LATE PALEOCENE-EARLY EOCENE BENTHIC FORAMINIFERA FROM THE ESNA SHALE OF DUWI SECTION, RED SEA COAST OF EGYPT

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ABSTRACT: *Issawi et al. (1999) distinguished detailed seven facies that characterized the upper Cretaceous-Paleogene sedimentary rocks of Egypt, from north to south: Sinai Facies (SF), Ataqa Facies (AF), North Western Desert Facies (NWDF), Southern Galala Facies (SGF), Farafra Bahariya Facies (FBF), Nile Valley Facies (NVF), Nuba Abu Ballas Facies (NABF), which suggest gradual paleogeographical changes from transitional open marine environmental facies in the northern Egypt to shallow shelf setting in the south due to paleorelief (highs and lows of the Syrian Arc System, Laramid Orogeny) in the upper Cretaceous. Each type facies has certain formations, which differ from the adjacent one, though some formations may cross the boundaries between two contiguous facies. According to these authors the contact between the deep (in the north) and shallow marine facies (in the south) nearly coincides around Lat. 28º N (but about Lat. 27º N of Anan, 1987). The studied Duwi section, Red Sea coast of Egypt, represents the Nile Valley Facies. The Tethyan aspect, Midway-Type Fauna (MTF) of middle-outer neritic environment (100-200 m) is interpreted for the Esna Shale of this section. This study deals with the paleontology and stratigraphy of sixty nine diagnostic benthic foraminiferal species were recorded from the upper Paleocene-early Eocene transition of the study section, and thirty seven species of them are illustrated. Its paleobiogeography distribution in different localities in the Northern and Southern Tethys is detected.*

KEYWORDS: Paleogene, foraminifera, Esna Shale, Duwi section, Egypt, Tethys.

INTRODUCTION

Alegret et al. (2005) noted that the Global Stratotype Section and Point (GSSP) for the PE boundary in Egypt was defind at Dababiya Quarry, south of Luxor (Figure 1), at the base of the Carbon Isotope Extersion (CIE) which coincides with the major turnover in foraminiferal assemblages, and benthic foraminifera from Dababiya indicate an outer shelf depth of deposition during the Paleocene and early Eocene. This section with Duwi section are represented the Nile Valley Facies (Figure 2). The Esna Shale in Duwi section extends from the top of the Tarawan Chalk to the base of the limestone of the Thebes Formation includes the Paleocene/Eocene (PE) succession (Figure 3).

Egger et al. (2006) noted that the calcareous benthic foraminiferal assemblages there was no major extinction of agglutinated taxa acros the PE boundary, while Alegret and Ortiz (2007) noted that at the Benthic foraminiferal extention event (BFEE) the species richness and diversity decreased and the relative abundance of non-calcareous agglutinated foraminifera increase dramatically which may be causs, among other, of the foraminiferal turnover. Ouda et al. (2013) noted that the PE boundary in Egypt lies at the lowest part of the Esna shale, but here it lies about the middle part of the study Duwi section, Red Sea coast of Egypt.

The stratigraphy and paleontologic studies on Gabal Duwi, Red Sea coast of Egypt of many authors: Nakkady (1950, 1955, 1957); Krasheninikov and Abdel Razek (1969); Speijer (1994), Schmitz et al. (1996); Anan (1998, 2001, 2002, 2004, 2006, 2007, 2008, 2009, 2010, 2011, 2012a,b, 2015b, 2017); Speijer et al. (2000). These studies are relevant to the present study.

This study aims at throwing light on sixty nine diagnostic early Paleogene benthic foraminiferal species from Gabal Duwi section, Egypt and some other localities in the Northern and Southern Tethys: North America (USA, Mexico), Caribbean Sea (Trinidad, Barbados, Puerto Rico), Europe (North Atlantic, Spain, France, Germany, Italy, Poland, Hungaria, Romania, Czech, Slovakia), Asia (Jordan, Iraq, Saudi Arabia, Qatar, UAE, Iran, Pakistan, India), Africa (Tunisia, Libya, Egypt, Mali, Nigeria). Figure (4) shows the extension of the Paleogeography distribution of the Northern and the Southern Tethys, which also detected the location of the Duwi section of Egypt in the Southern Tethys. An additional new informations about the paleontologic, stratigraphic and paleogeographic distribuion and paleoenvironmente of the recorded species are also presented.

MATERIAL OF STUDY

Fifteen samples of upper Paleocene-lower Eocene succession of Esna Shale (about 80 meter) of Duwi section, Red Sea coast of Egypt were collected and paleontologically studied (Figure 3). Fifty grams of rock sample of each one were dried at 80ºC and weighed. Most shale, marl and calcarenite samples (do as a ledges) are disintegrated readily and washed carefully over a 63 µm screen until the clay fractions washed completely, then dried, sieved over 125, 250 and 500 µm and picked.

TAXONOMY

Sixty nine benthic foraminiferal species from the upper Paleocene-lower Eocene Esna Shale succession in Duwi section, Qusseir area, Red Sea coast are identified and thirty seven species of them are illustrated in one Plate (Plate 1). The classification of Loeblich and Tappan (1987)

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is followed in this study. A brief remarks will be added to the species. The reference of the identified type species is given. Some modern references have been added to complete descriptions and synonymies.

Order Foraminiferida Eichwald, 1830

Suborder Textulariina Delage and Hérouard, 1896

Bathysiphon arenaceous Cushman, 1927, p. 129, pl. 1, fig. 2 (Pl. 1, fig. 1)

This species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Shahin, 1990; Hewaidy and Strougo, 2001). It is rare to common in the late Paleocene-early Eocene of the Esna Shale of Duwi section (Fig. ?), and also recorded from the Paleocene of the United Arab Emirates (UAE) by Anan (1993a).

Spiroplectinella esnaensis (LeRoy, 1953), p. 50, pl. 1, figs. 11, 12.

This species was recorded by many authors in Egypt (i. e.: Shahin, 1990; Speijer, 1994; Hewaidy and Strougo, 2001). It is common to abundant in the Late Paleocene-Early Eocene of the Esna Shale of Duwi section, and also recorded from the Paleocene of Tunisia (Aubert and Berggren, 1976), France (Sztrákos, 2005) and Iran (VahdatiRad et al., 2016).

Vulvulina colei Cushman, 1932, p. 84, pl. 10, figs. 21, 22 (Pl. 1, fig. 2)

This Paleocene-Eocene species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Said and Kenawy, 1956; Hewaidy and Strougo, 2001). It is rare to common in the study section.

Plectina chapmani (Franke, 1928), p. 146, pl. 13, fig. 12 (Pl. 1, fig. 3)

This species was recorded by LeRoy (1953). It is rare in the early Eocene of the study section.

Gaudryina ameeri Anan, 2012, p. 63, pl. 1, fig. 7 (Pl. 1, fig. 6)

This species was recorded, so far, in Egypt. It is an index marker species for the PE boundary. Anan (2012a) proposed that this species was descendent from *G. pyramidata* Cushman (1926).

Gaudryina inflata Israelisky, 1951, p. 16, pl. 6, figs. 1, 2 (Pl. 1, fig. 7)

This species is common to abundant in the late Paleocene of the study section. It is close to *G. africana* LeRoy, but differs in the shorter triserial part of the test. It was also recorded from the Paleocene of Tunisia (Aubert and Berggren, 1976).

Gaudryina pyramidata Cushman, 1926

This Maastrichtian-early Eocene cosmopolitan species was originally recorded from the Maastrichtian Velasco Shale in Mexico, Trinidad, Atlantic Ocean and California (USA), and later on in the Paleocene-early Eocene strata in many parts in the Tethys: Spain, France, Italy, Tunisia, Egypt, Qatar, Iran, Pakistan. The author believes that, one edge of *G. pyramidata* grow to produce a carinate rib, which exists along the pre-final chamber of the biserial stage and extends on the whole triserial portion in *G. ameeri*, while it starts in another edge from the final chamber of the biserial stage and extends along the triserial stage in *G. speijeri* Anan (2012b) .

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Gaudryina soldadoensis Cushman and Renz, 1942, p. 4, pl. 1, fig. 2.

This early Eocene species is common to abundant in the study section. It was recorded from Sinai (Said and Kenawy, 1956), but Paleocene in Luxor (Anan and Hewaidy, 1986) and in Kharga Oasis (Anan and Sharabi, 1988).

Siphogaudryina africana (LeRoy, 1953), p. 30, pl. 1, figs. 7, 8 (Pl. 1, fig. 4)

This species was recorded by many authors in the early Eocene of Egypt (i. e.: LeRoy, 1953; Hewaidy and Strougo, 2001; Anan, 2009; but Paleocene by Speijer et al., 2000). It was recorded in Egypt and, so far, Italy (Proto Decima and de Biase, 1975). It is an index marker species for the PE boundary in Egypt. Anan (2009) proposed that it is developed from the Paleocene *S. nekhlensis* (Said and Kenawy, 1956).

