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BIOSTRATIGRAPHY AND PALEOECOLOGY OF THE CAMPANIAN-PALEOCENE AGGLUTINATED FORAMINIFERA FROM GEBEL UM EL GHANAYIM, KHARGA OASIS, EGYPT.

BY

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Abstract

A detailed study of the Campanian-Paleocene agglutinated Foraminifera from Gebel Um El Ghanayim, Kharga Oasis in the Western Desert of Egypt yielded 55 species belonging to 22 genera.

The paleoecological implications of the investigated species are discussed and the biostratigraphical classification of the agglutinated assemblages is attempted. Four biozones of agglutinated Foraminifera are distinguished the late Cretaceous and three belonging to Paleocene.

The Cretaceous / Tertiary boundary is marked by a disconformity surface covered by a conglomerate rich in reworked Maastrichtian macrofossils. This conglomerate bed at the K/T boundary is overlies claystone beds contain genus Ammoastuta. This genus regarded as a facies index fossil for

brackish littoral environment.

The Paleocene sequence is characterized by a higher percentage of calcareous agglutinated Foraminifera than the Upper Cretaceous one. It is believed that the higher content of CaO in the Paleocene sequence (particularly the Upper Kharga Shale Member and Tarawan Formation) is responsible for the predominance of calcareous agglutinated Foraminifera in these rock units.

INTRODUCTION

Purpose of Study

The study of the Campanian and Early Tertiary agglutinated Foraminifera in Egypt is unfortunately scarce. The scope of the present work is to study the agglutinated Foraminifera of Gebel Um El Ghanayim, Kharga Oasis Western Desert (Fig. 1) to throw more light on the agglutinated Foraminifera distribution and their biostratigraphic value of the time equivalent agglutinated assemblages characteristic for the different rock units.

A total of 42 rock samples were collected from Gebel Um El Ghanayim representing the Campanian to the Paleocene rocks. The succession is made up of the Duwi, Dakhla, Tarawan and Esna formations. The whole succession rests over the Mut Formation and is overlain by the Thebes Formation .

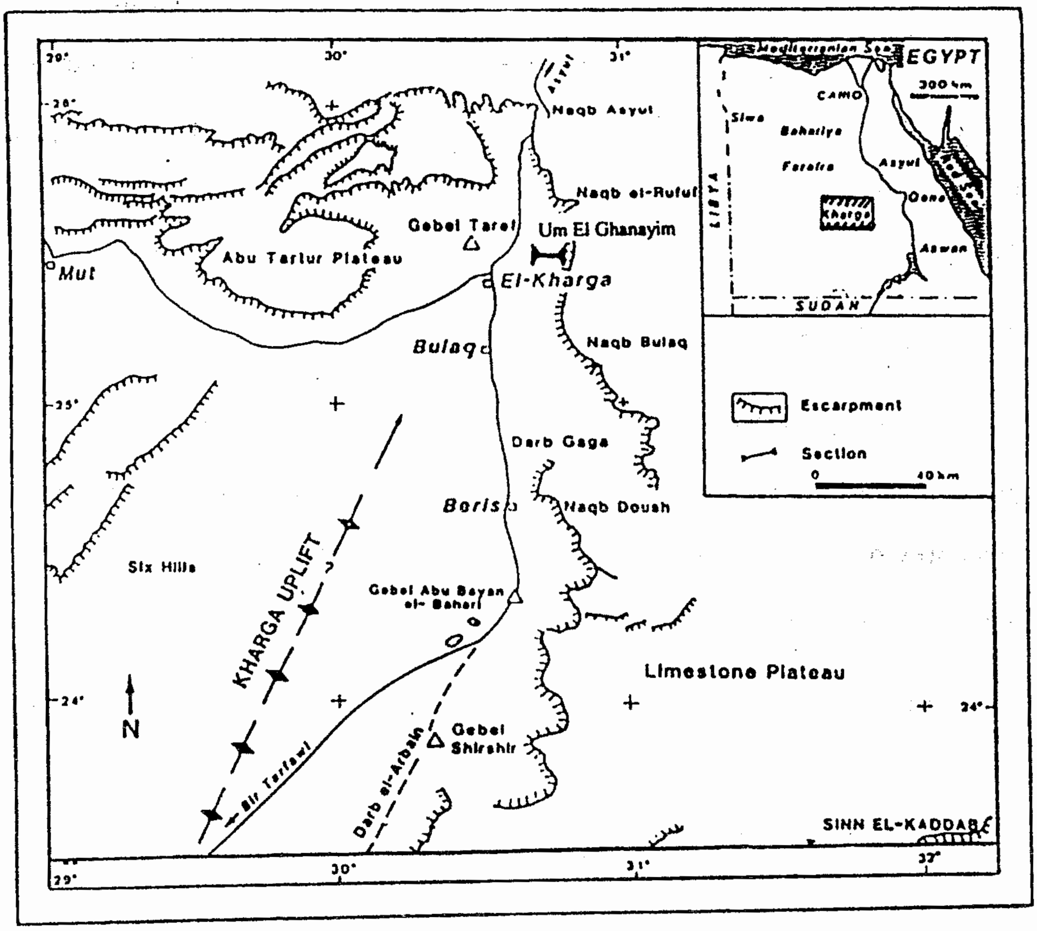

Fig.1: LOCATION MAP.

The percentage of the agglutinated/calcareous, the calcareous agglutinated/arenaceous agglutinated, the planktonic/benthonic ratio and the chemical analysis (CaO%) of hte different rock units (Fig. 2) were calculated in a trial to interpret the paleoecological conditions prevailing during deposition. On the other hand the K/T boundry will be disscussed in the present work.

Previous Work

As mentioned above the study of agglutinated Foraminifera in Egypt is scarce. The study of the late Cretaceous/Tertiary planktonic Foraminifera was previously attempted by many authors while the agglutinated forams were relatively neglacted.

LE Roy (1953) studied the Upper Cretaceous-Lower Tertiary in hte Maqfi section, Farafra Oasis, Western Desert. He recorded 19 species of Foraminifera from the Upper Cretaceous and 112 species from the Lower Tertiary. LE Roy noticed a disconformity between Cretaceous and Lower Tertiary .

Nakkady (1950, 1952, 1959) studied the foraminiferal content of the Upper Cretaceous-Lower Tertiary succession in many localities in Egypt, from Sinai, Eastern Desert, Nile Valley and Western Desert. In 1959, he studied the planktonic Foraminifera of Gebel Um El Ghanayim, Kharga Oasis.

