Journal of Al Azhar University-Gaza (Natural Sciences), Vol. 24, Dec. 2022, p: 1-13

Homeomorphy in the development of some benthic foraminiferal species

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(Received 11/04/2022, Accepted 02/08/2022)

الشكل المتماثل في تطوير بعض أنواع الفورامنيفرا القاعية

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(تاريخ الاستلام 2022/04/11، تاريخ القبول 2022/08/02)

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Abstract:

Homeomorphy is the ability of an organism to simulates an unrelated organism in form and function. In biology the homeomorphy is the evolution of similar external forms from very distant ancestors, happening as a result of convergent evolution. In paleontology this phenomenon means the existence of two or more fossil taxa that appear to have similar morphology, although they are unrelated. They might occur in rather different stratigraphic levels, and the test consists of a number of chambers that arrange in numerous shapes and sizes. Many examples are known involving planktonic foraminifera, but only some cases of benthic foraminiferal homeomorphy is known in the fossil record. The present study proposes four benthic foraminiferal homeomorphy. (1) the Paleocene Bathysiphon paleocenica El-Dawy and the middle-late Eocene B. saidi (Anan), (2) the Paleocene Annulofrondicularia nakkadyi (Futyan) and the late Eocene A. sztrakosae Anan, n. sp., (3) the late Eocene Marginulina karimae (Anan) and the Pleistocene Marginulina coarctata Silvestri, (4) the middle Eocene Hemirobulina bassiounii Anan and the Oligocene-Miocene H. hantkeni (Bandy).

Key words. Cenozoic, evolution, Homeomorphy, benthic foraminifera, Neotethys

ملخص:

المتماثل هو قدرة الكائن الحي على محاكاة كائن غير ذي صلة في الشكل والوظيفة. ففي علم الأحياء: فإن التماثل هو تطور أشكال خارجية مماثلة من أسلاف بعيدة جدًا ويحدث نتيجة للتطور المتقارب. وفي علم الحفريات: تعني هذه الظاهرة وجود نوعين أو أكثر من الأصناف الأحفورية التي يبدو أنها تمتلك مورفولوجيا مماثلة، على الرغم من عدم وجود علاقة بينهما، وتحدث في مستويات طبقية مختلفة، ويتكون الاختبار من عدد من الحجرات التي يتم ترتيبها بأشكال وأحجام عديدة. من المعروف أن العديد من الأمثلة تشمل الفورامنيفرا الهائمة، ولكن فقط في بعض حالات التماثل للفورامنيفرا القاعية في السجل الأحفوري. تقترح الدراسة الحالية أربعة أشكال متجانسة من الفورامنيفرا القاعية.

الكلمات المفتاحية: حقب الحياة الحديثة، التطور، التماثل، الفورامنيفرا القاعية.

Introduction

There are Paleogene-Neogene planktonic foraminiferal species showing homeomorphy. i.e., the late Paleocene *Globanomalina pseudomenardii* (Bolli (1957) (Pl. 1, fig. 1) and the Pliocene *Globorotalia margaritae* Bolli & Bermudez (1965) (Pl. 1, fig. 2) by Hunter et al. (1988), the late Paleocene-early Eocene *Morozovella velascoensis* (Cushman (1925) (Pl. 1, fig. 3) and early-middle Eocene *Morozovella caucasica* (Glaessner (1937) (Pl. 1, fig. 4) by Stainforth et al. (1975), Toumarkine & Luterbacher (1985) and also Berggren & Pearson (2005, 2006) (Fig. 1). Another attempt was also treated by Seiglie (1982) for three soritid benthic foraminiferal genera.

