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BIOSTRATIGRAPHY AND PALEOECOLOGY OF
THE SUBSURFACE UPPER SENONIAN AND
UPPER EOCENE OF THE NORTH WESTERN
DESERT, EGYPT

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The present paper deals with the planktonic and benthonic Foraminifera of Upper Senonian and Uppermost Eocene in a subsurface section (Well Horus-1) in the Northwestern desert. Six planktonic biozones are identified: Globotruncana ventricosa, Globotruncanella havanensis, Globotruncana aegyptiaca, Gansserina gansseri, Abathomphalus mayaroensis and Turborotalia cerroazulensis cerroazulensis. The paleoecological parameters in the form of Total Foraminiferal number, Planktonic/Benthonic ratio, Diversity and Fischer α Index are discussed. Also a brief discussion is submitted on the Cretaceous climate derived from the Global Sedimentary Geology Program for studying the Cretaceous Resources, Event and Rhythms. The recent studies in this program point to the fact that the Cretaceous began during a warm interval followed by a cooler episode (Early Cretaceous). Global climates had warmed substantially during the Albian-Cenomanian but began to cool again in the Turonian. After a final warm interval in the Coniacian-Santonian, the Cretaceous closed with marked cooling.

INTRODUCTION

The study of planktonic Foraminifera enables many paleontologists to subdivide the subsurface sequences into several zones and to identify the pay intervals in the oil fields. The importance of Cretaceous stratigraphy in the northwestern desert increases much after discovering some new oil potentialities. The studied interval includes the Campanian-Maastrichtian and Upper Eocene sequences in the subsurface section of Horus well-1 in the northwestern desert (Fig. 1). In addition to the biostratigraphic study, an attempt is carried out to delineate the paleoenvironmental conditions that

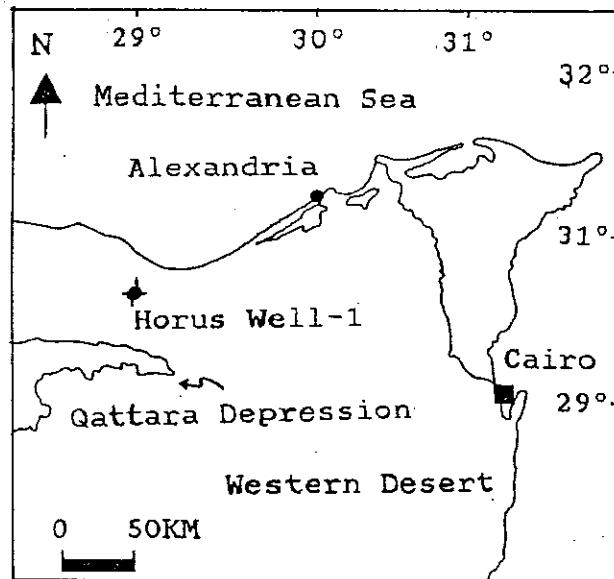


Fig. 1 Location Map showing the studied well (+)

Age	Fm.	Biozones	Depth in Feet	Lithology	Description
L.B		Turb. cerr. cerr.			Limestone, light green, argillaceous
		Abathomphalus mayaroensis	3600		
		Gansserina gansseri	3700		
		Globotruncana aegyptiaca	3800		Chalk to chalky limestone, white, glauconitic, pyritic and microcrystalline
		Globotruncanella havanensis	3900		
		Globotruncana ventricosa	4000		
Campanian Middle	E		4100		
			4200		

Fig. 2 The composite log of the studied section

prevailed during the deposition of the studied sequences. Also, a brief discussion is introduced about the paleoclimate of the Cretaceous System depending on recent results derived from the Global Sedimentary Geology Program for studying the Cretaceous Resources, Events and Rhythms.

LITHOSTRATIGRAPHY

The studied succession includes two rock units: Khoman Chalk (Campanian-Maastrichtian) and the lower part of Ghoroud Formation or may be the upper part of Guindi Formation (Uppermost Eocene), (Fig. 2).

1) Khoman Chalk

It occupies the interval from 4220' to 3514'. This formation unconformably overlies the Abu Roash Formation and unconformably underlies the Upper Eocene rocks. It is composed mainly of Chalk to Chalky limestone. In the structurally high areas, the Khoman Chalk exhibits a marked change in facies showing two units: The lower unit which is mainly shale with highly argillaceous limestone, and the upper unit which is chalky limestone with some chert bands. The Campanian-Maastrichtian time and the open marine environment were suggested to this rock unit.

2) Upper Eocene Rocks

These deposits may belong to either Ghoroud Formation (the lower part) or the Guindi Formation (the upper part). This section is encountered at the interval from 3514' to 3484'. It unconformably overlies the Abu Roash Formation. These rocks are composed of limestone with shaly streaks and scattered chert bands. It is worthmentioning that on the structurally high areas, thin sedimentary sequence is deposited and the thick sedimentary sequence is eroded. As in the studied section, the Paleocene (Esna Shaei), and Lower and Middle Eocene (Appolonia Formation) are missing. Also, in the Abu Roash area, the Middle Eocene rocks unconformably overlie the Khoman Chalk in the surface exposure juxtaposing the study area.

BIOSTRATIGRAPHY AND PALEOECOLOGY

Six planktonic biozones are recognized as follows in the studied section. The paleoecological parameters in the form of Total Foraminiferal Number (TF), Planktonic/Benthonic Ratio (P/B), Diversity (S) (Fig. 3a) and Fischer α Index are also discussed (Fig. 3b).

1. *Globotruncana ventricosa* Zone (Middle Campanian). It occupies the interval from 4220' to 4030'. The associated fauna are: *Archaeoglobigerina cretacea*, *A. blowi*, *Pseudoguembelina costulata*, *Rosita formicata*, *Globotruncana linneiana*, *Gr. bulloides*, *Gr. arca*, *Gr. falsostuarti*, *Globotruncanita stuartiformis*, *Gt. stuarti*, *Spiroplectammina knebeli*, *Gaudryina aissana*, *Dorothia oxycona*, *Bolivinoides curta*, and *B. Draco milliaris*.

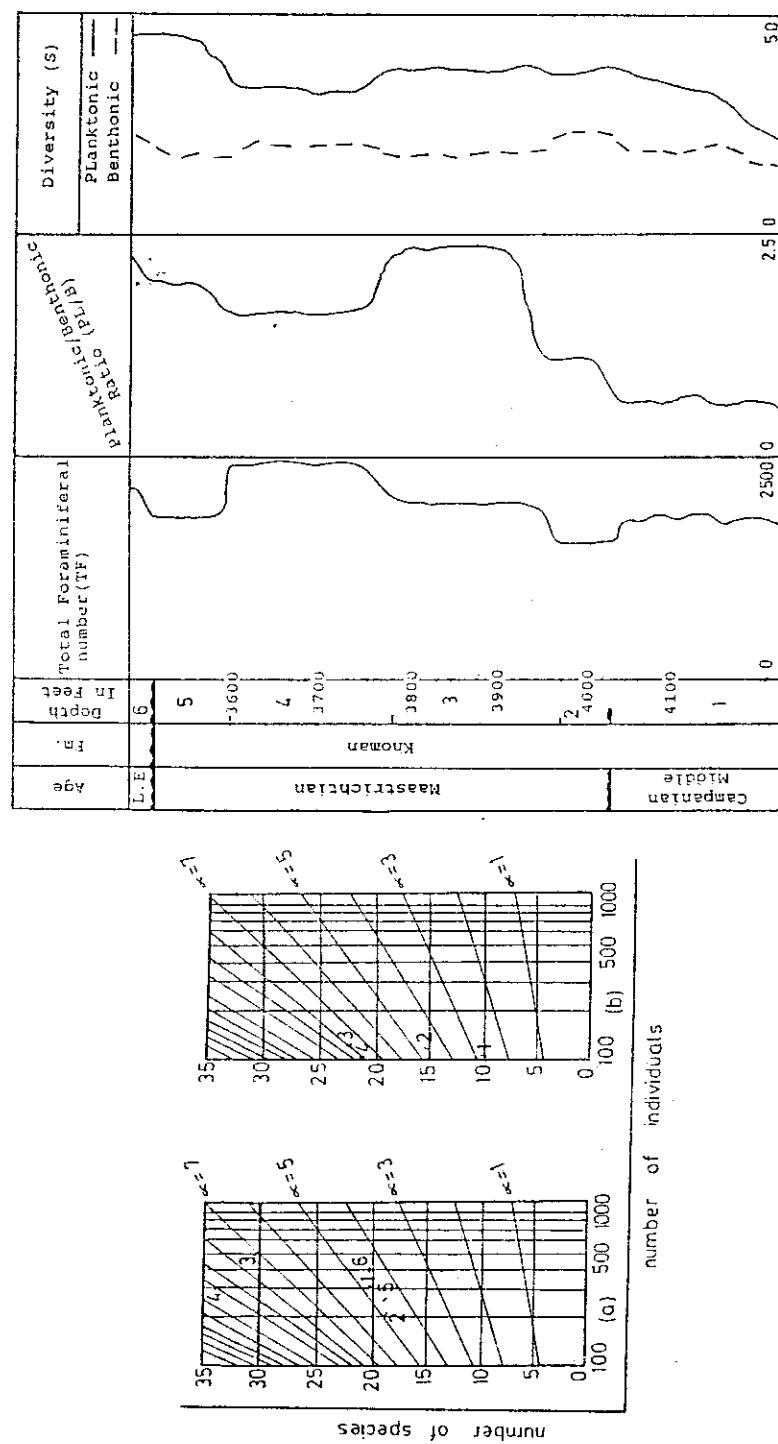


Fig. 3a The paleoecological parameters of the identified biozones in Horus well-1

Fig. 3b Fischer α Index of the planktonic (a) and benthonic (b) Foraminifera of the six identified zones.