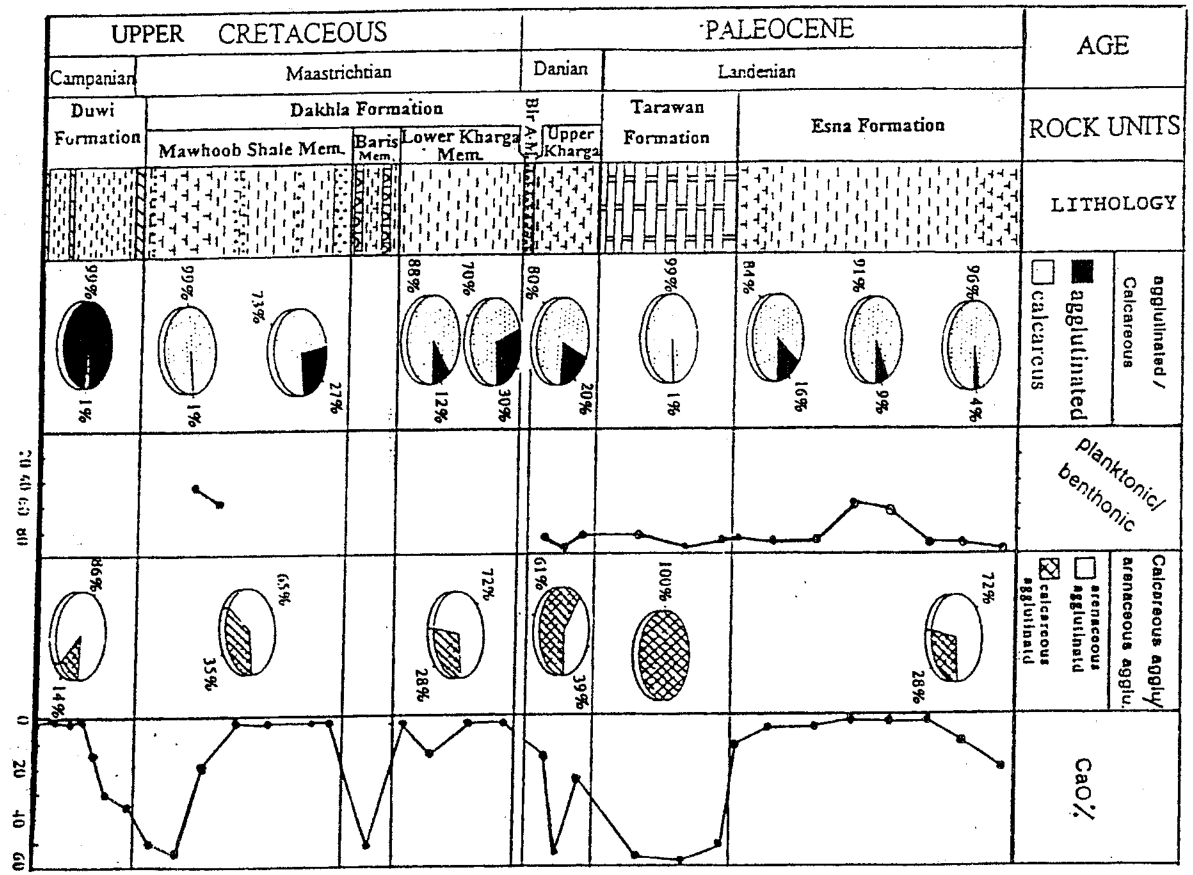

Fig.2: Shows the agglutinated/calcareous ratio, the planktonic/benthonic ratio, the calcareous agglutinated/arenaceous agglutinated and the CaO percentage in the Um El Ghanayim section.

Abdou (1960) studied the biostratigraphy of Gebel El Teir (near Gebel Um El Ghanayim) and introduced some biozones in the Maastrichtian, Paleocene and Ypresian.

In 1964, Shinnawi studied the planktonic Foraminifera of Gebel Ghanima (south of Gebel Um El Ghanayim). He recorded the presence of Maastrichtian, Danian, Landenian and Ypresian.

Abdou et al. (1969) identified the planktonic Foraminifera of Gebel Ghanima, they recognized an unconformity between the Maastrichtain and Upper Danian.

Eissa (1978) identified 16 arenaceous and 23 calcareous foraminiferal species from the area west Dakhla between Dakhla nd Abu Minqar. This area represents the Garra El Arbain Facies.

Mohamed (1982) identified thiry Paleocene benthonic Foraminifera from five sections in central Egypt. Six of these are arenaceous while the other are hyaline.

Luger (1985) studied the Upper Cretaceous-Lower Tertiary succession in southern Egypt, inclucing the Nile Valley and Garra El Arbain facies. Sixty eight planktonic foraminiferal species, 25 arenaceous species and 92 calcareous species are described.

Anan and Hewaidy (1986) identified ninety benthonic foraminiferal species from the Paleocene rocks of Gebel Teir, Gebel Tarawan and Gebel Ghanima in the Kharga are, Gebel Dandara and Gebel Gurnah in the Nile Valley and Um El Huetat section in the Red Sea coastal area. The calcareous benthonic Foraminifera have been used to define two biostratigraphic zones within this sequence.

Luger (1988) reported for the first time from southern Egypt the genus *Ammoastuta* from the Campanian-Paleocene rocks which is regarded as a facies index fossil for brackish littoral conditions.

Hewaidy and Soliman (1993) studied the Masstrichtain-Paleocene sequence of Garra El Arbain facies which is exposed in Gebel El Borga. They subdivided the studied sequency into six biostratigraphic zones according to planktonic and areanceous Foraminifera.

LITHO-AND BIOSTRATIGRAPHY

Lithostratigraphical subdivision of the Late Cretaceous to Early Tertairy in the Kharga Oasis (Um El Ghanayim section) is mainly based on the work of Awad and Ghobrial (1966) and Luger (1985). Bassiouni and Luger (1990) provided a lithostratigraphical scheme to link lithostratigraphic units of Nile Valley, Baris, Dungul, Bir Murr with those of Kharga (Fig. 3).

The stratigraphic range chart of the identified agglutinated Foraminifera is given in Fig. 4. including the most important biozones recognized in

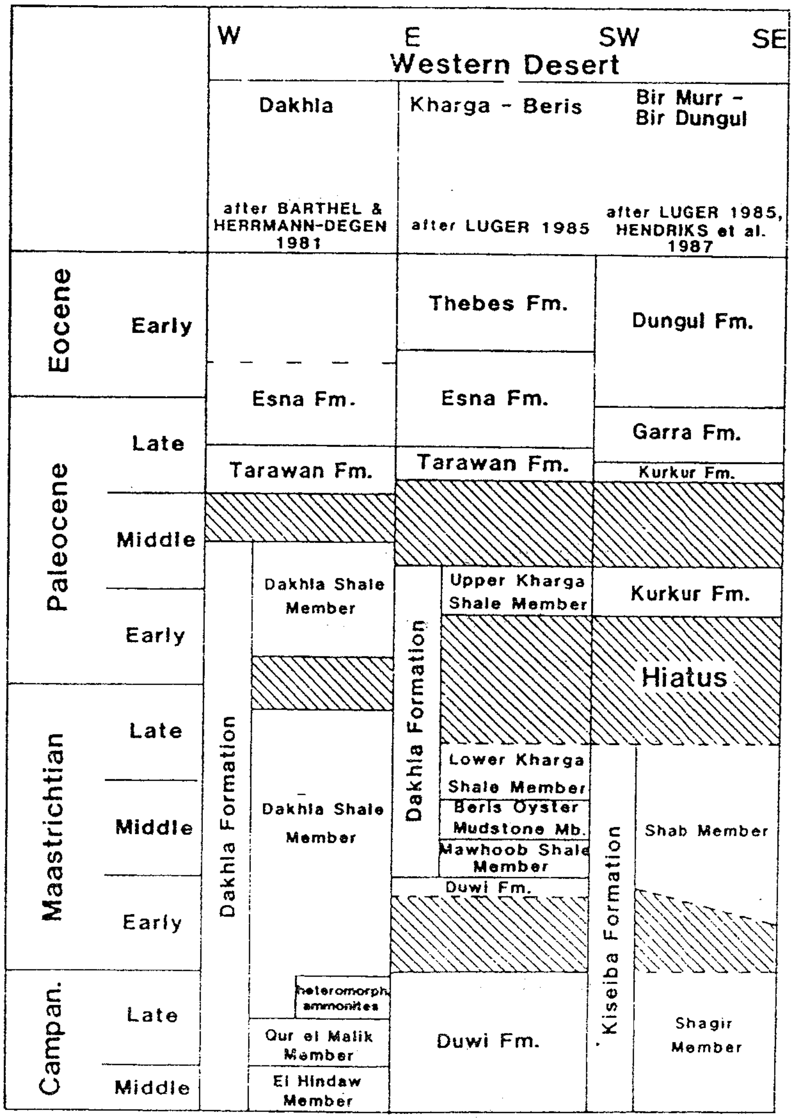

Fig. 3: Correlation of the Campanian -Early Eocene lithostratigraphic units in Western Desert (after Luger, 1988).

