

# NANNOPLANKTON BIOSTRATIGRAPHY OF EOCENE FORMATIONS IN THE GELIBOLU PENINSULA

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ABSTRACT. — Nannoplankton from the stratigraphic sections of Eocene formation have been determined and used to establish the biostratigraphy and paleogeography of the area in Gelibolu peninsula adjacent to the bay of Saros. These Eocene formations of about 3600 m in thickness are represented lithologically by conglomerates, sandstones, mudstones and a variety of limestones. 77 Nannoplankton species have been distinguished in Karaağaç limanı, Koyun limanı, Fiçitepe, Soğucak, Burgaz, Korudağ-Keşan and Kanlıbent formations. The following biozones have been defined; *Sphenolithus pseudoradians* zone, *Isthmolithus recurvus* zone, *Discoaster saipanensis* zone, *Discoaster tani nodifer* zone. These biozones have been correlated with the worldwide distribution of the same range biozones.

## INTRODUCTION

The studied area is located in the Gelibolu peninsula (Fig. 1). Most of the geological investigations have been done in this area by various companies and institutions based on coal and oil explorations.

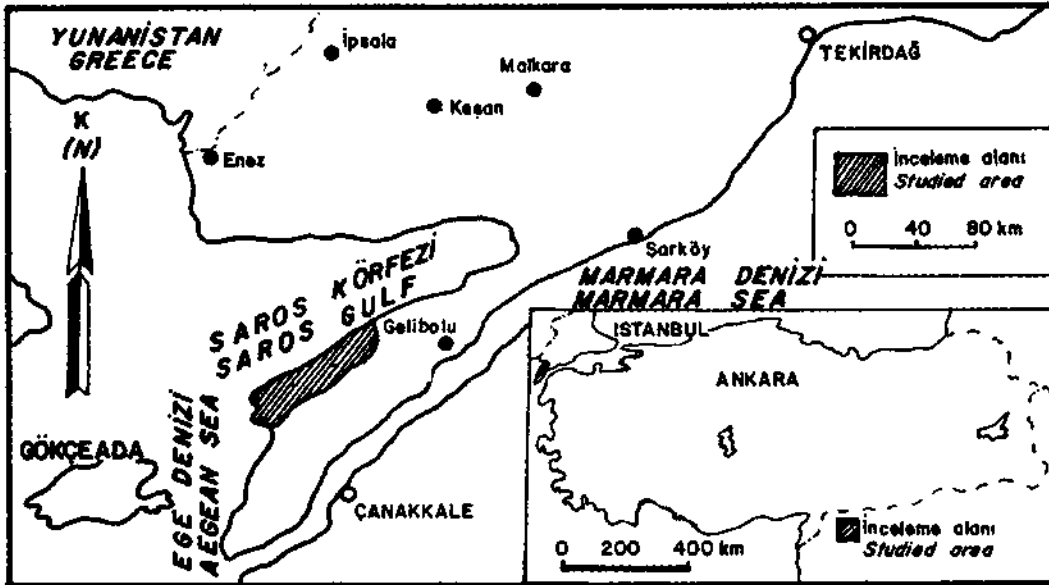


Fig. 1 - Location map

The common lithological units of this area consist of conglomerate, sandstone, siltstone, mudstone and limestone.

In different age and position dacite, andesite and basalt tuffites exist in alternation in these sediments. Existence of Upper Cretaceous-Lower Miocene aged deposits have been reported in this area by Saltık and Saka, 1972; Saltık, 1974; Önem, 1974; Druit, 1961; Doust and Arıkan, 1974; Sfondrini, 1961.

This paper contains brief descriptions and discussions of zones which can be defined by the use of Nannoplankton. The correlation of Nannoplankton with planktonic Foraminifera could not be made due to the scarcity of data and poor preservation of the forms. Paleocene-Lower Eocene deposits which have been reported by some geologists but have not been found in the studied area. Paleocene-Lower Eocene aged Nannoplankton species have been observed in the Middle-Upper Eocene sediment samples as a reworked material.

#### **STRATIGRAPHY**

Upper Cretaceous limestone is the oldest unit in this area. This unit is unconformably overlain by Middle Eocene deposits. Middle Eocene sediments are followed concordantly by Upper Eocene deposits (Fig. 2). Eocene unit which crops out in Gelibolu peninsula was divided into seven formations.

These formations have been named by the MTA geologists who are currently working for the Tertiary project of Thrace.

#### **LITHOSTRATIGRAPHY**

##### **Lort formation (K1)**

This formation crops out in Foça cape with Karaağaç harbour and Lort bank and named by Sfondrini (1961) for the first time. This Maastrichtian formation consists of light gray colored limestones of 100 m in thickness and contain abundant *Globotruncana* species.

##### **Karaağaç limanı formation (Tk)**

This formation is exposed in Batarya hill, Koyun harbour and Foça cape region. Type section is measured on Batarya hill 544 m in thickness, gray, dark gray colored mudstone and between them in shape of lens sandstone and conglomerate are cropped out. Karaağaç limanı formation unconformably overlies Lort formation and is conformably overlain by Koyun limanı formation. According to the contained macrofossils and Nannoplankton, the age of this formation is Middle Eocene.

##### **Koyun limanı formation (Tky)**

This formation is exposed in narrow area at the Koyun harbour region. Lower and middle parts of the formation composed of gray colored mudstone and also upper part is represented with sandstone. Thickness of this formation is 350 m.

It has lateral and vertical transitional contact with the underlying Karaağaç limanı formation and overlying Fıçitepe formation. Lamellibranchiata and Gastropoda shell fragments are seen in the sandstones. The mudstones contain abundant nannoplankton indicated a Middle Eocene age.



**Fıçitepe formation(Tf)**

This formation crops out in Fıçı hill-Sağırtaş area. It is composed of alternating red and red-wine color conglomerate sandstone and mudstone. The thickness of this formation is 450 m. The fossils have not been found in it. On the basis of its stratigraphic position the age of the formation is considered to be Middle Eocene.

**Soğucak formation (Ts)**

This formation crops out Kozlu hill-Peynir hill area and composed of yellow color sandstone, limestone, sandy limestone and mudstone and its thickness is 320 m.

This formation sediment contain abundant Gastropoda, Coral, Echinoid shell fragment and also Nummulites and Nannoplankton which indicates a Middle Eocene age.

**Burgaz formation (Tb)**

This formation crops out around Burgaz and Tayfur Village area. The thickness of this formation is 430 m.

Burgaz formation composed of gray color mudstone containing tuffite intercalations, described by Sfondrini (1961). It conformably overlies the Soğucak formation and is conformably overlain by Korudağ-Keşan formation mudstone rich in Nannoplankton species indicate an Upper Eocene age.

**Korudağ (Tko)-Keşan(Tkş) formation**

This formation is the most widely exposed in the studied area. The type locality of Korudağ-Keşan formation is around Küçük Anafarta-Büyük Kemikli cape and Küçük Kemikli cape area. The thickness of this formation is 1100 m. The lower part of Korudağ-Keşan formation is composed of alternating mudstone and sandstone and this part is followed by interbedded conglomerate and sandstone. The Korudağ-Keşan formation conformably overlies the Burgaz formation. Korudağ-Keşan is conformably overlain by the Kanlıbent dere formation. Nannoplankton species indicate an Upper Eocene age.