The Total Foraminifera Number (TF) reflects a transitional environment where at the Lower Campanian (*Gt. elevata*) some phosphate bands were deposited at many localities in Egypt under shallow conditions. In the Middle Campanian (*Gr. ventricosa*) a relatively marine environment prevailed as reflected from P/B ratio but not much deeper. Furthermore, the diversity values decrease and Fischer α Index values for planktonics and benthonics are less than 7. This reflects a shallow marine environment in this zone. The Late Campanian is missing in the present work as indicated by absence of the marker zone *Globotruncanita calcarata*, although it is found as a transitional form between *Gt. calcarata* and *Gt. subspinosa*. The absence of *Gt. calcarata* zone is probably due to a slight fall of the sea level.

2- *Globotruncanella havanensis* Zone (Early Maastrichtian). It occupies the interval from 4030' to 3970'. The associated fauna are: *Archaeoglobigerina cretacea*, *A. blowi*, *Rosita fornicata*, *Globotruncana linneiana*, *Gr. arca*, *Pseudotextularia elegans*, *Globotruncanita stuarti*, *Rugoglobigerina rugosa*, *Gaudryina limbata*, *Lenticulina pseudocultratus*, *B. curta*, *Bulimina reussi* and *Globorotalites conicus*.

A relatively normal marine environment prevailed during the deposition of this interval. This can be interpreted from the Paleoecological parameters. The (TF) values increase due to the dominance of benthonic Foraminifera and the (S) values of benthonics increase while those of the planktonics relatively decrease. Also, Fischer α Index being less than 7, indicates a shallow marine environment.

3- *Globotruncana aegyptiaca* Zone (Middle Maastrichtian). It occupies the interval from 3970' to 3780'. The associated species are: *Hedbergella delrioensis*, *Rosita fornicata*, *Globotruncana linneiana*, *Heterohelix striata*, *H. navaroensis*, *Globotruncanita stuarti*, *Gt. subspinosa*, *Globigerinelloides praeiehillensis*, *G. ultramicros*, *Bolivinoides draco milliaris*, *B. draco draco*, *Bulimina reussi*, *B. stokei*, *Cibicides aff. abdurbensis* and *Gyroidina depressus*.

This interval represents an open marine facies where (TF) and (S) values are higher than those in the previous zones. Also, (α) values are 7 indicating a normal marine environment.

4- *Gansserina gansseri* Zone (Middle Maastrichtian). It occupies the interval from 3780' to 3600'. The associated species are: *Pseudotextularia elegans*, *Pseudoguembelina excolata*, *P. costulata*, *Globotruncana linneiana*, *Gr. bulloides*, *Globotruncanita conica*, *Globotruncanella citae*, *Gl. havanensis*, *Gl. petaloidea*, *Rugoglobigerina rugosa*, *R. reicheli*, *Spiroplectammina knebeli*, *Marginulina tuberculata*, *Gyroidina girardana*, *Bulimina reussi* and *Cibicides loeblichii*.

The open marine facies continued during this interval, with approximately the same paleoecological parameters.

5- *Abathomphalus mayaroensis* Zone (Late Maastrichtian). It occupies the interval from 3600' to 3514'. The associated fauna are: *Archaeoglobigerina cretacea*, *Globotruncana esnehensis*, *Gr. linneiana*, *Globotruncanita conica*, *Rugoglobigerina rugosa*, *Rosita contusa*, *R. plicata*, *R. patelliformis*, *Abathomphalus intermedius*, *Bolivinoides draco milliaris*, *Dorothia oxycona*, *Bulimina reussi*, *Cibicides loeblichii* and *Globorotalites conicus*.

This zone is considered one of the controversial zones, especially in Egypt, due to the rarity of its key fossil in the sediments. For this reason and, although two individuals only were found, the authors suggest the *Globotruncana esnehensis* as a marker for the Late Maastrichtian (Ismail, in press). From the paleoecological point of view this zone represents the end of the open marine facies that started at the *Globotruncana aegyptiaca* zone.

6- *Turborotalia cerroazulensis cerroazulensis* Zone (Uppermost Eocene). It occupies the interval from 3514' to 3484'. The associated species are: *Turborotalia cerroazulensis cerroazulensis*, *T.c. cocoanis*, *T. opima opima*, *Globigerina ampliapertura*, *G. inaequispira*, *G. pseudoampliapertura*, *G. venezuelana* and *Catapsydrax dissimilis*.

It is worthmentioning that in the section studied, a big unconformity due to an intensive erosion occurred before the deposition of the uppermost Eocene interval. Accordingly, the intervals of Paleocene, Lower Eocene, Middle Eocene and the lower part of the Upper Eocene are missing. These conditions generally prevail in the structurally high areas in the northwestern Desert. Furthermore, some reworked fauna belonging to the missing intervals (e.g. *Orbulinoides beckmanni* of Middle Eocene) were found in the washed residue. The paleoecological parameters suggest a normal marine environment during the deposition of this interval.

CRETACEOUS CLIMATE

The Cretaceous is one of the most intriguing times in the earth history inasmuch as an abundance of data has been interpreted as indicating extraordinary warm climates in middle and high latitudes. At the beginning of the Cretaceous, climate was changing from an episode of global aridity at the end of the Jurassic to much more humid conditions in the Cretaceous. Ocean isotope data indicate a cooling phase in the Early Cretaceous. There are no records of ice-rafted deposits from the Late Albian onwards, indicating that high latitude climates became much warmer. However, the interval from the Cenomanian to the Santonian appears to have been a time of quite variable climates as there is conflicting evidence for both warming and cooling. Furthermore, it is quite clear that during the final part of the Cretaceous there was a distinct cooling trend. Both ocean and land temperatures dropped considerably. The latest part of the Maastrichtian appears to have been especially cool, with low temperatures, even freezing, at high latitudes and perhaps with similar conditions to those of the Early Cretaceous. All climate evidences point to a warming again during the

Paleocene. Perhaps the "Catastrophe" that hit the biota at the end of the Cretaceous was due to the shock of cold temperature after the mid-Cretaceous warmth.

Sea Level Changes

Although there are several ways to produce changes in global sea level, major changes over a long time period can be interpreted in terms of plate tectonic concept. The generalized sea level curve for the Phanerozoic as derived from stratigraphic data by Vail et al., (1977) is shown in Fig. 4. The long-term rise and fall of sea level, as depicted in Fig. 4 are accompanied by changes in exogenis cycle of the Ocean-atmosphere-sediment-biosphere system.

Sea Level Rise

During a long period of sea level rise brought about by increasing sea floor spreading rate and ridge volume, the following scenario would result, climaxing in the submergent (Mackenzie and Pigott, 1981) or green house (Fischer, 1982) modes of high sea levels of the Middle Paleozoic and Late Cretaceous.

- a- The carbon values of carbonate rocks and the sulfur values evaporite sulfate minerals would change. These changes reflect transfer of sedimentary carbon from the reduced organic carbon reservoir to the oxidized inorganic carbon in limestones.
- b- Carbon dioxide levels progressively increase resulting from an increased rate of CO_2 production from diagenetic and metamorphic reactions at subduction zones and input of volcanic CO_2 at ridges. Increased atmospheric carbon dioxide gives rise to an increases "green house" effect, and the average temperature of Earth increases during progressive flooding of the continents.

Sea Level Fall

During a long period of sea level fall as a result of decreased sea floor spreading rate and ridge volume, a scenario somewhat opposite to that of sea level rise would develop. The climax of the sea level fall scenario is that of the oscillatory (Mackenzie and Pigott, 1981) or ice house (Fischer, 1982) modes of low sea levels of the Late Precambrian-Early Cambrian, Permo-Triassic and Late Cenozoic.

- a- Carbon-Sulfur isotope exchange are opposite to those of rising sea level; reduced carbon and evaporitic sulfur fluxes increase relative to their counterparts of limestone carbon and pyritic sulfur.
- b- Erosion-sedimentation fluxes increase because of increasing land areas; more nutrients enter the ocean owing to erosion of previously submerged continental areas.

