Early Paleogene agglutinated foraminifera from the Middle East (Egypt and Arabia) and their distribution in the Tethys

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ABSTRACT

Thirty-two small benthic foraminiferal species belonging to sixteen genera are originally described from the Paleogene rocks (mainly Paleocene and Eocene) from three countries of the Middle East: Egypt, Jordan and United Arab Emirates (UAE). Some of these species are also recorded in other localities of the Tethys, i.e. United States of America (USA), France, Hungary, Tunisia, Qatar, Yemen and Pakistan. Some of these taxa extend into younger stratigraphic horizons than the Paleogene. The palaeontology, stratigraphy, palaeoenvironment and palaeogeography of these species in the Middle East and other Tethyan localities are presented.

Keywords: Paleogene, benthic foraminifera, Middle East, Tethys.

RESUMEN

En este trabajo se describen 32 especies de foraminíferos bentónicos, pertenecientes a 16 géneros, de rocas del Paleógeno (principalmente Paleoceno y Eoceno) de tres países de Oriente Medio: Egipto, Jordania y Emiratos Árabes Unidos. Algunas de estas especies han sido reconocidas en otras localidades del Tetis, como Norte América, Francia, Hungría, Túnez, Qatar, Yemen y Pakistán. Algunos de los taxa descritos se extienden hacia épocas más recientes. Se presenta la paleontología, el rango estratigráfico, el paleoambiente y la distribución paleogeográfica de estas especies en Oriente Medio y otras localidades del Tethys.

Palabras clave: Paleógeno, foraminíferos bentónicos, Oriente Medio, Tetis.

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1. INTRODUCTION

The present study aims at reviewing the palaeontology and biogeography of the thirty-two Paleogene small benthic foraminifera that were originally erected by many different authors from three Middle East countries (Fig. 1): Egypt (Schwager, 1876, 1883; Nakjadi, 1950, 1959; LeRoy, 1953; Said & Kenawy, 1956; Anan, 1994, 2002, 2008b, 2012b; Lugger, 1988; El-Dawy, 2001), Jordan (Futyan, 1976) and the United Arab Emirates (Anan, 2003, 2015). Many studies recorded some of these taxa in wider geographic areas in the Tethys than the original descriptions, from the Atlantic to Indian Oceans via the Mediterranean Sea (Fig. 2).

2. SYSTEMATIC PALAEOTOLOGY

The taxonomy of Kaminski (2014) is followed here. Thirty-two recorded species are illustrated in Figure 3. The stratigraphic value of these species is important for palaeobiogeographic correlations in three countries of the Middle East and other localities in the Tethys.

Class FORAMINIFEREA d’Orbigny, 1826
Subclass MONOTHALAMANA Pawlowski, Holzmann & Tyszka, in Kaminski, 2014
Order ASTRORHIZIDA Lankester, 1885
Suborder ASTRORHIZINA Lankester, 1885
Superfamily ASTRORHIZACEA Brady, 1881
Family Rabdamminidae Brady, 1884
Subfamily Bathysiphoninae Avnimelech, 1952
Genus Bathysiphon Sars, 1872
Type species Bathysiphon filiformis Sars, 1872

Bathysiphon paleocenicus El-Dawy, 2001 (Fig. 3a)

2001 Bathysiphon paleocenicus El-Dawy, p. 42, pl. 1, fig. 1.
2012b Bathysiphon paleocenicus Anan, p. 63, pl. 1, figs 2, 3.
2015 Bathysiphon paleocenicus Anan, p. 241, fig. 4.2.

This species was originally described from the late Paleocene of the El Sheikh Fadl area, east central Egypt.
(the holotype is deposited in Minia University, Geology Department, Egypt, MUGD F17). It was also recorded by Anan (2012b, 2015) in the Danian/Selandian transition of Jabal Mundassa (UAE), for the first time outside Egypt. An early Eocene Bathysiphon species is needed to complete the lineage from the Paleocene B. paleocenicus to the middle-late Eocene Bathysiphon saidi (Anan, 1994). The latter species was recorded from Egypt and the UAE.

*Bathysiphon saidi* (Anan, 1994)
(Fig. 3b)

1994 *Rhabdammina saidi* Anan, p. 218, fig. 8. 1.
2005a *Bathysiphon saidi* (Anan), Anan, p. 19, pl. 1, fig. 2.
2007 *Bathysiphon saidi* Ozsvárt, p. 29, pl. 1, figs 2, 3.
2007 *Bathysiphon saidi* Abd-Elshafy et al., p. 103.
2011 *Bathysiphon saidi* Boukhary et al., p. 537.
2011 *Bathysiphon saidi* Anan, p. 51, pl. 1, fig. 1.

The wide stratigraphic range of the Triassic-Holocene genus *Bathysiphon* differs from the Holocene *Rhabdammina* Sars (1869) by its straight unbranched elongated tube. This species has an elongated test and wall constructed of firmly cemented coarse sand grains with a rough exterior. The coarsely agglutinated *Bathysiphon abbassi* of Hussein (1997) and *Bathysiphon* sp. 1 of Abul-Nasr (2000) are closely conspecific with *B. saidi* (Anan, 1994). *B. saidi* (the holotype is deposited in Ain Shams University, Geology Department, Egypt, ASUGD A2) was originally described from the Bartonian-Priabonian of Fayoum and Sinai (Egypt), and later from the same stratigraphic horizon of Jabal Hafit (UAE) and Hungary.

