Egyptian Journal of Petroleum (2013) 22, 405–425

Egyptian Petroleum Research Institute

Egyptian Journal of Petroleum

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FULL LENGTH ARTICLE

Palaeoenvironment of the lower and middle Miocene successions in the Gulf of Suez region based on both planktonic and benthonic foraminifera

Medhat M.M. Mandur *, **Abdelhakam A. Baioumi**

Egyptian Petroleum Research Institute, Nasser City 11727, Cairo, Egypt

Received 9 September 2012; accepted 20 March 2013
Available online 5 December 2013

KEYWORDS

Miocene;
Foraminifera;
Paleoecology;
Paleobathymetry;
Ecozone;
Tectonic history

Abstract Based on the planktonic and benthonic foraminiferal content the lower and middle Miocene successions at the Gulf of Suez in Egypt have been identified (30 planktonic species and 101 benthonic species), seven paleoecologic parameters are studied, which include; foraminiferal frequency; predominance of the planktonic foraminiferal groups; predominance of benthonic foraminiferal groups, diversity of the foraminiferal species, P/B foraminiferal ratio, A/C foraminiferal ratio and benthonic genus/genera predominance. According to this study, the studied successions are divided into five ecozones. The paleoenvironment of each ecozone is deduced. The deduced paleoenvironments point to outer neritic for the Nukhul formation, middle neritic to inner neritic for the Rudeis formation, inner neritic to littoral for the Kareem formation and littoral neritic for the Belayim formation. A proposed paleobathymetric curve is presented. The interpretation of this curve helped to deduce the tectonic history of the early and middle Miocene in the studied areas.

1. Introduction

The paleoecologic study is done on the basis of the quantitative stratigraphic distribution of the foraminiferal fauna and its paleoecologic parameters of the three studied wells in the Gulf of Suez region (Gs 160-1 well, Gs 196 1-A well and Gs 216-1 well), Fig. 1.

Only brief accounts on the paleoecology of the tertiary sediments in Egypt are to be found in the literature such as those carried out by [1–24].

The main goals of the present study are based on:

(1) Study of the foraminiferal distribution and their paleoenvironmental significance in the studied area.
(2) Use of the paleoecological indicators combined with a series of qualitative and quantitative analyses. Such combination provides insight into basin history, depositional processes, paleotectonic and detailed paleoenvironmental conditions of the basin.
(3) Drawing paleobathymetric or paleoslope charts of the foraminiferal distribution and correlate it with the global eustatic sea level charts.

* Corresponding author.
E-mail address: Medhatmandur@yahoo.com (M.M.M. Mandur).
Peer review under responsibility of Egyptian Petroleum Research Institute.

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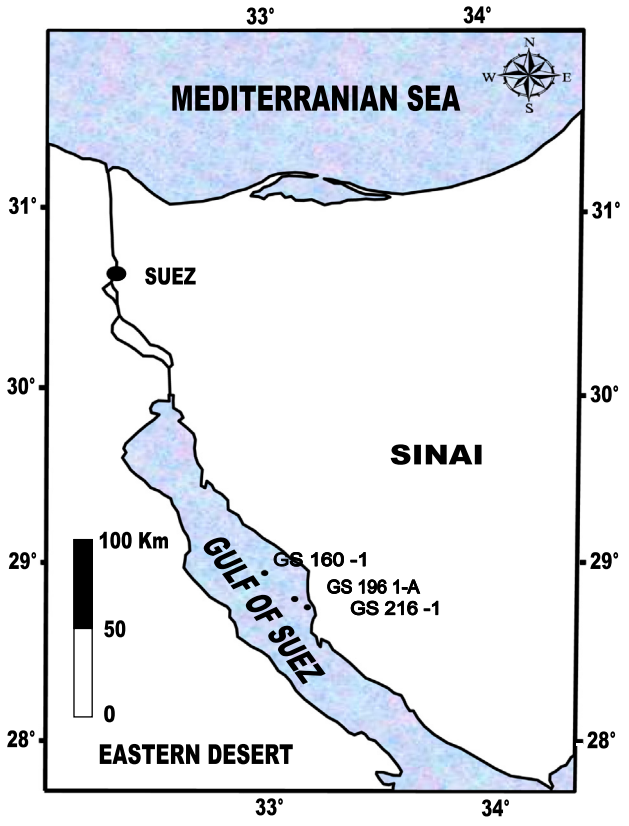

Figure 1 Location map of the studied wells.

