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Contribution to the lithostratigraphy and chronostratigraphy of the middle Eocene - early Miocene succession in N. El Faras-1X Well in the Qattara Depression, Egypt

Shahin, B. El Khawaga, S. and Shahin, A.

Department of Geology, Faculty of Science, Mansoura University, Egypt

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Abstract: The subsurface middle Eocene- early Miocene succession from the N. El Faras- 1X Well of Qattara Depression in the north Western Desert was carefully investigated for their foraminiferal assemblages. Lithostratigraphically, this interval was divided into three lithostratigraphic units as the upper portion of the Apollonia Formation, the Dabaa Formation, and the lower portion of the Moghra Formation. They are correlated with their equivalents in the Nile delta and the northern Western Desert. This interval is rich in planktonic foraminifera that enable the recognition of twelve biozones. The foraminiferal assemblages and the proposed biozones enable the delineation of the chronostratigraphic contacts of Bartonian - Priabonian boundary, Priabonian - Rupelian boundary, Rupelian - Chattian boundary and Chattian - Aquitanian boundary within the studied interval

keywords: Qattara Depression, chronostratigraphy, Eocene - Miocene, foraminifera, Western Desert, Egypt

1.Introduction

The Egyptian Western Desert represents about two-thirds of the total Egyptian area. The Qattara Depression is located in the northern part of the Western Desert of Egypt, 180 km west of Alexandria city and about 120 Km south of Matruh city. The depression gently slopes to the south (1). This Depression is a product of the excavation of Paleogene sedimentary rocks which have a northward gentle dip. The northern part of this depression is a sharp cliff up to 280 meters high that forms the edge of El Diffa Plateau. The northern wall is the steep slope of a cuesta that is covered by carbonate rocks of the middle Miocene age. This cliff slopes southwards to the pediments that is capped by sabkha deposits, marshes and saline crusts that slope to the west into the deeper portion of the basin where an elevation of -134 m B.S.L. is found (2). N. El Faras-1X Well was drilled in the Qattara Depression by Agiba Petroleum Company in 2000, with a total depth of-3981 ft but it has been classified as a dry hole and has been plugged. It is located in the northern part of the Qattara Depression, north of Abu El Gharadig Basin at Latitude 30° 08′ 53″and longitude 27° 26′ 35″ (Fig. 1).

Many previous works were focused on planktonic and benthonic foraminifera of the middle Eocene - early Miocene interval in the north Western Desert and Nile Delta include (3), (4), (5), (6), (7), (8), (9), (10), (11), (12), (13), (14).

The main target of the present study is focused on the lithostratigraphy, foraminiferal evidence for the age determination of middle Eocene to early Miocene succession and the chronostratigraphy of the studied interval

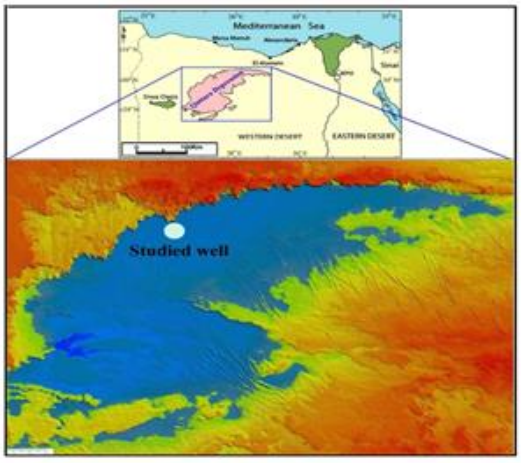

Fig.1. Location map of N. El Faras-1X well in the northern sector of the Qattara Depression