**Kanlıbent dere formation (Tkb)**

This formation crops out Kanlıbent creek area, and its thickness is 250 m. Kanlıbent dere formation starts with alternating mudstone and mudstone passing upwards into sandstone and mudstone it conformably overlies the Korudağ-Keşan formation and is conformably overlain by the Çakıl dere formation. The sediments contain abundant Nannoplankton indicate an Upper Eocene age.

**BIOSTRATIGRAPHY**

In the investigated area, the following biozones were defined by means of Nannoplankton species which are distinguished in the samples. General correlation of these zones are also presented.

*Discoaster tani nodifer zone*

Definition: Interval from the last occurrence of *Rhabdosphaera gladius* Locher to the last occurrence of *Chiasmolithus solitus* (Bramlette and Sullivan).

Authors: Hay, 1967, emend. Martini, 1970.

Locality: Foça cape and Kozlu hill.

Common species: *Discoaster tani nodifer* Bramlette and Riedel, *Discoaster barbadiensis* Tan Sin Hok, *Reticulofenestra umbilica* (Levin), *Chiasmolithus grandis* (Bramlette and Riedel), *Cyclococcolithus formosus* Kamptner, *Chiasmolithus solitus* (Bramlette and Sullivan) (Table 1).

This zone was determined in the measured stratigraphic sections in Foça cape and Kozlu hill (Fig. 3).

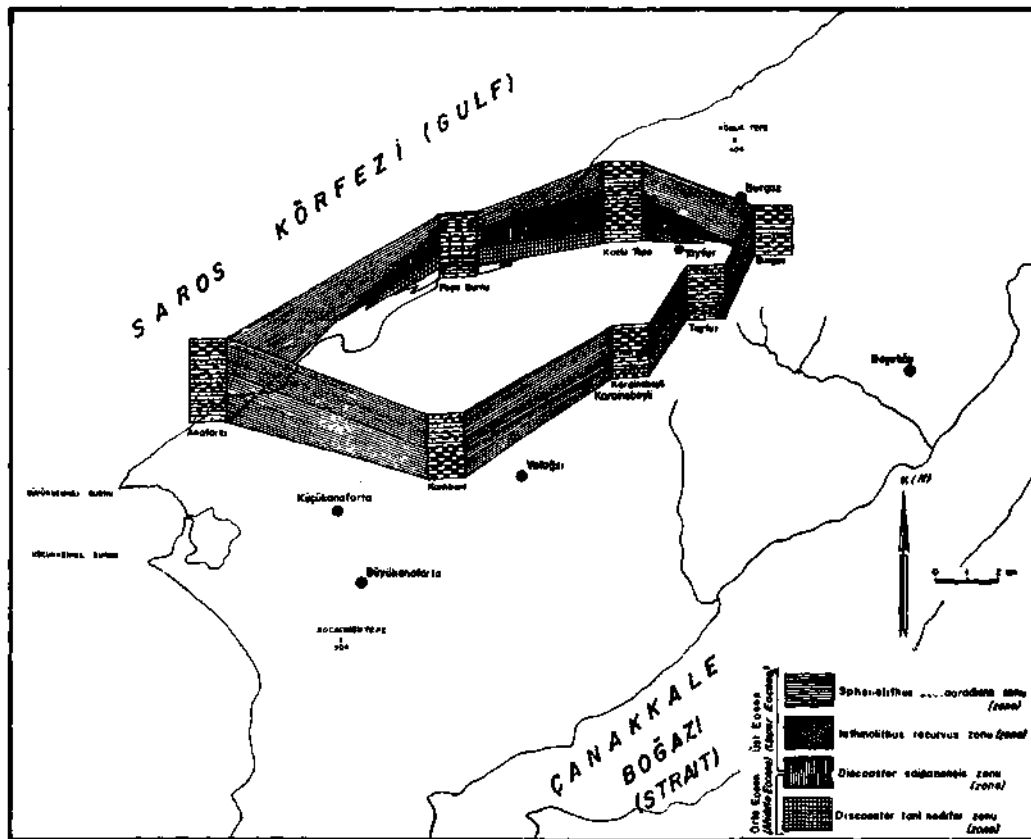


Fig. 3 - Distribution of Nannoplankton zones of the investigated area in panel diagram.

Correlation and remarks: This zone which is determined in this study by the authors, has been used by Martini (1971) as a standard calcareous nannoplankton zonation (Fig. 4). Roth, Baumann and Bertolina (1971) used *Discoaster saipanensis* subzone for this stratigraphic interval in their studies in North Italy. Perch-Nielsen (1972) determined *Discoaster tani nodifer* zone in Upper Middle Eocene with the samples from well core of deep sea drilling in the North Atlantic.

*Discoaster tani nodifer* zone has been used by Decima, Roth and Todesco (1975) for the upper part of the Middle Eocene and lower part of the Upper Eocene in the Passagno region of North Italy. Toker (1982) defined this zone at the Kaman region (Central Anatolia). Nannoplankton species show great similarity with Gelibolu peninsula and Kaman region.

Eocene	Orta Eosen Middle Eocene	Martini, 1971, Standart zonlama Standart zonasion	Roth, Baumann, Bertolino, 1971, Kuzey Italya Northern Italy	Perch-Nielsen, 1972, Kuzey Atlantik North Atlantic	Decimo, Rorth, Todesco, 1973, Italya Italy	Toker, 1982 Koman	Toker-Erkan, 1983 Saras Körfezi Saras Gulf	Sphenolithus pseudoradians Zonu (Zone) (NP 20)	Sphenolithus pseudoradians Zonu (Zone)	Sphenolithus pseudoradians Zonu (Zone)	Sphenolithus pseudoradians Zonu (Zone)	Sphenolithus pseudoradians Zonu (Zone)
								Isthmolithus recurvus Zonu (Zone) NP (19)	Isthmolithus recurvus Zonu (Zone)	Isthmolithus recurvus Zonu (Zone)	Isthmolithus recurvus Zonu (Zone)	Isthmolithus recurvus Zonu (Zone)
Eocene	Orta Eosen Middle Eocene	Martini, 1971, Standart zonlama Standart zonasion	Roth, Baumann, Bertolino, 1971, Kuzey Italya Northern Italy	Perch-Nielsen, 1972, Kuzey Atlantik North Atlantic	Decimo, Rorth, Todesco, 1973, Italya Italy	Toker, 1982 Koman	Toker-Erkan, 1983 Saras Körfezi Saras Gulf	Chiasmolithus oamaruensis Zonu (Zone) NP (18)	Chiasmolithus oamaruensis Subzonu (Subzone)	Chiasmolithus oamaruensis Subzonu (Subzone)	Chiasmolithus oamaruensis Subzonu (Subzone)	Chiasmolithus oamaruensis Subzonu (Subzone)
								Discoaster saipanensis Zonu (Zone) NP (17)	Discoaster saipanensis Subzonu (Subzone)	Discoaster saipanensis Subzonu (Subzone)	Discoaster saipanensis Subzonu (Subzone)	Discoaster saipanensis Subzonu (Subzone)
Eocene	Orta Eosen Middle Eocene	Martini, 1971, Standart zonlama Standart zonasion	Roth, Baumann, Bertolino, 1971, Kuzey Italya Northern Italy	Perch-Nielsen, 1972, Kuzey Atlantik North Atlantic	Decimo, Rorth, Todesco, 1973, Italya Italy	Toker, 1982 Koman	Toker-Erkan, 1983 Saras Körfezi Saras Gulf	Discoaster tani nodifer Zonu (Zone) NP (16)	Discoaster tani nodifer Zonu (Zone)	Discoaster tani nodifer Zonu (Zone)	Discoaster tani nodifer Zonu (Zone)	Discoaster tani nodifer Zonu (Zone)
								Reticulofenestra umbilica Zonu (Zone)	Reticulofenestra umbilica Zonu (Zone)	Reticulofenestra umbilica Zonu (Zone)	Reticulofenestra umbilica Zonu (Zone)	Reticulofenestra umbilica Zonu (Zone)

Fig. 4 - Correlation of Eocene Nannoplankton biozones.

