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NANNOBIOSTRATIGRAPHY OF THE LATE CRETACEOUS PALEOCENE SUCCESSION IN ESH EL-MALLAHA RANGE, EASTERN DESERT, EGYPT

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ABSTRACT

This paper emphasis the biostratigraphic significance of thirty nannofossil species recorded from the Maestrichtian - Paleocene succession in Esh El-Mellaha Range, Eastern Desert, Egypt. These species participated in making up three nannobiostratigraphic zones, arranged from top to base as follows:

3. *Discoaster multiradiatus* Zone (Late Paleocene)
2. *Lithraphidites quadratus* Zone (Maestrichtian)
1. *Arkhangelskiella cymbiformis* Zone (Maestrichtian)

In comparison with the planktonic foraminiferal zones, the *Arkhangelskiella cymbiformis* Zone together with the overlying *Lithraphidites quadratus* Zone are equated with the *Globotruncana fornicata* and *Globotruncana gansseri* Zone denoting a Maestrichtian age. The *Discoaster multiradiatus* Zone coinsides with the *Globoratalia vellascoensis* Zone both of Late Paleocene age.

INTRODUCTION

The Late Cretaceous - Early Tertiary succession is one of the most spectacular and widely distributed sequence in Egypt. It covers vast areas within the frame of the Western Desert, Nile Valley, Eastern Desert and Sinai Peninsula. Besides and toward the north, the subsurface geology may detect sediments of such succession. However, the stratigraphy and Paleontology of these sediments have the attracted the attention of many workers since the early days of geological investigations in Egypt.

The classic Maestrichtian - Paleocene section of Egypt is that of Gebel Owaina, southeast of Esna, Nile Valley. This section has been the subject of enormous literature, among recent literature; Said (1962), Said & Sabry (1964), El-Naggar (1966), El-Dawody (1978, 1984) ... and some others.

A number of localities in Europe and America were thouroughly studied for their nannofossils and the results have been quite effectively used for

stratigraphic purposes. Particularly useful range charts have been presented in the last thirty years by many authors. Among them, Martini must be singled out for his notable contributions on the Creraceous - Tertiary succession. In a series of publications (1959-1977), Martini described and commented on the stratigraphic value of the calcareous nannoflora.

In Egypt, El-Dawoody (1970) studied the microbio-stratigraphy of some sections from Upper and Lower Egypt with special emphasis on calcareous nannoplankton. This was followed by different investigations toward this goal, the following are worth mentioning; Kerdany (1970), Shafik & Stradner (1971), El-Dawoody & Barakat (1973), Perch-Nielsen *et al.*, (1974), El-Dawoody & Zidan (1976) and last but not least El-Dawoody (1978, 1984).

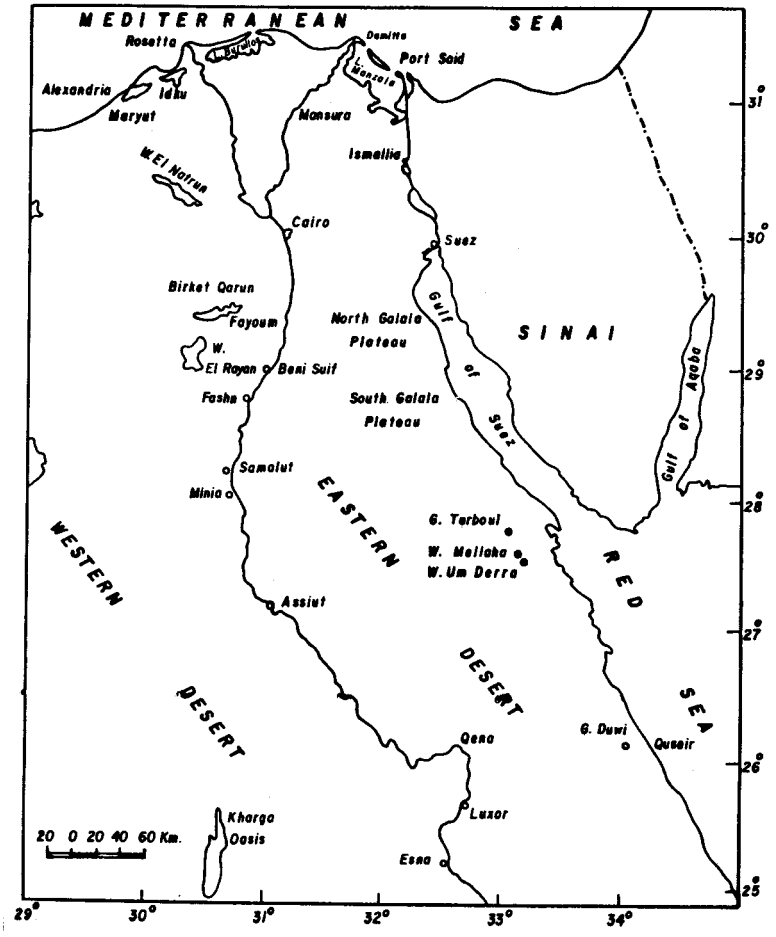

Fig. 1: Location map showing the investigated sections.

In the present study, the calcareous nannoplankton and the co-existent planktonic foraminifera were identified and used to interpret the stratigraphy of the sections investigated (Fig. 1). Somtimes, the stratigraphical ranges of the calcareous nannoplankton could be established on the light of planktonic foraminiferal zonation, thus ending the controversy of their time boundaries. During the progress of this work, it was possible to separate several planktonic species which characterize the Late Cretaceous-Early Tertiary rocks of many parts of the world.

BIOSTRATIGRAPHY

The oldest microfossiliferous rocks in the studied sections are those of the Maestrichtian. This succession overlies the phosphate beds that contain some minute forms of foraminifera which couldn't be identified with certainty. The calcareous nannoplankton content, on the other hand, seems to be rare, sometimes common but without diagnostic forms.

The biostratigraphic zonation proposed here for the Maestrichtian - Late Paleocene succession is based on a system of zonation using the calcareous nannoflora. Rich assemblages with highly distinctive nannofossils have been described from a number of horizons and some of those formal zone names already in common usage have been applied to this interval. This leads to establish an interregional correlation for such period in the section investigated.

