Journal of Earth Science, Vol. 28, No. 1, p. 001–008, February 2017 *ISSN 1674-487X*
Printed in China
DOI: 10.1007/s12583-016-0906-2

Facies Analysis and Biostratigraphy of the Miocene Sequence, Cairo-Suez District, Egypt

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ABSTRACT: Miocene siliciclastic-carbonate deposits are widely exposed in Cairo-Suez District, Egypt. These deposits are underlain and overlain by continental sediments of Oligocene and post Miocene, respectively. Three stratigraphic sections were investigated at Gabals Geneife, Homeira and Gharra. Lithostrtigraphically, the Miocene sequence could be differentiated into two main rock units representing shallow deposits with relatively intermittent deep marine incursions. These are from base to top, Gharra Formation and Genefe Formation. Detailed macrofossils investigations led to the recognition of four macrofossil zones, namely *Alectryonella plicatula-Crassostrea frondosa* Range Zone, *Echinolampas amplus-Scutella ammonis* Range Zone, *Chlamys* (*Macrochlamys*) *sardoa-Chlamys* (*Argopecten*) *submalvinae* Range Zone, and *Chlamys gentoni-Pecten* (*Oppenheimopecten*) *benedictus-Pecten* (*P.*) *ziziniae* Assemblage Zone. Microfacies analysis and identified taxa indicated that the Miocene sequence was deposited in transgressive-regressive cycles ranged from near shore, warm shallow inner to middle shelf marine environments with storm influence during the accumulation of the oyster banks.
KEY WORDS: facies analysis, biostratigraphy, Miocene, Cairo-Suez District, Egypt.

0 INTRODUCTION

In Egypt, the Miocene rocks are widely distributed covering about 1/8 of the area of the exposed sedimentary rocks. They outcropped mainly in the following areas: north western desert, Cairo-Suez area, Gulf of Suez and Red Sea coastal plain. The Cairo-Suez area is situated at the east of Cairo and extends about 120 km to the city of Suez. It lies between 29º55′N–30º20′N and 31º15′E–32º35′E (Fig. 1). The topography of the area is largely controlled by its structure and the relief is generally low except for few hills and small mountains. Topographically, the area is subdivided into three ridges crossing the district in a more or less E-W alignment; between these ridges there are two depressions. The Cairo-Suez asphaltic road passes through the southern one. Gabal Ataqa, Gabal Abou Treifiya, Gabal Qattamiya, Gabal Anqabiaya, Gabal Nasuri and Gabal Mokattam form an elongated ridge running parallel to Cairo-Suez High Way depression from east to west and to the south of it (Abou Khadrah et al., 1993). The oldest exposed rocks in the area are of Early Cretaceous age while the youngest rocks are of Quaternary age of synrift sedimentary sequence (Bruce and Hotzl, 1988).

The Miocene rocks of the Cairo-Suez area were the subject of many studies since the last quarter of the 19th century. Most of these studies focused on the stratigraphy and sedimentology with little emphasis on the micro- and macrofossils that could delineate, to a great extent, the age of the different rock units. Therefore, the main target of the present work is to study the facies analysis and biostratigraphy of the Miocene sequence in Cairo-Suez District, Egypt.

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Manuscript received July 9, 2014.
Manuscript accepted December 10, 2014.

1 STUDY SECTIONS

The early Middle Miocene is a time of an extensive marine transgression following a major drop of the sea level at the Burdigalian/Langhian transition (Hardenbol et al., 1998; Haq et al., 1987). The Miocene rocks of Cairo-Suez District are differentiated into marine and non-marine deposits and have been previously discussed by different authors (e.g., El-Sorogy, 2015, 2002; Tawfik et al., 2015; El-Hedeny, 2005; El-Sorogy et al., 2005; Abdelghany, 2002; Mandic and Piller, 2001; El-Sorogy and Ziko, 1999; Ismail and Abdelghany, 1999; El-Safory and El-Sorogy, 1998; Said and Metwalli, 1964; Said and Yallouze, 1955; Shukri and Akmal, 1953).

1.1 Gabal Geneifa Section

This section lies between the exposed Eocene limestones of Gabal Geneifa to the west and Suez-Port Said asphaltic road to the east. It extends between longitudes 32º20′30″E–32º22′30″E, and latitudes 30º12′20″N–30º13′20″N (Fig. 1). The base of the succession is unexposed. The scarp of Geneifa gets gradually low and low southwards. The lowermost rock samples are available to be collected from a mine near the asphaltic road, south of Geneifa Town. The succession measures a total thickness of 97.1 m (Fig. 2).