In the studied area, abundance of *Pemma*, *Braarudosphaera*, *Micrantholitus* species and rareness of Discoaster species indicate that in this region deposits have been accumulated at the shallow water environment (0-200 m).

*Discoaster saipanensis* zone

Definition: Interval from the last occurrence of *Chiasmolithus solitus* (Bramlette and Sullivan) to the first occurrence of *Isthmolithus recurvus* Deflandre.

Author: Martini, 1970.

Locality: Between Kozlu hill and Peynir hill.

Common species: *Discoaster tani nodifer* Bramlette and Riedel, *Discoaster saipanensis* Bramlette and Riedel, *Reticulofenestra umbilica* (Levin), *Cyclococcolithus formosus* Kamptner, *Discoaster barbadiensis* Tan Sin Hok, *Chiasmolithus grandis* (Bramlette and Riedel). This zone was determined in the measured stratigraphic section of Kozlu hill.

Correlation and remarks: Martini (1971) named this zone as NP 17 *Discoaster saipanensis* zone in standart calcareous Nannoplankton zonation. This zone was found in upper Middle Eocene to lower Upper Eocene (Fig. 4). Roth, Baumann and Bertolina (1972) used *Discoaster barbadiensis* zone in the determination of the Upper Eocene and divided into three subzones. Perch-Nielsen (1972) used *Reticulofenestra umbilica* zone for Upper Eocene in her study in North Atlantic. Decima, Roth and Todesco (1975) defined *Discoaster saipanensis* zone in their study and divided into the following subzones: *Chiasmolithus oamaruensis* and *Isthmolithus recurvus*. In various studies, different Eocene nannoplankton zone names have been used, due to the difference of latitude and the change of ecologic factors from region to region. Zone marker *Chiasmolithus solitus* is especially rare or absent in low latitude but it was defined in our region in high latitude. *Discoaster saipanensis* zone was determined by Toker (1982) in the Kaman region and in this study. And also nannoplankton association of these regions are very similar.

*Isthmolithus recurvus* zone

Definition: Interval from the first occurrence of *Isthmolithus recurvus* Deflandre to the first occurrence of *Sphenolithus pseudoradians* Bramlette and Wilcoxon.

Authors: Hay, Mohler and Wade, 1966, emend. Martini, 1970.

Locality: Kozlu hill and Burgaz.

Common species: *Isthmolithus recurvus* Deflandre, *Sphenolithus predistentus* Bramlette and Wilcoxon, *Lanternithus minutus* Stradner, *Discoaster barbadiensis* Tan Sin Hok. This zone was determined in the measured stratigraphic sections of Kozlu hill and Burgaz.

Correlation and remark: Martini (1971) called this zone NP 19 *Isthmolithus recurvus* in standart zonation. This zone is generally defined in high latitudes and also it has been reported as an older part of the Eocene. *Isthmolithus recurvus* Deflandre is rare or absent in many low latitude areas. The association of *Isthmolithus recurvus* zone shows great similarity in all regions. NP 18 *Chiasmolithus oamaruensis* zone has not been defined in studied area due to absence of *Chiasmolithus oamaruensis* (Deflandre). So, *Discoaster saipanensis* zone passes upwards into *Isthmolithus recurvus* zone.

*Sphenolithus pseudoradians* zone

Definition: Interval from the first occurrence of *Sphenolithus pseudoradians* Bramlette and Wilcoxon to the last occurrence of *Discoaster saipanensis* Bramlette and Riedel.

Author: Martini, 1970.

Locality: Küçük Anafarta, Kanlibent and Tayfur.

Common species: *Sphenolithus pseudoradians* Bramlette and Wilcoxon, *Reticulofenestra umbilica* (Levin), *Cyclococcolithus formosus* Kamptner, *Sphenolithus predistentus* Bramlette and Wilcoxon, *Helicopontosphaera reticulata* (Bramlette and Wilcoxon), *Discoaster barbadiensis* Tan Sin Hok, *Lanternithus minutus* Stradner.

Correlation and remarks: Martini (1971) named this zone NP 20 *Sphenolithus pseudoradians* zone in the standard calcareous nannoplankton zonation. This zone was defined by Roth, Baumann and Bertolina (1977) in Italy; Perch Nielsen (1972) in North Atlantic; Decima, Roth, Todesco (1975) in Italy.

#### SYSTEMATIC

There is no general agreement in the classification of calcareous nannofossils. One of them was used in this paper has been presented by Perch-Nielsen (1970).

Family : Braarudosphaeraceae Deflandre, 1947

Genus : Braarudosphaera Deflandre, 1947

*Braarudosphaera bigelowi* (Gran and Braarud, 1935)

(Plate I, fig. 1)

1935 *Pontosphaera bigelowi* Gran and Braarud, p. 389, fig. 67

1961 *Braarudosphaera bigelowi* (Gran and Braarud), Bramlette and Sullivan, p. 153, pl. 8, fig. 3-5

1973 *Braarudosphaera bigelowi* (Gran and Braarud), Risatti, p. 27, pl. 3, fig. 23

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

*Braarudosphaera discula* Bramlette and Riedel, 1954

1954 *Braarudosphaera discula* Bramlette and Riedel, p. 394, pl. 38, fig. 7

1971 *Braarudosphaera discula* Bramlette and Riedel, Manivit, p. 126, pl. 3, fig. 17

1973 *Braarudosphaera discula* Bramlette and Riedel, Risatti, p. 27-28, pl. 3, fig. 19-20

Range : *Discoaster tani nodifer*-*Discoaster saipanensis* zones.

Genus : *Micrantholithus* Deflandre, 1950

*Micrantholithus basquensis* Martini, 1959

(Plate I, fig. 2).

1959 *Micrantholithus basquensis* Martini, p. 417, pl. 1, fig. 9-12

1971 *Micrantholithus basquensis* Martini, Perch-Nielsen, p. 59, pl. 56, fig. 1

Range : *Discoaster tani nodifer* zone.

