

Late Eocene (Priabonian) Planktic Foraminifera from Jabal Hafit, Al Ain area, United Arab Emirates

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Abstract

Thirty two planktic foraminiferal species belonging to seven genera: *Catapsydrax* (two species), *Subbotina* (8 species), *Globigerinatheka* (4 species), *Cribohantkenina* (1 species), *Hantkenina* (3 species), *Dentoglobigerina* (3 species), *Pseudohastigerina* (1 species), *Turborotalia* (9 species), *Chiloguembelina* (1 species) of the time interval corresponding to the Late Eocene (Priabonian) from the top part of Mazyad Member of the Dammam Formation from the eastern limb of Jabal Hafit anticline, Al Ain area, United Arab Emirates (UAE) are identified and twenty five of them are illustrated. The taxonomic consideration, biostratigraphic position, and probable phylogeny of these species are presented. The number of the Late Eocene planktic foraminifera species in the current study yields a higher number (32 species) than others in or outside the Al Ain area, UAE. Three planktic foraminiferal biozones (Tripartite) are recognized in the current study, according to the modern biozonation (after Berggren and Pearson, 2005, and Wade et al., 2011), from base to top: *Globigerinatheka semiinvoluta* Zone (E14), *G. index* Zone (E15), and *Hantkenina alabamensis* Zone (E16). The temporal distribution is also compared with the same stratigraphic horizon in the surrounding areas in Al Ain (UAE and Oman border), and some other Tethyan localities. The identified species are recognized in different localities in the Tethys: the Atlantic Ocean (USA, Mexico, Trinidad), the Northern Tethys (Spain, France, Italy, Caucasus), and the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, Oman, Pakistan, India, Indian Ocean, Pacific Ocean, New Zealand, Australia).

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1. Introduction

The present paper is one of a series of studies of planktic and benthic foraminiferal assemblages from the Maastrichtian-Paleogene succession of the Al Ain area. The current work presents a review of the complete record of the foraminiferal content of the Late Eocene of the upper part of Mazyad Member of the Dammam Formation of the eastern limb of Jabal Hafit (the upper part of Tle5 of Hunting, 1979), in the Al Ain, UAE (Fig. 1). This succession is composed of different lithologies, from base to top: shale, marl, phosphatic limestone, shale, marl, glauconitic limestone, marl in the top, separated by a conglomeratic limestone as an unconformity (P15/P16). This late Eocene succession is compared with the synchronous outcrops in Al Ain-Al Buraimi area, west of the Northern Oman Mountains, which are located at the border line between the western limb of Jabal Malaqet, UAE (Anan, 1995) and J. Qatar, to the east of J. Malaqet in the Sultanate of Oman (Abdelghany, 2002). The previous studies of the planktic faunal content of the study area by Cherif and El Deeb (1984), Cherif et al. (1992), and Anan et al. (1992) are also pertinent to the present study.

2. Stratigraphy

Five marly samples (nos. 17, 19, 20-22, Fig. 2) were collected from about 100 m thick vertical succession of the Late Eocene sediments of the eastern limb of Jabal Hafit anticline (Lat. 24° 06' - 24° 09' N, Long. 55° 46'-55° 49' E) along Al Ain-Mazyad asphalted road, which consists

mainly of marl, as a part of the Middle-Late Eocene Mazyad Member of the Dammam Formation, which consists of alternated lithologies of shales and marls. These rocks are intercalated by phosphatic limestone and glauconitic limestone beds (Fig. 3). Thirty two planktic foraminiferal species are identified and recorded from the Late Eocene (Priabonian) succession of the study area, and twenty-five species of them are illustrated in three Plates (1-3). Some differences in the definition of the Late Eocene biozonation from Al Ain area (around the border line between east UAE and west Oman) were made by Cherif and El Deeb (1984) as *Globorotalia c. cerroazulensis* Zone, followed by Cherif et al. (1992) as *Turborotalia c. cerroazulensis* Zone, Anan et al. (1992) as *Globigerinatheka semiinvoluta* and *Turborotalia c. cerroazulensis* Zones, Anan (1995) as *Cribohantkenina inflata* Zone and *C. inflata* or younger, and Abdelghany (2002) as *Turborotalia cunialensis/Cribohantkenina inflata* Concurrent-Range Zone. The disappearance of the spinose genera *Morozovella* and *Truncorotaloides* has been taken by many authors (Toumarkine and Luterbacher, 1985; Haggag, 1990; Anan et al., 1992) to mark the Middle/Upper Eocene boundary in the tropical and Mediterranean regions.

The Late Eocene planktic foraminiferal content was subdivided early into two zones (Bipartite) by some authors (Stainforth et al., 1975; Toumarkine and Luterbacher, 1985; Keller, 1985): the lower *Globigerinatheka semiinvoluta* Zone (P 15) and the upper *Turborotalia cerroazulensis*

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Zone (P16/17), while it was subdivided it into three zones (Tripartite) by others (Blow, 1969; Berggren and Miller, 1988; Coccioni et al, 1988; Anan, 1995): the lower *Globigerinatheka semiinvoluta* Zone (P15), the middle *Cribrohantkenina inflata* Zone (P16), and the upper *Turborotalia cerroazulensis* Zone (P17), which was based on the stratigraphic range of the *C. inflata* between *G. semiinvoluta* and *T. cunialensis*. The tripartite subdivisions are currently used by different authors (Fig. 4). On the other hand, Haggag (1990) introduced the *Globigerina pseudoampliapertura* Zone as an interval from the last occurrence of *Truncorotaloides rohri* to the first appearance of *Globigerinatheka semiinvoluta* and was assigned to the Late Eocene in the Egyptian stratigraphy. Three planktic foraminiferal conventional biozones are recognized in the studied section, from base to top: *Globigerinatheka semiinvoluta* Zone (E14), *Globigerinatheka index* Zone (E15) and *Hantkenina alabamensis* Zone (E16) of the worldwide standard zonation of Berggren and Pearson (2005), Pearson et al. (2006), Wade et al. (2011) and Molina (2015).

3. Systematic Paleontology

The taxonomy followed in this study is that of Pearson et al. (2006). Thirty two Late Eocene planktic foraminiferal species are identified from the upper part of Mazyad Member, Dammam Formation of Jabal Hafit, and twenty five of them are illustrated in Plates 1-3. The stratigraphic ranges of the identified species are presented in Fig. 3.

Order: Foraminifera Eichwald, 1830

Suborder: Globigerinina Delage and Hérouard, 1896

Superfamily: Globigerinacea Carpenter, Parker and Jones, 1862

Family: Globigerinidae Carpenter, Parker and Jones 1862

Genus: *Catapsydrax* Bolli, Loeblich and Tappan, 1957

Type species: *Globigerina dissimilis* Cushman and Bermúdez, 1937

***Catapsydrax dissimilis* (Cushman and Bermúdez, 1937)**

1937 *Globigerinina dissimilis* Cushman and Bermúdez, p. 25, pl. 3, figs. 4-6.

1957 *Catapsydrax dissimilis*; Bolli et al., 36, pl. 7, fig. 6.

1970 *Globigerinina dissimilis*; Samanta, p. 35, pl. 6, fig. 1.

1992 *Catapsydrax dissimilis*; Anan et al., p. 239, fig. 11.13.

1997 *Catapsydrax dissimilis*; Pearson and Chaisson, p. 57, pl. 2, fig. 12.

2000 *Catapsydrax dissimilis*; Sztrákos, p. 143, pl. 21, figs. 15,16.

2006 *Catapsydrax dissimilis*; Olsson et al., p. 71, pl. 5.3, figs. 18-20.

2021 *Catapsydrax dissimilis*; Salama et al., p. 12, fig. 7. K.

Remarks: This Middle-Late Eocene species is characterized by its obligate bulla with a uniform continuous lip bordering the infralaminar apertures. Olsson et al. (2006) suggested that this species probably evolved from the Early-Late Eocene *C. unicavus* in the Late Eocene. It is recorded in Al Ain area before (Anan et al., 1992). It was also recorded in the Atlantic Ocean, the Northern Tethys (Spain, France), and the Southern Tethys (Tanzania, Libya, Egypt, UAE, Pakistan, India, Indian Ocean, and Pacific Ocean (Table 1).

***Catapsydrax unicavus* Bolli, Loeblich and Tappan, 1957** (Pl. 1, fig. 1)

1957 *Catapsydrax unicavus* Bolli et al., p. 37, pl. 7, fig. 9.

1969 *Globigerinina unicava*; Samanta, p. 332, pl. 1, fig. 4.

2006 *Catapsydrax unicavus*; Olsson et al., p. 75, pl. 5.3, figs. 1-17.

2006 *Catapsydrax unicavus*; Hernitz Kučenjok et al., p. 30, pl. 1, fig. 10.

2015 *Catapsydrax unicavus*; Molina, p. 172, fig. 5.

2015 *Catapsydrax unicavus*; Pearson and Wade, p. 8, fig. 4. 1-5.

2021 *Catapsydrax unicavus*; Salama et al., p. 12, fig. 7. M.

Remarks: This Eocene species has 4 globular chambers in the final whorl with slightly inflated bulla extending over the umbilicus. It is recorded and illustrated in Al Ain area herein, for the first time. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain), and the Southern Tethys (Tanzania, Libya, Egypt, Syria, India, New Zealand, and in the Pacific Ocean).

Genus *Subbotina* Brotzen and Pozaryska, 1961

Type species *Globigerina triloculinooides* Plummer, 1926

***Subbotina angiporoides* (Hornibrook, 1965)**

1965 *Globigerina angiporoides* Hornibrook, p. 835, figs. 1, 2.

1968 *Globigerina angiporoides*; Srinivasan, p. 147, pl. 15, fig. 9.

1969 *Globigerina angiporoides*; Samanta, pl. 330, pl. 3, fig. 1.

1975 *Globigerina angiporoides*; Toumarkine and Bolli, p. 182, pl. 5, figs. 5-7.

1971 *Globigerina (Subbotina) a. angiporoides*; Jenkins, pl. 20, figs. 588-594.

1992 *Subbotina angiporoides*; Anan et al., p. 239, fig. 10.10.

2006 *Subbotina angiporoides*; Olsson et al., p. 126, pl. 6.6, figs. 1-13.

2021 *Subbotina angiporoides*; Salama et al., p. 14, fig. 8. D.

Remarks: This Middle-Late Eocene species have strongly embracing final chamber and a low slit-like aperture with a thick lip. Olsson et al. (2006) suggested that it evolved from the long-range Eocene *S. linaperta*. It is recorded in Al Ain area before (Anan et al., 1992; Anan, 1995). It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Italy, Caucasia), and the Southern Tethys (Egypt, New Zealand, Indian Ocean, and New Zealand, Fig. 5).

***Subbotina corpulenta* (Subbotina, 1953)**

1953 *Globigerina corpulenta* Subbotina, p. 101, pl. 9, figs. 5-7.

1970 *Globigerina corpulenta*; Samanta, p. 32, pl. 7, figs. 9,10.

1992 *Globigerina corpulenta*; Anan et al., p. 239, pl. 10, fig. 15.

1995 *Globigerina corpulenta*; Anan, p. 8, pl. 1, fig.11.

2006 *Subbotina corpulenta*; Olsson et al., p. 75, pl. 6.7, figs. 1-14.

2006 *Subbotina corpulenta*; Hernitz Kučenjok et al., p. 30, pl. 1, fig. 7.

2015 *Subbotina corpulenta*; Molina, p. 172, fig. 5.

2015 *Subbotina corpulenta*; Pearson and Wade, p. 13, fig. 10. 3, 4.

2021 *Subbotina corpulenta*; Salama et al., p. 14, fig. 8. G.

Remarks: The *Subbotina corpulenta* Middle-Late Eocene species has a larger-size test with 4 globular chambers in the final whorl. Stainforth et al. (1975) considered that *S. corpulenta* is a half way between *S. eocaena* and *S. gortanii*, while it may probably evolve from *S. eocaena* by Haggag and Luterbacher (1991), or from *S. hagni* by Olsson et al. (2006). It is recorded only in E14 in this study. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France), and the Southern Tethys (Tanzania, Egypt, UAE, Oman, India, Indian Ocean, and Pacific Ocean).

