Egyptian Journal of Geology, v. 64, 2020, p. 455-470

BIOSTRATIGRAPHY OF THE MIOCENE SUCCESSIONS IN THE SADAT AREA, WEST GULF OF SUEZ-EGYPT

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ABSTRACT

The age of the exposed Sadat, Hommath and Hagul formations in Sadat area on the west side of the Gulf of Suez, is inadequately resolved due to the scarcity of diagnostic planktic foraminifera and calcareous nannofossil taxa. The detailed analysis of the calcareous nannofossil content, planktic and larger benthic foraminifera of three sections measured in Wadi El-Ramiya, Wadi Hommath and Wadi Hagul at Sadat area, allows identification of 23 calcareous nannofossil species, 23 planktic foraminiferal species and 152 benthic foraminiferal species. Our results indicate that the Sadat Formation is assigned to Burdigalian-Langhian age according to the occurrence of *Miogypsina cushmani* and *Miogypsina intermedia* in its lower part and the appearance of *Borelis melo* in its upper part. The Hommath Formation is assigned to the Langhian-Serravallian age depending on the occurrence of *Borelis melo curdica* together with *Borelis melo melo.* The Hagul Formation is barren from any zonal marker but it is assigned to the late Miocene age according to its stratigraphic position.

Keywords: Miocene biostratigraphy, microfossil content, larger benthic foraminifera, Sadat Area.

INTRODUCTION

The Sadat area lies in the west side of the Gulf of Suez about 30 km southwest of the Suez city. The Miocene sediments are widely distributed in the Sadat area, it is forming a low land bounded from the north and south by Eocene rocks (Fig. 1). The importance of the Sadat area comes from being a source of calcium carbonate that exploited in the fertilizers and chemical industries company Cherif (1966). Many workers have been studied the Miocene rocks of the Sadat area such as Sadek (1926 and1959), Metwalli (1964), Abdallah and Abdelhady (1968), Cherif (1966), Youssef et al (1971 and 1973), N.S.S.C (1974), Abbass (1977), Cherif and Yehia (1977), Abdelshafy and Abdelmoneim (1992), Elsorogy and Ziko (1999), Ismail and Abdelghany (1999), El-Azabi (2000), Strougo et al (2006), Hamad (2009) and Elattaar (2003 and 2017). The present work focused on the integration between calcareous nannofossils and foraminifera to refine and increase the resolution of the age of the Miocene succession in the Sadat area.

LITHOSTRATIGRAPHY

Three Miocene formations in the Sadat area of the northern part of the Gulf of Suez, at the foot slopes of Gebel Ataqa, were recognized by Abdallah and Abdelhady (1968). These are: Sadat, Hommath and Hagul formations. The aerial distribution of the studied formations is illustrated in a geologic map at scale of 1:100,000 (Fig.1) (modified after Conoco, 1987). The Sadat Formation which is named after a quarry carrying the same name crops out at the southern scarp of Gebel Ataqa and also cover the cliffs bordering the coastal plain from Barabir hills to the mouth of Wadi Hommath (Issawi et al., 1999). It consists of 52 m thick of limestone with marls and sandy marl intercalations. It unconformably overlies middle or upper Eocene units that are separated by a conglomerate bed (Abdallah and Abdelhady, 1968; Fig. 2). Lithologically, the Hommath Formation is a 54 m thick made of shales, marls, limestone, sandstone and grits. It unconformably overlies the Sadat Formation and unconformably underlies the Hagul Formation (Abdallah and Abdelhady, 1968; Fig. 2). The Hagul Formation overlies the Hommath Formation and is made of 19m thick of chalky limestone, sandstone and shale (Fig. 2). The lithological characteristic of these formations and their faunal contents suggest a permanent connection between the northern part of the Gulf of Suez and the Mediterranean Sea since the Chattian (Issawi et al., 1999; Popov et al., 2004; Gargani et al., 2008., Ayyad et al., 2018).

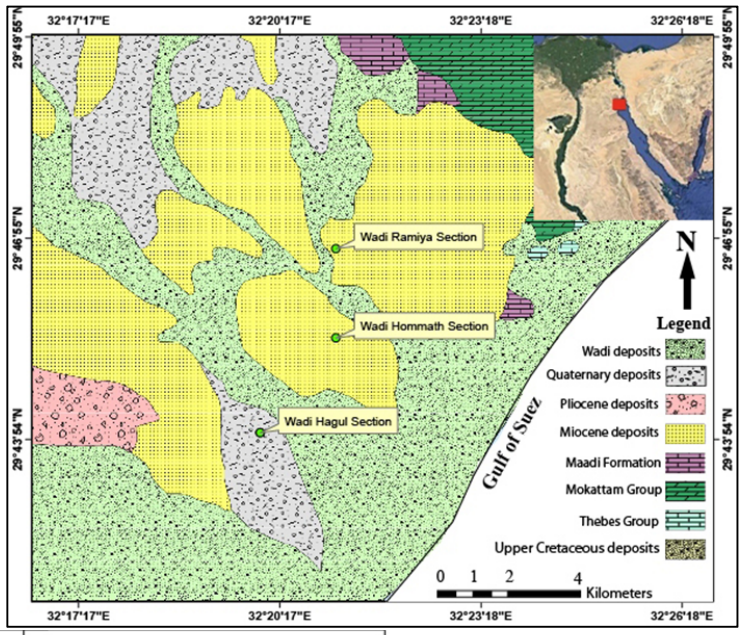

Fig. 1; Geologic map of the study area, showing the location of the measured sections (modified after Conoco, 1987).

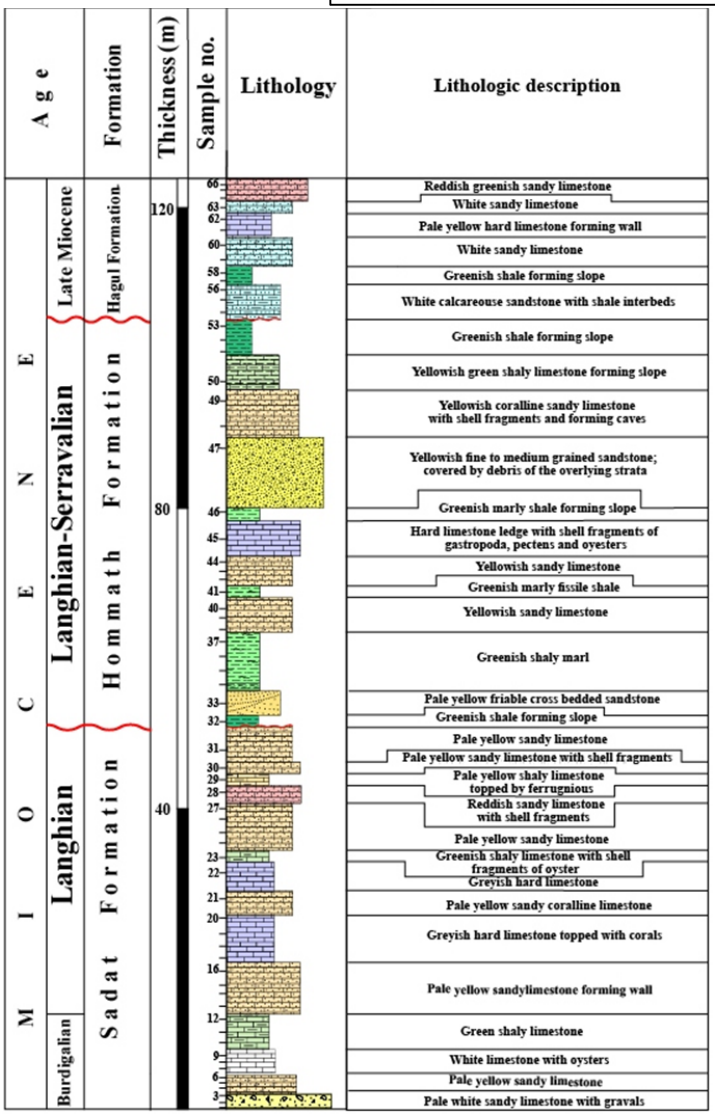

Fig. 2: A composite stratigraphic section exposed in the Sadat area.

