

COCCOLITHS FROM SOME PALEOGENE ROCKS IN THE GULF OF SUEZ AREA, EGYPT

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كوكوليثات بعض صخور الباليوجين بمنطقة خليج السويس - مصر

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يصف ويصور هذا البحث الحفريات الجيرية المجهرية الدقيقة (الكوكوليثات) والمسجلة في ٢٤٠ عينة جمعت من صخور الباليوجين بقطاعات وادي بلاعيم / وادي نخل بمنطقة خليج السويس - مصر . ولقد تم التعرف على ثلاثين نوعاً من الكوكوليثات تتبع أربعة عشر جنساً وأربع عائلات من رتبة الكوكوليثوفوراليس . كما تمت مناقشة التوزيع الاستراتيجرافي لهذه الانواع .

تعمل أنواع الكوكوليثات هذه على التعرف على نطاقين حيويين للنانوبلانكتون :
١ - نطاق الـ *Nannotetrina fulgens* ٢ - نطاق الـ *Rectiulofenestra Umbilica*
هذا النطاقان ينتميان إلى عصر الايوسين الاوسط ، ويمكن مقارنتهما بالنطاقات الحيوية للفورامينيفرا والتي تنتمي إلى نفس العصر نتبين أن النطاقات الحيوية الدقيقة هذه ذات قيمة إذا ما قورنت بنظيراتها في أجزاء أخرى من العالم .

Key Words: Coccoliths, Paleogene, Biostratigraphy, Egypt.

ABSTRACT

This paper describes and illustrates the calcareous nannoplankton (coccoliths) recorded in 240 samples collected from the Paleogene rocks in Wadi Belayim/Wadi Nukhul surface sections, Gulf of Suez area, Egypt. Thirty species of coccoliths belonging to 14 genera and 4 families of the Suborder Coccolithineae Order Coccolithophorales are defined. A shortened discussion on their stratigraphic occurrences is presented.

Analysis of the nannoflora has led to the definition of two proposed nannoplankton zones. These are the *Nannotetrina fulgens* and the *Reticulofenestra umbilica* zones both of which are of Middle Eocene age. Such nannobiozones are equated with the planktonic foraminiferal zones of the same age. Both microbiostratigraphic zones were found to be correlatable with those in other parts of the world.

INTRODUCTION

Since the later part of the nineteenth century the highly fossiliferous Paleogene rocks of Egypt have been subject of numerous stratigraphical and paleontological studies. However, no satisfactory classification of these rocks has been established and their correlation with the type sections in Europe has proved difficult. The difficulty has been mainly explained by the fact that, the rich macrofaunas of these rocks are strictly localized in nature, and can hardly be correlated with the faunas of corresponding strata outside the Tethyan region. As a result the limits of the various stages and substages of the Paleogene have been interpreted differently by the various authors.

Recently, while the rich microfossil content of these rocks has

been dealt with the many authors (El-Dawoody, 1970-1977; El-Dawoody & Morsi, 1985), their correlation with the type section has still proved very difficult, and the stratigraphical boundaries were once again, differently interpreted. However, the accumulation of knowledge during the last decades has emphasized the value of planktonic Foraminifera as well as calcareous nannoplankton as guide fossils for stratigraphical zonation, and for regional as well as worldwide correlation (El-Dawoody, 1970-1977; El-Dawoody & Morsi, 1985).

Thus, in the present study both the calcareous nannoplankton and co-existent planktonic Foraminifera are identified and are used to interpret the stratigraphy of the region. These two types of fossils provided a sound basis for the zonation of the succession and its correlation with the type sections and with the

known calcareous nannoplanktonic and planktonic Foraminiferal zones elsewhere. Moreover, the stratigraphical ranges of calcareous nannoplankton could be established in the light of the planktonic Foraminiferal zonation, thus ending a long controversy about their ranges.

The rich calcareous nannoplankton and planktonic Foraminiferal populations encountered in some Paleogene succession measured in the Wadi Nukhul and the Wadi Belayim, of southwestern and central Sinai, Egypt (Fig. 1) have helped to clear up this confusion and has established the morphological characteristics and the stratigraphical range of each of these species.

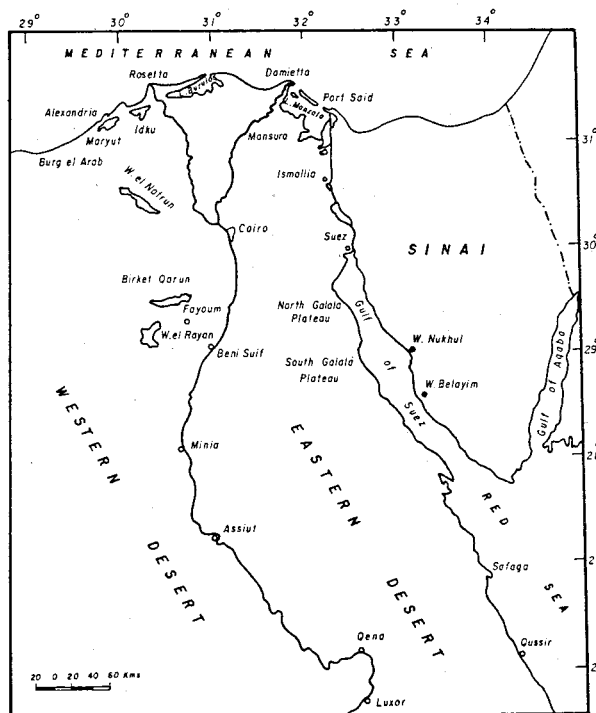


Fig. 1: Location map showing the investigated sections.

