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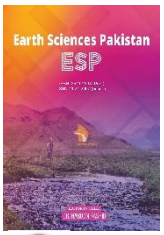

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RESEARCH ARTICLE

LEROYI: A NEW TETHYAN LAGENID BENTHIC FORAMINIFERAL GENUS

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ABSTRACT

Leroyi n. gen., is introduced to include the Cretaceous-Neogene (predominantly Maastrichtian-Eocene) benthic Lagenid foraminiferids from many Tethyan localities that characterized by its slightly coiled early portion of the smooth test, later slightly arcuate uniserial chambers increasing in length as added, oblique depressed sutures, aperture radial of dorsal angle. I suggest *Leroyi* as a new genus to accommodate foraminifera with these characters. This new genus have been previously assigned to *Marginulina* sp. C of LeRoy (1953), and here assigned as a genotype of the new genus. Four species were previously described from two localities in Egypt (Maqfi section, Farafra Oasis and Nekhl section, Sinai) are treated here as a new species of the new genus, and formally named as: *Leroyi aegyptiaca* Anan, n. sp., *L. maqfiensis* Anan, n. sp., *L. deserti* (Said & Kenawy, 1956), *L. ghorabi* (Said & Kenawy, 1956). One Tunisian species: *Leroyi tunisiana* Anan, n. sp. is added to these Egyptian species. Another European and American species: *Leroyi glabra* (d'Orbigny) is added to these Laginid group. These six species of the Lagenid new genus *Leroyi* are recorded in six localities in the Tethys (USA, France, Italy, Tunisia Egypt, UAE and India).

KEYWORDS

Benthic foraminifera, Lagenid, *Leroyi*, Cretaceous, Paleogene, Neogene, Tethys.

1. INTRODUCTION

Previously, some forms have been assigned to the genus *Marginulina* without an ornamented surface, e.g. *M. glabra*, *Marginulina* sp. C, *M.* sp. (Orbigny, 1826; LeRoy, 1953; Berggren and Aubert, 1975). However, due to the fact that the type of this genus *M. raphanus* previously been characterized by its ornamented ribs, among other characters, the assessment of these forms of d'Orbigny, LeRoy and Berggren and Aubert to this genus is not accepted. Different species of this genus sufficiently morphologically distinct to warrant assignment to another taxonomic Lagenid foraminiferal group. The new genus *Leroyi* differs, essentially from the genotype of the genus *Marginulina, M. raphanus*, by its mainly smooth surface, unornamented by prominent longitudinal costae (Orbigny, 1826).

The present study is mainly devoted to the systematic description of *Leroyi* n. gen., and other two related common and diverse Maastrichtian-Eocene species: *Leroyi aegyptiaca* Anan, n. sp. and *L. maqfiensis* Anan, n. sp., which have been recorded from diagnostic outcrop Maqfi section in the Farafra Oasis, Western Desert, Egypt (Figure 1). Another two species of the new genus are added: *L. deserti* and *L. ghorabi*, from other diagnostic Nekhl section in central Sinai of Egypt (Figure 1) (Said and Kenawy, 1956). Also, another two species: *Leroyi tunisiana* Anan from the Paleocene of Tunisia, as well as the other previously recorded species from the European and American Paleogene localities *Leroyi glabra* (d'Orbigny) are added to this genus. Finally, the objective of this study is to proposed a new genus *Leroyi* and assigns the *L. aegyptiaca* as the genotype of this new genus, besides another five species belong it: *L. maqfiensis, L. deserti, L. ghorabi, L. glabra* and *L. tunisiana*.