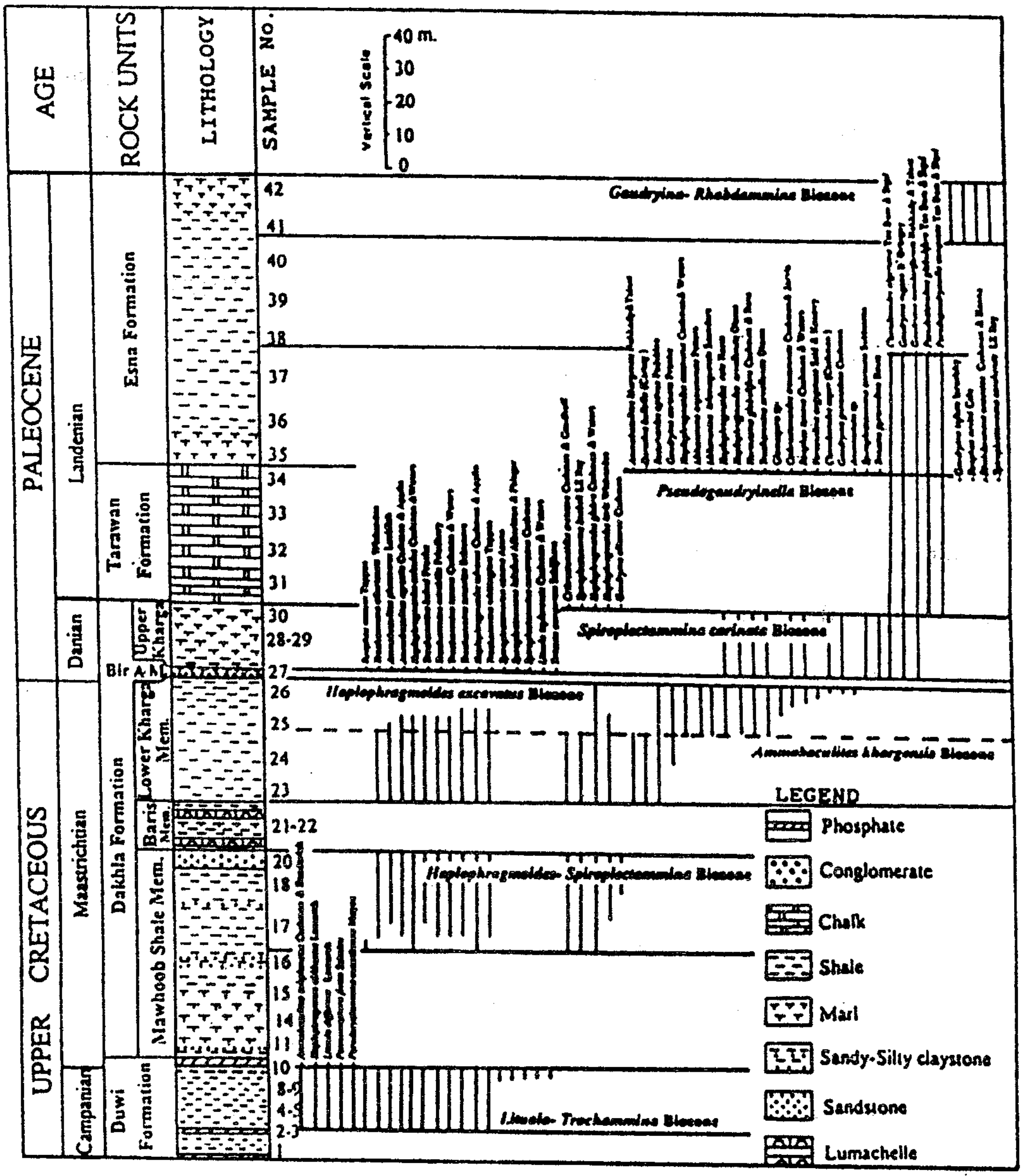

Fig.4: Stratigraphic range of Campanian-Paleocene agglutinated foraminifera identified in Um El Ghanayim section with agglutinated foraminiferal biozones.

the studied area.

The lithologic characteristics and agglutinated foraminferal assemblages of each stratigraphic unit are discussed from base to the top as follows :

1- Duwi Formation (Campanian-Early Maastrichtian)

This rock unit was established by Youssef (1957), it is the Phosphate Formation of Awad and Ghobrial (1966). This formation overlies the Quseir Formation and underlies the Dakhla Formation. The Duwi Formation is subdivided into two phosphate bearing horizons (A and B Horizon). The A Horizon is less than 1m thick at Um El Ghanayim section and marks the base of this formation, it is followed upward by shales and phosphatic beds of B Horizon.

The Duwi Formation at Um El Ghanayim section attains a thickness of 30m and yields the following agglutinated forams :

Ammobaculites subplanatus Cushman & Deaderick, *A. plummerae* Loeblich, A. agrestis Cushman & Applin, Haplophragmium abkhasicus *Keller*, Lituola difformis Lamarck, *L. taylorensis* Cushman & Waters, Pssamosphera fusca Schulze, Spiroplectammina ezoana Asano, *S. lalickeri* Albcritton & Phleger, *S.* navarroana Cushman, Tritaxia compressa Schijfsma, Trochammina albertensis Wickenden, *T. bohmi Franke, T.* mirabilis Friedberg,

T. texana Cushman & Waters, T. senonica Belousova, *T. whittingtoni* Tappan, *Reophax* minuta Tappan, *Haplophragmoides calculus* Cushman & Waters, *H. advenus* Cushman & Applin and Pseudocyclammina massiliensis Maync.

2- Dakhla Formation (early Middle Masstrichtian-early Middle Paleocene)

This formation was introduced by Said (1961) to describe the shales overlying the phosphate beds and underlying the Tarawan chalk in the northern scarp of the Dakhla Oasis.

At Um El Ghanayim section, it is formed mainly of laminated claystones, marls, calcareous sandstones and siltstone. The base of the Dakhla Formation consists of marls with planktonic Foraminifera of earlier *Ganssarina gansseri* Zone. This formation grades into unfossiliferous claystones in which only agglutinated forms were observed.

The Dakha Formtion attains a thickness of 142m and is subdivided into the following members in the area under consideration.

2.1 Mawhoob Shale Member (early Middle Masstrichtian)

This rock unit was established by Awad and Ghobrial (1966) and recorded by Luger (1985). It consists of marls and shales of early Middle Masstrichtian due to the presence of *Ganssarina gansseri* (Hendriks et al. 1984).

At the studied area, it attains a thickness of 65m and yields the following agglutinated Foraminifera : *Reophax* minuta Tappan, Trochammina albertensis Wickneden, *T.* bohmi Franke, *T.* mirabilis Friedberg, *T* .texana Cushman & Waters, *T.*. senonica Belousova, *T.* whittingtoni Tappan, Ammobaculites plummerae Loeblich, A. agrestis Cushman & Applin, Haplophragoides calculus Cushman & Waters, *H.* advenus Cushman & Applin, *H.* glabra Cushman & Waters, *H.* kirki Wickenden, Cribrostomides cretacea Cushman & Goudkoff, Spiroplectammina knebeli LE Roy and Gaudryina ellisorae Cushman.

2.2 Baris Oyster Mudstone Member (Middle Masstrichtian)

This rock unit was establidshed by Awad and Ghobrial (1966) and recorded by Luger (1985). It is formed mainly of a number of fossiliferous marl beds, intraformational conglomerate of phosphatic pebbles and mudstone beds. The presence of *Exogyra (Exogyra) overwegi* v.Buch indicaing Middle Masstrichtian age (Malchus, 1990). This member reprsents a shallow shelf facies of deposition and attains a thickness of 15m. The marl layer contains Foraminifera of the *Ganssarina ganssei* zone (Luger. 1985).

