Journal of African Earth Sciences 91 (2014) 89–109

Contents lists available at ScienceDirect

Journal of African Earth Sciences

journal homepage: www.elsevier.com/locate/jafrearsci

Subsurface Miocene sequence stratigraphic framework in the Nile Delta, Egypt

Sherif Farouk [a,*], Abdelmohsen Ziko [b], Shehtta A. Eweda [b], Ali E. Said [b]

[a] Exploration Department, Egyptian Petroleum Research Institute, Nasr City, Cairo 11727, Egypt
[b] Geology Department, Faculty of Science, Zagazig University, Zagazig 44519, Egypt

ARTICLE INFO

Article history:
Received 8 May 2013
Received in revised form 13 December 2013
Accepted 19 December 2013
Available online 30 December 2013

Keywords:
Planktonic biostratigraphy
Nile Delta
Miocene deposits
Foraminiferal association
Sequence stratigraphy

ABSTRACT

The Miocene depositional history of the Nile Delta is dominated by fluvial–deltaic, marginal marine and marine shelf sedimentation. It exhibits radical lateral facies changes due to its tectonic setting. Different attributions in age assignments characterise the Miocene Nile Delta due to the lack of large vertical facies changes, which consists mainly of siliciclastic with different environments. This study uses integrating lithologic, biostratigraphic, gamma-ray log and benthic foraminiferal biofacies, at four boreholes (Tanta-1, Rommana-1X, El-Fayrouz and Rosetta-7) in the Nile Delta, Egypt. Planktonic foraminifera allow subdivision of the Miocene Nile Delta succession into 12 planktonic biozones and benthic species are used in paleobathymetic estimates.

Eight third-order Nile Delta Miocene sequences are bounded by eight major sequence boundaries, that can be correlated within and outside Egypt based upon planktonic foraminifera biostratigraphy. Chattian/Aquitanian (SB1) and Aquitanian/Burdigalian (SB2), intra-Burdigalian (SB3), Burdigalian/Langian (SB4), Langian/Serravallian (SB5), Serravallian/Tortonian (SB6) Tortonian/Messinian (SB7) and intra-Messinian (SB8): these boundaries in the Nile Delta are controlled by either eustatic processes and/or tectonic events.

Each sequence contains a transgressive system tract bounded above by a maximum-flooding surface, and a highstand system tract. The lowstand systems tract and falling-stage systems tract is the main gas reservoir in the Nile Delta and recorded only below the Tortonian/Messinian and intra-Messinian sequence boundaries, that are marked by deep incisions and truncations. Variable patterns in the timing of regional deposition and erosion indicate different tectonic and sedimentary regimes, that encompass progressively greater periods of time southward in the Nile Delta.

1. Introduction

The Nile Delta has been commonly considered part of the passive leading edge of the colliding African plate along the southern shores of the shrinking Mediterranean Sea (Harms and Wary, 1990). It is one of the earliest known deltas in the world and occupies an area of approximately 22,000 km^2 situated in the north-eastern margin of the African plate at the south-eastern part of the Mediterranean Sea (Fig. 1).

The subsurface Miocene successions in the Nile Delta are one of the most important gas reservoirs in Egypt. The Nile Delta attracted the attention of many geologists after the giant gas discoveries in the subsurface (Vandre et al., 2007). Nevertheless, there is disagreement about the stratigraphic framework, particularly among different oil companies. The most important investigations have concentrated on the Miocene biostratigraphy and paleoenvironment (Rizzini et al., 1978; Harms and Wary, 1990; Haggag and Abu El Enein, 1991; El-Heiny and Morsi, 1992; Ouda and Obaidalia, 1995; Obeid et al., 2000; Faris et al., 2007; Ismail et al., 2010).

The Miocene Nile Delta exhibits radical lateral facies changes due to its tectonic setting, which has led previous authors to use different informal and formal stratigraphic names with different attributions in age assignments.

Nile Delta tectonic setting played an important role in configuration of the depositional sequences and the resulted in the initiation of many palaeo-highs and lows, which played a major role in facies distribution. This made the correlation between these rock units based upon the lithology and geophysical logs very difficult. However, correlations based upon biostratigraphy in different boreholes with the global cycle chart and sequence stratigraphy are very useful tools for local and regional correlations. The main objective of this study is to propose a sequence stratigraphic framework and paleobathymetic framework, using integrated lithologic, biostratigraphic, gamma-ray log, foraminiferal biofacies and

* Corresponding author. Tel.: +20 2 01281719573.
E-mail addresses: geo.sherif@hotmail.com (S. Farouk), abdelmohsenziko@yahoo.com (A. Ziko).