Verneuilina aegyptiaca Said and Kenawy, 1956, p. 122, pl. 1, fig. 16.

This Maastrichtian-Paleocene species was recorded in Egypt and UAE (Anan, 1993b). It is common in the study section.

Verneuilina karreri Said and Kenawy, 1956

This species was recorded from the Maastrichtian-Paleocene of Sinai, and later from Qatar. It is recorded here in the early Eocene of Duwi section.

Verneuilina luxorensis Nakkady, 1950, p. 683, pl. 89, figs. 6, 7 (Pl. 1, fig. 5)

This early Eocene species was recorded, so far, in Egypt. Anan (2004) proposed that this species is developed from the Paleocene *Verneuilina aegyptiaca* Said and Kenawy (1956). It is an index marker species for the PE boundary.

Tritaxia midwayensis (Cushman, 1936)

This Paleocene-Eocene species was recorded from USA, and later from Egypt and Tunisia.

Dorothia pontoni Cushman, 1933

This species was recorded from the Maastrichtian-Paleocene of USA. It is recorded in the early Eocene of Duwi section.

Textularia schwageri LeRoy, 1953, p. 51, pl. 2, figs. 5, 6 (Pl. 1, fig. 8)

This species was recorded, so far, in Egypt. It is an index marker species for the PE boundary. It is common in the early Eocene of the study section.

Textularia washitensis Carsey, 1926, p. 24, pl.7, fig. 6 (Pl. 1, fig. 9)

It seems that this species is recorded here, for the first time in Egypt, which observed in the early Eocene of Duwi section, Egypt, while from the Cretaceous of Texas (USA). The Egyptian form of it has more width in last portion of the test.

Suborder Lagenina Delage and Hérouard, 1896

Laevidentalina colei (Cushman and Dusenbury, 1934), p. 54, pl. 7, figs. 10-12 (Pl. 1, fig. 10)

This Paleocene-early Eocene species was recorded in the USA, Egypt (LeRoy, 1953), Tunisia (Aubert and Berggren, 1976), UAE (Anan, 1993a) and Bulgaria (Valchev, 2007). It is rare to common in the early Eocene of the study section.

*Nodosaria limbat*a d'Orbigny 1840

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This Maastrichtian-Paleocene species was recorded from Europe, USA, Mexico, Trinidad, Tunisia, Egypt. It is rare to common in the Paleocene of the study section.

Pseudonodosaria bulla (Said and Kenawy, 1956)

This Paleocene species was originally recorded from Sinai of Egypt and treated to belong the genus *Rectoglandulina*. This genus was considered by Loeblich and Tappan (1988) as a junior synonym of the genus *Pseudonodosaria*. This species was recorded, so far, from Egypt.

Pseudonodosaria manifesta (Reuss, 1851), p. 22, pl. 1, fig. 4.

This Maastrichtian-early Eocene species has rounded initial end with greatest width near middle and upper portion. It was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Luger, 1985; Anan and Sharabi, 1988). It is rare to common in the Paleocene-early Eocene of the study section.

Pyramidulina affinis (Reuss, 1845), p. 26, pl. 13, fig. 16.

This Maastrichtian-early Eocene species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Nakkady, 1955; Anan and Sharabi, 1988). Nakkady (1955) proposed the accelerated tempo of evolution for the *Pyramidulina* group: *vertebralis-affinis-zippei* in the gradual inflation of the chambers and the sutures becoming higher. It is rare to common in the Paleocene-early Eocene of the study section.

Pyramidulina latejugata (Gümbel, 1868), p. 619, pl. 1, fig. 32.

This Maastrichtian-early Eocene species is characterized by its very large costate test. It was also recorded from the Paleocene of Tunisia (Aubert and Berggren, 1976), but the Paleocene-early Eocene of Egypt (Speijer, 1994; this study).

Pyramidulina vertebralis (Batsch, 1791), p. 3, pl. 2, fig. 6.

This Maastrichtian-early Eocene species is characterized by its longitudinal ribs along the test with flush sutures. It represents the first step of accelerated tempo of evolution for *Pyramidulina* group as noted by Nakkady (1955).

Pyramidulina zippei (Reuss, 1845), p. 25, pl. 8, figs. 1-3.

This species was recorded by many authors in Egypt (i. e.: Nakkady, 1955; Said and Kenawy, 1956; Anan and Sharabi, 1988). It is rare to common in the Paleocene-early Eocene of the study section.

Frondicularia goldfussi Reuss, 1860, p. 192, pl. 4, fig. 7.

This species was recorded Europe, USA (Cushman, 1946), Mexico (Sliter, 1968), Egypt (Said and Kenawy, 1956), Pakistan (Haque, 1956) and UAE (Anan, 1993a).

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

This Paleocene-early Eocene species was recorded from the Paleocene of Jordan, and also Anan (2002) in Egypt, but early Eocene in Egypt by Speijer (1994).

Frondicularia phosphatica Russo, 1934, p. 358, pl. 16, figs. 6-8 (Pl. 1, fig. 11)

This Paleocene species is characterized by its central raised ridge along the test. It is common to abundant in the Paleocene study section. It was recorded by many authors in Egypt (i.e.:

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Nakkady, 1950; Luger, 1985; Speijer, 1994; Anan, 2002), and also Tunisia. It is an index marker species for the PE boundary.

Lenticulina budensis (Hantken, 1875), p. 58, pl. 7, fig. 1 (Pl. 1, fig. 12)

This Eocene-Oligocene species characteristically shows a decided inflation of 6-7 chambers in the last whorl, accompanied by depressed narrow sutures in the medium, moderately compressed test with acute periphery. It is recorded in the early Eocene of Maqfi section in Egypt, and in the study section. it considered here the second record of this species in Egypt.

Lenticulina midwayensis Plummer, 1927, p. 75, pl. 13, fig. 5.

This Maastrichtian-early Eocene cosmopolitan species was recorded in many sites in the Tethys: USA, Atlantic Ocean (Tjalsma and Lohmann, 1983), South America (Dailey, 1983); Tunisia (Aubert and Berggren, 1976), Egypt (Nakkady, 1959; El-Duwi, 2001; this study), UAE (Anan, 1993b, 2015b) and Pakistan (Haque, 1956).

Lenticulina oligostegia (Reuss, 1860), p. 213, pl. 8, fig. 8.

This species was recorded from Maastrichtian-Paleocene from Europe, USA, Mexico, Trinidad. It is recorded in the Paleocene of the study section.

Lenticulina pseudomamilligera Plummer, 1927, p. 98, pl. 7, fig. 11 (Pl. 1, fig. 13)

This species was recorded from USA, France (Sztrákos, 2000), Tunisia (Berggren and Aubert, 1975), Egypt (Luger, 1985; Anan and Sharabi, 1988; this study), UAE (Anan, 1993a, 2015a) and Pakistan (Haque, 1956).

Percultazonaria jordanensis (Futyan, 1976), p. 525, pl. 81, fig. 5 (Pl. 1, fig. 15)

This Paleocene species was recorded from Jordan, and also Egypt by Anan (2015b).

Percultazonaria longiscata (Nakkady, 1950), p. 684, pl. 89, fig. 13.

This early Eocene species was recorded from Esna Shale of Luxor, Farafra Oasis and Duwi section.

Saracenaria triangularis (d'Orbigny, 1840)

This Maastrichtian-early Eocene species was recorded was Europe, USA, Mexico, Trinidad, Egypt. It is recorded in the Paleocene-early Eocene of the study section.

Palmula woodi Nakkady, 1950, p. 684, pl. 89, fig. 24.

This Paleocene-early Eocene species was recorded from Egypt, and later from Tunisia, Jordan and Iraq. It is rare in the early Eocene of the study section.

Vaginulinopsis midwayensis (Fox and Ross, 1942), p. 669.

This Paleocene species is distinguished by high protruding sutures. It was recorded, so far, from USA, Tunisia and Egypt.

Citharina plummerae Anan, 2001, p. 135, pl. 1, fig. 1 (Pl.1, fig. 16)

This Paleocene species is distinguished from *Citharina plumoides* (Plummer, 1927) by its elongate and narrow width, raised and distinct striae.

Planularia dissona (Plummer, 1931), p. 145, pl. 11, figs. 17, 18 (Pl.1, fig. 17)

This species does not seem to have described earlier from Egypt (except in the Maastrichtian Dakhla Shale of southern Egypt by Luger, 1985) and Anan (2001) in Duwi section.

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Lagena sulcata (Walker and Jacob, 1798, p. 64, pl. 14, fig. 5 (Pl.1, fig. 18)

This Maastrichtian-Eocene cosmopolitan species is characterized by its globulosa to subglobulose test with numerous longitudinal costae. It was recorded from USA, France (Sztrákos, 2005), Egypt (LeRoy, 1953; Said and Kenawy, 1956; Ismail, 2012; Anan, 2014; this study), Qatar (Hewaidy and Al-Hitmi, 1993) and UAE (Anan, 1993a).