MATERIAL AND TECHNIQUE

Two sections were measured along east-west lines by the use of the compass and tape, arranged from north to south as follows:

1. Wadi Nukhul surface section

The section is situated six kilometers southeast of Abu Zeinima town, eastern coast of the Gulf of Suez. The Eocene section (Lat. $29^{\circ} 01' 00''$, Long. $33^{\circ} 09' 49''$) was measured along the lower course of Wadi Nukhul where it cuts through the cliffs and low hills of Eocene limestones and shales, which border the wadi to its mouth near the shore of the Gulf.

The Paleocene-Eocene section of Wadi Belayim was measured to cover the missing lowermost part of the Eocene section destroyed by the basaltic dyke in the Wadi Nukhul section and to enhance correlation with it.

2. Wadi Belayim surface section

This section is located near Gebel Abu Durba and close to the Belayim bay. The Eocene section (Lat. $28^{\circ} 35' 30''$, Long $35^{\circ} 25'$

$00''$) amounts to 212 m and samples were taken at 4 m intervals.

For biostratigraphic determinations, the sections were studied using a light microscopy and the writer attempted to identify and record all the taxa encountered. The range of the most-common coccolith species in the Paleogene succession in west central Sinai is given in a general distribution chart (Fig. 2).

BIOSTRATIGRAPHY

The recorded zones are arranged from the older to younger; ten nannoplankton zones are proposed. These are: *Discoaster multiradiatus* zone (Late Paleocene), *Tribraehiatus contortus* zone, *D. binodosus* zone, *T. orthostylus* zone and *D. Iodoensis* zone (Early Eocene), *D. sublodoensis* zone, *Nannotetrina flugens* zone, *Reticulofenestra umbilica* zone, *D. taninodifer* zone and *D. saipanensis* zone (Middle Eocene). Two of these zones were based on coccolith data, these *Nannotetrina flugens* zone and *Reticulofenestra umbilica* zone. The markers of each zone are discussed and reference is made to its author, the datum indicators and most common species as well as the reference type locality.

1. *Nannotetrina flugens* zone (= *Chiphragmalithus quadratus* zone of Hay et al, 1967); (= *C. alatus* zone of Martini, 1970, 1971):

Definition: This zone is referred to in the literature as the *Chiphragmalithus alatus* zone, or *C. quadratus* zone. *Chiphragmalithus* (Martini), however, it should be referred to as *Nannotetrina flugens* (Stradner) (See Loeblich & Tappan, 1966, p. 1083 & 154; and Loeblich & Tappan, 1970, pp. 165-166).

The zone was established by (Hay, 1967), and emended by (Martini, 1970). The type locality was the Media Agua, Creek area, Kern County, California, and defined as the interval from the first occurrence of *Nannotetrina flugens* (Stradner) (= *C. alatus* of some authors) to the last occurrence of *Rhabdosphaera gladius* Locker. However, due to the scarcity of *R. gladius* in the studied materials from Wadi Nukhul the first occurrence of large forms of *Reticulofenestra umbilica* (Levin) is considered as a marker for the top of *N. quadrata* zone (Bukry, 1973). The stratigraphic range of the *N. quadrata* is equivalent to that of *N. fulgens*.

At Wadi Nukhul section, this zone straddles the interval between Early and Middle Eocene of the Thebes and Darat Formations. It spans the interval between samples (101-131) and correlatable with the upper part of *A. pentacamerata*, and the main part of *H. aragonensis* zones.

The most common fossil assemblage of this zone includes: *Discoaster barbadiensis* Tan Sin Hok *D. deflandrei* (Bramlette & Reidel), and *Nannotetrina flugens* (Stradner).

Correlation: The recorded *N. fulgens* from the studied section at Wadi Nukhul is approximately equivalent to the Unnamed Unit 6 at its base (Bramlette & Sullivan, 1961), in California; to *C. alatus* zone (part) of (Martini, 1971); to the *N. quadrata* zone (CP13) (part) of (Bukry, 1973, 1975; Okada & Bukry, 1980), with approximately the lower two sub-zones, *D. strictus* (CP13a), and *C. gigas* (CP13b); to *N. fulgens* zone of (El Boukhary, 1973) from the Tayiba-Nukhul sections, Sinai; to *N. fulgens* zone (part) of (Proto Decima et al, 1975) from the Possagno section, northern Italy; and lastly it is approximately

equivalent to *C. alatus* zone (part) of (Ehrlich & Moshkovitz, 1981) from Israel.

2. *Reticulofenestra umbilica* zone:

Definition: The original definition of this zone was the interval between the first occurrence of *R. umbilica* to the last occurrence of *C. solitus*.