***Subbotina eocaena* (Guembel, 1868)**

- 1868 *Globigerina eocaena* Guembel, p. 662, pl. 2, fig. 109.
 1953 *Globigerina pseudoeocaena* var. *pseudoeocaena* Subbotina, p. 81, pl.5, figs.1, 2.
 1953 *Globigerina pseudoeocaena* var. *compacta* Subbotina, p. 81, pl. 5, fig. 3.
 1953 *Globigerina pseudoeocaena* var. *trilobata* Subbotina, p. 84, pl. 5, fig. 5.
 1969 *Globigerina eocaena*; Samanta, pl. 330, text- fig. 1.
 1975 *Globigerina eocaena*; Toumarkine and Bolli, p. 180, pl. 4, figs. 1, 2.
 1992 *Globigerina eocaena*; Anan et al., p. 239, pl. 10, fig.11.
 1992 *Globigerina eocaena*; Haggag, p. 106, pl. 2, figs. 5,6.
 1992 *Subbotina eocaena*; Cherif et al., p. 46, pl. 1, fig. 36.
 1995 *Globigerina eocaena*; Anan, p. 8, pl. 1, fig. 10.
 2000 *Subbotina eocaena*; Sztrákos, p. 124, pl. 22, fig. 8.
 2002 *Subbotina eocaena*; Abdelghany, p. 214, pl. 1, fig. 7.
 2006 *Subbotina eocaena*; Olsson et al., p. 138, pl. 6,9, figs. 1-16.
 2015 *Subbotina eocaena*; Molina, p. 172, fig. 5.
 2015 *Subbotina eocaena*; Pearson and Wade, p. 13, fig. 10. 5-8.
 2020 *Subbotina eocaena*; Anan, p. 497.
 2021 *Subbotina eocaena*; Salama et al., p. 12, fig. 7. T.

Remarks: *Subbotina eocaena* recorded here from Middle-Late Eocene is characterized by its 3½-4 globular embracing chambers in the last whorl, with an embracing aperture bordered by a thin irregular lip. It is recorded from many localities in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus) and the Southern Tethys (Tanzania, Libya, Egypt, UAE, Oman, India, Indian Ocean).

***Subbotina gortanii* (Borsetti, 1959)**

(Pl. 1, fig. 2)

- 1959 *Catapsydrax gortanii* Borsetti, p. 205, pl. 1, fig. 1.
 1969 *Globigerina g. gortanii*; Blow, p. 320, pl. 17, fig. 1.
 1970 *Globigerina gortanii*; Samanta, p. 32, pl. 7, figs. 11,12.
 1995 *Globigerina gortanii*; Anan, p. 8, pl. 1, fig. 12.
 2002 *Subbotina gortanii*; Abdelghany, p. 214, pl. 1, fig. 8.
 2006 *Subbotina gortanii*; Olsson et al., p. 138, pl. 6,10, figs. 1-17.
 2015 *Subbotina gortanii*; Molina, p. 172, fig. 5.
 2015 *Subbotina gortanii*; Pearson & Wade, p. 8, fig. 11. 1-8.
 2020 *Subbotina gortanii*; Anan, p. 498, pl. 1, fig. 2.

Remarks: The Middle-Late Eocene *Subbotina gortanii* species is characterized by its trochospiral loosely coiled test, 4 globular loosely embracing chambers in the final whorl with a large umbilicus enclosed by surrounding chambers. It

was also recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus), and the Southern Tethys (Tanzania, Libya, Egypt, UAE, Oman, India, and Indian Ocean).

***Subbotina jacksonensis* (Bandy, 1949)**

(Pl. 1, fig. 3)

- 1949 *Globigerina rotundata jacksonensis* Bandy, p. 121, pl. 23, fig. 6.
 2006 *Subbotina jacksonensis*; Olsson et al., p. 146, pl. 6.13, figs. 1-20.
 2020 *Subbotina jacksonensis*; Anan, p. 498, pl. 1, fig. 4.

Remarks: The Middle-Late Eocene *Subbotina jacksonensis* species is characterized by its much-embracing chambers, with a reduced final chamber projecting and covering the umbilicus. It was originally recorded from the USA, the Northern Tethys (Spain), and the Southern Tethys (Egypt). It is recorded and illustrated here, for the first time, from Al Ain area.g

***Subbotina linaperta* (Finlay, 1939)**

(Pl. 1, fig. 4)

- 1939 *Globigerina linaperta* Finlay, p. 125, pl. 23, figs. 54-57.
 1968 *Subbotina linaperta*; Srinivasan, p. 149, pl. 16, figs. 7, 10, 11.
 1970 *Globigerina linaperta*; Samanta, p. 33, pl. 6, figs. 19, 20.
 1971 *Globigerina (Subbotina) linaperta*; Jenkins, p. 162, pl. 18, figs. 551-554.
 1975 *Globigerina linaperta*; Toumarkine and Bolli, p. 182, pl. 5, figs. 1, 2.
 1990 *Subbotina linaperta*; Premoli Silva and Spezzaferrri, p. 312, pl. 2, fig. 2.
 1992 *Globigerina linaperta*; Haggag, p. 106, pl. 2, fig. 4.
 2000 *Subbotina linaperta*; Sztrákos, P. 143.
 2002 *Subbotina linaperta*; Abdelghany, p. 214, pl. 1, figs. 10-11.
 2006 *Subbotina linaperta*; Olsson et al., p. 149, pl. 6.14, figs. 1-16.
 2015 *Subbotina linaperta*; Molina, p. 172, fig. 5.
 2020 *Subbotina linaperta*; Anan, p. 498, pl. 1, fig. 5.
 2021 *Subbotina linaperta*; Salama et al., p. 12, fig. 7. W.

Remarks: *Subbotina linaperta* from the Eocene was considered by several authors (e.g. Stainforth et al., 1975; Bolli and Saunders, 1985; Haggag and Luterbacher, 1991) as the basic stock, from which all Eocene *Globigerina* groups or lineage have been differentiated. Olsson et al. (2006) considered *S. linaperta* belongs to a group of tightly coiled subbotinids with a coarse, symmetrical cancellate wall texture which include *S. velascoensis*, *S. patagonica*, *S. angiporoides*, *S. utilisindex*. It appears that Early-Late Eocene *S. linaperta* is derived from Early-Middle Eocene *S. patagonica* by flattening of chambers and rotation of the aperture to a more extraumbilical position. This cosmopolitan species was recorded in Al Ain area, UAE as a part of the Southern Tethys (Tanzania, Libya, Egypt, Oman, Pakistan, India, Indian Ocean, New Zealand, Pacific Ocean), and recorded also in the Northern Tethys (Spain, France, Italy, and the Caucasus).

***Subbotina utilisindex* (Jenkins and Orr, 1973)**

(Pl. 1, fig. 5)

1973 *Globigerina utilisindex* Jenkins and Orr, p. 1089, pl. 10, figs. 6-8.2000 *Subbotina linaperta utilisindex*; Sztrákos, p. 143.2006 *Subbotina utilisindex*; Olsson et al., p. 161, pl. 6.6, figs. 14-20.2021 *Subbotina utilisindex*; Salama et al., p. 14, fig. 8. P.

Remarks: This Late Eocene species is characterized by its trilobate test, spinose wall, final chamber comprising about half of the test, and umbilical-extraumbilical slit-like aperture. It is recorded and illustrated, for the first time, in the current study. It was recorded in the Northern Tethys (France) and also the Southern Tethys (Egypt, Indian Ocean, and Pacific Ocean).

***Subbotina yeguaensis* (Weinzierl and Applin, 1929)**

(Pl. 1, fig. 6)

1929 *Globigerina yeguaensis* Weinzierl and Applin, p. 409, pl. 43, fig. 1.1968 *Subbotina yeguaensis*; Srinivasan, p. 149, pl. 16, figs. 1-4.1969 *Globigerina yeguaensis*; Samanta, p. 332, pl. 3, fig. 7.1992 *Globigerina yeguaensis*; Anan et al., p. 239, fig. 10.18.1992 *Globigerina yeguaensis*; Haggag, p. 106, pl. 2, figs. 7, 8.1995 *Globigerina yeguaensis*; Anan, p. 8, pl. 1, fig. 13.2006 *Globigerina yeguaensis*; Olsson et al., p. 162, pl. 6.18, figs. 1-16.2015 *Globigerina yeguaensis*; Molina, p. 172, fig. 5.2021 *Globigerina yeguaensis*; Salama et al., p. 12, fig. 7. Y.

Remarks: The *Subbotina yeguaensis* Eocene species is characterized by its smaller ultimate chamber size than its penultimate chamber size. Haggag and Luterbacher (1991) considered *D. tripartita* (Koch) as being developed from *S. yeguaensis* with many transitional forms, while Olsson et al. (2006) noted that *S. yeguaensis* arose in the Early Eocene possibly from *S. eocaena* (Guembel). It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Caucasus), and the Southern Tethys (Tanzania, Libya, Egypt, UAE, Pakistan, India, Indian Ocean, New Zealand, and the Pacific Ocean).

Genus *Globigerinatheka* Brönnimann, 1952Type species *Globigerinatheka barri* Brönnimann, 1952***Globigerinatheka index* (Finlay, 1939)**

(Pl. 1, fig. 7)

1939 *Globigerinoides index* Finlay, p. 125, pl. 14, figs. 85-88.1968 *Globigerapsis index*; Srinivasan, p. 149, pl. 16, figs. 8,9,12.1985 *Globigerinatheka index*; Keller, p. 886, fig. 4.15.1988 *Globigerinatheka index*; Coccioni et al., p. 75, pl. 1, figs. 11, 12.1990 *Globigerinatheka index*; Premoli Silva and Spezzaferri, p. 311, pl. 1, fig. 8.1992 *Globigerinatheka i. index*; Anan et al., p. 239, fig. 10.6.1992 *Globigerinatheka i. index*; Haggag, p. 108, pl. 3, fig. 12.1995 *Globigerinatheka i. index*; Anan, p. 8, pl. 1, fig. 4.2000 *Globigerinatheka i. index*; Sztrákos, p. 143, pl. 23, fig. 3.2006 *Globigerinatheka index*; Premoli Silva et al., p. 183, pl. 7.5, figs. 1-20.2013 *Globigerinatheka index*; Strougo, et al., p. 128, fig. 12. L.2015 *Globigerinatheka index*; Molina, p. 172, fig. 5.9.

Remarks: The *Globigerinatheka index* species recorded from Middle-Late Eocene is characterized by its three inflated chambers in the last whorl and the last one making almost one-half of the test size, and secondary aperture at the base of the last chamber above the sutures of the previous chambers usually without bullae. *G. index* is one of the three members of the genus *Globigerinatheka* in the Late Eocene besides *G. luterbacheri* and *G. tropicalis*. It is evolved from the Middle Eocene *G. subconglobata* according to Premoli Silva et al. (2006). It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus), and also the Southern Tethys (Tanzania, Libya, Egypt, UAE, India, Indian Ocean, New Zealand, and the Pacific Ocean).

***Globigerinatheka luterbacheri* Bolli, 1972**

(Pl. 1, fig. 8)

1972 *Globigerinatheka subconglobata luterbacheri* Bolli, p. 132, pl. 7, fig. 13.1988 *Globigerinatheka luterbacheri*; Coccioni et al., p. 75, pl. 1, fig. 13.1990 *Globigerinatheka luterbacheri*; Premoli Silva and Spezzaferri, p. 312, pl. 2, fig. 7.1992 *Globigerinatheka subconglobata luterbacheri*; Anan et al., p. 239, fig. 10.1.2006 *Globigerinatheka luterbacheri*; Premoli Silva et al., p. 191, pl. 7.4, figs. 9,10,13.16.2015 *Globigerinatheka luterbacheri*; Molina, p. 172, fig. 5.

Remarks: The Middle-Late Eocene species is characterized by its robust wall and nearly globular large test with numerous secondary apertures mostly without bullae. It is recorded only in E14 only. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Italy), and also the Southern Tethys (Egypt, UAE, Indian Ocean and Pacific Ocean).

***Globigerinatheka semiinvoluta* (Keijzer, 1945)**

(Pl. 1, fig. 9)

1945, *Globigerinoides semi-involutus* Keijzer, p. 206, pl. 4, fig. 58.1957 *Globigerapsis semiinvoluta*; Bolli et al., p. 34, pl. 6, fig. 7.1975 *Globigerinatheka semiinvoluta*; Toumarkine and Bolli, p. 184, pl. 6, figs. 15-24.1985 *Globigerinatheka semiinvoluta*; Keller, p. 886, fig. 4.16.-1988 *Globigerinatheka semiinvoluta*; Coccioni et al., p. 75, pl. 1, fig. 10.-1990 *Globigerinatheka semiinvoluta*; Premoli Silva and Spezzaferri, p. 312, pl. 2, fig. 4.1992 *Globigerinatheka semiinvoluta*; Anan et al., p. 239, fig. 10.9.1996 *Globigerinatheka semiinvoluta*; Haggag and Bolli, p. 368, fig. 3.15-22.2000 *Globigerinatheka semiinvoluta*; Sztrákos, p. 144.

