



## Paleocene agglutinated foraminifera from Jabal Mundassa, Al Ain area, United Arab Emirates

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### ABSTRACT

The Paleocene succession of Jabal Mundassa, Al Ain area, United Arab Emirates (UAE) contains prolific and well-preserved species of agglutinated, planktic and calcareous benthic foraminifera at the Danian/Selandian (D/S) transition. This succession is considered as the only one that has Danian sediments in the Al Ain area. The present study is deals with the taxonomy, palaeogeography and stratigraphic distribution of twenty-six agglutinated benthic species at Jabal Mundassa and other Paleocene outcrops localities in the Tethys.

**Keywords:** Danian, Selandian, Mundassa, United Arab Emirates (UAE).

### RESUMEN

La sucesión del Paleoceno en Jabal Mundassa, zona de Al Ain, Emiratos Árabes Unidos (EAU), contiene especies prolíficas bien conservadas de foraminíferos aglutinados planctónicos y bentónicos calcáreos, de la transición Daniense/Selandiense. Esta sucesión se considera como el único afloramiento que tiene sedimentos del Daniense en el área de Al Ain. Este estudio se enfoca en la taxonomía, paleogeografía y distribución estratigráfica de veintiséis especies de foraminíferos bentónicos aglutinados, que pertenecen a diecinueve géneros. La paleontología, la paleogeografía y distribución estratigráfica de la fauna identificada en Jabal Mundassa es comparada con la de otros afloramientos del Paleoceno en el Mar del Tetis.

**Palabras clave:** Daniense, Selandiense, Mundassa, Emiratos Árabes Unidos (EAU).

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## 1. INTRODUCTION

The present paper is a part of a comprehensive study concerned with the complete record of smaller benthic foraminifera of the post-nappe Upper Cretaceous and Paleogene sediments in the United Arab Emirates (UAE). The micropaleontological content of this succession was treated by many authors: Cherif *et al.* (1992) studied the Middle Eocene-Miocene benthic foraminifera of Jabal (mountain) Hafit, Al Ain area (Fig. 1), and recorded 31 benthic species (7 of them are agglutinated). Anan *et al.* (1992) studied the Lower Eocene-Oligocene succession of Jabal Hafit and identified 69 species of planktic and 19 species of larger benthic foraminifera. Anan (1993a) recorded 70 benthic species (15 of them are agglutinated) from the Middle-Upper Paleocene beds in J. Malaqet, Al Ain area. Anan (1993b) recorded 28 benthic species (19 of them are agglutinated) from the Maastrichtian-Paleocene succession of the Qarn El Barr section, Al Dhayd area, central north UAE. Anan (1996) recorded 27 benthic species (8 of them are agglutinated) from the Lower Eocene rocks of J. Hafit. Abdelghany (2003) recorded 27 benthic species (4 of them are agglutinated) from the Campanian-Maastrichtian rocks of the Qarn El Barr and Malaqet sections, UAE. Anan (2005a) recorded 15 agglutinated species from Middle-Upper Eocene rocks of J. Hafit. Anan (2007) recorded 42 benthic species (5 of them are agglutinated) from the upper Eocene rocks of J. Malaqet. In the present study, 26 agglutinated species at the D/S transition are identified (21 of them are illustrated). The micropaleontology, paleogeography, and stratigraphy of the Paleocene rocks of the studied section, UAE, and other localities in the Tethys are also presented.



**Figure 1.** Location map of the study section at Jabal Mundassa, Al Ain area, UAE.

## 2. GEOLOGY AND STRATIGRAPHY OF THE STUDIED SECTION

The upper Maastrichtian to Paleogene (M/P) post-nappe rocks crop out as a discontinuous belt in jabals (mountains) and qarns (hills) around the western front of the Northern Oman Mountains (NOM) in the UAE. The folded anticlines of J. Mundassa and J. Malaqet in the Al Ain area are parts of the NOM and located approximately 25 km south of Al Ain city (UAE), and about 20 km east of J. Hafit. These jabals are related in the eastern side of the Al Jaww Plain, near the border with the Sultanate of Oman (Fig. 1). The pre-Maastrichtian Semail Ophiolite (SO) forms the core of the breached anticlines of J. Mundassa and J. Malaqet. During the last stage of the emplacement of the Semail Ophiolite onto the passive continental margin of the Arabian platform, several foredeep basins were developed including the Ras Al Khaima basin and the Mundassa basin. These basins hosted deposition of a Maastrichtian-Paleogene (M/P) sedimentary succession, which unconformably overlies deposits that deformed later by contemporaneous thrust faults and folds. The D/S transition is attributed to the shaley marl neoautochthonous sediments belonging to the Mundassa Member of the Muthaymimah Formation, which are nonconformably overlying the Pre-Maastrichtian allochthonous Semail Ophiolite (serpentinites and serpentinitized peridotites). This depositional gap is most probably due to submarine erosion not to subaerial denudation, and corresponds to an episode of tectonic activity that exists in most localities in the world. The neoautochthonous and the underlying allochthonous rocks were deformed by post-obduction compression and formed folds and thrust fault belts along the western flank of the Northern Oman Mountains (Warrak, 1996). In the region have been carried out the outcrops of these belts comprise many jabals in the Al Ain area (i.e., J. Mundassa, J. Malaqet, J. Hafit, Fig. 1).

The Paleocene shaley marl post-nappe sediments, which unconformably overlie the obducted Semail Ophiolite in the J. Mundassa anticline (Fig. 2) are related to the Mundassa Member (of Hamdan & Anan, 1993 and Anan, 1993a) of the Muthaymimah Formation (of Nolan *et al.*, 1990), but to the Mundassa Formation (of Noweir & Eloutefi, 1997), while it was attributed to the lower part of Malaqet Formation of J. Malaqet (in Boukhary *et al.*, 2003). The shaley marl of J. Mundassa was attributed to the Late Paleocene by Noweir & Eloutefi (1997), but it referred to the Early-Middle Paleocene based on the planktic foraminiferal biozonation.

The gypsiferous green shale in J. Malaqet, which unconformably overlies the Late Maastrichtian Simsimah Formation, was observed to the Middle Paleocene by Hamdan & Anan (1993), Anan & Hamdan (1993) and Anan (1993a), but was attributed to the Late Paleocene by Noweir & Eloutefi (1997) and Boukhary *et al.* (2003). On

the other hand, Speijer (2003) noted that the D/S transition in Egypt is marked by a black shale bed rich in organic carbon and fish remains, strongly dominated by anomalous foraminiferal assemblages, and defined as the “*Neo-duwi* event”, while in Tunisia, a palaeoenvironmental change is recorded during the same interval although it was not marked by a black shale bed. In the section presented in this study, J. Mundassa in UAE, neither marked black shale bed in this interval nor *Neoeponides duwi* are recorded. In total 26 agglutinated benthic foraminiferal species are recorded, 21 of which are illustrated in Figure 4 from the D/S transition (Early-Middle Paleocene, P1a-P3) of the shaley marl succession in J. Mundassa. Based on the planktic foraminiferal zonation the duration of the hiatus at the Cretaceous/Paleogene (K/P) boundary includes the two earliest Danian biozones (P0 and Pa, about 0.02 Ma, Fig. 2).



**Figure 2.** View of the Paleocene sediments (Danian-Selandian transition, Mundassa Member of the Muthaymimah Formation) which nonconformably overly the obducted pre-Maastrichtian Semail Ophiolite.

