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Research Article

GEOLOGY

Biostratigraphical studies of the subsurface Paleogene sequence in Abu Gharadig Field, Western Desert, Egypt

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ABSTRACT

Detailed study of the foraminifera and calcareous nannofossils in the Abu Gharadig wells (AG-32 and AG-22), from the Paleocene to Middle Eocene limestones of the Apollonia Formation and the Late Eocene to Oligocene of the Daba'a Formation has led to the recognition of 21 planktonic foraminiferal zones and 17 calcareous nannofossil biozones. Two prominent major gaps are recognized within the Paleocene: The basal hiatus cover most of the early Paleocene NP1 to NP2 nannofossil zones) which corresponds to absence of zones of P0, Pα, P1a and lowermost part of P1b b, the second hiatus comprises mainly late Paleocene NP6 to NP7/8 zones which corresponds to absence of Zone P4. These hiatuses are thought to be related to eustatic sea-level falls as well as to compressional tectonic phases. The Eocene/Oligocene boundary in terms of foraminifers and calcareous nannofossils, appears to be complete, it occurs within the lowermost part of Daba'a Formation and could be placed at the extinction of late Eocene index fossil *Turborotallia cerroazulensis*, and *Turborotalia cunialensis* and the extinction of the *Hantkenina alabamensis*, which mark the Eocene/Oligocene boundary. Furthermore it coincides with the extinction of rosette-shaped discoasters such as *Discoaster saipanensis* and *D. barbadiensis* at the top of zones NP19/20 and/or the highest occurrence of *Cribrocentrum reticulatum*.

Introduction

The Western Desert of Egypt is characterized by the presence of a thick subsurface Paleozoic to Recent stratigraphic column. The Abu Gharadig basin lies in the northern part of the Western Desert, Egypt (Fig. 1), 128 km south of Mediterranean Sea and about 260 km west Cairo. The Paleogene sequences of two studied wells have been studied: AG-22 (Lat. 29 45 45 N, Long. 28 31 11 E), and AG-32 (Lat. 29 47 33 N, Long, 28 32 16 N).It is about 330 km long and 50–75 km wide (El Gazzar *et al*., 2016) and trends E-W. The Abu Gharadig basin has a huge subsurface stratigraphic column containing several reservoir beds. It was formed during the Jurassic time and continued to subside throughout the Cretaceous time.

The aim of the present study is to investigate the subsurface rocks of Abu Gharadig Field (AG-22 &AG-32) wells, in term of their planktonic foraminifera and calcareous nannofossils content.

The following topics indicate the general outline of this study:

1- Preparation of the Paleogene samples from Abu Gharadig Field, Western Desert, for foraminiferal and Calcareous nannofossils using different techniques.

2- Detailed micro paleontological examination of foraminifers and nannofossils of the Paleogene in Abu Gharadig Field, Western Desert, including: separation, identification and classification.

3- Shed some light on stratigraphical seting of the Paleogene in Western Desert.

4- Document the stratigraphic range of the species for establishing different biostratigraphic zones.

As a result of recent active oil exploration work in the Western Desert of Egypt, the Abu Gharadig basin has attracted the attention of many authors as: Awad 1984; Demerdash et al. 1984; Abd El Aal 1988; Bayoumi and Lotfy 1989; Khaled 1999; Ibrahim 2002; Nabawy and El Hariri 2008; Halisch et al. 2009; El Diasty and Moldowan 2012; El Gazzar et al. 2016; Sarhan 2017a; Sarhan, 2017b; Sarhan and Collier 2018, Hewaidy et al. 2018; Elmahdy et al. 2020; El Bagoury 2020).

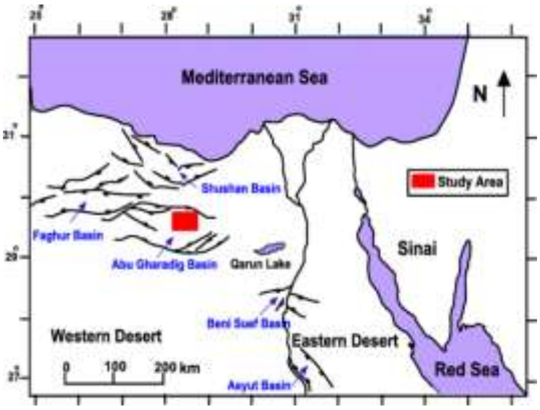

Fig. (1): Location map of (Abu Gharadig basin).

Lithostratigraphy

The Paleocene-early Oligocene succession of the Abu Gharadig wells could be subdivided lithostratigraphically (based mainly on lithologic characters) into five rock units arranged from base to top as: Apollnia (D), Apollonia (C), Apollonia (B), and Apollonia (A) (Figs. 2-3).

Apollonia Formation

This Formation is represented in our study by a thick section of limestone with subordinate shales of Paleocene to middle Eocene age. It rests unconformably on the Khoman Formation and is conformably overlain by the Daba'a Formation. Apollonia Formation has been subdivided into four informal members: A; B, C and D. The Apollonia 'D' Member is the oldest and unconformably overlies the white chalky limestone of the Khoman Formation (Upper Cretaceous).

The Apollonia 'C' Limestone; light tan, occasionally white, soft, medium hard, very fine-grained, argillaceous with some streaks of shale at the middle, hard disseminated chert fragments. The Apollonia 'B' Member is the thinnest and is dominated by shales. The Apollonia 'A' Member is the youngest member with Limestone; brownish grey, intercalated with shale near the top, highly argillaceous, grading to shale.

Daba'a Formation

This unit is represented by a thick section of shales, light to dark grey in colour, occasionally fissile, highly calcareous at the bottom and non-calcareous at the top, with a few streaks of limestone at the base. This formation is assigned to the upper Eocene to early Oligocene. It rests with a minor disconformity on the Apollonia Formation (Apollonia 'A' Member) and is conformably overlain by the lower Miocene sediments (Moghra Formation). According to Issawi *et al.*, (1990) the Daba 'a Formation is the only marine Oligocene Formation in Egypt as result of the subsidence along the northern shores of Africa, which led to the formation of structurally controlled basins, including this formation.

Planktonic Foraminiferal Biostratigraphy

The Paleogene planktonic foraminiferal scheme of Berggren *et al*., (1995) modified by Berggren and Pearson (2005) was adopted here in the present study which is the stratigraphic distribution charts of planktonic foraminifera species which identified from the Paleogene represented in the studied wells (AG-22, AG32) and the recognized biozones are given in (Figs. 4).

Lower Oligocene foraminiferal biozones

Pseudohastigerina naguewichiensis Highest-occurrence Zone (O1). **Author:** Berggren *et al*., (1995). **Definition:** It is defined by interval between the HO of *H. alabamensis* and the HO of the nominate taxon. **Correlation*:*** It is approximately is equal to *Turborotaloides cerroazulensis – Peudohastigrina* spp. Interval Zone (P18) Berggren *et al*., (1995) and Wade et al., (2011). It corresponds to lower part of NP21 Zone. **Occurrence*:*** Within the lowermost part of Daba'a Formation. This zone comprises samples 3000 and 3100 in well AG-22 and 3600 and 3500 in well AG-32.

***Hankenina alabamensis* Highest-occurrence Zone (E16)**

Author: Berggren *et al*., (1995). **Definition:** Partial range of the nominate taxon between the HO of *Globigerinatheka* and the HO of *H. alabamensis*. **Correlation:** It is approximately is equal to upper part of *Turborotalia cunialensis/Cribrohankenia inflata* Concurrent–range Zone of (P16) and *T. cerroazulensis* Partial-range Zone (P17) of Berggren *et al*., (1995 and Wade et al.,(2011). It corresponds to uppermost part of NP19/20 and lowermost part of NP21 Zone. Occurrence: Within the uppermost part of Apollonia Formation (topmost part of the Apollonia "A"). This zone comprises samples 2750 and 2720 in well AG-22 and 3350 and 3370 in well AG-32.