El-Sorogy, A. S., Abd-Elmoneim, M., Mowafi, A., et al., 2017. Facies Analysis and Biostratigraphy of the Miocene Sequence, Cairo-Suez District, Egypt. *Journal of Earth Science*, 28(1): 1–8. doi:10.1007/s12583-016-0906-2. http://en.earth-science.net

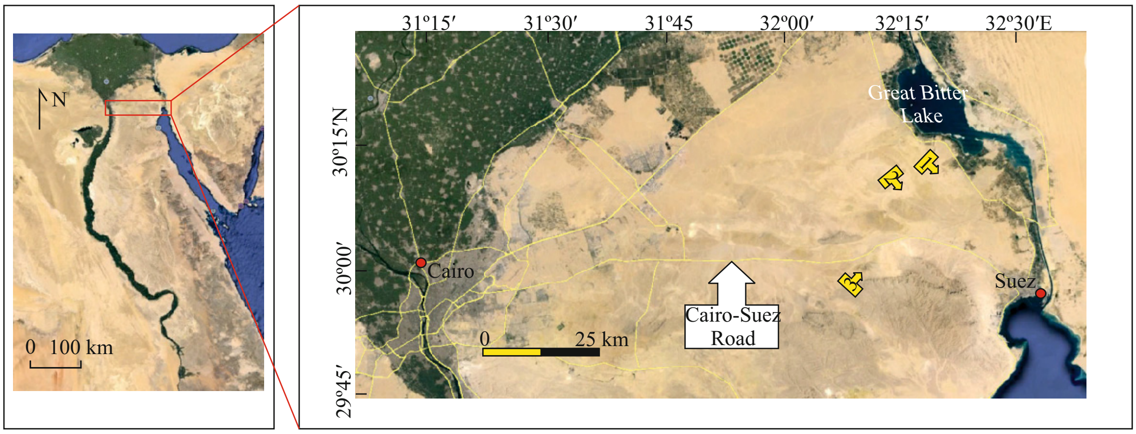

Figure 1. Location map of the studied sections. 1. Gabal Geneifa; 2. Gabal Gharra; 3. Gabal Homeira.

