

## **Middle Miocene Benthic Foraminifera from Wadi Kaam area, Northwestern Libya: Systematics and biostratigraphy**

Sherif M. El Baz\*, Mohamed A. Ahmed, Abd-Alrahman A., Embaby, Ahmed Al Furjany

Damietta University, Faculty of Science, Geology Department, New Damietta, Egypt.

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\* Corresponding author: Sherif772003@du.edu.eg

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### **Abstract**

The Middle Miocene section exposed at Wadi Kaam area, northwestern Libya was carefully studied. Detailed investigation of the foraminiferal content led to the recognition of 27 benthic foraminiferal species belonging to 15 genera and 13 families. They are moderately preserved. The absence of the index planktonic foraminifera doesn't enable the recognition of any planktonic biozone within Al Khums Formation. The studied Miocene succession includes one biostratigraphic zone based on the vertical distribution of the larger benthic foraminifera *Borelis melo melo*. The studied sequence was characterized by a fairly common occurrence of benthic foraminiferal species living in a shallow neritic environment.

*Keywords:* Foraminifera, Middle Miocene, Taxonomy, Biostratigraphy, Libya.

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### **Introduction**

This study is concerned with the Middle Miocene benthic foraminifera from exposed section at Wadi Kaam area in the northwestern Libya (Fig. 1). It is directed to their taxonomy and biostratigraphy. Few studies have been published on the Miocene foraminifera of Libya. Significant papers are those by Berggren (1967), Barr & Weegar (1972), Szczechura & Abd-Elshafy (1988), Sherif (1991), Abdulsamad & Barbieri (1999), Imam (1999a), Hamad (2013), Abdulsamad & El Zanati (2013).

### **Material and Methods**

In the present study, a total of 30 samples were carefully collected and detailed studied. The samples were prepared to release the foraminiferal content. All the identified foraminifera were photographed by the Scanning Electron Microscope. The photographs were arranged in two plates.

#### **Lithostratigraphy**

In the study area, the Middle Miocene succession is mainly comprised of the Al Khums Formation.

It was described and established by Mann (1975) for the Middle Miocene sequence

exposed in the vicinity of Al Khums. It can be locally subdivided by Salem & Spreng (1980) into two informal members, from base to top: An Naggazah Member and Ras Al Mannubiyah Member. In the present study, An Naggazah Member composed mainly of reefal limestone at the base followed by white, massive, and fossiliferous limestone, with pelecypods, gastropods, bryozoan fragments, foraminifera and ostracods. It reaches about 9 m (Fig. 2). Ras Al Mannubiyah Member

overlies conformably An Naggazah Member and attains a thickness of 6 m. It consists of white creamy limestone with rare ostracods and foraminifera. *Borelis melo melo* was considered as a marker for the Middle Miocene beds (Barr & Weegar, 1972; Imam, 1999 a, Hamad, 2013). It is clear that the presence of *Borelis melo melo* in the present study gives a strong support that the Al Khums Formation is of Middle Miocene (Langhian to Early Serravallian) age.