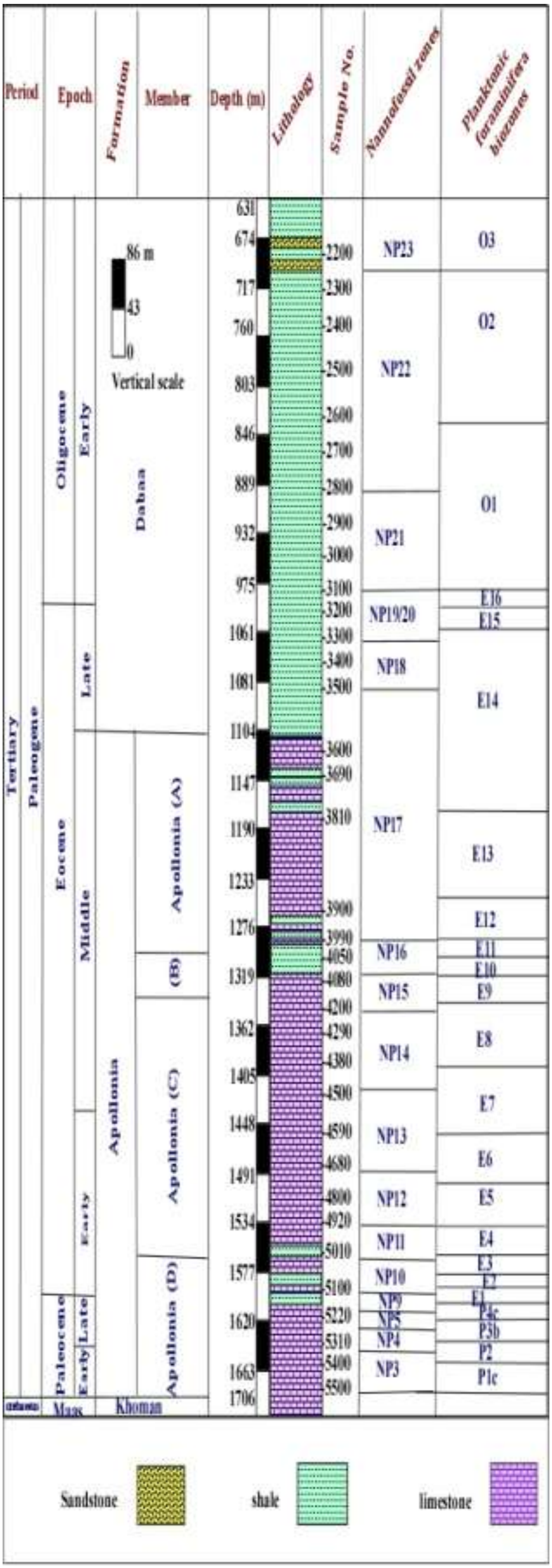

Fig. (2): Columnar section of well Abu Gharadig-22, Western desert, Egypt

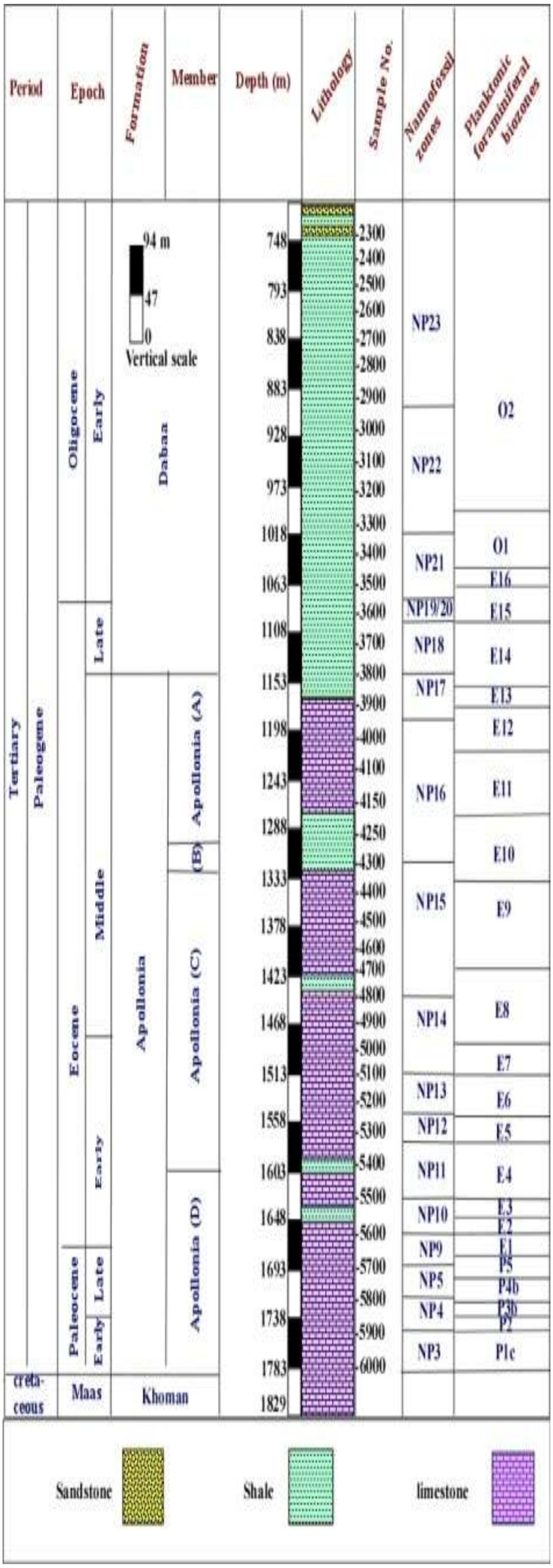

Fig. (3): Columnar section of well Abu Gharadig - 32, Western desert, Egypt

***Globigerinatheka index* Highest-occurrence Zone (E15)**

Author: Berggren *et al*., (1995). **Definition:** The interval between the HO of *Gl. semiinvoluta* and the HO of the nominate taxon *Glob. Index*, *semiinvoluta* interval Zone (P15) and lower part of (P16) *Turborotalia*. **Correlation:** It is approximately is equal part correlative with upper part of *Porticulaspher aunialensis/ Cribrohankenia inflate* lower part of NP16 Concurrent Zone of (P16) of Berggren *et al*., (1995) and Wade *et al*., 2011). It corresponds to uppermost part Zone of NP19/NP20.

Occurrence: Within the middle part of Apollonia Formation (topmost of the Apollonia "B"/or lowermost part of the Apollonia "A"). This zone comprises samples2850, 2970 in well AG-22 and 3450 and 3470 in well AG-32.

***Globigerinatheka semiinvoluta* Highest-occurrence Zone (E14)**

Author*:* Berggren *et al*., (1995). **Definition:** The interval between the HO of *M. crassata* and the HO of the nominate taxon. **Correlation*:*** It is approximately equal to *Poticulasphaera semiinvoluta* Interval Zone (P15) of Berggren *et al*., (1995) and Wade *et al*., (2011). It corresponds to NP18 Zone. **Occurrence:** Within the middle part of Apollonia Formation (topmost of the Apollonia "B"/or lowermost part of the Apollonia "A"). This zone comprises samples 3000 and 3100 in well AG-22 and 3600 and 3500 in well AG-32.

***Morozovella crassta* Highest-occurrence Zone (E13)**

Author: Berggren *et al*., (1995). **Definition***:* The interval of the marker zone between the HO of *O. beckmanii* and the HO of the *M. crassata*". **Correlation:** It is approximately equal to *Truncorotaloides rohri–M. spinulosa* Partial Zone of (P14) Blow (1979; Berggren and Miller (1988); Berggren *et al*., (1995) and Wade *et al*., (2011). It corresponds to lower part of NP17. **Occurrence*:*** Within the middle part of Apollonia Formation (topmost of the Apollonia "B"/or lowermost part of the Apollonia "A"). This zone comprises samples 3990 and 3600 in well AG-22 and 3900 and 3800 in well AG-32.

***Orbulinoides beckmanni* Taxon–range Zone (E12)**

Author*:* Berggren *et al*., (1995). **Definition**: The total range of the zonal marker. **Correlation:** It is approximately equal to (P13) of Berggren *et al*., (1995) and Wade *et al*., (2011). It corresponds to the uppermost part of NP16 and lowermost part of NP17. **Occurrence*:*** Within the middle part of Apollonia Formation (topmost of the Apollonia "B"/or lowermost part of Apollonia "A"). This zone comprises samples 3990 and 3600 in well AG-22 and 3900, 3800 in well AG-32.

***Morozovella lehneri* Partial-range Zone (E11)**

Author: Berggren *et al*., (1995). **Definition:** The concurrent range of the nominate taxon between the HO of taxon *Gu. nuttalli* and the LO of *Orbulinoides beckmanni*. **Correlation*:*** It is approximately equal to the upper part of *M. lehneri* Partial–range Zone (P12) of Berggren and other 1995and Wade et al., (2011). It corresponds to upper part of NP16. **Occurrence*:*** Within the middle part of Apollonia Formation (topmost of the Apollonia "C"). This zone comprises samples 4080 in well AG-22 and 4300 in well AG-32.

***Acarinina topilensis* Partial-range Zone (E10)**

Author: Berggren *et al*., (1995). **Definition:** It is defined as the partial range between the HO of *M. aragonensis* to the HO of *Guembelitrioide snuttalli*. **Correlation:** It is approximately equal to the *G. kugleri* /*M. aragonensis* Concurrent-range Zone (P11) of Berggren *et al*., (1995) and Wade *et al*., 2011). It corresponds to upper part of NP15. **Occurrence*:*** Within the middle part of Apollonia Formation (topmost of the Apollonia "C"). This zone comprises samples 4080 in well AG-22 and 4300 in well AG-32.

***Globigerinatheka kugleri /Morozovella aragonensis* Concurrent-range Zone (E9)**

Author*:* Berggren *et al*., (1995). **Definition***:* Concurrent range of the nominate taxa between the LO of *Gl. kugleri* and the HO of *M. aragonensis*. **Correlation*:*** It is approximately equal to *Gl. kugleri*/*M. aragonensis* Concurrent-range Zone (P11) of Berggren and others, (1995) and Wade *et al*., 2011). It corresponds to uppermost part of NP15. **Occurrence:** Within the middle part of Apollonia Formation (topmost of the Apollonia "C"). It comprises samples 4080 in well AG-22 and 4300 in well AG-32.

