

**Review of the Foraminiferal Genus *Marginulinopsis* Silvestri, 1904 to identify the *Wignallyi* new Genus**

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**Abstract:** The benthonic foraminiferal genus *Wignallyi* n. gen., of the Family Vaginulinidae Reuss, 1860 from the Late Middle Eocene of Northeast Beni Suef area, Nile Valley, Egypt is described based on scanning electron microscope (SEM) studied of the inner and outer structure and ultrastructure of the shell walls of some *Marginulinopsis* species. The *Wignallyi* n. gen. shows close relationship to the genus *Marginulinopsis* (Silvestri, 1904) from which it differs in possessing two lamellar canaliculate wall structures. It accommodates a lineage which is characterized by longitudinal costae that only cover the latest chambers in their uncoiled stage. In addition, *Wignallyi* n. genus is characterized by having a globular chamber in the uncoiled stage with depressed sutures, and an aperture situated on the central part of the last chamber.

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**Keywords:** Foraminifera, systematic, new genus, late middle Eocene, Egypt.

**1. Introduction**

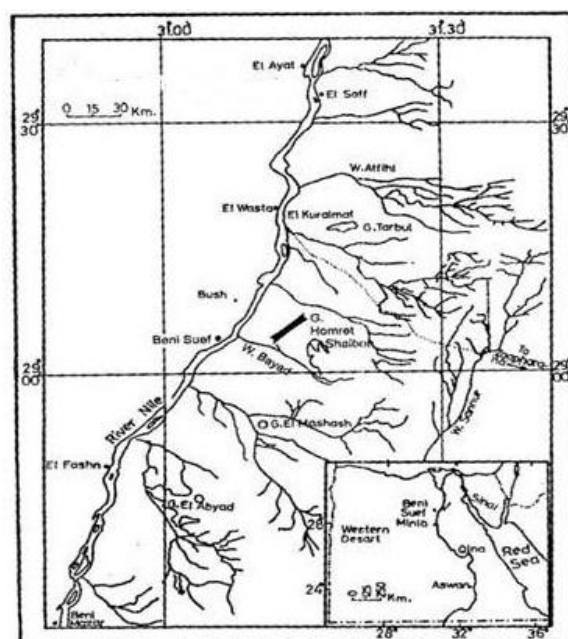
The *Marginulinopsis* genus of Silvestri (1904) is a well-known and stratigraphically important taxon. It's widely distributed and obtained from various parts of the World. It has been recorded from north Atlantic, at depth from 370 fathoms to 1240 fathoms; from south Atlantic at greater depth; from Mediterranean and from the Adriatic (Brady, 1884, p. 528); from Trinidad by Bolli et al. 1994 and from Slovenia by Cimerman et al. 2006. Also, it has been recorded in Egypt by; Nakkady, 1950, Le Roy 1953; Ansary, 1955; Aly et al. 2011 and others. Some of the foraminiferal species under this genus name sufficiently morphologically distinct to warrant assignment to another genus as in Text-figure A. This study proposes a new genus and assigns some of *Marginulinopsis* species to this new taxon based on the morphological characters, inner and outer shell structure and shell wall ultrastructure.

**2. Materials and Methods**

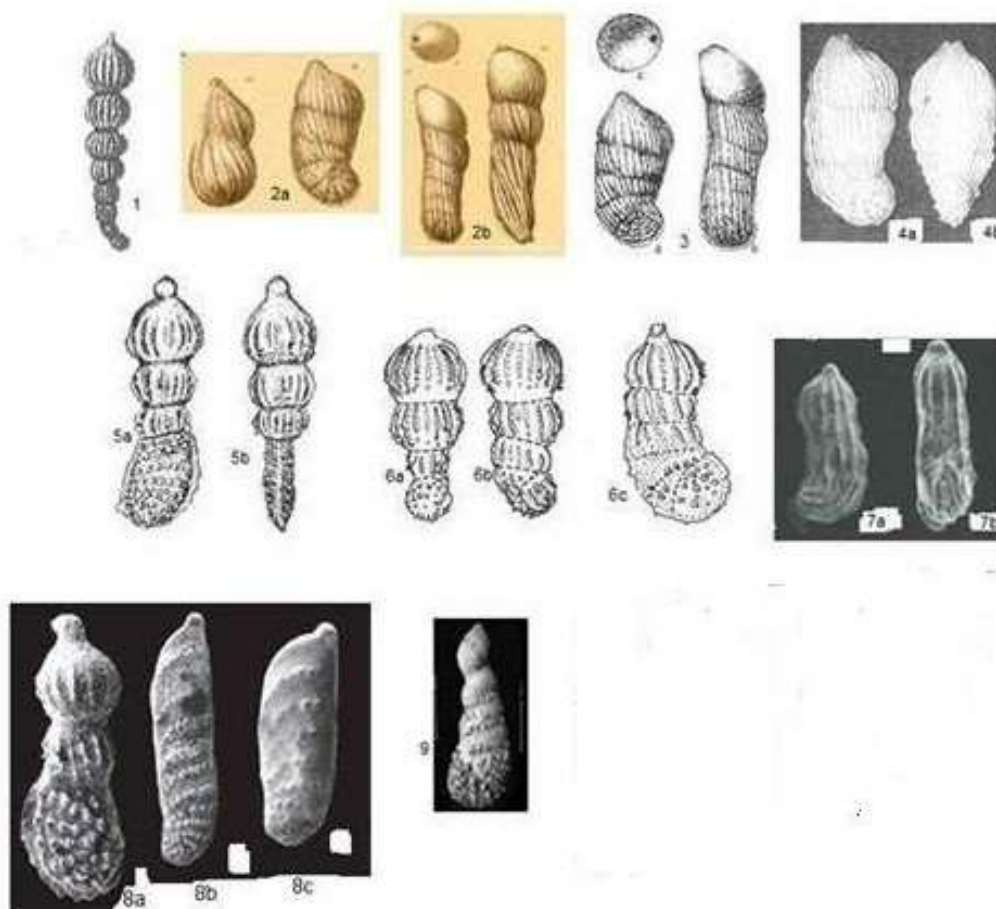
A total of twenty eight rock samples from El Fashn formation, Beni Suef, Nile Valley, Egypt (collected in 2004) and prepared in the geology lab, Beni Suef University to benthic foraminiferal studies, that picked samples were kindly provided by Dr. Abd El Gaied and Dr. Abdel-Aziz, to home the author is deeply thankful. The benthic foraminiferal studied it has been published in 2011.