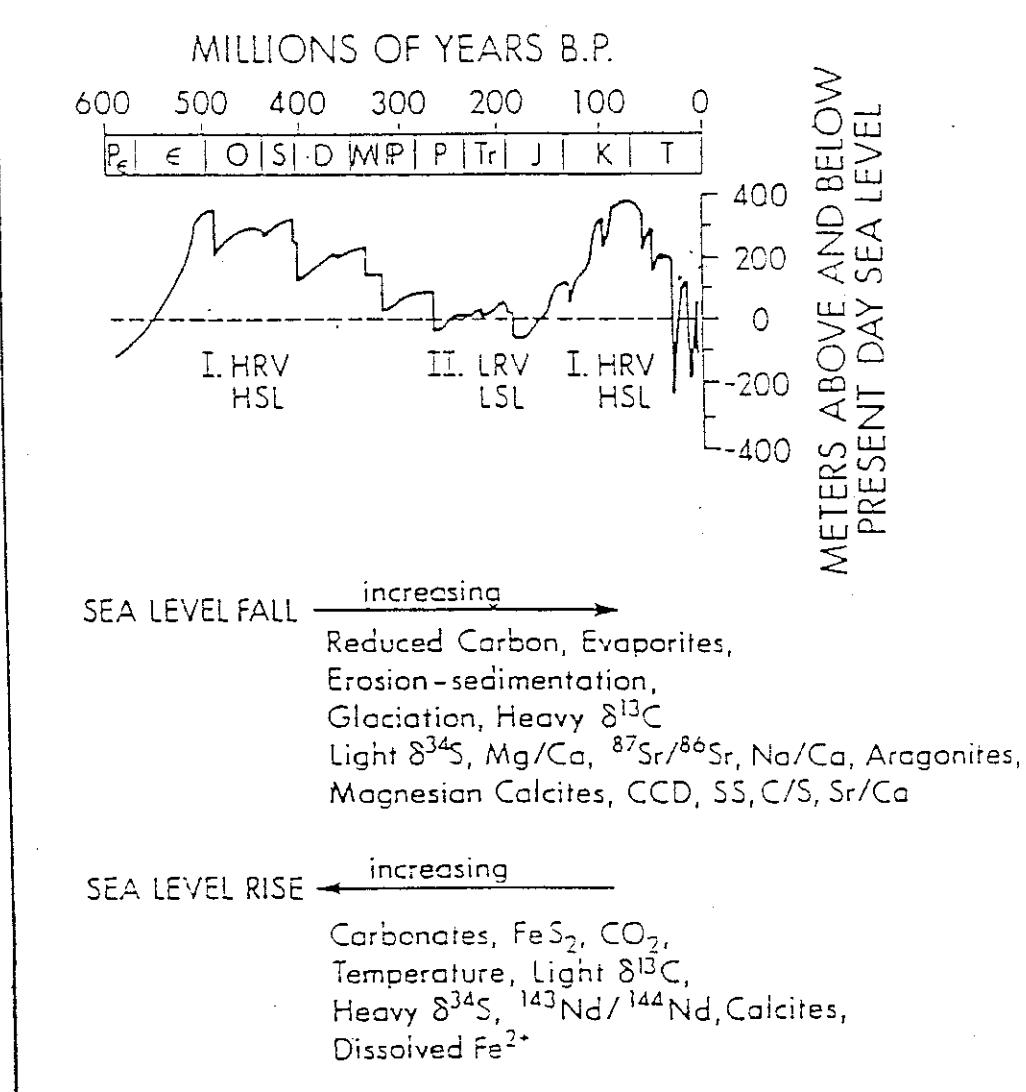


Fig. 4 Generalized Phanerozoic eustatic curve and predicted changes in the isotopic and elemental composition and the deposition of sedimentary materials for periods of falling and rising sea level (after Mackenzie, 1990).

c- Decreasing temperatures brought about by lower levels of atmospheric CO₂ increase the probability of continental glaciations whose direct use may be changes in orbital parameters.

TAXONOMIC NOTES

The identified planktonic species have been taxonomically reviewed using the scheme of both Robaszyski et al. (1984) and Caron (1985). Extensive literature has been used in benthonic identification, but the most important ones are; Nakkady (1950), Le Roy (1953), Ansary (1955), Said and Kenawy (1956), Ansary and Fakhr (1958), Ansary and Emara (1962), Ansary, Andrawis and Fahmy (1962) Ansary and Tewfik (1966) Luger (1985), Anan and Sharabi (1988) and Ismail (1991). Also, the Treatise of Loeblich and Tappan (1988) was used in the classification of the identified fauna. The type specimens of this work are deposited in the Geological Museum, Faculty of Science, Ain Shams University, Cairo, Egypt.

Phylum	Protista
Subphylum	Sarcodina Schmarda, 1871
Class	Rhisopodea Von Siebold, 1845
Subclass	Lobosia Carpente, 1861
Order	Foraminifera Eichwald, 1830

Family Spirolectamminidae Cushman, 1927

Genus *Spirolectammina* Cushman, 1927

Spirolectammina knebeli Le Roy
pl. 1, fig. 1

1953 *Spirolectammina knebeli* Le Roy, p. 51, pl. 2, figs. 10-11.

1956 *Spirolectammina knebeli* Le Roy-Said & Kenawy, p. 121, pl. 1, fig. 10.

Occurrence: It is recorded in sample 4110' (*Gr. ventricosa* zone).

Family Verneuilinidae Cushman, 1911

Genus *Gaudryina* d'Orbigny, 1839

Gaudryina limbata Said & Kenawy
pl. 1, fig. 2

1956 *Gaudryina limbata* Said & Kenawy, p. 123, pl. 1, fig. 23.

Occurrence: It is found in sample 4070' (*Gr. ventricosa* zone).

