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

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ABSTRACT

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

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

RESUMEN

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

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

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1. INTRODUCTION

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

Figure 1. Map of the Middle East countries: Egypt (**1**. Sinai, **2**. El Sheikh Fadl area, **3**. Fayoum area, **4**. Maqfi section, **5**. Duwi section, **6**. Luxor section), Jordan (**7**. Tell Burma section) and the United Arab Emirates, UAE (**8**. J. Hafit).

2. SYSTEMATIC PALAEOTOLOGY

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

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

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

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

This species was originally described from the late Paleocene of the El Sheikh Fadl area, east central Egypt

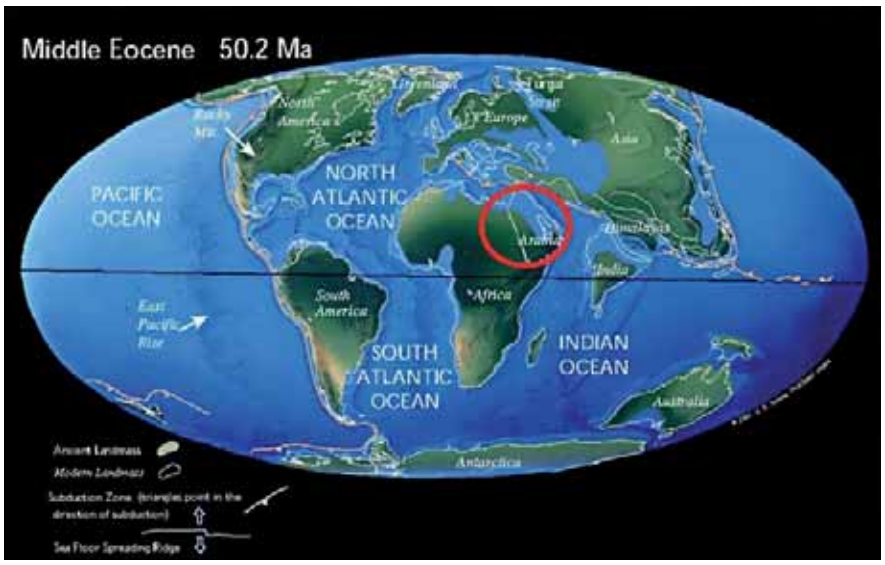

Figure 2. Paleaogeographic map during the middle Eocene including the location of the Middle East (Egypt and Arabia). After http://www.newjerseypaleo.com/fossilsbyera/tertiary-fossils.

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

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

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

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

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

Orbulinelloides arabicus Anan, 2003
(Fig. 3c)

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

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

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

Miliammina kenawyi Anan, 1994
(Fig. 3d)

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

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

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

Ammomassilina sp Anan, 1994
(Fig. 3e)

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

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

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

Ammobaculites coprolithiformis (Schwager, 1876)
(Fig. 3f)

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

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

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

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

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

Suborder SPIROPLECTAMMININA Mikhalevich, 1992
Superfamily SPIROPLECTAMMINACEA Cushman, 1927
Family **Spiroplectamminidae** Cushman, 1927
Subfamily Spiroplectammininae Cushman, 1927
Genus *Spiroplectinella* Kisel'man, 1972
Type species *Spiroplecta wrightii* Silvestri, 1903

Spiroplectinella esnaensis (LeRoy, 1953)
(Fig. 3h)

1953 *Spiroplectammina esnaensis* LeRoy, p. 50, pl. 1, figs. 11, 12.
1976 *Spiroplectinella esnaensis* Aubert & Berggren, p. 409, pl. 1, fig. 6.
1994 *Spiroplectinella esnaensis* Speijer, p. 147, pl. 3, fig. 1.
2003 *Spiroplectinella esnaensis* Ali, p. 124, pl. 4, figs. 16, 17.
2005 *Spiroplectinella esnaensis* Sztrákos, p. 184, pl. 12, fig. 16.
2007 *Spiroplectinella esnaensis* Alegret & Ortiz, p. 437, pl. 1, fig. 6.
2011 *Spiroplectinella esnaensis* Aly *et al*., p. 83, pl. 1, fig. 8.
2012 *Spiroplectinella esnaensis* Youssef & Taha, pl. 1, fig. 16.

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

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

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

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

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

Plectina emiratensis Anan, 2003
(Fig. 3j)

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

This species has short subconical test, subterminal and traverse elongate slit aperture on the apertural face

of the last chambers and rather coarse-grained arenaceous wall. *P. emiratensis* (the holotype is deposited in the UAE University, Geology Department, UAE, UAEUGD A3) was originally described from the Bartonian of Jabal Hafit (UAE). So far, it seems to be confined also in the UAE.

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

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

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

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

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

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

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

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

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

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

Gaudryina speijeri Anan, 2012
(Fig. 3n)

1994 *Gaudryina* cf. *ellisorae* Cushman, Speijer, p. 147, pl. 5, fig. 1.
2005 *Gaudryina* cf. *ellisorae* Alegret *et al*., p. 531.
2012b *Gaudryina speijeri* Anan, p. 66, pl. 1, fig. 10.

This Eearly Eocene species has very distinct carinate rib which extended from the last formed chamber of the biserial stage as well as the whole triserial portion. It differs from the Upper Cretaceous *G. (Pseudogaudryina) ellisorae* Cushman by its semiglobular last chamber with more circular aperture rather than a triangular last chamber with more elongated aperture as in Cushman's species. *G. speijeri* (the holotype from the R. Speijer's collection, 1994, sample S 738, Wadi Nukhul, Egypt) has a longer and bigger test than *G. ameeri*. Anan (2012b) explained that one edge of *G. pyramidata* grows to produce a carinate rib that existed along the pre-final chamber of the biserial stage and extends on the whole triserial portion on *G. ameeri*, while it starts in another edge from the final chamber of the biserial stage and extends along the triserial stage in *G. speijeri*.