1464-343X/$ - see front matter © 2014 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.jafrearsci.2013.12.010

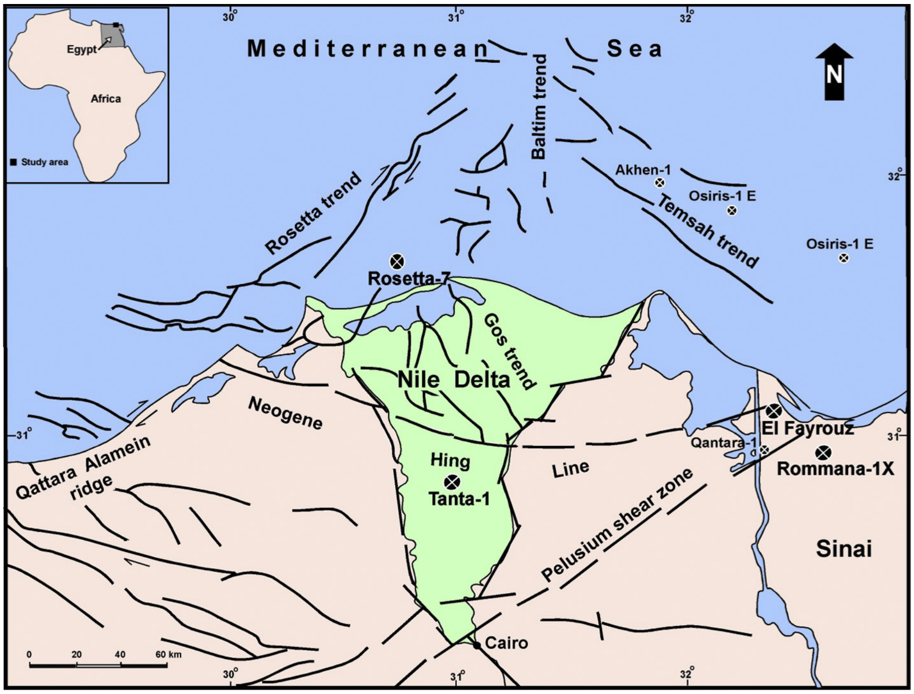

Fig. 1. Location map of the Nile Delta showing the major structural trends (modified after Abdel Aal et al., 1994).

their relationship to systems tracts. These well-dated sequences can be correlated with the local and global cycle charts to distinguish the tectonic events from the eustatic signatures within the study stratigraphic successions.

2. Material and methods

Qualitative and quantitative analyses were made on the foraminiferal assemblages of one hundred and seventy-five cutting samples collected from four boreholes (Tanta-1, Rommana-1X, El-Fayrouz and Rosetta-7) in the Nile Delta. The planktonic and benthic foraminiferal contents of these sections were studied to determine the foraminiferal biostratigraphy and paleobathymetriy and their relationship with system tracts. Samples were processed with standard techniques. Approximately 200 g of dry rock samples were soaked in hydrogen peroxide, disaggregated in water, washed through a 63 mm sieve, and then dried.

3. Geologic setting and lithostratigraphy

The Nile Delta basin was affected by the complex evolution and interaction among the African, Eurasian and Arabian plates. The Nile Delta Miocene subsurface sediments investigated here exhibit radical lateral facies changes. These sediments are dominated by siliciclastic of fluvial–deltaic, marginal marine and marine shelf sedimentation with lack of large vertical facies changes and therefore have led previous authors to use different informal and formal lithostratigraphic units with different attributions in age assignment (Fig. 2). Six major structural trends delineate the present Nile Delta and affect the distribution of the Miocene sediments in the Nile Delta. These trends are the E–W Neogene Hinge zone, the NE Rosetta fault trend, the NW Temsah structural trend, the Pelusim shear zone, the NW Red Sea-Gulf of Suez fault trend and the minor NS Baltim fault trend (Abdel Aal et al., 1994; Fig. 1). The Neogene Hinge Zone is one of the main tectonic features subdivides the onshore Nile Delta into two major distinct areas. This zone consists of narrow faulted blocks, has a width of approximately 30–40 km and trends roughly E–W with a big throw down to the north, controlling the origin of the Nile Delta. The Nile Deep Sea Fan started to develop at the end of the Eocene (Salem, 1976) with the offshore deposition of a thick northwards prograding detrital series (Ross and Uchupi, 1977).

In the late Miocene, the Mediterranean Sea was isolated from the Atlantic Ocean, causing the deposition of evaporites in the deeper basins. This occurrence is known as the Messinian salinity crisis event. This isolation resulted in a "salinity crisis" of the Mediterranean, whereby the world's ocean lost 6‰ of its salinity because approximately one million cubic kilometres of evaporites were deposited on the floor of the deep Mediterranean basins (Hsü et al., 1973; Krijgsman et al., 1999). The following is a lithostratigraphic description for the subsurface Miocene succession in the Nile Delta, as penetrated by the studied wells, and arranged from bottom to top.

3.1. The Tineh Formation (Oligocene–Aquitanian)

This formation is widely distributed in the subsurface of the eastern Nile Delta and north Sinai. The calcareous planktonic microfossil content of the formation indicates that its age is middle Oligocene to early Miocene (El-Heiny and Morsi, 1992). The Tineh Formation occurs between 3070 and 2725 m in the El-Fayrouz borehole and in the Rommana-1X borehole occurs between 2805 and 2555 m. The base of this formation was not in penetrated the study boreholes. It is completely missing south of the Hinge zone at the Tanta-1 Well, where the Burdigalian Moghra Formation overlies the Ruperlian Dabaa Formation directly above a major unconformity (Fig. 3). It unconformably overlies the Qantara Formation separated by 20 m conglomeratic sand with carbonate intraclastic below the top of Zone NN2 at the top of the Tineh Formation equivalent to Event I of El-Heiny and Morsi (1992) in the Qantara-1 borehole. This formation consists of (upper Oligocene) greenish grey, fissile, shale, silty sandstone, and siltstone, and contains rare to common agglutinated benthic foraminifera with low species diversity. It is nearly barren of planktonic foraminifera