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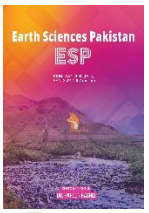

*RESEARCH ARTICLE*

# *LENTICUBELLA*: A NEW TETHYAN LAGENID BENTHIC FORAMINIFERAL GENUS

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**ABSTRACT**

*Lenticubella* n. gen. is introduced here to include the Paleocene benthic Lagenid Foraminiferids from some Tethyan localities (Poland and Egypt) that characterized by symmetrical planispirally enrolled hyaline calcareous test in the early stage, followed by later uniserial stage, moderately involute chambers, smooth surface, radiate aperture, with periphery keeled in some individuals. Some representatives of the new genus have been previously assigned to the genus *Darbyella*, or *Lenticulina*, or *Robulus*. The new genus has a compiled characters between its lenticular test (as the genus *Lenticulina* Lamarck (with its symmetrical planispirally enrolled test, and smooth surface), and also another genus *Darbyella* Howe and Wallace (which has planispiral-uniserial test with inclined positon on the uniserial part on the early planispiral direction). Two Paleocene species of the new genus are described from Poland in the Northern Tethys (*L. irregularis* and *L. polonica*), and another two species from Egypt in the Southern Tethys (*L. kurkurensis* and *L. misrensis*). The Polonian species have flush or slightly depressed sutures, while the Egyptian species have raised sutures, mainly in the planispiral stage, but slightly depressed sutures in the uniserial stage.

**KEYWORDS**

Lagenid benthic foraminifera, *Lenticulina, Lenticubella*, Paleocene, Tethys

## 1. INTRODUCTION

The paleontological occurrence of species belonging to the new Paleocene Lagenid genus Lenticubella has been reported from some localities in Northern Tethys (Poland) and Southern Tethys (Egypt). The type species of the genus Lenticubella was recorded from the Paleocene. The author has examined a large number of species belonging to this genus, which is distinguished by its large test, early stage close coiled, later uncoiled and inclined or nearly rectilinear, chambers mostly broad, sutures oblique and curved, may be plush, depressed or raised, periphery subacute in the coil part, wall calcareous, hyaline and perforate, surface smooth, peripheral keel may be found, aperture radiate terminal at the end of the uncoiled part. The intent of this study is to bring together many data scattered in the literature under a unifying theme, and to detect its paleontology, stratigraphy and paleogeographic distribution of about four Paleocene species in Egypt and Poland (Figure 1).

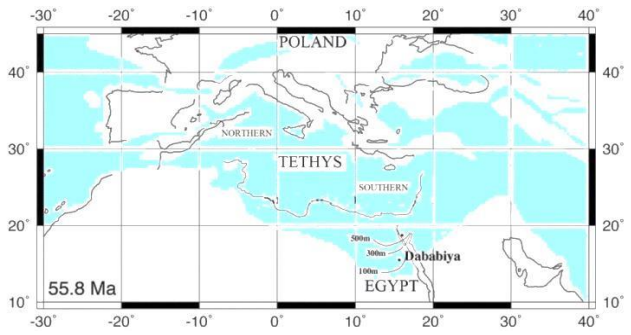


**Figure 1:** The paleogeographic distribution of the Tethys in the Late Paleocene including the location of Poland (in the Northern Tethys) and Egypt (in the Southern Tethys) (after Alegret and Ortiz, 2007, with some modifications).

## 2. PREVIOUS STUDIES

The American authors studying the microfauna of the Upper Eocene Jackson formation in the State of Louisiana, and described specimens otherwise similar to *Lenticulina*, but having in adult stage trochoidal tests with a low spiral (Howe and Wallace, 1932). This character, along with the type of aperture in the form of a single elongate slit without any accessory radiate opening, induced these authors to separate such specimens and to erect a new genus *Darbyella*, with *D. danvillensis* Howe & Wallace as a type species. The occurrence of anomalies in foraminifers is not a rare phenomenon, and deviations from the normal development are observed within various groups. Mostly, they consist in an abnormal development of the last chambers, or in the disturbance in a usual direction of the test growth. Sometimes, both these peculiarities occur simultaneously and, in such cases, chambers, asymmetrically arranged in relation to a previous plan of structure, are also differently shaped. A researchers describing few, asymmetrically built American specimens from Eocene of *Darbyella* and supposes that these may be abnormal forms of *Robulus* (Toulmin, 1941). Some researcher does not preclude the possibility that the representatives of *Darbyella* do not form independent species, but make up varieties of the species of the genus *Robulus*, originated as a result of unfavourable living conditions (Boltovskoy, 1954). He also suggests that poor nutrition cause, in most foraminifers, changes which consist in a general decrease in dimensions and poorer ornamentation. In some species, they evoke asymmetry. This cannot, however, explain anomalies, observed in lenticulins, since, as mentioned above, the loss of a symmetric plan of structure is primarily recorded in bulky individuals. In such cases,