### 3. MATERIAL OF STUDY

Fourteen samples from the shaley marl succession of J. Mundassa (samples 1-14, with about 26 m thick interval, composed of beds 1-3 which contain a yellow brown hard ledge bed no. 2 with sample 9) were collected from the exposed neoautochthonous Paleocene rocks of the Mundassa Member of the Muthaymimah Formation, which nonconformably rest on the peneplained allochthonous Pre-Maastrichtian Semail Ophiolite (Fig. 3).

#### 3.1. Systematic palaeontology

This study concentrates on the taxonomy and palaeogeographic distribution of twenty-six identified agglutinated benthic foraminiferal species (belonging to

nineteen genera), and twenty one of them are illustrated in Figure 4. The suprageneric systematics of the agglutinated foraminifera by Kaminski (2004) is used herein.

Class FORAMINIFERA d'Orbigny, 1826

Order ASTRORHIZIDA Lankester, 1855

Suborder ASTRORHIZINA Lankester, 1855

Superfamily ASTRORHIZACEA Brady, 1881

Family **Bathysiphonidae** Avnimelech, 1952

Subfamily Bathysiphoninae Avnimelech, 1952

Genus *Bathysiphon* Sars, 1872

Type species *Bathysiphon filiformis* Sars, 1872

*Bathysiphon eocenicus* Cushman & Hanna, 1927  
(Fig. 4.1)

1927 *Bathysiphon eocenicus* Cushman & Hanna, p. 210, pl. 13, figs. 2, 3.

1994 *Bathysiphon eocenicus*; Bolli *et al.*, p. 65, fig. 18. 3.

2005a *Bathysiphon eocenicus*; Anan, p. 18, pl. 1, fig. 1.

The species was originally described from the Eocene of California. It is also recorded from Paleocene-Eocene rocks of other localities in the Tethys (i.e., Ecuador, Trinidad, Italy, Egypt, UAE), as well as from the Paleocene sediments of the J. Mundassa section.

*Bathysiphon paleocenicus* El-Dawy, 2001  
(Fig. 4.2)

2001 *Bathysiphon paleocenicus* El-Dawy, p. 42, pl. 1, fig. 1.

2012 *Bathysiphon paleocenicus*; Anan, p. 63, pl. 1, fig. 3.

This species was originally described from the upper Paleocene deposits of central Egypt. It was also recorded for the first time outside Egypt by Anan (2012) in the Danian-Selandian transition of J. Mundassa. The latter author (op. cit.) also noted that the middle-late Eocene *Bathysiphon saidi* of Anan (1994, 2005a) were recorded from Egypt and UAE is most probably the youngest form of *B. paleocenicus*.

Genus *Nothia* Pflaumann, 1964

Type species *Rhizammina grilli* Noth, 1951

*Nothia excelsa* (Grzybowski, 1898)  
(Fig. 4.3)

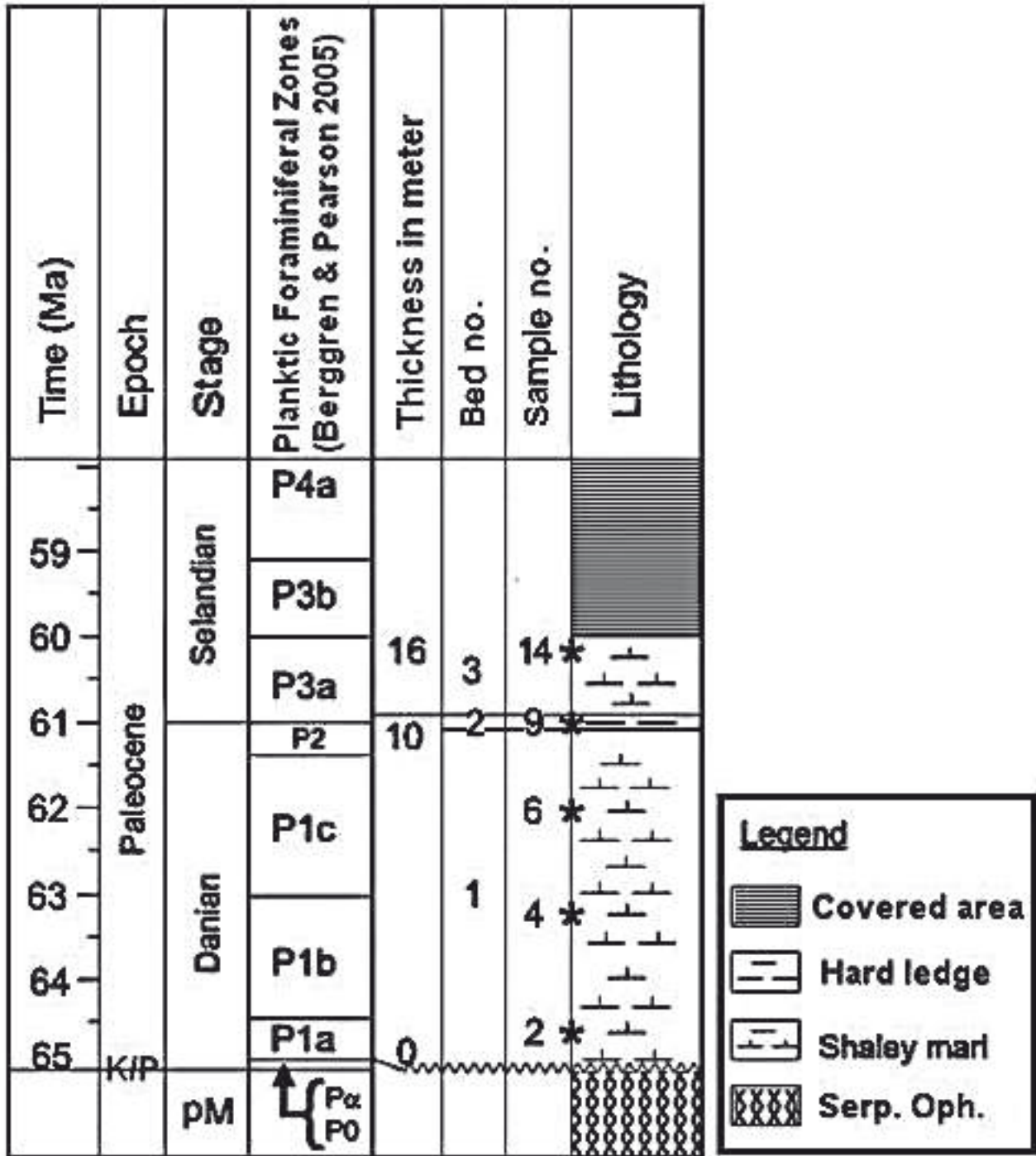


Figure 3. The stratigraphic log of the Danian-Selandian transition in the eastern limb of J. Mundassa anticline, Al Ain area, UAE (pM= pre-Maastrichtian, K/P= Cretaceous/Paleogene boundary, Serp. Oph.= serpentine Semail Ophiolite).

1898 *Dendrophrya excelsa* Grzybowski, p. 272, pl. 10, figs. 1-4.

1972 *Dendrophrya excelsa*; Hanzlíková, p. 32, pl. 2, fig. 6.

1977 *Dendrophrya excelsa*; Krasheninnikov & Pflaumann, p. 567, pl. 1, fig. 7.

1981 *Dendrophrya excelsa*; Morgiel & Olszewska, p. 7, pl. 1, figs. 5, 6.

1992 *Nothia excelsa*; Geroch & Kaminski, p. 265, pl. 1, fig. 2.

1993 *Dendrophrya excelsa*; Kuhnt & Kaminski, p. 72, pl. 1, fig. 2.

1996 *Nothia excelsa*; Kuhnt & Collins, p. 212.