*Micrantholithus vesper* Deflandre, 1950

(Plate I, fig. 3)

1954 *Micrantholithus vesper* Deflandre, in Deflandre and Fert, p. 52, 13, fig. 17, 5, 115, 116

1975 *Micrantholithus vesper* Deflandre, Decima, Roth, Todesco, p. 46, pl. 1, fig. 16

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

Genus : Pemma Klumpp, 1953

*Pemma rotundum* Klumpp, 1953

1953 *Pemma rotundum* Klumpp, p. 381, 16, fig. 3,4; 2,3

1961 *Pemma rotundum* Klumpp, Stradner and Papp, p. 119, 38, fig. 1

1975 *Pemma rotundum* Klumpp, Decima, Roth, Todesco, p. 46, pl. 1, fig. 15 a-b

Range : *Sphenolithus pseudoradians* zone.

*Pemma papillatum* Martini, 1959

1959 *Pemma papillatum* Martini, p. 139, fig. 1 a-b

1961 *Pemma papillatum* Martini, Stradner and Papp, p. 120, 38, fig. 2-6

1977 *Pemma papillatum* Martini, Toker, p. III, 15, fig. 9

Range : *Discoaster tani nodifer* zone.

Family : Calyptosphaeraceae Boudreaux and Hay, 1969

Genus : Lanternithus Stradner, 1962

*Lanternithus minutus* Stradner, 1962

1962 *Lanternithus minutus* Stradner, p. 375, 2, fig. 12-15

Range : *Isthmolithus recurvus*-*Sphenolithus pseudoradians* zones.

Genus : Zygrhablithus Deflandre, 1959

*Zygrhablithus bijugatus* (Deflandre, 1954)

(Plate I, fig. 4)

1954 *Rhapholithus costatus* Deflandre (in Deflandre and Fert), p. 157, pl. 11, fig. 8-11

1961 *Zygrhablithus bijugatus* (Deflandre), Bramlette and Sullivan, p. 151, pl. 6, fig. 16-18

1973 *Zygrhablithus bijugatus* (Deflandre), Kapellos, p. 109, pl. 9, fig. 10, pl. 6, fig. 11-12

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

Family : Coccolithaceae Kamptner, 1928

Genus : Chiasmolithus Hay, Mohler and Wade, 1966

*Chiasmolithus consuetus* (Bramlette and Sullivan, 1961)

1961 *Coccolithus consuetus* Bramlette and Sullivan, p. 139, pl. 1, fig. 2

1964 *Coccolithus consuetus* (Bramlette and Sullivan), Sullivan, p. 180, pl. 3, fig. 1

1967 *Chiasmolithus consuetus* (Bramlette and Sullivan), Hay and Mohler, p. 1526, pl. 196, fig. 23-25, pl. 198, fig. 16

Range : *Discoaster tani nodifer* zone.

*Chiasmolithus gigas* (Bramlette and Sullivan, 1961)

- 1961 *Coccolithus gigas* Bramlette and Sullivan, p. 140, pl. 1, fig. 6
- 1971 *Chiasmolithus gigas* (Bramlette and Sullivan), Perch-Nielsen p. 17, pl. 14, fig. 6  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
*Chiasmolithus grandis* (Bramlette and Riedel, 1954)  
 (Plate I, fig. 5)
- 1954 *Coccolithus grandis* Bramlette and Riedel, p.391, 392, pl. 38, fig. 1
- 1966 *Chiasmolithus grandis* (Bramlette and Riedel), Hay, Mohler and Wade, p. 388
- 1968 *Chiasmolithus grandis* (Bramlette and Riedel), Bukry and Kennedy, p. 42
- 1973 *Chiasmolithus grandis* (Bramlette and Riedel), Kapellos, p. 106, pl. 15, fig. 8, pl. 21, fig. 5,8  
 pl. 22, fig. 2, 3, 5, 6  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
*Chiasmolithus solitus* (Bramlette and Sullivan, 1961)
- 1961 *Coccolithus solitus* Bramlette and Sullivan, p. 140, pl. 2, fig. 4 a-c
- 1968 *Chiasmolithus solitus* (Bramlette and Sullivan), Locker, p. 221, 222, 227, pl. 1, fig. 56  
 Range : *Discoaster tani nodifer* zone.  
 Genus: *Coccolithus* Schwarz, 1894  
*Coccolithus eopelagicus* (Bramlette and Riedel), 1954
- 1954 *Tremalithus eopelagicus* Bramlette and Riedel, p. 392, pl. 38, fig. 2 a-b
- 1961 *Coccolithus eopelagicus* (Bramlette and Riedel), Bramlette and Sullivan, p. 141
- 1967 *Coccolithus eopelagicus* (Bramlette and Riedel), Bramlette and Sullivan, Bramlette and Wilcoxon,  
 p. 102, pl. 4, fig. 6, 7  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
 Genus : *Cyclicargolithus* (Roth and Hay, 1970)  
*Cyclicargolithus floridanus* (Roth and Hay, 1967)
- 1967 *Coccolithus floridanus* Roth and Hay, in Hay p. 445, pl. 6, fig. 1-4
- 1970 *Cyclococcolithus floridanus* (Roth and Hay), Roth, p. 854, pl. 5, fig. 6
- 1971b *Cyclicargolithus floridanus* (Roth and Hay), Bukry, p. 312, 313  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
 Genus : *Cyclococcolithina* Kamptner, 1954  
*Cyclococcolithina formosa* Kamptner, 1963.  
 (Plate I, fig. 6)
- 1963 *Cyclococcolithus formosus* Kamptner, p. 163; pl. 2, fig. 8-20
- 1970 *Cyclococcolithina formosa* (Kamptner), Wilcoxon, p. 82
- 1975 *Cyclococcolithina formosa* (Kamptner), Decima, Roth, Todesco, p. 48  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
*Cyclococcolithina gammation* (Bramlette and Sullivan, 1961)

- 1961 *Coccolithites gammation* Bramlette and Sullivan, p. 152, pl. 7, fig. 7-14
- 1964 *Cydocololithus gammation* (Bramlette and Sullivan), Sullivan, p. 181, pl. 3, fig. 7a-b
- 1970 *Cyclococcolithina gammation* (Bramlette and Sullivan), Wilcoxon, p.82  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
*Cyclococcolithina kingi* (Roth, 1970)  
 (Plate I, fig. 7)
- 1970 *Cydocololithus kingi* Roth, p. 855, pl. 6, fig. 5, 7, fig. 1
- 1971 *Cyclococcolithina protoannula* Gartner, p. 109, pl. 5, fig. 1 a-c, 2
- 1973 *Cyclococcolithina kingi* (Roth), Roth, p. 730  
 Range : *Discoaster saipanensis*-*Isthmolithus recurcus* zones.  
 Genus : *Cyclolithella* Loeblich and Tappan, 1963  
*Cyclolithella robusta* (Bramlette and Sullivan, 1961)
- 1961 *Cyclolithus* (?) *robustus* Bramlette and Sullivan, p. 141, fig. 2, 7 a-c
- 1969 *Cyclolithella robusta* (Bramlette and Sullivan), Stradner, p. 414, pl. 86, fig. 1-4  
 Range : *Discoaster tani nodifer*-*Discoaster saipanensis* zones.  
 Genus : *Markalius* Bramlette and Martini, 1964  
*Markalius inversus* (Deflandre, 1954)
- 1954 *Cydocololithus leptoporus* var. *inversus* Deflandre, in Deflandre and Fert, p. 150, pl. 9, fig. 4-7
- 1964 *Markalius inversus* (Deflandre), Bramlette and Martini, p. 302, pl. 2, fig. 4-9, pl. 7, fig. 2a-b]
   
Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
 Family : Prinsiaceae Hay and Mohler, 1967  
 Genus : *Prinsius*  
*Prinsius bisulcus* (Stradner, 1963)
- 1963 *Coccolithus bisulcus* Stradner, p. 72, pl. 8, fig. 3-6, pl. 3, fig. 11 a-b
- 1967 *Prinsius bisulcus* (Stradner), Hay and Mohler, p. 1259, pl. 196, fig. 10-13, pl. 197, fig. 6  
 Range : *Discoaster tani nodifer* zone.  
 Genus : *Reticulofenestra* Hay, Mohler and Wade, 1966  
*Reticulofenestra bisecta* (Hay, Mohler and Wade, 1966)  
 (Plate I, fig. 8)
- 1966 *Syracosphaera bisecta* Hay, Mohler and Wade, p. 393, pl. 10, fig. 1-6
- 1970 *Reticulofenestra bisecta* (Hay, Mohler and Wade), Roth, p. 847, pl. 3, fig. 6  
 Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.  
*Reticulofenestra coenura* (Reinhardt, 1966)  
 (Plate I, fig. 9)

- 1966 *Coccolithus coenurus* Reinhardt, p. 515, pl. 1, fig. 7
- 1970 *Reticulofenestra coenura* (Reinhardt), Roth, p. 847  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
*Reticulofenestra oamaruensis* (Deflandre, 1954)
- 1954 *Discolithus oamaruensis* Deflandre, in Deflandre and Fert, p. 139, pl. 12, fig. 1-2
- 1968 *Reticulofenestra oamaruensis* (Deflandre), Stradner, Haq, p. 30, pl. 5, fig. 6-8  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
*Reticulofenestra reticulata* (Gartner and Smith, 1967)  
 (Plate I, fig. 10)
- 1967 *Cyclococcolithus reticulatus* Gartner and Smith, p. 4, 5, fig. 1-4
- 1972 *Reticulofenestra reticulata* (Gartner and Smith), Roth and Thierstein, p. 436  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
*Reticulofenestra umbilica* (Levin, 1965)  
 (Plate I, fig. 11)
- 1965 *Coccolithus umbilicus* Levin, p. 265, pl. 41, fig. 2
- 1968 *Reticulofenestra umbilica* (Levin), Martini and Ritzkowski, p. 245, pl. 1, fig. 11-12
- 1970 *Reticulofenestra umbilica* (Levin), Martini and Ritzkowski, Roth, p. 852  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
 Family : Discoasteraceae Vekshina, 1959  
 Genus : Discoaster Tan Sin Hok, 1927  
*Discoaster barbadiensis* Tan Sin Hok, 1927
- 1927 *Discoaster barbadiensis* Tan Sin Hok, p. 145
- 1965 *Discoaster barbadiensis* Tan Sin Hok, Sullivan, p. 41
- 1973 *Discoaster barbadiensis* Tan Sin Hok, Kapellos, p. 109, pl. 6, fig. 10  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
*Discoaster binodosus* Martini, 1958  
 (Plate I, fig. 12)
- 1958 *Discoaster binodosus* Martini, p. 362, pl. 4, fig. 18 a-b
- 1975 *Discoaster binodosus* Martini, Decima, Roth, Todesco, p. 48, pl. 3, fig. 3, 4  
 Range : *Discoaster saipanensis-Isthmolithus recurvus* zones.  
*Discoaster deflandrei* Bramlette and Riedel, 1954
- 1954 *Discoaster deflandrei* Bramlette and Riedel, p. 399, pl. 39, fig. 6
- 1964 *Discoaster deflandrei* Bramlette and Riedel, Sullivan, p. 190, pl. 11, fig. 8-9
- 1973 *Discoaster deflandrei* Bramlette and Riedel, Kapellos p. 110, pl. 13, pl. 1, 4, 7, 8  
 Range : *Discoaster saipanensis* zone.  
*Discoaster distinctus* Martini, 1958

- 1958 *Discoaster distinctus* Martini, p. 363, pl. 4, fig. 17 a-b
- 1973 *Discoaster distinctus* Martini, Kapellos, p. 3-9, fig. 12  
 Range : *Discoaster saipanensis-Sphenolithus pseudoradians* zones.
- Discoaster elegans* Bramlette and Sullivan, 1961
- 1961 *Discoaster elegans* Bramlette and Sullivan, p. 159, pl. 11, fig. 16 a-b
- 1975 *Discoaster elegans* Bramlette and Sullivan, Decima, Roth, Todesco, p. 48, pl. 3, fig. 6, 9  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.
- Discoaster lodoensis* Bramlette and Riedel, 1954
- 1954 *Discoaster lodoensis* Bramlette and Riedel, p. 389, pl. 39, fig. 3 a-b
- 1964 *Discoaster lodoensis* Bramlette and Riedel, Sullivan, p. 191, pl. 11, fig. 14
- 1975 *Discoaster lodoensis* Bramlette and Riedel, Decima, Roth, Todesco, p. 48, pl. 3, fig. 22-24  
 Range : *Discoaster saipanensis-Isthmolithus recurvus* zones.
- Discoaster minis* Deflandre, 1954
- 1954 *Discoaster minis* Deflandre, in Deflandre and Fert, p. 168, fig. 118
- 1975 *Discoaster minis* Deflandre, Decima, Roth, Todesco, p. 48, pl. 4, fig. 2-5  
 Range : *Discoaster saipanensis-Sphenolithiis pseudoradians* zones.
- Discoaster multiradiatus* Bramlette and Riedel, 1954
- 1954 *Discoaster multiradiatus* Bramlette and Riedel, p. 396, pl. 38, fig. 10
- 1967 *Discoaster multiradiatus* Bramlette and Riedel, Moshkowitz, p. 160, pl. 3, fig. 1-9
- 1975 *Discoaster multiradiatus* Bramlette and Riedel, Decima, Roth, Todesco, p. 48, pl. 4, fig. 6  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.
- Discoaster saipanensis* Bramlette and Riedel, 1954  
 (Plate I, fig. 13)
- 1954 *Discoaster saipanensis* Bramlette and Riedel, p. 398, pl. 39, fig. 4
- 1961 *Discoaster saipanensis* Bramlette and Riedel, Stradner and Papp, p. 90, pl. 22, fig. 5, 7, 9
- 1975 *Discoaster saipanensis* Bramlette and Riedel, Decima, Roth, Todesco, p. 48, pl. 3, fig. 25  
 Range : *Discoaster saipanensis-Sphenolithiis pseudoradians* zones.
- Discoaster salisburgensis* Stradner, 1961
- 1961 *Discoaster salisburgensis* Stradner, p. 84, fig. 77-78
- 1973 *Discoaster salisburgensis* Stradner, Kapellos, p. 113, pl. 10, fig. 10-11  
 Range : *Discoaster saipanensis* zone.
- Discoaster tani nodifer* Bramlette and Riedel, 1954  
 (Plate I, fig. 14)

1954 *Discoaster tani nodifer* Bramlette and Riedel, p. 397, pl. 39, fig. 2

1973 *Discoaster tani nodifer* Bramlette and Riedel, Kapellos, p. 114, pl. 23, fig. 2-3

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

*Discoaster trinus* Stradner, 1959

1959 *Discoaster molengraaffi* Tan, Stradner, p. 472-488, fig. 15, 24

1961 *Discoaster trinus* Stradner, p. 85, fig. 79

Range : *Discoaster saipanensis*-*Isthmolithus recurvus* zones.