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however, abnormal characters appear in a large number of individuals, whereas only few asymmetric lenticulins were found in studied samples. Another type of anomalies, caused by a mechanical damage of tests during an individual's life time, was also observed in lenticulins. A reconstruction of the test may take place, frequently accompanied by the loss of the planispiral structure. Tappan described *Darbyella volgensis*, and suggests that, after a detailed examination, the trochospiral species may turn out to be synonyms of symmetric species (Tappan, 1955). Kuznetsova noted that individuals with trochoid tests differ from *Darbyella* Howe & Wallace in the structure of aperture, and that the feature of trochospirality alone seems to be insufficient as a basis for distinguishing a separate genus (Kuznetsova, 1960). Moreover, he considers, in some cases, the character of trochospirality to be a sufficiently stable basis for distinguishing a new species, but not genus. Zobel noted that the lamellar structure of wall is identical in all representatives of *Lenticulina* and from Lias a to the Recent period no phylogenetic differences were recorded in the microstructure of wall and, consequently, it is not useful for the purposes referred to taxonomy and stratigraphy (Zobel, 1966). Jendryka noted that the detailed analysis of the abnormal structure, recorded in different groups of foraminifers, is a relatively recent subject of literature (Jendryka, 1968). In view of a considerable morphological variability of *Lenticulina*, some authors understand a species very broadly, whereas some others excessively narrow this concept giving various specific and even generic names to the forms which only slightly differ from each other. About 20 species of the genus *Darbyella*, cited from Jurassic, Cretaceous and Tertiary, as well as Recent ones, are known in literature. Since the apertures of these species are shaped either as in typical lenticulins (i. e., in the form of a radial opening at the peripheral angle of the last chamber, or as radiate aperture with a "Robulus"-type slit), it is only a trochoid structure of the test in adult stages that makes up the main character, on the basis of which several authors considered the specimens they examined to be representatives of *Darbyella*. He also noted that *Darbyella* has a trochoid structure of the test in adult stages that makes up the main character than *Lenticulina* or *Robulus*, and the specimens with a disturbed symmetry occur together with those having their structure typical of the genus *Lenticulina*. They have all characters of *Lenticulina* but, reaching the adult stage, change the symmetry of their structure by shifting the 1ast coil of chambers to one side of the test. In some cases, specimens with a different degree of shifting of the chambers may be arranged in a series with a symmetric species of the genus *Lenticulina* on the one, and the "*Darbyella*" stage of this species on the other end of it. Consequently, these are not representatives of some new development trend, but they should be examined as atypical ontogenetic stages of symmetric species. This phenomenon occurs less frequently in small species or in those displaying a tendency to uncoiling the last chambers. The number of lenticulins with a trochoid structure of test occurring in the Jurassic, Cretaceous and Tertiary material, is not great and makes up a small percentage of the entire foraminiferous assemblage. It is characteristic that in both large and small, both coiled and uncoiled species, this anomaly occurs almost exclusively in adult forms with closed ontogenetic development.

## 3. Faunal Discussion

The new genus *Lenticubella* has a compiled characters between its lenticular test, as the genus *Lenticulina* Lamarck (with its symmetrical planispirally enrolled test, and smooth surface), and also another genus *Darbyella* Howe and Wallace (has asymmetrical coiled to trochospirally test in its early stage, followed by uncoiled inclined uniserial chambers). The new Paleocene genus *Lenticubella* (in its large planispirally coiled test in early stage to uniserial smooth surface test) differs from the Paleocene-Early Eocene *Percultazonaria* Loeblich & Tappan (in its closed coiled planispiral stage to erected uniserial stage, with tubercle or row of nodes ornamented surface). The latter genus differs from the Maastrichtian-Eocene *Leroyia* Anan by its coiled early portion of the smooth surface, followed by slightly arcuate uniserial chambers increasing in length as added. The genus Lenticulina Lamarck (with its symmetrical planispirally enrolled test, and smooth surface), differs mainly from the genus *Lenticuzonaria* Anan in its symmetrical planispirally test with ornamented surface by spines, knobs or broken costae. Another related genus is *Marginulina* which characterized by its not completely enrolled coiled early stage and later uniserial rectilinear chambers with longitudinal costae ornamentation along the surface (Plate 1, figures. 1-10) (Orbigny, 1826).