2005 *Nothia excelsa*; Kaminski & Gradstein, p. 106, text-fig. 2, pl. 2a, 1-9, pl. 2b, 1-11.

2006 *Nothia excelsa*; Cieszkowski *et al.*, p. 208, fig. 6 A.

2009 *Nothia excelsa*; Kender *et al.*, p. 493, pl. 1, fig. 5.  
2013 *Nothia excelsa*; Bindu *et al.*, p. 122, fig. 4. 1-3.

Loeblich & Tappan (1987) noted that the Late Cretaceous-Paleogene genus *Nothia* commonly has elongated, tubular, and may branch sparsely and irregular test, while the early stage of the genus *Dendrophrya* consists of a hemispherical test. It was recorded from many parts of the Tethys: i.e., South Atlantic, Spain, Poland, the Czech Republic, Romania, and Angola. *Nothia excelsa* is recorded from the Danian strata of J. Mundassa, for the first time in UAE.

Suborder AMMODISCINA Mikhalevich, 1980

Superfamily AMMODISCACEA Reuss, 1862

Family **Ammodiscidae** Reuss, 1862

Subfamily Ammodiscinae Reuss, 1862

Genus *Ammodiscus* Reuss, 1862

Type species *Ammodiscus infimus* Bornemann, 1874

*Ammodiscus angustus* (Friedberg, 1901)  
(Fig. 4.4)

1901 *Cornuspira angusta* Friedberg, p. 178, pl. 1, fig. 8.  
1987 *Ammodiscus angustus*; Loeblich & Tappan, p. 47, pl. 36, figs. 5-9.  
1999 *Ammodiscus angustus*; Ansoorge *et al.*, p. 235.

This species is characterized by having a globular proloculus followed by planispirally enrolled and undivided tubular chamber. It is recorded from the Paleocene rocks of J. Mundassa, for the first time in UAE.

*Ammodiscus cretaceus* (Reuss, 1845)  
(Fig. 4.5)

1845 *Operculina cretacea* Reuss, p. 35, pl. 13, figs. 64, 65.  
1977 *Ammodiscus cretaceus*; Sliter, p. 677, pl. 1, fig. 3.  
1988 *Ammodiscus cretaceus*; Kaiho, p. 554, fig. 1. 23, p. 556, fig. 2. 11.  
1989 *Ammodiscus cretaceus*; Hulsbos *et al.*, p. 266, pl. 1, fig. 9.  
1993 *Ammodiscus cretaceus*; Kuhnt & Kaminski, p. 145, pl. 2, fig. 1.  
1993 *Ammodiscus cretaceus*; Hewaidy & Al-Hitmi, p. 471, pl. 1, figs. 1, 2.  
1999 *Ammodiscus cretaceus*; Ansoorge *et al.*, p. 235.  
2004 *Ammodiscus cretaceus*; Galeotti *et al.*, p. 94, pl. 2, fig. 1  
2005 *Ammodiscus cretaceus*; Kaminski & Gradstein, p. 106, text-fig. 14, pl. 14, figs. 1-10.

2005b *Ammodiscus cretaceus*; Anan, p. 78, pl. 1, fig. 1.  
2009 *Ammodiscus cretaceus*; Kender *et al.*, p. 495, pl. 1, fig. 16.

Kuhnt & Kaminski (1993) lumped *Ammodiscus glabratus* in *A. cretaceus* which is acceptable here. This cosmopolitan Paleocene-Miocene species was originally recorded from the Eocene of California (USA), and later from many parts of the Tethys: Ecuador, South Atlantic, Norwegian Sea, Italy, Trinidad, Spain, Poland, Bulgaria, Romania, Angola, Tunisia, Egypt, Qatar, UAE, Japan and New Zealand. It is also present in the Paleocene of J. Mundassa.

Subfamily Usbekistaniinae Vyalov, 1968

Genus *Glomospira* Rzehak, 1885

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

*Glomospira gordialis* (Jones & Parker, 1860)  
(Fig. 4.6)

1860 *Trochammina squamata* Jones & Parker var. *gordialis* Jones & Parker, p. 304.  
1977 *Glomospira gordialis*; Sliter, p. 677, pl. 1, fig. 7.  
1978 *Glomospira charoides*; Proto Decima & Bolli, p. 794, pl. 1, fig. 2.  
2004 *Glomospira charoides*; Galeotti *et al.*, p. 94, pl. 2, fig. 5  
2005 *Glomospira charoides*; Kaminski & Gradstein, p. 181, text-fig. 25, pl. 25, figs. 1-8.  
2008 *Glomospira charoides*; Filipescu & Kaminski, p. 27, pl. 2, fig. 6.  
2009 *Glomospira gordialis*; Kender *et al.*, p. 494, pl. 2, fig. 11.  
2013 *Glomospira gordialis*; Bindu *et al.*, p. 123, fig. 5. 3.

Loeblich & Tappan (1987) noted that the genus *Glomospira* has a streptospirally coiled. It is coiled like *Repmanina* in the early portion (trochospirally coiled test about a straight axis), and the latter portion is coiled glomospirally (planispiral whorls inclined at a small angle to each other). This has been shown by Bender (1995). The author believes that the two subspecies *gordialis* and *charoides* of Jones & Parker (1860) are difficult to differentiate from each other. *Glomospira gordialis* is a cosmopolitan form recorded from upper Cretaceous to Recent sediments, occurring in many parts of the Tethys: USA, Canada, Spain, Russia, Italy, Ukraine, Angola, Tunisia, Egypt. It is also reported from the Paleocene rocks of J. Mundassa, for the first time in UAE.

Genus *Repmanina* Suleymanov, 1966

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

*Repmanina* sp.

(Fig. 4.7)

Loeblich & Tappan (1987) noted that the genus *Repmanina* has regular trochospirally coiled test about a straight axis and forms a depressed crown-like coiled in outline, chambers have sharp edges with a smooth wall. This species differs from *Glomospira gordialis* by its regular and depressed crown coiled in outline, the center of the test is wider than the start and end of its coiling. It is recorded from the Selandian rocks of J. Mundassa.

Order LITUOLIDA Lankester, 1885

Suborder HORMOSININA Mikhalevich, 1980

Superfamily POLYCHASMININAE Kaminski, 2004

Family **Glaucoamminidae** Saidova, 1981

Genus *Psammolingulina* Silvestri, 1904

Type species *Lingulina papillosa* Neugeboren, 1856

*Psammolingulina* sp.

(Fig. 4.8)

This species has an elongated rectilinear uniserial test of inflated globular equal height chambers and rounded peripheral with terminal slit-like aperture, strongly depressed sutures, and wall of agglutinated coarse quartz particles giving a rough surface. It differs from the type species of the Miocene-Pliocene *P. papillosa* Neugeboren, 1856 by its more inflated chambers and its older occurrence at the Danian-Selandian transition, and in having more depressed sutures.

Suborder LITUOLINA Lankester, 1885

Superfamily LITUOLACEA de Blainville, 1827

Family **Lituolidae** de Blainville, 1827

Subfamily Ammomarginulinae Podobina, 1978

Genus *Ammobaculites* Cushman, 1910

Type species *Spirolina agglutinans* d'Orbigny, 1846

*Ammobaculites schwageri* Said & Kenawy, 1956

1956 *Ammobaculites schwageri* Said & Kenawy,  
p. 121, pl. 1, fig. 8.

This species is characterized by its planispirally non-umbilicate closed coiled initial stage followed by uncoiled chambers in the later stage with a smoothly finished agglutinated wall. It was originally recorded from the Paleocene rocks of Sinai, Egypt, and from the Paleocene rocks of J. Mundassa, for the first time in UAE.

