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Neogene Nannofossils and Biostratigraphy of the Sadaf-1 Well, Offshore Pakistan

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ABSTRACT

The biostratigraphy of Sadaf-1 well has been established on the basis of nannofossils. The rock samples between the interval 2640-13050 ft are dated from Early Pliocene to Early Miocene. Fifty-six species of nannofossils are identified, and with the help of the index species and some additional assemblage, Neogene nannofossil zonal boundaries are marked. Five important species are measured and their taxonomy is described.

INTRODUCTION

Occidental of Pakistan (Oxy) drilled Sadaf-1 well in Indus delta about 150 km SSW of Karachi. Nannofossil biostratigraphy of the well based on analysis of 56 rock samples (ditch cuttings at 200 feet interval and 3 core samples) has been carried out and reported in the present paper which also includes a range chart illustrating distribution of various species of nannofossils (Figure 1) and 4 plates containing photographs of important identifications.

In the Sadaf-1 borehole, the samples yielded nannofossils and barren samples are rare. Most of the samples have a poor frequency of nannofossils. The frequency of the nannofossils species is given in Figure 1. Reworked Cretaceous nannofossils are common throughout the samples. This reveals that the source of reworked material can be expected from the Kirthar Range. Paleogene and Miocene reworking is also present in some samples. Although the possible precautionary measures have been taken throughout the study yet the risk of contamination is still existing due to the ditch cuttings and clayey lithology. The stratigraphic Neogene ranges of nannofossils (which are present in the investigated samples) by different authors are given in Table 1. *Discoaster barbadiensis, D. mohleri, D. tanii, D. binodosus, Reticulofenestra scissura, Biantholithus sparsus, Sphenolithus radians* and *Ericsonia robusta* are restricted to the Paleogene and therefore interpreted as reworked.

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METHODS AND MATERIAL

Generally, to study nannofossils from ditch cuttings, washing of the samples is preferable to avoid contamination. But the Sadaf-1 well yields mainly clays so that washing of the samples was not practicable. Fifty-three ditch cutting samples from interval 2460-13050 ft and 3 core samples at 9760, 10710 and 10824 ft were analysed. The big pieces of cuttings were picked and washed to clean any mud particles attached to the cuttings. The cuttings were scratched with steel nail about .5 to 1 gram of sediments in a plastic beaker and filled with 10-20 ml of distilled water. To avoid dissolution of the nannofossils a small quantity of Ammonia was added to get a pH value above 7 of the distilled water. This water mixed rock sample was treated in ultrasonic bath for 4 minutes. This suspension then was decanted in another beaker to discard the coarser residue. After 10 minutes the suspension was decanted again and a few drops from the bottom suspension were mounted on the slides in Canada balsam as mountant.

Measuring and Study Techniques

A LEITZ Ortholux II polarizing microscope with phase contrast using oil immersion (x100 objective and x10 eyepiece) has been used for investigation. Not more than 300 specimens have been counted and four lines on each slide were investigated. The size of the coccoliths was measured by using an eyepiece graticule, each division on this graticule is equal to 2μm.

Data Presentation

The quantity of nannofossil species is presented in Figure 1. This presentation is in percentage (present = less than 5 %, common = 5 - 10 % and abundant = more than 10 %) of the nannofossils assemblage in the sample. Only those samples are considered for percentage presentation in which more than twenty specimens are counted. Only the presence of the species is mentioned in those samples which do not yield more than twenty specimens, but percentage is not counted.

Table 1. Stratigraphic ranges of selected Neogene species by different authors (for those index-markers and additional markers, where the ranges differ, the underlined ranges are considered in this report).

Name of species	Perch-Nielsen (1985)	Martini (1971)	Martini & Müller(1986)	Young (1990)
Calcidiscus macintyrei	NN4-NN19			
Coronocyclus nitescens	L.Eocene- L-Miocene		NP23-NN6	
Cyclicargolithus abisectus	LO in NN1 NP24-NN1		NP24-NN6	
Cyclicargolithus floridanus	LO in NN6		NP16-NN6	last occurrence in NN6
Discoaster bellus	NN9-NN10			
Discoaster brouweri	NN9-NN10 NN8-NN18	NN5-NN18	NN5-NN18	
Discoaster druggii	NN2-NN5	NN2-NN5	NN2-NN5	
Discoaster formosus	NN5	NN5	NN5	
Discoaster hamatus	NN9	NN9	NN9	
Discoaster quinqueramus	NN11	NN11	NN11	
Discoaster variabilis	NN4-NN16	NN4-NN16	NN4-NN16	
Helicoponto-sphaerakamptenri	NN2-NN21 NN1-NN21	NN2-NN21	NN1-NN21	
Reticulofenestra pseudoumbilica	NN7-NN15	NN11-NN15	NN1-NN15	NN5-NN15
Sphenolithus abies	NN11-NN15 NN9-NN15	NN10-NN15)	NN5-NN15	
Sphenolithus belemnos	NN3 NN1-NN3	NN1-NN3	NN1-NN3	
Sphenolithus capricornutus	NP25-NN1	NP25-NN1		
Sphenolithus conicus	NN1-NN3	NP25-NN1		
Sphenolithus dissimilis	NP24-NN2	LO in NN2		
Sphenolithus moriformis	NP12-NN9			
Sphenolithus verensis	NN10-NN13			

BIOSTRATIGRAPHY

The Neogene zonation (NN zones) of Martini (1971), Martini and Müller (1986) is used in the present study. In some parts of the well, due to the absence of index-markers, some other species are used as additional markers.

The original definitions of the zones are as follows:

Zone NN 15 - (*Reticulofenstra pseudoumbilica* zone): LO (last occurrence) of *Amaurolithus tricorniculatus* to LO of *R. pseudoumbilica.*
Modification: The LO of *Sphenolithus abies* is also used for the top of NN 15.