In this study, four cases of benthic foraminiferal homeomorphy are presented, for the first time, from the Middle East, as the author believe. The first one belongs to agglutinated taxa. The Paleocene *Bathysiphon paleocenicus* El-Dawy (2001) and Middle-Late Eocene *B. saidi* (Anan (1994), while the second one of Lagenina taxa includes three cases. (1) the Paleocene *Annulofrondicularia nakkadyi* (Futyan (1976) and the late Eocene *A. sztrakosae* (n. sp.), (2) the late Eocene *Marginulina karimae* (Anan (2009) and the Pleistocene *M. coarctata* Silvestri (1896), (3) the middle Eocene *Hemirobulina bassiounii* Anan (1994) and the Oligocene-Miocene *H. hantkeni* (Bandy (1949) (Fig. 2). These taxa were recorded from some localities in the Tethys. USA, France, Italy, Hungary, Romania, Egypt, Jordan and UAE (Fig. 3)

Systematic Palaeontology

Some modern references have been added to complete description and modern taxonomic consideration. The generic concept of the eight identified species in this study are adapted according to the taxonomic classification of Loeblich & Tappan (1988) and presented in Plate 1.

Order Foraminiferida Eichwald, 1830

Suborder Textulariina Delage and Hérouard, 1896

Genus *Bathysiphon* Sars, 1872

Type species *Bathysiphon filiformis* Sars, 1872

***Bathysiphon paleocenicus* El Dawy, 2001**

(Pl. 1, fig. 5)

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

2012 *Bathysiphon paleocenicus* El Dawy - Anan, p. 63, pl. 1, fig. 3.

2014 *Bathysiphon paleocenicus* El Dawy - Anan, p. 66, pl. 1, figs. 1, 2.

2015 *Bathysiphon paleocenicus* El Dawy - Anan, p. 241, fig. 4. 2.

Remarks. This species was originally described from the Late Paleocene (Thanetian) of El Sheikh-Fadl area, Eastern Desert of central Egypt. It was also recorded in the Early Paleocene (Danian) of Jabal Mundassa, Al Ain area, United Arab Emirates (UAE).

***Bathysiphon saidi* (Anan, 1994)**

(Pl. 1, fig. 6)

1994 *Rhabdammina saidi* Anan, p. 218, fi g. 8. 1.

1997 *Rhabdammina* sp. Birkenmajer & Jednorowska, p. 159, fig. 4 (1, 2).

2005 *Bathysiphon saidi* (Anan) - Anan, p. 19, pl. 1, fi g. 2.

2007 *Bathysiphon saidi* (Anan) - Ozsvárt, p. 29, pl. 1, figs 2, 3.

2011 *Bathysiphon saidi* (Anan) - Anan, p. 51, pl. 1, fig. 1.

2016 *Bathysiphon saidi* (Anan) - Anan, p. 355, fig. 3b.

2020 *Bathysiphon saidi* (Anan) - Anan, p. 71, pl. 1, fig. 1.

Remarks. The wide stratigraphic range of the Triassic-Holocene genus *Bathysiphon* differs from the Holocene *Rhabdammina* Sars by its straight unbranched elongated tube. *Bathysiphon saidi* has an elongated test and wall constructed of firmly cemented coarse sand grains with a rough exterior. It was originally described from the Bartonian-Priabonian of Fayoum and Sinai (Egypt), and later from the same stratigraphic horizon of Jabal Hafit (UAE), Hungary and Greenland.

Suborder Lagenina Delage and Hérouard, 1896

Genus *Annulofrondicularia* Keijzer, 1945

Type species *Frondicularia annularis* d'Orbigny, 1846

***Annulofrondicularia nakkadyi* (Futyan, 1976)**

(Pl. 1, fig. 7)

1976 *Frondicularia nakkadyi* Futyan, p. 528, pl. 82, fig.1.

1985 *Frondicularia nakkadyi* Futyan - Luger, p. 80, pl.4, fig. 3.

2002 *Frondicularia nakkadyi* Futyan - Anan, p. 633, fig. 2.4.

2012 *Frondicularia nakkadyi* Futyan - Youssef & Taha, p. 59 pl. 3, fig.10.