Superfamily HAPLOPHRAGMIACEA Eimer & Fickert, 1899

Family **Ammosphaeroidinidae** Cushman, 1927

Subfamily Ammosphaeroidininae Cushman, 1927

Genus *Ammosphaeroidina* Cushman, 1910

Type species *Haplophragmium sphaeroidiniforme*  
Brady, 1884

*Ammosphaeroidina pseudopauciloculata* (Mjatliuk, 1966)  
(Fig. 4.9)

1966 *Cystammina pseudopauciloculata* Mjatliuk, p.  
264, pl. 1, figs. 5-8, pl. 2, fig. 6, pl. 3, fig. 3.

1987 *Ammosphaeroidina pseudopauciloculata*;  
Loeblich & Tappan, p. 81, pl. 67, figs. 8-10.

1993 *Ammosphaeroidina pseudopauciloculata*; Kuhnt  
& Kaminski, p. 72, pl. 5, fig. 10.

1994 *Ammosphaeroidina pseudopauciloculata*; Kender  
*et al.*, p. 501, pl. 6, fig. 7.

2004 *Ammosphaeroidina pseudopauciloculata*; Galeotti  
*et al.*, p. 94, Pl. 4, fig. 1

2005 *Ammosphaeroidina pseudopauciloculata*;  
Kaminski & Gradstein, p. 376, text-fig. 87, pl. 87a, figs.  
1-5, pl. 87b, figs. 1-10.

2006 *Ammosphaeroidina pseudopauciloculata*;  
Cieszkowski *et al.*, p. 209, pl. 7, fig. G.

This species is characterized by its three embracing chambers in the final whorl and wall coarsely agglutinated with smoothly finished surface. It was originally recorded from the Paleocene-Eocene of the Carpathians and later in Spain, Angola, N. Atlantic, Gulf of Mexico and Caribbean, Mediterranean, Australia and N. Pacific. It also occurs in Paleocene rocks of J. Mundassa for the first time in UAE.

Subfamily Recurvoidinae Alekseychik-Mitskevich,  
1973

Genus *Recurvoides* Earland, 1934

Type species *Recurvoides contortus* Earland, 1934

*Recurvoides anormis* Mjatliuk, 1970  
(Fig. 4.10)

1970 *Recurvoides anormis* Mjatliuk, p. 84, pl. 18, fig. 4,  
pl. 19, figs. 1-4.

2005 *Recurvoides anormis*; Kaminski & Gradstein, p. 403, text-fig. 95, pl. 95, figs. 1-7.

2013 *Recurvoides anormis*; Bindu *et al.*, p. 123, fig. 5, 8, 9.

*Recurvoides anormis* is characterized by its subglobular, streptospirally and enrolled test of 6-8 chambers in the final whorl with depressed sutures. It is recorded from lower Maastrichtian-upper Eocene, from the Carpathians, Europe and Trinidad. It is also present in the Danian rocks of J. Mundassa.

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 dentata* (Alth, 1850)  
(Fig. 4.11)

1850 *Textularia dentata* Alth, p. 262, pl. 13, fig. 13.

1968 *Spiroplectammina dentata*; Neagu, p. 228, test-fig. 2. 20.

1972 *Semivulvulina dentata*; Hanzlíková, p. 49, pl. 9, fig. 6.

1978 *Spiroplectammina dentata*; Proto Decima & Bolli, 1978, p. 796, pl. 1, fig. 4.

1981 *Spiroplectammina dentata*; Morgiel & Olszewska, p. 14, pl. 4, fig. 4.

1985 *Spiroplectammina dentata*; Luger, p. 76, pl. 3, fig. 1.

1993a *Spiroplectammina dentata*; Anan, p. 314, pl. 1, fig. 3.

1994 *Spiroplectinella dentata*; Bolli *et al.*, p. 83, fig. 22. 4-7.

2005b *Spiroplectinella dentata*; Anan, p. 80.

2005 *Spiroplectinella dentata*; Kaminski & Gradstein, p. 349, text-fig. 106, pl. 106, figs. 1-8.

2013 *Spiroplectinella dentata*; Bindu *et al.*, p. 123, fig. 5. 5, 6.

This Maastrichtian to Paleocene cosmopolitan species was recorded in many Tethyan localities: Trinidad, USA, Netherlands, Poland, Czech, Romania, South Atlantic Ocean, Tunisia, Egypt, UAE. It is also found in the Paleocene rocks of J. Mundassa.

*Spiroplectinella subhaeringensis* (Grzybowski, 1896)  
(Fig. 4.12)

1896 *Textularia subhaeringensis* Grzybowski, p. 285, pl. 9, figs. 13, 16.

1983 *Spiroplectinella subhaeringensis*; Tjalsma & Lohmann, p. 20, pl. 2, fig. 3.

1996 *Spiroplectammina subhaeringensis*; Kuhnt & Collins, p. 214, pl. 2, fig. 12.

2005 *Spiroplectinella subhaeringensis*; Kaminski & Gradstein, p. 444, text-fig. 108-1, pl. 108, figs. 1-5.

Tjalsma & Lohmann (1983) noted that the stratigraphic range of this species is Paleocene, and it is rare and patchy in distribution. It is found in the Paleocene rocks of J. Mundassa.

Suborder TROCHAMMININA Saidova, 1981

Superfamily TROCHAMMINACEA Schwager, 1877

Family **Trochamminidae** Schwager, 1877

Subfamily Trochammininae Schwager, 1877

Genus *Trochammina* Parker & Jones, 1859

Type species *Nautilus inflatus* Montagu, 1808

*Trochammina globigeriniformis* (Parker & Jones, 1865)  
(Fig. 4.13)

1865 *Lituola globigeriniformis* Parker & Jones, p. 407, pl. 15, figs. 46, 47.

1946 *Trochammina globigeriniformis*; Cushman, p. 51, pl. 15, figs. 8, 10, 11.

1976 *Trochammina globigeriniformis*; Aubert & Berggren, p. 411, pl. 1, fig. 17.

1988 *Trochammina globigeriniformis*; Anan & Sharabi, p. 202, pl. 1, fig. 8.

This species has a trochospiral test, chambers increasing gradually as added with a coarsely finished surface. It occurs in Maastrichtian-Paleocene rocks at some localities: USA, Tunisia, Egypt, Poland. It is also recorded for the first time in UAE from the Paleocene rocks of J. Mundassa.