2.3 Lower Kharga Shale Member (Middle-Late Masstrichtian)

This subdivision is introduced by Awad and Ghobrial (1966) and recorded by Luger (1985) to designate a succession of claystones and shales containing agglutinated Foraminifera. The Lower Kharga Shale Member in the studied area reach 36m thick with no marked variation in lithological content as exhibited in Mawhoob and Baris members.

In addition to the separated agglutinated forams from the Mawhoob Shale Member, the following agglutinated species were recorded in this member; *Dorathia bullella* (Carsey), *Gaudryina carinata* Franke, *G. pyramidata* Cushman, *Ammobaculites khargensis* Nakkady & Tallat, Recurvoides optivus Podobina, Glomospira sp, *Verneuilina aegyptiaca* Said & Kenawy, *Haplophragmoides excavatus* Cushman & Waters, *H. rota* Nauss, *H. sewellensis* Olsson, *Miliammina onyeamensis* Petters, *M. telemaquensis* Saunders, *Hormosina globulifera* Cushman & Renz, *Trochammina sewellensis* Olsson, *Cribrostomoides trinitatensis* Cushman & Jarvis, *Reophax texana* Cushman & Waters, *Clavulinoides asper* (Cushman) and *Ammoastuta* sp.

2.4 Bir Abu Munqar Member (Late Masstrichtian)

The base of the Paleocene age is marked by a phosphatic-conglomerate layer. This layer marks the top of the Lower Kharga Shale Member and named Bir Abu Munqar Horizon of Dakhla Formation by Barthel and Herrmann-Degen (1981). It was later raised to member by Luger (1985).

Bir Abu Munqar Member of Luger (1985) attains a thickness of 70 cm and it seperates the Lower Kharga Shale Member from the Upper Kharga Shale Member of Paleocene age. Moreover, it contains reworked Masstrichtian fossils (Luger, 1985).

2.5 Upper Kharga Shale Member (late Early-early Middle Paleocene)

This rock unit was established by Awad and Ghobrial (1966) and recorded by Luger (1985) to designate a sequence of laminated marls rich in planktonic Foraminifera. It has an age ranging from late Early to early Middle Paleocene as indicated by the presence of *Morozovella trinidadensis* and *Morozovella angulata* (Luger,1985).

At Um El Ghanayim section, the Upper Kharga Shale Member is 25cm thick and yields the following agglutinated forms : *Trochammina wittingtoni* Tappan, *T. sewellensis* Olsson, *Haplophragmoides rota* Nauss, *H. sewellensis* Olsson, *Hormosina globulifera* Cushman &Renz, *Cribrostomoides trinitatensis* Cushman & Jarvis, *Reophax texana* Cushman & Waters *Clavulinoides asper* (Cushman), *C. algeriana* Ten Dam & Sigal, *Gaudryina pyramidata* Cushman, *G. rugosa* D'Orbigny, *G. textulariformis* Nakkday & Taalat, *Spiroplectammina carinata* Subbotina and *Pseudoclavulina globulifera* Ten Dam & Sigal.

3. Tarawan Formation (early Late Paleocene)

This rock unit was established by Awad and Ghobrial (1966). It separates the undelying Dakhla Formation from the overlying Esna Formation.

At Um El Ghanayim section, it is composed of light yellow chalk and chalky marl which changes into impure chalky limestone at the top. The Tarawan Formation belonges to the lower Upper Paleocene due to the presence of *Planoratalites pseudomenardii,* it attains a thickness of 42 m and yields : *Gaudryina textulariformis* Nakkady & Talaat, *G. rugosa* D'Orbigny and *Clavulinoides algeriana* Ten Dam & Sigal.

4. Esna Formation (late Late Paleocene)

This rock unit was recognized by Beadnell (1905), it overlies the Tarawan Formation and underlies the Thebes Formation. The Esna Formation belongs mainly to the Upper Paleocene due to the presence of *Morozovella velascoensis.* It consists of grey and green laminated calcareous shales with intercalation of marl.

In the area under consideration, this formation attains a thickness of 88m and yields the follwoing agglutinated Foraminifera : Gaudryina textulariformis Nakkady & Talaat, *G. inflata* Israelsky, Clavulinoides algeriana Ten Dam & Sigal, Pseudoclavulina globulifera Ten Dam & Sigal, Rhabdammina eocenica Cushman & Hanna, *Reophax nevini* Cole Spiroplectammina *esnaensis* LE Roy and *Pseudogaudryinella compacta* Ten Dam & Sigal.

AGGLUTINATED FORAMINIFERA BIOZONES

According to the stratigraphic ranges of the identified Foraminifera, the Campanian-Paleocene succession in the Um El Ghanayium section can be subdivided into seven newly erected agglutinated Foraminifera biozones (Fig. 4) which have been correlaed with planktonic zones in table 1.

1. *Lituola* spp-*Trochammina* spp Assemblage Zone

Type : Assemblage Zone

Definition : It is characterized by the abundant and restricted occurrence of *Lituola difformis* Lamarch and *L. taylorensis* Cushman & Waters beside *Trochammina ablertensis* Wichenden, *T. bohmi* Franke, *T. mirabilis* Friedberg, T. texana Cushman & Waters, *T. senonica* **Belousova** and*T whittingtoni* Tappan.

Faunal Assemblage : *Ammobaculites subplanatus* Cushman & Deadlerick, *A. plummerae* Loeblich, *A. agrestis* Cushman & Applin, *Psammosphera fusca* Schulze, *Pseudocyclammina massiliensis* Maync, *Reophax minuta* Tappan, *Haplophragmoides calculus* Cushman & Waters, *Hplophragmium abkhaicus* Lamarck, *Spiroplectammina navarroana* Cushman, *S. lalickeri* Alberitton & Phleger.

Stratigraphic Distribution : This biozone represents the upper part of the Duwi Formation .

AGE		ROCK UNITS	SAMPLE No.	PLANKTONIC BIOZONE revised after Luger, 1985, 1988	AGGLUTINATED BIOZONE of the present work
PALEOCENE	Landenian	Esna Formation	42, 41	*M. velascoensis*	*Gaudryina & Rhabdammina*
PALEOCENE	Landenian	Esna Formation	40, 39, 38, 37, 36, 35	*M. velascoensis*	*Pseudogaudryinella compacta* & *Pseudoclavulina globulifera*
PALEOCENE	Landenian	Tarawan Formation	34, 33, 32, 31	*P. pseudomenardii*	*Pseudogaudryinella compacta* & *Pseudoclavulina globulifera*
PALEOCENE	Danian	Dakhla Formation: Upper Kharga Mem.	30, 28-29	*M. angulata*, *M. trinidadensis*	*Spiroplectammina carinata*
PALEOCENE	Danian	Dakhla Formation: Bir A. M.	27		
UPPER CRETACEOUS	Maastrichtian	Dakhla Formation: Lower Kharga Mem.	26, 25	*G. gansseri*	*Haplophragmoides excavata*
UPPER CRETACEOUS	Maastrichtian	Dakhla Formation: Lower Kharga Mem.	24, 23	*G. gansseri*	*Ammobaculites khargensis*
UPPER CRETACEOUS	Maastrichtian	Dakhla Formation: Baris Mem.	21-22	*G. gansseri*	Not Zoned
UPPER CRETACEOUS	Maastrichtian	Dakhla Formation: Mawhoob Shale Mem.	20, 18-19, 17	*G. gansseri*	*Haplophragmoides* & *Spiroplectammina knebeli*
UPPER CRETACEOUS	Maastrichtian	Dakhla Formation: Mawhoob Shale Mem.	16, 15, 14, 11-12	*G. gansseri*	Not Zoned
UPPER CRETACEOUS	Campanian	Duwi Formation	10, 8-9, 4-5, 2-3, 1	Not Zoned	*Lituola & Trochammina*

Table 1: Correlation Between The Campanian-Paleocene agglutinated foraminiferal biozones in Um El Ghanayim section and the planktonic forminiferal Zones propesed by Luger 1985-1988.