2019 *Frondicularia nakkadyi* Futyan - Anan, p. 260, pl. 1, fig. 10.

Remarks. This Late Paleocene species has large proloculus surrounded by 7 uniserial chevron-shaped chambers, and the first one of them completely surrounding the proloculus, smooth surface with terminal protruding aperture on a slight neck. It is referred to the genus *Annulofrondicularia* due to its globular proloculus, followed by low and completely encircling uniserial chambers, not completely surrounding the base but strongly overlapping at the margin. *A. nakkadyi* was recorded from Jordan and Egypt (Fig. 2).

***Annulofrondicularia sztrakosae* Anan, n. sp.**

(Pl. 1, fig. 8)

2000 *Annulofrondicularia* sp. Sztràkos, p. 160, pl. 4, fig. 1.

Holotype. Pl. 1, fig. 8.

Dimension. Holotype, length 15 mm, width 13 mm.

Age. Late Eocene.

Etymology. After the French micropaleontologist Károly Sztrákos.

Depository. The private collection of Károly Sztrákos, Saint-Lon, DB 511.

Diagnosis. This species has palmate to subtriangular smooth test, 7 chevron-shaped broad overlapping uniserial chambers completely encircling the large globular proloculus, aperture terminal on a slight neck.

Remarks. This French species has large proloculus followed by 7 uniserial chevron-shaped chambers, not completely surrounding the base but strongly overlapping at the margin, with terminal protruding aperture on a slight neck. *Annulofrondicularia sztrakosae* Anan differs from *A. nakkadyi* by its larger length/width (1/¾) in the former than (1/1) in the latter,

larger inflated smooth proloculus than two or three longitudinal ribs on it, and younger stratigraphic level. It was recorded, so far, from the Late Eocene of Adour Basin, Aquitaine of France.

Genus *Marginulina* d'Orbigny, 1826

Type species *Marginulina raphanus* d'Orbigny, 1826

***Marginulina karimae* (Anan, 2009)**

(Pl. 1, fig. 9)

2009 *Marginulinopsis karimae* Anan, p. 6, pl. 1, fig. 8.

2019 *Marginulinopsis karimae* Anan - Anan, p. 260, pl. 1, fig. 17.

Remarks. The late Eocene *M. karimae* is characterized by its slightly coiled initial stage (not completely enrolled as in *Marginulinopsis*), later part uniserial with inflated chambers, surface with 20-22 longitudinal costae, extended over the sutures, straight and depressed sutures in the uniserial part but indistinct in the initial part, aperture terminal on a short and wide neck. It was recorded, so far, from UAE.

***Marginulina coarctata* Silvestri, 1896**

(Pl. 1, fig. 10)

1896 *Marginulina costata coarctata* Silvestri, p. 202.

1898 *Marginulina costata coarctata* Silvestri - Silvestri, pl. 1, fig. 10.

1974 *Marginulina* cf. *costata coarctata* Silvestri - LeRoy & Levinson, p. 8, pl. 3, figs. 15, 16.

Remarks. The Pleistocene figured specimen *Marginulina coarctata* has slightly coiled initial stage, uniserial later part with inflated chambers, surface with numerous longitudinal costae, straight and depressed sutures in the uniserial part but indistinct in the initial part, aperture terminal on a short wide neck. *M. coarctata* differs from M. costata in its depressed and slightly inclined, not horizontal sutures, more numbered longitudinal costae (more than 20). *M. karimae* differs from *M. coarctata* by its almost horizontal and depressed sutures, and older stratigraphic horizon. It was recorded from Italy and USA.

Genus *Hemirobulina* Stache, 1864

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

***Hemirobulina bassiounii* Anan, 1994**

(Pl. 1, fig. 11)

1994 *Hemirobulina bassiounii* Anan, p. 6, pl. 1, fig. 8.