Gaudryina tellburmaensis Futyan, 1976
(Fig. 3ñ)

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

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

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

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

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

This species belongs to the genus *Siphogaudryina* due to its subterminal apertural in the apertural face of

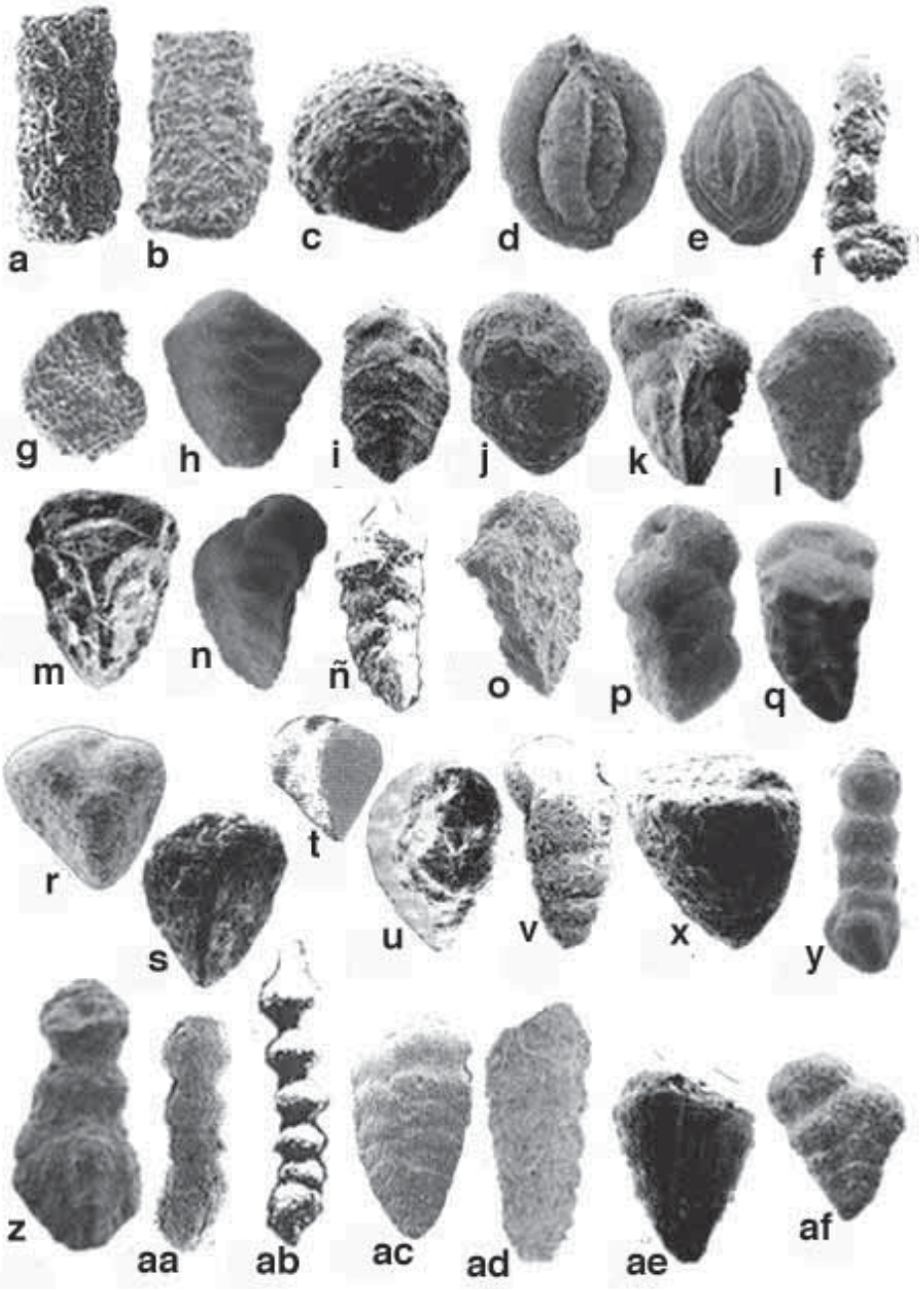

Figure 3. a) *Bathysiphon paleocenicus* El-Dawy, 2001 x 40; **b)** *Bathysiphon saidi* (Anan, 1994) x 20; **c)** *Orbulinelloides arabicus* Anan, 2003 x 55; **d)** *Miliammina kenawyi* Anan, 2005 x 33; **e)** *Ammomassilina* sp Anan, 1994 x 40; **f)** *Ammobaculites coprolithiformis* (Schwager, 1867; after Luger, 1988) x100; **g)** *Ammobaculites khargaensis* Nakkady & Talaat, in Nakkady, 1959 x 20; **h)** *Spiroplectinella esnaensis* (LeRoy, 1953; after Speijer, 1994) x 45; **i)** *Spiroplectinella paracarinata* (Said & Kenawy, 1956; after Anan, 1996) x 100; **j)** *Plectina emiratensis* Anan, 2003 x 40; **k)** *Gaudryina ameeri* Anan, 2012b x 50; **l)** *Gaudryina elegantissima* Said & Kenawy (1956; after Anan, 1993) x 30; **m)** *Gaudryina limbata* Said & Kenawy (1956; after Anan, 1993) x 100; **n)** *Gaudryina speijeri* Anan, 2012b x 50; **ñ)** *Gaudryina tellburmaensis* Futyan, 1976 x 40; **o)** *Siphogaudryina africana* (LeRoy, 1953; after Anan, 2008a) x 35; **p)** *Siphogaudryina nekhlensis* (Said & Kenawy, 1956; after Speijer, 1994) x 40; **q)** *Siphogaudryina strougoi* Anan, 2002 x 15; **r)** *Verneuilina aegyptiaca* Said & Kenawy (1956; after Anan, 2004) x 45; **s)** *Verneuilina karreri* Said & Kenawy (1956; after Hewaidy & Al-Hitmi, 1993) x 100; **t)** *Verneuilina luxorensis* Nakkady (1950; after Anan, 2004) x 60; **u)** *Arenobulimina aegyptiaca* Said & Kenawy (1956; after Anan, 1993) x 55; **v)** *Dorothia sinaensis* Said & Kenawy (1956; after Ali, 2003) x 50; **x)** *Marssonella hafitensis* Anan, 2003 x 50; **y)** *Pseudoclavulina farafraensis* LeRoy (1953; after Anan, 2005) x 50; **z)** *Pseudoclavulina hewaidyi* Anan, 2008b x 25; **aa)** *Pseudoclavulina maqfiensis* LeRoy (1953; after Ismail, 1996) x 50; **ab)** *Clavulina barnardi* Futyan, 1976 x 60; **ac)** *Textularia fahmyi* Anan, 1994 x 40; **ad)** *Textularia farafraensis* LeRoy (1953; after Aly *et al*., 2011) x 45; **ae)** *Textularia nilotica* (Schwager, 1883; after Hewaidy & Al Hitmi, 1993) x 170; **af)** *Textularia schwageri* LeRoy (1953; after Anan, 2008a) x 40.

