunosa* n. sp. looks similar to *B. parca* (STRADNER, 1963), BUKRY 1969 from the Campanian but the latter has transverse bars in some pores (BUKRY, 1969, Pl. 3, Fig. 7). The forms described by BUKRY have from 2 to 112 perforations.

STRADNER (1963) originally described the species *Arkhangelskiella parca* STRADNER, 1963. The drawings on Pl. 1, Fig. 3 show a Campanian coccolith with a narrow central plate divided by crossbars into sectors, each perforated by a few pores less than in *B. lacunosa* n. sp.

Gartner (1968) described *Arkhangelskiella parca* STRADNER, 1963 (p. 38, Pl. 8, Figs. 4–5; Pl. 11, Fig. 2) from the Campanian – Maastrichtian with a diamond-shaped central area, traversed by sutures aligned with the major and minor axes of the ellipse. The sutures are bordered by circular perforations on each side, but the number of perforations is not given.

PERCH-NIELSEN (1968) illustrated *Arkhangelskiella parca* STRADNER, 1963 from the Maastrichtian with a drawing (p. 61, Fig. 27) and micrographs (Pl. 21, Figs. 1–4) made by means of a transmission electron microscope. The structure of these forms has the generic characteristic of forms belonging to the genus *Arkhangelskiella* VEKSHINA, 1959. They also lack perforations in the central area, a characteristic of *Arkhangelskiella parca* STRADNER, 1963.

NOËL (1970) recorded *B. parca* (STRADNER, 1963) BUKRY, 1969 (p. 78, Text-

Fig. 18; Pl. 23, Fig. 3) from the Campanian which seems to have affinity with forms reported by PERCH-NIELSEN (1968).

B. lacunosa n. sp. differs also in size from *A. parca* STRADNER, 1963 which has a maximum diameter of about 9 μ .

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian – Albian.

Broinsonia handfieldii BUKRY, 1969

Pl. II, Figs. 3–4; Pl. XXVII, Fig. 1

1969 *Broinsonia handfieldii* BUKRY, n. sp. – BUKRY, p. 22, Pl. 2, Figs. 9–11.

DIMENSIONS. – Average length 6.8 μ ; average width 4.7 μ .

REMARKS. – *Broinsonia* species found in the investigated samples have a distal rim composed of about 40 elements. The same number of circular depressions arranged in a cycle is seen distally. The long arm of the cross widens towards the junction with the short axis of the ellipse. The crossbars form four elongated openings filled with 6–7 parallel transverse ribs perpendicular to the long axis of the coccolith. A short central process extends distally. The central area occupies about 30 percent of the coccolith area.

BUKRY (1969) did not mention the presence of the depressions or a central process. The structure visible in the centre of the specimen figured by BUKRY in Pl. 2, Fig. 10 is probably a central process.

The Köpingsberg forms are smaller than the specimens reported from the Campanian by BUKRY, the maximum diameter of the latter being 9 μ .

OCCURRENCE. – Campanian: Texas (BUKRY, 1969)
Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Genus *Gartnerago* BUKRY, 1969

Type species: *Arkhangelskiella concava* GARTNER, 1965

Gartnerago concavum (GARTNER, 1968) BUKRY, 1969

Pl. III, Fig. 5

1968 *Arkhangelskiella concava* GARTNER, p. 37, Pl. 14, Figs. 2–3; Pl. 16, Figs. 5–7; Pl. 17, Fig. 7; Pl. 18, Figs. 22–23; Pl. 19, Fig. 6; Pl. 21, Fig. 7; Pl. 22, Figs. 13–15.

1968 *Arkhangelskiella scapha* GARTNER, p. 39, Pl. 14, Fig. 1; Pl. 20, Figs. 1–3.

1969 *Gartnerago concavum* (GARTNER) BUKRY, n. comb. – BUKRY, p. 24, Pl. 4, Figs. 2–6.

1969 *Laffittius obliquus* (REINHARDT, 1967), – NOËL, p. 197, Text-Figs. 3 a–b; Pl. 3, Figs. 1 and 5.

1970 *Gartnerago obliquum* (REINHARDT) nov. comb. – NOËL, p. 79, Figs. 19–20; Pl. XXVI, Figs. 1 a, b, c, d – 7.

DIAGNOSIS. – Elliptical disc with at least three closely appressed rim cycles in proximal view. The central area characterized by irregular elements. Perforations never present.

DESCRIPTION. – The longitudinal suture of the central plate is aligned with the major axis of the ellipse and the transverse suture deviates a little from the short axis of the coccolith. The sutures are lined on each side with small square elements. The central area is imperforate.

DIMENSIONS. – Average length 10 μ ; average width 7 μ .

REMARKS. – The specimens described by NOËL (1970) as *Gartnerago obliquus* (REINHARDT) NOËL, 1970 have no perforations, and the presence of this character was stressed by STRADNER (1963) in the original description of *Arkhangelskiella obliqua* STRADNER, 1963 “varying number of pores perforate the sectors of the central area”.

A. concava GARTNER, 1968 is not a younger synonym to *A. obliqua* STRADNER, 1963, thus *G. concavum* (GARTNER, 1968) BUKRY 1969 cannot be substituted with *G. obliquus* (REINHARDT) NOËL, 1970.

OCCURRENCE. – Cenomanian – Campanian: Texas (GARTNER, 1968)
 Coniacian – Campanian: France (NOËL, 1969)
 Coniacian – Campanian: Texas (BUKRY, 1969)
 Köpingsberg Borehole No. 1: Barremian – Cenomanian.

Gartnerago costatum (GARTNER, 1968) n. comb.

Pl. IV, Figs. 2, 4

1968 *Arkhangelskiella costata* GARTNER, new species, – GARTNER, p. 37, Pl. 8, Figs. 1–3; Pl. 11, Figs. 1 a–c; Pl. 28, Fig. 2.

1969 *Gartnerago costatum costatum* (GARTNER) BUKRY, n. comb. – BUKRY, p. 24, Pl. 4, Figs. 7–9.

ORIGINAL DIAGNOSIS. – “Elliptical disc with four closely appressed rim tiers; sutures in central area bordered by ridge and lined with perforations.” (GARTNER, 1968.)

“Single crossbars bisect the rectangular perforations in proximal as well as in distal view.” (BUKRY, 1969.)

DESCRIPTION. – *Gartnerago* species with four closely appressed rim cycles. The distal shield consists of a cycle of imbricate elements. The central area is

convex in distal view and shows sutures of which the longitudinal one is aligned with the major axis, and the transverse one deviates from the minor axis of the coccolith. Small square elements form a double ridge along the sutures on each side. Usually the specimens show 28 perforations which are also visible in distal view. The perforations are bisected by transverse bars.

DIMENSIONS. – Average length 11 μ ; average width 8.6 μ .

REMARKS. – Forms with one crossbar in each perforation were referred by BUKRY (1969) to the subspecies *G. costatum costatum* and forms with more than one crossbar to *G. costatum porolatum*. The present author prefers to treat these forms as distinct species.

OCCURRENCE. – Santonian – Campanian: Texas (BUKRY, 1969)
Campanian: Texas (GARTNER, 1968)
Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Gartnerago obliquum (STRADNER, 1963) n. comb.

Pl. IV, Figs. 5–6

1963 *Arkhangelskiella obliqua* nov. spec. – STRADNER, p. 176, Pl. 1, Figs. 2 a–b.
1969 *Laffittius confossus* n. sp. – NOËL, p. 198, Pl. 3, Fig. 6; Pl. 2, Fig. 5.

DIMENSIONS. – Average length 9 μ ; average width 6 μ .

REMARKS. – *Gartnerago obliquum* (STRADNER, 1963) n. comb. differs from *G. concavum* (GARTNER, 1968) BUKRY, 1969 in having seven perforations in each quadrant of the central area. These perforations are larger in size and less frequent in number than in *G. zipperum* BUKRY, 1969.

OCCURRENCE. – Turonian: Austria (STRADNER, 1963)
Coniacian: France (NOËL, 1969)
Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Gartnerago porolatum (BUKRY, 1969) n. comb.

Pl. III, Figs. 2, 4

1969 *Gartnerago costatum porolatum* BUKRY, n. sp., n. ssp. – BUKRY, p. 24, Pl. 4, Figs. 10–12.

DIMENSIONS. – Average length 15 μ ; average width 9.5 μ .

REMARKS. – *Gartnerago porolatum* (BUKRY, 1969) n. comb. differs from *G. costatum* (GARTNER, 1968) in having perforations bisected by more than one transverse bar.

OCCURRENCE. – Campanian: Texas (BUKRY, 1969)
Köpingsberg Borehole No. 1; Albian.

Gartnerago striatum (STRADNER, 1963) n. comb.

Pl. III, Figs. 1, 3

1963 *Arkhangelskiella striata* nov. spec. – STRADNER, p. 176, Pl. 1, Figs. 1–1 a.

1966 *Arkhangelskiella striata* STRADNER, – STOVER, p. 137, Pl. 2, Figs. 3–4.

1968 *Zycolithus striatus* (STRADNER, 1963) nov. comb. – STRADNER et al, p. 38, Pl. 33.

DIMENSIONS. – Average length 9.3 μ ; average width 8 μ .

REMARKS. – STRADNER (1963) erected a new species *Arkhangelskiella striata* STRADNER for “elliptical coccoliths with wide central area and double marginal plates. Numerous pores are arranged in lines which meet at oblique angles at the straight central cross”. Studies of this species by STRADNER et al (1968) by transmission electron microscope contributed a new point of view: these forms are zygoliths with elliptical rim and a cross-shaped central structure, which subdivides the central area into four quadrants along the main axis of the ellipse. The authors distinguish between “juvenile” and “adult” forms. “In ‘juvenile’ forms (Pl. 32) these quadrants are partly filled with freely ending crystal spines, which are inserted in the longitudinal as well as in the transversal bars of the central structure at right angles. In the ‘adult’ forms (Pl. 33) these spines have united to form a cribrate filling of each quadrant. The rim is fashioned in typical zygolith manner with imbricating crystal plates as seen from the distal side.” The specimens found in the samples from Köpingsberg 1 and investigated by scanning electron microscope are characterized by four closely appressed rim cycles visible in proximal view. The central area is divided in four quadrants by a cross consisting of double rows of about 20 elements aligned with the long axis and about 15 elements aligned with the short axis of the ellipse. In proximal view as well as in distal view 18–22 perforations are visible in each quadrant.

OCCURRENCE. – Lower Hauterivian: Netherlands (STRADNER, 1963)

Lower Albian: Netherlands (STRADNER et al, 1968)

Albian: France (STOVER, 1966)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Genus *Kamptnerius* DEFLANDRE, 1959Type species: *Kamptnerius magnificus* DEFLANDRE, 1959*Kamptnerius pertusus* n. sp.

Pl. V, Figs. 1-4

DERIVATION OF NAME. – *pertusus* (lat.) – full of holes.

HOLOTYPE. – Specimen No.: S Kp 334 85a/35.

PARATYPE. – Specimen No.: S Kp 338 51a/20.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 904.72 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Kamptnerius* with a central plate divided into four quadrants. 10–15 perforations in each quadrant. The sutures dividing the central area consist of double rows of elements.

DESCRIPTION. – An asymmetrical slender flange surrounds the distal shield. In proximal view laminae are not seen. The sutures are aligned with the long and short axis, but a little deviated from them.

DIMENSIONS. – Average length 13.2 μ ; average width 10.9 μ .

REMARKS. – *Kamptnerius pertusus* n. sp. differs from *K. punctatus* STRADNER, 1963 in lacking the distinct laminae in the central area. The cross is slender and curved, reaching the margin of the central area.

OCCURRENCE. – Köpingsberg Borehole No. 1: Albian. – Cenomanian.

Kamptnerius punctatus STRADNER, 1963, emend.

Pl. IV, Figs. 1, 3; Pl. V, Figs. 5–6

1963 *Kamptnerius punctatus* n. sp. – STRADNER, p. 11, Pl. 2, Fig. 3.1964 *Kamptnerius magnificus* DEFLANDRE, – LEZAUD, p. 51, Pl. 1, Fig. 15.1966 *Kamptnerius magnificus* DEFLANDRE, – STOVER, p. 147, Pl. 4, Figs. 28–30.1967 *Kamptnerius magnificus* DEFLANDRE, – LYUL'eva, p. 96, Pl. 4, Fig. 50.

- 1968 *Kamptnerius magnificus* DEFLANDRE. – GARTNER, p. 39, Pl. 10, Figs. 11–12; Pl. 12, Figs. 9 a–c; Pl. 14, Figs. 11–12; Pl. 15, Figs. 10 a–b; Pl. 16, Figs. 17–19; Pl. 17, Figs. 11–12; Pl. 21, Figs. 12 a–b.
- 1969 *Kamptnerius magnificus magnificus* DEFLANDRE, – BUKRY, p. 25, Pl. 5, Figs. 7–9.
- 1969 *Kamptnerius magnificus sculptus* BUKRY, – BUKRY, p. 25, Pl. 5, Figs. 10–12.
- 1969 *Kamptnerius punctatus* STRADNER, – BUKRY, p. 26, Pl. 6, Figs. 4–5.

DESCRIPTION. – A species of *Kamptnerius* concave proximally, convex distally, consists of three rim cycles of elements, a central area and an asymmetrical flange. The central area is composed of irregular lamellae. A distinctive cross is visible as a rhomb-shaped structure in distal view, where about 60 perforations are seen very clearly. (Pl. IV, Figs. 1, 3.)

DIMENSIONS. – Average length 12.6 μ ; average width 9.3 μ .

REMARKS. – DEFLANDRE (1959) originally described *Kamptnerius magnificus* DEFLANDRE, 1959 and illustrated a number of specimens under the same name. STRADNER (1963) erected a new species *K. punctatus* STRADNER, 1963 and illustrated it by drawings (Pl. 2, Figs. 3–3 a) based on investigations carried out by light microscope. This form, however, shows a larger number of perforations than the specimens from Köpingsberg 1. *K. punctatus* STRADNER, 1963 was considered as a synonym to the *K. magnificus* DEFLANDRE, 1959 from the Senonian – Maastrichtian, although it ranged stratigraphically from the Turonian – Coniacian. BUKRY (1969) pointed out the differences between various species of the genus *Kamptnerius*.

K. magnificus DEFLANDRE, 1959 (Pl. 1, Figs. 2–4) is a younger form with a prominently developed asymmetrical flange surrounding only a part of the ellipse. It is smaller than *K. punctatus* STRADNER, 1963 but has a larger flange. Also the central area differs. The older forms have a cross with a checked structure while the central area of *K. magnificus* DEFLANDRE, 1959 consists of lamellae radiating from a line inside the coccolith parallel to the longer axis of the ellipse.

- OCCURRENCE. – Turonian: Russia (LYUL'eva, 1967)
 Turonian – Coniacian: France (LEZAUD, 1964)
 Turonian – Coniacian: Austria (STRADNER, 1963)
 Coniacian – Santonian: Alabama (CEPEK et HAY, 1970)
 Coniacian – Santonian: Texas (GARTNER, 1968)
 Coniacian – Santonian: France (MANIVIT, 1970)
 Santonian – Campanian: Texas (BUKRY, 1969)
 Campanian: France (STOVER, 1966)
 Senonian: Poland, Austria (DEFLANDRE, 1959)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Family COCCOLITHACEAE KAMPTNER, 1928

Genus *Biscutum* BLACK et BARNES, 1959

Type species: *Biscutum testudinarium* BLACK, 1959

Biscutum blacki GARTNER, 1968

Pl. VIII, Figs. 2, 4; Pl. IX, Fig. 5

1968 *Biscutum blacki* GARTNER, new species, – GARTNER, p. 18, Pl. 1, Fig. 7; Pl. 8, Figs. 8–10; Pl. 11, Fig. 8; Pl. 15, Fig. 2.
1969 *Biscutum blacki* GARTNER, – BUKRY, p. 28, Pl. 7, Fig. 12; Pl. 8, Figs. 1–3.

DIMENSIONS. – Average length 6.3 μ ; average width 4.7 μ .

REMARKS. – Specimens seen in proximal view show a cycle of elongated perforations 22 in number surrounding the central area. The specimens described by GARTNER (1968) have “a peculiar granular structure in the centre which is built of calcite rhombs arranged in a rosette in the centre of the proximal shield”.

No perforations surrounding the central area have been observed by GARTNER.

OCCURRENCE. – Albian – Campanian: France, Texas (BUKRY, 1969)
Campanian – Maastrichtian: Texas (GARTNER, 1968)
Köpingsberg Borehole No. 1: Barremian – Cenomanian.

Biscutum kennedyi BUKRY, 1969

Pl. VI, Figs. 3, 5

1969 *Biscutum kennedyi* BUKRY, n. sp. – BUKRY, p. 27, Pl. 7, Figs. 10–11.

DIMENSIONS. – Average length 4.2 μ ; average width 3.8 μ .

OCCURRENCE. – Santonian: Texas (BUKRY, 1969)
Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Genus *Calolithus* NOËL, 1965Type species: *Calolithus martelae* NOËL, 1965*Calolithus martelae* NOËL, 1965

Pl. XIII, Figs. 1-2, 6

1965 *Calolithus martelae* nov. spec. – NOËL, p. 135, Figs. 50-52; Pl. 14, Figs. 1-10; Pl. 15, Figs. 1-6.1969 *Watznaueria martelae* (NOËL) BUKRY, n. comb. – BUKRY, p. 32, Pl. 11, Figs. 1-3.DIMENSIONS. – Average length 5.4 μ ; average width 4.3 μ .

REMARKS. – *Calolithus martelae* NOËL, 1965 found in samples from Köpingsberg 1 is an elliptical coccolith with a distal shield composed of about 32 elements and a proximal shield of about 30 elements which are tooth-shaped at the margin. Oval perforations surround the central area which occupies 47 percent of the coccolith area. BUKRY (1969) transferred this species into the genus *Watznaueria* REINHARDT, 1964. *C. martelae* NOËL, 1965 differs from specimens belonging to the genus *Watznaueria* in having shields with a serrated margin, not closely appressed to each other, and in side view forming a furrow (Pl. VII, Fig. 6).

OCCURRENCE. – Oxfordian: Alger (NOËL, 1965)

Santonian – Campanian: Texas (BUKRY, 1969)

Köpingsberg Borehole No. 1: Albian.

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

Pl. VIII, Fig. 6; Pl. XIII, Fig. 4; Pl. XIV, Figs. 1-2

1965 *Cyclagelosphaera margereli* nov. sp. – NOËL, p. 130, Fig. 46; Pl. 17, Figs. 7, 10.1965 *Coccolithus* sp. – BLACK, pp. 132-133, Fig. 7.1966 *Cyclagelosphaera margereli* NOËL, – MARESCH, p. 378, Pl. 2, Fig. 5.1969 *Tergestiella margereli* (NOËL) nov. comb. – SHUMENKO, p. 36, Pl. 2, Fig. 8.1969 *Cyclagelosphaera margereli* NOËL, – BUKRY, p. 29, Pl. 9, Figs. 5-6.DIMENSIONS. – Average diameter 6.2 μ .

REMARKS. – NOËL (1965) erected a new genus *Cyclagelosphaera* NOËL, 1965 with the type species *C. margereli* NOËL, 1965. In 1970 she included

besides *C. aff. C. margereli* NOËL, 1965 and *C. sp.* also forms described by other authors as species of the genus *Cyclagelosphaera* in the synonym list of *Markalius circumradiatus* (STOVER) PERCH-NIELSEN, 1968 (p. 93). She noted that the forms described by her in the paper in 1970 lack the tubus in the centre, and thus differ from those described in 1965 which have a tubus between the proximal and distal shields. As the presence or absence of a tubus between the shields is difficult to determine when studying the species in distal view, such a difference is doubtful. The specimens found in the investigated samples from K opingsberg 1 show a similarity to *C. margereli* NOËL, 1965. They are photographed only in distal view. They are circular and show the affinity to species belonging to the genus *Markalius*. Therefore, they should also be transferred into the genus *Markalius*.

OCCURRENCE. – Oxfordian – Valanginian: France, Algeria (NOËL, 1965)
 Kimmeridgian: England (BLACK, 1965)
 Lower Cretaceous: Austria (MARESCH, 1966)
 Albanian – Santonian: Texas (BUKRY, 1969)
 Turonian: Russia (SHUMENKO, 1969)

K opingsberg Borehole No. 1: Hauterivian.

Genus *Discorhabdus* NOËL, 1965

Type species: *Discorhabdus patulus* (DEFLANDRE, 1954) NOËL, 1965

Discorhabdus ignotus (G RKA, 1957) PERCH-NIELSEN, 1968

Pl VI, Figs. 8–9

- 1957 *Tremalithus ignotus* n. sp. – G RKA, p. 248, Pl. 2, Fig. 9.
 1965 *Biscutum tredenale* n. sp. – REINHARDT, p. 32, Fig. 2; Pl. 1, Fig. 3.
 1966 *Biscutum tredenale* REINHARDT, – REINHARDT, p. 31, Fig. 13; Pl. 2, Figs. 3 a–b.
 1967 *Biscutum ignotum* (G RKA, 1957) n. comb. et emend. – REINHARDT et G RKA, p. 245, Pl. 31, Figs. 9–13.
 1968 *Discorhabdus ignotus* (G RKA, 1957) n. comb. – PERCH-NIELSEN, p. 81, Figs. 41–42; Pl. 28, Figs. 6–9.
 1969 *Bidiscus cruciatus cruciatus* BUKRY, n. sp., n. ssp. – BUKRY, p. 27, Pl. 6, Figs. 10–11.
 1970 *Discorhabdus ignotus* (G RKA, 1957) PERCH-NIELSEN, 1968, – NOËL, p. 87, Fig. 21; Pl. 32, Figs. 1–7, 9–10, 14–16.

DIMENSIONS. – Average diameter 3.4 μ .

OCCURRENCE. – Turonian: France, Germany (REINHARDT, 1966)
 Campanian: France (NOËL, 1970)
 Campanian – Santonian: Texas (BUKRY, 1969)
 Lower Maastrichtian: Denmark (PERCH-NIELSEN, 1968)

Maastrichtian: Poland (GÓRKA, 1957)

Maastrichtian: Germany (REINHARDT, 1965)

Köpingsberg Borehole No. 1: Barremian – Aptian, Cenomanian.

Genus *Margolatus* n. gen.

DERIVATION OF NAME. – *margo* (lat.) – margin; *latus* (lat.) – wide.

DIAGNOSIS. – Elliptical to nearly circular coccoliths with a wide rim cycle composed of about 35 elements overlapping each other. No secondary cycle is visible in distal view. The central area is depressed and composed of irregular elements. A central perforation is visible in distal view.

REMARKS. – Genus *Margolatus* n. gen. differs from the genus *Coccolithus* SCHWARZ, 1894 and the genus *Watznaueria* REINHARDT, 1964 in lacking the inner rim cycle surrounding the central area in distal view. The width of the outer rim cycle of the species belonging to the genus *Margolatus* n. gen. is also different.

Type species: *Margolatus manivitae* n. gen., n. sp.

Margolatus manivitae n. gen., n. sp.

Pl. XIV, Figs. 5–6

1970 *Watznaueria prolongata* BUKRY, 1969, – MANIVIT, p. 112, Pl. 28, Figs. 10–11.

DERIVATION OF NAME. – In honour of Dr. Helene Manivit, Université de Paris, Laboratoire de Paléontologie, Orsay, France.

HOLOTYPE. – Specimen No.: S Kp 137 23a/27.

PARATYPE. – Specimen No.: S Kp 359 pol.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 1 004.4 m.

TYPE STRATUM. – Hauterivian.

DIAGNOSIS. – Elliptical coccolith showing in distal view a wide single rim cycle composed of elements overlapping each other. The depressed central area showing a circular perforation, is composed of irregular elements.

DESCRIPTION. – The specimen illustrated on Pl. XIV, Fig. 6 shows 35 elements in the rim cycle. The central area is badly preserved and shows a large irregular shaped opening in the centre. Pl. XIV, Fig. 5 presents a coccosphere of *Margolatus manivitae* n. sp. probably composed of eight coccoliths. A circular perforation is visible in the centre of one of the coccoliths.

DIMENSIONS. – Average length 6.7 μ ; average width 6.4 μ . Coccosphere diameter 17 μ .

REMARKS. – *Margolatus manivitae* n. sp. differs from *Watznaueria barnesae* (BLACK, 1959) PERCH-NIELSEN, 1968 in lacking the secondary rim cycle visible in distal view. MANIVIT (1970) described and illustrated forms with two scanning electron micrographs which probably represent the same species as that found in the studied samples from Köpingsberg 1. She determined this species as *Watznaueria prolongata* BUKRY, 1969 without respect to BUKRY's description (1969, p. 34) of the Campanian species with a scalloped multi-layered elongate rim and an open central area (Pl. 12, Figs. 10–12).

OCCURRENCE. – Upper Turonian: France (MANIVIT, 1970) Köpingsberg Borehole No. 1: Hauterivian, Albian – Cenomanian.

Genus *Markalius* BRAMLETTE et MARTINI, 1964 emend. PERCH-NIELSEN, 1968
Type species: *Markalius inversus* (DEFL., 1954) BRAMLETTE et MARTINI, 1964

Markalius sulcatus n. sp.

Pl. VIII, Fig. 5

DERIVATION OF NAME. – *sulcus* (lat.) – furrow.

HOLOTYPE. – Specimen No.: S Kp 450 pol.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 945.9 m.

TYPE STRATUM. – Barremian.

DIAGNOSIS. – Circular coccolith with a distal shield composed of imbricate elements. A second rim cycle composed of strongly imbricate elements surrounds the central area in distal view. Four square elements form the central area. A rhombic perforation in the centre is visible in distal view.

DESCRIPTION. – A species of *Markalius* shows a rim cycle composed of 33–35 elements in distal view. A secondary inner rim cycle is composed of an equal number of elements. The central area including the inner cycle occupies about 50 percent of the coccolith area.

DIMENSIONS. – Average diameter 6.7 μ .

REMARKS. – *Markalius sulcatus* n. sp. differs from *Cyclagelosphaera margereli* NOËL, 1965 in the composition of the inner rim cycle which is composed of strongly imbricate elements. A further difference between the two species is the four square elements in the central area of the new species. It differs from *C. rotaclypeata* BUKRY, 1969 (p. 30, Pl. 9, Fig. 9) in lacking the 9–22 radially arranged irregular elements of which 8–11 dominate the central area described by BUKRY. The inner rim cycle of the Santonian – Campanian species consists of radial elements.

M. sulcatus n. sp. differs from *M. circumradiatus* (STOVER, 1966) PERCH-NIELSEN, 1968, described and illustrated with scanning electron micrographs by NOËL, (1970, pp. 93–94, Pl. 36, Figs. 1–7) in lacking the star-shaped central structure with 6–7 arms visible in distal view of the Campanian species.

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian, Albian – Cenomanian.

