ZIBELINE INTERNATIONAL™ PUBLISHING

E-ISSN: 2990-9295
CODEN: MAGACU

Malaysian Applied Geography (MAGG)

DOI: http://doi.org/10.26480/magg.01.2024.43.52

RESEARCH ARTICLE

TAXONOMIC CONSIDERATION OF THE PALEOGENE PLANKTIC FORAMINIFERA OF OMAN, ARABIAN SEA

Haidar Salim Anan*

Stratigraphy and paleontology, former Vice President of Al Azhar University-Gaza, P. O. Box 1126, Palestine, former Professor of Stratigraphy and paleontology, Ain Shams University, Egypt.
Corresponding Author Email: profanan@gmail.com

ARTICLE DETAILS

Article History:

Received 01 September 2024
Revised 03 October 2024
Accepted 05 November 2024
Available online 29 December 2024

ABSTRACT

The present study deals with the taxonomical consideration of the forty-seven species of planktic foraminiferal Paleogene species belonging to 6 genera from Ja'alan area, south East Sultanate of Oman, Arabian Sea, and represent good example of the Southern Tethyan Paleogene assemblage, which were originally identified by Al-Sayigh, (1998). The Oman assemblage are recognized between the Upper Palaeocene (P4) and upper Middle Eocene (P14). Eight species of the recorded assemblage are believed here to be new: *Globigerinatheka arabica, Globigerinatheka omanica, Acarinina umbilicata, Morozovella elbadrii, Morozovella elsayighi, Morozovella omanica, Morozovella surensis* and *Morozovella wadimusawaensis*. A possible hiatus representing the planktonic zones P5/P8 is recognized. The wide paleogeographic distribution of this assemblage in Oman and different localities around the surrounding area and also other Northern and Southern Tethys indicates that the ancestral Tethys is connected with the ancestral Atlantic to Pacific Oceans (via Mediterranean Sea and Indian Ocean). The study section was deposited in an open deep marine environment which represent outer shelf (~200m), and was tectonically active, with marked oscillations in sea level.

KEYWORDS

Planktic Foraminifera, Paleogene, Oman, Arabian Sea, Tethys

1. INTRODUCTION

The Paleogene rocks in Oman outcrop as a discontinuous belt in mountains around the eastern front of the North Oman Mountains. The present paper of Ja'alan area is one of a series of studying planktic foraminiferal assemblages of the Paleogene succession of Oman. Previous studies on the stratigraphy and planktic foraminiferal content of Ja'alan area, SE Oman are pertinent to the present study (Roger et al., 1991; Racey, 1988; White, 1989; Jones and Racey; 1994; and El-Sayigh, 1998). Another comprehensive studies of other surrounded areas are pertinent to this study: United Arab Emirates (UAE): Glennie et al., 1974; Hunting, 1979; Cherif and El-Deeb, 1984; Anan et al., 1992; Anan and Hamdan, 1993; Anan, 1993a,b, 1994, 1995, 1996, 2014, 2015a-c, 2016, 2018, 2020a,b, 2023; Saudi Arabia (SA): El-Khayal, 1947, Hasson, 1985, El-Naggar and Kamel, 1988. Kuwait: Al-Naqib, 1967, El-Nakhal and El-Naggar, 1988; Qatar: Smout, 1954. Yemen: El-Naggar and El-Nakhal, 1988. Iran: VahdatiRad et al, 2016; Salahi, A. 2021. Pakistan: Haque: 1956, 1960, 1962; Shafique, 2001; Gibson, 2007. India: Samanta, 1969; 1970.

Sultanate of Oman lies on the eastern margin of the Arabian Peninsula and is bordered by the Gulf of Oman to the North and Arabian Sea to the East (Figure 1A). The study area (Wadi Musawa Section) are located in the Ja'alan area to the South East of Muscat (Figure 1B). The present study deals with the taxonomic consideration of 47 planktic foraminiferal Paleogene species of Ja'alan area, south Sur City, East Oman (Figure 1 A, B).

The recorded species of Oman are correlated with the synchronous foraminiferal species from other surrounded Southern Tethyan localities, e.g.: Saudi Arabia: (El-Khayal, 1974; Hasson, 1985; EI-Naggar and Kamel, 1988), United Arab Emirate, UAE (Anan, et al., 1992; Anan and Hamdan, 1993; Anan, 1993; 2015a-c; 2016; 2018; 2020a,b; 2023), Iran: (VahdatiRad et al, 2016; Salahi, 2021), Pakistan: (Haque, 1956; Samanta, 1973) .

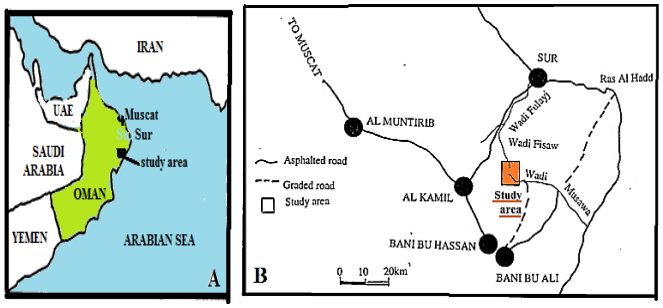


Figure 1A, B: Location map of the study Ja'alan area, south Sur city, south East of Oman (after Al-Sayigh, 1998).

2. STRATIGRAPHY OF THE STUDY JA'ALAN AREA

The modern taxonomical consideration of 47 planktic foraminiferal species belonging to 6 genera of the faunal assemblage were recorded from the Paleocene-Eocene of the Wadi Musawa section in Ja'alan area, which was subdivided into three formations namely the Abat Formation (Lat. 22° 19' N - Long. 58° 23' E), Musawa Formation (Lat. 22° 19' 11'' N – Long 58° 23' 10'' E) and Tahwah Formation (Lat. 22° 19' 11'' N - Long. 58° 23' 13'' E) (Figures 2-5).

Quick Response Code	Access this article online	
	Website: www.magg.com.my	**DOI:** 10.26480/magg.01.2024.43.52

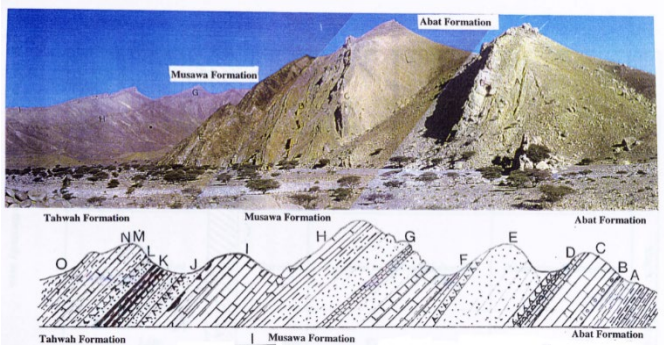


Figure 2: The schematic lithostratigraphic succession of Ja'alan area, which consists of the Abat Formation (units A-D), the Musawa Formation (units E-L) and the Tahwah Formation (units M-0).

The age of the different formations of the Ja'alan area by different authors is shown in Table 1.

Table 1: The general stratigraphy of Oman Mountains compared with Ja'alan area, SE Oman (after El-Sayigh, 1998).

OMAN MOUNTAINS			JA'ALAN AREA	
Age	Glennie, 1974	Nolan, 1986	Roger, 1991	Al-Sayigh, 1998
Late Eocene to Early Oligocene			Tahwah Fm.	Tahwah Fm.
Mid Eocene	Dammam Fm.	Seeb Fm.	Musawa Fm	Musawa Fm.
Early to Mid Eocene	Rus Fm.	Rusayl Fm.		
Late Palaeocene to Early Eocene	Um-Er Radhuma Fm.	Jafnayn Fm.	Abat Fm.	Abat Fm.

The stratigraphic log of the Late Paleocene-Early Eocene Abat Formation (including the hiatus at Paleocene/Eocene boundary within this formation) and Early to Middle Eocene Musawa Formations of Ja'alan area is shown in Figure 3.

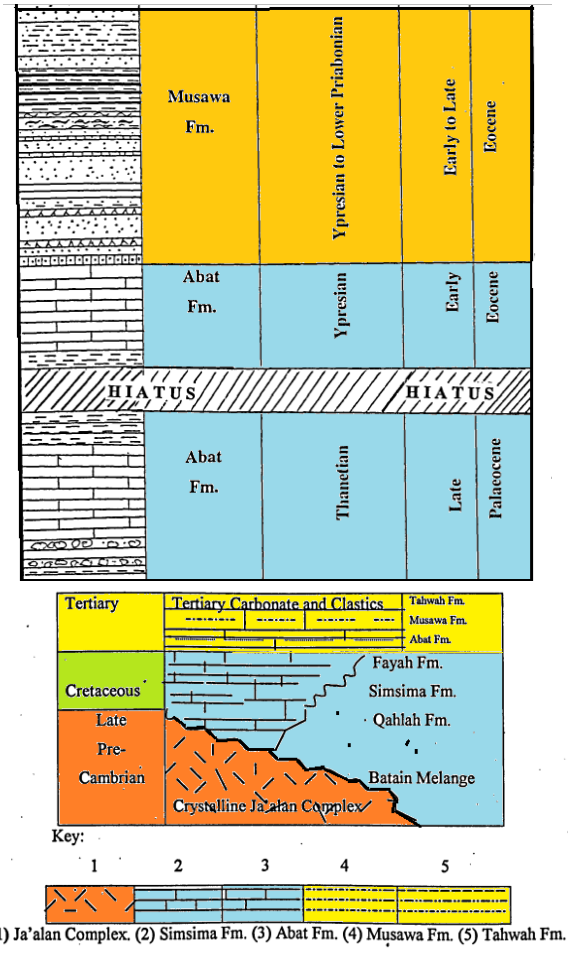


Figure 3: The stratigraphy of the Late Paleocene-Middle Eocene succession of Abat and Musawa Formations (after Al-Sayigh, 1998).