Suborder VERNEUILININA Mikhalevich & Kaminski, 2004

Superfamily VERNEUILINACEA Cushman 1911

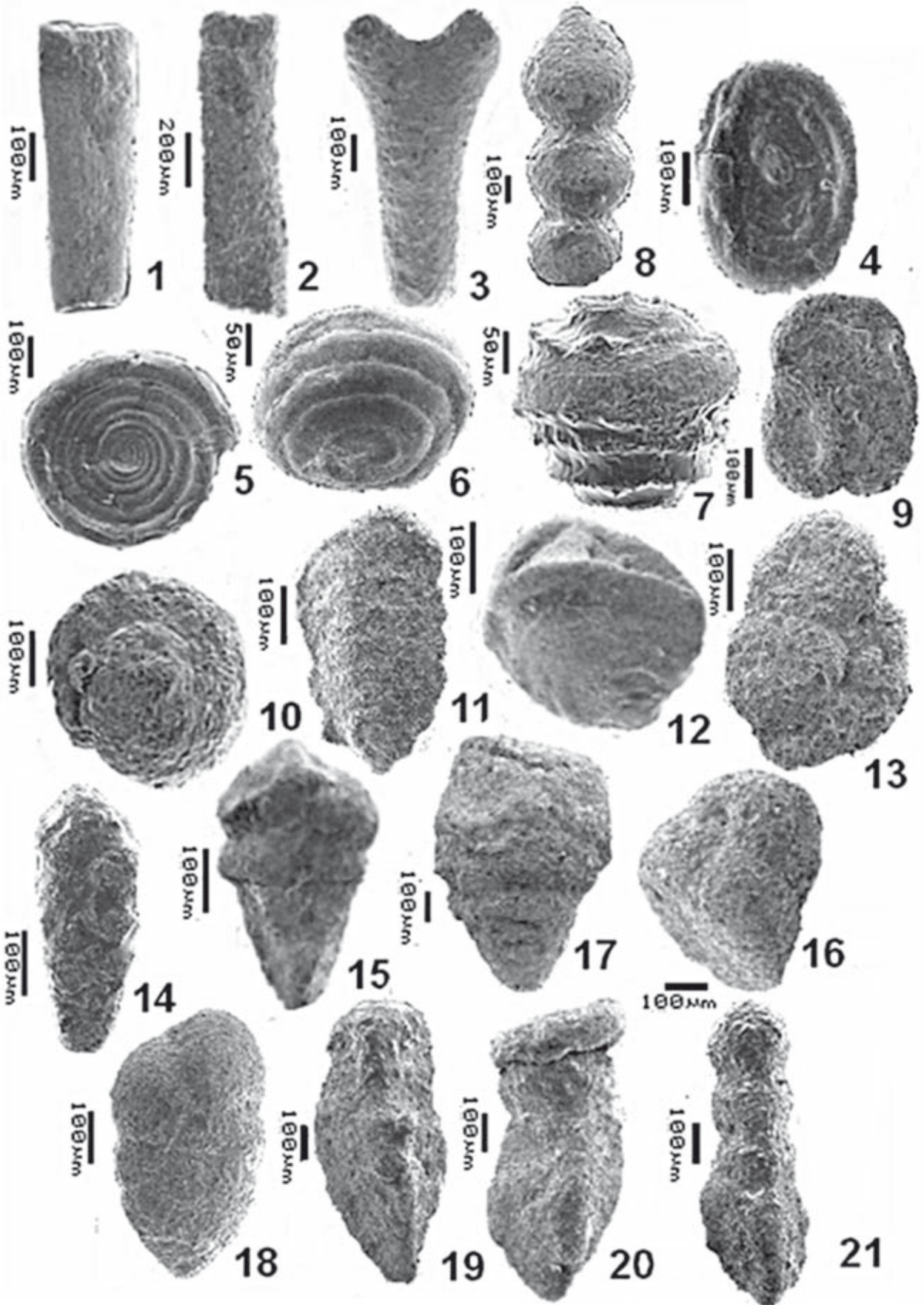
Family **Verneulinoididae** Cushman 1911

Subfamily Verneulinoidinae Suleymanov, 1973

Genus *Gaudryinopsis* Podobina, 1975

Type species *Gaudryina vulgaris* Kipriyanova, 1960

*Gaudryinopsis vulgaris* Kipriyanova, 1960  
(Fig. 4.14)





1960 *Gaudryina vulgaris* Kipriyanova, p. 78.

1987 *Gaudryinopsis vulgaris*; Loeblich & Tappan, p. 133, pl. 140, figs. 26-32.

The genus *Gaudryinopsis* differs from *Gaudryina* by its inflated subglobular chambers and rounded section. *Gaudryinopsis vulgaris* has an elongate test, with a short early triserial stage, later biserial and commonly with nearly parallel sides, chambers subglobular to slightly appressed, sutures depressed, test rounded to ovoid in section, wall finely agglutinated. This Triassic to Eocene species is recorded for the first time in the Danian rocks of J. Mundassa.

Superfamily VERNEUILINACEA Cushman, 1911

Family **Verneulinidae** Cushman, 1911

Subfamily Verneulininae Cushman, 1911

Genus *Gaudryina* d'Orbigny, 1839

Type species *Gaudryina rugosa* d'Orbigny, 1839

*Gaudryina pyramidata* Cushman, 1926

1926 *Gaudryina laevigata* Franke var. *pyramidata* Cushman, p. 587, pl. 16, fig. 8.

1956 *Gaudryina pyramidata*; Said & Kenawy, p. 124, pl. 1, fig. 26.

1978 *Spiroplectamina dentata*; Proto Decima & Bolli, 1978, p. 793, pl. 1, fig. 6.

1983 *Gaudryina pyramidata*; Tjalsma & Lohmann, p. 12, pl. 2, fig. 4., pl. 8, fig. 1.

1993 *Gaudryina pyramidata*; Hewaidy & Al-Hitmi, p. 478, pl. 4, fig. 8.

1994 *Gaudryina pyramidata*; Bolli *et al.*, p. 90, fig. 24. 4-6.

2005 *Gaudryina pyramidata*; Sztrákos, p. 184, pl. 2, fig. 5.

2005b *Gaudryina pyramidata*; Anan, p. 81, pl. 1, fig. 4.

2012 *Gaudryina pyramidata*; Anan, p. 64, pl. 1, figs. 8, 9.

This cosmopolitan species was recorded from the Maastrichtian Velasco Shale in Mexico, Trinidad and California, and later from the Paleocene rocks in some localities in the Tethys (i.e., Atlantic Ocean, Spain, France, Italy, Tunisia, Egypt, Qatar, UAE) as well as from Paleocene rocks of J. Mundassa. Anan (2012) considered that cosmopolitan Maastrichtian-Paleocene species *G. pyramidata* has an evolutionary development to the two Early Eocene *G. speijeri* and *G. ameeri* (both described by Anan, 2012), from the *G. pyramidata*-*G. speijeri* lineage on one hand, as well as the *G. pyramidata*-*G. ameeri* lineage on the other.

*Gaudryina rugosa* d'Orbigny, 1840  
(Fig. 4.15)

1840 *Gaudryina rugosa* d'Orbigny, p. 44, pl. 4, figs. 20, 21.

1993a *Gaudryina rugosa*; Anan, p. 314, pl. 1, fig. 6.

2001 *Gaudryina rugosa*; Hewaidy & Strougo, p. 15, pl. 1, fig. 9.

2005b *Gaudryina rugosa*; Anan, p. 82.

The species was recorded from the Paleocene rocks from Egypt, and later in UAE. It is also found in the Paleocene rocks of J. Mundassa.

Genus *Verneulina* d'Orbigny, 1839

Type species *Verneulina tricarinata* d'Orbigny, 1839

*Verneulina aegyptiaca* Said & Kenawy, 1956

1956 *Verneulina aegyptiaca* Said & Kenawy, p. 122, pl. 1, fig. 16.

1993b *Verneulina aegyptiaca*; Anan, p. 656, pl. 2, fig. 2.

1994 *Gaudryina pyramidata*; Speijer, p. 44, pl. 4, fig. 1.

2004 *Verneulina aegyptiaca*; Anan, p. 41, pl. 1, fig. 1.