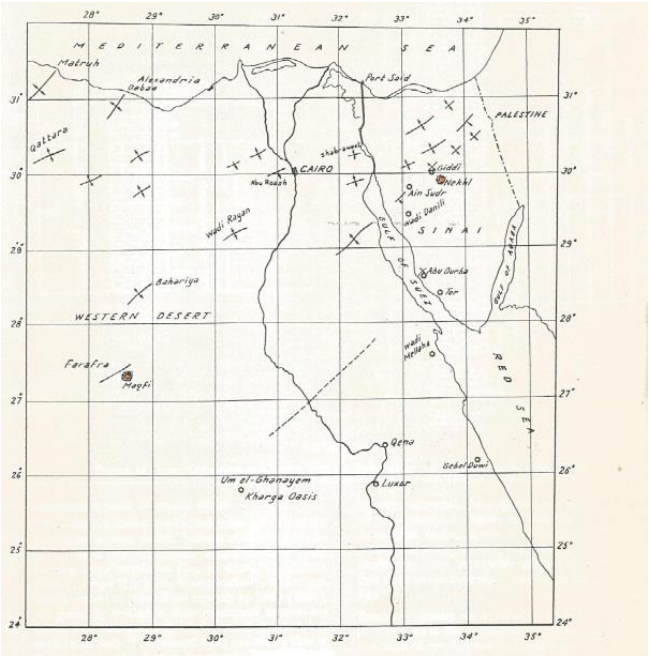

Figure 1: Map of Egypt showing location of section studied (Maqfi section and Nekhl section) in relation of the Syrian-swell structural trend (after Said & Kenawy, 1956)

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2. GEOLOGICAL SETTING

In the Late Cretaceous-Paleogene time, deep marine sediments were deposited in the north Egypt (north Lat. 27° N), whereas gradually becoming shallower and less thick southward to the coeval lithofacies predominated, as mentioned by many authors (LeRoy, 1953; Said and Kenawy, 1956; Issawi and Osman, 2000). LeRoy noted that in northern and central Egypt the Cretaceous deposits (chalks, limestone, shales) are more or less restricted to local structural uplift (LeRoy, 1953). Along the Farafra-Bahariya structural trend different stratigraphic levels of the Eocene are in juxtaposition with various stratigraphic portions of the Cretaceous, and the depositional idiosyncrasies are attributed to progressive Eocene overlap, and a disconformity between the Cretaceous (his A unit) and the Lower Tertiary (unit IV) in the Maqfi section, Farafra Oasis, Western Desert of Egypt (Figure 2). Said & Kenawy (1956) noted that the Maastrichtian outcrop is represented by the Chalk in the deeper Nekhl section, and the species of *Dentalina* and *Marginulina* seem to flourish. The lower Esna Shale unit (sample no.7) is characterized by the absence of *Globotruncana* species and by the presence of a flood of *Globigerina* species together with certain characteristic benthic species, as: *Bolivinoides delicatula, Neoflabellina suturalis, Stilostomella paleocenica, Nodosaria affinis* (Figure 3). Some researchers also noted that during the Cretaceous and Tertiary span of time, the land of Egypt witnessed many phases of transgressions and regressions of Tethys over a paleorelief (highs and lows of Syrian Arcs) by the syntectonic structures, which varied considerably from one place to other (Issawi and Osman, 2000). Lat. 28° N was considered by these authors to be detected the contact between the deep-water facies in the north and shallower in the south, detected that contact at nearly coincides around Lat. 27° N (Anan, 1987).

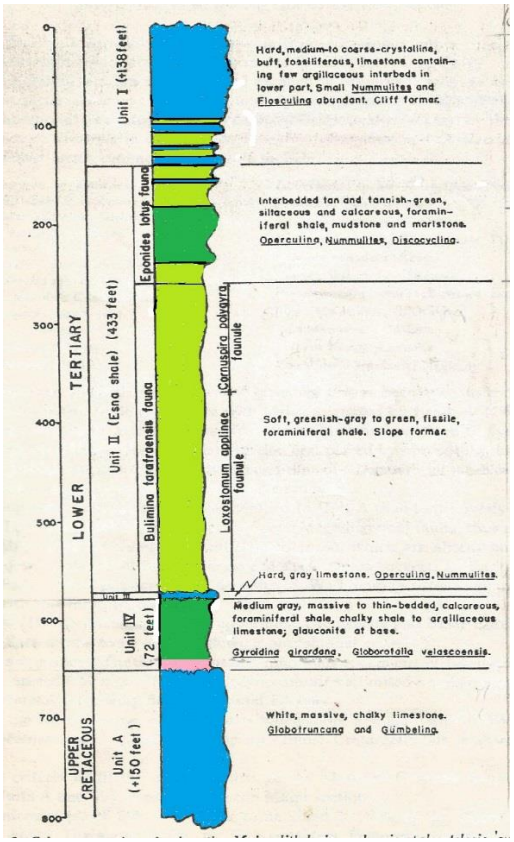

Figure 2: Columnar section of major lithologic and micropaleontological subdivisions of the Maqfi section, Farafra Oasis, Western Desert of Egypt (after LeRoy, 1953)