Material and Methods

The present study is based on the examination and investigation of calcareous nannofossils and foraminifera found in 66 rock samples collected from three Miocene sections at Sadat area. These are Wadi Ramiya section (Latitude 29° 46' 45" and Longitude 32° 24' 6"), Wadi Hommath section (Latitude 29° 45' 25" and Longitude 32° 21' 8") and Wadi Hagul section (Latitude 29° 44' and Longitude 32° 2') (Fig.1). The samples were prepared for foraminiferal investigations and calcareous nannofossils examination (Figs 3, 4, 5 and 6).

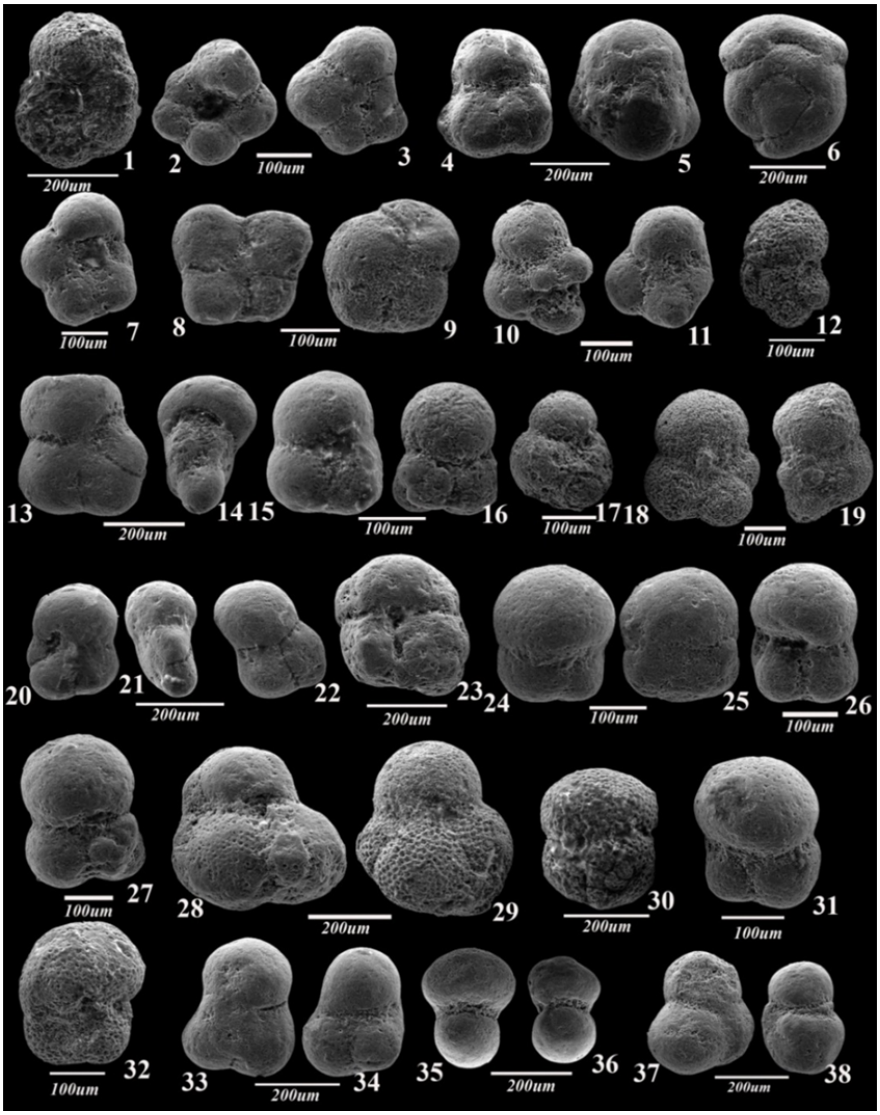

Fig. 3: *Paragloborotalia mayeri* (Cushman and Ellisor), sample No. 9. 2-3. Turborotalita *quinqueloba* (Natland), sample No. 15. 4-5. *Catapsydrax pravulus* (Bolli, Loeblich and Tappan), sample No. 18. 6. *Globoquadrina dehiscens* (Chapman, Parr and Collins), sample No. 13. 7. *Globigerina angustiumbilicata* (Bolli), sample No. 18. 8-9. *Globigerina diplostoma* (Reuss), sample No. 15. 10-11. *Globigerina falconensis* (Blow), sample No. 40. 12. *Globigerinella obesa* (Bolli), sample No. 17. 13-14. *Globigerinella praesiphonifera* (Blow), sample No.18. 15-16. *Globoturborotalita connecta* (Jenkins), sample No.17. *Globoturborotalita druryi* (Akers), sample No. 17. 18-19. *Globoturborotalita occulusa* (Blow and Banner), sample No. 50. 20-22. *Globoturborotalita pseudopraebulloides* (Blow), sample No.18. 23. *Globigerinoides subquadratus* (Brönnimann), sample No. 4. 24-25. *Trilobatus bisphericus* (Todd and Post), sample No. 50. 26-27. *Trilobatus immaturus* (Le Roy), sample No. 17. 28-29. *Trilobatus quadrilobatus* (d′Orbigny), sample No. 21. 30-*Trilobatus sacculiferus* (Brady), sample No. 23. 31. *Trilobatus sicanus* (De Stefani), sample No. 17. 32-33. *Trilobatus trilobus* (Russ), sample No. 17. 34-35. *Sphaeroidinellopsis disjuncta* (Finlay), sample No. 17. 36-37. *Orbulina bilobata* (d′Orbigny), sample No. 28. 38-39. *Praeorbulina transitoria* (Blow), sample No. 17.

