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Paleontology, stratigraphy, paleoenvironment and paleogeography of the seventy Tethyan Maastrichtian-Paleogene foraminiferal species of Anan, a review

Abstract

During the last four decades ago, seventy foraminiferal species have been erected by the present author, which start at 1984 by one recent agglutinated foraminiferal species *Clavulina pseudoparisensis* from Qusseir-Marsa Alam stretch, Red Sea coast of Egypt. After that year tell now, one planktic foraminiferal species *Plummerita haggagae* was erected from Egypt (Misr), two new benthic foraminiferal genera *Leroyia* (with its 3 species) and *Lenticuzonaria* (2 species), and another 18 agglutinated species, 3 porcelaneous, 26 Lagenid and 18 Rotaliid species. All these species were recorded from Maastrichtian and/or Paleogene benthic foraminiferal species. Thirty nine species of them were erected originally from Egypt (about 58 %), 17 species from the United Arab Emirates, UAE (about 25 %), 8 specie from Pakistan (about 11 %), 2 species from Jordan, and 1 species from each of Tunisia, France, Spain and USA. More than one species have wide paleogeographic distribution around the Northern and Southern Tethys, i.e. *Bathysiphon saidi* (Egypt, UAE, Hungary), *Clavulina pseudoparisensis* (Egypt, Saudi Arabia, Arabian Gulf), *Miliammina kenawyi, Pseudoclavulina hamdani, P. hewaidyi, Saracenaria leroyi* and *Hemirobulina bassiounii* (Egypt, UAE), *Tritaxia kaminskii* (Spain, UAE), *Orthokarstenia nakkadyi* (Egypt, Tunisia, France, Spain), *Nonionella haquei* (Egypt, Pakistan). Anan[1-5] suggested that the Egyptian and Pakistanian pelagic foraminiferal assemblage indicate an open connection to the Tethys and represents middle-outer neritic environment (100-200 m depth) and shows an affinity with Midway-Type Fauna (MTF). Seven out of the recorded species are believed here to be new: *Orbulinelloides sztrakosae, Repmanina mazeni, Psammolingulina bahri, Tritaxia kaminskii, Pseudoclavulina futyani, Pseudoclavulina youssefi* and *Ammomassilina misrensis*. The taxonomic consideration, phylogeny, stratigraphic values, paleoenvironment of these taxa are presented and discussed.

Keywords: paleontology, stratigraphy, planktic and benthic foraminifera, paleogeography, paleoenvironment, tethys

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Introduction

During the past four decades, the writer has been engaged in paleontology, stratigraphy and paleo-environmental investigations of the planktic and benthic foraminiferal Maastrichtian-Paleogene succession in some Southern Tethyan countries: Tunisia, Egypt, Jordan, UAE, Pakistan, and some Northern Tethyan countries: Spain and France (Figure 1). Most of the species have been erected from Egypt (one benthic genus, one planktic species, one recent species and many benthic foraminiferal species and subspecies, and also 17 species from UAE (Figure 2), and the other species from the other countries in the Southern and Northern Tethys. The taxonomic consideration and stratigraphic implication of the erected taxa are also presented and discussed.

Systematic paleontology

The taxonomy of Loeblich & Tappan[6] is followed here for sixty four benthic and one planktic foraminiferal species were erected by Anan (1984-2021) from Maastrichtian and/or Paleogene taxa, which including two genera: *Leroyia* (with its 3 species) and *Lenticuzonaria* (with its 2 species), and another 43 foraminiferal genera, which illustrated in the Plates (1, 2).

Order Foraminiferida Eichwald, 1830

Suborder Textulariina Delage & Hérouard, 1896

Superfamily Astrorhizacea Brady, 1881

Family Bathysiphonidae Avnimelech, 1952

Genus *Bathysiphon* Sars, 1872

Type species *Bathysiphon filiformis* Sars, 1872

***Bathysiphon saidi* (Anan)[7]** - (Pl. 1, fig. 1)

1994 *Rhabdammina saidi* Anan[7], p. 218, fig. 8. 1.

2005a *Bathysiphon saidi* (Anan)[8] - Anan, p. 19, pl. 1, fig. 2.

2007 *Bathysiphon saidi*; Ozsvárt,[9] p. 29, pl. 1, figs. 2, 3.

Remarks: This Bartonian-Priabonian species has an elongate test and wall constructed of firmly cemented coarse sand grains with rough exterior. The wide stratigraphic range of the Triassic-Holocene genus Bathysiphon differs from the Holocene *Rhabdammina* Sars[10] by its straight unbranched elongate tube. *B. saidi* originally described from Fayoum and Sinai of Egypt, and later also from the same stratigraphic

horizon of Jabal Hafit, United Arab Emirates (UAE) and Hungary (Ozsvárt)[9]. Anan[11] (in press) noted that the analysis of the tests of some Paleogene benthic foraminiferal species in some Tethyan localities in USA and other European countries (France, Italy, Hungary, Romania), as well as some Middle East countries (Egypt, Jordan, UAE) led to recognize some benthic foraminiferal homeomorphy, and one of them is presented between the Paleocene *Bathysiphon paleocenicus* El-Dawy[12] and Middle-Late Eocene *B. saidi* (Anan)[7].

Family Saccamminidae Brady, 1884

Subfamily Thurammininae Miklukho-Maklay, 1963

Genus *Orbulinelloides* Saidova, 1975

Type species *Orbulinelloides agglutinatus* Saidova, 1970

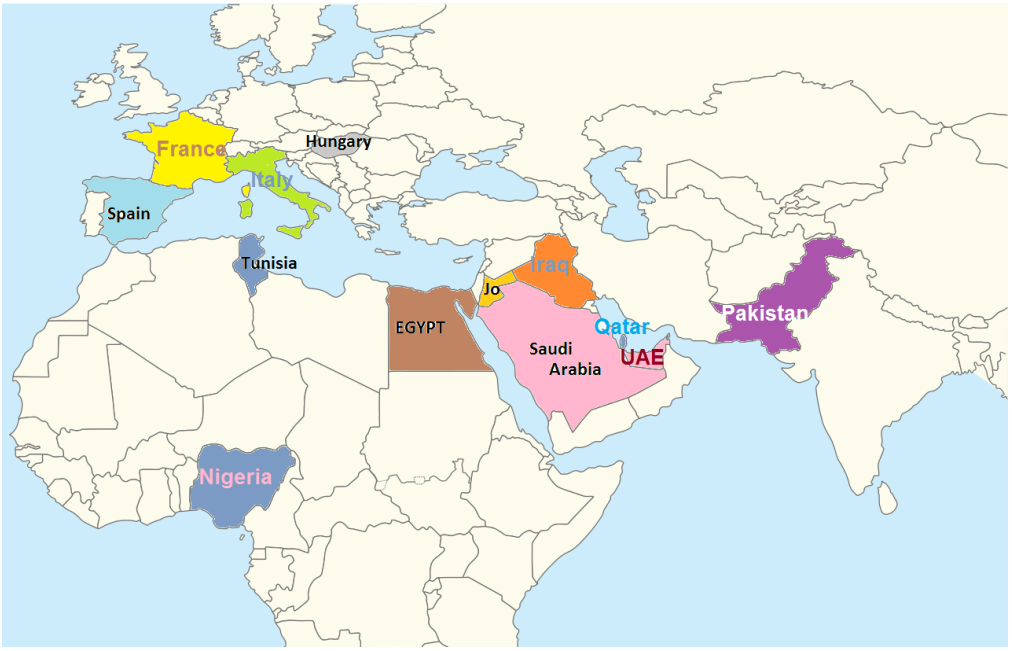

Figure 1 The geographic distribution of the identified foraminiferal species of Anan in the Northern Tethys (Spain, France, Italy, Hungary) and Southern Tethys (Tunisia, Nigeria, Egypt, Jordan, Iraq, Saudi Arabia, Qatar, United Arab Emirates, UAE and Pakistan).

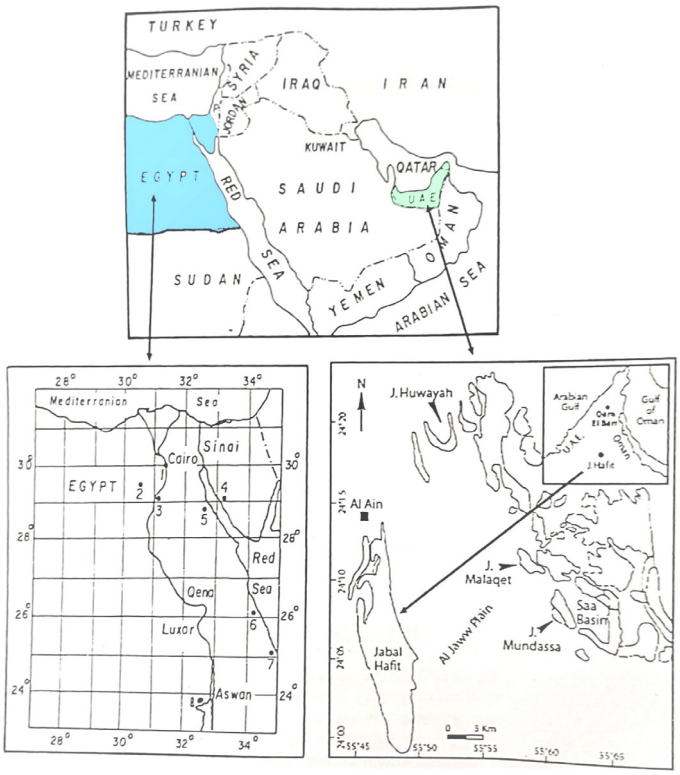

Figure 2 Location map of Egypt and UAE in the Southern Tethys. Egypt: 1. Greater Cairo, 2. Fayoum area, 3. Beni Suef, 4. Wadi Tayiba and Abu Zenima sections, 5. Wadi Ed Dakhl, 6. Duwi section, 7. Marsa Alam, 8. Southern Nile Valley. UAE: Jabal Hafit, J. Malaqet, J. Mundassa.

Citation: Anan HS. Paleontology, stratigraphy, paleoenvironment and paleogeography of the seventy Tethyan Maastrichtian-Paleogene foraminiferal species of Anan, a review. *J Microbiol Exp.* 2021;9(3):81–100. DOI: 10.15406/jmen.2021.09.00329

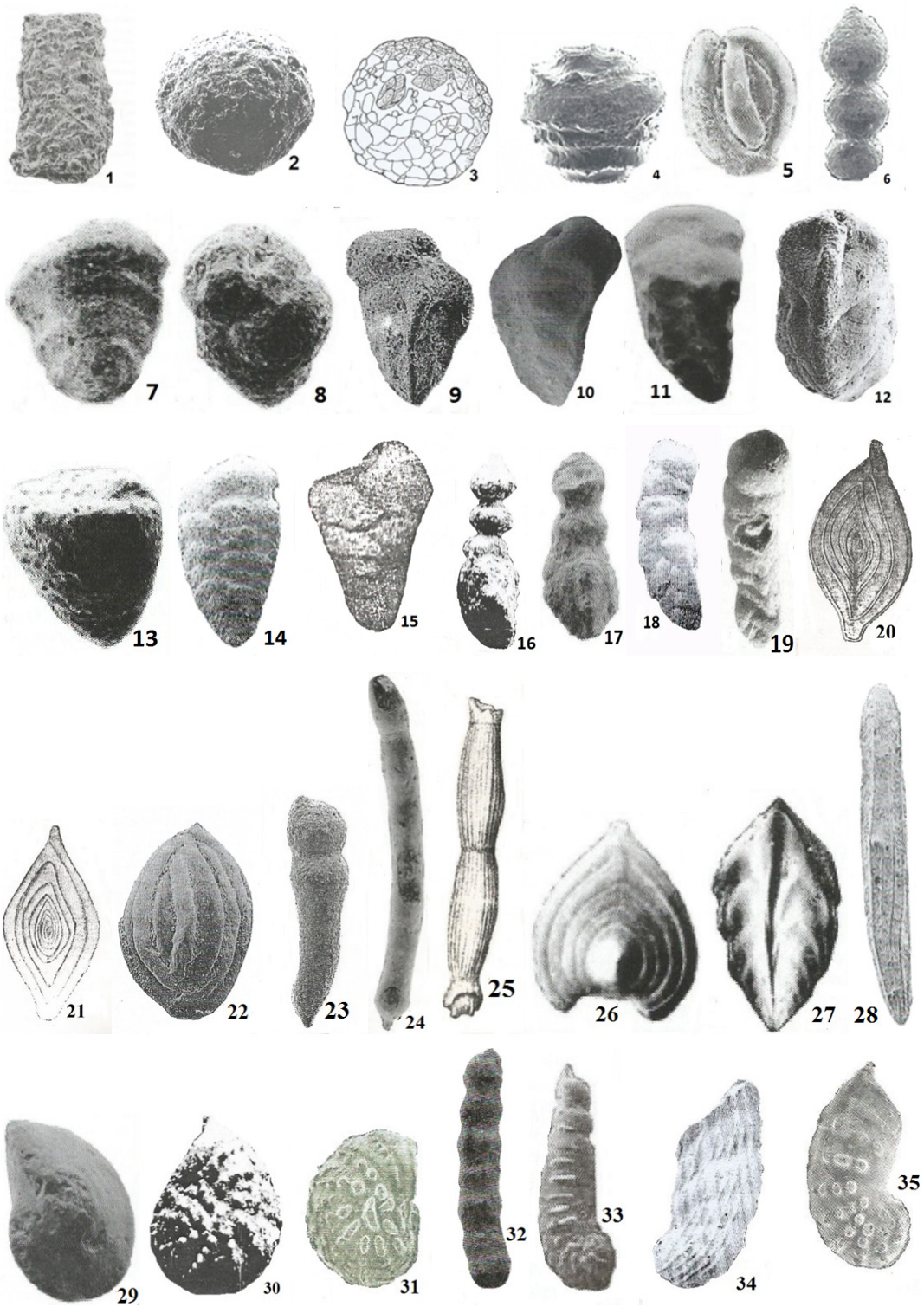

Plate 1 Fig. 1) *Bathysiphon saidi* (Anan, 2005) x 25, **2)** *Orbulinelloides arabicus* Anan, 2003 x 75, **3)** *Orbulinelloides sztrakosae* Anan**,** n. sp. x 25, **4)** *Repmanina mazeni* Anan, n. sp. x 35, **5)** *Miliammina kenawyi* Anan, 1994 x 45, **6)** *Psammolingulina bahri* Anan, n. sp. x 30, **7)** *Spiroplectinella hamdani* Anan, 1993 x 45, **8)** *Plectina emiratensis* Anan, 2003 x 60, **9)** *Gaudryina ameeri* Anan, 2012x50, **10)** *Gaudryina speijeri* Anan, 2012 x 60, **11)** *Siphogaudryina strougoi* Anan, 2002 x 15, **12)** *Tritaxia kaminskii* Anan, n. sp. x 30, **13)** *Marssonella hafitensis* Anan, 2003 x 70, **14)** *Textularia fahmyi* Anan, 1994 x 50, **15)** *Textularia haquei* Anan, 2020 x 40, **16)** *Pseudoclavulina futyani* Anan, n. sp. x 40, **17)** *Pseudoclavulina hewaidyi* Anan, 2008 x 45, **18)** *Pseudoclavulina youssefi* Anan, n. sp. x 12, **19)** *Clavulina pseudoparisensis* Anan, 1984 x 25, **20)** *Spiroloculina haquei* Anan, 2021, x 45, **21)** *Spiroloculina pakistanica* Anan, 2021, x 80, **22)** *Ammomassilina misrensis* Anan, n. sp. x 55, **23)** *Laevidentalina hudae* Anan, 2015 x 40, **24)** *Laevidentalina salimi* Anan, 2009 x 60, **25)** *Pyramidulina leroyi* Anan, 2020 x 40, **26)** *Annulofrondicularia bignoti* (Anan, 2002) x 75, **27)** *Tristix aubertae* Anan, 2002 x 80, **28)** *Amphimorphina youssefi* Anan, 1994 x 70, **29)** *Lenticulina ennakhali* Anan, 2010 x 80, **30)** *Lenticuzonaria hodae* Anan, 2021 x 35, **31)** *Lenticuzonaria misrensis* Anan, 2021 x 30, **32)** *Marginulinopsis emiratensis* Anan, 2010 x 25, **33)** *Percultazonaria abunnasri* Anan, 2015 x 55, **34)** *Percultazonaria alii* Anan x 45, **35)** *Percultazonaria allami* Anan, 2015 x 80.

