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Biostratigraphic zonation of the Middle Eocene in the Nile Valley, based on larger Foraminifera

By

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With 2 Text-figures and 2 Plates

ABSTRACT

The variable distribution of the different *Nummulites* species in the Samalut Formation and the overlying succession of the Nile valley have led to the recognition of four biostratigraphic zones, each having a considerable regional extension. These zones are from base to top: the *Nummulites uroniensis*/*N. laevigatus* Zone (Lower Lutetian), *N. brongniarti*/*N. perforatus* Zone, *N. gizehensis* Zone and *N. beaumonti* Zone (Upper

Lutetian). The first two zones are recorded here for the first time in Egypt. On the basis of this larger foraminiferal zonation, the age of the lower part of the Samalut Formation is determined as Lower Lutetian. The upper part of the Samalut Formation as well as the overlying succession are of Upper Lutetian age.

ZUSAMMENFASSUNG

Aus der Samalut-Formation und jüngeren Schichten des Nil-Tals konnten mit Hilfe von Nummuliten-Arten 4 biostratigraphische Zonen erkannt werden, und zwar (von der Basis zum Top) die *Nummulites uroniensis*/*N. laevigatus*-Zone des Unterlutet sowie die *N. brongniarti*/*N. perforatus*-Zone, *N. gizehensis*-Zone und *N. beaumonti*-Zone des Oberlutet.

Die ersten beiden Zonen wurden erstmals für Ägypten nachgewiesen. Aufgrund der Großforaminiferen-Zonierung ist der untere Abschnitt der Samalut-Formation in das Unterlutet zu stellen. Der höhere Abschnitt der Samalut-Formation wie auch die darüberfolgenden Schichten besitzen Oberlutet-Alter.

1. INTRODUCTION

The stratigraphy of the Middle Eocene in the Nile Valley has been studied by ZITTEL (1883), BLANKENHORN (1900), BEADNELL (1905), HUME (1911), FOURTAU (1896, 1912), CUVILLIER (1930), BARKER (1945), GHORAB & ISMAIL (1957), ISMAIL & FARAG (1957), ISMAIL & BASSIOUNI (1966), KRASHENINNIKOV & PONIKAROV (1964), SAID (1960, 1962, 1971), SAID & MARTIN (1964), BISHAY (1961, 1966), BOUKHARY (1970, 1973), KENAWY et al. (1977), BOUKHARY et al. (1982), and STROUGO et al. (1982). The typical Middle Eocene succession exposed in the Nile Valley shows conformable, but gradational contacts with the underlying Lower Eocene as well as the overlying Upper

Eocene sediments. Larger foraminifera, especially nummulites are the most abundant faunal elements in the greater part of the Middle Eocene.

The main object of this paper is the biostratigraphic classification of the Middle Eocene succession based on the larger foraminifera (nummulites) and the determination of the stratigraphic range of the Samalut and the Mokattam Formation. For this purpose, four representative columnar sections were measured in detail at Gabal El Shurafa (northeast of Minia), Gabal El Sheikh Masound (east of Maghagha), Gabal Humaret El Shaibon (northeast of Beni Suef) and Gabal El Mokattam (east of Cairo). Fig. 1 shows the location of these sections.

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2. LITHOSTRATIGRAPHY

The lithostratigraphic classification of the Middle Eocene in the Nile Valley is the subject of controversy between the authors (SAID 1960, 1962, 1971, SAID & MARTIN 1969, AWAD & SAID 1965, BISHAY 1961, 1966, BOUKHARY 1970, 1973). Detailed discussion of the subject is outside the scope of the present work.

SAID (1962) considered the succession overlying the Minia Formation and underlying the Upper Eocene as a Mokattam Formation. SAID & MARTIN (1964) and BOUKHARY (1970, 1973) subdivided the Mokattam Formation sensu SAID (1962) into a number of subunits (members). The base of the formation that is directly overlying the Minia Formation (SAID 1960) is termed Samalut Member by BOUKHARY (1970, 1973). BISHAY (1961, 1966) subdivided the succession into Samalut, Maghagha, Qarara, El Fashn and Beni Suef Formation. SAID (1971) subdivided the succession overlying the Minia Formation into Samalut and Mokattam Formation. The present authors (OMARA et al. 1977) and BOUKHARY (1973) followed BISHAY (op. cit.) and subdivided the succession into Samalut, Maghagha, Qarara and El Mercir Formation.