Zone NN 14 - (*Discoaster asymmetricus* zone): FO (first occurrence) of *Discoaster asymmetricus* to LO of *Amaurolithus tricorniculatus.*

Zone NN 13 - (*Ceratolithus rugosus* zone): FO of *Ceratolithus rugosus* to FO of *Discoaster asymmetricus.*

Zone NN 12 - (*Amaurolithus tricorniculatus* zone): LO of *Discoaster quinqueramus* to FO of *Ceratolithus rugosus.*

Zone NN 11 - (*Discoaster quinqueramus* zone): FO to LO of *D. quinqueramus.*

Zone NN 10 (*Discoaster calcaris* zone): LO of *Discoaster hamatus* to FO of *D. quinqueramus.*

Zone NN 9 - (*Discoaster hamatus* zone): FO to LO of *D. hamatus.*

Zone NN 8 - (*Catinaster coalitus* zone): FO of *Catinaster coalitus* to FO of *D. hamatus.*

Zone NN 7 - (*Discoaster kugleri* zone): FO of *D. kugleri* to FO of *Catinaster coalitus.*

Zone NN 6 - (*Discoaster exilis* zone): LO of *Sphenolithus heteromorphus* to FO of *D. kugleri.*
Modification: Due to the absence of *D. kugleri* the LO of *Cyclicargolithus floridanus* is used for the top of the NN 6 zone. (This boundary is comparatively lower than the standared boundary of Martini and Müller (1986), as the LO of *C. floridanus* is within NN 6)

Zone NN 5 - (*Sphenolithus heteromorphus* zone): LO of *Helicopontosphaera ampliaperta* to LO of *Sphenolithus heteromorphus.*
Modification: As the zone NN 4 has not been approached in this borehole, the LO of *H. ampliaperta* could not be applied for the identification of the base of NN

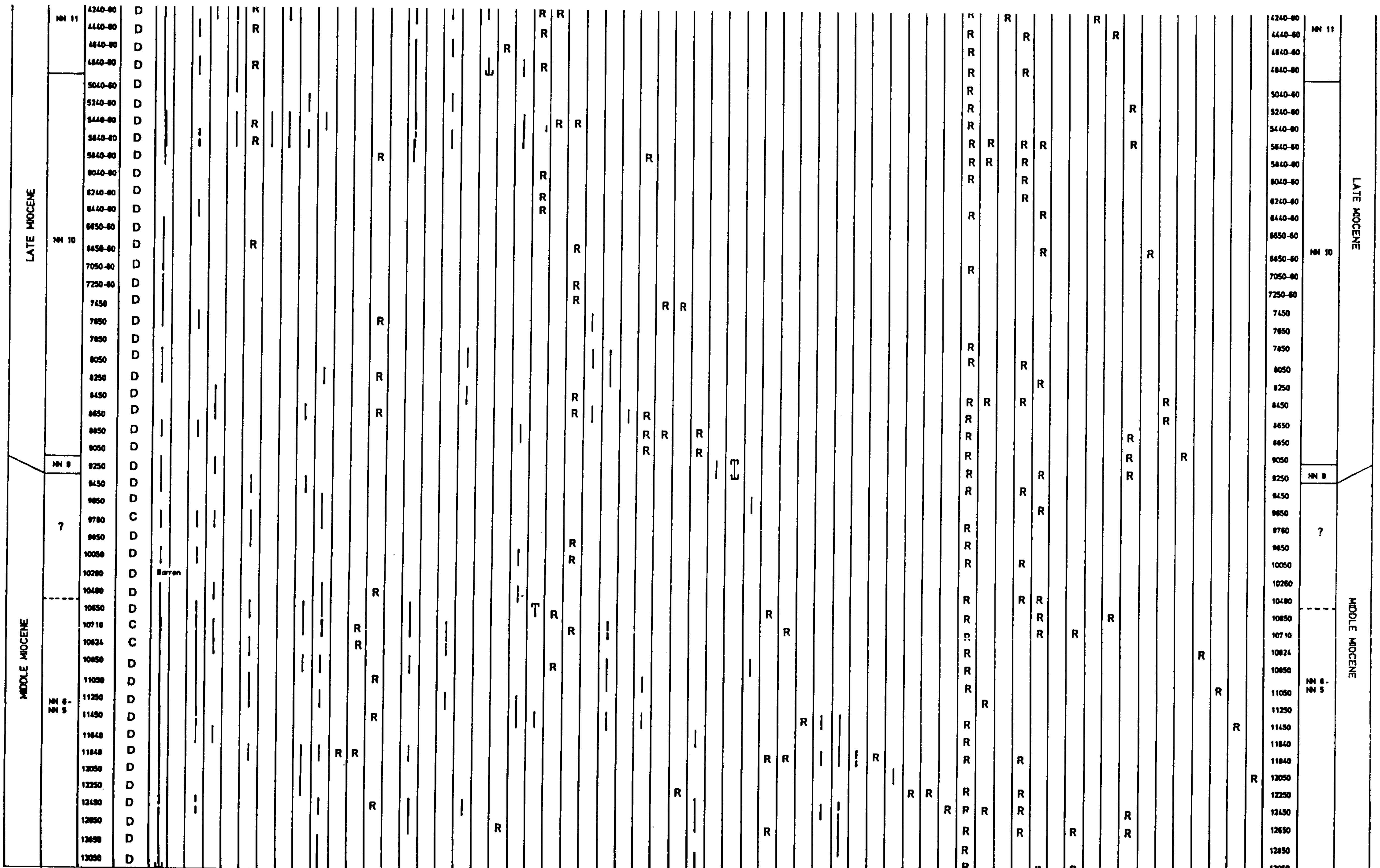


Figure 1— Neogene Nannofossils range chart Sadaf-1 well.

NANNOFOSSIL BIOSTRATIGRAPHY SADAF-1 WELL OCCIDENTAL PAKISTAN

Used makers: ⌊ First occurrence; ⌋ Last occurrence; R Reworked; | Present (< 5%); ¦ Common (5-10%); ┃ Abundant (> 10%); D Ditch cutting; C Cored sample