Suborder HEMISPHAERAMMINININA Loeblich & Tappan, 1961, emended Mikhailievich, 1995
Family Saccamminidae Brady, 1884
Subfamily Thurammininae Miklukho-Maklay, 1963
Genus *Orbulinelloides* Saidova, 1975
Type species *Orbulinelloides agglutinatus* Saidova, 1970

*Orbulinelloides arabicus* Anan, 2003
(Fig. 3c)

2003 *Orbulinelloides arabicus* Anan, p. 531, fig. 4. 1.
2011 *Orbulinelloides arabicus* Anan, p. 52, pl. 1, fig. 2.

This species has a spherical-subospherical coarsely agglutinated test, apertures flush with the surface. It was originally described from the Bartonian-Priabonian of Jabal Hafit (UAE) (the holotype is deposited in the UAE University, Geology Department, UAEUGD A5). So far, it seems to be confined to the UAE.

Suborder SCHLUMBERGERININA Mikhailievich, 1980
Superfamily RZEHAKINOIDEA Cushman, 1933
Family Miliamminidae Saidova, 1981
Subfamily Miliamminininae Saidova, 1981
Genus *Miliamina* Heron-Allen & Earland, 1930
Type species *Miliolina oblonga* (Montagu) var. arenacea Chapman, 1916

*Miliammina kenawy* Anan, 1994
(Fig. 3d)

1994 *Miliammina kenawy* Anan, p. 218, fig. 8. 2.
2005a *Miliammina kenawy* Anan, p. 19, pl. 1, fig. 3. 7.
2011 *Miliammina kenawy* Anan, p. 53, pl. 1, fig. 3.

This species has a fine agglutinated smooth wall in a loose quinqueloculine arrangement with half coil chambers. *M. kenawy* (the holotype is deposited in the UAE University, Geology Department, UAEUGD A3) was originally described from the Bartonian-Priabonian of Fayoum (Egypt), and later from the Bartonian of Jabal Hafit (UAE).

Family Ammomassilinidae Mikhailievich & Kaminski, 2008
Subfamily Ammomassilininae Mikhailievich & Kaminski, 2008
Genus *Ammomassilina* Cushman, 1933
Type species *Massilina alveoliniformis* Millett, 1898

*Ammomassilina* sp Anan, 1994
(Fig. 3e)

1994 *Ammomassilina* sp Anan, p. 219, fig. 8. 5.
2007 *Ammomassilina* sp Abd-Elshafy et al., p. 104.

This late Eocene species has a quinqueloculine early stage, later chambers are added on the opposite sides of the test in a single plane; wall porcelaneous with a surface layer of agglutinated fine-grains of quartz particles. It differs from the Holocene *A. alveoliniformis* by its finer quartz grains and older stratigraphic horizon. It is a rare species in the Guta section, Fayoum area, southwest Cairo, Egypt (the holotype is deposited in the Ain Shams University, Geology Department, Egypt, ASUGD A4). So far, it seems to be confined to Egypt.

Subfamily Ammomarginulinae Podobina, 1978
Genus *Ammobaculites* Cushman, 1910
Type species *Spirolina agglutinans* d’Orbigny, 1846

*Ammobaculites coprolithiformis* (Schwager, 1876) (Sch. 3f)
1876 *Haplophragmium coprolithiformis* Schwager, p. 661, pl. 1, fig. 3.
1949 *Ammobaculites coprolithiformis* Cushman, p. 2, pl. 1, fig. 9.
1972 *Ammobaculites coprolithiformis* Hanzlíková, p. 46, pl. 9, fig. 5.
1997 *Ammobaculites coprolithiformis* Gebhardt, p. 22, fig. 3. 3.
1988 *Ammobaculites coprolithiformis* Luger, p. 260, pl. 1, fig. 12.
2009 *Ammobaculites coprolithiformis* Al-Wosabi, p. 82, pl. 1, fig. 18.

This Upper Cretaceous-Paleogene species in longitudinal section shows a tightly coiled test with a planispiral coiled-early stage and a short rectilinear uncoiled adult stage. It was originally recorded from southwest Aswan (Egypt), and later from Arkansas (USA), Czech Republic, Nigeria and Yemen.

*Ammobaculites khargaensis* Nakkady & Talaat, in Nakkady, 1959
(Fig. 3g)

1959 *Ammobaculites khargaensis* Nakkady & Talaat, in Nakkady, p. 456, pl. 6, fig. 1.
1994 *Ammobaculites khargaensis* Hewaidy, p. 64, fig. 10. 3.
2001 *Ammobaculites khargaensis* Hewaidy & Strougo, p. 15, pl. 1, fig. 3.
2003 *Ammobaculites khargaensis* Ali, pl. 2, figs. 1, 2.
2009 *Ammobaculites khargaensis* Anan, p. 33, pl. 1, fig. 1.

This Maastrichtian-early Eocene species has a strongly compressed test, subcircular early stage, comprised of about two whorls, chambers close-coiled, wall arenaceous of subangular quartz grains rather smoothly finished, aperture is a small triangular opening at the base of the last septal face of the last chamber (the holotype is deposited in the U.S. National Museum, Washington, D. C.). It seems to be confined, so far, to Egypt.