In the present work the generalized composite succession is here subdivided into two units, the Samalut Formation below and a succession that is overlying the Samalut Formation above. The Samalut Formation is composed mainly of nummulitic limestones, with few white, fine limestone intercalations. The succession attains 65 meters in thickness. The overlying succession shows a vertical and lateral change in lithology (Fig. 2), where broad lenses of sandstone, arenaceous marls and dolomites are recognized in the Beni-Suef and Maghagha sections. It attains there a thickness of over 100 meters.

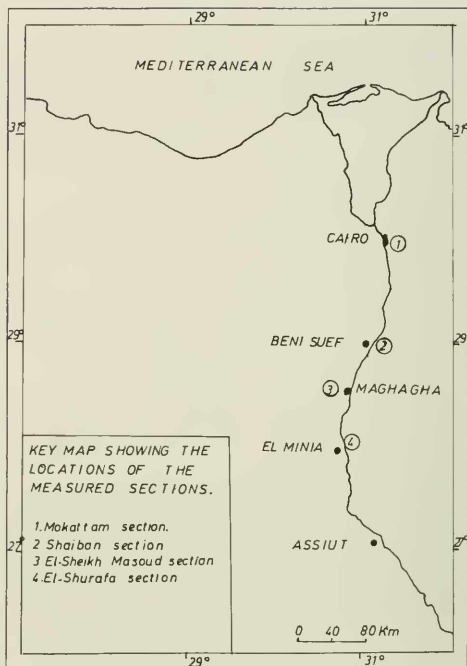


Fig. 1

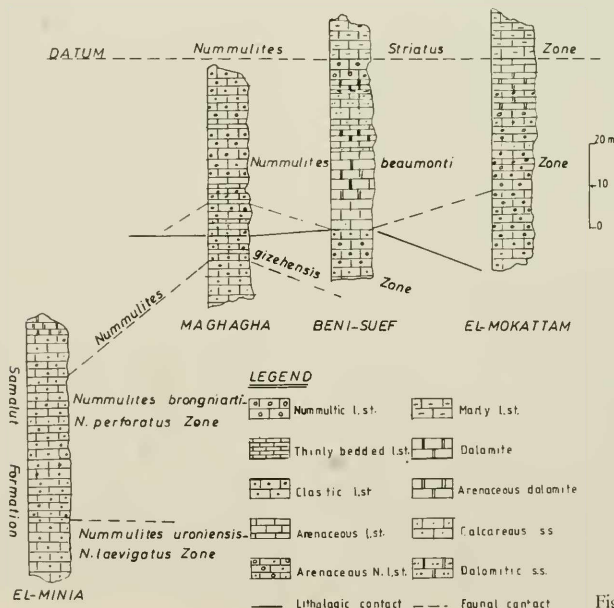
LITHO-AND BIOSTRATIGRAPHIC CORRELATION
BETWEEN THE MEASURED SECTIONS.

Fig. 2

3. BIOSTRATIGRAPHY

The Lower Lutetian/Upper Lutetian boundary has been a subject of controversy among some geologists in Egypt. BISHAY (1966) has drawn this boundary between the Samalut Formation and the overlying Mokattam Formation and considered the Samalut Formation as Lower Lutetian. According to SAID (1962), this boundary lies between the Samalut Formation and the underlying Minia Formation. However, SAID (1971) followed BISHAY (1961) and mentioned that the lower part of the Samalut Formation 'may be' of Lower Lutetian age. BASSIOUNI et al. (1975) considered the Samalut rock unit as a member of the Makattam Formation and assigned it to the Upper Lutetian.

3.1 BIOSTRATIGRAPHIC ZONATION

The variable distribution of the different species of larger foraminifers, in the studied sections there are mainly *Nummulites*, led to the recognition of four biostratigraphic zones which have a considerable vertical and lateral distribution (Fig. 2). These zones could be correlated with similar Middle Eocene sections from other parts of the world (LUECA 1929, FLANDRIN 1938, NEMKOV 1967, BLONDEAU 1972, SCHAUB 1981).

BISHAY (1966) and BASSIOUNI et al. (1975) classified the Samalut and overlying units into two biozones: the *Nummulites gizehensis* Zone at the base and *Nummulites beaumonti*/*Gypsina carterii* Zone at the top.

However, in the studied localities, four biostratigraphic zones, all belonging to the Middle Eocene could be detected. These are described in the following in an ascending order. Their vertical extension in each section is given in Fig. 2.