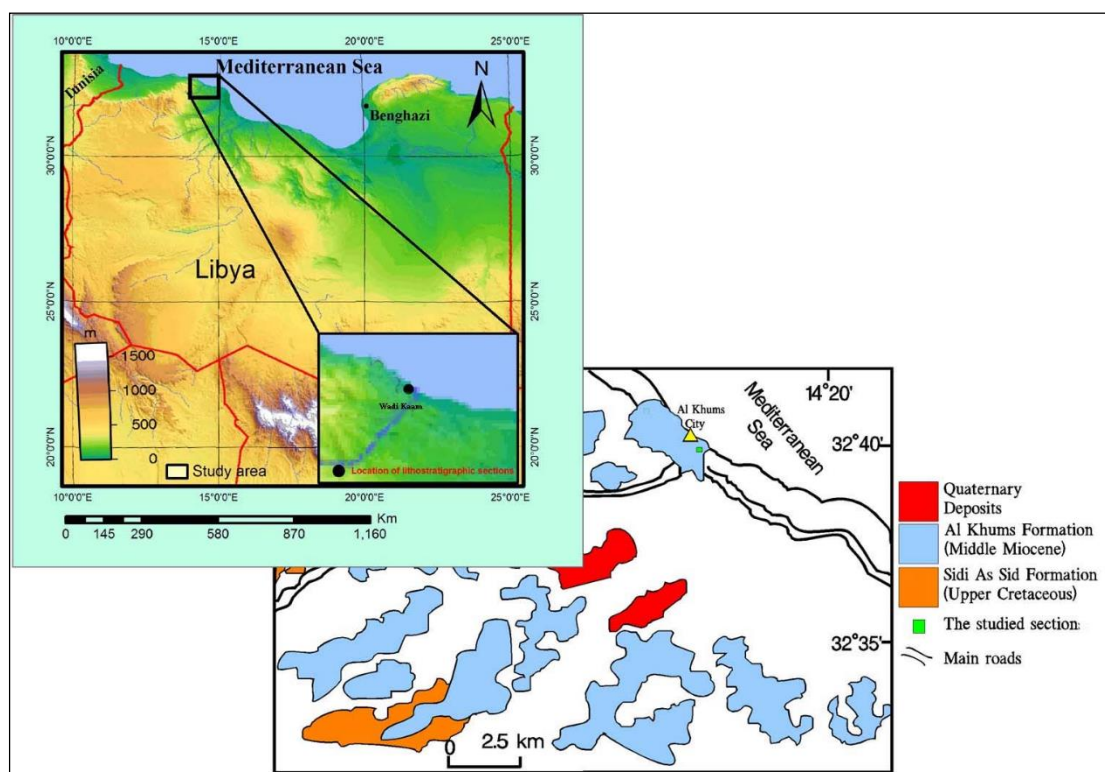


Fig.1. Geologic map of the study area (modified after, Hamad, 2013).

### Systematic Paleontology

Detailed investigation of the foraminiferal content led to the recognition of 27 species belonging to 15 genera and 13 families. The recorded species follow the classification of Loeblich & Tappan (1988). They are illustrated in two plates and their stratigraphic ranges are provided in Fig. 2.

Order: Foraminiferida Eichwald, 1830  
 Suborder: Miliolina Delag & Herouard, 1896  
 Superfamily: Miliolacea Ehrenberg, 1839  
 Family: Spiroloculinidae Wiesner, 1920  
 Genus: *Spiroloculina* d'Orbigny, 1826  
*Spiroloculina communis* Cushman & Todd, 1884, (Pl. 1, Fig. 1)

1963 *Spiroloculina* cf. *S. communis*  
 Cushman & Todd -Souaya, pl. 58, fig. 5.  
 Family: Hauerinidae Schwager, 1876  
 Subfamily: Hauerininae Schwager, 1876  
 Genus: *Quinquoloculina* d'Orbigny, 1826  
*Quinquoloculina laevigata* d'Orbigny, 1826  
 , (Pl. 1, Fig. 2)  
 1826 *Quinquoloculina laevigata* d'Orbigny, p. 301, no. 6.  
*Quinquoloculina cuvieriana* d'Orbigny, 1839, (Pl. 1, Fig. 3)  
 2013 *Quinquoloculina cuvieriana* d'Orbigny-Hewaidy et al., pl. 1, fig. 1.  
*Quinquoloculina seminula* (Linnaeus, 1758), (Pl. 1, Fig. 4)  
 2013 *Quinquoloculina seminulua* (Linnaeus)-Hewaidy et al., pl. 1, fig. 3.  
*Quinquoloculina vulgaris* d'Orbigny, 1826, (Pl. 1, Fig. 5)