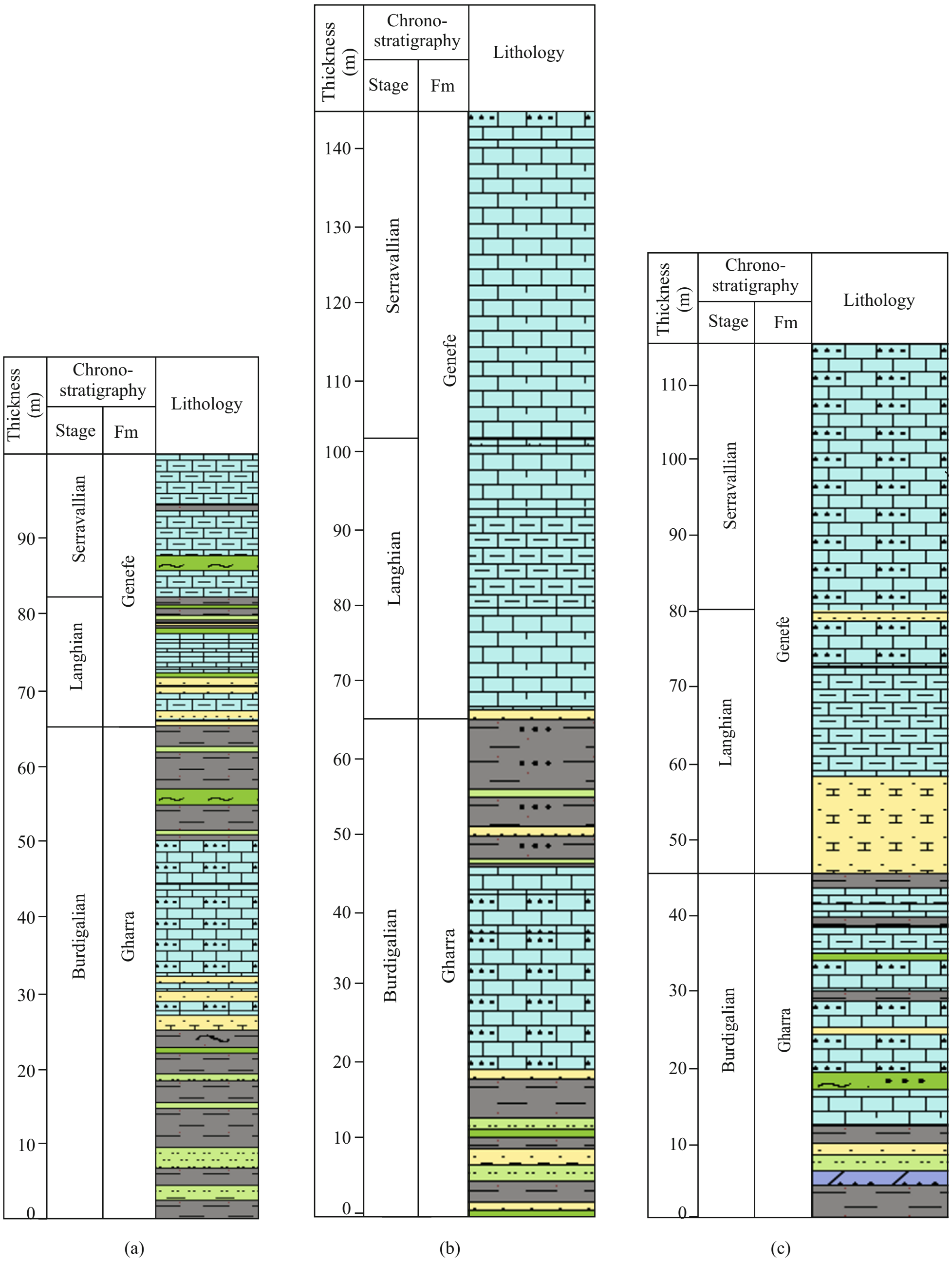

Figure 2. Lithostratigraphy of the three studied Miocene sections at Cairo-Suez District, Egypt. Fm. Formation.

1.2 Gabal Homeira Section

Gabal Homeira lies to the north of Gabal Ataqa and to the southeast of Gabal Iweibid. It extends between longitudes 32º17′00″E–32º18′00″E, and latitudes 30º10′30″N–30º12′00″N (Fig. 1). The lower part of the Miocene succession there is represented mainly by clastic deposits, unconformably overling the Oligocene sands and gravels, while its upper part is represented mainly by non-clastic sediments. This succession measures a total thickness of 110.9 m (Fig. 2).

1.3 Gabal Gharra Section

Gabal Gharra lies about 13 km to the west of Gabal Geneifa and about 13 km to the northeast of Gabal Iweibed. It extends between longitudes 32º11′00″E–32º13′20″E, and latitudes 30º02′12″N–30º03′18″N (Fig. 1). The base of the Miocene succession there is exposed and unconformably overlies the Oligocene sands and gravels. As in the previous two sections, the lower part is represented mainly by clastic deposits, while the upper one is made up of non-clastic sediments. This section measures a total thickness of 141.7 m (Fig. 2).

2 MATERIALS AND METHODS

The present work depends on three field trips to Cairo-Suez District. Three surface sections were selected, measured and sampled at Gabal Geneifa, Gabal Gharra, and Gabal Homeira (Figs. 1, 2). Invertebrate macrofossils were collected, cleaned and identified. Thirty representative rock samples were prepared for microfacies investigations.

3 RESULTS AND DISCUSSION

3.1 Facies Analysis

The Early Miocene sediments consist of sandstone and mudstone with minor intercalations of sandy limestone (Figs. 2, 3). They differ from the algal limestone of the Sadat Formation (Abdallah and Abd El-Hady, 1966). Thus it is possible to use Gharra Formation (Ghorab and Marzouk, 1965) to the studied Early Miocene sediments. On the other hand the Middle Miocene sediments consist mainly of algal, reefal limestones with oyster banks and with minor mudstone and sandstone intercalations (Figs. 2, 3). These facies associations are different from the clastic facies of the Hommath Formation (Abdallah and Abd El-Hady, 1966) and similar to the ones of Genefe Formation (Said, 1990), so it is applied in the present study.

The marine Miocene sequence could be divided into two sedimentary facies: The lower one is a clastic-dominated facies, which represents the Gharra Formation, while the upper one is a carbonate-dominated, representing the Genefe Formation.