For this study about 6 specimens of *Marginulinopsis* species were selected from North Gunna section, Western Desert, Egypt for the author's Ph.D. in 2001 and about hundred individuals of

*Wignallyi* benthic foraminiferal specimens were selected from El Fashn Formation (Late Middle Eocene). The light microscope studies and the photographed by scanning electron microscope it has been done at the School of Earth and Environments, Leeds University, United Kingdom. Type specimens of *Wignallyi* new genus are located at the University of California Museum of Paleontology (UCMP), United States of America under numbers (UCMP 11494.1) to (UCMP 11494.14).



**Text-figure A:** Location map of the studied section (after Aly *et al.* 2011).



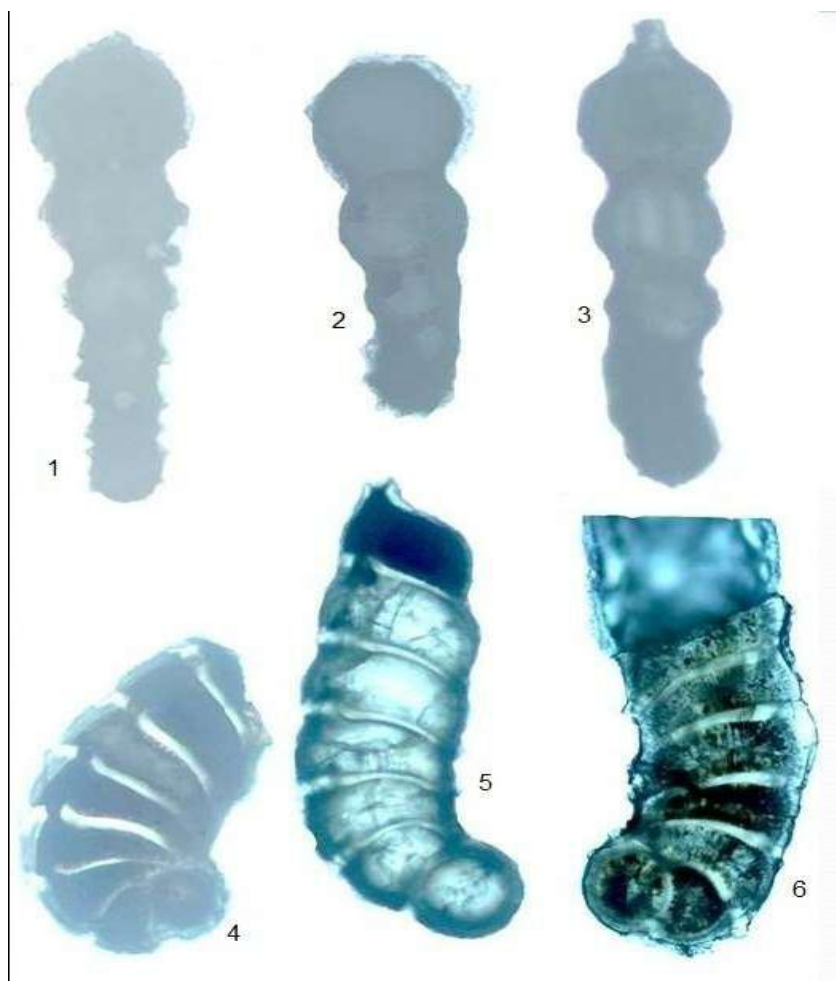
**Text-figure 1: Original illustration of the different morphological characters of genus *Marginulinopsis***

1. *Cristellaria behmi* Reuss (1866), 2a, b *Marginulina costata* Batch in Brady (1884), 3a-c *Marginulinopsis densicostata* Thalmann (1937), 4a, b *Marginulinopsis bradyi* (Goes) in Loeblich and Tappan (1988), 5a, b *Marginulinopsis infracompressa* Thalmann (1937), 6a-c *Marginulina behmi* (Reuss) van Klaus Gohrbandt, 1961 7a, b *Marginulinopsis curvisepta* (Cushman and Gohrbandt) in Bolli et al. (1994), 8 *Marginulinopsis behmi* (Reuss) Cimermann (2006), 9 *Marginulinopsis tuberculata* (Plummer, 1927).

### 3. Discussion

The *Marginulinopsis* genus Silvestri, 1904 first reported as *Nautilus (Orthoceras) costatus* by Batsch 1791; Reuss (1866, pl. 2, fig. 37) identified a *Cristellaria behmi* as a new species (Text-figure 1; 1); Brady 1884 renamed a *Cristellaria behmi* (Reuss) to *Marginulina costata*; Plummer 1927, identified a *Marginulinopsis tuberculata* characterized by planispiral at early stage, sutures raised, covered by tubercles and aperture is periphery. This species was recorded by many authors in Egypt such as; Anan (1994, p. 222, fig. 8; 10, 11), El Deep and El Gammal (1994, pl. 1, fig. 17), Hewaidy (1994, fig. 12; 3) and Ismail (1996, p. 207, fig. 5; 16); Thalmann (1937, p. 355, pl. 21, figure 2) renamed the Batsch's species cited by Brady (1884) a *Marginulinopsis densicostata* (Text-figure 1; 3); Thalmann defined in the same paper (p. 356, pl. 23, fig. 2) *Marginulinopsis infracompressa*

(Text-figure 1; 5a, b) as a new species, that is differs from *M. densicostata* in having its early stage is covered by tubercles instead of ribs and the aperture situated in the center of last chamber; Gohrbandt (1961, p. 69, pl. 1, figs. 11, 12) included *Cristellaria behmi* Reuss (1866) (Text-figure 1; 6a-c) as a form of the *Marginulina behmi* (Reuss); Loeblich and Tappan (1988, p. 406) considered the specimens of Brady (1884) as the lectotype for *Cristellaria bradyi* Goes (1894) and used that as a type species for the *Marginulinopsis* genus. Bolli et al. (1994, p. 111, figs. 29.25-31 & 30. 1-5) cited six different species of genus *Marginulinopsis*, in which three species of them (*Marginulinopsis curvisepta* Cushman & Goudkoff, *M. multicostata* Lipnik and *M. praetschoppi* Trujillo) have their surfaces covered by well-developed longitudinal costae.