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Plate 2 Fig. 36) *Percultazonaria ameeri* Anan, 2015 x 30, **37)** *Saracenaria leroyi* Anan, 1994 x 70, **38)** *Palmula ansaryi* Anan, 1994 x 25, **39)** *Palmula berggreni* Anan, 2001 x 30, **40)** *Palmula salimi* Anan, 2002 x 65, **41)** *Leroyia aegyptiaca* Anan, 2020 x 70, **42)** *Leroyia maqfiensis* Anan, 2020 x 60, **43)** *Leroyia tunisica* Anan, 2020 x 55, **44)** *Hemirobulina bassiounii* Anan, 1994 x 60, **45)** *Hemirobulina olae* Anan, 2015 x 45, **46)** *Marginulina karimae* (Anan, 2009) x 130, **47)** *Vaginulinopsis boukharyi* Anan, 2010 x 75, **48)** *Citharina plummerae* Anan, 2001 x 65, **49)** *Lagena rawdhae* Anan, 2020 x 100, **50)** Ramulina elkhoudaryi Anan, 2002 x 65, **51)** *Ramulina futyani* Anan, 2015 x 35, **52)** *Parafissurina pakistanica* Anan, 2021, x 50, **53)** *Plummerita haggagae* Anan, 2008 x 145, **54)** *Bolivinoides draco aegyptiaca* Anan, 2017 x 15, **55)** *Bolivinoides zikoi* Anan, 2011 x 75, **56)** *Turrilina hassani* Anan, 2010 x 75, **57)** *Hopkinsina haquei* Anan, 2020 x 30, **58)** *Euloxsostomum mouradi* Anan, 2011 x 80, **59)** *Orthokarstenia nakkadyi* Anan, 2009 x 85, **60)** *Uvigerina nakkadyi* Anan, 1994 x 70, **61)** *Ellipsoglandulina arafati* Anan, 2009 x 70, **62)** *Pleurostomella haquei* Anan, 2019 x 75, **63)** *Pleurostomella osmani* Anan, 2019 x 30, **64)** *Pleurostomella plummerae* Anan, 2019 x 75, **65)** *Nonionella haquei* Anan, 2019 x 100, **66)** *Anomalinoides leroyi* Anan, 2008 x 70, **67)** *Gyroidinoides luterbacheri* Anan, 2004 x 100, **68)** *Ornatanomalina ennakhali* Anan, 2011 x 45, **69)** *Ornatanomalina pakistanica* Anan, 2021 x 50, **70)** *Elphidium cherifi* Anan, 2010 x 85.

Citation: Anan HS. Paleontology, stratigraphy, paleoenvironment and paleogeography of the seventy Tethyan Maastrichtian-Paleogene foraminiferal species of Anan, a review. *J Microbiol Exp.* 2021;9(3):81–100. DOI: 10.15406/jmen.2021.09.00329

***Orbulinelloides arabicus* Anan[13] -** (Pl. 1, fig. 2)

2003 *Orbulinelloides arabicus* Anan,[13] p. 531, fig. 4. 1

2011a *Orbulinelloides arabicus*; Anan,[3] p. 52, pl. 1, fig. 2.

Remarks: This Bartonian-Priabonian species has spherical-subspherical coarsely agglutinated test, apertures flush with the surface. It was described from J. Hafit, UAE.

***Orbulinelloides sztrakosae* Anan, n. sp. -** (Pl. 1, fig. 3)

2000 *Psammosphaera* sp. Sztrákos,[14] p. 156, pl. 1, fig. 2.

Holotype: Illustrated specimen in Pl. 1, fig. 3 x 50.

Age: Ypresian-Lutetian.

Etymology: After the French micropaleontologist Prof. Károly Sztrákos.

Depository: The holotype is deposited in the private collection of Sztrákos, Adour Basin (Aquitaine, France).

Diagnosis: This species is characterized by its large spherical test, coarsely ill-sorted angular agglutinated wall with organic cement, aperture scattered over the entire surface.

Remarks: Loeblich & Tappan[6] treated the genus *Psammosphaera* of Hofker[15] as a junior synonym of the Silurian-Permian genus *Thurammina* of Brady[16], while Kaminski[17] treated the genus *Psammosphaera* of Schulze[18] as a separate genus. The figured form of Sztrákos treated here to belong to the genus *Orbulinelloides*. The latter genus has coarsely agglutinated grains with organic cement, and numerous scattered apertures on the entire surface without elevated on projection. This Early-Middle Eocene new species has an older stratigraphic occurrence than the Arabian Middle-Late Eocene *O. arabicus* Anan[13].

Superfamily Ammodiscacea Reuss, 1862

Family Ammodiscidae Reuss, 1862

Subfamily Uzbekistaniinae Vyalov, 1968

Genus *Repmanina* Suleymanov, 1966

Type species *Trochammina squamata* Jones & Parker var. *charoides* Jones & Parker, 1860

***Repmanina mazeni* Anan, n. sp. -** (Pl. 1, fig. 4)

2016 *Repmanina* sp. Anan,[19] p. 244, fig. 4.7.

Holotype: Illustrated specimen in Pl. 1, fig. 4.

Age: Danian.

Etymology: After my late cousin Mazen Anan.

Depositary: United Arab Emirates University, Geology Department, Anan collection (UAEUGD A40).

Diagnosis: This species has regular trochospiral coiled test about a straight axis formed a depressed crown-like coiled in outline, central part is wider than the start and end of its coiling, chambers have sharply edges, smooth finely agglutinated wall.

Remarks: This species differs from *R. charoides* by its regular trochoid test, sharply edges chambers, and younger stratigraphic occurrence. It also differs from *Glomospira gordialis* by its regular and depressed crown coiled in outline. It is, so far, an endemic to UAE.

Superfamily Rzehakinacea Cushman, 1933

Family Rzehakinidae Cushman, 1933

Genus *Miliammina* Heron-Allen & Earland, 1930

Type species *Miliammina oblonga* (Montagu) *arenacea* Chapman, 1916

***Miliammina kenawyi* Anan[7] -** (Pl. 1, fig. 5)

1994 *Miliammina kenawyi* Anan,[7] p. 218, fig. 8. 2.

2011a *Miliammina kenawyi*; Anan,[3] p. 53, pl. 1, fig. 3.

Remarks: This Bartonian-Briabonian species has fine agglutinated smooth wall with loose quinqueloculine arrangement test with half coil chambers. It was described from Fayoum area (Egypt), and from J. Hafit (UAE).

Superfamily Hormosinacea Haeckel, 1894

Family Hormosinidae Haeckel, 1894

Subfamily Cuneatinae Loeblich & Tappan, 1984

Genus *Psammolingulina* Silvestri, 1904

Type species *Lingulina papillosa* Neugeboren, 1904

***Psammolingulina bahri* n. sp. -** (Pl. 1, fig. 6)

2016 *Psammolingulina* sp. Anan,[19] p. 244, fig. 4.8.

Holotype: Illustrated specimen in Pl. 1, fig. 6.

Age: Danian.

Etymology: After the late micropaleontologist Dr. Salah Bahr, Islamic University-Gaza, Palestine.

Depository: United Arab Emirates University, Geology Department, Anan collection (UAEUGD A41).

Diagnosis: This species has an elongated rectilinear uniserial test, inflated globular three chambers, rounded periphery, depressed sutures, wall of coarse quartz particles giving a rough surface, terminal aperture.

Remarks: This species differs from the Miocene-Pliocene *P. papillosa* by its more inflated chambers, more depressed sutures, and older stratigraphic occurrence. It is, so far, an endemic to UAE.

Superfamily Spiroplectamminacea Cushman, 1927

Family Spiroplectamminidae Cushman, 1927

Subfamily Spiroplectammininae Cushman, 1927

Genus *Spiroplectinella* Kisel'man, 1972

Type species *Spiroplecta wrightii* Silvestri, 1903

***Spiroplectinella hamdani* (Anan)[1] -** (Pl. 1, fig. 7)

1993 *Spiroplectammina hamdani* Anan,[1] p. 652, pl. 1, fig. 14.

2005b *Spiroplectinella hamdani* (Anan) - Anan,[20] p. 79, pl. 1, fig. 2.

2011a *Spiroplectinella hamdani*; Anan,[2] p. 53, pl. 1, fig. 4.

Remarks: This Maastrichtian species has larger test, coiled stage and highly raised sutures than *S. knebeli* (LeRoy)[21]. It was originally described from the Maastrichtian of Qarn El Barr section, UAE (about

80 km north of J. Hafit) and, later on, from Wadi Ed Dakhl section, Egypt.

Superfamily Verneuilinacea Cushman, 1911

Family Prolixoplectidae Loeblich & Tappan, 1985

Genus *Plectina* Marsson, 1878

Type species *Gaudryina ruthenica* Reuss, 1851

***Plectina emiratensis* Anan[13] -** (Pl. 1, fig. 8)

2003 *Plectina emiratensis* Anan,[13] p. 534, fig. 4. 2.

2011a *Plectina emiratensis*; Anan,[2] p. 53, pl. 1, fig. 5.

Remarks: This Bartonian species has short subconical test, coarse-grained surface, subterminal and traverse elongate slit aperture on the apertural face of the last chambers and rather coarse-grained arenaceous wall. *P. emiratensis* was described from the J. Hafit, UAE.

Subfamily Verneuilininae Cushman, 1911

Genus *Gaudryina* d'Orbigny, 1839

Type species *Gaudryina rugosa* d'Orbigny, 1840

***Gaudryina ameeri* Anan[22] -** (Pl. 1, fig. 9)

2012 *Gaudryina ameeri* Anan[22], p. 63, pl. 1, fig. 7.

Remarks: This very distinct Early Eocene species has front craniate rib, which exists along the pre-final chamber of the biserial stage as well as the whole triserial portion, while it exists in the final chamber of the biserial stage and extends to the triserial stage. Anan[22] proposed that this Early Eocene species most probably evolved from the Maastrichtian-Paleocene *Gaudryina pyramidata* Cushman[23]. It is recorded from the Duwi section, Red Sea coast of Egypt. It is an excellent marker species for the in Egypt. It is, so far, an endemic to Egypt.

***Gaudryina speijeri* Anan[22] -** (Pl. 1, fig. 10)

1994 *Gaudryina* cf. *ellisorae* Cushman; Speijer,[24] p. 147, pl. 5, fig. 1.

2005 *Gaudryina* cf. *ellisorae*; Alegret et al.,[25] p. 531.

2012 *Gaudryina speijeri* Anan,[22] p. 66, pl. 1, fig. 10.

Remarks: According to Speijer[24] the carinate rib is very distinct in this Early Eocene species. It differs than the Later Cretaceous *Gaudryina (Pseudogaudryina) ellisorae* Cushman by its semiglobular last chamber with more circular aperture than the triangular last chamber with more elongate aperture. Moreover, the elongate and tapering final chamber with semicircular aperture at the apertural face in *G. ameeri* Anan differs from the semiglobular final chamber with circular aperture in the other G. speijeri Anan, but *G. speijeri* is longer and bigger test than *G. ameeri*. Anan[22] proposed that the Early Eocene *Gaudryina speijeri* species most probably evolved from the Maastrichtian-Paleocene *G. pyramidata* Cushman[25] in another direction of evolution than *G. ameeri*. *G. speijeri* is abundant in Sinai, Nile Valley and Red Sea coast of Egypt. It is an excellent marker species for the Early Eocene in Egypt. It is, so far, an endemic to Egypt.

Genus *Siphogaudryina* Cushman, 1935

Type species *Gaudryina stephensoni* Cushman, 1928

***Siphogaudryina strougoi* Anan[26] -** (Pl. 1, fig. 11)

2002b *Siphogaudryina strougoi* Anan[26], p. 141, fig. 2. 1.

2011a *Siphogaudryina strougoi*; Anan[2], p. 53, pl. 1, fig. 6.

Remarks: This Late Paleocene species has an elongate large test, greatest near the apertural end. Early stage triserial, tapering, triangular in cross section, later becoming biserial with nearly quadrangular section, has distinctive five longitudinal ridges running nearly parallel to the periphery and three out of them appear on the apertural view along the test. Wall arenaceous and smoothly finished. Sutures raised and transverse, basal aperture interiomarginal in the final chamber instead of subterminal on the apertural face. *S. strougoi* originally described from Wadi Ed Dakhl, Egypt.

Family Tritaxiidae Plotnikova, 1979

Genus *Tritaxia* Reuss, 1860

Type species *Textularia tricarinata* Reuss, 1844

***Tritaxia kaminskii* Anan, n. sp. -** (Pl. 1, fig. 12)

1993 *Tritaxia* sp. Kuhnt & Kaminski[27], p. 78, pl. 7, fig. 8.

1996 *Tritaxia* sp. Anan[19], p. 150, fig. 3. 7.

Holotype: Illustrated specimen of the holotype in Pl. 1, fig. 10a x 53.

Paratype: Pl. 1, fig. 10b x 45.

Age: Paleocene-Early Eocene.

Etymology: After Prof. M. Kaminski, King Fahd University of Petroleum and Minerals, Saudi Arabia (SA).

Depository: The paratype is deposited in the UAE University, Geology Department (UAEUGD A39).

Diagnosis: Test finely agglutinated smooth wall, triangular throughout with distinct angles, aperture rounded, terminal and central in the uniserial stage.

Remarks: The Early Eocene specimen *Tritaxia* sp. Anan[19] from UAE is closely related to the Early Paleocene *Tritaxia* sp. of Kuhnt & Kaminski[27] from the Basque Basin (Sopelana section) of Northern Spain, but has a shorter length, wider width and younger stratigraphic level.

Superfamily Textulariacea Ehrenberg, 1838

Family Eggerellidae Cushman, 1937

Subfamily Dorothiinae Balakhmatova, 1972

Genus *Marssonella* Cushman, 1933

Type species *Gaudryina oxycona* Reuss, 1860

***Marssonella hafitensis* Anan[13] -** (Pl. 1, fig. 13)

2003 *Marssonella hafitensis* Anan[13], p. 535, fig. 4. 3.

2011a *Marssonella hafitensis*; Anan[2], p. 54, pl. 1, fig. 7.