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

Pl. XIII, Figs. 3,5

1966 *Coccolithites circumradiatus* STOVER, new species, – STOVER, p. 138, Pl. 5, Figs. 2–4; Pl. 9, Fig. 10.

1968 *Markalius circumradiatus* (STOVER) n. comb. – PERCH-NIELSEN, p. 73, Figs. 36–37; Pl. 25, Figs. 2–7; Pl. 26, Figs. 1–7.

1970 *Markalius circumradiatus* (STOVER, 1966) PERCH-NIELSEN, 1968, – NOËL, pp. 93–94, Pl. 36, Figs. 1–7.

DIMENSIONS. – Diameter 6 μ .

REMARKS. – *Markalius* species with seven rays connected together in the center forming an asteroid ornamented central area. Two specimens were found in the samples studied.

OCCURRENCE. – Albian – Turonian: France (STOVER, 1966)

Campanian: France (NOËL, 1970)

Maastrichtian: Denmark (PERCH-NIELSEN, 1968)

Köpingsberg Borehole No. 1: Albian.

Genus *Repagulum* n. gen.

DERIVATION OF NAME. – *repagulum* (lat.) – gate.

DIAGNOSIS. – Elliptical coccoliths with the distal shield larger than the proximal one. Each rim cycle consists of very narrow elements forming a fine striated rim. The central area is occupied by transverse and, at the focuses of the ellipse, longitudinal bars. The transverse bars are connected by a bridge aligned with the long axis of the coccolith.

REMARKS. – Genus *Repagulum* n. gen. differs from the genus *Watznaueria* REINHARDT, 1964 in having rim cycles composed of about 70 narrow elements and a central area with longitudinal and transverse bars. It differs from the genus *Reticulofenestra* HAY et al, 1966 in lacking the large central opening spanned by a reticulate or lacy membrane.

BLACK (1967) erected a genus *Dictyococcites* BLACK 1967 including “coccoliths consisting of two elliptical shields joined together at the margin of a large central opening which is occupied by a grid of calcite bars meeting along the major diameter of the ellipse, each bar being continuous with one or more of the rays of the proximal shield”.

The central area of the *Repagulum* species occupies 20 percent of the coccolith area.

Type species: *Repagulum parvidentatum* (DEFLANDRE et FERT, 1954)
n. gen., n. comb.

Repagulum parvidentatum (DEFLANDRE et FERT, 1954) n. gen., n. comb.
Pl. XII, Figs. 1–7

- 1954 *Discolithus parvidentatus* DEFLANDRE et FERT, cent. nov. – DEFLANDRE et FERT, p. 23, Text-Figs. 28–29.
1959 *Tremalithus burwellensis* sp. nov. – BLACK, p. 324, Pl. 8.
1966 *Coccolithus parvidentatus* (DEFLANDRE et FERT, 1954) n. comb. – REINHARDT, p. 20, Pl. 20, Figs. 1–2.
1966 *Coccolithus burwellensis* (BLACK, 1959), – MARESCH, p. 378, Pl. 1, Fig. 1.
1967 *Dictyococcites burwellensis* comb. nov. – BLACK, p. 142.
1969 *Watznaueria? parvidentata* (DEFLANDRE and FERT) BUKRY, n. sp. – BUKRY, p. 33, Pl. 12, Figs. 5–8.
1970 *Reticulofenestra? parvidentata* (DEFLANDRE et FERT, 1954) nov. comb. – NOËL, pp. 94–95, Text-Fig. 22; Pl. 36, Figs. 8–14.
1970 *Watznaueria parvidentata* (DEFLANDRE et FERT) BUKRY, – MANIVIT, p. 112, Pl. 24, Figs. 11–15.

DIMENSIONS. – Average length 3.9 μ ; average width 3.3 μ .

REMARKS. — *Repagulum parvidentatum* (DEFLANDRE et FERT, 1954) n. gen., n. comb. is very abundant in all the samples treated in the present paper. If badly preserved, the specimens lack the bars in the central area and might thus be wrongly interpreted when studied by light microscope. Pl. XII, Figs. 1 and 3 show *R. parvidentatum* in distal as well as proximal view. The structures of the central area are lacking. Pl. XII, Figs. 5 and 7 show specimens in distal and proximal view with a fragment of the central structure. Pl. XII, Fig. 6 shows a fragment of a coccosphere where the central structures are complete. Pl. XII, Figs. 2 and 4 present specimens from younger levels (Aptian). The fossils are better preserved and show a central area fully occupied by transverse and longitudinal bars. DEFLANDRE et FERT (1954) originally described *Discolithus parvidentatus* DEFLANDRE et FERT, 1954 from the Senonian. BLACK et BARNES (1959) erected *Tremalithus burwellensis* BLACK et BARNES, 1959. REINHARDT (1966) transferred the form to the genus *Coccolithus* SCHWARZ 1894. BLACK (1967), BUKRY (1969) and NOËL (1970) were doubtful whether this species belonged to the genus *Coccolithus* and transferred it to the genus *Dictyococci-tes* BLACK, 1967, the genus *Watznaueria* REINHARDT, 1964 and the genus *Reti-culofenestra* HAY et al, 1966 respectively. The genus *Repagulum* n. gen. is proposed for coccoliths from the Cretaceous with the characteristics mentioned above.

OCCURRENCE. — Aptian — Upper Cenomanian: France (MANIVIT, 1970)
 Albian: France (BUKRY, 1969)
 Upper Cenomanian: England (BLACK et BARNES, 1959)
 Upper Turonian: Germany (REINHARDT, 1966)
 Coniacian — Campanian: France, Germany, Texas
 (BUKRY, 1969)
 Senonian: France (DEFLANDRE et FERT, 1954)
 Campanian: Austria (MARESCH, 1966)
 Campanian: France (NOËL, 1970)
 Köpingsberg Borehole No. 1: Hauterivian — Cenomanian.

Family DEFLANDRIACEAE BLACK, 1967

Genus *Deflandrius* BRAMLETTE and MARTINI, 1964 emend.

DIAGNOSIS emend. — Rhabdoliths with a circular to slightly elliptical basal plate, consisting of two¹⁾ rim cycles with 16 nearly equal-sized elements in each.

¹⁾ Investigations of *Deflandrius cantabrigensis* BLACK, 1967 in JEM 1000 KV (FORCHHEIMER, 1970) show the possibility of more than two rim cycles with 16 elements in each. It is desirable to continue these studies in order to clarify the number of shields present in these coccoliths as well as in many other forms.

In distal view they interlock along zigzag sutures or are wedge-shaped. Open central area spanned by one or two pairs of crossbars, in the latter case forming a proximal and a distal set. They are X-shaped or aligned to the long and short axis. At their intersection there is a square or rounded opening. Some specimens show a central process composed of four longitudinal elements with delicate spines attached at the top, or a stem supported by four buttresses. The stems show protuberances in the middle, and a small cross or four well developed wings at the distal end.

Type species: *Deflandrius intercisus* (DEFLANDRE) BRAMLETTE et MARTINI, 1964

REMARKS. – More than a century ago SORBY (1861) described coccoliths from the Chalk and illustrated them by drawings (Figs. 3–4) but unfortunately he did not name these fossils. The description (p. 197) and the drawings correspond very well to species of the genus *Deflandrius* BRAMLETTE et MARTINI, 1964.

ARKHANGELSKY (1912) described *Coccolithophora cretacea* as being oval-shaped and consisting of two convex shields. The distal shield has in the centre an oval depression from which thin sutures extend. Every suture terminates at the periphery with a depression. It makes the margin tooth-shaped. The central opening is spanned by X-shaped crossbars. The inner shield is sometimes tooth-shaped or sometimes smooth at the margin.

DEFLANDRE in DEFLANDRE et FERT (1954) proposed a new species. The illustrations in Text-Figs., 91, 92 and light microscope micrographs in Pl. 13, Figs. 12–13 present a coccolith composed of a basal shield and a process, named by DEFLANDRE as *Rhabdolithus intercisus* DEFLANDRE, 1954.

GÓRKA (1957) published *Discolithus cretaceus* (ARKHANGELSKY) citing *Coccolithophora cretacea* ARKHANGELSKY as synonymy. The specimen illustrated with a drawing (Pl. 2, Fig. 11) shows a rim cycle composed of 14 elements and a central opening spanned by a straight cross. GÓRKA, however, mentioned in the diagnosis of this species 18–48 suture lines in the rim.

DEFLANDRE (1959) erected a new genus *Zygrhablithus* with the type species *Zygrhablithus bijugatus* (DEFLANDRE, 1954) and transferred *Rhabdolithus intercisus* DEFLANDRE, 1954 to this genus.

In the same year VEKSHINA (1959) erected a new genus *Prediscosphaera* with the type species *Prediscosphaera decorata* VEKSHINA, 1959 (Pl. 1, Figs. 8–9; Pl. 2, Figs. 13 a–c). According to her diagnosis, coccoliths belonging to this genus are of rhabdolith type. Most characteristic of the species *Prediscosphaera decorata* is the presence of a secondary shield on the distal end of the central

process, much less developed than the proximal shield. The shields are ring-shaped. The rhabdolith has a close affinity to the genus *Discosphaera* due to the funnel-shaped top of the process. As synonymy she proposed *Coccolithophora cretacea* ARKHANGELSKY although *Rhabdolithus intercisus* DEFLANDRE, 1954 has been known.

GARTNER (1968) stated that the genus *Prediscosphaera* VEKSHINA, 1959 has to be given priority over the genus *Deflandrius* BRAMLETTE et MARTINI, 1964. His conclusions were based on numerous electron micrographs of specimens belonging to this genus. As type species he designated *P. cretacea* (ARKHANGELSKY) due to the fact that *P. decorata* VEKSHINA, 1959 is an "objective junior synonym to *Coccolithophora cretacea* ARKHANGELSKY, 1912". GARTNER continues: "The species was first described by ARKHANGELSKY in 1912, but his illustrations are ambiguous. In 1954 DEFLANDRE described *Rhabdolithus intercisus*, but illustrations of this species are also rather unclear. In 1959 VEKSHINA named and described *Prediscosphaera decorata*, citing *Coccolithophora cretacea* ARKHANGELSKY in her synonymy. She also pointed out the similarity of her specimens to ARKHANGELSKY's. The specific name '*decorata*' is an objective junior synonym of the specific name '*cretacea*' and, therefore, is invalid. The transmission electron micrographs of VEKSHINA (1959, Pl. 1, Figs. 8-9) are more accurate than her drawings, which appear to be largely interpretations. In 1959 DEFLANDRE redescribed *R. intercisus*, reillustrated the type specimen and transferred the species to the new genus *Zygrhablithus*. DEFLANDRE's 1959 characterization and illustration of *Z. intercisus* are excellent and he indicated that he did not believe *C. cretacea* ARKHANGELSKY to be the same species."

As there is no possibility of studying the holotype material of *Coccolithophora cretacea* ARKHANGELSKY, 1912, a comparison with the drawings on Pl. 6, Figs. 12, 13 is unreliable. Fig. 12 presents an elliptical coccolith with a very small central opening surrounded by a broad inner cycle. Fig. 13 shows a coccolith with a larger central opening and an outer rim cycle composed of 18 elements. A central process is not mentioned by ARKHANGELSKY (1912).

VEKSHINA's illustrations and drawings are also difficult to interpret and the diagnosis differs from that of *Rhabdolithus intercisus*. Further, VEKSHINA did not mention the paper of DEFLANDRE et FERT (1954) where *R. intercisus* was described. The genus *Deflandrius* BRAMLETTE et MARTINI, 1964 was erected for species originally described by DEFLANDRE. This genus includes species with "elliptical to nearly circular base with open area bridged by crossbars; rim composed of about 16 larger nearly equidimensional units of keystone shape, each one a unit of calcite, with their optical axis oriented more nearly tangentially than radially. Usually with a smaller and thinner ring composed of fine radial elements, closely attached on the concave basal side and extending

within and thus partially closing the central opening. Bars arched up and surmounted at the center by a small knob or an elongated stem of complex construction”.

The present author follows this diagnosis with emendations based on scanning electron microscope studies which provide additional fine structure.

A collection of figures redrawn from original publications concerning the taxonomical problem of *Deflandrius* is shown in chronological order in Fig. 6.

Deflandrius cantabrigensis BLACK, 1967

Pl. VII, Figs. 1-6

1861 SORBY, H. C., p. 199, Figs. 3-4, p. 197.

1965 "*Deflandrius*" sp. - BLACK, p. 134, Figs. 14-15.

1966 *Deflandrius cretaceus intercisus* (DEFLANDRE, 1954), - REINHARDT, p. 35, Pl. 22, Fig. 2, Text-Fig. 20 a.

1967 *Deflandrius cantabrigensis* sp. nov. - BLACK, p. 140, Fig. 1.

1968 *Deflandrius columnatus* STOVER, - STRADNER, p. 31, Pls. 18, 19.

1968 *Deflandrius cantabrigensis* BLACK, - BLACK, p. 807, Pl. 151, Fig. 1.

1968 *Prediscosphaera cretacea* (VEKSINA), - GARTNER, p. 19-20, Pl. 9, Figs. 1-4; Pl. 12, Figs. 1 a-c; Pl. 14, Fig. 20; Pl. 18, Fig. 8; Pl. 22, Figs. 1-3; Pl. 23, Figs. 4-6; Pl. 25, Figs. 12-13.

1969 *Prediscosphaera cretacea cretacea* (ARKHANGELSKY), - BUKRY, p. 38, Pl. 17, Figs. 1-6.

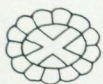
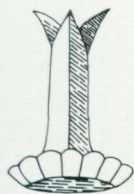
1970 *Deflandrius cantabrigensis* BLACK, - FORCHHEIMER, p. 37, Figs. 34-40.

ORIGINAL DIAGNOSIS. - "Rhabdoliths with the generic characters of *Deflandrius* and with a whorl of four protuberances at the junction of the two bundles of crystal which form the stalk."

DESCRIPTION. - *Deflandrius* sp. with subcircular basal shield showing in distal view a cycle consisting of 16 large elements interlocking along zigzag sutures. The central area is lined with a cycle composed of about 16 narrow elements. X-shaped crossbars with a square opening at their intersection rise from this cycle in distal view. A massive central process with a ring of protuberances and with triangular expansions is seen distally. The process is supported up to the protuberances by four buttresses. Pl. VII, Figs. 5-6.

DIMENSIONS. - Average diameter of basal shield 5 μ ; total average height 6.1 μ .

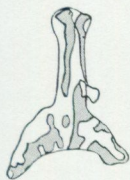
REMARKS. - As mentioned by BLACK (1967) *Deflandrius cantabrigensis* BLACK, 1967 differs from previously described species in having well-developed expansions on the central process. This species differs from *D. intercisus* (DEFLANDRE, 1954) in having a more massive process with larger expansions at the top. *D. columnatus* STOVER, 1966 is similar to *D. cantabri-*



"Coccoliths with a sort of spine, - SORBY (1861)



Coccolithophora cretacea ARKHANGELSKY, 1912



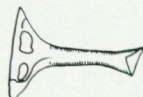
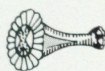
Rhabdolithus intercisus DEFLANDRE, 1954



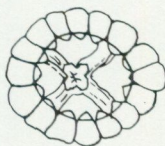
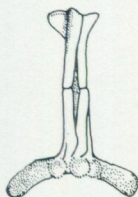
Discolithus cretaceus (ARKHANGELSKY) GORKA, 1957



Prediscosphaera decorata VEKSHINA, 1959



Prediscosphaera decorata VEKSHINA, 1959



Zygrhablithus intercisus (DEFL.) DEFLANDRE, 1959



Deflandrius intercisus (DEFL.) BRAMLETTE ET MARTINI, 1964

Fig. 6. The taxonomical problem of *Deflandrius* (figures redrawn from original publications).

gensis BLACK, 1967 but differs in having a narrow process and less developed wing-like expansions. The quality of the illustrations (Pl. 6, Figs. 6–10), however, does not allow any reliable comparison with the present material.

REINHARDT (1966) proposed a separation of forms with and without a process and proposed these as two subspecies of *D. cretaceus* (ARKHANGELSKY, 1912) BRAMLETTE et MARTINI, 1964. He designated forms without a process as *D. cretaceus cretaceus* (ARKHANGELSKY, 1912), and with a process as *D. cretaceus intercisus* DEFLANDRE, 1954).

The present author proposes the same species for forms with or without a process, which can be broken in badly preserved material or can be missing due to the treatment during the preparation of the sample. Therefore, the taxonomy should not be based on presence or absence of a process. Further, it is clear that several species of the genus *Deflandrius* are represented among the specimens without a process.

Among specimens illustrated by GARTNER (1968) only those given in the synonym list are similar to *D. cantabrigensis* BLACK, 1967.

- OCCURRENCE. – Aptian – Turonian: France (MANIVIT, 1970)
 Middle Cenomanian: Denmark (FORCHHEIMER, 1970)
 Cenomanian: England (BLACK, 1967)
 Cenomanian – Campanian: Texas (GARTNER, 1968)
 Turonian: Germany (REINHARDT, 1966)
 Santonian – Campanian: Texas (BUKRY, 1969)
 Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Deflandrius spinosus BRAMLETTE et MARTINI, 1964

Pl. VI, Figs. 1–2, 4, 6–7

- 1964 *Deflandrius spinosus* BRAMLETTE et MARTINI, p. 301, Pl. 2, Figs. 17–20.
 1965 *Eiffellithus cretaceus cretaceus* (ARKHANGELSKY, 1912), – REINHARDT, p. 35, Pl. 2., Fig. 4; Text-Fig. 3.
 1966 *Deflandrius cretaceus cretaceus* (ARKHANGELSKY, 1912), – REINHARDT, p. 35, Pl. 10, Figs. 1 a–b, 2 a–b; Text-Fig. 4.
 1966 *Deflandrius cretaceus intercisus* (DEFLANDRE, 1954), – REINHARDT, p. 35, Pl. 37, Text-Fig. 20 b.
 1967 *Deflandrius spinosus* BRAMLETTE et MARTINI, 1964, – LYUL'eva, p. 96, Pl. III, Figs. 24–24 a.
 1968 *Deflandrius spinosus* BRAMLETTE et MARTINI, – PERCH-NIELSEN, p. 35, Pl. 11, Fig. 1; Pl. XIV, Figs. 3–8.
 1968 *Prediscosphaera spinosa* (BRAMLETTE et MARTINI, 1964), – GARTNER, p. 20, Pl. 2, Figs. 15–16; Pl. 3, Figs. 9–10; Pl. 5, Figs. 7–9; Pl. 6, Fig. 16; Pl. 11, Fig. 17.
 1969 *Prediscosphaera spinosa* (BRAMLETTE et MARTINI, 1964), – BUKRY, p. 40, Pl. 8, Figs. 7–9.
 1970 *Prediscosphaera spinosa* (BRAMLETTE et MARTINI, 1964) GARTNER, 1968, – NOËL, p. 66, Pl. 16, Figs. 4–5, 6–9 and 10.

DESCRIPTION. – Coccolith with an elliptical base consisting of two superimposed cycles (the proximal one smaller than the distal one), each composed of 16 wedged-shaped elements. The open central area is lined by a narrow rim consisting of 16 elements building up a wall. The central area occupying about 55 percent of the basal shield is spanned by two pairs of bars perpendicular to each other. A long and slender process shows four delicate spines attached at the top.

DIMENSIONS. – Average length 4.5μ ; average width 3.8μ ; average length of the central process 4.2μ .

REMARKS. – BRAMLETTE et MARTINI (1964) erected the species *Deflandrius spinosus*. Their illustrations (Pl. 2, Figs. 17–20) clearly show the slender process and delicate spines attached at the top. Under the light microscope the difference in the process as well as in the bars between this species, *D. cantabrigensis* BLACK, 1967 and *D. intercicus* (DEFLANDRE, 1954) BRAMLETTE et MARTINI, 1964 could be observed. Electron microscope micrographs show also the difference in the shape of the elements constituting the cycles of the basal shield. Due to the fact that the process is often broken or missing, it is difficult to identify the various species of the genus *Deflandrius* by light microscope. REINHARDT (1966) described *D. cretaceus intercicus* (DEFLANDRE, 1954). The drawing (p. 37, Fig. 20) shows a process like that of *D. cantabrigensis* BLACK, 1967, and a basal shield similar to that of *D. spinosus* BRAMLETTE et MARTINI, 1964.

The studies of several *Deflandrius* forms by scanning electron microscope show that specimens with a process ending with spines have wedge-shaped elements in the cycles of the basal shield. The crossbars are always perpendicular.

The taxonomic problems with the specific name *Prediscosphaera* used by GARTNER (1968) and BUKRY (1969) are discussed above (pp. 39–42, Fig. 6).

OCCURRENCE. – Turonian: Russia (LUYL'EVA, 1967)
Coniacian – Campanian: Texas (BUKRY, 1969)
Campanian: France (NOËL, 1970)
Campanian – Maastrichtian: Texas (GARTNER, 1968)
Campanian – Maastrichtian: France (MANIVIT, 1970)
Lower Maastrichtian: Denmark (PERCH-NIELSEN, 1968)
Lower Maastrichtian: Germany (REINHARDT, 1966)
Maastrichtian: America, Europe (BRAMLETTE et MARTINI, 1964)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Deflandrius cf. *D. stoveri* PERCH-NIELSEN, 1968

Pl. VI, Figs. 10–11

?1966 *Discolithus incohatus* STOVER, new species, – STOVER, p. 143, Pl. 2, Figs. 23–24; Pl. 8, Fig. 17.

1968 *Deflandrius stoveri* n. sp. – PERCH-NIELSEN, pp. 66–67, Pl. 16, Figs. 11–13.

DIMENSIONS. – Length 6.4 μ ; width 4.7 μ .

REMARKS. – STOVER (1966) published *Discolithus incohatus* STOVER, 1966 illustrated with light microscope micrographs and a drawing. The unclear fine structure of this species makes a comparison with the (only one) specimen found in Köpingsberg 1 material difficult. *Deflandrius* cf. *D. stoveri* PERCH-NIELSEN, 1968 shows the same composition of the coccolith as that visible in the transmission electron micrograph (PERCH-NIELSEN, 1968, Pl. 16, Fig. 10) with the exception of the crossbars. The crossbars of *D.* cf. *D. stoveri* PERCH-NIELSEN, 1968 show double rows of elements while *D. stoveri* PERCH-NIELSEN, 1968 has only single crossbars.

OCCURRENCE. – Coniacian – Campanian: France (STOVER, 1966)
 Maastrichtian: Denmark (PERCH-NIELSEN, 1968)
 Köpingsberg Borehole No. 1: Albian.

Family EIFELLITHACEAE REINHARDT, 1964

Genus *Chiastozygus* GARTNER, 1968Type species: *Zygodiscus amphipons* BRAMLETTE et MARTINI, 1964*Chiastozygus cuneatus* (LUYL'EVA, 1967) CEPEK et HAY, 1969

Pl. XVIII, Figs. 1–4

1967 *Zygodiscus cuneatus* sp. nov. – LUYL'EVA, p. 93, Pl. 1, Fig. 13.

1969 *Chiastozygus cuneatus* (LUYL'EVA) n. comb. – CEPEK et HAY, p. 325, Fig. 4 (1).

REMARKS. – *Chiastozygus cuneatus* (LUYL'EVA, 1967) was originally described by LUYL'EVA (1967) and illustrated by a drawing (p. 93, Pl. 1, Fig. 13). This species is easily recognized under the light microscope and therefore a

comparison with LUYL'EVA's excellent drawing and relatively detailed description is possible. The elliptical coccolith has a distal rim cycle composed of about 45 very strongly inclined elements. The central plate is spanned by two S-shaped irregular crossbars. In distal view the crossbars are narrow at the centre and broad at the rim. The opening aligning the long axis and the short axis respectively are of equal size. BUKRY (1969, p. 50, Pl. 27, Figs. 7–8) described *C. interruptus* BUKRY, 1969 as having four perforations of equal size, a fifth bar interrupting the crossbars and an elongated process. He reported the occurrence as being the Santonian – Campanian layers of Texas. The specimens studied in the Swedish material do not show a central process. They differ from the form described by BUKRY also in lacking the fifth bar.

OCCURRENCE. – Cenomanian – Turonian: U.S.A. (CEPEK et HAY, 1969)
 Turonian: Russia (LUYL'EVA, 1967)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Genus *Eiffellithus* REINHARDT, 1964

Type species: *Eiffellithus turriseiffeli* (DEFLANDRE, 1962) REINHARDT, 1964

Eiffellithus eximius (STOVER, 1966) PERCH-NIELSEN, 1968

Pl. XV, Figs. 1–3

- 1966 *Clinorhabdus eximius* STOVER, n. sp. – STOVER, p. 138, Pl. 2, Figs. 15–16; Pl. 8, Fig. 15.
 1967 *Clinorhabdus eximius* STOVER, – LUYL'EVA, p. 93, Pl. 2, Figs. 21–21 a.
 1968 *Eiffellithus turriseiffeli* (DEFLANDRE) REINHARDT, – GARTNER, p. 26, Pl. 16, Fig. 2; Pl. 17, Fig. 3; Pl. 18, Fig. 10; Pl. 19, Figs. 1–2; Pl. 23, Fig. 8; Pl. 24, Fig. 2.
 1968 *Eiffellithus eximius* (STOVER) n. comb. – PERCH-NIELSEN, p. 30, Pl. 3, Figs. 8–10.
 1968 *Zygrabolithus turriseiffeli* (DEFLANDRE), – MANIVIT, p. 284, Pl. 2, Figs. 4 a–b.
 1970 *Eiffellithus eximius* (STOVER) PERCH-NIELSEN, 1968, – NOËL, p. 40, Pl. 6, Figs. 4–5 a, b–7; Pl. 7, Figs. 1–7.
 1970 *Eiffellithus eximius* (STOVER) PERCH-NIELSEN, – MANIVIT, p. 88, Pl. 11, Figs. 10–11.

DIMENSIONS. – Average length 6.3 μ ; average width 4.9 μ .

OCCURRENCE. – Turonian: Russia (LUYL'EVA, 1967)

Turonian – Campanian: France (STOVER, 1966)

Coniacian: France (MANIVIT, 1970)

Coniacian – Campanian: Texas (GARTNER, 1968)

Campanian: France (NOËL, 1970)

Maastrichtian: Denmark (PERCH-NIELSEN, 1968)

Köpingsberg Borehole No. 1: Hauterivian, Aptian – Cenomanian.

Genus *Helicolithus* NOËL, 1970Type species: *Helicolithus anceps* (GÓRKA) NOËL, 1970*Helicolithus stillatus* n. sp.

Pl. XI, Figs. 1-4; Pl. XVI, Figs. 5-6

DERIVATION OF NAME. – *stilla* (lat.) – drop.

HOLOTYPE. – Specimen No.: S Kp 177 33a/10.

PARATYPE. – Specimen No.: S Kp 196 31a/3.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 995.7 m.

TYPE STRATUM. – Hauterivian.