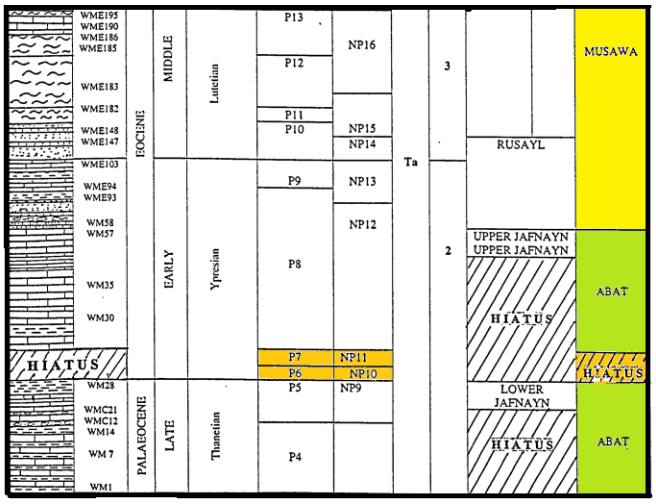


Figure 4: Summary stratigraphy Eastern Oman Mountains compared with Western Oman Mountains: 1) Planktonic Foraminifera, 2) Calcareous nannoplankton, 3) Larger Foraminifera (modified after Jones and Racey, 1994; El-Sayigh, 1998).

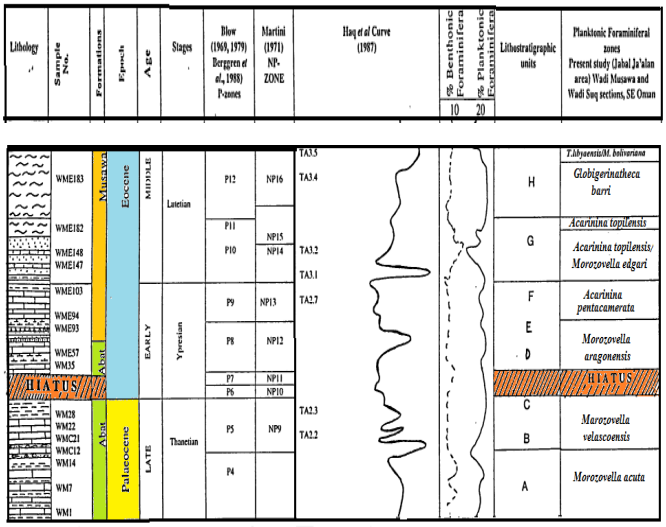


Figure 5. Sequence stratigraphic framework of the study area: The calibration of local lithostratigraphic units against bio- and sequence stratigraphic standers. Note the hiatus between Paleocene (*Morozovella velascoensis* Zone) and the Ypresian (*Morozovella aragonensis* Zone) (after El-Sayigh, 1998).

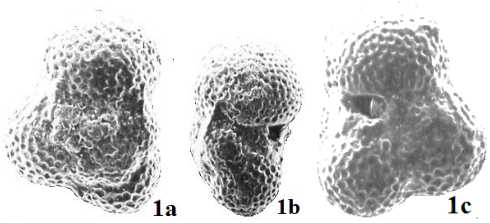
3. SYSTEMATIC PALEONTOLOGY

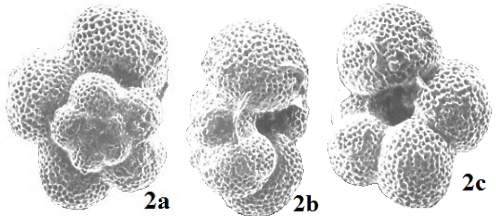
The systematic taxonomy of the foraminifera is still undergoing active revision. The modern taxonomical consideration of the Paleocene-Eocene planktonic foraminiferal species of Abat and Musawa Formations of Ja'alan area, Southeast of Oman: Olsson et al., 1999 and Pearson et al., 2006 are treated in this study included forty-seven species belonging to 6 genera (*Parasubbotina*, *Globigerina*, *Subbotina*, *Globigerinatheka*, *Acarinina* and *Morozovella*) are illustrated in Plates 1.

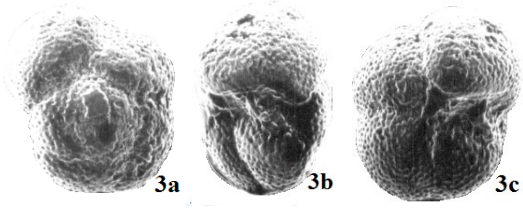
Plate 1 (all figures x 100, a=dorsal view, b= side view, c=ventral view)

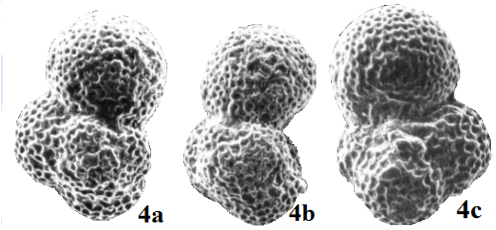
Figure 1: *Parasubbotina eoclava* Coxall, (Huber and Pearson, 2003) **2.** *Parasubbotina inaequispira* (Subbotina, 1953), **3.** *Parasubbotina pseudowilsoni* (Olsson and Pearson, 2006), **4.** *Globigerina officinalis* (Subbotina, 1953), **5.** *Subbotina hornibrooki* (Brönnimann, 1952), **6.** *Subbotina quadrata* (El-Naggar, 1966), **7.** *Subbotina triangularis* (White, 1928), **8.** *Subbotina triloculinoides* (Plummer, 1926), **9.** *Subbotina trivialis* (Cushman, 1953), **10.** *Subbotina yeguaensis* (Weinzierl and Applin, 1929), **11.** *Globigerinatheka arabica* (Anan, n. sp.) **12.** *Globigerinatheka barri* (Brönnimann, 1952), **13.** *Globigerinatheka index* (Finlay, 1939), **14.** *Globigerinatheka omanica* Anan, n. sp., **15**. *Globigerinatheka s. subconglobata* Shutskaya, 1958), **16.** *Acarinina aspensis* (Colom, 1954), **17.** *Acarinina centralis* (Cushman and Bermudez, 1937), **18.** *Acarinina collactea* (Finlay, 1939), **19.** *Acarinina esnaensis* (LeRoy, 1953), **20.** *Acarinina pentacamerata* (Subbotina, 1947), **21.** *Acarinina praetopilensis* (Blow, 1979), **22.** *Acarinina quetra* (Bolli, 1957), **23.** *Acarinina rohri*

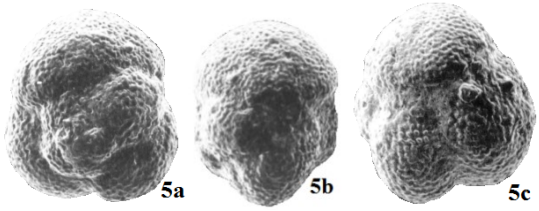
(Brönnimann and Bermúdez, 1953), **24.** *Acarinina soldadoensis* (Brönnimann, 1952), **25.** *Acarinina topilensis* (Cushman, 1925), **26.** *Acarinina umbilicata* (Anan, n. sp.) **27.** *Morozovella abundocamerata* (Bolli, 1957), **28.** *Morozovella acuta* (Toulmin, 1941), **29.** *Morozovella aequa* (Cushman and Renz, 1942), **30.** *Morozovella angulata* (White, 1928), **31.** *Morozovella aragonensis* (Nuttall, 1930), **32.** *Morozovella caucasica* (Glaessner, 1937), **33.** *Morozovella crater* (Finlay, 1939), **34.** *Morozovella edgari* (Premoli Silva and Bolli, 1973), **35.** *Morozovella elbadrii* (Anan, sp.), **36.** *Morozovella elsayighi* (Anan, n. sp.) **37.** *Morozovella f. formosa* (Bolli, 1957), **38.** *Morozovella gracilis* (Bolli, 1957), **39.** *Morozovella marginodentata* (Subbotina, 1953), **40.** *Morozovella nicoli* (Martin, 1943), **41.** *Morozovella occlusa* (Loeblich and Tappan, 1957), **42.** *Morozovella omanica* (Anan, n. sp.) **43.** *Morozovella pasionensis* (Bermudez, 1961), **44.** *Morozovella subbotinae* (Morozova, 1939), **45.** *Morozovella surensis* (Anan, n. sp.) **46.** *Morozovella velascoensis* (Cushman, 1925), **47.** *Morozovella wadimusawaensis* (Anan, n. sp.)