Remarks: *R. umbilica* defines the top of *N. quadrata* zone in (Bukry, 1973, 1975), is an equivalent of zone (NP16) and it has also been used as a marker by (Roth and Thirestein, 1972), as well as (El Boukhary, 1973) for the base of *R. umbilica* zone. In the present work, the definition of the top is modified to be on the basis of the first occurrence of *D. taninodifer* which may have a shorter range than outside Egypt. Accordingly, the zone definition is the interval from the first occurrence of large sized *R. umbilica* at base, to the first occurrence of *D. taninodifer* at top.

At Wadi Nukhul section, this zone lies within the Darat and Khaboba Formations, and spans the interval between samples (132-178), and is correlatable with the uppermost part of *H. aragonensis*, as well as most of the *G. subconglobata*/*M. lehneri* zones.

The most common fossil assemblage of this zone includes: *Discoaster saipanensis* Bramlette & Riedel and *Reticulofenestra umbilica* (Levin).

Correlation: The *R. umbilica* zone recorded from the studied section at Wadi Nukhul is equivalent approximately to the lower part of *D. taninodifer* zone of (Proto Decima *et al*, 1975) from Possagno section, northern Italy; and at last approximately equivalent to a part of *D. taninodifer* zone of (Ehrlich & Moshkovitz, 1981) from Israel.

CLASSIFICATION

The most common coccolith species encountered in the investigated sections are discussed in this chapter. They are regarded here as plant remains, and consequently the rules of the I.C.B.N. are followed. Higher taxonomic units have been arranged according to the classification given by (Hay & Beaudry, 1973 and Romein, 1979). The suprageneric assignment of the genera recognized in this study are arranged as:

- Kingdom Plantae
- Order Coccolithophorales
- Suborder Coccolithineae
- Family Coccolithaceae Kamptner, 1928
- Tribe Coccolitheae Kamptner, 1958
- Subtribe Coccolithinae Kamptner, 1958
- Genus: *Campylosphaera* Kamptner, 1963
- Chiasmolithus* Hay, Mohler & Wade, 1966
- Coccolithus* Schwarz, 1894
- Reticulofenestra* Hay, Mohler & Wade, 1966
- Subtribe Cyclococcolithinae Kamptner, 1958
- Genus: *Cyclococcolithina* Wilcoxon, 1970
- Subtribe Rhabdosphaerinae Stradner, 1968
- Genus: *Rhabdosphaera* Haeckel, 1894
- Tribe Pontosphaerae Hay, 1966
- Genus: *Pontosphaera* Lohmann, 1902
- Transversopontis* Hay, Mohler & Wade, 1966
- Family Zygodiscaceae Hay & Mohler, 1967

Genus: *Neochiastozygus* Perch-Nielsen, 1971

Neococcolithes Sujkowski, 1931

Family Calyptosphaeraceae Boudrseaux & Hay, 1969

Genus: *Zygrhablithus* Deflandre, 1959

Family Sphenolithaceae Vekshina, 1959

Genus: *Sphenolithus* Deflandre, 1952

Fasciculithus Bramlette & Sullivan, 1961

Incertae sedis:

Genus: *Nannotetrina* Achuthan & Stradner, 1969

The following short comments and the selected synonyms of the most-common nannofossil species encountered here are introduced.

Genus: *Campylosphaera* (Kamptner, 1963), *Campylosphaera dela* (Bramlette & Sullivan) (Pl. 1, Fig. 1).

1961 *Coccolithus delus* Bramlette & Sullivan; *Micropaleont.*, 7: 151, (Pl. 7, Figs. 1, 2).

1967 *Campylosphaera dela* (Bramlette & Sullivan; Hay & Mohler), *J. Paleont.*, 41, 1531, (Pl. 198, Fig. 14).

Remarks: This species is distinguished by a cross in the central area and by the strongly inward curved ends of the subquadrate ends.

Occurrence: This species was originally described from the Lodo Formation of California in the *Discoaster multiradiatus* zone ranging through the whole section. This species is found to range throughout the Early and Middle Eocene of Wadi Nukhul, as well as the Early Eocene of Belayim section.

Genus: *Chiasmolithus* (Hay, Mohler & Wade, 1966), *Chiasmolithus bidens* (Bramlette & Sullivan) (Pl. 1, Fig. 3)

1961 *Coccolithus bidens* (Bramlette & Sullivan); *Micropaleont.*, 7, 139, (Pl. 1, Fig. 1).

1967 *Chiasmolithus bidens*. (Bramlette & Sullivan; Hay & Mohler), *J. Paleont.*, 41, 1526, (Pl. 196, Figs. 14, 15, 17, Pl. 197, Figs. 4, 9, 14).

Remarks: This species is similar to *Chiasmolithus consuetus* (Bramlette & Sullivan) except in having, small toothlike projections in the central opening running usually perpendicular though, not prominent to the short axis of the coccolith. Central-opening transversely spanned by a robust X-shaped structure consisting of one straight and one sigmoid bar.