Age : Campanian

2. *Haplophragmoides* spp-*Spiroplectammina knebeli* Assemblage Zone

Type : Assemblage Zone

Definition : This assemblage zone is characterized by the predominance and the first appearance of the restricted Maastrichtian species *Haplophragmoides kirki* Wickenden, *H. glabra* Cushman & Waters and *Spiroplectammina knebeli* LE Roy.

Faunal Assemblage : *Cribrostomoides cretacea* Cushman & Goudkoff, *Gaudryina ellisorae* Cushman, *Trochammina albertensis* Wickneden, *T. bohmi* Franke, *T. mirabilis* Friedbery, *T. texana* Cushman & Waters, *T. senonica* Belousova, *T. whittingtoni* Tappan, *Ammobaculites agrestis* Cushman & Applin and *A. plummerae* Loeblich.

Stratigraphic Distribution : This assemblage zone distinguishes the upper part of the Mawhoob Shale Member.

Age : Masstrichtian.

3. *Ammobaculites khargensis* Range Zone

Type : Range Zone

Definition : It is characterized by the limited occurrence of the Masstrichtain species *Ammobaculites khargensis* Nakkady and Talaat.

Faunal Assemblage : *Recurvoides optivus* Podobina, *Dorothia bulletta* (Carsey), *Haplophragmoides kirki* Wickenden, *H. glabra* Cushman & Waters, *Trochammina texana* Cushman & Waters *T. senonica* Belousova, *T. mirabilis* Friedberg and *Gaudryina carinata* Franke.

Stratigraphic Distribution : This range zone represents the lower part of the Lower Kharga Shale Member.

Age : Masstrichtian.

4. *Haplophragmoides excavatus* Range Zone

Type : Range Zone

Definition : It is characterized by the first appearance and restricted occurrence of *Haplophragmoides exavatus* Cushman & Waters of Maastrichtian age.

Faunal Assemblage : This range zone is rich in the Maastrichtian species *Haplophragmoides rota* Nauss, *Reophax texana* Cushman & Waters, *Clavulinoides asper* (Cushman) and *Gaudryina pyramidata* Cushman. On the other hand late

Maastrichtian-Danian species have been met with as *Trochammina* swellensis Olsson, *Hormosina globulifera* Cushman & Renz, *Cribrostomoides triniıatensis* Cushman & Jarvis.

Stratigraphic Distribution : This range zone represents the upper part of the Lower Kharga Shale Member and ends by a thin phosphatic rolled pebbles bed of Bir Abu Munqar Member.

Age : The first appearance of hte Danian species and the extinction of all late Maastrichtian Globotruncanidae and Heterohelicidae species inicate the begging of the Tertiary Era.

5. *Spiroplectammina carinata* Range Zone

Type : Range Zone

Definition : It is distinguished by the limited occurrence of the *Spiroplectammina carinata* Subbotina.

Faunal Assemblage : *Haplophragmoides rota* **Nauss**, *H. seweliensis* **Olsson**, *Hormosina globulifera* **Cushman & Renz**, *Trochammina sewellensis* **Olsson**, *Cribrostomides trinitatensis* **Cushman & Jarvis**, *Reophax texana* **Cushman & Waters**, *Tritaxia pyramidata* **Reuss**, *Clavulinoides alger-*

iana **Ten Dam & Sigal**, *Gaudryina pyramidata* **Cushman**, *G. rugosa* **D'Orbigny** and *G. textulariformis* **Nakkady & Talaat**.

Stratigraphic Distribution : This biozone characterizes the Upper Kharga Shale Member.

Age : Lower Paleocene (Danian).

6. *Pseudogaudryinella compacta - Pseudoclavulina globulifera* Assemblage Zone

Type : Assemblage Zone

Definition : This biozone characterizes by the first apearance of *Pseudogaudryinella compacta* **Ten Dam & Sigal** and *Pseudoclavulina globulifera* **Ten Dam & Sigal.**

Faunal Assemblage : *Clavulivoides algeiana* **Ten Dam & Sigal** and *Gaudryina rugosa* **D'Orbigny**.

Stratigraphic Distribution : This biozone is restricted to the Tarawan Formation and the lower part of teh Esna Formation.

Age : Upper Paleocene (Landenian).

7. *Gaudryina inflata-Rhabdammina eocenica* Assemblage Zone

Type : Assemblage Zone

Definition : This biozone is distinguised by the restricted occurrence of the Upper Paleocene *Gaudryina inflata* Israelsky beside the common occurrence of hte Paleocene-Lower Eocene *Rhabdammina eocenica* Cushman & Hanna.

Faunal Assemblage : *Spiroplectammina esnehensis* LE Roy and *Reophax nevini* Cole.

Stratigraphic Distribution : This biozone characterizes the upper part of the Esna Formation.

Age : Upper Paleocene (Landenian).

WALL STRUCTURE

Phleger (1960) and Murray (1973b) mentioned that the agglutinated Foraminifera species are geographically the most widespread Foraminifera at the present day, this is due to the oraganic cement which binding the foreign particles of the wall allows them to flourish below the calcite compensation depth (CCD) on the abyssal plain as well as in brackish and marginal marine environments.

Many genera of agglutinated Foraminifera are selective of particular kind and sizes of material. Lipps (1973) found that *Trochammina pacifica* builds its test of finer sized material than *Miliammina fusca,* although these species live together of marshes at Bodega Bay.

Hedley (1963); Towe (1967) and Murray (1973a) showed that the cement of the majority of agglutinated forams is mixed with organically bound iron which on oxidation hardens the test and gives it a red-brown colour. Moreover, the common occurrence of larger sand or silt grains packed in a matrix of small grains is related to tha fact that Foraminifera not noly feed on the bacteria and algae coating these grains but that the surface chemistry of quartz may increase the solubility of iron (Towe, 1967).

The wall composition of 55 agglutinated foraminiferal species of the Campanian-Paleocene rocks of the Um El Ghanayim section was studied (plate 1,2) and two groups are distinguished, one calcareous and the other typically arenaceous. The calcareous agglutinated Foraminifera precentage was calculated in the different rock units, where it helps to interpret the condition prevailing during deposition.

1. Calcareous agglutianated Foraminifera

These forms are composed of calcareous grains, having different sizes and cemented by calcareous matters. In the area under consideration, the distribution of the calcareous forms in the different stratigraphic unit increases upwards. It is 14% in the Duwi Formation, 35% in the Mawhoob Member, 28% in the Lower Kharga Shale Member (16% in the *Ammobaculites khargensis* Biozone and 12% in the *Haplophragmoides excavata* Biozone), 61% in the upper Kharga Shale Member, 100% in the Tarawan Formation and lower part of teh Esna Formation *(Pseudoclavulina compacta-pseudoclavulina globulifera* Assemblage zone) and 38% in the upper part of the Esna Formation.

The following species are calcareous agglutinated forms : *Spiroplectammina lalickeri* Alberitton & Phleger, *S. navarroana* Cushman, *S. knebeli* LE Roy, *S. carinata* Subbotina, *Tritaxia compressa* Schijfsma, *T. pyramiddata* Reuss, *Gaudryina ellisorae* Cushman, *G. rugosa* D'Orbigny, *G. pyramidata* Cushman, *G. carinata* Franke, *G. textulariformis* Nakkady & Talaat, *G. inflata* Israeldky, *Clavulinoides asper* (Cushman), *C. algeriana* Ten Dam & Sigal, *Pseudogaudryinella compacta* Ten Dam & Sigal, *Pseudoclavulina globulifera* Ten Dam & Sigal and *Dorothia bullella* (Carsey).

2. Arenaceous agglutinated Foraminifera

The walls of these forms consist mainly of quartz grains with some feldspars and opaque minerals. The cementing materials are siliceous, calcareous or iron-oxide.