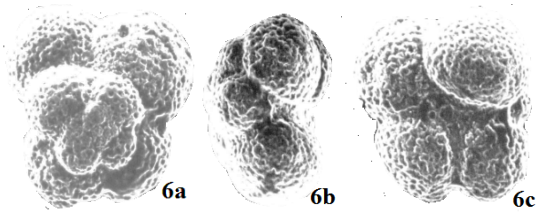


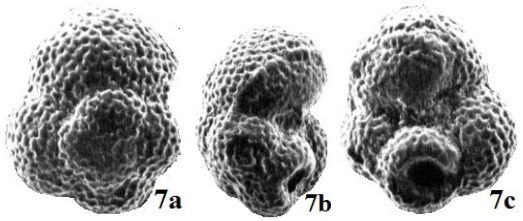


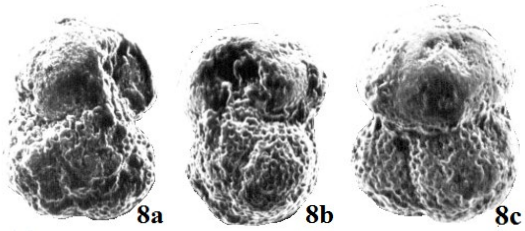


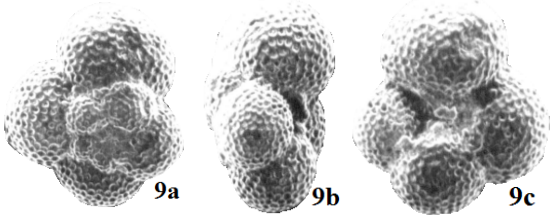


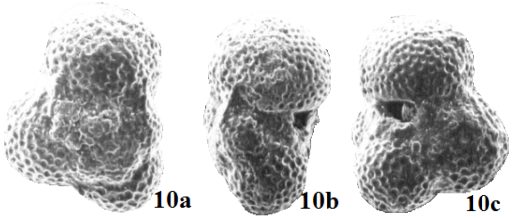


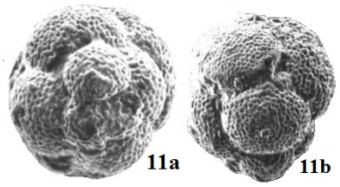


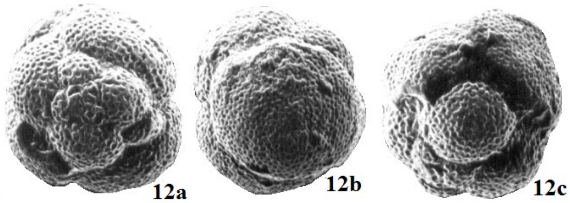


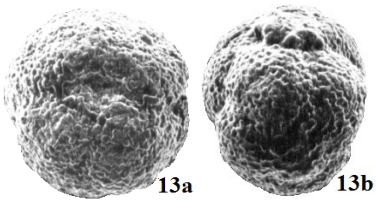


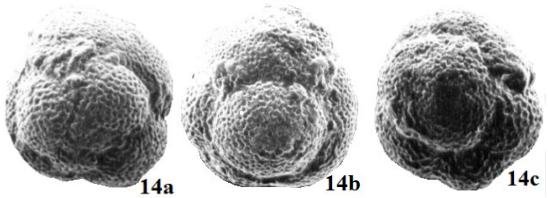


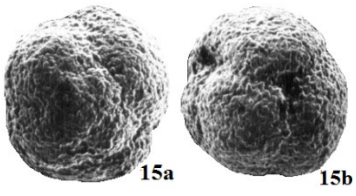


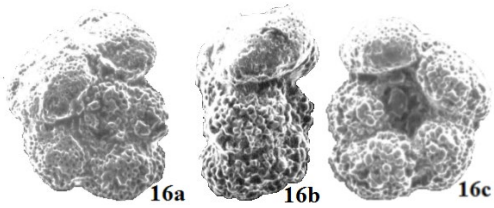


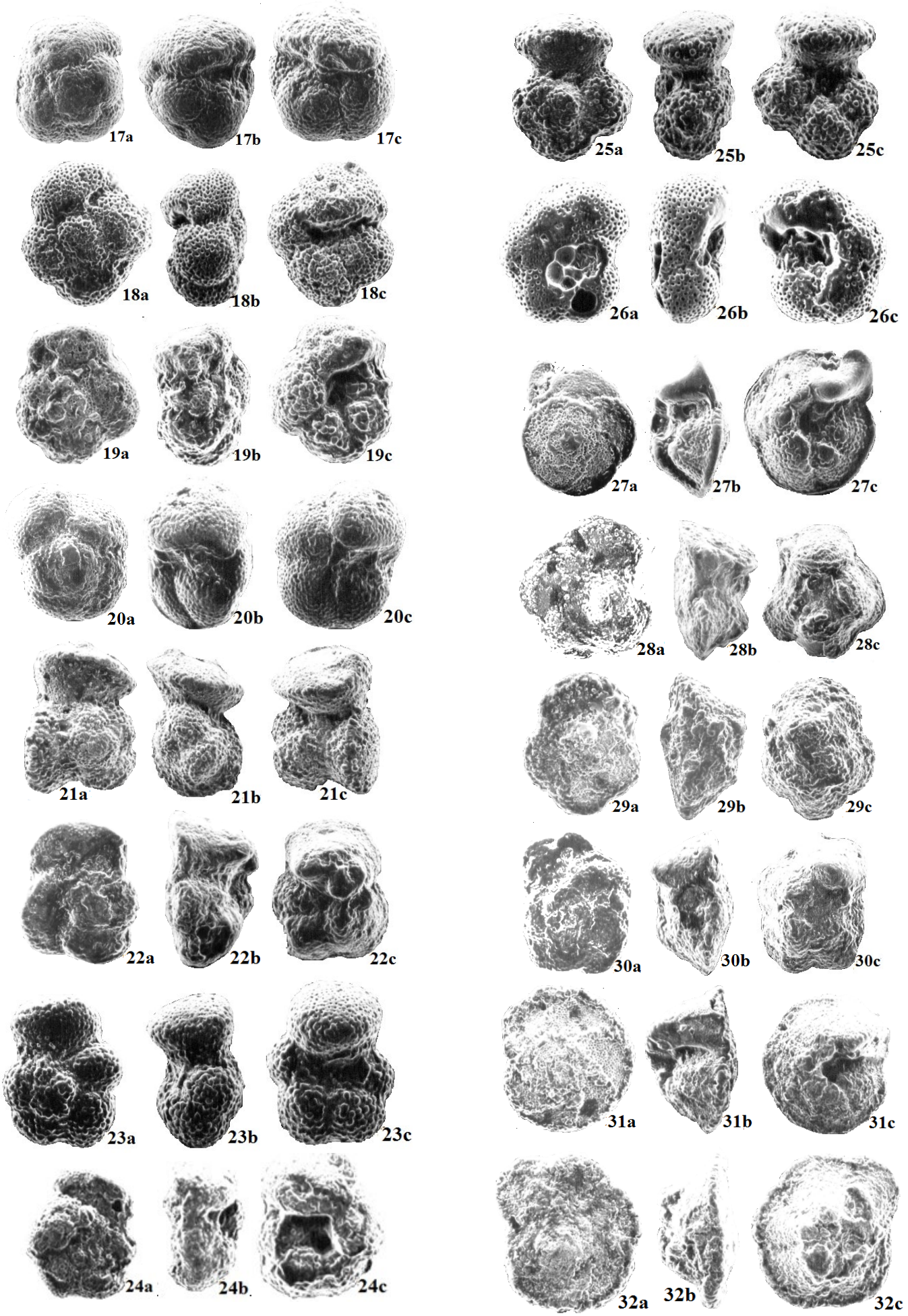


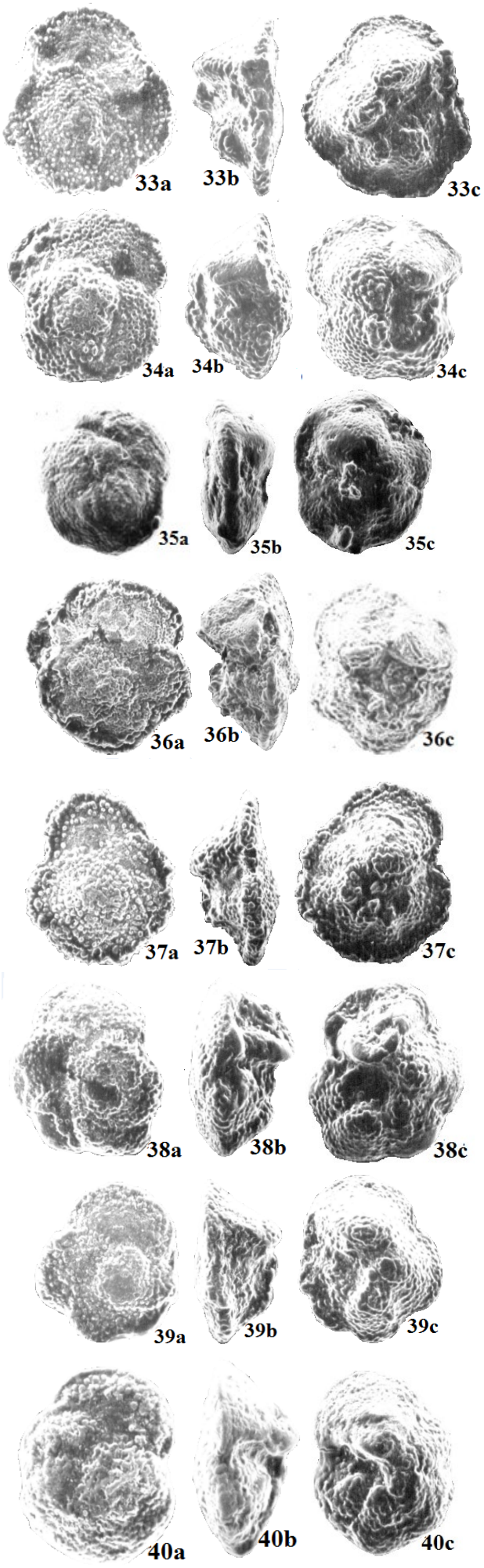


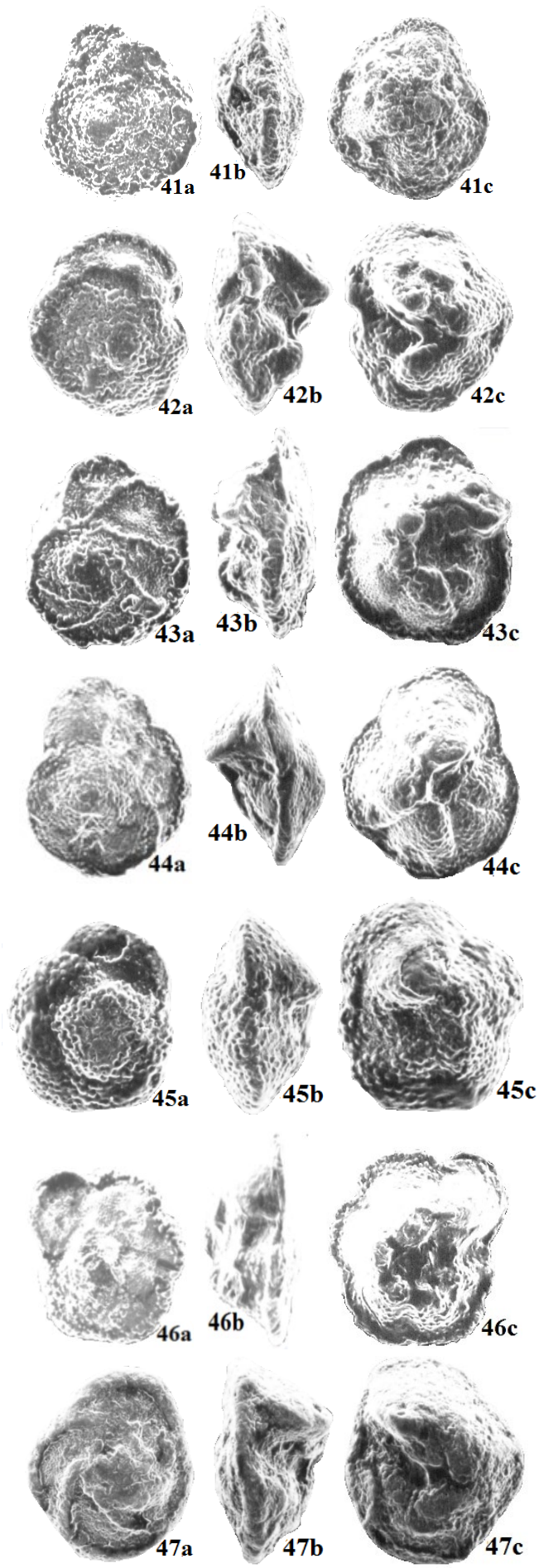







17a
17b
17c
18a
18b
18c
19a
19b
19c
20a
20b
20c
21a
21b
21c
22a
22b
22c
23a
23b
23c
24a
24b
24c
25a
25b
25c
26a
26b
26c
27a
27b
27c
28a
28b
28c
29a
29b
29c
30a
30b
30c
31a
31b
31c
32a
32b
32c





Order Foraminiferida Eichwald, 1830

Suborder Globigerinina Delage and Hérouard, 1896

3.1 Genus *Parasubbotina* (Olsson et al., 1992)

- *Parasubbotina eoclava* Coxall, Huber and Pearson, 2003, p. 99, plate 5.9, figures. 1-16 (=*Globigerina linaperta* group – El-Sayigh, 1998, p. plate 16, figures. 1-3). Eocene. North Atlantic, Tanzania, Oman, Pacific Ocean

- *Parasubbotina inaequispira* (Subbotina, 1953) (=*Globigerina inaequispira* Subbotina, 1953, p. 84, plate 6, figures 1-4) (=*Globigerina linaperta* group, plate 16, figures 10-12). Eocene. Caucasus, Tanzania, Egypt, UAE, Oman

- *Parasubbotina pseudowilsoni* Olsson and Pearson, 2006, p. 103, plate 5.12, figures 1-6 (=*Morozovella bolivariana* (Petters, 1954), plate 3, figures 1-3). Eocene. Mexico, Oman

3.2 Genus *Globigerina* (d'Orbigny, 1826)

- *Globigerina officinalis* Subbotina, 1953, p. 105, plate. 11 figures. 1- 7 (=). Eocene. USA, Caucasus, Tanzania, Egypt, Oman.

3.3 Genus *Subbotina* (Brotzen and Pozaryska, 1961)

- *Subbotina hornibrooki* (Brönnimann, 1952) (=*Globigerina hornibrooki* Brönnimann, 1952, p. 15, plate. 2, figures. 4-6; El-Sayigh, 1998, plate 15, figures. 9-11). Paleocene-Eocene. Trinidad, Caucasus, Maly, Azerbaydzhan, Oman, Pacific Ocean

- *Subbotina quadrata* (EI-Naggar, 1966) (=*Globorotalia quadrata* EI-Naggar, 1966, p. 233, plate 18, figs. 4; El-Sayigh, 1998, p. plate 7, figures. 10-12). Eocene. Egypt, Oman, India

- *Subbotina triangularis* (White, 1928) (=*Globigerina triangularis* White, 1928: p. 195, pl. 28, figure 1; El-Sayigh, 1998, plate 11, figures 7-9). Paleocene. Mexico, Trinidad, Caucasus, Maly, Turkmenia, Egypt, UAE, Oman

- *Subbotina triloculinoides* (Plummer, 1926) (=*Globigerina triloculinoides* Plummer, 1927, p. 134, plate 8, figure 10; El-Sayigh, 1998, plate 11, figures 10-12). Paleocene. USA, Mexico, Trinidad, Atlantic Ocean, Denmark, Sweden, Italy, Turkmenia, Tanzania, Egypt, UAE, Oman, Australia,