Ramulina navarroana Cushman, 1938

The Maastrichtian *Ramulina ornata* Cushman (1938) differs from the Maastrichtian-Eocene species *R. navarroensis* by its ornamented globular body at least 7 arms. It is rare in the early Eocene of this study.

Oolina globosa (Montagu, 1803), p. 523.

This cosmopolitan species has unilocular, globular test with smooth surface. It was recorded from Trinidad (Bolli et al., 1994), Egypt (LeRoy, 1953; Said and Kenawy, 1956; Anan, 2014), UAE (Anan, 1993b), Pakistan (Nomura and Brohi, 1995). It is rare-common in the Paleocene-early Eocene of Duwi section.

Guttulina communis (d'Orbigny, 1826), p. 266, pl. 12, figs. 1-4 (Pl.1, fig. 19)

This species was recorded from France, Poland (Pozaryska and Szczechura, 1968) and Bulgaria (Valchev, 2007). It seems that is recorded here, for the first time in Egypt, which observed rare in the Paleocene-early Eocene of the study section.

Suborder Rotaliina Delage and Hérouard, 1896

Neobulimina farafraensis LeRoy, 1953, p. 39, pl. 8, figs. 3, 4 (Pl.1, fig. 20)

This early Eocene species was recorded from some authors in Egypt (i. e.: LeRoy, 1953; Speijer, 1994; Shahin, 2001; Anan, 2008). It is rare to common in the Early Eocene of the study section.

Orthokarstenia applinae (Plummer, 1927), p. 69, pl. 4, fig. 1 (Pl.1, fig. 21)

Plummer (1927) noted that the initial part of this Paleocene-early Eocene species is obscure. Anan (1998) regarded the species *applinae* is an evolutionary development from the Maastrichtian *O. oveyi* (Nakkady) (= the junior synonym of *Orthokarstenia parva* (Cushman) by Koutsoukos and de Klasz, 2000). Anan (op. cit.) also added that all members of the genus *Orthokarstenia in* Egypt seem to have been restricted to the south Egypt (*Orthokarstenia* province of Hewaidy, 1997). It has a triserial part that becomes biserial and uniserial, for this it should belong to the genus *Orthokarstenia.* Moreover, the taxonomic status of *Orthokarstenia applinae* was also used by Ismail (2012).

Orthokarstenia eleganta (Plummer, 1927), p. 126, pl. 8, fig. 1 (Pl.1, fig. 22)

This Paleocene-early Eocene species was recorded by some authors in Egypt (i. e.: LeRoy, 1953; Anan and Sharabi, 1988; Speijer, 1994; Anan, 1998; Shahin, 2001), and also in Tunisia (Berggren and Aubert, 1975).

Orthokarstenia nakkadyi Anan, 2009, p. 37, pl. 1, fig. 7.

This Paleocene-early Eocene species is characterized by its longitudinal costae on the early chambers (lower half of the test), but without costae on the last chambers (upper half of the

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test). It is recorded in different localities in Egypt by some authors, but in different names (Anan, 1998; El-Dawy, 2001; Alegret and Ortiz, 2007), as well as in Tunisia (Saint-Marc, 1992) and France (Sztrákos, 2000),

Bulimina cacumenata Cushman and Parker, 1936, p. 40, pl. 7, fig. 3 (Pl.1, fig. 24)

This species was recorded from the Paleocene in USA. It is common in the early Eocene of Duwi section.

Bulimina midwayensis Cushman and Parker, 1936, p. 73, pl. 4, fig. 3 (Pl.1, fig. 25)

This Paleocene-early Eocene species was originally recorded from the Paleocene in USA, and also in Sweden, Tunisia (Aubert and Berggren, 1976), Egypt (Said and Kenawy, 1956) and UAE (Anan, 1993a).

Praeglobobulimina quadrata (Plummer, 1927), p. 72, pl. 4, figs. 4, 5.

This Maastrichtian-Paleocene species was recorded from USA, France (Sztrákos, 2005), Tunisia (Aubert and Berggren, 1976), Egypt (Luger, 1985; Samir, 2002; this study) and UAE (Anan, 1993b).

Fursenkoina dubia (Haque, 1956), pl. 25, figs. 3, 4 (Pl.1, fig. 26)

Our figured specimen from Duwi section, Egypt is closely related to the holotype of *F. dubia* (Haque), especially in the initial part of the test. This species was recorded, so far, from Pakistan and Egypt.

Stilostomella paleocenica (Cushman and Todd, 1946)

This Maastrichtian-Paleocene species was recorded from USA, Egypt and Pakistan.

Cancris auricula (Fichtel and Moll, 1798), p. 108, pl. 20, figs. A-c (Pl.1, fig. 27)

This species was recorded from the early Eocene of Egypt (LeRoy, 1953) and Norwegian Sea (Hulsbos et al., 1989). It is rare to common in the Early Eocene of the study section.

Valvulineria aegyptiaca LeRoy, 1953, p. 53, pl. 9, figs. 21-23 (Pl.1, fig. 28)

This species was recorded from some authors in Egypt (i. e.: LeRoy, 1953; Said and Kenawy, 1956). It is rare to common in the Paleocene-early Eocene of the study section.

Eponides lunatus Brotzen, 1948, p. 77, pl. 10, figs. 17, 18 (Pl.1, fig. 30)

This species is rare to common in the Paleocene-Early Eocene of the study section.

Neoeponides duwi (Nakkady, 1950), p. 688, pl. 90, figs. 5-7.

Speijer (2003) considered *duwi* appears to have no phylogenetic relationship with *Discorbis pseudoscopos*.

Cibicidoides decoratus (LeRoy, 1953), p. 23, pl. 6, figs. 15-17 (Pl.1, fig. 31)

This Paleocene-early Eocene species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Speijer, 1994; Anan, 2008; this study).

Cibicidoides farafraensis (LeRoy, 1953), p. 24, pl. 10, figs. 1-3 (Pl.1, fig. 32)

This species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Said and Kenawy, 1956; Luger, 1985; Hewaidy and Strougo, 2001; Anan, 2008). It is rare-common in the early Eocene of the study section.

Cibicidoides libycus (LeRoy, 1953)

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This Paleocene-early Eocene species is characterized by its depressed sutures in both sides than elevated and taper sutures in the dorsal side and slightly in the ventral side in *C. alleni* (Plummer). It was recorded, by many authors, from Libya, Tunisia, France, Turkmenia, North and South Atlantic Oceans

Cibicidoides pharaonis (LeRoy, 1953), p. 24, pl. 7, figs. 9-11(Pl.1, fig. 33)

This species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Alegret et al., 2005; Anan, 2008). It was originally recorded from the Early Eocene (LeRoy, 1953), but in Paleocene-early Eocene by other authors from different localities in Egypt, Sinai, Dababiya section and this study.

Cibicidoides pseudoacutus (Nakkady, 1950), p. 691, pl. 90, figs. 29-32.

This Paleocene species was recorded from Egypt, Tunisia (Speijer, 1994) and France (Sztrákos, 2005).

Alabamina midwayensis Brotzen, 1948, p. 99, pl. 16, figs. 1, 2.

This Paleocene-early Eocene species was recorded by many authors in many localities: Sweden (Brotzen, 1948), Egypt (Said and Kenawy, 1956; Nakkady, 1959; Luger, 1985; Speijer, 1994; this study), Tunisia (Aubert and Berggren, 1976). It is rare to common in the study section.

Valvalabamina depressa (Alth, 1850), p. 266, pl. 13, fig. 21.

The umbilical area of this Maastrichtian-Early Eocene long-ranged species is covered by an umbilical flap. The *Gyroidina depressa* of Cushman (1946), *G. orbicularis* and *G. planata* of LeRoy (1953) are related here to *V. depressa* (Alth) due to the great similarity between them.

Anomalinoides aegyptiacus (LeRoy, 1953), p. 17, pl. 7, figs. 21-23.

This Paleocene-early Eocene species was originally recorded from the early Eocene in Maqfi section (LeRoy, 1953), Tunisia (Salaj, 1976), Duwi section (Speijer and Zwaan, 1994; Speijer et al., 2000; this study).

Anomalinoides desertorum (LeRoy, 1953), p. 17, pl. 7, fids. 18-20 (Pl.1, fig. 34)

This Paleocene-early Eocene species was originally recorded from the Paleocene in Maqfi section (LeRoy, 1953) and later in the Arabian Sea (Boltovskoy and Verna Ocampo, 1993), Duwi section (Anan, 2008).

Anomalinoides praeacutus (Vasilenko), 1950, p. 208, pl. 5, figs. 2, 3.

This Paleocene-early Eocene species was originally recorded from the later Soviet Union, Tunisia (Aubert and Berggren, 1976) and Egypt (Speijer and Zwaan, 1994; this study).

