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# Lower Miocene stratigraphy of the Gebel Shabrawet area, north Eastern desert Egypt

Osman Abdelghany *

*Department of Geology, Faculty of Science, United Arab Emirates University, P.O. Box 17551, Al Ain, United Arab Emirates*

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**Abstract**

The Lower Miocene carbonate/siliciclastic sequence of the Shabrawet area, comprises a complex alternation of autochthonous and allogenic sediments. The sequence can be subdivided into two lithostratigraphic units. The lower unit (unit I) is equivalent to the Gharra Formation. It is mainly clastic and composed of sandstones, siltstones and shales with minor limestone intercalations. These sediments are rich in *Clypeaster* spp., *Scutella* spp., *Miogypsina intermedia*, *Operculina complanata*, and smaller foraminifera. The upper unit (unit II) was considered by previous workers as being equivalent to the Marmarica Formation. It consists mainly of non-clastic rocks, dominated by sandy and chalky limestones rich in larger foraminifera (miogypsinids and nummulitids). This unit is topped by a highly fossiliferous (*Heterostegina*, *Operculina* and *Planostegina*) sandy limestone. The present study places both units in the Gharra Formation and reports for the first time *M. intermedia* from the Miocene sequence of the Shabrawet area.


*Keywords:* Egypt eastern; Desert; Miocene; Stratigraphy

## 1. Introduction

Gebel Shabrawet is a well known landmark located a few kilometers southwest of Fayid City, situated to the west of the Great Bitter Lake (Fig. 1) in the northern part of the Eastern Desert. It is a prominent structure consisting mainly of Cretaceous rocks, forming an inlier surrounded by gently sloping Eocene, Oligocene and Miocene beds. The latter, which are well-exposed on the northern and northwestern side of the Shabrawet area, represent the same Miocene facies as those exposed in the Cairo-Suez district and the north Western Desert.

There have been relatively few papers dealing specifically with the Miocene rocks in Shabrawet area (Fig. 2). The geology of the area has been investigated by Sadek (1926, 1959), Macfadyen (1930), Fawzi (1959), Faris and Abbass (1961), Said (1962), Al-Ahwani (1982), Mohammad and Omran (1991), Moustafa and Khalil (1995) and Shamah et al. (1995). Faris and Abbass (1961) assigned the Shabrawet sequence to Albian–Miocene age. Said (1962) correlated the lower sandy and the upper calcareous beds of the marine Miocene in the Cairo-Suez district with the Lower Miocene Moghra Formation and the Middle Miocene Marmarica limestone (described from the Western Desert). Al-Ahwani (1982) emphasized that the Miocene deposits at Gebel Shabrawet unconformably overlie the Oligocene fluviatile clastics. Mohammad and Omran (1991) were the first to use the name Gharra Formation for the Lower Miocene sequence in Gebel Shabrawet. The succession consists of 36.8 m of sandstone, clay and minor fossiliferous limestone. They also used the term Marmarica Formation of Said (1971) for the Middle Miocene succession in the area consisting of about 43 m sequence of limestone with minor sandstone and clay interbeds. Most of the recent publications have focused on the stratigraphy, sedimentology and tectonic attributes of the Shabrawet sequence. Only minor emphasis has been placed on its micropaleontology despite the Miocene sequence comprising several horizons containing abundant smaller foraminifera (planktic and benthic) or larger foraminifera. Therefore, the present study aims to determine of the litho- and biostratigraphy and facies distribution of the Miocene sedimentary rocks in Shabrawet area. About 53 rock samples were collected from the two stratigraphic sections A and B (Fig. 3).

* Tel.: +971-3-7064-736; fax: +971-3-767-1291.
*E-mail address:* osman.abdelghany@uaeu.ac.ae (O. Abdelghany).

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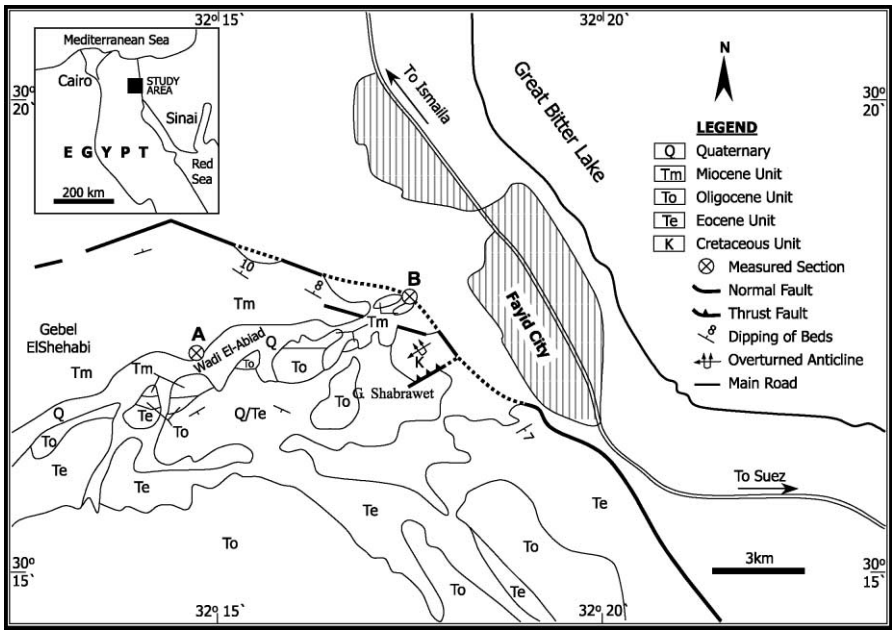