**Text-figure 2**

Thin section photos by the light microscope shows the effect of the light on *Wignallyi* n. gen. (1-3) and the *Marginulinopsis* genus (4-6). The first looks like dark, chambers are globular and the second is shiny-smooth, its sutures lighter than its chambers.

The others three species are (*Marginulinopsis cephalotes* (Reuss), *M. lituola* (Reuss) and *M. subrecta* (Frank) characterized by their chambers are smooth. Cimerman et al. (2006, p. 24, pl. 5, figs.1-3) figured two species as a *Marginulinopsis* in which one of them (*Marginulinopsis behmi* (Reuss) have its shape of chambers in later stage are globular, sutures depressed and the aperture is situated in the central part of last formed chamber (Text-figure 1; 8a). On the other hand, the other species is (*Marginulinopsis provaensis* (Hantken) is distinguished by its shape of chambers are cylindrical, smooth, sutures beaded tubercles, raised, and its aperture is marginal (TEXT-FIGURE 1; 8b, c).

Le Roy (1953, p. 39, pl. 4, figs. 5, 7) described an unknown species as *Marginulinopsis* sp. the current author believes it to be closer in its morphology to *Marginulinopsis tuberculata* (Plummer, 1927). Le Roy (1953) emphasize that his *Marginulinopsis* sp.

characterized by coiled early stage, uncoiled late stage, sutures gently curved with numerous well defined nodes and he couldn't recognized the aperture details due to his form was broken; Ansary (1955, p. 38, pl. 2, fig. 29) renamed the Thalmann's *Marginulinopsis infracompresa* to *Marginulina infracompresa*; Aly et al. (2011, p. 92, pl. 3, figs 2) identified a *Marginulinopsis hewaityi* as a new species based on the presence of longitudinal costae.

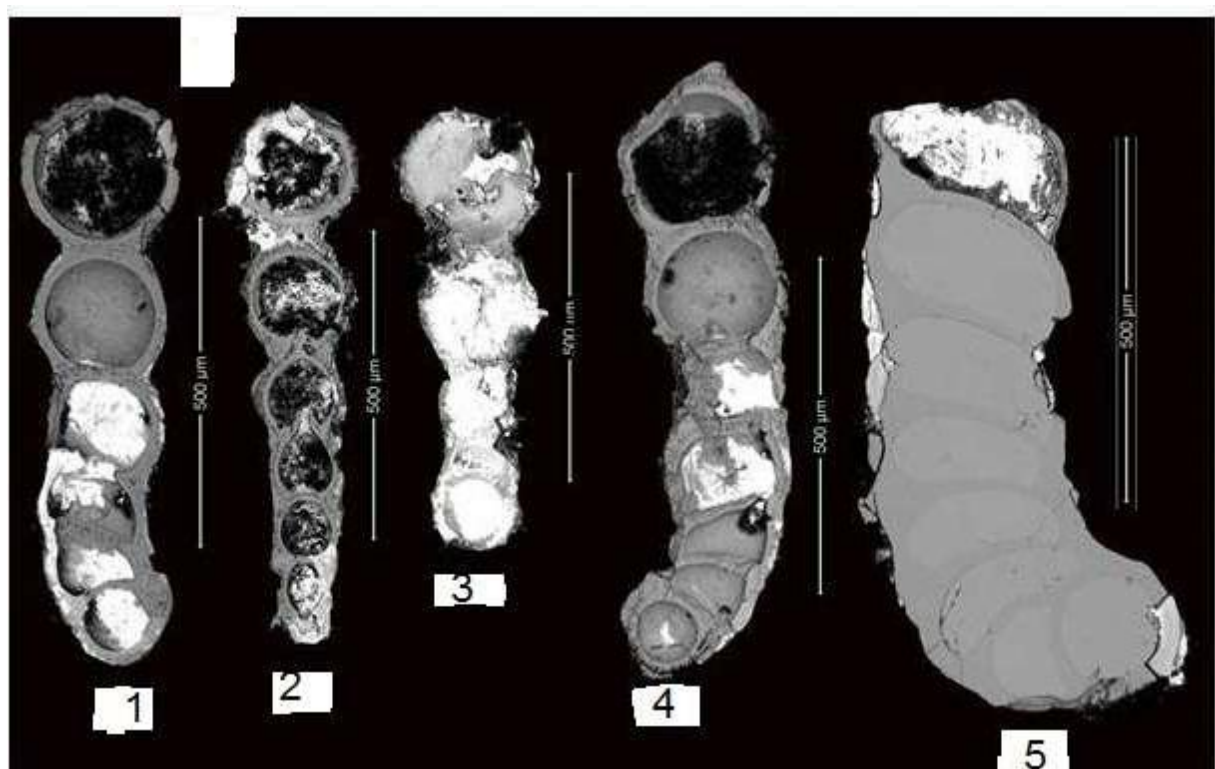
#### 4. Results

The differences between the *Wignally* new genus and *Marginulinopsis* (Silvestri, 1904) are seen in the morphology and ultrastructure of the wall and aperture. The morphologically distinct specimens in (Text-figure 1) have been divided into two groups; the first is group A includes specimens attributable to *Marginulinopsis* figures (2, 3, 4, and 7). These groups is characterized by; early stage planispiral or closed



coil, later stage uncoiled, chambers numerous in late stage, flattened, cylindrical, tapered, sutures slightly depressed, curved, whole test ornamented by costeae or ribs, aperture is periphery. The second is group B includes specimens belonging to *Wignallyi* figures (5, 6, 8a and all figures in plates 1-3). This group is characterized by; early stage closed coil (not

planispiral), chambers indistinct in early stage, later stage uncoiled, chambers globular, suture wide, depressed, horizontal, early stage ornamented by tubercles, chambers in late stage ornamented by costeae or ribs not covered the suture lines, aperture is situated at the central part of last formed chambers.



**Text-figure 3**

Thin section under the Electronic Scanning Microscope photos shows the microspheric (2) and the megalospheric (3) forms for the *Wignallyi* n. gen. also, early chambers in *Wignallyi* n. gen.