***Guembelitrioides nuttalli* Lowest-occurrence Zone (E8)**

Author*:* Berggren *et al*., (1995). **Definition:** The interval between the LO of the nominate taxon and the LO of *Globigerinatheka kugleri*. **Correlation*:*** It is approximately equal to *H. nuttalli* Zone Partial-range Zone (P10) of Berggren *et al*., (1995) and Wade *et al*., (2011). It is corresponds to uppermost part of NP14 Zone, and lowermost part of NP15 Zone. **Occurrence:** Within the middle part of Apollonia Formation (topmost of the Apollonia "C").This zone comprises samples 4500 in well AG-22 and 5100 in well AG-32.

***Acarinina cuneicamerata* Lowest-occurrence Zone (E7)**

Author*:* Berggren *et al*., (1995). **Definition*:*** the interval between the LO of the nominate taxon *A. cuneicamerata* and the LO of *Guembilitrioides nuttalli*. **Correlation*:*** It is approximately equal to *Planorotalites palmerta-Hantekenina nuttalli* Zone Interval Zone (P9) of Berggren *et al*., (1995) and Wade *et al*., (2011). It corresponds to the uppermost part of NP13 Zone and lowermost part of NP14 Zone. **Occurrence*:*** Within the lower part of Apollonia Formation (topmost of the Apollonia "C"). This zone comprises samples 4500 in well AG-22 and 5200 in well AG-32.

***Acarinina pentacamerata* Partial-range Zone (E6)**

Author: Berggren (1969) emended by Berggren *et al*., (1995). **Definition**: It is defined as the Partial range of the nominate taxon between the HO of *M. subbotinae* and the LO of *A. cuneicamerata*. **Correlation:** It is approximately equal to *M. aragonensis* Zone (P9) of Berggren *et al*., (1995) and Wade *et al*., (2011). This zone is defined herein to reflect the use of the HO of *M. subbotinae* (rather than the HO of *M. formosa*) as criterion for the base of the zone. It is corresponds to uppermost part of NP12 and lowermost part of NP13 Zone. Occurrence: Within the lower part of Apollonia Formation (topmost of the Apollonia "C") this zone comprises in samples 4920 in well AG-22 and 5380 in well AG-32.

***Morozovella aragonensis/ Morozovella subbotinae* Concurrent– Range Zone (E5)**

Author: Berggren *et al*., (1995). **Definition:** It is defined as the concurrent range of the nominate taxon between the LO of *M. aragonensis* and HO of *M. subbotinae*. **Correlation:** The Eocene Zone E5 is equivalent to the *M. aragonensis-M. formosa formosa* Concurrent-range Zone (P7) of Berggren *et al*., (1995) and Wade *et al*., (2011). This zone corresponds to upper part of NP 12 Zone. Occurrence: Within the lower part of Apollonia Formation (topmost of the Apollonia "C") this zone comprises in samples 4920 in well AG-22 and 5380 in well AG-32.

***Morozovella formosa* Lowest-Occurrence Zone (E4)**

Author*:* Berggren *et al*., (1995). **Definition*:*** The interval between the LO of the nominate taxon and the LO of *M. aragonensis*. **Correlation*:*** The early Eocene Zone E4 is equivalent to the *M. formosa formosa/M. Lensiforms-M. aragonensis* Interval Zone (Pb6) of Berggren *et al*., (1995) and Wade *et al*., (2011).This zone corresponds to uppermost part NP10 Zone and lower part of NP 11 Zone. **Occurrence:** Within the lower part of Apollonia Formation (topmost of the Apollonia "D"). It comprises in samples 4920 in well AG-22 and 5380 in well AG-32.

***Morozovella marginodentata* Partial–Range Zone (E3)**

Author: Berggren *et al*., (1995). **Definition*:*** The interval between the Partial–range of nominate taxon between the HO of *M.* v*elascoensis* and the LO of *M.* f*ormosa.* **Correlation*:*** This Zone is equivalent to *M. velascoensis*, *M. formosa formsa* and/or *M. lensiforms* Interval Zone (P6b) of Berggren *et al*., (1995) and Wade *et al*., (2011). It is corresponds to lowermost part NP10 calcareous nannofossil Zone. **Occurrence:** Within the lower part of Apollonia Formation (topmost of the Apollonia "D"). It comprises in samples 4920 in well AG-22 and 5380 in well AG-32.

***Pseudohastigerina wilcoxensis/Morzovella velascoensis* Concurrent-Range Zone (E2)**

Author: Berggren *et al*., (1995). **Definition:** It is defined by the range of the nominate taxon between the LO of *Ps. wilcoxensis* and the HO of *M. velascoensis*. **Correlation:** The early Eocene Zone E2 is equivalent to the upper part *M. velascoensis* (P5) Interval Zone of Berggren *et al*., (1995) and Wade *et al.*, (2011). This zone corresponds to the uppermost part NP9 and lower part of NP10 Zone. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D"). It comprises samples 5100 and 5010 in well AG-22 and 5600 and 5500 in well AG-32.

Eocene foraminiferal biozones

***Acarinina sibaiyaensis* Lowest-Occurrence Zone (E1)**

Author*:* Molina *et al*., (1999), emended by Berggren *et al*., (1995). **Definition*:*** It is defined to include the interval between the LO of the nominate taxon to the LO of *Pseudohastigerina wilcoxensis.* **Correlation:** The Eocene Zone E1 is equivalent to the middle part of *M. velascoensis* (P5) Zone interval Zone of Berggren *et al*., (1995) and Wade *et al*., 2011). It corresponds to middle part NP 9 Zone. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of Apollonia "D") .It comprises samples 5100 in well AG-22 and 5700 in well AG-32

***Morozovella velascoensis* Partial–Range Zone (P5)**

Author*:* Berggren *et al*., (1995) amended by Berggren and Miller (1988) and renamed by Berggren and Pearson (2005). **Definition***:* It is defined to includes the partial range of the nominate species between the HO of *G. pseudomenardii* and the LO of *Acarinina sibaiyensis*. **Correlation:** It is approximately equivalent to lower part of *M. velascoensis* Zone (P5) of Berggren *et al*., (1995) and Wade *et al*., (2011). It corresponds to within NP9 Zone, co-occurring with large hiatuse including subzone of P4a, P4b, P4C. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D"). It comprises sample 5220 in well AG-22 and 5700 in well AG-32.

***Igorina albeari* Lowest Occurrence Subzone (P3b)**

Author: Berggren *et al.*, (1995), renamed by Berggren and Pearson (2005). **Definition:** It includes the interval from the LO of *I. albeari* to the LO of *G. pseudomenardii.* **Correlation:** This subzone is equivalent to the *I. al-*

beari–G. pseudomenardii Interval Subzone (P3b) of Berggren *et al.*, (1995), Berggren and Pearson (2005) and Wade *et al*., (2011). This subzone corresponds to uppermost part NP4 Zone. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of Apollonia "D"). It comprises sample 5220 in well AG-22 & 5700 in well AG-32.

Igorina pusilla **Partial-Range Subzone (P3a)**

Author: Berggren *et al*., (1995) amended by Berggren and Miller (1988) and renamed by Berggren and Pearson (2005). **Definition:** Biostratigraphic interval defined by the partial range of *I. pusilla* between the LO of *M. angulata* and the LO *I. albeari*. **Correlation:** This subzone is equivalent to P3a Subzone of Berggren *et al*., (1995), Berggren and Pearson (2005) and Faris *et al*., (2005) and to *M. angulata* Zone of Obaidalla *et al*., (2009). This subzone corresponds to the nannofossil Zone NP4. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D" .It comprises samples 5310 in well AG-22 & 5900 in well AG-32.

Morozovella angulata **Lowest-Occurrence Zone (P3)**

Author: Berggren *et al.*, (1995) emended by Berggren and Miller (1988) and renamed by Berggren and Pearson (2005). **Definition**: It is defined as the interval from LO of *M. angulata* and the LO of *G. pseudomenardii*. **Correlation:** It is equivalent to the *M. angulata-G. pseudomenardii* Interval Zone (Zone P3) of Berggren et al. (1995). Based on the LO of *Igorina albeari*, Berggren *et al*., (1995) followed by Berggren and Pearson (2005) and Wade *et al*., (2011), subdivided the *M. angulata* Zone into subzones P3a and P3b. It corresponds to upper part NP4 nannofossil Zone. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D"). It comprises samples 5310 to 5220 in well AG22 & 5900 to 5790 in well AG-32.

Praemurica uncinata **Lowest-Occurrence Zone (P2)**

Author: Berggren *et al.*, (1995) emended by Berggren and Miller (1988) and renamed by Berggren and Pearson (2005). **Definition:** The interval between the LO of *P. uncinata* and the LO of *Morozovella angulata.* **Correlation:** This Zone P2 is nearly equivalent to the *P. uncinata- M. angulata (*Zone) P2 Zone of Berggren and others, 1995 and Wade *et al*., 2011). It corresponds to the within NP4 Zone. It comprises samples 5310, 5220 in well AG22 & 5900, 5790 in well AG-32. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D"). It comprises samples 5310 to 5220 in well AG22 & 5900 to 5790 in well AG-32.