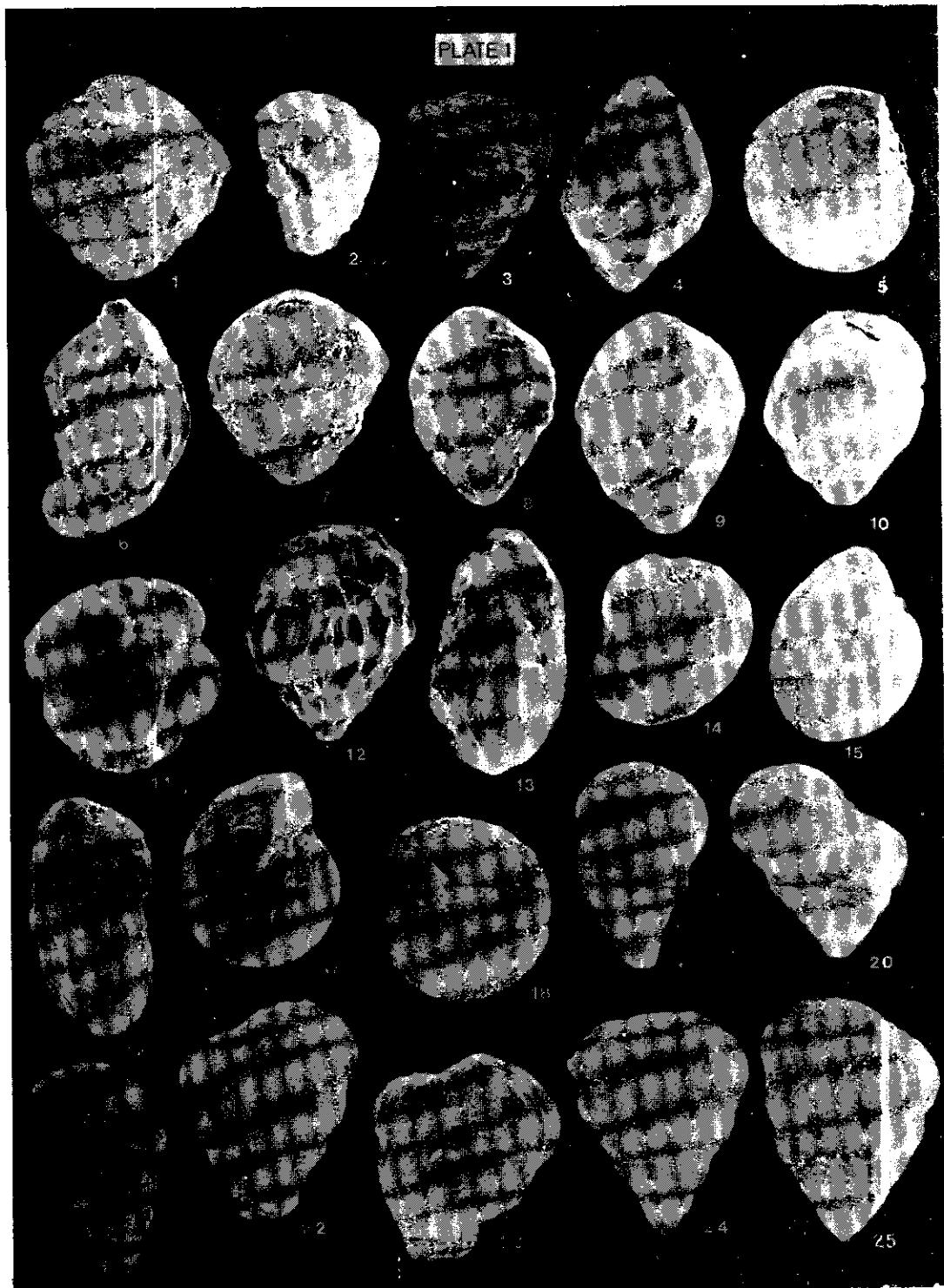
Family Eggerellidae Cushman, 1937

Genus *Dorothia* Plummer, 1931

PLATE 1

- 1 *Spiroplectammina knebeli* Le Roy, Sample 4110'.
- 2 *Gaudryina limbata* Said & Kenawy, Sample 4070'.
- 3 *Dorothia oxycona* (Reuss), sample 4060'.
- 4,5 *Lenticulina pseudocultratus* (Cole) sample 4180'.
4- side view 5- lateral view
- 6 *Marginulina tuberculata* (Plummer), sample 4150'.
- 7 *Bolivinoides curta* Reiss, sample 4020'.
- 8 *Bolivinoides draco draco* (Marsson), sample 3780'.
- 9 *Bolivinoides draco milliaris* Hiltermann & Koch, sample 4030'.
- 10 *Bulimina reussi* Morrow, sample 4000'.
- 11 *Bulimina stokesi* Cushman & Renz, sample 3640'.
- 12 *Bulimina* sp., sample 3640'.
- 13,14 *Cibicides* cf. *abdurbensis* Nakkady, sample 4180'.
13- side view . 14- lateral view .
- 15,16 *Cibicides loeblichii* Said & Kenawy sample 4180'.
15- lateral view . 16- side view .
- 17 *Gyroidina depressa* (Alth), umbilical view, sample 4100'.
- 18 *Gyroidina girardana* (Reuss), umbilical view, sample 4100'.
- 19,20 *Heterohelix globulosa* (Ehrenberg) sample 4010'.
19- apertural view . 20- lateral view .
- 21,22 *Heterohelix navaroensis* Loeblich sample 3930'.
21-apertural view . 20- lateral view .
- 23 *Heterohelix striata* (Ehrenberg), sample 3830'.
- 24 *Pseudotextularia elegans* (Rzehak), sample 3960'.
- 25 *Pseudoguembelina costulata* (Cushman), lateral view , sample 3920'.

Note: Specimens 1-6, 13-18 from *Gr. ventricosa* zone, specimens 7, 9, 10, 19, 20 from *Gl. havanensis* zone, specimens 8, 11, 12 from *G. gansseri* zone and specimens 21-25 from *Gr. aegyptiaca*. All specimens from Khoman Chalk (Campanian-Maastrichtian).



Dorothia oxycona (Reuss)
pl. 1, fig. 3

1946 *Marssonella oxycona* (Reuss)-Cushman, p. 43, pl. 12, figs. 3-5.
 1956 *Marssonella oxycona* (Reuss)-Sais & Kenawy, p. 127, pl. 1, fig. 48.
 Occurrence: It is found in sample 4060' (*Gr. ventricosa* zone).

Family Vaginulinidae Reuss, 1860

Genus *Lenticulina* Lamarck, 1804

Lenticulina pseudocultratus (Cole)
pl. 1, figs. 4, 5

1927 *Robulus pseudocultratus* Cole, p. 19, pl. 1, fig. 5
 1956 *Robulus pseudocultratus* Cole-Said & Kenawy, p. 130, pl. 2, fig. 5
 Occurrence: It is recorded in sample 4180' (*Gr. ventricosa* zone).

Genus *Marginulina* d'Orbigny, 1826

Marginulina tuberculata (Plummer)
pl. 1, fig. 6

1948 *Marginulina tuberculata* (Plummer)-Cushman and Bermudez, p. 69, pl. 11, fig. 5.
 Occurrence: It is recorded in sample 4150' (*Gr. ventricosa* zone).

Family Bolivinoididae Loeblich and Tappan, 1984

Genus *Bolivinoides* Cushman, 1927

Bolivinoides curta Reiss
pl. 1, fig. 7

1954 *Bolivinoides curta* Reiss, p. 158, pl. 30, figs. 15-16
 Occurrence: It is found in sample 4020' (*Gl. havanensis* zone).

Bolivinoides draco draco (Marsson)
pl. 1, fig. 8

1950 *Bolivinoides draco draco* (Marsson)-Hiltermann & Koch, p. 598, fig. 1.
 1956 *Bolivinoides draco draco* (Marsson)-Said & Kenawy, p. 140, pl. 3, fig. 41.
 Occurrence: It is found in sample 3780' (*G. gansseri* zone).

Bolivinoides draco milliaris Hiltermann & Koch
pl. 1, fig. 9

1950 *Bolivinoides draco milliaris* Hiltermann & Koch, p. 604, figs. 2-4.
1956 *Bolivinoides draco milliaris* Hiltermann & Koch-Said & Kenawy, p. 140,
pl. 3, fig. 40.

Occurrence: It is found in sample 4030' (*Gl. havanensis* zone).

Family Buliminidae Jones, 1875

Genus *Bulimina* d'Orbigny

Bulimina reussi Morrow
pl. 1, fig. 10

1947 *Bulimina reussi* Morrow-Cushman & Parker, p. 84, pl. 19, fig. 31.
1956 *Bulimina reussi* Morrow-Said & Kenawy, p. 143, pl. 4, fig. 15.

Occurrence: It is recorded in sample 4000' (*Gl. havanensis* zone).

Bulimina stokesi Cushman & Renz
pl. 1, fig. 11

1946 *Bulimina stokesi* Cushman & Renz, p. 37, pl. 6, fig. 14.
1956 *Bulimina stokesi* Cushman & Renz-Said & Kenawy, p. 143, pl. 4, fig. 14.
Occurrence: It is found in sample 3640' (*G. gansseri* zone).

Bulimina sp.
pl. 1, fig. 12

Family Cibicididae Cushman, 1927

Genus *Cibicides* de Montfort, 1808

Cibicides cf. *abdurbensis* Nakkady
pl. 1, figs. 13, 14

1950 *Cibicides abdurbensis* Nakkady, p. 691, pl. 90, figs. 33-34.
Occurrence: It is found in sample 3990' (*Gl. havanensis* zone).

Cibicides loeblichii Said & Kenawy
pl. 1, figs. 15, 16

1956 *Cibicides lobelichi* Said & Kenawy, p. 155, pl. 7, fig. 11.
Occurrence: It is recorded in sample 4180' (*Gr. ventricosa* zone).

Family Gavelinellidae Hofker, 1956

Genus *Gyroidina* d'Orbigny, 1826

Gyroidina depressa (Alth)
pl. 1, fig. 17

- 1946 *Gyroidina depressa* (Alth)-Cushman, p. 139, pl. 58, figs. 1-2.
 1956 *Gyroidina depressa* (Alth)-Said & Kenawy, p. 149, pl. 5, fig. 11.
Occurrence: It is found in sample 4100' (*Gr. ventricosa* zone).

Gyroidina girardana (Reuss)
pl. 1, fig. 18

- 1946 *Gyroidina girardana* (Reuss)-Cushman, p. 140, pl. 58, fig. 9.
 1956 *Gyroidina girardana* (Reuss)-Said & Kenawy, p. 148, pl. 5, fig. 2.
Occurrence: It is recorded in sample 4100' (*Gr. ventricosa* zone).

Family Heterohelicidae Cushman, 1927

Genus *Heterohelix* Ehrenberg, 1843

Heterohelix globulosa (Ehrenberg)
pl. 1, figs. 19, 20

- 1967 *Heterohelix globulosa* (Ehrenberg)-Pessagno, p. 260, fig. 5.
 1985 *Heterohelix globulosa* (Ehrenberg)-Caron, p. 60, fig. (24-5).
Remarks and Occurrence: It is characterized by globular chambers and the later ones increase rapidly in size. It is found in sample No. 4010' (*Gl. havanensis* zone).

Heterohelix navarroensis Loeblich
pl. 1, figs. 21, 22

- 1951 *Heterohelix navarroensis* Loeblich, p. 107, pl. 12, fig. 3.
 1985 *Heterohelix navarroensis* Loeblich-Caron, p. 60, fig. (24.8-9).
Remarks and Occurrence: It is characterized by more compressed and finer costate of the test. It is found in sample 3930' (*Gr. aegyptiaca* zone).

Heterohelix striata (Ehrenberg)
pl. 1, fig. 23

- 1967 *Heterohelix striata* (Ehrenberg)-Pessagno, p. 264, fig. 2.
 1985 *Heterohelix striata* (Ehrenberg)-Caron, p. 60, fig. (24.12-13).
Remarks and Occurrence: It is characterized by having much more strongly developed costate. It is recorded in sample 3830' (*Gr. aegyptiaca* zone).

Genus *Pseudotextularia* Rzehak, 1891

Pseudotextularia elegans (Rzehak)
pl. 1, fig. 24

1929 *Guembelina elegans* (Rzehak)-White, pl. 7, fig. 1.