Occurrence: Originally described from the Paleocene of USA (California, Alabama) as well as France and England. This species is recorded throughout the Early Eocene of Wadi Belayim surface section.

Chiasmolithus consuetus (Bramlette & Sullivan) (Pl. 1, Fig. 2)

1961 *Coccolithus consuetus* (Bramlette & Sullivan; *Micropaleont.*, 7, 139, (Pl. 1, Fig. 2)

1967 *Chiasmolithus consuetus* (Bramlette & Sullivan) Hay & Mohler; *J. Paleont.*, 41, 1526, (Pl. 196, Figs. 23-25, Pl. 198, Fig. 16).

Occurrence: Paleocene of France, Paleocene to Lower Eocene of California, Middle Eocene of Texas, and Upper Eocene of Alabama. This species is found to range throughout the Early and Middle Eocene of Wadi Nukhul section, as well as the Early Eocene of Wadi Belayim section.

Chiasmolithus danicus (Brotzen) (Pl. 1, Fig. 4)

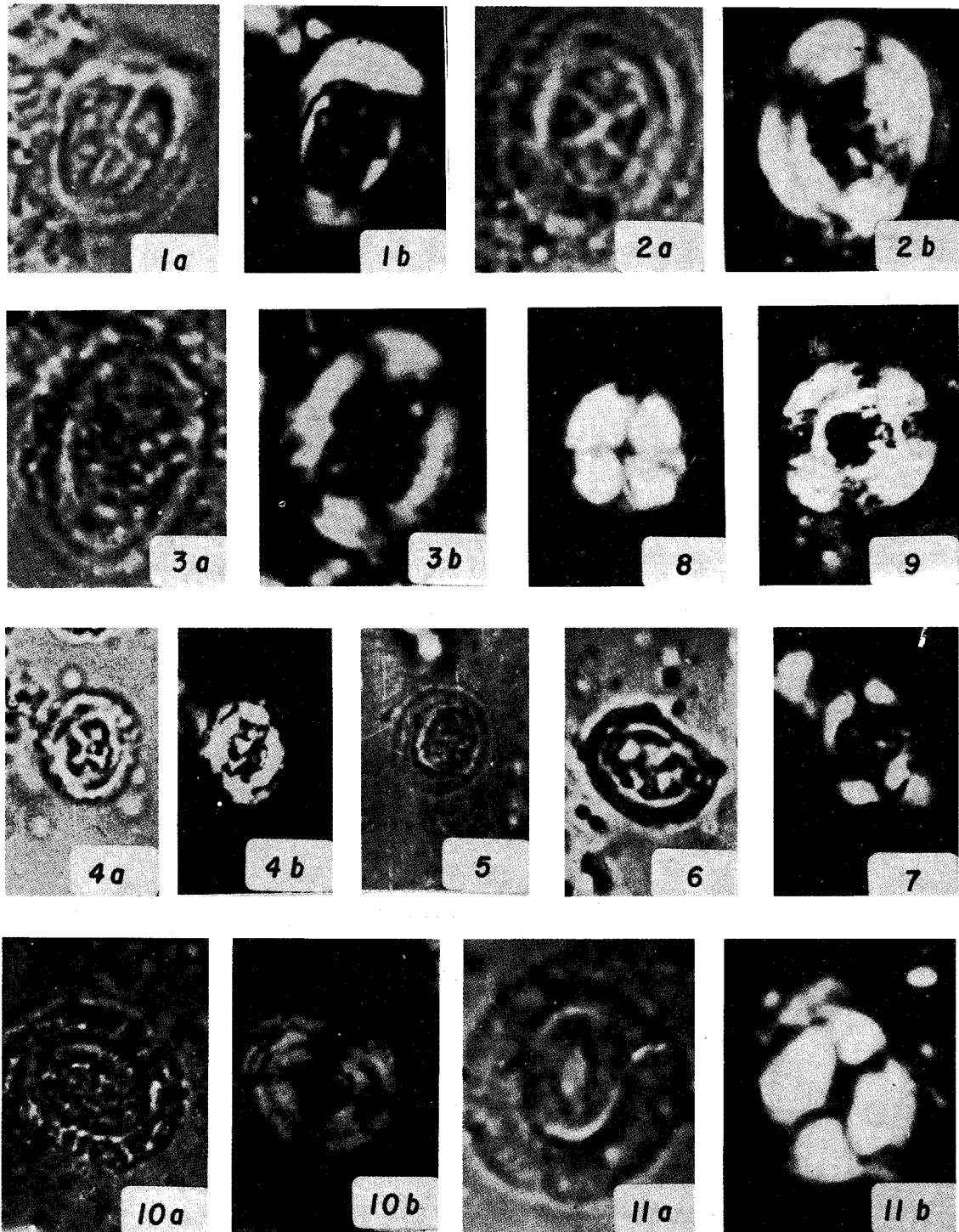


PLATE I

Figures 1-3, 7-9, 10 = 3000 × Figures 4-6 = 1500 ×

Fig. 1: *Campylosphaera dela* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 793, sample 17. Fig. 2: *Chiasmolithus consuetus* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 794, sample 9. Fig. 3: *Chiasmolithus bidens* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 795, sample 79. Fig. 4: *Chiasmolithus danicus* (Brotzen), a = nl, b = x-nicHypotype 798, sample 141. Fig. 5: *Chiasmolithus solitus* (Bramlette & Sullivan), nlHypotype 801, sample 98. Fig. 6: *Coccolithus bisulcus* (Stradner), a = nl, b = x-nicHypotype 826, sample 179. Fig. 7: *Coccolithus eopelagicus* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 804, sample 114. Fig. 8: *Fasciculithus involutus* (Bramlette & Sullivan), x-nicHypotype 810, sample 1. Fig. 9: *Reticulofenestra dictyoda* (Deflandre & Fert), x-nicHypotype 816, sample 141. Fig. 10: *Pontosphaera multipora* (Kamptner), a = nl, b = x-nicHypotype 831, sample 137.

1959 *Cribrosphaerella danica* (Brotzen); Sver. Geol. Undersok, (C), 571, 25, (Fig. 9).

1964 *Coccolithus danicus* (Brotzen), (Bramlette & Martini); Micropaleont., 10; 298, (Pl. 1, Figs. 15, 16).

1966 *Chiasmolithus danicus* (Brotzen) (Hay, Mohler & Wade), Eclog. Geol. Helvet., 59, 388.

Remarks: The forms with the oblique cross show similarities with those of the Paleocene and Eocene *Chiasmolithus bidens* (Bramlette & Sullivan) as well as *Chiasmolithus grandis* (Bramlette & Riedel) but differ in details.

Occurrence: This form was originally described from the Paleocene of Sweden, the type danian and in equivalents in SW France, Tunisia and Alabama. This form is found rarely in the Middle Eocene of Wadi Nukhul section and most probably reworked.

Chiasmolithus solitus (Bramlette & Sullivan) (Pl. 1, Fig. 5)

1961 *Coccolithus solitus* (Bramlette & Sullivan), Micropaleont. 7, 140, (Pl. 2, Fig. 4).