Fig. 1. Geologic map of the Shabrawet area, northern Eastern Desert, Egypt. (Modified after Hermina et al. (1989); Moustafa and Khalil (1995)).

| Author / Stage | Gebel Shabrawet (Faris & Abbass, 1961) | Gebel Shabrawet (Al-Ahwani, 1982) | Cairo-Suez district (Said, 1990) | Gebel Shabrawet (Mohammad & Omran, 1991) | Present study | |
|---|---|---|---|---|---|---|
| Upper Miocene | White limestone rich in *Clypeaster* spp. and *Scutella* spp. of Miocene age. | Limestones intercalated with clays and sandstones at the base. | | | Gharra Formation<br>*Miogypsina* (*M.*) *intermedia*<br>*Globigerinoides altiaperturus*<br>*Gs. Primordius* | Lower Miocene (Burdigalian) |
| Middle Miocene | | | Genefe Formation | Marmarica Formation | | |
| Lower Miocene | | | Gharra Formation | Gharra Formation | | |

Fig. 2. Correlation table showing the different rock units and their ages.

Thin sections were made to provide details of the morphologic characteristics of the larger foraminifera.

## 2. Lithostratigraphy

The rocks exposed in the study area include the Lower Miocene Gharra Formation (Said, 1990; and unpublished data Ghorab and Marzouk, 1967) with unexposed base. Its type locality is at Gebel Gharra (Abdelghany and Piller, 1999). The presence of alternations of siliciclastic and carbonate rocks suggests further subdivision into two units. The lower unit (unit I) of 49.5 m thickness is composed mainly of siliciclastic sediments with sandstones, siltstones and claystones with an intervening carbonate unit (Fig. 3). The upper unit (unit II) with a thickness of 42.2 m consists mainly of non-clastic rocks, dominated by sandy and chalky limestones rich in larger foraminifera (*Miogypsina intermedia*). This unit is topped by a highly fossiliferous (*Heterostegina*, *Operculina* and *Planostegina*) sandy limestone. The Gharra Formation is exposed in isolated outcrops throughout the north Eastern Desert (G. Shabrawet, G. Gharra type section, Agroud and Homeira area) containing abundant macrofossils. In the studied sections, macrofossils, especially molluscan shells (pelecypods and gastropods), echinoderms (*Clypeaster* spp. and *Scutella* spp.), ostreids and pectinids, smaller foraminifera in addition to *Heterostegina* (*Vlerkina*) *borneensis*, *Operculina complanata*, *Planostegina costata*, and *M. intermedia* are abundant and widely distributed. Stratigraphic correlation is possible between the study area, Gebel Gharra, at its type locality, and Agroud area (Fig. 4).