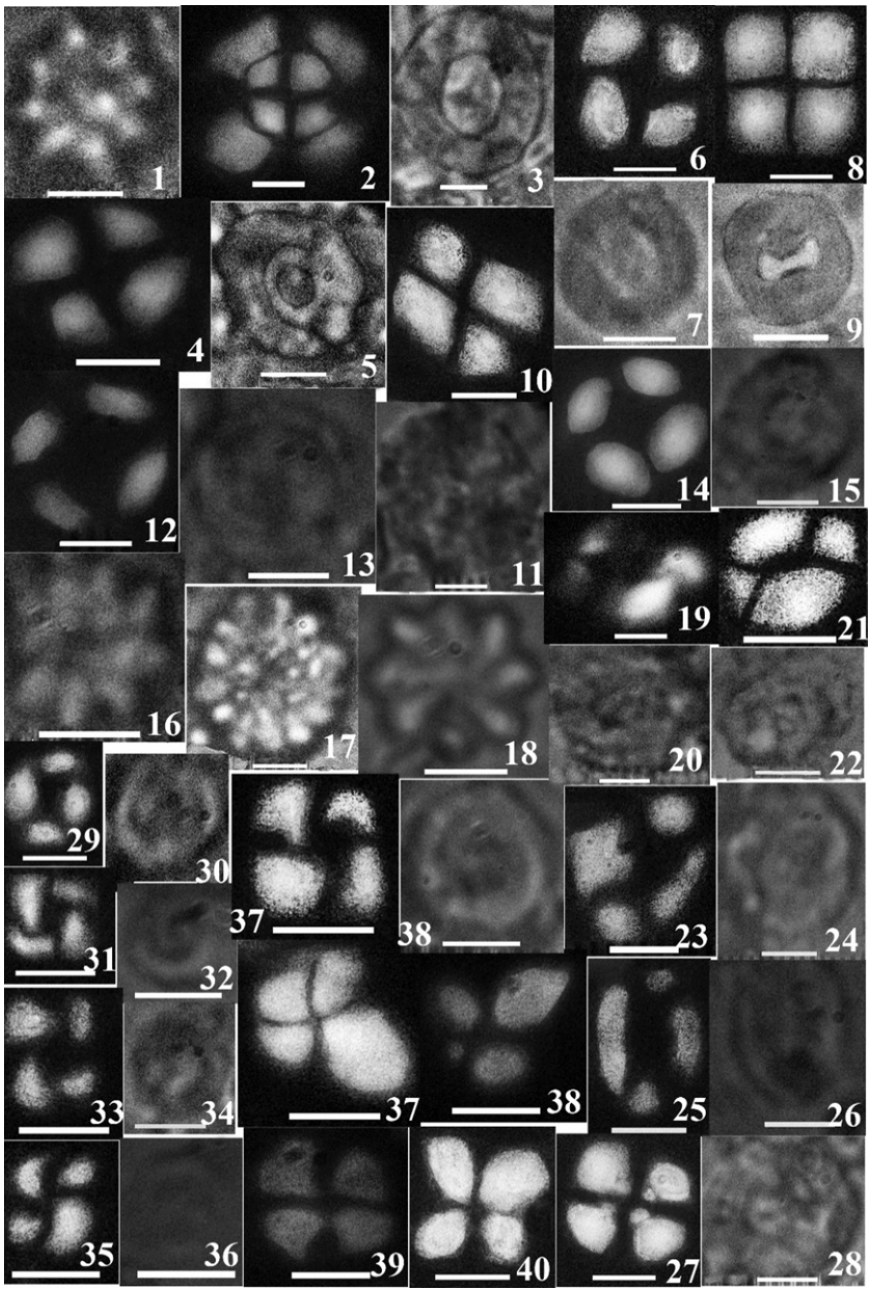

Fig. 4: *Corannulus germanicus* (Stradner), sample No. 47. 2-3. *Coccolithus miopelagicus* (Bukry), sample No. 45. 4-5. *Coccolithus pelagicus* (Wallich), sample No. 45. 6-7. *Ericsonia cava* (Hay et al), sample No. 47. 8-9. *Ericsonia ovalis* (Black), sample No. 49 10-11. *Calcidiscus leptoporus* (Murry and Blackman), sample No. 47. 12-13. *Coronocyclus nitescence* (Kamptner), sample No. 45. 14-15. *Pyrocyclus hermosus* (Hay Mohler and Wade), sample No. 45. 16. *Discoaster mohleri* (Martini), sample No. 47. 17. *Discoaster nobilis* (Martini), sample No. 45. 18. *Hayaster perplexs* (Bramlette and Riedel), sample No. 47. 19-20. *Helicosphaera ampliaperta* (Bramlette and Wilcoxon), sample No. 29. 21-22. *Helicosphaera carteri* (Wallich), sample No. 47. 23-24. *Helicosphaera oblique* (Bramlette and Wilcoxon), sample No. 45. *25-26. Pontosphaera discopora*, sample No. 47. 27-28. *Cyclicargolithus floridanus* (Hay et al.), sample No. 49. 29-30. *Reticulofenestra haqii* (Backman), sample No. 49. 31-32. *Reticulofenestra minuta* (Roth), sample No. 49. 33-34. *Reticulofenestra producta* (Kamptner), sample No. 47. 35-36. *Reticulofenestra pseudoumbilica,* (Gartner), sample No. 49. 37-38. *Sphenolithus heteromorphus* (Deflandre), sample no. 47. 39-40. *Sphenolithus moriformis,* (Bronnimann and Stradner), sample No. 45.

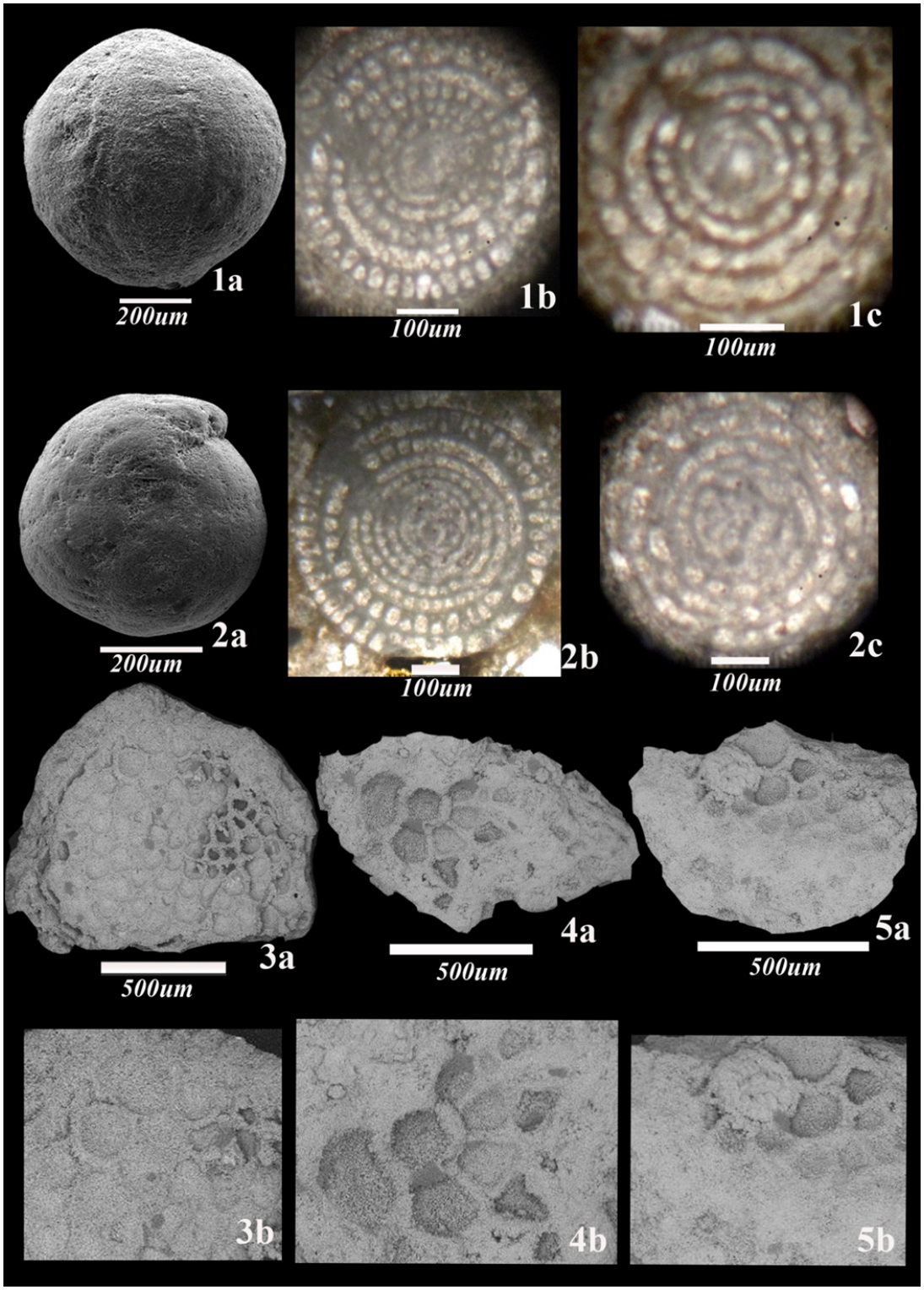

Fig. 5. 1. *Borelis melo curdica* (Reichel), sample no. 50, 1a. external view, 1b. axial view, 1c. equatorial view. 2. *Borelis melo melo* (Fichtel and Moll), sample no. 50, 2a. external view, 2b. axial view, 2c. equatorial view. 3. *Miogypsina cushmani* (Vaughan), sample no. 4. Figs. 4-5. *Miogypsina intermedia* (Drooger) sample no. 4, 6.