This group includes the following species in the area under study : *Ammobaculites subplanatus* Cushman & Deaderick, *A. plummerae* Loeblich, *A. agrestis* Cushman & Applin, *A. khargensis* Nakkady & Talaat, *Haplophragmium abkhaicus* Lamarck, *Lituola difformis* Lamarck, *L. taylorensis* Cushman & Waters, *Haplophragmoides calculus* Cushman & Waters, *H. advenus* Cushman & Appline, *H. glabra* Cushman & Waters, *H. kirki* Wickenden, *H. excavatus* Cushman & Waters, *H. rota* Nauss, *H. sewellensis* Olsson, *Psammosphera fusca* Schulze, *Pseudocyclammina massiliensis* Maync, *Reophax minuta* Tappan, *R. texana* Cushman & Waters, *R. nevini* Cole, *Trochammina albertensis* Wickenden, *T. bohmi* Franke, *T. mirabiis* Friedbery, *T. texana* Cushman & Waters, *T. senonica* Belousova, *T. whittingtoni* Tappan, *T. sewellensis* Olsson, *Glomospira* sp., *Ammoastuta* sp., *Rhabdammina eocenica* Cushman & Hanna, *Verneuilina aegyptiaca* Said & Kenawy, *Hormosina globulifera* Cushman & Renz, *Miliammina onyeamensis* Petters, *M. telemaquensis* Saunders, *Recurvoides optivus* Podobina and *Cribrostomoides cretacea* Cushman & Goudkoff.

The solubility of CaCo3 is less in warm than in cool water, and increases with pressure. Thus, it will increase at lower temperature, i.e. as depth increases. This explains the predominant occurrence of the calcareous forms in hte lower part of the Mawhoob Member and the sudden disappearance of agglutinated forms.

TEST FORMS DISTRIBUTION AND THEIR ENVIRONMENT

The agglutinated Formainifera as many organisms show a good relation between their form and the environment in which they live. Jones and Chamock (In Murray, 1991) they illustrated four morphogroups of agglutinated Foraminifera with their postulated life positions. Moreover, they show the classification of agglutinated Foraminifera into morphogroups with their distinctive distribution.

In the area under study, the distribution of test form and the paleoecological interpreatation of agglutinated benthic Foraminifera for each stratigraphic unit is discussed from base to the top as follows :

1. Duwi Formation :

The upper part of this rock unit is flooded with agglutinated Foraminifera of most lituolids and *Trochmmina* which belongs to group B_3 of Jones and Chamock (In Murray, 1991). This group is particularly common in shelf and marginal marine environment.

The CaO content of this part ranges between 0.06%-0.34% with an average of 0.12% indicates deposition in a relatively shallow water (Phleger, 1960 & Moore, 1964). Moreover, the presence of *Haplopheragmoides* and *Trochammina* in the agglutinated assemblage, indicates deposition at a lower PH (Bandy, 1956) and may be cold water at shallow depth (Bolin, 1956).

The top of the Duwi Formation shows abrupt change in CaO content (ranges between 30.8%-32.2%) and characterized by elongate, mixed growth of agglutinated forms of Group C_1 which is common in inner and outer shelf to upper bathyal environment. This indicates the oscillating environmental conditions of the Duwi Formation from shelf and marginal marine at its lower part to inner and outer shelf at its upper part . Here the first transgressive peak is documented in the Late Campanian.

2. Dakhla Formation

2.1 Mawhoob Shale Member

The upper part of this member yields only agglutinated forms of Group B_3 of Jones and Chamock (In Murray, 1991) with some elongated, mixed growth genera, which inicates shelf and marginal marine environment with some connection to inner and outer shelf due to the presence of elongated forms.

The lower part of Mawhoob Shale Member shows higher CaO content with an average of 40% beside the abundant occurrence of calcareous forms (99%) which indicates deeper water (Phleger, 1960 & Moore, 1964).

The presence of Heterohelicidae and Globotruncanidae in the middle part of this member indicates that the temperature is higher than the cold deep water of the lower part of the Duwi Formation. The second transgressive peak is documented in the base of the Mawhoob Shale Member.

2.2 Baris Oyster Mudstone Member

This member is flooded with *Exogyra (Exogyra) overwegi* V. Buch embedded in a sandy limestone bed of high carbonate content (CaO 50%). The depositional environment of this member may be turbulent shallow marine.

2.3 Lower Kharga Shale Member

The lower part of this member is characterized by the abundant occurence of *Ammobaculites, Haplophragmoides, Cribrostomides* and *Trochammina* of Group B_3 (multilocular, planispiral/trochospiral) of shelf and marginal marine environment.

The carbonate content of the lower part of this member ranges between 0.17%-15.7% it is devoid of planktonic Foraminifera. The Lower Kharga Shale Member is a transitional episode between the shallow Baris Oyster Mudstone Member and the relatively deeper lower part of a restricted marine facies. This episode represents the third transgressive peak which affected on this area.

The upper part of this member shows a progressive transgression of the sea, where it has *Glomospira, Reophax, Miliammina, Hormosina, Gaudryina, Verneuilina* and *Clavulinoides.* These forms range between Group B_2 and Group C_1, which extend from inner shelf to lower bathyal (Murray, 1991).

The top of this member is marked by a phosphatic conglomerate layer (Bir Abu Munqar Member), it contains well preserved open marine Masstrichtian megafossils. Barthel and Herrmann-Degen (1981) mentioned that in some cases this conglomerate layer contains Late Masstrichtian planktonic foraminifera. This conglomerate bed marked an unconformity surface and represents a regressive episode at the Cretaceous/Tertiary boudary in the area under study .

Moreover, this conglomerate bed overlies claystone beds included genus *Ammoastuta* beside *Miliammina, Haplophragmoides* and *Trochamina.* The presence of *Ammoastuta* in these claystone beds inicates brackish littoral environment in warm climates with high rainfall and high run off (Luger, 1988). This indicates that during the late *Masstrichtian* at Um El Ghanayim section a transgressive period was prevailed than a regressive one and the Upper Maastrichtian strata must have been reworked later, probably during Early Paleocens.

2.4 Upper Kharga Shale Member

This rock unit shows a distinctive distribution of elongated agglutinated Foraminifera; *Gaudryina, Spiroplectammina, Calvulinoides, Pseudoclavulina* and *Reophax* of Group C_1 which is common in inner shelf to upper bathyal.

This member has CaO ranging between 20.5%-55.5%, it is characterized by the presence of planktonic species which indicate connection with the open sea (Eicher, 1967 & Frerichs, 1970), the P/B ratio is very high (93%) and denotes outer shelf depth.

It is intersting to note that the lower Paleocene genera show change in agglutinated assemblages from shallow marine to deep marine forms beside a decrease in the abundance of agglutinants in general. A similar change is observed at the K/T boundary of the Caravaca section in southern Spain (Fabbrucci, 1989). Here Spiroplectamminids are the only benthic Foraminifers occuring in the first layer above the K/T boundary (Fabbrucci, 1989).

LE Roy (1953) recorded the same assemblage of arenaceous Foraminifera from the Esna Formation of the Maqfi section, Farafra Oasis. He mentioned that this assemblage suggests a deeper water biotope than the Midway fauna. The depositional environment of the Upper Kharga Shale Member represents deep marine facies after a short shallow marine phase.

3. Tarawan Formation

This rock unit is characterized by the decreasing of agglutinated Forminifera upwards. The Ataxophragmids is the most diverse and dominant family. The planktonic Foraminifera are the main component, where the P/B ratio is very high (86%-93%) which indicates deep water deposition (Butt, 1981 & Grunig and Herb, 1980). The Tarawan Formation represents a transgressive peak affected the area under study and is documented in early Late

Paleocene.