- 2006 *Globigerinatheka semiinvoluta*; Premoli Silva et al., p. 197, pl. 7.9, figs. 1-15.
 2013 *Globigerinatheka semiinvoluta*; Strougo et al., p. 128, fig. 12. M.
 2015 *Globigerinatheka semiinvoluta*; Molina, p. 172, fig. 5.10,11.
 2021 *Globigerinatheka semiinvoluta*; Salama et al., p. 14, fig. 8. V1-V3.

Remarks: *Globigerinatheka semiinvoluta* early Late Eocene [E14] species is characterized by its globular test, inflated enveloping last chamber, and large circular height secondary apertures. It is recorded in the upper part of the Mazyad Member of the Dammam Formation. *G. semiinvoluta* was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus) and in the Southern Tethys (Tanzania, Libya, Egypt, UAE, Indian and Pacific Oceans).

***Globigerinatheka tropicalis* (Blow and Banner, 1962)**

- 1962 *Globigerinoides tropicalis* Blow and Banner, p. 124, pl. 15, figs. D-F.
 1970 *Globigerapsis tropicalis*; Samanta, p. 35, pl. 6, figs. 21-23.
 1972 *Globigerinatheka index tropicalis*; Bolli, p. 127, text-figs. 58-59.
 1990 *Globigerinatheka tropicalis*; Premoli Silva and Spezzaferri, p. 311, pl. 1, fig. 9.
 1992 *Globigerinatheka index tropicalis*; Anan et al., p. 239, fig. 10.8.
 2000 *Globigerinatheka index tropicalis*; Sztrákos, p. 143.
 2006 *Globigerinoides tropicalis*; Premoli Silva et al., p. 204, pl. 7.3, figs. 9-16.
 2015 *Globigerinatheka index tropicalis*; Molina, p. 172, fig. 5.
 2013 *Globigerinatheka tropicalis*; Strougo et al., p. 128, fig. 12. I.
 2020 *Globigerinatheka tropicalis*; Anan, p. 498, pl. 1, fig. 9.

Remarks: The Middle-Late Eocene *Globigerinatheka tropicalis* species is characterized mainly by its mainly sub-circular secondary apertures with rims. Blow (1969) considered it to be largely restricted to cooler water, but Bolli (1972) extends its distribution to mid-latitudes. Anan (1995) noted the presence of keels (*T. cunialensis*), accessory apertures (*Globigerinatheka* members), and tubular spines (*Hantkenina* members), which predominant in tropical warm-temperature regions. He suggested that in the Late Eocene time, the UAE had been in the tropical belt. This species was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus), and the Southern Tethys (Tanzania, Libya, Egypt, UAE, India, Indian Ocean, New Zealand, and the Pacific Ocean).

Family Hantkeninidae Cushman, 1927

Genus *Cribohantkenina* Thalmann, 1942

Type species *Hantkenina* (*Cribohantkenina*) *bermudezi* Thalmann, 1942

***Cribohantkenina inflata* (Howe, 1928)**

(Pl. 2, fig. 10)

- 1928 *Hantkenina inflata* Howe, p. 14, pl. 14, fig. 2.
 1969 *Cribohantkenina inflata*; Samanta, p. 337, pl. 1, fig. 11.

- 1975 *Cribohantkenina inflata*; Martinez-Gallego and Molina, p. 178, pl. 1, fig. 2.
 1988 *Cribohantkenina inflata*; Coccioni, p. 87, pl. 2, figs. 9-12; pl. 3, figs. 1-8 .
 1990 *Cribohantkenina inflata*; Premoli Silva and Spezzaferri, p. 311, pl. 1, fig. 7.
 1992 *Cribohantkenina inflata*; Anan et al., p. 236, fig. 8.8.
 1992 *Cribohantkenina inflata*; Cherif et al., p. 46, pl. 1, fig. 32.
 1995 *Cribohantkenina inflata*; Anan, p. 8, pl. 1, figs. 14, 15.
 1997 *Cribohantkenina inflata*; Pearson and Chaisson, p. 57, pl. 2, fig. 9.
 2002 *Cribohantkenina inflata*; Abdelghany, p. 215, pl. 2, figs. 3-6.
 2006 *Cribohantkenina inflata*; Coxall and Pearson, p. 226, pl. 8.3, figs. 1-14.
 2006 *Cribohantkenina inflata*; Hernitz Kučenjak et al., p. 32, pl. 2, fig. 7.
 2015 *Cribohantkenina inflata*; Molina, p. 173, fig. 6.2.
 2015 *Cribohantkenina inflata*; Pearson and Wade, p. 20, fig. 22. 1-3; fig. 23. 1-21.
 2018 *Cribohantkenina inflata*; Anan, p. 124, fig. 5a.

Remarks: The genus *Cribohantkenina* is regarded as a monotypic genus. Blow (1969), Toumarkine and Luterbacher (1985), Anan (1995, 2018), Coxall and Pearson (2006), and Pearson and Wade (2015) consider this genus to have evolved from the genus *Hantkenina* Cushman (1924). The Late Eocene species *C. inflata* is distinguished from all other hantkeninids by the presence of one or more areal secondary circular apertures with lips in the final adult chamber. It was recorded in the low-mid latitudes: the Atlantic Ocean, the Northern Tethys (Spain, Italy), and also the Southern Tethys (Egypt, UAE, India, Indian Ocean). Anan (1995) presented a map (Fig. 6) showing the distribution of *C. inflata* in six localities in the world (between 40° N-20°S): the Atlantic Ocean, the Northern Tethys (Spain, Italy, Caucasus), the Southern Tethys (UAE, Oman, and India).

Genus *Hantkenina* Cushman, 1924

Type species *Hantkenina alabamensis* Cushman, 1924

***Hantkenina alabamensis* Cushman, 1924**

(Pl. 2, fig. 11)

- 1924 *Hantkenina alabamensis* Cushman, p. 3, pl. 1, figs. 1-6.
 1968 *Hantkenina alabamensis*; Srinivasan, p. 145, pl. 13, figs. 5, 6, 9.
 1970 *Hantkenina alabamensis*; Samanta, p. 37, pl. 7, fig. 8.
 1975 *Hantkenina alabamensis*; Toumarkine and Bolli, p. 174, pl. 1, figs. 10-13.
 1975 *Hantkenina alabamensis*; Martinez-Gallego and Molina, p. 180.
 1985 *Hantkenina alabamensis*; Keller, p. 886, fig. 3. 9,10.
 1988 *Hantkenina alabamensis*; Coccioni, p. 85, pl. 1, figs. 1-9.
 1990 *Hantkenina alabamensis*; Premoli Silva and Spezzaferri, p. 311, pl. 1, figs. 4-6.
 1992 *Hantkenina alabamensis*; Anan et al., p. 239, fig. 8.6.
 1992 *Hantkenina alabamensis*; Haggag, p. 106, pl. 2, fig. 3.
 1995 *Hantkenina alabamensis*; Anan, p. 8, pl. 1, fig. 16.

1997 *Hantkenina alabamensis*; Pearson and Chaisson, p. 61, pl. 1, fig. 8.

2000 *Hantkenina alabamensis*; Sztrákos, p. 143.

2006 *Hantkenina alabamensis*; Coxall and Pearson, p. 230, pl. 8.4, figs. 1-14.

2015 *Hantkenina alabamensis*; Pearson and Wade, p. 22, fig. 24.1-6.

2015 *Hantkenina alabamensis*; Molina, p. 172, fig. 5.

2018 *Hantkenina alabamensis*; Anan, p. 125, fig. 5b.

2020 *Hantkenina alabamensis*; Anan, p. 499, pl. 1, fig. 11.

Remarks: Coxall et al. (2003) revealed that the Middle-Late genus *Hantkenina* was evolved gradually from the clavata species *Clavigerinella eocenica* (Nuttall), and contrary to the long-held view it is related to the genus *Pseudohastigerina* (Banner and Blow). The genus *Hantkenina* Cushman (1924) is characterized by having tubulospine on some or all of the chambers in the adult whorls. The cosmopolitan Middle-Late Eocene species *H. alabamensis* is the most advanced representative of the genus. It was recorded in the low-mid latitudes: the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus) and also the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian Ocean, and New Zealand).

***Hantkenina compressa* Parr, 1947**

(Pl. 2, fig. 12)

1947 *Hantkenina compressa* Parr, p. 46, text-figs. 1-7.

2006 *Hantkenina compressa*; Coxall and Pearson, p. 233, pl. 8.6, figs. 1-21.

2015 *Hantkenina compressa*; Molina, p. 173, fig. 6.

2018 *Hantkenina compressa*; Anan, p. 127, fig. 5d.

2020 *Hantkenina compressa*; Anan, p. 499.

Remarks: The *Hantkenina compressa* Middle-Late Eocene species is characterized by its more laterally compressed chambers than *H. alabamensis*. The final 2-3 chambers are in contact with the posterior wall of the adjacent chambers. Coxall and Pearson (2006) noted that this species is intermediate in morphology between Middle Eocene *H. dumblei* and Middle-Late Eocene *H. alabamensis* and overlaps stratigraphically with them both, and the morphospecies of the latter species and *H. compressa* seem to be linked by a continuous gradation of morphology. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Italy) and also the Southern Tethys (Tanzania, Egypt, UAE and Australia).

***Hantkenina primitiva* Cushman and Jarvis, 1929**

(Pl. 2, fig. 13)

1929 *Hantkenina alabamensis* Cushman var. *primitiva* Cushman and Jarvis, p. 16, pl. 3, figs. 2, 3.

1969 *Hantkenina primitiva*; Samanta, p. 340, pl. 1, fig. 9.

1992 *Hantkenina primitiva*; Anan et al., p. 236, fig. 8.7.

2006 *Hantkenina primitiva*; Coxall and Pearson, p. 250, pl. 8.12, figs. 1-20.

2015 *Hantkenina primitiva*; Molina, p. 173, fig. 6.

2015 *Hantkenina primitiva*; Pearson and Wade, p. 23, fig. 25. 5-9.

2018 *Hantkenina primitiva*; Anan, p. 127, fig. 5f.

Remarks: *Hantkenina primitiva* Middle-Late Eocene species has 5-6 compressed polygonal chambers extending into hollow tubulospine and increasing steadily in size as

added. Coxall and Pearson (2006) noted that this species might have evolved from *H. compressa* at the base of Middle Eocene E13 (*Morozovella crassata* Zone). It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Italy) and the Southern Tethys (Tanzania, Libya, Egypt, UAE and India).

Family Globoquadrinidae Blow, 1979

Genus *Dentoglobigerina* Blow, 1979

Type species *Globigerina galavisi* Bermúdez, 1961

***Dentoglobigerina galavisi* (Bermúdez, 1961)**

(Pl. 2, fig. 14)

1961 *Globigerina galavisi* Bermúdez, p. 1183, pl. 4, fig. 3.

1975 *Globigerina galavisi*; Toumarkine and Bolli, p. 72.

2006 *Dentoglobigerina galavisi*; Olsson et al., p. 403, pl. 13.1, figs. 1-16.

2006 *Dentoglobigerina galavisi*; Hernitz Kučenjok et al., p. 30, pl. 1, fig. 11.

2015 *Dentoglobigerina galavisi*; Molina, p. 172, fig. 5.

2015 *Dentoglobigerina galavisi*; Pearson and Wade, p. 17, fig. 15.1-8.

2021 *Dentoglobigerina galavisi*; Salama et al., p. 12, fig. 7. N.

Remarks: *Dentoglobigerina galavisi* Middle-Late Eocene species is characterized by 3½ nearly globular chambers in the final whorl with a small umbilicus enclosed by surrounding chambers. It is recorded and illustrated in the study section, for the first time, in UAE. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, Italy, Caucasus) and also the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, Indian Ocean and Pacific Ocean).

***Dentoglobigerina pseudovenezuelana* (Blow and Banner, 1962)**

(Pl. 2, fig. 15)

1962 *Globigerina yeguaensis pseudovenezuelana* Blow and Banner, p. 100, pl. 11, figs. J-L.

1992 *Globigerina pseudovenezuelana*; Anan et al., p. 239, fig. 11.1.