Thirty species of calcareous nanoflora were recognized in some of the outcrop samples of the studied sections in Esh Mellaha Range (Plates 1-4). The most common species of which are given in a general distribution chart (Fig. 2). Within this frame, the present author propose the following calcareous nannoplankton zones. For the Maestrichtian - Late Paleocene deposits of the region under investigation:

1. *Akhangelskiella cymbiformis* Zone

This represents the lowest recognized calcareous nannoplankton zone in the succession. It is recorded in the Lower part of Suder Formation in G. Tarboul, W. El Mellaha and W. Um Derra sections, Esh El Mellaha Range. In Gebel Tarboul section, it attains a thickness of 27.5 mts., while it measures 12.5 mts. in the other two sections. Such formation is distinguished by the first flood of *Arkhangeskiella cymbiformis* Vekshina, after which this zone is coined. it is usually associated with multiple of calcareous nannoplankton species that characterize the Maestrichtian of Holland (Bramlette & Martini, 1964). The most common and diagnostic species are:

Ahmuellerella octoradiata (Gorka), ***Arkhangelskiella cymbiformis*** Vekshina, ***Cratarhabdus pienaari*** (Shafik & Stradner), ***Cribrosphaerella ehrenbergi***

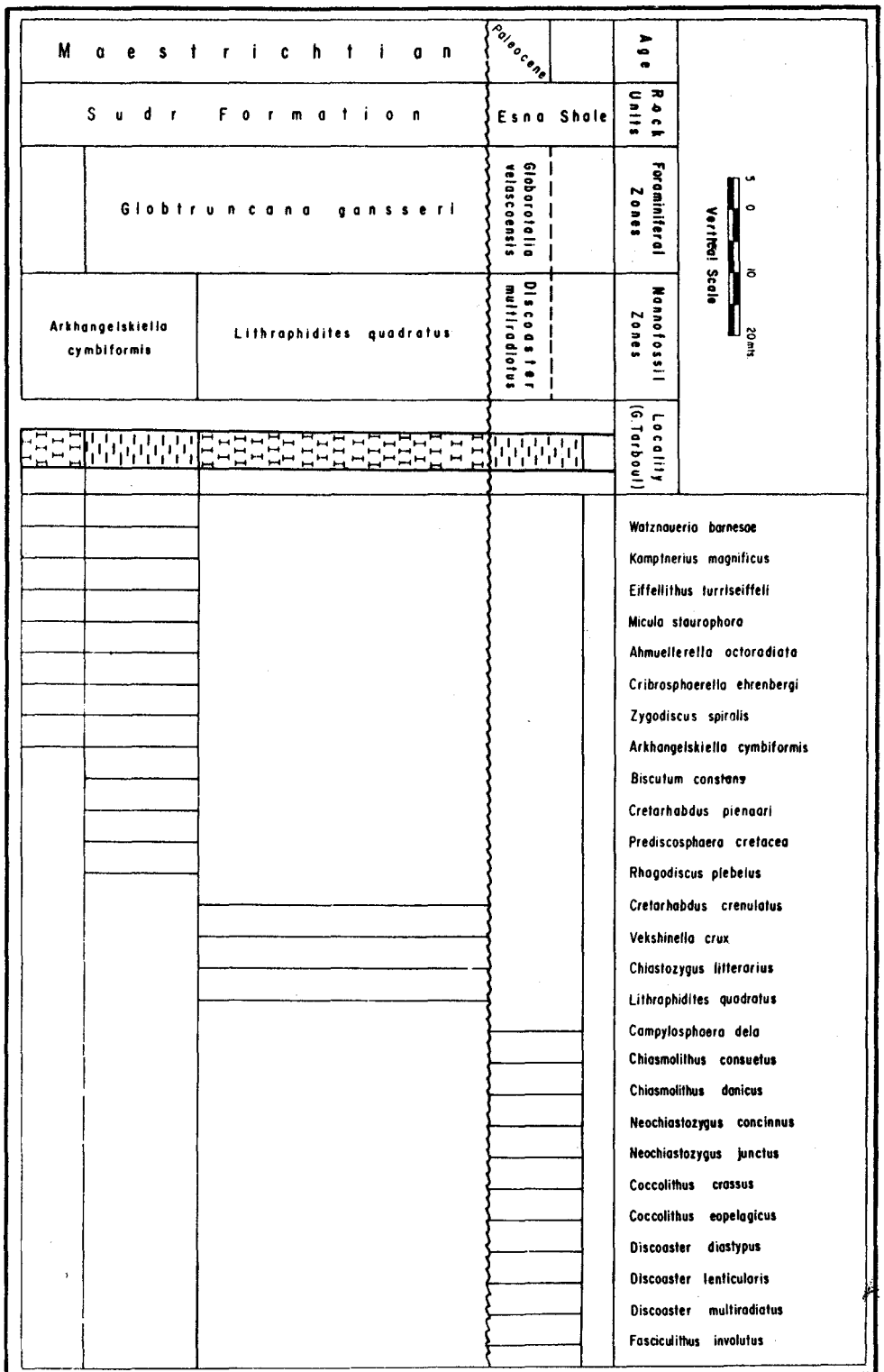

Fig. 2: Distribution of the most common species of nannofossils in the Maestrichtian-Paleocene of Esh El Mellaha Range.

(Arkhangelsky), *Kamptnerius magnificus* Deflandre, *Micula staurophora* (Gardet), *Predicosphaera cretacea* (Arkhangelsky)

The zone under investigation may be correlated with *Tetralithus nitidus trifidus* Zone of Bukry & Bramletre (1970), following them Cita & Gartner (1971) in the North Atlantic. The equivalent of the latter zone under the name *Tetralithus gothicus trifidus* Zone was previously traced by Perch-Nielsen *et al.* (1974) in the Nile Valley, Egypt. They applied such zone to the lowest part of their succession irrespective to the first appearance of the nominate species clearly shown by Roth & Theirstein (1972). In Gebel Tarboul, the *Arkhangelsliella cymbiformis* Zone coicides with the upper part of the planktonic foraminiferal *Globotruncana fornicata* zone together with lowermost part of *Globotruncana gansseri* zone denoting a Maestrichtian age. The boundary of such zone is marked by the first occurence of *Lithraphidites quadratus* (Bramlette & Martini, 1964).