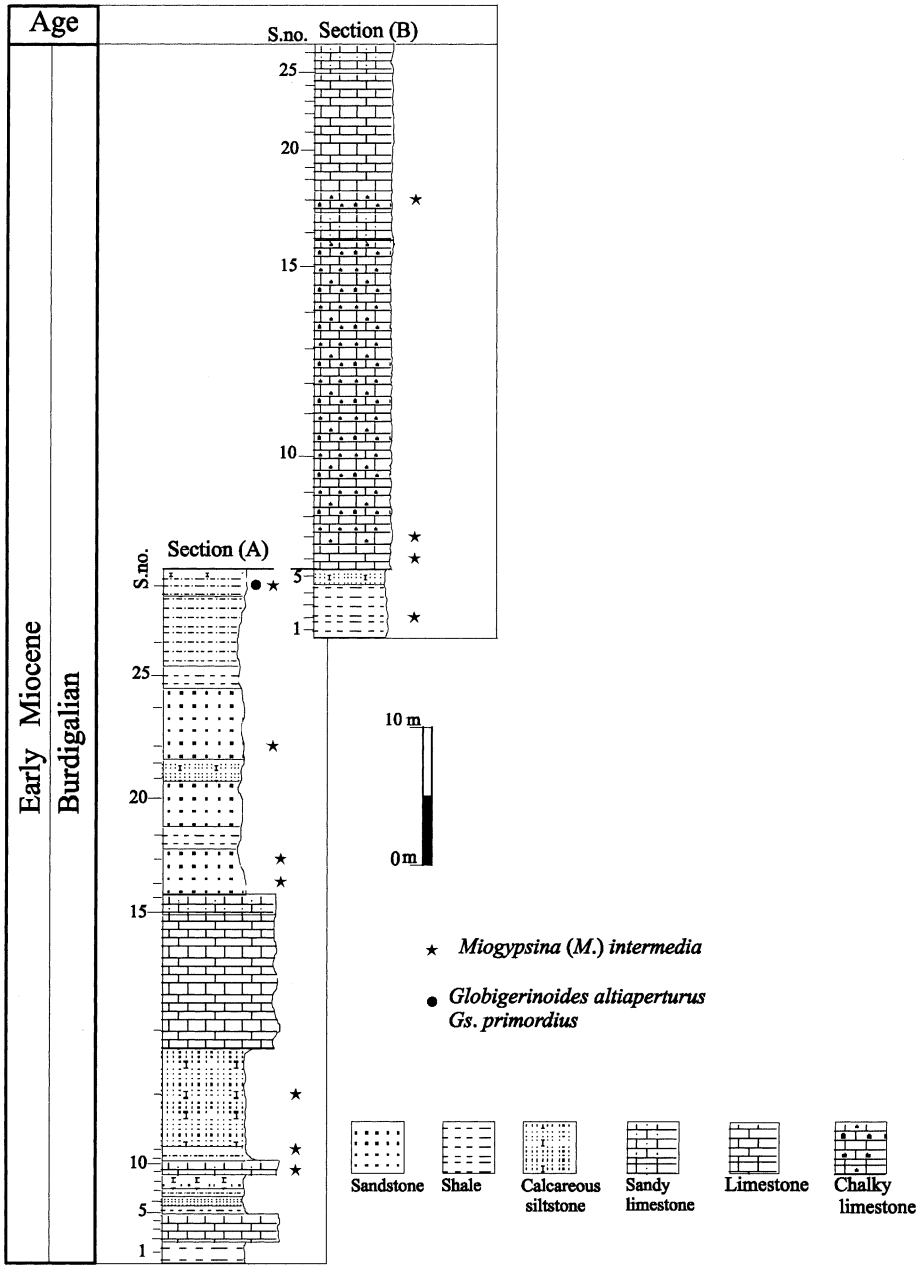


Fig. 3. Stratigraphic correlation between the studied sections.

## 3. Biostratigraphy

Although the sediments in the studied sections were deposited mainly in a shallow water, neritic environment, very detailed and careful sampling revealed a few planktic forams (Fig. 3). *Globigerinoides primordius* and *Globigerinoides altiaperturus* were detected in section A, sample 27. According to Kennett and Srinivasan (1983), *G. primordius* occurs between N4A–N5, and *G. altiaperturus* from N5–N7. The range of co-occurrence of these two species covers therefore N5, representing M2 sensu Berggren et al. (1995). In addition to planktonic foraminifera in section A, larger foraminifera of the genus *Miogypsina* were also detected in samples from the studied sections. According to Drooger's scheme (Drooger, 1993) the identified *M. intermedia* species define the Burdigalian stage of the Lower Miocene.

## 4. Biometric analysis of larger foraminifera

Drooger (1952, 1963, 1993) introduced several biometric parameters for the Miogypsinidae. Some of these parameters are listed in Table 1.