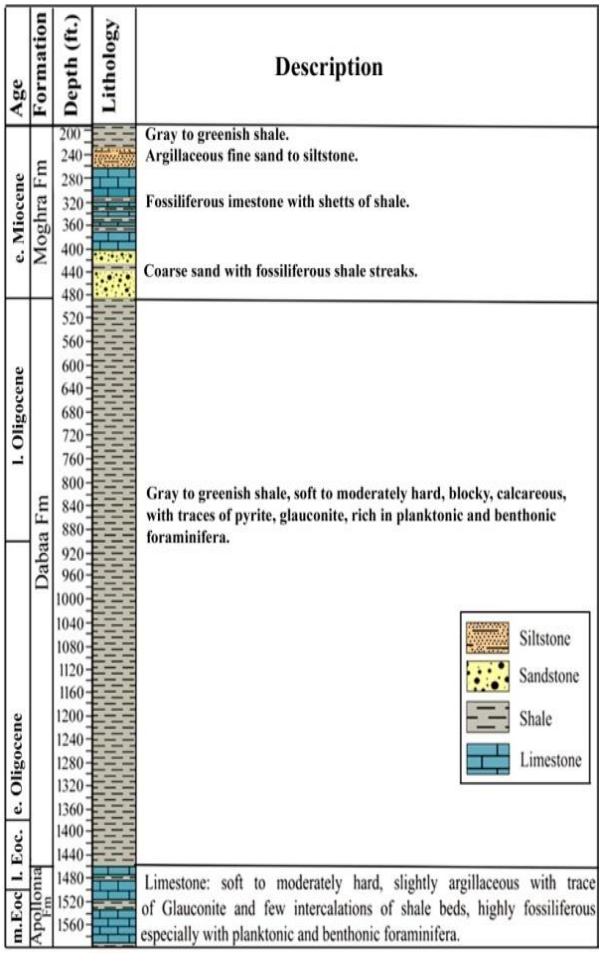

Fig. 2. lithostratigraphic log of the subsurface middle Eocene - early Miocene section in N. El Faras-1x well.

2. Material and methods:

The present study is based on 42 ditch samples from N-El Faras-1x well ranging from depth 240 ft to 1530 ft with 30 ft vertical interval. These samples represent upper portion of the Apollonia Formation, Dabaa Formation and lowest part of the Moghra Formation. About 150 grams of each sample was dried on a hotplate at 80°C, and then boiled in 10% H_2O_2 solution. After the sample was disintegrated, it was submerged and washed in water through 0.063 mm sieve until getting clean residue. The residue was dried and the microfaunal contents were picked by using a binocular microscope and placed in slides for investigation. The picked microfaunal contents were identified, systematically ranked and used in biostratigraphic and chronostratigraphic distinction. Using the Scanning Electron Microscope, the identified foraminifera were photographed.

3. Lithostratigraphy

The studied interval in the N. El Faras- 1X Well is made up of three lithostratigraphic units ranked from the oldest to the youngest as Apollonia Formation, Dabaa Formation and Moghra Formation (Fig. 2). These lithostratigraphic units were compared with their coevals in the north Western Desert and Nile Delta regions (Fig. 3). They were briefly discussed in a stratigraphic order as follows:

3. 1. The Apollonia Formation

Author: (15)

Type section: The Apollonia Formation is an extensive siliceous limestone with some shale intercalation and numerous chert bands of Paleocene to Eocene age. It has a thickness of 250 m representing the hills south of the Apollonia village (Libya). In the north Western Desert of Egypt, this section consists mainly of white, light grey or brownish grey nummulitic limestone with some shale beds (16). It unconformably overlies the Khoman Chalk and conformably underlies the Dabaa Formation (15).

Lithological characteristics and stratigraphic position: In the studied well, only the top part of the Apollonia Formation was studied with a thickness of 60 ft, from the depth 1530 ft to depth 1470 ft. It consists mainly of moderately hard, slightly argillaceous limestone with traces of glauconite. It underlies the Dabaa Formation, whereas the base of this Formation is not reached in this study. It is rich in both planktonic and benthic foraminifera.

Equivalents: This unit is partially equivalent to the same unit recorded by (9) in the north Western Desert and to the majority of the Apollonia Formation reported by (14) in the Nile Delta. It is compared with the Apollonia Formation and the lower portion of the Dabaa Formation described by (8) in the Qattara Depression, by (17) in the north Western Desert and by (18) in the Qattara Depression. It is also nearly equal to the Mokattam Formation and the lower portion of Qasr El Sagha Formation recorded by (19) in the Nile Delta (Fig. 3).

3.2. The Dabaa Formation

Author: (20)

Type section: The upper Eocene-Oligocene Dabaa Formation was a subsurface shale unit of

the north Western Desert. The name was firstly given by (20) and was amended by (21). This Formation was known as the Qasr El Sagha, Maadi, Birqet Qarun, and Gehannam (15). The type section of the Dabaa Formation has a thickness of 242 m in the Dabaa-1 Well (15), (22) and consists of mild grey to greenish grey shales with few thin beds of limestone. In the southern direction in the Fayum area, Dabaa Formation grades laterally into the Gebel Qatrani Formation, which is distinguished by littoral to deltaic deposits. It unconformably overlies the Paleocene-middle Eocene Apollonia Formation and conformably underlies the Maghra Formation of lower Miocene (15), (22).

