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Tectonic and structural setting of the northeastern central Gulf of Suez area using aeromagnetic data

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ABSTRACT

Cumulative qualitative and quantitative analysis of the filtered regional and residual magnetic components of the northeastern central area of the Gulf of Suez, as well as images of the second vertical derivatives of the reduced to the northern magnetic pole map of the total magnetic intensity field images, supplemented with the available geologic information, enabled the precise delineation of the detailed structural configuration of the basement complex, which consequently illustrated the structural deformational pattern of the overlying sedimentary succession. The basement tectonic map reflects a series of N–S to NNW–SSE oriented belts of high and low basement structures. These structures are interrupted by a set of NE–SW crossing diagonal faults having varying throws and creating promising blocks for exploration.

An often remarkable correlation between the reduced to the magnetic pole map and the basement relief map is noted, in particular the outline of various oil fields. A larger number of the tilted fault blocks and basement culminations have been outlined and numerous interesting exploration prospects are indicated, which appear to warrant further follow up investigation.

1. Introduction

Seismic data are sometimes difficult to interpret below the evaporites section in the Gulf of Suez region. In this regard, magnetic tools provide a powerful way for delineating the basement depths and the sub-evaporites configurations.

At 1998, the airborne geophysics department of the Nuclear Materials Authority of Egypt (NMA) conducted a high sensitivity 3D airborne magnetometer survey, over the Gulf of Suez. A total of 15,000 line kilometers of geophysical data was acquired at barometric altitude of 100 m above sea level, with an average aircraft speed of 220 km/h. The aircraft is also equipped with EFIS-84 Electronic flight instrument system added to the electromechanical instrument as stand by for the copilot. This EFTS system is used for navigation during the high altitude normal flying. The direction of the flight lines was chosen to be NW–SW (145/325) with the spacing of 250 m, while the tie line direction was NE–SW (55/235) with spacing of 400 m. The surveyed area, totaling 2200 Km^2 included Abu Rudeis, Abu Zenima and Ras Budran concessions. The interpretation of magnetic data is accomplished using a computer based automated inversion program. The interpretation attempts to depict the general configuration of the basement surface.

An integrated study between the geological and aeromagnetic is carried out to evaluate the subsurface geologic conditions in the area occupying the northeastern central part of the Gulf of Suez, between latitudes 28° 48′ and 28° 59′ N and longitudes 33° 02′ and 33° 15′ E. This area includes three important oil fields, Ras Budran Field to the north, Abu Rudeis-Sidri Field to the south and Abu Zenima Field in the middle, in addition to East October Field to the west (Fig. 1).

2. Geological setting

The stratigraphic sequence of the area under investigation represents an ideal succession of the central part of the Gulf of Suez. Such a succession is observed not only on the surface outcrops at the different locations in the eastern side of the Gulf of Suez, but also in the drilled wells scattered in the area. A sedimentary sequence ranging in age from Paleozoic to Recent with non-depositional and erosional hiatuses was penetrated in the area of consideration. Fig. 2 shows the stratigraphic column of the area, as

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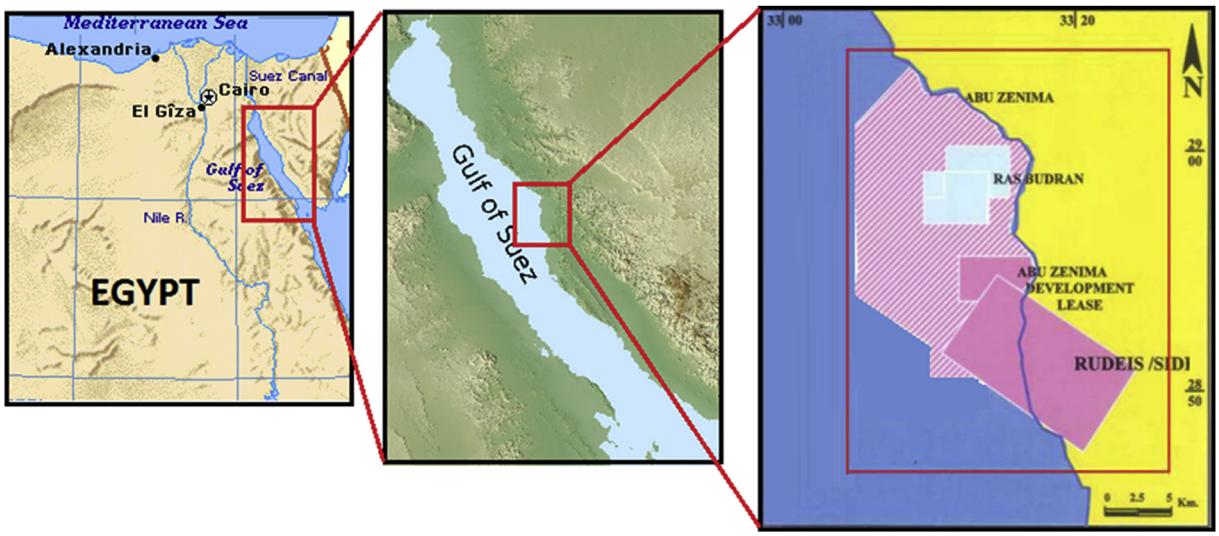

Fig. 1. Location map of the study area.

well as the tectonic events which affected the deposition of the various rock units.