The species was originally recorded from Maastrichtian to Paleocene rocks from Egypt. It is also found in

**Figure 4.** 1) *Bathysiphon eocenicus* Cushman & Hanna, 1927; Sample 15, 2) *Bathysiphon paleocenicus* El-Dawy, 2001; S. 6, Danian (P1c), 3) *Nothia excelsa* (Grzybowski, 1898); S. 3, Danian (P1b), 4) *Ammodiscus angustus* (Friedberg, 1901); S. 11, Selandian (P3), 5) *Ammodiscus cretaceus* (Reuss, 1845); S. 13, Selandian (P3), 6) *Glomospira gordialis* (Jones & Parker, 1860); S. 12, Selandian (P3), 7) *Repsmanina* sp.; S. 10, Selandian (P3), 8) *Psammolingulina* sp., S. 3, Danian (P1b), 9) *Ammosphaeroidina pseudopauciloculata* (Mjatliuk, 1966); S. 6, Danian (P1c), 10) *Recurvoides anormis* Mjatliuk, 1970; S. 7, Danian (P2), 11) *Spiroplectinella dentata* (Alth, 1850); S. 12, Selandian (P3), 12) *Spiroplectinella subhaeringensis* (Grzybowski, 1896); S. 14, Selandian (P3), 13) *Trochammina globigeriniformis* (Parker & Jones, 1865); S. 10, Selandian (P3), 14) *Gaudryinopsis vulgaris* Kipriyanova, 1960; S. 5, Danian (P1c), 15) *Gaudryina rugosa* d'Orbigny, 1840; S. 15, Selandian (P3), 16) *Verneulina paleocenica* (Tjalsma & Lohmann, 1983); S. 5, Danian (P1c), 17) *Remesella varians* (Glaessner, 1937); S. 10, Selandian (P3), 18) *Dorothyia pupa* (Reuss, 1860); S. 10, Selandian (P3), 19) *Clavulinoides concavus* (Cushman, 1931); S. 14, Selandian (P3), 20) *Pseudoclavulina farafraensis* LeRoy, 1953; S. 13, Selandian (P3), 21) *Pseudoclavulina hewaidyi* Anan, 2008; S. 3, Danian (P1b).

Maastrichtian rocks of Tunisia and Paleocene rocks of J. Malaqet (UAE). It occurs in Paleocene rocks in J. Mundassa (this study). Anan (2004) presented some phylogenetic lineages in the Maastrichtian to Eocene transition of Egypt, one of which is the *Verneuilina aegyptiaca* - *V. luxorensis* lineage.

*Verneuilina paleocenica* (Tjalsma & Lohmann, 1983)  
(Fig. 4.16)

1983 *Tritaxia paleocenica* Tjalsma & Lohmann, p. 21, pl. 1, figs. 6-8, text-fig. 18.

This species was originally recorded from Paleocene sediments of the Rio Grande Rise in the South Atlantic. It belongs here to the genus *Verneuilina* due to its triserial test and triangular cross section as noted by Tjalsma & Lohmann (1983), not triserial to uniserial as in the genus *Tritaxia*. Tjalsma & Lohmann (op. cit.) added that in fully developed individuals the chambers are sometimes uniserial arranged. In the Paleocene rocks from J. Mundassa, this species has a triserial chamber arrangement as originally described. It is recorded here for the first time from UAE and Arabia, and may be outside also the original record.

Suborder ATAXOPHRAGMIINA Fursenko, 1958

Superfamily ATAXOPHRAGMIACEA Schwager, 1877

Family **Ataxophragmiidae** Schwager, 1877

Subfamily Liebusellinae Saidova, 1981

Genus *Remesella* Vašiček, 1947

Type species *Remesella mariae* Vašiček, 1947 =

*Textulariella? varians* Glaessner, 1937

*Remesella varians* (Glaessner, 1937)  
(Fig. 4.17)

1937 *Textulariella? varians* Glaessner, p. 366-367, pl. 2, fig. 15.

1988 *Matanzia varians*; Kaminski *et al.*, p. 196, pl. 9, fig. 14, pl. 10, fig. 14.

1996 *Remesella varians*; Kuhnt & Collins, p. 213, pl. 2, fig. 1.

1996 *Pseudotextulariella cretosa*; Anan, p. 150, fig. 3. 8.

2004 *Remesella varians*; Galeotti *et al.*, p. 96, pl. 4, fig. 14.

The species is characterized by its conical test, triserial to biserial arrangement with low basal aperture, finally agglutinated wall. It was recorded from the upper Cretaceous in Europe, and later from Trinidad and

UAE. It is recorded here from the Paleocene rocks of J. Mundassa.

Family **Eggerellidae** Cushman, 1937

Subfamily Dorothisinae Balakhmatova, 1972

Genus *Dorothia* Plummer, 1931

Type species *Dorothia bulletta* Carsey, 1926

*Dorothia bulletta* (Carsey, 1926)

1926 *Gaudryina bulletta* Carsey, p. 28, pl. 4, fig. 4.

1956 *Dorothia bulletta*; Haque, p. 51, pl. 3, fig. 5.

1985 *Dorothia bulletta*; Luger, p. 78, pl. 3, fig. 12.

1993a *Dorothia bulletta*; Anan, p. 314, pl. 1, fig. 10.

2005 *Dorothia bulletta*; Sztrákos, p. 200, pl. 2, fig. 8.

This species was observed from the Maastrichtian to Lower Eocene rocks in many parts of the Tethys: USA, France, Egypt, UAE, Qatar, Pakistan. It is recorded here from the Paleocene of J. Mundassa.

*Dorothia pupa* (Reuss, 1860)  
(Fig. 4.18)

1860 *Textularia pupa* Reuss, p. 232, pl. 13, figs. 4, 5.

1953 *Dorothia pupa*; LeRoy, p. 28, pl. 1, figs. 14, 15.

1956 *Dorothia pupa*; Said & Kenawy, p. 128, pl. 1, fig. 53.

1993a *Dorothia pupa*; Anan, p. 314, pl. 1, fig. 12.

This species is characterized by having trochospirally enrolled early stage and a small number of inflated biserial chambers in the last stage with fine finished surface. It was recorded from the Maastrichtian-Lower Eocene rocks in some parts of the Tethys (i.e., USA, Europe, Egypt, UAE). It is presented here from the Paleocene succession of J. Mundassa.

Genus *Marssonella* Cushman, 1930

Type species *Gaudryina oxycona* Reuss, 1860

*Marssonella oxycona* (Reuss, 1860)

1860 *Gaudryina oxycona* Reuss, p. 229, pl. 12, fig. 3.

1953 *Marssonella oxycona*; LeRoy, p. 39, pl. 1, figs. 3, 4.

1956 *Marssonella oxycona*; Haque, p. 51, pl. 3, fig. 4.

1993 *Marssonella oxycona*; Hewaidy & Al-Hitmi, p. 479, pl. 5, figs. 8, 9.

1994 *Marssonella oxycona*; Bolli *et al.*, p. 94, fig. 25. 5, 6.

2005b *Marssonella oxycona*; Anan, pl. 1, fig. 8.

This species was found in Maastrichtian to Lower Eocene rocks in many parts of the Tethys: USA, Caribbean region, France, Egypt, UAE, Qatar, Pakistan. It occurs in the Paleocene rocks of J. Mundassa.

Family **Pseudogaudryinidae** Loeblich & Tappan, 1985

Subfamily Pseudogaudryininae Loeblich & Tappan, 1985

Genus *Clavulinoides* Cushman, 1936

Type species *Clavulina trilatera* Cushman, 1926

*Clavulinoides concavus* (Cushman, 1931)  
(Fig. 4.19)

1931 *Clavulina trilatera* Cushman var. *concava* Cushman, p. 302, pl. 34, fig. 12.

1946 *Clavulina trilatera* Cushman var. *concava*; Cushman, p. 38, pl. 9, fig. 18.

1956 *Clavulinoides trilatera concavus*; Said & Kenawy, p. 126, pl. 1, fig. 40.

1988 *Clavulinoides trilatera*; Weidich, p. 350, pl. 3, figs. 13, 14, 17.

2011 *Clavulinoides concavus*; Anan, p. 298, pl. 1, fig. 2.