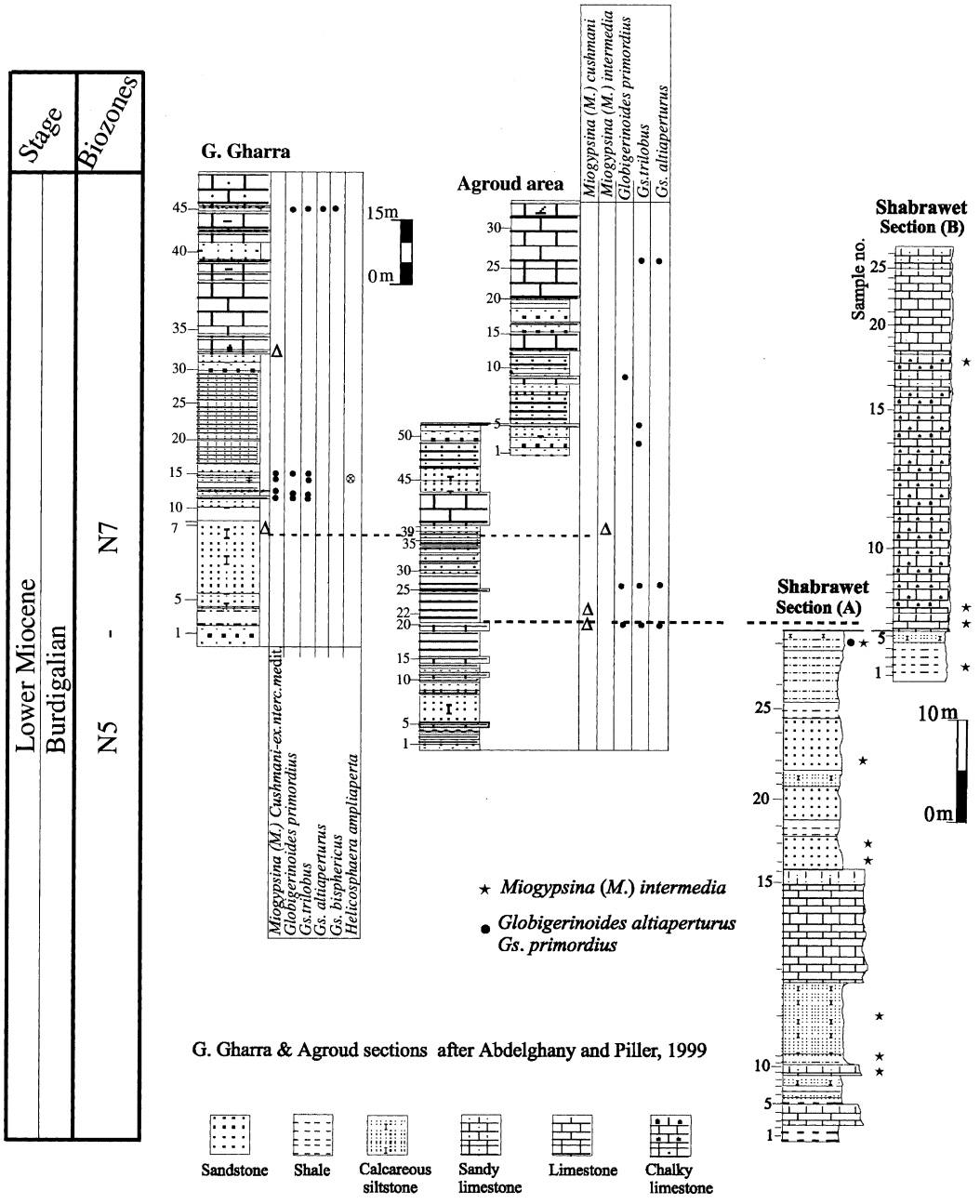


Fig. 4. Correlation of the studied sections with Gharra and Agroud type sections.

### 4.1. Stratigraphic distribution of miogypsina species in the study area

The identified *M. intermedia* is reported here for the first time in the Shabrawet area. This species has been described from the Burdigalian by Souaya (1963) from the Gebel Gharra section, about 20 km south of the study area. Cherif (1966, 1980) described this species from the Sadat area, about 50 km south of the present study, and assigned it to Burdigalian age. Abdelghany and Piller (1999) described this species from the Agroud, Homeira and Sadat area. According to Drooger (1993), *M. intermedia* represents Burdigalian.

### 4.2. Systematic notes

The classification of Loeblich and Tappan (1988) and Drooger (1993) has been applied in this study. Twentynine smaller and larger foraminiferal species were identified from the Lower Miocene of the studied two sections as shown in (Fig. 3). The important features and occurrences of the identified larger foraminifera in the study area are discussed below.

Order: Foraminiferida Eichwald, 1830
Suborder: Globigerinina Delage and Herouard, 1896

Table 1
Biometric parameters of *Miogypsina* specimens of the studied sections. [DI = maximum diameter of protoconch, DII = maximum diameter of deuteroconch, $\alpha$ = arc length of the circumference of the protoconch underlying the shorter spiral, $\beta$ = arc length of the circumference of the protoconch underlying both protoconchal spirals, $\gamma$ = angle between the apical frontal line through center of protoconch and the line connecting the centers of embryonic chambers (sensu Amato and Drooger, 1969)

| Specimen number | DI | DII | $\alpha$ | $\beta$ | $\gamma$ | $V = 200\alpha/\beta$ |
|---|---|---|---|---|---|---|
| *Shabrawet section B, sample (2)* | | | | | | |
| S1 | 0.15 | 0.21 | 90 | 270 | 42 | 66.7 |
| S2 | 0.18 | 0.24 | 95 | 275 | 13 | 69 |
| Mean (*M*) | 0.165 | 0.225 | 92.5 | 272.5 | 27.5 | 67.85 |
| *Shabrawet section B, sample (6)* | | | | | | |
| S1 | 0.21 | 0.27 | 88 | 278 | 36 | 63.3 |
| S2 | 0.165 | 0.195 | 100 | 279 | 20 | 71.6 |
| S3 | 0.18 | 0.27 | 88 | 268 | 10 | 65.6 |
| Mean (*M*) | 0.185 | 0.245 | 92 | 275 | 22 | 66.83 |

Superfamily: Globigerinacea Carpenter, Parker and Jones, 1862
Family: Globigerinidae Carpenter, Parker and Jones, 1862
Genus: *Globigerinoides* Cushman, 1927
*Globigerinoides altiaperturus* Bolli, 1957
Plate 1(1, 2)

1957c—*Globigerinoides triloba altiapertura* Bolli; p. 113, Plate 25(7a–c).