2006 *Dentoglobigerina pseudovenezuelana*; Olsson et al., p. 404, pl. 13.2, figs. 1-16.

2008 *Dentoglobigerina pseudovenezuelana*; Wade and Pearson, p. 249, fig. 5.

2015 *Dentoglobigerina pseudovenezuelana*; Molina, p. 172, fig. 5.

2015 *Dentoglobigerina pseudovenezuelana*; Pearson and Wade, p. 18, fig. 17.1-6.

2021 *Dentoglobigerina pseudovenezuelana*; Salama et al., p. 12, fig. 7. O.

Remarks: *Dentoglobigerina pseudovenezuelana* Late Eocene species is characterized by its embracing 3¼ chambers in the last whorl, which led to a compact subcircular test. Olsson et al. (2006) regarded that this species evolved from *D. galavisi*. It was recorded in the Northern Tethys (Spain, Caucasus) and also the Southern Tethys (Tanzania, Egypt and UAE).

***Dentoglobigerina tripartita* (Koch, 1926)**

(Pl. 2, fig. 16)

1926 *Globigerina bulloides* var. *tripartita* Koch, p. 742, fig. 21.

1975 *Globigerina tripartita*; Toumarkine and Bolli, p. 180, pl. 4, figs. 3,4.

- 1992 *Globigerina tripartita*; Anan et al., p. 239, fig. 11. 5.
 1992 *Globigerina tripartita*; Haggag, p. 104, pl. 1, fig. 16.
 2000 *Subbotina tripartita*; Sztrákos, p. 143.
 2006 *Globigerina tripartita*; Hernitz Kučenjok et al., p. 36, pl. 4, fig. 4.
 2006 *Dentoglobigerina tripartita*; Olsson et al., p. 408, pl. 13.3, figs. 1-16.
 2015 *Dentoglobigerina tripartita*; Molina, p. 172, fig. 5.
 2021 *Dentoglobigerina tripartita*; Salama et al., p. 12, fig. 7. Q.
- Remarks: *Dentoglobigerina tripartita* Middle-Late Eocene species is characterized by its compact test with 3 chambers increasing rapidly in size in the last whorl, the final chamber hangs over the umbilicus. Olsson et al. (2006) regarded that this species evolved from *D. galavisi*. It was recorded in the Northern Tethys (Spain, France, Italy, Caucasus) and also Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian and Pacific Oceans).
- Family Hedbergellidae Loeblich and Tappan, 1961
 Genus *Pseudohastigerina* Banner and Blow, 1959
 Type species *Nonion micrus* Cole, 1927
***Pseudohastigerina micra* (Cole, 1927)**
 1927 *Nonion micrus* Cole, p. 22, pl. 5, fig. 12.
 1957 *Hastigerina micra*; Bolli, p. 161, pl. 35, fig. 2.
 1959 *Pseudohastigerina micrus*; Banner and Blow, p. 19, fig. 4.1-9.
 1969 *Pseudohastigerina micrus*; Samanta, p. 342, pl. 1, fig. 6.
 1975 *Pseudohastigerina micrus*; Toumarkine and Bolli, p. 174, pl. 1, figs. 1, 2.
 1975 *Pseudohastigerina micrus*; Martinez-Gallego and Molina, p. 181, pl. 2, fig. 1.
 1985 *Pseudohastigerina micrus*; Keller, p. 886, fig. 3.3,4.
 1988 *Pseudohastigerina micrus*; Coccioni et al., p. 75, pl. 1, figs. 14, 15.
 1992 *Pseudohastigerina micrus*; Anan et al., p. 242, fig. 8,9.
 1992 *Pseudohastigerina micrus*; Haggag, p. 106, pl. 2, figs. 1,2 .
 2000 *Pseudohastigerina micrus*; Sztrákos, p. 143.
 2002 *Pseudohastigerina micrus*; Abdelghany, p. 214, pl. 2, figs. 1,2.
 2006 *Pseudohastigerina micrus*; Hernitz Kučenjok et al., p. 30, pl. 1, fig. 5.
 2008 *Pseudohastigerina micrus*; Olsson and Hemleben, p. 422, pl. 14.3, figs. 11-24.
 2008 *Pseudohastigerina micrus*; Wade and Pearson, p. 249, fig. 5.
 2015 *Pseudohastigerina micrus*; Molina, p. 172, fig. 5, p. 173, fig. 6.4.
 2015 *Pseudohastigerina micra*; Pearson and Wade, p. 23, fig. 26. 1-7.
 2020 *Pseudohastigerina micra*; Anan, p. 500.
 2021 *Pseudohastigerina micra*; Salama et al., p. 12, fig. 7. Z2.
- Remarks: This Eocene species is characterized by its planispiral compressed test with 6-7 globular chambers, an equatorial symmetrical circular aperture bordered by a narrow lip. Olsson and Hemleben (2006) considered it evolved from Early-Middle Eocene *P. wilcoxensis* (Cushman and Ponton). This cosmopolitan species was recorded in the many Tethyan localities, i.e.. USA, Mexico, Trinidad, Spain, France, Italy, Egypt, Syria, UAE and India.
- Genus *Turbrotalia* Cushman and Bermúdez, 1949
 Type species *Globorotalia centralis* Cushman and Bermúdez, 1937
***Turbrotalia ampliapertura* (Bolli, 1957)**
 (Pl. 2, fig. 17)
 1957 *Globigerina ampliapertura* Bolli, p. 108, pl. 22, figs. 4-6.
 1968 *Globigerina ampliapertura*; Srinivasan, p. 147, pl. 16, figs. 5, 6.
 1970 *Globigerina ampliapertura*; Samanta, p. 31, pl. 6, figs. 9,10, pl.7, figs. 1, 2.
 1975 *Globigerina ampliapertura*; Toumarkine and Bolli, p. 180, pl. 4, figs. 17, 18.
 1985 *Globigerina ampliapertura*; Keller, p. 886, fig. 3. 14,15.
 1992 *Globigerina ampliapertura*; Cherif et al., p. 46, pl. 1, fig. 34.
 1992 *Globigerina ampliapertura*; Anan et al., p. 239, fig. 11. 9.
 1990 "*Globigerina*" *ampliapertura*; Premoli Silva and Spezzaferri, p. 312, pl. 2, fig. 1.
 2006 *Turbrotalia ampliapertura*; Pearson et al., p. 441, pl. 15.2, figs. 1-20.
 2006 *Turbrotalia ampliapertura*; Hernitz Kučenjok et al., p. 32, pl. 2, figs. 10.
 2008 *Turbrotalia ampliapertura*; Wade and Pearson, p. 249, fig. 5.
 2015 *Turbrotalia ampliapertura*; Pearson and Wade, p. 23, fig. 27. 1-6.
 2021 *Turbrotalia ampliapertura*; Salama et al., p. 10, fig. 6. M, p. 14, fig. 8. B.
- Remarks: This *Turbrotalia ampliapertura* Late Eocene species is characterized by its high trochospiral test with normally four globular chambers in the last whorl, with a high arched wide umbilical-extraumbilical aperture. Pearson et al. (2006) regarded this species evolved from Middle-Late Eocene *T. increbescens* (Bandy). It was recorded in the Atlantic Ocean, the Northern Tethys (Italy, Caucasus) and the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian Ocean, New Zealand and Pacific Ocean).
- Turbrotalia cerroazulensis* (Cole, 1928)**
 (Pl. 2, fig. 18)
 1928 *Globigerina cerro-azulensis* Cole, p. 217, pl. 32, figs. 11-13.
 1970 *Globigerina cerro-azulensis*; Samanta, p. 36, pl. 6, figs. 24,25.
 1970 *Globorotalia c. cerroazulensis*; Toumarkine and Bolli, p. 144, pl. 1, figs. 19-24.
 1979 *Globorotalia (Turbrotalia) cerroazulensis*; Blow, p. 1054, pl. 242, figs. 1-7.
 1985 *Globorotalia c. cerroazulensis*; Toumarkine and Luterbacher, p. 137, figs. 34.3-4.
 1985 *Globorotalia cerroazulensis*; Keller, p. 886, fig. 9-11.
 1992 *Globorotalia c. cerroazulensis*; Anan et al., p. 236, fig. 9.6.
 1992 *Turbrotalia c. cerroazulensis*; Haggag, p. 106, pl. 2,

fig. 12.

- 1995 *Turbrotalia c. cerroazulensis*; Anan, p. 8, pl. 1, fig. 7.
 2000 *Turbrotalia c. cerroazulensis*; Sztrákos, p. 142.
 2006 *Turbrotalia cerroazulensis*; Pearson et al., p. 442, pl. 15.3, figs. 1-20.
 2006 *Turbrotalia cerroazulensis*; Hernitz Kučenjak et al., p. 32, pl. 2, figs. 4,5.
 2008 *Turbrotalia cerroazulensis*; Wade and Pearson, p. 249, fig. 5.
 2015 *Turbrotalia cerroazulensis*; Molina, p. 172, fig. 5.
 2013 *Turbrotalia cerroazulensis*; Strougo et al., p. 128, fig. 12. D.
 2015 *Turbrotalia cerroazulensis*; Pearson and Wade, p. 24, fig. 28. 1-4.
 2020 *Turbrotalia cerroazulensis*; Anan, p. 500, pl. 2, fig. 20.
 2021 *Turbrotalia cerroazulensis*; Salama et al., p. 10, fig. 6. H1, H2.

Remarks: Toumarkine and Bolli (1970) introduced a Middle-Late Eocene *Turbrotalia cerroazulensis* lineage to include a series of six subspecies, and four of them are recorded in the Late Eocene: *T. pomeroli*, *T. cerroazulensis*, *T. cocoaensis* and *T. cunialensis*, while the other two subspecies *T. frontosa* and *T. possagnoensis* normally exist at a lower stratigraphic level than Late Eocene. The Middle-Late Eocene *T. cerroazulensis* species is characterized by its moderate trochospiral test, conical shape in side view, flat spiral side, and a broad arched aperture. Pearson et al. (2006) considered this species evolved from the Middle-Late Eocene *T. pomeroli*. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus) and also the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian Ocean, New Zealand and Pacific Ocean).

***Turbrotalia cocoaensis* (Cushman, 1928)**

(Pl. 3, fig. 19)

- 1928 *Globorotalia cocoaensis* Cushman, p. 75, pl. 10, fig. 3.
 1975 *Globorotalia cerroazulensis cocoaensis*; Toumarkine and Bolli, p. 176, pl. 2, figs. 16-18.
 1985 *Globorotalia cerroazulensis cocoaensis*; Keller, p. 886, fig. 4.5-7.
 1992 *Turbrotalia cerroazulensis cocoaensis*; Anan et al., p. 236, fig. 9.7.
 1995 *Turbrotalia cerroazulensis cocoaensis*; Anan, p. 8, pl. 1, fig. 2.
 1997 *Turbrotalia cocoaensis*; Pearson and Chaisson, p. 65.
 2000 *Turbrotalia cerroazulensis cocoaensis*; Sztrákos, p. 142.
 2002 *Turbrotalia cocoaensis*; Abdelghany, p. 214, pl. 1, figs. 1, 2.
 2006 *Turbrotalia cocoaensis*; Hernitz Kučenjak et al., p. 32, pl. 2, figs. 1, 2.
 2006 *Turbrotalia cocoaensis*; Pearson et al., p. 446, pl. 15.4, figs. 1-12.
 2008 *Turbrotalia cocoaensis*; Wade and Pearson, p. 249, fig. 5.
 2015 *Turbrotalia cocoaensis*; Molina, p. 172, fig. 5, p. 173, fig. 6.3.
 2015 *Turbrotalia cocoaensis*; Pearson and Wade, p. 24, fig. 28. 5-13.

- 2021 *Turbrotalia cocoaensis*; Salama et al., p. 10, fig. 6. I1, I2.g

Remarks: This *Turbrotalia cocoaensis* Middle-Late Eocene species is characterized by its low to moderate trochospiral biconvex test with 4-5 chambers in the last whorl. It distinguished from *T. cerroazulensis* by having a distinctly acute periphery to the final chamber as seen in the side view and evolved from it. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Italy, Caucasus) and also the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian and Pacific Oceans).

***Turbrotalia* sp.**

(Pl. 3, fig. 20)

Transition specimen between *Turbrotalia cocoaensis* (Cushman) and *Turbrotalia cunialensis* (Toumarkine and Bolli), *Globigerinatheka index* Zone (E15), Late Eocene, J. Hafit, UAE.