The most distinct features of genus *Marginulinopsis* is the presence of the superficial longitudinal costate or ribs (number and degree). Careful examination of these costeae show that are distributed to cover a whole test (including early portion, late stage, suture lines and the aperture) in group A. In contrast, that costeae excludes the early portion, suture lines, and the aperture to cover only the latest chambers in group B. In addition, the early stage of the shell is planispiral or closed coil, that ornamented by costeae or ribs in group A. the early stage of the shell in group B usually closed coil, covered by well-defined raised nodes or tubercles and vary in length from  $\frac{1}{3}$  or less (Pl. 3, fig. 1) to  $\frac{1}{2}$  or slightly more of the whole of test (Pl. 3, fig. 9a).

Besides, the aperture in group A is marginal, radial, short necked and covered by costeae or ribs (Text-figure 1; 2, 3 and 4) or smooth as in (Text-figure 1; 9). While the aperture in group B is situated on the

central part of last formed chamber and is usually has a long cylindrical apertural neck (Pl.3 3, figs. 1a, b, 5, 6a, b, 8, 9a, b). The outer surface is smooth in some forams (Pl. 3, figs. 9a, b) or ornamented with pustules, fine granules, perforate (Pl. 3, figs. 1a, b, 4, 8), nodes or spinose (Pl. 3, figs. 5, 6a, b) in some other forms.

Another diagnostics features is shape of chambers in both foraminiferal groups. Chambers in group A is moderately distinct in early portion and became more clearly defined in the later uncoiled stage. They display a rectangular shape in side view (Text-figure 1; 2, 3, 4, 7, 10, Text-figure 2; 4-6 and Text-figure 3; 5) and triangular or oval appearance in a transverse section and a greater width than height. (Pl. 1, fig. 1). The chambers in group B are undifferentiated in early portion (pl. 3, all figures except 1b, 6b, 9b) and became clearly differentiated globular or spherical forms in the uncoiled stage (Text-figure 2; 1-3, pl. 3 all figures) with rounded

outline in transverse section. The chambers in that part are broad than higher (Pl. 1, fig. 4 and pl. 3, figs. 1b, 5, 6a, b).

The outer surface of the chambers wall in group A is covered by numerous longitudinal costae that are slightly oblique on the borders but its straight and vertical on the ventral periphery (Text-figure 1; 2, 3, 4, 7). The pore openings are rare and can be seen under 200  $\mu$  magnifications by ESM (Pl. 1, fig. 1). Under a light microscope the outer surface of the chambers is smooth with hyaline appearance (Text-figure 2; 4-6). In group B the outer surface of the chambers wall covered by discontinuous longitudinal costae with internal smooth or rough granular texture. These costae does not cover the entire test surface (pl. 3, all figures), its surface may be smooth (Pl. 3, figs 1a, 3, 7, 9a, b, 10 and 11), or perforate (Pl. 3, fig 12), slightly pustules in last chambers (Pl. 3, fig. 1b). In some forams, the last chambers and the aperture are distinguished by existence of nodes (Pl. 3, figs. 5, 6a, b). Under the light microscope the outer surface of the chambers in group B looks rough, dark, and granular (Text-figure 2; 1-3).

The suture lines in group A are slightly depressed, straight or curved that covered by costae or ribs (Text-figure 1; 2, 3, 4, 7) with a shiny appearance under light microscope (Text-figure 2; 4-6). In group B sutures are wide, depressed, horizontal, smooth (Text-figure 1; 5, 6, 8 and Pl. 3, figs. 2-4, 7, 8, 11).

The shell periphery is various from its rounded to carinate in its early portion in group A to keeled or spinose in group B (Pl. 3, figs. 1-4, 5, 6a, 9a, 10, 12).

### Wall ultrastructure

Transverse breaks of the shell wall of both *Marginulinopsis* genus (group A) (Pl. 2, figs. 1-3) and *Wignallyi* new genus (group B) (pl. 2, figs. 4-6) and their surface aperture also provide other means of differentiation between these forams. The shell wall in group A consist of long, opaque, radial calcite crystal that extend along the thickness of the wall (Pl. 1, figs. 2, 3). The crystals are volumetric size. The shell wall of group B consists of small, sub prismatic calcite crystals with some small sand grain; the calcite crystals are arranged in two layers, from inner to outer layer and obverse (Pl. 1, figs. 4, 5). The crystals are different in size and shape, canaliculate (Pl. 2, fig. 5). The inner shell of group B is characterized by its highly pore spaces between the calcite crystals. Closer the examination of the specimens under higher magnification about 5 $\mu$  shows these opening pores are situated in the depression between the crystals (Pl. 1,

fig. 6). It is possible to see of coccolithophorid shell attached to the calcite crystals (Pl. 1, fig. 6). Some of the holes are deep with circular outline can penetrate the shell wall (pl. 3, figs. 2, 3) which could be interpreted as perdition activity.

