Contribution to the Paleontology, Stratigraphy and Paleoenvironment of Ten Diagnostic Egyptian Benthic Foraminifera

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Abstract: Ten Maastrichtian-Early Eocene diagnostic benthic foraminiferal species from Egypt were recorded and illustrated in this study, for the first time, from Abu Zenima section, west central Sinai of Egypt, but not recorded outside Egypt in other localities in the Tethys. These species are: Höglundina esnaensis (LeRoy, 1953), Eouvigerina aegyptiaca Nakkady (1950), Valvulinera sp. cf. brotzeni Nakkady and Talaat (1959), Eponides marielisi Said and Kenawy (1956), Eponides sigali Said and Kenawy (1956), Trochulina aegyptiaca (LeRoy, 1953), Cibicoides grandis (LeRoy, 1953), Anomalinoidea sinaensis Said and Kenawy (1956), Stensiöina esnehensis Nakkady (1950), Angulogavelinella nekhliana (Said and Kenawy, 1959). The paleontology, stratigraphy and paleoenvironment of these species are presented.

Keywords: Paleontology, paleoenvironment, stratigraphy, benthic foraminifera, Egypt, Tethys

1. Introduction

detailed seven distinguished facies were presented by Issawi et al. (1999), from north to south of Egypt: Sinai Facies (SF), North Western Desert Facies (NWDF), Ataqa Facies (AF), Southern Galal Facies (SGF) all of them in the north; Farafra Bahariya Facies (FBF) and Nile Valley Facies (NVF) in the center; and Nuba Abu Ballas Facies (NABF) and each facies of them has certain formations (which differ from the adjacent one) though some formations may cross the boundaries between two contiguous facies (Fig. 1). Issawi and Osman (2000) also noted that during the Cretaceous and Tertiary span of time, the land of Egypt witnessed many phases of transgressions and regressions of Tethys over a paleorelief (highs and lows of Syrian Arcs) by the syntectonic structures, which varied considerably from one place to other, and Lat. 28° N was considered by them to be detected the contact between the deep-water facies in the north and shallower in the south, but Anan (1987) detected that contact at nearly coincides around Lat. 27° N. In the Late Cretaceous-Paleogene time, deep marine sediments were deposited in the north Egyptian, whereas gradually becoming shallower and less thick southward to the coeval lithofacies predominated, as mentioned by some authors (i.e. Youssef, 1957; Issawi and Osman, 2000).

2. Previous Studies

More than one hundred Maastrichtian-Paleogene benthic foraminiferal species and subspecies were erected by some authors: Nakkady (1950, 1955, 1959), LeRoy (1953) and Said and Kenawy (1956) from different sections in Egypt: Sinai, Nile Valley, Eastern and Western Deserts of Egypt. Some of these new species are recorded outside the original area outside Egypt in the Northern Tethys (Spain, France, Italy, Turkmenia) and also in the Southern Tethys (Nigeria, Mali, Tunisia, Libya, Jordan, Iraq, United Arab Emirates, Qatar, Pakistan), i.e.: Spiroplectinella esnaensis, S. knebeli, Siphogaudryina africana, Pseudoclavulina farafraensis, Spiroplectinella paracanina, Verneulinia aegyptiaca, Tritaxia barakai, Palmula woodi, Aragonia semireticulata, Orthokarstenia oveyi, Cibicoides abudurbensis, C. mellahensis, C. pseudocactus, Quadrimorphina esnehensis, Trifarina esnaensis, Anomalinoidea aegyptiaca, Arenobulimina aegyptiaca, while other ten Egyptian diagnostic Maastrichtian-Paleogene benthic foraminiferal species are not recorded (or neglected or identified by another names by other authors in different localities in the Tethys outside Egypt: Höglundina esnaensis (LeRoy, 1953), Eouvigerina aegyptiaca Nakkady (1950), Valvulinera brotzeni Nakkady and Talaat (in Nakkady, 1959), Eponides marielisi Said and Kenawy (1956), Eponides sigali Said and Kenawy (1956), Trochulina aegyptiaca (LeRoy, 1953), Cibicoides grandis (LeRoy, 1953), Anomalinoidea sinaensis Said and Kenawy (1956), Stensiöina esnehensis Nakkady (1950), Angulogavelinella nekhliana (Said and Kenawy, 1956).