DIAGNOSIS. – A species of *Helicolithus* with a smooth cycle of radial elements in distal view, and a secondary cycle of small elements on the proximal surface. The open central area is divided by X-shaped crossbars into two small and two large drop-shaped openings surrounded by cycles of small elements. A central process is present in distal view, or can be missing.

DESCRIPTION. – The elliptical coccolith has in distal view a rim cycle composed of about 60 radial elements and a central area which occupies 70 percent of the coccolith area. The X-shaped crossbars consist of a double row of elements. The small openings have a diameter of 0.83μ , and the large openings of 1.66μ . Specimens found at levels 1 004.4 m to 924.2 m mostly lack the central process showing a square opening in the centre. The secondary cycle at the margin of the central area is composed of about 60 elements.

REMARKS. – *Helicolithus stillatus* n. sp. resembles *Chiastozygus litterarius* (GÓRKA) MANIVIT, 1970. However, the comparison with the original form described by GÓRKA (1957, p. 251, Pl. 3, Fig. 3) requires great care. GÓRKA described an elliptical coccolith from the Maastrichtian, with a narrow rim (0.5μ). The central opening is rectangular. Every corner of the rectangle extends into a ray reaching the rim, which is sometimes broader than the rays. Sometimes small perforations are visible in the central area. The brief description with accompanying generalized drawing of *Discolithus litterarius* GÓRKA, 1957 does not make a comparison possible.

OCCURRENCE. – Köpingsberg Boerhole No. 1: Hauterivian – Cenomanian.

Family PODORHABDACEAE NOËL, 1965

Genus *Cretarhabdus* BRAMLETTE et MARTINI, 1964Type species: *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964*Cretarhabdus actinosus* (STOVER, 1966) n. comb.

Pl. XIX, Fig. 4

- 1966 *Coccolithus actinosus* STOVER, new species, – STOVER, p. 138, Pl. 1, Figs. 15–16; Pl. 8, Fig. 7.
 1968 *Cretarhabdus crenulatus* BRAMLETTE et MARTINI, – GARTNER, p. 22, Pl. 1, Fig. 8.
 Non 1968 *Polypodorhabdus actinosus* (STOVER, 1966) n. comb. – PERCH-NIELSEN, p. 35, Pl. 14, Figs. 7–9.
 1969 *Cretarhabdus crenulatus hausmanii* BUKRY, n. ssp. – BUKRY, p. 35, Pl. 14, Figs. 7–9.
 Non 1969 *Watznaueria actinosa* (STOVER), BUKRY n. comb. – BUKRY, p. 31, Pl. 9, Fig. 12.

DIMENSIONS. – Average length 4.8 μ ; average width 4 μ .

REMARKS. – STOVER (1966) erected and described *Coccolithus actinosus*, illustrating this species by light microscope micrographs and an excellent drawing. *Cretarhabdus actinosus* (STOVER) n. comb. differs from *C. bisertiatus* n. sp. in having only one cycle of 12 perforations. *C. actinosus* (STOVER) n. comb. differs from *Polypodorhabdus actinosus* (STOVER, 1966) PERCH-NIELSEN, 1968 in the composition of the central area which in the latter is composed of 10–12 elements and smaller elements aligned with the major axis (1968, p. 50, Fig. 19; Pl. 10, Figs. 1–6).

C. actinosus (STOVER, 1966) n. comb. differs from *Watznaueria actinosa* (STOVER) BUKRY, 1969 in having the composition typical of *Cretarhabdus* species, consisting of the distal rim cycle and crossbars dividing the central area into four parts. According to BUKRY a cross structure has not been observed in *W. actinosa*. The central area is perforated by 7–10 openings while *C. actinosus* has usually three perforations in each quadrant of the central area.

OCCURRENCE. – Neocomian – Lower Cenomanian: France (STOVER, 1966)
 Cenomanian – Maastrichtian: Texas (GARTNER, 1968)
 Campanian – Maastrichtian: Texas (BUKRY, 1969)
 Köpingsberg Borehole No. 1: Albian.

Cretarhabdus biseriatus n. sp.

Pl. XIX, Figs. 5–6, Pl. XXI, Fig. 6

DERIVATION OF NAME. – *biseriatus* (lat.) – arranged in two rows.

HOLOTYPE. – Specimen No.: S Kp 338 53a/1.

PARATYPE. – Specimen No.: S Kp 94 90/11.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 924.2 m.

TYPE STRATUM. – Albanian.

DIAGNOSIS. – A species of *Cretarhabdus* with two cycles of perforations. The outer perforations are about 2/3 of the size of the inner perforations.DESCRIPTION. – Elliptical coccoliths with a 2-cycle distal rim. The outer rim is narrow. The inner rim cycle, composed of about 33 elements, terminates in a cycle of about 30 small circular perforations (diameter 0.18 μ). The central plate is divided by an axial cross into four quadrants. In every quadrant four larger perforations (0.27 μ in diameter) are arranged mainly concentrically with the cycle of smaller perforations. A central process rises in distal view. The proximal shield is smaller than the distal shield (Pl. XIX, Fig. 5). The perforations mentioned above as well as a central perforation are seen in proximal view.DIMENSIONS. – Average length 7.6 μ ; average width 5.9 μ .REMARKS. – *Cretarhabdus biseriatus* n. sp. differs from *C. loriei* GARTNER, 1968 in having two cycles of perforations.

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Cretarhabdus conicus BRAMLETTE et MARTINI, 1964

Pl. XIX, Figs. 1–3

1964 *Cretarhabdus conicus* BRAMLETTE et MARTINI, new species, – BRAMLETTE et MARTINI, p. 299, Pl. 3, Figs. 5–8.1965 *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964, – MANIVIT, p. 193, Pl. 1, Figs. 2 a–d.

- 1966 *Cretarhabdus conicus* BRAMLETTE et MARTINI, – STOVER, p. 140, Pl. 1, Figs. 19–2f; Pl. 8, Fig. 9.
- 1968 *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964, – GARTNER, pp. 21–22, Pl. 1, Fig. 11; Pl. 3, Figs. 5–6; Pl. 6, Figs. 3–4; Pl. 11, Figs. 12 a–c; Pl. 22, Figs. 20–21.
- Non 1968 *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964, – PERCH-NIELSEN, p. 51, Pl. 12, Figs. 1–4.
- 1969 *Cretarhabdus conicus* BRAMLETTE et MARTINI, – BUKRY, p. 35, Pl. 13, Figs. 7–12.
- 1970 *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964, – MANIVIT, p. 97, Pl. 2, Figs. 13–18.
- Non 1970 *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964, – NOËL, p. 58, Text-Fig. 14, Pl. 17, Figs. 2–4.

DIMENSIONS. – Average length 6 μ ; average width 5 μ .

REMARKS. – *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964 was erected and described on a basis of investigations by light microscope. The cone-shaped central area perforated by many pores is reported in several papers except those of PERCH-NIELSEN (1968) and NOËL (1970). PERCH-NIELSEN reported: “. . . die Granulae, die das Zentralfeld besetzen sind dicht gepackt und ca 0.5 μ gross”. NOËL described the central area as follows: “L’aire centrale conique est faite de petits cristaux équidimensionnels”. *Cretarhabdus conicus* BRAMLETTE et MARTINI, 1964 differs from *C. biseriatus* n. sp. and from *C. actinosus* (STOVER, 1966) in having three or more concentric cycles of equal perforations in the central area. All the specimens of *C. conicus* BRAMLETTE et MARTINI, 1964 found in the samples studied from Köpingsberg Borehole No. 1 are smaller than the forms reported in the synonym list where the long axis varies between 7,7 μ and 12 μ .

OCCURRENCE. – Albian – Campanian: France, Texas (BUKRY, 1969)
 Cenomanian – Maastrichtian: Texas (GARTNER, 1968)
 Cenomanian: England (BLACK, 1968)
 Turonian – Maastrichtian: France (MANIVIT, 1970)
 Campanian – Maastrichtian: France (STOVER, 1966)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Cretarhabdus octoperforatus n. sp.

Pl. XX, Figs. 1–2

DERIVATION OF NAME. – *octo* (lat.) – eight, *perforatus* (lat.) – perforate.

HOLOTYPE. – Specimen No.: S Kp 96 20a/23.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 846.4 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Cretarhabdus* with eight perforations, two in each quadrant of the central shield, spanned by a thin transverse bar.

DESCRIPTION. – A broad elliptical *Cretarhabdus* species with a proximal shield smaller than the distal one. The central area occupies about 20 percent of the area of the coccolith. No perforation is present in the centre.

DIMENSIONS. – Average length 7 μ ; average width 6.4 μ .

REMARKS. – *Cretarhabdus octoperforatus* n. sp. differs from the other *Cretarhabdus* species in having the perforations spanned by transverse bars dividing the openings radially in two equal parts.

OCCURRENCE. – Köpingsberg Borehole No. 1: Albian – Cenomanian.

Cretarhabdus unicornis STOVER, 1966

Pl. XX, Figs. 3–6

- 1966 *Cretarhabdus unicornis* STOVER, new species, – STOVER, p. 140, Pl. 5, Figs. 15–16; Pl. 9, Fig. 15.
1969 *Cretarhabdus unicornis* STOVER, – BUKRY, p. 36, Pl. 15, Figs. 7–9.
1970 *Cretarhabdus unicornis* STOVER, 1966, – NOËL, p. 59, Fig. 15; Pl. 18, Figs. 1–3.
1970 *Cretarhabdus unicornis* STOVER, 1966, – MANIVIT, p. 100, Pl. 9, Figs. 13–16.

DIMENSIONS. – Average length 10.8 μ ; average width 9.4 μ .

REMARKS. – The specimen illustrated on Pl. XX, Figs. 3–4 is the same specimen seen from various angles. The fine structure of the central area in proximal view is very clearly shown on both micrographs. The four circular openings are of equal size with a diameter of about 1.45 μ . They are surrounded by cycles of square elements filling out the central area. The first two cycles consist of about 12 elements each. The outline of the third cycle is more drop-shaped, converging to the centre. The elliptical central area is thus divided into four sectors. A third rim cycle with about 45 radially oriented elements in the proximal view is clearly visible.

Openings surrounded by small square elements occur also in *Helicolithus stillatus* n. sp. (P: XI, Figs. 1–4) and in *Amphizygus broksii broksii* BUKRY, 1969 (Pl. 25, Figs. 1–3).

OCCURRENCE. – Albian – Coniacian: France (STOVER, 1966)
Albian – Coniacian: France (MANIVIT, 1970)
Santonian: France, Texas (BUKRY, 1969)
Campanian: France (NOËL, 1970)

Köpingsberg Borehole No. 1: Hauterivian – Barremian, Albian.

Family *POLYCYCLOLITHACEAE* n. fam.

DIAGNOSIS. – Calcareous nannofossils, asteroid or circular, composed of several rim cycles of rhombohedral or zigzag elements or rim cycles with triangular rays, surrounding an open or closed central area. The rhombohedrad or zigzag elements form concentric cycles covering each other.

The central area is constructed of the same number of elements as the outer rim. The central area varies in the composition of the overlapping or triangular elements.

The cubic forms of the genus *Micula* Vekshina, 1959 may also belong to this family as the shape of the corners evidently may change and the concavities may form a central area.

Type genus: *Polycyclolithus* FORCHHEIMER, 1968

Genus *Lithastrinus* STRADNER, 1962

Type species: *Lithastrinus grilli* STRADNER, 1962

Lithastrinus septenarius n. sp.

Pl. XXIV, Figs. 1–4; Pl. XXVII, Fig. 2

DERIVATION OF NAME. – *septenarius* (lat.) – composed of seven.

HOLOTYPE. – Specimen No.: S Kp 217 85a/3.

PARATYPE. – Specimen No.: S Kp 136 24a/9.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 936.9 m.

TYPE STRATUM. – Aptian.

DIAGNOSIS. – *Lithastrinus* species with seven rays surrounding the central area.

DESCRIPTION. – The circular central area composed of seven sectors is proximally and distally surrounded by triangular rays. The average length of the rays about 3.6μ and the diameter of the central area 2μ .

DIMENSIONS. – Average diameter of the specimen including the rays 8.2μ .

REMARKS. – *Lithastrinus septenarius* n. sp. differs from *L. grilli* STRADNER, 1962, reported from the Turonian (p. 369, Pl. 2, Figs. 1–5) in having seven rays. The transmission electron micrographs of *L. grilli* published by GARTNER (1968, Pl. 18, Figs. 1–2; Pl. 20, Fig. 17; Pl. 22, Fig. 26) and BUKRY (1969, p. 43, Pl. 21, Figs. 3–6) also show six rays, occurring in forms from the Cenomanian – Campanian. BUKRY did mention six or seven conical rays arising at each end but as lectotype species he designated a form with six rays illustrated by STRADNER (1962, Pl. 2, Fig. 2).

The light microscope micrographs of *L. grilli* illustrated by MANIVIT (1970, Pl. 15, Figs. 4–5) from the Turonian show a form with star-shaped outline composed of seven shorter rays.

OCCURRENCE. – Hauterivian – Cenomanian.

Genus *Micula* VEKSHINA, 1959

Type species: *Micula decussata* VEKSHINA, 1959

(non *M. degussata*, VEKSHINA, 1959)

Micula cubiformis n. sp.

Pl. XXV, Figs. 1, 3–5

DERIVATION OF NAME. – *cubiformis* (lat.) – cubical.

HOLOTYPE. – Specimen No.: S Kp 211 39a/6.

PARATYPE. – Specimen No.: S Kp 472 69a/4.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 809.35 m.

TYPE STRATUM. – Aptian.

DIAGNOSIS. – *Micula* species, cube-shaped with a centric depression in each face. The corners are square or rounded.

DESCRIPTION. – The coccoliths are composed of irregular elements giving the six more or less concave faces a rough surface. A centric depression on each face is clearly visible in the scanning electron micrographs (Pl. XXV, Fig. 1).

DIMENSIONS. – Average diagonal 9.5 μ .

REMARKS. – *Micula cubiformis* n. sp. differs from *M. decussata* VEKSHINA, 1959 reported from the Maastrichtian in Russia, in being cube-shaped (Pl. XXV, Fig. 5) and not a “parallelogram”. The presence of the centric depression is a further difference.

OCCURRENCE. – K pingsberg Borehole No. 1: Hauterivian – Cenomanian.

Micula staurophora (GARDET, 1955) STRADNER, 1963

Pl. XXIV, Figs. 5–6; Pl. XXV, Figs. 2, 6

1955 *Discoaster staurophorus* n. cent. – GARDET, p. 534, Pl. 10, Fig. 96.

1963 *Micula staurophora* (GARDET), – STRADNER, p. 13, Figs. 12 a–c.

1964 *Micula staurophora* (GARDET), – BRAMLETTE et MARTINI, pp. 318, 320, Pl. 6, Figs. 10–11.

1968 *Micula decussata* VEKSHINA, – GARTNER, pp. 47–48, Pl. 2, Figs. 6–7; Pl. 9, Figs. 19–20; Pl. 14, Fig. 14.

1969 *Micula decussata concava* (STRADNER), – BUKRY, p. 67, Pl. 40, Figs. 7–8.

DESCRIPTION. – A cube-shaped *Micula* species with corners elongated into points varying in length from short to quite long (Pl. XXIV, Fig. 5; Pl. XXV, Fig. 6).

DIMENSIONS. – Average length of diagonals 11 μ –10.6 μ .

REMARKS. – *Micula staurophora* (GARDET) STRADNER, 1963 differs from *M. cubiformis* n. sp. in having corners elongated into points.

OCCURRENCE. – Upper Turonian – Maastrichtian – early Tertiary?: Locality not given (STRADNER, 1963)

Campanian – Maastrichtian: Europe, Australia, U.S.A. (BRAMLETTE et MARTINI, 1964)

Campanian – Maastrichtian: Texas (GARTNER, 1968)

Santonian – Campanian: Texas (BUKRY, 1969)

Tertiary: Alger (GARDET, 1955)

K pingsberg Borehole No. 1: Hauterivian – Barremian, Albian – Cenomanian.

Genus *Polycyclolithus* FORCHHEIMER, 1968 emend.

1968 Genus *Polycyclolithus* n. gen. – FORCHHEIMER, p. 39.

DIAGNOSIS emend. – Cycles composed of nine rhombohedral or zigzag elements surround a central area. The rim cycles, at least three in number, are concentric, covering each other. The central area consists of triangular or overlapping elements of the same number as the elements of the rim. An asteroid opening is present in the centre in species with a central area composed of triangular elements.

REMARKS. – Genus *Polycyclolithus* FORCHHEIMER, 1968 emend. differs from genus *Lithastrinus* STRADNER, 1962 in including forms with more than two rim cycles composed of nine elements, concentrically covering each other.

The central area is composed of nine triangular elements with an asteroid opening in the centre, or of nine overlapping elements without a perforation in the centre. The rays forming the rim cycles in genus *Lithastrinus* STRADNER, 1962 are pointed and curved.

Type species. – *Polycyclolithus brotzenii* FORCHHEIMER, 1968

Polycyclolithus brotzenii FORCHHEIMER, 1968

Pl. XXVII, Fig. 3

1966 *Eprolithus floralis* STOVER ex parte, – STOVER, p. 149, Pl. 7, Figs. 6 a–b.

1968 *Polycyclolithus brotzenii* n. gen., n. sp. – FORCHHEIMER, p. 41, Pl. 6, Figs. 6 a–c, 7 a–b; Fig. 3 (17); SEM 15–16.

DIMENSIONS. – Average diameter 6.9 μ .

REMARKS. – *Polycyclolithus brotzenii* FORCHHEIMER, 1968 differs from *P. floralis* (STRADNER, 1962) n. comb. in having a central area composed of nine triangular elements leaving an opening in the centre. *P. floralis* (STRADNER, 1962) n. comb. on the other hand has a central plate composed of nine elements overlapping each other. No opening in the centre could be observed.

OCCURRENCE. – Cenomanian: Sweden (FORCHHEIMER, 1968) K opingsberg Borehole No. 1; Hauterivian – Barremian, Cenomanian.

Polycyclolithus floralis (STRADNER, 1962) n. comb.

Pl. XXVII, Fig. 4

1962 *Lithastrinus floralis* nov. spec. – STRADNER, p. 370, Pl. 3, Figs. 10–11.1968 *Lithastrinus floralis* STRADNER, – STRADNER et al, pp. 42–43, Pl. 42.DIMENSIONS. – Average diameter 6.3 μ .

REMARKS. – STRADNER (1962) originally described *Lithastrinus floralis* as being calcareous body composed of 7–9 sectors. Two rim cycles composed of these elements covering each other form a “flower-like” picture. The description was made on a basis of observations by light microscope.

STRADNER et al (1968) gave a new description of this species based on investigations by transmission electron microscope. The spool-shaped coccoliths of usually nine-rayed symmetry with a circular or rosette-like circumference have a central depression on either side, decorated by a regular stellate pattern which is composed of nine square elements overlapping each other. The outer rims of the coccolith are composed of elements corresponding in number to the elements in the centre. Under the scanning electron microscope the Köpingsberg forms show more than two rim cycles surrounding the central area as in the species belonging to the genus *Polycyclolithus*. The differences between *P. floralis* (STRADNER, 1962) n. comb. and *P. brotzenii* FORCHHEIMER, 1968 are mentioned above (p. 56).

OCCURRENCE. – Upper Senonian: Austria (STRADNER, 1962)

Albian: Netherlands (STRADNER et al, 1968)

Köpingsberg Borehole No. 1: Hauterivian – Barremian.

Polycyclolithus orbiculatus n. sp.

Pl. XXVII, Figs. 5–6

1969 *Lithastrinus floralis* STRADNER, – SHUMENKO, p. 24, Pl. 2 (w) .DERIVATION OF NAME. – *orbiculatus* (lat.) – forming a round plate.

HOLOTYPE. – Specimen No.: S Kp 472 70a/4.

PARATYPE. – Specimen No.: S Kp 22 84/20.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 785.4 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Polycyclolithus* with a rim cycle composed of nine zigzag elements.

DESCRIPTION. – *Polycyclolithus* species with a central area composed of nine elements overlapping each other. The zigzag elements of the rim cycle are rounded at the margin.

DIMENSIONS. – Average diameter 6 μ .

REMARKS. – *Polycyclolithus orbiculatus* n. sp. differs from *P. brotzenii* FORCHHEIMER, 1968 in having a central area filled with nine elements overlapping each other. There is no opening in the centre. The rim cycle is rounded and consists of nine zigzag elements which distinguishes *P. orbiculatus* n. sp. from *P. floralis* (STRADNER).

SHUMENKO (1969) illustrated a Turonian – Coniacian form of *Lithastrinus floralis* SRADNER. In view of the typical structure of the rim cycles named above this species is transferred by the present author to the genus *Polycyclolithus* as a new species *P. orbiculatus* n. sp.

OCCURRENCE. – Turonian – Coniacian: Russia (SHUMENKO, 1969) Köpingsberg Borehole No. 1: Albian – Cenomanian.

Family ZYGODISCACEAE HAY et MOHLER, 1967

Genus *Cyclolithella* LOEBLICH et TAPPAN, 1963

Type species: *Cyclolithus inflexus* DEFLANDRE, 1952

Cyclolithella sp.

Pl. XV, Figs. 4, 6

DIMENSIONS. – Length 9.5 μ ; width 7.4 μ .

REMARKS. – Large, elliptical, very delicately ornamented ring-shaped specimen. The open central area occupies about 35 percent of the coccolith area. Only one specimen has been found in the samples studied.

OCCURRENCE. – Köpingsberg Borehole No. 1: Albian.

Genus *Loxolithus* NOËL, 1965Type species: *Loxolithus armilla* (BLACK et BARNES) NOËL, 1965*Loxolithus armilla* (BLACK et BARNES, 1959) NOËL, 1965

Pl. XVIII, Figs. 5–6

1959 *Cyclolithus armilla* sp. nov. – BLACK et BARNES, p. 327, Pl. 12, Fig. 2.1965 *Loxolithus armilla* (BLACK et BARNES) nov. comb. – NOËL, p. 67, Fig. 3.1968 *Loxolithus* cf. *armilla* (BLACK et BARNES, 1959), – FORCHHEIMER, p. 54, Pl. 4, Figs. 2 a–b; Pl. 8, Figs. 8 a–c; Fig. 2 (21, 26); SEM 20–21.1970 *Loxolithus armilla* (BLACK et BARNES) NOËL, – MANIVIT, Pl. 17, Figs. 7–10.DIMENSIONS. – Average length 7.8 μ ; average width 6.3 μ .

REMARKS. – BLACK et BARNES (1959) originally described this species. They noted some trace of a membrane visible in the species illustrated on Pl. 12, Fig. 2. They doubted whether any of these forms were originally open rings. They suggested that the centre was closed by a delicate membrane which is not present in badly preserved specimens. The forms found in the investigated K opingsberg 1 material also show fragments of a structure in the centre.

OCCURRENCE. – Oxfordian: Alger (NOËL, 1965)

Gault – Cenomanian: Sweden (FORCHHEIMER, 1968)

Cenomanian: England (BLACK et BARNES, 1959)

K opingsberg Borehole No. 1: Hauterivian – Cenomanian.

Genus *Pontilithus* GARTNER, 1968Type species: *Pontilithus obliquicancellatus* GARTNER, 1968*Pontilithus flabellosus* (STRADNER et al, 1968) BLACK, 1968

Pl. X, Figs. 1–2; Pl. XI, Figs. 5–6

1968 *Zygodolites flabellosus* nov spec. – STRADNER et al, p. 37, Pl. 31.1968 *Pontilithus flabellosus* (STRADNER) comb. nov. – BLACK, p. 806, Pl. 149, Fig. 11.

DIMENSIONS. – Basal shield; average length 6 μ ; average width 4.1 μ .
Central process: average length 5.5 μ .

REMARKS. – *Pontilithus flabellosus* (STRADNER) BLACK, 1968 has a massive central process (Pl. 10, Fig. 2). The basal shield is constructed like the Ceno-

manian form *P. obliquicancellatus* GARTNER, 1968. GARTNER, however, has not observed a central process. *P. obliquicancellatus* is probably a younger synonym to *P. flabellus* (STRADNER) BLACK, 1968.

OCCURRENCE. – Albian: Netherlands (STRADNER et al, 1968)

Cenomanian: England (BLACK, 1968)

Köpingsberg Borehole No. 1: Aptian – Cenomanian.

Genus *Tranolithus* STOVER, 1966 emend.

DIAGNOSIS emend. – Elliptical coccoliths with a single rim cycle of imbricate elements in distal view and a secondary cycle of elements surrounding the central area in proximal view. The central area can be filled by irregular elements leaving two larger and two smaller openings. When complete the central area is spanned by a transverse bar. The bar is composed of small granulae and shows an indication of a central process.

REMARKS. – The genus *Tranolithus* STOVER, 1966 emend, differs from the genus *Zygodiscus* BRAMLETTE et SULLIVAN, 1961, the genus *Chiastozygus* GARTNER, 1968 and the genus *Vagalapilla* BUKRY, 1969 in the composition of the central area.

Species of the genus *Tranolithus* lack the crossbar of the type occurring in species belonging to the genus *Zygodiscus*. They also lack the X-shaped crossbars developed in species of the genus *Chiastozygus* and the set of crossbars with a bilateral symmetry visible in the central area in species of the genus *Vagalapilla*.

Type species: *Tranolithus manifestus* STOVER, 1966

Tranolithus exiguus STOVER, 1966 emend.

Pl. IX, Fig. 6; Pl. XVI, Figs. 2, 4; Pl. XVII, Figs. 1–4

- 1966 *Tranolithus exiguus* STOVER, new species, – STOVER, p. 146, Pl. 4, Figs. 21 a–c.
 1966 *Zygodiscus ponticulus* (DEFLANDRE) STOVER, new combination, – STOVER, p. 148, Pl. 4, Figs. 2–5.
 1966 *Parhabdololithus? bitraversus* STOVER, new species, – STOVER, p. 145, Pl. 6, Figs. 20–22; Pl. 9, Fig. 19.
 1966 *Tranolithus gabalus* STOVER, new species, – STOVER, p. 146, Pl. 4, Fig. 22; Pl. 9, Figs. 5 a–c.
 1968 *Zygodiscus diplogrammus* DEFLANDRE, – STRADNER et al, p. 35, Pl. 26, Figs. 3–7; Pl. 27, Fig. 1.
 1968 *Glaukolithus diplogrammus* (DEFLANDRE, 1954), – FORCHHEIMER, p. 50, Pl. 5, Figs. 1 a–b; Fig. 2 (14).

- 1968 *Tranolithus* cf. *T. exiguus* STOVER, 1966, - FORCHHEIMER, p. 49, Pl. 5, Figs. 2 a-b; Fig. 2 (12).
 1968 *Zycolithus diplogrammus* DEFLANDRE, 1954, - MANIVIT, p. 179, Pl. 1, Figs. 8 a-b.
 1968 *Zycolithus exiguus* (STOVER) nov. comb. - MANIVIT, Pl. 1, Figs. 11 a-c.
 1970 *Tranolithus exiguus* STOVER, 1966, - MANIVIT, p. 81, Pl. 26, Figs. 10-12.