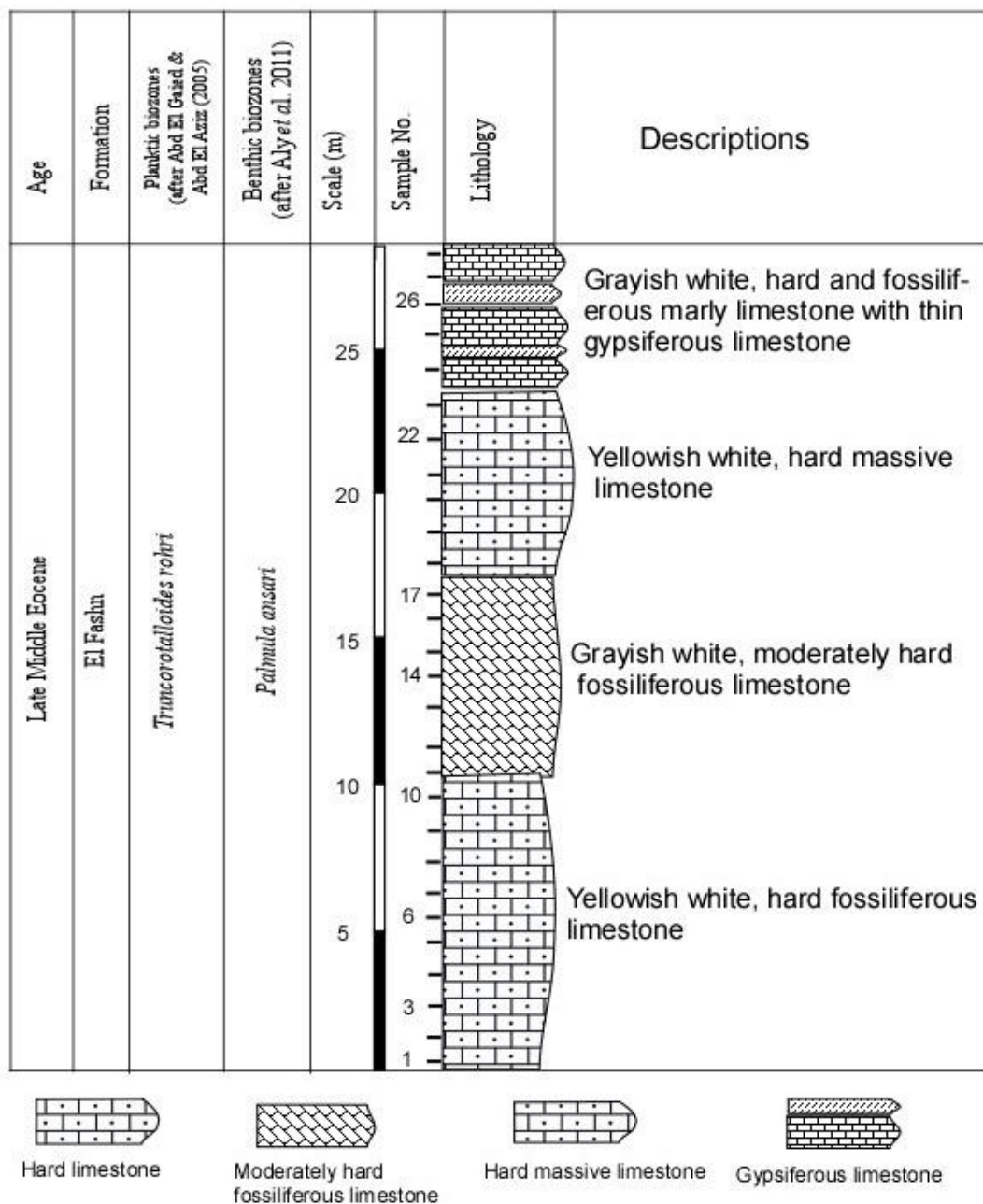
The above mentioned discussion indicates that group A is easily distinguished from group B because of the variation in their morphological features such as; early stage, shape of chambers, sutures line, ornamentation, apertural shape and position, in addition to the ultrastructure of wall and aperture. The author believes that these morphological differences necessitate the group B is to be regarded to a new genus *Wignallyi* in this case. In addition group A is typically represents the *Marginulinopsis* genus as it was described by Loeblich and Tappan (1988, p. 406).

The *Wignallyi* forams are represented by microspheric and megalospheric generations (Text-figure 3; 2, 3, pl. 3, figs 5, 6a, 9a, 10, 11). The microspheric shells are longer and more slender with a U-shaped. Attaining six to eight chambers, the test appears under thin section with smaller and narrower initial chambers, (Text-figure 3; 2). The megalospheric shells are shorter with less total chamber's number (about four), slightly widening towards the aperture's face with rounded base that have big and rather wide initial chambers (Text-figure 3; 3).

### Stratigraphy

The Middle Eocene succession in northeast Beni Suef area, Nile Valley, Egypt consists of in chronologic order, the Qarara Formation, El Fashn Formation and Beni Suef Formation. The measured part of El Fashn Formation at Bayad El Arab section is about 28 m (Text-figure 4) with unexposed base. El Fashn Formation is composed of mainly of yellowish to grey white, moderately hard fossiliferous limestone, intercalated with yellowish white fossiliferous marls. The limestone is well-bioturbated and contains abundant bivalves and echinoids skeletons near the base. Abdel El Gaied and Abd El Aziz (2005) assigned a Late Middle Eocene age for El Fashn Formation based on the presence of the *Turborotalia pseudoampliapertura*- *Truncorotaloides rohri* planktic foraminiferal zone (P15).

Aly *et al.*, (2011) identified the benthic *Bulimina jacksonensis*-*Uvigerina jacksonensis* assemblage Zone from El Fashn Formation and regarded that is equivalent to the *Turborotalia pseudoampliapertura* - *Truncorotaloides rohri* (P15) planktic foraminiferal zone.



**Text-Figure 4:** Lithostratigraphy, description of lithology of El Fashn Formation of the studied section.

#### Systematic

The classification of Loeblich and Tappan (1988) has been used for the taxonomic rank.

Suborder **Lagenina** Delage & Hérourad, 1896.

Superfamily **Nodosariacea** Ehrenberg, 1838.

Family **Vaginulinidae** Reuss, 1860.

Subfamily **Marginulininae** Wedekind, 1937.

Genus **Wignallyi** Alyn. gen.

**Type species:** *Marginulinopsis infracompresa* Thalmann, 1937.

**Etymology:** The name is dedicated to Paul Wignall Professor of Palaeoenvironments, Leeds University, United Kingdom.

**Material:** About 100 individuals from twenty eight rock samples that were collected from El Fashn Formation, Nile Valley, Egypt.

**Holotype:** The specimens illustrated here (pl. 3, fig 5).

**Paratype:** The specimens illustrated here (pl. 3, fig. 6a).

**Type locality:** Bayad Al Arab section, Beni Suef area, Nile Valley, Egypt.

**Occurrence:** *Wignallyi* n. gen. is abundant in El Fashn Formation, Nile Valley, Egypt.

**Age:** Late Middle Eocene.

**Diagnosis:** Test elongate, closed coil then uniserial, chambers in later stage is ornamented by discontinuous longitudinal costae or ribs extend over the suture lines. Sutures horizontal, depressed. Periphery keeled in early stage, lobulate in the later stage. Aperture single, rounded, terminal, situated in centrally on the last formed chamber. wall calcareous, perforate.