2017 *Hemirobulina bassiounii* Anan - Hewaidy et al., p. 85, pl. 3, fig. 30.

2019 *Hemirobulina bassiounii* Anan - Anan, p. 260, pl. 1, fig. 17.

Remarks. It is characterized by four to six chambers added in the initial stage the base, later becoming rectilinear, the last chamber is globular and large, makes about 2/3 of the smooth test, the aperture is radiate on a neck at the pointed end of the apertural face. It was originally described from the middle Eocene of Fayoum region, Egypt, and later from UAE (Anan, 2009) as first record outside Egypt.

***Hemirobulina hantkeni* (Bandy, 1949)**

(Pl. 1, fig. 12)

1875 *Marginulina subbullata* Hantken, p. 46, pl. 4, figs. 9-10; pl. 5, fig. 9.

1949 *Marginulina hantkeni* Bandy, p. 46, pl. 6, fig. 9.

1965 *Marginulina hantkeni* Bandy - Souaya, p. 328, pl. 1, fig. 9.

2007 *Marginulina hantkeni* Bandy - Ozsvárt, p. 54, pl. 5, fig. 20.

2000 *Hemirobulina hantkeni* (Bandy) - Sztrákos, p. 161.

2015 *Hemirobulina hantkeni* (Bandy) - Rupp & Ćorić, p. 51.

2015 *Hemirobulina hantkeni* (Bandy) - Székely & Filipescu, p. 44, fig. 9.11.

Remarks. Test squattish, planispiral in earlier chambers, becoming uniserial in thew final stage, when the last two or three chambers are added; oval in outline, circular in cross-section; chambers increasing gradually in size, final chambers strongly inflated; wall calcareous, smooth, finely perforated; sutures distinct, strongly depressed; aperture terminal, radiate on short neck. It was recorded from USA, France, Austria, Hungary, Romania, and Egypt.

Paleogeographic distribution

In the Paleogene the Neotethys was connected with the Atlantic and Indian Oceans via Mediterranean Sea as noted by some authors (i. e. Haq & Aubry, 1980; Mintz, 1981; Anan, 1995; Rögl, 1999; Rosenbaum et al., 2002). *Bathysiphon paleocenicus* El-Dawy (2001) expands its paleogeographic distribution from Egypt to the UAE in the Southern Tethys. *Bathysiphon saidi* (Anan, 1994) is recorded from Egypt, UAE (Southern Tethys) and Hungary and Greenland (Northern Tethys). *Annulofrondicularia nakkadyi* (Futyan, 1976) is recorded from Jordan and Egypt (Southern Tethys). *Annulofrondicularia sztrákosi* Anan (n. sp.) is recorded, so far, from France. *Marginulina karimae* (Anan, 2009) was recorded, so far, from Egypt. *Marginulina coarctata* Silvestri (1896) was recorded from Italy and USA. *Hemirobulina bassiounii* Anan (1994) was recorded from Egypt and UAE (Southern Tethys). *Hemirobulina hantkeni* (Bandy, 1949) is recorded in USA, France, Austria, Hungary, Romania and Egypt (Northern and Southern Tethys).

Paleoenvironments

Murray (1973) noted that arenaceous foraminifera tend to increase in cooler environment. Birkenmajer & Jednorowska (1997) noted that the strong tests of agglutinated foraminifera that built in the Polar region occur in shallow-water environments. Hewaidy45 noted that complex-walled agglutinated foraminiferal assemblage of coarse sand grains including the species of the genera Trochammi*na* and *Bathysiphon* is interpreted as of deeper littoral environment. El-Dawy (2001) noted that Late Paleocene assemblage from Egypt including his species *Bathysiphon paleocenicus* shows an inner to littoral environment and accompanied by the lowest oxygen content. Anan[26] noted that the Paleogene Tethyan foraminiferal assemblage from USA in the west to Pakistan in the east indicate an open connections of the Tethys which represents middle-outer neritic environment (100-200 m depth) and shows an affinity with Midway-Type Fauna "MTF" of Berggren & Aubert (1975).