3. Taxonomy

The micropaleontological studies of the Maastrichtian-Paleogene succession of the Abu Zenima section, west central Sinai of Egypt Fig. 2 were treated by many authors: i.e. Ghorab (1961), Bassioumi et al. (1980), Galal (2004), Anan (1992, 2004, 2010, 2014). The taxonomy of Loeblich and Tappan (1988) are followed in this study. These ten neglected species are: Höglundina esnaensis (LeRoy, 1953), Eouvigerina aegyptiaca Nakkady (1950), Valvulinera sp. cf. brotzeni Nakkady and Talaat (in Nakkady, 1959), Eponides marielisi Said and Kenawy (1956), Eponides sigali Said and Kenawy (1956), Trochulina aegyptiaca (LeRoy, 1953), Cibicoides grandis (LeRoy, 1953), Anomalinoidea sinaensis Said and Kenawy (1956), Stensiöina esnehensis Nakkady (1950), Angulogavelinella nekhliana (Said and Kenawy, 1956). These species are illustrated in Figure 3. a-j.

Order: Foraminifera EICHWALD, 1830
Suborder: Robertinina LOEBLICH and TAPPAN, 1984
Superfamily: Ceratobuliminacea CUSHMAN, 1927
Family: Epistominidae WEDEKIND, 1937
Subfamily: Epistomininae WEDEKIND, 1937
Genus: *Hoeglundina* BROTZEN, 1940  
Type species: *Rotalia elegans* DORBIGNY, 1826  
*Hoeglundina esnaensis* (LEROY, 1953)  

Fig. 3.a

1953 *Epistomina esnaensis* LEROY, p. 29, pl. 5, figs 7-9.  
1956 *Hoeglundina esnaensis*; SAID and KENAWY, p. 152, pl. 6, fig. 14.  
1996 *Hoeglundina esnaensis*; AREF and YOUSSEF, p. 552.  
2001 *Epistomina esnaensis*; HEWAIDY and STRUOGO, p. 11, fig. 6.  
2008 *Hoeglundina esnaensis*; ANAN, p. 363.

Remarks: Loeblich and Tappan (1988, p. 446) considered the genus *Epistomina* Salaj (1984) as a junior synonym of the genus *Hoeglundina*. *H. esnaensis* is characterized by more convex ventral than dorsal side, 7-8 chambers in the last whorl, sutures ventrally near straight and mainly flush, aperture at the base of last chamber with smooth surface. This species differs from *E. eocenica* Cushman and Hanna (1927) by less conspicuous ventral sutures and by being more punctate. It was originally described from the Early Eocene of Maqti section, Egypt (Fig. 1.8), and later on from the Paleocene of northern Sinai and the Red Sea coast. It is illustrated in this study for the first time from Egypt. This Paleocene-Early Eocene species seems so far, to be confined in Egypt.

Suborder: Rotaliina DELAGE and HÉROUARD, 1896  
Superfamily: Eouvginerinacea CUSHMAN, 1927  
Family: Eouvginerinidae CUSHMAN, 1927  
Genus: *Eouvginerina* CUSHMAN, 1926  
Type species: *Eouvginerina americana* CUSHMAN, 1926  
*Eouvginerina aegyptiaca* NAKKADY, 1950  
Fig. 3.b

1950 *Eouvginerina aegyptiaca* NAKKADY, p. 686, pl. 89, fig. 18.  
1956 *Eouvginerina aegyptiaca*; SAID and KENAWY, p. 141, pl. 4, fig. 2.  
1965 *Eouvginerina aegyptiaca*; KRASHENNINKOV and PONIKAROV, p. 5.  
1994 *Eouvginerina aegyptiaca*; HEWAIDY, p. 64, fig. 11, 5; p. 68, fig. 13, 2, 3.  
2009 *Eouvginerina aegyptiaca*; ANAN, p. 37.