- *Subbotina trivialis* (Subbotina, 1953) (=*Globigerina trivialis* Subbotina, 1953, p. 64, plate 4, figure 4; *Globigerina linaperta* - El-Sayigh, 1998, plate 17, figures 4-6). Paleocene. Caucasus, Brazil, Atlantic Ocean, Turkmenia, Indian and Pacific Ocean, Egypt, UAE, Oman

- *Subbotina yeguaensis* (Weinzierl and Applin, 1929) (=*Globigerina yeguaensis* Weinzierl and Applin, 1929, p. 409, plate 43, figure 1; *Globigerina linaperta* - El-Sayigh, 1998, plate 16, figures 1-3). Eocene. USA, Trinidad, Atlantic Ocean, Caucasus, Tanzania, Egypt, UAE, Oman, Pakistan, India, Indian and Pacific Oceans,

3.4 Genus *Globigerinatheka* (Brönnimann, 1952)

- *Globigerinatheka arabica* Anan, n. sp. (=*Globigerinatheka* sp. A. - El-Sayigh, 1998, p. 153, plate 14, figures 11-12).

Holotype: : illustrated specimen in Plate 1, figures 11a-b.

Etymology: after Wadi Musawa section, Sultanet of Oman, Arabian Sea.

Stratigraphic level: Middle Eocene.

Diagnosis: Globular coarsely perforate test with four chambers in the last whorl, which increasing in size towards the last whorl, sutures deep and curved, only two to three openings visible between chambers, without obvious bulla.

Remarks: The Omani species is similar to *Globigerinatheka barri* but lacks the bullae. This new species in association with *Globigerinatheka barri* and *Truncorotaloides topilensis.*

- *Globigerinatheka barri* Brönnimann, 1952, p. 27 (partim), text-figure 3a (=El-Sayigh, 1998, p. 148, plate 14, figures 1-3). Eocene. USA, Trinidad, Atlantic Ocean, Italy, Hungary, Tanzania, Tunisia, Egypt, UAE, Oman, Pakistan, India, Pacific Ocean, New Zealand

- *Globigerinatheka index* (Finlay, 1939) (=*Globigerinoides index* Finlay, 1939, p. 125 (partim), plate 14: figures 85-88; *Globigerinatheka euganea* - El-Sayigh, 1998, p. 151, plate 14, figures. 7, 8). Eocene. USA, Mexico, Caucasus, Atlantic Ocean, Slovakia, Hungary, Italy, Tanganyika, Tanzania, Toumarkine, Egypt, UAE, Oman, India, Indian and Pacific Oceans, New Zealand

- *Globigerinatheka omanica* Anan, n. sp. (=*Globigerinatheka* cf. *curryi* – El-Sayigh, 1998, p. 150, plate 14, figures 4-6).

Holotype: illustrated specimen in Plate 1, figures 14a-c.

Etymology: after Wadi Musawa section, Sultanet of Oman (see Figure 1A, B).

Stratigraphic level: Middle Eocene.

Diagnosis: Globular to subglobular coarsely perforations with reticulate ornament test, chambers globular increased moderately in size towards the end of the last whorl, which three chambers are present in the last whorls, sutures slightly curved deep sutures, large bulla is obvious.

Remarks: The Oman specimen is smaller in size and has less chambers in the last stage than *Globigerinatheka curryi*. *Globigerinatheka omanica* differs from *G. euganea* in having more strongly incised sutures, more strongly inflated chambers and consequently a less spherical test shape.