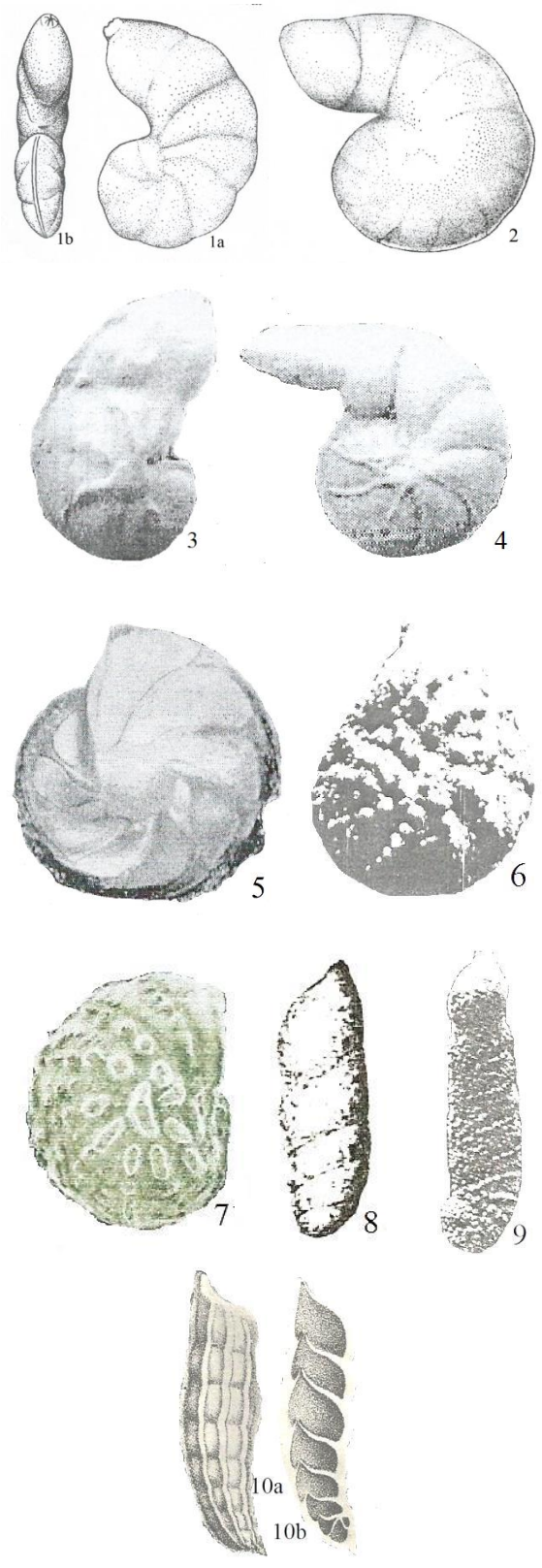


**Plate 1:** Figure 1a,b. Lenticubella irregularis, a. side view, b. side view x 25, 2. Lenticubella polonica Anan, n. sp. x 25, 3 (Pożaryska, 1957). Lenticubella kurkurensis Anan, n. sp., side view x 40 , 4. Lenticubella misrensis Anan, n. sp. x 60, 5. Lenticulina rotulata x 30, 6. Lenticuzonaria hodae x 30, 7 (Lamarck, 1804; Anan, 2021). L. misrensis Anan, 2021 x 50, Leroyia aegyptiaca x 50, 9. Percultazonaria tuberculata x 55, 10. Marginulina raphanus x 50 (Anan, 2020; Plummer, 1927; Orbigny, 1826).

## 4. Taxonomy

The taxonomy of foraminifers worked out includes *Darbyella* and *Robulus*, together with its uncoiling equivalent (i.e. *Darbyellina* Harris & Sutherland), in the synonymy of *Lenticulina* (Loeblich and Tappan, 1964 and 1988; Howe and Wallace, 1932; Montfort, 1808; Lamarck, 1804). Thus, *Darbyella danvillensis* and *Robulus danvillensis* are subjective

secondary homonyms of *Lenticulina danvillensis* (Howe and Wallace, 1932). On the other hand, noted that some lenticulins have a tendency in the later chambers toward uncoiling, i. e. the Upper Cretaceous *Lenticulina navicula* (d'Orbigny) (Cushman, 1931). It is suggested here that the Paleocene *Lenticubella* and its members most probably evolved from Maastrichtian *Lenticulina navicula* or others like it, which have the same character in the last chamber and the same characters of sutures.