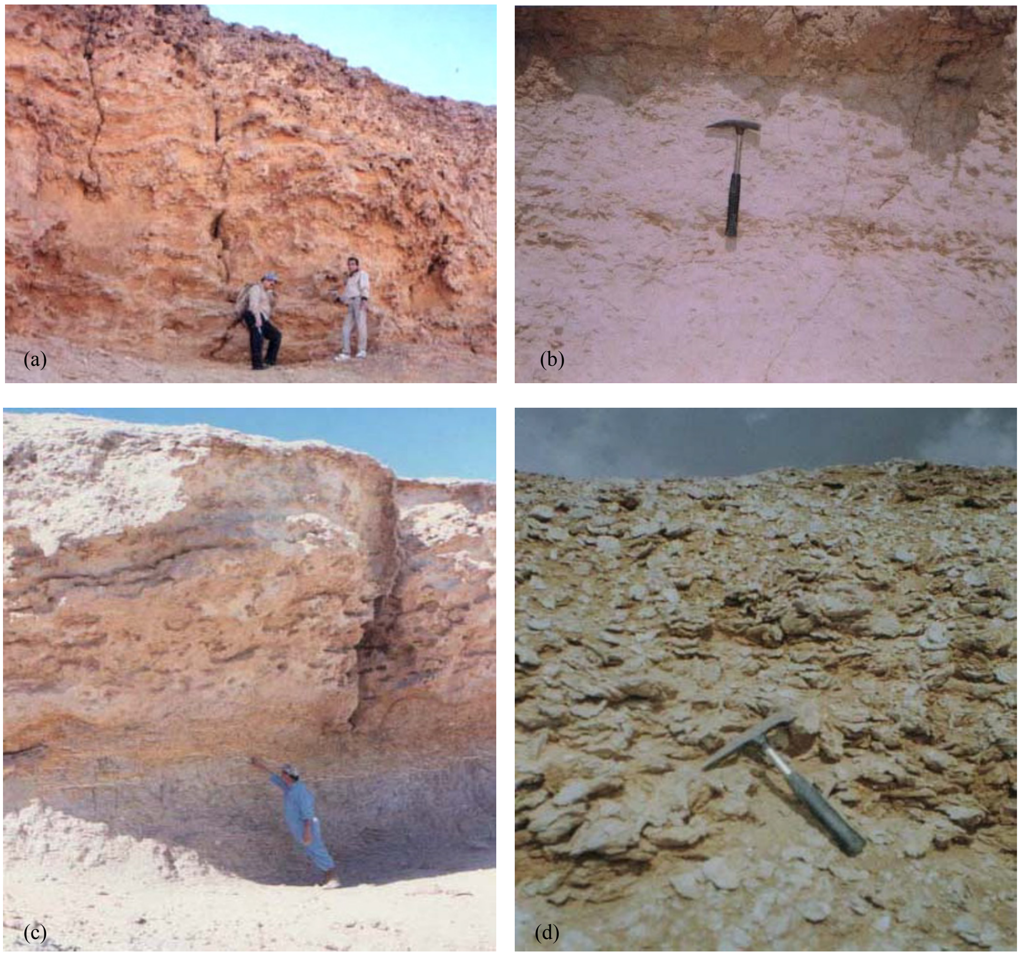

Figure 3. Photographs showing (a) fossiliferous limestone, middle part of Gharra Formation, Gabal Geneifa Section; (b) 0.5 m band of large-sized pectinids in the limestone of the middle part of Gharra Formation, Gabal Gharra Section; (c) succession of claystone, fossiliferous marl and limestone, middle part of Genefe Formation; Gabal Geneifa Section; (d) oyster bank of the middle part of Genefe Formation, Gabal Homeira Section.

3.1.1 Clastic-dominated facies

The lower segment of this facies is an erosional base with extra- and intraformational clasts, followed upward by cross-bedded sandstones. It terminated by thinly laminated, partly bioturbated mudstone, with rare pant remains, which are interpreted to represent a fluvial-fluviomarine depositional system. The upper segment of this facies consists mainly of sandy limestone with oyster banks intercalated with mudstone and sandstone (Fig. 3a).

The sandstone is mainly of fine to coarse grained, subrounded to subangular, calcareous, fossiliferous with pectinids and other bivalves (Fig. 3b), echinoids (*Scutella*, *Clypeaster* and *Echinolampas*) and gastropod molds. The mudstones are medium to thick bedded, non-fossiliferous, moderately compact, jointed, and ferruginous. The limestones are mainly thin to medium bedded, compact, massive, jointed and rich essentially with molluscs (especially pelecypods), gastropod molds, red algae, scleractinian corals and badly preserved echinoderms. Oysters of large size are common.

This sedimentary facies is characterized by the following microfacies associations: calcareous quartz arenite, dolomitic calcareous quartz arenite, calcareous fossiliferous quartz arenite, calcareous ferrugineous quartz arenite, sandy echinoidal foraminiferal grainstone, sandy dolomitic wackestone, sandy fossiliferous grainstone, sandy echinoidal packstone, sandy algal grainstone, sandy bioclastic packstone, and sandy foraminiferal bryozoan packstone. Representatives are illustrated in Figs. 4a, 4b, 4d and 4e.

Based on sedimentary structures, microfacies associations and fossil content the lower part of the Gharra Formation was deposited in a fluvial-fluviomarine depositional system, while the upper part indicates deposition on typical reef flank with some intervals of high energetic shoaling.

3.1.2 Carbonate-dominated facies

This sedimentary facies consists essentially of limestones, sandstones and claystones. The limestones are thick-bedded, compact, massive, chalky, jointed, fractured, bioturbated and