DIMENSIONS. - Average length 6.5 μ ; average width 4.6 μ .

REMARKS. - *Tranolithus exiguus* STOVER, 1966 emend. has a rim cycle composed of about 60 imbricate elements in distal view. The central area is spanned by a transverse bar consisting of small granulae. An indication of a central process is visible in Pl. XVI, Figs. 2, 4. In badly preserved specimens the crossbar is missing and only the four "triangular projections" as named by STOVER (1966) are left extending into the central area.

OCCURRENCE. - Neocomian - Lower Cenomanian: France (STOVER, 1966)

Aptian - Albian: France (STOVER, 1966)

Gault - Cenomanian: Sweden (FORCHHEIMER, 1968)

Albian: Netherlands (STRADNER et al, 1968)

Albian - Cenomanian: France (STOVER, 1966)

Albian - Maastrichtian: France (MANIVIT, 1970)

Turonian: France (MANIVIT, 1968)

Köpingsberg Borehole No. 1: Hauterivian - Cenomanian.

Tranolithus skoglundii n. sp.

Pl. XVII, Figs. 5-6

DERIVATION OF NAME. - In honour of Dr. Roland Skoglund, the Head of the Section for Stratigraphy and Palaeontology, S. G. U., Stockholm.

HOLOTYPE. - Specimen No.: S Kp 133 73a/21.

TYPE LOCALITY. - Köpingsberg Borehole No. 1, 1 004.4 m.

TYPE STRATUM. - Hauterivian.

DIAGNOSIS. - A species of *Tranolithus* with a central area filled with irregular elements forming four openings.

DESCRIPTION. - Elliptical coccolith showing in distal view a single rim cycle composed of about 60 imbricate elements. The rim is 0.8 μ wide. The

central area which occupies 58 percent of the cocolith area contains four large elements. These elements form two large circular openings at the focuses of the ellipse, and two smaller ones aligned with the short axis of the coccolith.

The contact lines of the elements form a cross in the centre. No central process is present.

DIMENSIONS. – Average length 7.5 μ ; average width 5 μ .

REMARKS. – *Tranolithus skoglundii* n. sp. differs from *T. exiguus* STOVER, 1966 emend. in lacking a transverse crossbar as well as a central process. The large elements filling the central area differ in shape from the “triangular projections” of the *T. exiguus*.

OCCURRENCE. – Köpingsberg Borehole No. 1: Albian – Cenomanian.

Genus *Vagalapilla* BUKRY, 1969

Type species: *Vekshinella imbricata* GARTNER, 1968

Vagalapilla alata n. sp.

Pl. XXII, Figs. 5–6

DERIVATION OF NAME. – *alatus* (lat.) – winged.

HOLOTYPE. – Specimen No.: S Kp 338 51a/16.

PARATYPE. – Specimen No.: S Kp 217 44a/19.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 924.2 m.

TYPE STRATUM. – Aptian.

DIAGNOSIS. – A species of *Vagalapilla*, broad elliptical with a narrow rim cycle in distal view. An axial cross divides the central area into four big openings. The arms are winged at the end. A central process extends distally.

DESCRIPTION. – The rim consists of about 50 elements, which are slightly inclined in distal view. The central area occupies about 50 percent of the coccolith area. The distal rim has a width of 0.86 μ and the arms have a width of 0.8 μ . At the ends the short arm has a width of 2.2 μ and the long arm 1.6 μ .

The maximum length of the openings is 2.3μ and the maximum width 1.7μ . A secondary rim cycle of elements is visible in proximal view.

DIMENSIONS. – Average length 7.4μ ; average width 5.9μ .

REMARKS. – *Vagalapilla alata* n. sp. occurs often with a broken cross in the samples studied. Comparison with light microscope micrographs and drawings of species looking like *V. alata* n. sp. and published before is very difficult. *Zycolithus caelatus* (KAMTNER, 1955) in MANIVIT (1965, pp. 190–191, Pl. 2, Figs. 15 a–b) from Aptian – Albian, *Discolithus mielnicensis* GÓRKA, 1957 (p. 249, Fig. 14) from Maastrichtian and *Zycolithus crux* (DEFLANDRE) in STRADNER (1963, p. 179, Pl. 4, Figs. 7 a–b) do not allow comparison due to the fact that the structural details clearly visible in the scanning electron microscope are here missing.

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Vagalapilla coroniformis n. sp.

Pl. XXI, Figs. 3–5

DERIVATION OF NAME. – *coroniformis* (lat.) – having the form of a corona.

HOLOTYPE. – Specimen No.: S Kp 359 75a/6.

PARATYPE. – Specimen No.: S Kp 208 47a/6.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 986.4 m.

TYPE STRATUM. – Hauterivian.

DIAGNOSIS. – A species of *Vagalapilla* with an elliptical open area spanned by two crossbars of complex construction. The short bar is aligned with the short axis of the coccolith, while the long arm is S-shaped. A broad wall composed of inclined and striated elements is serrate at the periphery.

DIMENSIONS. – Average length 5.7μ ; average width 4μ .

DESCRIPTION. – Specimens seen in proximal view show a narrow rim cycle composed of 36 elements with slightly inclined suture lines. A central cross with a short arm aligned with the short axis of the ellipse and with a long S-shaped arm is inserted in this rim cycle. Each of the crossbars is composed of two rows of square elements. A broad wall built up of counterlockwise, strongly inclined and striated elements has a height of 2.3μ . The central area occupies about 28 percent of the coccolith area. The length of each opening is 1.1μ and the width $0,5 \mu$.

REMARKS. – *Vagalapilla coroniformis* n. sp. occurs rarely in the studied samples. MANIVIT (1965) reported *Zycolithus crux* (DEFLANDRE et FERT) BRAMLETTE et SULLIVAN, 1961, illustrated by light microscope micrographs (Pl. 2, Figs. 13 a–b). Also STOVER (1966) described *Zycolithus crux* (DEFLANDRE et FERT) BRAMLETTE et SULLIVAN, 1961 based on light microscope micrographs (Pl. 3, Figs. 17, 18, 22A). These forms show the typical S-shaped crossbars of *Vagalapilla coroniformis* n. sp. and thus differ from other *Zycolithus crux* specimens showing straight crossbars [DEFLANDRE et FERT (1954), GÓRKA (1957), STRADNER (1963)].

OCCURRENCE. – Hauterivian – Barremian.

Vagalapilla partita n. sp.

Pl. XXI, Figs. 1–2; Pl. XXII, Figs. 1–4

DERIVATION OF NAME. – *partitus* (lat.) – divided into parts.

HOLOTYPE. – Specimen No.: S Kp 94 90/1.

PARATYPE. – Specimen No.: S Kp 470 68a/31.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 846.4 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Vagalapilla* with a broad rim cycle of strongly inclined elements in distal view. The perpendicular crossbars have a width of about two-thirds of that of the distal rim cycle.

DESCRIPTION. – The distal shield is composed of a single rim cycle of about 36 imbricate elements showing strong inclination. The width of the rim

is about 1μ . The central area occupies about 35 percent of the coccolith area. The crossbars have a width of about 0.7μ and at the junction with the rim a width of about 1.5μ . The openings have a length of about 1.5μ and a width of about 0.8μ . A central massive process at the base and pointed at the end extends distally. The length of the central process is about 7μ . A smaller rim cycle having a width of about 0.6μ surrounds the central area in proximal view. No central pore is visible.

DIMENSIONS. – Average length 5.8μ ; average width 3.8μ .

REMARKS. – *Vagalapilla partita* n. sp. resembles forms described previously as *Zycolithus crux* (DEFLANDRE et FERT, 1954) BRAMLETTE et SULLIVAN, 1961.

DEFLANDRE et FERT (1954) erected a new species, *Discolithus crux* from the Tertiary. The electron micrograph in DEFLANDRE et FERT (Pl. 14, Fig. 4) was made without carbon replica, and thus lacks details of the fine structure. Also the drawing (p. 20, Fig. 55) is schematic and the description on p. 23 only reports elliptical coccoliths with a narrow margin and an axial cross in the central area. The specimens belonging to this species are smaller than *Vagalapilla partita* n. sp. and have a length of 3.6μ and a width of 2.7μ .

Z. crux (DEFLANDRE et FERT, 1954) BRAMLETTE et SULLIVAN, 1961 has been reported from the Cretaceous by many authors in synonymies as *Cyatosphaera crux* (DEFLANDRE et FERT, 1954) HAY et TOWE (1962b, p. 507, Pl. 2) and *Staurolithites crux* (DEFLANDRE et FERT, 1954) CARATINI, 1963.

STRADNER et al (1968) reported *Zycolithus crux* (DEFLANDRE et FERT, 1954) BRAMLETTE et SULLIVAN, 1961 with a thorough description illustrated by electron and light micrographs (p. 36, Pls. 28–30). *Vagalapilla partita* n. sp. does not show the central pore mentioned by STRADNER et al (1968): "In some specimens there is a small central pore left open". *Vagalapilla partita* n. sp. differs also from *Zycolithus crux* (DEFLANDRE et FERT, 1954) in having winged crossbars. The author does not agree with the synonym list published by STRADNER et al (1968): they included too many clearly distinct species as for example *Staurolithites bochothicae* (GÓRKA, 1957) CARATINI, 1963 in REINHARDT (1965) p. 39, Pl. 3, Fig. 3 and 1966, p. 33, Pl. 15, Fig. 1; Pl. 19, Fig. 4; Pl. 22, Fig. 8; Pl. 23, Fig. 1. The diagnosis of this species (REINHARDT 1965 and 1966) is: "40 schräg liegende Elementa petala fügen einen elliptischen Ring zusammen. Den Binnenraum überspannt ein 0.8μ dickes Kreuz. Seine Arme erstrecken sich in die Richtung der Ellipsenachsen. Grösse 5.5μ ". *Vagalapilla partita* n. sp. differs from *Staurolithites bochothicae* (GÓRKA, 1957) CARATINI, 1963 in having a central process. The crossbars are winged at the junction with the rim.

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Vagalapilla solida n. sp.

Pl. XXIII, Figs. 1-2

1969 *Vagalapilla elliptica* (GARTNER, 1968) BUKRY, 1969 n. comb. ex parte, - BUKRY, p. 57, Pl. 32, Figs. 9-10.

DERIVATION OF NAME. - *solida* (lat.) - massive.

HOLOTYPE. - Specimen No.: S Kp 318 80a/14.

PARATYPE. - Specimen No.: S Kp 94 7a/26.

TYPE LOCALITY. - Köpingsberg Borehole No. 1, 846.4 m.

TYPE STRATUM. - Albanian.

DIAGNOSIS. - Elliptical coccoliths with a rather broad rim cycle. The central area occupies about 25 percent of the coccolith area. A broad massive crossbar is aligned with the axes of the ellipse. A perforation in the centre and a central process are present.

DESCRIPTION. - *Vagalapilla* species seen in distal view shows a rim composed of about 38 inclined elements. The open central area is spanned by crossbars with a width of 0.8μ . The micrograph in Pl. XXIII, Fig. 1 shows a perforation in the centre of the process.

REMARKS. - *Vagalapilla solida* n. sp. differs from *V. elliptica* (GARTNER, 1968) BUKRY, 1969 in having a cross with bars perpendicularly intersecting. Micrographs in Pl. 32, Figs. 11-12 (BUKRY, 1969) show *V. elliptica* (GARTNER 1968) BUKRY, 1969 with bars evidently dissimilar to those of *V. solida* n. sp. The present author proposes therefore a new species for specimens with a straight, massive cross, broad rim and rather small central area.

OCCURRENCE. - Köpingsberg Borehole No. 1: Aptian - Albanian.

Genus *Zygodiscus* BRAMLETTE et SULLIVAN, 1961

Type species: *Zygodiscus adamas* BRAMLETTE et MARTINI, 1964

Zygodiscus compactus BUKRY, 1969

Pl. XXVI, Figs. 1-4

1969 *Zygodiscus compactus* BUKRY, n. sp. - BUKRY, p. 59, Pl. 34, Figs. 1-2.

1969 *Zygodiscus elegans* GARTNER, emend. BUKRY, - BUKRY, p. 39, Pl. 34, Fig. 8.

- 1970 *Zygodiscus compactus* (BUKRY) nov. comb. – NOËL, p. 26, Text-Figs. 2, 3; Pl. 2, Figs. 2–8; Pl. 3, Figs. 1–3.
 1970 *Zygodiscus bussoni* NOËL, 1956, – NOËL, p. 26, Text-Fig. 1; Pl. 1, Figs. 4–7; Pl. 2, Fig. 1.

DIMENSIONS. – Average length 6.2 μ ; average width 4.4 μ .

REMARKS. – BUKRY (1969) erected the new species *Zygodiscus compactus* BUKRY, 1969. He described this species and illustrated it by two micrographs in distal view (Pl. 34, Figs. 1–2). The broad rim and the large irregularly ordered bar crossing the central area are typical of this species. In the investigated material the bar is composed of two rows of elements. The bar is smaller in proximal view than in distal view (1.58 μ distally, 1.25 μ proximally). A rim cycle surrounding the central area is composed of about 30 elements. The central area occupies about 50 percent of the coccolith area. *Zygodiscus elegans* GARTNER, emend. BUKRY, 1969 in Pl. 34, Fig. 8 and *Zygodiscus bussoni* NOËL, 1956 in NOËL, 1970 (p. 26, Text-Fig. 1; Pl. 1, Figs. 4–7; Pl. 2, Fig. 1) seem to be indistinguishable from *Zygodiscus compactus* BUKRY, 1969 seen in proximal view. Although the specimens found in the investigated samples lack a process, they are included in the genus *Zygodiscus* BRAMLETTE et SULLIVAN, 1961.

OCCURRENCE. – Coniacian – Campanian: Germany, Texas (BUKRY, 1969)

Campanian: France (NOËL, 1970)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Zygodiscus erectus (DEFLANDRE, 1954) MANIVIT, 1970

Pl. XXVI, Figs. 5–6

- 1954 *Zygodiscus erectus* DEFLANDRE, new species, – DEFLANDRE, p. 29, Pl. 15, Figs. 14–17; Text-Figs. 60–62.
 1965 *Zygodiscus erectus* DEFLANDRE, – MANIVIT, p. 191, Pl. 2, Figs. 12 a–b.
 1965b *Zygodiscus erectus* DEFLANDRE, – NOËL, p. 62, Pl. 1, Figs. 3–4, Text-Fig. 2.
 1966 *Zygodiscus erectus* DEFLANDRE, – REINHARDT, p. 40, Pl. 15, Fig. 13.
 1968 *Zygodiscus erectus* DEFLANDRE, – STRADNER et al, p. 34, Pls. 25, 26, Figs. 1–2.
 1969 *Zygodiscus erectus* (DEFLANDRE) nov. comb. – BUKRY et BRAMLETTE, p. 373.
 1970 *Zygodiscus erectus* (DEFLANDRE) n. comb. – MANIVIT, p. 85, Pl. 29, Figs. 1–3, 5–8.

DESCRIPTION. – Elliptical coccolith with a rim cycle of strongly inclined and imbricated elements as seen in distal view. The central area is divided into two semicircular openings by a transverse bridge. A central process extends distally, massive at the base and pointed at the end.

DIMENSIONS. – Average length 8.3 μ ; average width 7 μ .

REMARKS. – *Zygodiscus erectus* (DEFLANDRE, 1954) MANIVIT, 1970 has the generic characteristics of the genus *Zygodiscus* BRAMLETTE et SULLIVAN, 1961.

BUKRY et BRAMLETTE (1969) previously included *Zygodiscus erectus* (DEFLANDRE et FERT, 1954) in the genus *Zygodiscus* BRAMLETTE et SULLIVAN, 1961, but this new combination was declared invalid by LOEBLICH and TAPPAN (1970, p. 42).

OCCURRENCE. – Malm: Germany (REINHARDT, 1966)
 Oxfordian: France (DEFLANDRE et FERT, 1954)
 Oxfordian: Algeria (NOËL, 1965)
 Aptian – Cenomanian: France (MANIVIT, 1970)
 Albian: France (MANIVIT, 1965)
 Albian: Netherlands (STRADNER et al, 1968)
 Albian: Blake-Bahama Basin (BUKRY et BRAMLETTE, 1969 b)

Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

Zygodiscus inclinatus n. sp.

Pl. III, Figs. 6–7

DERIVATION OF NAME. – *inclinare* (lat.) – incline.

HOLOTYPE. – Specimen No.: S Kp 502 84a/30.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 759.3 m.

TYPE STRATUM. – Cenomanian.

DIAGNOSIS. – Small elliptical coccoliths with a distal rim composed of two cycles visible in distal view. The outer rim cycle consists of about 30 elements. An inner cycle surrounding the central area consists of the same number of strongly imbricate elements. A broad bar divides the central area into two large openings. A short process, massive at the base and pointed at the top is seen in distal view.

DESCRIPTION. – *Zygodiscus* species seen in distal view in Pl. III, Fig. 6 is an elliptical coccolith with two cycles of elements, a broad transverse bar and a central process. The diameter of this process at the base is 1μ , decreasing towards the end. The outer rim with a width of 0.5μ is composed of radial elements. The inner rim has a width of 0.3μ .

DIMENSIONS. – Average length 4.2 μ ; average width 3.5 μ .

REMARKS. – *Zygodiscus inclinatus* n. sp. differs from *Zygodiscus acanthus* (REINHARDT, 1965) in having an inner cycle composed of strongly inclined narrow elements as seen in distal view. REINHARDT (1966, p. 40) reported: "Eine Art von *Zygodiscus* mit 40 Elementa petala pro Randscheibe". These cycles have the same width while *Zygodiscus inclinatus* n. sp. has an inner cycle more narrow than the outer one. BUKRY (1969) described and illustrated (Pl. 33, Figs. 8–9) *Zygodiscus acanthus* (REINHARDT, 1965) with circular openings in the central area.

OCCURRENCE. – Köpingsberg Borehole No. 1: Cenomanian.

INCERTAE SEDIS

Genus *Lucianorhabdus* DEFLANDRE, 1959

Type species: *Lucianorhabdus cauyeuxi* DEFLANDRE, 1959

Lucianorhabdus arcuatus n. sp.

Pl. X, Fig. 5

DERIVATION OF NAME. – *arcuatus* (lat.) – curved.

HOLOTYPE. – Specimen No.: S Kp 316 81a/15.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 888 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Lucianorhabdus* with a massive curved process. The diameter of the basal shield is equal to the width of the process.

DESCRIPTION. – The massive process with a granulate surface is bent into a "knee" situated at about 3/4 of its length from the basal shield. Six parallel ridges are equidistantly arranged along the whole length.

DIMENSIONS. – Average length of the longer straight part of the process 15.1 μ ; average length of the shorter straight part 11 μ ; average width 5.5 μ .

REMARKS. – *Lucianorhabdus arcuatus* n. sp. differs from *L. quadrifidus* n. sp. in having a bent and slender process and a basal shield with a diameter equal to the width of the process.

DEFLANDRE (1959) illustrated a specimen of *Lucianorhabdus* (Pl. 4, Fig. 21) with a curved process but without a basal shield. However, the process is larger than in *L. arcuatus* n. sp.

GARTNER (1968) reported a species of *Lucianorhabdus* with a slender and smooth process and without a basal shield. Both species are reported from the Senonian.

OCCURRENCE. – Köpingsberg Borehole No. 1; Aptian – Cenomanian.

Lucianorhabdus quadrifidus n. sp.

Pl. IX, Fig.2; Pl. X, Figs. 3–4, 6

DERIVATION OF NAME.. – *quadrifidus* (lat.) – square.

HOLOTYPE. – Specimen No.: S Kp 334 76a/2.

PARATYPE. – Specimen No.: S Kp 94 7a/7.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 904.72 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Lucianorhabdus* with a massive central process terminating in a crown consisting of triangular elements. Four large elements form the central area of the basal shield leaving a rhombic opening at the centre.

DESCRIPTION. – The central process is provided with four ridges and has a coarse granulate surface. The basal shield is composed of cycle of imbricate elements surrounding the central area in proximal view.

DIMENSIONS. – Central process: average length 11.7 μ ; average width 2.8 μ . Basal shield: average length 7 μ ; average width 5.8 μ .

REMARKS. – *Lucianorhabdus quadrifidus* n. sp. occurs often with basal shield and central process separated. The complete specimens with the crown

at the top are rare. *Eurhabdus luciiformis* REINHARDT, 1965 (p. 39, Pl. 2, Fig. 5) is illustrated in side view. Since no crown is reported and no information is given on the structure of the basal shield, the specimens from Köpingsberg 1 cannot be compared to the form described by REINHARDT.

OCCURRENCE. – Köpingsberg Borehole No. 1: Aptian – Cenomanian.

Genus *Marthasterites* DEFLANDRE, 1959

Type species: *Marthasterites furcatus* DEFLANDRE, 1959

Marthasterites duplex n. sp.

Pl. VIII, Figs. 1, 3

DERIVATION OF NAME. – *duplex* (lat.) – double.

HOLOTYPE. – Specimen No.: S Kp 470 68/11.

TYPE LOCALITY. – Köpingsberg Borehole No. 1, 912.52 m.

TYPE STRATUM. – Albian.

DIAGNOSIS. – A species of *Marthasterites* built up of two identical parts, each consisting of three branches of about equal length. The interspaces between the branches are U-shaped. The two parts are connected by a common axis and oriented in different directions.

DESCRIPTIONS. – Small calcareous bodies with branches in a cone-shaped arrangement. The U-shaped interspaces are broad. The curved arms terminate in lobes.

DIMENSIONS. – Average length 4.7 μ .

REMARKS. – *Marthasterites duplex* n. sp. differs from *M. furcatus furcatus* (DEFLANDRE) DEFLANDRE, 1959 in BUKRY (1969), p. 65, Pl. 38, Figs. 2–4) known from the Santonian – Campanian in having broader and shorter arms. The specimens reported by BUKRY have a maximum diameter of 8.7 μ .

OCCURRENCE. – Köpingsberg Borehole No. 1: Hauterivian – Cenomanian.

STRATIGRAPHY

Coccoliths in the Lower Cretaceous and in the Cenomanian have previously been investigated mainly by light microscope but also by transmission and scanning electron microscope (Fig. 2).

STRADNER (1963), STOVER (1966), REINHARDT (1966), FORCHHEIMER (1968), BUKRY et BRAMLETTE (1969) and MANIVIT (1965, 1968, 1970) have described the stratigraphic distribution of the coccoliths in the early Cretaceous and in the Cenomanian.

According to STRADNER (1963) the basal part of the Lower Cretaceous is easily recognized by the great abundance of *Coccolithus pelagicus* and *Nannoconus steinmani* KAMPTNER. *Braarudosphaera discula* BRAMLETTE et RIEDEL is rarely missing. The Upper Hauterivian and Barremian show a development of nannoconids which continues into the Aptian – Albian in addition to *Zygo-lithus diplogrammus* DEFLANDRE, 1954. The Cenomanian associations mostly consist of Lower Cretaceous species, with *Rhabdolithus turriseiffeli* DEFLANDRE as a newcomer (*Turriseiffeli* associations).

STOVER (1966) characterized Cretaceous layers as follows: "Lower Cretaceous assemblages are characterized mainly by an abundance of *Coccolithus*, *Parhabdolithus* and *Zygo-lithus* specimens, although a particular species of a sparsely occurring genus may be abundant locally. Several new species appear in successively younger Lower Cretaceous stages". According to STOVER (1966) the assemblages from the Cenomanian contain a mixture of certain Lower and Upper Cretaceous forms, as *Arkhangelskiella*, *Discolithus*, *Eprolithus*, *Tranolithus* and *Zygo-lithus* species.

According to REINHARDT (1966) *Braarudosphaera*, *Lithastrinus*, *Micrantholithus*, *Abmuellerella*, *Nannoconus*, *Staurolithites* and *Zygo-lithus* species occur in the Hauterivian of N. Germany. The first appearance of *Cretarhabdus*, *Deflandrius*, *Eiffelolithus* and *Glaukolithus* species was observed in the Albian, which in regard to nannofossils is difficult to separate from the Cenomanian.

The present author described in 1968 coccoliths in the boundary Gault – Cenomanian, and in the Cenomanian from the Höllviken Borehole No. 1, SW Sweden. The *Coccolithus pelagicus* group amounts to 64 percent in the Gault – Cenomanian, and 34 percent in the Cenomanian. *Tranolithus*, *Discolithus* and *Cricolithus* species have been abundant in the Gault – Cenomanian layers. *Cribrosphaera*, *Cretarhabdus*, *Polycyclolithus* and *Watznaueria* species appeared first in the Cenomanian.

BUKRY in BUKRY et BRAMLETTE (1969) reported *Braarudosphaera*, *Cruciplacolithus*, *Discolithus*, *Micrantholithus*, *Parhabdolithus* and *Nannoconus* species from the Hauterivian. *Apertapetra*, *Arkhangelskiella*, *Corollithion*, *Eiffelolithus* and *Watznaueria* species are reported from the Albian, and *Lithastrinus*

and *Prediscosphaera* species from the Cenomanian in cores from the Gulf of Mexico.

MANIVIT (1970) investigated coccoliths from the Aptian – Danian in France. She distinguished seven biostratigraphical zones in the Aptian – Cenomanian deposits. The zones with *Prediscosphaera columnata* and *Parhabdolithus angustus* represent the Lower and Upper Aptian respectively. The Albian is represented by three zones: Lower Albian with *Hayesites albiensis*, Middle Albian with *Corollithion rhombicum* and Upper Albian with *Staurolithites matalosus*. The Lower and Middle Cenomanian is represented by the zone with *Staurolithites orbiculofenestrus*, and the Upper Cenomanian by the zone with *Gartnerago obliquum* (non *obliquus*).

In the present paper concerning the Köpingsberg Borehole No. 1 the stratigraphic distribution of the coccoliths was studied by means of the scanning electron microscope. It is of particular interest that many species previously reported only from the Upper Cretaceous are found to occur in the Lower Cretaceous sequence in the core. Examples are species of the genera *Biscutum*, *Broinsonia*, *Gartnerago*, *Helicolithus*, *Kamptnerius*, *Lucianorhabdus*, *Marthasterites*, *Microrhabdulus* and *Micula*.

The Lower Cretaceous and the Cenomanian are dominated by *Biscutum kennedyi*, BUKRY, 1969; *Coccolithus barnesae* (BLACK) BRAMLETTE et MARTINI, 1964; *Deflandrius cantabrigensis* BLACK, 1967; *Eiffelithus turriseiffeli* (DEFLANDRE) REINHARDT, 1965; *Gartnerago costatum* (GARTNER) n. comb.; *Gartnerago striatum* (STRADNER) n. comb.; *Helicolithus stillatus* n. sp.; *Kamptnerius punctatus* STRADNER, 1963; *Lithraphidites carniolensis* DEFLANDRE, 1963; *Micula cubiformis* n. sp.; *Repagulum parvidentatum* (DEFLANDRE) n. gen., n. comb.; *Tranolithus exiguus* STOVER, 1966 emend.; *Vagalapilla partita* n. sp.; *Zygodiscus compactus* BUKRY, 1969 and *Zygodiscus erectus* (DEFLANDRE) MANIVIT, 1970. Nannoconids have not been found.

