Journal of African Earth Sciences 117 (2016) 135–149

Contents lists available at ScienceDirect

Journal of African Earth Sciences

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

Structures and sequence stratigraphy of the Miocene successions, southwestern Gulf of Suez, Egypt

Ahmed Abd El Naby [a, *], Ali Younis [b], Mohamed Abd El-Aal [c], Asmaa Alhamshry [b]

[a] Faculty of Science, Ain Shams University, Abbassia sq, 11566, Cairo, Egypt
[b] National Research Center, Cairo, Egypt
[c] Faculty of Education, Ain Shams University, Roxy, Cairo, Egypt

ARTICLE INFO

Article history:
Received 23 September 2015
Received in revised form
6 December 2015
Accepted 21 January 2016
Available online 26 January 2016

Keywords:
Miocene
Sequence stratigraphy
Structures
South Gharib Formation
Gulf of Suez
Egypt

ABSTRACT

The subsurface structural evolution, facies changes and sequence stratigraphic interpretations of the Miocene successions of the southwestern part of the Gulf of Suez, Egypt, were studied by seismic reflection data of Twenty seven 3D seismic sections supported by the composite, velocity and vertical seismic profiles (VSP) logs of eight wells. Among them five sections and two geoseismic cross sections were selected to reveal the structural framework and depositional history of the study area. The analysis of depth-structure contour maps revealed that the Miocene strata are dissected by two major faults trends: The NW–SE trending faults (Clysmic trend) and the NE–SW trending cross faults running nearly perpendicular to the Clysmic faults. The facies changes of the syn-depositional Miocene units are controlled by the structural framework of the southern part of the Gulf of Suez being evolving diapiric structure of South Gharib Formation. The Miocene units are subdivided into two major 3rd order depositional sequences: S1 and S2.

1. Introduction

Gulf of Suez rift is a Neogene continental rift that developed by the separation of the African plate away from the Arabian plate during the Late Oligocene-Early Miocene. It represents a world-class hydrocarbon province that formed as a northwest-elongated structural depression at the northern end of the Red Sea that is 350 km long and ranges in width from 52 km in the north to 90 km in the south (Patton et al., 1994; Bosworth and McClay, 2001; Abd-Allah et al., 2014). Opening of the Gulf of Suez rift was initiated as a result of N60°E extension that developed a set of faults in the NW–SE direction (Robson, 1971; Garfunkel and Bartov, 1977; Lyberis, 1988; Moustafa, 1993; Patton et al., 1994; Bosworth and McClay; Younes and McClay, 2002).

Gulf of Suez is divided into several fault blocks, which are mainly bounded by NW oriented normal faults (N310°- 335°W) with a pure dip-slip (Robson, 1971) or oblique-slip (Lyberis, 1988). NW oriented faults propagated upward from the crystalline basement rocks through most of the overlying pre-rift and syn-rift strata (Younes and McClay, 2002). These faults are linked by NNE to NE and WNW oriented faults, allowing the displacement transferring among the affecting faults and produced a characteristic zigzag fault system (Abd-Allah et al., 2014). NNE to NE and WNW oriented faults have oblique-slip; sinistral and dextral, respectively (Abd-Allah and Nabih, 1998; Abd-Allah, 2008; Abd-Allah et al., 2014).

The interaction of NW, N–S, NNE, and E–W fault systems resulted in a complex structural pattern consisting mainly of numerous tilted fault blocks. Based on the tilting polarity of these blocks, Gulf of Suez is subdivided into three structural provinces: the northern Araba dip province (SW dips), the central Belayim dip province (NE dips), and the southern Amal-Zeit dip province (SW dips, Fig. 1). These provinces are separated by two NE-trending accommodation zones: the Galala-Abu Zenima Accommodation zone (GAZAZ) in the north, and the Morgan Accommodation zone (MAZ) in the south.

The study area (about 4.5 km long and 4.5 km wide) covers the northern part of the Amal-Zeit dip province (Fig. 1). The intent of this paper is to emphasize the effects of structures on the facies variations, to interpret sequence stratigraphy of the syn-rift rocks, and to construct a schematic diagram illustrating the diapiric evolution of the South Gharib Formation related to basement

* Corresponding author.
E-mail addresses: zowail2000@yahoo.com (A. Abd El Naby), aliyounis64@yahoo.co.uk (A. Younis), mabdelaal81@yahoo.com (M. Abd El-Aal), asma_nrc@yahoo.com (A. Alhamshry).