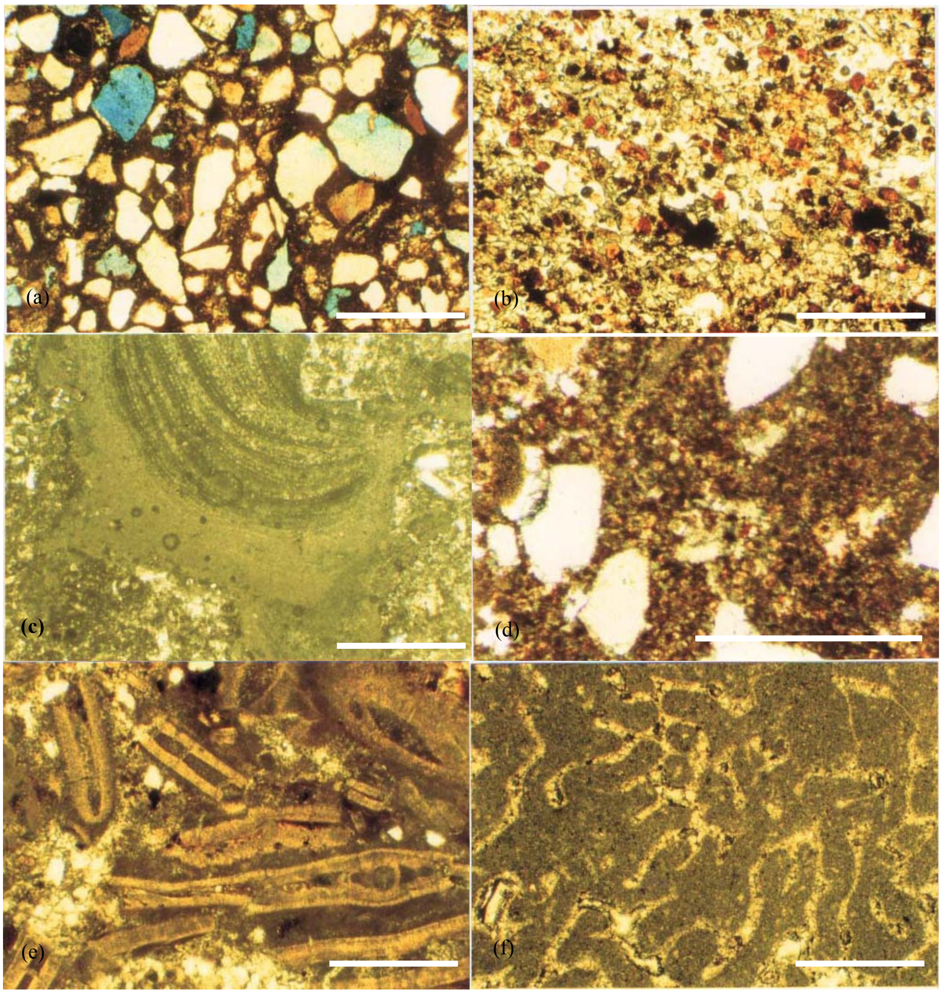

Figure 4. Microphotographs showing representatives of the microfacies associations (scale bar=7 mm). (a) Calcareous quartz arenite with fine to medium, subangular to subrounded quartz grains, cemented with calcareous materials, bed 3, Gharra Formation, Gabal Geneifa, crossed nicols; (b) calcareous ferruginous quartz arenite, bed 3, Gharra Formation, Gabal Gharra, crossed nicols; (c) sandy algal grainstone with red algal and molluscan fragments, cemented by sparite, bed 16, Genefe Formation, Gabal Homeira, plane light; (d) sandy dolomitic wackestone with rhombic zoned, idiotypic dolomite crystals and fine to medium quartz grains, bed 2, Gharra Formation, Gabal Homeira, crossed nicols; (e) sandy foraminiferal bryozoan packstone, with biomorpha of *Operculina* and *Heterostegina* tests, molluscan and bryozoan fragments, all embdded in microsparite cement, bed 10, Gharra Formation, Gabal Gharra, plane light; (f) coralline framestone, the coral skeleton are recrystallized, coral cavities are filled with micrite matrix, bed 13, Gabal Gharra, Genefe Formation, plane light.

highly fossiliferous with coralline red algae, *Amphistigina*, *Miogypsina* and oysters (Figs. 3c, 3d). Sandstone is characterized by abundance of *Scutella* and large *Pecten* forms.

The carbonate-dominated facies gave the following microfacies associations: sandy bioclasts packstone, sandy foraminiferal bryozoan packstone, sandy molluscan grainstone, foraminiferal algal wackestone, sandy bioclastic packstone, sandy echinoidal foraminiferal grainstone, sandy algal grainstone, algal coralline framestone and coralline framestone. Representatives are illustrated in Figs. 4c and 4f.

The fossil content, microfacies associations and sedimentary structures indicated that the environment of deposition was reefal environment for the lower part to shelf lagoons with open circulation and an intertidal environment with low energy conditions for the deposition of mudstones in the top most part of Genefe Formation. The reefal part is similar to the carbonate Safra Formation in southern Sinai and Red Sea coast (El-Sorogy, 2001; Abu El-Enain and El-Sorogy, 1994).

3.2 Biostratigraphy

Few biostratigraphic studies were carried out on the Miocene rocks of the study area. They mostly based on larger foraminifera, especially *Heterostegina costata*, *H. heterostegina*, *Miogypsina intermedia*, *Miogypsina*, *Cushmani*, *Planostegina heterostegina*, and *Operculina complanata* (Abdelghany, 2002; Cherif, 1980, 1966; Souaya, 1963).