- 1826 *Quinqueloculina vulgaris* d'Orbigny, p. 302, no. 33.  
 Subfamily: Miliolinellinae Vella, 1957  
 Genus: *Triloculina* d'Orbigny, 1826  
*Triloculina gibba* d'Orbigny, 1826, (Pl. 1, Fig. 6)  
 1974 *Triloculina gibba* d'orbigny-Luczkowska, p. 134, pl. 23, figs. 2 a-c.  
*Triloculina inflata* d'Orbigny 1846, (Pl. 1, Fig. 7)  
 1991 *Triloculina inflata* d' Orbigny - Sherif, pl.2, figs. 2a,b.  
*Triloculina tricarinata* d'Orbigny, 1826, (Pl. 1, Fig. 8)  
 1826 *Triloculina tricarinata* d'Orbigny, Annals des sci. Naturelles, p.209, v. 7, model no. 94.  
*Triloculina trigonula* (Lamarck, 1804), (Pl. 1, Fig. 9)  
 1991 *Triloculina trigonula* (Lamarck) - Sherif, pl.2, figs. 53a,b.  
 Family: Alveolinellidae Cushman, 1927  
 Genus: *Borelis* Montfort, 1808  
*Borelis melo melo* (Fichtel & Moll, 1798), (Pl. 1, Fig. 10),  
 1798 *Nautilus melo* Fichtel & Moll, p. 123, pl. 24, figs. a-h.  
 Suborder: Lagenina Delage & Herouard, 1896  
 Superfamily: Nodosariacea Ehrenberg, 1838  
 Family: Vaginulinidae Reuss, 1860  
 Subfamily: Lenticulininae Chapman, Parr & Collins, 1934  
 Genus: *Lenticulina* Lamarck, 1804  
*Lenticulina inornatus* (d'Orbigny, 1846), (Pl. 1, Fig. 11)  
 1846 *Robulina inornata* d'Orbigny, p. 102, pl. 24, figs. 25-26  
 Family: Polymorphinidae d'Orbigny, 1839  
 Genus: *Guttulina* d'Orbigny, 1839  
*Guttulina communis* (d'Orbigny, 1829), (Pl. 1, Fig. 12)  
 1829 *Polymorphina communis* d'Orbigny, p. 150, pl. 9  
 Suborder: Rotaliina Delage & Herouard, 1896  
 Superfamily: Bolivinaea Glaessner, 1937  
 Family: Bolivinidae Glaessner, 1937  
 Genus: *Bolivina* d'Orbigny, 1839  
*Bolinina arta* Macfadyen, 1931, (Pl. 1, Fig. 13)  
 1931 *Bolivina arta* Macfadyen, p. 58, pl. 4, fig. 2 la-b.  
*Bolivina dilatata* Reuss, 1850, (Pl. 1, Fig. 14)  
 1931 *Bolivina dilatata* Reuss – Macfadyen, p. 57, pl. 2, figs. la-b.  
 Family: Uvigerinidae Jones, 1875  
 Subfamily: Uvigerininae Haeckel, 1894  
 Genus: *Uvigerina* d'Orbigny, 1826  
*Uvigerina semiornata* d'Orbigny, 1826, (Pl. 2, Fig. 1)  
 1953 *Uvigerina semiornata* d'Orbigny – Papp & Turnovsky, p. 128, pl. 5, figs. C1-3.  
 Superfamily: Orbitoidacea Schwager, 1876  
 Family: Amphisteginidae Cushman, 1927  
 Genus: *Amphistegina* d'Orbigny, 1826  
*Amphistegina lessonii* (d'Orbigny, 1843), (Pl. 2, Fig. 2)  
 1991 *Amphistegina lessonii* (d'Orbigny) – Sherif, pl. 4, figs. 7a,b.  
 Superfamily: Nonionacea Schultze, 1854  
 Family: Nonionidae Schultze, 1854  
 Subfamily: Nonioninae Schultze, 1854  
*Nonion boueanus* d'Orbigny, 1846, (Pl. 2, Fig. 3)  
 1991 *Nonion boueanus* d'Orbigny-Sherif., pl. 5, figs. 7a,b.  
 Family: Heterolepidae Gonzales-Donoso, 1969  
 Genus : *Heterolepa* Franzén 1884  
*Heterolepa dutempli* (d'Orbigny, 1846), (Pl. 2, Figs. 4, 5)  
 1846 *Rotalinad dutempl* d'Orbigny, p. 157, pl. 8, figs. 19-21.  
 Family: Gavelinellidae Hofker, 1956  
 Subfamily: Gavelinellina Hofker, 1956  
 Genus: *Hanzawaia* Asano, 1944  
*Hanzawaia boueana* (d'Orbigny, 1846), (Pl. 2, Fig. 6)  
 1965 *Cibicides boueanus* (d'orbigny)-Souaya, pl. 3, figs. 1a,b.  
 Family: Rotaliidae Ehrenberg, 1839  
 Subfamily: Pararotaliinae Reiss, 1963  
 Genus: *Pararotalia* Le Calvez, 1949  
*Pararotalia armata* (d'Orbigny, 1826), (Pl. 2, Fig. 7)  
 1988 *Pararotalia armata* (d'Orbigny)-Szczechura & Abd-Elshafy, pl. 12, figs. 1, 2.  
*Pararotalia mexicana* (Nuttall, 1928), (Pl. 2, Fig. 8)  
 1928 *Rotalia mexicana* (Nuttall), pl. 50, figs. 6-7.  
 Subfamily: Ammoninae Saidova, 1981  
 Genus: *Ammonia* Brunnich, 1771  
*Ammonia beccarii* (Linné, 1758), (Pl. 2, Fig. 9)  
 1758 *Nautilus beccarii* Linné, p. 710.  
*Ammonia parkinsoniana* (d'Orbigny, 1839), (Pl. 2, Fig. 10)