1966 *Chiasmolithus solitus* (Bramlette & Sullivan; Hay, Mohler & Wade), Eclog. Geol. Helv., 59, 388.

Remarks: Coccoliths (Placoliths) distinguished by its relatively small size with large central opening transversely spanned by a somewhat X-shaped structure.

Occurrence: Originally described from the Early-Middle Eocene strata of Texas, California and Italy. This form is recorded from the Early and Middle Eocene of Wadi Nukhul section.

Genus: *Coccolithus* (Schwarz, 1894); *Coccolithus bisulcus* (Stradner), (Pl. 1, Fig. 6)

1963 *Coccolithus bisulcus* (Stradner), (in Gohrbandt), Mitt. Geol. Ges. Wien., 56, 72, (Pl. 8, Figs. 3-6).

Remarks: This species is easily distinguished in the light microscope by thin elliptical to subcircular placoliths have two apparent furcae at the ends of the major axis of the ellipse in the central area.

Occurrence: Originally described from the Paleocene of Austria. This form occurs sparsely throughout the Eocene section of Wadi Nukhul and most probably considered as a reworked Paleocene form.

Coccolithus eopelagicus (Bramlette & Riedel) (Pl. 1, Fig. 7)

1954 *Tremalithus eopelagicus* (Bramlette & Riedel), Paleont., 28, 392, (Pl. 38, Fig. 2).

1961 *Coccolithus eopelagicus* (Bramlette & Riedel; Bramlette & Sullivan), Micropaleont., 7, 141.

Remarks: Elliptical forms with elliptical central openings. Periphery finely serrate and striae slightly curved, the shape may be oval or circular.

Occurrence: Originally recorded from the Upper Eocene (Oceani Formation) of Barbados. It is also common in the Eocene-Oligocene in many parts of the world. The form is recorded from the Early and Middle Eocene of Wadi Nukhul as well as the Late Paleocene-Early Eocene of Wadi Belayim surface sections.

Genus: *Reticulofenestra* (Hay, Mohler & Wade, 1966); *Reticulofenestra dictyoda* (Deflandre & Fert) (Pl. 1, Fig. 9)

1954 *Discolithus dictyodus* (Deflandre & Fert.) Ann. Paleont., 40, 140, text (Fig. 15, non tex Fig. 16).

1962 *Cyclococcolithus dictyodus* (Deflandre & Fert; Hay & Towe), Eclog. Geol. Helvet., 55, 503, (Pl. 5, Fig. 4, Pl. 7, Fig. 1).

1966 *Reticulofenestra dictyoda*. (Deflandre & Fert; Hay, Mohler & Wade), Eclog. Geol. Helv. 59, 387.

Remarks: This species is distinguished by the smooth appearance of the shields which is due to the high number of the segments.

Occurrence: It has been recorded from the Middle Eocene of France, Upper Eocene-Oligocene of New Zealand, Upper Eocene of Syria and NW Germany. The form is recorded from the Early-Middle Eocene of Wadi Nukhul.

Reticulofenestra umbilica (Levin) (Pl. 2, Fig. 9)

1965 *Coccolithus umbilicus* (Levin), J. Paleont., 39, 265, (Pl. 41, Fig. 2).