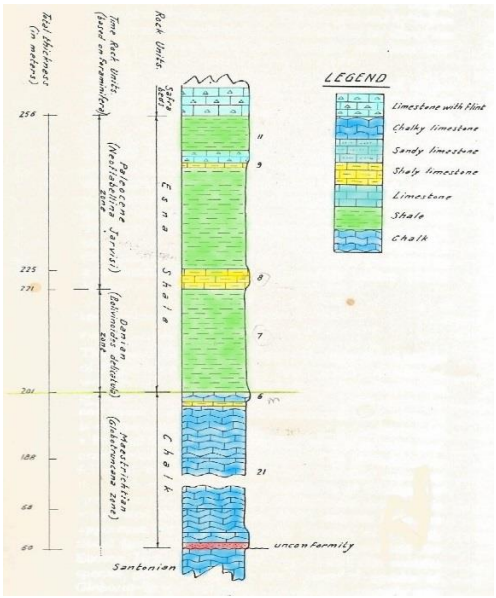

Figure 3: Columnar section showing the major subdivisions of the Nekhl section, northern Sinai, Egypt (after Said and Kenawy, 1956)

3. Faunal Discussion

Leroyi n. gen. has elongate slightly arcuate test, circular in section, early stage slightly coiled but not completely enrolled, later uniserial chambers gradually increased as added, sutures slightly oblique, wall calcareous hyaline radial, surface perforated, smooth without prominent longitudinal costae, aperture radiate, terminal at the dorsal angle and may be produced on a neck. *Leroyi* differs from the other related genus *Marginulina* by its smooth wall than ornamented costate surface (Orbigny, 1826). This morphological character looks-like the difference between the two genera: *Nodosaria* and *Pyramidulina* in smooth surface or existing ornamented surface, respectively, which both Lagenid benthic foraminiferal uniserial rectilinear genera (Lamarck, 1812; Fornasini, 1894). As treated the early portion of *Leroyi* and *Marginulina* are slightly coiled, but not completely enrolled as in *Marginulinopsis* (LoeSilvestri, 1904; Loeblich and Tappan, 1988). Both genera *Marginulina* and *Marginulinopsis* have prominent longitudinal costae surface, and both are arcuate tests, like the genus *Dentalina* (Risso, 1826).

4. Taxonomy

The taxonomy is followed here. *Leroyi* n. gen. is treated here to belong to Subfamily Marginulininae Wedekind (1937) of the Lagenid Family Vaginulinidae Reuss (1860). Six species belong to this genus are illustrated in Plate 1 (Loeblich and Tappan, 1988).

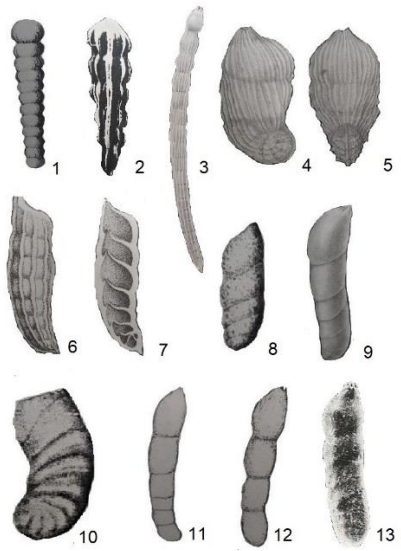

Plate: 1. Micrographs of selected benthic foraminiferal genera and species that used in this study: **1**. the genotype of genus *Nodosaria* Lamarck (1812) x 19, **2**. the genotype of the genus *Pyramidulina* Fornasini (1894) x 18, **3**. the genotype of the genus *Dentalina* Risso (1826) x 10, **4**, **5**. *Marginulinopsis bradyi* (Goës, 1894), side and front views x 24, **6, 7**. *Marginulina raphanus* d'Orbigny (1826) x 33, side view and longitudinal section, **8**. the genotype and the holotype of *Leroyi aegyptiaca* Anan, n. gen. and n. sp. x 45, **9**. *Leroyi glabra* (d'Orbigny, 1826), side view x 33, **10**. *Leroyi maqfiensis* Anan, n. sp. x 41, **11**. *Leroyi deserti* (Said and Kenawy, 1956) x 37, **12**. *Leroyi ghorabi* (Said and Kenawy, 1956) x 78., **13**. *Leroyi tunisiana* Anan, n. sp. x 30.