*Discoaster wemmelensis* Achutan and Stradner, 1969

(Plate I, fig. 15)

1969 *Discoaster wemmelensis* Achutan and Stradner, p. 5, pl. 4, fig. 3-4

Range : *Discoaster tani nodifer*-*Discoaster saipanensis* zones.

Genus : Discoasteroidies Bramlette and Sullivan, 1961

*Discoasteroides megastypus* Bramlette and Sullivan, 1961

1961 *Discoasteroides megastypus* Bramlette and Sullivan, p. 163, pl. 13, fig. 14 a-d, 15 a-c

1975 *Discoasteroides megastypus* Bramlette and Sullivan, Decima, Roth, Todesco, p. 49, pl. 4, fig. 19 a-b

Range : *Discoaster saipanensis*-*Isthmolithus recurvus* zones.

Genus : Marthasterites Deflandre, 1959

*Tribrachiatulus orthostylus* Shamrai, 1963

(Plate I, fig. 16)

1954 *Discoaster tribrachiatulus* Bramlette and Riedel, p. 397, pl. 38, fig. 11

1959 *Marthasterites tribrachiatulus* (Bramlette and Riedel), Deflandre, p. 138

1963 *Tribrachiatulus orthostylus* Shamrai, p. 38, pl. 2, fig. 13-14

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

Family : Fasciculithaceae Hay and Mohler, 1967

Genus : Fasciculithus Bramlette and Sullivan, 1961

*Fasciculithus involutus* Bramlette and Sullivan, 1961

1961 *Fasciculithus involutus* Bramlette and Sullivan, p. 164, pl. 14, fig. 1-5

1973 *Fasciculithus involutus* Bramlette and Sullivan, Kapellos, p. 115, pl. 5, fig. 3-10

1975 *Fasciculithus involutus* Bramlette and Sullivan, Decima, Roth, Todesco, p. 49, pl. 5, fig. 4-7

Range : *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

Family : Helicopontosphaeraceae Haq, 1973

Genus : Helicopontosphaera Hay and Mohler, 1967

*Helicopontosphaera intermedia* Martini, 1965

1965 *Helicosphaera -intermedia* Martini, p. 404, pl. 35, fig. 1-2

- 1967 *Helicopontosphaera intermedia* (Martini), Hay and Mohler, p. 448  
 Range : *Discoaster saipanensis-Sphenolithus pseudoradians* zones.  
*Helicopontosphaera lophota* (Bramlette and Sullivan, 1961)  
 (Plate II, fig. 1)
- 1961 *Helicosphaera seminulum lophota* Bramlette and Sullivan, p. 144, pl. 4, fig. 3-4  
 1964 *Helicosphaera seminulum lophota* Bramlette and Sullivan, Sullivan, p. 184  
 1970 *Helicopontosphaera lophota* (Bramlette and Sullivan), Bukry, p. 214  
 Range : *Discoaster tani nodifer-Isthmolithus recurvus* zones.  
*Helicopontosphaera seminulum* (Bramlette and Sullivan, 1961)  
 (Plate II, fig. 2)
- 1961 *Helicosphaera seminulum* Bramlette and Sullivan, p. 114, pl. 4, fig. 1 a-c  
 1970 *Helicopontosphaera seminulum* (Bramlette and Sullivan), Roth, p. 863  
 Range : *Discoaster saipanensis-Sphenolithus pseudoradians* zones.  
*Helicopontosphaera reticulata* Bramlette and Wilcoxon, 1967
- 1967 *Helicosphaera reticulata* Bramlette and Wilcoxon, p. 106, pl. 6, fig. 15  
 1970 *Helicopontosphaera reticulata* (Bramlette and Wilcoxon), Roth, p. 863, pl. 10, fig. 5  
 Range : *Discoaster saipanensis-Sphenolithus pseudoradians* zones.
- Family : Pontosphaeraceae Lemmermann, 1908  
 Genus : Pontosphaera Ramsay, 1971  
*Pontosphaera multipora* (Kamptner, 1948)
- 1948 *Discolithus multiporus* Kamptner, p. 5, fig. 1  
 1970 *Pontosphaera multipora* (Kamptner), Roth, p. 860  
 Range : *Discoaster saipanensis-Sphenolithus pseudoradians* zones.  
*Pontosphaera plana* (Bramlette and Sullivan, 1961)  
 (Plate II, fig. 3)
- 1961 *Discolithus planus* Bramlette and Sullivan, p. 143, pl. 3, fig. 7 a-c  
 1971 *Pontosphaera plana* (Bramlette and Sullivan), Haq, p. 22, pl. 10, fig. 1  
 Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.  
 Genus : Transversopontis Hay, Mohler and Wade, 1966  
*Transversopontis obliquipons* Deflandre, 1954  
 (Plate II, fig. 4)
- 1954 *Discolithus obliquipons* Deflandre (in Deflandre and Fert), p. 139, pl. 11, fig. 1-2, fig. 53  
 1966 *Transversopontis obliquipons* (Deflandre) Hay, Mohler and Wade, p. 391, pl. 8, fig. 5  
 Range : *Sphenolithus pseudoradians* zones.  
*Transversopontis pulcher* (Deflandre, 1954)

1954 *Discolithus pulcher* Deflandre (in Deflandre and Fert), p. 142, pl. 12, fig. 17-18

Range : *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.

Family : Rhabdosphaeraceae Lemmermann, 1908

Genus : Blackites Hay and Towe, 1962

*Blackites creber* (Deflandre, 1954)

1954 *Rhabdolithus creber* Deflandre (in Deflandre and Fert), p. 157, pl. 31, fig. 81-82

1961 *Rhabdosphaera crebra* (Deflandre), Bramlette and Sullivan, p. 146, pl. 5, fig. 1-3

1970 *Blackites creber* (Deflandre), Roth, p. 857

Range : *hthmolithus recurvus* zones.

Genus : Rhabdosphaera Haeckel, 1894

*Rhabdosphaera perlonga* (Deflandre, 1954)

(Plate II, fig. 5)

1954 *Rhabdosphaera perlongus* Deflandre (in Deflandre and Fert), p. 158, pl. 12, fig. 34-35

1961 *Rhabdosphaera perlonga* (Deflandre), Bramlette and Sullivan, p. 146, pl. 5, fig. 7

Range: *Discoaster saipanensis-Sphenolithus pseudoradians* zones.