- 1839 *Rosalina parkinsoniana* d'Orbigny, p. 99, pl. 4, figs. 25-27.  
 Family: Elphidiidae Galloway, 1933  
 Subfamily: Elphidiinae Galloway, 1933  
 Genus: *Elphidium* Montfort, 1808  
*Elphidium advenum* (Cushman, 1922), (Pl. 2, Fig. 11)  
 1939 *Elphidium advenum* (Cushman)-Cushman, pl. 16, figs. 31-35.  
*Elphidium crispum* (Linee 1758), (Pl. 2, Fig. 12)  
 1965 *Elphidium crispum* (Linee)- Souaya, pl. 3, fig. 13.  
*Elphidium macellum* (Fichtell & Moll, 1981), (Pl. 2, Fig. 13)  
 1965 *Elphidium macellum* (Fichtell & Moll) - Souaya, pl.3, fig. 10.  
*Elphidium minutum* (Reuss, 1864), (Pl. 2, Fig. 14)  
 1965 *Elphidium cf minutum* (Reuss) - Souaya, pl. 3, fig. 12.

**Biostratigraphy**

In the present study, the absence of the index planktonic foraminifera doesn't enable the recognition of any planktonic biozone. The studied Miocene section include one biostratigraphic zone based on the vertical distribution of *Borelis melo melo*.

*Borelis melo melo* Biozone

This zone is defined in the present work by the total range of the nominated taxon. It covers the whole Al Khums Formation. The associated foraminifera include *Pararotalia mexicana*, *Quinqueloculina* spp, *Triloculina* spp., *Elphidium crispum*, *Heterolepa dutempli* and *Ammonia beccarii*. The biostratigraphic importance of this taxon as Middle Miocene index species have been discussed by many authors. Souaya (1963) recorded this species from the Middle Miocene succession in the Red Sea, Egypt. Sherif (1991) recorded it from Al Khums Formation in Al Khums area, NW Libya. Imam (1999 a, b) also recorded this biozone in the Middle Miocene Al Jaghboub Formation in Al Bardia area, NE Libya. Hamad (2013) defined this zone from the Middle Miocene Al Khums Formation. Abdulsamad & Zanati (2013) identified this species from the Soluq area, NE Libya. This biozone could be correlated with the *Praeorbulina glomerosa*, *Orbulina suturalis* and *Orbulina universa* planktonic foraminiferal Zones.