1967 *Apertaperta umbilica* (Liven; Levin & Joerger), Micropaleont., 13, 166, (Pl. 1, Fig. 9).

1968 *Reticulofenestra umbilica* (Levin; Martini & Ritzkowski), Nachr. Akad. Wiss. Gottingen., Math. Phys. 1968: 245, (Pl. 1, Figs. 11-12).

Remarks: Coccoliths of this species possess large central openings usually a third or more of the diameter, spanned by a reticulate net which is not preserved in the fossil state in Wadi Nukhul materials.

Occurrence: Originally recorded from the Tortonian of the Vienna Basin, Austria. It was also recorded from the Eocene-Oligocene of North America, and the Upper Eocene of USSR.

This form is recorded to range throughout the Middle Eocene of Wadi Nukhul.

Genus: *Cyclococcolithina* Wilcoxon, 1970., *Cyclococcolithina gammation* (Bramlette & Sullivan) (Pl. 2, Fig. 8)

1961 *Coccolithites gammation* (Bramlette & Sullivan), Micropaleont., 7, 152, (Pl. 7, Figs. 7, 14).

1964 *Cyclococcolithus gammation* (Bramlette & Sullivan; Sullivan) Uni. Calif. Publ. Geol. Sci., 44, 181, (Pl. 3, Fig. 7).

1975 *Cyclococcolithina gammation* (Bramlette & Sullivan) Proto Decima, (Roth & Todesco; Schweiz) Palaont. Abh., 97, 7, (Pl. 2, Fig. 20).

Remarks: Circular coccolith, its central area is somewhat depressed, with a tiny central spot which may represent a central opening. Between crossed nicols the outer portion is indistinct but the inner portion shows clearly the extinction cross, curving strongly in the form of a swastika.

Occurrence: Originally described from the Lower-Middle Eocene of California, Texas, France and Italy. This form is recorded from the Early-Middle Eocene of Wadi Nukhul, as well as the Early Eocene of Wadi Belayim section.

Genus: *Pontosphaera* (Lohmann, 1902); *Pontosphaera multipora* (Kamptner) (Pl. 1, Fig. 10)

1948 *Discolithus multipora* (Kamptner); S.B. Osterr. Akad. Wiss., Math. Naturw. Kl. Abt. 1, 157, 5, (Pl. 1, Fig. 9).

1961 *Discolithus distinctus* (Bramlette & Sullivan); Micropaleont., 7, 141, (Pl. 2, Figs. 8-9).

1965 *Discolithina multipora* (Kamptner, Martini), Proc. 17th.