3.1.1 *Nummulites uroeniensis*/*N. laevigatus* Zone (Lower Lutetian)

This zone is here introduced for the first time in the biostratigraphy of the Middle Eocene. Its lower boundary is marked by the sudden appearance of *Nummulites uroeniensis* HAIM and *N. laevigatus* BRUGUIERE as well as the disappearance of the early Lutetian *Alveolina frumentiformis* SCHWAGER, that characterizes the underlying succession. In addition to the index species, this zone contains *N. obesus* D'ARCHIAC & HAIME, *N. globulus* LEYMERIE, *N. distans* DESHAYES, *N. discorbinus* (SCHLOTHEIM), *N. irregularis* DESHAYES, and *N. ataticus* LEYMERIE. In the studied sections, this zone forms the lower 8.5 m of Gabal El Shurafa.

According to BLONDEAU (1972) *Nummulites uroeniensis* and *N. laevigatus* were recorded from the Lower Lutetian of many parts of the world viz. Aquitaine, Alps Maritimes, Spain, Morocco, Algier, USSR, Madagascar, Turkey, Afghanistan. In Egypt, BISHAY (1966) described this species from the Lutetian of the Nile Valley and Sinai. *N. laevigatus* together with *N. gizehensis* were found by CUVILLIER (1934) at the top of the Giza Pyramid Plateau. However, BISHAY (1966) in his study on

the larger foraminifera of the Eocene in Egypt had not mentioned this species.

3.1.2 *Nummulites brongniarti*/*N. perforatus* Zone (Upper Lutetian)

This zone is also introduced here for the first time. It is defined by the first appearance of *N. brongniarti* D'ARCHIAC & HAIME and *N. perforatus* (DE MONTFORT). The upper limit of this zone is marked by the abrupt increase in the frequency of *N. gizehensis* (FORSKAL). Beside the above mentioned index *Nummulites* species, this zone contains also *N. distans* DESHAYES and *N. discorbinus* (SCHLOTHEIM). This zone extends vertically for about 30 m in the section of Gabal El Shurafa (Samalut Formation).

These two important species characterize the Upper Lutetian all over the world viz. Aquitaine, northern part of the Mediterranean province, Armenia, Iran and Afghanistan (BLONDEAU 1972).

3.1.3 *Nummulites gizehensis* Zone (Upper Lutetian)

This zone was originally described by BISHAY (1966). The *N. gizehensis* bearing beds form a useful mappable unit in many parts of Egypt. This zone is here defined as the interval from the earliest appearance of *Nummulites gizehensis* (FORSKAL) to the first appearance of *N. beaumonti* D'ARCHIAC & HAIME.

N. gizehensis Zone extends vertically for about 25 m through all the studied sections.

N. gizehensis received a great deal of detailed study to fix the variations exhibited by its external as well as its internal characters. DE LA HARPE (1883) recognized eight 'races'. SAID (1951) carried out a quantitative statistical study on these eight races of DE LA HARPE and raised them to species rank. *N. gizehensis* is a world-wide occurring species and is an excellent marker for the Upper Lutetian.

3.1.4 *Nummulites beaumonti* Zone (Uppermost Lutetian)

BISHAY (1966) and BASSIOUNI et al. (1975) recorded this zone in the Middle Eocene of Egypt. It represents here the uppermost biostratigraphic unit of the Middle Eocene of the analysed sections. It is rich in *Nummulites beaumonti* D'ARCHIAC & HAIME together with *N. discorbinus* (SCHLOTHEIM), *N. variolaris* (LAMARCK), *N. aturicus* JOLY & LEYMERIE. Therefore the upper limit of this zone marks the upper boundary of the Upper Lutetian. The *beaumonti* zone measures about 42 m in the studied sections.

Nummulites beaumonti is an index fossil for the uppermost Lutetian (Middle Eocene) in the world. It has a wide distribution all over the Mediterranean province (e.g. Aquitaine, Europe, Somalia, India, Senegal and Madagascar; BLONDEAU 1972). The following zone is defined by the first appearance of the early Late Eocene fauna such as *Nummulites striatus*.

4. SYSTEMATIC DESCRIPTION

In the following a detailed description of the important *Nummulites* species recorded in the four measured sections is given.