AGE	EARLY PLIOCENE							
BIOZONE (MARTINI 1971)	NN 15- NN 12							
DEPTH IN FEET	4040-80	3840-80	3640-80	3440-80	3240-80	3040-80	2940-80	2840-80
TYPE OF SAMPLES	D	D	D	D	D	D	D	D
Reticulofenestra pseudoumbilica	—	—	—	—	—	—	—	—⌋
Discoaster druggii							R	
Coccolithus pelagicus		– –			– –		– –	
Helicopontosphaera kamptneri	–	—			—	—	—	– –
Sphenolithus abies	—	—	—			—	—	—⌋
Sphenolithus moriformis		R			R		R	
Sphenolithus verensis		– –				—	—	—
Reticulofenestra cf. haqii	—	– –				—	—	– –
Reticulofenestra sp.			—	—	—		—	
Calcidiscus macintyrei		—			– –		—	
Sphenolithus conicus							R	
Sphenolithus dissimilis							R	
Discoaster barbadiensis							R	
Discoaster tanii							R	
Dictyococcites antarcticus	—						—	
Dictyococcites productus					—			
Discoaster sp.	—							
Calcidiscus leptoporus		—			—			
Discoaster quinqueramus	–	—⌋						
Discoaster mohleri			R					
Coccolithus miopelagicus		—						
Cyclicargolithus floridanus								
Cyclagelosphaera margerelii								
Reticulofenestra scissura								
Discoaster brouweri		—						
Umbilicosphaera sibogae		—						
Pyrocyclus inversus		—						
Braarudosphaera bigelowii								
Calcidiscus protoannulus								
Biantholithus sparsus								
Coronocyclus nitescens								
Discoaster bellus								
Discoaster hamatus								
Discoaster formosus								
Sphenolithus belemnos								
Sphenolithus capricornutus								
Discoaster binodosus								
Calcidiscus sp.								
Cyclicargolithus abisectus								
Sphenolithus sp.								
Sphenolithus radians								
Discoaster cf. variabilis								
Pemma rotundum								
Pemma papillatum								
Ericsonia robusta								
REWORKED CRETACEOUS SPECIES								
Watznaueria barnesae	R	R	R	R	R	R	R	
Ceratolithoides aculeus							R	
Quadrum trifidum							R	
Stradneria crenulata			R		R		R	
Micula staurophora					R	R		
Quadrum sp.					R			
Prediscosphaera cretacea			R					
Eprolithus floralis								
Nephrolithus frequens								
Eiffellithus eximius								
Micrantholithus obtusus								
Micula murus								
Microrhabdulus decoratus								
Braarudosphaera discula								
Biscutum constans								
Watznaueria biporta								
Rucinolithus sp.								

DEPTH IN FEET	4040-80	3840-80	3640-80	3440-80	3240-80	3040-80	2840-80	2840-80
BIOZONE (MARTINI 1971)	NN 15- NN 12							
AGE	EARLY - PLIOCENE							

NANNOFOSSIL BIOSTRATIGRAPHY SADAF-1 WELL OCCIDENTAL PAKISTAN

5 zone. The FO of *Reticulofenestra pseudoumbilica* is used additionally to mark the base of this zone.

Interval 2840-60 to 3640-60 ft (Zones NN 15 - NN 12)

Due to the absence of the index-markers *Amaurolithus tricorniculatus, Discoaster asymmetricus* and *Ceratolithus rugosus* it is not possible to differentiate between the zones NN 15 - NN 12. The LO of *D.quinqueramus* in sample 3840-60 indicates the base of NN12. The LO's of *R. pseudoumbilica* and *Sphenolithus abies* are used for the top of NN 15 - NN 12 in sample 2840-60 ft. A number of specimens of *R. pseudoumbilica* range in size of 4µm - 5µm. The recent study of Young (1990) supports to put this size of *R. pseudoumbilica* in the late NN 11 - NN 15.
Age: Early Pliocene

Interval 3840-60 to 4840-60 ft (Zone NN 11)

The LO of *D. quinqueramus* in sample 3840-60 ft and its FO in 4840-60 ft demarcates the NN 11 zone. In this interval reworked Cretaceous and Tertiary nannofossils are present however the specimens of *D. quinqueramus* are in situ.
Age: Late Miocene

Interval 5040-60 to 9050 ft (Zone NN 10)

The FO of *D. quinqueramus* in the overlying sample 4840-60 ft defines the top of zone NN 10 in sample 5040-60 ft, and the LO of *Discoaster hamatus* in sample 9250 ft indicates the base of zone NN 10 in 9050 ft.
Age: Late Miocene

Interval 9250 ft (Zone NN 9)

The sample has yielded single specimen of *D.hamatus* and *D.bellus. D.hamatus* is index species for NN9, therefore this sample is assigned NN9 zone. Some reworked Cretaceous species are also encountered.
Age: According to Martini and Müller (1986) the boundary between Middle and Late Miocene lies in zone NN9.

Interval 9450 to 10060 ft

In this interval most of the samples are almost barren, but some samples have yielded long ranging species therefore zonation is not possible.

Age: According to law of superposition this interval can be assigned the Middle Miocene age.

Interval 10650 to 13050 ft (Zones NN 6-NN5)

The index-markers of the zones NN 8 to NN 5 *Catinaster coalitus, Discoaster kugleri* and *Sphenolithus heteromorphus* are absent in this interval. However, the LO's of *Cyclicargolithus floridanus, Cyclicargolithus abisectus* and *Coronocyclus nitescens*, (NN 6) and the FO of *R. pseudoumbilica* (NN 5) is used to define the NN 6 - NN 5 zones. Because of the absence of *Sphenolithus heteromorphus* or other markers the differentiation between NN 5 and NN 6 is not possible.
Age: Middle-Early Miocene.

TAXONOMY

Reticulofenestra pseudoumbilica
(Gartner 1967) Gartner 1969

* 1967 *Coccolithus pseudoumbilicus* Gartner p. 4, pl. 6, figs. 1,2,3a - c, 4a - c.
1969 *Reticulofenestra pseudoumbilica* (Gartner 1967). -Gartner p. 598, pl. 2, fig. 4.
1971 *Reticulofenestra pseudoumbilica* (Gartner 1967 Gartner 1969).- Martini p. 769, pl. 4, figs. 10 - 11.
1975 *Reticulofenestra ampla* (Kamptner 1958).- Jafar p. 65, pl. 8, figs. 1, 14, 15.
1978 *Reticulofenestra pseudoumbilica* (Gartner 1967 Gartner 1969).- Backman p. 100, pl. 1, figs. 5,6.
1978 *Reticulofenestra gelidus* (Geitzenauer 1972).-Backman p. 112, pl. 1, figs. 7-9.
1979 *Reticulofenestra pseudoumbilica* (Gartner 1967 Gartner 1969).- Chi p. 135, pl. 1, figs. 9-11, 27-28.
1980 *Reticulofenestra pseudoumbilica* (Gartner 1967 Gartner 1969).- Backman p. 38, pl. 5, figs. 1-8.
1985 *Reticulofenestra gelidus* (Geitzenauer 1972 Backman 1978).- Perch-Nielsen fig. 59.