http://dx.doi.org/10.1016/j.jafrearsci.2016.01.025
1464-343X/

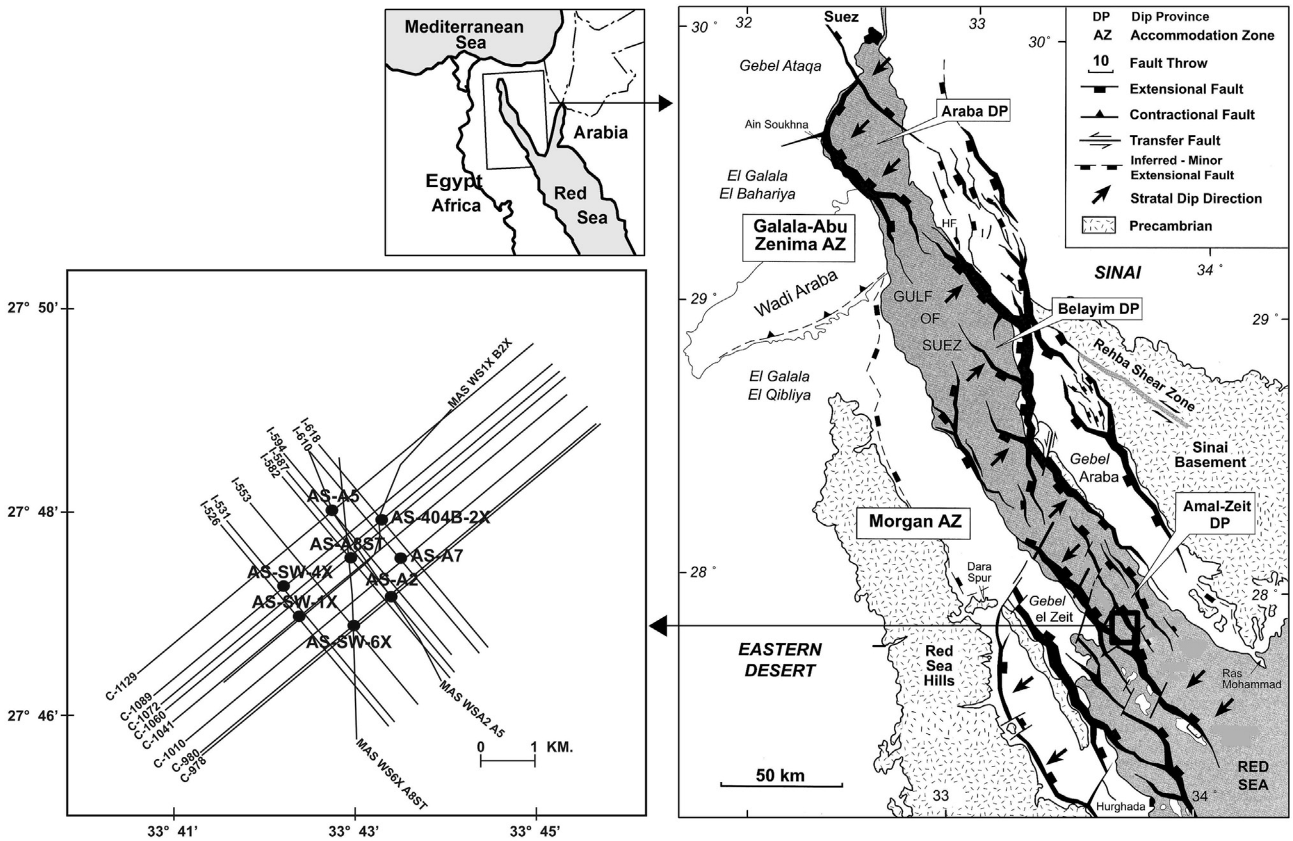

Fig. 1. Tectonic map of the Gulf of Suez Rift modified after Bosworth and McClay (2001). The study area (rectangle, including location of the wells) is located in the northern part of Amal-Zeit dip province.

faulting, differential compaction and loading.

2. Stratigraphy of Gulf of Suez

The stratigraphic successions of the Gulf of Suez can be subdivided into three tectonostratigraphic mega-units relative to the Miocene rifting in Gulf of Suez (Fig. 2), which are, from base to top, as follows:

2.1. The pre-rift mega-unit

This unit represents the Precambrian basement rocks and Paleozoic to Upper Eocene sediments. Granites were intruded by Dokhan Volcanics in the exposed Precambrian rocks along the Gulf of Suez rift shoulders (Figs. 1 and 2). These rocks are overlain by the Jurassic–Lower Cretaceous shales and sandstones of Nubia Sandstone (Fig. 2). The Upper Cretaceous rocks consist mainly of sandstones, shales, marls and limestones at the base and changed upward into mainly limestones, dolomites and chalk (Fig. 2). These rocks are overlain by the Paleocene Esna Shale in several outcrops and in many drilled wells (Abd-Allah et al., 2014). Esna Shale is topped by the Eocene limestones. Rocks of pre-rift mega-unit are capped by a regional unconformity throughout the Gulf of Suez rift, which separates between the pre-rift and syn-rift sediments. The pre-rift sediments are also described by many workers (e.g. Evans, 1988; Patton et al., 1994; Bosworth, 1995; Bosworth et al., 1998; Bosworth and McClay, 2001). These sediments are important as source and reservoir rocks.

2.2. The upper Oligocene-Miocene syn-rift mega-unit

This unit changes laterally throughout the Gulf of Suez, from north to south (Fig. 2). Variable lithologies and thicknesses of the Miocene syn-rift rocks are resulted from the deposition of these rocks on tilted pre-rift blocks. The deposition of marine sediments of the lower part of the Late Oligocene-Early Miocene Nukhul Formation on a regional unconformity surface in the south and a rapid transition from the Abu Zenima red beds to the shallow marine Nukhul Formation at the center are coupled with the onset of rifting in the Gulf of Suez area (Bosworth and McClay, 2001, Fig. 2). The deposition of the upper part of the Nukhul fluvial and shallow marine sediments is associated with the first major phase of extension and slow subsidence of the gulf basin (Patton et al., 1994). The sandstones with thin shales of the lower Rudeis Formation is topped by a mainly carbonates and shales of the upper Rudeis Formation. Two parts of Rudeis Formation are separated by an intra-formational unconformity contemporaneous with the “mid-clysmic” or “mid-Rudeis” event, which continued during deposition of the Kareem Formation (Patton et al., 1994). The anhydrites, carbonates and salts increase upward to form the main lithology of Belayim Formation associated with a noticeable decrease in the subsidence rates (Fig. 2). The deposition of the South Gharib and Zeit Formations is coupled with mild extension and subsidence and isolation of the northern Gulf of Suez and Red Sea from the Mediterranean (Patton et al., 1994). Many unconformities are recorded in the syn-rift rocks in the southern Gulf of Suez (Bosworth and McClay, 2001). These rocks contain several source, reservoir, and seal intervals that are associated mainly with different structural traps.