1985 *Pseudotextularia elegans* (Rzehak)-Caron, p. 65, fig. (24.20-21).

Remarks and Occurrence: It is characterized by having a broader and finer costate test. It is found in sample 3960' (*Gr. aegyptiaca* zone).

Genus *Pseudoguembelina* Brönnimann and Brown, 1953

Pseudoguembelina costulata (Cushman)

pl. 1, fig. 25; pl. 2, fig. 1

1938 *Guembelina costulata* Cushman, p. 16, pl. 3, fig. 7.

1985 *Pseudoguembelina costulata* (Cushman)-Caron, p. 65, fig. (24.14-15).

Occurrence: It is recorded in sample 3920' (*Gr. aegyptiaca* zone).

Pseudoguembelina excolata (Cushman)

pl. 2, figs. 2, 3

1926 *Guembelina excolata* Cushman, p. 20, pl. 2, fig. 9.

1985 *Pseudoguembelina excolata* (Cushman)-Caron, p. 65, fig. (24.16-17).

Occurrence: It is found in sample 3950' (*Gr. aegyptiaca* zone).

Family Globigerinelloididae Longoria, 1974

Genus *Globigerinelloides* Cushman and ten Dam, 1948

Globigerinelloides prairiehillensis Pessagno

pl. 2, fig. 4

1967 *Globigerinelloides prairiehillensis* Pessagno, pl. 90, figs. 1-2.

1985 *Globigerinelloides prairiehillensis* Pessagno-Caron, p. 47, fig. (29.14-15).

Remarks and Occurrence: It is characterized by possessing fewer chambers. It is recorded in sample 3740' (*G. gansseri* zone).

Globigerinelloides ultramicra (Subbotina) pl. 2, fig. 5

1949 *Globigerinella ultramicra* Subbotina, p. 33, pl. 2, fig. 17-18.

1985 *Globigerinella ultramicra* (Subbotina)-Caron, p. 47, fig. (29.18-19).

Remarks and Occurrence: It is characterized by having a small test and great number of chambers. It is found in sample 3950' (*Gr. aegyptiaca* zone).

Family Hedbergellidae Loeblich and Tappan, 1961

Genus *Hedbergella* Brönnimann and Brown, 1958

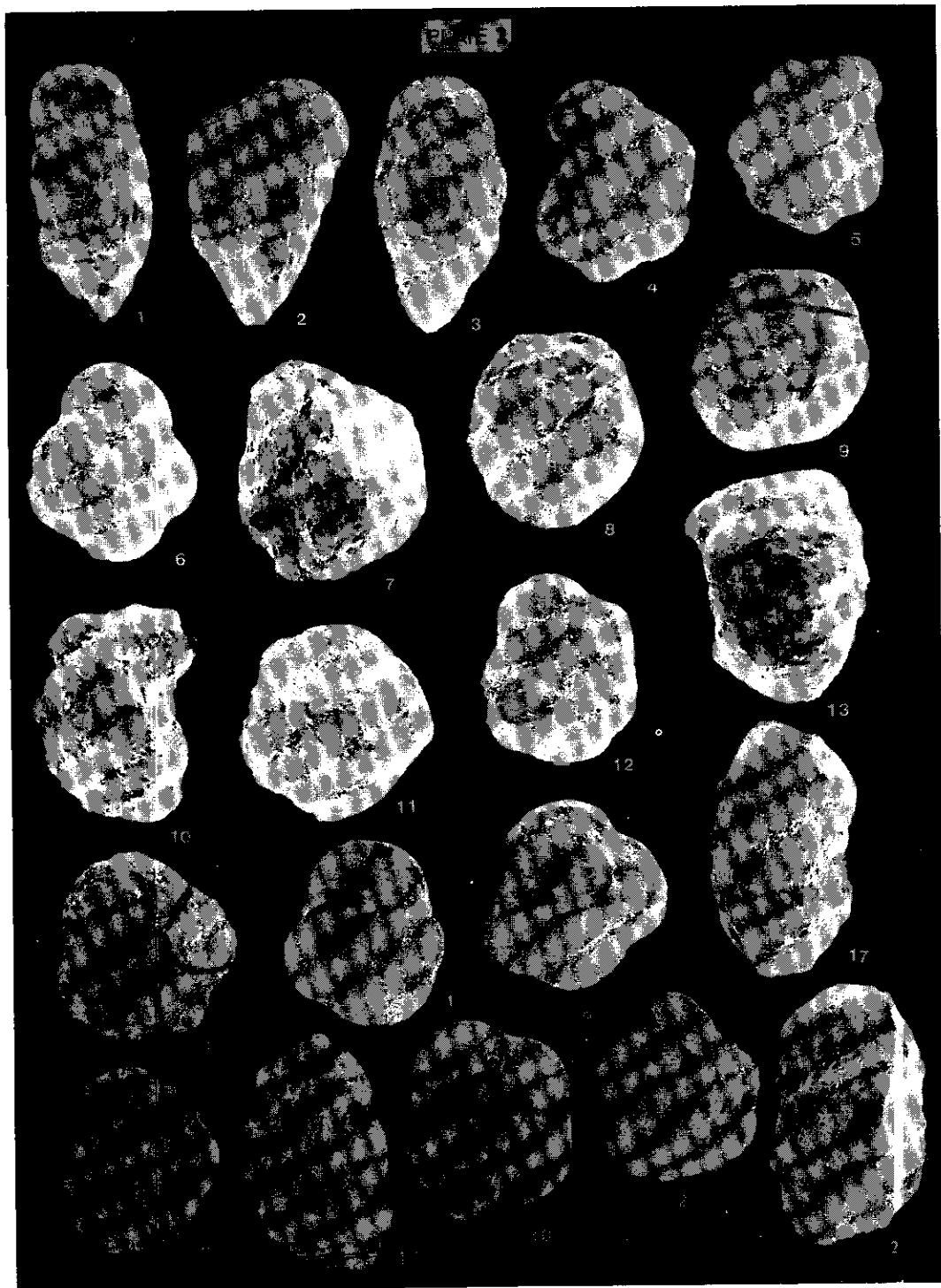
Hedbergella delrioensis (Carsey)

pl. 2, fig. 6

PLATE 2

- 1 *Pseudoguembelina costulata* Cushman, apertural view, sample 3920'.
- 2,3 *Pseudoguembelina excolata* Cushman, sample 3950'.
2- lateral view . 3- apertural view .
- 4 *Globigerinelloides prairiehiliensis* Pessagno, umbilical view, sample 3740'.
- 5 *Globigerinelloides ultramicra* Subbotina, ubmilical view, sample 3950'.
- 6 *Hedbergella delrioensis* (Carsey), umbilical view, sample 3690'.
- 7,8 *Rosita contusa* (Cushman), sample 3600'.
7- side view . 8- umbilical view .
- 9,10 *Rosita formicata* (Plummer), sample 4000'.
9- umbilical view . 10- side view .
- 11 *Rosita patelliformis* (Gandolfi), umbilical view, sample 3660'.
- 12 *Rosita plicata* (White), umbilical view, sample 3640'.
- 13,14 *Gansserina gansseri* (Bolli), sample 3720'.
13- side view . 14- umbilical view .
- 15,16,17 *Globotruncana aegyptiaca* Nakkady, sample 3830'.
15- dorsal view . 16- umbilical view .
17- side view .
- 18,19 *Globotruncana esnehensis* Nakkady, sample 3600'.
18- umbilical view . 19- side view .
- 20,21,22 *Globotruncana esnehensis* Nakkady, sample 3600'.
20- umbilical view . 22- dorsal view .
22- side view .

Note: Specimens 1-3,5, 15-17 from *Gr. aegyptiaca* zone, specimens, 4, 6, 11-14, 18, 19 from *G. gansseri* zone, specimens 7, 8, 20-22 from *A. mayaroensis* zone and specimens 9, 10 from *Gl. havanensis* zone. All specimens from Khoman Chalk (Campanian-Maastrichtian).



1974 *Hedbergella delrioensis* (Carsey)-Longoria, p. 5, pl. 10, figs. 1-3.

1985 *Hedbergella delrioensis* (Carsey)-Caron, p. 57, fig. (25.6-7).

Occurrence: It is found in sample 3690' (*G. gansseri* zone).

Family Globotruncanidae Brotzen, 1942

Genus *Rosita* Robaszynski, Caron, Gonzales and Wonders, 1984

Rosita Contusa (Cushman)
pl. 2, figs. 7, 8

1946 *Pulvinulina arca* Cushman var. *contusa* Cushman, p. 150, pl. 52, fig. 6.

1985 *Rosita contusa* (Cushman)-Caron, p. 67, fig. (28.1-2).

Remarks and Occurrence: It is characterized by concave umbilical side and highly convex dorsal side. It is recorded in sample 3600' (*A. mayaroensis* zone).

Rosita fornicata (Plummer)
pl. 2, figs. 9, 10

1931 *Globotruncana fornicata* Plummer, p. 130, pl. 13, fig. 4.