Summary and Conclusions

The analysis of the tests of eight early Paleogene benthic foraminiferal species in some Tethyan localities in USA and other European countries (France, Italy, Hungary, Romania, Greenland), as well as some Middle East countries (Egypt, Jordan, UAE,

Iran) led to recognition of four benthic foraminiferal homeomorphy. (1) Paleocene *Bathysiphon paleocenicus* El-Dawy (2001) and Middle-Late Eocene *B. saidi* (Anan, 1994), (2) Paleocene *Annulofrondicularia nakkadyi* (Futyan, 1976) and *A. sztrakosae* Anan (n. sp.), (3) Late Eocene *Marginulina karimae* (Anan, 2009) and Miocene *M. coarctata* Silvestri (1896), (4) Middle Eocene *Hemirobulina bassiounii* Anan (1994) and Oligocene-Miocene *H. hantkeni* (Bandy, 1949).

Acknowledgements

My sincere thanks go to the Editor of the Deanship of Scientific Research of Al-Azhar University-Gaza for his comments, and for my daughter Dr. Huda Anan for her help in the development of the figures and plate.

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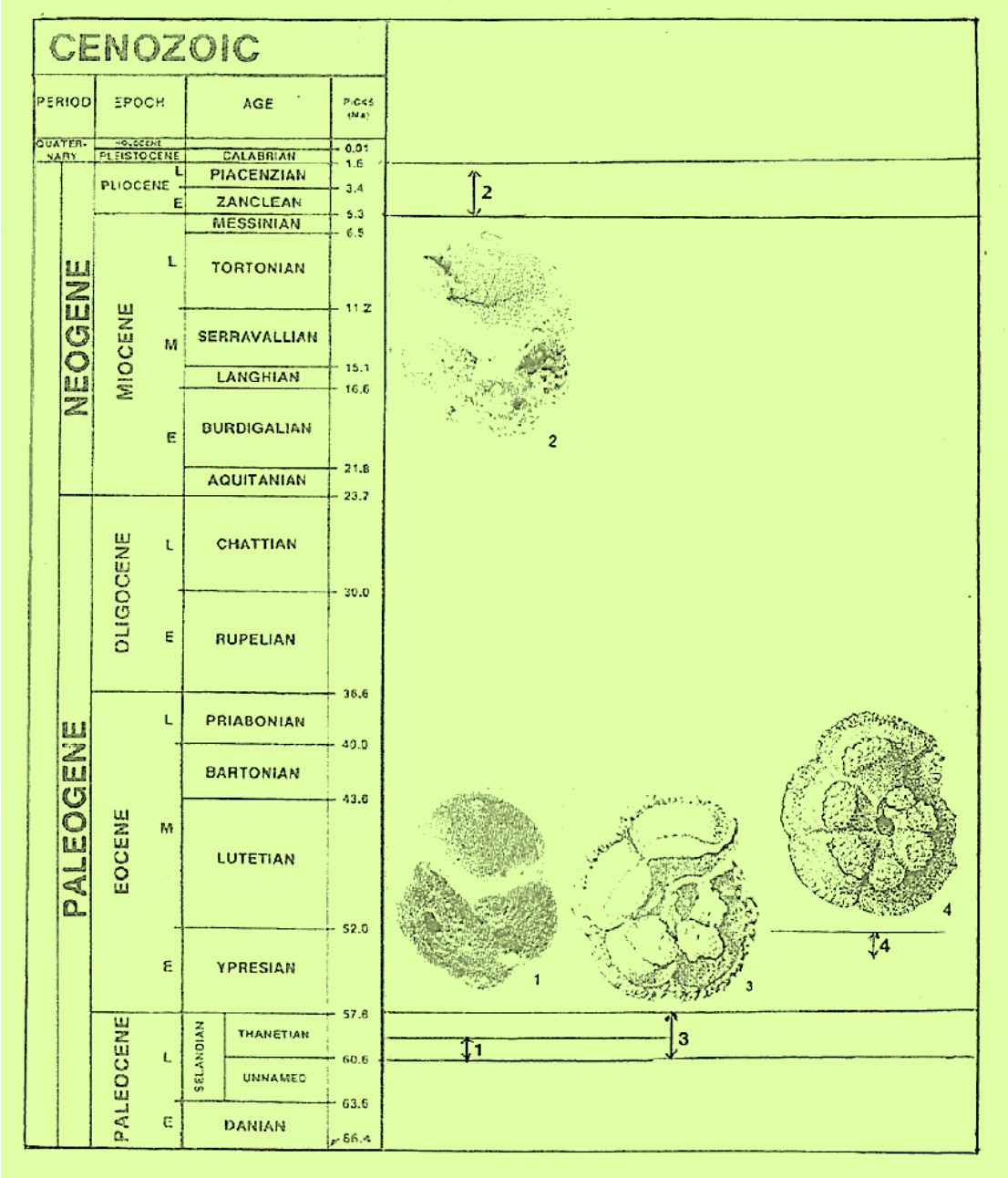