Anomalinoides welleri (Plummer, 1927), p. 143, pl. 9, fig. 6.

This Paleocene species was recorded in USA, North Atlantic (Berggren, 1974), Tunisia (Berggren and Aubert, 1975), South Atlantic (Dailey, 1983), Japan (Kaiho, 1988), S. America (Malumiàn and Caramés,1997), Egypt (El-Dawy, 2001). It is rare to common in the Paleocene-early Eocene in the study section.

Anomalinoides zitteli (LeRoy, 1953), p. 25, pl. 6, figs. 20-22. (Pl.1, fig. 35)

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This species was recorded by many authors in Egypt (i. e.: LeRoy, 1953; Speijer, 1994; Speijer and Schmitz, 1998; Hewaidy and Strougo, 2001; Anan, 2008). It is rare to common in the early Eocene in this study.

Gyroidinoides girardanus (Reuss, 1851), p. 73, pl. 5, fig. 34 (Pl. 1, fig. 36)

This species was originally recorded from the Eocene of Germany, and later from Maastrichtian and Paleocene by different authors in different localities (i. e.: Cushman and Stainforth, 1951; LeRoy, 1953; Said and Kenawy, 1956; Nakkady, 1959; Luger, 1985; Anan and Sharabi, 1988; Kaiho, 1988; Speijer, 1994; Ali, 2003). Anan (2004) proposed an lineage phylogeny for the Maastrichtian-Paleocene *G. girardanus* to the Paleocene *G. luterbacheri* Anan. It is rare to common in the Paleocene-early Eocene of the study section.

Karreria fallax Rzehak, 1891, p. 4 (in Rzehak, 1895), pl.7, fig. 7 (Pl. 1, fig. 37)

This Maastrichtian-early Eocene species is characterized by its trochospirally enrolled early stage with one and more volution, alter stage uncoiled, suture slightly depressed with terminal and rounded aperture. It seems that the *Stichocibicides* sp. of LeRoy (1953) and *Rectoeponides dubia* Haque (1956) is closely related to *K. fallax* Rzehak (1891). It was recorded also from the North Atlantic (Berggren, 1974), France (Sztrákos, 2005), Tunisia (Aubert and Berggren, 1976), Egypt (LeRoy, 1953; Luger, 1985) and Pakistan (Haque, 1956).

PALEOGEOGRAPHY

The following remarks of the paleobiogeographic distribution of the recorded Tethyan benthonic foraminiferal species can be presented:

1. Berggren and Aubert (1975) noted that during the Paleogene a widespread geographic distribution of planktic and benthic foraminiferal elements occurred between Tethys-Caribbean-Gulf Coast regions.
2. Moore *et al*. (1978) recorded the extended realms of the Tethys, Indo-Pacific with Atlantic Oceans in the Maastrichtian-Late Eocene.
3. Haq and Aubry (1980) noted that North Africa and the Middle East formed important parts of the Tethys link between the Atlantic Ocean and the western Pacific Ocean in the Early Cenozoic.
4. Adams et al. (1983) noted that the continuous marine Paleogene connection between the area occupied by the present-day Mediterranean and the Indian Ocean had been lost by mid Burdigalian (early Miocene) times when a land bridge connected S. W. Asia to Arabia, which means that the faunas of the Mediterranean and Indo-West Pacific began to diverge. They also added that the final disconnection must have been caused by a general elevation of this region rather than by a global eustatic change.
5. Solakius et al. (1990) show that the ancestral Tethys is connected with the ancestral Atlantic and Indian Oceans via Mediterranean Sea.
6. Haynes and Nwabufo-Ene (1998) suggested wider Tethyan connections, as far as the Carpathian and Pakistan.

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The following remarks on some diagnostic recorded species can be presented:

1. The paleogeographic distribution of the Paleocene-Early Eocene *Spiroplectinella esnaensis* LeRoy was recorded from Southern Tethys: Egypt, Tunisia (Aubert and Berggren, 1976) and Northern Tethys: France (Sztrákos, 2005).
2. The Paleocene *Vulvulina colei* Cushman was recorded from USA, Europe, Libya, Egypt and UAE.
3. The Maastrichtian-Paleocene *Textularia washitensis* Carsey (1926) was recorded from the Cretaceous of Texas (USA), and later from the Paleocene of Duwi section, for the first time (this study).
4. The Paleocene-early Eocene *Frondicularia nakkadyi* Futyan was recorded from the Paleocene of Jordan, and later in the Paleocene of Egypt (Anan, 2002), but early Eocene only (Sprijer, 1994).
5. The Paleocene *Frondicularia phosphatica* Russo (1934) species was recorded in Morocco, Tunisia and Egypt.
6. The Paleogene *Lenticulina budensis* (Hantken, 1875) was recorded from the late Oligocene of Hungaria (Central Europe), and later from the the same horizon of Puerto Rico (Caribbean Sea), and also from the early Eocene of Maqfi section (Egypt), and now from the same horizon of Duwi section, Egypt (this study).
7. The Maastrichtian-Paleocene species *Lenticulina pondi* (Cushman, 1941) has wide geographic distribution: USA, Europe (Netherlands, Germany, Poland, Czech, Slovakia) and Egypt.
8. The Paleocene *Fursenkoina dubia* (Haque, 1956) is recorded here from Duwi section which considered the second record area of this species, outside Pakistan.
9. The Paleocene *Nonionella africana* LeRoy (1953) was recorded from Egypt: Maqfi section (Farafra Oasis), Duwi section, (Red Sea Coast), and also Pakistan.
10. The Maastrichtian-Early Eocene *Karreria fallax* Rzehak (1891) has wide geographic distribution: North Atlantic, France, Tunisia, Egypt and Pakistan.

PALEOECOLOGY

1. Boersma (1977) noted that the during a cooling the benthic forams demonstrate increased spinosity, increased numbers of rectilinear species, increased numbers of benthic relative to planktonic foraminifera, increased numbers of generalists of cosmopolitan species, and increased size of individuals.
2. Tjalsma and Lohmann (1983) noted that in Trinidad only 53% of the Paleocene benthic species continue into the Lower Eocene.
3. Alegret et al (2005) noted that the Global Stratotype Section and Point (GSSP) for the PE boundary was defind at Dababiya Quarry in Egypt at the base of the CIE which coincides with

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the major turnover in foraminiferal assemblages, and benthic foraminifera from Dababiya indicate an outer shelf depth of deposition during the Paleocene and early Eocene.

4. Egger et al. (2006) noted that the calcareous benthic foraminiferal assemblages there was no major extinction of agglutinated taxa acros the P/E boundary, while Alegret and Ortiz (2007) noted that at the BEE the species richness and diversity decreased and the relative abundance of non-calcareous agglutinated foraminifera increase dramatically which may be causs, among other, of the foraminiferal turnover.
5. Zachos et al. (2005) noted that the Paleocene/Eocene Thermal Maximum (PETM) event is contemporaneous with the benthic foraminiferal extenction event (BFEE) and also the Carbon Isotope Excursion (CIE). Aubry et al (2007) noted that the PETM event in Egypt, which was the warmest event in the last 90 millions of years, extends within the lowest part of Esna Shale. Ouda et al. (2016) noted that the Early Eocene El Aguz Limestone represents the invasion of the Tethyan flood during the subsequent decrease of temperature and continuously increased faunal densities as a result of gradual increase in content of disslved oxygen at the base of PETM.
6. Ouda et al. (2013) noted that the PE boundary in Egypt lies at the lowest part of the Esna shale, but it lies about the middle part of the study Duwi section, Red Sea coast of Egypt, this study (Fig. 3).

PALEOBATHYMETRY

1. Speijer (1994) noted that the benthic foraminifera from the Paleocene-Eocene succession (PE) in the Red Sea coast of Egypt suggest middle neritic deposition and only minor sea-level variation.

   Speijer et al. (2000) noted that Gabal Duwi is located near the edge of the early Paleogene epicontinental Tethys margin.
2. Alegret and Ortez (2007) noted that during the late Paleocene and early Eocene of Dababiya Quarry this part of the southern Tethys was occupied by an epicontinental basin, and the sediments were deposited in an outer shelf environment (~ 150-200m depth).

PALEOCLIMATOLOGY AND PALEOECOLOGY

1. Boersma (1977) noted that the during a cooling the benthic forams demonstrate increased in spinosity, numbers of rectilinear species, numbers of benthic relative to planktonic foraminifera, numbers of generalists of cosmopolitan species, and increased size of individuals.
2. Norris and Röhl (1999) noted that the PE boundary contains evidenceof a warming of ~5^o to ~7^o within a single processional cycle.