Description

Elliptical to sub-elliptical placolith, having a wide elliptical margin around an elliptical central opening, which is nearly one third of the length of the coccolith. In crossed polarized light the margin appears bright surrounding a dark squarish-rectangular central area. In some specimens the central area shows dark points representing the fine network of the central area. In most of the specimens the

PLATE I

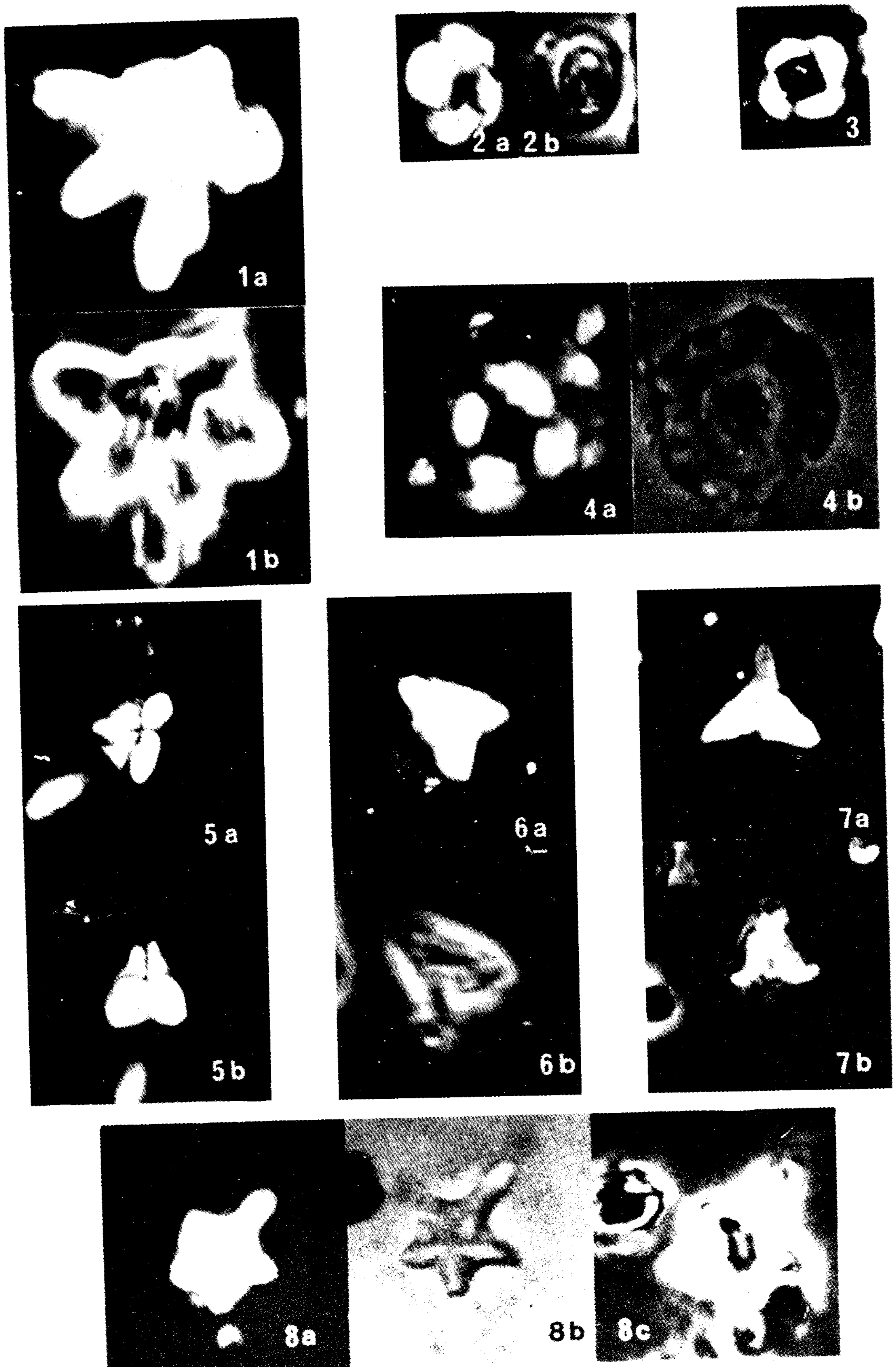


PLATE II

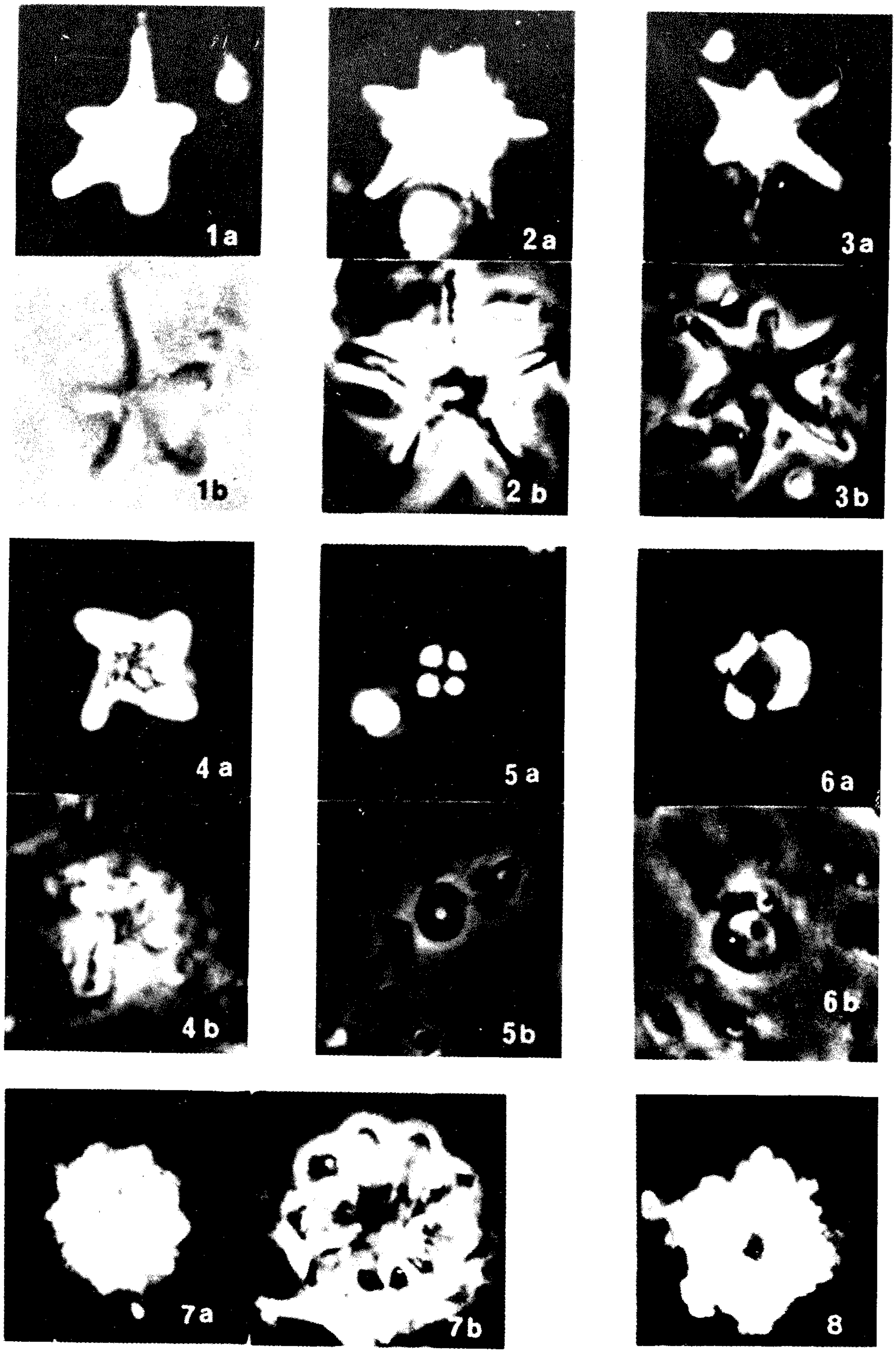


PLATE III

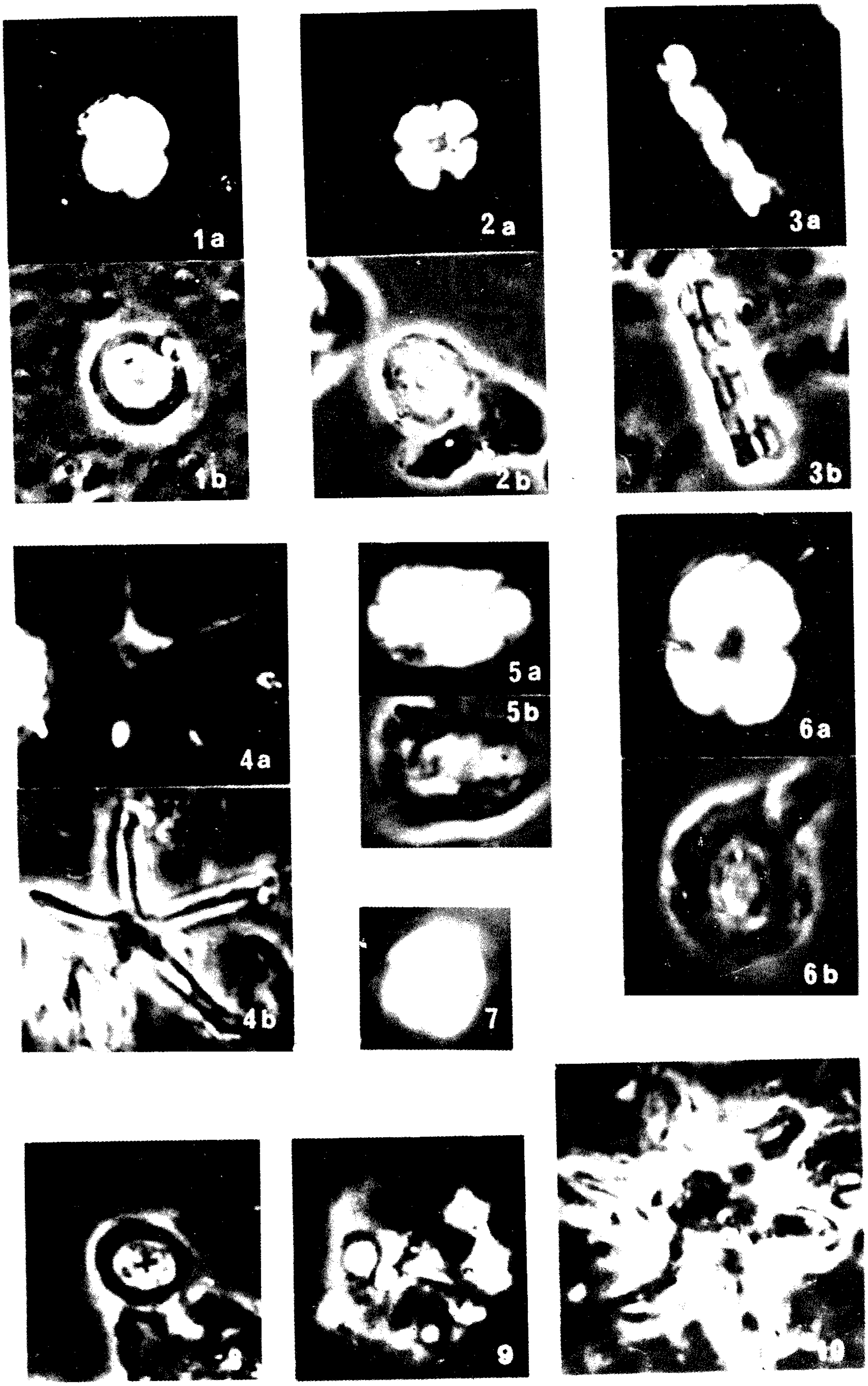
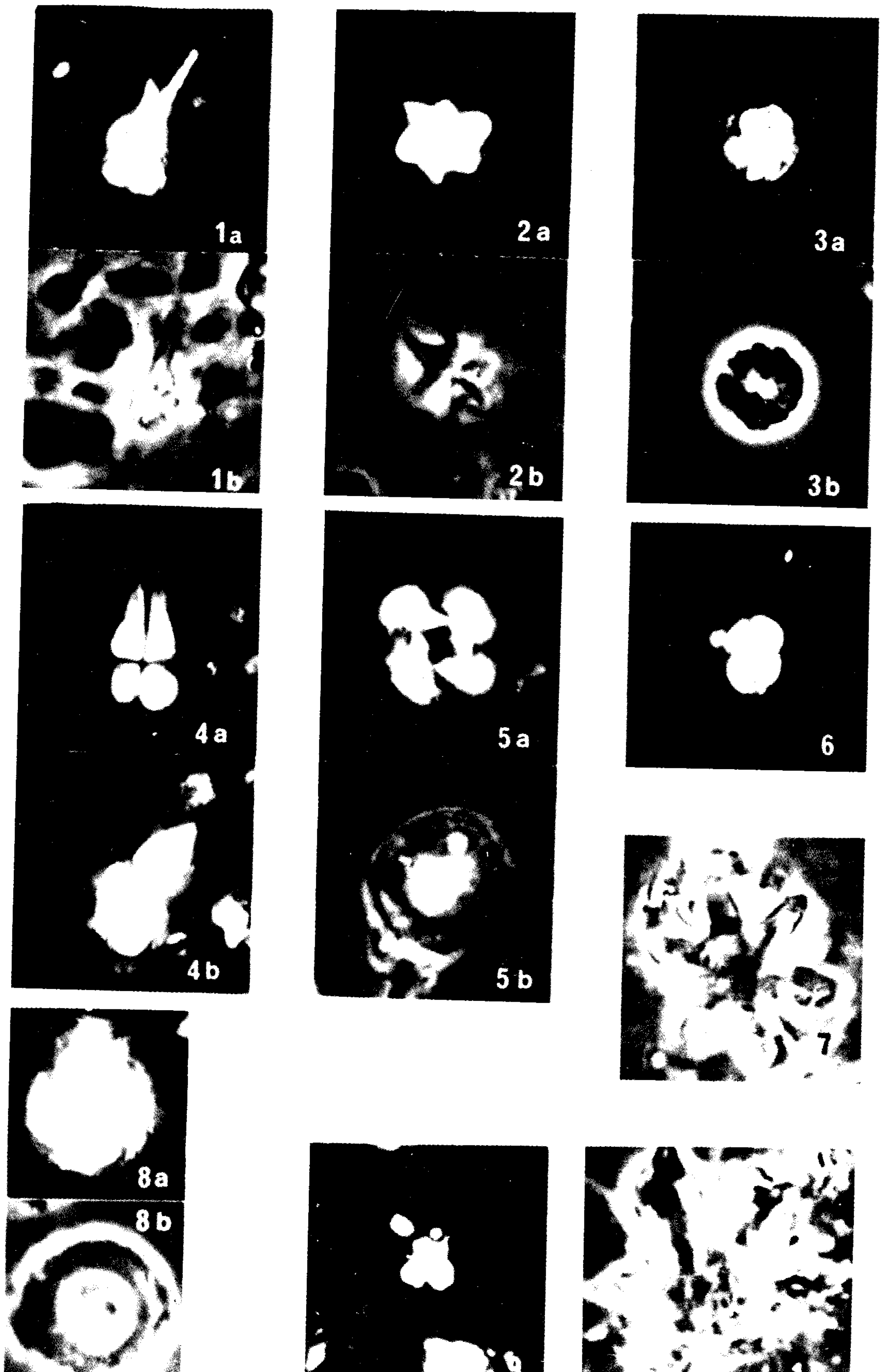