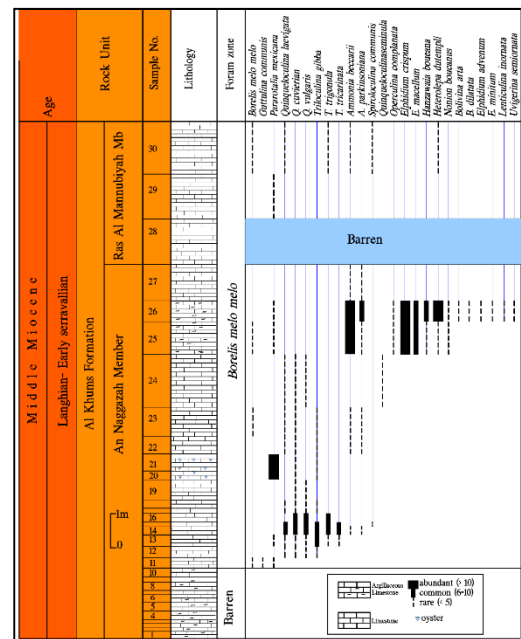
Due to the abovementioned discussion, the presence of *Borelis melo melo* in the present study gives a strong support that Al Khums Formation is of Middle Miocene age (Langhian-Early Serravallian).

**Conclusions:**

Detailed investigation of the foraminiferal content from the stratigraphic section that exposed at Wadi Kaam area led to the recognition of 27 benthic foraminiferal species belonging to 15 genera and 13 families. Based on the vertical distribution of *Borelis melo melo*, one biostratigraphic zone has been recognized. The recorded benthic foraminifera indicated shallow neritic environment. The co-occurrence of corals, large oysters and algae supports shallow marine shelf environments for the deposition of Al Khums Formation.

*Plate 1*

Scale bar = 100 µm, except for 7, 13, 14= 50 µm.



**Fig.2.** Stratigraphic range charts of the recorded foraminifera.

Fig.1: *Spiroloculina communis* Cushman & Todd, sample no. 30.

Fig.2: *Quinquiloculina laevigata* d'Orbigny, sample no. 30.

Fig.3: *Q. cuvieriana* d'Orbigny, sample no. 24.

Fig.4: *Q. seminula* (Linnaeus), sample no. 24.

Fig.5: *Q. vulgaris* d'Orbigny, sample no. 15.

Fig.6: *Triloculina gibba* d'Orbigny, sample no. 23.

Fig.7: *T. inflata* d'Orbigny, sample no. 24.

Fig.8: *T. tricarinata* d'Orbigny, sample no. 30.

Fig.9: *T. trigonula* (Lamarck), sample no. 30.

Fig.10: *Borelis melo melo* (Fichtel & Moll), sample no. 25.

Fig.11: *Lenticulina inornatus* (d'Orbigny), sample no. 26.

Fig.12: *Guttulina communis* (d'Orbigny), sample no. 11.

Fig.13: *Bolinina arta* Macfadyen, sample no. 26.

Fig.14: *B. dilatata* Reuss, sample no. 26.

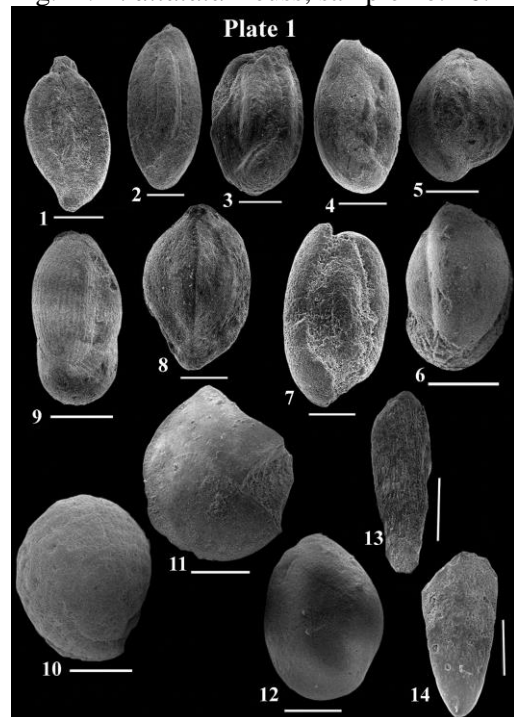


Plate 1

Scale bar = 100 µm, except for 3, 6, 8, 9, 10, 14= 50 µm.

