Riv. Ital. Paleont.	v. 83	n. 4	pp. 759-802	tav. 40-46	Milano 1977

UPPER CRETACEOUS AND EARLY TERTIARY NANNOPLANKTON FROM THE SCAGLIA UMBRA FORMATION (GUBBIO, ITALY) **

SIMONETTA MONECHI *

Summary. Calcareous nannofossils from Turonian to Paleocene portion of the Scaglia Umbra in the Bottaccione Section (Gubbio, Central Apennines) are listed and figured. They were studied by means of scanning electron microscope. Fifty species have been determined and described in detail. The *Cruciplacolithus tenuis* Zone and *Biscutum* ? *dimorphosum* and *Ericsonia subpertusa* subzone have been recognized in the Paleocene levels.

Particular attention has been given to the Cretaceous-Tertiary boundary: the nannoplankton occurrences compared with the Foraminifera distribution allow some considerations about the biotic crisis.

Riassunto. In questa nota vengono descritti e figurati i nannofossili calcarei per l'intervallo Turoniano-Paleocene della Scaglia Umbra nella serie del Bottaccione (Gubbio, Appennino centrale). Lo studio del nannoplancton è stato eseguito per mezzo del microscopio elettronico a scansione. Sono state riconosciute e descritte in dettaglio 50 specie. Per il Paleocene inferiore è stata riconosciuta la Zona a *Cruciplacolithus tenuis* e la sottozona a *Biscutum* ? *dimorphosum* e *Ericsonia subpertusa*.

Particolare attenzione è stata rivolta allo studio del limite Cretaceo-Terziario: la presenza del nannoplancton comparata con la distribuzione dei Foraminiferi planctonici permette alcune considerazioni sulla crisi biologica del Cretaceo terminale.

Introduction.

This study is based on scanning electron microscope analyses of the calcareous nannoplankton found in the Turonian to Paleocene interval of the Bottaccione sequence (Gubbio, Central Apennines). Particular attention has been given to the Cretaceous-Tertiary boundary, which has already been dealt with by an earlier paper (Monechi & Pirini Radrizzani, 1975). The Bottaccione sequence includes a complete succession of

* Institute of Geology and Paleontology, University of Florence (Italy).

** This paper was supported by the contribution of C.N.R. n. 76.00.130, Paleopelagos research group, Unity of the University of Florence.

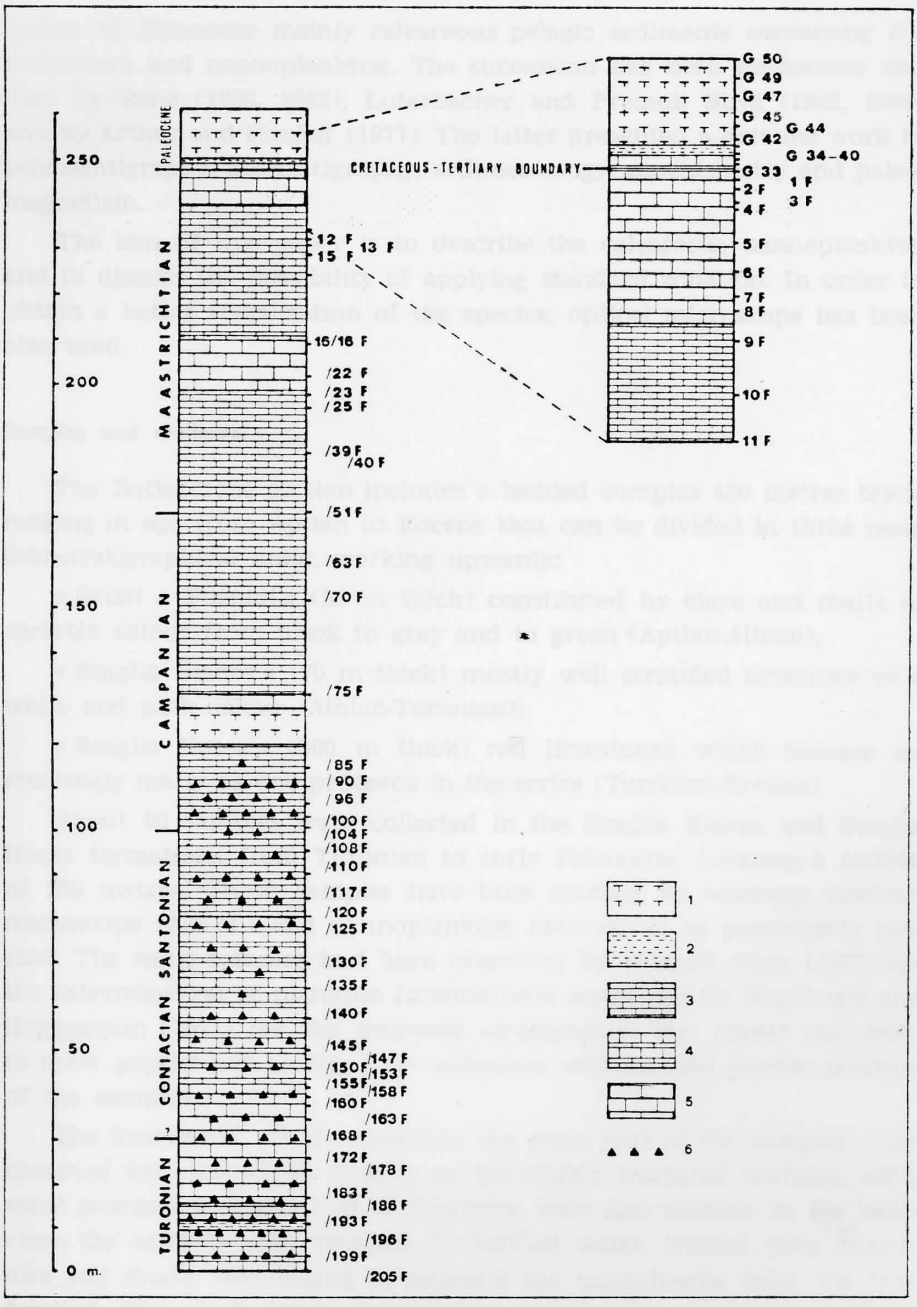


Fig. 1 - Generalized stratigraphic section, Gubbio (after Arthur & Fischer, 1977) and position of the samples. Symbols: 1. marlstone and shaly marlstone; 2. shale; 3. thin-bedded limestone (< 25 cm beds); 4. variably bedded limestone; 5. thick-bedded limestone (> 25 cm beds); 6. chert; density of symbols represents abundance.

Aptian to Paleocene mainly calcareous pelagic sediments containing Foraminifera and nannoplankton. The succession has been extensively studied by Renz (1936, 1952), Luterbacher and Premoli Silva (1962, 1964) and by Arthur and Fischer (1977). The latter presented a detailed work in lithostratigraphy, biostratigraphy, sedimentology, geochemistry and paleomagnetism.

The aim of this paper is to describe the calcareous nannoplankton and to discuss the possibility of applying standard zonation. In order to obtain a better visualization of the species, optical microscope has been also used.

Samples and methods.

The Bottaccione section includes a bedded complex 400 metres thick, ranging in age from Aptian to Eocene that can be divided in three main lithostratigraphical units, working upwards:

« Scisti a Fucoidi » (50 m thick) constituted by clays and marls of variable colour from black to grey and to green (Aptian-Albian);

« Scaglia Bianca » (70 m thick) mostly well stratified limestone of a white and pink colour (Albian-Turonian);

« Scaglia Rossa » (300 m thick) red limestones which become increasingly marly as one proceeds in the series (Turonian-Eocene).

About 80 samples were collected in the Scaglia Bianca and Scaglia Rossa formations from Turonian to early Paleocene, covering a section of 250 metres. These samples have been studied by scanning electron microscope (S.E.M.) and nannoplankton resulted to be persistently present. The same samples had been examined by Premoli Silva (1977) for the determination of plankton foraminiferal zones and by Napoleone and Roggenthen (1977) for the magnetic stratigraphy. The reader can refer to these papers and to Fig. 1 for columnar sections and precise position of the samples.

The limestones, which constitute the main part of the samples, were observed with the S.E.M. directly on the freshly fractured surfaces, while some powders of marls and of limestone were also studied. In the latter cases the samples were crushed in distilled water, treated with ultrasonies and finally centrifuged to separate the nannofossils from the finer fraction. The marly levels appeared to contain the smallest quantity of nannoplankton and in such a state of conservation that made determination extremely arduous.

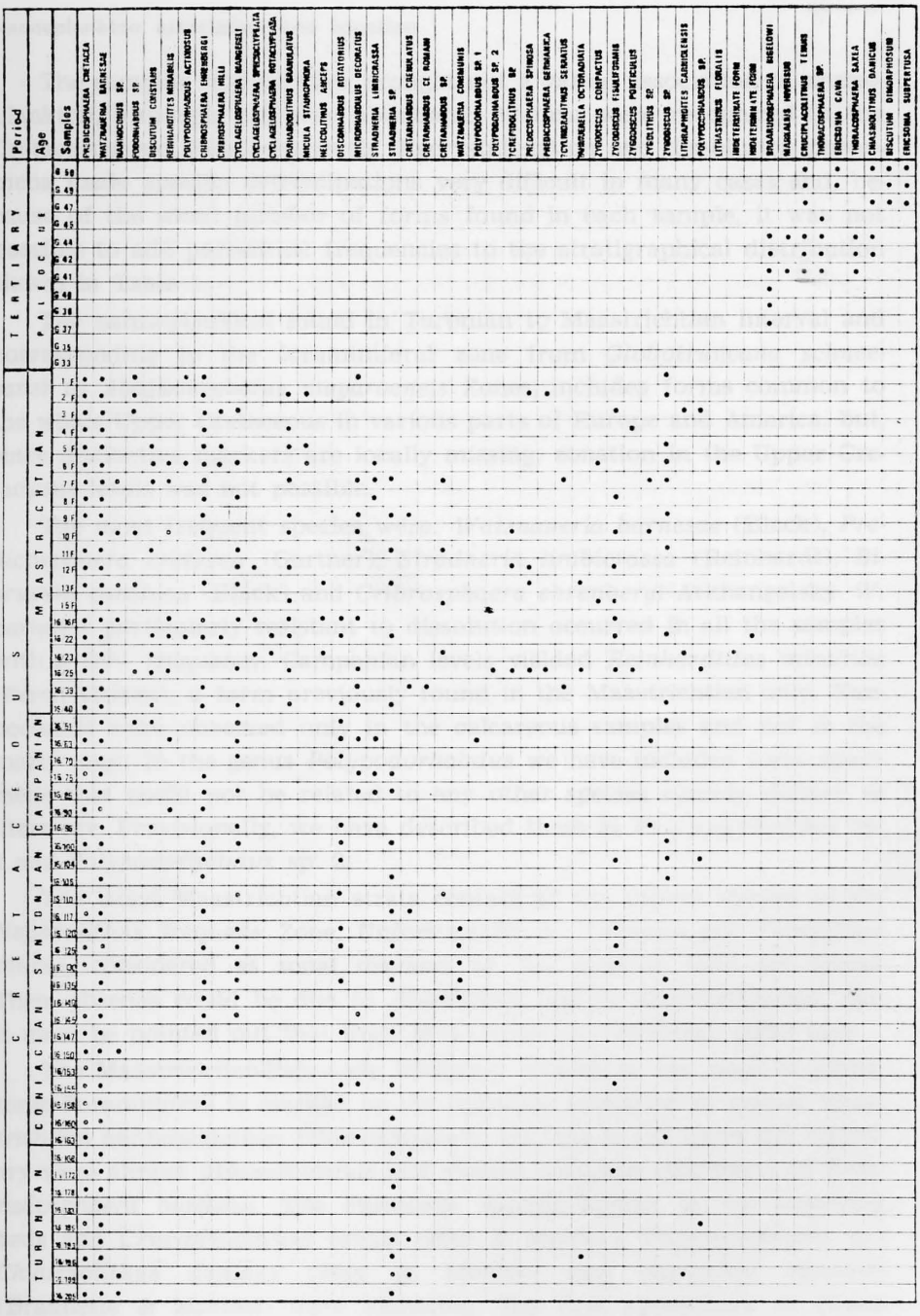


Table 1 - Distribution of Coccolith species from Turonian to Early Paleocene in the Bottaccione series.

Nannoplankton association and zonation.

The samples studied have brought out a varied association of nannoplankton, although not very abundant: 50 taxa were recognized in the Cretaceous and Paleocene levels. Recrystallization and dissolution phenomena made specific determinations very difficult in many cases and, because of the small number of forms found in each sample, it was not possible to add percentual frequencies to the stratigraphical distribution shown in Table 1.

The nannoplankton found in Turonian to Maastrichtian interval and corresponding to the foraminiferal zone from *Globotruncana schneegansi to Abathomphalus mayaroensis* Zones, includes forms common to the whole Upper Cretaceous in various parts of Europe and America, but, since distinctive markers are locally missing, zonation in the Upper Cretaceous levels was not possible.

The most frequent species were: *Watznaueria barnesae* (Black), *Predicosphaera cretacea* (Gartner), *Stradneria limbicrassa* (Reinhardt), *Biscutum constans* (Black) and *Cribrosphaera ehrenbergi* Arkhangelsky. *W. barnesae* particularly resistant to dissolution occurred in all the samples with a 50% frequency. Campanian levels yielded *Reinhardtites mirabilis* (Perch-Nielsen), a form previously found in the Maastrichtian only. Nannoconids were observed only in the calcareous samples and not in the marly ones. In the genus *Polypodorhabdus* we have included some specimens that could not be related to any other species already defined in literature. Provisionally, we have described them as *Polypodorhabdus* sp. 1 and *Polypodorhabdus* sp. 2.