Remarks: This Bartonian-Priabonian species has conical test, nearly equal length and width, with subrounded early trochospiral stage, followed by a biserial stage of gradually increasing diameter, agglutinated of coarse grained wall, concave terminal face with low basal arch aperture. *M. hafitensis* was described from J.Hafit, UAE.

Family Textulariidae Ehrenberg, 1838

Subfamily Textulariinae Ehrenberg, 1838

Genus *Textularia* Defrance, 1824

Type species *Textularia sagittula* Defrance, 1824

***Textularia fahmyi* Anan[7] -** (Pl. 1, fig. 14)

1994 *Textularia fahmyi* Anan[7], p. 218, fig. 8. 3.

2002 *Textularia fahmyi*; Helal[29], p. 107, pl. 1. Fig. 3.

2007 *Textularia fahmyi*; Abd-Elshafy et al.[30], p. 103.

Remarks: This Bartonian-Priabonian species has large 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, about 8-10 pairs chambers increasing gradually in size as added, depressed sutures, arenaceous wall consists of fine sand grains, occasionally rosecolored. Low arched aperture at the base of the final chamber. *T. fahmyi* was described from the Fayoum and Sinai. It is, so far, an endemic to Egypt.

***Textularia haquei* Anan[31] -** (Pl. 1, fig. 15)

1956 *Textularia* sp. Haque[32], p. 32, pl. 9, fig. 10.

2020c *Textularia haquei* Anan[31], p. 3, pl. 1, fig. 6.

Remarks: This Paleocene species has 8-10 biserial enlarge chambers gradually increasing in size as added. This species is closely to *T. farafraensis* LeRoy[21], but differs by its smaller size, moderate coarse wall and recorded in an older stratigraphic level. Anan[31] considered the Paleocene *Textularia haquei* Anan as the ancestor of the descendent early Eocene *T. farafraensis* LeRoy.

Family Pseudogaudrynidiae Loeblich & Tappan, 1985

Subfamily Pseudogaudryniniae Loeblich & Tappan, 1985

Genus *Pseudoclavulina* Cushman, 1936

Type species *Clavulina clavata* Cushman, 1926

***Pseudoclavulina futyani* Anan, n. sp. -** (Pl. 1, fig. 16)

1976 *Clavulina barnardi* Futyan[33], p. 522, pl. 81, fig. 4 (*non* fig. 3).

Holotype: Illustrated specimen in Pl. 1, fig. 14 x 60.

Age: Danian.

Etymology: In the honor of Jordanian micropaleontologist Abdurrahman I. Futyan.

Depository: The holotype of this species (= the paratype Danian species *barnardi* of Futyan, Figure 4) is deposited in British Museum of Natural History (BMNH), P49101.

Diagnosis: This species has large triserial part and comprise one-half of the test, and the uniserial part has slightly irregular three flask-shaped inflated chambers, with rounded terminal at the end of tubular neck, and deeply excavated sutures.

Remarks: *P. futyani* n. sp. differs from *P. barnardi* (Futyan) in its larger triserial portion of *futyani* to be one-half of the entire test instead of one-fifth in *barnardi*, and three uniserial chambers in the former instead of five to eight chambers in the latter. It is, so far, an endemic to Jordan.

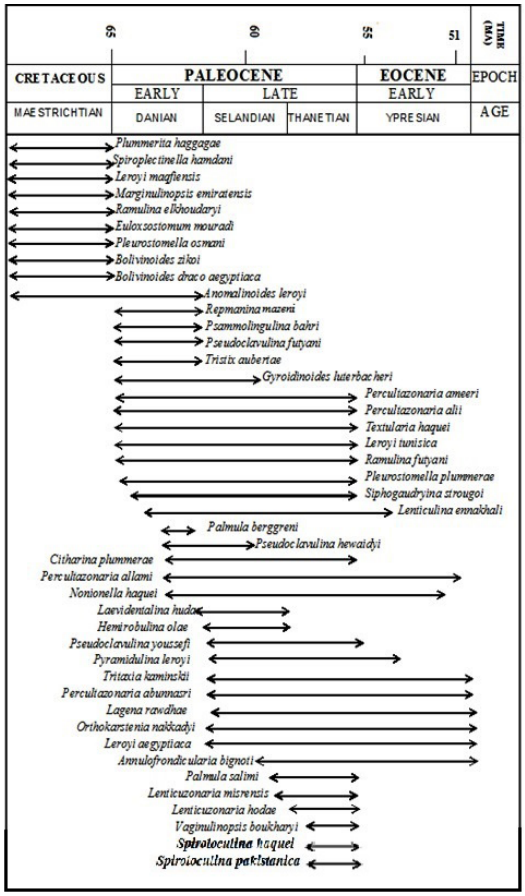

Figure 3 Stratigraphic ranges of the foraminiferal species of Anan in the Maastrichtian-Early Eocene.

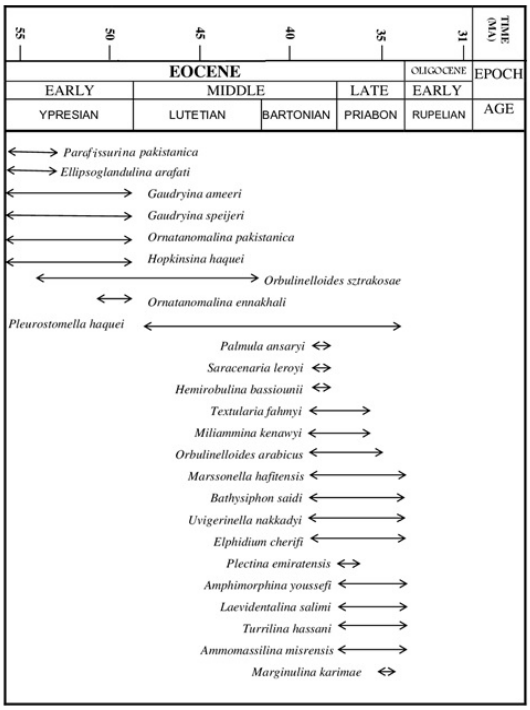

Figure 4 Stratigraphic ranges of the erected foraminiferal species of Anan in the Early-Late Eocene.

***Pseudoclavulina hewaidyi* Anan[34] -** (Pl. 1, fig. 17)

2008b *Pseudoclavulina hewaidyi* Anan[34], p. 248, pl.1, fig. 1.

2015a *Pseudoclavulina hewaidyi*; Anan[35], p. 249, fig. 4.21.

2017 *Pseudoclavulina hewaidyi*; Hewaidy et al.[36], p. 83, pl. 2, fig. 25,

Remarks: This Danian-Selandian species has distinctly large test, triserial stage and triangular in cross section, then discoidal chambers in the uniserial stage which circular in top view and strongly depressed sutures, finely arenaceous wall, terminal aperture. It was recorded from Abu Zenima section (Egypt), and J. Mundassa (UAE).

***Pseudoclavulina youssefi* Anan, n. sp. -** (Pl. 1, fig. 18)

2003 *Tritaxia* sp. Ali [37], pl. 3, fig. 14.

Holotype: Illustrated specimen in Pl. 1, fig. 9 x 120.

Age: Late Paleocene.

Etymology: In the honor of Egyptian micropaleontologist Prof. Mohammad Youssef Ali.

Depository: The holotype of this species is deposited in the private collection of the Prof. M. Youssef Ali, South Valley, University, Qena, Egypt.

Diagnosis: The triserial part is large and comprises one-half of the test, and the uniserial part has slightly three discoidal chambers, with rounded terminal aperture, and straight deep sutures.

Remarks: The genus *Pseudoclavulina* has triserial early stage and elongate uniserial one than the triangular test of both early triangular triserial portion and also later uniserial portion with carinate angles in the genus *Tritaxia*. The Danian *Pseudoclavulina futyani* n. sp. (from Jordan) differs from the Thanetian *P. youssefi* n. sp. (from Egypt) in the flask-shape uniserial chambers of the former than discoidal uniserial chambers of the latter.

Family Valvulinidae Berthelin, 1880

Subfamily Valvulininae Berthelin, 1880

Genus *Clavulina* d'Orbigny, 1826

Type species *Clavulina parisiensis* d'Orbigny, 1826

***Clavulina pseudoparisensis* Anan[38]** - (Pl. 1, fig. 19)

1984 *Clavulina pseudoparisensis* Anan[38], p. 239, pl. 1, figs. 6, 7.

1992 *Clavulina pseudoparisensis*; El Deeb[39], p. 193, pl. 1, fig. 8.

2015 *Clavulina tricarinata* d'Orbigny; Youssef[40], p. 244, figs. 12.1, 14.10.

Remarks: Test has triangular triserial stage and the early portion of the uniserial stage is triangular, but rounded in its later portion. Wall agglutinated, arenaceous with calcareous cement and aperture terminal with single tooth. It originally described from the littoral coast of the Red Sea of Egypt, and Arabian Gulf of the UAE by El Deeb[39]. The figured specimens of Youssef[40] from the Red Sea of Saudi Arabia are closely related to *C. pseudoparisensis.* Anan 2020a[41] suggested that this species most probably evolved from the Paleocene-Middle Eocene *Clavulina parisiensis*.

Suborder Miliolina Delage & Héroard, 1896

Superfamily Miliolacea Ehrenberg, 1839

Family Spiroloculinidae Wissner, 1920

Genus *Spiroloculina* d'Orbigny 1826

Type species *Spiroloculina depressa* d'Orbigny 1826

***Spiroloculina haquei* Anan[5]-** (Pl. 1, fig. 20)

1956 *Spiroloculina* sp. A, Haque[32], p. 153, pl. 34, fig. 3.

Remarks: This Late Paleocene porcelaneous species is characterized by its limbate sutures between the successive pair-chambers and thick final chamber periphery. It was recorded from Patala Shales, horizon B 26, Pakistan.

***Spiroloculina pakistanica* Anan[5] -** (Pl. 1, fig. 21)

1956 *Spiroloculina* sp. B, Haque[32], p. 60, pl. 28, fig. 10.

Remarks: This Late Paleocene porcelaneous species is characterized by its simple limbate sutures, less thick final chambers periphery than *S. haquei,* and more added pair-chambers in the test. It was recorded from Nammal Limestone and Shales, horizon B 79, Pakistan.

Family Hauerinidae Schwager, 1876

Subfamily Siphonapertinae Saidova, 1975

Genus *Ammomassilina* Cushman, 1933

Type species *Massilina alveoliniformis* Milleti, 1898

***Ammomassilina misrensis* Anan, n. sp. -** (Pl. 1, fig. 22)

1994 *Ammomassilina* sp. Anan[7], p. 219, fig. 8. 5.

2007 *Ammomassilina* sp.; Abd-Elshafy et al.[30], p. 104.

Holotype: Illustrated specimen in Pl. 1, fig. 18.

Age: Late Eocene.

Etymology: The Arabic name of Egypt.

Depositary: Geology Department, Ain Shams University, Cairo, Egypt (ASUGD A4).

Diagnosis: This species is characterized by its large test, more than 1 mm in length, chambers one-half coil in length, quinqueloculine early stage, later added on opposite sides, imperforated calcareous porcelaneous wall.

Remarks: The genus *Ammomassilina* was originally described from the Holocene in Pacific Ocean., but this species was recorded from the Late Eocene from Fayum area, Egypt.

Suborder Lagenina Delage & Hérouard, 1896

Superfamily Nodosariacea Ehrenberg, 1838

Family Nodosariidae Ehrenberg, 1838

Subfamily Nodosariinae Ehrenberg, 1838

Genus *Laevidentalina* Loeblich & Tappan, 1986

Type species *Laevidentalina aphelis* Loeblich & Tappan, 1955

***Laevidentalina hudae* Anan[35] -** (Pl. 1, fig. 23)

2015b *Laevidentalina hudae* Anan[35], p. 65, pl. 1, fig. 1.

Remarks: This Selandian species has apiculate proloculus, more widely cylindrical, less arcuate and ended by only two globular

chambers than three or more semiglobular chambers. It was recorded from J. Mundassa, UAE.

***Laevidentalina salimi* Anan[42] -** (Pl. 1, fig. 24)

2009a *Laevidentalina salimi* Anan[42], p. 3, pl. 1, fig. 2.

2011a *Laevidentalina salimi*; Anan[2], p. 55, pl. 1, fig. 11.

Remarks: This Middle-Late Eocene species has elongate and arcuate test with almost parallel sides and proloculus rounded and apiculate, hyaline wall with smooth surface, nearly cylindrical chambers and gradually grow, flush sutures and limbate in the most uniserial chambers but slightly depressed in the last chambers. This species was has more elongated test and less number of globular last two chambers than the Paleocene *L. hudae*. Anan[35] suggested that *L. salimi* may be evolved from the Paleocene *L. hudae*. On the other hand, Anan[44] proposed that *L. salimi* is most probably the youngest form of the Maastrichtian-Paleocene *L. granti* Plummer. *L. salimi* was described from J. Hafit, UAE.

Genus *Pyramidulina* Fornasini, 1894

Type species *Pyramidulina eptagona* Fornasini, 1894

***Pyramidulina leroyi* Anan[45] -** (Pl. 1, fig. 25)

1953 *Nodosaria* sp. LeRoy[21], p. 41, pl. 4, fig. 9.

2020b *Pyramidulina leroyi* Anan[45], p. 4, pl. 1, fig. 10.

Remarks: This Late Paleocene-Early Eocene species has extremely long chambers ornamented by 20-22 closely spaced ribs. It differs from the Paleocene *P. robinsoni* Futyan[33] by its longer elongated chambers than inflated and nearly globular uniserial chambers, which suggested by Anan[45] that the *P. robinsoni* most probably the ancestor of *P. leroyi.* It was recorded from Maqfi section, Farafra Oasis, Egypt.

Subfamily Frondicularriinae Reuss, 1860

Genus *Annulofrondicularia* Defrance, 1826

Type species *Frondicularia annularis* d'Orbigny, 1846

***Annulofrondicularia bignoti* (Anan)[41] -** (Pl. 1, fig. 26)

2002a *Frondicularia bignoti* Anan[41], p. 632, fig. 2. 2.

2011a *Frondicularia bignoti*; Anan[2], p. 55, pl. 1, fig. 12.

Remarks: This Late Paleocene species belongs here to the genus *Annulofrondicularia* due to its large proloculus followed by a low and completely encircling early chambers, later four chambers broad and equitant, not completely surrounding the base but overlapping at the margin. Slightly depressed suture. Terminal and protuberant aperture. Anan[45] suggested that the Late Paleocene *A. bignoti* with its smooth test and large proloculus, for uniform chambers is considering as the ancestor of the descendent Paleocene-Early Eocene *A. nakkadyi* (Futyan) throughout changing to larger test and more number uniserial chambers. It was described from Duwi section, Egypt.

Genus *Tristix* Macfadyen, 1941

Type species *Rhabdogonium liasinum* Berthelin, 1879

***Tristix aubertae* Anan[41] -** (Pl. 1, fig. 27)

2002a *Tristix auberti* Anan[41], p. 634, fig. 2. 6.

2007a *Tristix aubertae*; Anan[47], p. 304, pl. 1, fig. 2.

Remarks: This Danian species has triangular test face, flattened, concave triangular chambers and acute periphery. It was described from Duwi section, Egypt.

Subfamily Plectofrondicullariinae Cushman, 1927

Genus *Amphimorphina* Neugeboren, 1850

Type species *Amphimorphina haueriana* Neugeboren, 1850

***Amphimorphina youssefi* Anan[7] -** (Pl. 1, fig. 28)

1994 *Amphimorphina youssefi* Anan[7], p. 220, fig. 8. 7.