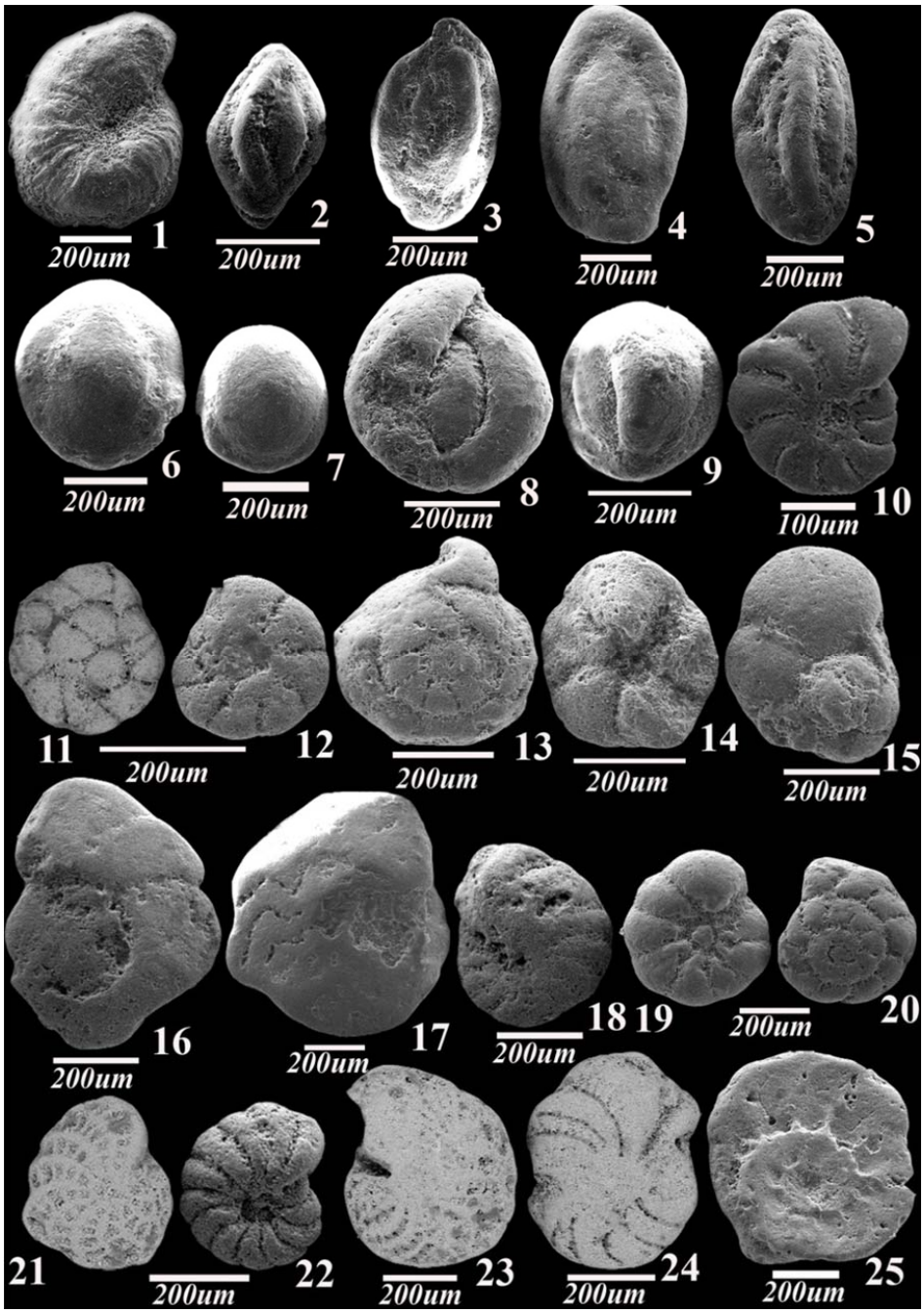

Fig. 6: 1. *Veleroninoides scitulus* (Brady), sample No. 49, 2. *Quinqueloculina akneriana* (d′ Orbigny), sample No. 3. *Quinqueloculina berthelotiana* (d′ Orbigny), sample No. 21, 4-5. *Quinqueloculina laevigate* (d′ Orbigny) sample No. 24, 6. *Pyrgo anomala* (Schlumberger) sample No., 7. Pyrgo depressa (d′ Orbigny) sample No. 15, 8. *Triloculina rotunda* (d′ Orbigny) sample No. 50, 9. *Triloculina trigonula* (Lamarck) sample No. 38, 10. *Peneroplis proteus* (Forskal) sample No. 49, 11-12. *Valvulineria complanata* (d' Orbigny) sample No. 4, 13. *Discorbis dimidiatus* (*Parker and Jones*), sample No. 39, 14. *Gavelinopsis holkos* (Finger and Lipps), sample No. 30, 15. *Rosalina obtusus* (d' Orbigny) sample No. 39, 16. *Cibicidella variabilis* (d' Orbigny) sample No. 10, 17. *Amphistegina lessonii* (d' Orbigny) sample No. 14, 18. *Nonion boueanus* (d' Orbigny) sample No. 15, 19-20. *Ammonia beccarii* (Linné) sample No. 50, 21. *Elphidium advenum* (Cushman) sample No. 4, 22. *Elphidium antoninum* (d' Orbigny) sample No. 39, 23. *Elphidium crispum* (Linne') sample No. 39, *24. Elphidium macellum* (Fichtel and Moll), sample No. 13, 25. *Operculina carpanteri* (Silvesteri) sample No. 13.

Biostratigraphy

The foraminiferal and nannofossil contents are restricted to certain horizons in the three studied sections. A detailed investigation of the studied samples revealed two larger benthic foraminifera contributed in age determination (Fig. 5). Otherwise the planktonic foraminifera and calcareous nannofossils assemblages are not significant in age determinations (Figs. 8, 9, 10, 11 and 12).

Foraminiferal biozones

Biozone (SB 25) *Miogypsina* zone

Definition: In the present study, the lower boundary of this zone is defined by the presence of *Miogypsina cushmani* and *M. intermedia*, while its upper boundary is delimited by the extinction of these species (Ogg et al., 2016).

Author: Cahuzac and Poignant (1997).

Age: Early Miocene (Late Burdigalian).

Stratigraphic position: It is recorded in the lower part of the Sadat Formation at Wadi El-Ramiya section (Fig. 8).

Remarks and correlation: *Miogypsina* is the most conspicuous large benthic foraminiferal taxon recorded in this zone. Drooger (1952 and 1993) assigned the *Miogypsina* group which includes (*Miogypsina intermedia*, *M. cushmani*, *M. globulina* and *M. complanata*) to the Burdigalian Age. In Egypt, Souaya (1961and1963) and Cherif (1966) recorded *Miogypsina intermedia* from the Miocene deposits of Cairo-Suez district and assigned the rocks to the Burdigalian. Nassif et al., (1992) recorded the same species from the Miocene sequence of Wadi Feiran, south west Sinai and assigned the assemblage to the early Miocene (Burdigalian). Ouda (1998) described *Miogypsina intermedia* and *M. cushmani* from the Miocene deposits of the northern Western Desert and assigned to late Burdigalian. Abdelghany and Piller (1999) recorded the *Miogypsina intermedia* and *M. cushmani* from the early Miocene Gharra and Sadat formations in Cairo-Suez district and assigned to late Burdigalian age. Imam and Refaat (2000) identified these species from the early Miocene deposits of Wadi Abura and Gabal Hammam Sayidna Musa, southern Sinai. Abdelghany (2002) recorded the *Miogypsina intermedia* from Gebel Shabrawet area north Eastern Desert and assigned to Burdigalian age. Hamad (2009) recorded *Miogypsina cushmani* and *M. intermedia* from the lower part of the Sadat Formation, Sadat area, Cairo-Suze district and assigned them to early Miocene (early Burdigalian). Moreover, the presence of the larger benthic foraminifera *Miogypsina intermedia* that is widely distributed throughout the Tethys Ocean and known to be restricted to the late early Miocene (Burdigalian); Wildenborg, 1991; Drooger, 1993; Cahuzac and Poignant, 1997; Özcan et al., 2009. Furthermore, Hamad (2013) recorded *Miogypsina intermedia* from the Miocene sequence of Wadi Zaqlum, Sirte basin in Libya and assigned to Burdigalian age. Recently geologic time scale workers correspond the first occurrence of *Miogypsina cushmani* to the base of Zone M4 and corresponds the last occurrence of *Miogypsina* to the top of M4 zone or (SBZ-25). In the present study, the lower part of the Sadat Formation that assigned to this zone is of the late Burdigalian age according to the presence of *Miogypsina intermedia* and *M. cushmani* (Figs. 5 and 8).