The latest Maastrichtian strata contain all the typical species of the *Nephrolithus frequens* Zone. Unfortunately *N. frequens* and *Tetralithus murus*, considered as zonal markers of this interval were not found. Their absence could be due to dissolution and/or recrystallization, but it must be pointed out that their occurrences are generally quite rare.

The Maastrichtian-Paleocene boundary located on the basis of planktonic Foraminifera is marked by the complete extinction of typical Maastrichtian nannoplankton. Nine samples in the first 40 cm above the boundary were almost unfossiliferous and yielded only few specimens of *Braarudosphaera bigelowi*. The Paleocene species appear in the overlying beds and *Cruciplacolithus tenuis* (Hay & Mohler), *Thoracosphaera* sp., *Chiasmolithus danicus* (Hay & Mohler) and *Markalius inversus* (Bramlette & Martini) were identified. The first appearance of *Cruciplacolithus tenuis* defines the base of the zone named for it and the ex-

tinction level of this species is younger than the section studied. The co-occurrence of *Biscutum* ? *dimorphosum* (Perch-Nielsen) and *Ericsonia subpertusa* (Hay & Mohler) from 3 m above the Maastrichtian-Paleocene boundary up to the top of section allows the recognition of the *B. dimorphosum* and *E. subpertusa* subzone.

Some problems arise for the zonation of the 40 cm interval at the base of the Paleocene beds. As already mentioned, the absence of significant forms prevents any safe attribution. Beneath the *Cruciplacolithus tenuis* Zone, Martini (1971) established the *Markalius inversus* Zone. On the validity of this zone there is actually a controversy (Bukry, 1973), on whether it should represent an impoverishment of the *Cruciplacolithus tenuis* Zone or a distinct biostratigraphic unit.

In the Bottaccione section no *Markalius inversus* in the first Paleocene levels has been found and the base of the *Cruciplacolithus tenuis* Zone correlates with the boundary between « *Globigerina* » *eugubina* and « *Globorotalia* » *pseudobulloides* Zones.

It is worth to be noted that in this section after the biotic crisis at the end of Cretaceous time new species of nannoplankton appear with some delay with respects to Foraminifera. This delay could suggest ecological stresses particularly acting on nannoplankton under variable environments or, alternatively, the absence of new species could be imputed to selective solution. In the first case and with an average sedimentation rate of 2.4 m/m.y. for the Paleocene, the time gap between incoming Paleocene Foraminifera and nannoplankton would be roughly around 300.000 years.

If we examine the Cretaceous-Tertiary boundary in other areas such as Stevns Klint (Denmark) (Perch-Nielsen, 1972) and Zumaya in Spain (Percival & Fischer, 1977) we see that mixed association, that is to say joint occurrences of Cretaceous and Paleocene coccoliths, prevail. As previously mentioned, this is not the case of the Bottaccione section.

Conclusions.

In the Turonian to Paleocene portion of the Bottaccione section 50 nannoplankton taxa were recognized in a fair to poor state of preservation. In spite of the notable amount of species, correlation with conventional zones was possible only for *Cruciplacolithus tenuis* Zone and, within the latter, for the *B. dimorphosum* and *E. subpertusa* subzone (Lower Paleocene).

The absence of many zone markers can be accounted for by a selective

solution or by ecological control. Thus, for the first 40 cm above the Cretaceous - Tertiary boundary which are almost barren of nannoplankton, with the exception of *Braarudosphaera bigelowi*, a very long-lived species, we could assume either a very strong recrystallization or an ecological instability. In the latter case nannoplankton community recovered from the biotic crisis later than Foraminifera. In fact, new species of Foraminifera, although of tiny size, occur since the very base of the Paleocene, which is locally devoid of nannoplankton.

ACKNOWLEDGEMENT.

I would like to give warmest thanks to Prof. Denise Noël for having welcomed me to the Laboratoire de Géologie du Muséum d'Histoire Naturelle in Paris, and for having encouraged my work and for the critical appraisal of the manuscript. My thanks also to Mr. Bossy for the help given to me while using the scanning electron microscope, and to Miss M. Destarac for the photographs. I would also like to thank Miss C. Weber from the Laboratoire de Paléontologie du Muséum d'Histoire Naturelle in Paris for kindly letting me use the electron microscope. To Prof. Camilla Pirini Radrizzani from the University of Florence, I would like to thank for the help she gave me in the development of this work and for a critical reading of the manuscript. Most sincere thanks also to the SEM technicians L. Giannini and F. Cozzini from the University of Florence and A. Rizzi from the University of Milan.

Systematic descriptions

The classification followed in this paper is based on those proposed by Noël (1965, 1970) and by Perch-Nielsen (1968). In the description of the species not all synonymies have been given, but only the most important sources have been cited.

No photographs have been supplied for some of the most common and most widely known forms.

Hereby are listed in alphabetical order the species of nannofossils identified in the Bottaccione sequence from Turonian to Paleocene levels.

? *Ahmuellerella octoradiata* (Gorka, 1957) Reinhardt, 1964
Biscutum constans (Gorka, 1957) Black, 1959
Biscutum ? *dimorphosum* Perch-Nielsen, 1969
Braarudosphaera bigelowi (Gran & Braarud, 1935) Deflandre, 1947
Chiasmolithus danicus (Brotzen, 1959) Hay & Mohler, 1967
Crepidolithus sp.
Cretarhabdus crenulatus Bramlette & Martini, 1964
Cretarhabdus cf. *romani* (Gorka) Maresh, 1966
Cretarhabdus sp.
Cribrosphaera ehrenbergi Arkhangelsky, 1912
Cribrosphaera hilli (Black, 1964) Reinhardt, 1967
Cruciplacolithus tenuis (Stradner, 1961) Hay & Mohler, 1967
Cyclagelosphaera margereli Noël, 1965
Cyclagelosphaera rotaclypeata Bukry, 1969
Cyclagelosphaera specioclypeata Bukry, 1969

? *Cylindralithus serratus* Bramlette & Martini, 1964
Discorhabdus rotatorius (Bukry, 1969) Thierstein, 1973
Ericsonia cava (Hay & Mohler, 1967)
Ericsonia subpertusa Hay & Mohler, 1967
Helicolithus anceps (Gorka, 1957) Noël, 1970
Lithastrinus floralis Stradner, 1962
Lithraphidites carniolensis Deflandre, 1963
Markalius inversus (Deflandre, 1954) Bramlette & Martini, 1964
Microrhabdulus decoratus Deflandre, 1959
Micula staurophora decussata (Vekshina) Noël, 1970
Nannoconus sp.
Parhabdolithus granulatus Stover, 1966
Podorhabdus sp.
Polypodorhabdus actinosus (Stover) Perch-Nielsen, 1968
Polypodorhabdus sp.
Predicosphaera cretacea (Arkhangelsky) Gartner, 1968
Predicosphaera spinosa (Bramlette & Martini) Gartner, 1968
Predicosphaera cf. *germanica* Bukry, 1969
Reinhardtites mirabilis Perch-Nielsen, 1968
Stradneria limbicrassa Reinhardt, 1964
Stradneria sp.
Thoracosphaera saxea Stradner, 1961
Thoracosphaera sp.
Watznaueria barnesae (Black, 1959) Perch-Nielsen, 1968
Watznaueria communis Reinhardt, 1964
Zygodiscus compactus Bukry, 1969
Zygodiscus fibuliformis (Reinhardt, 1966) Bukry, 1969
Zygodiscus ponticulus (Deflandre, 1954) Reinhardt, 1967
Zygodiscus sp.
Zygolithus sp.

Class Coccolithophyceae Rothmaler, 1951
Order Heliolithae Deflandre, 1952
Family *Zygolithaceae* Noël, 1965 emend. 1970
Genus *Zygolithus* Kamptner, 1956

Zygolithus sp.

Remarks. These forms differ from *Glaucolithus* Reinhardt on account of the disposition of the elements. *Zygolithus* has the elements of the rim inclined while the elements of *Glaucolithus* were disposed radially.

Occurrence. In the Bottaccione series it was found from Campanian to Maastrichtian.

Genus *Ahmuellerella* Reinhardt, 1964

? **Ahmuellerella octoradiata** (Gorka, 1957) Reinhardt, 1964

1957 *Discolithus octoradiatus* Gorka, p. 259, pl. 4, fig. 10.
1964 *Ahmuellerella limbitenuis* Reinhardt, p. 751, pl. 2, fig. 6.
1967 *Ahmuellerella octoradiata* - Reinhardt & Gorka, p. 242, pl. 31, fig. 1-4; pl. 32, fig. 2.

DESCRIPTION. Elliptical coccolith formed by: 1) a marginal rim of two series of overlapping elements. The first series is formed by about 34 calcite elements tilted and overlapping each other in the clockwise direction; 2) a rather large central area, very badly preserved, containing various crystals. The five central perforations cannot be distinguished so that a precise genus definition is rather incertain.

OCCURRENCE. Known range from Upper Turonian to Maastrichtian. Found in Maastrichtian samples (in this paper).

Genus *Helicolithus* Noël, 1970

Helicolithus anceps (Gorka, 1957) Noël, 1970

1957 *Discolithus anceps* Gorka, pp. 252-275, pl. 3, fig. 4.
1965 *Eiffelithus turriseiffeli inturratus* Reinhardt, pl. 2, fig. 3.
1968 *Glaucolithus fessus* - Perch-Nielsen, p. 34, pl. 4, fig. 20-23.
1970 *Helicolithus anceps* - Noël, p. 41, fig. 6, pl. 8, fig. 1-5; pl. 9, fig. 1, 2.

DESCRIPTION. Elliptical coccolith formed by a marginal rim composed by many closely sloping and overlapping elements. From this external rim 8 large crystals develop which define a small central area composed by four small crystals.

REMARKS. Only few specimens were found.

OCCURRENCE. Known range: Cenomanian - Maastrichtian. In the Bottaccione series it was found from Campanian to Maastrichtian.

Genus *Parhabdolithus* Deflandre, 1952

Parhabdolithus granulatus Stover, 1966

Pl. 43, fig. 12; Pl. 44, fig. 9

1966 *Parhabdolithus granulatus* Stover, p. 144, pl. 6, fig. 11-15; pl. 9, fig. 17.
1969 *Parhabdolithus granulatus* - Bukry, p. 53, pl. 30, fig. 4-7.

DESCRIPTION. Elliptical coccolith formed by a cycle of numerous elements and by a large central area filled with a mosaic of polygonal elements.

OCCURRENCE. Known range from Neocomian to Campanian, but in the Bottaccione series most frequently it was found in Maastrichtian samples.

Genus *Zygodiscus* Bramlette & Sullivan, 1961

Zygodiscus compactus Bukry, 1969

1969 *Zygodiscus compactus* Bukry, p. 59, pl. 34, fig. 1, 2.
1971 *Zygolithus compactus* - Noël, p. 26, fig. 2, 3; pl. 2, fig. 2-8; pl. 3, fig. 1-3.

DESCRIPTION. Elliptical coccolith formed by a cycle of about 19 elements joined in a clockwise direction. The central area is characterized by a central bridge formed by two or more elements, which are mostly recrystallized.

OCCURRENCE. Mentioned in literature in the Coniacian-Campanian; it has also been found in our Maastrichtian samples.

Zygodiscus fibuliformis (Reinhardt, 1966) Bukry, 1969

Pl. 41, fig. 3

1966 *Glaucolithus fibuliformis* Reinhardt, p. 41, pl. 9, fig. 1-3; pl. 22, fig. 22.
1968 *Zygodiscus nanus* Gartner, p. 33, pl. 14, fig. 17; pl. 18, fig. 12-14.
1969 *Zygodiscus fibuliformis* - Bukry, p. 59, pl. 34, fig. 9, 10.

DESCRIPTION. Only the proximal side has been recognized. Elliptical coccolith formed by a marginal rim of 35 elements slightly joined in a clockwise direction. The proximal shield is slightly smaller and it contains a similar number of elements. The central area is not very large and it is characterized by a bridge formed by many small crystals.

OCCURRENCE. Known range: Turonian-Maastrichtian. Found in the Bottaccione series from Turonian to Maastrichtian.

Zygodiscus ponticulus (Deflandre, 1954) Reinhardt, 1967

Pl. 41, fig. 2, 6

1954 *Discolithus ponticulus* Deflandre in Deflandre & Fert, p. 144, pl. 13, fig. 18, 19; text-fig. 32, 54.
1967 *Zygodiscus ponticulus* - Reinhardt, p. 40, pl. 10, fig. 3.

REMARKS. Few specimens were found in Maastrichtian and in Upper Cenomanian.

OCCURRENCE. Known range Senonian.

Zygodiscus sp.

Pl. 41, fig. 1, 4, 5

DESCRIPTION. Elliptical coccolith formed by a marginal rim of radial elements. The central area is large and frequently occupied by crystals of secondary calcite.

Genus *Reinhardtites* Perch-Nielsen, 1968

Reinhardtites mirabilis Perch-Nielsen, 1968

1968 *Reinhardtites mirabilis* Perch-Nielsen, pp. 40-41, pl. 7, fig. 1; text-fig. 17.

DESCRIPTION. Elliptical coccolith formed by a marginal rim of overlapping elements. A second cycle of elements defines the central area which is quite large and filled by granular crystals disposed along 8 segments.

REMARKS. This species was found in the Bottaccione series from Campanian to Maastrichtian. Stratigraphically the appearance was only known from Maastrichtian.