Suborder *SPIROPECTAMMINININA* Mikhailovich, 1992
Superfamily *SPIROPECTAMMINACEA* Cushman, 1927
Family *Spiropectaminidiae* Cushman, 1927
Subfamily *Spiropectamininae* Cushman, 1927
Genus *Spiropectinella* Kisel’man, 1972
Type species *Spiroplecta wrightii* Silvestri, 1903

*Spiropectinella esnaensis* (LeRoy, 1953)
(Fig. 3h)

1953 *Spiropectantina esnaensis* LeRoy, p. 50, pl. 1, figs. 11, 12.
1976 *Spiropectanella esnaensis* Aubert & Berggren, p. 409, pl. 1, fig. 6.
1994 *Spiropectantina esnaensis* Speijer, p. 147, pl. 3, fig. 1.
2003 *Spiropectantina esnaensis* Ali, p. 124, pl. 4, figs. 16, 17.
2005 *Spiropectantina esnaensis* Sztrákos, p. 184, pl. 12, fig. 16.
2007 *Spiropectantina esnaensis* Alegret & Ortiz, p. 437, pl. 1, fig. 6.
2011 *Spiropectantina esnaensis* Youssef & Taha, pl. 1, fig. 16.

This Paleocene-early Eocene species is characterized by its raised sutures and a broad apertural face. It was originally recorded from the Paleocene of the Maqfi section (Egypt) (the holotype is deposited in the Cushman Collection No. 58024), and later from some sections in the Nile Valley, west and south Egypt, and also Tunisia and France.

*Spiropectantina paracarinata* (Said & Kenawy, 1956)
(Fig. 3i)

1956 *Spiropectantina paracarinata* Said & Kenawy, p. 122, pl. 1, fig. 13.
1996 *Spiropectantina paracarinata* Anan, p. 149, fig. 3. 2.
2012 *Spiropectantina paracarinata* Anan, p. 63, pl. 1, fig. 6.

This species was originally described from the lower Eocene rocks of Sinai (Egypt) (the holotype is deposited in the U.S.N.M. P3987), and later from the early Eocene of Jabal Hafit (UAE).

Suborder VERNEUILININA Mikhailovich & Kaminski, 2004
Superfamily VERNEUILINACEA Cushman, 1911
Family *Prolixoplectidae* Loeblich & Tappan, 1985
Genus *Plectina* Marsson, 1878
Type species *Gaudryina ruthenica* Reuss, 1851

*Plectina emiratensis* Anan, 2003
(Fig. 3j)

2003 *Plectina emiratensis* Anan, p. 534, fig. 4. 2.
2011 *Plectina emiratensis* Anan, p. 53, pl. 1, fig. 5.

This species has short subconical test, subterminal and traverse elongate slit aperture on the apertural face
of the last chambers and rather coarse-grained arenaceous wall. *P. emiratensis* (the holotype is deposited in the UAE University, Geology Department, UAE, UAEUGD A3) was originally described from the Bartonian of Jabal Hafit (UAE). So far, it seems to be confined also in the UAE.

Family **Reophacellidae** Mikhalevich & Kaminski, 2004
Subfamily **Verneuilininae** Cushman, 1911
Genus **Gaudryina** d’Orbigny, 1839
Type species **Gaudryina rugosa** d’Orbigny, 1839

**Gaudryina ameeri** Anan, 2012b
(Fig. 3k)

2012b *Gaudryina ameeri* Anan, p. 63, pl. 1, fig. 7.

This early Eocene species has a distinctive front carinate rib, which exists along the pre-final chamber of the biserial stage, as well as the whole triserial portion. It was originally recorded from the Duwi section (Egypt) (the holotype is deposited in the Al Azhar University-Gaza, Geology Department, ASUGD A27).

**Gaudryina elegantissima** Said & Kenawy, 1956
(Fig. 3l)

1956 *Gaudryina elegantissima* Said & Kenawy, p. 123, pl. 1, fig. 21.
1993b *Gaudryina elegantissima* Anan, p. 655, pl. 1, fig. 16.
1993 *Gaudryina elegantissima* Hewaidy & Al-Hitmi, p. 478, pl. 4, figs. 4, 5.
2012 *Gaudryina elegantissima* Ismail, p. 29, pl. 1, fig. 14.

This Paleocene species has an elongated test, chambers distinct, very slightly inflated, gradually increasing in size as added, wall arenaceous smooth, aperture a semicircular opening at the base of the last chamber. It was originally recorded in Sinai (Egypt) (the holotype is deposited in the U.S.N.M. P3959), and later from the same horizon of Qarn El Barr (UAE) and Qatar.

**Gaudryina limbata** Said & Kenawy, 1956
(Fig. 3m)

1956 *Gaudryina limbata* Said & Kenawy, p. 123, pl. 1, fig. 23.
1993a *Gaudryina limbata* Anan, p. 314, pl. 1, fig. 6.
2003 *Gaudryina limbata* Ali, p. 120, pl. 4, fig. 4.

This Paleocene species was originally recorded from Sinai and south Egypt (the holotype is deposited in the U.S.N.M. P3961), and later from the Paleocene of Jabal Malaqet (UAE).

**Gaudryina tellburmaensis** Futyan, 1976
(Fig. 3n)

1976 *Gaudryina soldadoensis tellburmaensis* Futyan, p. 521, pl. 81, figs. 1, 2.

This Paleocene-early Eocene species has an elongated test with a pyramidal triserial early portion forming about one-third of the test, followed by inflated biserial chambers semicircular in cross-section separated by deeply depressed sutures. It was recorded from the Tell Burma section, south Jordan (the holotype is deposited in the British Museum Natural History, BMNH. P49102). It seems to be confined, so far, to Jordan.