PLATE IV



DISCRIPTION OF PLATES
(All photographs x3300)

PLATE I

1. *Discoaster druggii* Bramlette and Wilcoxon 1967
   Depth 2840-60 ft; NN 15 - NN 12, Early Pliocene (reworked from Early - Middle Miocene).
   a) Polarized light; b) Phase contrast.

2. *Reticulofenestra pseudoumbilica* (Gartner 1967) Gartner 1969
   Depth 2840-60 ft; NN 15 NN 12, Early Pliocene.
   a) Polarized light; b) Phase contrast.

3. *Reticulofenestra pseudoumblica* (Gartner 1967) Gartner 1969
   Depth 3840-60 ft; NN 11, Late Miocene.
   Polarized light.

4. *Coccolithus miopelagicus* Bukry 1971
   Depth 4840-60 ft; NN 11, Late Miocene.
   a) Polarized light; b) Phase contrast.

5. *Sphenolithus conicus* Bukry 1971
   Depth 2840-60 ft; NN 15 - NN 12, Early Pliocene (reworked from Early Miocene).
   a) Polarized light at 45^{o}; b) Polarized light at 0^{o}.

6. *Ceratolithoides aculeus* (Stradner 1961) Prins and Sissingh 1977
   Depth 2840-60 ft; NN 15 - NN 12, Early Pliocene (reworked from Cretaceous).
   a) Polarized light, b) Phase contrast.

7. *Quadrum trifidum* (Stradner 1961) Prins and Perch-Nielsen 1977
   Depth 2840-60 ft; NN 15 - NN 12, Early Pliocene (reworked from Cretaceous).
   a) Polarized light; b) Phase contrast.

8. *Discoaster sp.*
   Depth 4040-60 ft; NN 11, Late Miocene.
   a) Polarized light; b) Bright field; c) Phase contrast.

PLATE II

1. *Discoaster sp.*
   Depth 4640-60 ft; NN 11, Late Miocene.
   a) Polarized light; b) Phase contrast.

2. *Discoaster quinqueramus* Gartner 1969
   Depth 3840-60 ft; NN 11, Late Miocene.
   a) Polarized light; b) Phase contrast.

3. *Discoaster brouweri* Tan 1927 emend. Bramlette and Riedel 1954
   Depth 7650 ft; NN 10, Late Miocene.
   a) Polarized light; b) Phase contrast.

4. *Micula murus* (Martini 1961) Bukry 1973
   Depth 8650 ft; NN 10, Late Miocene (reworked from Late Cretaceous).
   a) Polarized light; b) Phase contrast.

5. *Umbilicosphaera sibogae* Gartner 1970
   Depth 8050 ft; NN 10, Late Miocene
   a) Polarized light; b) Phase contrast.

6. *Coronocyclus nitescens* (Kamptner 1963) Bramlette and Wilcoxon 1967
   Depth 8850 ft; NN 10, Late Miocene.
   a) Polarized light; b) Phase contrast.

7. *Discoaster barbadiensis* Tan 1927
   Depth 5840-60 ft; NN 10, Late Miocene (reworked from Eocene).
   a) Polarized light; b) Phase contrast.