2011a *Amphimorphina youssefi*; Anan[2], p. 56, pl. 2, fig. 14.

Remarks: This Bartonian- Priabonian species has an elongate test, early portion frondicularian but nodosarian and semi-circular in the later part, sutures slightly arched in early part, but straight and horizontal at later part, sharply keeled periphery with three keels on either sides running at the whole length of the test, two supplementary raised costae are recognized in the early part on either side, aperture terminal and rounded. *A. youssefi* was described from the Bartonian of Fayoum, and later on from the Priabonian of J. Malaqet (UAE).

Family Vaginulindae Reuss, 1860

Subfamily Lenticulinidae Chapman, Parr & Collins, 1934

Genus *Lenticulina* Lamarck, 1804

Type species *Lenticulina rotulatus* Lamarck, 1804

***Lenticulina ennakhali* Anan[47] -** (Pl. 1, fig. 29)

2010a *Lenticulina ennakhali* Anan[47], p. 20, fig. 2.

2011a *Lenticulina ennakhali*; Anan[2], p. 56, pl. 2, fig. 15.

Remarks: This Paleocene-Early Eocene species has elongate test with gradually added 7-10 smooth chambers, acute periphery with faint keel, curved flush sutures, radial aperture at the apex of a tapering elongate septal face. The most outstanding characteristics which differntiate of the *L. ennakhali* from the other species of the genus *Lenticulina* are the tapering last chamber in an elongate test, flush sutures and sharp periphery with faint keel. It was originally described from Dakhla Shale of Abu Zenima section, Sinai, Egypt.

Genus *Leticuzonaria* Anan, 2021

Type species *Leticuzonaria hodae* Anan, 2021

***Leticuzonaria hodae* Anan[48]-** (Pl. 1, fig. 30)

2021b *Lenticuzonaria hodae* Anan[48], p. 33, pl. 1, fig. 3.

Remarks: This Late Paleocene species has planispirally enrolled symmetrical test, calcareous hyaline perforated wall, spinose ornamented surface and periphery, elevated sutures with a row of nodes broken sutures with a row of tubercles, aperture radial at the peripheral angle, commonly slightly produced.

***Leticuzonaria misrensis* Anan[48]** - (Pl. 1, fig. 31)

2021b *Lenticuzonaria misrensis* Anan[48], p. 33, pl. 1, figs. 5-8.

Diagnosis: This species has planispirally enrolled symmetrical test, calcareous hyaline perforated wall, surface ornamented by elevated sutures with a row of tubercles or broken into a row of nodes along the sutures that become progressively more prominent, aperture radial at the peripheral angle, commonly slightly produced. It differs from *L. hodae* by lacking spinose surface, and from the *Marginulinopsis tuberculata* (Plummer)[49] by its planispirally test than planispiral to uniserial test.

Genus *Marginulinopsis* Silvestri, 1904

Type species *Cristellaria bradyi* Goës, 1894

***Marginulinopsis emiratensis* Anan[1], 1993 -** (Pl. 1, fig. 32)

1993 *Marginulinopsis emiratensis* Anan[1], p. 657, pl. 2, fig. 12.

2011a *Marginulinopsis emiratensis*; Anan[2], p. 58, pl. 2, fig. 16.

Remarks: This Late Maastrichtian species has an elongate, rectilinear to gently arcuate test and initial portion planispirally coiled followed by 5-7 inflated chambers, calcareous hyaline finely perforated wall, smooth surface, depressed sutures, terminal aperture and radiate with neck. *M. emiratensis* was described from Qarn El Barr section, Al Dhayd area (about 80 km north of J. Hafit), UAE.

Genus *Percultazonaria* Loeblich & Tappan, 1968

Type species *Cristellaria subaculeata* Cushman, 1923

***Percultazonaria abunnasri* Anan[50] -** (Pl. 1, fig. 33)

2015a *Percultazonaria abunnasri* Anan[50], p. 16, pl. 1, fig. 1.

Remarks: The Paleogene genus *Percultazonaria* was recorded from Holocene, but it now ranges from Cretaceous to Holocene. The Paleocene-Middle Eocene *P. abunnasri* has elongate compressed test, with raised costate ridges in the closed coiled early portion, five-six erected chambers uncoiled portion slightly increasing in size as added, sutures distinct and raised strait, surface ornamented by broken row of ridges, periphery erected with a narrow keel, aperture at the peripheral margin. It was recorded from Wadi Tayiba section, Sinai of Egypt.

***Percultazonaria alii* Anan[50] -** (Pl. 1, fig. 34)

2003 *Marginulina* sp.- Ali[37], pl. 6, fig. 1.

2015a *Percultazonaria alii* Anan[50], p. 16, pl. 1, fig. 2.

Remarks: This Paleocene species has elongate and compressed test, early portion closed coiled, later uncoiled portion is slightly increasing in size as added, sutures gently curved, wall smooth, surface ornamented by ridges running continuously throughout the test and not interrupted at the sutures, periphery slightly convex with a narrow keel, aperture at the peripheral margin. It is characterized by running ridges along the two portions of the test, which differs from E. Eocene *P. longiscata* of Nakkady by its interrupted ridges at sutures. The more breadth test and raised ridges running across the sutures of Sweden Paleocene *A. paleocenicus* Brotzen which often interrupted over the sutures, make it differs from *P. alii.*

***Percultazonaria allami* Anan[50] -** (Pl. 1, fig. 35)

2011 *Percultazonaria cristobalensis* Aly- Aly et al.[51], p. 92, pl. 3, fig. 3.

2015a *Percultazonaria allami* Anan[50], p. 17, pl. 1, fig. 3.

Remarks: This Paleocene-Middle Eocene species has closed coiled initial portion of the test, but elongate 4-5 chambers in inclined uncoiled portion, ornamented by sporadic numerous well-defined nodes, periphery slightly convex with a narrow keel, aperture on neck at peripheral margin. It characterized by its inner margin slightly curved, while the outer margin is curved with keel. It was recorded from north Nile Valley, Egypt.

***Percultazonaria ameeri* Anan[50] -** (Pl. 2, fig. 36)

1953 *Marginulinopsis* sp. - LeRoy[21], p. 39, pl. 4, figs. 6, 7.

2003 *Marginulinopsis tuberculata* (Plummer)[49] - Ali, pl. 5, fig. 25 (non 23, 24, 26, 27).

2015a *Percultazonaria ameeri* Anan[50], p. 17, pl. 1, fig. 4.

Remarks: This Paleocene species has large test, early portion closed coiled and making up about the third of test, later portion uncoiled, slightly increasing in size as added and gently curved and nearly circular in cross section, sutures gently curved, surface ornamented by sporadic numerous well-defined nodes running continuously throughout the test, periphery subrounded. It can be recognized by its large size test, and conspicuous sutural nodes along the coiled and inclined uniserial portions of the test. Anan[41] considered *P. ameeri* as the ancestor of *P. allami. P. ameeri* was recorded from Maqfi section, Western Desert, Egypt.

Genus *Saracenaria* Defrance, 1824

Type species *Saracenaria italic* Defrance, 1824

***Saracenaria leroyi* Anan[7] -** (Pl. 2, fig. 37)

1994 *Saracenaria leroyi* Anan[7], p. 222, fig. 8. 14, 15.

2011a *Saracenaria leroyi*; Anan[2], p. 58, pl. 2, fig. 18.

Remarks: This Bartonian-Priabonian species has planispiral test, enrolled in the early stage, later flaring and triangular in cross section, dorsal side with the coiled portion acute, flush surface, broad and flat apertural face, small aperture at the periphery angle and radiate, hyaline and smooth wall. *S. leroyi* was described from the Bartonian of Fayoum and Sinai of Egypt, and later on, it is recorded from J. Hafit, UAE.

Subfamily Palmulinae Saidova, 1981

Genus *Palmula* Lea, 1833

Type species *Palmula sagittaria* Lea, 1833

***Palmula ansaryi* Anan[7] -** (Pl. 2, fig. 38)

1994 *Palmula ansaryi* Anan[7], p. 222, fig. 8. 14, 15.

1998 *Palmula ansaryi*; Hussein[52], p. 206, fig. 2a.

2002 *Palmula ansaryi;* Helal[27], p. 114, pl. 2, fig. 6.

2011 *Palmula ansaryi;* Aly et al.[51], p. 94, pl. 3, fig. 8.

Remarks: This Bartonian species has large palmate test, small coiled stage, while the height and width in the uniserial stage has eight to twelve chevron-shaped chambers, sutures slightly rose, smooth surface, but with one or more raised ribs in the coiled stage, terminal and radial aperture. It was recorded from Fayum, and Greater Cairo and Bani Suef of Egypt.

***Palmula berggreni* (Anan)[53]** - (Pl. 2, fig. 39)

2001 *Planularia berggreni* Anan[53], p. 138, pl. 1, fig. 2.

2011a *Planularia berggreni*; Anan[2], p. 62, pl. 3, fig. 31.

Remarks: Loeblich & Tappan[6] considered the genus *Planularia* as a junior synonym of the genus *Palmula,* which is accepted here. The Danian *P. berggreni* has large compressed test, quite sides, semicircular in outline, chambers increasing very gradually in size, sutures extending backward*,* raised and beaded in the umbilical area but depressed in the last chambers, surface smooth except for the raised sutures, slit-like aperture at the peripheral angle. It was recorded from Duwi section, Egypt.

***Palmula salimi* Anan[42]** - (Pl. 2, fig. 40)

2002a *Palmula salimi* Anan[42], p. 636, fig. 2. 7.

2011a *Palmula salimi*; Anan[2], p. 59, pl. 2, fig. 20.

Remarks: This Thanetian species has large elongate palmate test with greatest width toward the middle, semi-circular early planispiral stage, while the rhomboidal uniserial stage has four to seven broad chevron-shaped chambers, slightly depressed suture, terminal aperture, truncated periphery and irregular in distal part of the test, hyaline with smooth surface wall. *P. salimi* was originally described from Duwi section, Egypt.

Subfamily Marginulininae Wedekind, 1937

Genus *Leroyia* Anan, 2020

Type species *Leroyia aegyptiaca* Anan, 2020

***Leroyia aegyptiaca* Anan[54] -** (Pl. 2, fig. 41)

1953 *Marginulina* sp. LeRoy[21], p. 38, pl. 8, fig. 8.

2020e *Leroyi aegyptiaca* Anan[54], p. 55, pl. 1, fig. 8.

Remarks: This Late Paleocene-Early Eocene has small test, early coiled stage minute indistinct, later uniserial four chambers inflated increasing in length as added, sutures slightly depressed and moderately oblique, peripheral margins rounded, surface smooth, aperture radiate extended at dorsal angle. This species differs from *L. glabra* (d'Orbigny) by its smaller size and number of the uniserial chambers, more lobulate periphery, more perforate test, and different stratigraphic age. It was recorded from Maqfi section, Farafra Oasis, Egypt.

***Leroyia maqfiensis* Anan[54] -** (Pl. 2, fig. 42)

1953 *Marginulina* sp. LeRoy, p. 39, pl. 10, fig. 24.

2020e *Leroyi maqfiensis* Anan, p. 55, pl. 1, fig. 10.

Remarks: This Maastrichtian species has large test, coiled early portion, and uncoiled later portion at least six chambers increasing in size very slightly as added, sutures slightly curved, dorsal periphery subacute, ventral margin concave, wall smooth, aperture radial at outer periphery angle. It differs from *L. aegyptiaca* by its larger test size and larger uniserial chamber numbers. It was recorded from Maqfi section, Farafra Oasis, Egypt.

***Leroyia tunisica* Anan[54] -** (Pl. 2, fig. 43)

1975 *Marginulina* sp. Berggren & Aubert[55], p. 177, pl. 16, fig. 1.

2020e *Leroyia tunisica* Anan[54], p. 56, pl. 1, fig. 13.

Remarks: This Paleocene species has large smooth test, early stage slightly coiled, later stage uniserial rectilinear, sutures slightly oblique and depressed, aperture radiate at the dorsal angle on neck. It differs from *L. aegyptiaca* by its more elongate test, less lobulate periphery and protrude aperture. It was recorded from Tunisia.

Genus *Hemirobulina* Stache, 1864

Type species *Cristellaria (Hemirobulina) arcuatula* Stache, 1864

***Hemirobulina bassiounii* Anan[7] -** (Pl. 2, fig. 44)

1994 *Hemirobulina bassiounii* Anan[7], p. 223, fig. 8. 16.

2017 *Hemirobulina bassiounii*; Hewaidy et al.[36], p. 85, pl. 3, fig. 30.

Remarks: This Bartonian species has large elongate test, circular in cross section, four to six chambers closely coiled and rapidly increasing in size as added in a slight curve at the base, but later becoming rectilinear, the last globose chamber occupies about ⅔ of the test, slightly depressed sutures, radiate aperture on neck at the pointed end of the apertural face, hyaline wall with smooth surface. The middle Eocene *Hemirobulina bassiounii* Anan[7] and the Oligocene-Miocene *H. hantkeni* (Bandy) has another example of benthic homeomorphy as noted by Anan[11]. *H. bassiounii* was originally described from Fayoum, Egypt, and also of J. Hafit, UAE.

***Hemirobulina olae* Anan[43] -** (Pl. 2, fig. 45)

2015b *Hemirobulina olae* Anan[43], p. 71, pl. 1, fig. 8.

Remarks: This Selandian species has elongate and arcuate smooth test, inflated numerous closely coiled chambers added in a slight curve at the base, later becoming rectilinear, circular in cross section and terminal aperture. It differs from *H. bassiounii* by its more inflated test and circular cross section, more rounded periphery and younger stratigraphic level. It was described from J. Mundassa, UAE.

Genus *Marginulina* d'Orbigny, 1826

Type species *Marginulina raphanus* d'Orbigny, 1826

***Marginulina karimae* (Anan)[42]** - (Pl. 1, fig. 46)

2009a *Marginulinopsis karimae* Anan[42], p. 6, pl. 1, fig. 8.

2011a *Marginulinopsis karimae*; Anan[2], p. 58, pl. 2, fig. 17.

Remarks: The Late Eocene *M. karimae* is characterized by its slightly coiled initial stage (not completely enrolled as in *Marginulinopsis*), later part uniserial with inflated chambers, surface with 20-22 longitudinal costae, extended over the sutures, straight and depressed sutures in the uniserial part but indistinct in the initial part, aperture terminal on a short and wide neck. The late Eocene *Marginulina karimae* (Anan) and the Pleistocene *M. coarctata* Silvestri represent another example of homeomorphy in benthic foraminifera as noted by Anan[11]. It was recorded, so far, from J. Hafit, UAE.

Genus *Vaginulinopsis* Silvestri, 1904

Type species *Vaginulina soluta* Silvestri var. *carinata* Silvistri, 1898

***Vaginulinopsis boukharyi* Anan[56] -** (Pl. 2, fig. 47)

2010b *Vaginulinopsis boukharyi* Anan[56], p.30, pl. 1, fig. 12.

2011a *Vaginulinopsis boukharyi*; Anan[2], p. 59, pl. 2, fig. 22.

Remarks: This Late Paleocene species has large test, early stage planispirally enrolled and involutes, but later uncoiled with gradually increased chambers, laterally compressed, dorsal margin commonly straight, ventral margin curved, septa horizontal slightly thickened and raised, surface smooth other than the elevated septa, terminal aperture at the dorsal end. It was recorded from Duwi section, Egypt.