Remarks: The test of *Eouvginerina aegyptiaca* is elongate, slender tapering at both ends with smoothwall, greatest width formed by last chamber, the biserial portion constitutes about one-third the length of the test and later chambers become uniserial, aperture rounded at the end of a short cylindrical neck. It differs from *E. gracilis* Cushman (1926) in having non-spinoso surface, in the presence of a groove on either side of the last chamber and semi-rounded final chamber not elongated shape with elongate neck ended with small lip. On the other hand, Speijer (1994) noted that *E. aegyptiaca* possibly should be regarded as senior synonym of *E. subsulpta* McNeil and Caldwell (1981), but unfortunately the type description of *E. aegyptiaca* is not very clear. This species was originally described from the Maastrichtian rocks of Sinai and Red Sea coast. Later on it was recorded in many sites of Egypt by different authors: Western Desert, Nile Valley, Kharga Oasis and southwest Aswan.

Superfamily: Discorbacea EHERENBERG, 1838  
Family: Bagginidae CUSHMAN, 1927  
Subfamily: Baggininae CUSHMAN, 1927  
Genus: *Valvulineria* CUSHMAN, 1926  
Type species: *Valvulineria californica* CUSHMAN, 1926  
*Valvulineria* sp. cf. *brotzeni* NAKKADY and TALAAT, 1959  
Fig. 3.c

1959 *Valvulineria brotzeni* NAKKADY, p. 460, pl. 7, fig. 2.  
1965 *Valvulineria brotzeni*; KRASHENNINKOV and PONIKAROV, p. 6.  
2009 *Valvulineria brotzeni*; ANAN, p. 39, pl. 1, fig. 9.

Remarks: Nakkady (1959) put the figured specimens *Gyroïdina planulata* of both LeRoy (1953, p. 35, pl. 11, figs. 1-3) and Said and Kenawy (1956, p. 149, pl. 5, fig. 8; non Cushman and Renz, 1944, p. 23, pl. 4, fig. 1) in the synonym of *Valvulineriabrotzeni* Nakkady and Talaat (in Nakkady, 1959). This species has biconvex smooth test and the dorsal side slightly more convex than the ventral, last chamber extending more toward the umbilicus than the other, sutures very slightly depressed or flush with the surface, aperture a slit and extending from the umbilicus to near the dorsal edge beneath a very thin lip. It is very similar to *V. laevis* Brotzen (1948) but differs by its more convex dorsal side, the triangular apertural facead narrower umbilical area. The recorded specimen in our material does not match with the holotype provided by Nakkady and Talaat. Therefore, the *Valvulineria* sp. cf. *brotzeni* is recorded and illustrated from the studied section for the first time. This was originally described from the Paleocene of Um Elghanyayen section (Fig. 1.11). Later on, it was recorded in the same stratigraphic horizon of Gabal Aweina (Fig. 1.10), but the Maastrichtian succession of both Abu Tartur section and El Qusaima section, Sinai, Egypt (Fig. 1.1).

Family: Eponididae HOFKER, 1951  
Genus: *Eponides* DE MONTFORT, 1808  
Type species: *Nautilus repandus* FICHTEL and MOLL, 1798  
*Eponides mariei* SAID and KENAWY, 1956  
Fig. 3.d

1956 *Eponides mariei* SAID and KENAWY, p. 148, pl. 5, fig. 2.  
1995 *Eponides mariei*; Ismail and El Saadany, p. 199, fig. 12.  
2012 *Eponides mariei*; ANAN, p. 25, pl. 1, fig. 13.

Remarks: The species has biconvex test with rounded periphery, 5-6 chambers in the adult whorl. *Oridorsalis mariei* of Nomura and Brohi (1995) from Pakistan has small secondary openings occur at the junction of spiral and interiomarginal sutures on the spiral side, which don't exist in the species of Said and Kenawy (1956). This species was originally recorded in the Maastrichtian-Danian rocks of Giddi section of Sinai (Fig. 1.2), and later on in the Maastrichtian of El Qusaima (Fig. 1.1) and El Hassana, Sinai. It seems that this species, so far, is confined in Sinai of Egypt.