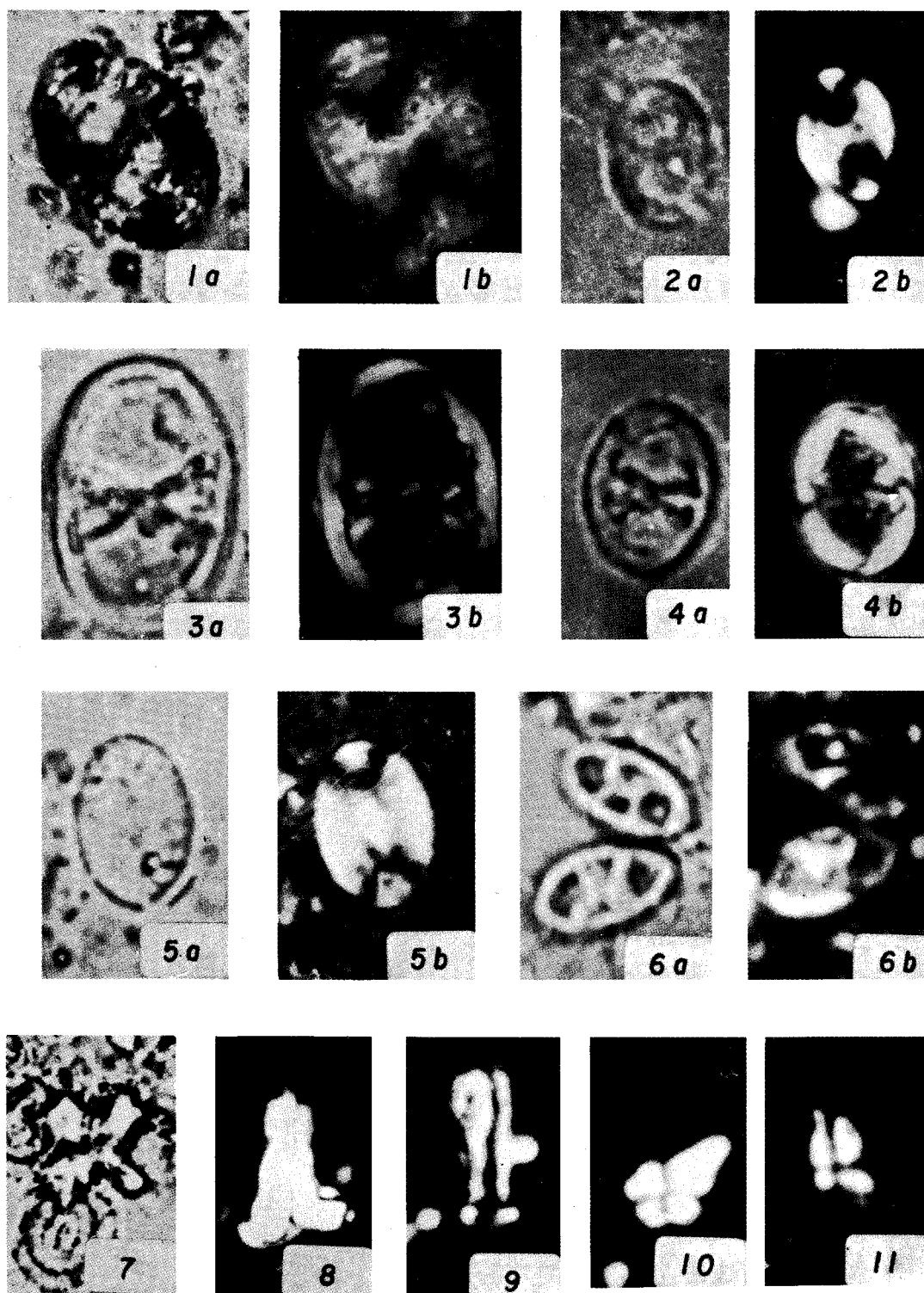


PLATE II

Figures 1, 3, 4, 5, 6, 9 = 3000 ×

Figures 2, 5, 7, 8 = 1500 ×

Fig. 1: *Transversopontis pulchra* (Deflandre), a = nl, b = x-nicHypotype 832, sample 97. Fig. 2: *Transversopontis pulcheroides* (Sullivan), a = nl, b = x-nicHypotype 839, sample 179. Fig. 3: *Neochiastozygus junctus* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 844, sample 3. Fig. 4: *Neochiastozygus concinuss* (Martini), a = nl, b = x-nicHypotype 845, sample 2. Fig. 5: *Pontosphaera plana* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 837, sample 76. Fig. 6: *Neococcolithes dubius* (Deflandre) a = nl, b = x-nicHypotype 851, sample 9. Fig. 7: *Nannotetrina fulgens* (Stradner), nlHypotype 866, sample 17. Fig. 8: *Cyclococcolithina gammation* (Bramlette & Sullivan), a = nl, b = x-nicHypotype 812, sample 79. Fig. 9: *Reticulofenestra umbilica* (Levin),Hypotype 819, sample 207.

Symp. Colston Res. Soc., London, 17, 400.

1975 *Pontosphaera multipora* (Kamptner) Proto Decima, Roth & Todesco; Schweiz. Palaont. Abh., 97, 50, (Pl. 5, Fig. 24).

Remarks: Elliptical discoliths with central area perforated by numerous pores arranged more or less in a circular form.

Occurrence: Originally known in the Miocene deposits of Austria. This form is found to range throughout the Early-Middle Eocene of Wadi Belayim section.

Pontosphaera plana (Bramlette & Sullivan) (Pl. 2, Fig. 5)

1961 *Discolithus planus* (Bramlette & Sullivan), Micropaleont., 7, 143, (Pl. 3, Fig. 7).

1971 *Pontosphaera plana* (Bramlette & Sullivan) Haq; Stockh. Contr. Geol., 25, 22, (Pl. 10, Fig. 1, Pl. 12, Fig. 6).

Remarks: Elliptical discoliths consisting of a single plate with a line along the long axis, with two slit-like openings appear to have a slightly sigmoid curvature in plane view.

Occurrence: Originally described from the Lower-Middle Eocene of California and Texas. It is also reported from the Upper Eocene-Lower Oligocene in Mississippi and Alabama. This form is found to range throughout the Early Eocene of Wadi Belayim surface section.

Genus: *Transversopontis* (Hay, Mohler & Wade, 1966),

Transversopontis pulcheroides (Sullivan) (Pl. 2, Fig. 2)

1964 *Discolithus pulcheroides* (Sullivan), Univ. Calif. Publ. Sci., 44, 183, (Pl. 4, Fig. 7).

1969 *Ciscolithina pulcheroides* (Sullivan, Martini), Senckenb. Leth., 50, 135, (Pl. 1, Figs. 9-10).

1971 *Transversopontis pulcheroides* (Sullivan, Perch-Nielsen), Biol. Skr. Dan. Vid. Selsk., 18, 40, (Pl. 43, Figs. 3, 7).

Remarks: This species is distinguished from *Transversopontis pulchra* (Deflandre) by having a more oblique central bridge separating two oblique semicircular windows.

Occurrence: This species has been recorded from the Paleocene-Upper Eocene strata of Europe and North America. This form is known in the Early-Middle Eocene of Wadi Nukhul as well as the Late Paleocene-Early Eocene of Wadi Belayim surface sections.

Transversopontis pulchra (Deflandre) (Pl. 2, Fig. 1)

1954 *Discolithus pulcher* Deflandre (in Deflandre & Fert), Ann. Paleont., 40, 142, (Pl. 12, Figs. 17-18).