8. *Coccolithus miopelagicus* Bukry 1971
   Depth 5440-60 ft; NN 10, Late Miocene.
   Polarized light.

DISCRIPTION OF PLATES
(All photographs x3300)

PLATE III

1. *Cyclicargolithus floridanus* (Roth and Hay 1967) Bukry 1971
   Depth 6440 ft; NN 10, Late Miocene (reworked from Early Miocene).
   a) Polarized light; b) Phase Contrast.

2. *Pyrocyclus inversus* (Bukry and Bramlette 1969) Wise 1976
   Depth 8650 ft; NN 10, Late Miocene.
   a) Polarized light; b) Phase contrast.

3. *Microrhabdulus decoratus* Deflandre 1959
   Depth 9050 ft; NN 10, Late Miocene (reworked from Cretaceous.
   a) Polarized light; b) Phase contrast.

4. *Discoaster hamatus* Martini and Bramlette 1963
   Depth 9250 ft; NN 9, Late Miocene.
   a) Polarized light; b) Phase contrast.

5. *Helicopontosphaera kamptneri* Hay and Mohler 1967
   Depth 10710 ft; NN 6 - NN 5, Middle Miocene.
   a) Polarized light; b) Phase contrast.

6. *Reticulofenestra pseudoumbilica* (Gartner 1967) Gartner 1969
   Depth 10710 ft; NN 6 - NN 5, Middle Miocene.
   a) Polarized light; b) Phase contrast.

7. *Cyclagelosphaera margerelii* Noel 1965
   Depth 5440 ft; NN 10, Late Miocene (reworked from Cretaceous).
   Polarized light.

8. *Prediscosphaera cretacea* (Arkhangelsky 1912) Gartner 1968
   Depth 10710 ft; NN 6 - NN 5, Middle Miocene (reworked from Cretaceous).
   Phase contrast.

9. *Pemma papillatum* Martini 1959
   Depth 12250 ft; NN 6 - NN 5, Middle Miocene (reworked from Eocene).
   Polarized light.

10. *Discoaster formosus* Martini and Worsley 1971
    Depth 9650 ft; Middle Miocene.
    Phase contrast.

PLATE IV

1. *Sphenolithus capricornutus* Bukry and Percival 1971
   Depth 10710 ft; NN 6 - NN 5, Middle Miocene (reworked from Late Oligocene - Early Miocene).
   a) Polarized light; b) Phase contrast.

2. *Rucianolithus sp.*
   Depth 12050 ft; NN 6-NN 5, Middle Miocene (reworked from Cretaceous.
   a) Polarized light; b) Phase contrast.

3. *Calcidiscus leptoporus* (Murray and Blackman 1898) Loeblich and Tappan 1978
   Depth 12450 ft; NN 6 - NN 5, Middle Miocene.
   a) Polarized light; b) Phase contrast.

4. *Sphenolithus radians* Deflander 1952
   Depth 11840 ft; NN 6 - NN 5, Middle Miocene (reworked from Eocene).
   a) Polarized light at 0^{o}; b) Polarized light at 45^{o}.

5. *Cyclicargolithus abisectus* (Müller 1970) Wise 1973
   Depth 12450 ft; NN 6 - NN 5, Middle Miocene.
   a) Polarized light; b) Phase contrast.

6. *Dictyococcites antarcticus* Haq 1976
   Depth 12450 ft; NN 6-NN 5, Middle Miocene.
   Polarized light.

7. *Discoaster formosus* Martini and Worsley 1971
   Depth 10850 ft; NN-6-NN 5, Middle Miocene.
   Phase contrast.

8. *Calcidiscus macintyrei* (Bukry and Bramlette 1969) Loeblich and Tappan 1978
   Depth 10710 ft; NN 6 - NN 5, Middle Miocene.
   a) Polarized light; b) Phase contrast.

9. *Sphenolithus belemnos* Bramlette and Wilcoxon 1967
   Depth 11840 ft; NN 6 - NN 5, Middle Miocene (reworkedfrom Early Miocene).
   Polarized light.

10. *Discoaster cf. variabilis* Martini and Bramlette 1963
    Depth 12050 ft; NN 6 - NN 5, Middle Miocene.
    Phase contrast.

central area has been destroyed. The extinction bands are sharp in the centre but faint in the distal area.

Size

From the sample 3840-60 feet 200 specimens are measured. Among 200 specimens 150 specimens have a length in between 4µm - 5µm, and 48 specimens are larger than 5µm but not more than 6µm. Similarly width-wise 150 specimens lie in between 3µm - 4µm and 45 in between 4µm - 5µm. Only 2 specimens have the length of 7µm and 5 specimens have a width of larger than 5µm and smaller than 6µm.

Remarks

R. pseudoumbilica closely resembles *R. umbilica* (Levin 1965) Martini and Ritizkowski (1968) but *R. umbilica* is much larger in size i.e. 11-21µm (according to Romein, 1979); *R. pseudoumbilica* has the size of 4-7µm in the sample under investigation and not more than 10µm in the literature. Backman (1980) has discussed in detail the comparison of *Reticulofenestra pseudoumbilica* and *R. gelidus* (Geitzenauer 1972) and proposed *R. gelidus* as a junior synonym of *R. pseudoumbilica, R. minutula* (Gartner 1967) Haq and Berggren 1978 also looks similar (may be synonym) to *R. pseudoumbilica* but cannot be differentiated in light microscope study.

Occurrence

NN 5 - NN 15 according to Young (1990).

Sphenolithus verensis
Backman 1978

1969 *Sphenolithus abies* (Deflandre 1953). - Boudreaux p. 280, figs. 1,2,3.

* 1978 *Sphenolithus verensis* Backman p. 111, pl. 2, figs. 4 - 6, 11, 12.

1985 *Sphenolithus verensis* (Backman 1978).- Perch-Nielsen p. 522, figs. 70-71.

Description

The species has a broad base which consists of longer spines. The distal part is also made up of smaller spines forming a cone shape. In polarized light the species shows median extinction bands.

Size

Height 4-7µm, 15 specimens in sample 3840-60 ft are measured.

Remarks

In light microscope S. verensis can be confused with *S. abies* and *S. moriformis* (Brönnimann and Stradner 1960) Bramlette and Wilcoxon 1967 but it can be distinguished due to its broader base and more irregular outline. *S. moriformis* has a hemispheric outline and *S. abies* has shorter basal spines.