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Remarks: This species is characterized by its large biconvex test with rounded periphery, 7 chambers in the adult whorl, aperture ventral and elongate between the umbilicus and periphery, without supplementary apertures. Speijer (1994) treated this species as junior synonym of *Eponides plummerae* Cushman (1948) and related it to the genus *Oridorsalis* (*O. plummerae*), due to the existence of the secondary apertures on the spiral side, while Bolli *et al.* (1994) noted that the Campanian-Paleocene species *Gyroidinoides girardanus* (Reuss, 1851) may be possible a senior synonym of the Maastrichtian *Eponides sigali* Said and Kenawy (1956). It was originally recorded in the Maastrichtian rocks of Nehkl section of Sinai (Fig. 1.2) and later on from Sufr El Dara section (Fig. 1.7), west Gulf of Suez, Egypt.

Family: Discorbidae EHRENBERG, 1838
Genus: *Trochulina* D’ORBIGNY, 1839
*Trochulina aegyptiaca* (LEROY, 1953) Fig. 3.f

1953 *Rotborinella aegyptiaca* LEROY, p. 48, pl. 7, figs. 1-3.

Remarks: Loeblich and Tappan (1988) considered the genus *Rotborinella* Bandy (1944) as a junior synonym of the genus *Trochulina*. Test of this species is nearly circular with nearly flat ventrally, but strongly convex dorsally, dorsal sutures oblique and depressed; but mainly flush in the ventral side, aperture a slit at base of septal face between periphery and umbilical plug. It is related to T. *colliculus* (Bandy, 1944) but differs by its deep depressed ventral sutures and being more compressed. The Early Eocene *T. aegyptiaca* is illustrated and recorded for the first time in this study (Fig. 1.4) outside the original description from Maqfi section (Fig. 1.8), Western Desert of Egypt.

Superfamily: Discorbineellacea SIGAL, 1952
Family: Parrellioididae HOFKER, 1956
Genus: *Cibicidoides* THALMANN, 1939
Type species: *Truncatulina mundula* BRADY, PARKER and JONES, 1890
*Cibicidoides grandis* (LEROY, 1953) Fig. 3.g

1953 *Anomalina grandis* LEROY, p. 18, pl. 9, figs. 6-8.

Remarks: According to Loeblich and Tappan (1988) the genus *Cibicidoides* Thalmann has a low interiomarginal and equatorial arch at the base of the apertural face. The *grandis* LeRoy species has nearly peripheral aperture, then it belongs to the genus *Cibicidoides*. This species has nearly equal biconvex, about 12 chambers in the last whorl increasing gradually as added, periphery rounded, wall rather coarsely perforated. The Maastrichtian *C. grandis* is illustrated and recorded for the first time in this study (Fig. 1.4) outside the original description from Maqfi section (Fig. 1.8), Egypt.

Family: Heterolepididae GONZÁLES-DONOSO, 1969
Genus: *Anomalinoideas* BROTZEN, 1942
Type species: *Anomalinoideas plummerae* BROTZEN, 1942
*Anomalinoideas sinaensis* SAID and KENAWY, 1956 Fig. 3.h

1956 *Anomalinoideas sinaensis* SAID and KENAWY, p. 154, pl. 7, fig. 3.

Remarks: *Anomalinoideas sinaensis* characterized by its biconvex and compressed test, ventral and dorsal umbilical regions somewhat hollowed, sutures curved and depressed, aperture interiomarginal but extending dorsally to the umbilicus. This Sinai Maastrichtian-Paleocene species is similar to the Early Eocene *A. aegyptiaca* (LeRoy, 1953), but differs from Maqfi section, Western Desert of Egypt (Fig. 1.8) by its character of the interiomarginal aperture, more compressed test, more depressed dorsal umbilicus and the different stratigraphic ranges of the two species. The Sinai Maastrichtian-Paleocene *A. sinaensis* recorded and illustrated for the first time in this study (Fig. 1.4) outside the original description from Maqfi section (Fig. 1.8), Egypt.