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3. Zachos et al. (2001) noted that the PE transition is characterized by a brief intensive interval of global warming and coeval with huge perturbation of the global carbon budget, and also a rapid excursion to shallower depths of the global CCD by Kroon et al (2004).
4. Hinsbergen et al. (2005) noted that the ratio between planktonic and benthic foraminifera is related to water depth, and the percentage planktonic (% *P*) generally increases with increasing distance to shore. However, next to water depth the oxygen level of bottom waters has a profound effect on the abundance of benthic foraminifera, and as such influence the % *P*.
5. Zachos et al. (2005) noted that this PETM event is contemporaneous with the benthic foraminiferal extenction event (BFEE) and also the Carbon Isotope Excursion (CIE).
6. Aubry et al (2007) noted that the PETM event in Egypt, which was the warmest event in the last 90 millions of years, extends within the lowest part of Esna Shale.
7. Ouda et al. (2016) noted that the Early Eocene El Aguz Limestone represents the invasion of the Tethyan flood during the subsequent decrease of temperature and continuously increased faunal densities as a result of gradual increase in content of disslved oxygen at the base of PETM.
8. During the Paleocene and Eocene (65.5–33.9 Ma) the Earth experienced the warmest conditions of the Cenozoic. The PETM (~55.5 Ma) is globally the best documented and most prominent.

REFERENCES

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

Alegret, L. and Ortiz, S. 2006 (2007). Global extinction event in benthic foraminifera across the Paleocene/Eocene boundary at the Dababiya Stratotype section. Micropaleontology, 52(5): 433-447.

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

Alth, A. (1850). Geognostisch-paläontologische Beschreibung der nächsten Umgebing von Lemberg. Haidinger's Naturwissenschaftlich Abhandllungen, Vienna, 3: 171-284.

Anan, H. S. (1987). Biostratigraphy and paleoecology of Maastrichtian and Paleocene benthonic foraminifera from Jiran El Ful section, Abu Rawash area, Egypt. Middle East Research Center (MERC), Ain Shams University, Earth Science Series, Cairo, 1: 207-227.

Anan, H. S. (1993a). Paleocene benthonic foraminifera of Jabal Malaqet, Al Ain region, United Arab Emirates. Al-Azhar Bulletin of Sci., Al Azhar Univ., Cairo, 4(1): 293-320.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

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 Univ., 4(2): 639-670.

Anan, H. S. (1998). Accelerated evolution in representatives of the genera Orthokarstenia and Discorbis (Benthic foraminifera) in the Maastrichtian and Paleocene of Egypt (Misr). Neues Jahrbuch für Geologie und Paläontologie, Mh., 6: 365-375.

Anan, H. S. (2001). Paleocene Vaginulininae (benthic foraminifera) of Duwi section, Red Sea coast, Egypt. Egyptian Journal of Paleontology, 1: 135-139.

Anan, H. S. (2002). Stratigraphy and paleobiogeography of some Frondiculariinae and Palmulinae benthic foraminiferal general in the Paleocene of Egypt (Misr). Neues Jahrbuch für Geologie und Paläontologie, Mh., 10: 629-640.

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

Anan, H. S. (2008). Maastrichtian-Paleogene LeRoy's benthic foraminiferal species from Egypt and Tethyan-Atlantic regions. Revue de Paléobiologie, 27(2): 357-376.

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

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

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

Anan, H. S. (2014). Maastrichtian benthic foraminiferal Lagenina in Wadi Ed Dakhl section, West Gulf of Suez, Egypt. Egyptian Journal of Paleontology, 14: 137-156.

Anan, H. S. (2015a). Paleocene agglutinated foraminifers of Jabal Mundassa, Al Ain area, United Arab Emirates. Spanish Journal of Paleontology, 30(2): 239-256.

Anan, H. S. (2015b). Paleogene Lagenid Percultazonarias (Foraminifera) in Egypt: paleontology, stratigraphy, paleogeography and some taxonomical considerations. Egyptian Journal of Paleontology, 15: 13-30.

Anan, H. S. (2015c). Paleocene Lagenid benthic foraminifera of Jabal Mundassa, Al Ain Area, United Arab Emirates. Egyptian Journal of Paleontology, 15: 61-83.

Anan, H. S. (2017). Paleontology and paleogeography of the Paleogene benthic foraminiferal species of Plummer in Egypt and other Atlantic-Tethyan regions. Journal of Tethys, 5(3): 272-296.

Anan, H. S. and Hewaidy, A. (1986). Biostratigraphy and distribution of the Paleocene benthonic foraminifera in the Nile Valley Facies in Egypt. MERC, Ain Shams Univ., Earth Science Series, Cairo, 6: 1-32.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Anan, H. S and Sharabi, S. A. (1988). Benthonic foraminifera from Upper Cretaceous-Lower Tertiary rocks of northwest Kharga Oasis, Egypt. MERC, Ain Shams University, Earth Science Series, Cairo, 2: 191-218.

Aubert, J. and Berggren, W. A. (1976). Paleocene benthonic foraminiferal biostratigraphy and paleoecology of Tunisia. Bulletin du Centre de Recherches Pau- SNPA, 10 (2): 379- 469.

Aubry, M.-P., Ouda, Kh., Dupuis, C., Berggren, W. A. and Van Couvering, J. A. (2007). The Global Standard Stratotype-section and Point (GSSP) for the base of the Eocene Series in the Dababiya section (Egypt). Episodes, 30(4), 271-286.

Basha, S. H. (2005). Biostratigraphy of the Jebel Fedyat-Adhahikiya East Jordan-Saudi Arabia borders. Dirasat, Pure Sciences, 32(2): 203-225.

Batsch, A. I. G.C (1791). Sechs Kupfertafeln mit Conchylien des Seesandes, gezeichnet und gestochen von A. J. G. K. Batsch, Jena.

Berggren, W. A. (1974). Late Paleocene-Early Eocene benthonic foraminiferal biostratigraphy and Paleoecology of Rockall Bank. Micropaleontology, 20(4): 426- 448.

Berggren, W. A. and Aubert, J. (1975). Paleocene benthonic foraminiferal biostratigraphy, paleobiogeography and paleoecology of Atlantic-Tethyan regions: Midway-type fauna. Palaeogeography, Palaeoclimatology, Palaeoecology, 18: 73-192.

Berggren, W. A. and Aubert, J. (1976). Late Paleogene (Late Eocene and Oligocene) benthonic foraminiferal biostratigraphy and paleobathymetry of Rockall Bank and Hatton-Rockall Basin. Micropaleontology, 22 (3): 307-326.

Boersma, A. (1977). Eocene to Early Miocene benthic foraminifera DSDP Leg 39, South Atlantic. Deep Sea Drilling Project, 39: 643-656.

Bolli, H.M; Beckmann, J.P. and Saunders, J.B. (1994). Benthic foraminiferal biostratigraphy of the south Caribbean region. Cambridge University:1-408.

Boltovskoy, E. and Vera Ocampo, J. (1993). Benthic foraminifers from DSDP site 219 (Eocene-Pleistocene, Arabian Sea). Revista Espaňola de Micropaleontologia, 25(1): 127-156.

Brotzen, F. (1948). The Swedish Paleocene and its foraminiferal fauna. Sweden Sveriges Geologiska Undersökning, ser. C, no. 493: 1-140.

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

Cushman, J. A. (1926). The foraminifera of the Velasco Shale of the Tampico Embayment. American Associaion of Petroleum Geology Bulletin, 10: 581-612.

Cushman, J. A. (1927). An outline of the re-classification of the Foraminifera. Contributions from the Cushman Laboratory for foraminiferal Research, 3: 1-105.

Cushman, J. A. (1932). The foraminifera of the tropical Pacific collections of the "Albatross", 1899-1900, pt. 1, Astrorhizidae to Trochamminidae. U.S. Natural Museum Bulletin, 161: 1-88.

Cushman, J. A. (1941). Some fossil Foraminifera from Alaska: Cushman Lab. Foram. Research Contr., 17 (2):33-38.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Cushman, J. A. (1946). Upper Cretaceous Foraminifera of the Gulf Coastal Region of the United States and adjacent areas. United States Geological Survey, Professional Paper, 206: 1-241.

Cushman, J.A. and Parker, F. L. (1936). Some American Eocene Buliminas. Contributions from the Cushman Laboratory for Foraminiferal Research, 12(2): 39-45.

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

Cushman, J.A. and Stainforth, R.M. (1951). Tertiary foraminifera of the coastal Ecuador: Part 1, Eocene. Journal of Paleontology, 25(2): 129-164.

Dailey, D. H. (1983). Late Cretaceous and Paleocene benthic foraminifers from Deep Sea Drilling Project Site 516, Rio Grande Rise, Western South Atlantic Ocean. DSDP, 72: 757-782.

Egger, H., Heilmann-Clausen, C., Homayoun, M., Rögl, F. and Schmitz, B. (2006). Paleontological, sedimentological and geochemical events across the Paleocene/Eocene boundary in the northwest Tethyan realm (Eastern Alps, Austria). Geophysical Research Abstracts, 8: 07083.