Genus **Siphogaudryina** Cushman, 1935
Type species **Gaudryina stephensoni** Cushman, 1928

**Siphogaudryina africana** (LeRoy, 1953)
(Fig. 3o)

1953 *Gaudryina africana* LeRoy, p. 30, pl. 2, figs. 7, 8.
2000 *Pseudogaudyrina ? africana* Sztrákos, p. 136.
2001 *Gaudryina africana* Hewaidy & Strougo, p. 15, pl. 1, figs. 6, 7.
2008a *Siphogaudryina africana* Anan, p. 361, pl. 1, fig. 1.

This species belongs to the genus *Siphogaudryina* due to its subterminal apertural in the apertural face of
Figure 3. a) Bathysiphon paleocenicus El-Dawy, 2001 x 40; b) Bathysiphon saidi (Anan, 1994) x 20; c) Orbulinelloides arabicus Anan, 2003 x 55; d) Miliammina kenawayi Anan, 2005 x 33; e) Ammomassilina sp Anan, 1994 x 40; f) Ammobaculites coprolithiformis (Schwager, 1867; after Lugher, 1988) x100; g) Ammobaculites khargaensis Nakkady & Talaat, in Nakkady, 1959 x 20; h)Spiroplectinella esnaensis (LeRoy, 1953; after Speijer, 1994) x 45; i) Spiroplectinella paracarinata (Said & Kenawy, 1956; after Anan, 1996) x 100; j) Plectina emiratensis Anan, 2003 x 40; k) Gaudryina ameeri Anan, 2012b x 50; l) Gaudryina elegantissima Said & Kenawy (1956; after Anan, 1993) x 30; m) Gaudryina limbata Said & Kenawy (1956; after Anan, 1993) x 100; n) Gaudryina speijeri Anan, 2012b x 50; o) Gaudryina tellburmaensis Futyan, 1976 x 40; p) Siphogaudryina africana (LeRoy, 1953; after Anan, 2008a) x 35; q) Siphogaudryina nekhlensis (Said & Kenawy, 1956; after Speijer, 1994) x 40; r) Siphogaudryina strogoi Anan, 2002 x 15; s) Verneuilina aegyptiaca Said & Kenawy (1956; after Anan, 2004) x 45; t) Verneuilina karreri Said & Kenawy (1956; after Hewaidy & Al-Hitmi, 1993) x 100; u) Verneuilina luxorensis Nakkady (1950; after Anan, 2004) x 60; v) Arenobulimina aegyptiaca Said & Kenawy (1956; after Anan, 1993) x 55; w) Dorothia sinaensis Said & Kenawy (1956; after Ali, 2003) x 50; x) Marsssonella haftensis Anan, 2003 x 50; y) Pseudoclavulina farafransi LeRoy (1953; after Anan, 2005) x 50; z) Pseudoclavulina hewaidyi Anan, 2008b x 25; aa) Pseudoclavulina maghribensis LeRoy (1953; after Ismail, 1996) x 50; ab) Clavulina barnardi Futyan, 1976 x 60; ac) Textularia fahmyi Anan, 1994 x 40; ad) Textularia farafransi LeRoy (1953; after Aly et al., 2011) x 45; ae) Textularia nilotica (Schwager, 1883; after Hewaidy & Al Hitmi, 1993) x 170; af) Textularia schwageri LeRoy (1953; after Anan, 2008a) x 40.
the last-formed chamber, instead of the inner marginal aperture of the genus *Gaudryina* d’Orbigny. It has a large elongated robust test, tapering initial triserial portion and greatest breadth at the beginning of the biserial stage, with distinctive four longitudinal not acute edges running nearly parallel to the periphery, two out of them appear on the apertural view along the test, sutures indistinct and depressed (the holotype is deposited in the Cushman Collection No. 58006). Hewaidy & Strougo (2001) considered the first appearance of this species in the early Eocene of the Maqfi section, Egypt and later in France.

*Siphogaudryina nekhlensis* (Said & Kenawy, 1956) (Fig. 3p)

1956 *Gaudryina nekhlensis* Said & Kenawy, p. 124, pl. 1, fig. 24.
1994 *Gaudryina nekhlensis* Speijer, p. 147, pl. 1, fig. 1.
2003 *Gaudryina nekhlensis* Ali, p. 120, pl. 4, fig. 6.
2012a *Siphogaudryina nekhlensis* Anan, p. 20, pl. 1, fig. 4.

This species belongs to the genus *Siphogaudryina* due to its subterminal apertural face of the last-formed chamber, instead of the inner marginal aperture of the genus *Gaudryina*. It has large elongated robust test, tapering initial triserial portion and greatest breadth at the beginning of the biserial stage, with distinctive four longitudinal not acute edges running nearly parallel to the periphery and two out of them appearing on the apertural view along the test, sutures indistinct and depressed. This species (the holotype is deposited in the U.S.N.M. P3962) was originally recorded in the Paleocene of the Nekhl section and south Egypt. So far, it seems to be confined to Egypt.

*Siphogaudryina strougoi* Anan, 2002
(Fig. 3q)

2002 *Siphogaudryina strougoi* Anan, p. 141, fig. 2. 1.

This Paleocene species has an elongated large test with a smoothly finished arenaceous wall, tapering early stage, triserial and triangular in cross section, later reaching biserial greatest width a near the apertural end with nearly quadrangular section. It is distinguished by distinctive five longitudinal ridges running nearly parallel to the periphery and three of them appear on the apertural view along the test, sutures raised and transverse, subterminal apertural face of the last-formed chamber. *S. strougoi* (the holotype is deposited in the Ain Shams University, Geology Department, Egypt, ASUGD A15) was originally described from the Thanetian of Wadi Ed Dakhli (Egypt). Anan (2010) considered it an excellent marker species for the Paleocene-Eocene boundary in Egypt.