Order Foraminiferida Eichwald, 1830
Suborder Lagenina Delage & Hérouard, 1896
Superfamily Nodosariacea Ehrenberg, 1838
Family Vaginulinidae Reuss, 1860
Subfamily Marginulininae Wedekind, 1937
Genus: *Leroyi* Anan, n. gen.
Type species: *Leroyi aegyptiaca* Anan, n. sp.
Etymology: In the honor of American micropaleontologist L.W. LeRoy.
Holotype: The specimen illustrated here Pl.1, fig. 8.
Type Locality: Maqfi section, Farafra Oasis, W. Desert, Egypt.
Age: Maastrichtian-Eocene.
Occurrence: In Maqfi section, and Nekhl section in northern Sinai, Egypt, as well as Tunisia, Europe and USA.
Diagnosis: It has elongate arcuate calcareous hyaline test, early stage slightly curved but not completely enrolled, later uniserial chambers inflated increasing in length as added, sutures slightly oblique, aperture radiate, terminal at the dorsal angle and may be produced on a neck.

Leroyi aegyptiaca Anan, n. sp. – (Pl. 1, fig. 8)
1953 *Marginulina* sp. - C LeRoy, p. 38, pl. 8, fig. 8.

Holotype: Illustrated specimen in Pl. 1, fig. 8 x 45.
Diameter: Length 0.54 mm, width o.17 mm.
Depository: Cushman collection No. 58055, USA.
Etymology: After the Arab Republic of Egypt.
Type locality and level: Fcr-59 (Unit II), Maqfi section, Farafra Oasis, W. Desert, Egypt.
Age: Late Paleocene-Early Eocene (after Berggren & Aubert, 1975), or Early Eocene (after Hewaidy & Strougo, 2001). According to Berggren & Aubert (1975, p. 110) the Lower Paleocene is absent in Maqfi section, and the lowest beds of Esna Shale being in the *P. pseudomenardii* Zone (P4, after Berggren & Pearson, 2005).
Diagnosis: Test small, early coiled stage minute indistinct, later uniserial four chambers inflated increasing in length as added, sutures slightly depressed and moderately oblique, peripheral margins rounded, surface smooth, aperture radiate extended at dorsal angel.
Remarks: The Early Eocene *Leroyi aegyptiaca* new species differs from the Maastrichtian-Pliocene *L. glabra* (d'Orbigny, 1826) by its smaller size and number of the uniserial chambers, more lobulate periphery, more perforate test, and different stratigraphic age.

Leroyi glabra (d'Orbigny, 1826) – (Pl. 1, fig. 9)
1826 *Marginulina glabra* d'Orbigny, p. 259, pl. 6, fig. 55.
1927 *Marginulina glabra* d'Orbigny - Plummer, p. 104, pl. 6, fig. 3.
1951 *Marginulina glabra* d'Orbigny - Cushman, p. 18, pl. 5, figs. 25-27.
1975 *Marginulina glabra* d'Orbigny - Braga & Grünig, p. 105.
1998 *Marginulina glabra* d'Orbigny - Carboni & Palagi, p. 56, pl.2, fig. 6.
2019 *Marginulina glabra* d'Orbigny - Venkatachalapthy & Harini, p. 107.

Remarks: Plummer (1927) described the species *glabra* d'Orbigny as slightly curved, bluntly rounded at the base with smooth surface and slightly depressed, aperture radiate and protruding. Cushman (1944) noted that the genotype of this taxa is characterized by generally rounded section, somewhat coiled in the early portion. As noted before, the early portion of *Leroyi* and *Marginulina* slightly coiled but not completely enrolled, but the new genus *Leroyi* has smooth surface, while the other genus *Marginulina* has prominent longitudinal costae. This Cretaceous-Pliocene species is marked by the close incoiling of the first few smooth chambers. It was recorded, so far, from USA, Europe and India.