Family *Podorhabdaceae* Noël, 1965

Genus *Stradneria* Reinhardt, 1964

Stradneria limbicrassa Reinhardtt, 1964

Pl. 43, fig. 10

1964 *Stradneria limbicrassa* Reinhardt, p. 752, fig. 3, pl. 1.
1966 *Cretarhabdus crenulatus* - Reinhardt, p. 25, pl. 7, fig. 1, 2 (no pl. 14, fig. 2).
1967 *Cretarhabdus conicus* - Reinhardt, p. 169, fig. 5, 7/7, 8.
1968 *Stradneria limbicrassa* - Perch-Nielsen, p. 152, pl. 10, fig. 7.
1970 *Stradneria limbicrassa* - Noël, p. 54, pl. 17, fig. 1 a-c.

DESCRIPTION. Elliptical coccolith formed by a marginal rim composed by two concentric cycles. The central area is conical and defined by a regular cycle of rhombohedral elements together with some small crystals placed in groups along the axes of the ellypse.

OCCURRENCE. Known range from Campanian to Maastrichtian. In the Bottaccione series it was found from Campanian to Maastrichtian.

Stradneria sp.

Pl. 42, fig. 9, 11; Pl. 44, fig. 3

DESCRIPTION. Elliptical coccolith formed by two cycles of elements and a central area quite large. Many specimens appear without the external cycle and have rounded margin.

REMARKS. Many specimens have been found in the whole Bottaccione series.

Genus *Cretarhabdus* Bramlette & Martini, 1964

Cretarhabdus crenulatus Bramlette & Martini, 1964

Pl. 42, fig. 7; Pl. 43, fig. 11

1964 *Cretarhabdus crenulatus* Bramlette & Martini, p. 300, pl. 2, fig. 21-24.
1970 *Cretarhabdus surirellus* - Reinhardt, p. 50, pl. 1, fig. 6-8; pl. 2, fig. 1-6.
1973 *Cretarhabdus crenulatus* - Roth, p. 724, pl. 19, fig. 6.

DESCRIPTION. Elliptical coccolith formed by two overlapping series of elements radially arranged and forming the marginal rim. The distal series is formed by two concentric cycles of elements. The two cycles are often fused together giving the appearance of a smooth marginal rim. The central area is large and formed by numerous small crystals.

OCCURRENCE. Known range from Santonian to Maastrichtian. In the Bottaccione series it was found from Turonian to Maastrichtian.

Cretarhabdus cf. **romani** (Gorka) Maresh, 1966

Pl. 42, fig. 9

DESCRIPTION. Elliptical coccolith formed by two series of elements forming a large central area made of many elements deriving from the elements of the marginal rim. In fig. 9 the central area is filled by crystals of secondary calcite.

OCCURRENCE. Known range from Aptian to Maastrichtian. In the Bottaccione series it was found in Campanian samples.

Cretarhabdus sp.

Pl. 42, fig. 6

DESCRIPTION. Elliptical coccolith formed by two series of overlapping polygonal elements and out of line with each other. The central area is rather small and filled by long crystals forming a central stem. In the Bottaccione series these specimens were found from Coniacian to Maastrichtian.

Genus *Predicosphaera* Vekshina, 1959

Predicosphaera cretacea (Arkhangelsky) Gartner, 1968

Pl. 40, fig. 1, 2; Pl. 43, fig. 7, 8, 9; Pl. 45, fig. 8, 10

1912 *Coccolithophora cretacea* Arkhangelsky, p. 410, pl. 6, fig. 12, 13.
1954 *Rhabdolithus intercisus* - Deflandre & Fert, p. 159, pl. 13, fig. 12, 13; text-fig. 91, 92.
1957 *Discolithus cretaceus* - Gorka, p. 274, pl. 11, fig. 11.
1959 *Predicosphaera decorata* Vekshina, p. 73, pl. 1, fig. 8, 9; pl. 2, fig. 13 a.

1964 *Deflandrius intercisus* - Bramlette & Martini, p. 301, pl. 2, fig. 13, 14-16.
1968 *Predicosphaera cretacea* - Gartner, p. 19, pl. 2, fig. 10-14; pl. 3, fig. 8; pl. 4, fig. 19-24; pl. 6, fig. 4-15 pl. 9, fig. 1-4; pl. 12, fig. 1; pl. 14, fig. 20-22; pl. 18, fig. 8; pl. 22, fig. 1-3; pl. 23, fig. 4-6; pl. 25, fig. 12-14; pl. 26, fig. 2.

DESCRIPTION. Subcircular coccolith formed by a marginal rim of 16 elements which are large and closely joined into a radial arrangement. The central area is rather wide and shows four ridges forming a cross; at the summit of the ridges there is a very characteristic stem formed by four long calcite crystals.

OCCURRENCE. Known range from Albian to Maastrichtian; it was found from Turonian to Maastrichtian (in this paper).

Predicosphaera spinosa (Bramlette & Martini) Gartner, 1968

Pl. 40, fig. 3

1964 *Deflandrius spinosus* Bramlette & Martini, p. 301, pl. 2, fig. 17-20.
1968 *Predicosphaera spinosa* - Gartner, p. 20, pl. 2, fig. 15, 16; pl. 3, fig. 9, 10; pl. 5, fig. 7-9; pl. 6, fig. 16; pl. 11, fig. 17.

DESCRIPTION. A subcircular coccolith, with a marginal rim composed by 16 rectangular calcite elements. The central area which is quite large contains four ridges in the shape of a cross joined in the center and forming a stem of four calcite crystals. *P. spinosa* differs from *P. cretacea* due to the shape of the 16 elements forming the marginal rim, which in the former is composed of subrectangular crystals and in the latter of piano-key crystals.

OCCURRENCE. Known range from Coniacian to Maastrichtian; it was found from Campanian to Maastrichtian in the Bottaccione series.

Predicosphaera cf. **germanica** Bukry, 1969

DESCRIPTION. Elliptical coccolith formed by a marginal rim of 16 elements. The sutures among the elements are radially arranged and the central area is defined by an internal cycle composed of rectangular calcite elements arranged around the central area and slightly overlapping each other. Four badly preserved ridges can be partially seen forming a cross in the central area.

OCCURRENCE. Known range Campanian; found in the Bottaccione series in Campanian.

Genus *Podorhabdus* Noël, 1965

Podorhabdus sp.

Pl. 41, fig. 10; Pl. 44, fig. 1; Pl. 45, fig. 12

DESCRIPTION. Elliptical coccolith made by a marginal rim with radial elements. The central area is quite large and is defined by a cycle of small square elements. These specimens are rare and badly preserved.

REMARKS. We have also found a specimen in a Maastrichtian sample (Pl. 44, fig. 1) that could be referred to genus *Podorhabdus* but it is impossible to compare with other species already described in literature. It is a circular coccolith formed by a marginal rim of 18-20 square large calcite elements which are joined and radially ordered. The central area is quite large and is defined by a cycle of smaller square elements. Dimension 6,3 μ × 5,5 μ.

OCCURRENCE. Found only in Maastrichtian samples.

Genus *Polypodorhabdus* Noël, 1965

Polypodorhabdus actinosus (Stover) Perch-Nielsen, 1968

Pl. 42, fig. 4, 5, 8

1966 *Coccolithus actinosus* Stover, p. 138, pl. 1, fig. 15, 16; pl. 8, fig. 7.
1968 *Polypodorhabdus actinosus* - Perch-Nielsen, p. 50, pl. 10, fig. 1-6; text-fig. 19.

DESCRIPTION. Elliptical coccolith formed by a marginal rim of about 26 elements slightly overlapping in an anticlockwise direction. The central area is rather large and is characterized by radially arranged crystals; the interior crystals are half number compared to the elements of the marginal rim.

OCCURRENCE. Known range Maastrichtian. In the Bottaccione series it was found in Maastrichtian samples.

Polypodorhabdus sp.

Pl. 42, fig. 3, 10; Pl. 44, fig. 10, 11

DESCRIPTION. Elliptical or subcircular coccoliths characterized by a marginal rim of about 20 radial calcite elements. The central area is not quite large and filled by numerous crystals.

REMARKS. In the Maastrichtian and Campanian samples have been found two forms that could be related to this genus.

Polypodorhabdus sp. 1 (Pl. 44, fig. 10): elliptical coccolith formed by

a marginal rim composed of 14 thick elements radially arranged and slightly overlapping in the clockwise direction. The central area is rather narrow and is characterized by eight long crystals which depart from the marginal rim and joining in the middle forming a central bar. Size: max. diameter 7,5 μ, min. diameter 5,6 μ. Only one specimen was found in the Campanian.

Polypodorhabdus sp. 2 (Pl. 42, fig. 10; Pl. 44, fig. 11): elliptical coccolith formed by a marginal rim composed by about 20 elements. Only the distal side was known. The central area is rather small and is composed by eight elongate elements which join in the middle. This form is quite similar to *Polypodorhabdus* sp. 1 above described, but it differs for having a larger number of rim elements. Size: max. diameter 8 μ, min. diameter 6,3 μ. Only few specimens was found in Maastrichtian samples.

Genus *Cribrosphaera* Arkhangelsky, 1912

Cribrosphaera ehrenbergi Arkhangelsky, 1912

Pl. 40, fig. 4-8; Pl. 43, fig. 1-6

1912 *Cribrosphaera ehrenbergi* Arkhangelsky, p. 412, pl. 6, fig. 19, 20.
1954 *Cribrosphaera erhenbergi* - Deflandre & Fert, p. 155.
1964 *Favocentrum laughtoni* Black, p. 313, pl. 53, fig. 1, 2.
1964 *Cribrosphaerella romanica* Reinhardt, p. 28, pl. 22, fig. 13, 26; text-fig. 8.
1968 *Cribrosphaerella ehrenbergi* - Perch-Nielsen, p. 570, fig. 21, pl. 17, fig. 1, 8.
1970 *Cribrosphaera ehrenbergi* - Noël, p. 70, fig. 17, pl. 18, fig. 4-7; pl. 19, fig. 1 a-c, 2, 3, 4; pl. 20, fig. 3.
1973 *Cribrosphaera ehrenbergi* - Roth, p. 725, pl. 20, fig. 3.

DESCRIPTION. Elliptical coccolith formed by a marginal rim of about 17-25 calcite rectangular elements. The central area is quite large, convex and made of small crystals arranged so as to form a bee-hive structure. Between the marginal rim and the central area we can found a second cycle of elements radially arranged.

REMARKS. Various specimens were found and they resembled to *C. ehrenbergi* even if they showed some slightly differences. These specimens (Pl. 43, fig. 1, 2, 3, 6 and Pl. 40, fig. 6) are formed by a marginal rim of about 14-21 elements slightly overlapping. The central area is not quite large and it is often filled with big crystals of secondary calcite. On the proximal side the central area is defined by a second cycle of little elements radially arranged (Pl. 43, fig. 1, 2, 6 and Pl. 40, fig. 6). On distal side (Pl. 40, fig. 5, 6 and Pl. 43, fig. 3) it seems that the second cycle of little elements is missing.

OCCURRENCE. Known range from Santonian to Maastrichtian. In the Bottaccione series it was found from Campanian to Maastrichtian.

Cribrosphaera hilli (Black, 1964) Reinhardt, 1967

1964 *Favocentrum hilli* Black, p. 314, pl. 53, fig. 3, 4.
1968 ? *Cribrosphaerella hilli* - Perch-Nielsen, p. 55, fig. 22, pl. 12, fig. 5, 6.
1970 *Cribrosphaera* ? cf. *Cribrosphaera hilli* - Noël, p. 73, pl. 21, fig. 1 a-b, 2 a-b, 3 a-b, 4, 5.

DESCRIPTION. Elliptical coccolith formed on the distal side by one series of calcite elements. The most external series is made of subrectangular crystals on which a set of inner scales is arranged, defining the central area. The central area is formed by a series of small equal size desordered crystals.

OCCURRENCE. Known range from Campanian to Maastrichtian. Found in the Bottaccione series in Maastrichtian samples.

Family *Stephanolithionaceae* Black, 1968
Genus *Lithastrinus* Stradner, 1962

Lithastrinus floralis Stradner, 1962

1962 *Lithastrinus floralis* Stradner, p. 370, pl. 2, fig. 6-11.
1968 *Polycyclolithus brotzeni* Forchheimer, p. 41, pl. 6, fig. 6, 7.
1975 *Polycyclolithus brotzeni* - Monechi & Pirini Radrizzani, p. 34, pl. 6, fig. 2.

DESCRIPTION. This species is characterized by 9 petaloid elements; the central area is open. Many specimens have undergone a recrystallization.

OCCURRENCE. Known range from Albian to Upper Senonian; found in our Maastrichtian samples.

Genus *Cylindralithus* Bramlette & Martini, 1964

? **Cylindralithus serratus** Bramlette & Martini, 1964

1964 *Cylindralithus serratus* Bramlette & Martini, p. 310, pl. 5, fig. 18-20.

DESCRIPTION. Cylindrical coccolith formed by long vertical elements. The upper side of the coccolith is formed by a rim of large calcareous elements which are radially arranged. The central area is rather small and is frequently occupied by a crystal of secondary calcite.

REMARKS. The found forms are in an extremely bad state of preservation.

OCCURRENCE. Known range from Campanian to Maastrichtian. In the Bottaccione series it was found in Campanian and Maastrichtian samples.

Genus *Crepidolithus* Noël, 1965

Crepidolithus sp.

DESCRIPTION. A robust coccolith formed by overlapping vertical or subvertical calcite elements. There is no marginal rim and the central area is rather wide.

REMARKS. The central area is not visible, but some recrystallization occur. Few specimens has been found.

Family *Coccolithaceae* Kamptner, 1928

Genus *Discorhabdus* Noël, 1965

Discorhabdus rotatorius (Bukry, 1969) Thierstein, 1973

Pl. 45, fig. 8-11

1968 *Biscutum testudinarium* - Stradner, Adamiker & Maresh, p. 29, pl. 11, 12.
1969 *Bidiscus rotatorius* Bukry, p. 27, pl. 27, fig. 5-9.
1973 *Discorhabdus rotatorius* - Thierstein, p. 42, pl. 5, fig. 13-16.