Subfamily Vaginulininae Reuss, 1860

Genus *Citharina* d'Orbigny, 1839

Type species *Vaginulina (Citharina) strigillata* Reuss, 1846

***Citharina plummerae* Anan[53] -** (Pl. 2, fig. 48)

2001 *Citharina plummerae* Anan[53], p. 135, pl. 1, fig. 1.

2017 *Citharina plummerae;* Hewaidy et al.[36], p. 85, pl. 3, fig. 22.

Remarks: This Paleocene species characterized by its wing-shaped flattened test with thin acuminates, globular to ovate proloculus and later uniserial chambers increasing gradually in breadth. Wall hyaline with numerous regular spaced longitudinal striae parallel to

the direction of growth, raised oblique suture and somewhat curved, protruding aperture at the dorsal angle. It originally described from Duwi section, Egypt.

Family Lagenidae Reuss, 1862

Genus *Lagena* Walker & Jacob, 1798

Type species *Serpula (Lagena) sulcata* Walker & Jacob, 1798

***Lagena rawdhae* Anan[57] -** (Pl. 2, fig. 49)

2020b *Lagena rawdhae* Anan[57], p. 5, pl. 1. 23.

Remarks: This Late Paleocene-Early Eocene species has nearly subglobular unilocular test, slightly longer than broad, surface ornamented with about 30 longitudinal costae covering only about two-thirds of the surface, extended neck with phialine lip. It differs from *L. sulcata* by its not extended ribs all over the test-surfsce. It was recorded from Duwi section, Egypt.

Family Polymorphinidae D'Orbigny, 1839

Subfamily Ramulininae Brady, 1884

Genus *Ramulina* Jones, 1875

Type species *Ramulina laevis* Jones, 1875

***Ramulina elkhoudaryi* Anan[26] -** (Pl. 3, fig. 50)

2002b *Ramulina elkhoudaryi* Anan[26], p. 143, fig. 2. 2.

2011a *Ramulina elkhoudaryi;* Anan[2], p. 60, pl. 2, fig. 24.

Remarks: This Maastrichtian species has globular chamber with seven stout tubular arms and five out of them radiating on the central part of the chamber, while the other two arms are nearly perpendicular from the two ends (poles) of the surface, wall calcareous and finally perforated, surface smooth with some scattered small projections. *R. elkhoudaryi* originally described from Abu Zenima section, Sinai of Egypt.

***Ramulina futyani* Anan[35] -** (Pl. 3, fig. 51)

2015b *Ramulina futyani* Anan[35], p. 72, pl. 1, fig. 11.

Remarks: This Paleocene species is characterized by its globose test with hispid surface and only one stout arm. It differs from *R. elkhoudaryi* by its hispid surface than smooth, one stout arm than four perpendicular arms and younger stratigraphic level. It was recorded, so far, from J. Mundassa, UAE.

Family Ellipsolagenidae Silvestri, 1923

Subfamily Parafissurininae Jones, 1984

Genus *Parafissurina* Parr, 1947

Type species *Lagena ventricosa* Silvestri, 1904

***Parafissurina pakistanica* Anan[5]-** (Pl. 3, fig. 52)

Remarks: This Early Eocene species is characterized by its unilocular globular smooth test with double periphery keels, oval hooded subterminal crescentic aperture at a test apex which consisting of radial arranged slits that lead through channels to the interior. It was recorded from the basal Laki Formation, horizon B-56, Pakistan.

Suborder Globigerinina Delage & Hérouard, 1896

Superfamily Rugoglobigerinacea El Nakhal, 2002

Family Rugoglobigerinidae Subbotina, 1959

Genus *Plummerita* Brönnimann, 1952

Type species *Rugoglobigerina (Plummerella) hantkeninoides* subspecies *hantkeninoides* Brönnimann, 1952

***Plummerita haggagae* Anan[34] -** (Pl. 3, fig. 53)

2008 *Plummerita haggagae* Anan[34], p. 249, pl. 1, figs. 2, 3.

2011a *Plummerita haggagae*; Anan[2], p. 60, pl. 3, fig. 25.

2012 *Plummerita haggagae;* Anan[58], p. 594, pl. 1, figs. 5, 6.

Remarks: This latest Maastrichtian planktic species has well separated peripheral four inflated stellate chambers in low trochospiral volution. The three penultimate chambers elongate in radial direction with axially situated spines, while the forth end one doesn't possess a spine with deep umbilicus and strongly rugose surface. It differs from other species of the genus *Plummerita* by its only four-chambered volution in the last whorl, radial ridges and axially pointed spine-like prolongation for the three penultimate chambers, but without spine of the last fourth chamber. It seems that the figured specimens with four-chambered volution of the Maastrichtian *P. hantkeninoides* of Ziko et al.[59] from Sinai, and Keller[60] from Gabal Qreiya in central Egypt conspecific with the *P. haggagae*, which originally described from Duwi section, Egypt.

Suborder Rotaliina Delage & Hérouard, 1896

Superfamily Bolivinacea Glaessner, 1937

Family Bolivinoididae Loeblich & Tappan, 1984

Genus *Bolivinoides* Cushman, 1927

Type species *Bolivina draco* Marsson, 1878

***Bolivinoides draco aegyptiacus* Anan[61] -** (Pl. 3, fig. 54)

2017a *Bolivinoides draco aegyptiacus* Anan[61], p. 3, pl. 1, fig 1.

Remarks: This Late Maastrichtian species is characterized by its small test, well-developed two divergent longitudinal ribs along the smooth surface, as well as another one rib in the central part between them, aperture has narrow arched at the base of last formed chamber. It differs from the other members of *B. draco* group (*B. d. draco and B. d. dorreeni*) by its no reticulate ornamented surface. Anan[61] noted that the Early Maastrichtian *B. miliaris* is not related to the *B. draco* group.

***Bolivinoides zikoi* Anan[62] -** (Pl. 3, fig. 55)

2011b *Bolivinoides zikoi* Anan[62], p. 140, pl. 1, fig. 11.

Remarks: This Late Maastrichtian species is characterized by its rather broad test, acute periphery, narrow arched aperture at the base of the last chamber, and differs from other members of the genus *Bolivinoides* by its discontinuously irregular rows of raised oblong lobes. It was recorded from Wadi Ed Dakhl section, Egypt.

Superfamily Turrilinacea Cushman, 1927

Family Turrilinidae Cushman, 1927

Genus *Turrilina* Andreae, 1884

Type species *Turrilina alsatica* Andreae, 1884

***Turrilina hassani* Anan[63] -** (Pl. 3, fig. 56)

2010a *Turrilina hassani* Anan[63], p. 160, pl. 1, fig. 3.

2011a *Turrilina hassani*; Anan[2], p. 61, pl. 3, fig. 26.

Remarks: This Middle-Late Eocene species has an ovoid test, the last three chambers consists about 9/10 time of the whole test, trochospiral enrolled in the early stage but later triserial with rapidly enlarging and inflated chambers strongly overlapping those preceding, sutures depressed, surface smooth, aperture has large an opposite v-shaped opening at the interiomarginal part of the last chamber. *T. hassani* differs from other *Turrilina* spp. by its opposite v-shaped aperture at the interiomarginal of the last chamber. It was recorded from J. Hafit, UAE.

Family Stainforthiidae Reiss, 1963

Genus *Hopkinsina* Howe & Wallace, 1932

Type species *Hopkinsina danvillensis* Howe & Wallace, 1932

***Hopkinsina haquei* Anan[45] -** (Pl. 3, fig. 57)

1956 *Hopkinsina* sp. Haque[32], p. 138, pl. 28, fig. 9.

2020c *Hopkinsina haquei* Anan[45], p. 4, pl. 1, fig. 16.

Remarks: This species has triserial initial portion, followed by uniserial chambers, smooth surface, wide opening terminal aperture with lip. Anan[45] suggested that the Maastrichtian *H. arabina* Futyan most probably evolved to the Early Eocene *H. haquei.* It was recorded from Nammal Shale and Limestone, Pakistan.

Superfamily Buliminacea Jones, 1875

Family Siphogenerinoididae Saidova, 1981

Subfamily Siphogenerinoidinae Saidova, 1981

Genus *Euloxsostomum* McCulloch, 1077

Type species *Loxostoma instabile* Cushman & McCulloch, 1942

***Euloxsostomum mouradi* Anan[64] -** (Pl. 3, fig. 58)

2011c *Euloxsostomum mouradi* Anan[64], p. 303 , pl. 1, fig. 9.

Remarks: This Late Maastrichtian species has elongate text, compressed, chambers enlarged rapidly, small alternated biserial early stage but finally rhomboid uniserial chambers which consists the most test, sutures depressed, surface smooth, aperture an elongate terminal slit with a distinct bordering lip. It has a perpendicular successive enlarged uniserial chambers as added without short spine at the basal part of the test, whlie the Pliocene-Holocene holotype *Loxostoma instabile* from Pacific, off Mexico, off California and Japan (in Loeblich & Tappan[6]) has cuneate and alternated uniserial chambers, which nearly have the same size in parallel periphery with its basal short spine. It was recorded from the Wadi Ed Dakhl section, west Gulf of Suez, Egypt.

Subfamily Tubulogenerininae Saidova, 1981

Genus *Orthokarstenia* Dietrich, 1935

Type species *Orthocerina ewaldi* Karsten, 1858

***Orthokarstenia nakkadyi* Anan[56] -** (Pl. 3, fig. 59)

1998 Transitional form between *O. higazyi* (Nakkady) and *O. eleganta* (Plummer) - Anan[66], p. 368, fig. 3.8.

2009b *Orthokarstenia nakkadyi* Anan[65], p. 37, pl. 1, fig. 7.

2014 *Orthokarstenia nakkadyi* Anan[67], p. 69, pl. 1, figs. 7-12.

Remarks: This Selandian-Lutetian species has longitudinal costae only in the lower half of the test, while it is smooth without ornamentation in the upper half test. The cosmopolitan Paleocene-Early Eocene species *O. eleganta* (Plummer) is characterized, among other characters, by its mainly smooth surface (without ribs, but with indistinct and irregularly longitudinal striation in the very earliest portion of the test), while the Paleocene species *O. higazyi* (Nakkady) has longitudinal costae on the wall of the test covers all of the chambers. The figured forms of Saint-Marc[68] (p. 1, fig. 17) from El Kef section of Tunisia, Sztrákos[14] (p. 106, pl. 13, fig. 2) of France, Ortiz & Thomas[69] (p. 132, pl. 11, fig. 4) of Spain, Alegret & Ortiz[70] (p. 441, pl. 2, fig. 43) of Egypt are closely related to *O. nakkadyi.* It was originally described from the Selandian of Duwi section, Egypt, and later on, its stratigraphic range extends to the Ypresian and Lutetian.

Family Uvigerinidae Kaeckel, 1894

Subfamily Uvigerininae Kaeckel, 1894

Genus *Uvigerinalla* Cushman, 1926

Type species *Uvigerina (Uvigerinella) californica* Cushman, 1926

***Uvigerinella nakkadyi* Anan[7] -** (Pl. 3, fig. 60)

1994 *Uvigerinella nakkadyi* Anan[7], p. 224, fig. 9. 5.

2011a *Uvigerinella nakkadyi*; Anan[2], p. 62, pl. 3, fig. 29.

Remarks: This Middle Eocene species has elongate test, circular in cross section, tapering in initial part, chambers triserial increasing in height as added, tending to become uniserial, sutures depressed, surface smooth, aperture slit-like in the final chamber. It was recorded from Fayum area of Egypt.

Superfamily Pleurostomellacea Reuss, 1860

Family Pleurostomellidae Reuss, 1860

Subfamily Pleurostomellinae Reuss, 1860

Genus *Ellipsoglandulina* Silvestri, 1900

Type species *Ellipsoglandulina laevigata* Silvestri, 1900

***Ellipsoglandulina arafati* Anan[71]-** (Pl. 3, fig. 61)

2009c *Ellipsoglandulina arafati* Anan[71], p. 111, fig. 2.

2011a *Ellipsoglandulina arafati*; Anan[2], p. 62, pl. 3, fig. 30.

Remarks: This Early Eocene species has smooth test wall, flaring, circular in section and in apertural view, widest in the middle (length/width=1.37), pointed initial end, uniserial throughout and strongly overlapping chambers increase rapidly in size, last chamber comprising greater part (about ¾) of the test, slightly depressed straight and horizontal sutures, terminal and semilunate aperture. It was recorded from Abu Zenima, Sinai of Egypt.

Genus *Pleurostomella* Reuss, 1860

Type species *Dentalina subnodosa* Reuss, 1851

***Pleurostomella haquei* Anan[72] -** (Pl. 3, fig. 62)

1960 *Pleurostomella* sp. Haque[73], p. 28, pl. 5, fig. 7.

2019b *Pleurostomella haquei* Anan[72], p. 175, pl. 1, fig. 10.

Remarks: This Middle-Late Eocene species has short and cuneate finely perforated elongate test, the initial chambers arrangement varying from lax biserial to nearly uniserial, sutures depressed, the last chamber inflated. It was recorded from Sor Range West Pakistan.

***Pleurostomella osmani* Anan[72] -** (Pl. 3, fig. 63)

2019b *Pleurostomella osmani* Anan[72], p. 176, pl. 1, fig. 15.

Remarks: This Late Maastrichtian species has short finely perforated test with rounded initial periphery, the initial chambers obscured, while later inflated chambers varying from lax biserial to nearly uniserial, sutures depressed, aperture subterminal elliptical with overhanging hood and without teeth, which distinguished it from other members of the genus. It was recorded from Sinai of Egypt.

***Pleurostomella plummerae* Anan[72]-** (Pl. 3, fig. 64)

1927 *Pleurostomella alternans* Plummer[49], p. 69, pl. 4, fig. 2b (*non* fig. 2a).

2019b *Pleurostomella plummerae* Anan[72], p. 176, pl. 1, fig. 17.

Remarks: This Paleocene species has short and cuneate finely perforated test, the initial chambers obscured, while later inflated chambers varying from biserial to nearly uniserial, sutures initially are indistinct but later distinct and depressed, aperture with overhanging hood with a deep reentrant toward the base of opening. It differs from *P. osmani* by its more chamber numbers and younger stratigraphic range, which may be evolved from it. It was recorded from the Midway Formation of Nicobar Island, USA.

***Nonionella haquei* Anan[74] -** (Pl. 3, fig. 65)

1956 *Nonionella* sp. Said & Kenawy[75], p. 156, pl. 7, fig. 21.

1960 *Nonionella* sp. Haque[73], p. 24, pl. 6, fig. 2.

2019a *Nonionella haquei* Anan[74], p. 33, pl. 2, fig. 15.

Remarks: This Paleocene-Eocene species has large inflated with equally biconvex test, but not symmetrically developed, periphery rounded, about ten to twelve chambers in the last formed whole, sutures distinct, a slit aperture at the base of the last chamber. The Paleocene figures specimen of Said & Kenawy[75] strongly falls within the morphologic characters of *N. haquei.* It differs from the *N. africana* LeRoy[21] by its larger inflated test and more enlarged chambers. It was recorded from the Sor Range, West Pakistan.