Family: Gavelinellidae HOFKER, 1956
Subfamily: Gavelinellidae HOFKER, 1956
Genus: *Stensiöina* BROTZEN, 1936
Type species: *Rotalia exsculpta* REUSS, 1860
*Stensiöina esnehensis* NAKKADY, 1950 Fig. 3.i

1950 *Stensiöina esnehensis* NAKKADY, p. 689, pl. 90, figs. 8-10.
1987 *Stensiöina esnehensis* ANAN, p. 223.

Remarks: *Stensiöina esnehensis* was planococonvex test, about 2 whorls visible on the flat dorsal side with raised and ornate sutures, ventral sutures slightly raised and gently curved, aperture an arched slit at base of chamber on ventral side. This species is similar to *S. excolata* (Cushman, 1940), but differs in the smooth ventral side and distinct chambers. Speijer (1994) treated this species as a junior synonym of *S. pommerana* Brotzen (1936), but the latter species has thicker ridges on the spiral sutures, large pores and umbilical flaps on the umbilical side. *S. esnehensis* was originally described by Nakkady (1950) from the Maastrichtian Wadi Danilesection, Sinai (Fig. 1.3). It does not recorded, so far, outside the original record, except Jirán El Ful section (Fig. 1.5), west Cairo by Anan (1987).

Superfamily: Chilostomellacea BANDY, 1881
Family: Gavelinellidae HOFKER, 1956
Subfamily: Gavelinellinae HOFKER, 1956
Genus: *Angulogavelinella* HOFKER, 1957
Type species: *Discorbina gracilis* MARSSON, 1878
*Angulogavelinella nekhliana* (SAID and KENAWY, 1956) Fig. 3.j

1956 *Angulogavelinella nekhliana* SAID and KENAWY, p. 155, pl. 7, fig. 9.
1987 *Angulogavelinella nekhliana*; ANAN, p. 222, pl. 1, fig. 18.
1995. Cibicides nekhlianus; ISMAIL and EL SAADANY, p. 200, fig. 12, 13.
2004. Angulogavelinella nekhliana; ANAN, p. 50, pl. 1, fig. 15.
2012. Angulogavelinella nekhliana; ANAN, p. 26, pl. 1, fig. 15.

Remarks: Angulogavelinella nekhliana may be recognized by its strong ventral umbo and shell deposits in the central part of the ventral sutures. Anan (1987) considered this species to belong to the genus Angulogavelinella due to the type and position of aperture. This species was originally recorded in the Maastrichtian of Nekhl and Giddi sections, Sinai (Fig. 1.2). Later on, it was recorded from other sections in Sinai: El Hassana, Abu Zenima (Fig. 1.4), as well as Jiran El Ful west Cairo (Fig. 1.5). Anan (2004) considered the Maastrichtian A. nekhliana with distinct umbilical umbo as the former species of the Paleocene A. avnimelechi (Reiss) species, due to lacks this umbo and has moderately deep and open umbilicus. For that he treated these two species in Angulogavelinellaneakhliana – A. avnimelechi lineage.

4. Paleoenvironment and Paleogeography

1) LeRoy (1953) noted that in certain respects the microfauna of the Esna Shale of Maqfi section (Fig. 1.10) exhibits an affinity with the Midway Type Fauna (MTF) of the American Gulf Coastal area. Also Berggren (1974) and Berggren and Aubert (1975) considered the faunal assemblage of Maqfi section (here represents the Farafra Bahariya Faecies, FBF of Issawi et al., 1999) be predominantly related to the “Midway-type fauna, MTF”, middle-outneritic environment (50-200 m).

2) Said and Kenawy (1956) described and recorded 263 benthic foraminiferal species from the Upper Cretaceous-Lower Tertiary strata of the two sections (Nekhl and Giddi) in northern Sinai, Egypt. These taxa shown an affinity with Midwayfaunas of American Gulf Coastal Plain, which indicate a similarity with fauna of Trinidad and Tampico Embayment of Mexico (about 70%), together with a few froms from northern Europe.