The following species occur first in the Barremian: *Biscutum blacki* GARTNER, 1968; *Gartnerago concavum* (GARTNER) BUKRY, 1969; *Discorhabdus ignotus* (GÓRKA) PERCH-NIELSEN, 1968 and *Rhabdolithina splendens* (DEFLANDRE) REINHARDT, 1967.

The species which occur first in the Aptian include: *Chiastozygus amphipons* (BRAMLETTE et MARTINI, 1964); *Corollithion geometricum* (GÓRKA) MANIVIT, 1970; *Corollithion rhombicum* (STRADNER et al) BUKRY, 1969; *Lucianorhabdus arcuatus* n. sp.; *Lucianorhabdus quadrifidus* n. sp.; *Pontilithus flabellus* (STRADNER et al) BLACK, 1968; *Solasites horticum* (STRADNER et al) BLACK, 1967 and *Vagalapilla solida* n. sp. The following new forms have been found in the Albian: *Calolithus martelae* NOËL, 1969; *Corollithion delftensis* (STRADNER et al) BUKRY et BRAMLETTE, 1969; *Cyclolithella* sp.; *Deflandrius* cf. *D. stoveri* PERCH-NIELSEN, 1968; *Gartnerago porolatum* (BUKRY) n. comb. and *Markalius circumradiatus* (STOVER) PERCH-NIELSEN, 1968.

The following continue from the Albian into the Cenomanian: *Actinozygus regularis* (GÓRKA) GARTNER, 1968; *Costacentrum lowei* BUKRY, 1969; *Cretarhabdus octoperforatus* n. sp.; *Deflandrius intercisus* (DEFLANDRE) BRAMLETTE et MARTINI, 1964; *Discolithina porosoturalis* BUKRY, 1969; *Discolithina theta* (BLACK) FORCHHEIMER, 1968; *Kamptnerius pertusus* n. sp.; *Polycyclolithus orbiculatus* n. sp.; *Rhabdolithus* cf. *R. rectus* DEFLANDRE, 1954; *Rhabdolithus decussatus* (MANIVIT) STRADNER, 1963; *Scapholithus fossilis* DEFLANDRE, 1954; *Zygodiscus biperforatus* GARTNER, 1968 and *Zygodiscus pseudoanthophorus* BRAMLETTE et MARTINI, 1964.

The Cenomanian layers yielded badly preserved coccoliths as mentioned above (p. 13).

Broinsonia dempta n. sp., *Podorhabdus albianus* BLACK, 1968 and *Zygodiscus inclinatus* n. sp. have been found in addition to forms from the Lower Cretaceous.

Fig. 12 shows the vertical distribution of the coccoliths.

DISCUSSION

The coccoliths investigated from the Lower Cretaceous and the Cenomanian of the Köpingsberg Borehole No. 1 include genera and even species previously known only from the Upper Cretaceous (Turonian – Maastrichtian, Figs. 7–10).

From the very beginning the present author has been surprised to find the following species in the Lower Cretaceous layers: *Actinozygus regularis* (Campanian – Maastrichtian), *Ahmuellerella octoradiata* (Turonian – Maastrichtian), *Biscutum kennedyi* (Santonian), *Broinsonia handfeldii* (Campanian), *Costacentrum lowei* (Coniacian – Campanian), *Cylindralithus serratus* (Campanian), *Deflandrius spinosus* (Turonian – Maastrichtian), *Discolithina porosoturalis* (Campanian), *Discorhabdus ignotus* (Turonian – Maastrichtian), *Eiffellithus eximius* (Turonian – Maastrichtian), *Gartnerago costatum* (Santonian – Campanian), *Kamptnerius punctatus* (Turonian – Senonian), *Microrhabdulus belgicus* (Turonian – Lower Maastrichtian), *Micula staurophora* (Upper Turonian – ? early Tertiary), *Zygodiscus biperforatus* (Coniacian – Campanian), *Zygodiscus compactus* (Coniacian – Campanian) and *Zygodiscus pseudoanthophorus* (Campanian – Maastrichtian). Genera *Lucianorhabdus* and *Marthasterites* are known from the late Cretaceous, the latter also from the early Tertiary.

As many of the forms have often been used as guide fossils for zones in the Upper Cretaceous, it has been necessary to recheck the vertical distribution of the coccoliths. Eleven new samples from the same stratigraphical stages from the core were selected and new studies on coccoliths as well as on foraminifera have been carried out. The coccolith assemblages examined showed the same

composition as previously found; the foraminifera were typical of the Lower Cretaceous.

As under certain conditions porous rocks may be contaminated by absorption of water from the drilling mud, additional well consolidated new core samples have been selected. Examination of this material from the following levels 1 002.45–1 002.49 m, 1 002.17–1 002.21 m, 999.80–999.90 m, 998.20–998.27 m, 997.58–997.63 m, 996.96–997.08 m, and 995.35–995.41 m carried out after the main investigation shows the same results.

Preliminary examination of the spore and pollen contents of four samples (1 000.64 m, 986.35 m, 847.3 m and 805.8 m) by Drs. Miller and Skarby (personal communication) points to an early Cretaceous age and confirms the determination made by Norling (1968) based on foraminifera.

According to Drs. Kjellström and Sarjeant (personal communication) who examined the dinoflagellates of a sample (1 000.64 m) the assemblage is signally lacking in stratigraphically characteristic forms. Tentatively, however, an Aptian or Lower Albian age has been suggested.

The coccolith flora from the Lower Cretaceous and the Cenomanian in the Köpingsberg Borehole No. 1 is rather confusing. The occurrence of forms previously reported only from the Upper Cretaceous can hardly be explained as resulting from contamination by material from younger layers. This would be equivalent to stating that from a core of 1 000.4 m, drilled in such a way that every 6 m section has been collected, 250 m (25 %) are contaminated. Such a contamination seems to be rather unlikely. This opinion is supported by the fact that the pollen investigation did not show any Upper Cretaceous forms. It should also be kept in mind that some of the forms in question, especially the *Kamptnerius* species, occur far more abundantly, and are better preserved in the lowest part of the core.

The problem will certainly be solved more easily by supposing that the forms in question occur in situ also in Lower Cretaceous layers. This will lead to the conclusion that some forms have to be eliminated as Upper Cretaceous "guide fossils". It seems that coccolith investigations have to be continued with the purpose of finding genuine guide fossils with established stratigraphic limitations.

An essential condition for reaching the necessary differentiation is a high resolution of the fine structures, and the scanning electron microscope is at present the most suitable instrument for this purpose.

<i>Ahmuellerella octoradiata</i> (GORKA, 1957)											
AUTHOR	DATE	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
Bramlette et Martini	1964										
Bukry	1969								—	—	
Bukry et Bramlette	1969								—	—	
Caratini	1963										
Cepek et Hay	1969										
Deflandre et Fert	1954										—
Deflandre	1959										—
Forchheimer	1971	////	////	////	////	////	.....	.....	.....	.....	.....
Gartner	1968										—
Gorka	1957										—
Lezaud	1964										—
Lyul'eva	1967										—
Manivit	1970							—	—	—	—
Noël	1970									—	—
Perch-Nielsen	1968										—
Reinhardt	1966										—
Stover	1966										—
Stradner	1963						—	—	—	—	—
Vekshina	1959										—

Fig. 7. STRATIGRAPHIC DISTRIBUTION. Unbroken line: reported in literature. Shaded line: Köpingsberg Borehole No. 1. Dotted line: Investigation not finished.

<i>Deflandrius spinosus</i> BRAMLETTE et MARTINI, 1964											
AUTHOR	DATE	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
Bramlette et Martini	1964										
Bukry	1969										
Bukry et Bramlette	1969										
Caratini	1963										
Cepek et Hay	1969										
Deflandre et Fert	1954										
Deflandre	1959										
Forchheimer	1971	////	////	////	////	////	.....	.....	.....	.....	.....
Gartner	1968										
Gorka	1957										
Lezaud	1964										
Lyul'eva	1967										
Manivit	1970										
Noël	1970										
Perch-Nielsen	1968										
Reinhardt	1966										
Stover	1966										
Stradner	1963										
Vekshina	1959										

Fig. 8. STRATIGRAPHIC DISTRIBUTION. Unbroken line: reported in literature. Shaded line: Köpingsberg Borehole No. 1. Dotted line: Investigation not finished.

<i>Kamptnerius punctatus</i> STRADNER, 1963											
AUTHOR	DATE	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
Bramlette et Martini	1964										
Bukry	1969										
Bukry et Bramlette	1969										
Caratini	1963										
Cepek et Hay	1969										
Deflandre et Fert	1954										
Deflandre	1959										
Forchheimer	1971	////	////	////	////	////	.....	.....	.....	.....	.....
Gartner	1968										
Gorka	1957										
Lezaud	1964										
Lyul'eva	1967										
Manivit	1970										
Noël	1970										
Perch-Nielsen	1968										
Reinhardt	1966										
Stover	1966										
Stradner	1963										
Vekshina	1959										

Fig. 9. STRATIGRAPHIC DISTRIBUTION. Unbroken line: reported in literature. Shaded line: Köpingsberg Borehole No. 1. Dotted line: Investigation not finished.

<i>Micula staurophora</i> (GARDET, 1955)											
AUTHOR	DATE	Hauterivian	Barremian	Aptian	Albian	Cenomanian	Turonian	Coniacian	Santonian	Campanian	Maastrichtian
		Bramlette et Martini	1964								
Bukry	1969										
Bukry et Bramlette	1969										
Caratini	1963										
Cepek et Hay	1969										
Deflandre et Fert	1954										
Deflandre	1959										
Forchheimer	1971	////	////	////	////	.....	.....	.....	.....	.....	.....
Gartner	1968										
Gorka	1957										
Lezaud	1964										
Lyul'eva	1967										
Manivit	1970										
Noël	1970										
Perch-Nielsen	1968										
Reinhardt	1966										
Stover	1966										
Stradner	1963										
Vekshina	1959										

Fig. 10. STRATIGRAPHIC DISTRIBUTION. Unbroken line: reported in literature. Shaded line: K pingsberg Borehole No. 1. Dotted line: Investigation not finished.

QUANTITATIVE OCCURRENCE OF COCCOLITHS IN THE CRETACEOUS OF THE KÖPINGSBERG BOREHOLE NO.1

SPECIES	HAUTER		BARREMIAN		APTIAN		ALBIAN					CENOMANIAN					M
	LEVEL	METER															
* <i>Actinozygus regularis</i>																	
o <i>Ahmuellerella octoradiata</i>																	
<i>Biscutum blacki</i>																	
<i>Biscutum kennedyi</i>																	
<i>Broinsonia dempta</i>																	
<i>Broinsonia handfieldii</i>																	
<i>Broinsonia lacunosa</i>																	
<i>Calolithus martelae</i>																	
* <i>Chiastozygus amphipans</i>																	
<i>Chiastozygus cuneatus</i>																	
* <i>Coccolithus barnesae</i>																	
* <i>Corallithion delftensis</i>																	
* <i>Corallithion geometricum</i>																	
* <i>Corallithion rhombicum</i>																	
* <i>Costacentrum lowei</i>																	
<i>Cretarhabdus actinosus</i>																	
<i>Cretarhabdus bisericatus</i>																	
<i>Cretarhabdus conicus</i>																	
<i>Cretarhabdus octoperforatus</i>																	
<i>Cretarhabdus unicornis</i>																	
o <i>Cribrosphaera ehrenbergi</i>																	
<i>Cyclagelosphaera margereli</i>																	
<i>Cyclolithella sp.</i>																	
* <i>Cylindralithus serratus</i>																	
<i>Deflandrius cantabringensis</i>																	
* <i>Deflandrius intercisus</i>																	
<i>Deflandrius spinosus</i>																	
<i>Deflandrius cf. D.stoveri</i>																	
* <i>Discolithina porosaturalis</i>																	
* <i>Discolithina theta</i>																	
<i>Discorhabdus ignotus</i>																	
<i>Eiffelithus eximius</i>																	
o <i>Eiffelithus turriseiffeli</i>																	
<i>Gartnerago concavum</i>																	
<i>Gartnerago costatum</i>																	
<i>Gartnerago obliquum</i>																	
<i>Gartnerago porolatum</i>																	
<i>Gartnerago striatum</i>																	
<i>Helicolithus stillatus</i>																	
<i>Kampfnerius pertusus</i>																	
<i>Kampfnerius punctatus</i>																	
<i>Lithostrinus septenarius</i>																	
* <i>Lithraphidites carniolensis</i>																	
<i>Loxolithus armilla</i>																	
<i>Lucianorhabdus arcuatus</i>																	
<i>Lucianorhabdus quadrifidus</i>																	
<i>Margolites manivittae</i>																	
<i>Markalius circumradiatus</i>																	
<i>Markalius sulcatus</i>																	
<i>Marthasterites duplex</i>																	
* <i>Microrhabdulus belgicus</i>																	
<i>Micula cubiformis</i>																	
<i>Micula staurophora</i>																	
* <i>Podorhabdus albianus</i>																	
<i>Polycyclolithus brotzenii</i>																	
<i>Polycyclolithus floralis</i>																	
<i>Polycyclolithus orbiculatus</i>																	
<i>Pontilithus flabellus</i>																	
<i>Repagulum parvidentatum</i>																	
o <i>Rhabdolithina splendens</i>																	
* <i>Rhabdolithus cf. R.rectus</i>																	
* <i>Rhabdolithus decussatus</i>																	
* <i>Scapholithus fossilis</i>																	
* <i>Solasites horticum</i>																	
* <i>Stephanolithion laffittei</i>																	
<i>Tranolithus exiguus</i>																	
<i>Tranolithus skoglundii</i>																	
<i>Vagalapilla alata</i>																	
<i>Vagalapilla coroniformis</i>																	
<i>Vagalapilla partita</i>																	
<i>Vagalapilla solida</i>																	
o <i>Zygodiscus biperforatus</i>																	
<i>Zygodiscus compactus</i>																	
<i>Zygodiscus erectus</i>																	
<i>Zygodiscus inclinator</i>																	
* <i>Zygodiscus pseudoanthoporus</i>																	

Fig. 11.

DISTRIBUTION OF COCCOLITHS
IN THE CRETACEOUS OF THE KÖPINGSBERG BOREHOLE NO.1

SPECIES	HAUTER.	BARREM.	APTIAN	ALBIAN	CENOM.
* not described or illustrated in this paper					
o not described but illustrated					
<i>Cyglagelosphaera margereli</i> NOEL, 1965					
<i>Vagalapilla coroniformis</i> n.sp.					
* <i>Cylindralithus serratus</i> BRAMLETTE et MARTINI, 1964					
<i>Broinsonia lacunosa</i> n.sp.					
<i>Cretarhabdus unicornis</i> STOVER, 1966					
<i>Cretarhabdus actinosus</i> (STOVER, 1966)					
<i>Polycyclolithus brotzenii</i> FORCHHEIMER, 1968					
<i>Polycyclolithus floralis</i> (STRADNER, 1962) n.comb.					
o <i>Cribrosphaera ehrenbergi</i> ARKHANGELSKY, 1912					
<i>Eiffellithus eximius</i> (STOVER, 1966)					
* <i>Microrhabdulus belgicus</i> HAY et TOWE, 1963					
<i>Micula staurophora</i> (GARDET, 1955)					
<i>Margolatus manivitae</i> n.gen., n.sp.					
<i>Markalius sulcatus</i> n.sp.					
* <i>Stephanolithion laffittei</i> NOEL, 1965					
<i>Tranolithus skoglundii</i> n.sp.					
o <i>Ahmuelterella octoradiata</i> (GORKA, 1957)					
<i>Biscutum kennedyi</i> BUKRY, 1969					
<i>Broinsonia handfieldii</i> BUKRY, 1969					
<i>Chiastozygus cuneatus</i> (LYUL'EVA, 1967)					
* <i>Coccolithus barnesae</i> (BLACK, 1959)					
<i>Cretarhabdus biseriatus</i> n.sp.					
<i>Cretarhabdus conicus</i> BRAMLETTE et MARTINI, 1964					
<i>Deflandrius cantabrigensis</i> BLACK, 1967					
<i>Deflandrius spinosus</i> BRAMLETTE et MARTINI, 1964					
o <i>Eiffellithus turriseiffeli</i> (DEFLANDRE, 1954)					
<i>Gartnerago costatum</i> (GARTNER, 1968) n.comb.					
<i>Gartnerago obliquum</i> (STRADNER, 1963) n.comb.					
<i>Gartnerago striatum</i> (STRADNER, 1963) n.comb.					
<i>Helicolithus stillatus</i> n.sp.					
<i>Kamptnerius punctatus</i> DEFLANDRE, 1954					
<i>Lithastrinus septenarius</i> n.sp.					
* <i>Lithraphidites carnialensis</i> DEFLANDRE, 1963					
<i>Loxolithus armilla</i> (BLACK, 1959)					
<i>Marthasterites duplex</i> n.sp.					
<i>Micula cubiformis</i> n.sp.					
<i>Repagulum parvidentatum</i> (DEFLANDRE, 1954) n.gen., n.comb.					
<i>Vagalapilla partita</i> n.sp.					
<i>Vagalapilla alata</i> n.sp.					
<i>Tranolithus exiguus</i> STOVER, 1966					
<i>Zygodiscus compactus</i> BUKRY, 1969					
<i>Zygodiscus erectus</i> (DEFLANDRE, 1954)					
<i>Discorhabdus ignotus</i> (GORKA, 1957)					
<i>Biscutum blacki</i> GARTNER, 1968					
<i>Gartnerago concavum</i> (GARTNER, 1968)					
o <i>Rhabdalithina splendens</i> (DEFLANDRE, 1954)					
* <i>Solasites horticum</i> (STRADNER et al, 1966)					
<i>Vagalapilla solida</i> n.sp.					
* <i>Chiastozygus amphipons</i> (BRAMLETTE et MARTINI, 1964)					
* <i>Corollithion geometricum</i> (GORKA, 1957)					
* <i>Corollithion rhombicum</i> (STRADNER et al, 1966)					
<i>Lucianorhabdus arcuatus</i> n.sp.					
<i>Lucianorhabdus quadrifidus</i> n.sp.					
<i>Pontolithus flabellus</i> (STRADNER et al, 1968)					
<i>Calolithus martelae</i> NOEL, 1965					
* <i>Corollithion delftensis</i> (STRADNER et al, 1968)					
<i>Cyclolithella</i> sp.					
<i>Deflandrius cf. D.stoveri</i> PERCH NIELSEN, 1968					
<i>Markalius circumradiatus</i> (STOVER, 1966)					
<i>Gartnerago porolatum</i> (BUKRY, 1966) n.comb.					
* <i>Actinozygus regularis</i> (GORKA 1957)					
* <i>Costacentrum lowei</i> BUKRY, 1969					
<i>Cretarhabdus octoperforatus</i> n.sp.					
* <i>Deflandrius intercisus</i> (DEFLANDRE, 1954)					
* <i>Discolithina porosuturalis</i> BUKRY, 1969					
* <i>Discolithina theta</i> (BLACK, 1959)					
<i>Kamptnerius pertusus</i> n.sp.					
<i>Polycyclolithus orbiculatus</i> n.sp.					
* <i>Rhabdalithus cf. R.rectus</i> DEFLANDRE, 1954					
* <i>Rhabdalithus decussatus</i> (MANIVIT, 1961)					
* <i>Scapholithus fossilis</i> DEFLANDRE, 1954					
o <i>Zygodiscus biperforatus</i> GARTNER, 1968					
* <i>Zygodiscus pseudoanthophorus</i> BRAMLETTE et MARTINI, 1964					
<i>Broinsonia dempta</i> n.sp.					
* <i>Podorhabdus albianus</i> BLACK, 1967					
<i>Zygodiscus inclinatus</i> n.sp.					

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Species	Literature
<i>Actinozygus regularis</i> (GÓRKA)	GARTNER, 1968
<i>Ahmullerella octoradiata</i> (GÓRKA)	REINHARDT, 1964
<i>Chiastozygus amphipons</i> (BRAMLETTE et MARTINI)	GARTNER, 1968
<i>Coccolithus barnesae</i> (BLACK)	BRAMLETTE et MARTINI, 1964
<i>Corolithion delftensis</i> (STRADNER et al)	BUKRY et BRAMLETTE, 1969
<i>Corolithion geometricum</i> (GÓRKA)	MANIVIT, 1970
<i>Corolithion rhombicum</i> (STRADNER et al)	BUKRY, 1969
<i>Costacentrum lowei</i>	BUKRY, 1969
<i>Cribrosphaera ehrenbergi</i>	ARKHANGELSKY, 1912
<i>Cylindralithus serratus</i>	BRAMLETTE et MARTINI, 1964
<i>Deflandrius intercicus</i> (DEFLANDRE)	BRAMLETTE et MARTINI, 1964
<i>Discolithina porosoturalis</i>	BUKRY, 1969
<i>Discolithina theta</i> (BLACK)	FORCHHEIMER, 1970
<i>Eiffellithus turriseiffeli</i> (DEFLANDRE)	REINHARDT, 1965
<i>Lithraphidites carniolensis</i>	DEFLANDRE, 1963
<i>Microrhabdulus belgicus</i>	HAY et TOWE, 1963
<i>Podorhabdulus albianus</i>	BLACK, 1967
<i>Rhabdolithina splendens</i> (DEFLANDRE)	REINHARDT, 1966
<i>Rhabdolithus</i> cf. <i>R. rectus</i> DEFLANDRE	MANIVIT, 1965
<i>Rhabdolithus decussatus</i> (MANIVIT)	STRADNER, 1963
<i>Scapholithus fossilis</i>	DEFLANDRE et FERT, 1954
<i>Solasites horticum</i> (STRADNER)	BLACK, 1967
<i>Stephanolithion laffittei</i>	NOËL, 1965
<i>Zygodiscus biperforatus</i>	GARTNER, 1968
<i>Zygodiscus pseudoantophorus</i>	BRAMLETTE et MARTINI, 1964

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ADDENDUM

The following papers recently published should be included in the reference list:

- BLACK, M., 1971: The systematics of coccoliths in relation to the palaeontological record. – The Micropalaeontology of Oceans, Cambridge University Press, 611–620.
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- Taxonomische Untersuchungen an Coccolithineen aus der Kreide Norddeutschland anhand elektronenmikroskopischer Aufnahmen. – Idem., 163–198.
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As these investigations were finished before the papers named above were obtainable no consideration has been taken to the results described there. It must, however, be pointed out that HOFFMAN (1970), REINHARDT (1970–1971), BUKRY (1971) and BLACK (1971) described some forms dealt with in the present paper. It has also to be mentioned that BUKRY found a *Micula* sp. aff. *M. decusata* VEKSHINA, 1959 in the Cenomanian, and BLACK a *Polycyclolithus brotzenii* FORCHHEIMER, 1968 in the Barremian.