Superfamily Chilostomellacea Brady, 1881

Family Heterolepidae Gonzáles-Donoso, 1969

Genus *Anomalinoides* Brotzen, 1942

Type species *Anomalinoides plummerae* Brotzen, 1942

***Anomalinoides leroyi* Anan[76] -** (Pl. 3, fig. 66)

1953 *Anomalina* sp. K LeRoy[21], p. 19, pl. 3, figs. 26-28.

2008a *Anomalinoides leroyi* Anan[76], p. 367, pl. 1, fig. 12.

Remarks: This latest Maastrichtian-Danian species has characterized by its medium planoconvex test, convex ventral side with deep umbilicus, while nearly plan in dorsal side, gradually enlarging 10-12 chambers as added, coarsely perforated wall, gently raised limbate sutures and curved in both sides, rounded and faintly lobulate periphery, low and peripheral aperture with distinct lip. It was originally described from Duwi section, Egypt.

Family Gavelinellidae Hofker, 1956

Subfamily Gyroidinoidinae Saidova, 1981

Genus *Gyroidinoides* Brotzen, 1942

Type species *Rotalia nitida* Reuss, 1844

***Gyroidinoides luterbacheri* Anan[77] -** (Pl. 3, fig. 67)

2004 *Gyroidinoides luterbacheri* Anan[77], p. 49, pl. 1, fig. 13.

2011a *Gyroidinoides luterbacheri*; Anan[2], p. 63, pl. 3, fig. 33.

Remarks: This Danian-Selandian species characterized by its medium planoconvex test, ventral side strongly convex, while flat plan in dorsal side, gradually enlarging 10-12 chambers as added, but without deep umbilicus, sutures raised in both sides, wall hyaline and smooth, aperture slit-like, extending from umbilicus to the dorsal edge along the base of the broad apertural face. It was originally described from Duwi section, Egypt.

Superfamily Rotaliacea Ehrenberg, 1839

Family Rotaliidae Ehrenberg, 1839

Subfamily Culvillierininae Loeblich & Tappan, 1964

Genus *Ornatanomalina* Haque, 1956

Type species *Ornatanomalina geei* Haque, 1956

***Ornatanomalina ennakhali* Anan[2] -** (Pl. 3, fig. 68)

1996 *Ornatanomalina* sp. Anan[28], p. 154, fig. 4. 10.

2011a *Ornatanomalina ennakhali* Anan[2], p. 63, pl. 3, fig. 34.

Remarks: This Ypresian species is characterized by its discoidal test, weakly trochospiral in early stage but planispiral in the most later coiling final whorl with acute but semi lobulate periphery, as well as randomly arranged discontinuous ribs on the six to seven chamber surface ended by depressed sutures and equatorial aperture. It differs from the type species *O. geei* and its subspecies *Ornatanomalina geei compressa* and other six species of Haque[32,73] from Pakistan (*O. crookshanki, O. c. rugosa. O. glaessneri, O. hafeezi, O. elegantula and O. pustulosa*) by its discontinuous ribs, not rounded periphery and lacking the radial median ridges across the chamber surface. Loeblich & Tappan[6] considered the Pakistanian genus *Ornatanomalina* Haque (1956) as a senior synonym of *Saudella* Hasson[78] from Saudi Arabia and considered *O. hafeezi* as a junior synonym of *O. geei* (the type species of the genus *Ornatanomalina*), which not accepted here. Hewaidy[79] recorded two species of the genus *Ornatanomalina (O. hafeezi* and *O. rugosa*) from the Early Eocene Umm Er Radhuma Formation in Qatar. *O. ennakhali* Anan was recorded from J. Hafit (UAE).

***Ornatanomalina pakistanica* Anan[3] -** (Pl. 3, fig. 69)

1960 *Ornatanomalina* cf. *geei* Haque[73], p. 40, pl. 2, fig. 1.

2021a *Ornatanomalina pakistanica* Anan[3], p. 13, pl. 1, fig. 8.

Remarks: This Early Eocene species is characterized by its discoidal test, 5-7 chambers weakly trochospiral in the early stage and later planispiral, rounded periphery, surface with spiraling costae that interrupted near the depressed sutures at the edges of the chamber surface, aperture interiomarginal and equatorial, round opening with imperforated limbate border. The *O. pakistanica* differs from *O. geei* by its spiraling costae (instead of ribs) that flush with the surface (not raised), sharply angled interrupted near the depressed sutures at the edges of the chamber surface (not at the radial median ridges), round opening aperture (not slit-like aperture), and recorded in a younger stratigraphic level in the Early Eocene than the Late Paleocene of *O. geei*. It was recorded from Sor Range, Quetta District, West Pakistan.

Family Elphididae Galloway, 1933

Subfamily Elphidinae Galloway, 1933

Genus *Elphidium* de Montfort, 1808

Type species *Nautilus macellus* Fichtel & Moll, 1798

***Elphidium cherifi* Anan[63] -** (Pl. 3, fig. 70)

2010a *Elphidium cherifi* Anan[63], p. 172, pl. 2, fig. 8.

2011a *Elphidium cherifi*; Anan[2], p. 64, pl. 3, fig. 35.

Remarks: This Middle-Late Eocene has lenticular test, planispirally enrolled, involute, biumbonate (with umbilical plug on both sides). Numerous chambers (17-20) in the last whorl with deeply incised sutures. The chambers of this species have backward extensions at the acute periphery. *E. cherifi* is characterized by its backward extensions of the chambers and without intraseptal canal system between the chambers. It differs from the figured form *E. leave* of Cherif et al.[80] (p. 52, pl. 4, fig. 18) from the Priabonian of J. Hafit by its backward extensions of the chambers. *E. cherifi* was recorded from J. Hafit, UAE.

Stratigraphic value of Anan's species

The stratigraphic ranges of Anan species are presented in Fig. 3 (Maastrichtian-Early Eocene) and Fig. 4 (Early-Late Eocene).

a. One Maastrichtian planktic foraminiferal species: *Plummerita haggagae*.

b. Eight Maastrichtian foraminiferal species: *Spiroplectinella hamdani, Marginulinopsis emiratensis, Leroyia maqfiensis, Ramulina elkhoudaryi, Bolivinoides draco aegyptiacus, B. zikoi, Euloxsostomum mouradi, Pleurostomella osmani* which considered an excellent marker species for the Maastrichtian in the Middle East.

c. One Maastrichtian-Paleocene species: *Anomalinoides leroyi*.

d. Twenty three Paleocene benthic species: *Siphogaudryina strougoi*, *Textularia haquei*, *Pseudoclavulina futyani, P. hewaidyi, P. youssefi, Spiroloculina haquei, S. pakistanica, Laevidentalina hudae*, *Annulofrondicularia bignoti, Tristix aubertae, Lenticuzonaria hodae, L. misrensis, Percultazonaria alii, P. ameeri, Palmula berggreni, P. salimi, Leroyia tunisica, Hemirobulina olae, Vaginulinopsis boukharyi, Citharina plummerae, Ramulina futyani, Pleurostomella plummerae, Gyroidinoides luterbacheri.*

e. Seven Paleocene-Early Eocene benthic species*: Tritaxia kaminskii, Pyramidulina leroyi, Lenticulina ennakhali, Percultazonaria allami, Leroyia aegyptiaca, Lagena rawdhae, Nonionella haquei.*

f. Seven Early Eocene benthic species: *Gaudryina ameeri, G. speijeri, Hopkinsina haquei, Ellipsoglandulina arafati, Ornatanomalina ennakhali, O. pakistanica, Parafissurina pakistanica.*

g. Two Early-Middle Eocene benthic species: *Orbulinelloides sztrakosae, Orthokarstenia nakkadyi.*

h. Eighteen Middle-Late Eocene benthic species: *Bathysiphon saidi, Orbulinelloides arabicus, Miliammina kenawyi, Plectina emiratensis, Marssonella hafitensis, Textularia fahmyi, Ammomassilina misrensis, Laevidentalina salimi, Amphimorphina youssefi, Percultazonaria abunnasri, Saracenaria leroyi, Palmula ansaryi, Hemirobulina bassiounii, Marginulina karimae, Turrilina hassani, Uvigerinella nakkadyi, Pleurostomella haquei. Elphidium cherifi.*

i. One Recent benthic species: *Clavulina pseudoparisensis.*

Paleogeography

Many authors, i.e. Mintz[81], Rögl[82], Thomas et al.[83], Meulenkamp & Sissingh[84], Arinobu et al.[85], Keller[86] using the Cretaceous-Paleogene paleogeographical maps show that a large eastwest Tethyan Sea extended from the Indo-Pacific Ocean in the east to the Atlantic Ocean in the west. Berggren[87] suggested that during the Paleogene, the fauna of the Mediterranean and the Indo-Pacific exhibit pronounced similarities, which indicate that the connection between the two areas mentioned by a marine seaway, and the East Atlantic fauna was much more closely related to the fauna than it is today. In western Atlantic a narrow connection between it and Pacific existed. Adams et al.[88] noted that the continuous marine Paleogene connection between the area occupied by the present-day Mediterranean and the Indian Ocean had been lost by mid Burdigalian (early Oligocene) times when a land bridge connected S. W. Asia to Arabia, which means that the faunas of the Mediterranean and Indo-West Pacific began to diverge. They also added that the final disconnection must have been caused by a general elevation of this region rather than by a global eustatic change. Haynes & Nwabufo-Ene[89] noted that the Paleocene foraminiferal fauna inNigeria is of Tethyan aspect and shows very close relations to shallow shelf faunas in Libya and North Africa, and also suggest wider Tethyan connections, as far as the Carpathian and Pakistan. Meulenkamp & Sissingh[84] noted that the Arabian Platform, still largely covered by the sea in Early to Middle Eocene times, was subject to a major regression in the Middle to Late Eocene. In the Early Oligocene, it was almost completely emerged. The sea re-invaded the more central parts of the Arabian Platform in the latest Early to earliest Middle Miocene, but regressed again prior to the late Middle Miocene. Anan[90] noted that twenty one benthic foraminiferal species were originally erected from the Southern Tethyan (Egypt and Pakistan) were recorded from different localities in Northern Tethys France, Spain, Italy, Hungary).

Some paleogeographic remarks of some diagnostic species in the Maastrichtian-Eocene and recent

Most of the identified species were erected from Egypt (40/70, about 57%), 13 species from UAE (18.5%), 8 species from Pakistan (about 11%), 1 species (about 0.14%) from each of USA, Spain, France, Tunisia, Jordan. *Clavulina pseudoparisensis* Anan[38] originally described from the Qusseir-Marsa Alam stretch of the Red Sea coast of Egypt. Later on, it also recorded by El Deeb[39] from the UAE coast of the Arabian Gulf, and also from Jeddah at the east coast of Saudi Arabia of Youssef[40]. *Plummerita haggagae* Anan[34] originally described from the latest Maastrichtian of Duwi section, central Egypt. The closed forms to this species which recorded by some authors (i. e. Ziko et al.[59], and Keller[60]) have wide geographic distribution in Sinai and central Egypt. The Maastrichtian *Spiroplectinella hamdani* (Anan[1]) was originally described from UAE, and its related species were also recorded from the same stratigraphic horizon in many localities in Sinai, Egypt.

Palmula ansaryi Anan[7] has wide geographic distribution in Egypt and was described from the Bartonian of many sections in Fayoum area, Greater Cairo, Nile Valley and Sinai, and it seems confined to the Lutetian-Bartonian planktic foraminiferal zones of Berggren & Pearson[91] and equated the homogeneous benthic foraminifera *P. ansaryi* benthic foraminiferal Zone of Anan[7]. It considered an excellent marker for the Bartonian/Priabonian (Middle/Late Eocene) boundary in Egypt. *Hemirobulina bassiounii* Anan[7] originally described from the Bartonian of Fayoum area in Egypt, and later on

at the same stratigraphic horizon in J. Hafit, UAE (Anan[42]). *Plectina emiratensis* Anan[13] occurs also in the Bartonian of Jabal Hafit, UAE. *Amphimorphina youssefi* and *Saracenaria leroyi* both of Anan[7] were originally described from the Bartonian of Fayoum area (Egypt), and later on in the Priabonian of J. Malaqet (Anan[92]). *Uvigerinella nakkadyi* Anan[7] originally described from the Bartonian of Fayoum (Western Desert, Egypt), and later on from Bartonian-Oligocene succession of Withr section, south western Sinai of Egypt (Shahin[93]), and it is also recorded from Priabonian of J. Malaqet, UAE (Anan[92]). *Miliammina kenawyi* and *Bathysiphon saidi* both of Anan[7] were originally described from the Bartonian-Priabonian of Egypt. Later on, it is also recorded in the Bartonian of J. Hafit (Anan[8]), and also in Priabonian of J. Malaqet (Anan[92]). *Textularia fahmyi* Anan[7] originally described from the Bartonian-Priabonian of many sections in Fayoum and Sinai (Tayiba section), Egypt, and later on from Bartonian-Priabonian of El-Nazia section, Fayoum area of Egypt by Helal (2002). *Orbulinelloides arabicus* Anan[13] occurs in the Bartonian-Priabonian sequence of J. Hafit. The genus *Orbulinelloides* and its species arabicus are recorded, so far, for the first time from Arabia and the Middle East.

The Paleocene-Middle Eocene *Orthokarstenia nakkadyi* Anan[65] has wide geographic distribution in the northern and southern Tethys, but under different names by different authors: *Siphogenerinoides eleganta* (Plummer)[49] from Egypt (El-Dawy[12]) and Tunisia (Saint-Marc[68]) as well as *Rectuvigerina clavata* (Franzenau) from France (Sztrákos, 2000). All these forms have the same characters: diagnostic longitudinal costae only in the lower half of the test, but smooth without ornamentation in the upper half test. *Ornatanomalina ennakhali* Anan[2] was recorded from the upper Ypresian (late Early Eocene) of Jabal Hafit (UAE). The genus *Ornatanomalina* and its representatives extends their geographic distribution earlier from Pakistan (Haque[32]), later on from Rub' Al Khali Basin of Saudi Arabia (Hasson[78]), Qatar (Hewaidy[79]) and UAE (Anan[19,2]), which means a wide geographic distribution of these taxa in the Western Asia. Anan[3] noted that the paleogeographic distribution of the genus *Ornatanomalina* and its species are expanded into many localities in Southern and Northern Tethys, which contradict what previously noted by some authors that this genus appear to endemic to Pakistan. Anan[90] noted that the six representatives of the Maastrichtian-Early Eocene genus *Leroyia* (*aegyptiaca, glabra, maqfiensis, deserti, ghorabi, tunisica*) have wide geographic distribution in the Tethys, from west to east: N. America (USA), Europe (France, Italy), Africa (Tunisia, Egypt), Asia (India).

Paleoenvironment

LeRoy[21] noted that in certain respects the microfauna of the Esna Shale of Maqfi section exhibits an affinity with the Midway Type Fauna (MTF) of the United States Gulf Coastal area. Murray[94] noted that arenaceous foraminifera tend to increase in cooler (usually deeper) environments. Berggren[95] and Berggren & Aubert[55] considered the faunal assemblage of Maqfi section (here represents the Farafra Bahariya Facies, FBF of Issawi et al.[96] to be predominantly related to the "Midway-Type Fauna, MTF", middle-outer neritic environment (50-200m). Miller et al.[97] infer that certain hydrographic properties (low oxygen, high CO_2, low pH, and more corrosive waters) favor the development of agglutinated assemblages.