*Clavulinoides concavus* was originally recorded from the Upper Cretaceous of Texas (USA), and later from the Maastrichtian to Paleocene in Egypt and UAE. Weidich (1988) noted that *Clavulinoides trilatera* is perhaps one of the most variable “*Clavulina*” species and there are intermediate forms at least between seven species, subspecies and varieties: *C. trilatera*, *C. trilatera concava*, *C. trilatera aspera*, *C. aspera whitei*, *C. compressa*, *C. insings*, *C. plummerae*. Specimens with concave sides are the extreme variants on one end, while thin concave-convex types from the other end. The figured specimen from UAE has concave sides, acute periphery and triangular cross section. It is recorded here from the Paleocene of J. Mundassa, for first time in UAE.

Genus *Pseudoclavulina* Cushman, 1936

Type species *Clavulina clavata* Cushman, 1926

*Pseudoclavulina farafraensis* LeRoy, 1953  
(Fig. 4.20)

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

1993a *Pseudoclavulina farafraensis*; Anan, p. 314, pl. 1, fig. 10.

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

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

2002 *Pseudoclavulina farafraensis*; Al-Hitmi, p. 45, pl. 1, fig. 13.

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

The species was recorded in all Egyptian Upper Cretaceous rocks, as well as in some localities in the Tethys: Egypt, Pakistan, Qatar and UAE. It is documented here from the Paleocene of J. Mundassa.

*Pseudoclavulina hewaidyi* Anan, 2008  
(Fig. 4.21)

2008 *Pseudoclavulina hewaidyi* Anan, p. 248, pl. 1, fig. 1.

This species was originally recorded from the Paleocene rocks of Sinai, Egypt. It is characterized by its large triserial early stage and discoidal chambers in the uniserial later stage with depressed sutures. It is observed in the Paleocene of J. Mundassa, for the first time in UAE and Arabia.

#### 4. TEMPORAL DISTRIBUTION OF THE PALEOCENE SPECIES

Table 1 shows the identified twenty-six agglutinated foraminiferal species in the Paleocene succession of J. Mundassa, UAE. The recorded species of J. Malaqet and Qarn El Barr sections was observed by Anan (1993a, b, respectively) as well as some other chronological horizon in some localities of the Tethys: Egypt (LeRoy, 1953; Said & Kenawy, 1956; Luger, 1985; Anan & Sharabi, 1988; Speijer, 1994; El-Dawy, 2001; Anan, 2004, 2005a, b, 2008, 2011), Tunisia (Aubert & Berggren, 1976; Speijer, 1994; Saint-Marc & Berggren, 1988), Spain (Kuhnt & Kaminski, 1993), France (Sztrákos, 2005), Italy (Proto Decima & De Biase, 1975), Trinidad (Bolli *et al.*, 1994), Atlantic Ocean (Cushman, 1946; Berggren, 1974; Tjalsma & Lohmann, 1983), Japan & New Zealand (Kaiho, 1988). The following remarks can be presented:

1. The Paleocene succession of J. Mundassa yields 26 agglutinated species compared with 16 species from J. Malaqet, 12 species from Qarn El Barr, and the total of UAE are 35 species.

2. The Paleocene from Egypt yields 35 agglutinated species compared with 16 species from Tunisia, 13 species from France, 8 species from Spain, 5 species from Italy, 14 species from Trinidad, 5 species from the Atlantic Ocean, and only 3 species from Japan & New Zealand.

**Table 1.** Paleogeographic distribution of the Paleocene agglutinated benthic foraminifera in the United Arab Emirates = UAE (MN = Mundassa, MQ = Malaqet, QB = Qarn El Barr sections) and some other Tethyan localities (E = Egypt, T = Tunisia, F = France, S = Spain, I = Italy, D = Trinidad, AO = Atlantic Ocean, JZ = Japan and New Zealand). Note: x = recorded species, - = not recorded.

Sp. No.	Paleocene agglutinated Benthic foraminiferal species		United Arab Emirates				Some Tethyan localities							
			MN	MQ	QB	UAE	E	T	F	S	I	D	AO	JZ
1	<i>Bathysiphon</i>	<i>arenaceous</i>	-	x	x	x	x	x	-	x	-	-	-	-
2		<i>eocenicus</i>	x	-	-	x	-	-	-	-	-	x	-	-
3		<i>Paleocenicus</i>	x	-	-	x	x	-	-	-	-	-	-	-
4	<i>Nothia</i>	<i>excelsa</i>	x	-	-	x	-	-	-	x	-	x	-	-
5	<i>Ammodiscus</i>	<i>angustus</i>	x	-	-	x	-	-	-	-	-	-	-	-
6		<i>cretaceus</i>	x	x	x	x	x	x	x	-	-	-	-	x
7	<i>Glomospira</i>	<i>gordialis</i>	x	x	-	x	x	x	x	x	-	x	-	-
8	<i>Repmanina</i>	sp.	x	-	-	x	-	-	-	-	-	-	-	-
9	<i>Psammolingulina</i>	sp.	x	-	-	x	-	-	-	-	-	-	-	-
10	<i>Ammobaculites</i>	<i>khargaensis</i>	-	-	-	-	x	-	-	-	-	-	-	-
11		<i>schwageri</i>	x	-	-	x	-	-	-	-	-	-	-	-
12	<i>Ammosphaeroidina</i>	<i>pseudopauciloculata</i>	x	-	-	x	-	-	x	x	-	x	-	-
13	<i>Recurvoides</i>	<i>anormis</i>	x	-	-	x	-	-	-	-	-	-	-	-
14	<i>Spiroplectinella</i>	<i>dentata</i>	x	x	-	x	x	x	x	x	x	x	-	-
15		<i>esnaensis</i>	-	-	-	-	x	x	x	-	-	-	-	-
16		<i>spectabilis</i>	-	-	-	-	x	x	x	-	-	x	x	x
17		<i>subhaeringensis</i>	x	-	-	x	x	-	x	-	-	-	x	-
18	<i>Vulvulina</i>	<i>colei</i>	-	x	-	x	x	-	-	-	-	x	x	-
19	<i>Trochammina</i>	<i>globigeriniformis</i>	x	-	-	x	-	x	-	-	-	-	-	-
20	<i>Plectina</i>	<i>chapmani</i>	-	-	-	-	x	-	-	-	-	-	-	-
21	<i>Gaudryinopsis</i>	<i>vulgaris</i>	x	-	-	x	-	-	-	-	-	-	-	-
22	<i>Gaudryina</i>	<i>aissana</i>	-	-	-	-	-	x	-	-	-	-	-	-
23		<i>elegantissima</i>	-	-	x	x	x	-	-	-	-	-	-	-
24		<i>laevigata</i>	-	-	x	x	x	-	-	-	-	x	-	-
25		<i>limbata</i>	-	x	-	x	x	-	-	-	-	-	-	-
26		<i>neklensis</i>	-	-	-	-	x	-	-	-	-	-	-	-
27		<i>pyramidata</i>	x	-	x	x	x	x	x	x	x	x	x	-
28		<i>rectiangulara</i>	-	-	-	-	-	x	-	-	-	-	-	-
29		<i>rugosa</i>	x	x	x	x	x	-	x	-	-	x	-	-
30	<i>Verneuilina</i>	<i>aegyptiaca</i>	x	-	x	x	x	-	-	-	-	-	-	-
31		<i>cretacea</i>	-	x	-	x	x	-	-	-	-	-	-	-
32		<i>karreri</i>	-	-	-	-	x	-	-	-	-	-	-	-
33		<i>paleocenicus</i>	x	-	-	x	-	-	-	-	-	-	-	-
34	<i>Arenobulimina</i>	<i>aegyptiaca</i>	-	x	x	x	x	-	-	-	-	-	-	-