Lithological characteristics and stratigraphic position: In the studied well, it attains a thickness of about 990ft, from the depth 1470 ft to depth 480 ft. It is made up of grey to greenish grey, soft to moderately hard, blocky, slightly calcareous shales with traces of pyrite and glauconite. It overlies the Apollonia Formation and underlies the Moghra Formation. It is moderately rich in both planktonic and benthonic foraminifera.

Equivalents: This unit is partially equivalent to the Dabaa Formation and the lowest portion of the Moghra Formation recorded by (9) in the north Western Desert. It is equivalent to the upper portion of Qasr El Sagha Formation and the Dabaa Formation described by (19) in the Nile Delta area and to most of the Dabaa Formation recorded by (8) in the Qattara Depression. It is compared with the uppermost portion of the Apollonia Formation and most of the Tineh Formation recorded by (14) in the Nile Delta. It is also compared with the upper two-thirds of the Dabaa Formation reported by (12) in the north Western Desert, by (18) in the Qattara Depression and by (17) in the north Western Desert (Fig. 2).

3.3. The Moghra Formation

Author: (23)

Type section: The Moghra Formation is a heavy fluvio-marine clastic unit in the north Western Desert. It rests on the Dabaa Formation and underlies the Marmarica Formation. This Formation grades north and westwards into the marine Mamura Formation and to the south into fluviatile redbeds of Gebel Khesheb Towards the north and west, the Moghra. The type section of Moghra Formation has a thickness of 203m at the north of Moghra Oasis in the eastern tip of the Qattara well (15), (22).

Lithological characteristics and stratigraphic position: In the studied well**,** it is represented only by the lowest part of the Formation with a thickness of 280 ft, from the depth 480 to depth 200 ft. This part overlies the Dabaa Formation and is composed mainly of sandstone with few intercalations of shales and limestone at the base grading upwards to shale with little sandstone. It is highly fossiliferous, especially with planktonic and benthic foraminifera.

Equivalents: This lower portion of the Moghra Formation is correlated with the lower portion of the Moghra Formation recorded by (19) in the Nile Delta, by (8) in the Qattara Depression, by (9) in the north Western Desert, by (17) in the north Western Desert and by (18) in the Qattara Depression. It is also compared with a top portion of the Tineh Formation reported by (14) in the Nile Delta area (Fig. 2).

4. Chronostratigraphy

The planktonic foraminifera were obtained from an interval including the upper portion of

the Apollonia Formation, the Dabaa Formation and the lower portion of the Moghra Formation in the studied well. This interval ranges from middle Eocene to early Miocene age. The rich planktonic foraminifera encountered in this interval enables the recognition of twelve planktonic foraminiferal biozones. One biozone (E13) belongs to the middle Eocene within the Apollonia Formation, three biozones (E14 to E16) belong to the upper Eocene within the Dabaa Formation, seven biozones (O1 to O7) belong to the lower and upper Oligocene within the Dabaa Formation and one biozone (M1a) belongs to the lowermost of Miocene within the Moghra Formation (Fig. 3). The classification of the recorded planktonic foraminifera flows that of (24). The planktonic foraminiferal assemblages and the biozones enable the delineation of the chrono-stratigraphic contacts within the studied interval that are discussed in detail as follows