Biozone (SB26) *Borelis melo* zone:

Definition: this zone is defined by the first occurrence of *Borelis melo* (Fichtel and Moll) and the disappearance of *Miogypsina* spp., Ogg et al. (2016).

Author: Cahuzac and Poignant (1997).

Age: Middle Miocene age.

Stratigraphic position: Two distinct spherical subspecies of *Borelis melo* are recognized including *Borelis melo melo* (Fichtel and Moll) recorded from the upper part of the Sadat Formation and covering the whole Hommath Formation (Figs. 8 and 9). The second one is *Borelis melo curdica* (Reichel) recorded only from the upper part of the Hommath Formation (Fig. 9).

Remarks and Correlation: Many workers have discussed the stratigraphical importance of *Borelis melo* as a zonal marker defining the beginning of the Middle Miocene age. In Egypt, many authors have used the *Borelis melo* as an evidence for beginning the Middle Miocene age. Souaya (1963a) recorded the *Borelis melo* with the *Miogypsina* in the middle Miocene of Gabal Gharra, Cairo-Suez district. Souaya (1963b) recognized the *Borelis melo* from the middle Miocene- Pliocene in the Red sea. Youssef et al. (1971) recorded the *Borelis melo* from the upper part of the Sadat Formation in the Sadat area and attributed it to Langhian age (Fig. 7). Szczechura and Abd-Elshafy (1988) recorded the *Borelis melo* from the Hommath Formation in Bir El-bada area at the western side of the Gulf of Suez and assigned to Middle Miocene age. Imam et al. (1997) recorded this taxon from the Middle Miocene deposits of Sarbut El-Gamal Formation, west central Sinai. Ouda (1998) recorded the *Borelis melo* from the Miocene successions in the north Western Desert. He considered the *Borelis melo* as a diagnostic taxon for the late Langhian-Serravallian age. Imam and Refaat (2002) recognized the *Borelis melo* Zone from the middle Miocene Marmarica Formation in the Sallum area, Western Desert. Abul Naser et al. (2009) recorded this taxon from the Middle Miocene Hammam Faroun Member of Belayium Formation, between Wadi Sudr and Wadi Wardan, Gulf of Suez region. In the present study, two distinct subspecies of *Borelis melo* are recognized *Borelis melo melo* (Fichtel and Moll) and *Borelis melo curdica* (Reichel). The presence of these two species suggests that the upper part of the Sadat Formation and the whole Hommath Formation is of Langhian-Serravallian age.

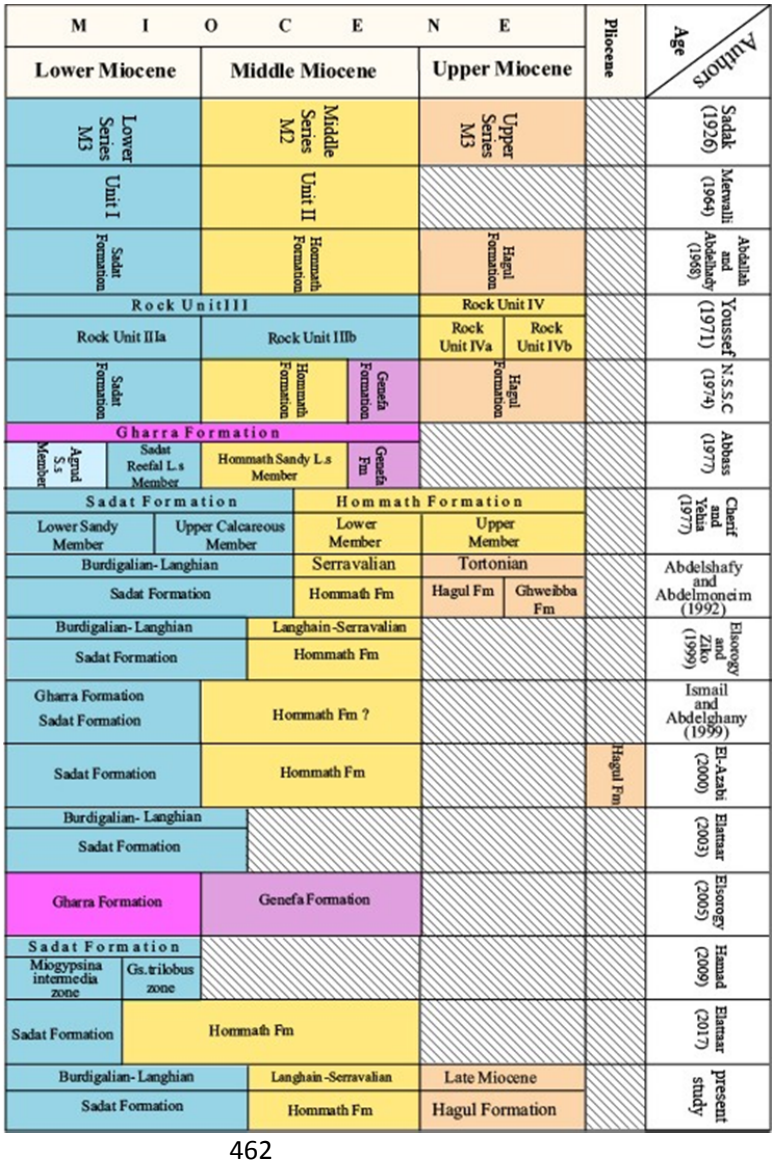

Fig. 7: Different rock units proposed by different author for the Miocene rocks in the Cairo-Suez district.

Planktic foraminifera

The planktic foraminiferal assemblage obtained from the studied area is very restricted. It includes 23 species recorded from the Sadat Formation where 14 of them recorded from the Hommath Formation (Figs. 3, 11 and 12). This assemblage is not significant in age determination due to the absence of the age diagnostic taxa (Fig. 3).