Fig.1: *Uvigerina semiornata* d'Orbigny, sample no. 26.

Fig.2: *Amphistegina lessonii* (d'Orbigny), sample no. 24

Fig.3: *Nonion boueanus* d'Orbigny, sample no. 26.

Figs.4, 5: *Heterolepa dutempli* (d'Orbigny), sample no. 25.

Fig.6: *Hanzawaia boueana* (d'Orbigny), sample no. 25.

Fig.7: *Pararotalia armata* (d'Orbigny), sample no. 29.

Fig.8: *Pararotalia mexicana* (Nuttall), sample no. 21.

Fig.9: *Ammonia beccarii* (Linné), sample no. 27.

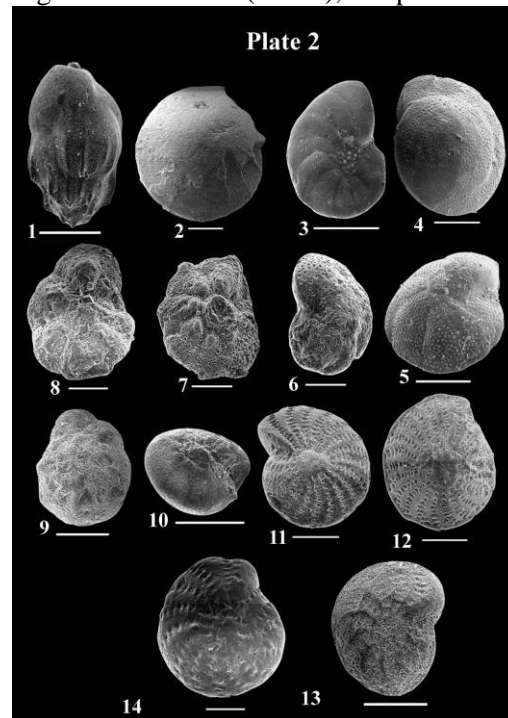
Fig.10: *Ammonia parkinsoniana* (d'Orbigny), sample no. 27.

Fig.11: *Elphidium advenum* (Cushman), sample no. 26.

Fig.12: *E. crispum* (Linee), sample no. 26.

Fig.13: *E. macellum* (Fichtel & Moll), sample no. 26.

Fig.14: *E. minutum* (Reuss), sample no. 26.



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## الملخص العربي

عنوان البحث: أحافير الفورامينيفرا في الميوسين الأوسط من وادي كنام ، الخمس ، شمال غرب ليبيا

شريف الباز ، محمد أحمد ، عبد الرحمن امبابي ، أحمد الفرجاني

قسم لجيولوجيا - كلية العلوم – جامعة دمياط

أسفرت دراسة أحافير الفورامينيفرا التي تم فصلها من منطقة الخمس في ليبيا عن تعريف 28 نوعا تتبع 16 جنس و 14 عائلة، وقد تم تصويرها جميعا بواسطة الميكروسكوب الماسح الإلكتروني ووضحت في لوحتين. وقد اشتملت القطاعات المدروسة علي نطاق حيوي واحد بواسطة الفورامينيفرا القاعية وهو : Borelis melo melo Biozone تم تحديد مكون الخمس والذي يتكون من صخور جيرية ومارل وقد أمكن تقسيمه صخريا (من الأقدم الي الاحداث) إلي عضوين هما : أ- عضوا النقازة ، ب- عضوراس المنوبية. ومن خلال دراسة الانواع المختلفة من الفورامينيفرا من حيث الاعداد و التنوع واستخدام بعض الطرق الاحصائية تبين أن مكون الخمس قد ترسب تحت مياه بحرية دافئة و ضحلة.