Paleocene foraminiferal biozones

In the present study abbrivations used are: LO =lowest occurrence, HO =highest occurrence

Globanomalina compressa/Praemurica inconstans **Lowest-Occurrence Subzone (P1c)**

Author: Berggren *et al*., (1995) emended by Berggren and Miller (1988) and renamed by Berggren and Pearson (2005). **Definition:** This zone includes the interval between the LO of *G. compressa* and /or *P. inconstans* and the LO of *P. uncinata*. **Correlation:** The Paleocene Zone P1C is equivalent to the lower part of *G. compressa/P. inconstans* Subzone (P1C) Zone of Berggren *et al*., 1995 and Wade *et al*., 2011). It corresponds to the upper part of NP3, and lower part of NP4 Zone. **Occurrence:** Within the lowermost part of Apollonia Formation (topmost of the Apollonia "D". It comprises samples 5310, 5220 in well AG22 & 5900, 5790 in well AG-32.

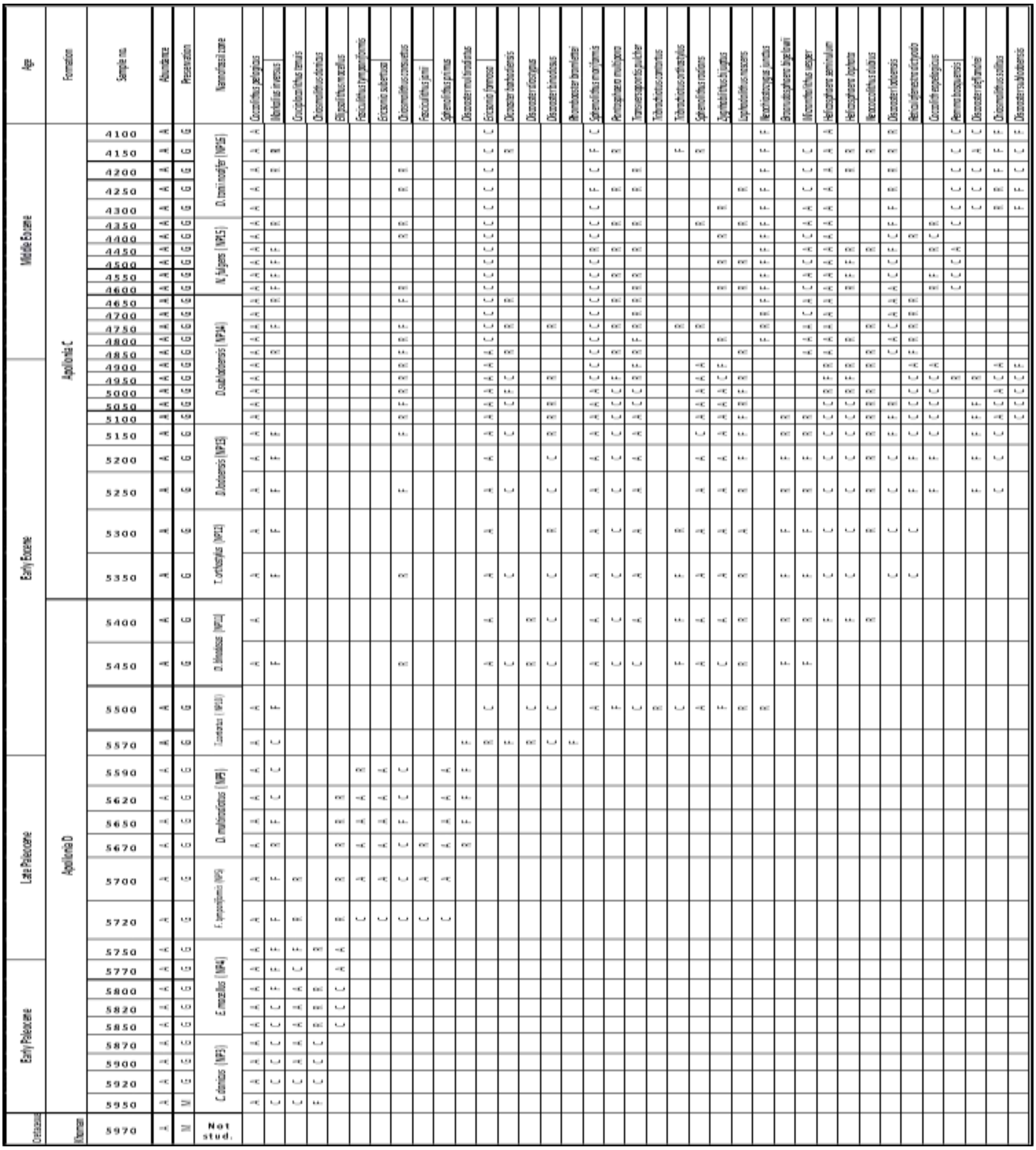

Fig.4: Distribution chart of Planktonic foraminifera in well AG-32

Nannoplankton Biostratigraphy

The coccoliths of the studied samples are rare in abundance and moderately preserved. They were identified by preparing smear-slides using the technique of Bramlette and Sullivan (1961). The stratigraphic distribution charts of calcareous nannofossil species which identified from the Paleogene represented in the studied wells (AG-22, AG32) and the recognized biozones are given in (Figs. 5). Representative of the identified calcareous nannofossil species are illustrated in (Figs.6,7). The recognized biozones and subzones and the correlation between them are discussed below:

***Sphenolithus predistentus* Zone (NP23)**
Definition*:* This zone includes the interval from the HO of *R. umbilicus* to the LO of *Sph. ciperoensis* (Martini, 1971). **Age:** Early Oligocene. **Correlation:** Its lowest part corresponds to the *Sph. predistentus* Zone (CP17) of Okada & Bukry (1980). The upper boundary do not delineated. **Occurrence:** It is recorded in the lowermost part of the Daba'a formation overlying NP22 in the studied wells. **Nannfloral association:** It is characterized by *Coranulus germanicus* and many others.

***Helicopontosphaera reticulata* Zone (NP22)**
Definition: It extends from the HO of *Coccolithus (=Ericsonia) formosus* to the HO of *R. umbilicus* (Martini, 1971).**Age:** early Oligocene. **Correlation** It corresponds to the upper part of *R. Reticulata* Zone (CP16c) of Okada and Bukry (1980), represented by the *R. hillae* Subzone. **Occurrence*:*** This zone is recorded in the lowermost part of the Daba'a Formation and overlying NP21 in the studied wells. **Nannfloral association*:*** It is characterized by the following nannofossils; *R. umbilicus, C .reticulatum, Cyclicargolithus floridanus, Dictycoccites bisectus, Lanternithus mintus, Zyg. bijugatus,* and *Coranulus germanicus.*

Lower Oligocene

***Ericsonia subdistica* Zone (NP21)**
Definition: This zone extends from the HO of *D. saipanensis* to the HO of *E. formosa* (Roth and Hay (1967), emended by Martini, 1970). **Age*:*** early Oligocene. **Correlation:** This zone nearly corresponds to the lower part of the *Helicopontosphaera reticulata* Subzone (CP16a) of Okada and Bukry (1980). **Occurrence:** This zone is recorded in the lowermost part of the Daba'a Formation and is overlying NP19/20 in the studied wells. **Nannfloral association:** The most common nannofossil species encountered in this zone includes: *Reticulofenestra umbilica, Cribrocentrum reticulatum, Cyclicargolithus floridanus, Dictycoccites bisectus, Lanternithus mintus* and *Zyg. bijugatus* as well as *I. recurvus* even scarce to rare.

Eocene/Oligocene (E/O) boundry

In the present study, the Eocene/Oligocene boundary appears to be complete. It occurs within the lowermost part of Daba'a Formation in the studied wells and could be placed at extinction of late Eocene index fossil turborotalids (*Tur. cerroazulensis,* and *Tur. cunialensis*) followed by a significant size reduction of the genus *Pseudohastigerina* and the extinction of the hantkeninids (*Hantkenina alabamensis.* This bioevent represents a well recognizable datum level in the biostratigraphy of the upper Eocene-lower Oligocene transition in the northern Western Desert of Egypt. It has been traced within the basal part of the Daba'a Formation in the subsurface of the northern Qattara Depression and the area between this depression and the Mediterranean, except of some subsurface structural highs (e.g. Mamura-Zayed-Mersa Matruh). In these areas, the HO of *T. cerroazulensis* involves the extinction of all representatives of the *T.cerroazulensis* lineage including *T.c Cerroazulensis*and*T. c. cocoaensis* (Ouda, 1998). This Last Appearance (LA) is often coincident with the First Appearance (FA) of *Gg. tapuriensis* from its ancestor *Gg. tripartita.*This bioevent can be used as a good indicator for the recognition of the Eocene / Oligocene boundary (Odin & Luterbacher, 1992; Cande & Kent, 1992; Berggren *et al*., 1995), instead of the HO of the *Hantkenindae*. The latter has been described as the most reliable bioevent for the location of the Priabonian / Rupelian boundary in its GSSP in the Massignano section (Nocchi *et al*., 1988).In tropical areas the HO of both *Tur. cerroazulensis* and the *Hantkenindae* have been considered as being probably simultaneous (e.g. Toumarkine & Luterbacher, 1985; Coccioni *et al*., 1988; Berggren & Miller, 1988). However, in northern Egypt, like in many other temperate areas (e.g. Toumarkine & Luterbacher, 1985), the Hantkeninidae become very rare or even absent in the uppermost Eocene strata, whereas the highly evolved forms of the *Tur. cerroazulensis* lineage are frequently presented.

