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), Valulineria sp. cf. brotzeni Nakkady and Talaat (1959), Eponides mariel 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). The paleontology, stratigraphy and paleoenvironment of these species are presented.

Keywords: Paleontology, paleo-environment, 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 the contact between the deep-water facies in the north and shallow 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 Egypt, 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 paracarinata, Verneulinia aegyptiaca, Tritaxia barakai, Palmula woodi, Aragonia semireticulart, Orthokarstenia oveyi, Cibicoides abudurbensis, C. mellahensis, C. pseudoacutus, Quadrimorpha 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), Valulineria brotzeni Nakkady and Talaat (in Nakkady, 1959), Eponides mariel 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 the Abu Zenima section, west central Sinai of Egypt (Fig. 2) were treated by many authors: i.e. Ghorab (1961), Bassiouni et al (1980), Galal (2004), Anan (1992, 2004, 2010, 2014). The taxonomy of Loeblich and Tappan (1888) are followed in this study. These ten neglected species are: Höglundina esnaensis (LeRoy, 1953), Eouvigerina aegyptiaca Nakkady (1950), Valulineria sp. cf. brotzeni Nakkady and Talaat (in Nakkady, 1959), Eponides marieli 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) and 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: Cetabolabinaceae CUSHMAN, 1927
Family: Epistominidae WEDEKIND, 1937
Subfamily: Epistomininae WEDEKIND, 1937

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Paper ID: ART202095
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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 strougO, p. 11, fig. 6.
2008*Hoeglundina esnaensis*; aNaN, p. 363.

Remarks: Loeblich and TAPPan(1888, 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 Maqfi 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 Eocenespecies seems so far, to be confined in Egypt.

Suborder: Rotaliina DELAGE AND HÉROUARD, 1896
Superfamily: Eouvigerinacea CUSHMAN, 1927
Family: EouvigerinidAE CUSHMAN, 1927
Genus: Eouvigerina CUSHMAN, 1926
Type species: *Eouvigerina americana* CUSHMAN, 1926
*Eouvigerina aegyptica* NAKKADY, 1950
Fig. 3.b

1950*Eouvigerina aegyptica* NAKKADY, p. 686, pl. 89, fig. 18.
1956*Eouvigerina aegyptica*; SaiD AND KENawy, p. 141, pl. 4, fig. 2.
1965*Eouvigerina aegyptica*; Krasheninnikov AND PonikaroV, p. 5.
1994*Eouvigerina aegyptica*; heWAidy, p. 64, fig. 11. 5; p. 68, fig. 13. 2, 3.
2009*Eouvigerina aegyptica*; aNaN, p. 37.

Remarks: The test of *Eouvigerina aegyptica*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-spinose surface, in the presence of a groove on either side of the last chamberand semi-rounded final chamber not elongated shape with elongate neck ended with small lip. On the other hand, Speijer (1994) noted that *E. aegyptica* possibly should be regarded as senior synonym of *E. subsculptura* McNeil and Caldwell (1981), but unfortunately the type description of *E. aegyptica* 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 EHenREikkiN, 1838
Family: Bagginiidae CUSHMAN, 1927
Subfamily: Bagginiinae 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*; Krasheninnikov AND Ponikarov, p. 6.
2009*Valvulineria brotzeni*; aNaN, p. 39, pl. 1, fig. 9.

Remarks: NAKKADY (1959) put the figured specimens *Gyroidina 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, 1941, 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 face of 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 Elghanyen section (Fig. 1.1). 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 marielSAID and Kenawy, 1956
Fig. 3.d

1956*Eponides mariel* SAID and Kenawy, p. 148, pl. 5, fig. 2.
1995*Eponides mariel*; IsmaI and El Saadany, p. 199, fig. 12. 3.
2012*Eponides mariel*; aNaN, p. 25, pl. 1, fig. 13.

Remarks: The species has biconvex test with rounded periphery, 5-6 chambers in the adult whorl. *Oridorsalismariel* 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.
Eponides sigali SAID and KENAWY, 1956
Fig.3.e

1956 Eponides sigali SAID and KENAWY, p. 148, pl. 5, fig. 6.

1992 Eponides sigali; ISMAIL, p. 238, pl. 2, fig. 4.

2012 Eponides sigali; ANAN, p. 25.

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 Nehkhl 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 aegyptica (LEROY, 1953)
Fig. 3.f

1953 Rotorbinella aegyptica LEROY, p. 48, pl. 7, figs. 1-3.

Remarks: Loeblich and Tappan (1988) considered the genus Rotorbinella 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. aegyptica is recorded and illustrated 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: Discorbilacea SIGAL, 1952
Family: Parrelloididae HOFKER, 1956
Genus: Cibicidoides THALMANN, 1939
Type species: Truncatulina mundula BRADY, PARKER and JONES, 1890
Cibicidoides grandis (LEROY, 1953)
Fig. 3.g