1985 *Rosita fornicata* (Plummer)-Caron, p. 67, fig. (28.3-4).

Remarks and Occurrence: It is characterized by fewer chambers in the last whorl. It is found in sample 4000' (*Gl. havanensis* zone).

Rosita patelliformis (Gandolfi)
pl. 2, fig. 11

1955 *Globotruncana* (*Globotruncana*) *contusa* (Cushman) ssp. *patelliformis*
Gandolfi, p. 54, pl. 4, fig. 2.

1984 *Rosita patelliformis* (Gandolfi)-Robaszynski et al., p. 252, pl. 39, figs. 1-3.

Remarks and Occurrence: It is an intermediate trochospire form between *R. contusa* and *R. fornicata*. It is recorded in sample 3660' (*G. gansseri* zone).

Rosita plicata (White)
pl. 2, fig. 12

1928 *Globotruncana conica* White var. *plicata* White, p. 285, pl. 38.

1984 *Rosita plicata* (White)-Robaszynski et al., p. 254, pl. 40, fig. 1-2.

Remarks and Occurrence: It is characterized by a subtrapezoidal and elongated chambers in the direction of coiling. It is recorded in sample 3640' (*G. gansseri* zone).

Genus *Gansserina* Caron, Gonzalez Donoso, Robaszynski and Wonders, 1984

Gansserina gansseri (Bolli)
pl. 2, figs. 13, 14

1951 *Globotruncana gansseri* Bolli, p. 196, pl. 35, figs. 1-3.

1985 *Gansserina gansseri* (Boli)-Caron, p. 45, fig. (30.11-13).

Remarks and Occurrence: It is characterized by a plano-convex test single keeled and strongly convex on the umbilical side. It is recorded in sample 3720' (*G. gansseri* zone).

Genus *Globotruncana* Cushman, 1927

Globotruncana tiegypatiaca Nakkady
pl. 2, figs. 15, 16, 17

1950 *Globotruncana aegyptiaca* Nakkady, p. 690, pl. 90, fig. 20.

1985 *Globotruncana aegyptiaca* Nakkady-Caron, p. 50, fig. (19.1-3).

Remarks and Occurrence: It is characterized by typically 4-chambers in the last whorl. It is recorded in sample 3830' (*Gr. aegyptiaca* zone).

Globotruncana arca (Cushman)
pl. 2, figs. 18, 19

1926 *Pulvinulina arca* Cushman, p. 23, pl. 3, fig. 1

1985 *Globotruncana arca* (Cushman) Robaszynski et al., p. 182, pl. 4, figs. 1-3.

Remarks and Occurrence: It is recorded in sample 3710' (*G. gansseri* zone).

Globotruncana esnehensis Nakkady
pl. 2, figs. 20, 21, 22

1950 *Globotruncana arca* (Cushman) var. *esnehensis* Nakkady, p. 690, pl. 90, figs. 23-26.

1985 *Globotruncana esnehensis* Nakkady-Robaszynski et al., p. 192, pl. 9, fig. 1-4.

Occurrence: It is found in sample 3600' (*A. mayaroensis* zone).

Globotruncana falsostuarti Sigal
pl. 3, figs. 1, 2

1952 *Globotruncana falsostuarti* Sigal, p. 43, pl. 46.

1985 *Globotruncana falsostuarti* Sigal-Caron, p. 50, fig. (19.9-10).

Occurrence: It is recorded in sample 3840' (*Gr. aegyptiaca* zone).

Globotruncana linneiana (d'Orbigny)
pl. 3, figs. 3, 4, 5

1839 *Rosalina linneiana* d'Orbigny, p. 101, pl. 15, figs. 10-12.

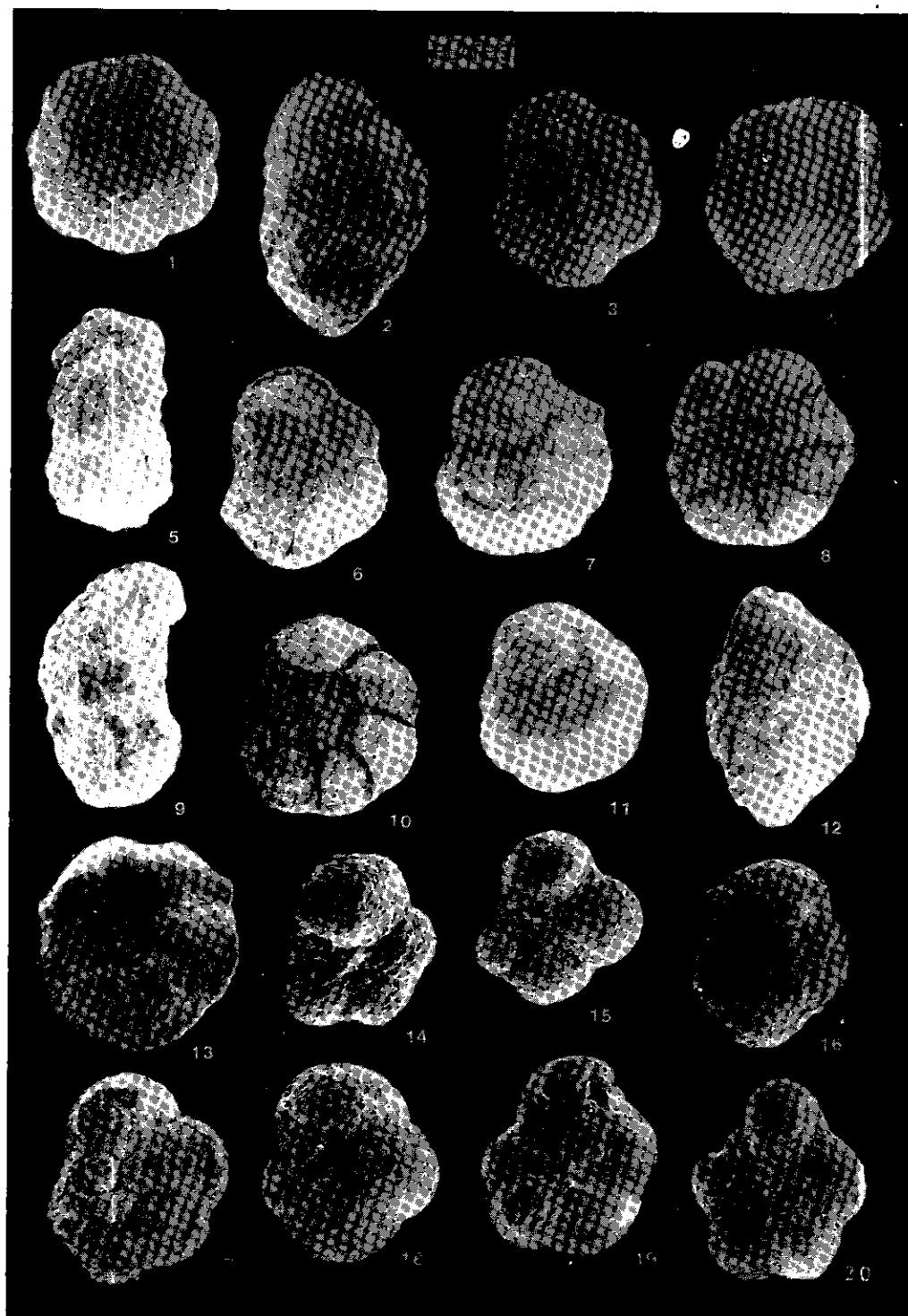
1985 *Globotruncana linneiana* (d'Orbigny)-Caron, p. 50, fig. (20.5-6).

Remarks and Occurrence: It is characterized by a box-like shape with two well raised and widely spaced keels. It is recorded in sample 3910' (*Gr. aegyptiaca* zone).

PLATE 3

- | | | |
|-------|--|------------------|
| 1,2 | <i>Globotruncana falsostuarti</i> Sigal, sample 3840'.
1- umbilical view . | 2- dorsal view . |
| 3,4,5 | <i>Globotruncana linneiana</i> (d'Orbigny), sample 3910'.
3- umbilical view . | 4- dorsal view . |
| | 5- side view . | |
| 6 | <i>Globotruncana ventricosa</i> White, umbilical view, | sample 4220'. |
| 7 | Transitional form between <i>Globotruncanita calcarata</i> and <i>Gt. subspinosa</i> , umbilical view. | sample 3910'. |
| 8,9 | <i>Globotruncanita conica</i> (White), sample 3730'.
8- umbilical view . | 9- side view . |
| 10 | <i>Globotruncanita stuarti</i> (de Lapparent), umbilical view ,
3740'. | sample |
| 11,12 | <i>Globotruncanita stuartiformis</i> (Dalbiez), sample 3740'.
11- umbilical view . | 12- side view . |
| 13 | <i>Globotruncanita subspinosa</i> (Pessagno), umbilical view,
3960'. | sample |
| 14 | <i>Globotruncanita havanensis</i> (Voorwijk), umbilical view,
4030'. | sample |
| 15 | <i>Globotruncanella petaloidea</i> (Gandolfi), umbilical view,
3720'. | , sample |
| 16 | <i>Abathomphalus intermedius</i> (Bolli), umbilical view, | sample 3600'. |
| 17 | <i>Abathomphalus mayaroensis</i> (Bolli), umbilical view, | sample 3600' |
| 18 | <i>Archaeoglobigerina blowi</i> Pessagno, umbilical view, | sample 3780'. |
| 19 | <i>Archaeoglobigerina cretacea</i> (d'Orbigny), umbilical view,
3780'. | sample |
| 20 | <i>Rugoglobigerina reicheli</i> Brnnimann, umbilical view,
3710' | sample |

Note: Specimens 1-5, 7, 13 from *Gr. aegyptiaca* zone, specimen 6 from *Gr. ventricosa* zone, specimens 8-12, 15, 18-20 from *G. gansseri* zone, specimen 14 from *Gl. havanensis* zone and specimens 16, 17 from *A. mayaroensis* zone. All specimens from Khoman Chalk (Campanian-Maastrichtian).