1983—*G. altiaperturus* Bolli–Kennett and Srinivasan; p. 54, Plate 10(1); Plate 11(4–6).

1985—*G. altiaperturus* Bolli–Bolli and Saunders; p. 192, (20.10, 7, 9, 12).

1999—*G. altiaperturus* Bolli–Abdelghany and Piller; 616, Plate 1(3, 4).

### 4.3. Description

Test low trochospiral, chambers spherical, increasing rapidly in size as added. Primary aperture interiomarginal, umbilical, large, high and distinct.

### 4.4. Occurrence

Section A, sample 27.
*Globigerinoides* cf. *altiaperturus* Bolli, 1957 Plate 1 (3, 4).

### 4.5. Occurrence

Section A, sample 27.
*Globigerinoides primordius* Blow and Banner, 1962 Plate 1(5, 6).

1962—*G. primordius* Blow and Banner; p. 15, Plate ix(Dd–Ff).

1983—*G. primordius* Blow and Banner–Kennett and Srinivasan; p. 54, Plate 11(1–3).

1985—*G. primordius* Blow and Banner–Bolli and Saunders; p. 195, (20, 6, 7, 9, 12).

1999—*G. primordius* Blow and Banner–Abdelghany and Piller; 616, Plate 1(1, 2).

### 4.6. Description

Test low trochospiral. Three and a half chambers in the final whorl, increasing rapidly in size as added. Primary aperture, a low to moderate arch, interiomarginal, umbilical. A single small supplementary aperture on the spiral side.

### 4.7. Occurrence

Section A, sample 27.
*Globigerinoides trilobus* immaturus LeRoy (1939) Plate 1(7, 8).

### 4.8. Description

Test trochospiral, chambers spherical, three in the final whorl, increasing rapidly in size as added. Primary aperture interiomarginal, umbilical, a low slit, supplementary aperture along spiral sutures in the form of an irregular slit.

### 4.9. Occurrence

Section A, sample 27.

Suborder: Rotaliina Delage and Herouard, 1896
Superfamily: Rotaliacea Ehrenberg, 1839
Family: Miogypsinidae Vaughan, 1928
Genus: *Miogypsina* Sacco, 1893
Type species: *Nummulites globulina* Michelotti, 1841
*M. intermedia* Drooger, 1952
Plate 1(9–14)