Genus *Verneuilina* d’Orbigny, 1839
Type species *Verneuilina tricarinata* d’Orbigny, 1839

*Verneuilina aegyptiaca* Said & Kenawy, 1956
(Fig. 3r)

1956 *Verneuilina aegyptiaca* Said & Kenawy, p. 122, pl. 1, fig. 16.
1970 *Verneuilina aegyptiaca* Al-Omari, p. 49.
1993b *Verneuilina aegyptiaca* Anan, p. 656, pl. 2, fig. 2.
2004 *Verneuilina aegyptiaca* Anan, p. 41, pl. 1, fig. 1.
2012a *Verneuilina aegyptiaca* Anan, p. 21, pl. 1, fig. 5.
2015 *Verneuilina aegyptiaca* Anan, p. 41.

This species was originally recorded in the Maastrichtian-Paleocene of Sinai, Egypt (the holotype is deposited in the U.S.N.M. P3954), and later from the Qarn El Barr (UAE) and Jabal Mundassa sections (UAE) and Iraq. Anan (2004) considered *V. aegyptiaca* as the precursor of the Early Eocene *V. luxorensis* (Nakkady) in the *V. aegyptiaca - V. luxorensis* lineage. Anan (2010) considered it an excellent marker species of the Paleocene-Eocene boundary in Egypt.

*Verneuilina karreri* Said & Kenawy, 1956
(Fig. 3s)

1956 *Verneuilina karreri* Said & Kenawy, p. 122, pl. 1, fig. 17.
1970 *Valvoreussella karreri* Al-Omari, p. 49.
1993 *Valvoreussella karreri* Hewaidy & Al-Hitmi, p. 481, pl. 6, figs. 7, 8.
2005b *Verneuilina karreri* Anan, p. 82, pl. 1, fig. 5.
2012a *Verneuilina karreri* Anan, p. 21, pl. 1, fig. 6.

This species was recorded from the Maastrichtian-Paleocene of Sinai, Egypt (the holotype is deposited in the U.S.N.M. P3955), and later from Wadi Ed Dakhli, west Gulf of Suez (Egypt), and Iraq. It occurs in Maastrichtian-early Eocene of Qatar.

*Verneuilina luxorensis* Nakkady, 1950
(Fig. 3t)

1950 *Verneuilina luxorensis* Nakkady, p. 683, pl. 89, figs. 6, 7.
2004 *Verneuilina luxorensis* Anan, p. 42, pl. 1, fig. 2.

This early Eocene species has a pyramidal triserial test, compressed and much excavated on the three lateral faces, edges thin, chambers long and narrow, septal faces in the form of isosceles triangles, wall with much cement and a smoothly finished surface. *V. luxorensis* differs from the Maastrichtian-Paleocene *V. aegyptiaca* by its pyramidal test, which is more compressed and much excavated on
three lateral thin edges. *V. luxorensis* (the holotype is deposited in the British Museum, Natural History) was originally recorded from the early Eocene of the Luxor section (Egypt). Anan (2010) considered it an excellent marker species to recognize the early Eocene in Egypt.

Suborder **ATAXOPHRAGMIINA** Fursenko, 1958
Superfamily **Ataxophragmiacea** Schwager, 1877
Family **Ataxophragmiidae** Schwager, 1877
Subfamily **Ataxophragmiinae** Schwager, 1877
Genus **Arenobulimina** Cushman, 1927
Type species *Bulimina preslii* Reuss, 1845

*Arenobulimina aegyptiaca* Said & Kenawy, 1956

(Fig. 3u)

1956 *Arenobulimina aegyptiaca* Said & Kenawy, p. 126, pl. 1, fig. 42.

1993a *Arenobulimina aegyptiaca* Anan, p. 314, pl. 1, fig. 9.

This Paleocene species has an arenaceous wall with much cement and a smooth, conical test, slightly rounded and gradually tapering at the base, greatest breadth at the apertural end, last-formed whorl making up somewhat less than one-half of the entire surface of the test, aperture a narrow loop-shaped opening at the base of the apertural face. It was originally recorded from Sinai, Egypt (the holotype is deposited in the U.S.N.M. P3982), and later from the Paleocene of Jabal Malaqet (UAE).

Suborder **TEXTULARIINA** Delage & Herouard, 1896
Superfamily **Eggerellacea** Cushman, 1937
Family **Eggerellidae** Cushman, 1937
Subfamily **Dorothiinae** Balakhmatova, 1972
Genus **Dorothia** Plummer, 1931
Type species *Dorothia bulletta* Carsey, 1926

*Dorothia sinaensis* Said & Kenawy, 1956

(Fig. 3v)

1956 *Dorothia sinaensis* Said & Kenawy, p. 128, pl. 2, fig. 1.

2003 *Dorothia sinaensis* Ali, p. 120, pl. 3, fig. 22.

This late Paleocene-early Eocene species is recognized by its elongated test and large number of inflated chambers. It was recorded from Sinai (the holotype is deposited in the U.S.N.M. P3995), and south Egypt.

Genus **Marssonella** Cushman, 1933
Type species *Gaudryina oxycona* Reuss, 1860

*Marssonella haftiensis* Anan, 2003

(Fig. 3x)

2003 *Marssonella haftiensis* Anan, p. 535, fig. 4. 3.