DESCRIPTION. Small circular coccolith formed by two overlapping closely joined shields. The distal shield is formed by 14 radially arranged elements. The central area is very small.

OCCURRENCE. Known range from Albian to Campanian. We have also found some specimens in the Maastrichtian samples.

Genus *Watznaueria* Reinhardt, 1964

Watznaueria barnaese (Black, 1959) Perch-Nielsen, 1968

Pl. 40, fig. 9; Pl. 41, fig. 7, 11, 12; Pl. 42, fig. 12; Pl. 45, fig. 1-3, 5-8, 10, 12

1959 *Tremalithus barnesae* Black in Black & Barnes, p. 325, pl. 9, fig. 1, 2.
1964 *Watznaueria angustoralis* Reinhardt, p. 753, pl. 2, fig. 2; text-fig. 4.
1968 *Watznaueria barnesae* - Perch-Nielsen, pp. 69-70, pl. 22, fig. 1-7; pl. 23, fig. 1, 4, 5, 16; text-fig. 32.

DESCRIPTION. Elliptical coccolith formed by two shields. The distal shield is formed by two overlapping cycles of which the exterior one is composed by 25 elements, while the interior one, which defines the central area, is composed of 18-20 elements.

REMARKS. This form is the most common one in the whole series, but it has not stratigraphic value as it does not vary throughout Cretaceous.

OCCURRENCE. Known range Cretaceous. In the Bottaccione series it was found from Turonian to Maastrichtian.

Watznaueria communis Reinhardt, 1964

1964 *Watznaueria communis* Reinhardt, p. 756, pl. 2, fig. 5; text-fig. 6.
1971 *Watznaueria communis* - Reinhardt, p. 34, text-fig. 38.
1973 *Watznaueria communis* - Thierstein, p. 43, pl. 6, fig. 17.

DESCRIPTION. Elliptical coccolith formed by two shields: the distal shield is composed by two cycles of elements. The central area is quite large compared to the one of *W. barnesae*.

OCCURRENCE. Known range from Oxfordian to Campanian. In the Bottaccione series it was found in Coniacian-Campanian samples.

Genus *Markalius* Bramlette & Martini, 1964

Markalius inversus (Deflandre, 1954) Bramlette & Martini, 1964

Pl. 46, fig. 9

1954 *Cyclococcolithus leptoporus* var. *inversus* - Deflandre & Fert, p. 150, pl. 9, fig 4, 5.
1963 *Cyclococcolithus astroporus* Stradner, p. 75, pl. 9, fig. 5-7; fig. 3 (a, b).
1964 *Markalius inversus* - Bramlette & Martini, p. 302, pl. 2, fig. 4-9; pl. 7, fig. 2 a-b.
1967 *Cyclococcolithus inversus* - Hay & Mohler, p. 389, pl. 7, fig. 2.

REMARKS. This form is not found in the first Paleocene strata, but appears together with *C. tenuis*.

Genus *Biscutum* Black, 1959

Biscutum constans (Gorka, 1957) Black, 1959

Pl. 42, fig. 1, 2; Pl. 44, fig. 12

1957 *Discolithus constans* Gorka, p. 279, pl. 4, fig. 7.
1959 *Biscutum testudinarium* Black & Barnes, p. 325, pl. 10, fig. 1.
1959 *Biscutum castrorum* Black & Barnes, p. 326, pl. 10, fig. 2.
1967 *Biscutum constans* - Black, p. 139.

DESCRIPTION. Elliptical coccolith formed by two shields, each composed by about 18-20 elements radially arranged. The elements at the poles of the coccolith are larger than the others. The central area is formed by rather small crystals.

OCCURRENCE. Known range from Lower Berriasian to Maastrichtian. In the Bottaccione series it was found from Campanian to Maastrichtian.

Biscutum ? dimorphosum Perch-Nielsen, 1969

Pl. 46, fig. 4, 5, 7, 8, 10, 11, 12

1964 *Coccosphaera* sp. Bramlette & Martini, p. 320, pl. 1, fig. 19-20.
1964 *Coccolithus*? sp. Martini, p. 52, pl. 2, fig. 5, 6.
1969 *Biscutum*? *dimorphosum* Perch-Nielsen, text-fig. 1, pl. 32, fig. 1-3 a.

DESCRIPTION. Small subcircular coccoliths; the distal shield formed by a marginal rim containing 12 subrectangular elements radially arranged and slightly overlapping. The central area is rather large and shaped as a crater, defined by a cycle of 6-7 elements. Coccospheres are commonly found.

OCCURRENCE. Known range Danian. In the Bottaccione series it was found in Early Paleocene samples.

Genus *Cyclagelosphaera* Noël, 1965

Cyclagelosphaera margereli Noël, 1965

Pl. 41, fig. 8; Pl. 45, fig. 2, 4

1965 *Cyclagelosphaera margereli* Noël, p. 130, text-fig. 44-46; pl. 17, fig. 4-9; pl. 18, fig. 1, 2; pl. 20, fig. 2-4.
1969 *Cyclagelosphaera margereli* - Bukry, p. 29, pl. 9, fig. 5, 6.

DESCRIPTION. Circular coccolith formed by two shields: the distal shield is formed by two series of elements of which the external one is made of about 30 calcite elements arranged in a counterclockwise direction and slightly overlapping. An internal series formed by overlapping subsquare calcite elements arranged in the same direction as the outer ones, defines a rather large central area. The proximal shield is formed by only one series of calcite elements.

REMARKS. Regards to Noël's classification these species show a greater number of elements.

OCCURRENCE. Known range from Oxfordian to Santonian, found also in Campanian in the Bottaccione series.

Cyclagelosphaera rotaclypeata Bukry, 1969

1969 *Cyclagelosphaera rotaclypeata* Bukry, p. 30, pl. 9, fig. 7.

DESCRIPTION. Circular coccolith formed by 31 elements inclined counterclockwise and slightly imbricate. There is a rather large central area defined by a cycle of 31 small polygonal elements; the interior of the central area is recrystallized and no structures can be defined within it.

OCCURRENCE. Known range from Santonian to Campanian. Found in our Campanian samples.

Cyclagelosphaera specioclypeata Bukry, 1969

Pl. 41, fig. 9

1969 *Cyclagelosphaera specioclypeata* Bukry, p. 30, pl. 9, fig. 9.

DESCRIPTION. Circular coccolith; distal shield formed by about 30 elements dextrally imbricate and sloping in a clockwise direction. The central area is defined by about 15 polygonal elements. Within the central area various elements can be seen forming a star-shaped figure.

OCCURRENCE. Known range Campanian. In the Bottaccione series it was also found in Maastrichtian samples.

Genus *Cruciplacolithus* Hay & Mohler, 1967

Cruciplacolithus tenuis (Stradner 1961) Hay & Mohler, 1967

1961 *Heliorthus tenuis* Stradner, p. 84, text-fig. 64, 65.
1964 *Coccolithus helis* - Bramlette & Martini, pp. 298-299, pl. 1, fig. 10, 12; pl. 7, fig. 5 a-b, 6.
1967 *Cruciplacolithus tenuis* - Hay & Mohler, p. 1527, pl. 196, fig. 29-31; pl. 198, fig. 1-17.

DESCRIPTION. « Evenly concave elliptical placoliths with a central area having arms orientated in the major and minor axes of the ellipse » (Hay & Mohler). These forms are usually in a bad state of preservation and in some cases the inner cross cannot be distinguished.

OCCURRENCE. Known range Danian. In the Bottaccione series, it was found in the Early Paleocene.

Genus *Chiasmolithus* Hay, Mohler & Wade, 1966

Chiasmolithus danicus (Brötzen, 1959) Hay & Mohler, 1967

1959 *Cribrosphaerella danica* Brötzen, p. 25, text-fig. 9.
1964 *Coccolithus danicus* - Bramlette & Martini, p. 298, pl. 1, fig. 15, 16.
1967 *Chiasmolithus danicus* - Hay & Mohler, pp. 1526-1527, pl. 196, fig. 16, 21, 22; pl. 198, fig. 8, 12, 13.
1976 *Chiasmolithus danicus* - Haq & Lohmann, pl. 3, fig. 5-7.

REMARKS. Forms which are rarely found and often in a bad state of preservation. Many times the cross within the central area is not well defined.

OCCURRENCE. Characteristic of Danian. Found in Early Paleocene in Bottaccione series.

Family *Prinsiaceae* Hay & Mohler, 1967
Genus *Ericsonia* Black, 1964

Ericsonia subpertusa Hay & Mohler, 1967

1967 *Ericsonia subpertusa* Hay & Mohler, p. 1531, pl. 198, fig. 11, 15, 18; pl. 199, fig. 1-3.
1973 *Ericsonia subpertusa* - Roth, p. 730, pl. 12, fig. 5.

DESCRIPTION. Subcircular or circular coccolith characterized on the distal shield by a marginal rim formed by a great number of elements. The central area is very large and contains an inner cycle of elements which forms a crater-like structure.

OCCURRENCE. Known range: Danian-Paleocene. In the Bottaccione series it was found in Early Paleocene.

Ericsonia cava (Hay & Mohler, 1967)

Pl. 46, fig. 1

1967 *Coccolithus cavus* Hay & Mohler, p. 1524, pl. 196, fig. 1-3; pl. 197, fig. 5, 7.
1969 *Ericsonia cava* - Perch-Nielsen, p. 61, pl. 2, fig. 7, 8.
1973 *Coccolithus cavus* - Roth, p. 729, pl. 14, fig. 1, 2, 4, 5.

DESCRIPTION. Elliptical or subcircular coccolith characterized by two shields. The distal shield is formed by a large number of elements slightly tilted and overlapping in a clockwise direction. The central area is rather wide and contains a crater-shaped structure formed by various cycles of small elements.

OCCURRENCE. Found in Danian in Denmark and in Alabama. In the Bottaccione series it was found in the *C. tenuis* Zone at the top of the series studied.

Family *Microrhabdulaceae* Deflandre, 1959
Genus *Microrhabdulus* Deflandre, 1959

Microrhabdulus decoratus Deflandre, 1959

Pl. 44, fig. 4, 5, 6

1959 *Microrhabdulus decoratus* Deflandre, p. 141, pl. 4, fig. 1-5.
1971 *Microrhabdulus decoratus* - Manivit pp. 128-129, pl. 18, fig. 1-5.

DESCRIPTION. Calcareous rods composed by rectangular regularly arranged elements. Two transversal sections have been recognized, made of 11 calcareous elements of triangular shape radially arranged around a small central opening.

REMARKS. Strange forms have been recognized in transversal section which could be related to *Microrhabdulus decoratus* (Pl. 44, fig. 4-6).

Genus *Lithraphidites* Deflandre, 1959

Lithraphidites carniolensis Deflandre, 1963

1963 *Lithraphidites carniolensis* Deflandre, p. 3486, fig. 1-8.
1968 *Lithraphidites carniolensis* - Gartner, p. 43, pl. 5, fig. 4; pl. 6, fig. 8; pl. 8, fig. 4; pl. 10, fig. 16, 17; pl. 12, fig. 8; pl. 22, fig. 24, 25; pl. 25, fig. 9.

DESCRIPTION. Small calcareous rods with four equal keels.

REMARKS. This form is not very frequent. Known range from Berriasian to Maastrichtian. In the Bottaccione series it was only found in Maastrichtian samples.

Order ORTHOLITAE Deflandre, 1959

Family *Thoracosphaeraceae* Schiller, 1930

Genus *Thoracosphaera* Kamptner, 1927

Thoracosphaera saxea Stradner, 1961

1954 *Thoracosphaera* sp. Bramlette & Riedel, p. 393, pl. 38, fig. 5.
1961 *Thoracosphaera saxea* Stradner, p. 84, fig. 71.
1967 *Thoracosphaera saxea* - Fischer, Honjo & Garrison, p. 34, fig. 8.
1975 *Thoracosphaera saxea* - Monechi & Pirini Radrizzani, p. 36, fig. 10-12, pl. 4.

REMARKS. Found in the *Cruciplacolithus tenuis* zone, badly preserved and often in tangential section.

OCCURRENCE. Recorded from Maastrichtian of Arkansas and also from the Danian of Denmark, Alabama and France. In the Bottaccione series it was found in Early Paleocene.

Thoracosphaera sp.

Pl. 46, fig. 2

REMARKS. *Thoracosphaera* composed of from 42 to 54 little overturned corolla. These corolla are composed of 8-10 imbricate elements. This species was found in the Early Paleocene levels in the Bottaccione section, and was described as *Toweius petalosus* in an earlier paper by Monechi and Pirini (1975).

Family *Braarudosphaeraceae* Deflandre, 1947
Genus *Braarudosphaera* Deflandre, 1947

Braarudosphaera bigelowi (Gran & Braarud, 1935) Deflandre, 1947

1935 *Pontosphaera bigelowi* Gran & Braarud, p. 388, fig. 67.
1947 *Braarudosphaera bigelowi* - Deflandre, p. 439, fig. 1-5.
1975 *Braarudosphaera bigelowi* - Monechi & Pirini Radrizzani, p. 35, pl. 5, fig. 6; pl. 6, fig. 7-9.

DESCRIPTION. Pentalith formed by five equidimensional trapezoidal elements. The sutures are depressed.

REMARKS. Known range from the Jurassic to Recent. In the Bottaccione series it was only found in the first levels of Paleocene.