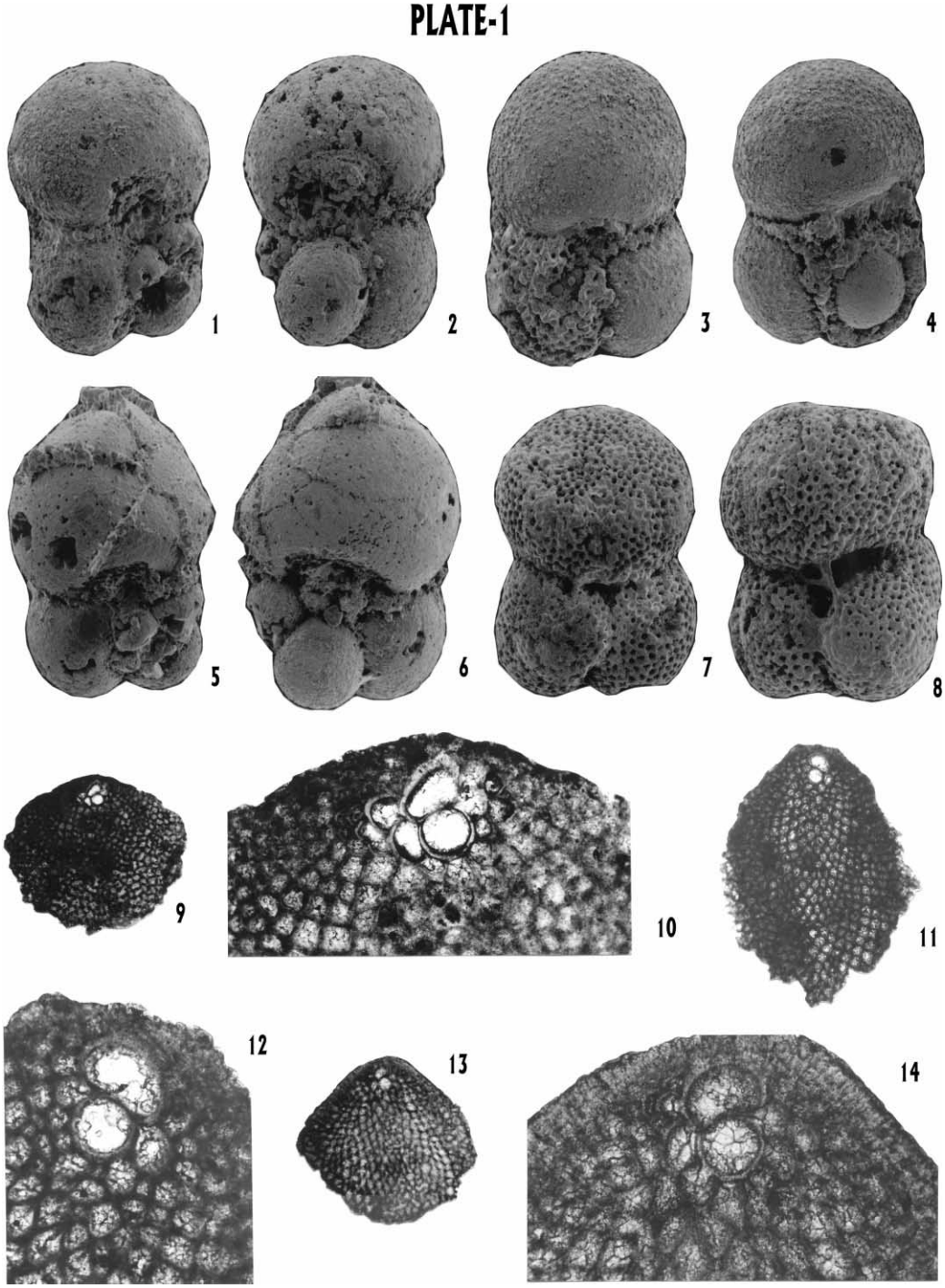


Plate 1. (1 and 2) *Globigerinoides altiaperturus* Bolli; section A, sample 27; 1—dorsal view, 2—ventral view, X1, 2 = 170. (3 and 4) *Globigerinoides* cf. *altiaperturus* Bolli; section A, sample 27; 3—dorsal view, 4—ventral view, X3, 4 = 170. (5 and 6) *Globigerinoides primordius* Blow and Banner; section A, sample 27; 5—dorsal view, 6—ventral view, X5, 6 = 230. (7 and 8) *Globigerinoides trilobus immaturus* LeRoy; section A, sample 27; 7—dorsal view, 8—ventral view, X7, 8 = 170. (9–14) *M. intermedia* (Drooger, 1952). (9–12) section (B), sample 6; X9 = 18, X10 = 72; X11 = 22 and X12 = 72. (13 and 14) section (B), sample 2; X13 = 14 and X14 = 77.

1952—*M. intermedia* Drooger; pp. 35, 55, Plate 2(30–34); Plate 3(4).

1961—*M. intermedia* Drooger–Souaya; p. 672, Plate 1(11–20); Plates 2 and 3(1, 7, 10–12); Plate 4(1–12).

1966—*M. intermedia* Drooger–Cherif; p. 157, Plate 5(7–12).

1966—*M. intermedia* Drooger–Hamam; p. 145, Plate 8(4, 5, 7).

1966—*M. intermedia* Drooger–Said and Metwalli; p. 58, Plate 4(2, 7, 11).
1980—*M. intermedia* Drooger–Cherif; pp. 328–330, Plate 1(1–3).
1991—*M. intermedia* Drooger–Wildenborg; p. 114, Plate 2(3), Plate 5(4–8), Tabs. 19, III.
1980—*M. intermedia* Drooger–Cherif; p. 328–330, Plate 1(1–3).
1999—*M. intermedia* Drooger–Abdelghany and Piller; p. 612, Plate 1(1, 2).

### 4.10. Description

Test compressed, triangular, oval to approximately circular in outline, embryonic is apically situated, surface covered by papillae; the mean value of the $V = 67.3$ indicates Lower Miocene (Burdigalian) (Drooger, 1993).

### 4.11. Occurrence

Samples 8, 9, 11, 12, 16, 17, 22 and 27, section A; samples 2, 6, 7 and 17, section B.

Superfamily: Nummulitacea de Blainville, 1827
Family: Nummulitidae de Blainville, 1827
Genus: *Heterostegina* d'Orbigny, 1826
*Heterostegina* (*Vlerkina*) *borneensis* Van der Vlerk, 1929
Plate 2(1–3)

1929—*H.* (*Vlerkina*) *borneensis* Van der Vlerk, p. 16(6a–c, 25a–b).
1968—*H.* (*Vlerkina*) *borneensis* Van der Vlerk–Eames, Clarke, Banner, Smout and Blow; p. 290.
1991—*H.* (*Vlerkina*) *borneensis* Van der Vlerk–Banner and Hodgkinson; p. 264, Plate 4(1–3).

### 4.12. Description

Test planispiral involute. Secondary septa arising perpendicularly from the primary septa in the direction of growth, dividing the chambers completely into subrectangular chamberlets.