Occurrence:

NN 10 - NN 13

Helicopontosphaera kamptneri
Hay and Mohler 1967

* 1967 *Helicopontosphaera kamptneri* Hay and Mohler p.448, pl. 10, figs.5, pl. 11, fig. 5.

1967 *Helicosphaera carteri* (Wallich 1877, Kamptner 1954). - Bramlette and Wilcoxon, p. 237, pl. 6, figs. 9-10.

1969 *Helicopontosphaera kamptneri* (Hay and Mohler 1967).-Boudreaux and Hay p. 272, pl. 6, figs. 8, 10-15.

1975 *Helicopontosphaera kamptneri* (Hay and Mohler 1967).-Jafar p. 76, pl. 9, figs. 1-7.

1977 *Helicopontosphaera kamptneri* (Hay and Mohler 1967).-Gartner p. 22, pl.2, figs. 32a, b, 41a, b.

1979 *Helicosphaera carteri* (Walllich 1877 Kamptner 1954).- Chi pl. 1, fig. 20.

1979 *Helicosphaera kamptneri* (Hay and Mohler 1967).- Chi p. 136, pl. 1, fig. 22.

1985 *Helicosphaera kamptneri* (Hay and Mohler 1967).- Perch-Nielsen p. 444, 445, figs. 43, 45, 46.

Description

The species has an outer wall in spiral form and a central area having two linear slits along the long axis. In outlook the species is elliptical to sub-elliptical. In polarized light it shows birefringes from centre to outward. Sometimes a dark line joins the two separated slits in polarized light. In some specimens the central portion is also perforated and these pores are very small in size.

Size

10 specimens in sample 2840-60 ft are measured; having length of 8-10µm.

Remarks

At some positions in polarized light it seems similar to *C. pelagicus* Schiller (1930) but it is completely different having two openings in the centre instead of one and outer wall is spirally coiled. In polarized light *H. kamptneri* also resembles *H. colombiana* Gartner (1977) and *H. compacta* Bramlette and Wilcoxon (1967) but *H. colombiana* is more elliptical than *H. kamptneri* and *H. compacta* is more round/egg shaped than *H. kamptneri.*

Occurrence

NN 2 - NN 21 according to Martini (1971) and Perch-Nielsen (1985).

Coccolithus miopelagicus **(Bukry 1971) emend. Wise 1973**

* 1971 *Coccolithus miopelagicus* Bukry p.310, pl. 2, figs. 6-9.
1973 *Coccolithus miopelagicus* (Bukry 1971).- Wise p.593, pl. 8, figs. 9-11.
1979 *Coccolithus miopelagicus* (Bukry 1971 emend. Wise 1973).- Huang and Ting pl. 1, fig. 1.
1980 *Coccolithus miopelagicus* (Bukry 1971 emend. Wise 1973).- Backman p. 8, pl. 1, figs. 3-4.
1985 *Coccolithus miopelagicus* (Bukry 1971 emend. Wise 1973).- Perch-Nielsen p. 463, fig. 23.

Description

Sub-elliptical, large coccolith having two shields. The outer shield is dark in polarized light. The inner shield is bright in polarized light. There is also a sub-elliptical small opening in the central area along the long axis of the palcolith. The outer shield has a number of elements which are visible in bright field and in phase contrast. The central area also shows birefringes in polarized light. In phase contrast the outer shield appears thick and the inner shield thinner.

Size

The measured specimen in sample 4840-60 ft has the length of 12μm and width of 10μm.

Remarks

C. miopelagicus resembles *C. pelagicus* (Schiller 1930) and *C. eopelagicus* (Bramlette and Riedel 1954) Bramlette and Sullivan (1961). But *C. miopelagicus* is larger in size and less elliptical than *C. pelagicus. C. miopelagicus* differs from *C. eopelagicus* in having a smaller central area than *C. eopelagicus.* In some specimens it is not possible to differentiate between *C. pelagicus* and *C. miopelagicus* and it seems that *C. miopelagicus* is a variety of *C. pelagicus.* So that its last occurrence may not be in the Middle Miocene.

Occurrence

Late Oligocene - Middle Miocene (according to Perch-Nielsen 1985).

Discoaster quinqueramus **Gartner 1969**

* 1969 *Discoaster quinqueramus* Gartner p. 598, pl. 1, figs. 6,7.
1971 *Discoaster quinqueramus* (Gartner 1969).- Martini p. 767 - 768, pl. 4, fig. 6.
1978 *Discoaster quinqueramus* (Gartner 1969).- Backman p. 98, 100, pl.1, figs. 10,11.
1979 *Discoaster quinqueramus* (Gartner 1969).- Chi p. 131, 136, pl.2, figs. 18-20, 22.
1985 *Discoaster quinqueramus* (Gartner 1969).- Perch-Nielsen p. 476, figs. 31, 33.

Description

D. quinqueramus is a five-rayed asterolith. Angles between all rays are similar. There is a prominent central knob also divided into 5 ridges. Each ridge of the knob lies in between the two arms. The 5 arms are smooth at the ends and all are bent on the proximal side.

Size

Diameter 8 - 12μm (5 specimens are measured in sample 4240-60 ft).

Remarks

D. quinqueramus is similar to *Discoaster brouweri* Bramlette and Riedel (1954), but *D. brouweri* differs in having 6 rays. *D. asymmetricus* Gartner (1969) and *D. pentaradiatus* Bramlette and Riedel (1954) are also five-rayed species but both species have no central knob and in *D. asymmetricus* the angles in between the arms are not equal. It is not possible to differentiate between *D. quinqueramus* and *D. berggrenii* Bukry (1971) in light microscopy.

Occurrence

NN 11

CONCLUSION

The interval 2640-13050 ft, of wildcat Sadaf-1 offshore well of Oxy, mainly consists of clastic sediments. Biostratigraphy of the well was carried out based on nannofossils. Generally, the occurrence of nannofossils ranged from rare to abundant.

Based on nannofossils age is designated to the well section and nannofossil zonation is established (downhole) as follows:

NN15-NN12 (interval 2840-60 to 3640-60 ft) Early Pliocene

NN11 (interval 3840-4860 ft) Late Miocene

NN10 (interval 5040-9050 ft) Late Miocene

NN9 (sample 9250 ft) Late - Middle Miocene

NN? (interval 9450-10060 ft) barren of diagnostic nannofossils.

NN6-NN5 (interval 10650-13050 ft) Middle-Early Miocene

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