Remarks: The Late Eocene *Turbrotalia* sp. resembles *T. cocoaensis* with acute periphery in the last final chamber but without a keel, on one hand, and resemble *T. cunialensis* in having weak raised keel in the first two chambers, on the other hand. It is recorded and illustrated, for the first time, in the current study.

***Turbrotalia cunialensis* (Toumarkine and Bolli, 1970)**

(Pl. 3, fig. 21)

- 1970 *Globorotalia cerroazulensis cunialensis* Toumarkine and Bolli, p. 144, pl. 1, figs. 37-39.
 1985 *Globorotalia cerroazulensis cunialensis*; Keller, p. 886, fig. 4.1-4.
 1988 *Turbrotalia cunialensis*; Coccioni et al., p. 75, pl. 1, figs. 7-9.
 1992 *Turbrotalia cerroazulensis cunialensis*; Anan et al., p. 236, fig. 9. 8.
 1995 *Turbrotalia cerroazulensis cunialensis*; Anan, p. 8, pl. 1, fig. 1.
 2000 *Turbrotalia cerroazulensis cunialensis*; Sztrákos, p. 142.
 2002 *Turbrotalia cunialensis*; Abdelghany, p. 214, pl. 1, figs. 3, 4.
 2006 *Turbrotalia cunialensis*; Pearson et al., p. 450, pl. 15.4, figs. 13-17.
 2015 *Turbrotalia cunialensis*; Molina, p. 173, fig. 6.
 2015 *Turbrotalia cunialensis*; Pearson and Wade, p. 25, fig. 29. 1-11.
 2021 *Turbrotalia cunialensis*; Salama et al., p. 10, fig. 6. J.

Remarks: *Turbrotalia cunialensis* Late Eocene species is characterized by its strongly compressed biconvex test with keel around periphery. It distinguished from *T. cocoaensis* by having a distinctly keel around periphery, and evolved from it. It was recorded in the Atlantic Ocean, the Northern Tethys (France, Italy) and also the Southern Tethys (Tanzania, Egypt, UAE, Oman, India and Indian Ocean).

***Turbrotalia increbescens* (Bandy, 1949)**

(Pl. 3, fig. 22)

- 1949 *Globigerina increbescens* Bandy, p. 120, pl. 23, fig. 3.
 1962 *Globorotalia (Turborotalia) increbescens*; Blow and Banner, p. 118, pl. 13, figs. T-V. 1968 *Turbrotalia increbescens*; Srinivasan, p. 146, pl. 14, figs. 5-7.

- 1970 *Globorotalia (Turborotalia) increbescens*; Samanta, p. 36, pl. 6, fig. 26, 27.
- 1985 *Globorotalia increbescens*; Keller, p. 886, fig. 3. 16.
- 1992 *Globorotalia (Turborotalia) increbescens*; Cherif et al., p. 50, pl. 3, fig. 2.
- 2000 *Turbrotalia increbescens*; Sztràkos, p. 142.
- 2006 *Turbrotalia increbescens*; Pearson et al., p. 453, pl. 15.6, figs. 1-15.
- 2006 *Turbrotalia increbescens*; Hernitz Kučenjãk et al., p. 32, pl. 2, figs. 11.
- 2015 *Turbrotalia increbescens*; Pearson and Wade, p. 25, fig. 27. 7-8.
- 2021 *Turbrotalia increbescens*; Salama et al., p. 10, fig. 6. L.

Remarks: *Turbrotalia increbescens* Middle-Late Eocene species is characterized by its highly trochospiral test including 4 globular chambers in the last whorl with a rounded periphery, a broad arched aperture in an intra-extraumbilical position. It differs from *T. cerroazulensis* by having a round periphery, fewer and fewer chambers, and more globular test shape. Pearson et al. (2006) regarded that this species is intermediate in morphology between *T. pomeroli* and *T. ampliapertura* and evolved from *T. pomeroli* in the Middle Eocene. It was recorded in the Atlantic Ocean, the Northern Tethys (Spain, France, Caucasus), and the Southern Tethys (Tanzania, Libya, Egypt, Syria, UAE, India, Indian Ocean, New Zealand and Pacific Ocean).

***Turbrotalia pomeroli* (Toumarkine and Bolli, 1970)**

(Plate 3, figure 23)

- 1970 *Globorotalia cerroazulensis pomeroli* Toumarkine and Bolli, p. 140, pl. 1, figs. 10-18.
- 1988 *Turbrotalia pomeroli*; Coccioni et al., p. 75, pl. 1, figs. 1-3.
- 1992 *Globorotalia (Turborotalia) cerroazulensis pomeroli*; Cherif et al., p. 50, pl. 3, fig. 1.
- 1992 *Turbrotalia cerroazulensis pomeroli*; Haggag, p. 106, pl. 2, fig. 12.
- 1995 *Turbrotalia cerroazulensis pomeroli*; Anan, p. 8, pl. 1, fig. 8.
- 2000 *Turbrotalia cerroazulensis pomeroli*; Sztràkos, p. 142, pl. 23, fig. 14.
- 2006 *Turbrotalia cerroazulensis pomeroli*; Pearson et al., p. 454, pl. 15.7, figs. 10-20.
- 2006 *Turbrotalia cerroazulensis pomeroli*; Hernitz Kučenjãk et al., p. 32, pl. 2, fig. 8.
- 2013 *Turbrotalia cerroazulensis pomeroli*; Strougo et al., p. 128, fig. 12. C.
- 2015 *Turbrotalia cerroazulensis pomeroli*; Molina, p. 172, fig. 5.
- 2020 *Turbrotalia pomeroli*; Anan, p. 500, pl. 2, fig. 21.
- 2021 *Turbrotalia pomeroli*; Salama et al., p. 10, fig. 6. K.

Remarks: The *Turbrotalia pomeroli* Middle-Late Eocene species is characterized by its moderate trochospiral test with 4 globular chambers increasing moderately in size, a broad arched aperture in umbilical-extraumbilical position. Pearson et al. (2006) regarded that this species evolved from *T. frontosa* in the Middle Eocene and was ancestral to *T. cerroazulensis* and *T. increbescens*. It was recorded in the Northern Tethys (Spain, France, Italy) and the Southern

Tethys (Tanzania, Libya, Egypt, Syria, UAE, India and Pacific Ocean).

***Turbrotalia pseudoampliapertura* (Blow and Banner, 1962)**

(Pl. 3, fig. 24)

- 1962 *Globigerina pseudoampliapertura* Blow and Banner, p. 95, pl. 12, figs. A-C.
- 1968 *Globigerina ampliapertura pseudoampliapertura*; Srinivasan, p. 147, pl. 17, figs. 4-6.
- 1969 *Globigerina pseudoampliapertura*; Samanta, p. 331, pl. 1, fig. 13.
- 1990 *Turbrotalia pseudoampliapertura*; Premoli Silva and Spezzaferri, p. 312, pl. 2, figs. 3,5.
- 1992 *Turbrotalia pseudoampliapertura*; Anan et al., p. 236, fig. 9.10.
- 1995 *Turbrotalia p. pseudoampliapertura*; Haggag and Luterbacher, p. 41, pl. 3, figs. 5-8.
- 1995 *Turbrotalia pseudoampliapertura*; Anan, p. 8, pl. 1, fig. 6.
- 2013 *Turbrotalia pseudoampliapertura*; Strougo et al., p. 128, fig. 12. F-G.

Remarks: *Turbrotalia pseudoampliapertura* Middle-Late Eocene species is characterized by its moderate trochospiral test with 4 globular chambers increasing moderately in size, a broader arched aperture in umbilical-extraumbilical position than *T. pomeroli*. Haggag and Luterbacher (1991) introduced in a younger part of the Middle-Late Eocene a *Turbrotalia pseudoampliapertura* lineage, which includes *T. pomeroli*, *T. nukhulensis*, *T. pseudoampliapertura*, *T. sinaiensis*. The members of *T. pseudoampliapertura* lineage flourish those of *T. cerroazulensis* lineage become rare or disappear. Haggag and Luterbacher (1995) regarded that this species evolved from their *T. nukhulensis* in the late Middle Eocene and was ancestral to their *T. sinaiensis*. Two only members of *T. pseudoampliapertura* lineage are recorded in the study section: *T. pseudoampliapertura* *T. sinaiensis*, while *T. nukhulensis* was recorded in Jabal Malaqet section, Al Ain area, UAE (Anan, 1995). *T. pseudoampliapertura* was used by Haggag (1992) as a zonal marker for her 'T. pseudoampliapertura Zone', which she considered as to be located between the *Truncorotaloides rohri* Zone (P14=E13) and *Globigerinatheka semiinvoluta* Zone (P15=E14). *T. pseudoampliapertura* was recorded, so far, in the Southern Tethys (Libya, Egypt, UAE, India, Indian Ocean and New Zealand).

***Turbrotalia sinaiensis* Haggag and Luterbacher, 1995**

(Pl. 3, fig. 25)

- 1995 *Turbrotalia pseudoampliapertura sinaiensis* Haggag and Luterbacher, p. 41, pl. 3, figs. 1-4.
- 2013 *Turbrotalia sinaiensis*; Strougo et al., p. 128, fig. 12. H.

Remarks: *Turbrotalia sinaiensis* Middle-Late Eocene species is characterized by its moderate trochospiral test with 4 globular chambers increasing moderately in size, a more broad arched aperture in umbilical-extraumbilical position than *T. pseudoampliapertura*. Haggag and Luterbacher (1995) regarded that this species evolved from *T. pseudoampliapertura* in the late Middle Eocene. *T.*

sinaiensis is recorded and illustrated, for the first time, in the study section, after its occurrence in Sinai of Egypt.

Family Chiloguembelinidae Reiss, 1963

Genus *Chiloguembelina* Loeblich and Tappan, 1956

Type species *Guembelina midwayensis* Cushman, 1940

***Chiloguembelina cubensis* (Palmer, 1934)**

1934 *Guembelina cubensis* Palmer, p. 74, figs. 1-6.

1957 *Chiloguembelina cubensis*; Beckmann, p. 89, pl. 21, fig. 21.

1968 *Chiloguembelina cubensis*; Srinivasan, p. 142, pl. 13, fig. 1.

1985 *Chiloguembelina cubensis*; Keller, p. 886, fig. 3.8.

1992 *Chiloguembelina cubensis*; Anan et al., p. 236, fig. 8.1.

1992 *Chiloguembelina cubensis*; Cherif et al., p. 46, pl. 1, fig. 32.

2006 *Chiloguembelina cubensis*; Hernitz Kučenjok et al., p. 36, pl. 4, fig. 11.

2015 *Chiloguembelina cubensis*; Molina, p. 172, fig. 5.

2015 *Chiloguembelina cubensis*; Pearson and Wade, p. 25, fig. 30. 3.

2021 *Chiloguembelina cubensis*; Salama et al., p. 10, fig. 6. B.

Remarks: The *Chiloguembelina cubensis* Middle-Late Eocene species is characterized by its biserial elongate test, surface texture distinctly costate in rows or striae aligned with the long axis of the test. It was recorded in the Northern Tethys (Spain) and the Southern Tethys (Tanzania, Egypt, Syria, UAE, India, New Zealand and Pacific Ocean).

The biozone *Gt. semiinvoluta* (E14) has yielded: *Catapsydrax dissimilis*, *C. unicavus*, *Subbotina angiporoides*, *S. corpulenta*, *S. eocaena*, *S. gortanii*, *S. jacksonensis*, *S. linaperta*, *S. utilisindex*, *S. yeguaensis*, *Globigerinatheka index*, *Gt. luterbacheri*, *Gt. semiinvoluta*, *Gt. tropicalis*, *Hantkenina alabamensis*, *H. compressa*, *Dentoglobigerina galavisi*, *D. pseudovenezuelana*, *D. tripartita*, *Turborotalia ampliapertura*, *T. cerroazulensis*, *T. cocoaensis*, *T. pomeroli*, *T. increbescens*, *T. pseudoampliapertura*, *T. sinaiensis*, *Pseudohastigerina micra*. The biozone *G. index* Zone (E15) has yielded all the previous species, except *Globigerinatheka semiinvoluta*, *G. luterbacheri*, *G. tropicalis* and *Subbotina corpulenta*, but added *Hantkenina primitiva*, *Cribohantkenina inflata* and *Chiloguembelina cubensis*. The biozone *H. alabamensis* Zone (E16) has yielded: *Catapsydrax dissimilis*, *C. unicavus*, *Pseudohastigerina micra*, *T. pseudoampliapertura*, *T. cunialensis* and *Hantkenina alabamensis*.