Nummulites uroniensis HEIM, 1908, A-Form

Pl. 1, Fig. 4 a, b

- 1908 *Nummulina uroniensis* (DE LA HARPE), emend. HEIM: 226, pl. 1, fig. 1-19.
 1938 *Nummulites uroniensis* HEIM. - FLANDRIN: 62, pl. 6, fig. 14-19.
 1966 *Nummulites uroniensis* HEIM. - BISHAY: 203.
 1967 *Nummulites uroniensis* HEIM, A-Form. - NEMKOV: 178, pl. 20, fig. 10-15.

Test small, globular. The surface shows falciform septal filaments. The granules are distinct, scattered on and between the septal filaments. The diameter of the test is 3-5 mm, its thickness 1-3 mm.

The equatorial section reveals the small proloculus; the thick spiral lamina forming 7 whorls. The septa are thin, slightly curved. The chambers are higher than wide. The axial section shows the rounded marginal cord. The whorls adhere rather closely to one another and the pillars are well-developed.

Remarks: DE LA HARPE (1883) considered this species as a variety of *N. perforatus* D'ORBIGNY. HEIM (1908) raised it to a species rank.

Age: Lower Lutetian.

Nummulites laevigatus (BRUGUIÈRE, 1792), B-Form

Pl. 2, Fig. 3

- 1853 *Nummulites laevigata* LAMARCK. - D'ARCHIAC & HAIME: 103, pl. 6, fig. 1-7.
 1955 *Nummulites laevigatus* BRUGUIÈRE. - DAVIES: 44, text-fig. 9.
 1967 *Nummulites laevigatus* (BRUGIÈRE). - NEMKOV: 147, pl. 13, fig. 6, 7, 9-11, pl. 14, fig. 1, 2.
 1972 *Nummulites laevigatus* (BRUGIÈRE). - BLONDEAU: 127, pl. 7, fig. 11-14.
 1981 *Nummulites laevigatus* (BRUGIÈRE). - SCHAUB: 171, pl. 6, fig. 18, 19.

The test of this species is large and flat with a diameter of 20 mm and a thickness of 4 mm. Periphery subacute. Surface of the test is undulated, covered with subreticulate pattern and coarse granulation. In the section, the coiling is regular and consists of 15 whorls. The spiral lamina is thin. The marginal

cord is thick and measures about $\frac{1}{3}$ of the spiral cavity. The pillars are well-developed.

Age: Lower Lutetian.

Nummulites brongiarti D'ARCHIAC & HAIME, 1853, B-Form

Pl. 2, Fig. 1

- 1853 *Nummulites brongiarti* n. sp. - D'ARCHIAC & HAIME: 110-112, pl. 5, fig. 1-4.
 1883 *Nummulites brongiarti* D'ARCHIAC & HAIME. - DE LA HARPE: 209.
 1938 *Nummulites brongiarti* D'ARCHIAC & HAIME. - FLANDRIN: 72, pl. 7, fig. 16-22.
 1963 *Nummulites brongiarti* D'ARCHIAC & HAIME, B-Form. - BIEDA: 194, pl. 14, fig. 1, 2, 4, 8.
 1967 *Nummulites brongiarti* D'ARCHIAC & HAIME. - NEMKOV: 154, pl. 14, fig. 5-9.
 1981 *Nummulites brongiarti* D'ARCHIAC & HAIME. - SCHAUB: 175, pl. 63, fig. 12.

The test is large, almost flat to lenticular; its diameter is 17 mm, its thickness 5 mm. The periphery is rounded. The surface is covered with subreticulate pattern bearing small granules. The granules are densely arranged, connected together by means of very delicate septal filaments. The spiral lamina is thick and the pillars are numerous.

Age: Upper Lutetian.

Nummulites aturicus JOLY & LEYMERIE, 1848, A-Form

Pl. 1, Fig. 1a, b

- 1853 *Nummulites perforatus* D'ORBIGNY. - D'ARCHIAC & HAIME: 115, pl. 6, fig. 1-12.
 1938 *Nummulites aturicus* JOLY & LEYMERIE. - FLANDRIN: 64, pl. 6, fig. 20-28.
 1966 *Nummulites aturicus* JOLY & LEYMERIE. - BISHAY: 168.
 1972 *Nummulites aturicus* JOLY & LEYMERIE. - BLONDEAU: 161, pl. 34, fig. 1-4.
 1981 *Nummulites aturicus* JOLY & LEYMERIE. - SCHAUB: 95, pl. 15, fig. 20, 24.