2. *Lithraphidites quadratus* Zone

This zone is met with the next 47.5 meters within the upper part of Sudr Formation just overlying the *Arkhangelskiella cymbiformis* Zone in Gebel Tarboul. In Wadi El Mellaha section, this zone attains a thickness of 43.5 mts., while it measures 61.5 mts. in Wadi Um Derra section. it is defined here by the first occurence of *Lithraphadites quadratus* (Bramlette & Martini) and corresponds to the full range of that marker species. The upper boudary of this zone is not well defined. Such zone is characterized by a calcareous nannoplankton assemblage, rich in the following species:

Cretarhabdus crenalatus Bramlette & Martini, *Lithraphidites quadratus* Bramlette & Martini, *Chiastozygus litterarius* (Gorka), *Vekshinella crux* (Deflandre & fert)

The *Lithraphidites quadratus* Zone was first introduced by Cêpek & Hey (1969) at its locality in Wilcox Country, Alabama. It was defined as the interval from the first occurrence of *Lithraphidites quadratus* Bramlette & Martini to the first occurrence of *Nephrolithus frequens* Górka. The difinition of this zone as used here differs from that given by Cêpek & Hay due to the lack of the nominate taxa characteristic to the top boundary of such zone. In Gebel Tarboul, this zone spans the major upper part of the planktonic foraminiferal *Globotruncana gansseri* Zone both of Maestrichtian age. It matches with the upper part of *Arkhangelskiella cymbiformis* Zone previously known by El-Dawoody & Barakat (1973) in Duwi Range, Red Sea Coast. Again the *Lithraphidites quadratus* Zone represents the youngest maestrichtian nannofossils zone in the area under investigation.

3. *Discoaster multiraiatus* Zone

It includes the Lower part of the Esna Shale rock unit, representing 10 mts. in thickness at G. Tarboul Section. In both W. El Mellaha and W. Um Derra sections, this zone shows a general thinning which measures arround two meters thick. This zone was first proposed by Bronnimann and Stradner (1960) as the *Discoaster multiradiatus/Marthasterites bramlettei/Marthasterites contortus* Zone in the La Habana area, Cuba. As a single fossil name, the *Discoaster multiradiatus* Zone was introduced by Bramlette and Sullivan (1961) and later defined by Hay & Mohler (1967). Such zone is defined here by the first occurrence and full range of *Discoaster multiradiatus* Bramlette & Riedel. The most common species in this zone are:

Campylosphaera dela **(Bramlette & Sulivan),** ***Chiasmolithus consuetus*** **(Bramlette & Sulivan),** ***Chiasmolithus danicus (Brotzen), Coccolithus crassus*** **(Bramlette & Sulivan),** ***Discoaster diastypus*** **(Bramlette & Sulivan),** ***Discoaster lenticularis*** **(Bramlette & Sulivan),** ***Discoaster multiradiatus*** **(Bramlette & Riedel)**

The *Discoaster multiradiatus* Zone is equated with the planktonic foraminiferal *Globorotalia velascoensis* Zone dated back to the Late Paleocene.

A biostratigraphic correlation of the previously mentioned calcareous nannoplankton and planktonic foraminiferal zones with the Maestrichtian-Late Paleocene succession is shown in Fig. 3.

SYSTEMATIC PALEONTOLOGY

The rapid advance in the study of living coccolithophores and of nannofossils have virtually made every attempt at a suprgeneric classification obsolete in a relative short time. Several such attempts have been made in the past thirty years, expecially those of Deflandre (in Grasse, 1952), Kamptner (1958), Deflandre (1959), Hay and Mohler (1967), Stradner (in Stradner & Edwards, 1968), Stradner (in Stradner, Adamiker & Maresch, 1968), Perch-Nielsen (1968), Gartner (1968), Bulry (1969), Proto Decima, Roth & Todesco (1975) and El-Dawoody (1977, 1984). Because of the limited scope of the study, however, any of these classifications will not be given preference.

Among the recorded forms, two main groups may be discerned, the elliptical, round, rhombical tubular or polygonal coccoliths related to suborder coccolithineae and the star and rosette shaped discoasters related to suborder Disccoasterineae. Both groups are derived from phototrophic and heterotrophic unicellular calcareous flagellates respectively. The suprageneric assignment of the nannofossils genera recognized in this follows:

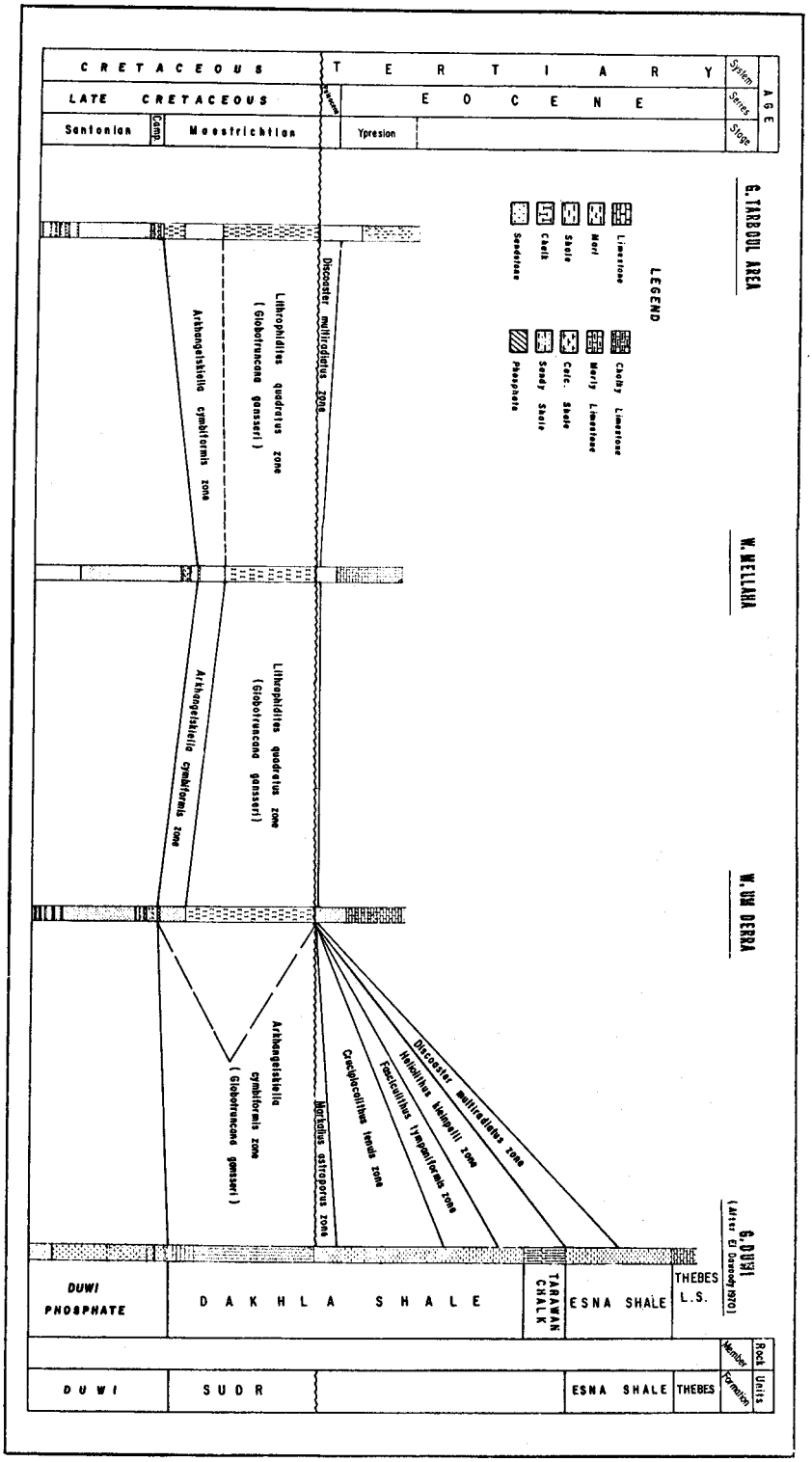

Fig. 3: Bio - Stratigraphic Correlation Chart

Order Coccolithophorales
Suborder Coccolithineae

Family Arkhangelskiellaceae Bukry, 1969
Genus *Arkhangelskiella* Vekshina, 1959
Kamptnerius Deflandre, 1959

Family Coccolithaceae Kamptner, 1928
Tribe Coccolitheae Kamptner, 1958
Genus *Campylospharea* Kamptner, 1963
Chiasmolithus hay, Mpher & Wade, 1966
Coccolithus Schwarz, 1894
Watznaueria Reinhardt, 1964

Subtribe Cyclococcolithineae Kamptner, 1958
Genus *Biscutum* Black, 1959
Subtribe Rhabdosphaerinae Stradner, 1958
Genus *Cretarhabdus* Bramlette & Martini, 1964
Prediscosphaera Vekshina, 1959

Tribe Cribrosphaerelleae Stradner, 1968
Genus *Cribrosphaerella* Deflandre, 1952
Rhagodiscus Reinhardt, 1967

Family Eiffelithaceae Reinhardt, 1965
Genus *Ahmuellerella* Reinhardt, 1964
Ahmuellerella Reinhardt, 1964
Eiffellithus Reinhardt, 1965
Vekshinella Loeblich & Tappan, 1963

Family Zygodiscaceae Hay & M Mohler, 1967
Genus *Chiastozygus* Gartner, 1968
Neochiastozgus Perch-Nielsen, 1971
Zygodiscus Bramlette & Sullivan, 1961

Family Microrhabdulaceae Deflandre, 1963
Genus *Lithraphidites* Deflandre, 1963

Family Sphenolithaceae Vekshina, 1959
Genus *Fasciculithus* Bramlette & Sullivan, 1961

Suborder Discoasterineae

Family Discoasteromonadaceae Bursa, 1965

(= Discoasteridae Tan Sin Hok, 1927)
Genus *Discoaster* Tan Sin Hok, 1927

Incertae sedis

Genus *Micula Vekshina,* 1959.

The detailed description of such coccoliths and discoasters found in the Late Cretaceous - Early Tertiary succession would go beyond the scope of this study. The following short comments of the most common and micrographed species are rather fragmentary. Besides, the stratigraphic ranges of nannofossil species ancountered here are introduced.

Genus : *Arkhangelskiella* Vekshina,1959
Arkhangelsiella cymbiformis Vekshina
(Pl, 3, Fig. 1)

1959: *Arkhangelskiella cymbiformis* Vekshina, p. 66, Pl. 1 Fig. 1, Pl 2, Fig. 3.

Stratigraphic range : Originally known in the Upper Cretaceous (Maestrichtian) deposits of Siberia. Abundant throughout the lower part of the Maestrichtian Sudr Formation in Gebel Taboul.

Genus : *Kamptnerius* Deflandre, 1959
***Kamptnerius magnificus* Deplandre**
(Pl. 3, Fig. 2)

1959: *Kamptnerius magnificus* Deplandre, P. 135, Pl. 1, Figs. 1-4.

Stratigraphic range: Originally described from the Upper Cretaceous (Santonian-Maestrichtian) of France, Texas, Australia, and Poland. This species is commonly found in the lower part of Sudr Formation of Gebel Tarboul.

Genus : *Campylosphaera* Kamptner, 1963
***Campylosphaera dela* (Bramlette & Sullivan)**
(Pl. 1, Figs. 1-2)

1961: *Coccolithus delus* Bramlette & Sullivan, p. 151, Pl. 7, Figs. 1-2.

1967: *Coccolithus delus* (Bramlette & Sullivan) Perch-Nielsen, p. 152, pl. 1, Figs. 1-3.

1967: *Campylosphaera dela* (Bramlette & Sullivan) Hay & Mohler,p. 1531, pl 198, Fig 14.

Stratigraphic range: Originally described from the Paleocene - Middle Eocene, U.S.A. (California, Texas), France and Pakistan. It occurs commonly throughout the Esna Shale unit in Gebel Tarboul.

Genus : *Chiasmolithus* Hay, Mohler & Wade, 1966
***Chiasmolithus consuetus* (Bramlette & Sullivan)**
(Pl 1, Figs. 5-7)

1961: *Coccolithus consuetus* Bramlette & Sullivan, P. 139, pl. 1, fig. 2.