Keller[98] noted that general cooling trend between Bartonian-Oligocene indicated by the successive replacement of warm Bartonian surface water species (planktic) by cooler Late Eocene intermediate water species, which indicated by the coexistence of surface, intermediate and deep dwelling species group, suggest that increased thermal gradients developed between the equator and poles nearly coincident with the development of late psychrosphere. Keller et al.[99] noted that the Middle-Late Eocene boundary marked by expansion of cooler water assemblages and a major extinction event among warmer water species involving 80% of the individuals of the population, or 23 % of the species population. 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). Keller[100] 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. Moreover, Culver[101] also noted that the epifaunal species dominated by trochospiral test morphologies and that they are less tolerant than infaunal species to lowoxygen conditions.

Cherif & El Deeb[102] noted that close to the end of Bartonian, the previously arid climates became markedly wetter and seems accompanied by a cooling of the water temperature, and the climatic changes inferred the Hafit area seem widespread, at least in parts of the Middle East. Anan[38] noticed warmer environments of the studied Qusseir-Marsa Alam stretch of the northern Red Sea coast (the type locality of *Clavulina pseudoparisensis*), which favor precipitation of carbonates, and it is probable that such a binding material contains a higher proportion of organic carbonates, helping in constructing more resistant tests after the death of the organisms. Moreover, the Red Sea coast, in general, is dynamically less active than most of the considered Mediterranean localities (Cherif[103]). Hewaidy & Anan[104] interpreted that Duwi section in east central Egypt represents middle-outer neritic environment (50-200m). Cherif et al.[80] noted that the general eustatic level of the sea during Priabonian times (deep marine sedimentation reaching into neritic depths) was shallower than that of the Rupelian (coralline, reefal, inner neritic facies). Anan & Hamdan[105] noted that an incursion of warm temperate water-mass on the foredeep was sporadic and intermittent throughout the Paleocene of J. Malaqet, UAE.

Loeblich & Tappan[106] noted that the foraminiferal suborder Astrorhizina reinstated for the typical monothalamous agglutinated taxa whose cementing material is solely organic, the suborder Haplophragmiina reinstated for multilocular agglutinated taxa with organic cement and simple to alveolar walls. The suborder Trochamminina is recognized for those with organic cement and simple agglutinated walls, and the suborder Textulariina is restricted to include only those with agglutinated walls containing biogenic calcareous cement, and typically canaliculated. El Deeb[39] noticed a relative abnormal high frequency of Textulariacea in Arabian Gulf forms 3.5 % resemble the Qusseir-Marsa Alam stretch of the Red Sea, which may be due to the assumption that in the warmer environments in Arabian Gulf and Red Sea regions. Moreover, the Arabian Gulf is generally a higher energy environment when compared with the coasts of the northern Red Sea and eastern Mediterranean. Anan[1] noted that Maastrichtian benthic foraminiferal species of Qarn El Barr section, UAE (include *Spiroplectinella hamdani* and *Marginulinopsis emiratensis*) and some other sections in Iraq, Jordan and Egypt are closest to the Maastrichtian fauna of Nekhl section (Sinai of Egypt). The Maastrichtian chalk of Jiran El Ful section, west of Cairo may indicative to open marine middle-outer neritic environment.

Anan[107] noted that in the Priabonian time in the UAE and surrounding area had been located in the tropical and warm-temperate region based on many faunal environmental elements (presence of keel, accessory apertures, tubular spines in some planktic foraminiferal assemblage, high P/B ratio, rich Miliolids and nummulitids assemblage in some horizons). Schmitz et al.[108] and Speijer et al.[109] noted that the high abundance of pelagic microfossils in central Egypt (NVF)

indicated open connections to the Tethys. Issawi & Osman[110] 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. Billups & Schrag[111] noted that the intermediate waters depth cooled during Bartonian and reached minimum temperatures by 40 Ma.

Anan[34] noted that the spine-like prolongation of the penultimate chambers of the *Plummerita haggagae* and other recorded *Plummerita* spp. in Duwi section are mostly represented warm water environment. The high diversity and abundance assemblage of planktic and benthic foraminifera in the top Maastrichtian chocolate marly bed in Duwi section seems deposited in upwelling of nutrient rich water. Moreover, he also noted that the barren dark shale bed that rest on the top Maastrichtian horizon in some Tethyan localities in Ain Dabadib (Anan & Sharabi[112]), Duwi section (Anan[41]) in Egypt, and in El Kef section in Tunisia (Keller[113]) is most probably indicative of low oxygenic level in that time. Anan[56] noted that *Vaginulinopsis boukharyi* is restricted in the Paleocene Tarawan Chalk of Duwi section, which may represents an endemic environment, reflects a lowstand deposition (sea-level fall) in, most probably, the inner neritic environment (about 50m) than middle-outer neritic environment (about 150-200m) of the Dakhla Shale below and Esna Shale above. Anan[2] noted that the probable environment for the Sinai Facies in the northern Egypt (represented by Abu Zenima section) is outer neritic-upper bathyal (200-400m), which it deeper than the following facies: the North Western Desert Facies (represented by Jiran El Ful), Farafra Bahariya Facies (Maqfi section) and Nile Valley Facies (Duwi section), central Egypt, which are deposited in the middle-outer neritic (75-200m). Anan[5] noted that due to the high abundance of pelagic Pakistanian foraminiferal assemblage indicate open connections to the Tethys and represents middle-outer neritic environment (100-200m depth) and shows an affinity with MTF.

Summary and conclusions

Detailed studies of the well preserved and diversified Maastrichtian-Late Eocene benthic and planktic foraminifera from many localities in the Northern and Southern Tethys made it possible to improve, clarify and erect seventy species by the present author during last four decades ago. Thirty nine species of them were erected originally from Egypt (about 56 %), 17 species from the United Arab Emirates, UAE (about 24 %), 8 species from Pakistan (about 11 %), 2 species from Jordan, and 1 species from each of Tunisia, France, Spain and USA. One planktic foraminiferal species, 19 agglutinated, 3 porcelaneous, 29 Lagenid and 18 Rotaliid species. Ten species of them are recorded from two or more countries in the Northern (Spain, France, Italy, Hungary) and Southern Tethys (Nigeria, Tunisia, Egypt, Jordan, Iraq, Saudi Arabia, United Arab Emirates, Qatar, Pakistan). The erected pelagic foraminiferal assemblage represents middle-outer neritic environment (100-200 m depth) and shows an affinity with Midway-Type Fauna, MTF. Seven out of the recorded species are believed here to be new: *Orbulinelloides sztrakosae, Repmanina mazeni, Psammolingulina bahri, Tritaxia kaminskii, Pseudoclavulina futyani, P. youssefi* and *Ammomassilina misrensis.*

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Conflicts of interest

Author declares that there is no conflict of interest.

References

1. Anan HS. Maastrichtian-Paleocene micropaleontology and biostratigraphy of Qarn El Barr section, Al Dhayd area, United Arab Emirates. *Al-Azhar Bulletin of Science, Al-Azhar University*. 1993;4(2):639–670.
2. Anan HS. Paleontology, paleoenvironments, palaeogeography and stratigraphic value of the Maastrichtian-Paleogene and Recent foraminiferal species of Anan in the Middle East. *Egyptian Journal of Paleontology*. 2011a;11:49–78.
3. Anan HS. Paleontology and paleogeography of the Tethyan Early Paleogene Rotaliid benthic foraminiferal Pakistanian genus *Ornatanomalina* and other related genera. *Earth Sciences Pakistan (ESP).* 2021a;5(1):12–15.
4. Anan HS. *Lenticuzonaria,* a new Tethyan Lagenid benthic foraminiferal genus. *Earth Sciences Pakistan (ESP).* 2021b;5(1):33–36.
5. Anan HS. Paleontology and paleoenvironment of the Early Paleogene Pakistanian benthic foraminiferal species of Haque–Suborders Miliolina and Lagenina. *Earth Sciences Pakistan (ESP).* 2021c;5(1):42–47.
6. Loeblich AR, Tappan H. *Foraminiferal genera and their classification*. Van Nostrand Reinhold (VNR): New York; 1988. Part 1: 970 p., part 2: 847 p.
7. Anan HS. Benthic foraminifera around Middle/Upper Eocene boundary in Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*. 1994;8:210–233.
8. Anan HS. Agglutinated middle-upper Eocene foraminifera in Jabal Hafit, Al Ain area, United Arab Emirates. *Revue de Paléobiologie*. 2005a;24(1):17–27.
9. Ozsvárt P. Middle and Late Eocene benthic foraminiferal fauna from the Hungarian Paleogene Basin: systematics and paleoecology. *Geologica Pannonica, Special Publication*. 2007;2:129.
10. Sars M. Fortsatte bemaerkninger over der dyriske livs udbredning i havets dybder. *Forhandlinger i Videnskasselskabet i Kristiania.* 1869,246–275.
11. Anan HS. Homeomorphy in some benthic foraminiferal species. *Journal of Himalyan Earth Sciences* (in press).
12. El-Dawy MH. Paleocene benthic foraminiferal biostratigraphy and paleobathymetry, El Sheikh Fadl and Ras Gharib, Eastern Desert, Egypt. *Micropaleontology*. 2001;4(1):23–46.
13. Anan HS. Three new species of benthic foraminifera from the Middle-Upper Eocene of Jabal Hafit, Al Ain area, United Arab Emirates. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte.* 2003;9:529–536.
14. Sztrákos K. Eocene foraminifers in the Adour Basin (Aquitaine, France): biostratigraphy and taxonomy. *Revue de Micropaléontologie.* 2000;43(1-2):71–172.
15. Hofker J. Primitive agglutinated foraminifera. Leiden: E.J. Brill; 1972.
16. Brady HB. Notes on some of the Reticularian Rhizopoda of the "Challenger" Expedition, part 1. On new or little known arenaceous types. *Quaternary Journal of Microscopical Science, new series*. 1879;19:20–63.
17. Kaminski MA. The year 2010 classification of the agglutinated foraminifera. *Micropaleontology.* 2014;60(1):89–108.
18. Schultze MS. Rhizopodenstdien III. *Archiv für Mikroskopische Anatomie*. 1875;11:9–30.
19. Anan HS. Early Paleogene agglutinated foraminifera from the Middle East (Egypt and Arabia) and its distribution in the Tethys. *Spanish Journal of Paleontology*. 2016;31(2):353–368.
20. Anan HS. Maastrichtian agglutinated foraminifera in Egypt and other Tethyan countries. *Egyptian Journal of Paleontology*. 2005b;5:75–92.
21. LeRoy LW. Biostratigraphy of Maqfi section, Egypt. *Geological Society of American Memoir*. 1953;54:1–73.

22. Anan HS. A lineage phylogeny from some Cretaceous-Tertiary agglutinated benthic foraminiferal species in Egypt and Tethys. *Egyptian Journal of Paleontology*. 2012;12:59–72.

23. Cushman JA. The foraminifera of the Velasco Shale of the Tampico Embayment. *American Association of Petroleum Geology Bulletin.* 1926;10(6):581–612.

24. Speijer RP. Extinction and recovery patterns in benthic foraminiferal paleocommunities across the Cretaceous/Paleogene and Paleocene/Eocene boundaries. *Geologica Ultraiectina, Universiteit Utrecht*. 1994;124:1–191.

25. Alegret L, Ortiz S, Arenillas I, et al. Paleoenvironmental turnover across the Paleocene/Eocene boundary at the Stratotype section in Dababiya (Egypt) based on benthic foraminifera. *Terra Nova*. 2005;17(6):526–536.

26. Anan HS. Two new benthic foraminiferal species from the Maastrichtian and Paleocene rocks of northern Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*. 2002b;16:141–144.

27. Kuhnt W, Kaminski MA. Changes in the community structure of deep water agglutinated foraminifers across the K/T boundary in the Basque Basin (Northern Spain). *Revista Española de Micropaleontologia.* 1993;25(1):57–92.

28. Anan HS. Early Eocene foraminifera of Jabal Hafit, United Arab Emirates. *Middle East Research Center, Ain Shams University, Earth Science Series*. 1996;10:147–162.

29. Helal SA. Contribution to the Eocene benthic foraminifera and ostracoda of the Fayoum Depression, Egypt. *Egyptian Journal of Paleontology*. 2002;2:105–155.

30. Abd-Elshafy E, El-Fawal FM, Nassif MS, et al. *Foraminiferal biostratigraphy of the Eocene exposures between Wadi Bagha and Wadi Matulla, West Central Sinai, Egypt*. Proceeding of the 8th Conference on the Geology of Sinai for Development: Ismailia; 2007. 91–125 p.

31. Anan HS. Taxonomic consideration and stratigraphic implication of the accelerated evolution of the Maastrichtian-Eocene transition of twenty benthic foraminiferal species in the Tethys. *Earth Sciences Pakistan (ESP)*. 2020c;4(1):1–06.

32. Haque AFM. The foraminifera of the Ranikot and the Laki of the Nammal Gorge, Salt Range, Pakistan. *Memoirs of Geological Survey of Pakistan, Paleontologia Pakistanika*. 1956;1:1–229.

33. Futyan AI. Late Mesozoic and Early Cainozoic benthonic foraminifera from Jordan. *Palaeontology*. 1976;1:53–66.

34. Anan HS. Latest Maastrichtian *Plummerita haggagae* and Paleocene *Pseudoclavulina hewaidyi*, two new foraminiferal species from Egypt. *Egyptian Journal of Paleontology*. 2008b;8:245–254.

35. Anan HS. Paleocene Lagenid benthic foraminifera of Jabal Mundassa, Al Ain Area, United Arab Emirates. *Egyptian Journal of Paleontology*. 2015b;15:61–83.

36. Hewaidy AA, Farouk S, EL-Balkiemy AF. Foraminiferal Biostratigraphy, Stages Boundaries and Paleoecology of the Uppermost Maastrichtian-Lower Eocene Succession at Esh El-Mellaha Area, North Eastern Desert, Egypt. *Journal of American Science*. 2017;13(5):74–113.

37. Ali MY. Micropaleontological and stratigraphical analyses of the Late Cretaceous/Early Tertiary succession of the Southern Nile Valley (Egypt). *Der Fakultät für Geowissenschaften an der Ruhr-Universität Bochum vorgelegte Dissertation zur Erlangung des Grades eines*; 2003. 1–197 p.

38. Anan HS. Littoral Recent foraminifera from the Qussier-Marsa Alam stretch of the Red Sea coast, Egypt. *Revue de Paléobiologie*. 1984;3(2):235–242.

39. El Deeb WZ. Recent benthonic foraminifera from the south-eastern coast of the Arabian Gulf, United Arab Emirates. *Journal Faculty of Science, U.A.E. University*. 1992;4:181–199.

40. Youssef M. Heavy metals contamination and distribution of benthic foraminifera from the Red Sea coastal area, Jeddah, Saudi Arabia. *Oceanologia*. 2015;57(3):236–250.

41. Anan HS. Punctuationlism and gradualistic evolutionary trends of eight phylogenetic lineages of Maastrichtian to Eocene and Recent benthic foraminifera from the Tethys. *Journal of Sciences*. 2020a;31(1):63–73.

42. Anan HS. Stratigraphy and paleobiogeography of some Frondiculariinae and Palmulinae benthic foraminiferal general in the Paleocene of Egypt (Misr). *Neues Jahrbuch für Geologie und Paläontologie Monatshefte.* 2002a;10:629–640.