The test is small in size, lenticular; it measures about 7 mm in diameter and 3 mm in thickness. The septal filaments are characterized by an irregular course. The surface is covered with fine granules which are larger in the central part of the test. The equatorial section shows a big simple proloculus, a regular thick spiral lamina, six whorls, thin, slightly oblique septa and chambers which are higher than long. The axial section is very

Plate 1

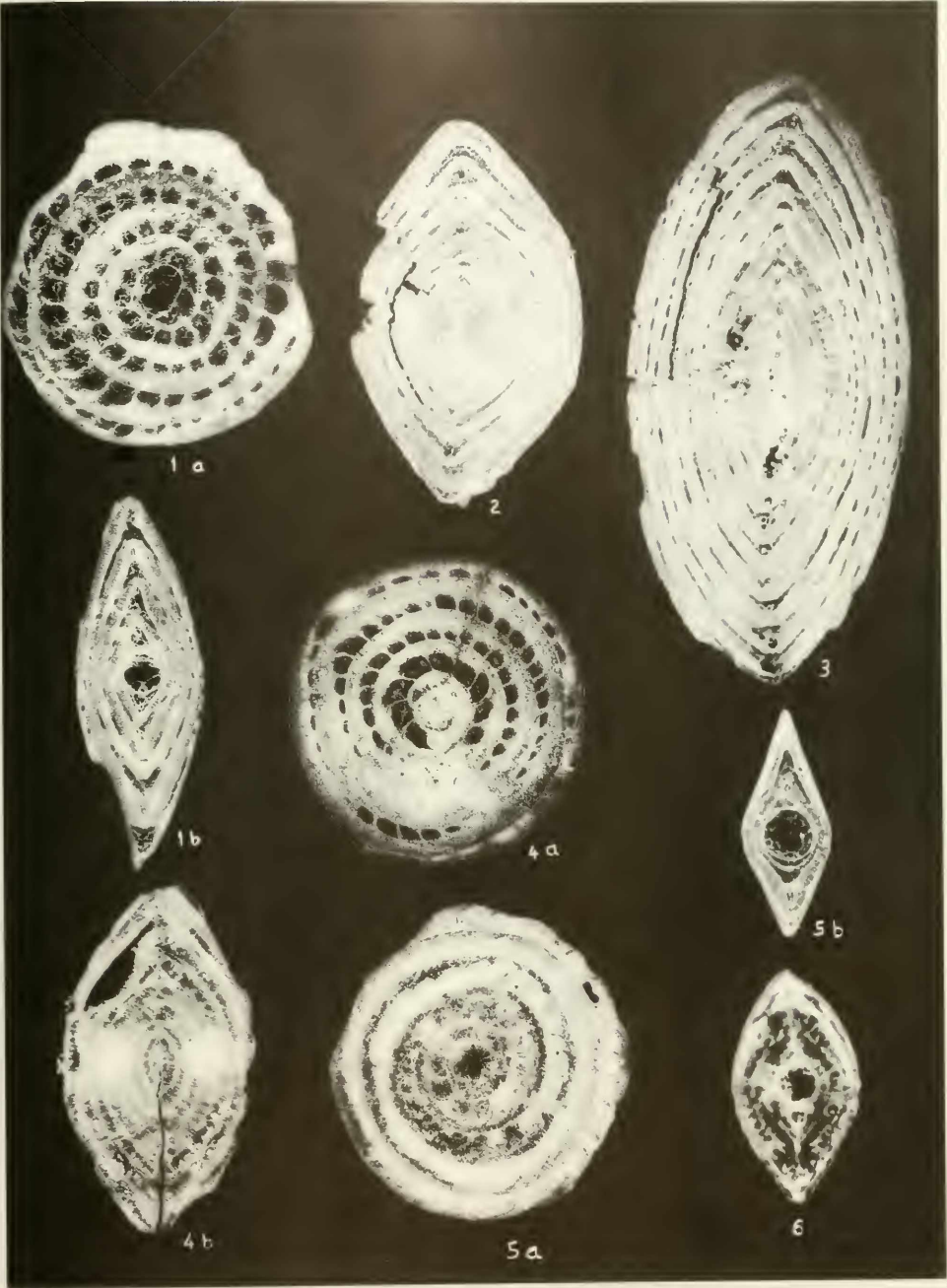
Fig. 1 *Nummulites aturicus* JOLY & LAYMERIE, A-Form. - a) equatorial section, x 12.5, b) axial section, x 12.5.

Fig. 2, 3 *Nummulites perforatus* (DE MONTFORT), B-Form. - axial section, x 12.5.