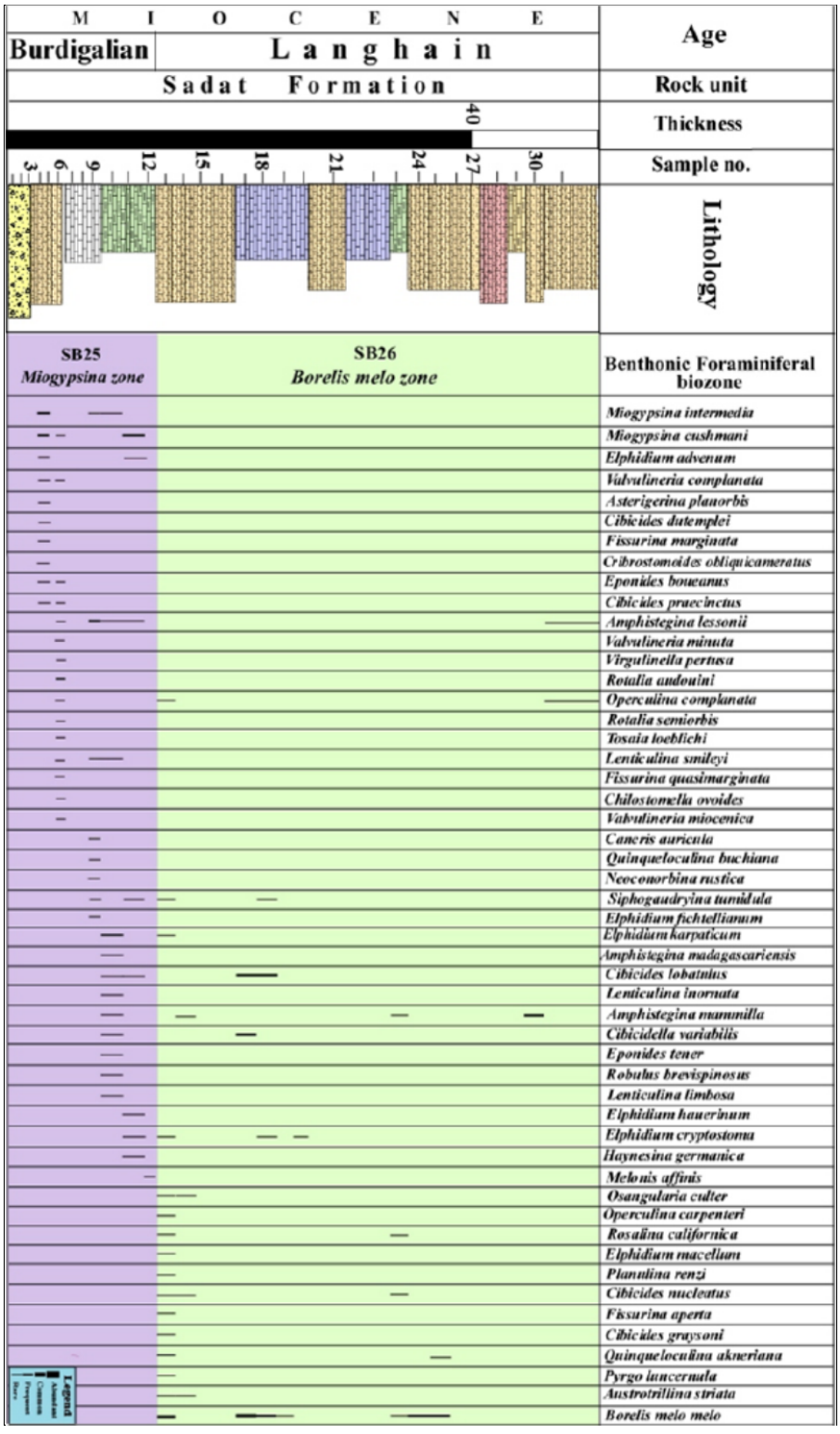

Fig. 8: Distribution chart of the identified benthic foraminiferal species at Wadi El-Ramiya section.

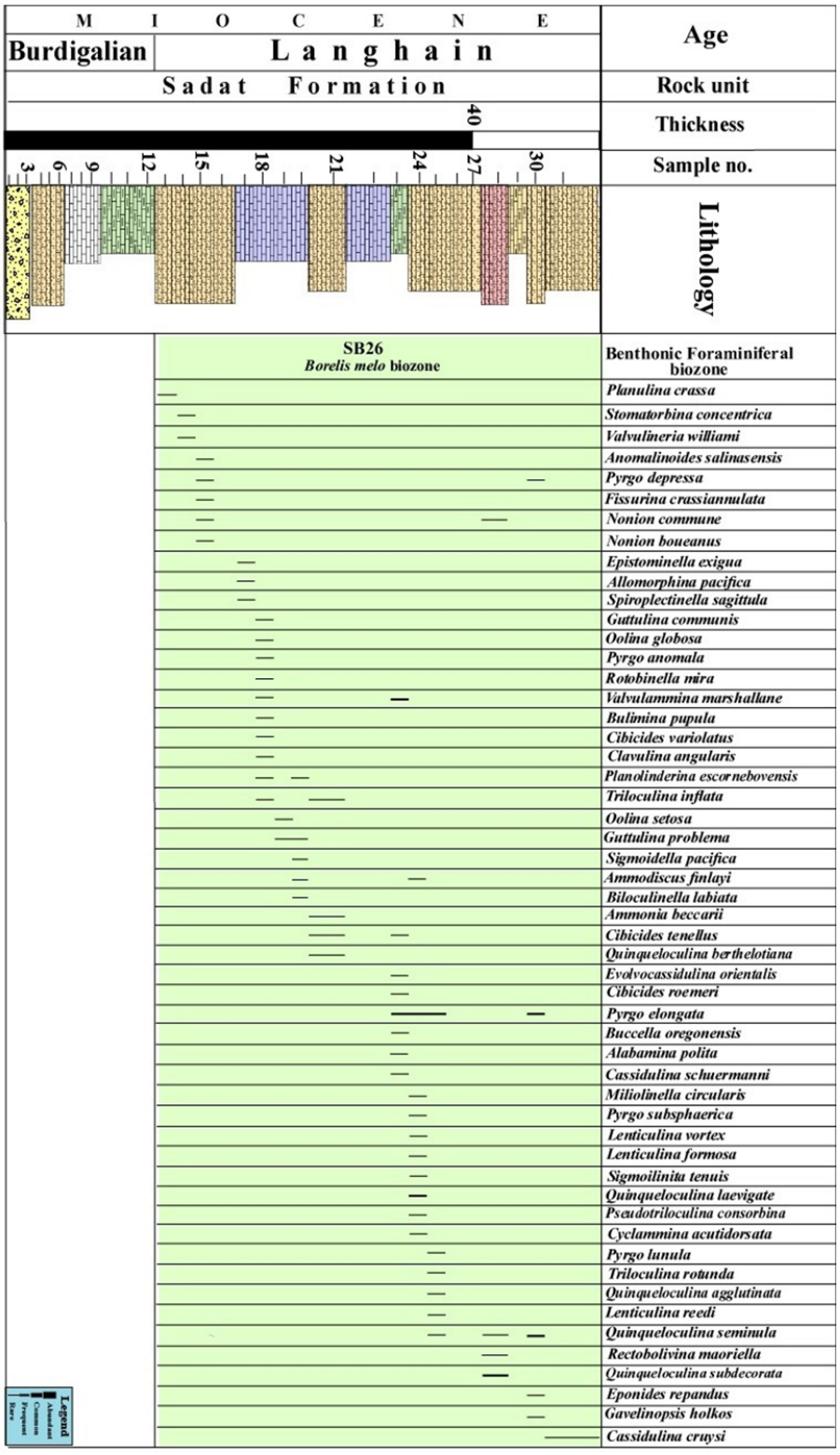

Fig. 8 cont.

Calcareous nannofossils

The recognized calcareous nannofossil assemblage described here includes 23 species recorded from the upper part of the Hommath Formation at Wadi Hommath section (sample 45, 47, 49) (Figs. 4 and 12),

six of them are recorded from the Sadat Formation (sample 4, 8, 26, 29) (Figs. 4 and 11). This nannofossil assemblage is poorly represented in the studied samples and sometimes only by single individual. Most of these species are not significant for age determination (Fig. 4). Only *Helicosphaera ampliaperta* that recorded from the upper part of the Sadat Formation and the lower part of the Hommath Formation that may refers to *Helicosphaera ampliaperta* Zone of early-middle Miocene Age. (Fig. 12).