43. Anan HS. Paleontology and stratigraphical distribution of suborder Lagenina (benthic foraminifera) from the Middle-Late Eocene Mazyad Member of the Dammam Formation in Jabal Hafit, Al Ain area, United Arab Emirates, northern Oman Mountains. *Revue de Paléobiologie*. 2009a;28(1):1–18.

44. Anan HS. Paleocene agglutinated foraminifers of Jabal Mundassa, Al Ain area, United Arab Emirates. *Spanish Journal of Paleontology*. 2015b;30(2):239–256.

45. Anan HS. Maastrichtian-Paleogene benthic foraminifera from the Middle East and its distribution in the Tethys, a review. *Journal of Microbiology & Experimentation*. 2019c;7(6):255–278.

46. Anan HS. Taxonomic consideration and stratigraphic implication of the accelerated evolution of the Maastrichtian-Eocene transition of twenty benthic foraminiferal species in the Tethys. *Earth Sciences Pakistan (ESP)*. 2020b;4(1):01–06.

47. Anan HS. *Paleontological and biostratigraphical remarks on some diagnostic Tethyan benthic foraminifera*. 2nd International Conference on the Geology of the Tethys, Cairo University; 2007a. 303–308 p.

48. Anan HS. *Lenticulina ennakhali* n. sp. (benthic foraminifera) from the Paleocene-Early Eocene succession of Abu Zenima section, west central Sinai, Egypt (Misr). Journal of Al Azhar University-Gaza, 1st International Conference for Basic and Applied Sciences (ICBAS): Gaza, Palestine; 2010a. 19–22 p.

49. Anan HS. *Lenticuzonaria*, A new Tethyan Lagenid benthic foraminiferal genus. *Earth Sciences Pakistan (ESP)*. 2021b;5(2):33–36.

50. Plummer HJ. Foraminifera of the Midway Formation in Texas. *Bulletin University of Texas*. 1927;2644:3–206.

51. Anan HS. Paleogene Lagenid Percultazonarias (Foraminifera) in Egypt: paleontology, stratigraphy, paleogeography and some taxonomical considerations. *Egyptian Journal of Paleontology*. 2015a;15:13–30.

52. Aly HA, Abd El-Aziz SM, Abd El-Gaied IM. Middle and Upper Eocene benthic foraminifera from Wadi Bayad El Arab-Gebel Homret Shaibon area, Northeastern Beni Suef, Nile Valley, Egypt. *Egyptian Journal of Paleontology.* 2011;11:79–131.

53. Hussein AI. Middle Eocene palmate benthonic foraminifera from the Nile Valley, and their paleoecological significance. *Middle East Research Center, Ain Shams University, Earth Science Series*. 1998;12:214–218.

54. Anan HS. Paleocene Vaginulininae (benthic foraminifera) of Duwi section, Red Sea coast, Egypt. Egyptian *Journal of Paleontology*. 2001;1:135–139.

55. Anan HS. *Leroyia*, A new Tethyan Lagenid benthic foraminiferal genus. *Earth Sciences Pakistan (ESP).* 2020c;4(2):53–57.

56. Berggren WA, Aubert J. Paleocene benthonic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Atlantic-Tethyan regions: Midway-type fauna. *Palaeogeography, Palaeoclimatology, Palaeoecology.* 1975;18(2):73–192.

57. Anan HS. Contribution to the Egyptian benthic foraminifera around the Paleocene/Eocene boundary in Egypt. *Egyptian Journal of Paleontology*. 2010b;10:25–47.

58. Anan HS. Early Paleogene benthic foraminifera of Duwi section, Red Sea coast, Egypt. *Journal of American Science.* 2020b;16(2):1–22.

59. Anan HS. Paleontology, paleoecology, paleobathymetry, paleogeography and stratigraphic significance of the latest Maastrichtian genus *Plummerita* in Duwi section, Egypt and Tethys. *Rev Paléobiologie*. 2012;31(2):589–600.

60. Ziko A, Darwish M, Eweda Sh. Late Cretaceous-Early Tertiary stratigraphy of the Themed area, East Central Sinai, Egypt. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte H*. 1993;3:135–149.

61. Keller G. *Guembelitria*-dominated late Maastrichtian planktic foraminiferal assemblages mimic early Danian in central Egypt. *Marine Micropaleontology*. 2002;47(1-2):71–99.

62. Anan HS. Evolutionary lineage of the Maastrichtian *Bolivinoides draco* group (benthic foraminifera) in Abu Zenima section, west central Sinai, Egypt. *Arabian Journal of Geosciences*. 2017a;10:431.

63. Anan HS. Paleontology and stratigraphic significance of the Maastrichtian-Paleocene genus *Bolivinoides* in Egypt and Tethys. *Egyptian Journal of Paleontology*. 2011b;11:133–144.

64. Anan HS. Paleontology and stratigraphical distribution of suborder Rotaliina (benthic foraminifera) from the Middle-Late Eocene Mazyad Member of the Dammam Formation in Jabal Hafit (Al Ain area), United Arab Emirates, Northern Oman Mountains. *Revue de Paleobiologie*. 2010a;29(1):157–184.

65. Anan HS. Additional to the Maastrichtian foraminifera of the Middle East. *Revue de Paleobiologie*. 2011c;30(1):295–311.

66. Anan HS. Paleontology, paleogeography, paleoenvironment and stratigraphic implications of the Nakkady's benthic foraminiferal fauna in Egypt and Tethys. *Egyptian Journal of Paleontology*. 2009b;9:31–52.

67. Anan HS. Accelerated evolution in representatives of the genera *Orthokarstenia* and *Discorbis* (Benthic foraminifera) in the Maastrichtian and Paleocene of Egypt (Misr). *Neues Jahrbuch für Geologie und Paläontologie.* 1998;6:365–375.

68. Anan HS. Maastrichtian benthic foraminiferal Lagenina in Wadi Ed Dakhl section, West Gulf of Suez, Egypt. *Egyptian Journal of Paleontology*. 2014;14:137–156.

69. Saint-Marc P. Biostratigraphy and bathymetric distribution of benthic foraminifera in Paleocene of El Haria Formation of Tunisia. *Journal of African Earth Sciences*. 1992;15(3/4):473–487.

70. Ortiz S, Thomas E. Lower-middle Eocene benthic foraminifera from the Fortuna Section (Betic Cordillera, southeastern Spain). *Micropaleontology*. 2006;52(2):97–150.

71. Alegret L, Ortiz S. Global extinction event in benthic foraminifera across the Paleocene/Eocene boundary at the Dababiya Stratotype section. *Micropaleontology.* 2006;52(5):433–447.

72. Anan HS. Early Eocene *Ellipsoglandulina arafati* n. sp. (benthic foraminifera) from Abu Zenima section, west central Sinai, Egypt. *Egyptian Journal of Paleontology*, 2009c;9:111–117.

73. Anan HS. On the variability of benthic foraminiferal species of the genus *Pleurostomella i*n the Tethys. *Journal of Microbiology & Experimentation.* 2019b;7(3):173–181.

74. Haque AFM. Some middle to late Eocene Smaller foraminifera from the Sor Range, Quetta District, W. Pakistan. *Memoirs of Geological Survey of Pakistan, Paleontologia Pakistanika*. 1960;2(2):9–75.

75. Anan HS. Contribution to the paleontology, stratigraphy and paleobiogeography of some diagnostic Pakistanian Paleogene foraminifer in the Middle East. *Earth Sciences Pakistan*. 2019a;3(1):29–34.

76. Said R, Kenawy A. Upper Cretaceous and Lower Tertiary foraminifera from northern Sinai, Egypt. *Micropaleontology*. 1956;2(2):105–173.

77. Anan HS. Maastrichtian-Paleogene LeRoy's benthic foraminiferal species from Egypt and Tethyan-Atlantic regions. *Revue de Paléobiologie.* 2008a;27(2):357–376.

78. Anan HS. A lineage phylogeny for some Maastrichtian to Ypresian benthic foraminifera in Egypt. *Egyptian Journal of Paleontology.* 2004;4:39–57.

79. Hasson PF. New observations on the biostratigraphy of the Saudi Arabian Umm er Radhuma Formation (Paleogene) and its correlation with neighboring regions. *Micropaleontology*. 1985;31(4):335–364.

80. Hewaidy AA. Biostratigraphy of the Umm Er Radhuma Formation in South-East Qatar, Arabian Gulf. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte Abh.* 1994;2:145–164.

81. Cherif OH, Al-Rifaiy IA, El Deeb WZ. "Post-Nappes" early Tertiary foraminiferal paleoecology of the northern Hafit area, south of Al Ain City (United Arab Emirates). *Micropaleontology*.1992;38(1):37–56.

82. Mintz LW. *Historical Geology, the Science of a Dynamic Earth*. 3rd Ed. Merrill Publ. Co: USA; 1981. 611p.

83. Rögl F. Mediterranean and Paratethys. Facts and hypotheses of an Oligocene to Miocene paleogeography (short overview). *Geological Carpathica*. 1999;50(4):339–349.

84. Thomas DJ, Bralower T, Jones CE. Neodymium isotopic reconstruction of late Paleocene-early Eocene thermohaline circulation. *Earth and Planetary Science Letters*. 2003;209(3-4):309–322.

85. Meulenkamp JE, Sissingh W. Tertiary palaeogeography and tectonostratigraphic evolution of the Northern and Southern Peri-Tethys platforms and the intermediate domains of the African-Eurasian convergent plate boundary zone. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 2003;196(1-2):209–228.

86. Arinobu T, Ishiwatari R, Kaiho K, et al. Abrupt and massive influx of terrestrial biomarkers into the marine environment at the Cretaceous-Tertiary boundary, Caravaca, Spain. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 2005;224(1–3):108–116.

87. Keller G. Biotic effects of late Maastrichtian mantle plum volcanism: implications of impacts and mass extinctions. *Lithos.* 2005;79(3–4):317–341.

88. Berggren WA. Micropaleontology and Cenozoic paleoclimatology, part II: 277-299 (in Berggren & Phillips: Influence of the Continental drift on the distribution of the Tertiary benthic foraminifera in the Caribbean and Mediterranean regions), In: Gray c. (ed.): *Symposium on the geology of Libya, Tripoli.* University of Libya, Faculty of Science; 1971. 263–299 p.

89. Adams CG, Gentry AW, Whybrow PJ. Dating the terminal Tethys event. *Utrecht Micropaleontological Bulletin.* 1983;30:273–298.

90. Haynes J, Nwabufo-Ene K. Foraminifera from the Paleocene phosphate beds, Sokoto, Nigeria. *Revue Española de Micropaleontologia.* 1998;30(2):51–76.

91. Anan HS. Southern Tethys benthic foraminifera in Northern Tethys. *Earth Sciences Pakistan (ESP).* 2020e;4(2):70–75.

92. Berggren WA, Pearson PN. A revised tropical to subtropical Paleogene planktonic foraminiferal zonation. *Journal of Foraminiferal Research*. 2005;35(4):279–298.

93. Anan HS. Taxonomy, paleogeography, paleoecology and paleoclimatology of the Late Eocene benthic foraminifera of Jabal Malaqet, United Arab Emirates, northern Oman Mountains. *Egyptian Journal of Paleontology.* 2007b;7:67–85.

94. Shahin A. Biostratigraphic significance, paleobiogeography and paleobathymetry of Tertiary Buliminacea and Bolivinacea in the Western Sinai, Egypt. *Neues Jahrbuch für Geologie und Paläontologie Monatshefte Abh.* 2000; 216(2):195–231.

95. Murray JW. *Distribution and Ecology of living benthonic foraminiferids*. Heineman Educational books; 1973. 274 p.

96. Berggren WA. Paleocene benthonic foraminiferal biostratigraphy, biogeography and paleoecology of Libya and Mali. *Micropaleontology.* 1974;20(4):449–465.

97. Issawi B, El Hennawi M, Francis M, et al. The Phanerozoic geology of Egypt. A geodynamic approach. *Egyptian Geological Survey, special publication, Cairo*. 1999;76:1–462.

98. Miller KG, Gradstein FM, Berggren WA. Late Cretaceous to Early Tertiary agglutinated benthic foraminifera in the Labrador Sea. *Micropaleontology.* 1982;28(1):1–30.

99. Keller G. Paleoclimatic analysis of Middle Eocene through Oligocene planktic foraminiferal faunas. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 1983;43(1–2):73–94.

100. Keller G, Herbert T, Dorsey R, et al. Global distribution of late Paleogene hiatuses. *Geology*. 1987;15(3):199–203.

101. Keller G. Paleoecological response of Tethyan benthic foraminifera to the Cretaceous-Tertiary boundary transition. *In*: Takayanagi Y, Saito T. (Eds.), studies in benthic Foraminifera. Tokai University Press: Tokyo; 1992. 77–91 p.

102. Culver SJ. Benthic foraminifera across the Cretaceous-Tertiary (K-T) boundary: a review. *Marine Micropaleontology*. 2003;47(3–4):177–226.

103. Cherif OH, El Deeb WZ. The Middle Eocene–Oligocene of the Northern Hafit Area, south Al Ain City (United Arab Emirates). *Geologie Méditerranéenne*, 1984;11(2):207–217.

104. Cherif OH. On the classification of the genus Quinqueloculina (Foraminifera). *Neues Jahrbuch für Geologie und Paläontologie Monatshefte Abh.* 1973;142(1):73–96.

105. Hewaidy AA, Anan HS. Paleocene benthonic foraminiferal paleoecology of central Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*. 1986;6:81–104.

106. Anan HS, Hamdan ARA. *Bolivinoides curtus* Reiss from the Paleocene of Jabal Malaqet, East of Al Ain, west of the Northern Oman Mountains, United Arab Emirates. *Journal Faculty of Science, U.A.E. University*. 1992;4(1):200–211.

107. Loeblich AR, Tappan H. Implications of wall composition and structure in agglutinated foraminifera. *Journal of Paleontology*. 1989;63(6):769–777.

108. Anan HS. Late Eocene biostratigraphy of Jabals Malaqet and Mundassa of Al Ain region, United Arab Emirates. *Revue de Micropaléontologie*. 1995;38(1):3–14.

109. Schmitz B, Speijer RP, Aubry MP. Latest Paleocene benthic extinction event on the southern Tethyan shelf (Egypt): Foraminiferal stable isotopic ($\delta^{13}C$, $\delta^{18}O$) record. *Geology*. 1996;24(4):347–350.

110. Speijer RP, Schmitz B, Luger P. Stratigraphy of late Paleocene events in the Middle East: implications for low-to middle latitude succession and correlation. *Journal of Geological Society*. 2000;157:37–47.

111. Issawi B, Osman R. *Upper Cretaceous-Lower Tertiary platform-ramp environment in northern Egypt*. 5th International Conference of Geology of Arab World, Cairo University, Egypt; 2000. 1289–1308 p.

112. Billups K, Schrag DP. Application of benthic foraminiferal Mg/Ca ratios to questions of Cenozoic climate change. *Earth and Planetary Science Letters*. 2003;209(1–2):181–195.

113. Anan HS, Sharabi SA. Stratigraphy and depositional environment of the Cretaceous-Lower Tertiary rocks of the northwest Kharga Oasis, Egypt. *Journal Faculty of Science, U.A.E. University*. 1992;4(1):123–156.

114. Keller G. Biotic turnover in benthic foraminifera across the Cretaceous/Tertiary boundary at al Kef, Tunisia. *Palaeogeography, Palaeoclimatology, Palaeoecology*. 1988;66(3-4):153–171.

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