Fig. 4 *Nummulites uroniensis* HEIM, A-Form. - a) equatorial section, x 15, b) axial section, x 15.

Fig. 5 *Nummulites millicaput* BOUBÉE, A-Form. - a) equatorial section, x 15, b) axial section, x 10.

Fig. 6 *Nummulites perforatus* (DE MONTFORT), A-Form. - axial section, x 12.5.



characteristic, showing the big proloculus, the thick walls and the great number of pillars.

Age: Upper Lutetian - Upper Eocene.

Nummulites perforatus (DE MONTFORT, 1808), B-Form
Pl. 1, Fig. 2, 3

- 1911 *Nummulites perforatus* (DE MONTFORT). - BOUSSAC: 60, pl. 3, fig. 3-7, 16.
1929 *Nummulites perforatus* (DE MONTFORT). - LLUECA: 191, pl. 9, fig. 30-38.
1963 *Nummulites perforatus perforatus* (DE MONTFORT). - BIEDA: 94, pl. 13, fig. 1, 4, 6; tab. 15; fig. 6, 7.
1967 *Nummulites perforatus* (DE MONTFORT), B-Form. - NEMKOV: 181, pl. 22, fig. 1-7.
1981 *Nummulites perforatus* (DE MONTFORT). - SCHAUB: 89, pl. 18, fig. 23 a, b.

Test globular; diameter 5 mm; thickness 2,3 mm. The septal filaments are radial, thin, flexous, sometimes wavy. The surface is covered by large granules which are situated on and between the septal filaments. The axial section shows the rounded marginal cord. The whorls adhere rather closely, and the colums are well-developed.

Nummulites perforatus (DE MONTFORT, 1808), A-Form
Pl. 2, Fig. 2 a, b

- 1853 *Nummulites lucasanus* DEFRANCE. - D'ARCHIAC & HAIME: 124-127, pl. 7, fig. 5-12.
1883 *Nummulites lucasanus* DEFRANCE. - DE LA HARPE: 208.
1929 *Nummulites rouaulti* D'ARCHIAC & HAIME. - LLUECA: 195, pl. 9, fig. 17-27; pl. 13, fig. 10.
1972 *Nummulites perforatus* (DE MONTFORT), A-Form. - BLONDEAU: 161.
1981 *Nummulites perforatus* (DE MONTFORT), A-Form. - SCHAUB: 89, pl. 18, fig. 25, 26.

In equatorial section, the protoconch is large in size, the deuteroconch being much smaller. There are 5 whorls; the width of the spacing of whorls increases till the fifth whorl. The septa are bent and somewhat inclined. The chambers are isometric in the first two whorls. In the following whorls, the chambers are lesser high than wide. In axial section, the thick spiral lamina and the numerous pillars can be observed.

Age: Upper Lutetian.

Nummulites millecaput BOUBÉE, 1832, A-Form
Pl. 1, Fig. 5a, b

- 1911 *Nummulites millecaput* BOUBÉE. - BOUSSAC: 115, pl. 5, fig. 43-44.

- 1929 *Nummulina millecaput* BOUBÉE. - ROZLOZNIK: 216.
1929 *Nummulites helvetica* KAUFMANN. - LLUECA: 158.
1963 *Nummulites millecaput* BOUBÉE. - BIEDA: 89, pl. 10, fig. 1-3, pl. 15, fig. 3-5.
1972 *Nummulites millecaput* BOUBÉE. - BLONDEAU: 131, pl. 13, fig. 1-9.
1981 *Nummulites millecaput* BOUBÉE. - SCHAUB: 186, pl. 68, fig. 25, 26.

Test small, lenticular; diameter 3,3 mm, thickness 5 mm. Periphery slightly rounded and undulated. The surface is covered with fine meandrine filaments and with a very fine granular ornamentation. The equatorial section shows the characteristic shape of the nucleoconch. The protoconch is large, spherical; the deuteroconch is much smaller, cap shaped. The spiral lamina is medium. The width of the spacing of whorls remains more or less equally large from the second to the fifth whorl. The septa are strongly bent. Chambers are longer than broad throughout the entire test. The axial section shows a thick whorl wall and well-developed pillars.

Age: Upper Lutetian.