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

Stratigraphic range: Originally known in the Paleocene - Lower Eocene of California, Middle Eocene of Texas and Paleocene of France. Such species occurs commonly through the Esan Shale in Gebel Tarboul.

***Chiasmoslithus danicus* (Brotzen)**
(Pl. 1, Figs. 3-4)

1959: *Cribrosphaerella danica* Brotzen, p. 25, text, fig. 9.

1964: *Coccolithus danicus* (Brotzen) Bramlette & Martini, p. 298, pl. , figs. 15-16.

1967: *Chiasmolithus danicus* (Brotzen) Hay & Mohler, p. 1526, pl. 196, figs. 16,21,22, pl. 198, figs. 8,12,13.
Stratigraphic range: Originally recorded in the Danian strata of Sweden. In Egypt this species lies within the basal part of Late Paleocene succession in Gebel Tarboul.

Genus : *Coccolithus* Schwarz, 1984
***Coccolithus crassus* Bramlette & Sullivan**
(Pl. 2, Figs. 2-3)

1961: *Coccolithus crassus* Bramlette & Sullivan, p. 139, pl. 1, ig. 4.

Stratigraphic range: Originally known in the Lower-Middle Eocene of Claifornia and France. This species occurs with variable frequencies throughout the whole Paleocene succession in Gebel Tarboul.

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

1954: *Trimalithus eopelagicus* Bramlette & Riendel, p. 392, pl. 38, fig. 2.

1961: *Coccolithus eopelagicus* (Bramlette & Riedel) Bramlette & Sullivan, p. 141.

Stratigraphic range: Originally recorded in the Upper Eocene Oceanic Formation of Bath, Barbados, also very common in the Eocene - Oligocene in many parts of the world. In Egypt, this species ranges commonly through the Esna Shale of Gebel Tarboul.

Genus : *Cretarhabdus* Bramlette & Martini, 1964
***Cretarhbdus crenulatus* Bramlette & Martini**
(Pl. 4, Fig. 1)

1964: *Cretarhabdus crenulatus* Bramlette & Martini, p. 300, pl. 2, figs. 21-24.

Stratigraphic range: Originally described from the Upper Cretaceous (Maetrichtian) of U.S.A. (Alabama, Arkansas) Denmark, France, Netherlands and Tunisia. This species is commonly found through the upper part of Sudr Formation in Gebel Tarboul.

***Cretarhabdus pienaari* (Shafik & Stradner)**
(Pl. 4, Fig. 2)

1971: *Polypodrhabdus pienaari* Shafik & Stradner, p. 86, pl. 14, figs. 1-4.

Stratigraphic range: Orignally decribed from the Upper Maestrichtian sediments in Gebel Tarboul, Eastern Desert, Egypt. It also occurs commonly through the Lower Maestrichtian in the same locality.

Genus : *Prediscosphaera* Vekshina, 1959
***Prediscosphaera cretacea* (Arkhangelsky)**
(Pl. 4, Fig. 3)

1912: *Coccolithophora cretacea* Arkhnagelsky, p. 410, pl. 6, figs. 12-13.

1957: *Discolithus cretaceus* (Arkhnagelsky) Gorka, p. 251-474, pl. 2, fig. 11.

1964: *Deflandrius cretaceus* (Arkhangelsky) Bramlette & Martini, p. 301, pl. 2. figs. 11-12.

1968: *Prediscosphaera cretacea* (Arkhangelsky) Gartner, p. 19,pl.2, figs. 10-14, pl. 3, fig. 8, pl. 4, figs. 19-24, pl. 5, figs. 14,15, pl. 9, figs. 1-4, pl. 12, fig. 1, etc.

Stratigraphic range: Oriinally recorded in the Upper Cretaceous deposits of USSR. In Gebel Tarboul, this species occurs nearly in the same horizon, ranges commonly through the Sudr Formation.

Genus : *Cribrospherella* Deflandre, 1952
***Cribrosphaera ehrenbergi* (Arkhangelsky)**
(Pl. 4, Fig. 4)

1912: *Cribrosphaera ehrenbergi* Arkhangelsky, p. 412, pl. 6, figs. 19,20.

1952: *Cribrosphaerella ehrenbergi* (Arkhangelsky) Deflandre, in Grasse, p. 465, fig. 362.

Stratigraphic range: Originally recorded in the Upper Cretaceous deposits of USSR. Thie species occurs frequently throughout the major

Lower part of the Maestrichtian Sudr Formation in Gebel Tarboul.

Genus : *Ahmuellerella* Reinhardt, 1964
***Ahmuellerella octoradiata* (Gorka)**
(Pl 4, Figs. 5-6)

1957: *Discolithus octoradiatus* Gorka, p. 259, 279, pl. 4, fig 10.
1963: *Zygolithus octoradiatus* (Gorka) Stradner, p. 10, pl. 5, fig. 2.
1966: *Ahmuellerella octoradiata* (Gorka) Reinhardt, p. 24, pl. 22, figs. 3-4.

Stratigraphic range: Originally recorded in the Upper Cretaceous (Maestrichtian) deposits of Poland. In Egypt, this species occurs commonly through the basal part of the Sudr Fromation of Gebel Tarboul.

Genus : *Vekshinella* Loeblich & Tappan, 1963
***Vekshinella crux* (Deflandre & Fert)**
(Pl. 4, Figs. 7-8)

1952: *Discolithus crux* Deflandre & Fert, p. 2101, fig. 8.
1961: *Zygolithus crux* (Deflandre & Fert) Bramlette & Sullivan p.149, pl. 6, Figs. 8-10.
1971: *Vekshinella crux* (Deflandre & Fert) Shafik & Stradner, p. 89, pl. 39.

Statigraphic range: Originally recorded in the Middle Eocene sediments of France. Here, this species is commonly restricted to the upper part of Sudr Formation of Gebel Tarboul denoting a Maestichtian age.

Genus : *Chiastozygus* Gartner, 1968
***Chiastozygus litterarius* (Gorka)**
(Pl. 4, Fig. 9)

1957: *Discolithus litterarius* Gorka, p. 251, 274, pl. 3, fig. 3.
1963: *Rhabdolithus litterarius* (Gorka) Stradner, p. 14, pl. 5, fig 1.
1967: *Zygolithus litterarius* (Gorka) Reinhardt & Gorka, p. 249, pl. 31, figs. 18-20, pl. 33, fig. 7.
1971: *Chiastozygus litterarius* (Gorka) Manivit, p. 92, pl. 4, figs. 1-5.