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

Remarks: According to Loeblich and Tappam (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 whor increasing gradually as added, periphery rounded, wall rather coarsely perforated. The Maastrichtian C. grandis 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: Heterolepidae GONZÁLES-DONOSO, 1969
Genus: Anomalinoides BROTZEN, 1942
Type species: Anomalinoides plummerae BROTZEN, 1942
Anomalinoides sinaensis SAID and KENAWY, 1956
Fig. 3.h

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

Remarks: Anomalinoides 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. aegyptica (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: Gyroidinoidinae SAIDOVA, 1981
Genus: Stensiöina BROTZEN, 1936
Type species: Rotalia exsulcpta 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 has planocoanvex 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 Danilisecion, Sinai (Fig. 1.3). It does not recorded, so far, outside the original record, except Jiran 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 nekhlia (SAID and KENAWY, 1956)
Fig. 3.j

1956 Angulogavelinella nekhlia SAID and KENAWY, p. 155, pl. 7, fig. 9.
1987 Angulogavelinella nekhlia; ANAN, p. 222, pl. 1, fig. 18.


2004. *Angulogavelinella nekhibianus*: ANAN, p. 50, pl. 1, fig. 15.

2012. *Angulogavelinella nekhibianus*: ANAN, p. 26, pl. 1, fig. 15.

Remarks: *Angulogavelinella nekhibianus* may be recognized by its strong ventral umbro and shell deposits in the central part of the ventral sutures. Anan (1987) considered this species belongs 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. nekhibiana* with distinct umbilical umbo as the former species of the Paleocene *A. avinimelechi* (Reiss) species, due to lacks this umbo and has moderately deep and open umbilicus. For that he treated these two species in *Angulogavelinellanekhibiana* – *A. avinimelechi* 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 Farafa Bahariya Facies, FBF of Issawi et al., 1999) to be preponderantly related to the "Midway-type fauna, MTF", middle-outer neritic 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 Midway faunas of American Gulf Coastal Plain, which indicate a similarity with fauna of Trinidad and Tampico Embayment of Mexico (about 70%), together with a few from northern America.

3) Berggren and Aubert (1975) noted that the Lower Tertiary fauna of Said and Kenawy (1956) in the northern part of the 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 to the MTF. It means that most northern and central Egypt, according to these authors, shows an affinity with the MTF, middle-outer neritic environment (50-200 m).

5) Keller (1992) also noted that based on foraminiferal morphotype distributional 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 eutasy, tectonics and pattern of sedimentation.

7) Anan (1993) noted that the Maastrichtian benthic foraminiferal species of Qarn El Barr section (UEA) 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 open marine middle-outer neritic environment.

8) Schmitz et al. (1996) and Speijer et al. (2000) noted that the high abundance of pelagic microfossils in four studied sections: Wadi Nakhol in north Egypt (SF), Qreiya, Aweina and Duwi sections in central Egypt (NVF) indicated open connections to the Tethys. Wadi Nakhol 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 neritic environment (150-200 m), while Gabal Duwi (Fig. 1.9) at Red Sea coast (NVF) represents middle-neritic environment (75-100 m).

9) Issawi et al. (1999) considered the contact between the deep and shallow marine 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 the northern Egypt during the Cretaceous, whereas gradually becoming shallower and less thick to the coeval lithofacies predominated.

11) Anan (2011) noted that the probable environment for the Sinai Facies (SF, in the northern Egypt, which represented by Nekhl, Giddi (Fig. 1.2) and Abu Zenima section (Fig. 1.4) the 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), Farafa Bahariya Facies (Maqfi, Fig. 1.8) and Nile Valley Facies (Duwi, Fig. 1.9) in central Egypt, which are deposited in the middle-outer neritic (75-200 m).

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References


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 aegyptiaca Nakkady (1950), s. 10; c. Valvulineria brotzeni Nakkady and Talaat (1959), s. 7; d. Eponides mariel.Said and Kenawy (1956), s. 9; e. Eponides sigali Said and Kenawy (1956), s. 6; f. Trochulina aegyptiaca (LeRoy, 1953), s. 32; g. Cibicidoides grandis (LeRoy, 1953), s. 10; h. Anomalinooides sinaensis Said and Kenawy (1956), s. 11; i. Stensiöïna esnehensis Nakkady (1950), s. 5; j. Angulogavelinella nekhliana (Said and Kenawy, 1956), s. 12.