Incertae Sedis
Genus *Micula* Vekshina, 1959

Micula staurophora decussata (Vekshina) Noël, 1970

Pl. 40, fig. 11, 12

1955 *Discoaster staurophora* Gardet, p. 534, pl. 10, fig. 96.
1959 *Micula decussata* Vekshina, p. 71, pl. 1, fig. 6; pl. 2, fig. 11.
1963 *Micula staurophora* - Stradner, p. 13, pl. 4, fig. 12 a.
1968 *Micula staurophora* - Perch-Nielsen, p. 86, fig. 43, pl. 31, fig. 1-5.
1970 *Micula staurophora decussata* Noël, p. 98, pl. 37, fig. 1-8; pl. 38, fig. 1, 2.

DESCRIPTION. A cubic coccolith formed by various crystals. In the forms which were figured the sutures of crystals, were not often clear.

OCCURRENCE. This form appears in the Upper Turonian and becomes common in the Campanian and Maastrichtian. In Bottaccione series it was found only in Maastrichtian samples.

Genus *Nannoconus* Kamptner, 1931

Nannoconus sp.

Pl. 40, fig. 10

These forms show a long shell formed by many small crystals. An equatorial section is circular in shape with an external rim made of cuneiform crystals and a compact central area formed by an only crystal. The nannoconids are found in limestone samples but not in the marls.

OCCURRENCE. Known range from Aptian to Maastrichtian? In the Bottaccione series they were found from Turonian to Maastrichtian.

Indeterminate specimen

Pl. 44, fig. 2

REMARKS. Elliptical coccolith formed by two shields. The upper shield consists of about 22 subrectangular elements apparently radial and joined. The central area is quite large, characterized by a bridge consisting of 3 or 4 calcite crystals that grow from the elements of the marginal rim. The bridge is in the direction of the ellipse's major axis. The sign of overlapping that we can see for some elements we think is due to an overgrowth. This form could not be referred to other species already described in literature. Only one specimen has been found in Maastrichtian samples.

Indeterminate specimen

Pl. 46, fig. 6

REMARKS. This form was found in the early Paleocene levels and could not be related to any other species already described in literature.

BIBLIOGRAPHY

ARKHANGELSKY A. D. (1912) - Verkhnemelovyya otolozhhenia vostoka evropeykoy Rossii (Upper Cretaceous deposits of east European Russia). *Mat. Z. Geol. Russland*, v. 25, pp. 1-631, 10 pl., Saint-Pétersbourg.

ARTHUR M. A. & FISCHER A. G. (1977) - Upper Cretaceous-Paleocene magnetic stratigraphy at Gubbio, Italy. I. Lithostratigraphy and sedimentology. *Geol. Soc. America Bull.*, v. 88, n. 3, pp. 367-389, 11 fig., Denver.

BLACK M. (1964) - Cretaceous and Tertiary coccoliths from Atlantic seamounts. *Palaeontology*, v. 7, pp. 306-316, 4 pl., Oxford, London.

BLACK M. (1965) - Coccoliths. *Endeavour*, v. 24, n. 93, pp. 137-147, 25 fig., London.

BLACK M. (1967) - New names for some coccolith taxa. *Proc. Geol. Soc. Lond.*, n. 1640, pp. 139-145, 9 fig., London.

BLACK M. (1968) - Taxonomic problems in the study of Coccoliths. *Palaeontology*, v. 11, pp. 793-813, 11 pl., London.

BLACK M. (1971) - Coccoliths of the Speeton Clay and Sutterby Marl. *Proc. Yorkshire Geol. Soc.*, v. 38, pp. 381-424, Leeds.

BLACK M. & BARNES B. (1959) - The structure of coccoliths from the English Chalk. *Geol. Mag.*, v. 96, n. 5, pp. 321-328, 5 pl., Hertford.

BOUCHE P. M. (1962) - Nannofossiles calcaires du Lutétien du bassin de Paris. *Rev. Micropaléont.*, v. 5, n. 2, pp. 75-103, 4 pl., Paris.

BRAMLETTE M. N. & MARTINI E. (1964) - The great change in calcareous nannoplankton fossils beetwen the Maestrichtian and Danian. *Micropaleont.*, v. 10, n. 3, pp. 291-322, 7 pl., New York.

BRAMLETTE M. N. & RIEDEL W. R. (1954) - Stratigraphic values of Discoasters and some other microfossils related to recent Coccolithophores. *J. Paleont.*, v. 28, n. 4, pp. 385-403, Tulsa.

BRAMLETTE M. N. & SULLIVAN F. R. (1961) - Coccolithophorids and related Nannoplankton of the early Tertiary in California. *Micropaleont.*, v. 7, n. 2, pp. 128-188, 14 pl., New York.

BRÖTZEN F. (1959) - On *Tylocydaris* species (Echinoidea) and the stratigraphy of the Danian of Sweden, with a bibliography of the Danian and the Paleocene. *Sweridges Geol. Undersökn.*, (C), v. 54, n. 2, pp. 1-81, Stockholm.

BUKRY D. (1969) - Upper Cretaceous coccoliths from Texas and Europe. *Univ. Kansas Paleont. Contr.*, v. 51, Protista 2, pp. 1-79, 40 pl., Lawrence.

BUKRY D. (1973) - Coccolith stratigraphy, eastern equatorial Pacific. Leg 16 Deep Sea Drilling Project. In: VAN ANDEL T. H., HEATH G. R. et al., *Init. Rep. Deep Sea Drill. Proj.*, v. 16, pp. 653-700, Washington.

CARATINI C. (1963) - Etude des Coccolithes du Cénomanian supérieur et du Turonien de la région de Rouen. *Publ. Lab. Géol. Appl. Univ. Alger*, 61 pp., 5 pl., Paris (Priester).

CARATINI C. (1964) - Contribution à la nomenclature et à la systématique des Coccolithes fossiles. *C. R. Som. Soc. Géol. Fr.*, pp. 154-155, Paris.

CEPEK P. & HAY W. W. (1969) - Calcareous Nannoplankton and biostratigraphic subdivision of the Upper Cretaceous. *Trans. Gulf Coast Ass. Geol. Soc.*, v. 19, pp. 323-336, Washington.

DEFLANDRE G. (1947) - *Braarudosphaera* nov. gen., type d'une famille nouvelle de Coccolithophoridés actuels à éléments composites. *C. R. Acad. Sc.*, n. 225, pp. 439-441, Paris.

DEFLANDRE G. (1959) - Sur les Nannofossiles calcaires et leur systématique. *Rev. Micropaleont.*, v. 2, pp. 127-152, 4 pl., Paris.

DEFLANDRE G. (1963) - Sur les Microrhabdulidés, famille nouvelle des Nannofossiles calcaires. *C. R. Acad. Sc.*, v. 256, pp. 3484-3486, 3 pl., Paris.

DEFLANDRE G. & DEFLANDRE-RIGAUD M. (1967) - Fichier micropaléontologique général. Série 17. Nannofossiles calcaires. *C. N. R. S.*, v. 1-2-3-4, Paris.

DEFLANDRE G. & FERT G. (1954) - Observations sur les Coccolithophoridés actuels et fossiles en microscopie ordinaire et électronique. *Ann. Paléont.*, v. 40, pp. 115-176, 15 pl., Paris.

EDWARDS A. R. (1966) - Calcareous nannoplankton from the uppermost Cretaceous and lowermost Tertiary of the Mid-Waipara section, South Island, New Zealand. *New Zealand J. Geol. Geophys.*, v. 9, n. 4, pp. 481-490, 3 pl., Wellington.

EL-DAWOODY A. S. & BARAKAT M. G. (1973) - Nannostratigraphy of the Upper Cretaceous-Paleocene contact in Duwi Range, Quseir district, Egypt. *Riv. Ital. Paleont. Strat.*, v. 79, n. 1, pp. 103-124, 3 pl., Milano.

ELLIS C. H. & LOHMAN W. H. (1973) - *Toweius petalosus* new species, a Paleocene calcareous nannofossil from Alabama. *Tulane Studies Geol. Paleont.*, v. 10, n. 2, pp. 107-110, 1 pl., New Orleans.

FARINACCI A. (1970) - Catalogue of calcareous nannofossils, v. 1-7, Ed. Tecnoscienza, Roma.

FISCHER A., HONJO S. & GARRISON R. E. (1967) - Electron micrographs of limestone and their nannofossils. *Princeton Univ. Press*, v. 1, pp. 1-141, 94 fig., Princeton.

FORCHHEIMER S. (1968) - Die Coccolithen des Gault-Cenoman, Cenoman und Turon in der Bohrung Höllviken I, Südwest-Schewden. *Sver. Geol. Undersök.*, s. C, n. 635, pp. 1-84, 9 pl., Stockholm.

FORCHHEIMER S. (1970) - Scanning electron microscope studies of some Cenomanian coccospheres and coccoliths from Bornholm (Denmark) and Kopinsberg (Sweden). *Sver. Geol. Undersök.*, s. C., n. 647, pp. 3-43, 44 fig., Stockholm.

GAZDZICKA E. (1975) - Upper Maestrichtian coccoliths of the Lublin Upland. *Acta Paleont. Polonica*, v. 25, n. 3, pp. 407-413, 8 pl., 2 fig., 1 tab., Warszawa.

GARDET M. (1955) - Contribution à l'étude des coccolithes des terrains néogènes d'Algérie. *Publ. Serv. Carte Géol. Algérie*, v. 5, pp. 477-550, 11 pl., 1 fig., Alger.

GARTNER S. (1968) - Coccoliths and related calcareous Nannofossils from Upper Cretaceous deposits of Texas and Arkansas. *Univ. Kansas Paleont. Contr.*, v. 48, *Protista* 1, pp. 1-56, 28 pl., 5 fig., Lawrence.

GORKA H. (1957) - Les Coccolithoridés du Maestrichtien supérieur de Pologne. *Acta Paleont. Polonica*, v. 2, n. 2-3, pp. 235-284, Warszawa.

GRAN H. H. & BRAARUD T. (1935) - A quantitative study of the phytoplankton in the Bay of Fundy and the Gulf of Maine (including observations on hidrology, chemistry and turbidity). *J. Biol. Board Canada*, v. 1, pp. 279-467, Ottawa.

HAQ B. (1971) - Paleogene calcareous nannoflora. *Acta Univ. Stockholm., Stockholm Contrib. Geol.*, v. 25, n. 1-4, pp. 1-157, Stockholm.

HAQ B. (1973a) - Evolutionary trends in the Cenozoic coccolithophore genus *Helicopontosphaera. Micropaleont.*, v. 19, n. 1, pp. 32-52, 7 pl., New York.

HAQ B. (1973 b) - Transgressions, climatic change and diversity of calcareous nannoplankton. *Marine Geol.*, v. 15, pp. M25-M30, Amsterdam.

HAQ B. & LOHMANN G. P. (1976) - Early calcareous nannoplankton biogeography of the Atlantic ocean. *Marine Micropaleont.*, v. 1, n. 2, pp. 119-194, 14 pl., 19 fig., Amsterdam.

HAY W. W. & MOHLER H. P. (1967) - Calcareous nannoplankton from early Tertiary rocks at Pont-Labau, France, and Paleocene-Early Eocene correlations. *Journ. Paleont.*, v. 41, n. 6, pp. 1505-1541, 11 pl., 5 fig., Tulsa.

HONJO S. (1976) - Coccoliths: production, transportation and sedimentation. *Marine Micropaleont.*, v. 1, n. 1, pp. 65-79, 2 pl., 2 fig., Amsterdam.

KAMPTNER E. (1927) - Beitrag zur Kenntnis adriatischer Coccolithophoriden. *Arch. Protistenk.*, v. 58, pp. 173-184, 6 fig., Jena.

KAMPTNER E. (1928) - Über das System und die Phylogenie der Kalflagellaten. *Arch. Protistenk.*, v. 64, pp. 19-43, Jena.

KAMPTNER E. (1931) - *Nannoconus steimanni* nov. gen. nov. sp. ein merkwürdiges gesteinsbildendes Mikrofossil aus dem jüngeren Mesozoikum der Alpen. *Paläontol. Z.*, v. 13, pp. 288-298, Berlin.

KAMPTNER E. (1952) - Das mikroscopische Studium des Skelettes der Coccolithineen (Kalkflagellaten). Übersicht der Methoden und Ergebnisse. *Mikroscopie*, v. 7, n. 7, 8, 11, 12, pp. 232-244, pp. 375-386, Wien.

KAMPTNER E. (1956) - Zur Systematik und Nomenklatur der Coccolithineen. *Anz. Österr. Akad. Wiss., Math-Naturw.*, v. 93, n. 1, pp. 4-11, Wien.

LOEBLICH A. R. & TAPPAN H. (1966) - Annotated index and bibliography of the calcareous nannoplankton. *Phycologia*, v. 5, pp. 81-216, La Habra.

LOEBLICH A. R. & TAPPAN H. (1968) - Annotated index and bibliography of the calcareous nannoplankton. II. *Journ. Paleont.*, v. 42, n. 2, pp. 584-598, Tulsa.

LOEBLICH A. R. & TAPPAN H. (1969) - Annotated index and bibliography of the calcareous nannoplankton. III. *Journ. Paleont.*, v. 43, n. 2, pp. 568-588, Tulsa.

LOEBLICH A. R. & TAPPAN H. (1970) - Annotated index and bibliography of the calcareous nannoplankton. IV. *Journ. Paleont.*, v. 44, n. 3, pp. 558-574, Tulsa.

LOEBLICH A. R. & TAPPAN H. (1970) - Annotated index and bibliography of the calcareous nannoplankton. V. *Phycologia*, v. 9, n. 2, pp. 157-174, La Habra.

LUTERBACHER H. P. & PREMOLI SILVA I. (1962) - Note preliminaire sur une révision du profil de Gubbio, Italie. *Riv. Ital. Paleont. Strat.*, v. 68, n. 2, pp. 253-288, 15 pl., Milano.