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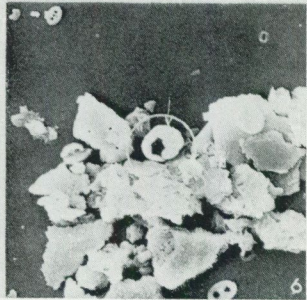
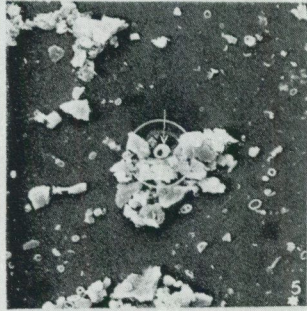
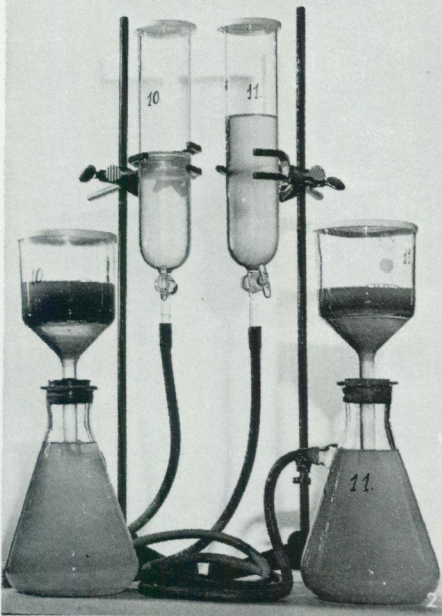
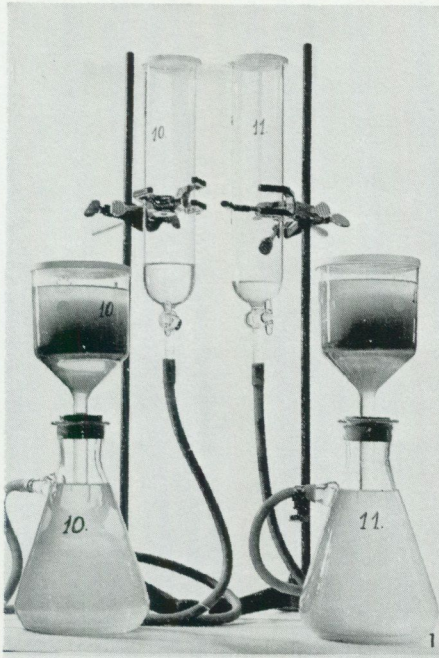


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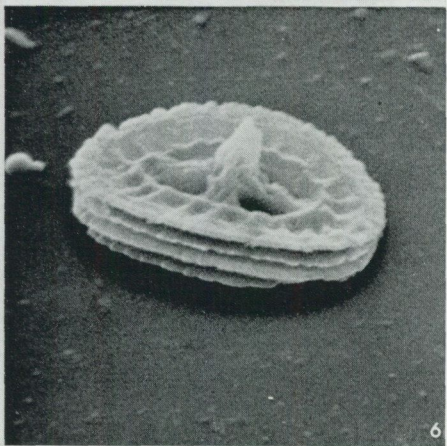
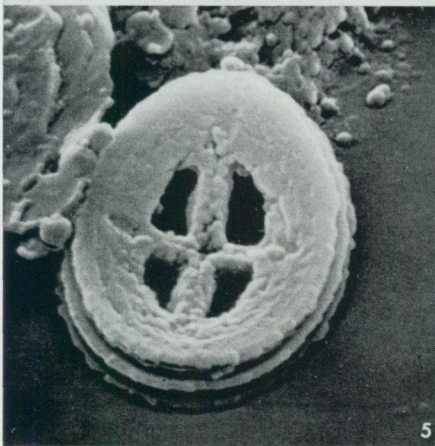
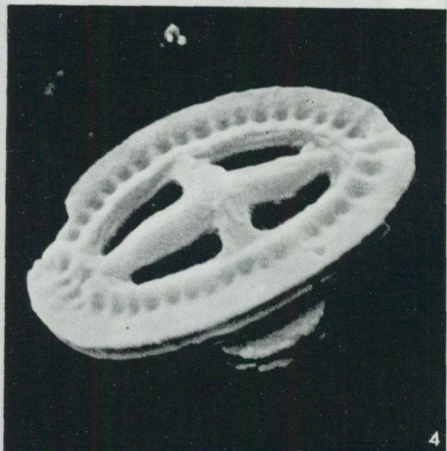
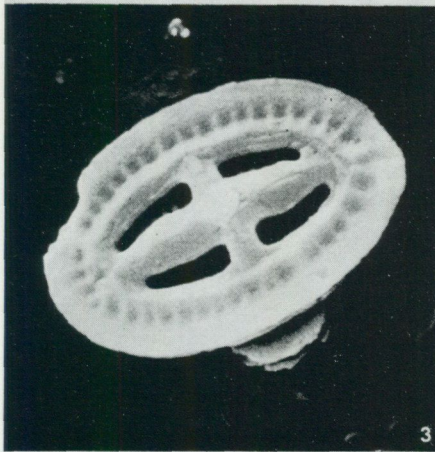
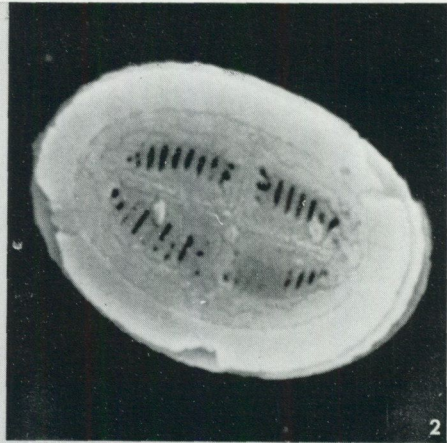
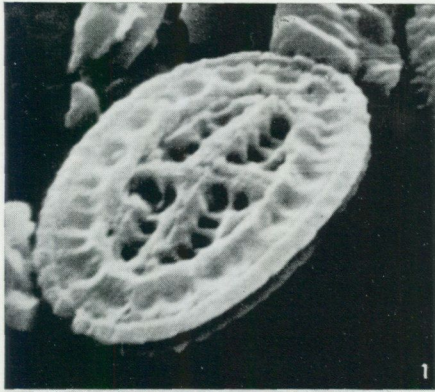


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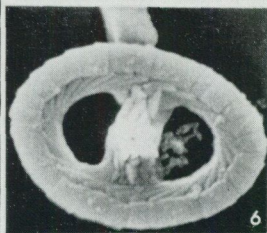
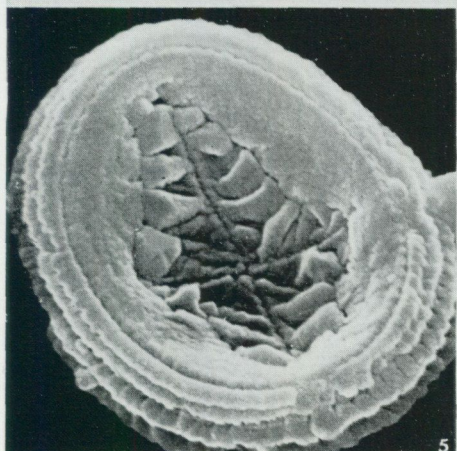
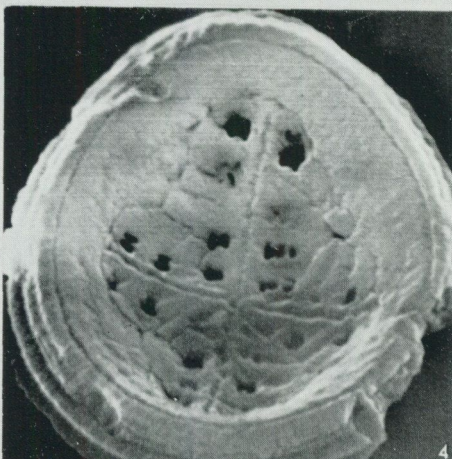
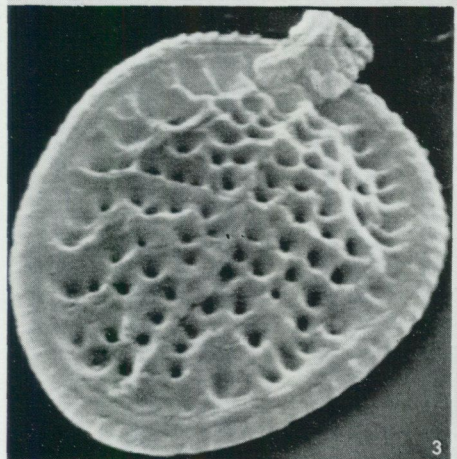
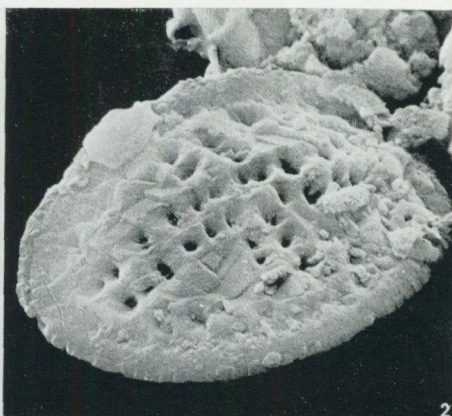
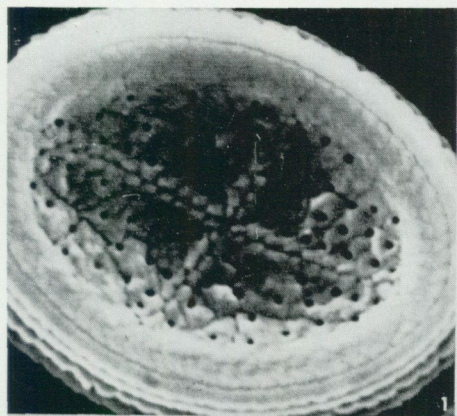


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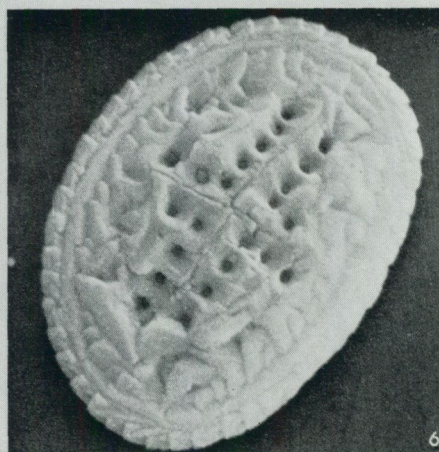
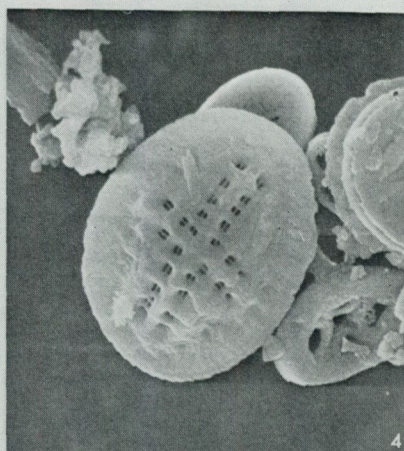
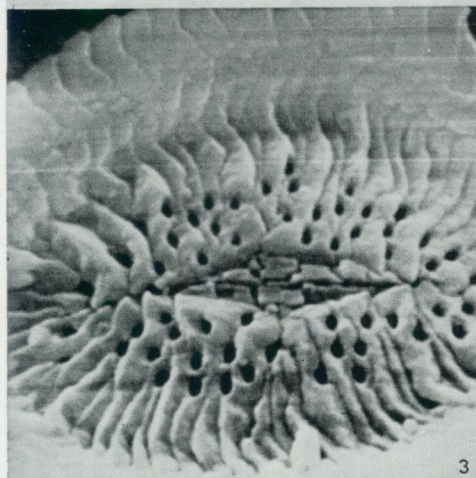
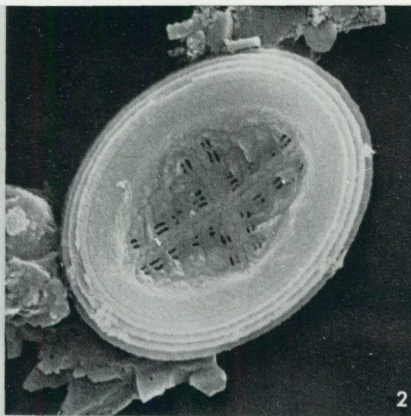
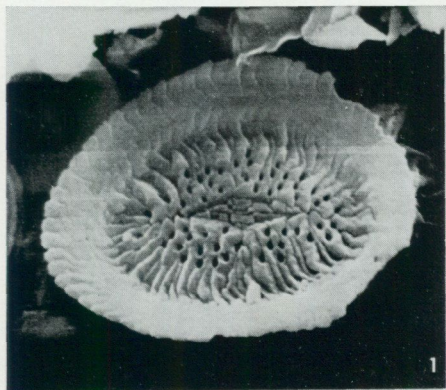


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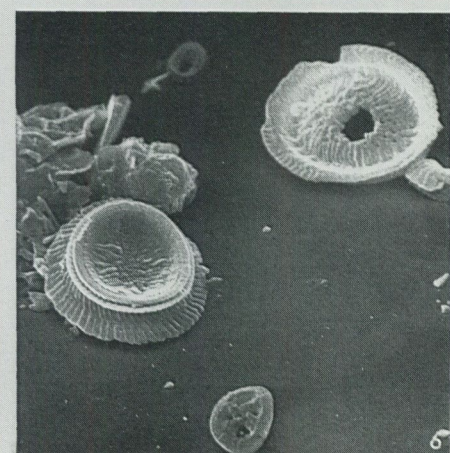
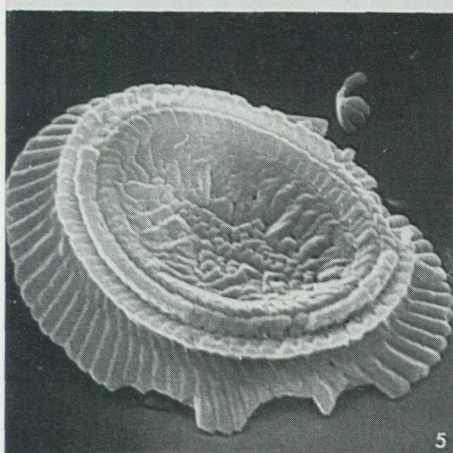
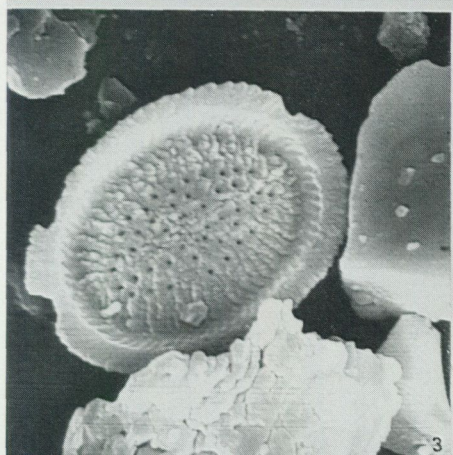
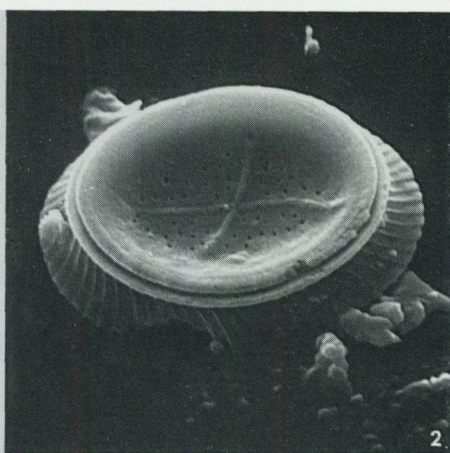
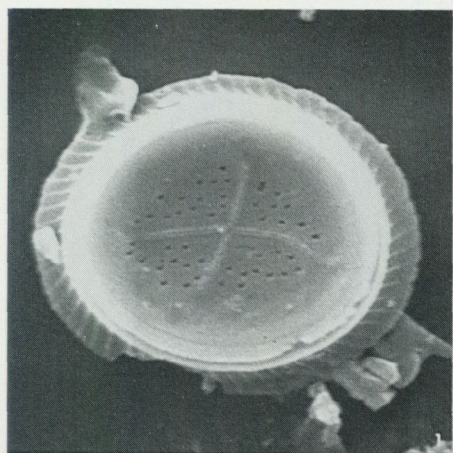


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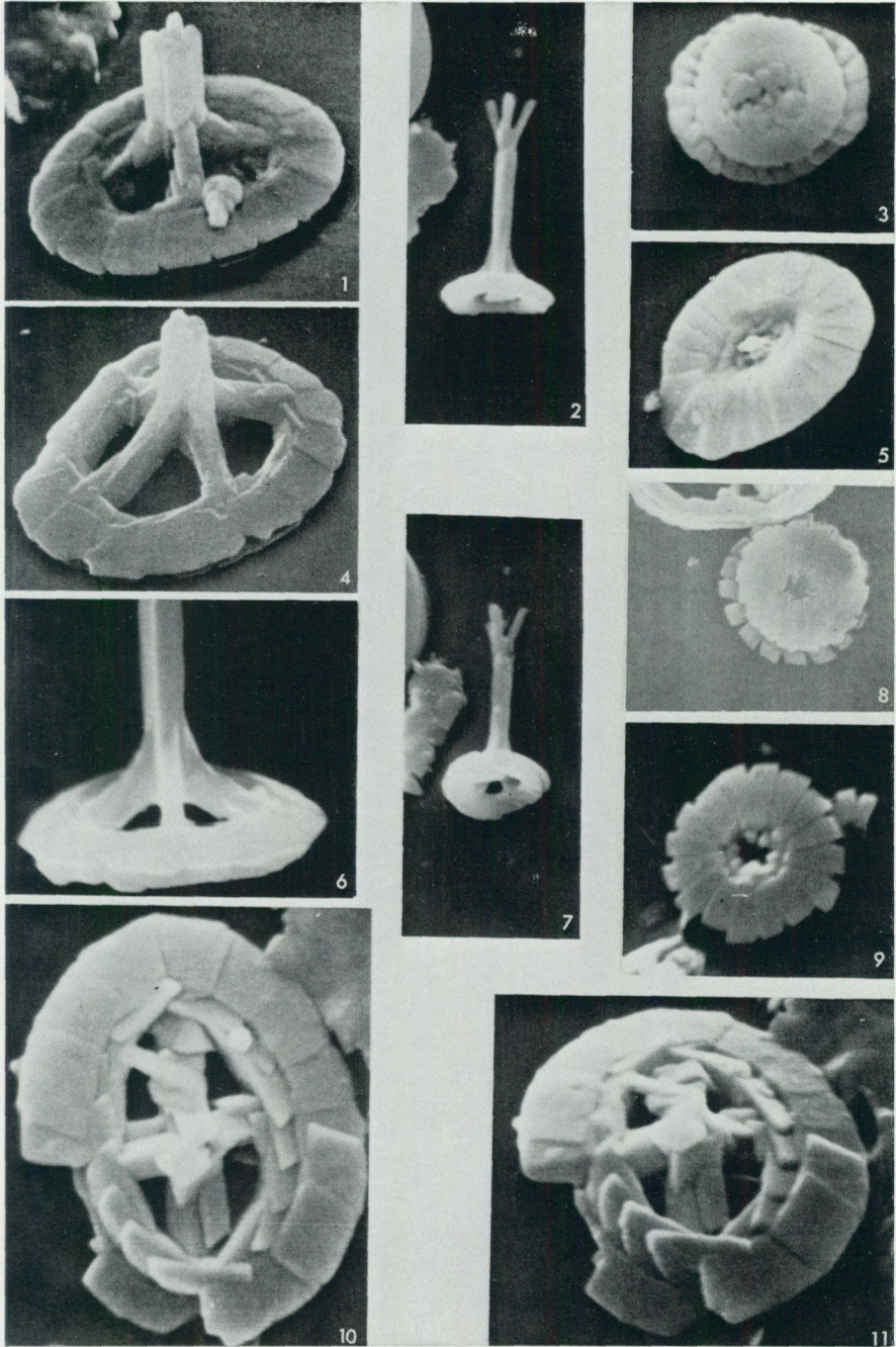


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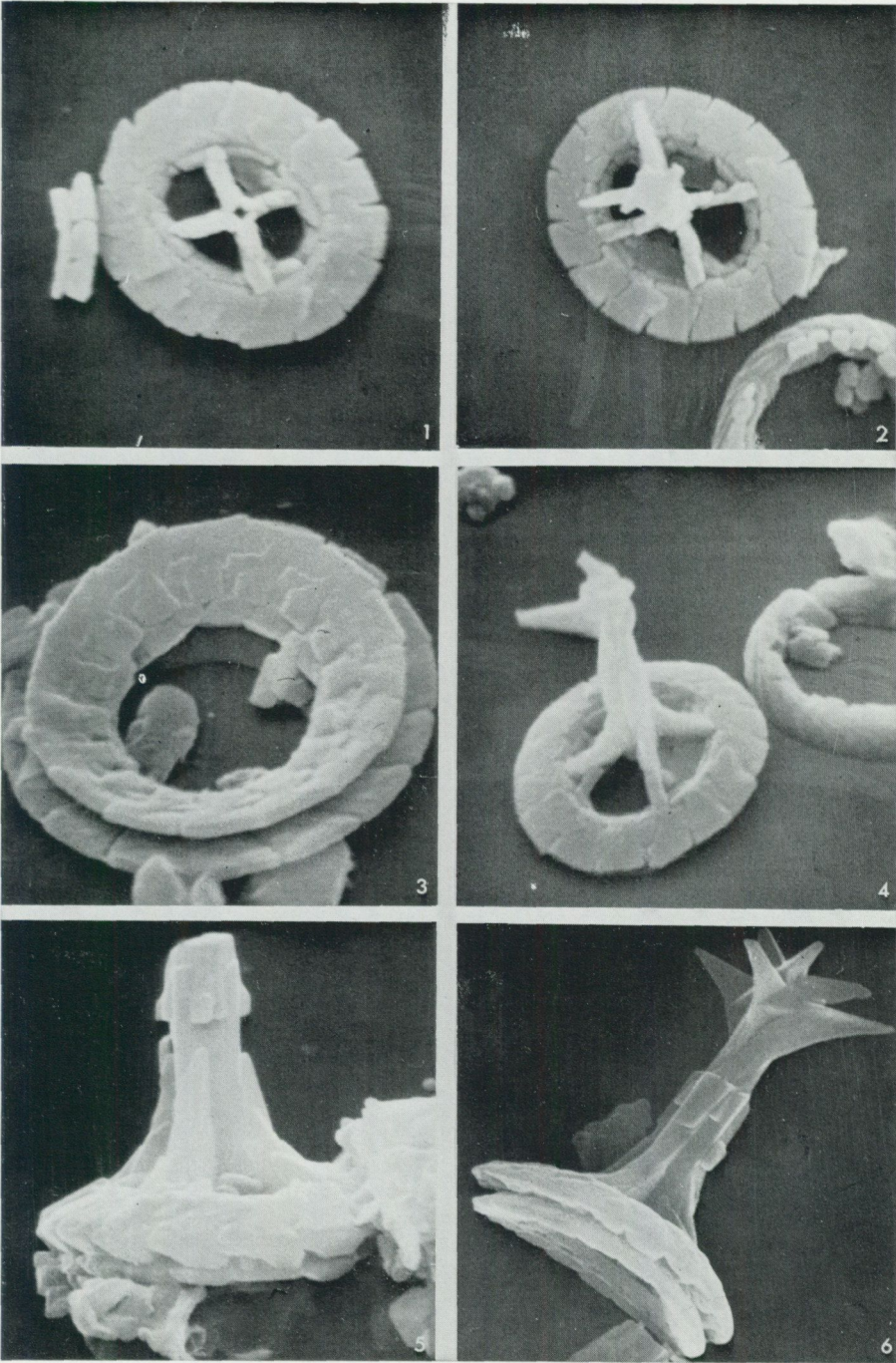


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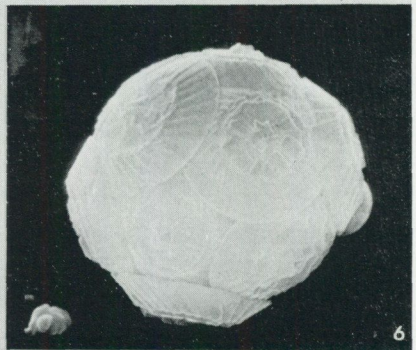
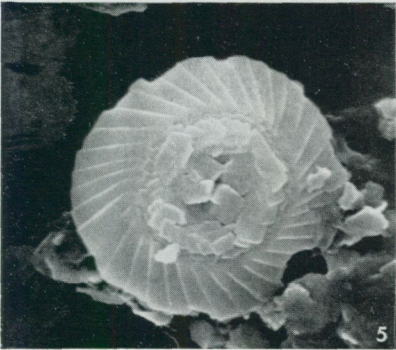
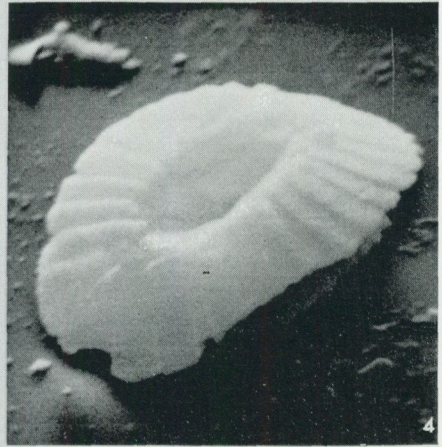
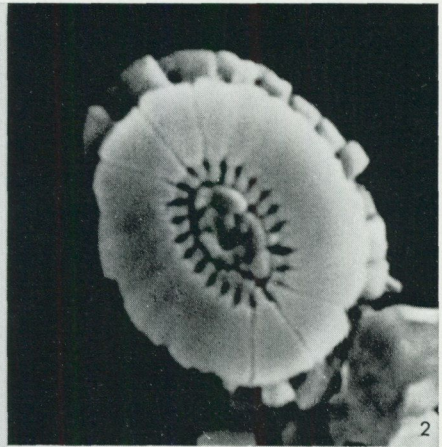
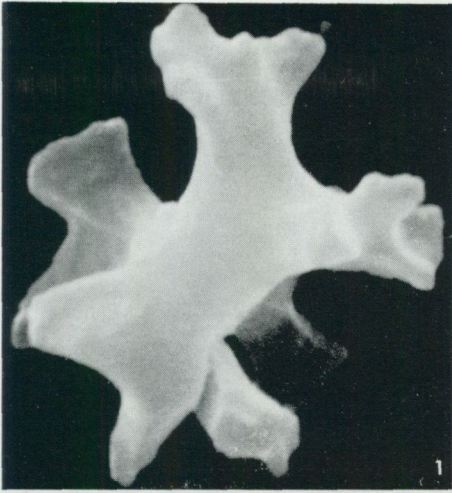


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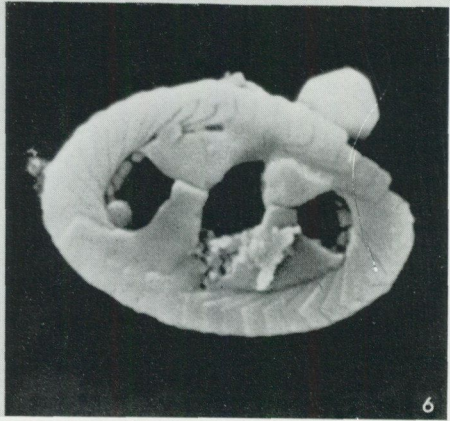
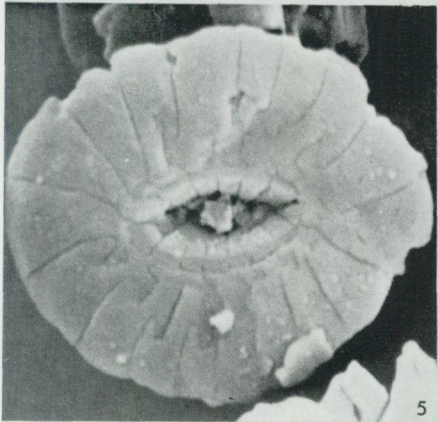
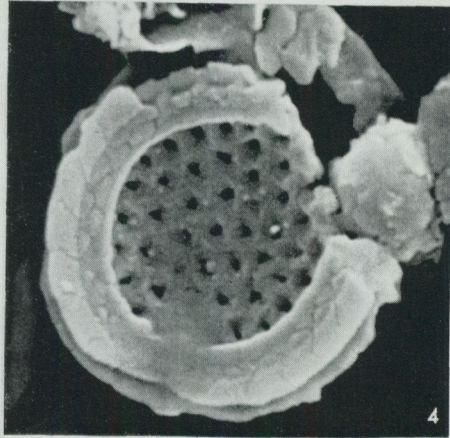
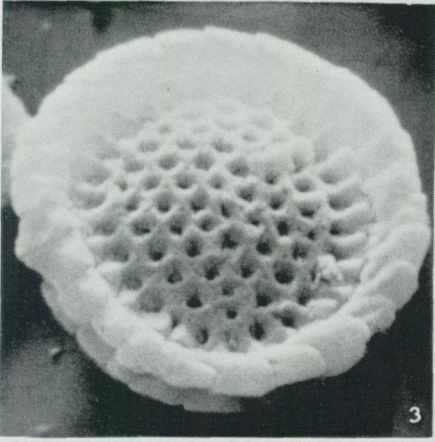
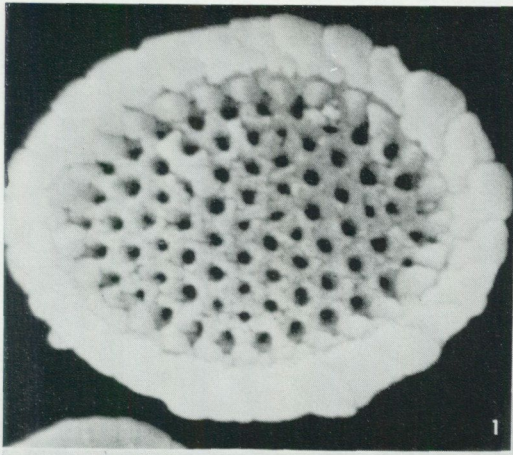