Family : Sphenolithaceae Deflandre, 1952

Genus : Sphenolithus Deflandre, 1952

*Sphenolithus moriformis* (Bronnimann and Stradner, 1960)

(Plate II, fig. 6)

1960 *Nannoturbella moriformis* Brönnimann and Stradner, p. 368, fig. 11-16

1967 *Sphenolithus moriformis* (Bronnimann and Stradner), Bramlette and Wilcoxon, p. 124-126, fig. 1-6

1970 *Sphenolithus moriformis* (Bronnimann and Stradner), Roth, p. 870, fig. 3-4

Range: *Discoaster tani nodifer-Sphenolithus pseudoradians* zones.

*Sphenolithus predistentus* Bramlette and Wilcoxon, 1967

(Plate II, fig. 7)

1967 *Sphenolithus predistentus* Bramlette and Wilcoxon, p. 126, pl. 6, fig. 10-11

Range: *Discoaster saipanensis-Sphenolithus pseudoradians* zones.

*Sphenolithus pseudoradians* Bramlette and Wilcoxon, 1967

(Plate II, fig. 8)

1967 *Sphenolithus pseudoradians* Bramlette and Wilcoxon, p. 126-128, fig. 12-14

1975 *Sphenolithus pseudoradians* Bramlette and Wilcoxon, Decima, Roth, Todesco, p. 51, pl. 6, fig. 8 a

Range: *Sphenolithus pseudoradians* zones.

*Sphenolithus radians* Deflandre, 1952

(Plate II, fig. 9)

1952 *Sphenolithus radians* Deflandre, p. 466-467, fig. 434

1961 *Sphenolithus radians* Deflandre, Bramlette and Sullivan, p. 116, pl. 14, fig. 6-8 b

1968 *Sphenolithus radians* Deflandre, Radomski, p. 588, fig. 14

Range: *Discoaster tani nodifer*-*Sphenolithus pseudoradians* zones.

Family. : Triquetrorhabdulaceae Lipps, 1969

Genus : Triquetrorhabdulus Martini, 1965 .

*Triquetrorhabdulus inversus* Bukry and Bramlette, 1969

1969 *Triquetrorhabdulus inversus* Bukry and Bramlette, p. 142, pl. 1, fig. 9-14

1975 *Triquetrorhabdulus inversus* Bukry and Bramlette, Decima, Roth, Todesco, p. 51, pl. 6, fig. 30 a

Range: *Isthmolithus recurvus*-*Sphenolithus pseudoradians* zones.

Family : Zygodiscaceae Hay and Mohler, 1967

Genus : Zygodiscus Bramlette and Sullivan, 1961

*Zygodiscus plectopons* Bramlette and Sullivan, 1961

(Plate II, fig. 11)

1961 *Zygodiscus plectopons* Bramlette and Sullivan, p. 148, pl. 4, fig. 12

1964 *Zygodiscus plectopons* Bramlette and Sullivan, Sullivan, p. 148, pl. 5, fig. 8

Range: *Discoaster tani nodifer*-*Discoaster saipanensis* zones.

Genus : Isthmolithus Deflandre, 1954

*Isthmolithus recurvus* Deflandre, 1954

(Plate II, fig. 10)

1954 *Isthmolithus recurvus* Deflandre (in Deflandre and Fert), p. 169, pl. 12, fig. 9-13

1969 *Isthmolithus recurvus* Deflandre (in Martini), p. 145

Range: *Isthmolithus recurvus* zone.

Incertae Sedis

*Nannotetrina cristata* (Martini, 1958)

1958 *Trochoaster cristatus* Martini, p. 368, pl. 5, fig. 26 a, b

1960 *Nannotetraster cristatus* (Martini), in Martini and Stradner p. 266, fig. 2

1971 *Nannotetrina cristata* (Martini), Perch-Nielsen, p. 66, pl. 56, fig. 9-12

Range: *Discoaster saipanensis*-*Isthmolithus recurvus* zones.

*Nannotetrina fulgens* (Stradner, 1960)

1960 *Nannotetraster fulgens* Stradner (in Martini and Stradner), p. 268, pl. 10, fig. 16 a,b

1969 *Nannotetrina fulgens* (Stradner), Stradner, p. 7, pl. 5, fig. 4-6

Range: *Sphenolithus pseudoradians* zone.



**RESULTS**

In this study, seventy-seven nannoplankton species were determined around the Bay of Saros and the following biozones were distinguished in the Middle-Upper Eocene interval

- *Sphenolithus pseudoradians* zone
- *Isthmolithus recurvus* zone
- *Discoaster saipanensis* zone
- *Discoaster tani nodifer* zone

The distribution of Nannoplankton species were given for the investigated area and general correlation of the Nannoplankton zones was presented.

**ACKNOWLEDGMENT**

The authors indebted to General Directorate of Mineral Research and Exploration of Turkey for supporting this investigation, also thanks are extended to Mr. İbrahim Çakmak, Head of Basic the Research Department and Mr. Zeki Atalay, Mr. Muhsin Sümengen, Mr. İsmail Terlemez, in the same Department.

*Manuscript received August 5, 1983*

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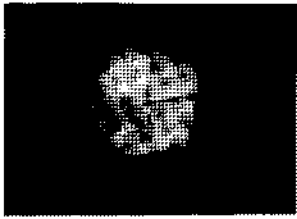
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# PLATES

**PLATE - I**

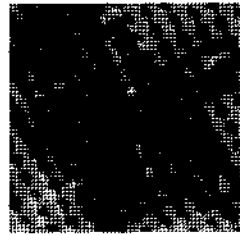
- Fig. 1 - *Braarudospharea bigelowi* (Gran and Braarud)  
Between crossed nicols, GB.8.93
- Fig. 2 - *Micrantholithus basquensis* Martini  
Between crossed nicols, GB. 8. 93
- Fig. 3 - *Micrantholithus vesper* Deflandre  
a- Ordinary transmitter light, b- Between crossed nicols, GC. 8. 74
- Fig. 4 - *Zygrhablithus bijugatus* (Deflandre)  
Between crossed nicols, GC.8.37
- Fig. 5 - *Chiasmolithus grandis* (Bramlette and Riedel)  
a- Ordinary transmitter light, b- Between crossed nicols, GC.8.96
- Fig. 6 - *Cyclococcolithina formosa* Kamptner  
a-Ordinary transmitter light, b- Between crossed nicols, ETC.0.1
- Fig. 7 - *Cyclococcolithina kingi* (Roth)  
Between crossed nicols, GB.8.93
- Fig. 8 - *Reticulofenestra bisecta* (Hay, Mohler and Wade)  
a- Ordinary transmitter light, b- Between crossed nicols, ETC.0.8
- Fig. 9 - *Reticulofenestra coenura* (Reinhardt)  
Between crossed nicols, ETC.0.8
- Fig. 10 - *Reticulofenestra reticulata* (Gartner and Smith)  
Between crossed nicols, ENB. 0.14
- Fig. 11 - *Reticulofenestra umbilica* (Levin)  
Between crossed nicols, GC.8.102
- Fig. 12 - *Discoaster binodosus* Martini  
Ordinary transmitter light, GC.8.96
- Fig. 13 - *Discoaster saipanensis* Bramlette and Riedel  
Between crossed nicols, GC.8.96
- Fig. 14 - *Discoaster tani nodifer* Bramlette and Riedel  
Ordinary transmitter light, GC.8.96
- Fig. 15 - *Discoaster wemmelensis* Achutan and Stradner  
Ordinary transmitter light, GC.8.45
- Fig. 16 - *Tribrachiatulus orthostylus* Shamrai  
Ordinary transmitter light, GB.8.93