Leroyi maqfiensis Anan, n. sp. - (Pl. 1, fig. 10)
1953 *Marginulina* sp. - D LeRoy, p. 39, pl. 10, fig. 24.

Holotype: Illustrated specimen in Pl. 1, fig. 10 x 41.
Diameter: Length 0.74 mm, width 0.33 mm.
Depository: Cushman collection No. 58110, USA.
Etymology: After the Maqfi section, Farafra Oasis, Western Desert, Egypt.
Type locality and level: Fcr-21 (Unit A), Maqfi section, Farafra Oasis, Western Desert, Egypt.
Age: Maastrichtian (after Berggren & Aubert, 1975 and Hewaidy & Strougo, 2001).
Diagnosis: Test large, coiled early portion and uncoiled later portion, six chambers at least increasing in size very slightly as added, sutures slightly curved, dorsal periphery subacute, ventral margin concave, wall smooth, aperture radiate at outer periphery angle.
Remarks: *Leroyi maqfiensis* n. sp. differs from *M. aegyptiaca* n. sp. by its larger test size and larger uniserial chamber numbers (six than four).

Leroyi deserti (Said & Kenawy, 1956) – (Pl. 1, fig. 11)
1956 *Marginulinopsis deserti* Said & Kenawy, p. 132, pl. 2, fig. 23.

Diameter: Length 0.8 mm, breadth 0.2 mm.
Type locality and level: Sample no. 6, Chalk of Nekhl section, Sinai, Egypt.
Age: Maastrichtian.
Depository: U.S.N.M. P4019, USA.
Diagnosis: Test elongate, early coiled partly coiled, rapidly becoming inflated uniserial uncoiled increasing gradually toward the apertural end, dorsal margin concave, wall smooth, sutures depressed, aperture radiate slightly toward the dorsal end.
Remarks: It is recognized by its slender smooth elongate test, slightly inflated and elongate uniserial chambers.

Leroyi ghorabi (Said & Kenawy, 1956) – (Pl. 1, fig. 12)
1956 *Dentalina ghorabi* Said & Kenawy, p. 133, pl. 2, fig. 25.
1993 *Dentalina ghorabi* Said & Kenawy - Anan, p. 657.
2012 *Dentalinoides ghorabi* (Said & Kenawy) - Anan, p. 22, pl. 1, fig. 10.

Diameter: Length 2 mm, breadth 0.4 mm.

Type locality and level: Samples nos. 6 (Chalk), 7 (Esna Shale), Nekhl section, Sinai, Egypt.
Ag: Maastrichtian-Danian.
Depository: U.S.N.M. P4023, USA.
Diagnosis: Test elongate, slightly arcuate, initial end not pointed, uniserial portion increasing in length as added, sutures slightly oblique, wall smooth.
Remarks: This species is distinguished by its few inflated uniserial chambers, and its blunt initial end. It was recorded from Egypt and United Arab Emirates (UAE).

Leroyi tunisiana Anan, n. sp. – (Pl. 1, fig. 13)
1975 *Marginulina* sp. - Berggren & Aubert, p. 177, pl. 16, fig. 1.

Holotype: Illustrated specimen in Pl. 1, fig. 13 x 30.
Diameter: Length 0.70 mm, width 0.18 mm.
Depository: The collection of Berggren & Aubert.
Etymology: After the Republic of Tunisia.
Type locality: Tunisia "Midway" association, zone P4-P5.
Age: Paleocene.
Diagnosis: Test smooth large, early portion slightly coiled, later uniserial rectilinear, sutures slightly oblique and depressed, aperture radiate at the dorsal side angle produced on neck.
Remarks: The Paleocene Tunisian figured specimen *Marginulina* sp. of Berggren & Aubert (1975) resembles the Egyptian Maastrichtian species *Leroyi aegyptiaca* of Anan, but differs by its more elongate test, less lobulate periphery and protrude aperture.