LUTERBACHER H. P. & PREMOLI SILVA I. (1964) - Biostratigrafia del limite Cretaceo-Terziario nell'Appennino centrale. *Riv. Ital. Paleont. Strat.*, v. 70, n. 1, pp. 67-128, 6 pl., Milano.

MANIVIT H. (1968) - Nannofossiles calcaires du Turonien et du Sénonien. *Rev. Micropaléont.*, v. 10, pp. 277-286, 2 pl., Paris.

MANIVIT H. (1971) - Nannofossiles calcaires du Crétacé français (Aptien- Maestrichtien). Essai de biozonation appuyée sur les Stratotypes. *Thèse. C.N.R.S.*, pp. 1-187, 32 pl., Paris.

MARESH O. (1966) - Die Erforschung von Nannofossilien mittels des Elektronenmikroskopes in der Erdölindustrie. *Erdoel-Erdgas Zeitschr.*, v. 82, n. 9, pp. 377-384, Wien.

MARTINI E. (1958) - Discoasteriden und verwandte Formen in NW deutschen Eozän (Coccolithophorida). I. Taxinomische Untersuchungen. *Senck. Leth.*, v. 39, n. 5-6, pp. 353-388, 6 pl., 31 fig., Frankfürt-am-Main.

MARTINI E. (1964) - Die Coccolithophoriden der Dan-Scholle von Katharinenhof (Fehmarn). *N. Jb. Geol. Paläontol. Abh.*, v. 121, n. 1, pp. 47-54, Stuttgart.

MARTINI E. (1971) - Standard Tertiary and Quaternary calcareous nannoplankton zonation. *Proc. II Planktonic Conf., Rome 1970* pp. 739-785, Roma.

MARTINI E. & WORSLEY T. (1970) - Standard Neogene Calcareous Nannoplankton zonation. *Nature*, v. 225, pp. 289-290, London.

MONECHI S. & PIRINI RADRIZZANI C. (1975) - Nannoplankton from Scaglia Umbra Formation (Gubbio) at Cretaceous-Tertiary boundary. *Riv. Ital. Paleont. Strat.*, v. 81, n. 1, pp. 31-44, 3 pl., Milano.

MÜLLER C. (1970) - Nannoplankton aus dem Mittel-Oligozän Norddeutschland und Belgien. *N. Jb. Geol. Paleont.*, v. 135, pp. 82-101, 4 pl., Stuttgart.

NAPOLEONE G. & ROGGENTHEN W. (1977) - IV Upper Maastrichtian-Paleocene Magnetic Stratigraphy. In: ARTHUR M. A. et al. - *Geol. Soc. Am. Bull.*, v. 88, pp. 378-382, Denver.

NOËL D. (1965) - Coccolithes jurassiques. Essai de classification des Coccolithes Fossiles. *C.N.R.S.*, pp. 1-209, 29 pl., Paris.

NOËL D. (1969) - Structure de quelques coccolithes du Crétacé supérieur du Bassin de Paris examinés au microscope électronique. *Proc. I. Intern. Conf. on Planktonic microfossils, Genève 1967*, v. 2, pp. 475-485, 3 pl., 6 fig., Leiden (Brill éd.).

NOËL D. (1970) - Coccolithes crétacés. Le craie campanienne du Bassin de Paris. *C.N.R.S.*, pp. 1-129, 47 pl., Paris.

NOËL D. (1971) - Contribution à la révision des Coccolithes secondaires: essai d'établissement d'une hiérarchie des caractères génériques. *Proc. II Plankt. Conf., Roma 1970*, v. 2, pp. 879-898, Roma.

PERCH-NIELSEN K. (1968) - Der Feinbau und die Klassifikation der Coccolithen aus Maastrichtien von Dänemark. *K. Danske Vidensk. Selks. Biol. Skr.*, v. 16, n. 1, pp. 1-96, 32 pl., 44 fig., Copenhagen.

PERCH-NIELSEN K. (1969) - Die Coccolithen einiger Dänischer Maastrichtien- und Danien-Lokalitäten. *Med. Dansk. Geol. Foren.*, v. 19, n. 1, pp. 51-67, 7 pl., Copenhagen.

PERCH-NIELSEN K. (1972) - Les nannofossiles calcaires de la limite Crétacé-Tertiaire. *Mém. B.R.G.M.*, n. 71, pp. 181-188, Paris.

PERCIVAL S. F. (1972) - Changes in calcareous nannoplankton in the Cretaceous-Tertiary biotic crisis at Zumaya, Spain. Dissertation presented to the Faculty of Princeton Univ., pp. 1-68, Princeton.

PERCIVAL S. F. & FISCHER A. (1977) - Changes in calcareous nannoplankton in the Cretaceous-Tertiary biotic crisis at Zumaya, Spain. *Evol. Theory*, v. 2, pp. 1-35, Chicago.

PREMOLI SILVA I. (1977) - II Biostratigraphy. In: ARTHUR M. A. et al. - *Geol. Soc. Am. Bull.*, v. 88, pp. 371-374, 2 fig., Denver.

PRINS B. (1971) - Speculations on relations, evolution and stratigraphic distribution of Discoasters. *Proc. II Plankt. Conf., Roma 1970*, pp. 1017-1037, Roma.

PROTO-DECIMA F. (1974) - Leg 27 calcareous nannoplankton. In ROBINSON P. T., BOLLI H. M. et al., *Init. Rep. Deep Sea Drill. Proj.*, v. 27, pp. 589-621, Washington.

REINHARDT P. (1964) - Einige Kalkflagellaten-Gattungen (Coccolithophoriden, Coccolithineen) aus dem Mesozoikum Deutschland. *Mber. Deut. Akad. Wiss. Berlin*, v. 6, n. 10, pp. 749-759, 2 pl., 2 fig., Berlin.

REINHARDT P. (1965) - Neue Familien für fossile Kalkflagellaten (Coccolithophoriden, Coccolithineen). *Mber. Deut. Akad. Wiss. Berlin*, v. 7, 30 pp., Berlin.

REINHARDT P. (1966) - Zur Taxinomie und Biostratigraphie des fossilen Nannoplanktons aus dem Malm, der Kreide un dem Altertiär Mitteleuropas. *Freib. Forsch.* C. n. 196, Paläontologie, pp. 1-109, 23 pl., 29 fig., 1 tab., Leipzig.

REINHARDT P. (1967) - Fossile Coccolithen mit rhagoidem Zentralfeld (Familie *Ahmuellerellaceae*, sub. ord. *Coccolithineae*). *N. Jb. Geol. Paläont. Mh.*, v. 3, pp. 163-178, 12 fig., Stuttgart.

REINHARDT P. (1970) - Synopsis der Gattungen und Arten der mesozoischen Coccolithen und anderer kalkiger Nannofossilien. Teil. II. *Freib. Forsch.*, C. n. 265, 43 pp., Leipzig.

REINHARDT P. (1971) - Synopsis der Gattungen und Arten der mesozoischen Coccolithen und anderer kalkiger Nannofossilien. Teil. III. *Freib. Forsch.*, C. n. 267, pp. 19-41, Leipzig.

REINHARDT P. & GORKA H. (1967) - Revision of some upper Cretaceous Coccoliths from Poland and Germany. *N. Jb. Geol. Paläont. Abh.*, v. 129, n. 3, pp. 240-256, 3 pl., Stuttgart.

RENZ O. (1936) - Stratigraphische und mikropaleontologische Untersuchung der Scaglia (Obere Kreide-Tertiär) in Zentralen Apennin. *Ecl. Geol. Elv.*, v. 29, n. 1, pp. 1-149, 15 pl., 14 fig., Basel.

RENZ O. (1952) - Ricerche stratigrafiche e micropaleontologiche sulla Scaglia dell'Appennino centrale. *Mem. Descr. Carta Geol. Ital.*, v. 29, pp. 1-173, 15 pl., Roma.

ROOD A. P., HAY W. W. & BARNARD T. (1971) - Electron microscope studies of Oxford Clay Coccoliths. *Ecl. Geol. Helv.*, v. 64, n. 2, pp. 245-272, Basel.

ROTH P. H. (1973) - Calcareous nannofossils, leg 17, Deep Sea Drilling Project. In WINTERER E. L., EWING J. L. et al., *Init. Rep. Deep Sea Drill. Proj.*, v. 17, pp. 695-741, Washington.

ROTH P. H. & THIERSTEIN H. (1972) - Calcareous nannoplankton, leg 14 of the Deep Sea Drilling Project. In HAYES D. E., PIMM A. C. et al., *Init. Rep. Deep Sea Drill. Proj.*, v. 14, pp. 421-485, Washington.

SCHILLER J. (1930) - *Coccolithineae*. In: L. Rabenhorst, Kryptogamen-Flora von Deutschland, Österreich un der Schweiz, v. 10, n. 2, pp. 89-267, 137 fig., Akademische Verlagsgellschaft, Leipzig.

SISSINGH W. (1977) - Biostratigraphy of Cretaceous calcareous nannoplankton. *Geologie in Mijnbouw*, v. 56, n. 1, pp. 37-65, 16 fig., Amsterdam.

SMITH C. (1975) - Upper Cretaceous calcareous nannoplankton zonation and stage Boundaries. *Trans. Gulf Coast Ass. Geol. Soc.*, v. 25, pp. 263-278, Washington.

STOVER L. E. (1966) - Cretaceous coccoliths and associated nannofossils from France and the Netherlands. *Micropaleont.*, v. 12, n. 2, pp. 133-167, 9 pl., New York.

STRADNER H. (1959) - Die fossilen Discoasteriden Österreichs. II Teil. *Erdoel. Erdgas Z.*, v. 75, pp. 472-488, Wien.

STRADNER H. (1961) - Vorkommen von Nannofossilien in Mesozoïkum und Alttertiär. *Erdoel. Erdgas Z.*, v. 77, pp. 77-89, 99 fig., Wien.

STRADNER H. (1962) - Ueber neue und wenig bekannte Nannofossilien aus Kreide und Alttertiär. *Verh. Geol. B.A.*, pp. 363-376, 3 pl., Wien.

STRADNER H. (1963) - New contributions to Mesozoic stratigraphy by means of nannofossils. *6th World Petroleum Congr. Frankfurt 1963*, sect. 1, 4, 16 pp., 6 pl., 5 tab., Frankfurt-am-Main.

STRADNER H. (1967) - Einleitung und Uebersicht der Nannoflora. In FUCHS W. & STRADNER H., Die Foraminiferenfauna und Nannoflora eines Bohrkernes aus dem hoeheren Mittel-Alb der Tiefboh rung Delft 2 (NAM), Niederland. *Geol. Bundesanst.*, v. 110, pp. 245-254, 3 fig., Wien.

STRADNER H., ADAMIKER A. & MARESH O. (1968) - Electron Microscope Studies on Albian calcareous Nannoplankton from the Delft 2 and Leidschenden I Deepwells, Holland. *Verhand. K. Nederl. Akad. Wetensch. Afd. Natuurk.*, v. 24, pp. 1-107, 48 pl., Amsterdam.

TAPPAN H. (1967) - Primary production, isotopes, extinctions and the atmosphere. *Palaeogeogr., Palaeocl., Palaeoecol.*, v. 4, n. 3, pp. 187-210, Amsterdam.

THIERSTEIN H. R. (1971) - Tentative Lower Cretaceous nannoplankton zonation. *Ecl. Geol. Helv.*, v. 64, n. 3, pp. 459-488, Basel.

THIERSTEIN H. R. (1973) - Lower Cretaceous Calcareous Nannoplankton Biostratigraphy. *Abh. Geol. Bundesanst.*, v. 29, pp. 1-52, 6 pl., 25 fig., Wien.

VEKSHINA V. N. (1959) - *Coccolithophoridae* in Maestrichtian deposits of the Western Siberian Lowland. *Tr. S.N.I.I.G.G.I.M.S.* 2, pp. 56-77, 2 pl., trad. A.T.S., New Jersey.

WORSLEY T. R. (1971) - Calcareous nannofossil zonation of Upper Jurassic and Lower Cretaceous sediments from the Western Atlantic. *Proc. II Planktonic Conf., Roma 1970*, pp. 1301-1322, Roma.

WORSLEY T. R. (1974) - The Cretaceous-Tertiary boundary event in the ocean. In HAY W. W. (ed.), Studies in Paleo-oceanography. *Soc. Econ. Paleont. Miner.*, Spec. Publ. n. 20, pp. 94-125, Tulsa.

PLATE 40

(CRETACEOUS)

Fig. 1 - *Predicosphaera cretacea* (Arkhangelsky) Gartner: sample 16/104; × 7.500.

Fig. 2 - *Predicosphaera cretacea* (Arkhangelsky) Gartner: sample 16/199; × 6.000.

Fig. 3 - *Predicosphaera spinosa* (Bramlette & Martini) Gartner: sample 12 F; × 12.000.

Fig. 4 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 16/40; × 7.000.

Fig. 5 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 2 F; × 6.000.

Fi. 6 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 5 F; × 5.700.

Fig. 7 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 13 F; × 6.000.

Fig. 8 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 16/39; × 7.000.

Fig. 9 - Proximal shield of *Watznaueria barnesae* (Black) Perch-Nielsen: sample 16/196; × 13.500.

Fig. 10 - *Nannoconus* sp.: sample 16/150; × 5.300.

Fig. 11 - *Micula staurophora decussata* (Vekshina) Noël: sample 6 F; × 10.000.

Fig. 12 - *Micula staurophora decussata* (Vekshina) Noël: sample 2 F; × 4.500 .

Scanning electron micrographs.