Nummulites gizebensis (FORSKAL, 1775), B-Form
Pl. 2, Fig. 4 a, b

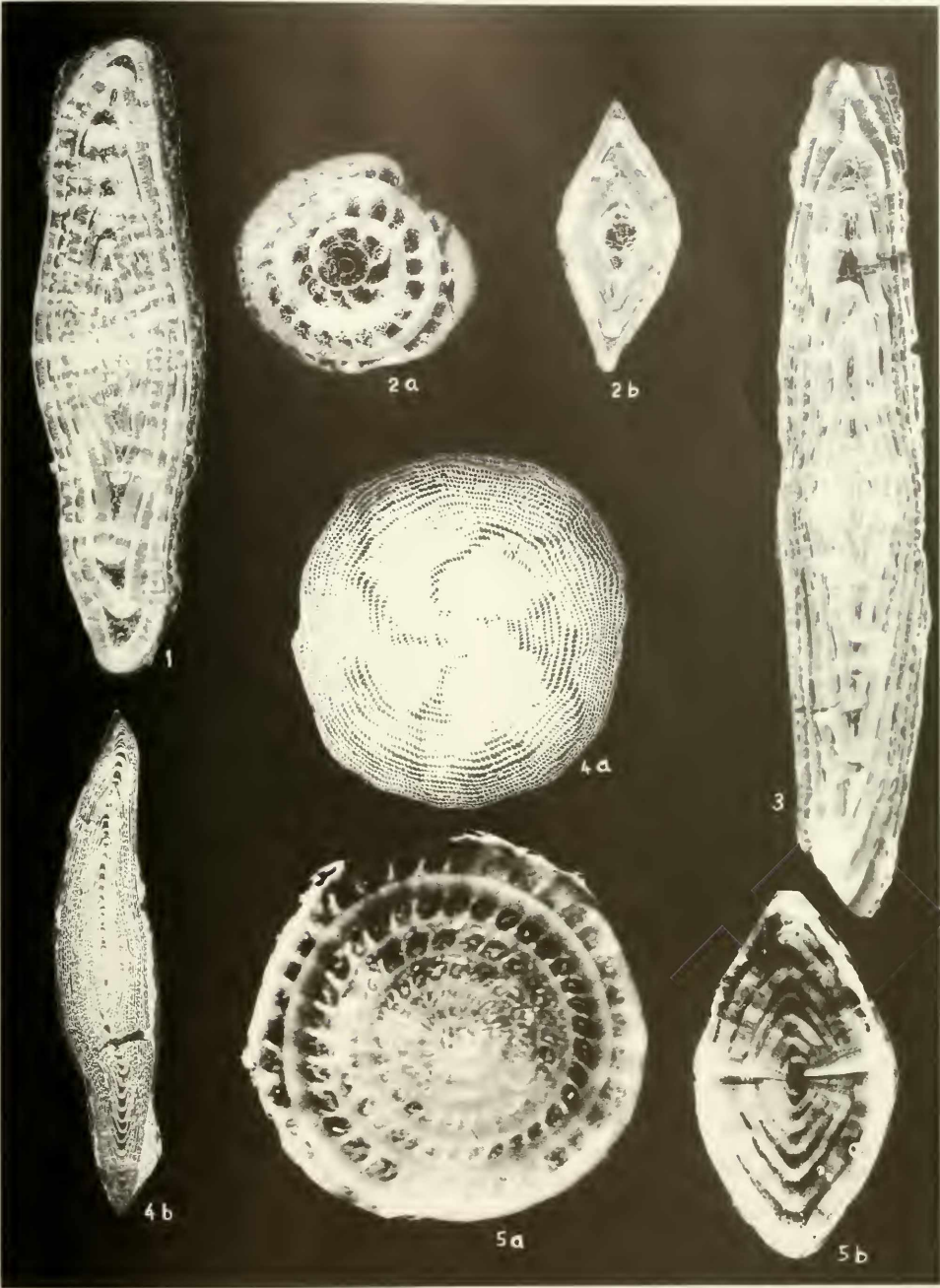
- 1853 *Nummulites gizebensis* EHRENBURG. - D'ARCHIAC & HAIME: 94, pl. 2, fig. 6-8.
1883 *Nummulites gizebensis* (FORSKAL). - DE LA HARPE: 186, pl. 32, fig. 16-26.
1928 *Nummulites gizebensis* FORSKAL. - ROSLOZNIK: 220, pl. 5, fig. 21; pl. 8, fig. 9-11.
1938 *Nummulites gizebensis* (FORSKAL). - FLANDRIN: 67, pl. 5, fig. 10-13.
1966 *Nummulites gizebensis* (FORSKAL). - BISHAY: 184.
1967 *Nummulites gizebensis* (FORSKAL). - NEMKOV: 196, pl. 36, fig. 4-6.
1972 *Nummulites gizebensis* (FORSKAL). - BLONDEAU: 161, pl. 26, fig. 1-7.
1981 *Nummulites gizebensis* (FORSKAL). - SCHAUB: 115, pl. 36, fig. 47, 48.