The HO of *Pseudohastigerina* spp. (32 Ma, Cande & Kent, 1995; Berggren *et al*., 1995). *Ps. naguewichiensis* represents the most common form of the genus *Pseudohastigerina* in the oldest Oligocene strata of the central part of the northern Western Desert and along its eastern coastal plain (Ouda, 1998). Its last occurrence in these areas marks the lower/middle Rupelian boundary and coincides approximately with the LA of *Gg. gortanii s.s* and *Gg. tripartite.* Furthermore, the Eocene/Oligocene boundary occurs within the lowermost part of Daba'a Formation in the studied wells and could be placed at the extinction of rosette-shaped discoasters such as *D. saipanensis* and *D. barbadiensis* at the top of zones NP19/20 or CP15 (e.g. Martini 1971; Bukry 1973; Martini & Muller1986). However, in the studied wells, where Discoasters are rare or absent within the uppermost Eocene, the last occurrence of *Cribrocentrum reticulatum* could be placed as a dutum level near the top of the Eocene (Muller 1970, 1979; Shafik 1981; Martini and Muller 1986) although the HO of *C. reticulatum* has been consistently found slightly below the HO of *D. saipanensis* in different regions around the world.

***Isthmolithus recurvus /Sphenolithus pseudoradians* Zone (NP19/NP20)**

Definition*:* It is defined from the LO of *I. recurvus* to the HO of *D. saipanensis* (Martini, 1970, emended by Martini, 1970). **Age:** late Eocene. **Correlation:** It equivalents to the *I. recurvus,* Zone (CP15b) of Okada and Bukry (1980). According to Martini (1971), the base of the *Sph. pseudoradians* Zone (NP20) is marked by the LO of the *Sph. pseudoradians*. The zones NP19/NP20 have been grouped in this zone since, *Sph. pseudoradians* is an unreliable marker cannot be distinguished. **Occurrence:** This zone is recorded in the lowermost part of the Daba'a Formation overlying NP18 Zone in the studied wells. **Nannfloral association:** The most common nannofossil species encountered in this zone includes: *Ch. oamaruensis, I. recurvus, Sph. Pseudoradians, R. umbilica, Cribrocentrum reticulatum, Lanternithus mintus,* and *Zyg. bijugatus. I. recurvus, Pemma basquensis, R. dictyoda, D. tanii,* and *R. hampdenensis.*

Upper Eocene:

***Chiasmolithus oamaruensis* Zone (NP18)**

Definition: This zone extends from the LO of *Ch. oamaruensis* to the LO of *Isthmolithus recurvus* (Martini, 1970). **Age:** late Eocene. **Correlation:** This zone, as identified here, is equivelant to the *Ch. oamaruensis* Subzone (CP15a) of Okada & Bukry (1980). **Occurrence*:*** The zone is recorded in the lowermost part of the Daba'a Formation overlying NP17 Zone in the studied wells. **Nannfloral association*:*** The assemblages of Zone NP18 differ from those of Zone NP17 by the appearance of Ch. *oamaruensis*. The assembages is characterized mainly by *Ch. oamaruensis, Ret. umbilica,* and *Ret. hillae.* *Cribrocentrum reticulatum, Dictycoccites bisectus, D. deflandre, D. saipanensis, D. deflandre, Pemma basquensis, D. tanii, Pemma papillatu Helicosphaera compacta, E. formosa, R. dictyoda,* and *R. hampdenensis.*

***Discoaster saipanensis* Zone (NP17)**

Definition*:* Zone NP17 is defined from the HO of *Ch. solitus* to the LO of *Ch. oamaruensis* (Martini, 1970). **Age:** Middle Eocene. **Correlation:** The HO *Ch. solitus* was used as a marker in the late middle Eocene (Martini, 1971 and Okada & Bukry, 1980). It is equivalent to the upper part of the zone (CP14) of Okada & Bukry (1980) and to the *D. saipanensis* Subzone (CP14b). **Occurrence:** This zone has been recognized in the Apollonia formation (Apollonia A) overlying NP16 in the studied wells. **Nannfloral association:** The assemblage of this zone includes: *R. hillae, Ch. grandis, Sphenolithus moriformis, Ret. umbilica, R. daviesii. Crib. reticulatum, Dic-*

tycoccites bisectus, D. tanii, D. saipenensis and *D. tanii nodife.*

***Discoaster tanii nodifer* Zone (NP16)**
Definition: This zone extends from the HO of *Rabdosphaera gladius* to the HO of *Ch. solitus* (Hay (1967) emended by Martini, 1970). **Age:** middle Eocene. **Correlation:** The LO of *R. umbilica* has been used by Okada & Bukry (1980 to mark the base of the CP14 a Subzone, that corresponds approximately to NP16. In the studied wells it has been recognized on the base of the HO of the genus *Nannotetrina* according to Perch- Nielsen (1985), owing to the absence of *R. gladius* does not allow the recognition of the upper boundary of this zone as defined by Martini (1971). **Occurrence:** It is recorded in the studied wells in the Apollonia Formation (Apollonia B or /and lowermost part of the Apollonia A) and overlying NP15 in the studied wells. **Nannfloral association:** It is characterized by a distinct nannofossil assemblaes *R. umbilica, R. dictyoda, R. daviesii, C. eopelagicus, E. formosa, Helicosphaera lophota, Ch. solitus, Neococcolith dubius,* and *Cribrocentrum reticulatum.*

***Nannoterina fulgens* Zone (NP15)**
Definition: Zone NP15 is defined from the LO of *N. fulgens* to the HO of *Rabdosphaera gladius* /or to the LO of *Retculofenestra umbilica* (Hay (1967), emended by Martini, 1970 and Bukry, 1973). **Age:** middle Eocene. **Correlation:** This zone corresponds to the lower part of the *N. quardata* Zone (CP13) of Okada & Bukry (1980). However, the upper boundary of this zone was drawn at the LO of the genus *Nannotetrina* as substitute marker, following Perch-Nielsen (1985). **Occurrence:** It is recorded in the Apollonia formation (uppermost part of Apollonia C) conformably overlying NP14 Zone in the studied wells. **Nannfloral association:** The most common nannofossil species encountered in this zone includes: *N. fulgens, C. eopelagicus, E. formosa, Ch. solitus,* and *Neococcolith dubius*.

Middle Eocene:
***Discoaster sublodoensis* Zone (NP14)**
Definition: Zone NP14 includes the interval from the LO of *D. sublodoensis* to the LO of *Nannotetrina fulgens* (Brönnimann & Stradner, 1960; Bukry, 1973; Hay1964). **Age:** Middle Eocene. **Correlation:** It is correlated with the *D. sublodoensis* Zone (CP12) of Okada and Bukry (1980) with a different definition for the top of the zone, when the LO of *R. inflata* is used as a substitute marker *D. lodoensis* overlaps with *D. sublodoensis* in the lower part of the zone and the FO of *R. inflata* is used as to subdivide the zone into Subzones CP12a and CP12b. **Occurrence:** It is recorded in two studied wells in the lower part of Apollonia Formation (lower part of Apollonia C) and is conformably overlying NP13. It is assigned to the early–middle Eocene (e.g. Aubry 1983; Bolli *et al*., 1985; Berggren *et al*., 1985, 1995). **Nannfloral association:** It is characterized by common presence of *D. sublodoensis*.

***Discoaster lodoensis* Zone (NP13)**
Definition: Zone NP13 extends from the HO of *T. orthostylus* to the LO of *D. sublodoensis* (Brönnimann & Stradner, 1960; Bukry, 1973; Hay, 1964). **Age:** Early Eocene (Ypresian). **Correlation:** It is correlated with the *D. lodoensis* Zone (CP11) of Okada & Bukry (1980). **Occurrence:** It is recorded in two studied wells in the lower part of the Apollonia formation (lowermost part of Apollonia C) conformably overlying NP12. **Nannfloral association:** It is characterized by common presence of *D. lodoensis*, and includes: *C. pelagicus, E. formosa, Helicosphaera lophota, Pontosphaera multipora, Sphenolithus moriformis, P. multipora, C. solitus, D. barbadiensis, Reticulofenestra dictyoda,* and *Neococcolithes dubius*.