the last-formed chamber, instead of the inner marginal aperture of the genus *Gaudryina* d'Orbigny. It has a large elongated robust test, tapering initial triserial portion and greatest breadth at the beginning of the biserial stage, with distinctive four longitudinal not acute edges running nearly parallel to the periphery, two out of them appear on the apertural view along the test, sutures indistinct and depressed (the holotype is deposited in the Cushman Collection No. 58006). Hewaidy & Strougo (2001) considered the first appearance of this species in the early Eocene of the Maqfi section, Egypt and later in France.

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

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

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

Siphogaudryina strougoi Anan, 2002
(Fig. 3q)

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

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

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

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

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

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

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

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

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

Verneuilina luxorensis Nakkady, 1950
(Fig. 3t)

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

This early Eocene species has a pyramidal triserial test, compressed and much excavated on the three lateral faces, edges thin, chambers long and narrow, septal faces in the form of isosceles triangles, wall with much cement and a smoothly finished surface. *V. luxorensis* differs from the Maastrichtian-Paleocene *V. aegyptiaca* by its pyramidal test, which is more compressed and much excavated on

three lateral thin edges. *V. luxorensis* (the holotype is deposited in the British Museum, Natural History) was originally recorded from the early Eocene of the Luxor section (Egypt). Anan (2010) considered it an excellent marker species to recognize the early Eocene in Egypt.

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

Arenobulimina aegyptiaca Said & Kenawy, 1956
(Fig. 3u)

1956 *Arenobulimina aegyptiaca* Said & Kenawy, p. 126, pl. 1, fig. 42.
1993a *Arenobulimina aegyptiaca* Anan, p. 314, pl. 1, fig. 9.

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

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

Dorothia sinaensis Said & Kenawy, 1956
(Fig. 3v)

1956 *Dorothia sinaensis* Said & Kenawy, p. 128, pl. 2, fig. 1.
2003 *Dorothia sinaensis* Ali, p. 120, pl. 3, fig. 22.

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

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

Marssonella hafitensis Anan, 2003
(Fig. 3x)

2003 *Marssonella hafitensis* Anan, p. 535, fig. 4. 3.
2005a *Marssonella hafitensis* Anan, p. 21.

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

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

Pseudoclavulina farafraensis LeRoy, 1953
(Fig. 3y)

1953 *Pseudoclavulina farafraensis* LeRoy, p. 44, pl. 2, fig. 9.
1993a *Tritaxia farafraensis* Anan, p. 314, pl. 1, fig.7.
1993 *Tritaxia farafraensis* Hewaidy & Al-Hitmi, p. 481, pl. 6, figs. 5, 6.
1995 *Tritaxia farafraensis* Nomura & Brohi, p. 227, pl. 1, fig. 19.
2005b *Pseudoclavulina farafraensis* Anan, p. 87, pl. 1, fig. 10.
2012 *Pseudoclavulina farafraensis* Ismail, p. 30, pl. 1, fig. 16.
2015 *Pseudoclavulina farafraensis* Anan, p. 43, fig. 4.20.

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

Pseudoclavulina hewaidyi Anan, 2008
(Fig. 3z)

2008b *Pseudoclavulina hewaidyi* Anan, p. 4, pl. l, fig. 1.
2015 *Pseudoclavulina hewaidyi* Anan, p. 249, fig. 4.21.

This species has distinctly large test, triserial stage triangular in cross section, discoidal chambers in the uniserial stage, which are circular in top view, wall finely arenaceous,

sutures strongly depressed in the uniserial stage with a terminal aperture. *P. hewaidyi* (the holotype is deposited in the Al Azhar University-Gaza, Geology Department, ASUGD A20) was originally described from the Danian of Abu Zenima, Sinai (Egypt), and later from the UAE.