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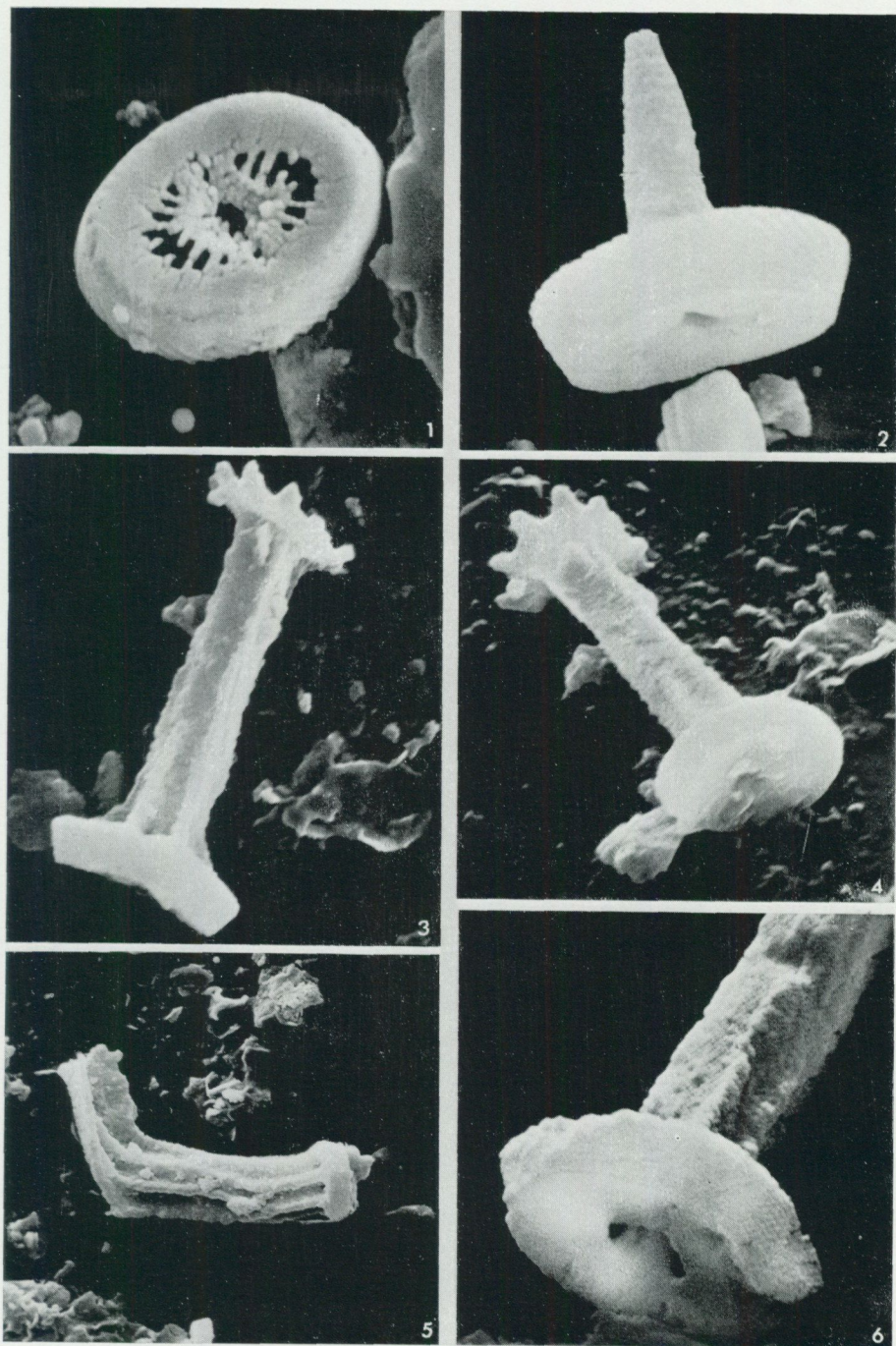


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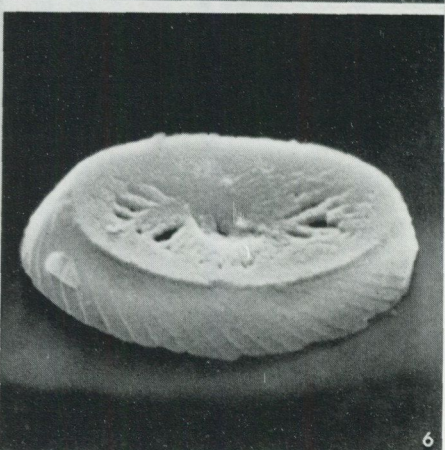
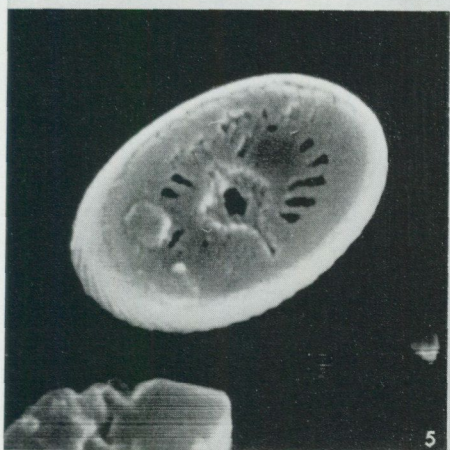
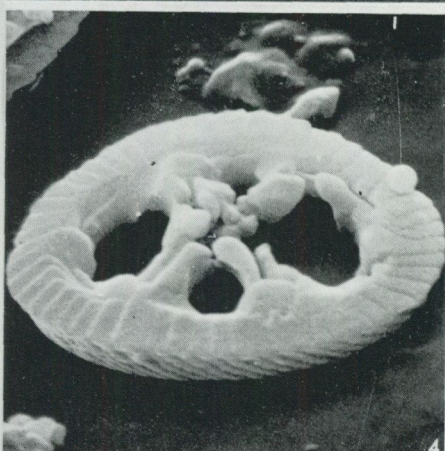
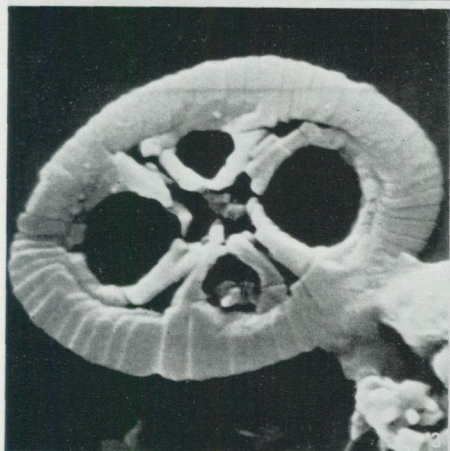
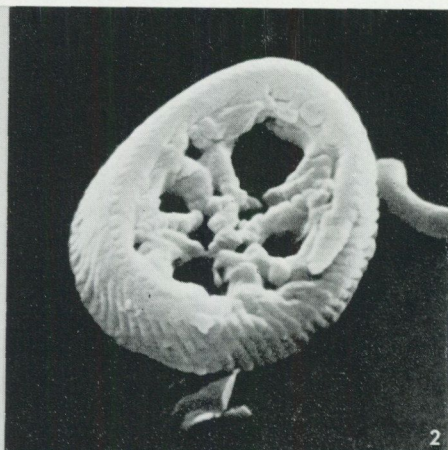
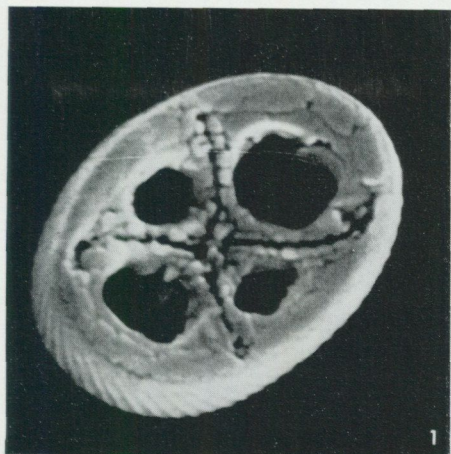


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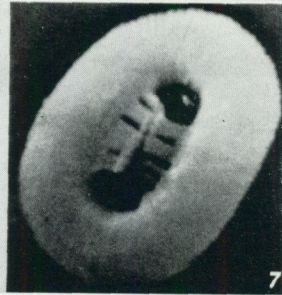
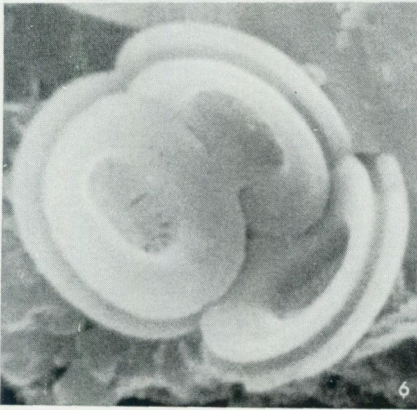
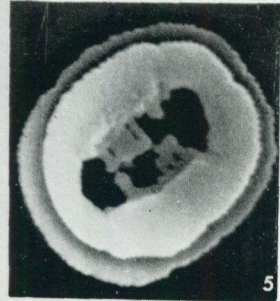
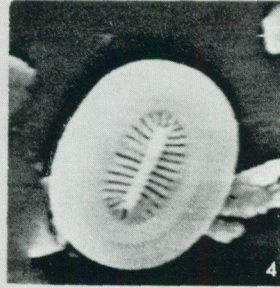
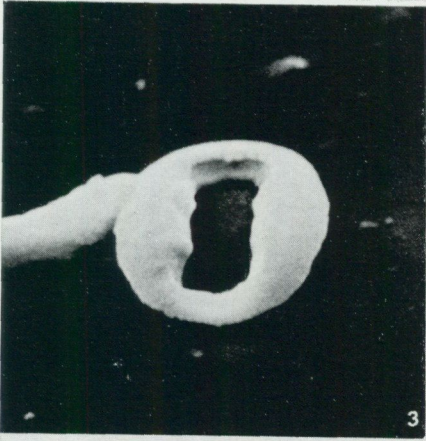
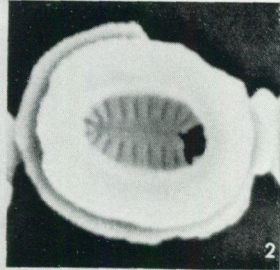


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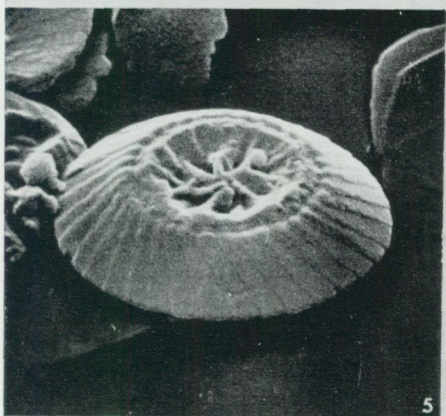
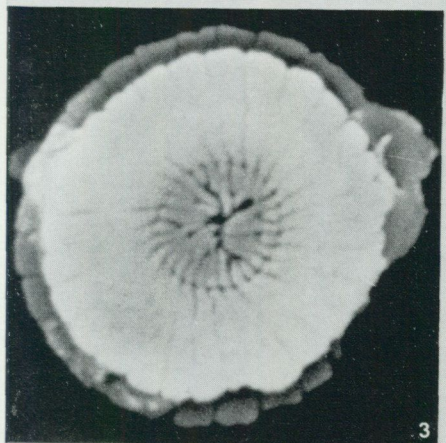
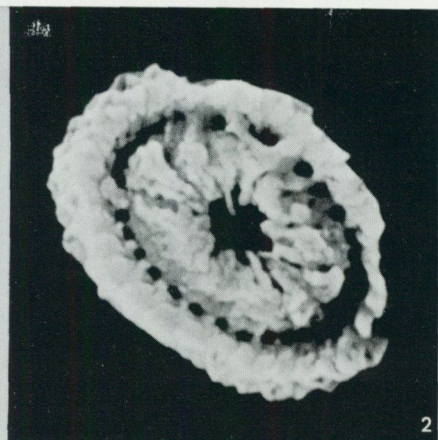
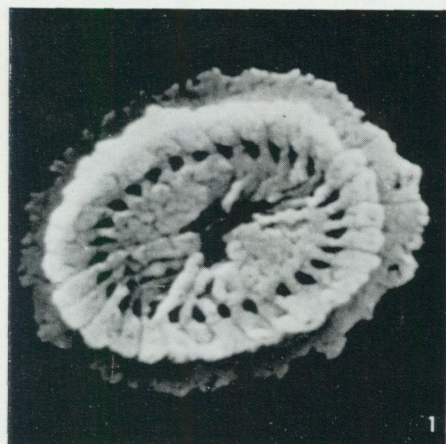


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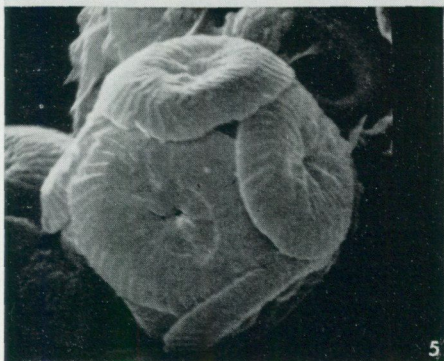
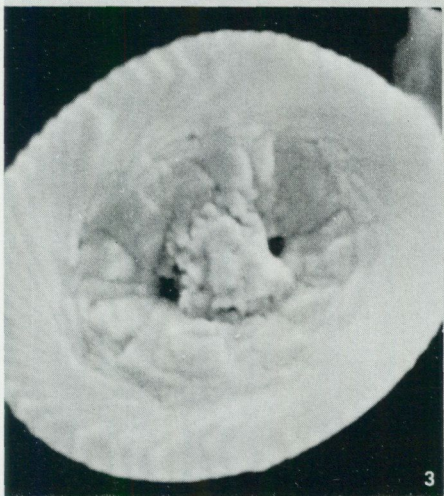
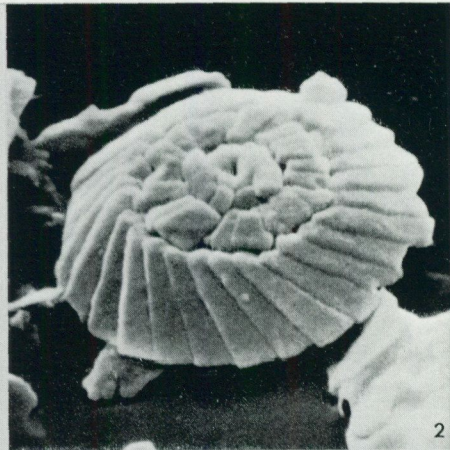


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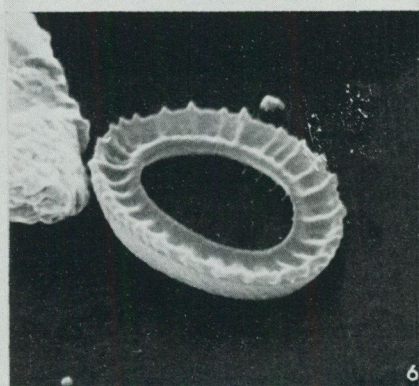
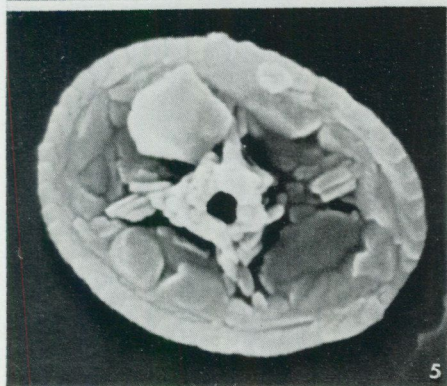
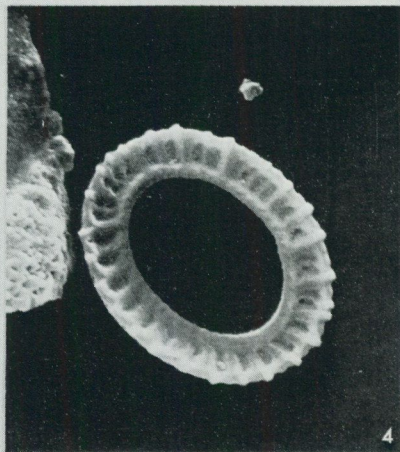
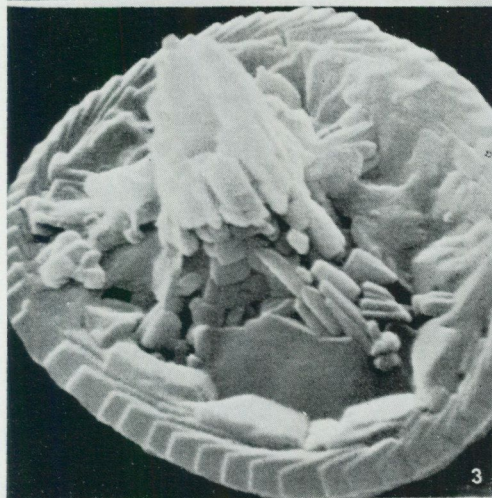
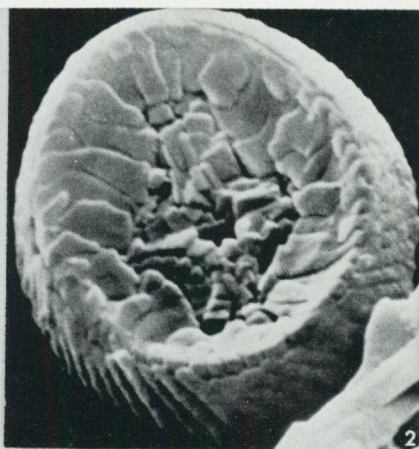
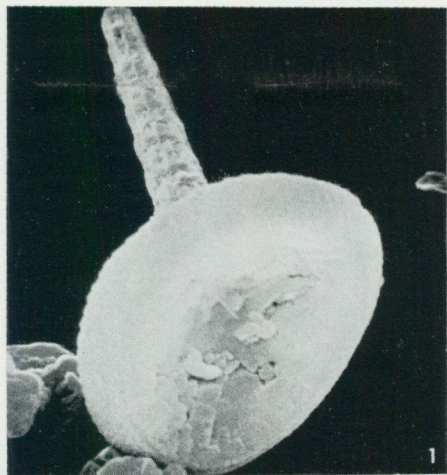


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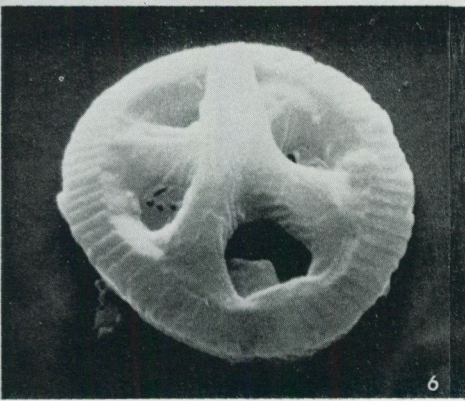
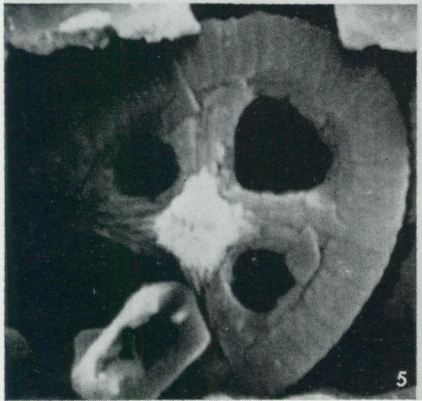
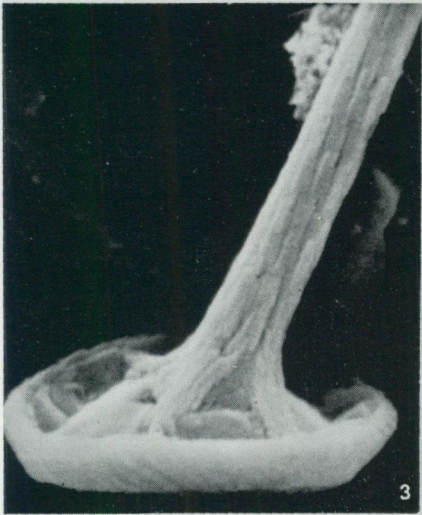
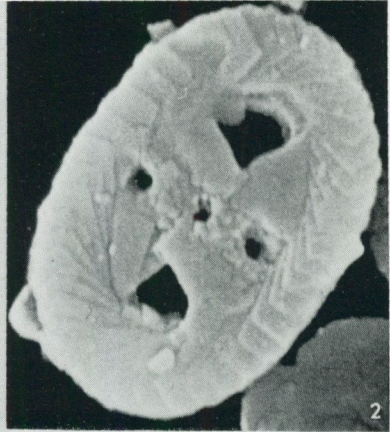
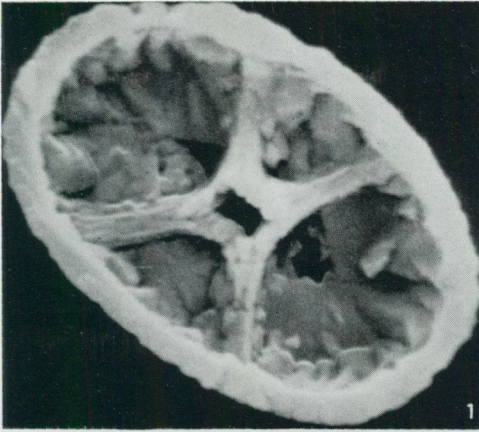


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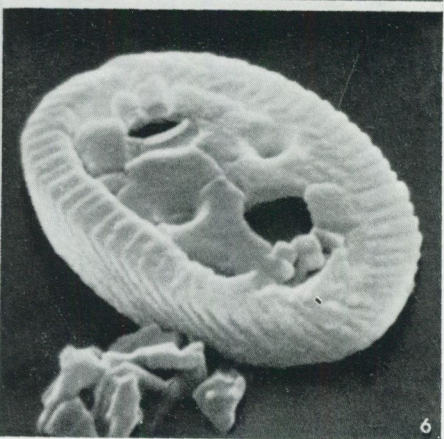
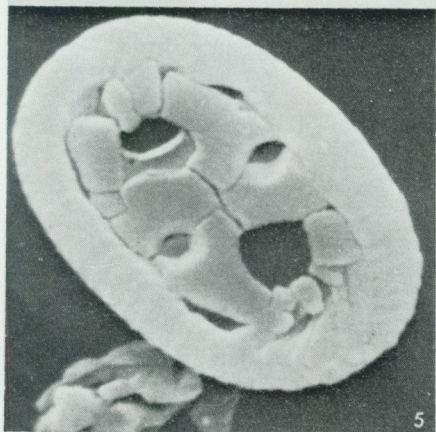
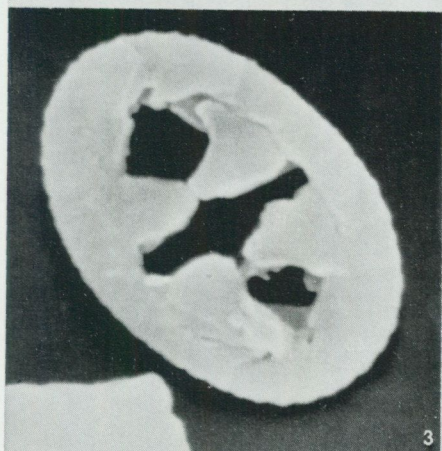
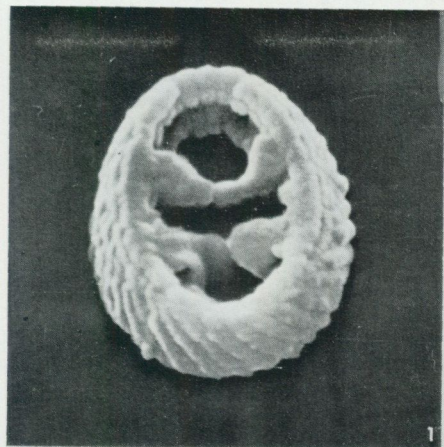


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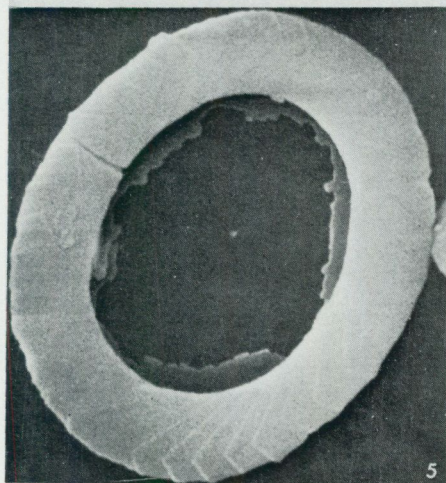
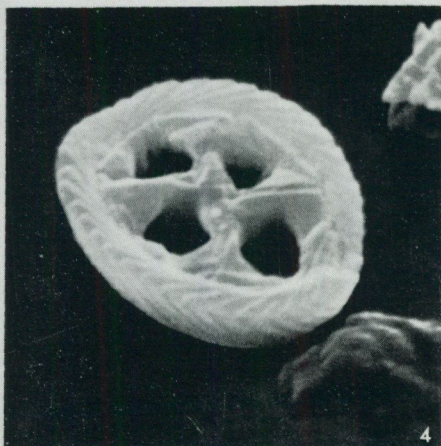
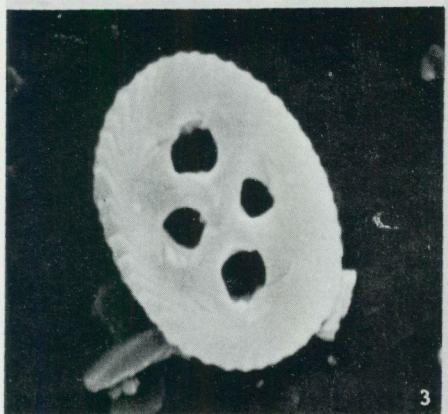
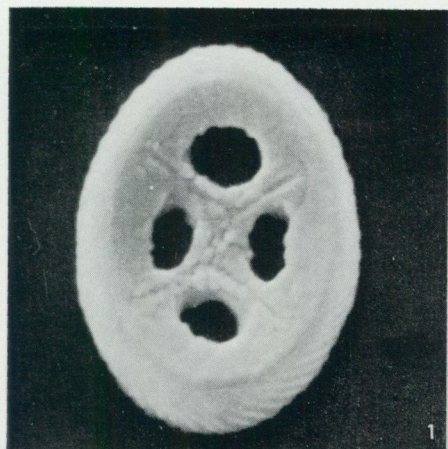