### 4.13. Occurrence

Sample 21, section (B).

Genus: *Operculina* d'Orbigny, 1826
*Operculina complanata* (Defrance, 1822)
Plate 2(4–7)

1822—*Lenticulites complanata* Defrance; p. 453.
1954—*Operculina complanata complanata* (Defrance)–Papp and Kuepper; Text-Plate 2(1–3, 5–8).
1963—*O. complanata* (Defrance)–Souaya; p. 444, Plate 53(1, 2).
1966—*O. complanata* (Defrance)–Hamam; Plate 7 (1, 3).
1980—*O. complanata* (Defrance)–Cherif; p. 329, Plate 1(4, 10); Plate 2(1, 5).

### 4.14. Description

Test bilaterally symmetrical, planispiral, evolute, flattened; primary septa are duplicate, thick walled, marginal spiral cord is comparatively thick.

### 4.15. Occurrence

Sample 8, section (A).

Genus: *Planostegina* Banner and Hodgkinson, 1991
Type species: *Heterostegina costata* d'Orbigny, 1846

### 4.16. Description

It is differs from *Heterostegina* in being completely evolute and from *Planoperculina* by the development of true secondary septa.

*Planostegina costata* (d'Orbigny, 1846).
Plate 2(8–10).

1846—*Heterostegina costata* d'Orbigny; p. 212, Plate 12(15).
1954—*H. costata costata* d'Orbigny–Papp and Kuepper; p. 116, Text-Plate 3(8–10); Plate 20(1–7); Plate 21(3–6).
1954—*H. costata levitesta* Papp and Kuepper; p. 116, Text-Plate 3(6, 7, 11); Plate 23(2).
1954—*H. costata politatesta* Papp and Kuepper; p. 117, Text-Plate 3(13–16); Plate 21(2).
1963—*H. costata* d'Orbigny–Souaya; p. 444, Plate 54(1, 6).
1966—*H. costata* d'Orbigny–Said and Metwali; p. 57, Plate 3(17).
1966—*H. costata costata* d'Orbigny–Hamam; Plate 7(9).
1966—*H. costata politatesta* Papp and Kuepper–Hamam; Plate 7(10).
1978—*H. costata* d'Orbigny–Papp; p. 285, Plate 12(3–5).
1980—*H. costata costata* d'Orbigny–Cherif; pp. 330–331, Plate 1(7); Plate 2(7, 8).
1980—*H. costata politatesta* Papp and Kuepper–Cherif; p. 331, Plate 1(8), Plate 2(4).
1985—*H. costata* d'Orbigny–Papp and Schmid; p. 76, Plate 68(3–9).
1991—*Planostegina costata* (d'Orbigny)–Banner and Hodgkinson; p. 258, Plate 1(4).