4. Paleogeography

Based on the paleogeographic distribution of the Late Eocene faunal content of the study section, a brief account is given: Twenty-five of thirty two identified planktic foraminiferal species have wide geographic distribution around the world (Fig. 5). Some of them have been recorded in five or more localities, i.e. *Catapsydrax dissimilis*, *C. unicavus*, *Subbotina angiporoides*, *S. corpulenta*, *S. eocaena*, *S. gortanii*, *S. linaperta*, *S. yeguaensis*, *Globigerinatheka index*, *G. semiinvoluta*, *G. tropicalis*, *Cribohantkenina inflata*, *Hantkenina alabamensis*, *H. primitiva*, *Dentoglobigerina galavisi*, *D.*

tripartita, *Turborotalia ampliapertura*, *T. cerroazulensis*, *T. cocoaensis*, *T. cunialensis*, *T. increbescens*, *T. pomeroli*, *T. pseudoampliapertura*, *Pseudohastigerina micra*, and *Chiloguembelina cubensis*. Haq and Aubry (1980) noted that North Africa and the Middle East formed important parts of the Tethyan link between the Atlantic and the Pacific Ocean during the Early Cenozoic. The paleogeographic map of Mintz (1981) shows that the ancestral Tethyan Ocean in the Paleogene time is connected with the ancestral Indian, Atlantic, and Pacific Oceans (Fig. 5). 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 Oligocene) times when a land bridge connected S.W. Asia to Arabia. Anan (1994) presented a map showing the paleogeographic distribution of some diagnostic Late Eocene planktic foraminiferal species from their original description, i.e.. *Cribohantkenina inflata* and *Turborotalia cunialensis* (Fig. 6), which are restricted in the tropical-subtropical provinces (Lat. 45° N- 30° S). Anan (1995) noted that the almost identical planktic foraminifera are barren in the cross-bedded nummulitic limestones succession, which represents the topmost Eocene rocks of both J. Hafit and J. Malaqet in Al Ain area, UAE. These rocks overlie a succession of gypsiferous calcareous marls (with limestone intercalations) with abundant planktic foraminifera, among them *Globigerinatheka index*, *Cribohantkenina inflata*, *Turborotalia cunialensis*, and *Hantkenina alabamensis*. Rögl (1999) noted that by the end of the Eocene the Tethyan Ocean had already vanished (the new Indian Ocean was born), and the western end of the Tethys was reduced to the Mediterranean Sea. The existence of marked differences between the number of recorded planktic foraminiferal species in the closest or farthest localities concerning Jabal Hafit may be due to one or more of these parameters: the differences in the paleoenvironment conditions (depth, temperature, salinity, nutrients, dissolved oxygen), scarce of detailed or documented studies, the deficiency of available works of literature, and/or due to less homogeneity in the species concept between different authors.

5. Paleoenvironment

The planktic foraminiferal Late Eocene species in the current study are rich and diversified in the marly samples of the study section of Jabal Hafit, and represent a middle-upper neritic environment. The following is a brief account of the relevant paleoenvironment and interpretation of the study area: Anan (1995) noted that in the Late Eocene in the UAE and surrounding areas had been located in the tropical and warm temperature region based on many faunal environmental elements, i.e. tubular spines in the hantkeninids and accessory apertures in the *Globigerinatheka* spp. The current study yields many Hantkeninids (*H. alabamensis*, *H. compressa*, *H. primitiva*) and *Globigerinatheka* species (*G. index*, *G. luterbacheri*, *G. semiinvoluta*), and also *Cribohantkenina inflata* with its accessory apertures and tubular spines (Plates 1, 2). These elements proved that J. Hafit had been located in the tropical and warm temperature region in the Late Eocene time. Bodiselitsch et al. (2004) noted that the Late Eocene

is a period of major changes, with a sharp temperature drop of about 2 °C near the Eocene/Oligocene boundary. Anan (2009) noted that an intraformational conglomeratic bed separates P15 and P16 (= E14 and E15) at Mazyad Member of the Dammam Formation within the Late Eocene (Fig. 3), which represents sea level lowering (about 39 Ma), which had not been presented in the Vail et al (1977), but in Keller et al. (1987) (Fig. 7). Anan (2018) noted that the presence of accessory apertures and tubulospine in the Hantkeninids planktic foraminiferal species are suggested by many authors (i.e. Coccioni 1988; Anan, 1994; Coxall and Pearson, 2006) to be restricted in the mid to low latitude, in the open ocean and shelf paleoenvironments and tropical-subtropical warm-temperate regions. Anan (2020) noted that the two intraformational conglomeratic beds in the Middle and Late Eocene of Jabal Hafit, UAE (Fig. 8), were documented by Keller et al. (1987) as (PHe and PHd, respectively), and represented a minimal reworking and accumulating in the low-energy environment in a short distance of transportation on a slight steepening paleoslope from a positive localized source area during the time of a marked fall in the eustatic sea level lowering with active tectonics.

6. Discussion and Conclusions

More than two decades have been dedicated to the Late Eocene planktic foraminiferal species content in various parts of Al Ain outcrops: Jabal Hafit, J. Malaqet (UAE), and J. Qatar (Oman). Several facts regarding the temporal and spatial distribution of the species have emerged.

- Many attempts were done on the biozonation of the Late Eocene: two zones (Bipartite) by some authors (i. e. Stainforth et al, 1975): the lower *Globigerinatheka semiinvoluta* Zone (P15) and the upper *Turborotalia cerroazulensis* Zone (P16), while it is subdivided to three zones (Tripartite) by others (i. e. Berggren and Miller, 1988): the lower *Globigerinatheka semiinvoluta* Zone (P15), the middle *Cribrohantkenina inflata* Zone (P16), and the upper *Turborotalia cerroazulensis* Zone (P17). Three planktic foraminiferal biozones (Tripartite), but with another planktic foraminiferal species, are recognized in the current study, according to the modern biozonation (after Berggren and Pearson, 2005; Pearson et al., 2006 and Wade et al., 2011), from base to top: *Globigerinatheka semiinvoluta* Zone (E14), *G. index* Zone (E15), and *Hantkenina alabamensis* Zone (E16).
- The recognized taxa have been correlated with those in Al Ain area: J. Malaqet, UAE, and J. Qatar, Oman (24 km northeast of Al Ain city) (Fig. 1), as well as other Late Eocene succession in some of the Northern and the Southern Tethys localities (i.e. the Atlantic Ocean, Spain, France, Italy, Carpathica, Caucasus, Tanzania, Libya, Egypt, Syria, India, Indian Ocean, New Zealand, Pacific Ocean, Fig. 5).
- The number of the Late Eocene planktic foraminifera species in the current study yields a higher number (32 species) than others in or outside Al Ain area, UAE: 31 species in Egypt, 26 species in

each of the Atlantic Ocean and Spain, 23 species in the Indian Ocean, 21 species in India, 20 species in Italy (Table 1). The existence of marked differences between the numbers of recorded species in different localities is most probably indicated by the differences in the paleoenvironmental conditions, land barriers, deficiency of the available literature, or misidentifying the species.

- The uncloses number of the Late Eocene faunal assemblages between J. Malaqet (18 species) and J. Qatar (8 species) and J. Hafit (32 species), in spit that all sections are located in the same basin at Al Jaw Plain (Fig. 1) may due to not detailed study for those sections by different authors.
- Some species are recorded in more than 15 localities in the world: *Subbotina linaperta*, *S. eocaena*, *Pseudohastigerina micra*, *Hantkenina alabamensis*, *Dentoglobigerina tripartita*, *Turborotalia cerroazulensis*, *T. cocoaensis*, while the lowest record is *T. sinaensis* and *T. sp.* in J. Hafit. The record of some species in a wide localities emphasizes the interpretations that were presented by different authors (e.g. Mintz, 1981; Adams et al., 1983) about the extended realms of Tethys Indo-Pacific with the Atlantic during the Late Eocene time.
- The presence of keels, accessory apertures, and tubular spines in some identified species reflect some aspect of the paleoenvironment, which suggests that the Late Eocene time in the Al Ain area, UAE had been in the subtropical-tropical belt during that period, in the open ocean and shelf paleoenvironments.
- The intraformational conglomeratic bed within the Late Eocene of Jabal Hafit, looks-like a “head-like “ rock (Fig. 9) caused by minimal reworking and accumulation in a low-energy environment associated with a short distance of transportation on a slight steepening paleoslope from a positive localized source area during that time accompanied with a marked fall in the eustatic sea level and active tectonics (Fig. 7, PHd).

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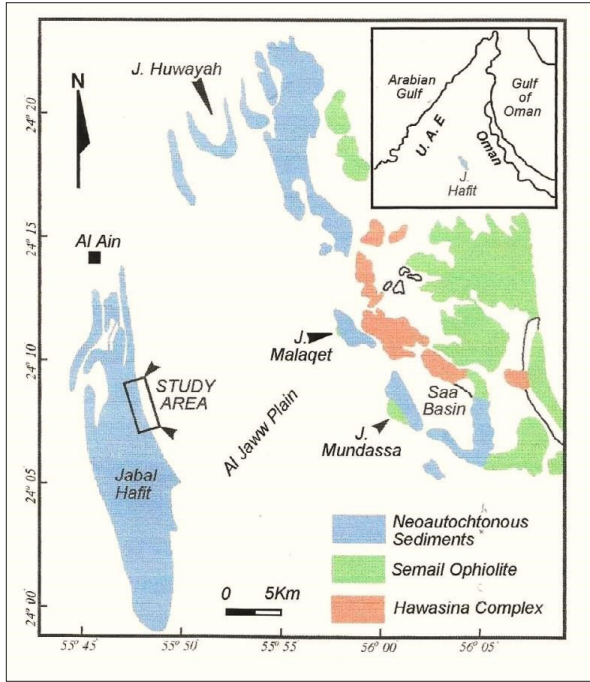


Figure 1. Location map of the study area at the eastern limb of Jabal Hafit, and also J. Malaqet and J. Mundassa, Al Ain area, UAE.

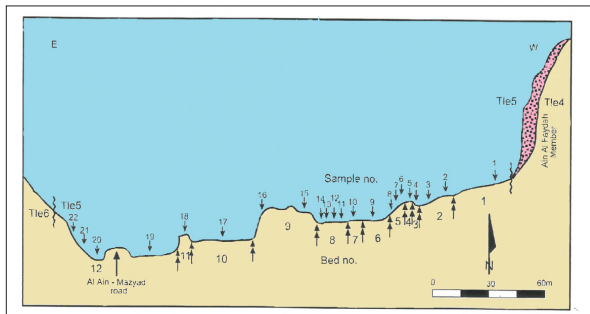


Figure 2. The schematic diagram of the upper part of T1e5 of Hunting, 1979 (= Mazyad Member of the Dammam Formation, after Hamdan and Bahr, 1992), which represents the Late Eocene succession of the studied section, sample nos. 17-22 (bed nos. 10-12), around Al Ain-Mazyad road, Al Ain area, UAE.

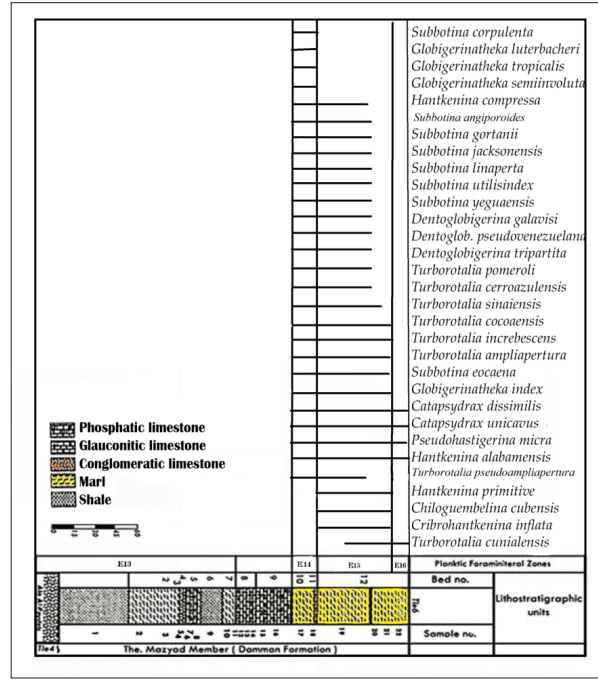


Figure 3. Stratigraphic ranges of the recorded Late Eocene planktonic foraminiferal species (E14-E16) of the upper Mazyad Member succession in the eastern limb of Jabal Hafit, Al Ain area, UAE.