4. Esna Formation

The lower part of this formation has the following agglutinated Foraminifera : *Gaudryina, Clavulinoides Pseudogaudryinella* and *Pseudoclavulina* of Group C_1 of Jones and Chamock (In Murray, 1991). This Group inidicates inner shelf to upper bathyal environment. Moreover, this formation has *Rhabdammina* of Group A which indicates deep sea environment.

On the other hand the agglutinated forms decrease upwards in this formation (16% in the lower part, 9% in the middle part and 4% in the upper part) also CaO content shows decrease in the middle part (0.4%) and reincrease in the upper part (22%), as well the P/B ratio changes from 83% in the lower part to 94% in the upper part which indicates that the conditions probably changed from a deep middle shelf to a deep outer shelf depth.

Grunig and Herb (1980) mentioned that the high P/B ratio as shown in the upper part of this formation (94%) indicates water depth of more than 1000m as well as the presence of *Pseudoclavulina globulifera* which is the common component of the Midway fauna of Bergren and Aubert (1975) indicates deep water deposits.

CONCLUSIONS

1. The Campanian-Paleocene sequence in the Um El Ghanayim section can be subdivided into seven biozones according to their agglutinated foraminiferal contents from base to top as follow :

   a- *Lituola* spp - *Trochammina* spp Assemblage zone, which represents the upper part of the Duwi Formation.

   b- *Haplophragmoides* spp *Spiroplectammina knebeli* Assemblage zone, which distinguishes the upper part of the Mawhoob Shale Member.

   c- *Ammobaculites khargensis* Range zone, which represents the lower part of the Lower Kharga Shale Member.

   d- *Haplophragmoides exavatus* Range zone, this biozone represents the upper part of the Lower Kharga Shale Member.

   e- *Spiroplictammina carinata* Range zone, this biozone represents the Upper Kharga Shale Member.

   f- *Pseudogaudryinella compacta-Pseudoclavulina globulifera* Assemblage zone, it is restricted to the Tarawan and the lower part of the Esna Formation.

   g- *Gaudryina inflata-Rhabdammina eocenica* Assemblage zone, it represents the upper part of the Esna Formation.

2. The conglomerate bed (Bir Abu Muqar Member) which lies at the top of

the Lower Kharga Shale Member marked an unconformity surface and represents a regressive episoede at the Cretaceous/Tertiary boudary. This conglomerate bed overlies claystone beds contain genus *Ammoastuta*. The presence of this genus indicates brackish littoral environment, which prevailed before the deposition of the conglomerate bed. On the other hand the K/T boundary shows a decrease in the abundance of agglutinants in general.

3. The agglutinated foraminiferal species show a good relation between their form and the environment in which they live. According to the classification of Jones and Chamock (In Murray, 1991) the agglutinated forms of the Um El Ghanayim section attributed to Group B_3, Group C_1, Group B_2 and Group A.

4. The presence of *Spiroplectammina, Gaudryina* and *Clavulinoides* as calcareous agglutinated forms in the Upper Kharga Shale Member and Tarawan Formation may be a result of high CaO content in these rock units (CaO averages to 20% & 55% respectively).

5. The Paleocene sequence is characterized by a higher percentage of calcareous agglutinated Foraminifera than the Upper Cretaceous, where the Paleocene section is characterized by the high CaO content.

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PLATE 1

1. *Hormosina globulifera* Cushamn & Renz, axial section, arenaceous agglutinated form, Lower Kharga Shale Member, sample 26, X 250.

2. *Reophax minuta* Tappan, axial section, arenaceous agglutinated form, Duwi Formation, sample 8, X 250.

3. *Spiroplectammina knebeli* LE Roy, axial section, calcareous agglutinated form, Lower Kharga Shale Member, sample 24, X 100.

4. *Ammobaculites plummerae* Loeblich, equatorial section of the uncoiled part, arenaceous agglutinated form, Mawhoob Shale Member, sample 18, X 250.

5. *Clavulinoides asper* (Cushman), axial section, calcareous agglutinated form, Upper Kharga Shale Member, sample 28, X 100.

6. *Reophax nevini* Cole, axial section, arenaceous agglutinated form, Esna Formation, sample 41, X 100.

7. *Lituola difformis* Lamarck, equatorial section, arenaceous agglutinated form, Duwi Formation , sample 4, X 150.

8. *Gaudryina pyramidata* Cushman, axial section, calcareous agglutinated form, Upper Kharga Shale Member, sample 29, X 100.

9. *Haplophragmoides* calcula Cushman & Waters, equatorial section, arenaceous agglutinated form, Lower Kharga Shale Member, Sample 23, X 250.

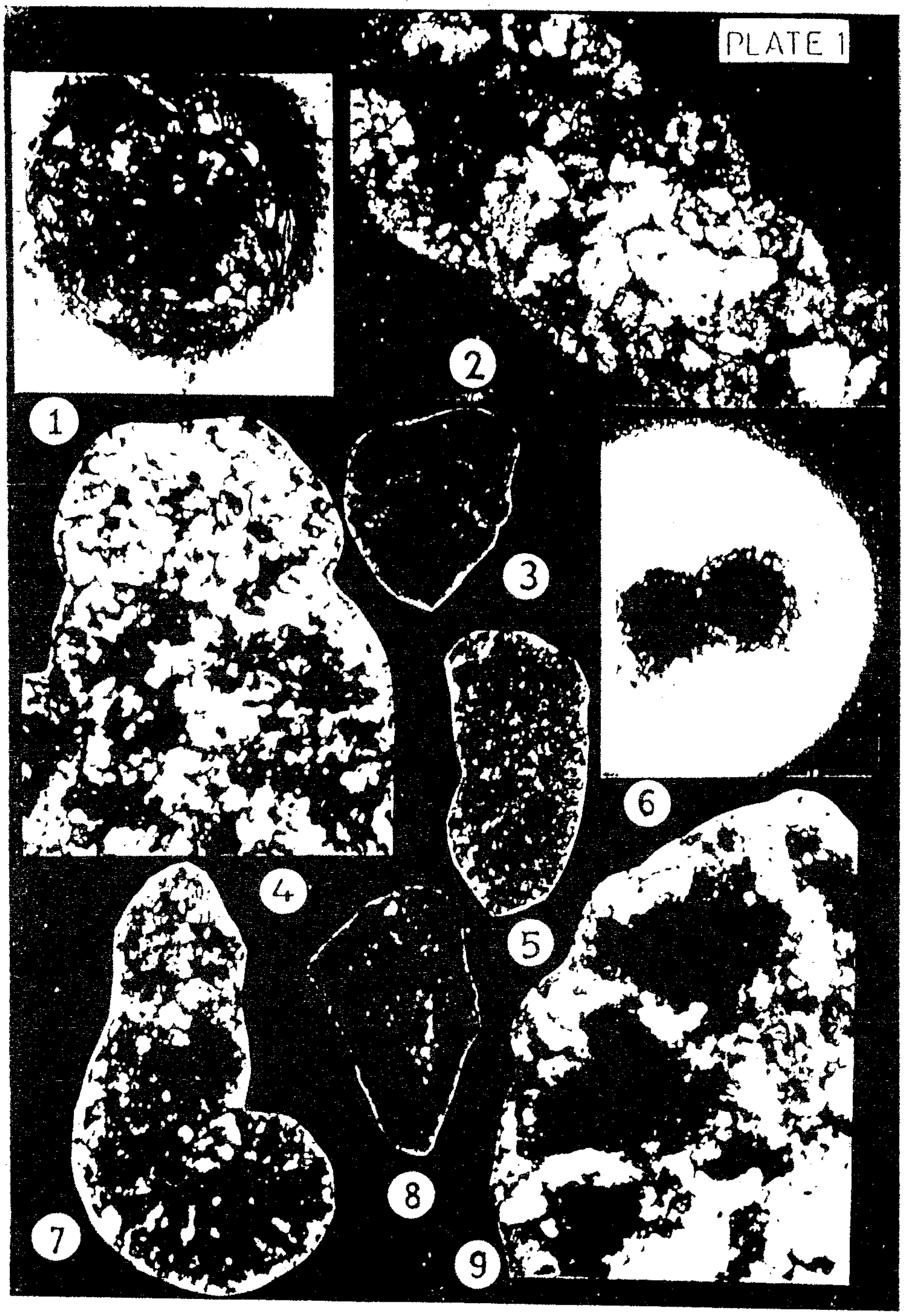
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PLATE 2