***Tribrachiatus orthostylus* Zone (NP12)**
Definition: This zone extends from the LO *D. lodoensis* to the HO *T. orthostylus* (Brön-

nimann & Stradner, 1960; Bukry, 1973). **Age:** early Eocene (Ypresian). **Correlation:** This zone is correlated with the *T. orthostylus* Zone (CP10) of Okada & Bukry (1980). **Occurrence:** It is recorded in the two studied wells in the lower part of Apollonia Formation (lowermost part of Apollonia C) and conformably overlying NP11 Zone. **Nannfloral association:** It contains nannofossil assemblages similar to that of NP11 Zone.

***Discoaster binodosus* Zone (NP11)**

Definition: Zone NP11 is defined from the HO of *T. contortus* to the LO of *D. lodoensis* (Hay, 1964; Mohler & Hay, 1967). **Age:** early Eocene (Ypresian). **Correlation:** It is equivalent to the *D. binodosus* Subzone (CP9b) of Okada & Bukry (1980). It is present through the lowermost part of the Apollonia Formation (topmost part of the Apollonia D) and conformably overlying the NP9 in wells AG-22 and AG-32. **Occurrence:** It is recorded in the two studied wells in the lower part of Apollonia Formation (lowermost part of Apollonia C). **Nannfloral association:** The most common nannofossil species encountered in this zone include: *T bramlltei, T. orthostylus, D. multiradiatus, D. diastypus, D. binodosus, Sphenolithus morifornis, Zygrhablithus bijugatus, Ericsonia formosa***,** *Pontoshaera pulchera*, and *D. barbadiensis.*

Lower Eocene

***Tribrachiatus contortus* Zone (NP10)**

Definition: Zone NP10 is defined from the LO of *T. bramlltei/* its base to the HO of *T. contortus* at its top. **Age:** early Eocene (Ypresian). **Correlation:** This biozone is equivalent to the *D. multiradiatus* Zone (CP9a) of Okada & Bukry (1980). **Occurrence*:*** It is present through the lowermost part of the Apollonia Formation (topmost part of the Apollonia D) and conformably overlying the NP9 in wells AG-22, AG-32. **Nannfloral association:** The most common species encountered in this zone include: *T bramlltei, T. contortus, T. orthostylus, D. multiradiatus, D. diastypus, D. binodosus,* and *D. barbadiensis.*

Paleocene/Eocene (P/E) boundary

The exact location of the Paleocene/Eocene (P/E) boundary has been a focal point of controversy. This boundary, as typified, occurs between calcareous nannoplankton NP9 (Thanetian) and NP10 (Yepresian). The NP9/NP10 zonal boundary of Martini (1971) has been recognized in the two studied wells (AG-22 and AG-32) within the lower most part of Apolllonia Formation “D” without any remarkable change in lithology. This boundary is marked by the first occurrence of *Tribrachiatus contortus*, according to Martini (1971), and has been recognized in the successions on base of the LO of *Tribrachiatus bramlettei* (= *T. nunni*). In addition, the LO of *D. diastypus* was used by Okada and Bukry (1980) to recognize this boundary.

***Discoaster multiradiatus* Zone (NP9)**

Definition: This zone spans the interval from the LO of *D. multiradiatus* to the LO of *Tribrachiatus bramlettei* (Bramlette & Sullivan (1961); emended by Martini, (1971). **Age:** late Paleocene (Thanetian). **Correlation:** This biozone is equivalent to the *D. multiradiatus* Zone (CP8) of Okada & Bukry (1980). **Occurrence:** It is present through the lowermost part of the Apollonia Formation (topmost part of the Apollonia D) and unconformably overlying the NP5 Zone in wells AG-22, AG-32.

***Fasciculithus tympaniformis* Zone (NP5)**

Definition: This zone covers the interval from the LO of *F. tympaniformis* to the LO of *Heliolithus kleinpellii* (Mohler & Hay in Hay *et al*., 1967). **Age:** late Paleocene (Thanetian, Selandian). **Correlation:** The present Zone is correlated with the *E. macellus* Zone (CP4) of Okada & Bukry (1980). **Occurrence:** It is present through the lowermost part of the Apollonia formation (lowermost part of the Apollonia D) is unconformably overlying the NP4 Zone in the studied wells. **Nannfloral association:** Especially noticeable is the presence of divers *Fasciculithus* species, including *F. typaniformis, F. ulii, F. janii,* and *F. bitectus.*

***Ellipsolithus macellus* Zone (NP4)**

Definition: This zone includes the interval from the LO of *Ellipsolithus macellus* to the LO of *Fasciculithus tympaniformis* (Martini, 1970). **Age:** early Paleocene (late Danian-earliest Selandian). **Correlation:** The present zone is correlated with the *E. macellus* Zone (CP3) of Okada & Bukry (1980). **Occurrence:** It is present through the lowermost part of the Apollonia Formation (lowermost part of the Apollonia D) and unconformably overlying the NP3 Zone in the studied wells. **Nannfloral association:** The most common nannofossil species encountered in this zone include those of previous zone, plus *E. macellus*.

Paleocene:

***Chiasmolithus danicus* Zone (NP3)**

Definition: This zone extends from the LO of *C. danicus* to the LO of *Ellipsolithus macellus* (Martini, 1970). **Age:** early Paleocene (late Danian). **Correlation:** This zone is equivalent to the *C.danicus* Zone, (CP2) of Okada & Bukry (1980). **Occurrence:** It is the oldest recognized nannofossil zone in the Paleocene of the studied wells through the lowermost part of the Apollonia Formation where the Paleogene sediments unconformably overlie the late Cretaceous sediments (Khoman formation). **Nannfloral association:** The most common nannofossil species encountered in this zone include: *Markalius inversus*, *Cruciplacolithus tenuis*, and *C. danicus.*

Hiatuses

The basal hiatus cover most of the early Paleocene (NP1 to NP2 nannofossil zones) which corresponds to absence of planktonic foraminiferal zones of P0, Pα, P1a & lowermost part of P1b and the second hiatus comprises mainly late Paleocene (NP6 to NP7/8 nannofossil zones)) which corresponds to absence of planktonic foraminiferal Zone of P4.As Luning *et al*., (1998) have shown for the Upper Cretaceous-Lower Tertiary of the Sinai Peninsula, hiatuses in this stratigraphic interval in northern Egypt can be related to compressional tectonic phases, eustatic sea–level falls, or a combination tectonic of the two processes. Luning *et al*., (1998) showed that significant eustatic sea–level low-stands occurred around the K/Pg boundary and, during the *M. angulata* (NP4) as well as most importantly, during *P. pseudomenardii* Zone (NP6-NP9). Especially the (NP6-NP7/8) hiatus documented for the Abu Gharadig wells studied her is likely to be associated mainly with this eustatic sea-level fall. A similar hiatus was described by Strougo (1986) from the Western Desert Oasis, which Luning et al. (1998) re-interpreted as being associated with Paleocene sea-level fall, contrasting with STROUGO's original tectonic interpretation. There is no doubt, however, that tectonic process have occurred during the Late Cretaceous-Early Tertiary in Egypt, which in some areas also strongly affected deposition, and caused or prolonged the formation of hiatuses. For this reason, the structural setting will be analyzed in some detail Salem (1976) reported that, the depositional style of the Tertiary in the northern half of Western Desert is closely related to tectonic setting of the area which is characterized as the ''Unstable Shelf' Zone (Said,1962) corresponding to a Late Triassic-Early Jurassic graben zone. Structurally, Abu Gharadig anticlines is a westward extension of the Syrian Arc System, a product of the inversion, which is composed of a series of NE-SW trending folds that are developed all over the Unstable Shelf (Said, 1962). The Abu Gharadig Field structure as result of NW- SE directed compressional which caused folding along a SW-NE trending axis with plunging folds that are asymmetric to the northwest (the Egyptian General Petroleum Corporation, 1992).

Recently, using integrated biostatigraphy based on planktonic foraminifera, calcareous nannofossil and macrofossil in surface sections at Bir Abu Minquar, Farafra , North El

Qasr and Gebel Gifata in the Western Desert of Egypt, Tantawy *et al*., (2001) reported that a major depositional hiatuses span the upper Maastrichtian through lower Paleocene interval in all sections in the Western Desert of Egypt, and attributed these hiatuses to be linked primarily to sea-level lowering and secondarily to regional tectonic activity.

Guiraud and Bosworth (1999) reported that a late Paleocene tectonic instability which probably is related to the late Paleocene (NP6 to NP7/8) hiatus documented in the present study, as evidenced by absence of most this interval, except the upper part of Zone NP4 and Zone NP5 as well as NP9 which are present. In addition, active subsidence affected most parts of Abu Gharadig and Gindi basins of northern Egypt (Said,1990) as well as in most of the Sirte trough (Wennekers *et al*., 1996). Several folds were uplifted and appeared as islands on the northern Unstable Shelf from northern Cyrenaica (Jebel Akhdar) to the Palmyrids (Syria). Moreover, late Paleocene tectonic phase in Egypt was previously proposed by Strougo, (1982) which termed it the "*Velascoensis* event". In northern Libya, northern Cyrenaica, in the Wadi al Athrun section, the Eocene Apollonia Limestone rests unconformably on the Maastrichtian Athrun Limestone. Recently, on data of Haq & Aubry (1981), and at Pyramid Peak Section, Libya, the oldest age can be assigned to the interval within the *Tribrachiatus orthstylus* (NP12) Zone of the early Eocene. Evidence for the late Paleocene tectonic activity was also reported from NW Saudi Arabia (El-Khyal, 1975) and from Jordan (Futyan, 1976).