Figure 1. The stratigraphic range of four planktic foraminiferal species. the Late Paleocene *Globanomalina pseudomenardii* (Bolli, 1957), the Pliocene *Globorotalia margaritae* Bolli & Bermudez (1965), the Late Paleocene-Early Eocene *Morozovella velascoensis* (Cushman, 1925) and Early-Middle Eocene *Morozovella caucasica* (Glaessner, 1937) by Stainforth et al. (1975).

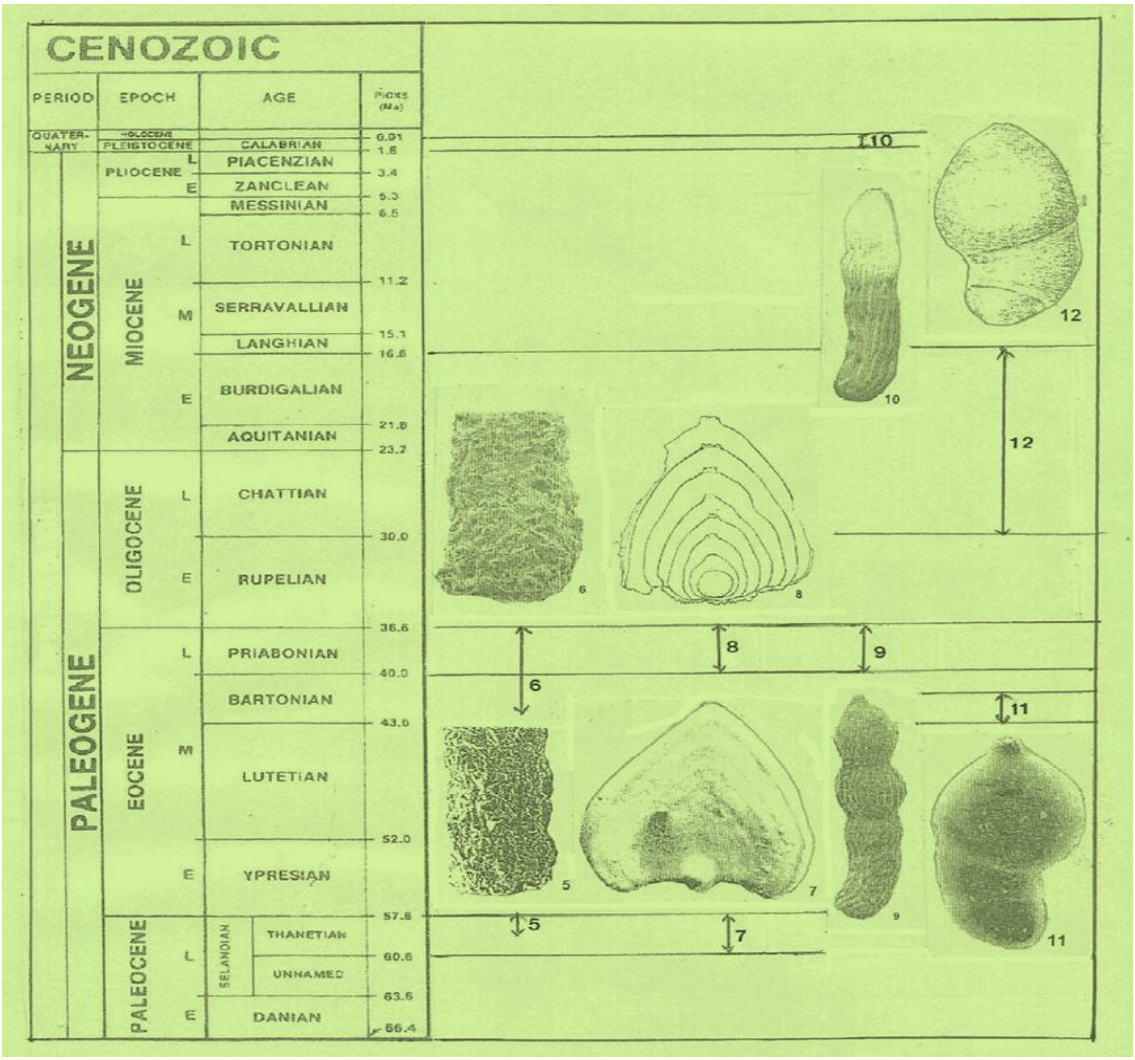
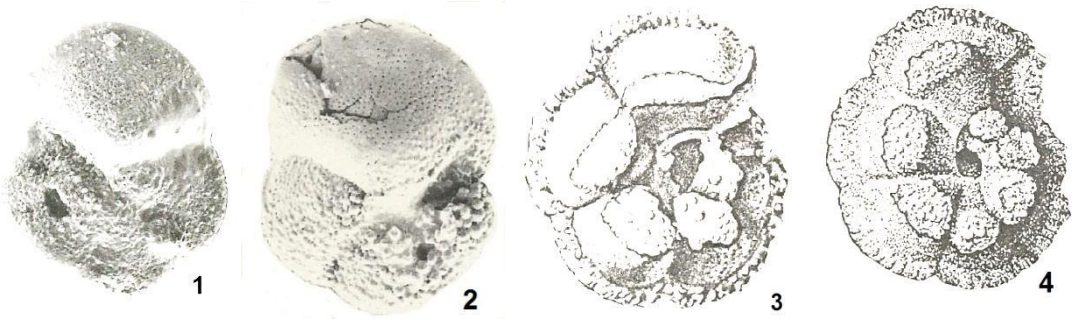