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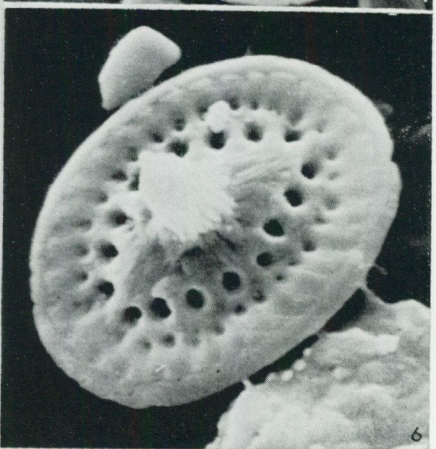
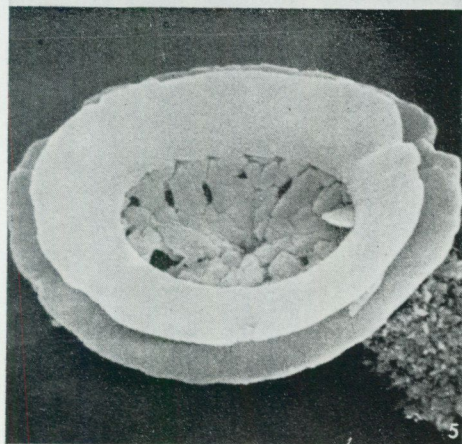
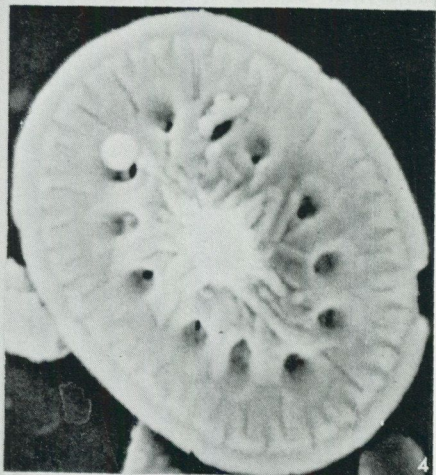
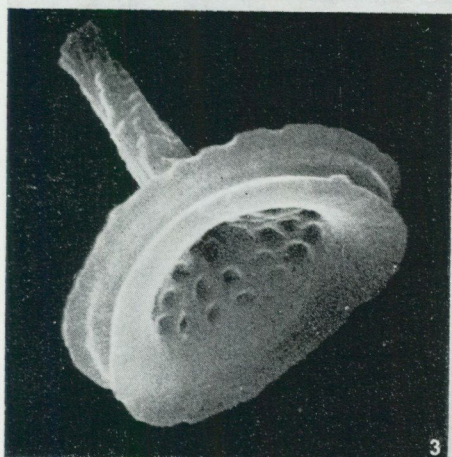
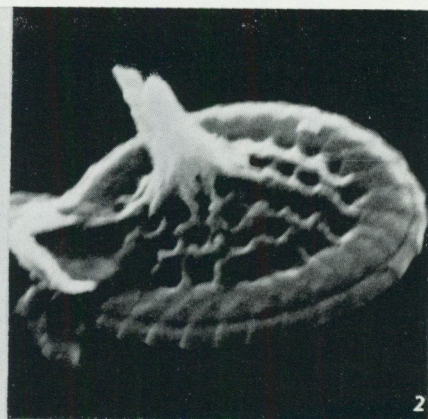
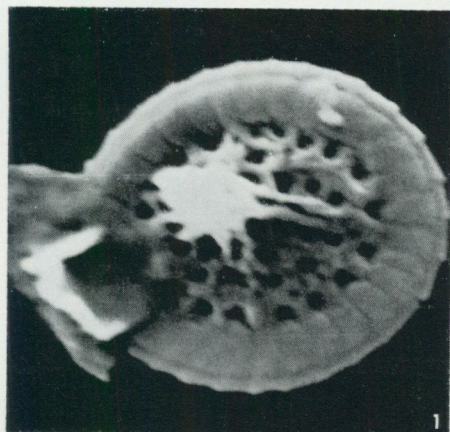


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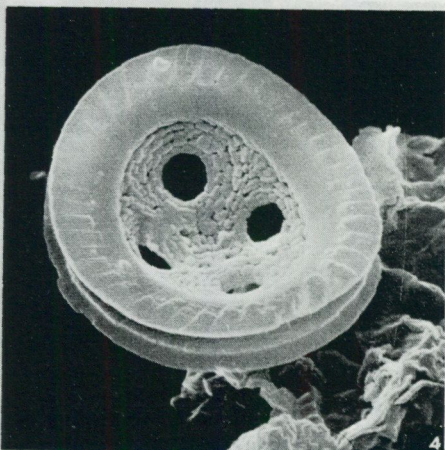
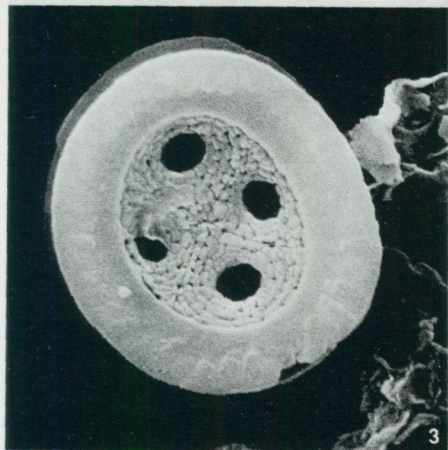
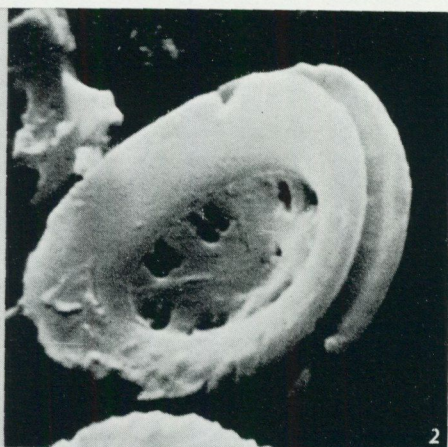
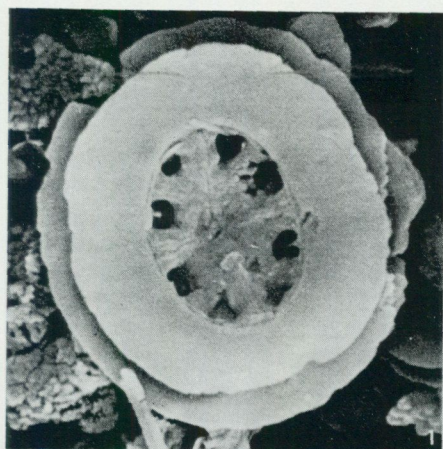


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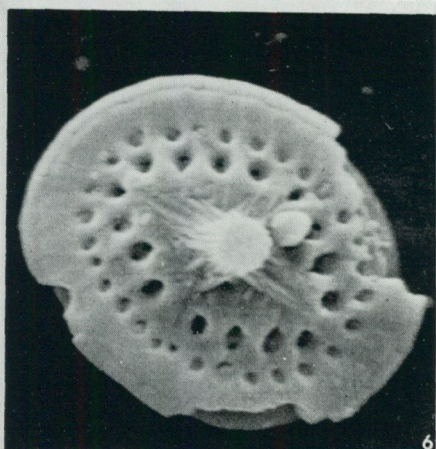
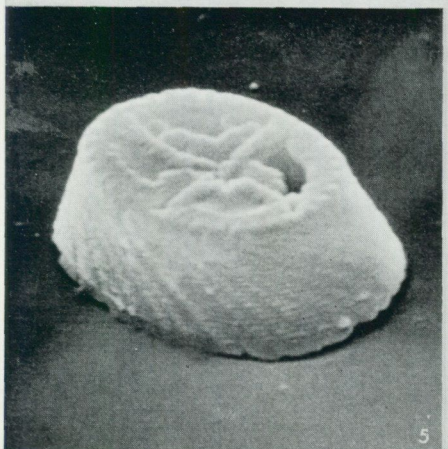
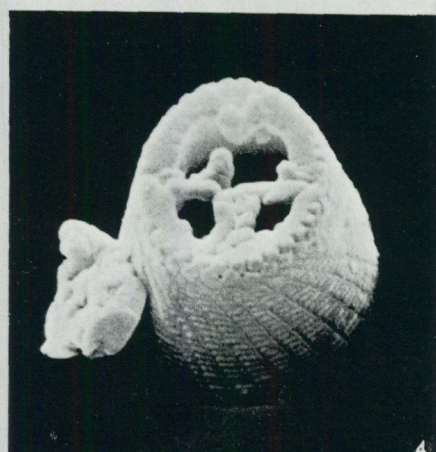
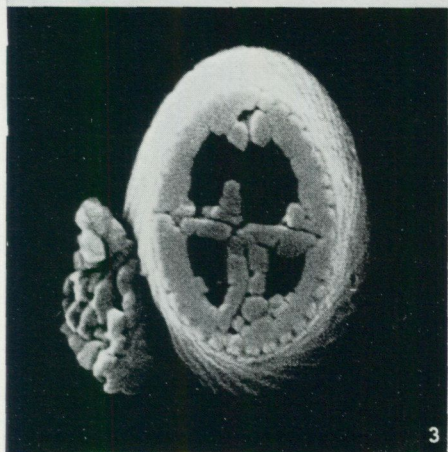
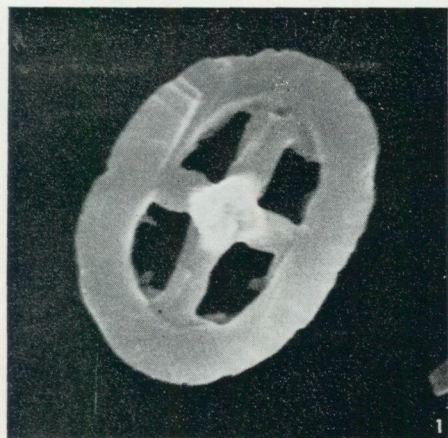


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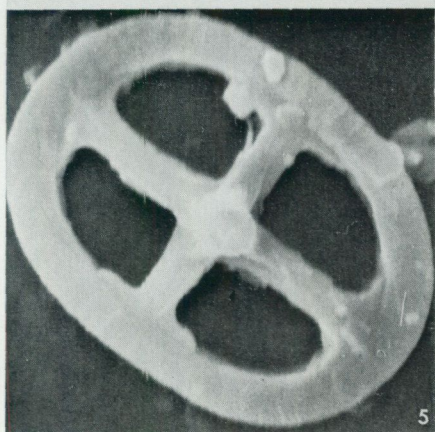
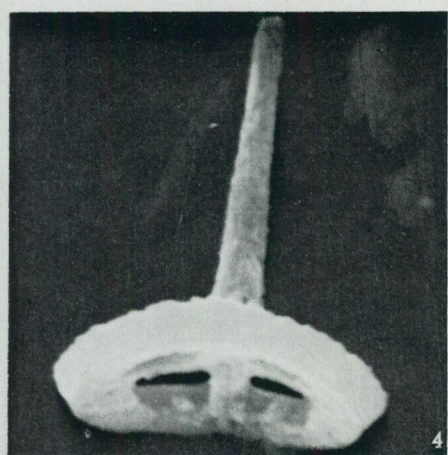
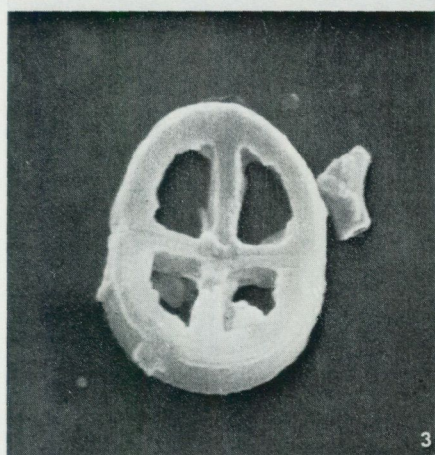
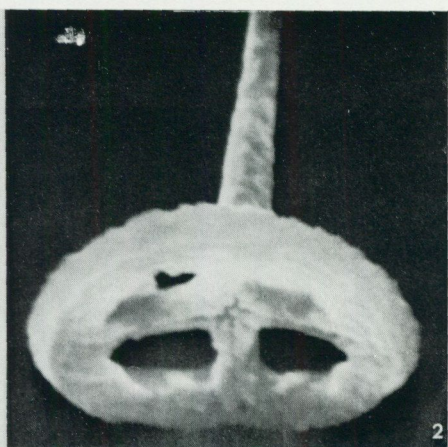


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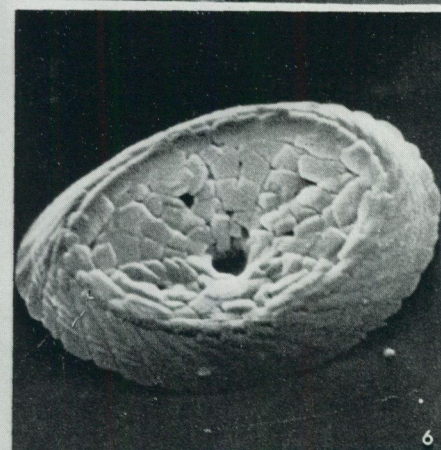
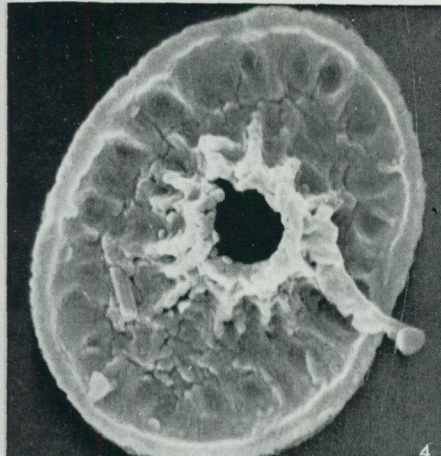
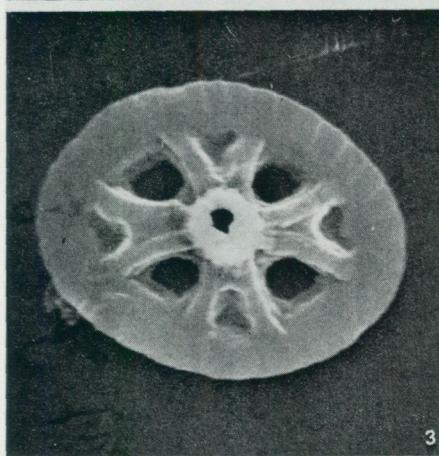


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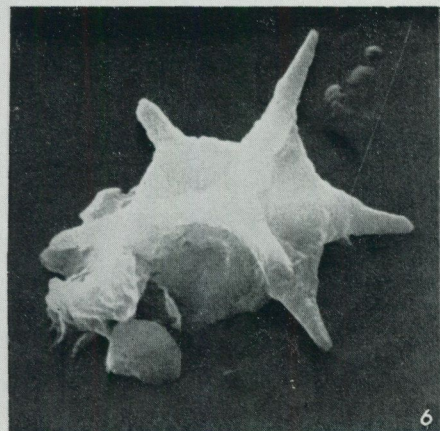
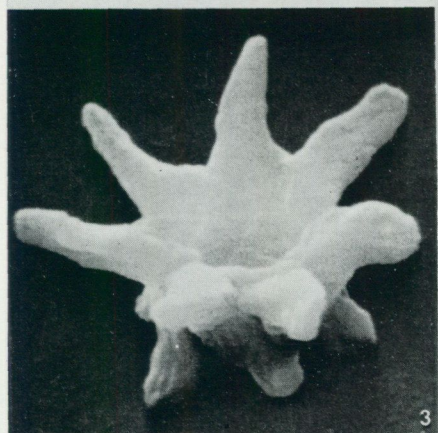
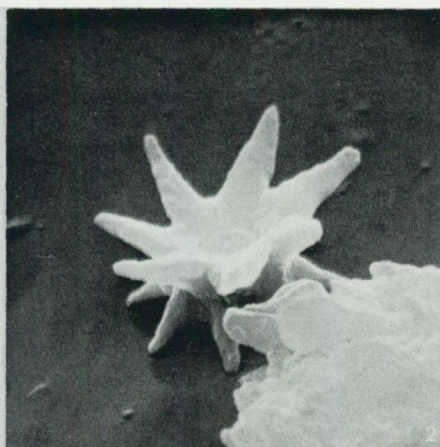
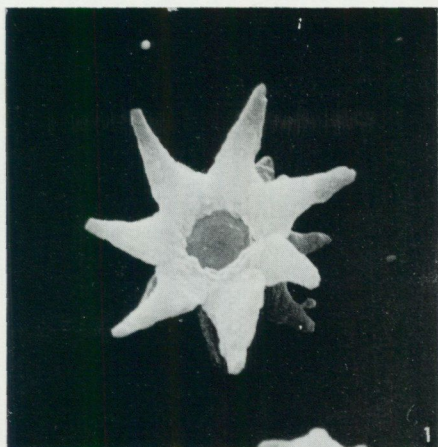


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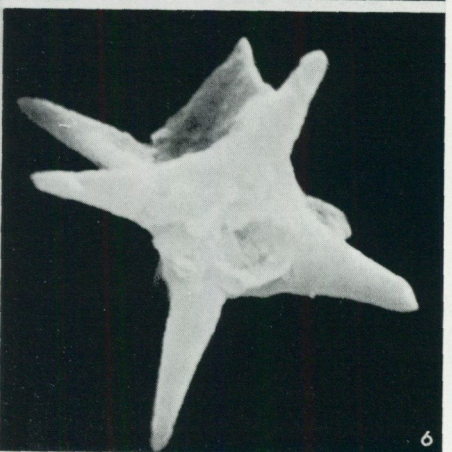
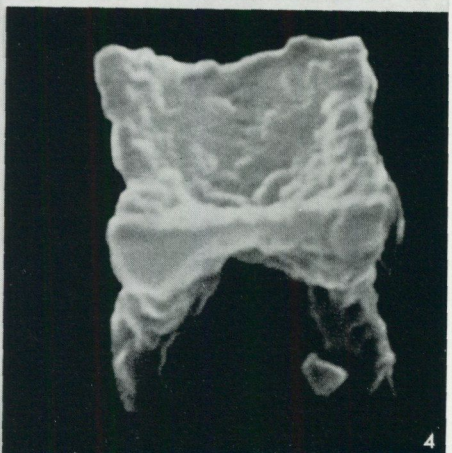
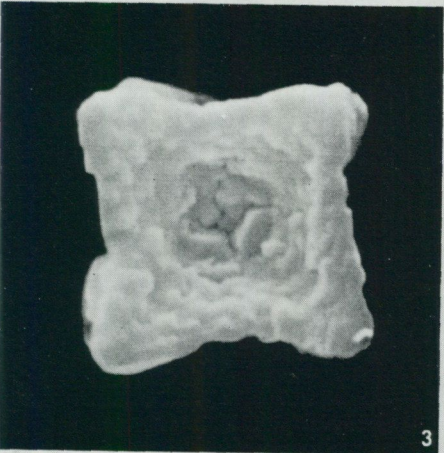
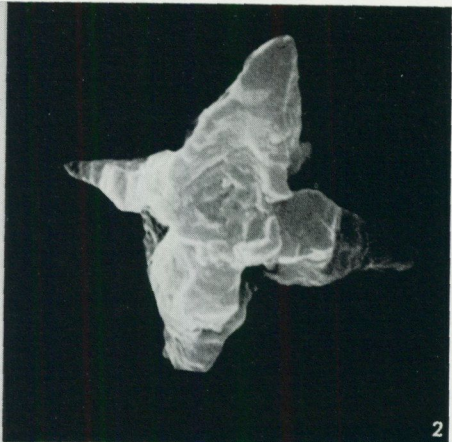
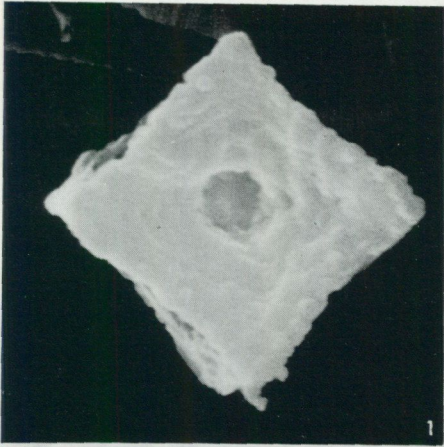


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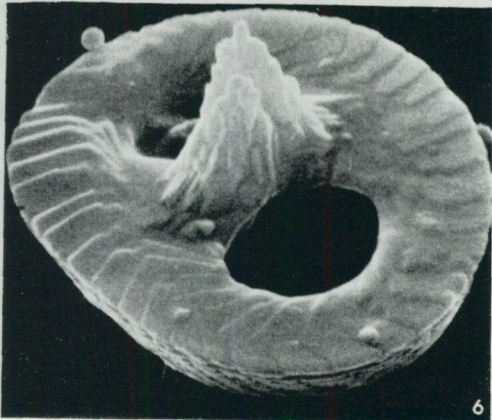
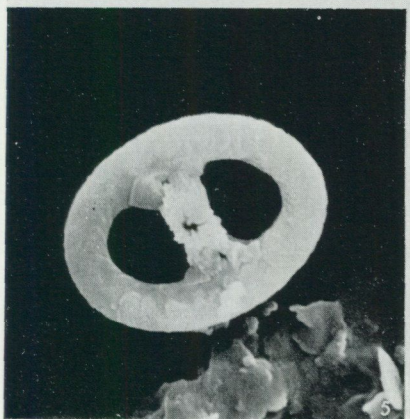
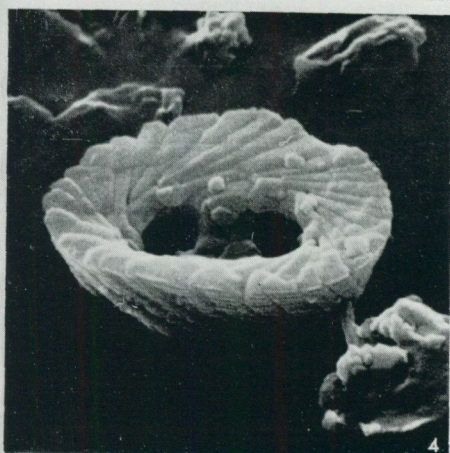
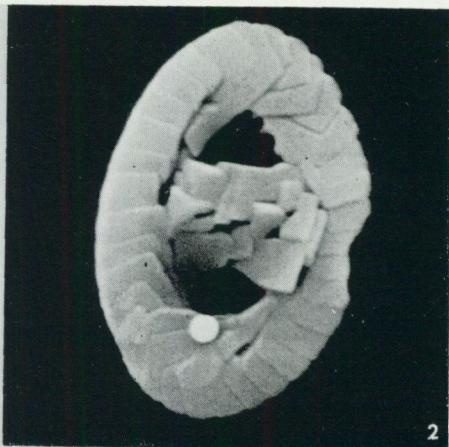
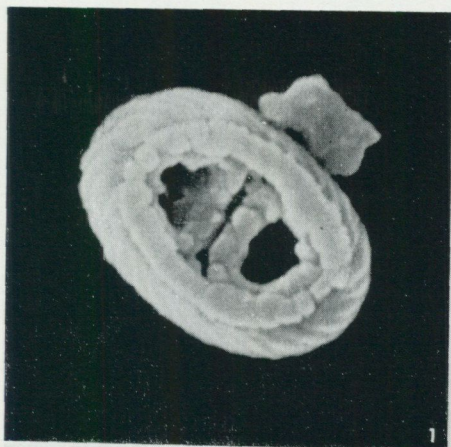


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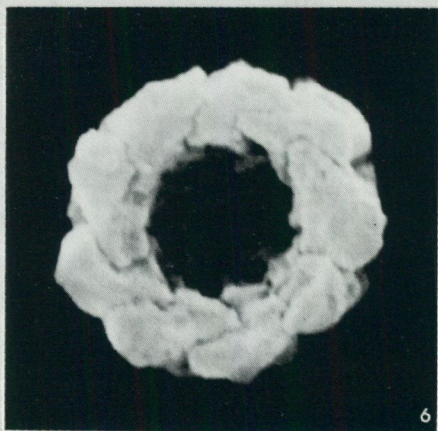
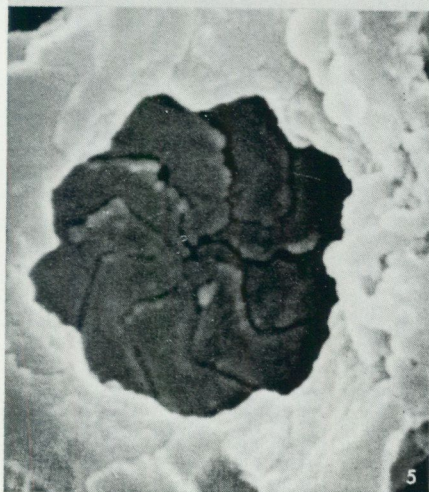
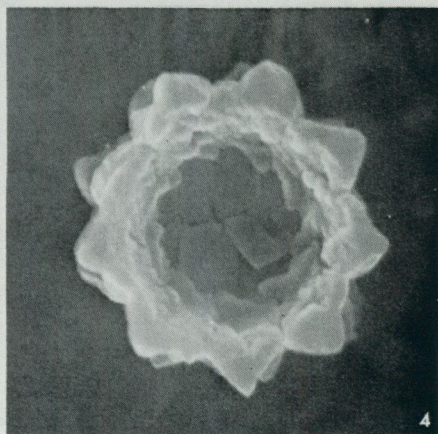
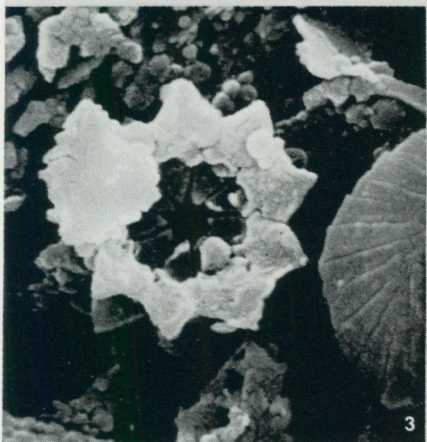
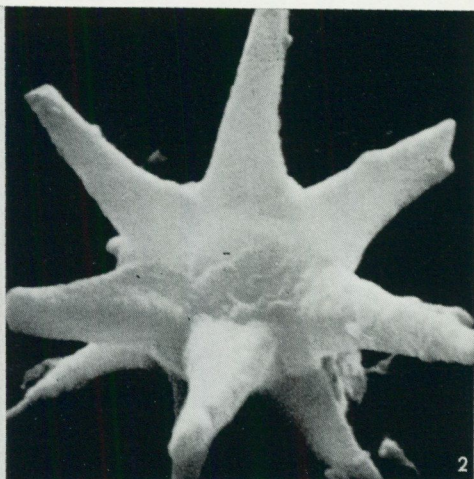
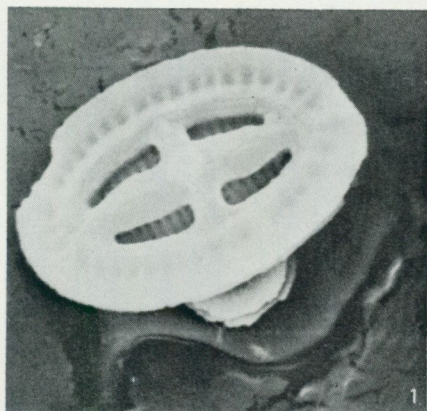


PLATE XXVII

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