2005a *Marssonella haftiensis* Anan, p. 21.

This Eocene species has conical test, nearly equal in length and width, with a subrounded early trochospiral stage, followed by a biserial stage of gradually increasing diameter, wall agglutinated of coarse grained material, terminal face concave, aperture a low basal arch on the final chamber. This species is similar to the Upper Cretaceous-Paleocene *M. oxycona*, but it differs by its more regular test, nearly equal length and width, coarser-grained wall and concave terminal face. *M. haftiensis* (the holotype is deposited in the UAE University, Geology Department, UAE, UAEGD A4) was originally described from the Bartonian-Priabonian of Jabal Haft. It seems to be confined, so far, to the UAE.

Subfamily **Pseudogaudryinae** Loeblich & Tappan, 1985
Genus **Pseudoclavulina** Cushman, 1936
Type species *Clavulina clavata* Cushman, 1926

*Pseudoclavulina farafraensis* LeRoy, 1953

(Fig. 3y)

1953 *Pseudoclavulina farafraensis* LeRoy, p. 44, pl. 2, fig. 9.

1993a *Tritaxia farafraensis* Anan, p. 314, pl. 1, fig. 7.

1993 *Tritaxia farafraensis* Hewaidy & Al-Hitmi, p. 481, pl. 6, figs. 5, 6.

1995 *Tritaxia farafraensis* Nomura & Brohi, p. 227, pl. 1, fig. 19.

2005b *Pseudoclavulina farafraensis* Anan, p. 87, pl. 1, fig. 10.

2012 *Pseudoclavulina farafraensis* Ismail, p. 30, pl. 1, fig. 16.

2015 *Pseudoclavulina farafraensis* Anan, p. 43, fig. 4.20.

The early triserial stage in *Tritaxia* Reuss is acute triangular and the uniserial stage is angular, whereas *Pseudoclavulina* Cushman differs in possessing a long cylindrical uniserial stage and subacute angles in the triserial stage. *Pseudoclavulina farafraensis* (the holotype is deposited in the Cushman Collection No. 58128) was recorded from the Paleocene of Egypt, and later from the UAE, Qatar and Pakistan.

*Pseudoclavulina hewaidyi* Anan, 2008

(Fig. 3z)

2008b *Pseudoclavulina hewaidyi* Anan, p. 4, pl. 1, fig. 1.

2015 *Pseudoclavulina hewaidyi* Anan, p. 249, fig. 4.21.

This species has distinctly large test, triserial stage triangular in cross section, discoidal chambers in the uniserial stage, which are circular in top view, wall finely arenaceous,
sutures strongly depressed in the uniserial stage with a terminal aperture. *P. hewaidyi* (the holotype is deposited in the Al Azhar University-Gaza, Geology Department, ASUGD A20) was originally described from the Danian of Abu Zenima, Sinai (Egypt), and later from the UAE.

*Pseudoclavulina maqfiensis* LeRoy, 1953

(Fig. 3aa)

1953 *Pseudoclavulina maqfiensis* LeRoy, p. 44, pl. 2, figs. 16, 17.
1956 *Pseudoclavulina maqfiensis* Said & Kenawy, p. 125, pl. 1, fig. 31.
1996 *Pseudoclavulina maqfiensis* Ismail, p. 203, fig. 5, 6.

This early Eocene species has a small test, with the earliest portion conspicuously triserial and triangular in cross-section, followed by an uniserial rounded and strongly inflated portion, wall finely arenaceous and smoothly finished. This species differs from *P. farafraensis* LeRoy by being consistently much smaller. It was originally recorded from the Maqfi section (the holotype is deposited in the Cushman Collection No. 58022), and later from Sinai and northeast Egypt.

Family Valvulinidae Berthelin, 1880
Subfamily Valvulininae Berthelin, 1880
Genus *Clavulina* d’Orbigny, 1826
Type species *Clavulina parisiensis* d’Orbigny, 1826

*Clavulina barnardi* Futyan, 1976

(Fig. 3ab)

1976 *Clavulina barnardi* Futyan, p. 522, pl. 81, figs. 3, 4.

This Paleocene species has an elongated slender test, early portion triserial with a sharply acute apical end comprising about one-fifth to one-half of the entire test, the uniserial portion consists of three to eight flask-shaped inflated chambers with deeply excavated sutures, wall finely arenaceous with a rough surface. It was originally recorded from the Tell Burma section, south Jordan (the holotype is deposited in the British Museum Natural History, BMNH. P49101).

Superfamily Textularioidea Ehrenberg, 1838
Family Textulariidae Ehrenberg, 1838
Subfamily Textulariinae Ehrenberg, 1838
Genus *Textularia* Defrance, 1824
Type species *Textularia sagittula* Defrance, 1824

*Textularia fahmyi* Anan, 1994

(Fig. 3ac)

1994 *Textularia fahmyi* Anan, p. 218, fig. 8, 3.
2002 *Textularia fahmyi* Helal, p. 107, pl. 1, fig. 3.
2007 *Textularia fahmyi* Abd-Elsahafy et al., p. 103.
2011 *Textularia fahmyi* Boukhary et al., p. 537.

This middle-late Eocene species has a large biserial test, 1¼ times as long as broad, tapering toward the initial end, greatest breadth at the end chambers, and rhomboid in cross section, acute periphery, chambers about 8-10 pairs, increasing gradually in size as added, sutures depressed, wall arenaceous, consists of fine sand grains, occasionally rose colored. It was recorded from the Fayoum area (the holotype is deposited in the Ain Shams University, Geology Department, Egypt, ASUGD A4), Sinai and Nile Valley. So far, it seems to be confined to Egypt.