Stratigraphic range: Originally recorded in the Upper Cretaceous (Maestrichtian) deposits of Poland. This species occurs commonly throughout the upper part of the Maestrichtian Sudr Fromation in Gebel Tarboul.

Genus : ***Neochiastozygus*** Perch-Nielsen, 1971
Neochiastozygus concinnus (Martini)
(Pl. 1, Fig. 8)

1961: *Zygolithus concinnus* Martini, p. 18, pl. 3, fig. 35, pl. 5, fig. 54.

1967: *Heliorthus concinnus* (Martini) Hay & Mohler, p. 1533, pl. 199, figs. 16-18, pl. 201, figs. 6,7,10.

1971: *Neochiastozygus concinnus* (Martini) Perch-Nielsen, p. 59, pl. 4, fig. 6, pl. 7, figs. 4-6.

Startigraphic range: Originally known in the Paleocene sediments of France. This species occurs commonly, sometimes rarely and sporadically thoughout the Paleocene succession in Gebel Tarboul.

Neochiastozygus junctus (Bramlette & Sullivan)
(Pl. 1, Fig. 9, Pl. 2, Fig. 1)

1961: *Zygolithus junctus* Bramlette & Sullivan, p. 150, pl. 6, fig.11.

1967: *Heliorthus junctus* Bramlette & Sullivan) Perch Nielsen, p. 61, pl. 4, figs. 7,8, pl. 7, figs. 18, 19.

1971: *Nechiastozygus junctus* (Bramlette & Sullivan) Perch Nielsen, p. 61, pl. 4, figs. 7,8, pl. 7, figs. 18,19.

Stratigraphic range : Originally known in the Paleocene sediments of California and Alabama. This species occurs commonly within the Esna Shale in Gebel Tarboul.

Genus : ***Lithraphidites*** Deflandre, 1963
Lithraphidite quadratus Bramlette & Martini
(Pl. 3, fig. 3)

1964: *Lithraphidites quadratus* Bramlette & Martini, p. 310, pl. 6, figs. 16, 17, pl. 7, figs. 8.

Stratigraphic range: Originally known in the Upper Cretaceous (Maestrichtian) of U.S.A. (Alabama), Denmark, France, Netherlands and Tunesia. This is commonly restricted to the upper part of Sudr Formation in Gebel Tarboul.

Genus : ***Fasciculitus*** Bramlette & Sullivan, 1961
Fasciculithus involutus Bramlette & Sullivan
(Pl. 2, Figs. 4, 5)

1961: *Facicuithus involutus* Bramlette & Sullivan, p. 164, pl. 14, figs. 1-5.

Stratigraphic range: Originally described from the Paleocene - Lower

Eocene of California, England and France. This is found in the Paleocene succession at Gebel Tarboul.

Genus :*Discaster* Tan Sink Hok, 1927
Discoaster diastypus Bramlette & Sullivan
(Pl. 2, Fig. 9)

1961: *Discoaster diastypus* Bramlette & Sullivan, p. 159, pl. 11, figs. 6-8.

Stratigraphic range: Originally known in the Lower Eocene of U.S.A. (California), W. Indies (Trinidad) and France. This species occurs commonly through the Paleocene succession at Gebel Tarboul.

Discoaster multiradiatus Bramlette & Riedel
(Pl. 2, Figs. 7,8)

1954: *Discoaster multiradiatus* Bramlette & Riedel. p. 396, pl. 38, fig. 10.

Stratigraphic range: Originally described from the Paleocene of U.S.A. (California), Mexico, W. Indies (Trinidad), New Zealand and Mid-Pacific Ocean. This species is widespread in many parts of the world. In Egypt, it is commonly found in the Esna Shale of Tarboul section.

Genus : *Micula* Vekshina, 1959
Micula staurophora (Gardet)
(Pl. 3, Figs. 4-7)

1955: *Discoaster staurophorus* Gardet, p. 534, p. 10, fig. 96.

1959: *Trochoaster staurophorus* Gardet, p. 480, figs. 49, 50.

1960: *Nannotetraster staurophorus* (Gardet) Martini & Stradner, p. 266, fig.

1963: *Micula staurophora* (Gardet) Stradner, p. 13, pl. 4, fig. 12.

Stratigraphic range; Originally recorded in the Miocene-Pliocene of Algeria, common in the Maestrichtian of Siberia. It is also found throughout the lower part of Sudr Formation in Gebel Tarboul.

SUMMARY AND CONCLUSIONS

The oldest microfossiliferous rocks in the studied area are those of the Maestrichtian. The author propose three calcareous nannoplankton zones for the Maestrichtian - Late Paleocene deposits of the region under investigation, arranged from top to base as:

3. *Discoaster multiradiatus* Zone
2. *Lithraphidites quadratus* Zone
1. *Arkhangelskiella cymbiformis* Zone

In Gebel Tarboul, the *Arkhangelsiella cymbiformis* Zone coinsides with the upper part of the planktonic forminiferal *Globotruncana fornicata* Zone together with the lowermost part of *Globotruncana gansseri* Zone denoting a Maestrichtian age. The *Lithraphidites quadratus* Zone spans the major upper part of the planktonic foraminiferal *globotruncana gansseri* Zone, both of Maestrichtian age. The *Discoaster muliradiatus* Zone is equated with the planktonic foramininferal *Globorotalia velascoensis* Zone dated back to the Late Paleocene.

Tentative correlation of calcareous nannoplankton zones with the foraminiferal zone of the different sections was attempted. Furthermore, the nannofossil and planktonic faraminiferal zones were correlated with comparable succesion in other parts of the world.

The extensive laboratory study included the micropaleontology of the Late Cretaceous and Paleocene sediments of the sections investigated. It comprises the detailed systematic study of calcareous nannoplankton in these sections.