El Dawoody (1990) mentioned that at Esh–el Mallaha, the K/Pg boundary is marked by a big hiatus in which the late Paleocene NP9 rests directly on the middle–late Maastichtian. Cherif and Ismail (1991) based on planktonic foraminifera of Esh–el Mallaha and Gharamul area (southwest of the Gulf of Suez) found that *M.velascoensis* Zone directly overlies the *M. uncinata* Zone suggesting the existence of a hiatus corresponding to the *M. angulata, P. pusilla pusilla* and *P. pseudomenardii* which are equivalent to nannofossil NP4 to the lower part of NP9.

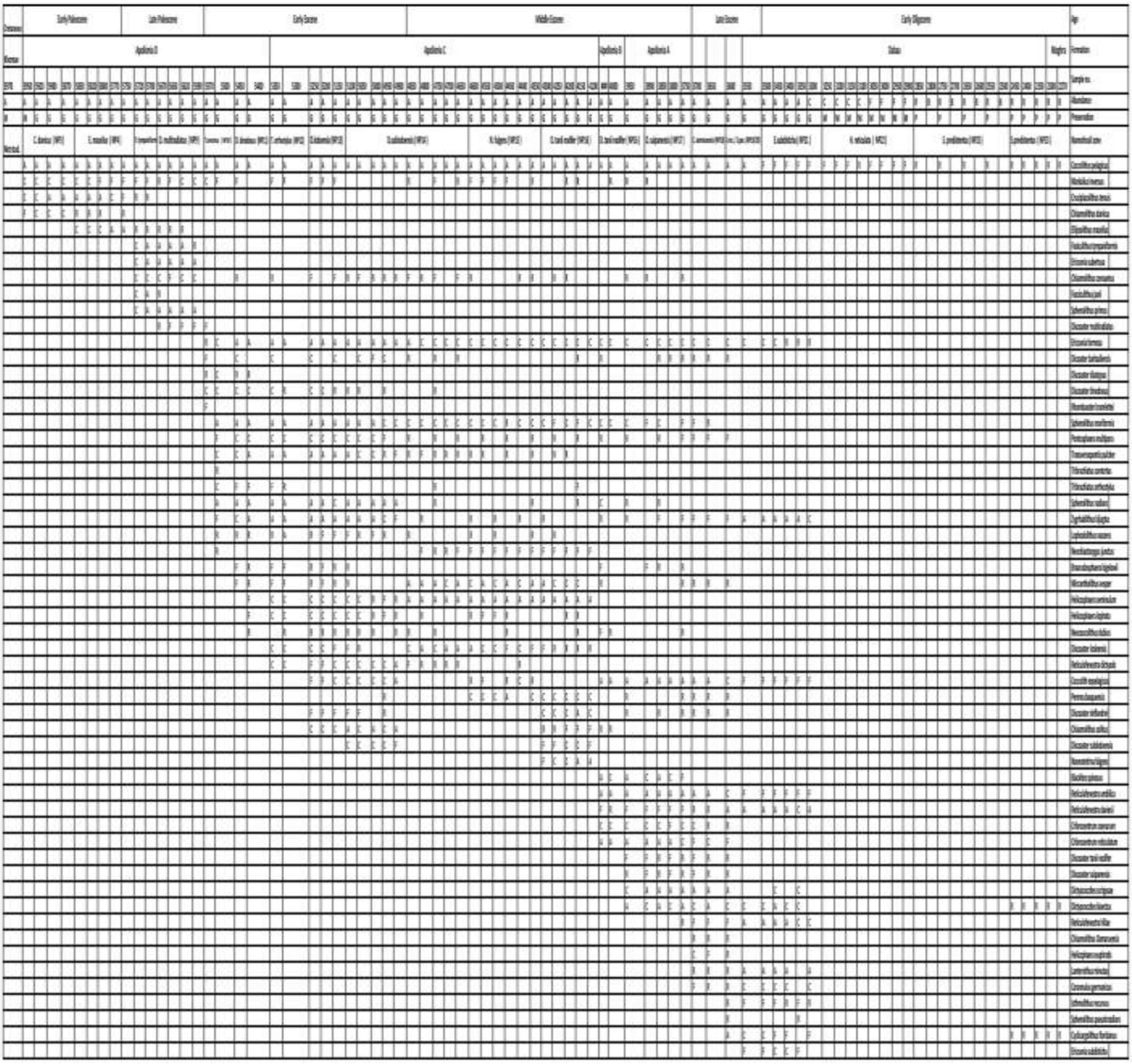

Fig.5: Distribution chart of Calcareous nannofossils in well AG-32.

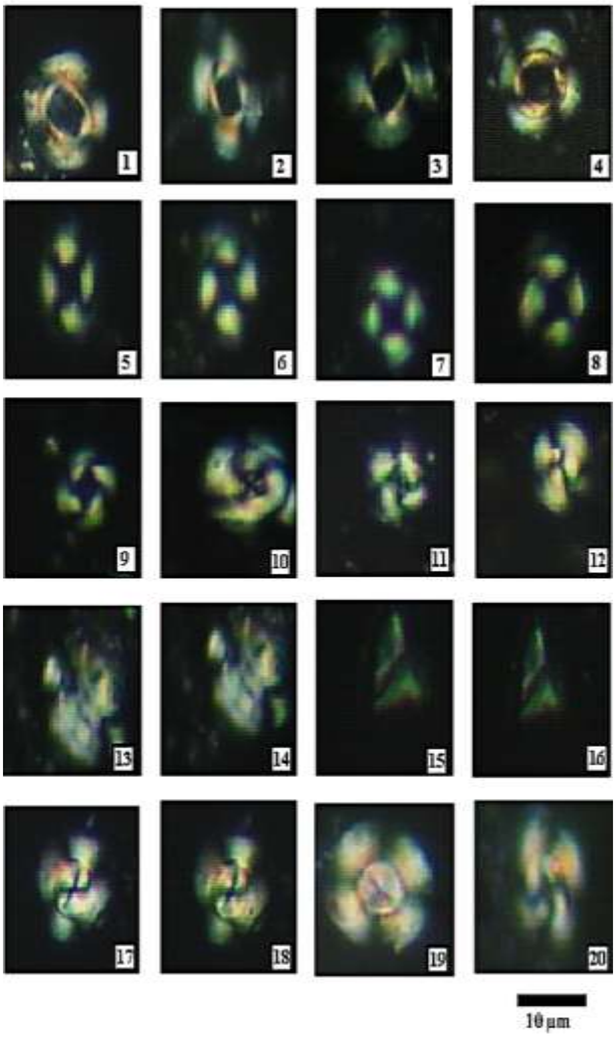

Fig. (6)

1, 2, 3, 4- *Reticulofenestra umbilica* (Levin, 1965) Martini & Ritzkowski (1968), Well AG-32, sample no 5870.

5, 6, 7, 8- *Coccolithus pelagicus* (Wallich, 1877) Schiller (1930), Well AG-22, Sample no 3960.

9, 10, 11, 12- *Cribrocenlrum reliculatum* (Gartner & Smith, 1967) Perch-Nielsen (1971d), Well AG-32, Sample no 5450.

13, 14- *Ellipsolithus macellus* (Bramlette & Sullivan, 1961), Well AG-22, Sample no 3960.

15, 16- *Fasciculithus alanii* Perch-Nielsen (1971), Well AG-22, Sample no 4230.

17, 18, 19, 20- Cyclicargolithus abisectus (Muller, 1970) Wise, 1973, AG-22, Sample no 2760 &2740.