Globotruncana ventricosa White
pl. 3, fig. 6

1928 *Globotruncana canaliculata* var. *ventricosa* White, p. 284, pl. 38, fig. 3.

1985 *Globotruncana ventricosa* White-Caron, p. 50, fig. (20-7-9).

Remarks and Occurrence: It is characterized by strongly inflated umbilical side. It is found in sample 4220' (*Gr. ventricosa* zone).

Genus *Globotruncanita* Reiss, 1957

Globotruncanita conica (White)
pl. 3, figs. 8, 9

1928 *Globotruncana conica* White, p. 285, pl. 38, fig. 7.

1985 *Globotruncanita conica* (White)-Caron, p. 51, fig. (22.1-2).

Remarks and Occurrence: It has numerous chambers and a single keel. It is found in sample 3730' (*G. gansseri* zone).

Globotruncanita stuarti (de Lapparent)
pl. 3, fig. 10

1918 *Rosalina stuarti* de Lapparent, p. 11, pl. 1, fig.s 5-7.

1985 *Globotruncanita stuarti* (de Lapparent)-Caron, p. 51, fig. (23.1-3).

Remarks and Occurrence: It is characterized by possessing trapezoidal chambers. It is found in sample 3740' (*G. gansseri* zone).

Globotruncanita stuartiformis (Dalbiez)
pl. 3, figs. 11, 12

1955 *Globotruncana* (*Globotruncana*) *elevata* *stuartiformis* Dalbiez, p. 169, text-fig. 10.

1985 *Globotruncana stuartiformis* (Dalbiez)-Caron, p. 51, fig. (23.4-5).

Remarks and Occurrence: It is characterized by having triangular chambers. It is found in sample 3740' (*G. gansseri* zone).

Globotruncanita subspinosa (Pessagno)
pl. 3, fig. 13

1960 *Globotruncana* (*Globotruncana*) *subspinosa* Pessagno, p.101, pl. 1, figs. 4-6.

1985 *Globotruncana subspinosa* (Pessagno)-Caron, p. 51, fig. (22.5-8).

Remarks and Occurrence: It is characterized by having crescent-shaped chambers. It is recorded in sample 3960' (*Gr. aegyptiaca* zone).

Genus *Globotruncanella* Reiss, 1957

Globotruncanella havanensis (Voorwijk)
pl. 3, fig. 14

1937 *Globotruncana havenensis* Voorwijk, p. 159, pl. 1, figs. 25, 26 & 29.

1985 *Globotruncanella havenensis* (Voorwijk)-Caron, p. 51, fig.(21.3-4).

Occurrence: It is found in sample 4030' (*G. havenensis* zone).

Globotruncanella petaloidea (Gandolfi)
pl. 3, fig. 15

1955 *Globotruncana (Rugoglobigerina) petaloidea* Gandolfi, p. 52, pl. 3, fig. 13.

1985 *Globotruncanella petaloidea* (Gandolfi)-Caron, p. 51, fig.(21.5-6).

Occurrence: It is recorded in sample 3720' (*G. gansseri* zone).

Genus *Abathomphalus* Bolli, Loeblich and Tappan, 1957

Abathomphalus intermedius (Bolli)
pl. 3, fig. 16

1951 *Globotruncana intermedia* Bolli, pl. 35, figs. 7-9.

1984 *Abathomphalus intermedius* (Bolli)-Robaszynski et al., p. 272, pl. 46.
figs. 1-2.

Occurrence: It is recorded in sample 3600' (*A. mayaroensis* zone).

Abathomphalus mayaroensis (Bolli)
pl. 3, fig. 17

1950 *Globotruncana mayaroensis* Bolli, p. 190, pl. 35, figs. 10-12.

1985 *Abathomphalus mayaroensis* (Bolli)-Caron, p. 42, fig. (21.10-11).

Occurrence: It is found in sample 3600' (*A. mayaroensis* zone).

Genus *Archaeoglobigerina* Pessagno, 1967

Archaeoglobigerina blowi Pessagno
pl. 3, fig. 18

1967 *Archaeoglobigerina blowi* Pessagno, p. 316, pl. 59, figs. 5-7.

1985 *Archaeoglobigerina blowi* Pessagno-Caron, p. 43, fig. (16.3-4).

Remarks and Occurrence: It has only 4 chambers in the last whorl. It is found in sample 3780' (*G. gansseri* zone).

Archaeoglobigerina cretacea (d'Orbigny)
pl. 3, fig. 19

1840 *Globigerina cretacea* d'Orbigny, p. 34, pl. 3, figs. 12-14.

1985 *Archaeoglobigerina cretacea* (d'Orbigny)-Caron, p. 43, fig. (16.1-2).

Remarks and Occurrence: It has 5-6 chambers in the last whorl. It is found in sample 3780' (*G. gansseri* zone).

Genus *Rugoglobigerina* Brönnimann 1952

Rugoglobigerina reicheli Brönnimann
pl. 3, fig. 20

1952 *Rugoglobigerina (Rugoglobigerina) reicheli* Brönnimann, p. 18, pl. 3, figs. 10-12.

1985 *Rugoglobigerina reicheli* Brönnimann-Caron, p. 72, fig. (34.5-6).
Occurrence: It is recorded in sample 3710' (*G. gansseri* zone).

Rugoglobigerina rugosa (Plummer)
pl. 4, fig. 1,2

1926 *Globigerina rugosa* Plummer, p. 38, pl. 2, fig. 10.

1985 *Rugoglobigerina rugosa* (Plummer)-Caron, p. 72, fig. (34.9-10).
Occurrence: It is found in sample 3780' (*G. gansseri* zone).

Family Globorotaliidae Cushman, 1927

Genus *Turborotalia* Cushman and Bermudez, 1949

Turborotalia cerroazulensis cerroazulensis (Cole)
pl. 4, fig. 3

1928 *Globigerina cerroazulensis* Cole, p. 217, pl. 1, figs. 11-13.

1985 *Turborotalia cerroazulensis* (Cole)-Toumarkine and Luterbacher, p. 137, fig. (34.3-4).

Occurrence: It is fund in sample 3540' (*T. c. cerroazulensis* zone).

Turborotalia cerroazulensis cocoaensis (Cushman)
pl. 4, fig. 4, 5

1928 *Globorotalia cocoaensis* Cushman, p. 75, pl. 10, fig. 3.

1985 *Turbolotalia cerroazulensis cocoaensis* (Cushman)-Toumarkine and Luterbacher, p. 138, fig. (34.2).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Turborotalia cerroazulensis cunialensis (Toumarkine & Bolli)
pl. 4, fig. 6

1970 *Globorotalia cerroazulensis cunialensis* Toumarkine and Bolli, p. 144, pl. 1, fig. 37.

1985 *Turborotalia cerroazulensis cunialensis* (Toumarkine and Bolli)-Toumarkine and Luterbacher, p. 138, fig. (34.1).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Turborotalia cerroazulensis pomerli (Toumarkine & Bolli) pl. 4, fig. 7

1970 *Globorotalia cerroazulensis pomerli* Toumarkine and Bolli, p. 140, pl. 1, fig. 13.

1985 *Turborotalia cerroazulensis pomerli* (Toumarkine and Bolli)-Toumarkine and Luterbacher, p. 137, fig. (34.9).
Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globorotalia increbescens Bandy
pl. 4, fig. 8

1949 *Globigerina increbescens* Bandy, p. 120, pl. 23, fig. 3.
1985 *Globorotalia increbescens* Bandy-Bolli and Saunders, p. 182, fig. (14.5).
Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globorotalia opima nana Bolli
pl. 4, figs. 9, 10

1957 *Globorotalia opima nana* Bolli, p. 118, pl. 28, fig. 3.
1985 *Globorotalia opima nana* Bolli-Bolli and Saunders, p. 202, fig. (26.15-20).
Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Family Catapsydracidae Bolli, Loelich and Tappan, 1957)

Genus *Catapsydrax* Bolli, Loeblich and Tappan, 1957

Catapsydrax dissimilis (Cushman & Berdumez)
pl. 4, fig. 11

1937 *Globigerina dissimilis* Cushman & Bermudez, p. 25, pl. 3, figs. 4-6.
1985 *Catapsydrax dissimilis* (Cushman & Berdumez)-Bolli & Saunders, p. 186, fig. (17.1-4).
Occurrence: It is found in sample 3540' (*T. c. cerrozoalensis* zone).