Order Foraminiferida Eichwald, 1830
Suborder Lagenina Délage and Hérouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family Vaginulinidae Reuss, 1860
Subfamily Lenticulininae Chapman, Parr & Collins, 1934
Genus *Lenticubella* Anan, n. gen. (Plate 1, figures 1-4).
Type species *Lenticubella irregularis* (Pożaryska, 1965)

***Lenticubella irregularis* (Pożaryska, 1957) – (Plate 1, figure 1)**

1957 *Lenticulina (Darbyella) irregularis* (Pożaryska). Pożaryska, p. 124, pl. 16, figure 1, 3.

1965 *Darbyella irregularis* Pożaryska, p. 66, pl. 8, figure 7 (*non* figure 6).


**Figure 2:** The location map of the Boryszew section, west the capital Warsaw of Poland.

Holotype: The illustrated specimen in Pl. 1, figure 1.
Dimension: Length 2,40 mm, width 0.48 mm.
Deposit: The private collection of Plonian paleontologist Pożaryska.
Type locality: Bochotnica, Sochaczew, G6ra Pulawska, Montian, Poland (Figure 2).
Type level: Nasilow from the phosphoritic layer, lying just on the top of Danian age.
Age: Paleocene.

Diagnosis: Test large, compressed, sometimes slightly convex on both sides, the first portion symmetric coiled, the remainder of test uncoiled; chambers numerous about 10, gently increasing in size as added; sutures distinct, limbate, slightly curved, depressed, surface smooth, convex; aperture radiate on the top of the last formed chamber; periphery rounded, lobate, with faint keel.

Remarks: This species is characterized by large size, large aperture, and faint keel in coiled stage.

***Lenticubella polonica* Anan, n. sp. – (Plate 1, figure 2)**

1965 *Darbyella irregularis* Pożaryska, p. 66, pl. 8, figure 6 (*non* figure 7).
Holotype: The illustrated specimen in Plate 1, figure 2.
Dimension: Length 2.00 mm, width 0.40 mm.
Deposit: The private collection of Plonian paleontologist Pożaryska.
Type locality: Bochotnica, Sochaczew, G6ra Pulawska, Poland.
Type level: Nasilow from the phosphoritic layer, lying just on the top of Danian age (Figure 3).
Age: Paleocene.

Diagnosis: Test large, compressed, sometimes slightly convex on both sides, the first portion symmetrical large size coiled, the remainder of test uncoiled; chambers numerous about 12, gently increasing in size as added; sutures distinct, limbate, slightly curved, flush; surface smooth, convex; aperture radiate on the top of the last formed chamber; periphery rounded.

Remarks: This species has larger size than *L. irregularis,* not depressed sutures, and without keel.

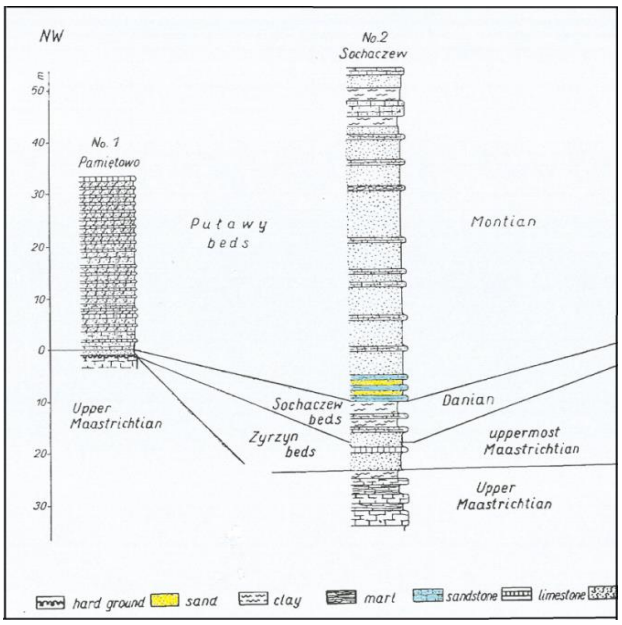


**Figure 3:** The Sochaczew section which yielded the Montian *Darbyella irregularis* and *Lenticubella polonica* Anan, n. sp (Pożaryska, 1957).