- *Globigerinatheka s. subconglobata* Shutskaya, 1958, p. 86, plate 1, figures. 1-14 (=*Globigerinatheka euganea* - El-Sayigh, 1998, pl. 14, figs. 7,8). Early Eocene. USA, Trinidad, Atlantic Ocean, Italy, Caucasus, Hungary, Arabian Sea, Pacific Ocean

3.5 Genus *Acarinina* (Subbotina, 1953)

- *Acarinina aspensis* (Colom, 1954) (=*Globigerina aspensis* Colom, 1954, p. 151, plate 3, figures. 1-35). Eocene. Trinidad, Cuba, Atlantic Ocean, Spain, Slovakia, Egypt, Oman, India, Pacific Ocean

- *Acarinina centralis* (Cushman and Bermudez, 1937) (=*Globorotalia centralis* Cushman and Bermudez 1937, p. 26, plate 2, figures. 62-65; *Morozovella centralis* - El-Sayigh, 1998, plate 13, figures. 1-3). Middle-Late Eocene. Cuba, Egypt, Oman, India

- *Acarinina collactea* (Finlay, 1939) (=*Acarinina esnaensis* (Le Roy)- El-Sayigh, 1998, plate 10, figures. 4-6). Early Eocene. USA, Trinidad, Denmark, Caucasus, Nigeria, Tanzania, Oman, India, Indian and Pacific Oceans, New Zealand

- *Acarinina esnaensis* (LeRoy, 1953)(=*Acarinina soldadoensis* (Brönnimann, 1952b) - El-Sayigh, 1998, plate 10, figures. 10-12). Paleocene-Early Eocene. Trinidad, Egypt, Oman, Arabian Sea

- *Acarinina pentacamerata* (Subbotina, 1947) (=*Globorotalia pentacamerata* Subbotina, 1947, p. 128, (partim), plate 7, figures 15-17; *Morozovella bolivariana* - El-Sayigh, 1998, p. 95, plate 3, figures 1-3). Eocene. Trinidad, Atlantic Ocean, Spain, Sweden, Germany, Austria, Ukraine, Italy, Caucasus, Azerbaijan, Egypt, UAE, Oman, Arabian Sea, India, Indian and Pacific Oceans

- *Acarinina praetopilensis* (Blow, 1979) (=*Globorotalia (Truncorotaloides) topilensis praetopilensis* Blow, 1979, p.1043, plate 155, figure 9; plate 203, figs. 1-2). Eocene. Atlantic Ocean, Tanzania, Oman

- *Acarinina quetra* (Bolli, 1957) (=*Globorotalia quetra* Bolli 1957, p. 79, plate 19, figures 1-3; *Morozovella* sp. A - El-Sayigh, 1998, p. 115, plate 9, figures 1-3). Early Eocene. Trinidad, Atlantic Ocean, Germany, Egypt, UAE, Oman, Pakistan, Pacific Ocean

- *Acarinina rohri* (Brönnimann and Bermúdez, 1953) (=*Truncorotaloides rohri* Brönnimann and Bermúdez, 1953, p. 818, plate 87, figures 7-9; *Truncorotaloides libyaensis* - El-Sayigh, 1998, plate 12, figures 1-6). Eocene. USA, Mexico, Trinidad, Hungary, Tanzania, Egypt, UAE, Oman, India

- *Acarinina soldadoensis* (Brönnimann, 1952) (=*Globigerina soldadoensis* Brönnimann, 1952, p. 7, plate 1, figures 1-9; El-Sayigh, 1998, plate 11, figure. 1-3). Paleocene-Early Eocene. Trinidad, Atlantic Ocean, Tanzania, Tunisia, Egypt, UAE, Oman, Azerbaizhan, Indian and Pacific Oceans, New Zealand

- *Acarinina topilensis* (Cushman, 1925) (=*Globigerina topilensis* Cushman, 1925, p. 7, plate 1, figure 9; *Truncorotaloides topilensis* (Cushman, 1925) – El-Sayigh, p. 1998, plate 12, figures 7-9). Eocene. USA, Mexico, Trinidad, Cuba, Atlantic Ocean, Hungary, Morocco, Egypt, UAE, Oman, India, Pacific Ocean, New Zealand

- *Acarinina umbilicata* Anan, n. sp. (=*Acarinina* sp. El-Sayigh, 1998, p. 127, plate 11, figures 4-6)

Holotype: illustrated specimen in Plate 1, figures. 26a-c.

Etymology: after the diagnostic wide umbilicus

Stratigraphic level: Early Eocene in Wadi Musawa section of the SE Oman Mountains.

Diagnosis: Test compact, 4-4.5 subglobular chambers in the last whorl with coarsely perforated surface, chambers increase in size compared with the much smaller chambers of the earlier whorls, flat dorsal side with slightly concave at the centre but slightly convex ventral side, rounded to subacute periphery, slightly depressed spiral sutures, while umbilical sutures are deep and curved, deep wide open umbilicus with a low arched aperture open to the umbilicus.

Remarks: This new species is characterized by its compact strongly perforated test, and deep wide open umbilicus

3.6 Genus *Morozovella* McGowran in Luterbacher, 1964

- *Morozovella abundocamerata* (Bolli, 1957) (=*Globorotalia angulata abundocamerata* Bolli,1957, p. 74, plate 17, figures 4-6; *Morozovella abundocamerata* - El-Sayigh, 1998, plate 1, figs. 1-3). Paleocene. Trinidad, Italy, Oman

- *Morozovella acuta* (Toulmin, 1941) (=*Globorotalia wilcoxensis* Cushman and Ponton var. *acuta* Toulmin 1941, p. 608, plate 82, figures. 6-8; *Morozovella acuta* - El-Sayigh, 1998, plate 1, figures. 4-6). Paleocene-Early Eocene. USA, Trinidad, Cuba, Puerto Rico, Tunisia, Egypt, UAE, Oman, Pakistan, India

- *Morozovella aequa* (Cushman and Renz, 1942) (=*Globorotalia crassata* Cushman var. *aequa* Cushman & Renz 1942, p. 12, plate 3, figure 3), *Morozovella acuta* - El-Sayigh, 1998, p. 85, plate 1, figures 10-12). Paleocene-Early Eocene. USA, Trinidad, Tunisia, Egypt, Jordan, Oman, India

- *Morozovella angulata* (White, 1928) (=*Globigerina angulata* White 1928, p. 191-192, pl. 27, fig. 13; *Morozovella angulata* - El-Sayigh, 1998, plate 2, figures. 4-6). Paleocene. Mexico, USA, Trinidad, Egypt, UAE, Oman, India

- *Morozovella aragonensis* (Nuttall, 1930) (=*Globorotalia aragonensis* Nuttall 1930, p. 288, plate 24, figures 6-11; *Morozovella aragonensis* - El-Sayigh, 1998, p. 85, plate 2, figures. 7-9). Early Eocene. Mexico, Trinidad, Egypt, UAE, Oman, India

- *Morozovella caucasica* (Glaessner,1937) (=*Globorotalia aragonensis* Nuttall *caucasica* Glaessner 1937, p. 31, plate 1, figure 6; *Morozovella caucasica* - El-Sayigh, 1998, plate 3, figs. 7-9). Early Eocene. Caucasus, Egypt, UAE, Oman, New Zealand

- *Morozovella crater* (Finlay, 1939) (=*Globorotalia crater* Finlay, 1939, p. 69, plate 1, figure 25; *Morozovella marginodentata* –El-Sayigh, 1998, plate 5, figures. 10-12). Early Eocene. New Zealand, Oman

- *Morozovella edgari* (Premoli Silva and Bolli, 1973)(=*Globorotalia edgari* Premoli Silva & Bolli 1973, p. 526, plate 7, figures. 10-12, plate 8, figures. 1-2; *Morozovella edgari* - El-Sayigh, 1998, plate 4, figures 10-12). Early Eocene. Caribbean, Spain, Egypt, UAE, Oman

- *Morozovella elbadrii* Anan, sp. (=*Morozovella* sp. D - El-Sayigh, 1998, p. 119, pl. 10, figures 1-3).

Holotype: illustrated specimen in Plate 1, figure. 35a-c.

Etymology: after Dr. Ahmad Saleh Elbadrii, Chairman of Consulting and Training

Stratigraphic level: Middle Eocene.

Diagnosis: Test low trochospiral planoconvex test, 5 chambers increase slowly in size as added in the last whorl, surface strongly perforated, periphery rounded to subacute, sutures curved limbate raised on spiral side but incised on umbilical side, shallow wide open umbilicus, aperture low arch and is umbilical to extraumbilical.

Remarks: This new species differs from all other known *Morozovella* species in having raised curved spiral sutures, depressed shallow wide open umbilicus, and low arch and is umbilical to extraumbilical aperture.

- *Morozovella elsayighi* Anan, n. sp. (=*Morozovella acuta* El-Sayigh, 1998, p. 88, plate 1, figures. 7-9).

Holotype: illustrated specimen in Plate 1, figure 36a-c.

Etymology: after the micropaleontologist Abdul Razak Siddiq El-Sayigh, University of Wales, United Kingdom.

Stratigraphic level:

Diagnosis: Test rhomboidal planoconvex, umbilical side strongly convex while spiral side almost flat, five chambers in the last whorls which increase slowly as added, well developed umbilical shoulders, periphery acute with keel, wide deep open umbilicus, umbilical sutures depressed, low arched aperture.