3) Berggren and Aubert (1975) noted that the Lower Tertiary fauna of Said and Kenawy (1956) in the northern part of Sinai Peninsula (represents the Sinai Facies, SF) shows an affinity with the MTF.

4) Anan and Hewaidy (1986) considered the Nile Valley Facies (NVF, represented by Duwi section) also related theothe MTF. It means that most northern and central Egypt, according to these authors, shows an affinity with the MTF, middle-outneritic environment (50-200m).

5) Keller (1992) also noted that based on foraminiferal morphotype distribution patterns in the Negev-Sinai fauna (=SF) across the K-T boundary have strong survivorship preference for species of epifaunal habitat.

6) Anan (1992) noted that the Maastrichtian to Ypresian stratigraphic section of Abu Zenima (Fig. 1.4) is a product of eustasy, tectonics and pattern of sedimentation.

7) Anan (1993) noted that the Maastrichtian benthic foraminiferal species of Qarn El Barr section (UAE) and some other sections in Iraq, Jordan and Egypt are closest to the Maastrichtian fauna of Nekhl section, Sinai of Egypt (Fig. 1.2). The Maastrichtian chalk of Jiran El Ful section (Fig. 1.5) may indicative to openmarine middle-outneritic environment.

8) Schmitz et al. (1996) and Speijer et al. (2000) noted that the high abundance of pelagic microfossils in four studied sections: Wadi Nukhul in north Egypt (SF), Qreiya, Aweina and Duwi sections in central Egypt (NVF) indicated openconnections to the Tethys. Wadi Nukhul section (SF) represent deep depression, bathyal environment (500-600 m) and Gabal Qreiya (Fig. 1.10) and Aweina sections at Eastern Desert of Egypt at Upper Nile (NVF) represent outer neriticenvironment (150-200 m), while Gabal Duwi (Fig. 1.9) at Red Sea coast (NVF) representsmiddle-neritic environment (75-100 m).

9) Issawi et al. (1999) considered the contact between the deep and shallowmarine facies in Egypt nearly coincides with Lat. 28° N, but around Lat. 27° N by Anan (1987).

10) Issawi and Osman (2000) noted that deep marine sediments deposited in thenorthern Egypt during the Cretaceous, whereas gradually becoming shallowerand less thick to the coeval lithofacies predominated.

11) Anan (2011) noted that the probable environment for the Sinai Facies (SF, in thenorthern Egypt, which represented by Nekhl, Giddi (Fig. 1.2) and Abu Zenima section (Fig. 1.4) is outer neritic-upper bathyal (200-400 m), which it deeper than the following facies: the North Western Desert Facies (Jiran El Ful, Fig. 1.5), Farafra Bahariya Facies (Maqfi, Fig. 1.8) and Nile Valley Facies (Duwi, Fig. 1.9) in central Egypt, which are deposited in the middle-outneritic (75-200 m).

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References


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Figure 2: Litho-and biostratigraphy of Abu Zenima section, west central Sinai, Egypt (The planktic foraminiferal zones after Berggren and Pearson, 2005).

Figure 3:  

a. Höglundina esnaensis (LeRoy, 1953), sample 10;  
b. Eouvigerina aegyiata Nakad (1950), s. 10;  
c. Valvulineria brotzeni Nakkady and Talaat (1959), s. 7;  
d. Eponides marielSaid and Kenawy (1956), s. 9;  
e. Eponides sigali Said and Kenawy (1956), s. 6;  
f. Trochulina aegyiata (LeRoy, 1953), s. 32;  
g. Cibicidoides grandis (LeRoy, 1953), s. 10;  
h. Anomalinoidea sinaensis Said and Kenawy (1956), s. 11;  
i. Stensiöina esnehensis Nakkady (1950), s. 5;  
j. Angulogavelinella nekhliana (Said and Kenawy, 1956), s. 12.