1965 *Discolithina pulchra* (Deflandre) Levin; J. Paleont., 39, 266, (Pl. 41, Fig. 6)

1966 *Transversopontis pulchra* (Deflandre) (Hay, Mohler & Wade), Ecol. Geol. Helvet., 59, 391.

Remarks: Elliptical discoliths with transverse bridge slightly oblique, almost coinciding with the short axis of the ellipse.

Occurrence: Originally recorded from the Middle Eocene of France. It was also known in the Lower and Middle Eocene of California, Upper Eocene-Middle Oligocene of Alabama and in the Eocene of Denmark. This form is found to range throughout the Early-Middle Eocene of Wadi Nukhul and the Late Paleocene-Early Eocene of Wadi Belayim surface sections.

Genus: *Neochiastozygus* (Perch-Nielsen, 1971), *Neochiastozygus concinnus* (Martini), (Pl. 2, Fig. 4)

1961 *Zycolithus concinnus* (Martini) Senckenb. Leth., 42, 18, (Pl. 3, Fig. 35, Pl. 5, Fig. 54).

1969 *Heliorthus concinnus* (Martini, Perch-Nielsen), Medd. Dan. Geol. Foren., 19, 62, (Pl. 5, Figs. 6-8).

1971 *Neochiastozygus concinnus* (Martini, Perch-Nielsen), Bull. Geol. Soc. Denmark, 21, 59, (Pl. 4, Fig. 6; Pl. 7, Figs. 4-6).

Remarks: An elliptical ring having an X-shaped structure spanning the central opening.

Occurrence: Originally recorded from the Upper Paleocene of Germany and from Paleocene-Early Eocene in various parts of the world. This form is found to occur in the Early Eocene of Wadi Nukhul.

Neochiastozygus junctus (Bramlette & Sullivan) (Pl. 2, Fig. 3)

1961 *Zycolithus junctus* (Bramlette & Sullivan), Micropaleont., 7, 150, (Pl. 6, Fig. 11a, b).

1967 *Heliorthus junctus* (Bramlette & Sullivan; Hay & Mohler), J. Paleont., 41, 1533.

1971 *Neochiastozygus junctus* (Bramlette & Sullivan; Perch Nielsen) Bull. Geol. Soc. Denmark, 21, 61, (Pl. 4, Figs. 7-8; Pl. 7, Figs. 18-19).

Remarks: Elliptical rings with a thin rim and open central area spanned by a delicately and very narrow cross in transversal direction.

Occurrence: Originally known in the Paleocene California and Alabama. It was also recorded from the Early Eocene of Wadi Belayim surface section.

Genus: *Neococcolithes* (Sujkowski, 1931), *Neococcolithes dubius* (Deflandre), (Pl. 2, Fig. 6)

1954 *Zycolithus dubius* (Deflandre), (in Deflandre & Fert); Ann. Paleont., 40: 149, (text Fig. 43-44, 68).

1964 *Chiphragmalithus dubius* (Deflandre) Sullivan; Univ. Calif. Publ. Geol. Sci., 44, 179 (Pl. 1, Fig. 2).

1967 *Neococcolithes dubius* (Deflandre) Black; Proc. Geol. Soc. London, 1640, 143.

Remarks: Elliptical zycoliths with a central area spanned by a longitudinal bar with forked ends giving rise to an H-shaped rather than X-shaped structure.

Occurrence: Originally known from the Eocene sediments of France. This species is found to occur in the Early and Middle Eocene of Wadi Nukhul as well as the Early Eocene of Wadi Belayim surface sections.

Genus: *Fasciculithus* (Bramlette & Sullivan, 1961); *Fasciculithus involutus* (Bramlette & Sullivan); (Pl. 1, Fig. 8)

1961 *Fasciculithus involutus* (Bramlette & Sullivan), Micropaleont., 7; 164, (Pl. 14, Figs. 1-5).

Remarks: The recorded specimens from the studied sections have more or less the characters like those originally recorded and described by (Bramlette & Sullivan, 1961) from California.

Occurrence: Originally described from the Paleocene-Early Eocene of California, also the same level from England and France. This species is reported sporadically in the Middle Eocene of Wadi Nukhul which is most probably a reworked form. On the other hand, it is recorded from the Late Paleocene-Early Eocene of Wadi Belayim section.

Genus: *Nannotetrina* (Achuthan & Stradner, 1969), *Nannotetrina fulgens* (Stradner) (Pl. 2, Fig. 7)

1960 *Nannotetrina fulgens* (Stradner) (in Martini & Stradner), Erdol Zeitschr., 76; 268 pp., Figs. 10, 16.

1961 *Chiphragmalithus quadratus* (Bramlette & Sullivan); Micropaleont., 17: 157, (Pl. 10, Figs. 14-15).

Remarks: This species is distinguished by its four rays slightly offset at the centre with no marginal rim not forming windows. The specimens recorded in the studied materials are mostly overgrown.

Occurrence: Originally described from the Middle Eocene of many countries as California, Trinidad, Italy, Yugoslavia and Germany. It is recorded from the Early-Middle Eocene of Wadi Nukhul surface section.

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