Pseudoclavulina maqfiensis LeRoy, 1953
(Fig. 3aa)

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

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

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

Clavulina barnardi Futyan, 1976
(Fig. 3ab)

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

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

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

Textularia fahmyi Anan, 1994
(Fig. 3ac)

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

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

Textularia farafraensis LeRoy, 1953
(Fig. 3ad)

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

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

Textularia nilotica (Schwager, 1883)
(Fig. 3ae)

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

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

Textularia schwageri LeRoy, 1953
(Fig. 3af)

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

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

3. PALAEOGEOGRAPHY

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

Accordingly, the following remarks can be presented (Table 1). Most of the identified Paleogene species from the Middle East were described from Egypt (27/32, about 84 %), while 3 species from the UAE (about 0.09) and only two species from Jordan (about 0.06 %). Fourteen of the identified species (14/32, about 43.0 %), so far, are endemic to Egypt: *Ammobaculites khargaensis*, *A. schwageri*, *Gaudryina ameeri*, *G. speijeri*, *Siphogaudryina africana*, *S. nekhlensis*, *S. strougoi*, *Verneuilina luxorensis*, *Dorothia sinaensis*, *Pseudoclavulina hewaidyi*, *P. maqfiensis*, *Textularia fahmyi*, *T. farafraensis*, *T. schwageri*. Four of these species (4/32, 12.0 %), so far, are endemic to the UAE: *Orbulinelloides arabicus*, *Ammomassilina* sp., *Plectina emiratensis*, and *Marssonella hafitensis*. Two of these species (2/32, 6.0 %), so far, are endemic to Jordan: *Gaudryina tellburmaensis* and *Clavulina barnardi.*

Table 1. Palaeogeographic distribution of the Paleogene benthic foraminiferal taxa in the different Tethyan localities: **1**. United State of America (USA), **2**. France, **3**. Hungary, **4**. Tunisia, **5**. Egypt, **6**. Jordan, **7**. United Arab Emirates (UAE), **8**. Qatar, **9**. Yemen, **10**. Pakistan.

Paleogene benthic foraminiferal		Tethyan localities									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Bathysiphon	*paleocenicus*					x		x			
	saidi			x		x		x			
Orbulinelloides	*arabicus*							x			
Miliammina	*kenawyi*					x		x			
Ammomassilina	sp							x			
Ammobaculites	*coprolithiformis*	x				x				x	
	khargaensis					x					
Spiroplectinella	*esnaensis*		x		x	x					
	paracarinata					x		x			
Plectina	*emiratensis*							x			
Gaudryina	*ameeri*					x					
	elegantissima					x		x	x		
	limbata					x		x			
	speijeri					x					
	tellburmaensis						x				
Siphogaudryina	*africana*					x					
	nekhlensis					x					
	strougoi					x					
Verneuilina	*aegyptiaca*					x		x			
	karreri					x		x	x		
	luxorensis					x					
Arenobulimina	*aegyptiaca*					x		x			
Dorothia	*sinaensis*					x					
Marssonella	*hafitensis*							x			
Pseudoclavulina	*farafraensis*					x		x	x		
	hewaidyi					x					
	maqfiensis					x					
Clavulina	*barnardi*						x				
Textularia	*fahmyi*					x					
	farafraensis					x					
	nilotica					x					
	schwageri					x			x		x

Eleven of these species (11/32, about 34 %) are recorded in both Egypt and UAE: *Bathysiphon paleocenicus*, *B. saidi*, *Miliammina kenawyi*, *Ammobaculites schwageri*, *Spiroplectinella paracarinata*, *Gaudryina limbata*, *G. elegantissima*, *Verneuilina aegyptiaca*, *V. karreri*, *Pseudoclavulina farafraensis*, and *Arenobulimina aegyptiaca*. Three of these species (3/32, about 6 %) are also endemic to Qatar.

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

the Jordanian *Gyroidinoides tellburmaensis* (one of three Jordanian species) is recorded outside Jordan in Tunisia (Speijer, 1994; Culver, 2003; Widmark & Speijer, 1997), Atlantic Ocean and Spain (Widmark & Speijer, 1997). Four Middle East species are recorded in Spain (*Spiroplectinella knebeli*, *Eouvigerina aegyptiaca*, *Cibicidoides pseudoacutus*, and *Gyroidinoides tellburmaensis*) and in Tunisia (*S. knebeli*, *E. aegyptiaca*, *G. Tellburmaensis*, and *Cibicidoides abudurbensis*), but only 3 species in Atlantic Ocean (*E. aegyptiaca*, *C. pseudoacutus*, and *G. tellburmaensis*) and also 3 in Pakistan (*Tritaxia barakai*, *Pseudoclavulina farafraensis*, and *Eponides mariei*), 2 species in France (*C. abudurbensis*, and *C. pseudoacutus*) and also in the Negev (*Verneuilina aegyptiaca*, and *C. abudurbensis*), but only *E. aegyptiaca* from Indian Ocean.

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

4. PALAEOECOLOGY

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

5. CONCLUSIONS

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

1. Most of these identified species were erected from Egypt (27/32, about 84.00 %), and 9/27 of Egyptian species are erected by Said & Kenawy (1956), 8/27 after Anan (1994, 2002, 2008a, 2008b, 2012b), 7/27 after LeRoy (1953), 2/27 after Nakkady (1950, 1959), 2/27 after Schwager (1867, 1883), 1/27 after El-Dawy (2001).

2. Three of 32 species (about 9.00 %) from UAE were erected by Anan (2003).

3. Only two of 32 species (about 6.00 %) from Jordan were erected by Futyan (1976).

4. Cherif & El Deeb (1984) and Anan (1995) noted that the distribution of the identified Paleogene species from the Middle East represent tropical-subtropical fauna.

5. The unclosed recorded number of Paleogene agglutinated species in different localities in the Middle East may due to the lack of detailed study for these localities, different latitudes, land barriers and/or different palaeoenvironmental conditions (depth, dissolved oxygen, salinity and temperature).

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REFERENCES

Abd-Elshafy, E., El-Fawal, F.M., Nassif, M.S. & Mattar, Y.E. 2007. 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, 91-125.

Abul-Nasr, R.A. 2000. Middle-Upper Eocene benthic foraminifera of Wadi Tayiba and Wadi Bagha (western Sinai): A comparative study. *Middle East Research Center, Ain Shams University, Earth Science Series*, 14, 49-76.

Adams, C.G., Gentry, A.W. & Whybrow, P.J. 1983. Dating the terminal Tethys event. *Utrecht Micropaleontological Bulletin*, 30, 273-298.