El-Dawy, M. H. (2001). Paleocene benthic foraminiferal biostratigraphy and paleobathymetry, El Sheikh Fadl and Ras Gharib, Eastern Desert, Egypt. Micropaleontology, 4(1): 23-46.

Fichtel, L. von and von Moll, J. P. C. (1798). Testacea microscopic, aliaque minuta ex genetibus Aragonauta et Nautilus, ad naturam picta et descripta, Vienna: Camesina.

Gümbel, C. W. (1868). Beiträge zur Foraminiferenfauna der nordalpinen Eocängebilde. Abhandlungen der K. Bayerische Akademie der Wissenschaften, Cl. II, 10 (2): 579-730.

Franke, A. (1928). Die Foraminiferen der Oberen Kreide Nord- und Mitteldeutschlands. Abhandlungen der Preußischen Geologischen Landesanstalt, Neue Folge (Akademie-Verlag) Berlin 111: 1–207.

Futyan, A. I. (1976). Late Mesozoic and Early Cainozoic benthonic foraminifera from Jordan. Palaeontology, 19 (3): 53-66.

Hantken, M. (1875). Die Fauna der Clavulina Szaboi Schichten, I. Theil: Foraminiferen. Mitt. Jb. K. Ungaren Geol. Anstalt, 4: 1-93.

Haq, B. U. and Aubry, M.-P. (1980). Early Cenozoic calcareous nannoplankton biostratigraphy and palaeobiogeography of North Africa and the Middle East and Trans-Tethyan correlations. The Geology of Libya (1)- 2nd Symp. Geol. Libya, Tripoli: 271-304.

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

Haynes, J. and Nwabufo-Ene, K. (1998). Foraminifera from the Paleocene phosphate beds, Sokoto, Nigeria. Revue Española de Micropaleontologia, 30(2): 51-76.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Hewaidy, A. A. (1997). A proposed paleoecologic scheme for the Upper Cretaceous-Lower Tertiary sequences in Egypt. MERC, Ain Shams Univ., Earth Science Series, Cairo, 11: 159-168.

Hewaidy, A. A. and Al-Hitmi, H. (1993a). Cretaceous-Early Eocene foraminifera from Dukhan oil field, west Qatar, Arabian Gulf (A-Suborders Textulariina, Involutinina and Miliolina). Al-Azhar Bulletin of Science, 4(2): 469-494.

Hewaidy, A. A. and Al-Hitmi, H. (1993b). Cretaceous-Early Eocene foraminifera from Dukhan oil field, west Qatar, Arabian Gulf (B-Superfamilies Nodosariacea and Globorotaliacea. Al-Azhar Bulletin of Science, 4 (2): 495-516.

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

Hinsbergen van, D. J. J., Kouwenhoven, T. J. and van der Zwaan, G. J. (2005). Paleobathymetry in the backstripping producer: Correction for oxygenation effects on depth estimates. Palaeogeography, Palaeoclimatology, Palaeoecology 221: 245-265.

Hulsbos, R. E., Kroon, D.,. Jansen, H. S. M and Van Hinte, J. E. (1989). Lower Eocene benthic foraminifera and paleoenvironment of the outer Vøring Plateau, Norwegian Sea (DSDP Site 338). Micropaleontology, 35 (3): 256-273.

Ismail, A. A., (2012). Late Cretaceous-Early Eocene benthic foraminifera from Esh El Mallaha area, Egypt. Revue de Paléobiologie, 31 (1): 15-50.

Israelisky, M.C. (1951). Foraminifera of the Lodo Formation, Central California. U.S. Geological Survey, Professional Paper, 240-A: 1-29.

Kaiho, K. (1988). Uppermost Cretaceous to Paleocene bathyal benthonic foraminiferal biostratigraphy of Japan and New Zealand: Latest Paleocene-Middle Eocene benthic foraminiferal species turnover. Revue de Paléobiologie, special volume 2 (Benthos'86): 553-559.

Karoui-Yaakoub, N. (2006). Effet du réchauffement climatique global sur le comportement des foraminiféres benthiques l'intervalle de passage Paléocène-Eocene de la coupe d'Ellès (Tunisie). Revue de Paléobiologie, Genéve, 25 (2), 575-591.

Koutsoukos, E. M. and de Klasz, I. (2000). Late Cretaceous foraminiferal biogeography (Families Bolivinidae, Buliminellidae, Gavelinellidae, Siphogenerinoididae, Turrilinidae) in northeastern Brazilian shelf and central West African basins. Cretaceous Research, 21: 381-405.

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

Loeblich, A.R. and Tappan, H. (1988). Foraminiferal genera and their classification. Van Nostrand Reinhold (VNR), New York, Part 1: 970 p., part 2: 847 p.

Luger, P. (1985). Stratigraphie der marinen Oberkreide und des Alttertiars im sudwestlichen Obernil-Becken (SW-Agypten) under besonderer Berucksichtig, der Micropaläontologie,

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Palökologie und Paläogeographie. Berliner Geowissenschaftliche Abhandlungen, (A), 63: 1-151.

Malumiàn, N. and Caramés, A. (1997). Upper Campanian-Paleogene from the Río Turbio coal measures in southern Argentina: micropaleontology and the Paleocene/Eocene boundary. Journal of South American Earth Science, 10(2): 189-201.

Mojtahid, M, Jorissen, F., Durrieu, J., Galgani, F., Howa, H., Redois, J. and Camps, R. (2006). Benthic foraminifera as bio-indicators of drill cutting disposal in tropical east Atlantic outer shelf environments. Marine Micropaleontology, 61(1-3): 58-75.

Montagu, G. (1803). Testacea Britannica, or Natural History of British Shells Marine, Land and Fresh Water, including the most Minute. Romsey, England: J. S. Hollis.

Moore, Jr., T. C., van Andel, Tj. H., Sancetta, C. and Pisias, N. (1978). Cenozoic hiatuses in pelagic sediments. Micropaleontology, 24(2): 113-138.

Nakkady, S. E. (1950). A new foraminiferal fauna from the Esna Shale and Upper Cretaceous chalk of Egypt. Journal of Paleontology, 24(6): 675-692.

Nakkady, S. E. (1955). The stratigraphic implication of the accelerated tempo of evolution in the Mesozoic- Cenozoic transition of Egypt. Journal of Paleontology, 29(4): 702-706.

Nakkady, S. E. (1957). Biostratigraphy and inter-regional correlation of the Upper Senonian and Lower Paleocene of Egypt. Journal of Paleontology, 31 (2): 428-447.

Nakkady, S. E. (1959). Biostratigraphy of the Um Elghanayem section, Egypt. Micropaleontology, 5(4): 453-472.

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

Norris, R.D. and Röhl, U. (1999). Carbon cycling and chronology of climate warming during the Paleocene/Eocene transition. Nature, 401: 775-778.

Orbigny, A. D. d' (1826). Tableau méthodique de la classe des Céphalopodes. Annals des Sciences de la Naturelles, Paris, 7: 245-314.

Ortiz, S. and Thomas, E. (2006). Lower-middle Eocene benthic foraminifera from the Fortuna Section (Betic Cordillera, southeastern Spain). Micropaleontology, 52, (2): 97-150.

Ouda, Kh., Berggren, W. A. and Abdel Sabour, A. (2013). Planctonic foraminiferal biostratigraphy of the Paleocene/Eocene boundary interval in the Dababiya Quarry Corehole, Dababiya, Upper Nile Valley, Egypt. *In*: Berggren, W. and Ouda, Kh. (Eds), Early Paleogene Geohistory of Egypt: The Dababiya Quarry Corehole. Stratigraphy, 9(3-4): 213-227.

Ouda, Kh., Berggren, W. A. and Abdel Sabour, A. (2016). Biostratigraphy of the Upper Paleocene-Lower Eocene succession of Gebel El Aguz, northeastern Kharga Oasis, Western Desert, Egypt. Revue de Paléobiologie, 35(1): 341-371.

Plummer, H. J. (1927). Foraminifera of the Midway Formation in Texas. Bulletin Univ. of Texas, 2644: 3-206.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Poźaryska, K. and Szczechura, J. (1968). Foraminifera from the Paleocene of Poland, their ecological and stratigraphical meaning. Paleontologica Polonica, 20: 1-138.

Proto Decima, F. and R. de Biase (1975). Foraminiferi bentonici del Paleocene, dell' Eocene inferiore e medio. *In*: Braga, G. et al.: Foraminiferi bentonici del Paleocene ed Eocene della sezione di Possagno. Schweizerische Paläontologische Abhandlungen, 97: 87-98.

Reuss, A. E. (1845). Die Versteinerungen der Böhmischen Kreideformation. Verlagsbuchhandlung E. Schweizerbart'sche, Stuttgart, 1: 1-58.

Reuss, A. E. (1850). Neues Foraminiferen aus den Schichten des österreichischischen Terriärbeckens. Denkschriftender Kaiserlichen Akademie Wissenschchaften, Mathematisch-Naturwissenschaftiliche Classe 1, 465-390.