**Description:** Test free, elongate, early stage closed coil (not planispiral), slightly curved (Pl. 3, fig. 1a) to straight (Pl. 3, fig. 6a) but not completely enrolled when it's curved, compressed, sharply keeled (Pl. 3, fig. 9a). Suture indistinct, ornamented by short, raised nodes (Pl. 3, figs. 1a, 2, 3, 4). Chambers indistinct. The length of the early portion ranges from approximately less than  $\frac{1}{4}$  (Pl. 3, fig. 1a) to slightly more than  $\frac{1}{2}$  the whole test (pl. 3, fig. 9a). The uniserial stage curved (Pl. 3, figs. 8, 9a, 10) to rectilinear (Pl. 3, fig. 6a). Latest chambers spherical (Pl. 3, figs. 5, 6a) to globular (Pl. 3, figs. 1, 7, 9), rounded in section (Pl. 1, fig. 4), ranges from slightly increase in size as added (Pl. 3, fig. 1a) to rapidly increase in size as added (Pl. 3, figs. 2, 7, 11). Chambers surface is ornamented with twelve (Pl. 3, fig. 11) to eighteen (Pl. 3, fig. 7) thick, discontinuous "not extend over the suture lines" longitudinal costae (Pl. 3 all figures). The costae are tilted towards the early portion (Pl. 3, figs. 9a, 10-12) with inter-costal spaces are smooth (Pl. 3, figs. 7, 8), but sometimes are occupied by faint node (Pl. 3, figs 5, 6a). Sutures are distinct, horizontal, wide, and deep in later stage (Pl. 3, figs. 1, 2, 3, 7). Periphery slightly keeled, broadly rounded (Pl. 3, figs 2, 3, 4). Wall calcareous, perforate (Pl. 2, fig. 4). Aperture simple, rounded, situated at the central part of the last-formed chamber, with long wide neck (Pl. 3, all figures).

**Remarks:** This genus differs from the *Marginulinopsis* Silvestri (1904) in possessing discontinuous longitudinal costae that cover only uncoiled portion. Chambers usually globular, rounded in section. Sutures horizontal, depressed, smooth. Periphery keeled at early stage, lobulate in latest stage. Aperture placed at the central part of the last chamber, carried on long neck. Wall perforate, in addition to the wall structure is canaliculate wall structure.

*Wignallyi hewaidyi* (Aly 2011).

Plate 3, figures 1-3.

2011 *Marginulinopsis hewaidyi* Aly *et al.*, p. 92, pl. 3, fig. 2.

**Description:** Test elongate, early portion compressed, closed coil, slightly curved, represent about  $\frac{1}{4}$  of the whole test. Latest stage elongate, straight, rapidly uncoiling, formed from four globular chambers. Chamber increasing in size as added, covered by nodes. Test ornamented by 16 discontinuous, straight, thick, longitudinal costae. Intra-costal space covered by faint nodes. Aperture carried on slightly long central wide neck, perforate, rounded, ornamented by faint nodes or fine granules, highly perforate, periphery lobulate, wall calcareous.

**Remarks:** This species differs from other *Wignallyi* spp. by having sixteen to eighteen straight ribs or costa that are thicker than those in other species. Early stage present about nearly  $\frac{1}{8}$  of the whole of test. Aperture is covered by some small, faint nodes, highly perforate. The inter-costal space usually smooth.

*Wignallyi infracompressa* (Thalman, 1937).

Plate 3, figures 5, 6a, b.

1937 *Marginulinopsis infracompressa* Thalman: 348, pl. XXI, fig. 2.

1955 *Marginulina infracompressa* (Thalman): Ansary: 38,

2006 *Marginulinopsis behmi* (Reuss), Cimerman *et al.*: 24, pl. 5, fig. 1.

2011 *Marginulinopsis infracompressa* Thalman, Aly: 92, pl. 2, fig. 29, pl. 3, fig. 1.

**Remarks:** This species differs from *Marginulinopsis infracompressa* Thalman in its early stage shorter, uncoiled stage formed from four chambers and its aperture is longer than Thalman's species. Also, it differs from other *Wignallyi* spp. in its last formed chamber, last suture and aperture are covered by raised nodes instead of costae. The inter-costal spaces in the last chambers are covered by these nodes as well. Test tapering towards its end and has a long cylindrical apertural neck. Apertural opening is wide and flat.

*Wignallyi johnsonii* Aly n. sp.

Plate 3, figures 4, 9-11.

**Etymology:** in the honor of Dr. Colin A. Johnson, retired senior Lecturer, Department of Russian Studies, University of Leeds.