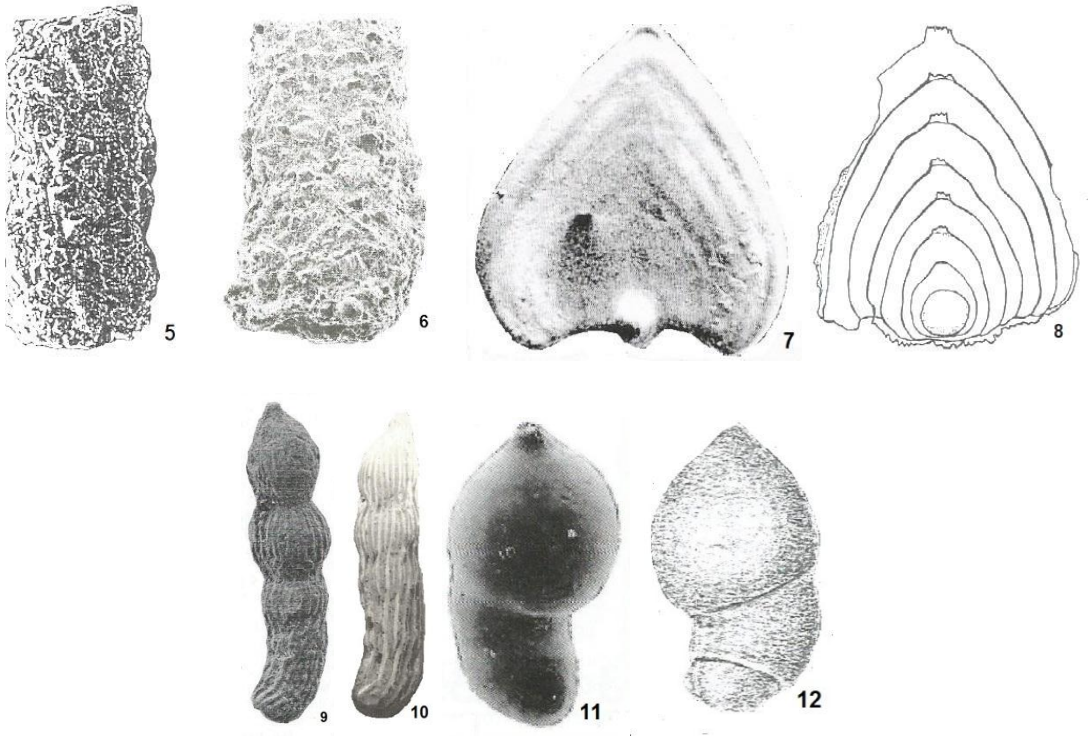
Figure 2. The stratigraphic range of eight benthic foraminiferal species. The Paleocene *Bathysiphon paleocenicus* El-Dawy (2001), the Middle-Late Eocene *B. saidi* (Anan, 1994), the Paleocene *Annulofrondicularia nakkadyi* (Futyan, 1976), the Late Eocene *A. sztrakosae* (n. sp.), the Late Eocene *Marginulina karimae* (Anan, 2009), the Pleistocene *M. coarctata* Silvestri (1896), the Middle Eocene *Hemirobulina bassiounii* Anan (1994), and the Oligocene-Miocene *H. hantkeni* (Bandy, 1949).

Figure 3. The early Paleogene paleogeographic map showing some Tethyan localities. USA in the west Atlantic, and also some Mediterranean counties in the Northern Tethys (France, Italy) and Southern Tethys (Egypt, Jordan, UAE).

Plate 1

Fig. **1**. Late Paleocene *Globanomalina pseudomenardii* (Bolli, 1957) x 115 (after Hunter et al., 1988), **2**. Pliocene *Globorotalia margaritae* Bolli & Bermudez, 1965 x 75 (after Hunter et al., 1988), **3**. late Paleocene-early Eocene *Morozovella velascoensis* (Cushman, 1925) x 60 (after Stainforth et al., 1975), **4**. early-middle Eocene *Morozovella caucasica* (Glaessner, 1937) x 55 (after Stainforth et al., 1975), **5**. Paleocene *Bathysiphon paleocenica* El Dawy, 2001 x 35, **6.** middle-late Eocene *Bathysiphon saidi* (Anan, 1994) x 30, **7**. Paleocene *Annulofrondicularia nakkadyi* (Futyan. 1976) x 20, **8**. late Eocene *A. sztrakosae* Anan, n. sp. x 15, **9**. late Eocene *Marginulina karimae* (Anan, 2009) x 20, **10**. Pleistocene *Marginulina coarctata* Silvestri, 1896 x 20, **11**. middle Eocene *Hemirobulina bassiounii* Anan, 1994 x 20, **12**. Oligocene-Miocene *Hemirobulina hantkeni* (Bandy, 1949).

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