Ali, M.Y. 2003. 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*, 1-197.

Alegret, L. & Ortiz, S. 2007. Global extinction event in benthic foraminifera across the Paleocene/Eocene boundary at the

Dababiya Stratotype section. *Micropaleontology*, 52, 433-447.

Alegret, L., Ortiz, S., Arenillas, I. & Molina, E. 2005. Paleoenvironmental turnover across the Paleocene/Eocene boundary at the Stratotype section in Dababiya (Egypt) based on benthic foraminifera. *Terra Nova*, 17, 526-536.

Al-Omari, F.S. 1970. Upper Cretaceous and lower Cenozoic foraminifera of three oil wells in northwestern Iraq. Ph.D. Missouri University of Science and Technology, 2207, 213 p.

Al-Wosabi, M.A. 2009. Foraminiferal fauna of the Amran Group, Jabal Al-Balaq, Marib Governorate, Republic of Yemen. *Egyptian Journal of Paleontology*, 9, 75-103.

Aly, H.A., Abd El-Aziz, S.M. & Abd El-Gaied, I.M. 2011. 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*, 11, 79-131.

Anan, H.S. 1993a. Paleocene benthonic foraminifera of Jabal Malaqet, Al Ain region, United Arab Emirates. *Al-Azhar Bulletin of Science,* 4, 293-320.

Anan, H.S. 1993b. Maastrichtian-Paleocene micropaleontology and biostratigraphy of Qarn El Barr section, Al Dhayd area, United Arab Emirates. *Al-Azhar Bulletin of Science*, 4, 639-670.

Anan, H.S. 1994. Benthic foraminifera around Middle/Upper Eocene boundary in Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*, 8, 210-233.

Anan, H.S. 1995. Late Eocene biostratigraphy of Jabals Malaqet and Mundassa of Al Ain region, United Arab Emirates. *Revue de Micropaléontologie*, 38, 3-14.

Anan, H.S. 1996. Early Eocene foraminifera of Jabal Hafit, United Arab Emirates. *Middle East Research Center, Ain Shams University, Earth Science Series*, 10, 147-162.

Anan, H.S. 2002. Two new benthic foraminiferal species from the Maastrichtian and Paleocene rocks of northern Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*, 16, 141-144.

Anan, H.S. 2003. 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, Mh.*, 9, 529-536.

Anan, H.S. 2004. A lineage phylogeny for some Maastrichtian to Ypresian benthic foraminifera in Egypt. *Egyptian Journal of Paleontology*, 4, 39-57.

Anan, H.S. 2005a, Agglutinated Middle-Upper Eocene foraminifera in Jabal Hafit, Al Ain Area, United Arab Emirates. *Revue de Paléobiologie*, 24, 17-27.

Anan, H.S. 2005b. Maastrichtian agglutinated foraminifera in Egypt and other Tethyan countries. *Egyptian Journal of Paleontology*, 5, 75-92.

Anan, H.S. 2008a. Maastrichtian-Paleogene LeRoy's benthic foraminiferal species from Egypt and Tethyan-Atlantic regions. *Revue de Paléobiologie*, 27, 357-376.

Anan, H.S. 2008b. Latest Maastrichtian *Plummerita haggagae* and Paleocene *Pseudoclavulina hewaidyi,* two new foraminiferal species from Egypt. *Egyptian Journal of Paleontology*, 8, 245-254.

Anan, H.S. 2009. Paleontology, paleogeography, paleoenvironment and stratigraphical implications of the Nakkady's benthic foraminiferal fauna in Egypt and Tethys. *Egyptian Journal of Paleontology*, 9, 31-52.

Anan, H.S. 2010. Contribution to the Egyptian benthic foraminifera around the Paleocene/Eocene boundary in Egypt. *Egyptian Journal of Paleontology,* 10, 25-47.

Anan, H.S. 2011. Paleontology, paleoenvironments, palaeogeography and stratigraphic value of the Maastrichtian-Paleogene and Recent foraminiferal species of Anan in the Middle East. *Egyptian Journal of Paleontology*, 11, 49-78.

Anan, H.S. 2012a. Paleontology, paleoenvironment and stratigraphic value of the Maastrichtian-Paleogene benthic foraminifera of Said & Kenawy (1956) from Egypt and Tethys. *Egyptian Journal of Paleontology*, 12, 17-30.

Anan, H.S. 2012b. A lineage phylogeny from some Cretaceous-Tertiary agglutinated benthic foraminiferal species in Egypt and Tethys. *Egyptian Journal of Paleontology*, 12, 59-72.

Anan, H.S. 2015. Paleocene agglutinated foraminifera from Jabal Mundassa, Al Ain area, United Arab Emirates. *Spanish Journal of Palaeontology*, 30, 239-256.

Aubert, J. & Berggren, W.A. 1976. Paleocene benthonic foraminiferal biostratigraphy and paleoecology of Tunisia. *Bulletin du Centre de Recherches Pau- SNPA*, 10, 379- 469.

Avnimelech, M. 1952. Revision of the tubular Monothalamia. *Contributions from the Cushman Foundation for Foraminiferal Research*, 3, 60-68.

Balakhmatova, V.T. 1972. K sistematike semeystva Ataxophragmiidae Schwager, 1877. *Voprosy Mikropaleontologii*, 15, 70-74.

Berggren, W.A. 1978. Recent advances in Cenozoic planktonic foraminiferal biostratigraphy, biochronology, and biogeography: Atlantic Ocean. *Micropaleontology*, 24, 337-370.

Berthelin, G. 1880. Mémoire sur les foraminiféres fossiles de l'Etage Albien de Moncley (Doubs). *Mémoires de la Société Géologique de France*, 31, 1-84.

Boukhary, M., Abd-Elshafi, E. & Mattar, Y. 2011. *Sanctus sinaicus* n. gen., n. sp. (Foraminiferida, Amphisteginidae) from Late Eocene of Sinai, Egypt. *Micropaleontology*, 57, 537-542.