Remarks: This new species *M. elsayighi* differs from *M. acuta* by its rhomboidal low trochospiral test than semi-rounded test of the latter.

- *Morozovella f. formosa* (Bolli, 1957) (=*Globorotalia f. formosa* Bolli 1957, p. 76, pl. 18, figs. 1-3; *Morozovella gracilis* – El-Sayigh, 1998, plate 5, figures. 4-6). Early Eocene. Trinidad, Egypt, UAE, Oman, India

- *Morozovella gracilis* (Bolli, 1957) (=*Globorotalia formosa gracilis* Bolli 1957, p. 75, plate 18, figures. 4-6; *Morozovella f. formosa* – El-Sayigh, 1998, plate 5, figures. 1-3). Early Eocene. Trinidad, Italy, Tunisia, Egypt, UAE, Oman, Pakistan, India

- *Morozovella marginodentata* (Subbotina, 1953) (=*Globorotalia marginodentata* Subbotina 1953, p. 212, plate 17, figures. 14-16; p. 18, figures. 1-3; *Morozovella marginodentata* - El-Sayigh, 1998, plate 6, figures. 1-3). Early Eocene. Caucasus, Trinidad, Mexico, Spain, Tunisia, Egypt, UAE, Oman, Pakistan, India

- *Morozovella nicoli* (Martin, 1943) (=*Globorotalia nicoli* Martin 1943, p. 27, plate 7, figure 3; *Morozovella nicoli* - El-Sayigh, 1998, plate 6, figures 4-6). Paleocene-Early Eocene. USA, France, Egypt, Oman, India

- *Morozovella occlusa* (Loeblich and Tappan, 1957) (=*Globorotalia occlusa* Loeblich and Tappan. 1957, p. 191, plate 55, figure 3; plate 64, figure 3; *Morozovella occlusa* - El-Sayigh, 1998, plate 6, figures 7-9). Mexico, USA, Italy, Austria, Egypt, USA, Oman, Pakistan, India

- *Morozovella omanica* Anan, n. sp. (=*Morozovella* cf. *parva* El-Sayigh, 1998, p.110, plate 6, figures 10-12, plate7, figures 1-3).

Holotype: illustrated specimen in Plate 1, figure 19.

Etymology: after Wadi Musawa section, Sultanet of Oman (see Figure 1A,B)

Stratigraphic level: Late Paleocene.

Diagnosis: Test plano-convex with. rugose surface, periphery circular to slightly lobate with distinct keel, 4-5 subangular chambers which increase rapidly in size as the last whorl as added, umbilical side strongly convex with well-developed umbilical shoulders, spiral side almost flat to slightly convex, sutures on umbilical side depressed and radial, but curved on spiral side, raised and beaded, aperture a narrow, low arch, umbilicus narrow, very deep.

Remarks: This species differs from the holotype of *Morozovella parva* Rey (1955) in being higher or more conical in shape, in having more chambers in the last whorl and a more circular outline.

- *Morozovella pasionensis* (Bermudez, 1961) (=*Pseudogloborotalia pasionensis* Bermudez, 1961, p. 1346, plate 16, figures 8a,b; *Morozovella caucasica* – El-Sayigh, 1998, plate 3, figures. 7-9). Paleocene-Early Eocene. Mexico, Guatemala, Italy, Egypt, UAE, Oman, India

- *Morozovella subbotinae* (Morozova, 1939) (=*Globorotalia subbotinae* Morozova 1939, p. 80, plate 2, figures 16-17; *Morozovella subbotinae* - El-Sayigh, 1998, pl. 8, figs. 1-3). Late Paleocene-Early Eocene. USSR (Russia), Caucasus, Italy, Tunisia, Egypt, OAE, Oman, India

- *Morozovella surensis* Anan, n. sp. (=*Morozovella* sp. C - El-Sayigh, 1998, p. 118, plate 9, figures 7-12)

Holotype: illustrated specimen in Plate 1, figure 21.

Etymology: after the Sur area, north of Wadi Musawa section, SE Oman.

Stratigraphic level: Early Eocene, from the middle of the Wadi Musawa

Section, SE Oman Mountains.

Diagnosis: Test low trochospiral biconvex, 4-5 angular to subangular chambers which increase slowly in size as added in the final whorl, periphery acute to moderately lobate, sutures depressed in umbilical but curved in spiral sutures and spinose surface.

Remarks: This new species is characterized by its 4-5 angular chambers, acute periphery and spinose surface.

- *Morozovella velascoensis* (Cushman, 1925) (=*Pulvinulina velascoensis* Cushman 1925, p. 19, plate 3, figure 5; 2 *Morozovella caucasica* - El-Sayigh, 1998, plate 3, figures 10-12). Late Paleocene. Mexico, Trinidad, Caucasus, Italy, Tunisia, Egypt, Jordan, UAE, Oman, Pakistan, India

- *Morozovella wadimusawaensis* Anan, n. sp. (=*Morozovella* sp. B - El-Sayigh, 1998, p. 116, plate 9, figures 1-3)

Holotype: illustrated specimen in Plate 1, figure 23.

Etymology: after Wadi Musawa section, SE Oman.

Stratigraphic level: Early Eocene, Wadi Musawa section of the SE of Oman Mountains.

Diagnosis: Planoconvex trochospiral oval shape test, almost flat spiral side and convex umbilical side, 4-5 chambers in the last whorl which increase slowly in size as added, periphery very thick with well developed keel, thick and strongly curved spiral sutures, but incised and slightly curved umbilical sutures, aperture curved slit in deep narrow umbilicus with lip.

Remarks: This new species is characterized by its 4-5 chambers in the last whorl, thick peripheral margin with thick keel, and raised curved limbate dorsal sutures.

4. PALEOGEOGRAPHY

The Paleogene paleogeographic maps of many authors (Zachos et al., 1993; Salahi, 2021) show that the Tethyan realm had been connected with the Indo-Pacific Ocean from east to Atlantic Ocean to the west (Figure 6).

Figure 6: Paleogene paleogeography of the Tethys Ocean (Salahi, 2021).

The recorded six planktic foraminiferal genera and its forty seven species were originally recorded from forty two different localities in the Northern Tethys (USA, Mexico, Trinidad, Cuba, Cuba, Puerto Rico, Guatemala, Atlantic Ocean, Spain, Slovakia, Spain, France, Denmark, Sweden, Germany, Austria, Italy, Slovakia, Hungary, Caucasus, Russia, Turkmenia, Azerbaijan), and Southern Tethyan (Brazil Tunisia, Maly, Nigeria, Tanganyika, Tanzania, Egypt, Jordan, UAE, Oman, Arabian Sea, Pakistan, India, Indian Ocean), and Pacific Ocean (Australia, New Zealand). Some other remarks are presented:

- More than one species have wide geographic distribution around the world. Some of them have more than five localities: *Subbotina hornibrooki*, *S. triangularis*, *S. triloculinoides*, *S. yeguaensis*, *Globigerinatheka barri*, *G. index*, *G. euganea*, *G. s. subconglobata*, *Acarinina aspensis*, *A. collactea*, *A. esnaensis*, *A. pentacamerata*, *A. rohri*, *A. soldadoensis*, *A. topilensis*, *Morozovella acuta*, *M. aequa*, *M. angulata*, *M. aragonensis*, *M. caucasica*, *M. f. formosa*, *M. gracilis*, *M. marginodentata*, *M. occlusa*, *M. pasionensis*, *M. subbotinae*, *M. velascoensis*.

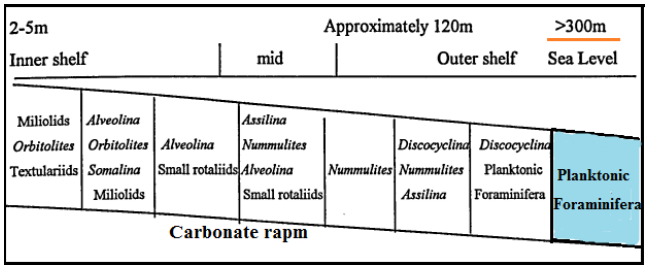
- Some species are recorded from five localities or less: *Parasubbotina eoclava*, *P. inaequispira*, *P. pseudowilsoni*, *Acarinina centralis*, *A. praetopilensis*, *A. quetra*, *Morozovella abundocamerata*, *M. edgari*, *M. nicoli*.

- Eight new species are recorded, so far, from Oman: *Globigerinatheka arabica*, *G. omanica*, *Acarinina umbilicata*, *Morozovella elbadrii*, *M. elsayighi*, *M. omanica*, *M. surensis* and *M. wadimusawaensis*.

5. PALEOENVIRONMENT

The sediments which included the planktic foraminiferal assemblage of the study section was deposited in an open deep marine environment which represent outer shelf (~200-400m), and was tectonically active, with marked oscillations in sea level (Table 2).

Table 2: The carbonate ramp illustrates the different calcareous group of Large and planktic foraminifera according to the shelf divisions (after El-Sayigh, 1998).



The planktic foraminifera are floating organism lived in the photic zone (~200m) and moving by surface currents which reflect the wide geographic distribution in all open sea water and oceans (Figure 7).