***Lenticubella kurkurensis* Anan, n. sp. - (Plate 1, figure 3)**

2003 *Saracenaria* sp. Ali, plate 6, figure 21.
Holotype: The illustrated specimen in Plate 1, figure 3.
Dimension: Length 3.70 mm, width 2. 20 mm.
Deposit: The private collection of Prof. M. Y. Ali, Department of Geology, Faculty of Science, South Valley University, Qena, Egypt.
Type locality: Kurkur Naqb Dungul section, south of Dababiya section, South Egypt (Figure 4).
Type level: Sample 23 of the Kurkur Naqb Dungul section.
Age: Late Paleocene, P5 planktic foraminiferal zone.

Diagnosis: Test with large prominent umbo, the first portion closed symmetrical coiled, followed by uncoiled inflated two chambers, increasing rapidly in size as added, surface smooth, sutures raised in the coiled stage but depressed between the last two chambers uncoiled stage, aperture radiate on the top of the last formed chamber.

Remarks: This species is characterized by its inflated uncoiled stage with prominent umbo, and two tapering chambers of the uncoiled part.

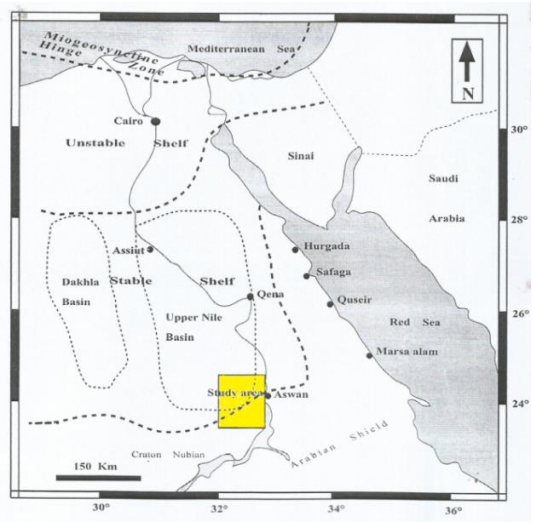


**Figure 4:** The location map of the study area of the southern Egypt, that yeilded the two species of *Lenticubella*: *L. kurkurensis* and *L. misrensis.*

***Lenticubella misrensis* Anan, n. sp. - (Plate 1, figure 4)**
2003 *Saracenaria* sp. Ali, plate 5, figure 13.

Holotype: The illustrated specimen in Plate 1, figure 4.

Dimension: Length 3.00 mm, width 2. 20 mm.

Deposit: The private collection of Prof. M. Y. Ali, Department of Geology, Faculty of Science, South Valley University, Qena, Egypt.

Type locality: Kurkur Naqb Dungul, south of Dababiya section, South Egypt.

Type level: Sample 19 of the Kurkur Naqb Dungul section (Figure 5).

Age: Late Paleocene, P5 planktic foraminiferal zone.

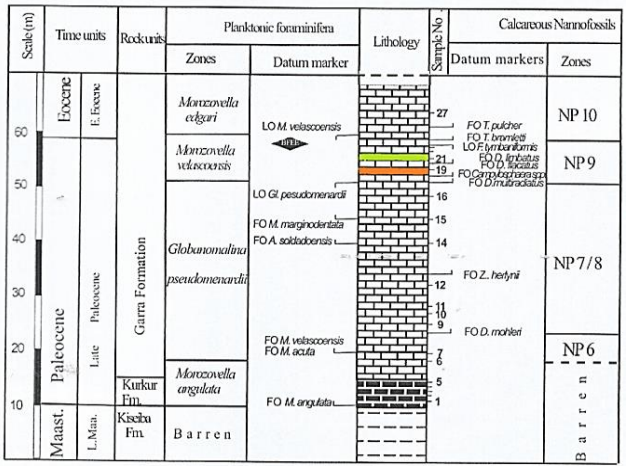


**Figure 5:** The stratigraphic horizons of the new species Thanetian *Lenticubella misrensis* (sample 19) and *L. kurkurensis* (Sample 21) of the Kurkur Naqb Dungul section, southern Egypt.