35	<i>Remesella</i>	<i>varians</i>	x	x	-	x	-	-	x	x	x	x	-	-
36	<i>Dorothia</i>	<i>bulletta</i>	x	x	x	x	x	-	x	-	-	-	-	-
37		<i>concinna</i>	-	-	-	-	x	-	-	-	-	-	-	-
38		<i>identata</i>	-	-	-	-	-	x	-	-	x	-	-	-
39		<i>plummerae</i>	-	-	-	-	-	x	-	-	-	-	-	-
40		<i>pontoni</i>	-	-	-	-	x	-	-	-	-	-	-	-
41		<i>pupa</i>	x	x	-	x	x	-	-	-	-	x	-	-
42		<i>sinaensis</i>	-	-	-	-	x	-	-	-	-	-	-	-
43	<i>Marssonella</i>	<i>ellisorae</i>	-	-	-	-	x	-	-	-	-	-	-	-
44		<i>oxycona</i>	x	x	x	x	x	x	x	x	-	x	-	-
45	<i>Clavulinoidea</i>	<i>concausus</i>	x	-	-	x	-	-	-	-	-	-	-	-
46		<i>trilaterus</i>	-	-	-	-	x	x	-	-	x	x	-	-
47	<i>Pseudoclavulina</i>	<i>farafraensis</i>	x	x	x	x	x	-	-	-	-	-	-	-
48		<i>maqfiensis</i>	-	-	-	-	x	x	-	-	-	-	-	-
49		<i>midwayensis</i>	-	-	x	x	x	x	-	-	-	-	-	-
50		<i>hewaidyi</i>	x	x	-	x	x	-	-	-	-	-	-	-
51	<i>Textularia</i>	<i>nilotica</i>	-	x	-	x	x	-	-	-	-	-	-	-
52		<i>farafraensis</i>	-	-	-	-	x	-	x	-	-	-	x	-
53		<i>plummerae</i>	-	-	-	-	-	-	-	-	-	x	-	x

3. The close resemblance of the Paleocene benthic foraminifera of J. Malaqet (UAE) with the synchronous age from the Sinai (Egypt) shows the most probably were parts of the same palaeogeographic province at that time. Moreover, a middle to outer neritic environmental deposition (Midway-Type Fauna, about 50-200 m water depth) is suggested for the Paleocene time (Anan, 1993a).

4. The unclosed number of Paleocene agglutinated species between the different localities in the Tethys may due to the lack of detailed study for those localities, to different latitudes, to differences in palaeoenvironmental conditions (depth, salinity, nutrients, dissolved oxygen, land barriers).

5. Some species are recorded at four or more localities: *Bathysiphon arenaceous*, *Ammodiscus cretaceous*, *Glomospira gordialis*, *Ammosphaeroidina pseudopauciloculata*, *Spiroplectinella dentata*, *S. spectabilis*, *S. subhaeringensis*, *Vulvulina colei*, *Gaudryina pyramidata*, *G. rugosa*, *Marssonella oxycona*. This record emphasizes the extended realms of Tethys, Indo-Pacific with Atlantic during the Paleocene.

## 5. PALAEOGEOGRAPHY

Paleogene palaeogeographic maps (partly or regionally) were used by many authors (i.e., Phillips, 1971; Berggren, 1978; Zachos *et al.*, 1993; Rosenbaum *et al.*, 2002) show

that the Tethyan realm had been connected with the Indo-Pacific Ocean from the east and the Atlantic Ocean to the west. Some other studies can be added:

1. Berggren (1971) 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 was mentioned by a marine seaway, and the East Atlantic fauna was much more closely related to the fauna than it is today. In the western Atlantic a narrow connection between it and Pacific existed. In the early Tertiary, a large east-west Tethyan sea extended from the Indian Ocean in the east to the Atlantic Ocean in the west, and in the western Atlantic a narrow connection between it and the Pacific existed.

2. Moore *et al.* (1978) noted the extended realms of Tethys, Indo-Pacific with Atlantic during the Paleogene.

3. Adams *et al.* (1983) 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 Miocene) 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.

4. Anan (1995) concluded that the Tethyan realm during the Eocene extends to the southeast and connected with the Indo-Pacific realm via the seaway separating Arabia from the Iran-India region.

5. Haynes & Nwabufu-Ene (1998) suggested wider Tethyan connections, as far as the Carpathians and Pakistan.

6. Rögl (1999) noted that by the end of the Eocene the Tethys Ocean had already vanished, a new Indian Ocean was born, the western end of the Tethys was reduced to a Mediterranean Sea, Europe was still an archipelago and intercontinental seas covered large areas of the European platform and of western Asia. He also noted that between the stable Eurasian platform and the relics of the western Tethys, elongate deep basins had formed and north of India a marine connection stretched to the West Pacific. It means that the western end of the relic Tethys connected the Indo-Pacific and the Atlantic Ocean.

7. Meulenkamp & Sissingh (2003) noted that the Arabian Platform was still largely covered by the sea in Paleocene, but was subject to a major regression in the Middle to Late Eocene.

## 6. CONCLUSIONS

1. Jabal Mundassa is considered the only outcrop in the Al Ain area (UAE) that has Danian sediments (samples 1-9, about 10m thick), and presented the most complete Danian section studied so far in the UAE.

2. Twenty-six agglutinated benthic foraminiferal species belonging to nineteen genera are recorded from J. Mundassa section. These are: *Bathysiphon eocenicus*, *B. paleocenicus*, *Dendrophrya excelsa*, *Ammodiscus angustus*, *A. cretaceus*, *Glomospira gordialis*, *Repmanina* sp., *Psammolingulina* sp., *Ammobaculites schwageri*, *Ammosphaeroidina pseudopauciloculata*, *Recurvoides anormis*, *Spiroplectinella dentata*, *S. subhaeringensis*, *Trochammina globigeriniformis*, *Gaudryinopsis vulgaris*, *Gaudryina pyramidata*, *G. rugosa*, *Verneuilina aegyptiaca*, *V. paleocenica*, *Remesella varians*, *Dorothia bulletta*, *D. pupa*, *Marssonella oxycona*, *Clavulinoides concavus*, *Pseudoclavulina farafrensis* and *Pseudoclavulina hewaidyi*. One of these illustrated species *Psammolingulina* sp. is the oldest known occurrence of the genus and is likely to be new.

3. The K/P boundary in the J. Mundassa section formed by an unconformity, and the missing horizon includes the two early Danian biozones: *G. cretacea* (P0) and *P. eugubina* (Pa). Development at the unconformity is most probably controlled by active tectonic, mainly synsedimentary faulting, and eustatic sea-level changes, which represents a major, but short-lived regression at J. Mundassa, at the end of the Cretaceous (Vail *et al.*, 1977 and Haq *et al.*, 1987).

4. After the close of the Danian, a rapid tectonic subsidence took place. The Cenozoic history of the Arabian Gulf began with a regression at the K/P boundary, which left most of the Arabia emergent with the exception of the

basinal areas in the northern UAE (i.e., at Ras Al Khaima basin). The J. Mundassa basin is the other basin in the eastern UAE that remained marine. This event followed by a rapid transgression that submerged the Al Ain area; in particular Selandian sediments (*M. angulata* Zone) were deposited at both J. Mundassa and J. Malaqet, as well as at the Qarn El Barr sections.

5. In the J. Mundassa section, the D/S transition is neither a marked black shale bed as in Egypt, nor the "Neoduwi event" of Speijer (2003) as in Tunisia.

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