**Type species:** new species.

**Type locality:** Beni Suef area, Nile Valley, Egypt.

**Type section:** Bayad El-Arab section.

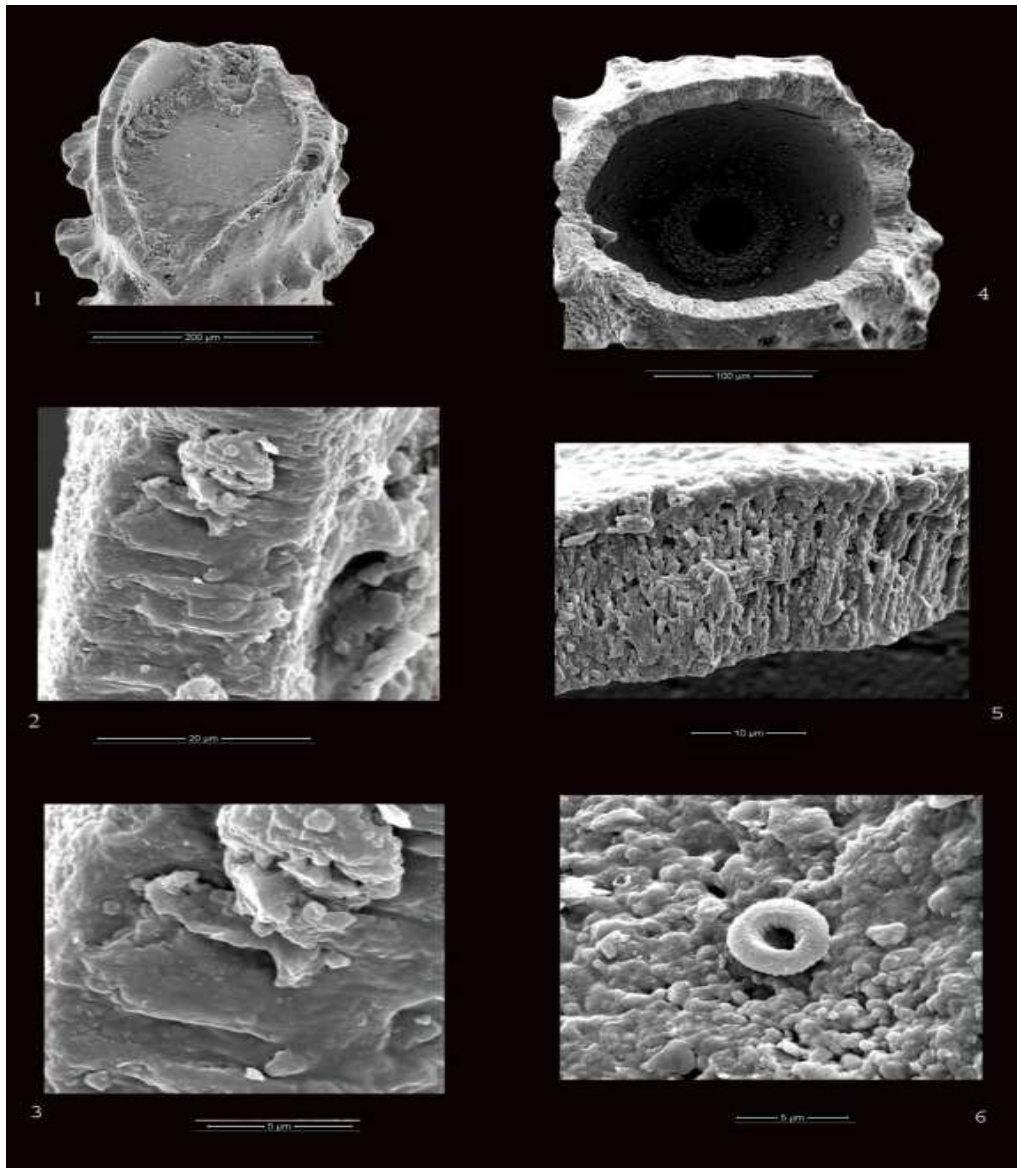
**Type stratum:** El Fashn Formation.

**Holotype:** Plate 3, figure 9.

**Paratype:** plate 3, figures 10-11.

**Stratigraphic range:** Late Middle Eocene.





**Plate 1**

1. Cutting test of *Marginulinopsis* genus showing the shape of chambers is nearly triangle, solid non-canalculated wall structure of this genus and the aperture is peripheral.
2. Magnification of figure 1 showing the wall structure of the *Marginulinopsis* is consisting of solid, lamellar crystals of calcite.
3. More magnification of figure 2.
4. Cutting test of the *Wignally* genus showing the shape of chamber is globular, the wall structure is consisting of two layers and the initial aperture is cited in the center of the septa.
5. Magnification of figure 4 showing the shape of the initial aperture is rounded.
6. More magnification of figure 4 showing the wall structure is consisting of fine grained, canaliculated and highly pores.

**Description:** Test elongate, keeled, early portion compressed, closed coil, slightly curved, represent about  $\frac{1}{2}$  of the whole of test. Sutures are indistinct, ornamented by raised nodes. Later portion rapidly

uncoiling; consists of two globular chambers. Last formed chamber is spherical with a long neck. Sutures are deep, smooth. Surface ornamented by 16-18 discontinuous longitudinal costae, raised, not extend



over the suture lines. Aperture simple, rounded at the end with apertural neck.

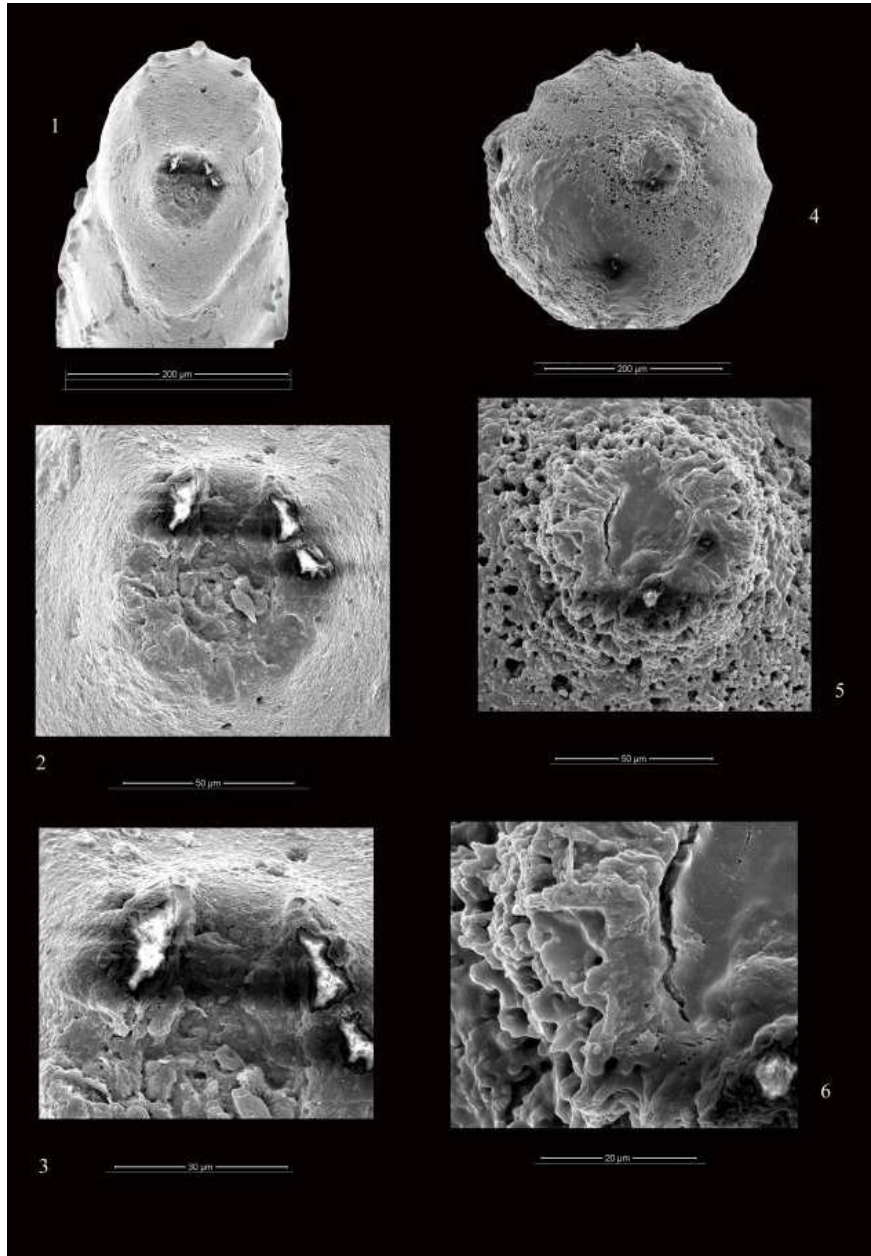
**Remarks:** This species differs from the other *Wignally* spp. in its last formed chamber and its aperture is smooth. Inter-costal spaces are smooth as

well, added to the early stage represented a half or slightly more of whole of the test.