In the present study, 63 macrofossil species (41 bivaves, 16 gastropods and 6 echinoids) belong to 34 genera and 26 families have been identified. Because studied taxa were previously described in numerous publications, only the 9 species used in biostratigraphic zonation are photographed (Figs. 5, 6) and their paleogeographic distribution is treated.

The recorded macrofauna are found enough and reliable for biostratigraphic differentiation of Gharra and Genefe formations. Occurences of all identified species within the three studied sections are recorded (Table S1). Investigation of this table and actual impression from field led to the establishment of very distinctive macro-biozones characterized by good feasibility in practical application.

The presented biostratigraphy based on the ranges and assemblages of macrofauna. Detailed investigations of the macrofaunal content of the studied sequence led to the

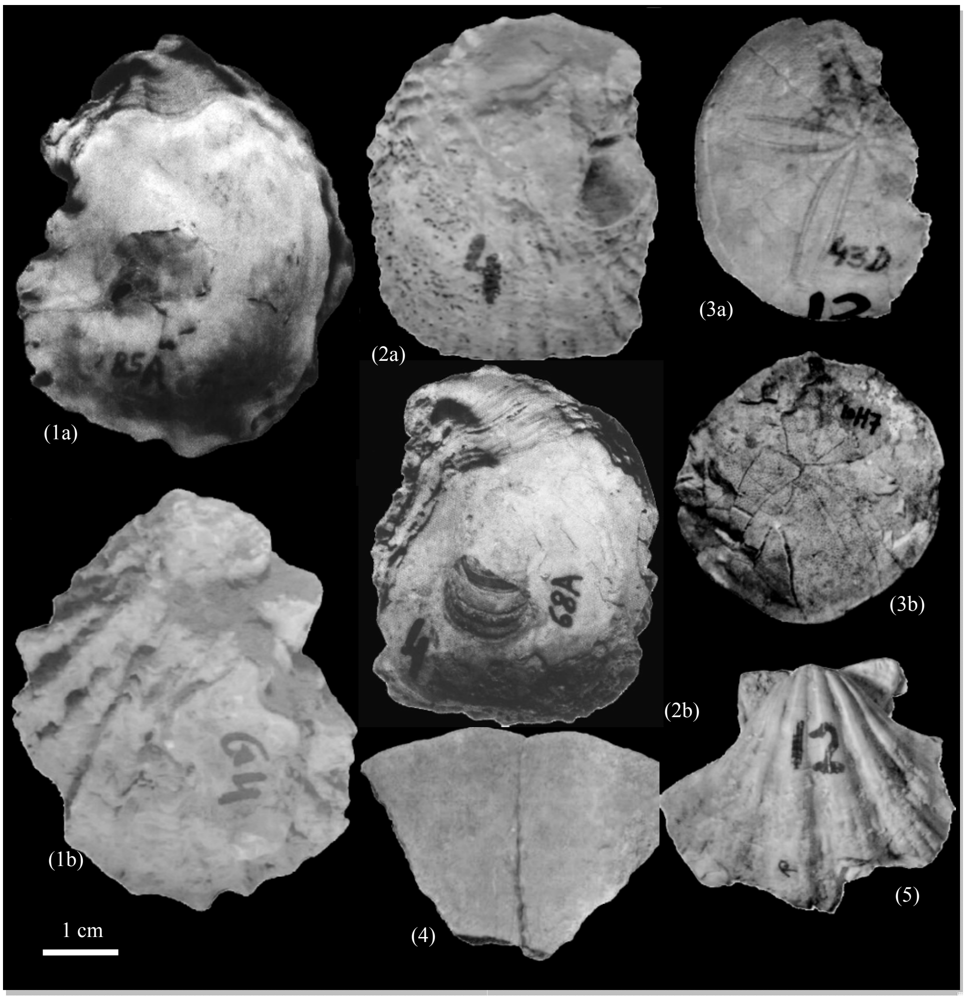

Figure 5. Plate showing macrofauna used in zonation. (1a) and (1b) External and internal views of left valve of *Alectryonella plicatula* (Gmelin), bed 6, Gharra Section; (2a) and (2b) external and internal views of left valve of *Crassostrea frondosa* (De Serres), bed 5, Geneife Section; (3) aboral and oral views of *Echinolampas amplus* Fuchs, bed 6, Gharra Section; (4) a fragment of *Scutella ammonis* Fuchs, bed 11, Homeira Section; (5) external view of right valve of *Chlamys* (*Macrochlamys*) *sardoa* Ugolini, bed 14, Gharra Section.

recongition of four bio-zones (Table S2).