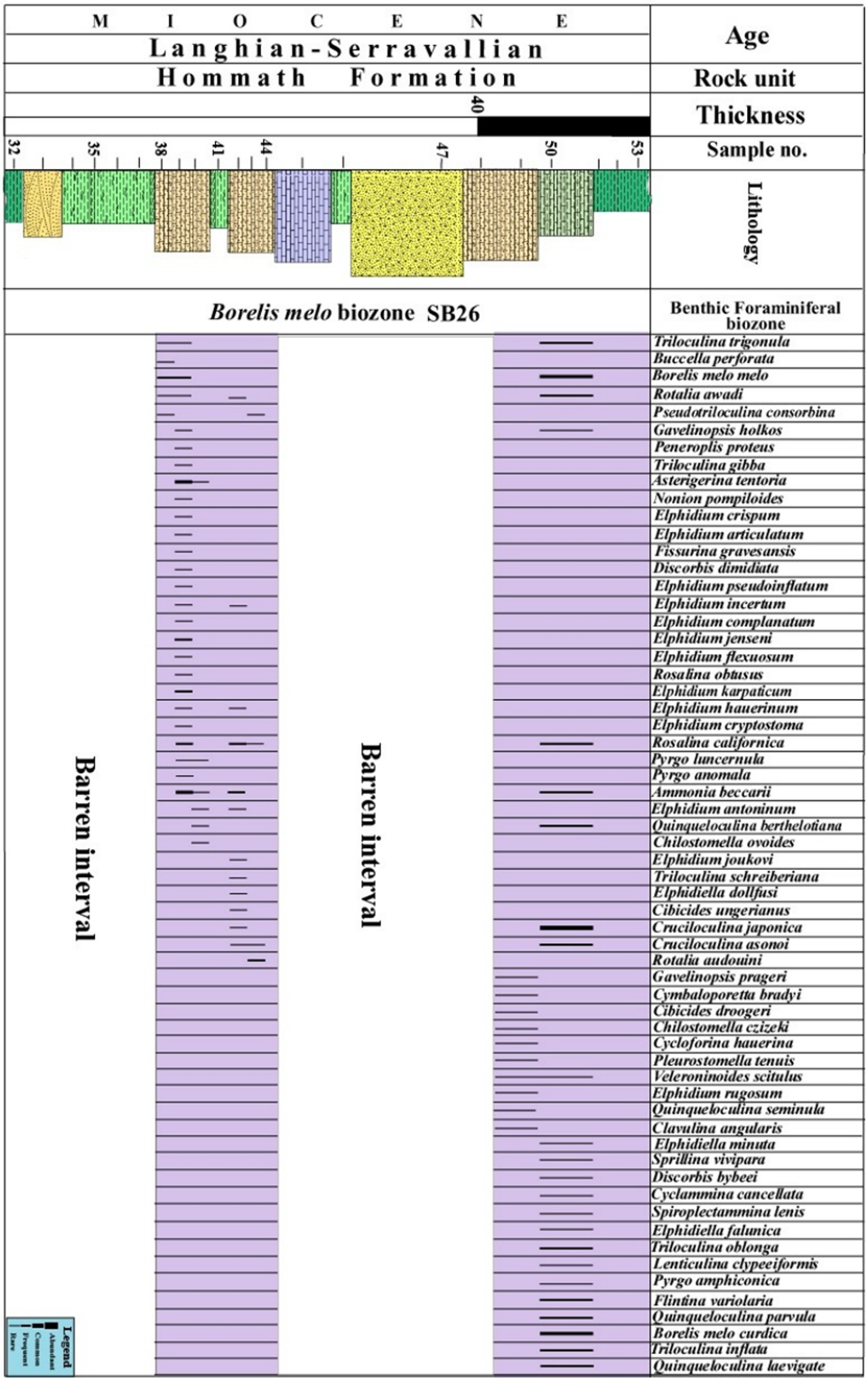

Fig. 9: Distribution chart of the identified benthic foraminiferal species at Wadi Hommath section.

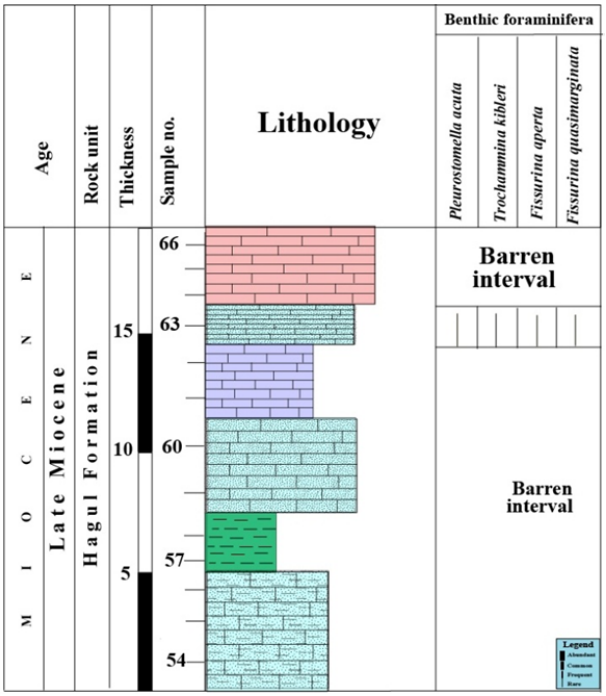

Fig. 10: Distribution chart of the identified benthic foraminiferal species at Wadi Hagul section.

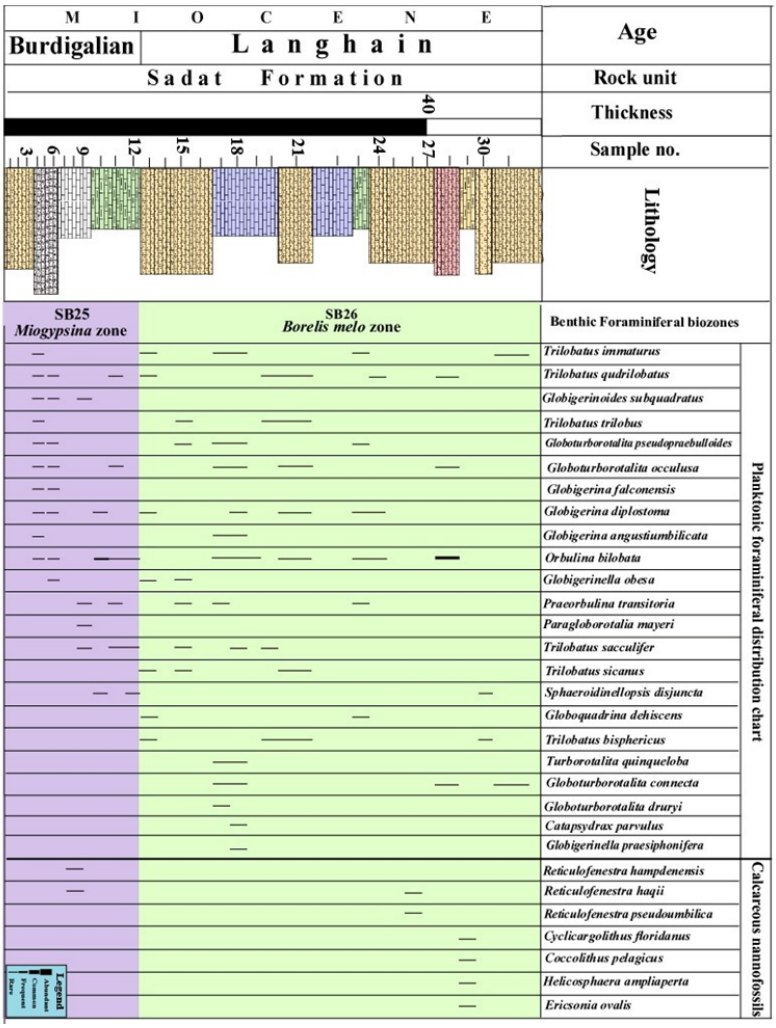

Fig. 11: Distribution chart of the identified planktic Foraminiferal and calcareous nannofossil species at Wadi El-Ramiya section.