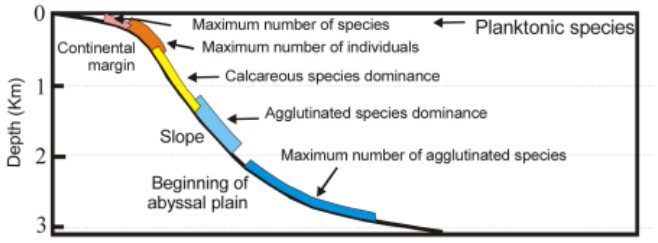


Figure 7: Depth distribution of planktic and benthic foraminifera (after Bolstovsky & Wright, 1976).

6. CONCLUSIONS

The present study deals with the recording six Paleogene planktic foraminiferal genera and its forty-seven species which identified from SE Oman, Arabian Sea. Eight of the identified species are confined to Oman, but the other species were recorded from many localities in the North America, South America, Europe, Africa, Asia, and Australia, New Zealand. This study confirms again that the extended realms of the Tethys have extended from the Atlantic Oceans to Indo-Pacific Oceans, via Mediterranean Sea during the Paleogene time. Environmental conditions of the identified species represent open deep marine outer shelf environment (~200m).

ACKNOWLEDGEMENT

The author thanks the editor and colleagues of the MAGG for kind cooperation, and my daughter Dr. Huda Anan for her help in the development of the figures, tables and plate.

REFERENCES

Anan, H.S., 1993a. Paleocene benthonic foraminifera of Jabal Malaqet, Al Ain region, United Arab Emirates. Al-Azhar Bulletin of Sci., Al Azhar University, Cairo, 4 (1), Pp. 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, Al-Azhar University, Cairo, 4 (2), Pp. 639-670.

Anan, H.S., 1994. Contribution to the stratigraphy and paleobiogeography of some diagnostic Upper Cretaceous and Paleogene Foraminifera -

Neues Jahrbuch für Geologie und Paläontologie, H. 5, Pp. 257-266.

Anan, H.S., 1995. Late Eocene biostratigraphy of Jabals Malaqet and Mundassa of Al Ain region, United Arab Emirates. Revue de Micropaléontologie, 38 (1), Pp. 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, Cairo, 10, Pp. 147-162.

Anan, H.S., 2014. Significant episodes of tectonic activities in the Paleogene of Al Ain area, United Arab Emirates. International Journal of Chemical and Natural Science, 2 (6), Pp. 180-188.

Anan, H.S., 2015a. Planktic foraminifera around the Early/Middle Eocene boundary in the United Arab Emirates and other Tethyan localities. Revue de Paléobiologie, 34 (1), Pp. 11-25.

Anan, H.S., 2015b. The global '*pentacamerata* event': A diagnostic episode of tectonic activity in combination with lowering sea-level around the Early/Middle Eocene boundary in the world. International Journal of Chemical and Natural Sciences, 3 (4), Pp. 287-296.

Anan, H.S., 2016. Planktic foraminifera of the Danian/Selandian transition in Jabal Mundassa Al Ain area, United Arab Emirates. Neues Jahrbuch für Geologie und Paläontologie, Mh. 282, 3, Pp. 305-318.

Anan, H.S., 2018. Hantkeninidae (planktonic foraminifera) from the Middle-Upper Eocene of Jabal Hafit, United Arab Emirates. Earth Sciences India, 11 (2), Pp. 122-132.

Anan, H.S., 2020. Taxonomic consideration and stratigraphic implication of the accelerated evolution of the Maastrichtian-Eocene transition of twenty benthic foraminiferal species in the Tethys. Earth Sciences Pakistan (ESP), 4 (1), Pp. 1-06.

Anan, H.S., 2020. Taxonomical considerations, phylogeny, paleogeography and paleoclimatology of the Middle Eocene (Bartonian) planktic foraminifera from Jabal Hafit, Al Ain area, United Arab Emirates. Earth Sciences Pakistan (ESP), 4 (1), Pp. 10-20.

Anan, H.S., 2023. Late Eocene (Priabonian) planktic foraminifera from Jabal Hafit, Al Ain area, United Arab Emirates. Jordan Journal of Earth and Environmental Sciences (JJEE), 14 (1), Pp. 30-49.

Anan, H.S., 2023. New geographic record of the UAE planktic foraminifera *Turborotalia semicunialensis* Anan in India and Egypt. Earth Sciences Pakistan (ESP) 7(2), Pp. 38-42.

Anan, H.S., Bahr, S.A., Bassiouni, M.A., Boukhary, M.A. and Hamdan, A.R., 1992. Contribution to Early Eocene-Oligocene biostratigraphy of Jabal Hafit succession, United Arab Emirates. Middle East Research Center, Ain Shams University, Earth Science Series, Cairo, 6, Pp. 225-247.

Anan, H.S., Hamdan, A.R., 1993. Paleocene planktonic foraminifera of Jabal Malaqet, East of Al Ain, United Arab Emirates. Neues Jahrbuch für Geologie und Paläontologie, H.1, Pp. 27-48.

Bermúdez, P.J., 1961. Contribucion al studio de las Globigerindea de la region Caribe-Antillana (Paleoceno-Reciente). Boletino Geologia (Venezuela), Special Publicacion 3 (Congres Geologia Venezolano, 3ed Caracas, 1959, Mem. 3), Pp. 1119-1393.

Blow, W.H., 1979. The Cainozoic Globigerinida. E. J. Brill, Leiden, Pp. 1-1413.

Bolli, H.M., 1957. The genera *Globigerina* and *Globorotalia* in the Paleocene-Lower Eocene Lizard Springs Formation of Trinidad. B.W.I. United States Natural Museum Bulletin, 215, Pp. 61-81.

Boltovskoy, E., Wright, R., 1976. Recent foraminifera. The Hague, the Netherlands, Pp. 1- 515.

Brönnimann, P., 1952. Trinidad Paleocene and Lower Eocene Globigerinidae. Bulletin of American Paleontology, 34, Pp. 1-34.

Brönnimann, P., Bermúdez, P.J., 1953. *Truncorotaloides*, a new foraminiferal genus from the Eocene of Trinidad, B.W.I. Journal of Paleontology, 27, Pp. 817-820.

Brotzen, F., Pozaryska, K., 1961. Foraminifères du Paléocène et de l'Eocène inférieur en Pologne septentrionale; remarques paléogéographiques. Revue de Micropaléontologie, 4, Pp. 155-166.

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 (2), Pp. 207-217.

Colom, G., 1954. Estudio de las biozonas con foraminíferos del Terciario de Alicante. Boletín del Instituto Geológico y Minero de España. 66, Pp. 1-279.

Coxall, H.K., Huber, B.T., Pearson, P.N., 2003. Origin and morphology of the Eocene planktonic foraminifer *Hantkenina*. Journal of Foraminiferal Research, 33 (3), Pp. 237-261.

Cushman, J.A., 1925. Some new foraminifera from the Velasco shale of Mexico. Contributions from the Cushman Laboratory for foraminiferal Research, 1, Pp. 18-23.

Cushman, J.A., Bermudez, P.J., 1937. Further new species of foraminifera from the Eocene of Cuba. Contributions from the Cushman Laboratory for Foraminiferal Research, 13, Pp. 1-29.

Cushman, J.A., Renz, H.H., 1942. Eocene Midway foraminifera from Soldado Rock, Trinidad. Contrib. from the Cushman Laboratory for Foraminiferal Research, 18(1), Pp. 1-14.

El-Khayal, A.A., 1974. Planktonic foraminiferal biostratigraphy of the Lower Tertiary Hiber Strata of northwest Saudi Arabia. Bulletin of the Faculty of Science, Riyadh University, 6, Pp. 174-194.

El-Naggar, Z.R., 1966. Stratigraphy and planktonic foraminifera of the Upper Cretaceous-Lower Tertiary succession in the Esna-Idfu region, Nile Valley, Egypt. Bulletin of British Museum (Natural History), Geological supplement 2, Pp. 1-291.

El-Naggar, Z.R., El-Nakhal, H., 1987. Stratigraphy and planktonic foraminifera of the Wasia Group (Cretaceous) in Kuwait. Journal of College Science, King Saud University, 18, Pp. 73-87.

El-Naggar, Z.R., Kamel, S., 1988. Biostratigraphical analysis of the Late Cretaceous-Early Paleogene succession in the Turayf area, Northwestern Saudi Arabia. Revista Españ̃ola de Micropaleontología, 20 (3), Pp. 329-353.

El-Nakhal, H.A., El-Naggar, Z., 1987. The genus *Globotruncana* from the subsurface Upper Cretaceous of Kuwait, Arabia. Palaeontographica Abt. A 197 (1-3), Pp. 39-84.

Al-Sayigh, A.R.S., 1998. Lower Tertiary Foraminifera From SouthEast Oman. Thesis presented for the degree of Doctor of philosophy at the University of Wales Aberystwyth, Pp. 1-343.

Finlay, H.J., 1939. New Zealand foraminifera: Key species in stratigraphy, 3. Transactions of the Royal Society of New Zealand, 69, Pp. 309-329.

Glaessner, M.F., 1937. Studien über Foraminiferen aus der Kreide und dem Tertiär des Kaukasus. I. Die Foraminifern der Ältesten Tertiärschichten des Nordwest-Kaukasus. Problemy Paleontologii, Paleontologicheskava Laboratotiya Moskovskogo Gosudarstvennogo Universiteta, [Studies on foraminifera from the Cretaceous and Tertiary of the Caucasus. I. The Foraminifers of the Oldest Tertiary Strata of the Northwest Caucasus. Problemy Paleontologii, Paleontologicheskava Laboratotiya Moskovskogo Gosudarstvennogo Universiteta], 2-3, Pp. 349-410.