3.2.1 *Alectryonella plicatula-Crassostrea frondosa* Range Zone

This zone is defined on the basis of stratigraphic and geographic range of the two nominated zonal taxa (*Alectryonella plicatula* (Gmelin) and *Crassostrea frondosa* Fuchs) within the studied sections. It occupies the upper part of Gharra Formation and nearly the whole sediments of Genefe Formation, from beds 6 to 15 in Gharra Section, from 5 to 14 in Geneife Section and from 11 to 18 in Homeira Section (Table S2). The range of this zone is characterized by high to moderate diversity of both genera and species.

Paleogeographically, *Alectryonella plicatula* (Gmelin) and *Crassostrea frondosa* Fuchs were previously recorded from many Egyptian Miocene localities as Cairo-Suez District and north western desert (El-Sorogy et al., 2005; Fuchs, 1883).

3.2.2 *Echinolampas amplus-Scutella ammonis* Range Zone

This zone is defined on the basis of the stratigraphic and geographic range of *Echinolampas amplus* Fuchs and *Scutella ammonis* Fuchs. It occupies the upper part of the Gharra Formation and the lower part of the Genefe Formation, from beds 6 to 13 in Gharra Section, from beds 5 to 13 in Geneife Section and from beds 11 to 16 in Homeira Section (Table S2).

Paleogeographically, *Echinolampas amplus* Fuchs and *Scutella ammonis* Fuchs were previously recorded from several Egyptian Miocene localities such as Cairo-Suez District and north western desert (El-Sorogy et al., 2005; Abd-Elmoniem, 1992; Ali, 1975; Said, 1962; Said and Yallouze, 1955).

3.2.3 *Chlamys* (*Macrochlamys*) *sardoa-Chlamys* (*Argopecten*) *submalvinae* Assemblage Zone

This zone is defined on the basis of the great abundance of *Chlamys* (*Macrochlamys*) *sardoa* Ugolini and *Chlamys* (*Argopecten*) *submalvinae* (Blanckenhorn, 1901). It occupies the upper part of Genefe Formation, from beds 14 and 15 in Gharra Section, from beds 12 and 13 in Geneife Section and bed 19 in Homeira Section (Table S2). *Chlamys* (*Argopecten*) *submalvinae* is not recorded in Homeira Section. The range of this zone