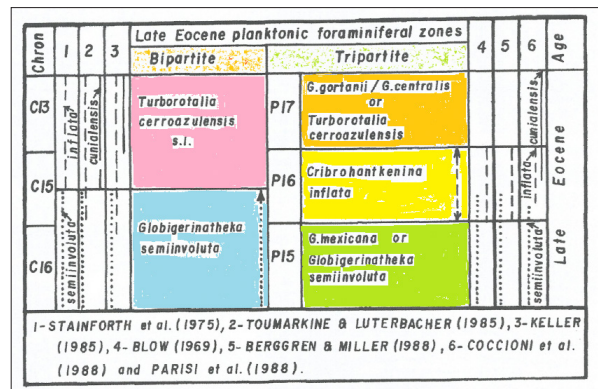


Figure 4. Stratigraphic ranges of the Late Eocene taxa: *Globigerinatheka semiinvoluta* (.... points), *Cribohantkenina inflata* (- - - dashed line), and *Turborotalia cerroazulensis cunialensis* (----- solid line) as recorded by some authors (after Anan, 1995).

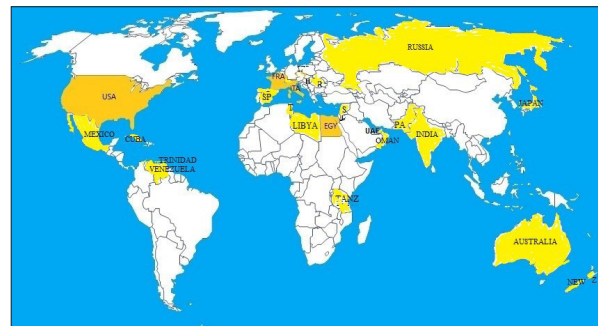


Figure 5. The geographic distribution of the identified planktic foraminiferal species in the study section (North and South America, Atlantic Ocean), Northern Tethys (Europe), Southern Tethys (North Africa, South Asia, Australia, New Zealand).

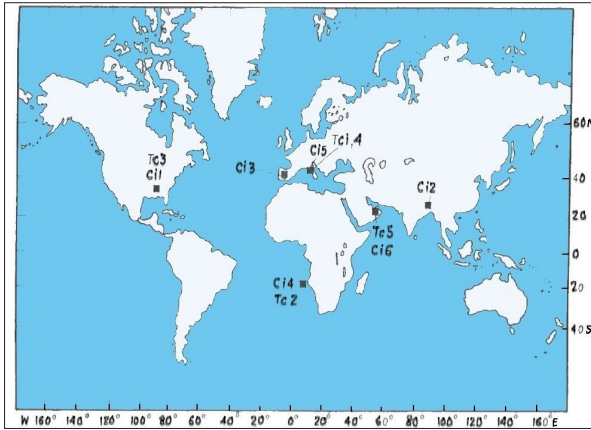


Figure 6. Geographic distribution of the occurrence of some diagnostic Late Eocene planktic foraminiferal species: *Ci*=*Cribrohantkenina inflata*, *Tc*=*Turborotalia cunialensis*. *Ci* 1: Cushman (1925), *Ci* 2: Samanta (1969), *Ci* 3: Martinez-Gallego and Molina (1975), *Ci* 4: Toumarkine (1978), *Ci* 5: Coccioni (1988), *Ci* 6 (Anan et al., 1992), *Tc* 1: Toumarkine and Bolli (1970), *Tc* 2: Toumarkine (1978), *Tc* 3: Keller (1985), *Tc* 4: Coccioni et al. (1988), *Tc* 5: Anan et al. (1992).



Figure 9. A diagnostic “head-like” rock constitutes a part of an intraformational conglomeratic limestone bed, which located between E14 and E15 in the studied section of J. Hafit, UAE (besides Al Ain-Mazyad asphalted road).

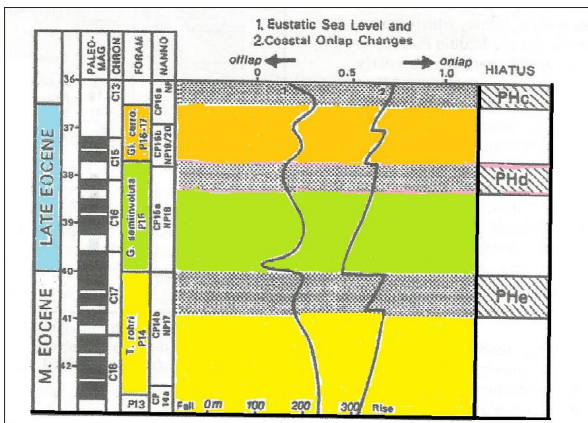


Figure 7. Global Paleogene hiatuses: PHc (the Eocene/Oligocene boundary), PHd (within the Late Eocene, between early (E14) and middle Late Eocene (E15) (after Keller et al., 1987).



Figure 8. The thick intraformational conglomeratic bed (arrows, nearly vertical) at the top part of Ain Al Faydha Member (Tle4), followed by the Mazyad Member (Tle5) of the Dammam Formation (nearly at the Middle/Late Eocene boundary) in the eastern limb of Jabal Hafit (at the ground).

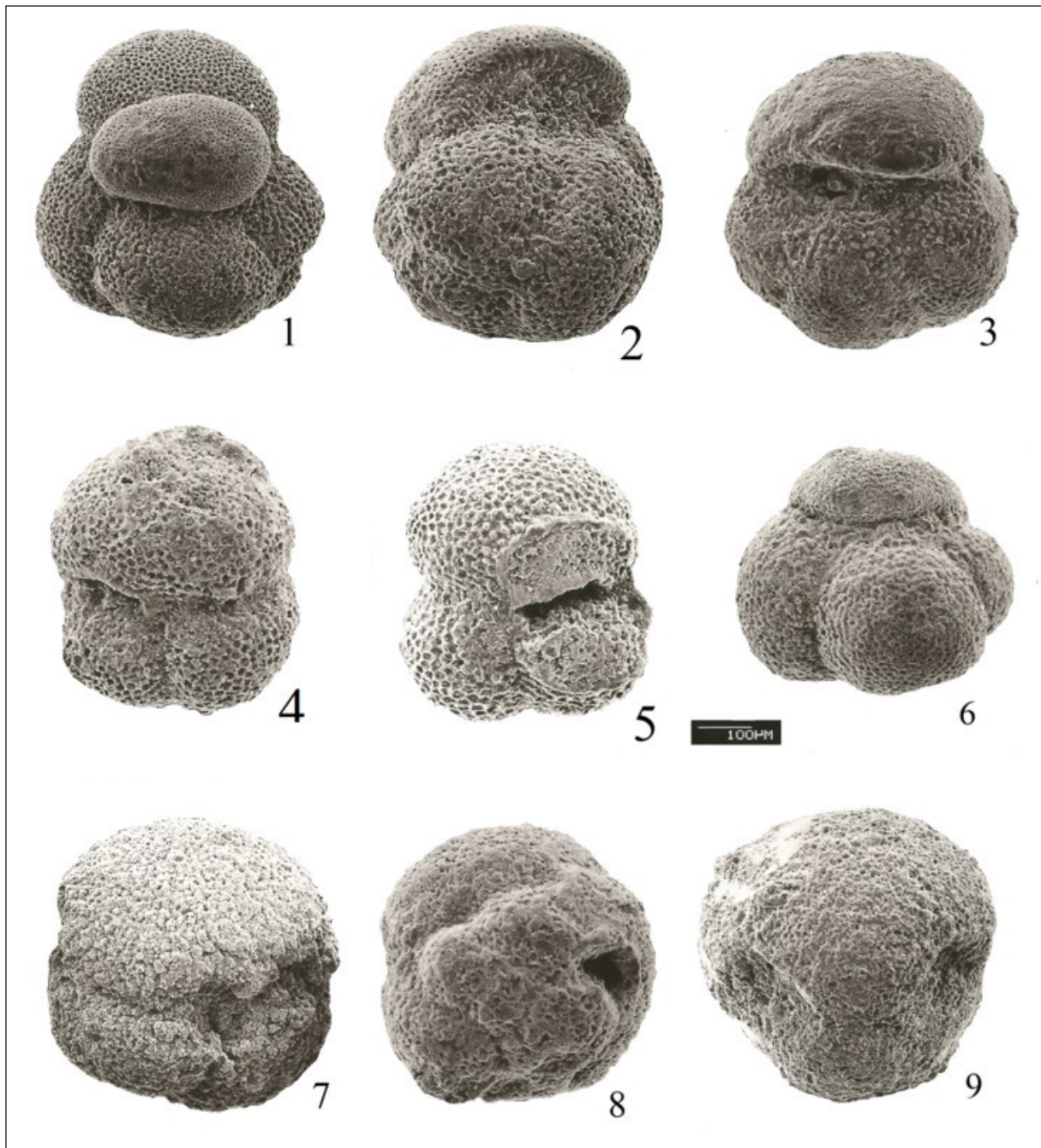


Plate 1. Fig. 1. *Catapsydrax unicavus* Bolli, Loeblich and Tappan, 1957, sample 19; 2. *Subbotina gortanii* (Borsetti, 1959), s. 19; 3. *Subbotina jacksonensis* (Bandy, 1949), s. 19; 4. *S. linaperta* (Finlay, 1939), s. 20; 5. *S. utilisindex* (Jenkins and Orr, 1973), s. 20; 6. *S. yeguaensis* (Weinzierl and Applin, 1929), s. 19; 7. *Globigerinathea index* (Finlay, 1939), s. 21; 8. *G. luterbacheri* Bolli, 1972, s. 17; 9. *G. semiinvoluta* (Keijzer, 1945), s. 17.

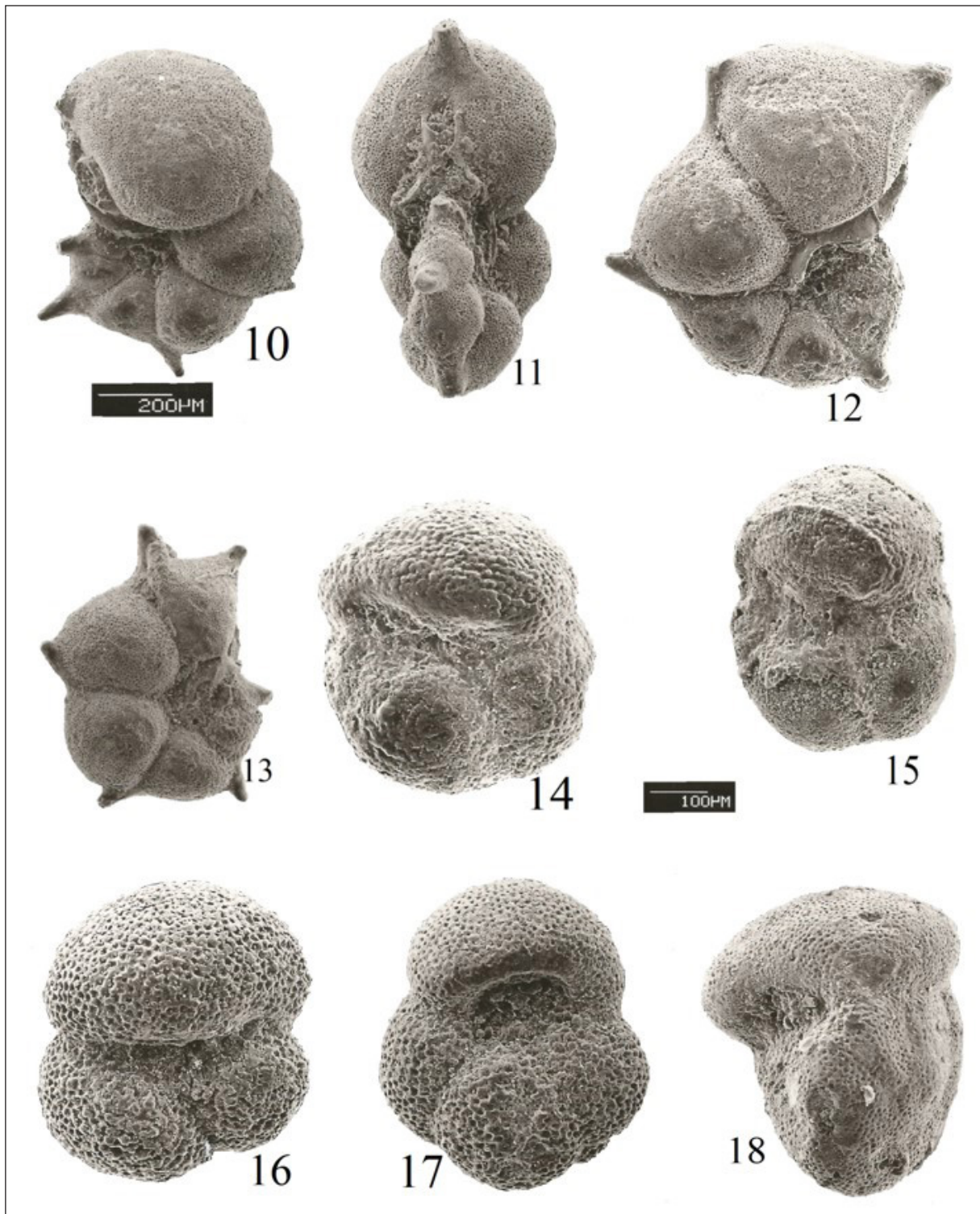


Plate 2. Fig. 10. *Cribohantkenina inflata* (Howe, 1928), s. 20; 11. *Hantkenina alabamensis* Cushman, 1924, s. 20; 12. *H. compressa* Parr, 1947, s. 19; 13. *H. primitive* Cushman and Jarvis, 1929, s. 20; 14. *Dentoglobigerina galavisi* (Bermúdez, 1961), s. 17; 15. *D. pseudovenezuelana* (Blow and Banner, 1962), s. 19; 16. *D. tripartita* (Koch, 1926), s. 20; 17. *Turbrotalia ampliapertura* (Bolli, 1957), s. 19; 18. *T. cerroazulensis* (Cole, 1928), s. s. 19.