The basement rocks were penetrated in several wells at shallow and deep depths in Abu Rudeis – Sidri, Abu Zenima, Ras Budran and October fields. The Pre-Cambrian basement in Ras Budran field was penetrated in two wells (RB-A2 and EE85-7C) in a fault contacted with the sedimentary rocks and intruded by younger intrusives along the fault plane. Some wells in Sidri area and Abu Zenima areas penetrated the basement at shallow depths (S-6, S-6R, Wadi El-Naqa, South Markha and South Zenima) along the main bounding fault. Sidri-8 and Sidri-4 wells hit the basement at deep depths (−3800 and −3570 m, respectively) as fault scarp relationships.

The Pre-Cambrian basement is unconformably overlain by the Paleozoic to Early Cretaceous sediments (Nubia D, C, B and A at the top). The Paleozoic sandstones with thin shale layers (Nubia D, C, and B) comprise the oldest section that is partially penetrated by most wells in Ras Budran field, but not penetrated by any well in Abu Rudeis-Sidri and Abu Zenima fields. Within this sequence, thus occurs an unconformity between the Paleozoic and Cretaceous sediments (Fig. 2).

Naggar and El-Hilaly (1985), believed that this unconformity is at the base of the shale unit due to some criteria:

a) The shale unit is thinner on the high relief structure and increases in thickness on the peripheries.
b) Lithologically, the sandstones of Nubia C and D are highly kaolinitic and differ from the sandstone layers within the shale unit, as in most of Ras Budran wells.
c) The presence of layers of hematitic sandstone within the sandstone of Nubia C and D and their absence in the overlying shale unit.

It is, therefore, suggested that, the shale unit may be Permian or even Cretaceous in age, as the sediments of Triassic to Early Cretaceous were not deposited in this part of the Gulf. The shale unit is overlaid by the sandstones of Nubia "A" Formation which is dated to Cretaceous of Albian to Cenomanian age. These sediments were the first fossiliferous strata laid down on the shale unit. Based on the detailed peak to peak correlation of log markers within the Nubia A sandstone, it is concluded that these sediments were deposited as sheet-like sands. The Nubia A Formation is hit in most of the drilled wells in the area under investigation with an average thickness ranging from 200 m to 300 m (Fig. 2). It represents the most interesting reservoir in the central part of the Gulf of Suez (Belayim, Abu Rudeis, October and Ras Budran fields).

The structural pattern of the area is mainly determined by a swarm of faults, which dissect the area into several blocks. The description of these fault trends has been the subject of many publications. Abdel Gawad (1969) classified the fault system of the gulf into five intersecting trends: two of them are oriented parallel with and perpendicular to the gulf, NW and NE and two other systems are diagonals to the gulf, N–S and NNW. The fifth trend is E–W, which cuts across Sinai.

Abdel Magid (1976) made a regional study across the Gulf of Suez and referred to the presence of two dominant fault trends, the northwest trend with greater throw and the northeast trend, along which trans-current movements have taken place.

Issawi et al. (1981), in his regional study on the western side of Sinai, referred to the presence of a major fault system (Clysmic trend) which associated with the NW (Erythyrean), added to the N5 W (Meridional), N15E (Aqaba) and N65E (Alexandria) fault trends. Also, the structure is delineated by two basement massifs enclosing a sedimentary basin in the middle, which are displaced against the high basement rocks, i.e. the dips are away from the basement towards a central line directed approximately NNW-SSE, parallel to the Gulf of Suez and occupied by El Qa'a plain, which is characterized by a general dip toward the east.

Sultan and Schutz (1984) made a study on the cross faults in the Gulf of Suez. They mentioned that, the major faults at the graben shoulders and inside the Gulf of Suez basin form NNW-SSE trends. However, these major faults are not long continuous features, but are composed of a complex of faults, which follow a pre-existing structural pattern (e.g. a pre-existing fault pattern); a 120″ angle of intersection between trends is common.

From the geological aspects of Ras Budran field, the Miocene structure is a northeast-southwest trending anticlinal feature, while the Pre-Miocene is highly faulted and these faults are mainly due to the intra-Rudeis severe tectonic movements.

Zahran (1986), from his study on the geology of October field concluded that, the structure of the area can be considered as the northwesterly extension of Gebel Nezzazat structure, where an elongated northwest-southeast trending fault block extends off shore from Gebel Nezzazat for a distance of 30 km through October