Brady, H.B. 1881. Notes on some of the reticularian *Rhizopoda* of the 'Challenger' Expedition, part 3. 1. Classification. 2. Further notes on new species. 3. Note on *Biloculina* mud. *Quaternary Journal of Microscopical Science, new series*, 21, 31-71.

Brady, H.B. 1884. Report on the foraminifera dredged by H.M.S. 'Challenger', during the years 1873-1876. *Report of the Scientific Results of the Voyage of the H.M.S., Zoology*, 9, 1-814.

Carsey, D.O. 1926. Foraminifera of the Cretaceous of central Texas. *University of Texas Bureau of Economic Geology and Technology Bulletin*, 2612, 1-56.

Chapman, F. 1916. Report on the foraminifera and ostracoda out of marine muds from soundings in the Ross Sea.

Reports of Scientific Investigations, British Antarctic Expedition 1907-1909, Geology, 2, 53-80.

Cherif, O.H. & El Deeb, W.Z. 1984. The Middle Eocene–Oligocene of the Northern Hafit Area, south of Al Ain City (United Arab Emirates). *Geologie Méditerranéenne*, 11, 207-217.

Culver, S.J. 2003. Benthic foraminifera across the Cretaceous-Tertiary (K-T) boundary: a review. *Marine Micropaleontology*, 47, 177-226.

Cushman, J.A. 1910. A monograph of the foraminifera of the North Pacific Ocean. Pt. 1, Astrorhizidae and Lituolidae. *Bulletin of the United States National Museum*, 71, 1-134.

Cushman, J.A. 1911. A monograph of the foraminifera of the North Pacific Ocean. Pt. 2, Textulariidae. *Bulletin of the United States National Museum*, 71, 1-108.

Cushman, J.A. 1925. An Eocene fauna from the Moctezuma River, Mexico. *American Association of Petroleum Geology Bulletin*, 9, 298-303.

Cushman, J.A. 1926. The foraminifera of the Velasco Shale of the Tampico Embayment. *American Association of Petroleum Geology Bulletin*, 10, 581-612.

Cushman, J.A. 1927. An outline of the re-classification of the Foraminifera. *Contributions from the Cushman Laboratory for Foraminiferal Research*, 3, 1-105.

Cushman, J.A. 1928. Foraminifera: their classification and economic use. *Special Publication Cushman Laboratory for Foraminiferal Research*, 1, 1-401.

Cushman, J.A. 1933. New foraminifera from the Upper Jackson Eocene of the southeastern coastal plain region of the United States. *Contribution from the Cushman Laboratory for Foraminiferal Research*, 9, 1-21.

Cushman, J.A. 1935. Fourteen new species of Foraminifera. *Smithsonian Miscellaneous Collections*, 91, 1-9.

Cushman, J.A. 1936. New genera and species of the families Verneuilinidae and Vulvulinidae and of the subfamily Virgulininae. *Cushman Foundation for Foraminiferal Research, Special Publication*, 6, 1-71.

Cushman, J.A. 1937. A monograph of the subfamily Virgulininae of the foraminiferal family Buliminidae. *Special Publications Cushman Laboratory for Foraminiferal Research*, 9, 1-228.

Cushman, J.A. 1949. The foraminiferal fauna of the Upper Cretaceous Arkadelphia marl of Arkansas. *Geological Survey, Professional Paper 221-A. United States Government Printing Office,* 1-31.

Defrance, J.L.M. 1824. Dictionnaire des Sciences Naturelles, 32. Moll-morf, Strasburg: E.G. Levrault.

Delage, Y. & Hérouard, E. 1896. *Truité de Zoologie Concréte, 1. La Cellule et les Protozoaires*, Paris, Schleicher Fréres.

El-Dawy, M.H. 2001. Paleocene benthic foraminiferal biostratigraphy and paleobathymetry, El Sheikh Fadl and Ras Gharib, Eastern Desert, Egypt. *Micropaleontology*, 4, 23-46.

Ehrenberg, C.G. 1838. Über dem blossen Auge unsichtbare Kalkthierchen und Kieselthierchen als Hauptbestandtheile der Kreidegobirge. *Bericht über die zu Bekanntmachung geeigneten Verhandlungen der Königlichen Preussischen Akademie der Wissenschaften zu Berlin*, 1838, 192-200.

Fursenko, A.V. 1958. Osnovnye etapy razvitiya faun foraminifer v geologicheskom proshlom. *Trudy Instituta Geologicheskikh Nauk. Akademiia Nauk Belorusskoi SSR. Minsk*, 1, 10-29.

Futyan, A.I. 1976. Late Mesozoic and Early Cainozoic benthonic foraminifera from Jordan. *Palaeontology*, 19, 53-66.

Futyan, A.I. 1976. Late Mesozoic and Early Cainozoic benthonic foraminifera from Jordan. *Palaeontology*, 19, 53-66.

Gebhardt, H. 1997. Cenomanian to Turonian foraminifera from Ashaka (NE Nigeria): quantitative analysis and palaeoenvironmental interpretation. *Cretaceous Research*, 18, 17-36.

Hanslíková, E. 1972. Carpathian Upper Cretaceous foraminifera of Moravia (Turonian-Maastrichtian). *Akademii, nakladatelstvi Československé akademie věd, Praha,* 160 p.

Haq, B.U. & Aubry, M.-P. 1978. Early Cenozoic calcareous nannoplankton biostratigraphy and palaeobiogeography of North Africa and the Middle East and Trans-Tethyan correlations. The Geology of Libya (1). 2nd Symposium on the Geology of Libya, Tripoli. 271-304.

Haque, A.F.M.M. 1956. The foraminifera of the Ranikot and the Laki of the Nammal Gorge, Salt Range, Pakistan. *Pakistan Geological Survey Memoir, Palaeontologica Pakistanica*, 1, 1-229.