Test large and lenticular. The diameter is 30 mm and the thickness is 5,0 mm. The edge is subrounded. The septal filaments are meandriform and bear some granulations of medium size. The equatorial surface shows 15 regular whorls. Spiral lamina is thin. The septa are thin and straight, become curved when joining the periphery. The chambers are always longer than broad. The axial section shows a thin spiral lamina and fine distinct pillars.

Age: Upper Lutetian - Bartonian (OMARA & KENAWY 1984).

Plate 2

- Fig. 1 *Nummulites brongiarti* D'ARCHIAC & HAIME, B-Form. - axial section, x 12,5.
Fig. 2 *Nummulites perforatus* (DE MONTFORT), A-Form. - a) equatorial section, x 12,5, b) axial section, x 12,5.
Fig. 3 *Nummulites laevigatus* (BRUGUIÈRE), B-Form. - axial section, x 10.
Fig. 4 *Nummulites gizebensis* (FORSKAL), B-Form. - a) equatorial section, x 3, b) axial section, x 3.
Fig. 5 *Nummulites beaumonti* D'ARCHIAC & HAIME, A-Form. - a) equatorial section, x 25, b) axial section, x 22,5.



Remarks: This species was studied by DE LA HARPE (1883). He recognized eight races: *N. ehrenbergi*, *lyelli*, *championi*, *pachoi*, *zitteli*, *visquimeli*, *mariettei* and *caillaudi*. SAID (1951) carried out a quantitative re-study on these races of the species and came to the conclusion that the eight races are distinct and valid species.

Nummulites beaumonti D'ARCHIAC & HAIME, 1853, A-Form
Pl. 2, Fig. 5 a, b

1853 *Nummulites beaumonti* n. sp. - D'ARCHIAC & HAIME:
133, pl. 8, fig. 1-3.

1883 *Nummulites beaumonti* D'ARCHIAC & HAIME. - DE LA
HARPE: 26, pl. 31, fig. 37-47.

1929 *Nummulites beaumonti* D'ARCHIAC & HAIME. -
LLUECA: 146, fig. 29.

1938 *Nummulites beaumonti* D'ARCHIAC & HAIME. -
FLANDRIN: 58, pl. 4, fig. 24-26.

1966 *Nummulites beaumonti* D'ARCHIAC & HAIME. - BISHAY:
171.

1972 *Nummulites beaumonti* D'ARCHIAC & HAIME. -
BLONDEAU: 149, pl. 24, fig. 11-14.

1981 *Nummulites beaumonti* D'ARCHIAC & HAIME. -
SCHAUB: 135, pl. 53, fig. 18, 19.

Test medium; diameter 6 mm, thickness 3 mm. The edge is subrounded. The septal filaments are sigmoidal and the surface is smooth. In the center of the test there is a median tubercle. The axial section shows tight whorls and thick spiral laminae.

There are 5 whorls. The septa are numerous, curved and slightly inclined backwards. The chambers are $1\frac{1}{2}$ times higher than long. The axial section is characterized by buried polar postuls.

5. SUMMARY AND CONCLUSIONS

The Samalut Formation and the overlying succession in the area between Minia and Cairo are very rich in different species of *Nummulites*. The distribution of the different species of *Nummulites* in these rock units enabled the subdivision of the studied sections into four biozones.

The Samalut Formation yields three biozones. These are from bottom to top: 1. *Nummulites uroniensis*/*N. laevigatus* Zone, 2. *Nummulites brongniartii*/*N. perforatus* Zone and 3. *Nummulites gizebensis* Zone. The first two biozones have

been introduced here for the first time in the biostratigraphy of the Middle Eocene of Egypt. On the basis of correlation with other areas in and outside Egypt the age of the Samalut Formation could be determined as Early Lutetian in its lower part and Late Lutetian in its upper part.

The overlying succession (Fig. 2), on the other hand, includes the *Nummulites beaumonti* Zone. The occurrence of this species together with *Nummulites aturicus*, *N. discorbinus*, *N. variolarius* points to a Late Lutetian age.

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