As a result of these studies, the following conclusions were reached:

1. The Sudr Formation conformably overlies the Duwi Formation. It is differentiated into the nannoplankton zones; the *Arkhangelskieslla cymbiformis* Zone followed upwards by the *Lithraphidites quadratus* Zone. These are dated back to the Maestrichtian. Such unit is mappable allover the range.
2. The Esna Shale unconformably overlies the Sudr Formation showing an obvious variation in thickness throuthout the investigated area. Generally, in Esh El Melleha Range, the Esna Shale is rather thin compared with its occurence in other parts of the Gulf area. It is characterized by the nannoplankton *Discoaster multiradiatus* Zone, dated back to the Late Paleocene.
3. The identification of thirty nannofossil species belonging to twenty one genera and seven families of the order Coccolithophorales.
4. The correlation of the nannoplankton zones and foraminiferal zones between the different studied sections was achieved.

ACKNOWLEDGEMENT

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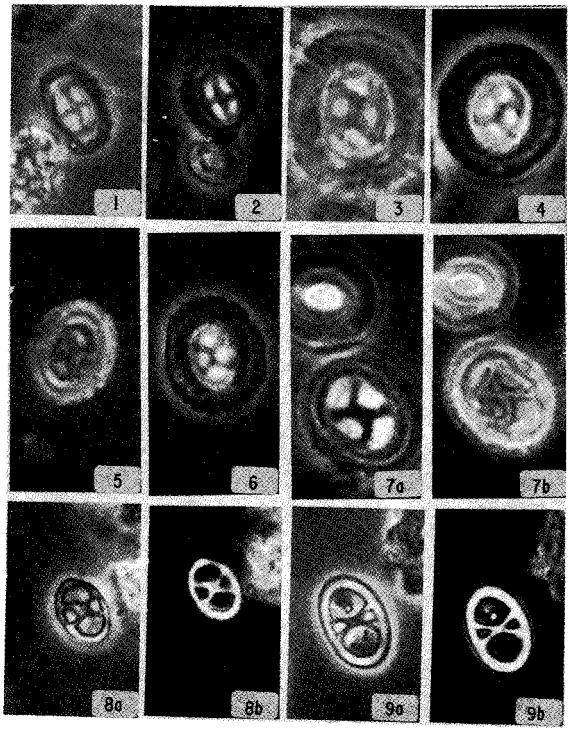
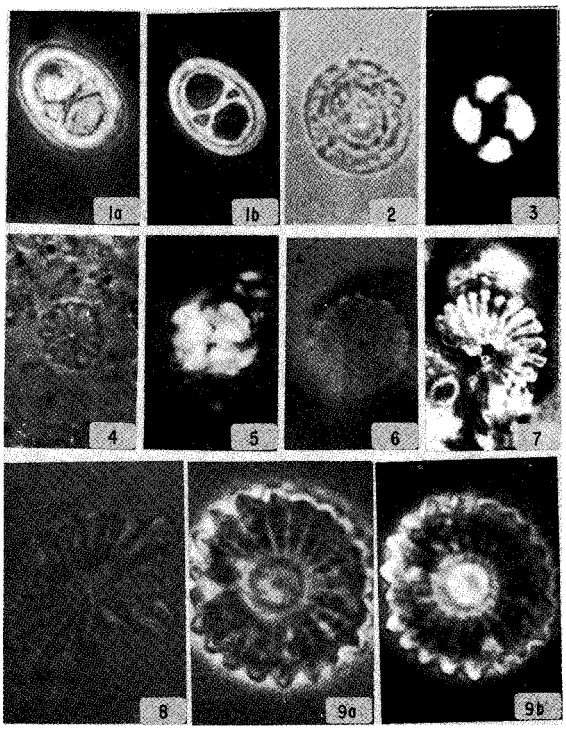
PLATE 1



1. *Campylosphaera dela* (Bramlette & Sullivan)
   negative phase-contrast ..... Hypotype 1022
2. *Campylosphaera dela* (Bramlette & Sullivan)
   negative phase-contrast ..... Hypotype 1023
3. *Chiasmolithus danicus* (Brotzen)
   positive phase-contrast ..... Hypotype 1024
4. *Chiasmolithus danicus* (Brotzen)
   negative phase-contrast ..... Hypotype 1025
5. *Chiasmolithus consuetus* (Bramlette & Sullivan)
   positive phase-contrast ..... Hypotype 1026
6. *Chiasmolithus consuetus* (Bramlette & Sullivan)
   negative phase-contrast ..... Hypotype 1027
7. *Chiasmolithus consuetus* (Bramlette & Sullivan)
   Coccolithus eopelagicus (Bramlette & Riedel)
   a = positive phase-contrast ..... Hypotype 1028
   b =negative phase-contrast ..... Hypotype 1028
8. *Neochiastozygus concinnus* (Matini)
   a = positive phase-contrast ..... Hypotype 1029
   b =negative phase-contrast ..... Hypotype 1029
9. *Neochiastozygus junctus* (Bramlette & Sulivan)
   a = positive phase-contrast ..... Hypotype 1030
   b =negative phase-contrast ..... Hypotype 1030

PLATE 2



1. *Neochiastozygus junctus* (Bramlette & Sullivan)
   a = positive phase - contr ..... Hypotype 1031
   b = negative phase - contr ..... Hypotype 1031

2. *Coccolithus crassus* Bramlette & Sullivan
   normal light ..... Hypotype 1032

3. *Ccccolithus crassus* Bramlette & Sullivan
   cross nicols ..... Hypotype 1033

4. *Fasciculithus involutus* Bramlette & Sullivan
   normal light ..... Hypotype 1034

5. *Fasciculithus involutus* Bramlette & Sullivan
   cross nicols ..... Hypotype 1035

6. *Discoaster lenticularis* Bramlette & Sullivan
   positive phase-contrast ..... Hypotype 1036