Diagenesis: Teat large, the first portion closed symmetrical coiled, followed by uncoiled inflated 2-3 chambers, increasing gradually in size as added, surface smooth, sutures raised in the coiled stage, but depressed in the last formed chambers in the coiled and uncoiled stages, aperture radiate on the top of the last formed chamber.

Remarks: This species differs from *Lenticubella kurkurensis* by its smaller size uncoiled tapering chambers, raised early part sutures in the coiled stage, then become depressed in the later part.

***Lenticulina rotulata* Lamarck, 1804 - (Plate 1, figure 5)**
***Lenticuzonaria hodae* Anan, 2021- (Plate 1, figure 6)**
***Lenticuzonaria misrensis* Anan, 2021 - (Plate 1, figure 7)**
***Leroyia aegyptiaca* Anan, 2020 - (Plate 1, figure 8)**
***Percultazonaria tuberculata* (Plummer, 1927) - (Plate 1, figure 9)**

## 5. Paleogeography

The new members of the new genus *Lenticubella* have wide geographic distribution in the Northern Tethys (Poland): *L. irregularis* and *L. polonica* and Southern Tethys (Egypt): *L. kurkurensis* and *L. misrensis* (Figure 6). Many authors concluded that the extended realms of the Tethys, Mediterranean Sea, Indo-Pacific with Atlantic are connected during the Paleogene, and the fauna pronounced similarities (Adams, 1967; Haq and Aubry, 1978; Vrielynck et al., 1995; Arinobu et al., 2005). Another Late Paleocene genus and species *Lenticuzonaria* of Anan were recorded from two localities in the Southern Tethys: south Jordan and south Egypt (Anan, 2021). The Egyptian two new species *L. kurkurensis* and *L. misrensis* are recorded also from the same locality in the southern Egypt that yeilded *Lenticuzonaria misrensis* **(**Anan, 2021).


**Figure 6:** The present-day location map of Poland (in northern Europe) and Egypt (in the northern Africa).

## 6. Paleoenvironment

Boltovskoy suggests that poor nutrition cause, in most foraminifers, changes which consist in a general decrease in dimensions and poorer ornamentation (Boltovskoy, 1954). In some species (i.e. *Darbyella*) they evoke asymmetry. This cannot, however, explain anomalies, observed in lenticulins, since, as mentioned above, the loss of a symmetric plan of structure is primarily recorded in bulky individuals. Changes in salinity and temperature of water, in secretion of CaC03 and disturbances in a normal gaseous regime are also considered factors which may cause certain deviations. Changes in salinity and temperature of water, in secretion of CaC03 and disturbances in a normal gaseous regime are also considered factors which may cause certain deviations. Ali noted that the assemblages dominated by buliminids, *Lenticulina* spp., *Stainforthia* spp., mark increased trophic levels and dysoxic conditions (Ali, 2003). Warm humid climates with high rainfall and high runoff prevailed during the Late Campanian-Early Paleocene, while arid climatic conditions persisted during the Late Paleocene and Early Eocene. The investigated sedimentary sequence generally reflects a continuous deepening of the marine sedimentary system from Campanian/Maastrichtian to Paleocene times for the southern Egypt. This transgressive development was interrupted by several short-lived regressions of varying intensity. After the climax of the transgression during Late Paleocene time which caused open marine deposits (Garra Formation, with lenticulins), a fall in the sea level was recorded in Early Eocene time. A group researchers noted that the Midway-Type Fauna "MTF' are dominated throughout the Dababiya section (see figure 1), although deeper water Velasco-Type "VT" assemblage species are consistently present (Aubry et al., 2007). A group researchers noted that the reorganization of the Paleocene foraminiferal ecosystem in Zumaia section (Spain) possibly involved changes in the food flux to seafloor, thus triggering changes in the benthic foraminifera (Bernaola et al., 2007).

## 7. Conclusions

The paleontology, stratigraphy, and paleogeography of the four recorded Paleocene lenticulins species are presented. Three out of them are believed to be new: *Lenticubella polonica* from Poland, *L. kurkurensis* and *L. misrensis* from Egypt. New species, erected on the basis of the deviations of such type, would only slightly differ from each other, have only, so far, local significance and may have stratigraphic value. The unclosed number of Paleocene lenticulins species in different localities in the neighboring localities of Poland and Egypt may be due to lack of detailed studies, misidentification, land barriers, and/or another different paleoenvironmental conditions (i.e. low-food, depth, dissolved oxygen, salinity, temperatures). More detailed studies in the future may prove the existence of the recorded species in another localities in the Tethys.

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