Haynes, J. & Nwabufo-Ene, K. 1998. Foraminifera from the Paleocene phosphate beds, Sokoto, Nigeria. *Revista Española de Micropaleontologia*, 30, 51-76.

Helal, S.A. 2002. Contribution to the Eocene benthic foraminifera and ostracoda of the Fayoum Depression, Egypt. *Egyptian Journal Paleontology*, 2, 105-155.

Heron-Allen, E. & Earland, A. 1930. Some new foraminifera from the south Atlantic, 3, *Miliammina*, a new siliceous genus. *Journal of the Royal Microscopical Society of London*, 350, 38-45.

Hewaidy, A.A. 1994. Biostratigraphy and paleobathymetry of the Garra-Kurkur area, southeast Aswan. Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*, 8, 48-73.

Hewaidy, A.A. & Al-Hitmi, H. 1993. Cretaceous-Early Eocene foraminifera from Dukhan oil field, west Qatar, Arabian Gulf (A-Suborders Textulariina, Involutinina and Miliolina). *Al-Azhar Bulletin of Science*, 4, 495-516.

Hewaidy, A.A. & Strougo, A. 2001. Maastrichtian-lower Eocene benthic foraminiferal distribution and paleoecology of three outcrop sections in Farafra. *Egyptian Journal Paleontology*, 1, 1-22.

Hussein, A.I. 1997. Some agglutinated foraminifera from the Middle Eocene rocks of Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*, 11, 106-114.

Ismail, A.A. 1996. Paleocene time-marker benthonic foraminifera of Egypt. *Middle East Research Center, Ain Shams University, Earth Science Series*, 10, 198-213.

Ismail, A.A. 2012. Late Cretaceous-Early Eocene benthic foraminifera from Esh El Mallaha area, Egypt. *Revue de Paléobiologie*, 31, 15-50.

Kaminski, M.A. 2004. The year 2000 classification of the agglutinated foraminifera. *In*: Bubík, M. & Kaminski, M.A. (eds). *Proceedings of the Sixth International Workshop on Agglutinated Foraminifera, London: Grzybowski Foundation Special Publication,* 8, 237-255.

Kaminski, M.A. 2014. The year 2010 classification of the agglutinated foraminifera. *Micropaleontology*, 60, 89-108.

Kisel'man, E.N. 1972. Verkhnemelovye i Paleotsenovye foraminifery novogo roda *Spiroplectinella*. *Trudy Sibirskogo Nauchno-Issledovatel'skogo Instituta Geologii Geofiziki i Mineral'skogo Syr'ya (SNIIGGIMS) Ministerstva Geologii i Okhrany Nedr SSSR*, 146, 134-140.

Lankester, E.R. 1885. Protozoa. In: *Encyclopaedia Britannica*, 19, 9th ed., 830-866.

LeRoy, L.W. 1953. Biostratigraphy of Maqfi section, Egypt. *Geological Society of America Memoir*, 54, 1-73.

Loeblich, A.R. & Tappan, H. 1961. The status of the foraminifera genera *Ammodiscus* Reuss and *Involutina* Terquem. *Micropaleontology*, 7, 189-192.

Loeblich, A.R. & Tappan, H. 1985. Some new and redefined genera and families of agglutinated foraminifera. *Journal of Foraminiferal Research*, 15, 91-104.

Luger, P. 1988. Maastrichtian to Paleocene facies evolution and Cretaceous/Tertiary boundary in middle and southern Egypt. *Revista Espaňola de Micropaleontologia, n° Extraordinario*, 83-90.

Marsson, Th. 1878. Die Foraminiferen der Weissen Schreibkreide der Inseln Rügen. *Mitteilugen des Naturwissenschaftlichen Vereins für Neu-Vorpommern und Rugen in Greifswald*, 10, 115-196.

Mikhalevich, V.I. 1980. Sistematica i evolyutsiya foraminifera v svete novykh po ikh tsitologii i ul'trastrukture. *Trudy Zoologicheskogo Instituta Academiya Nauk SSSR*, 94, 42-61.

Mikhalevich, V.I. 1992. Makrosistema foraminifer [The macrosystem of the Foraminifera] Ph.D. Thesis St.-Pb., 1-43 (In Russian).

Mikhalevich, V.I. 1995. A new classification of the class Astrorhizata. *Zoosystematica Rossica*, 3, 161-174.

Mikhalevich, V.I. & Kaminski, M.A. 2008. Revised systematics of the Schlumbergerinida (Phylum Foraminifera). In: *Proceeding of the Seven International Workshop on Agglutinated Foraminifera* (eds Kaminski, M.A. & Coccioni, R.). *Grzybowski Foundation, Special Publication*, 13, 157-166.

Miklukho-Maklay, A.D. 1963. Verkhniy Paleozoy sredney Azii. *Leningradskiy Universitet*, Leningrad, 1-300.

Millett, F.W. 1898. Report on the Recent foraminifera of the Malay Archipelago collected by Mr. A. Durrand, E.R.M.S. 3. *Journal of the Royal Microscopical Society*, 607-614.

Moore, Jr., T.C., van Andel, T.H., Sancetta, C. & Pisias, N. 1978. Cenozoic hiatuses in pelagic sediments. *Micropaleontology*, 24, 113-138.

Nakkady, S.E. 1950. A new foraminiferal fauna from the Esna Shale and Upper Cretaceous chalk of Egypt. *Journal of Paleontology*, 24, 675-692.

Nakkady, S.E. 1959. Biostratigraphy of the Um Elghanayem section, Egypt. *Micropaleontology*, 5, 453-472.

Nomura, R. & Brohi, I.A. 1995. Benthic foraminiferal fauna during the time of the Indian-Asian contact, in southern Balochistan, Pakistan. *Marine Micropaleontology*, 24, 215-238.