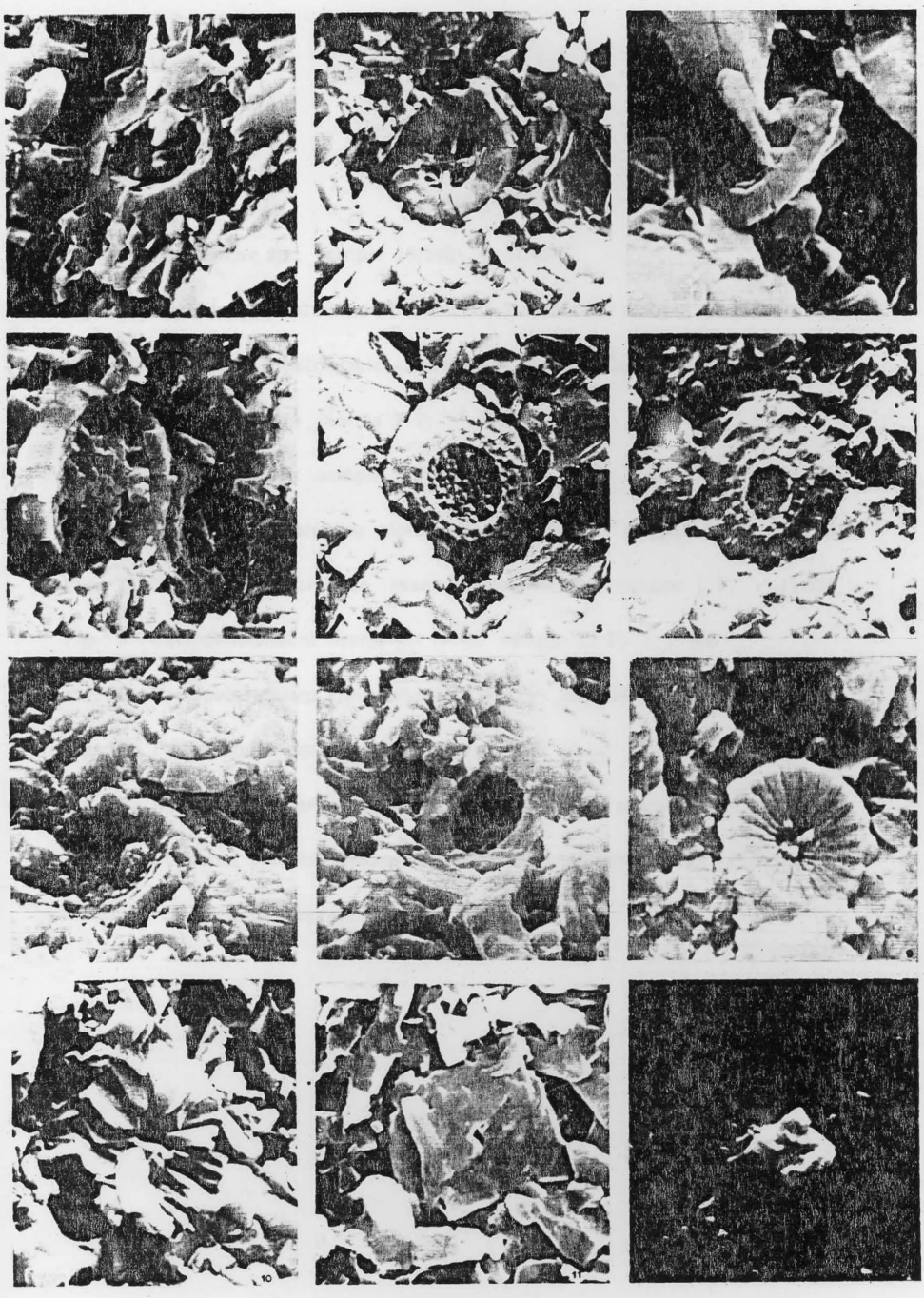


PLATE 41

(CRETACEOUS)

Fig. 1 - *Zygodiscus* sp.: sample 16/140; × 11.500.

Fig. 2 - *Zygodiscus ponticulus* (Deflandre) Reinhardt: sample 16/25; × 6.000.

Fig. 3 - *Zygodiscus fibuliformis* (Reinhardt) Bukry: sample 16/25; × 12.000.

Fig. 4 - *Zygodiscus* sp.: sample 7 F; × 12.000.

Fig. 5 - *Zygodiscus* sp.: sample 1 F; × 12.000.

Fig. 6 - *Zygodiscus ponticulus* (Deflandre) Reinhardt: sample 3 F; × 13.000.

Fig. 7 - *Watznaueria barnesae* (Black) Perch-Nielsen: sample 1 F; × 11.000.

Fig. 8 - *Cyclagelosphaera margereli* Noël: sample 12 F; × 11.800.

Fig. 9 - *Cyclagelosphaera specioclypeata* Bukry: sample 16/16; × 12.000.

Fig. 10 - *Podorhabdus* sp.: sample 1 F; × 6.000.

Fig. 11 - *Watznaueria barnesae* (Black) Perch-Nielsen: sample 16/16; × 12.000.

Fig. 12 - Proximal side of *Watznaueria barnesae*: sample 16/196; × 12.200.

Scanning electron micrographs.

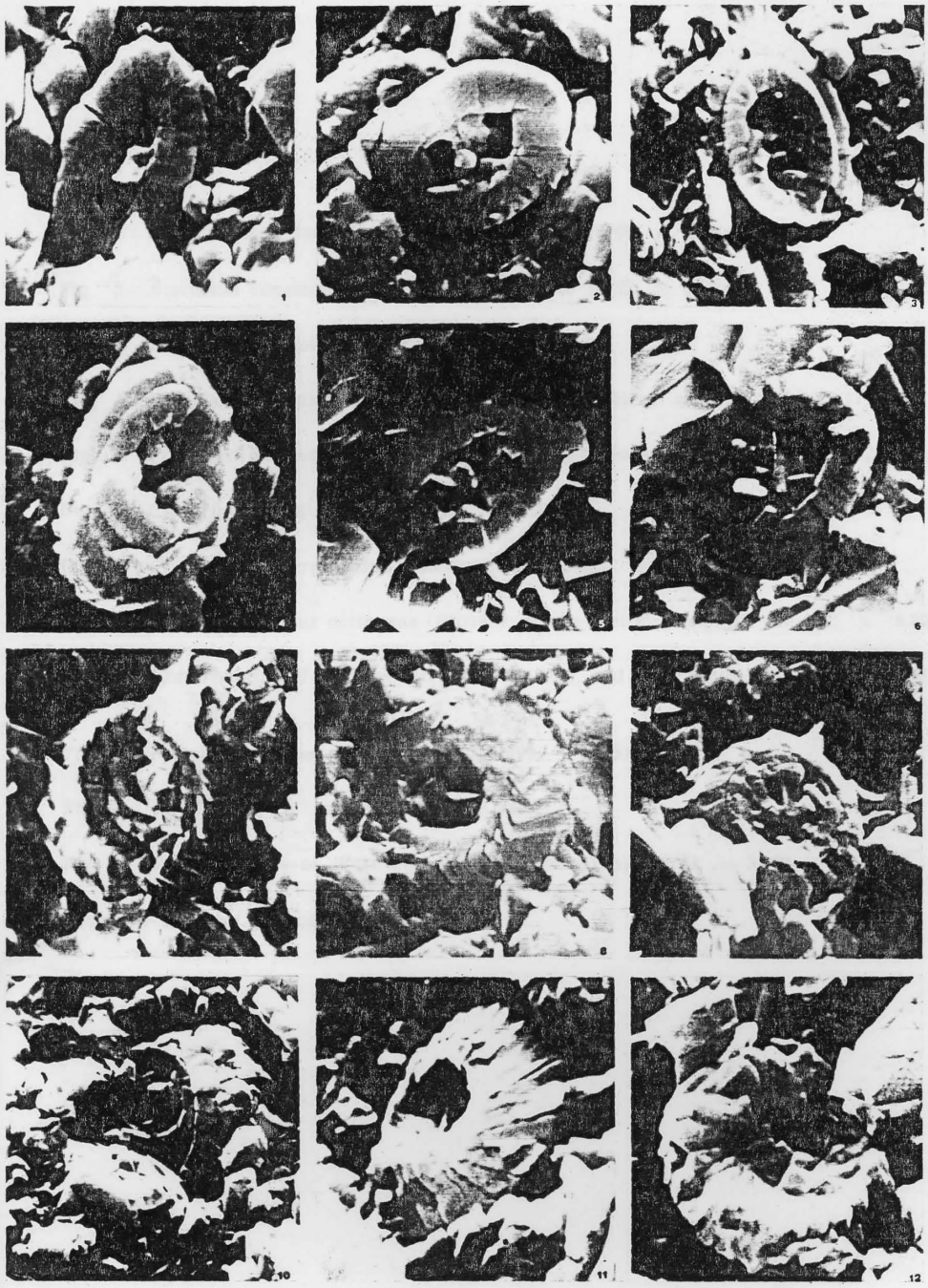


PLATE 42

(CRETACEOUS)

Fig. 1 - *Biscutum constans* (Gorka) Black: sample 16/96; × 10.500.

Fig. 2 - *Biscutum constans* (Gorka) Black: sample 16/22; × 10.800.

Fig. 3 - *Polypodorhabdus* sp.: sample 16/186; × 5.600.

Fig. 4 - *Polypodorhabdus actinosus* (Stover) Perch-Nielsen: sample 1 F; × 11.500.

Fig. 5 - *Polypodorhabdus actinosus* (Stover) Perch-Nielsen: sample 16/22; × 6.200.

Fig. 6 - *Cretarhabdus* sp.: sample 7 F; × 5.700.

Fig. 7 - *Cretarhabdus crenulatus* Bramlette & Martini: sample 16/186; × 11.000.

Fig. 8 - *Polypodorhabdus actinosus* (Stover) Perch-Nielsen: sample 16/104; × 6.500.

Fig. 9 - *Cretarhabdus* cf. *romani* (Gorka) Maresh and *Stradneria* sp.: sample 16/39; × 7.000.

Fig. 10 - *Polypodorhabdus* sp. 2: sample 16/199; × 6.000.

Fig. 11 - *Stradneria* sp.: sample 6 F; × 6.000.

Fig. 12 - Proximal side of *Watznaueria barnesae*: sample 16/63; × 5.000.

Scanning electron micrographs.

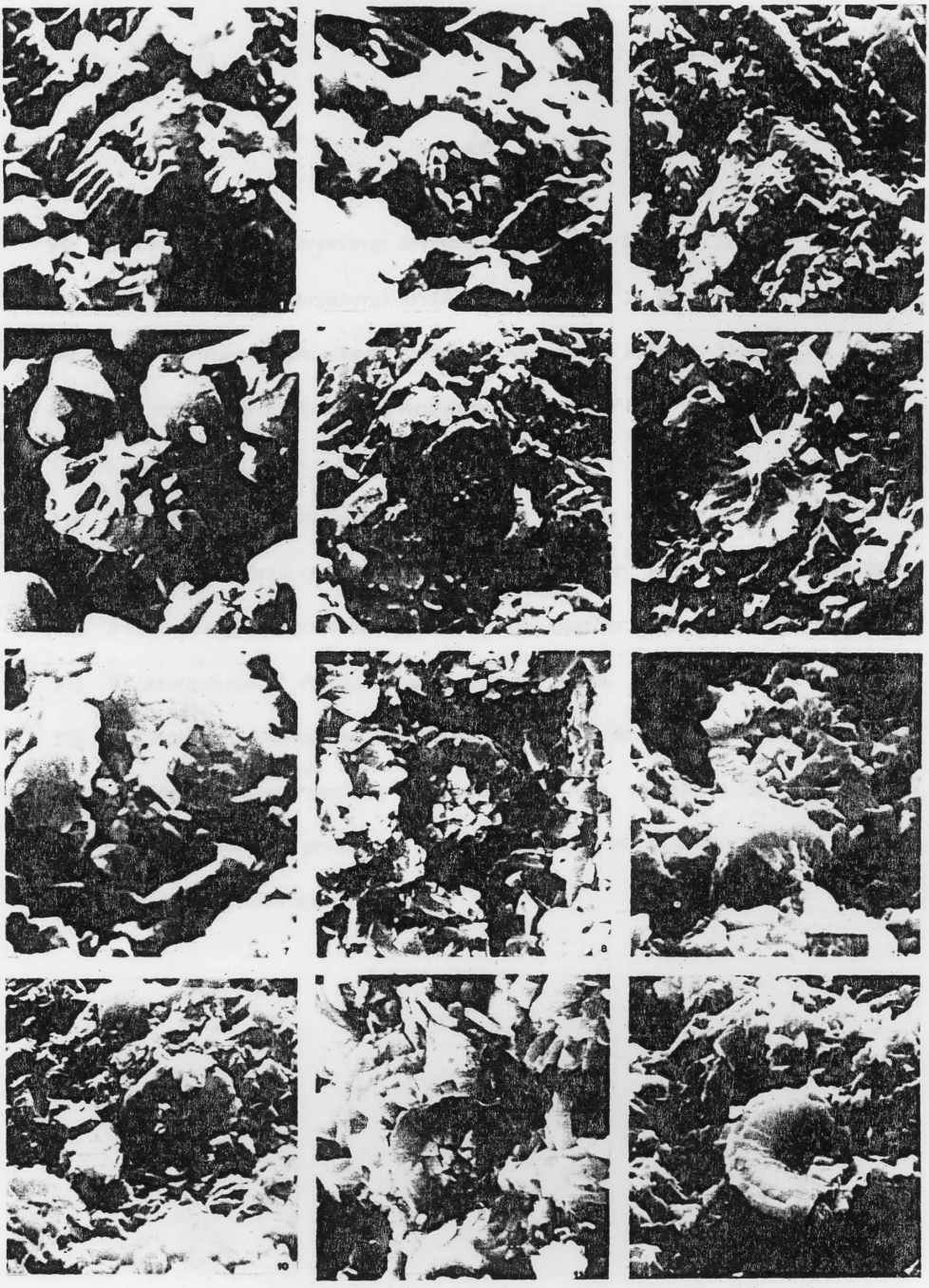


PLATE 43

(CRETACEOUS)

Fig. 1 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 2 F; × 12.500.