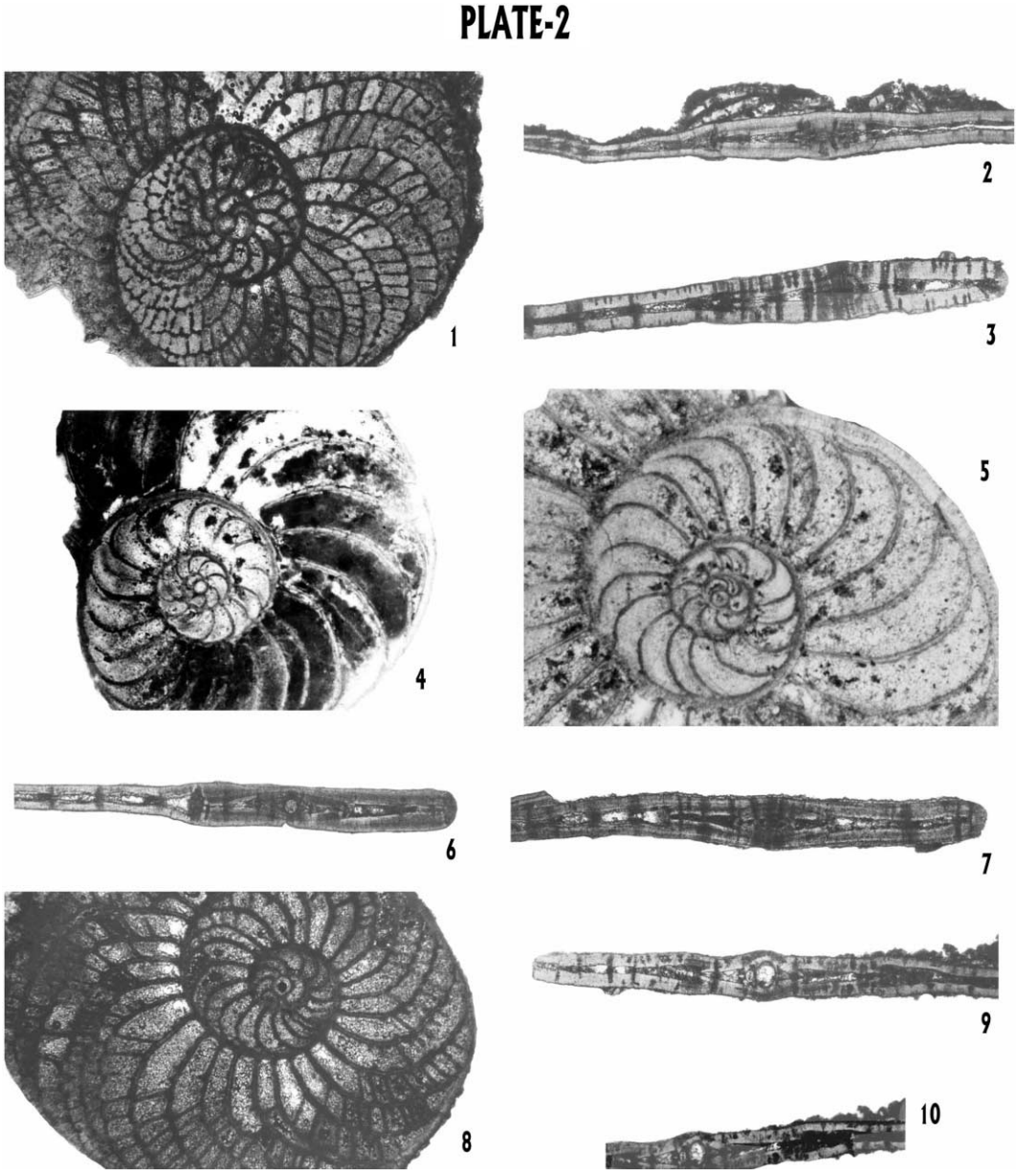


Plate 2. (1–3) *Heterostegina* (*Vlerkina*) *borneensis* Van der Van der Vlerk, 1929; section B, sample 21; (1) equatorial section, X1 = 33; (2 and 3) axial sections, X2 = 35. (4–7) *Operculina complanata* (Defrance, 1822); section A, sample 8; (4 and 5) equatorial sections, X4 = 20, X5 = 26.6; (6 and 7) axial sections, X6 = 28 and X7 = 28; (8–10) *Planostegina costata* (d'Orbigny, 1846); section B, sample 21; (8) equatorial section, X8 = 33; (9, 10), axial sections, X9 = 60 and X10 = 60.

### *4.17. Description*

The surface of the test is usually ornamented with medium to coarse-sized granules. It has numerous small, medium and long-sized secondary septa. The majority of secondary septa are long-sized and catch the next primary septa.

### *4.18. Occurrence*

Sample 21, section (B).

## 5. Depositional environment

The Lower Miocene (Burdigalian) sedimentary rocks in the northern part of the Eastern Desert between the Nile Delta and Gulf of Suez (Cairo-Suez-Shabrawet area) were deposited in a neritic environment, indicated by the high abundance of larger foraminifera (*Miogypsina*, *Heterostegina*, *Operculina* and *Planostegina*), in addition to the coralgal facies.

The macrofauna of the different biotopes of the Burdigalian transgression are represented by assemblages of pelecypods (*Ostrea* and *Pecten*) and echinoids

(*Scutella* and *Clypeaster*) in fine to coarse-grained sandstone and calcareous sandstone. Also the occurrence of calcareous red algae (rhodoliths) reflects a shallow water marine environment.

## 6. Conclusions

This contribution reports for the first time the recovery of *M. intermedia* from the previously undated carbonate sediments of the Shabrawet area (north Eastern Desert, Egypt). Miocene deposits are located to the north and northwest of the Cretaceous rocks in the Shabrawet area. These deposits can be subdivided into two lithostratigraphic units as follows: The lower unit (Gharra Formation) is mainly clastic and is composed of sandstones, calcareous sandstone, siltstone, calcareous siltstone, and shales with minor limestone intercalations rich in *Clypeaster* spp., *Scutella* spp., *M. intermedia Operculina complanata*, and smaller benthic foraminifera. The upper unit (Marmarica Formation according to Mohammad and Omran, 1991) consists mainly of non-clastic rocks, composed of sandy limestone, chalky limestone and limestone, rich in larger foraminifera (miogypsinids and nummulitids). This unit is topped by a highly fossiliferous (*Heterostegina Operculina and Planostegina*) sandy limestone.

On the basis of an Early Miocene (Burdigalian) age for lower and upper rock units, and the dissimilar lithology between the study area and the Marmarica Formation type section, it is evident that the upper unit in the Shabrawet area has a different age and lithology to the Marmarica Formation type section of the North Western Desert. Accordingly, it is preferred to combine these two units in the Gharra Formation. This formation can be correlated with the Gharra Formation at its type locality and in the Agroud area of the Cairo-Suez district.

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