1



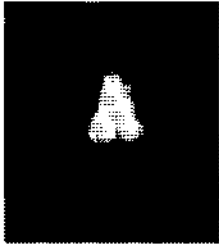
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3a



3b



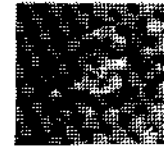
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5a



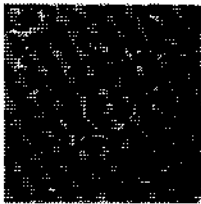
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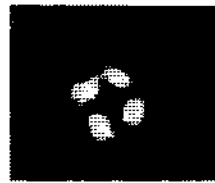
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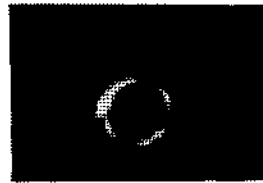
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6a



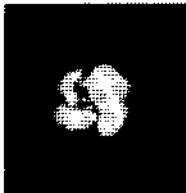
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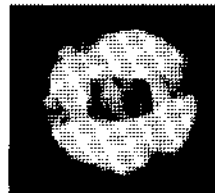
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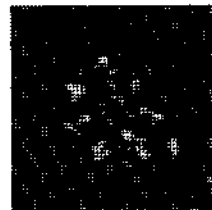
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10



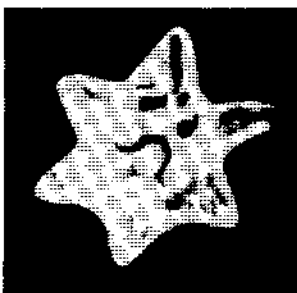
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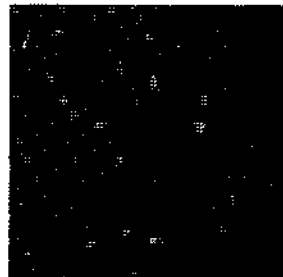
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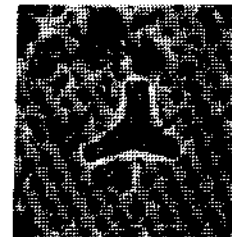
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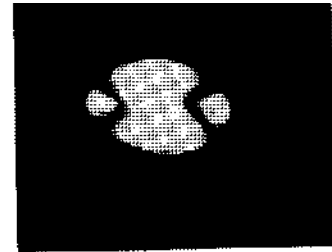
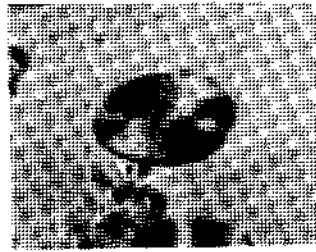
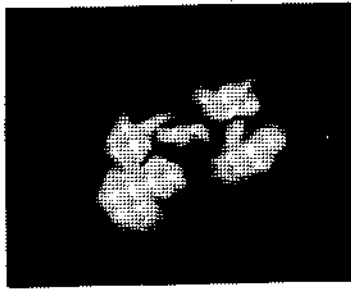
14



16

## PLATE - II

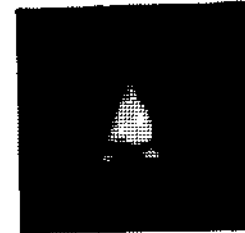
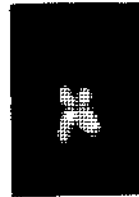
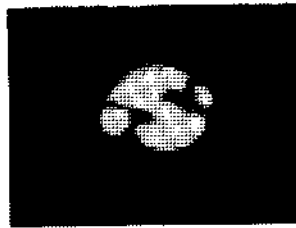
- Fig. 1 - *Helicopontosphaera lophota* (Bramlette and Sullivan)  
Between crossed nicols, GC.8.102
- Fig. 2 - *Helicopontosphaera seminulum* (Bramlette and Sullivan)  
Between crossed nicols, GC. 8. 102
- Fig. 3 - *Pontosphaera plana* (Bramlette and Sullivan)  
a- Ordinary transmitter light, b- Between crossed nicols, GC.8.96
- Fig. 4 - *Transvirsopontis obliquipons* Deflandre  
Between crossed nicols
- Fig. 5 - *Rhabdosphaera perlonga* (Deflandre)  
a- Ordinary transmitter light, b- Between crossed nicols, ENB.0.5
- Fig. 6 - *Sphenolithus moriformis* (Brönnimann and Stradner)  
Between crossed nicols, GC.8.96
- Fig. 7 - *Sphenolithus predistentus* Bramlette and Wilcoxon  
Between crossed nicols, ETC.0.14
- Fig. 8 - *Sphenolithus pseudoradians* Bramlette and Wilcoxon  
Between crossed nicols, ENB.0.14
- Fig. 9 - *Sphenolithus radians* Deflandre  
a- Ordinary transmitter light, b- Between crossed nicols, GC.8.102
- Fig. 10 - *Isthmolithus recurvus* Deflandre  
a- Ordinary transmitter light, b- Between crossed nicols, GC.8.102
- Fig. 11 - *Zygodiscus pelectopons* Bramlette and Sullivan  
Between crossed nicols, GC.8.87



3a

3b

I

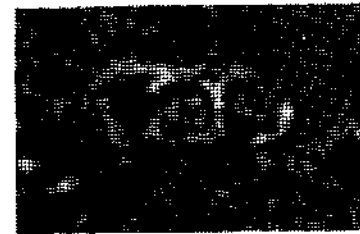
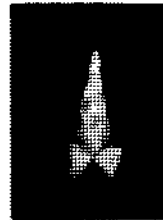
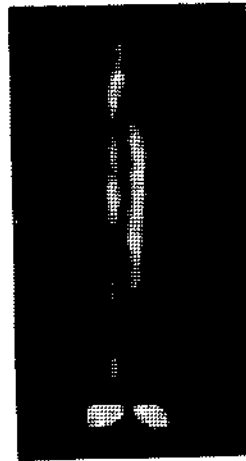
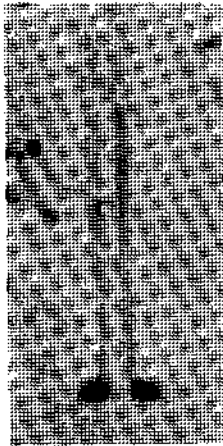


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6

7

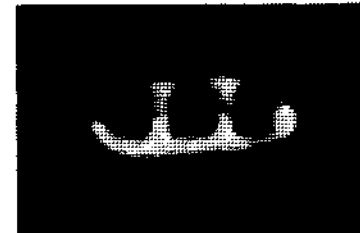


5a

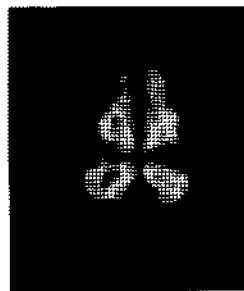
5b

8

10a



10b



9a

9b

11