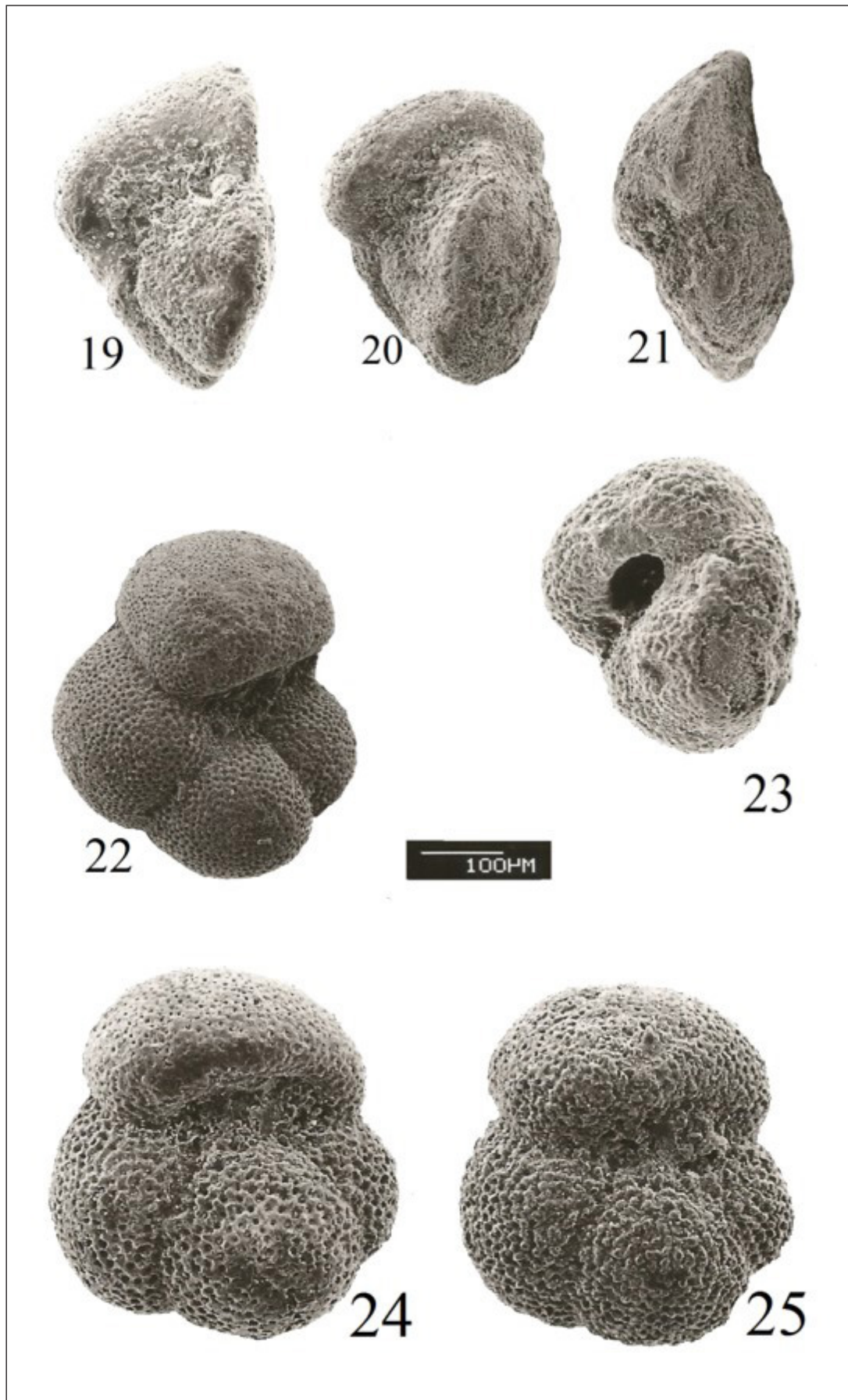


Plate 3. Fig. 19. *Turbrotalia cocoaensis* (Cushman, 1928), s. 20; 20. *T.* sp., Transitional specimen between *Turbrotalia cocoaensis* and *T. cunialensis*, s. 20; 21. *T. cunialensis* (Toumarkine and Bolli, 1970), s. 22; 22. *T. increbescens* (Bandy, 1949), s. s.19; 23. *T. pomeroli* (Toumarkine and Bolli, 1970), s. 19; 24. *T. pseudoampliapertura* (Blow and Banner, 1962), s. s.20; 25. *T. sinaiensis* Haggag and Luterbacher, 1995, s. 17.

Table 1. Paleogeographic distribution of the Late Eocene planktic foraminifera in the United Arab Emirates (UAE): Jabal Hafit: H1 (The current study), H2 (Anan et al., 1992), H3 (Cherif et al., 1992), Malaqet, M (Anan, 1995); Oman, Q=Qatar section (Abdelghany, 2002), and other Northern and Southern Tethyan localities: A= Atlantic Ocean (Cushman, 1925; Brönnimann, 1952; Stainforth et al., 1975; Keller, 1985; Pearson et al., 2006), Northern Tethys: S= Spain (Molina et al., 2006, Molina, 2015), F= France (Sztrákos, 2000), Y= Italy (Toumarkine and Bolli, 1975; Coccioni, 1988; Coccioni et al., 1988); CC= Carpathica, Caucasus (Samuel, 1972) Southern Tethys: T= Tanzania (Wade and Pearson, 2008); L= Libya (El Khoudary and Helmdach, 1981; Imam, 1999); E= Egypt (Abdel-Kireem, 1983; Haggag, 1992; Haggag and Luterbacher, 1995; Haggag and Bolli, 1996; Shahin, 1998); R= Syria (Hernitz Kučenjak et al., 2006), UAE=United Arab Emirates (H1. The current study, H2. Anan et al., 1992, H3. Cherif et al., 1992, M=Malaqet), O= Oman, Jabal Qatar (Abdelghany, 2002); P= Pakistan (Haque, 1956; Warraich et al., 2000; Warraich and Ogasawara, 2001); I= India (Samanta, 1969, 1970, Mukhopadhyay, 2005); IO= Indian Ocean (Premoli Silva and Spezzaferri, 1990), NA= New Zealand (Srinivasan, 1968, Jenkins, 1971) and Australia (Parr, 1947), PO= Pacific Ocean (Pearson et al., 2006). Θ = illustrated species, x = recorded species, - = not recorded species.

Sp. No.	Late Eocene planktic foraminiferal species		A	S	F	Y	C	T	L	E	R	UAE				O	P	I	IO	NA	PO
													H1	H2	H3	M	Q				
1	<i>Catapsydrax</i>	<i>dissimilis</i>	x	x	x	-	-	x	x	x	-	x	x	-	-	x	x	x	-	x	
2		<i>unicavus</i>	x	x	-	-	-	x	x	x	x	Θ	-	-	-	-	x	-	x	x	
3	<i>Subbotina</i>	<i>angiporoides</i>	x	x	-	x	x	-	-	x	-	x	x	-	x	-	-	x	x	-	
4		<i>corpulenta</i>	x	x	x	-	-	x	-	x	-	x	x	-	x	x	-	x	x	-	
5		<i>eocaena</i>	x	x	x	x	x	x	x	x	-	x	x	x	x	x	-	x	-	x	
6		<i>gortanii</i>	x	x	x	x	x	x	x	x	-	Θ	x	-	x	x	-	x	x	-	
7		<i>jacksonensis</i>	x	x	-	-	-	-	-	x	-	Θ	-	-	-	-	-	-	-	-	
8		<i>linaperta</i>	x	x	x	x	x	x	x	x	-	Θ	x	x	x	x	x	x	x	x	
9		<i>utilisindex</i>	-	-	x	-	-	-	-	x	-	Θ	-	-	-	-	-	x	-	x	
10		<i>yeguaensis</i>	x	x	-	-	x	x	x	x	-	Θ	x	-	x	-	x	x	x	x	
11	<i>Globigerinatheka</i>	<i>index</i>	x	x	x	x	x	x	x	x	-	Θ	-	-	x	-	-	x	x	x	
12		<i>luterbacheri</i>	x	x	-	x	-	-	-	x	-	Θ	x	-	-	-	-	x	-	x	
13		<i>semiinvoluta</i>	x	x	x	x	x	x	x	x	-	Θ	x	-	-	-	-	x	-	x	
14		<i>tropicalis</i>	x	x	x	x	x	x	x	x	-	x	x	-	-	-	-	x	x	x	
15	<i>Cribohantkenina</i>	<i>inflata</i>	x	x	-	x	x	x	-	x	x	Θ	x	x	x	-	-	x	x	-	
16	<i>Hantkenina</i>	<i>alabamensis</i>	x	x	x	x	x	x	x	x	x	Θ	x	x	x	-	-	x	x	x	
17		<i>compressa</i>	x	x	-	x	-	x	-	x	-	Θ	-	-	-	-	-	-	x	-	
18		<i>primitiva</i>	x	x	-	x	x	x	x	x	-	Θ	x	-	-	-	-	x	-	-	
19	<i>Dentoglobigerina</i>	<i>galavisi</i>	x	x	-	x	x	x	x	x	x	Θ	-	-	-	-	-	x	-	x	
20		<i>pseudovenezuelana</i>	-	x	-	-	x	x	-	x	-	Θ	x	-	-	-	-	-	-	-	
21		<i>tripartita</i>	x	x	x	x	x	x	x	x	x	Θ	x	x	x	-	-	x	x	-	
22	<i>Pseudohastigerina</i>	<i>micra</i>	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	x	x	
23	<i>Turborotalia</i>	<i>ampliapertura</i>	x	-	-	x	x	x	x	x	-	Θ	x	-	x	-	-	x	x	x	
24		<i>cerroazulensis</i>	x	x	x	x	x	x	x	x	x	Θ	x	x	x	-	-	x	x	x	
25		<i>cocoaensis</i>	x	x	x	x	x	x	x	x	x	Θ	x	x	x	x	-	x	x	-	
26		.sp	-	-	-	-	-	-	-	-	-	Θ	-	-	-	-	-	-	-	-	
27		<i>cunialensis</i>	x	-	x	x	-	x	-	x	-	Θ	x	-	x	x	-	x	x	-	
28		<i>increbescens</i>	x	x	x	-	x	x	x	x	x	Θ	-	x	-	-	-	x	x	x	
29		<i>pomeroli</i>	-	x	x	x	-	x	x	x	x	Θ	x	x	x	-	-	-	x	-	
30		<i>pseudoampliapertura</i>	-	-	-	-	-	-	x	x	-	Θ	x	-	x	-	-	x	x	-	
31		<i>sinaiensis</i>	-	-	-	-	-	-	-	x	-	Θ	-	-	-	-	-	-	-	-	
32	<i>Chiloguembelina</i>	<i>cubensis</i>	x	x	-	-	-	-	-	x	x	x	x	x	x	-	-	x	-	x	