*Wignally* sp. Aly.

Plate 3, figures 7, 8, 12

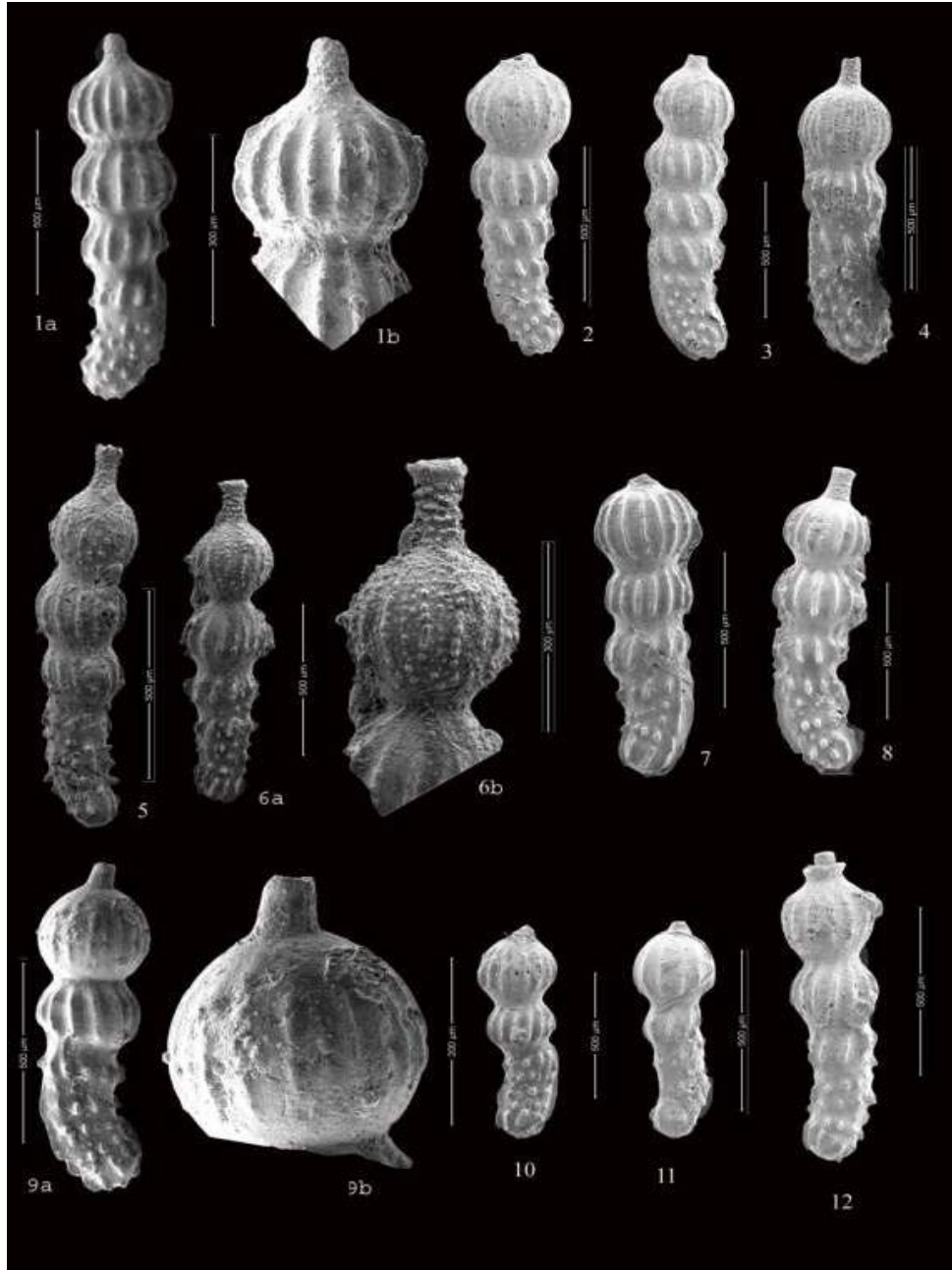
**Remarks:** This species differs from others *Wignally* species in its later stage more keeled, formed from three chambers. Inter-costal spaces are smooth.



**Plate 2**

1-3 the aperture view of the *Marginulinopsis* showing the aperture opening contains on and some particles of sediment might be like teeth and contain on calcite crystals closed its open.

4-6 the aperture view of the *Wignally* genus showing the aperture opening its closed and its outer surface is highly perforate.

**Plate 3**

All figures side view except 1b, 4b and 10 they are last chamber view.

1-3 *Wignally hewaidyi* (Aly, 2011), sample 18.

5-6 *Wignallyi infracompresa* (Thalman, 1937), sample 16.

4, 9-11 *Wignally johnsonii* n. sp. Aly, 2011, sample 10.

7-8, 12. *Wignallyi* sp. Aly

### Conclusions

Scanning Electron Microscope study of *Wignally* shells from El Fashn Formation, Beni Suef area, Nile Valley, Egypt reveals detailed ultrastructure of shell surface, the aperture characters and the ultrastructure. The latter is formed of sub prismatic crystal of calcite. Such an ultrastructure is characteristic of bilamellar,

canaliculate calcareous shell walls. Pore openings in the inner shell wall are wide, dark. The inner wall surface is smooth but rough around the septa. The inter-costal spaces on outer surface are smooth. In some species, these inter-costal spaces are perforate. Last formed chamber and aperture may be covered by nodes or spinose in some individual.

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