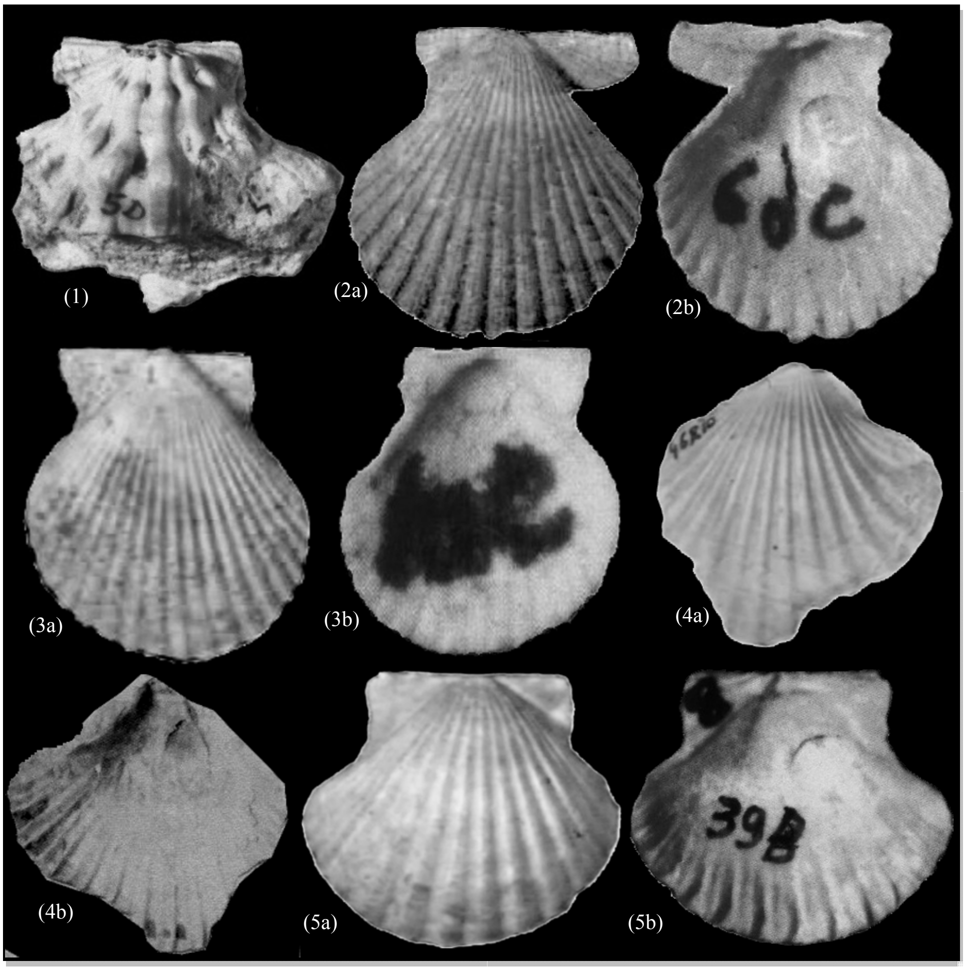

Figure 6. Plate showing macrofauna used in zonation. (1) Internal view of right valve of *Chlamys* (*Macrochlamys*) *sardoa* Ugolini, bed 14, Gharra Section; (2a) and (2b) external and internal views of right valve of *Chlamys* (*Argopecten*) *submalvinae* (Blanckenhorn), bed 12, Geneife Section; (3a) and (3b) external and internal views of left valve of *Chlamys gentoni* (Fontannes), bed 6, Gharra Section; (4a) and (4b) external and internal views of right valve of *Pecten* (*Oppenheimopecten*) *benedictus* Lamarck, bed 10, Homeira Section; (5a) and (5b) external and internal views of right valve of *Pecten* (*P.*) *ziziniae* Blanckenhorn, bed 5, Geneife Section.

is characterized by high diversity of both genera and species.

Paleogeographically, *Chlamys* (*Macrochlamis*) *sardoa* was previously recorded from Upper Miocene of Sardenia and Upper Burdigalian to Langhian of Egypt (El-Sorogy et al., 2005; Roger, 1939; Blanckenhorn, 1901). *Chlamys* (*Argopecten*) *submalvinae* (Blanckenhorn) was recorded from Miocene rocks of Italy, Egypt, Syria and Cyprus (El-Shazly and Saber, 1999; Roger, 1939).

3.2.4 *Chlamys gentoni-Pecten* (*Oppenheimopecten*) *benedictus-Pecten* (*P.*) *ziziniae biozone* Assemblage Zone

This zone is defined on the assemblage of *Chlamys gentoni* Fontannes, *Pecten* (*Oppenheimopecten*) *benedictus* Lamarck and *Pecten* (*Pecten*) *ziziniae* Blanckenhorn. It occupies Gharra Formation, from beds 6 to 10 in Gharra Section, from beds 5 to 8 in Geneife Section and from beds 10 to 13 in Homeira Section (Table S2). *Pecten* (*Oppenheimopecten*) *benedictus* is not recorded in Geneife Section.

Paleogeographically, *Chlamys gentoni* Fontannes is previously recorded from the Neogene sediments of Europe and Egypt (El-Sorogy et al., 2005; Roger, 1939). *Pecten* (*Oppenheimopecten*) *benedictus* Lamarck is recorded from the Miocene sediments of Rhone Valley; Pliocene of Italy, Spain and Algeria and Egypt (El-Sorogy et al., 2005; Fuchs, 1883). *Pecten* (*Pecten*) *ziziniae* Blanckenhorn is recorded from Burdigalian to Tortonian sediments in different localities of Egypt (El-Shazly and Saber, 1999).

4 CONCLUSIONS

(1) The investigated Miocene sediments at Gabals Geneife, Homeira and Gharra in Cairo-Suez District are differentiated into Early Miocene clastic-dominated Gharra Formation at the base and Middle Miocene carbonate-dominated Genefe Formation at the top.

(2) Sixty-three macrofossil species (41 bivalves, 16 gastropods and 6 echinoids) belong to 34 genera and 26 families have been identified from the three studied sections. Detailed macrofaunal investigations led to recognition of three macrofossil range zones and one assemblage zone, namely: *Alectryonella plicatula-Crassostrea frondosa* Range Zone, *Echinolampas amplus-Scutella ammonis* Range Zone, *Chlamys* (*Macrochlamys*) *sardoa-Chlamys* (*Argopecten*) *submalvinae* Range Zone and *Chlamys gentoni-Pecten* (*Oppenheimopecten*) *benedictus-Pecten* (*P.*) *ziziniae* Assemblage Zone.

(3) Based on identified taxa, microfacies analyses and sedimentary lithofacies analysis, the lower part of the Gharra Formation is deposited in a fluvial-fluviomarine depositional system, while the upper part indicates deposition on typical reef flank with some intervals of high energetic shoaling. The depositional environment of Genefe Formation ranged from reefal environment for the lower part, to shelf lagoons with open circulation and an intertidal environment with low energy conditions for the deposition of mudstones in the top most part.

ACKNOWLEDGMENTS

The authors would like to extend their sincere appreciation to the Deanship of Scientific Research at King Saud University for its funding this research group (No. RG-1436-036). The authors are deeply grateful to late Prof. Ezzat Abd-Elshafy, Zagazig University for assistance in megafossils identification. The final publication is available at Springer via http://dx.doi.org/10.1007/s12583-016-0906-2.

Electronic Supplementary Materials: Supplementary materials (Tables S1–S2) are available in the online version of this article at http://dx.doi.org/10.1007/s12583-016-0906-2.

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