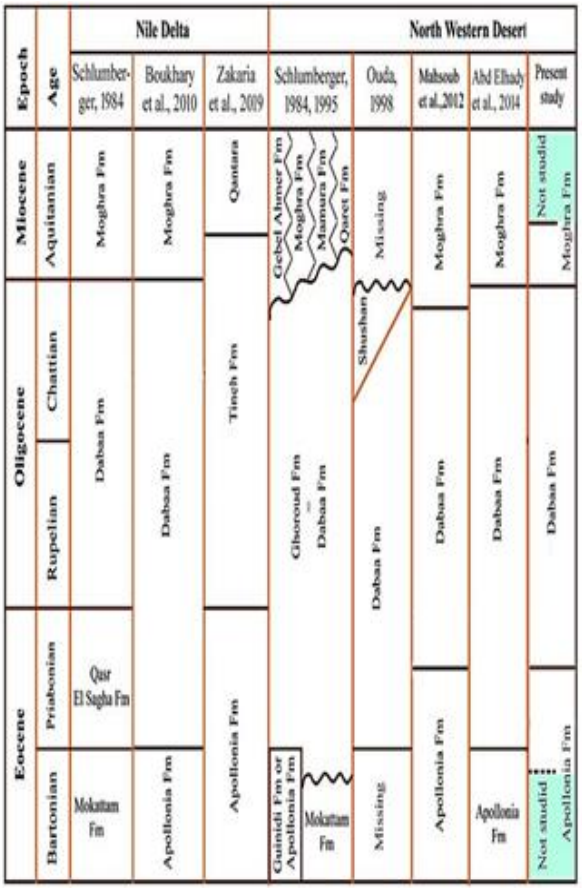

Fig. 3. Lithocorrelation of the studied m. Eocene - l. Miocene units with their equivalents in the Nile Delta ad North Western Desert.

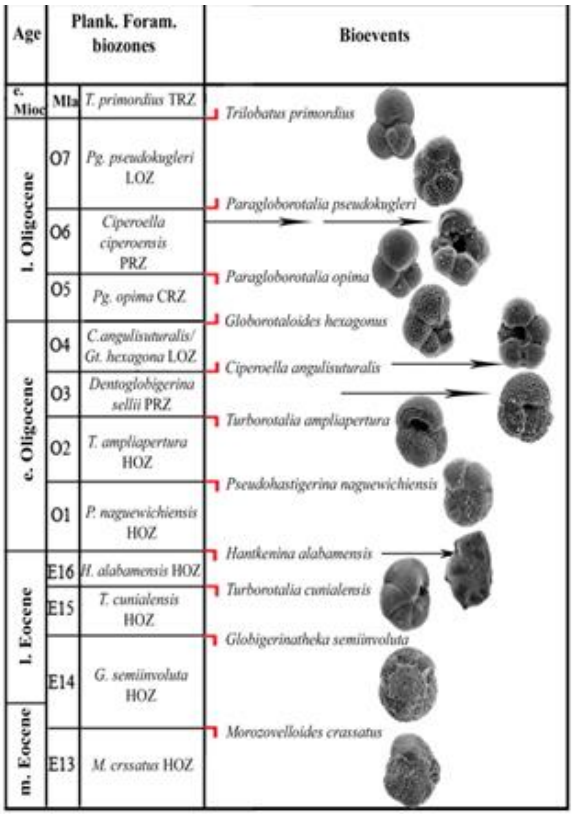

Fig. 4. Middle Eocene - early Miocene planktonic foraminiferal biozones and bioevents

4.1. Bartonian - Priabonian boundary (middle - upper Eocene boundary)

The historical type section of the Priabonian stage occurred in Priabona, northern Italy (25). Global stratotype Section and Point (GSSP) of Bartonian-Priabonian boundary has not been exactly assigned until now (26). This boundary was placed at the extinction-level (HO) of the muricate planktonic foraminifera in the Mediterranean and tropical provinces (27), (28), (29). The LO of *Globigerinatheka semiinvoluta* was recorded as a subordinate indicator because the LO of this taxon is somewhat older than the HO of the middle Eocene muricate species (30), (31), (32), (33), (34). This boundary was also placed below the LO of *Globigerinatheka semiinvoluta* because the HO of large *Acarinina* and *Morozovelloides* occurs below the LO of this taxon (35). In Egypt, this boundary was located at LO of *Globigerinatheka semiinvoluta* which lies somewhat above the extinction level of the muricate and spinose species planktonic foraminiferal species such as *Acarinina*, Morozovelloides and *Truncorotaloides* in the absence of *Globigerinatheka semiinvoluta* (10), (36), (37). In this study, this boundary is located at the upper portion of zone E13, at the HO of *Morozovelloides crassatus* which coincides with the Extinction of muricate forms. On the other hand, the LO of *Globigerinatheka semiinvoluta* lies slightly below the HO of the muricate species.