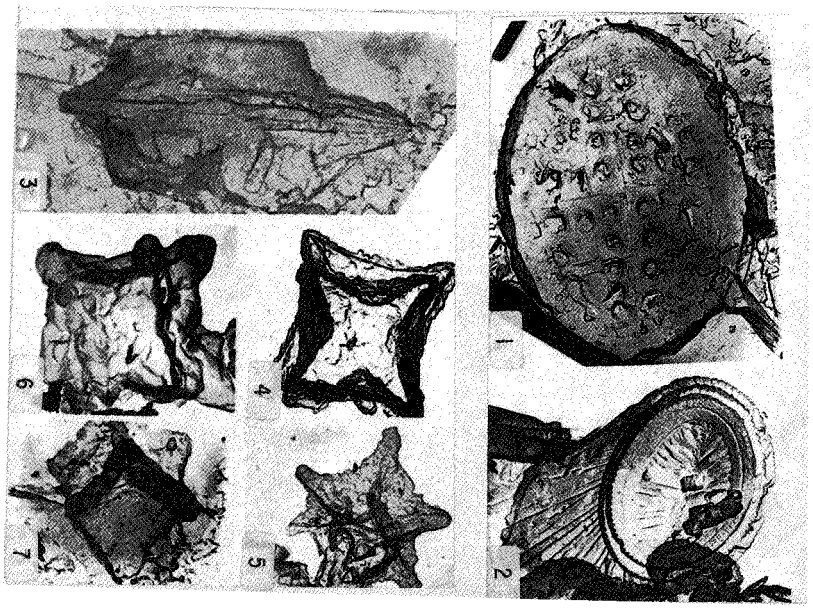
7. *Discoaster multiradiatus* Bramlette & Riedel
   negative phase-contrast ..... Hypotype 1037

8. *Discoaster multiradiatus* Bramlette & Riedel
   normal light ..... Hypotype 1038

9. *Discoaster diastypus* Bramlette & Sulivan
   a = positive phase-contrast ..... Hypotype 1039
   b =negative phase-contrast ..... Hypotype 1039

NB : All photomicrographs in pls. 11, 12 are reproduced at a magnification of 3500X.

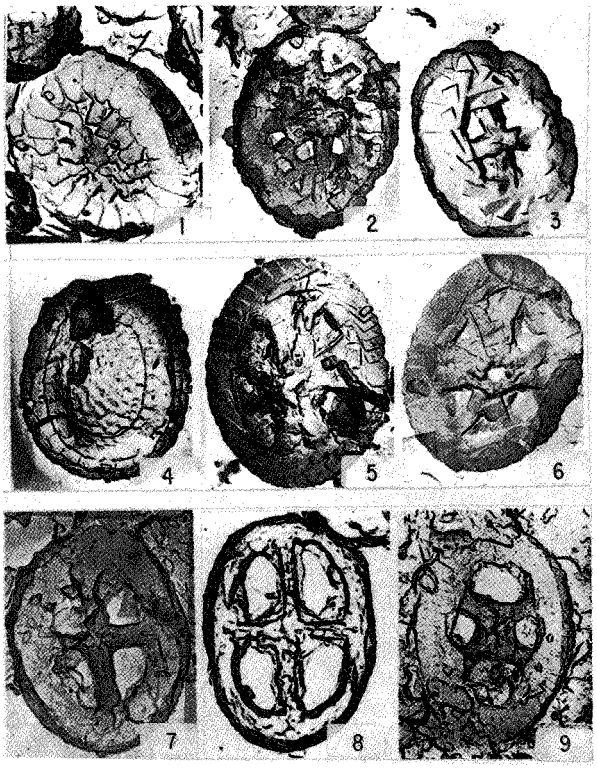
PLATE 3



1. *Arkhangelskiella cymbiformis* Vekshina
   Distal view ..... Hypotype 980
2. *Kamptnerius magnificus* Deflandre
   Distal view ..... Hypotype 981
3. *Lithraphidites quadratus* Bramlette & Martini
   Side view 20, 000X ..... Hypotype 1017
4. *Micula staurophora* (Gardet)
   Oblique view ..... Hypotype 1018
5. *Micula staurophora* (Gardet)
   Oblique view ..... Hypotype 1019
6. *Micula staurophora* (Gardet)
   Oblique view ..... Hypotype 1020
7. *Micula staurophora* (Gardet)
   Oblique view ..... Hypotype 1021

NB : All electronmicrographs are are reproduced at a magnification of 15,000X unless otherwise indicatd.

PLATE 4



1. *Cretarhabdus crenulatus* Bramlette & Martini
   Distal view ..... Hypotype 988
2. *Cretarhabdus pienaari* (Shafik & Stradner)
   Distal view 20,000X ..... Hypotype 989
3. *prediscosphaera cretacea* (Arkhangelsky)
   Distal view ..... Hypotype 994
4. *Cribrosphaerella ehrenbergi* (Arkhanelsky)
   Distal view ..... Hypotype 997
5. *Ahmuellerella octoradiata* (Gorka)
   Distal view ..... Hypotype 998
6. *Ahmuellerella octoradiata* (Gorka)
   Distal view ..... Hypotype 999
7. *Vekshinella crux* (Deflandre & Fert)
   Distal view ..... Hypotype 1008
8. *Vekshinella crux* (Deflandre & Fert)
   Proxial view ..... Hypotype 1009
9. ***Chisatozygus litterarius*** (Gorka)
   Distal view ..... Hypotype 1010

NB : All electromicrographs are reproduced at a magnification of 10,000 X unless otherwise indicated.

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الإستراتجرافية الحيوية الدقيقة لتتابع الطباشيري المتأخر ـ الباليوسين في منطقة عش الملاحة بالصحراء الشرقية ـ مصر

أحمد سامي الداودي

ينوه هذا البحث على الأهمية البيوستراتجرافية لثلاثين نوعاً من الحفريات الجيرية المجهرية الدقيقة والتي سجلت في تتابع الماسترختى ـ الباليوسين بمنطقة عش الملاحة بالصحراء الشرقية ـ مصر . وتعمل هذه الأنواع على التعرف على ثلاث نطاقات حيوية للنانوبلانكتون من أعلى إلى أسفل :

٣ ـ نطاق الـ *Discoaster multiradiatus*

٢ ـ نطاق الـ *Lithraphidites quadratus*

١ ـ نطاق الـ *Arkhangelskiella cymbiformis*

وبالمقارنة بالنطاقات الحيوية للفورامينفرا وجد ان النطاقين الأول والثاني السفليين يتعادلان مع النطاقين Globotruncana fornicata ونطاق الـ Globotruncana gansseri مشيراً إلى العصر الماسترختي . كما ان النطاق الثالث العلوي يتطابق مع نطاق الـ Globorotalia velascoensis مشيراً إلى عصر الباليوسين .