Fig. 2 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 11 F; × 12.000.

Fig. 3 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 8 F; × 10.000.

Fig. 4 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 8 F; × 6.500.

Fig. 5 - Detail: × 13.000.

Fig. 6 - *Cribrosphaera ehrenbergi* Arkhangelsky: sample 8 F; × 7.500.

Fig. 7 - *Predicosphaera cretacea* (Arkhangelsky) Gartner: sample 16/25; × 12.000.

Fig. 8 - *Predicosphaera cretacea* (Arkhangelsky) Gartner: sample 16/150; × 10.600.

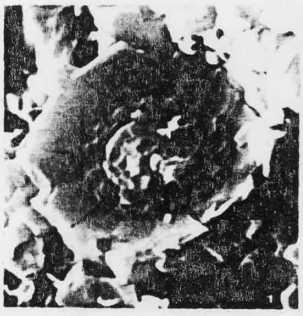
Fig. 9 - Assemblage of *Predicosphaera*: sample 16/186; × 6.200.

Fig. 10 - *Stradneria limbicrassa* Reinhardt: sample 16/40; × 11.000.

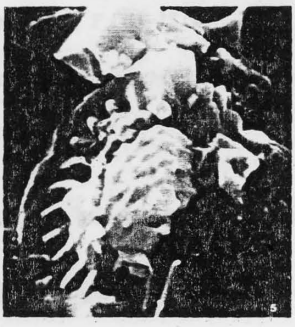
Fig. 11 - *Cretarhabdus crenulatus* Bramlette & Martini: sample 16/168; × 7.000.

Fig. 12 - *Parhabdolithus granulatus* Stover: sample 16/40; × 8.500.

Scanning electron micrographs.











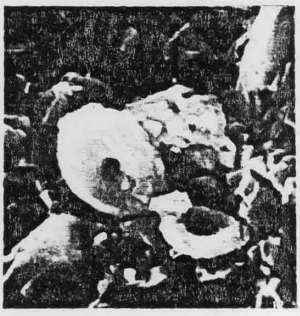



PLATE 44

(CRETACEOUS)

Fig. 1 - Indeterminate species (*Podorhabdus* ?): sample 16/22; × 13.000.

Fig. 2 - Indeterminate species: sample 16/16; × 13.500.

Fig. 3 - *Stradneria* sp.: sample 6 F; × 12.000.

Fig. 4 - Transversal section of *Microrhabdulus decoratus* Deflandre: sample 7 F; × 10.000.

Fig. 5 - Detail: × 30.000.

Fig. 6 - Transversal section of *Microrhabdulus decoratus* Deflandre: sample 16/39; × 16.000.

Fig. 7 - Stem: sample 9 F; × 10.500.

Fig. 8 - Doubtful forms: sample 16/22; × 8.000.

Fig. 9 - *Parhabdolithus granulatus* Stover: sample 16/108; × 11.000.

Fig. 10 - *Polypodorhabdus* sp. 1: sample 16/63; × 8.000.

Fig. 11 - *Polypodorhabdus* sp. 2: sample 16/25; × 6.500.

Fig. 12 - *Biscutum constans* (Gorka) Black: sample 11 F; × 12.000.

Scanning electron micrographs.

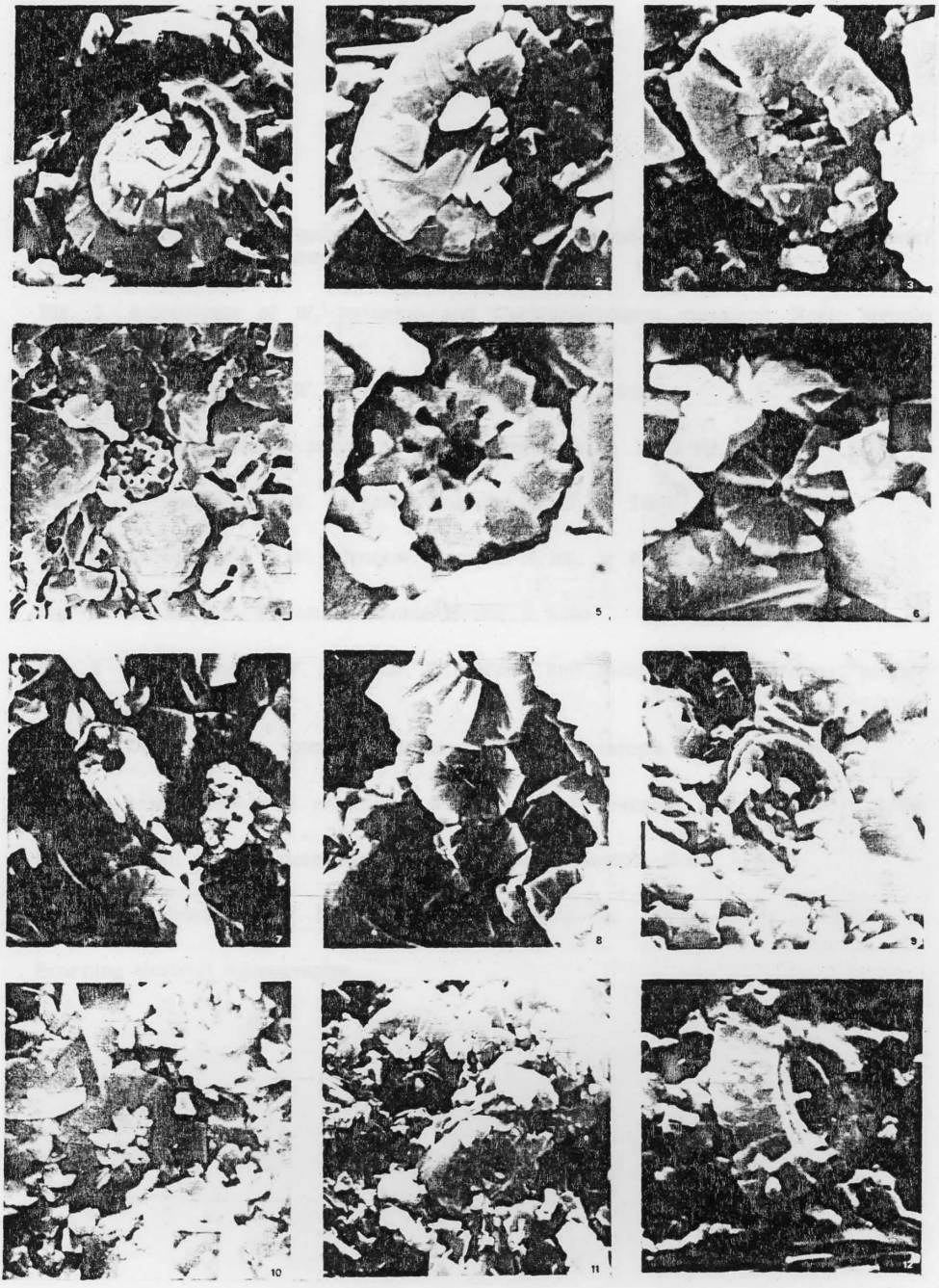


PLATE 45

(CRETACEOUS)

Fig. 1 - *Watznaueria barnesae* and a print in the limestone of *W. barnesae* (Black) Perch-Nielsen: sample 16/196; × 5.600.

Fig. 2 - Assemblage of *W. barnesae* and *Cyclagelosphaera margereli* Noël: sample 16/199; × 6.000.

Fig. 3 - Coccosphere of *W. barnesae*: sample 16/51; × 5.500.

Fig. 4 - *Cyclagelosphaera margereli* Noël: sample 16/22; × 12.000.

Fig. 5 - Coccosphere of *W. barnesae*: sample 16/145; × 7.000.

Fig. 6 - Coccosphere of *W. barnesae*: sample 16/100; × 6.000.

Fig. 7 - *Watznaueria barnesae*: sample 16/183; × 5.800.

Fig. 8 - Assemblage of *W. barnesae*, *P. cretacea* and *Discorhabdus rotatorius*: sample 16/104; × 6.500.

Fig. 9 - *Discorhabdus rotatorius* (Bukry) Thierstein: sample 16/63; × 8.000.

Fig. 10 - Assemblage of *D. rotatorius*, *W. barnesae*, *P. cretacea*: sample 16/40; × 4.000.

Fig. 11 - Detail of the Coccosphere of *D. rotatorius*: sample 16/40; × 8.000.

Fig. 12 - Assemblage of *W. barnesae* and *Podorhabdus* sp.: sample 16/51; × 7.250.

Scanning electron micrographs.

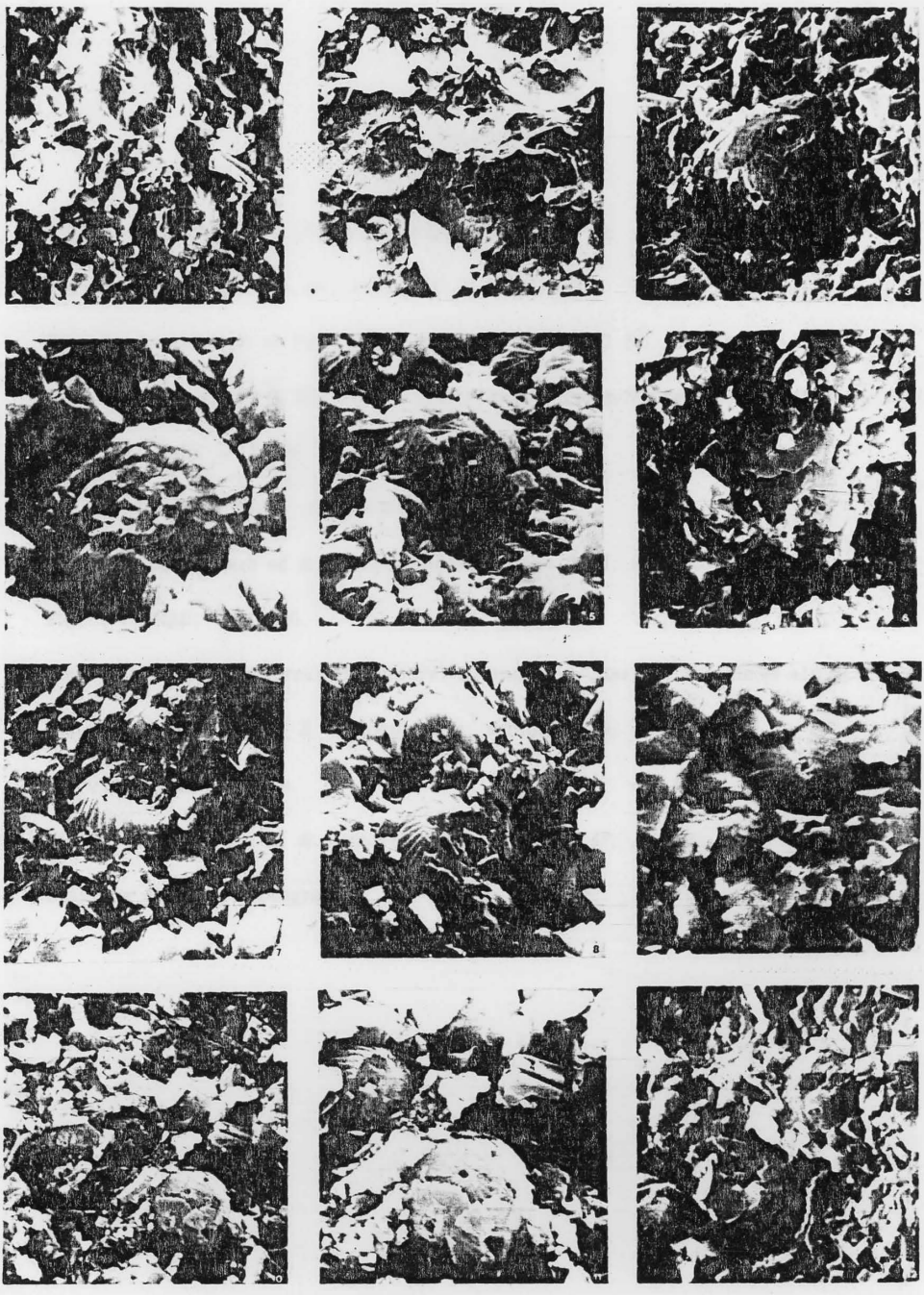


PLATE 46

(EARLY PALEOCENE)

Fig. 1 - *Ericsonia cava* (Hay & Mohler): sample G 50; × 6.000.

Fig. 2 - *Thoracosphaera* sp.: sample G 42; × 11.500.

Fig. 3 - Assemblage of Paleocene coccoliths: sample G 50; × 12.000.

Fig. 4 - Coccosphere of *Biscutum* ? *dimorphosum* Perch-Nielsen: sample G 50; × 6.800.

Fig. 5 - Detail: × 13.500.

Fig. 6 - Doubtful form: sample G 41; × 5.500.

Fig. 7 - Coccosphere of *B. dimorphosum*: sample G 47; × 8.000.

Fig. 8 - Detail: × 16.000.

Fig. 9 - *Markalius inversus* (Deflandre) Bramlette & Martini: sample G 41; × 5.800.

Fig. 10 - Coccosphere of *B. dimorphosum*: sample G 49; × 4.000.

Fig. 11 - Detail: × 8.000.

Fig. 12 - Coccosphere of *B. dimorphosum*: sample G 47; × 8.000.

Scanning electron micrographs.