4.2. Priabonian - Rupelian boundary (Eocene – Oligocene boundary):

The GSSP of the E/O boundary was positioned at the 19 m level in the Massignano Quarry section of the northern Apennines near Ancona, Italy (38).

The GSSP boundary level fits well with the last occurrence of the *Pseudohastigerina micra* and its diminishing in size which enables another means of correlation in case of the absence of *Hantkenina* (39), (40). Generally, the Eocene - Oligocene boundary conforms with the extinction of all specimens of *Hantkenina* and *Cribrohantkenina* (39). The low diversity and small size of globigerinids were a dominant feature of the early Oligocene. During the late Oligocene the diversity and size

of the assemblages were gradually recovered (41).

Eocene - Oligocene boundary (E/O) was located at the upper portion of the zone (E16) at the HO of *Hantkenina alabamensis* (42) (43), (40), (24). This boundary was also placed at the upper part of zone (P17) at the HO of *Turborotalia cerroazulensis* (41), (30).

In Egypt, (36) and (7) placed this boundary at the top of the zones (P16-P17) that coincides with the complete extinction of the *Turborotalia cerroazulensis* evolutionary lineage and with the LO of *Globigerina tapuriensis*. In the studied well, this boundary is marked by the extinction of *Hantkenina alabamensis* that coincides with the HO of *Turborotalia cerroazulensis* and with the LO of *Cassigerinella chipolensis.*

4.3. Rupelian - Chattian boundary:

Until now, there is no formal proposal for the GSSP of Chattian. In the Umbria-Marche northeastern Apennines of Italy, three pelagic sections of Pieve d'Accinelli, Monte, Cagnero and Contessa) displays continuous in Formation on the Rupelian - Chattian transition (44). They considered the HO of *Chiloguembelina cubensis* as a strong event at the base of Chattian in the Italian sections. This level is equated to the boundary between zones (O4 and O5) of (42) or the boundary between subzones (P21a and P21b) of (30).

(45) suggested that *Globorotaloides hexagonus* evolved from *Globorotaloides variabilis* at the top of the O4 zone. Also, (46), (47) and (45) reported that the LO of *Globorotaloides testarugosus* is an important biostratigraphic marker of Mid-Oligocene. In the studied well, Rupelian - Chattian boundary is cited at the top of Zone O4 which is detected by the LO of *Globorotaloides testarugosus* and *Globorotaloides hexagonus*. This is due to the occurrence of *Chiloguembelina cubensis* in much lower stratigraphic level.

4.4. Chattian - Aquitanian boundary (Oligocene - Miocene Boundary, O/M):

In the Lemme - Carrosio section of northern Italy, the GSSP of Oligocene - Miocene boundary was positioned at the 35 m level (as measured from the top towards down). (48) regarded that the base of the Aquitanian stratotype was located near the base of the *Globorotalia kugleri* Zone (his N4 Zone) at the LO of *Globigerinoides primordius*). (41) suggested placing the Chattian - Aquitanian boundary at the upper part of *Globorotalia kugleri* Zone at the LO of *Globigerinoides primordius*. (30) placed this boundary at the upper part of *Globigerina ciperoensis* Zone (P22) or at the lower part of *Globigerinoides primordius* Subzone (M1a). (40), (24) located this boundary at the upper portion of *Paragloborotalia pseudokugleri* Zone (O7) or at the lower part of *Paragloborotalia kugleri* Subzone (M1a). In Egypt, (36) located this boundary at the upper part of *Globigerina ciperoensis* Zone (P22/N3) that is equivalent to the base of *Globigerinoides primordius* Zone (N4). (7) cited this boundary at the upper part of *Globigerina ciperoensis* Zone (P22) or at the lower part of *Paragloborotalia kugleri* Subzone (M1a). (49), (50) suggested that this boundary is located at the top of *Globigerina ciperoensis* Zone (P22) that was marked by an obvious change in conservation, diversity and size of the foraminifera from the Chattian to Aquitanian and was distinguished by the LO of *Globigerinoides spp*. (51) recognized this boundary on the base of LO of *Globigerinoides primordius* at the lower boundary of M1. In the studied well this boundary is placed at the top of *Paragloborotalia pseudokugleri* Zone (O7) coinciding with the base of *Globigerinoides primordius* (*Trilobatus primordius*) Subzone (M1a) due to the absence of *Paragloborotalia kugleri* in the studied section

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