To achieve these goals, a proposed system of some paleoecological indices, both numerical and pictorial, was made.

A succinct survey of the paleoecological data was made taking into consideration that every planktonic foraminiferal zone of the studied succession according to [22], is acting here as paleoecologically "Ecozone" or "Ecosystem" [25]. Each ecozone has a similar definition of the comparative planktonic zone.

2. Materials and methods

The material of the present work includes 95 ditch samples obtained from Gs 160-1 well, which is located at latitude 28° 57′ N and longitude 32° 57′ E, 79 ditch samples obtained from Gs 196 1-A well, which is located at latitude 28° 50′ N and longitude 33°6′ E and 98 ditch samples obtained from Gs 216-1 well, which is located at latitude 28° 45′ N and longitude 33° 11′ E Fig. 1.

The Planktonic foraminifera fauna, separated from the studied samples, are identified by using a binocular microscope.

It should be kept in mind that the statistical data presented here were separated from 5 g of the residues of the original samples taken from each studied section through the Miocene interval as previously introduced.

2.1. Lithostratigraphy

According to [22] the studied sections is subdivided into four rock units Figs. 2–4, these are arranged chronologically, from base to top, as follows: Nukhul, Rudeis, Kareem and Belayim formations.

2.2. Biostratigraphy

The foraminiferal fauna separated from the studied 272 samples comprise of 30 planktonic species belonging to 11 genera and 101 benthonic species belonging to 59 genera. Figs. 2–7.

The biostratigraphy of the studied successions has been subdivided into biostratigraphic zones based on the vertical distribution of the planktonic foraminifera. The wide spread stratigraphic distribution of the planktonic foraminifera, permits the recognition of 5 planktonic foraminiferal zones according to [22]. These are from base to top as follow:

1. *Globigerinoides primordius* Zone (Aquitanian).
2. *Globigerinoides altiaperturus*/*Catapsydrax dissimilis* Zone (Burdigalian).
3. *Globigerinoides trilobus Zone* (Burdigalian).
4. *Praeorbulina glomerosa* Zone (Langhian).
5. *Orbulina suturalis*/*Globorotalia peripheroronda* Zone (Langhian–Serravallian). It was subdivided into two subzones these are: *Orbulina glomerosa* (Langhian) and *Orbulina, universa* (Serravallian).

2.3. Paleoecological indicator

The Following gives a brief overview of the different paleoecologic indicators used in this work. It includes their meaning and their application for the interpretation of paleoenviroments and palebathymetry.

2.3.1. Frequency

The frequency was considered here as the average number of individuals of the foraminiferal species in each sample [26]. Generally the frequency increases from the near shore (littoral areas) to outer continental shelf (outer neritic areas), then it decreases. The frequency of each sample in each ecozone was counted, and then the arithmetic mean of each ecozone was calculated Figs. 8 and 9. The frequency of each ecozone in the three studied wells was calculated, where very poor frequency = 0–100 individual, poor = 101–1000, moderate = 1001–5000, rich = 5001–10,000 and very rich ⩾ 10,000.

2.3.2. Planktonic foraminiferal groups

The identified planktonic foraminiferal taxa were recognized into three groups, according to the morphologic and taxonomic similarity at the generic level [27] as follows, Fig. 10:

a. The keeled planktonic group

The abundance of the keeled planktonic group indicates deep marine environments [27–29]. It comprises the species of the genus *Globortalia*, Fig. 10.

b. The unkeeled planktonic group

The abundance of this group indicates intermediate marine environments [27–29]. It comprises the species of the following genera: *Hastigerina*, *Globigerinella*, *Globigerina*, *Globigerinoides*, *Globequadrina*, *Globigerinanus*, *Catapsydrax*, *Praeorbulina* and *Orbulina*, Fig. 10. Figs. 11 and 12.

2.3.3. Benthonic foraminiferal groups

The most interesting works for foraminiferal benthonics as indicative of relative paleodepths were of [14,30–33], concluded that the benthonic foraminifera relatively have narrow ecologic