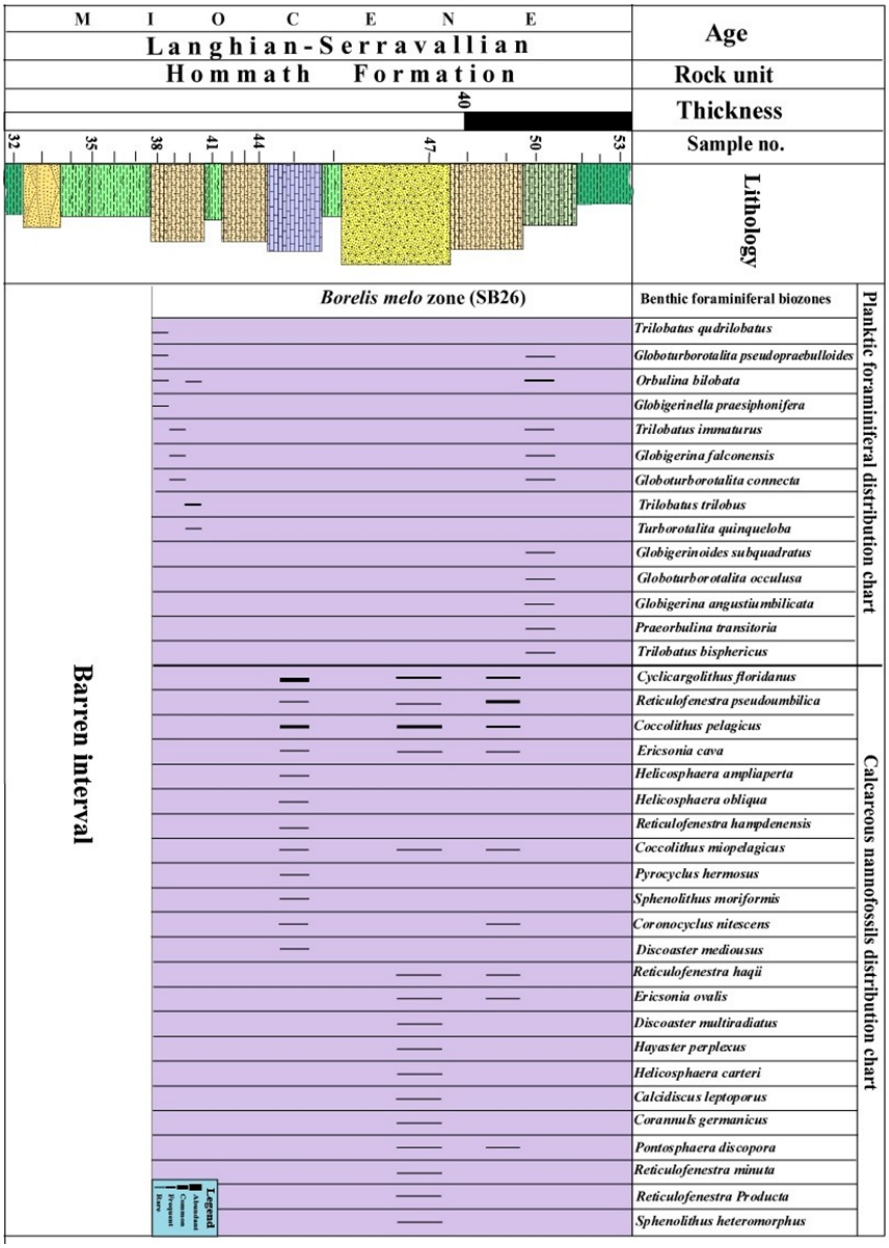

Fig. 12: Distribution chart of the identified planktic Foraminiferal and calcareous nannofossil species at Wadi Hommath section.

CONCLUSIONS

Three Miocene sections were measured from Sadat area on the west side of the Gulf of Suez, Egypt. These sections are subdivided from older to younger into Sadat Formation (Burdigalian- Langhian), Hommath Formation (Langhian-Serravallian), and Hagul Formation (late Miocene). The detailed investigations of the biostratigraphic data obtained from the studied sections led to the identification of 23 calcareous nannofossil species, 23 planktic foraminiferal species and 152 benthic foraminiferal species (Figs. 6, 8 and 10). The identified planktic foraminifera and calcareous nannofossil are not sufficient for establishing the biostratigraphic zonation. The stratigraphic distribution of larger benthic foraminifera allowed the subdivision of the Miocene sequences into two larger benthic foraminiferal biozones arranged from older to younger: *Miogypsina* zone (SP25) of Burdigalian Age and *Borelis melo* zone (SP26) of Langhian-Serravallian ages. The Sadat Formation occupied by two biozones *Miogypsina intermedia, M. cushmani* Zone in the lower part and *Borelis melo* Zone in the upper part while the Hommath Formation is assigned to *Borelis melo* Zone. The Hagul Formation is barren from the age diagnostic taxa and assigned to the late Miocene age according to its stratigraphic position (Fig. 10).

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بيواستراتجرافية تتابعات الميوسين بمنطقة السادات، غرب خليج السويس – مصر.

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الخلاصة

يتضمن هذا البحث الدراسة البيوستراتجرافيا لمنطقة السادات الواقعة في جنوب جبل عتاقة على الجانب الغربي لخليج السويس بين خطي عرض ٤٤′ ٢٩° و٤٩′ ٢٩°شمالا ويحدها من الشرق خليج السويس ومن الغرب خط طول ١٨′ ٣٢° وقد تم عمل دراسة حقلية لثلاثة تتابعات طبقية في منطقة السادات وهي وادي الراميه ، وادي حمث ، و وادي حاجول . ولقد ادت هذه الدراسة الى التعرف على ثلاث وحدات صخرية ترتيبها من الاقدم الى الاحدث كالتالي: مكون السادات (يتميز بوجود طبقات من الحجر الجيري الذي يستخدم في صناعة الاسمدة وينتمي الى عصر الميوسين المبكر وبداية الميوسين الاوسط بالمنطقة)، مكون حمث (يتكون من طبقات متبادلة من الصخر الرملي والطفلي وينتمي الى عصر الميوسين الاوسط) ، مكون الحاجول (يتكون من طبقات من الصخور الرملية والطفلية والطباشيرية التي تعزى الي عصر الميوسين العلوي) .

وقد ادت دراسة الوضع التصنيفي لكلا من الفورامينفرا والنانو بلانكتون الي تعريف 152 نوعا من الفورامنيفرا القاعية و 23 نوعا من الفورامينفرا الهائمة بالاضافة الى 23 نوعا من النانو بلانكتون .

لعبت الفورامينيفرا القاعية الكبيرة دورا اساسيا في تحديد النطاقات الحيوية لهذه التتابعات في ظل غياب الحفريات ذات الدلالة الزمنية الواضحة من الفورامينيفرا الهائمة و النانو بلانكتون. من هذه الدراسة تم تعريف نطاقين من الفورامينيفرا الكبيرة رتبت من الاقدم الى الاحدث كالتالي *Miogypsina intermedia* و *Miogypsina cushmani* zone وينتمي الى الميوسين المبكر ويغطي الجزء السفلي لمكون السادات و *Borelis melo* zone ، وينتمي هذا النطاق الى الميوسين الاوسط ويشغل الجزء العلوي من مكون السادات وكامل مكون الحمث . مكون الحاجول خالي من اي دلالات حفرية وقد عزي الى الميوسين العلوي بناءا علي وضعه الاستراتجرفي .