Orbigny, A. d'. 1826. Tableau méthodique de la classe des Céphalopodes. *Annales des Sciences Naturelles, Paris*, 7, 245-314.

Orbigny, A. d'. 1839. Foraminifères. In: *Ramon de la Sagra. Histoire Physique, Politique et Naturelle de l'ile de Cuba*. Paris, Arthus Bertrand. 224 p.

Orbigny, A. d'. 1846. Foraminifères fossiles du Bassin Tertiare de Vienne (Austriche). *Gide et Compagnie, Libraires-Editeurs, Paris*, 1-303.

Ozsvárt, P. 2007. Middle and Late Eocene benthic foraminiferal fauna from the Hungarian Paleogene Basin: systematics and paleoecology. *Geologica Pannonica, Special Publication*, 2, 1-129.

Pawlowski, J., Holzmann, M. & Tyszka, J. 2013. New supraordinal classification of Foraminifera: molecules meet morphology. *Marine Micropaleontology*, 100, 1-10; doi: 10.1016/j.marmicro.2013.04.002.

Phillips, J.D. 1971. Sea floor spreading and continental drift reconstructions around the Atlantic, part I: 266-276. Influence of the Continental drift on the distribution of the Tertiary benthic foraminifera in the Caribbean and Mediterranean regions. Symposium on the geology of Libya, University of Libya, Tripoli, 263-299.

Plummer, H.J. 1931. Some Cretaceous foraminifera in Texas. *Bulletin University of Texas*, 3101, 109-203.

Podobina, V.M. 1978. Sistematika i filogeniya Gaplofragmiidev. *Tomsk, Tomsk Universitet*.

Reuss, A.E. 1845. Die Versteinerungen der Böhmischen Kreideformation. *Erste Abtheilung* Stuttgart: *E. Schweizerbart'sche Verlagsbuchhandlung und Druckerei*, 1-58.

Reuss, A.E. 1851. Ober die fossilen foraminiferen und Entomostraceen der Septarienthone der Umgegend von Berlin. *Zeitschrift der Deutschen Geologischen Gesellschaft*, 3, 49-92.

Reuss, A.E. 1860. Die Foraminiferen der Westphälischen Kreideformation. *Sitzungsberichte der K. Academie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftliche Classe*, 40, 147-238.

Rosenbaum, G., Lister, G.S. & Duboz, C. 2002. Relative motions of Africa, Iberia and Europe during Alpine orogeny. *Tectonophysics*, 359, 117-129.

Said, R. & Kenawy, A. 1956. Upper Cretaceous and Lower Tertiary foraminifera from northern Sinai, Egypt. *Micropaleontology*, 2, 105-173.

Saidova, Kh.M. 1970. Planktonnye foraminifery iz rayona Kurilo-Kamchatskogo zheloba. *Trudy Instituta Okeanologii*, 86, 162-164.

Saidova, Kh.M. 1975. Bentosnye Foraminifery Tikhogo Okeana. *Institut Okeanologii P. P. Shirshova. Akademiya Nauk SSSR*, 875 p.

Saidova, Kh.M. 1981. O sovremennom sosttoyanii sidtemy nadvidovykh taksonov Kaynozoyskikh bentosnykh foraminifer. *Institut Okeanologii P. P. Shirshova. Akademiya Nauk SSSR*, 73 p.

Sars, M. 1869. Fortsatte bemaerkninger over der dyriske livs udbredning i havets dybder. *Forhandlinger i Videnskasselskabet i Kristiania*, 1868, 246-275.

Sars, M. 1972. Undersøgelser over Hardangerfjordens Fauna. *Forhandlinger i Videnskasselskabet i Kristiania*, 1871, 246-255.

Schwager, C. 1877. Quadro del proposto sistema di classificazione dei foraminiferi con guscio. *Bollettino R. Comitato Geologico d'Italia*, 8, 18-27.

Schwager, C. 1876. Saggio di una classificazione dei foraminiferi avuto riguardo alle loro famiglie naturali. *Bolletino R. Comitato Geologico d'Italia*, 7, 475-485.

Schwager, C. 1883. Die Foraminiferen aus dem Eocaenablegerungen der Libyschen wuste und Agyptens. *Paleontographica*, 30, 81-153.

Silvestri, A. 1903. Dimorfismo e nomenclatura d'una *Spiroplecta*. Altre notizie sulla struttura della *Siphogenerina columellaris*. *Atti della Pontificia Academia Romana dei Nuovi Lincei, Roma*, 56, 59-66.

Speijer, R.P. 1994. Extinction and recovery patterns in benthic foraminiferal paleocommunities across the Cretaceous/Paleogene and Paleocene/Eocene boundaries. *Geologica Ultraiectina, Universiteit Utrecht*, 124, 1-191.

Sztrákos, K. 2000. Eocene foraminifers in the Adour Basin (Aquitaine, France): biostratigraphy and taxonomy. *Revue de Micropaléontologie*, 43, 71-172.

Sztrákos, K. 2005. Paleocene and lowest Eocene foraminifera from the north Pyrenean trough (Aquitaine, France). *Revue de Micropaléontologie*, 48, 175-236.

Widmark, J.G.V. & Speijer, R.P. 1997. Benthic foraminiferal ecomarker species of the terminal Cretaceous (late Maastrichtian) deep-sea Tethys. *Marine Micropaleontology*, 31, 135-155.

Youssef, M. & Taha, S. 2012. Biostratigraphy and paleoecology of Paleocene/Eocene (P/E) interval of some geological sections in Central Egypt. *Arabian Journal of Geosciences*, 2012, 1-23.

Zachos, J.C., Lohmann, K.C., Walker, J.C.G. & Wise, S.W. 1993. Abrupt climate change and transient climates during the Paleogene: A marine perspective. *Journal of Geology*, 101, 191-213.