Reuss, A. E. (1860). Die Foraminiferen der Westphälischen Kreideformation. Sitzunggsberichte der Kaiserlichen Academie der Wissenschaften in Wien, Mathematisch-Naturwissenschaftiliche Classe 40: 147-238.

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

Russo, P. (1934). Recherches sur les fossiles du genre *Frondicularia recueillis* dans les couches phosphatées du Maroc Central. Bulletin Société Géologique de France, 5(3): 356-359.

Rzehak, A. (1891). Die Foraminifernfauna der alttertiären Ablagerungen von Bruderndorf in Niederösterreich, mit Berüchsichtigung der angeblichen Kreidevorkommens von Leitzersdorf. Annalen des K. K. Naturhistorischen Hofmuseums, 6: 1-12.

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

Saint-Marc, P. (1992). Biogeographic and bathymetric distribution of benthic foraminifera in Paleocene El Haria Formation of Tunisia. Journal of African Earth Sciences, 15(3/4): 473-487.

Salaj, J. (1976). Foraminiferida, zonation and subzonation of the Paleocene of Tunisia. Acta Palaeotologica Polonica 21(2): 127-190.

Samir, A. M. (2002). Biostratigraphy and paleo- environmental changes in the Upper Cretaceous-Early Paleogene deposits of Gebel Samra section, southwestern Sinai, Egypt. Egyptian Journal of Paleontology, 2: 1-40.

Shahin, A. (1990). Late Cretaceous-Early Tertiary agglutinated benthic foraminifera and their paleoecology in the Gebel Ekma succession, southwestern Sinai, Egypt. Neues Jahrbuch für Geologie und Paläontologie, Mh., 8: 493-512.

Shahin, A. (2000). Biostratigraphic significance, paleobiogeography and paleobathymetry of Tertiary Buliminacea and Bolivinacea in the Western Sinai, Egypt. Neues Jahrbuch für Geologie und Paläontologie, Abh. 216(2): 195-231.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

Solakius, N., Pomoni-Papaioannou, F. and Alexopouios, A. (1990). On the paleogeographic distribution of the Late Maastrichtian planktonic foraminiferal genus Kassabiana Salaj and Solakius, 1984. Acta Geologica Hispanica, 25(4): 289-298.

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

Speijer, R. P. and Schmitz, B. (1998). A benthic foraminiferal record of Paleocene sea level and trophic/redox conditions at Gebel Aweina, Egypt. Palaeogeography, Palaeoclimatology, Palaeoecology 137: 79-101.

Speijer, R. P., Van Der Zwaan, G. J. and Schmitz, B. (2000). The impact of Paleocene/Eocene boundary events on middle neritic benthic foraminiferal assemblages from Egypt. Marin Micropaleontology, 28: 99-132.

Sztrákos, K. (2000). Eocene foraminifers in the Adour Basin (Aquitaine, France): biostratigraphy and taxonomy. Revue de Micropaléontologie, 43(1-2): 71-172.

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

Tjalsma, R. C. and Lohmann, G. P. (1983). Paleocene- Eocene bathyal and abyssal benthic foraminifera from the Atlantic Ocean. Micropaleontology, Special Publication, 4: 1-90.

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

Valchev, B. (2007). Midway-Type Benthic foraminifera from the Paleocene of the coastal part of East Stara Planina (Eastern Bulgaria). Family Textulariidae Ehrenberg, 1838 to Family Stilostomellidae Finlay, 1947. Annual of the University of Mining and Geology "St. Ivan Rilski", Vol. 50, Part I, Geology And Geophysics: 129-137.

Walker, G. and Jacob, E. (1798). Descriptions of Serpula (Lagena) sulcata and Nautilus lobatulus . In Adams , E. , ed., Essays on the microscope, 2nd ed. With considerable additions and improvements by F. Kanmacher. London: Dillon and Keating , pp. 634 and 642.

Zachos, J. C., Pagani, M., Solan, L., Thomas, E. and Billups, K. (2001). Trends, Rhythms and Abberrations in Global Climate 65 Ma to present. Science, 292: 686-693.

Zachos, J. C., Röhl, U., Schellenberg, S. A., Sluijs, A., Hodell, D. A., Kelly, D.C, Thomas, E., Nicolo, M., Raffi, I., Lourens, L., Kroon, D. and Mc Carren, H. (2005). Rapid acidification of ocean during the Paleocene-Eocene Thermal Maximum. Science, 308: 1611-1615.

Print ISSN: 2397-7728, Online ISSN: 2397-7736

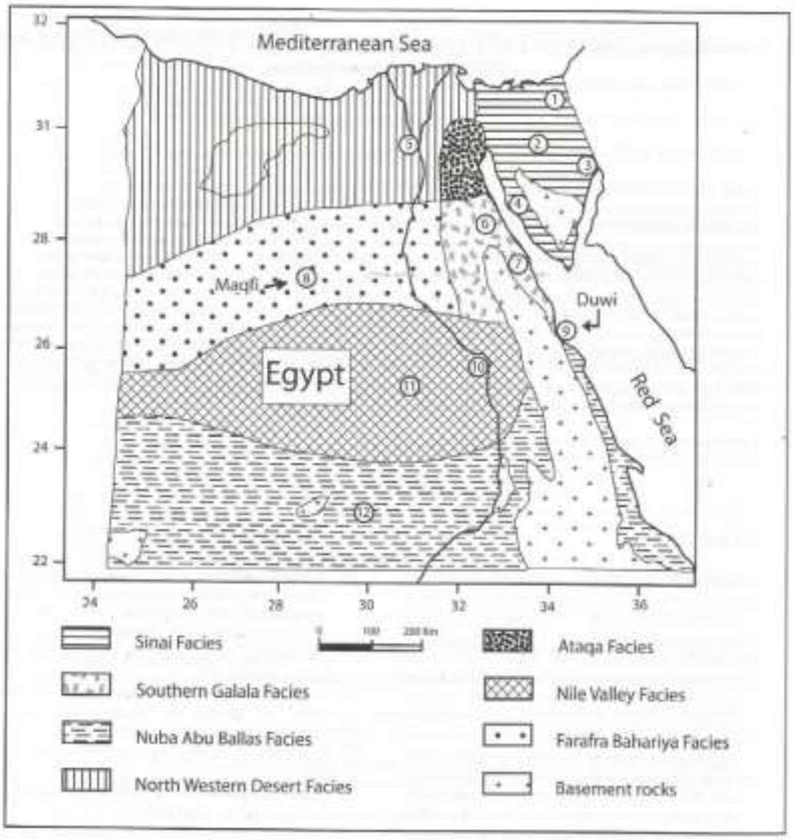

Figure 1 : Location map of the different facies in Egypt (after Issawi et al., 1999). The numbers are the locations of the sections were studied by the present author and other authors. Sinai Facies includes (**1**. Qusaima, **2**. Nukhul, **3**. Taba ; **4**. Ekma, Samra and Abu Zenima sections), North Western Desert Facies (**5**. Jiran El Ful section), Southern Galala Facies (**6**. Wadi Ed Dakhl, **7**. Esh El Mallaha and Sufr Ed Dara sections), Farafra Bahariya Facies (**8**. Maqfi, Gunna, Esheikh Marzouk and Twin Spikes sections), Nile Valley Facies (**9**. Duwi, **10**. Gurnah, Qena, Owaina sections ; **11**. Ain Dabadib, Um Elghanayem, and Ghanima sections), Nuba Abu Ballas Facies (**12**. Bir Kiseiba section and surroundings).

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Figure 2: Location map of the Duwi section, as well as the Type locality of Paleocene-Eocene boundary represented by the Dababiya section, south Luxor city in the Nile Valley.