Family Globigerinidae Carpenter, Parker and Jones, 1862

Genus *Globigerina* d'Orbigny, 1826

Globigerina ampliapertura Bolli
pl. 4, fig. 12

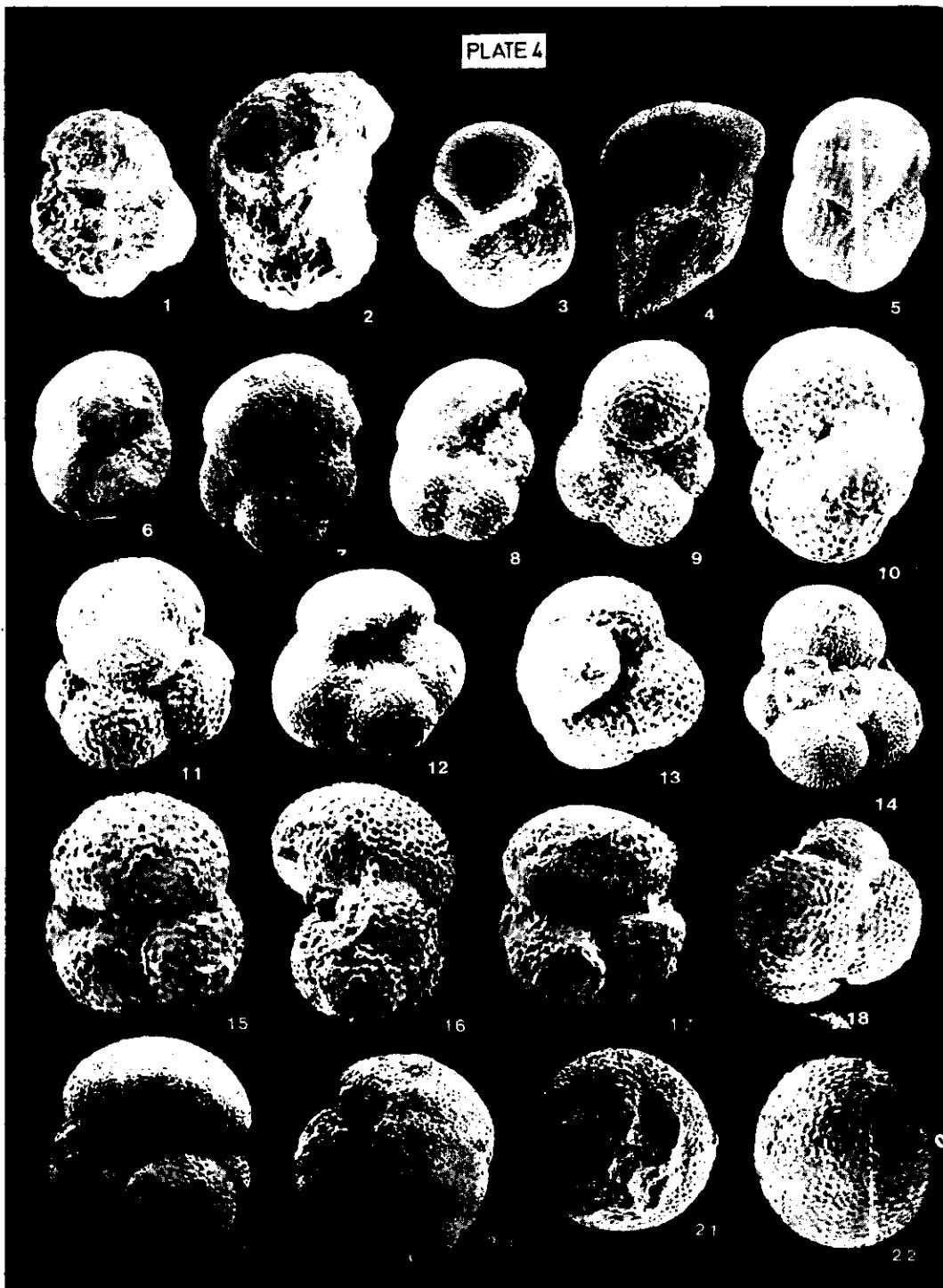
1857 *Globigerina ampliapertura* Bolli, p. 108, pl. 22, fig. 6.
1985 *Globigerina ampliapertura* Bolli-Bolli & Saunders, p. 128, fig. (14.1-5).
Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globigerina cryptomphala Glaessner
pl. 4, fig. 13

1937 *Globigerina bulloides* d'Orbigny var. *cryptomphala* Glaessner, p. 29, pl. 1,
fig. 1.

PLATE 4

Note: Specimens 1,2 from *G. gansseri* zone (Khoman Chalk, Campanian-Maastrichtian), specimens 3-20 from sample 3540'. (*Turborotalia cerroazulensis cerroazulensis* zone, Uppermost Eocene) and specimens 21, 22 from reworked sediments in sample 3560'.



1985 *Globigerina cryptomphala* Glaessner-Toumarkine & Luterbacher, p. 149, fig. (42.5-6).

Occurrence: It is found in sample 3540' (*T. c. cerrozoalensis* zone).

Globigerina hagni Gohrbandt
pl. 4, fig. 14

1967 *Globigerina hagni* Gohrbandt, p. 324, pl. 1, figs. 1-3.

1985 *Globigerina hagni* Gohrbandt-Toumarkine & Luterbacher, p. 150, fig. (42.7-9).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globigerina inaequispira Subbotina
pl. 4, figs. 15, 16

1953 *Globigerina inaequispira* Subbotina, p. 69, pl. 6, figs. 1-4.

1985 *Globigerina inaequispira* Subbotina-Toumarkine & Luterbacher, p. 117, fig. (19.5).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globigerina pseudoampliapertura Blow & Banner
pl. 4, fig. 17

1962 *Globigerina pseudoampliapertura* Blow & Banner, p. 95, pl. 12, figs. a-c.

1985 *Globigerina pseudoampliapertura* Blow & Banner-Bolli & Saunders, p. 182, fig. (14.1-5).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globigerina venezuelana Hedberg
pl. 4, fig. 18

1937 *Globigerina venezuelana* Hedberg, p. 681, pl. 92, fig. 7.

1985 *Globigerina venezuelana* Hedberg-Bolli & Saunders, p. 180, fig. (13.20-23).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Globigerina yegaensis Weinzierl & Applin
pl. 4, fig. 19

1929 *Globigerina yegaensis* Weinzierl & Applin, p. 408, pl. 43, fig. 1.

1985 *Globigerina yegaensis* Weinzierl & Applin-Bolli & Saunders, p. 180, fig. (13.20-23).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Genus *Globigerinatheka* Brnnimann, 1952

Globigerinatheka subconglobata subconglobata (Shutskaya)
pl. 4, fig. 20

1958 *Globigerinoides subconglobatus* Chalilov var. *subconglobata* Shutskaya, p. 7, pl. 1, figs. 4-11.

1985 *Globigerinatheka sunconglobatus subconglobata* (Shutskaya)-Toumarkine & Luterbacher, p. 144, fig. (37.7).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

Genus *Orbulinoides* Cordéy, 1968

Orbullinoides beckmanni (Saito)
pl. 4, figs. 21, 22

1962 *Porticulasphaera beckmanni* Saito, p. 2, pl. 34, fig. 1.

1985 *Orbulinoides beckmanni* (Saito)-Toumarkine & Luterbacher, p. 148, fig. (37.3).

Occurrence: It is found in sample 3540' (*T. c. cerroazulensis* zone).

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U. SENONIAN AND U. EOCENE BIOSTRAT. OF N.W. DESERT 163

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**لبيوستراتجافية والبيئة القديمة للسينونى
العلوى والإيوسين العلوى التحت السطحى لشمال
لصحراء الغربية - مصر**

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يشمل البحث دراسة الفورامينيفرا الهائمة والقاعدية للعصر سينونى العلوى والإيوسين العلوى فى قطاع بئر حرس رقم ١ بشمال سحراء الغربية؛ حيث تم التعرف على ستة نطق حيوية باستخدام فورامينيفرا الهئمة علاوة على دراسة البيئة القديمة من خلال استخدام العدد الكلى للفورامينيفرا الهائمة والقاعدية والنسبة بينهما ودرجة التنوع ومعامل فيشر لتحديد البيئة.

كما أشير في هذه الدراسة إلى مناخ الطباشيري وذلك من خلال الدراسات الحديثة للبرنامج العالمي الجيولوجي الروسي لدراسة ثور العصر الطباشيري حيث تبين من هذه الدراسات أن المناخ كان أردا في التورونيان، ثم هناك فترة أخرى دافعة في الكونياسيان - انتونيان ثم انتهى العصر الطباشيري بمناخ بارد ملحوظ.