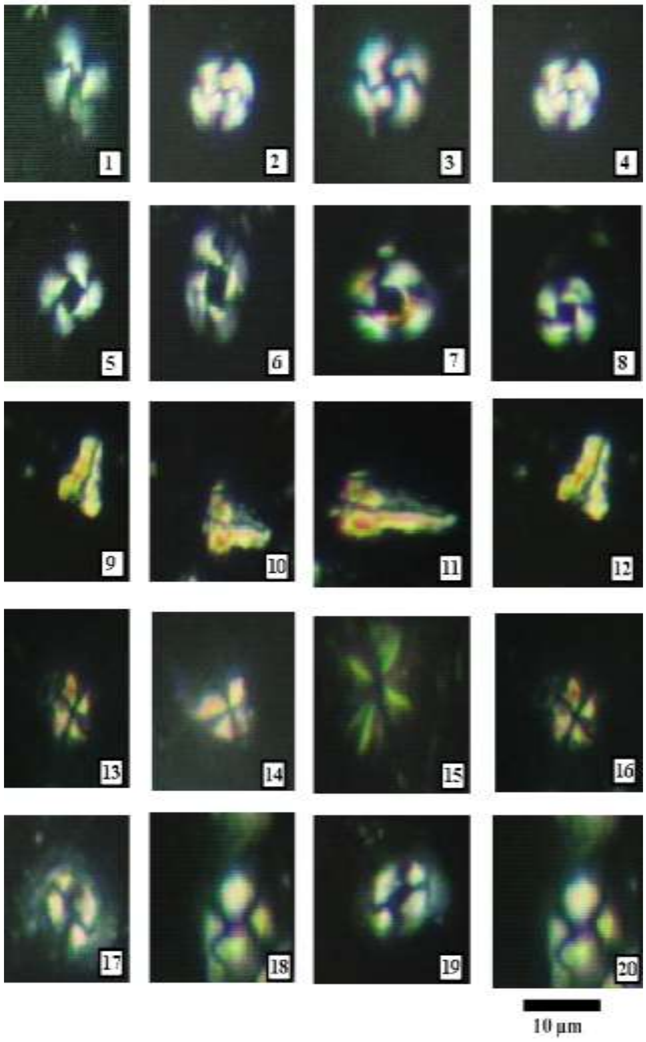

Fig. (7)

1, 2, 3, 4- Cyclicargolithus floridanus (Roth & Hay *in* Hay *et al*.. 1967) Bukry (1971a), well AG-32, Sample no 5670.

5,6,7,8- *Reticulofenestra dictyoda* (Deflandre *in* Deflandre & Pert, 1954) Stradner *in* Stradner & Edwards (1968), Well AG-32, sample no 5170.

9,10,11,12- *Zygrhablithus bijugatus* (Deflandre *in* Deflandre & Fert, 1954) Deflandre (1959), Well AG-32, Sample no 5650 &5450.

13,14,15,16 - *Sphenolithus moriformis* (Bron-nimann&Stradner, 1960) Bramlette &Wilcoxon (1967), AG-22, Sample no 4860.

17, 18, 19, 20- *Coccolithus eopelagicus* (Wallich 1877) Schiller, 1930, Well AG-22, Sample no 3960 &4230.

CONCLUSIONS

The available results of the present study can be concluded in the following:

1. The lower Paleogene succession in the Abu Gharadig Field (wells: AG-22 and AG-32), Western Desert, Egypt is differentiated into two formations of wide distribution in western Desert of Egypt. These units are arranged from base to top into: the Apollonia Formation (early Paleocene to middle Eocene), which has been subdivided into four informal members A, B, C, D, and Daba'a Formation (middle Eocene to early Oligocene).

2. Biostratigraphically, 21 planktonic foraminiferal zones and biozones were recognized; these are from older to younger: as follows: *Globanomalina compressa* subzone (P1c), *P. uncinata* Zone (P2), *M. angulata* Zone (P3), *I. pusilla* Subzone (P3a), *I. albeari* Subzone (P3b), *M. velascoensis* Zone (P5), *Ac. sibaiyaensis* Zone (E1), *Pseudohastigerina wilcoxensis/M. velascoensis* Zone (E2), *M. formosa* Zone (E4), *M. aragonensis/M. subbotinae* Zone (E5), *Ac. pentacamerata* Zone (E6), *Ac. cuneicamerata* Zone (E7), *Guembelitrioides nuttalli* Zone(E8), *Globigerinatheka kugleri* (E9) Zone, *A. topilensis* Zone(E10), *M. lehneri* Zone (E11), *Orbulinoides beckmanni* Zone (E12), *Globigerinatheka kugleri* Zone (E13), *G. semiinvoluta* Zone (E14), *G. index* Zone (E15), and *Pseudohastigrina naguewchiensis* Zone (O1).

3. Base on calcareous nannofossils, the stratigraphic ranges of the recorded taxa have been utilized to recognize 17 biostratigraphic zones arranged from older to younger as follows: *Ch. danicus* Zone (NP3), *Ellipsolithus macellus* Zone (NP4), *Fasciculithus tympaniformis* Zone (NP5), *D. multiradiatus* Zone (NP9), *Tribrachiatus contortus* Zone (NP10), D. *binodosus* Zone (NP11), *T. orthostylus* Zone (NP12), *D. lodoensis* Zone (NP13), *D. sublodoensis* Zone (NP14), *Nannoterina fulgens* Zone (NP15), *D. tanii* zone (NP16), *D. saipanensis* Zone (NP17), *Ch. oamarunsis* Zone (NP18), *I. recurvus –Sph. pseudoradians* Zone (NP19 /NP20), *E. subdisticha* Zone (NP21), *Helicopontosphaera reticulata* Zone (NP22), and *Sph. predistentus* Zone (NP23).

4. The Danian/Selandian boundary is tentatively placed within calcareous nannofossil Zone NP4 which is located within the Apollonia (D) Formation and at the top of the planktonic foraminifera Subzone *I. pusilla* (P3a) Subzone. It is placed at the level of the LO of *Fasciculithus pileatus, F. involutus ulii, and F. janii*.

5. The Paleocene /Eocene boundary is drawn tentatively at the base of foraminiferal Zone E1 where *Acarinina africana*, *Ac. sibaiyaensis* and *M. allinsoensis* recoded their LOs. For calcareous nannofossils, this boundary, as drawn, occurs between calcareous nannofossil zones NP9 (Thanetian) and NP10 (Ypresian).This level can be traced as defined by the LO of *Rhomboaster* spp. In addition, the LO of *D. diastypus* which co-occurring with the LO of *R. bramletti.*

6. The Eocene/Oligocene boundary in terms of calcareous nannofossils, appears to be complete, it occurs within the lowermost part of Daba'a formation in the studied wells and could be placed at the extinction of rosette-shaped discoasters such as *Discoaster saipanensis* and *D. barbadiensis* at the top of zones NP19/20 (= CP15)

7. Within the Paleocene, two prominent major gaps are recognized comprising: a) The basal hiatus covers most of the early Paleocene (NP1 to NP2 nannofossil zones) which corresponds to absence of planktonic foraminiferal zones of P0, Pα, P1a and lowermost part of P1b) The second hiatus comprises mainly late Paleocene (NP6 to NP7/8 nannofossil zones) which corresponds to ab-

sence of planktonic foraminiferal Zone of P4.The Paleocene sediments of the wells AG-32 and AG22 are attributed to nannofossil zones NP3 to NP5 equivalent to the planktonic foraminifers zones of P1c to lowermost part of Zone of P4. Whereas nannofossils Zone NP9 equivalent to the planktonic foraminifers Zone of P5. These hiatuses are thought to be related to eustatic sea-level falls as well as to compressional tectonic phases.

8. Three genera; *Acarinina, Morozovella*, and *Subbotinae* dominate the planktonic foraminiferal assemblages of the late Paleocene-early Eocene of the studied wells and suggest the presence of tropical-subtropical surface waters in the late Paleocene-early Eocene interval. It corresponds to uppermost part of NP12 Zone and uppermost part of NP13 and lowermost part of NP14 Zone. This zone comprises samples 4500 in well AG-22 &5200 in well AG-32.

The Eocene/Oligocene boundary in terms of foraminifers and calcareous nannofossils, appears to be complete, it occurs within the lowermost part of Daba'a Formation in the studied wells and could be placed at extinction of late Eocene index fossil turborotalids (*Turborotalia cerroazulensis, and Tur. cunialensis*) followed by a significant size reduction of the genus *Pseudohastigerina* and the extinction of the hantkeninids (*Hantkenina alabamensis),* which mark the Eocene/Oligocene boundary.

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الطباقية التحت سطحية لتتابع الباليوجين فى حقل ابو الغراديق الصحراء الغربية – مصر

اكمل مرزوق، حمزه خليل، جمال موسي، تقى حمدى

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يهدف البحث الى فحص سلسلة من الرواسب التحت سطحية للباليوجين فى حقل ابو الغراديق الصحراء الغربية – مصر لدراسة المحتوى الاحفورى باستخدام الفورامينفرا والهوائم الكلسية وذلك فى بئريي في حقل ابو الغراديق في الصحراء الغربيه – مصر وهما بئر ابو الغراديق -٢٢ وبئر ابو الغراديق -٣٢. ويشمل البحث تجهيز العينات لفحص الفورامينفرا والهوائم الكلسية وفحص المحتوى الاحفورى و الفصل والتعريف والوضع التصنيفى والتصوير. **وقد تم تحديد عدد ١٧ نظاقا حيويا من** الهوائم الكلسيه وعدد ٢٢ **نظاقا حيويا** من الفورامينفرا في البئريين. كما تم تحديد المدى الطبقى للانواع المختلفة لتعيين النطاقات الحيوية ومضاهات النطاقات الحيوية بمثيلتها خاصة فى حوض البحر المتوسط القديم والقاء الضوء على الوضع الطبقى لرواسب الباليوجين فى الصحراء الغربية كما تم تعيين الحدود الفاصلة بين الفترات الزمنية المختلفة و توضيح الوضع الجغرافى القديم والتنوع فى الهوائم الكلسية.