*Textularia farafraensis* LeRoy, 1953

(Fig. 3ad)

1953 *Textularia farafraensis* LeRoy, p. 51, pl. 2, figs 3, 4.
1956 *Textularia farafraensis* Said & Kenawy, p. 122, pl. 1, fig. 14.
2011 *Textularia farafraensis* Aly et al., p. 84, pl. 1, fig. 12.
2012 *Textularia farafraensis* Youssef & Taha, pl. 1, fig. 4.

This Paleocene-early Eocene species has an arenaceous wall that is rather coarse-textured, with a test about twice as long as broad. It was recorded from the Maqfi section (the holotype is deposited in the Cushman Collection No. 58069), Sinai and Nile Valley (Egypt). So far, it seems to be confined to Egypt.

*Textularia nilotica* (Schwager, 1883)

(Fig. 3ae)

1883 *Plecanium niloticum* Schwager, p. 115, pl. 26, fig. 14.
1953 *Textularia nilotica* LeRoy, p. 52, pl. 2, figs 1, 2.
1956 *Textularia* sp. Haque, p. 54, pl. 32, fig. 2.
1993 *Textularia nilotica* Hewaidy & Al-Hitmi, p. 480, pl. 5, fig. 12.
2011 *Textularia nilotica* Aly et al., p. 85, pl. 1, fig. 13.

This early Eocene species has an elongated test, elliptical in apertural view, broadening moderately toward the apertural end, peripheral margin rounded, wall moderately rough. It was recorded from Farafra Oasis (Egypt), and later in the Nile Valley, as well as in Qatar. It seems that Haque’s species is closely related to *T. nilotica*.

*Textularia schwageri* LeRoy, 1953

(Fig. 3af)
1953 *Textularia schwageri* LeRoy, p. 51, pl. 2, figs 5, 6.
2003 *Textularia schwageri* Ali, p. 124, pl. 3, fig. 17.
2008a *Textularia schwageri* Anan, pl. 1, fig. 2.
2012 *Textularia schwageri* Youssef & Taha, pl. 1, fig. 5.

This late Paleocene-early Eocene species has a medium test, maximum width near the apertural end, periphery rounded, wall moderately smooth. It was recorded from the Maqfi section (the holotype is deposited in the Cushman Collection No. 58072), and later from central and south Egypt. So far, it seems to be confined to Egypt.

### 3. PALAEOGEOGRAPHY

Paleogene palaeogeographic maps (Philips, 1971; Adams et al., 1983; Berggren, 1978; Zachos et al., 1993; Rosenbaum et al., 2002) show that the Tethyan Realm had been connected with the Indo-Pacific Ocean to the east and with the Atlantic Ocean to the west via the Mediterranean Sea cross the Middle East region during the Late Cretaceous and early Cenozoic times (Fig. 2). It is proved by the existence of the identified taxa from the Middle East of other localities in the Tethys. On the other hand, some authors (Moore et al., 1978; Zachos et al., 1993) recorded the extended realms of the Tethys, Indo-Pacific with Atlantic Oceans in the Maastrichtian-late Eocene. Haq & Aubry (1978) noted that the North Africa and the Middle East formed important parts of the Tethyan link between the Atlantic and Pacific Oceans during the aarly Paleogene, particularly middle Eocene (Fig. 2). Anan (1993a) noted that the Paleocene benthic foraminifera assemblages have a close resemblance between Egypt and UAE, which show the same palaeogeographic province, and belong to the Midway-Type Fauna (about 50-200 m water depth). Haynes & Nwabufo-Ene (1998) suggested wider Tethyan connections, as far distance as the Carpathian region and Pakistan.

Accordingly, the following remarks can be presented (Table 1). Most of the identified Paleogene species from the Middle East were described from Egypt (27/32, about 84 %), while 3 species from the UAE (about 0.09) and only two species from Jordan (about 0.06 %). Fourteen of the identified species (14/32, about 43.0 %), so far, are endemic to Egypt: *Ammobaculites khargaensis*, *A. schwageri*, *Gaudryina ameeri*, *G. speijeri*, *Siphogaudryina africana*, *S. nekhlensis*, *S. strougoi*, *Verneuilina luxorensis*, *Dorothy sinaiensis*, *Marssonella haftensis*, *Pseudoclavulina farafraensis*, *Clavulina barnardi*. Eleven of these species (11/32, about 34 %) are recorded in both Egypt and UAE: *Bathysiphon paleocenicus*, *B. saidi*, *Miliammina kenawyri*, *Ammobaculites schwageri*, *Spiroplectinella paracarinata*, *Gaudryina limbata*, *G. elegantissima*, *Verneuilina aegyptiaca*, *V. karreri*, *Pseudoclavulina farafraensis*, and *Arenobulimina aegyptiaca*. Three of these species (3/32, about 6 %) are also endemic to Qatar.