Glennie, K.W., Boeuf, M.G.A., Hughes Clarke, M.W., Moody-Stuart, M., Pilaar, W.F.H., Reinhardt, B.M., 1974. Geology of the Oman Mountains. Koninklijk Nederlands Geologisch-Mijnbouwkundig Genootschap, 31, Pp. 1-423.

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, Pp. 1-229.

Haque, A.F.M.M., 1960. Some middle to late Eocene smaller foraminifera from the Sor Rang, Quetta District, West Pakistan. Pakistan Geological Survey Memoir, Palaeontologica Pakistanica, 2 (2), Pp. 9-57.

Haque, A.F.M.M., 1962. The smaller foraminifera of the Meting Limestone (Lower Eocene) Meting, Hyderabad Division, West Pakistan. Pakistan Geological Survey Memoir, Palaeontologica Pakistanica, 2 (1), Pp. 1-43.

Gibson, Th., 2007. Upper Paleocene foraminiferal biostratigraphy and paleoenvironments of the Salt Range, Punjab, Northern Pakistan: *In*: Regional Studies of the Potwar Plateau Area, Northern Pakistan. USGS Bulletin 2078-E, Pp. 1-14.

Hasson, P.H., 1985. New observations on the biostratigraphy of the Saudi Arabian Umm er Radhuma Formation (Paleogene) and its correlation with neighboring regions. *Micropaleontology*, 31 (4), Pp. 335-364.

Hunting Geology and Geophysics Ltd., 1979. Report on a Mineral Survey of the United Arab Emirates, Al Ain area. Ministry of Petroleum and Mineral Resources, Abu Dhabi, 9, Pp. 1-29 (unpublished).

Jones, R.W., Racey, A., 1994. Cenozoic stratigraphy of the Arabian Peninsula and Gulf. *In*: Simmons, M.D. (Ed.), Micropalaeontology and Hydrocarbon Exploration in the Middle East. Pp. 273-3 07. Chapman and Hall, London

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

Loeblich, A.R., Tappan, H., 1957. Planktonic foraminifera of Paleocene and early Eocene age from the Gulf and Atlantic Coastal Plains. Bulletin of the United States National Museum, 215, Pp.173-198.

Luterbacher, H.P., 1964. Studies in some Globorotalia from the Palaeocene and Lower Eocene of the central Apennines. Ecologae Geologicae Helvetiae, 57, Pp. 631- 730.

Martin, LT., 1943. Eocene foraminifera from the type Lodo Formation, Fresno County, California. Stanford University Publications for Geological Sciences, 3, Pp. 93-125.

Morozova, V.G., 1939. On the stratigraphy of the Upper Cretaceous and Palaeogene of the Emba region according to the foraminiferal fauna. Bulletin Moskovskogo Obshchestva Ispytatelej Prirody, (Geol.), 17, Pp. 59-86. [In Russian].

Nuttall, W.L.F., 1930. Eocene foraminifera from Mexico. Journal of Paleontology, 4, Pp. 271-293.

Olsson, R.K., Hemleben, Ch., Berggren, W.A., Huber, B.T., 1999. Atlas of Paleocene Planktonic Foraminifera. Smithsonian Contributions to Paleobiology, no. 85, Pp. 1-252.

Olsson, R.K., Hemleben, Ch., Berggren, W.A., Liu, C., 1992. Wall texture classification of planktonic foraminifera genera in the Lower Danian. Journal of Foraminiferal Research, 22, Pp.195-213.

Olsson, R.K., Pearson, P.N., Huber, B.T., 2006. Taxonomy, Biostratigraphy, and phylogeny of Eocene *Catapsydrax*, *Globorotaloides, Guembelitrioides, Paragloborotalia, Parasubbotina*, and *Pseudoglobigerinella* N. Gen. (*In* Atlas of Eocene Planktonic Foraminifera). Cushman Foundation Special Publication, 41, Pp. 67-110.

Orbigny, A.D.d', 1826. Tableau méthodique de la classe des Céphalopodes. Annals des Sciences de la Naturelles, Paris, 7, Pp. 96-169, 245-314.

Subbotina, N.N., 1947. Foraminifery Datskikh i Paleogenovykh otlozheniy severnogo Kvkaza [Foraminifera of the Danian and Paleogene deposits of the northern Caucasus] in Mikrofauna Neftanykh Mestorozhdeiny. Emby i Sredny Azii. Leningrad: Vsesoyuzhnyy Neftyanoy Nauchno - issledovatel'skiy Geologo-razvedochnyy Institut (VNGRI), Pp. 39-160.

Subbotina, N.N., 1953. Fossil foraminifers of the USSR, Globigerinidae, Hantkeninidae and Globorotaliidae. Ttudy Vsesoyuznogo Neftyanogo Nauchno-issledovatel'skogo Geologorazvedochnogo Instituta, 76, Pp. 1-296 [in Russian].

Pearson, P.N., Nicholas, C.J., Singano, J.M., Bown, P.R., Coxall, H.K., van Dongen, B.E., Huber, B.T., Karega, A., Lees, J.A., MacLeod, K., McMillan, I.K., Pancost, R.D., Pearson, M., Msaky, E., 2006. Further Paleogene and Cretaceous sediment cores from the Kilwa area of coastal Tanzania: Tanzania Drilhng Project Sites 6-10. Journal of African Earth Sciences 45, Pp. 279-317.

Pearson, P.N., Olsson, R.K., Huber, B. T., Hemleben, C., Berggren, W.A., 2006. Atlas of Eocene Planktonic Foraminifera. Cushman Foundation Special Publication, 41, Pp. 1–513.

Plummer, H J., 1927, Foraminifera of the Midway Formation in Texas. Bulletin University of Texas, 2644, Pp. 3-206.

Premoli Silva, I., Bolli, H.M., 1973. Late Cretaceous to Eocene planktonic foraminifera and stratigraphy of Leg 15 sites in the Caribbean Sea. Initial Reports Deep Sea Drill Project, 15, Pp. 499–547.

Racey, A., 1988. Nummulitid biostratigraphy and Palaeogene palaeoenvironments, Sultanate of Oman. Unpublished Ph.D. dissertation, University of London.

Rey, M., 1955. Description de quelques especes nouvelles de foraminiferes dans le Nummulitique nord-marocain. Bullten de la Societi Giologique de France, 6 (4), Pp. 209-211.

Roger, J., Bechennec, F., Janjou, D., Le Metour, J., Wyns, R., Beurrier, M., 1991. Geological Map of Ja'alan, Sheet NF 40-8E, with Explanatory Notes. Bureau de Recherches G6ologiques et Miners, Orleans (for the Ministry of Petroleum and Minerals, Sultanate of Oman).

Salahi, A., 2021. Late Paleocene-Middle Eocene Planktonic and Small Benthic Foraminiferal Fauna from the Type Section of Khangiran Formation, Kopet-Dagh Basin (NE Iran), Southernmost Peri-Tethys. Stratigraphy and Geological Correlation, 29, (3), Pp. 303–321.

Samanta, B.K., 1969. Eocene planktonic foraminifera from the Garo Hills, Assam, India. Micropaleontology, 15, Pp. 325-350.

Samanta, B.K., 1970. Middle Eocene planktonic foraminifera from Lakhpat, Cutch, western India. Micropaleontology, 16, Pp. 185-215.

Smout, A.H., 1954. Lower Tertiary foraminifera of the Qatar Peninsula. British Museum (Natural History), London.

Shutskaya, E.K., 1958. Variabilité de quelques Foraminifères planctoniques du Paléogène du Caucase septentrional: Voprosy Mikropaleontlogyi, Akad. Nauk SSSR, 2: 84-90 (Translated from Russian by S. and J. Sigal, 1960, in Questions de Micropaléotologie 2, BRGM, Pp. 93-103.

Subbotina, N.N., 1947. Foraminifery Datskikh i Paleogenovykh otlozheniy severnogo Kvkaza [Foraminifera of the Danian and Paleogene deposits of the northern Caucasus] in Mikrofauna Neftanykh Mestorozhdeiny. Emby i Sredny Azii. Leningrad: Vsesoyuzhnyy Neftyanoy Nauchno - issledovatel'skiy Geologo-razvedochnyy Institut (VNGRI), Pp. 39-160.

Subbotina, N.N., 1953. Fossil foraminifers of the USSR, Globigerinidae, Hantkeninidae and Globorotaliidae. Ttudy Vsesoyuznogo Neftyanogo Nauchno-issledovatel'skogo Geologorazvedochnogo Instituta, 76, Pp. 1-296 [in Russian].

Toulmin, L.D., 1941. Eocene smaller foraminifera from the Salt Mountain Limestone of Alabama. Journal of Paleontology 15, Pp. 567-611.

VahdatiRad, M., Vahidinia M., Sadeghi A., 2016. Early Eocene planktonic and benthic foraminifera from the Khangiran Formation (northeast of Iran). Arab Journal of Geosciences, 9: 677, Pp. 1-13.

Weinzierl, L.L.; Applin, E.R., 1929. The Claiborne Formation on the Coastal Domes. Journal of Paleontology, 3(4): Pp.384-410.

Weinzierl, L.L., Applin, E.R., 1929. The Claiborne Formation on the Coastal Domes. Journal of Paleontology, 3(4), Pp. 384-410.

White, P. M., 1928. Some index foraminifera of the Tampico Embayment area of Mexico. Journal of Paleontology, 2, Pp. 177-215, 280-317.

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, Pp. 191-213.