1. *Ammobaculites subplanatus Cushman & Deaderick, equatorial section, arenaceous agglutinated from, Duwi Formation, sample 3,X 100.*

2- *Rhabdammina eocenica Cushman & Hanna, axial section, arenaceous agglutinated form, Esna Formation, sample 42, X150.*

3- *Haplophragmoids excavatus Cushman & Waters, equatorial section, arenaceous agglutinated form, Lower Kharga Shale Member, sample 26, X250.*

4,5 - *Clavulinoides algeriana Ten Dam & Sigal, axial section, calcareous agglutinated form, Tarawan Formation, sample 32, X 100, X 200.*

6- *Trochammina texana Cushman & Waters, equatorial section, arenaceous agglutinated from, Mawhoob Shale Member, sample 18, X100.*

7- *Tritaxia pyramidata Reuss, axial section, calcareous agglutinated form, Upper Kharga Shale Member, sample 29, X 200.*

8- *Spiroplectammina carinata Subbotina, axial section, calcareous agglutinated form, Upper Kharga Shale Member, sample 28, X 100.*

9- *Trochammina sewellensis Olsson, equatorial section, arenaceous agglutinated form, Lower Kharga Shale Member, sample 26, X 100.*

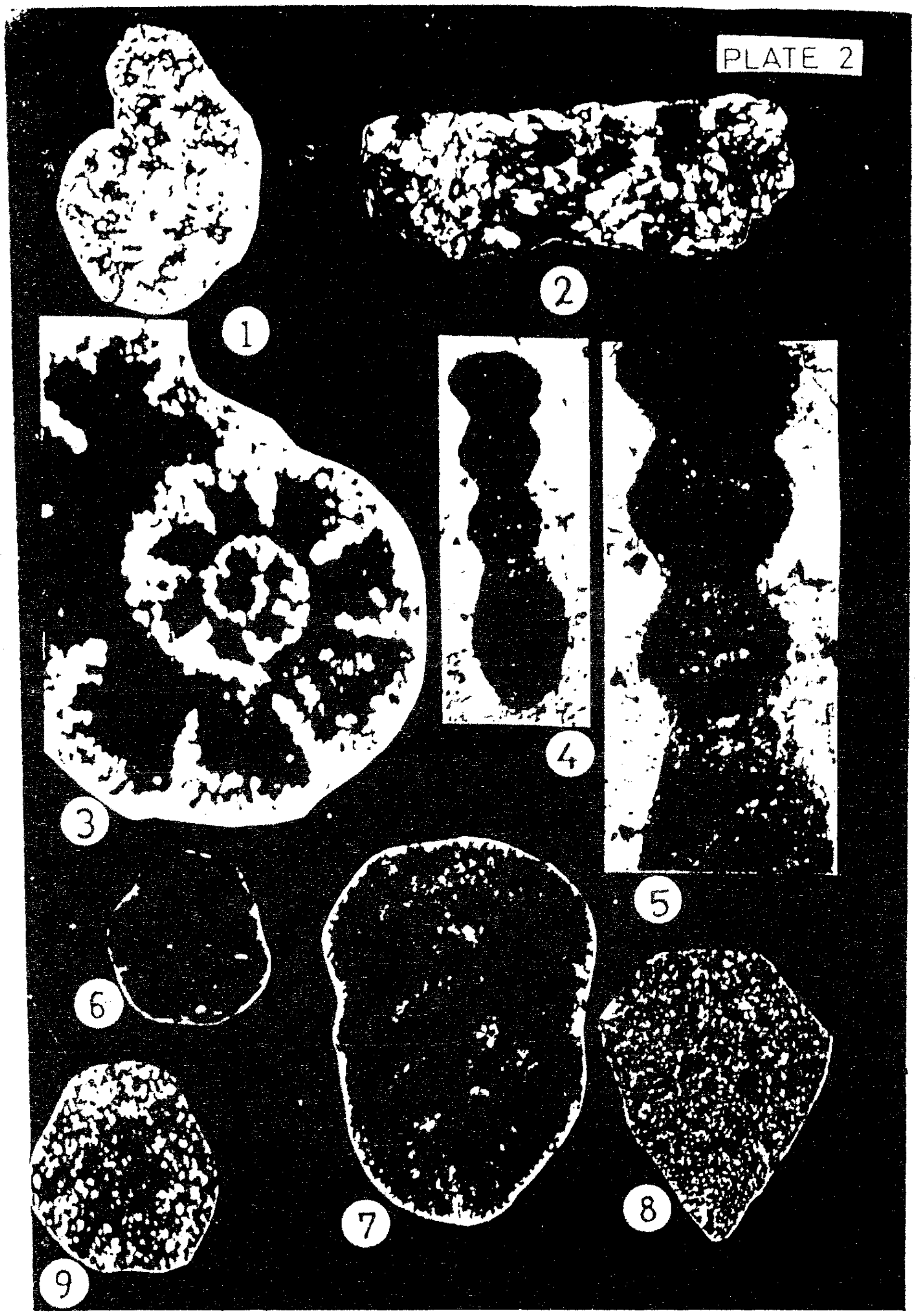
PLATE 2
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بيوستراتجرافية والبيئات القديمة للمثقبات الملزنة للكمبانى - الباليوسين لجبل أم الغنايم - الواحات الخارجة - مصر

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قام الباحث بدراسات تفصيلية للمثقبات الملزنة الموجودة فى الكمبانى حتى الباليوسين والتى جمعت من جبل أم الغنايم بالواحات الخارجة بمصر حيث تم تعريف وتمييز ٥٥ نوعاً تنتمى إلى ٢٢ جنس بين الباحث مدها الإستراتجرافى فى القطاع المدروس كما تم عمل قطاعات رقيقة لهذه الأنواع لمعرفة تكوين الجدار وعمل دراسة إحصائية لنسبة المثقبات الملزنة الجيرية إلى المثقبات الملزنة الرملية ونسبة الفورامنيفرا الرملية إلى الجيرية وأيضاً نسبة الفورامنيفرا الهائمة إلى القاعية هذا علاوة على التحليل الكيميائى لكربونات الكالسيوم للوحدات الصخرية المختلفة وقد تم إستنتاج البيئة القديمة التى سادت أبان الطباشيرى العلوى حتى الباليوسين.

وقد توصل الباحث بإستخدام المثقبات الملزنة إلى تمييز سبعة نطاقات حيوية أربعة منها تميز الطباشيرى العلوى والثلاثة الأخرين تنتمى للباليوسين.

بناء على دراسة المحتوى الصخرى والحفرى أمكن التعرف على أربعة تكاوين وخمسة أعضاء للقطاع المدروس. كما تم تمييز الحد الفاصل بين الطباشيرى العلوى والثلاثى بوجود طبقة من الكونجلوميرات تحتوى على كسرات من الحفريات الكبيرة تنتمى للمسترختى (طباشيرى علوى) وهى تعلو طبقة من الطين تحتوى على جنس Ammoastuta الذى يدل وجوده على بيئة ترسيبية ضحلة. كما لوحظ أيضاً من خلال دراسة تكوين الجدار أن الباليوسين يمتاز بوجود نسبة عالية من الجدار الجيرى الملزن مقارنة لعصر الطباشيرى العلوى ويعتقد أن أرتفاع نسبة كربونات الكالسيوم فى الباليوسين (تكوين طروان) هو المسئول عن أرتفاع هذه النسبة.