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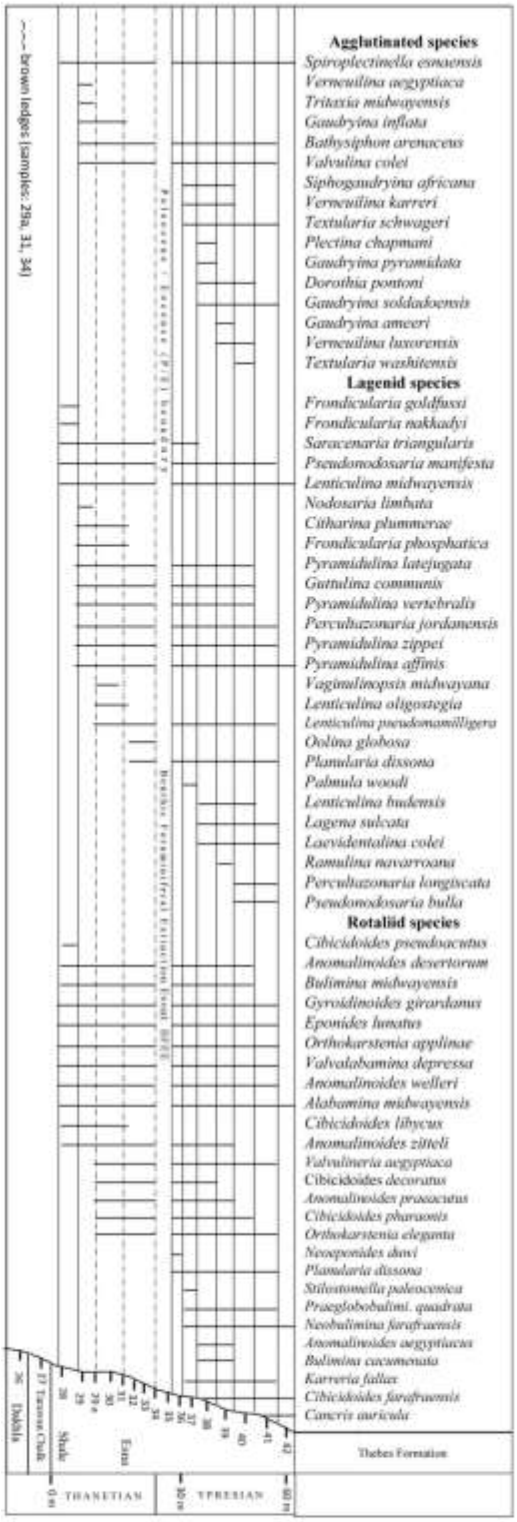

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Figure 3. Stratigraphy (litho- and bio-) and stratigraphic ranges of the identified benthic

foraminiferal species of the upper Paleocene-early Eocene succession of the Esna Shale in Duwi section, Red Sea coast of Egypt.

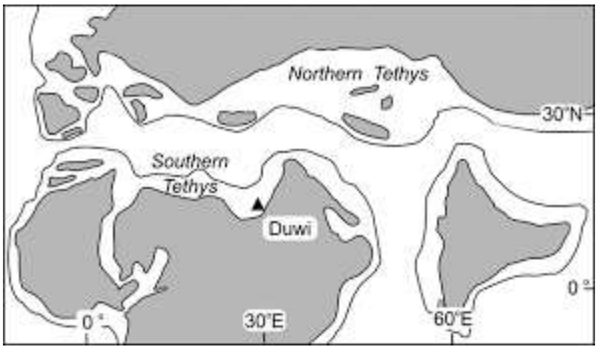

Figure 4: Paleocene Paleogeography distribution of the Northern Tethys and Southern Tethys throughout the west Africa (extend to Nigeria), which also detected the location of the Duwi section, Egypt.

Plate 1 (all figure approximately x50)

1. *Bathysiphon arenaceous* Cushman, 1927. **2**. *Vulvulina colei* Cushman, 1932. **3**. *Plectina chapmani* (Franke, 1928). **4**. *Siphogaudryina africana* (LeRoy, 1953). **5**. *Verneuilina luxorensis* Nakkady, 1950. **6**. *Gaudryina ameeri* Anan, 2012. **7**. *Gaudryina inflata* Israelisky, 1951. **8**. *Textularia schwageri* LeRoy. **9**. *Textularia washitensis* Carsey, 1926. **10**. *Laevidentalina colei* (Cushman and Dusenbury, 1934). **11**. *Frondicularia phosphatica* Russo, 1934. **12**. *Lenticulina budensis* (Hantken, 1875). **13**. *Lenticulina pseudomamilligera* Plummer, 1927. **14**. *Lenticulina turbinata* Plummer, 1927. **15**. *Percultazonaria jordanensis* (Futyan, 1976). **16**. *Citharina plummerae* Anan, 2001. **17**. *Planularia dissona* (Plummer, 1931). **18**. *Lagena sulcata* (Walker and Jacob, 1798). **19**. *Guttulina communis* (d'Orbigny, 1826). **20**. *Neobulimina farafraensis* LeRoy, 1953. **21**. *Orthokarstenia applinae* (Plummer, 1927). **22**. *Orthokarstenia eleganta* (Plummer, 1927). **23**. *Orthokarstenia nakkadyi* Anan, 2009. **24**. *Bulimina cacumenata* Cushman and Parker, 1936. **25**. *Bulimina midwayensis* Cushman and Parker, 1936. **26**. *Fursenkoina dubia* (Haque, 1956). **27**. *Cancris auricula* (Fichtel and Moll, 1798). **28**. *Valvulineria aegyptiaca* LeRoy, 1953. **29**. *Valvulineria depressa* (Alth, 1850). **30**. *Eponides lunatus* Brotzen, 1948. **31**. *Cibicidoides decoratus* (LeRoy, 1953). **32**. *Cibicidoides farafraensis* (LeRoy, 1953). **33**. *Cibicidoides pharaonis* (LeRoy, 1953). **34**. *Anomalinoides desertorum* (LeRoy, 1953). **35**. *Anomalinoides zitteli* (LeRoy, 1953). **36**. *Gyroidinoides girardanus* (Reuss, 1851). **37**. *Karreria fallax* Rzehak, 1891.

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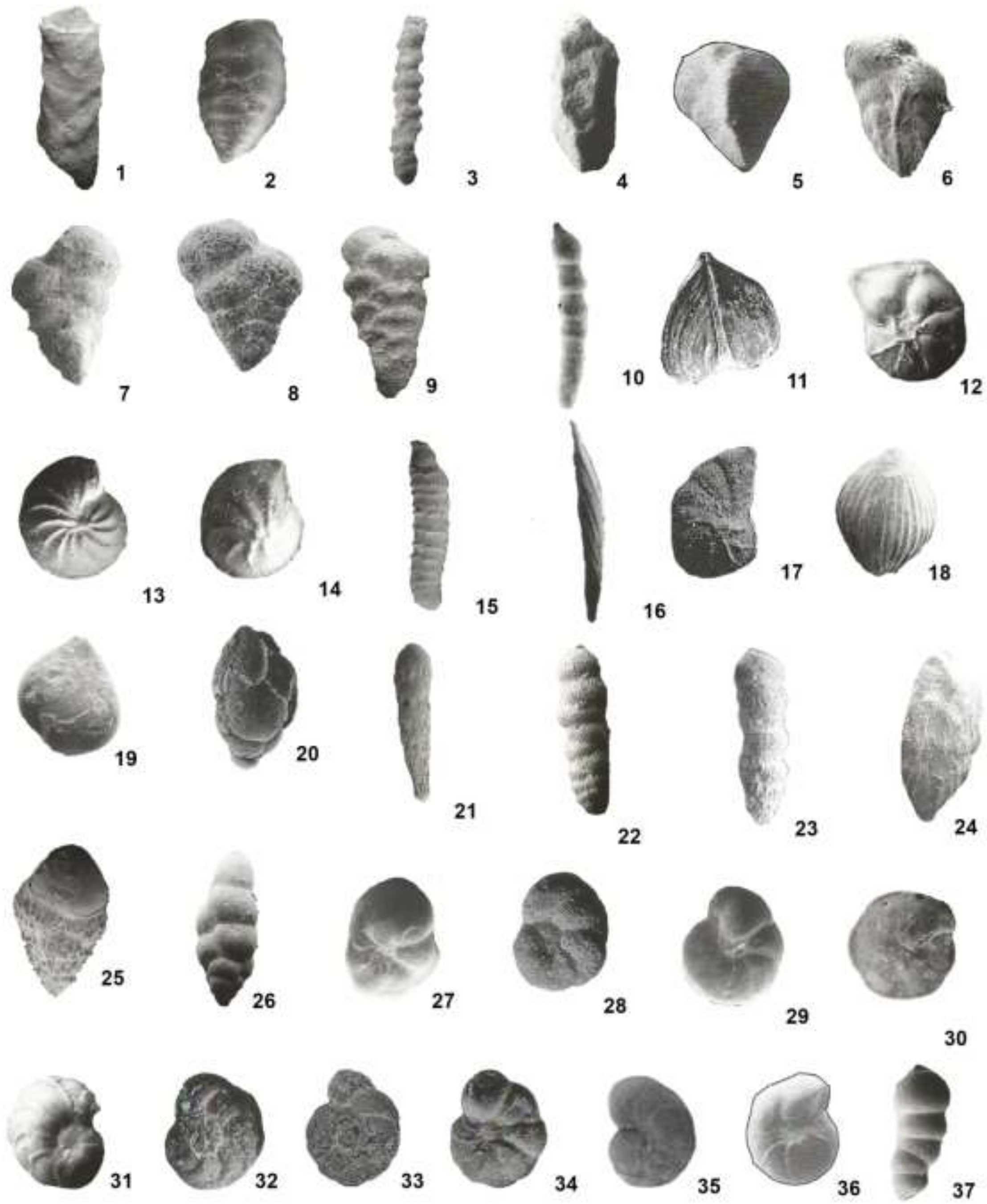

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