5. Paleogeography

The representatives of the new genus *Leroyi* Anan have wide geographic distributed in the Tethys, from west to east: North America, Europe, north Africa and south Asia (Figure 4). Four species are confined to Egypt: *Leroyi aegyptiaca* Anan, n. gen., n. sp., *L. maqfiensis* Anan, n. sp., *L. deserti*, *L. ghorabi* (Said and Kenawy, 1956). One species is recorded from Tunisia *Leroyi tunisiana* Anan, n. sp. Another species *Leroyi glabra* was previously recorded in USA, Europe (France, Italy) and India, but under another taxonomy as *Marginulina glabra*.

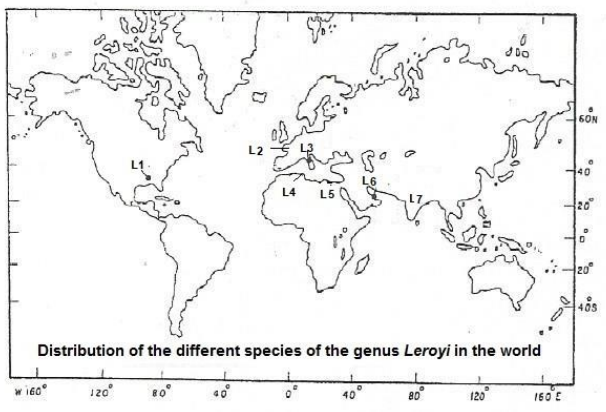

Figure 4. Paleogeographic distributions of the different species of the genus *Leroyi* in the world: A1: USA, A2: France, A3: Italy (*L. glabra*), A4: Tunisia (*L. tunisiana*), A5: Egypt (*L. aegyptiaca, L. maqfiensis, L. deserti, L. ghorabi*), A6: UAE (*L. ghorabi*), A7: India (*L. glabra*).

6. Paleoecology and Paleobathymetry

LeRoy noted that in certain respects the microfauna of the Esna Shale of Egypt exhibits an affinity with the Paleocene Midway Type fauna (MTF) assemblages of the United States Gulf Coast area (LeRoy, 1953). Some researcher described more than twenty hundreds of foraminifera species from the Maastrichtian-Paleogene of the northern Sinai, Egypt (Said and Kenawy, 1956). Berggren and Aubert noted that the Paleogene of these Egyptian fauna shows an affinity with the MTF (middle-outer neritic environment (50-200 m) (Berggren and Aubert, 1975). Anan & Hewaidy considered the Nile Valley Facies is related to the MTF (Anan and Hewaidy, 1986). It means that most northern and central Egypt, according to these authors, shows an affinity with the MTF, middle-outer neritic environment (50-200 m). Anan (2011) noted that the probable environment for Sinai, Egypt is outer neritic-upper bathyal (200-400 m), which it deeper than the other sites in Egypt: Farafra-Bahariya area (Maqfi section) and Nile Valley in central Egypt (Duwi section), which are deposited in the middle-outer neritic environment (75-200 m).

7. Conclusions

The present study deals with the recording of six identified species of the Lagenid genus *Leroyi* in six localities in the Tethys (USA, France, Italy, Tunisia Egypt, UAE and India): *Leroyi aegyptiaca*, *L. maqfiensis* and *L. tunisiana*, *L. deserti, L. ghorabi, L. glabra.* The first three out of these species are believed to be new. Four out of these species *Leroyi aegyptiaca*, *L. maqfiensis, L. deserti* and *L. ghorabi* are confined, so far, in Egypt. *Leroyi tunisiana* is confined in Tunisia, while *L. glabra* was recorded in a wide geographical distribution in USA, two localities in Europe (France and Italy), and also in India. Most of these identified species shows an affinity with the MTF middle-outer neritic environment (50-200 m) to outer neritic-upper bathyal (200-400 m) of Sinai species. The existence of marked differences between the number of recorded benthic Lagenid species in respect with this study may be due to one or more of the following reasons: (a) less homogeneity in the generic or species concept between the different authors, (b) the differences in the paleoenvironmental conditions i.e.: depth, water temperature, salinity, nutrients, dissolved oxygen, land barrier, climate etc., (c) the deficiency of available literatures, (d) significant episodes of tectonic activities in combinations with lowering sea-level in many stratigraphic horizons around the world during the Maastrichtian and Paleogene.

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