*Spiroplectinella hamdani* (one of the two recorded UAE species) is recorded in Egypt (Anan, 2005), while

| Paleogene benthic foraminiferal | Tethyan localities |
|--------------------------------|-------------------|
| **Table 1. Palaeogeographic distribution of the Paleogene benthic foraminiferal taxa in the different Tethyan localities:** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
| Bathysiphon | paleocenicus | x | x | x | x | x | x | x | x | x |
| * | saidi | x | x | x | x | x | x | x | x | x |
| Orbulinelloides | arabicus | x | x | x | x | x | x | x | x | x |
| Miliammina | kenawyri | x | x | x | x | x | x | x | x | x |
| Ammonoceras | sp | x | x | x | x | x | x | x | x | x |
| Ammobaculites | coprolithiformis | x | x | x | x | x | x | x | x | x |
| * | khargaensis | x | x | x | x | x | x | x | x | x |
| Spiroplectinella | esnaensis | x | x | x | x | x | x | x | x | x |
| Plectina | emiratensis | x | x | x | x | x | x | x | x | x |
| Gaudryina | ameeri | x | x | x | x | x | x | x | x | x |
| * | elegantissima | x | x | x | x | x | x | x | x | x |
| * | limbata | x | x | x | x | x | x | x | x | x |
| * | speijeri | x | x | x | x | x | x | x | x | x |
| * | tellburmaensis | x | x | x | x | x | x | x | x | x |
| Siphogaudryina | africana | x | x | x | x | x | x | x | x | x |
| * | nekhlensis | x | x | x | x | x | x | x | x | x |
| * | strougoi | x | x | x | x | x | x | x | x | x |
| Verneuilina | aegyptiaca | x | x | x | x | x | x | x | x | x |
| * | karreri | x | x | x | x | x | x | x | x | x |
| * | luxorensis | x | x | x | x | x | x | x | x | x |
| Arenobulimina | aegyptiaca | x | x | x | x | x | x | x | x | x |
| Dorothia | sinaiensis | x | x | x | x | x | x | x | x | x |
| Marssonella | haftensis | x | x | x | x | x | x | x | x | x |
| Pseudoclavulina | farafraensis | x | x | x | x | x | x | x | x | x |
| lina | heiwaidyi | x | x | x | x | x | x | x | x | x |
| * | magiensis | x | x | x | x | x | x | x | x | x |
| Clavulina | barnardi | x | x | x | x | x | x | x | x | x |
| Textularia | fahmi | x | x | x | x | x | x | x | x | x |
| * | farafraensis | x | x | x | x | x | x | x | x | x |
| * | nilotica | x | x | x | x | x | x | x | x | x |
| * | schwageri | x | x | x | x | x | x | x | x | x |
the Jordanian *Gyroidinoides tellburmaensis* (one of three Jordanian species) is recorded outside Jordan in Tunisia (Speijer, 1994; Culver, 2003; Widmark & Speijer, 1997), Atlantic Ocean and Spain (Widmark & Speijer, 1997). Four Middle East species are recorded in Spain (*Spiroplectinella knebeli*, *Eouvigerina aegyptiaca*, *Cibicidoides pseudoacutus*, and *Gyroidinoides tellburmaensis*) and in Tunisia (*S. knebeli*, *E. aegyptiaca*, *G. Tellburmaensis*, and *C. abudurbensis*), but only 3 species in Atlantic Ocean (*E. aegyptiaca*, *C. pseudoacutus*, and *G. tellburmaensis*) and also 3 in Pakistan (*Tritaxia barakai*, *Pseudoclavulina farafraensis*, and *Eponides mariei*), 2 species in France (*C. abudurbensis* and *C. pseudoacutus*) and also in the Negev (*Verneuilina aegyptiaca* and *C. abudurbensis*), but only *E. aegyptiaca* from Indian Ocean.

As explained in the palaeogeographic map (Fig. 2), the distribution of the identified Maastrichtian species from the Middle East and surrounding area in the Tethys represent tropical-subtropical faunas.

### 4. PALAEOECOLOGY

Cushman (1949) regarded *Ammobaculites coprolithiformis* as a facies-index fossil for brackish littoral conditions in warm climates with high rainfall and high runoff. Cherif & El Deeb (1984) noted that arid climate at the close of the middle Eocene became markedly wetter and seems to have been accompanied by a cooling of the water temperature. Moreover, the climatic changes inferred from the Jabal Hafi t area (UAE) seems to have been widespread, at least in part of the Middle East. Anan (1995) noted that in the late Eocene time in the UAE and surrounding areas had been located in the tropical and warm-temperate region based on many faunal environmental elements. This interpretation is in accordance with the worldwide conclusions of Berggren (1978) and Moore *et al.* (1978).

### 5. CONCLUSIONS

The palaeontology, stratigraphy and palaeogeographic remarks are presented for 32 diagnostic agglutinated foraminiferal species described from the Paleogene rocks from Egypt, Jordan and the United Arab Emirates in the Middle East. The analysis of the Paleogene foraminiferal species of the study area in the Middle East led to the following conclusions:

1. Most of these identified species were erected from Egypt (27/32, about 84.00 %), and 9/27 of Egyptian species are erected by Said & Kenawy (1956), 8/27 after Anan (1994, 2002, 2008a, 2008b, 2012b), 7/27 after LeRoy (1953), 2/27 after Nakkady (1950, 1959), 2/27 after Schwager (1867, 1883), 1/27 after El-Dawy (2001).
2. Three of 32 species (about 9.00 %) from UAE were erected by Anan (2003).
3. Only two of 32 species (about 6.00 %) from Jordan were erected by Futyan (1976).
4. Cherif & El Deeb (1984) and Anan (1995) noted that the distribution of the identified Paleogene species from the Middle East represent tropical-subtropical fauna.
5. The unclosed recorded number of Paleogene agglutinated species in different localities in the Middle East may due to the lack of detailed study for these localities, different latitudes, land barriers and/or different paleoenvironmental conditions (depth, dissolved oxygen, salinity and temperature).

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