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Structural interpretation of aeromagnetic data for the Wadi El Natrun area, northwestern desert, Egypt

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ABSTRACT

The Wadi El Natrun area in Egypt is located west of the Nile Delta on both sides of the Cairo–Alexandria desert road, between 30°00′ and 30°40′N latitude, and 29°40′ and 30°40′E longitude. The name refers to the NW-SE trending depression located in the area and containing lakes that produce natron salt. In spite of the area is promising for oil and gas exploration as well as agricultural projects, Geophysical studies carried out in the area is limited to the regional seismic surveys accomplished by oil companies. This study presents the interpretation of the airborne magnetic data to map the structure architecture and depth to the basement of the study area. This interpretation was facilitated by applying different data enhancement and processing techniques. These techniques included filters (regional-residual separation), derivatives and depth estimation using spectral analysis and Euler deconvolution. The results were refined using 2-D forward modeling along three profiles.

Based on the depth estimation techniques, the estimated depth to the basement surface, ranges from 2.25 km to 5.43 km while results of the two-dimensional forward modeling show that the depth of the basement surface ranges from 2.2 km to 4.8 km. The dominant tectonic trends in the study area at deep levels are NW (Suez Trend), NNW, NE, and ENE (Syrian Arc System trend). The older ENE trend, which dominates the northwestern desert is overprinted in the study area by relatively recent NW and NE trends, whereas the tectonic trends at shallow levels are NW, ENE, NNE (Aqaba Trend), and NE. The predominant structure trend for both deep and shallow structures is the NW trend.

The results of this study can be used to better understand deep-seated basement structures and to support decisions with regard to the development of agriculture, industrial areas, as well as oil and gas exploration in northern Egypt.

1. Introduction

The magnetic method has an advantage that it is a fast and effective technique for studying subsurface geological structure and mapping the fractured basement (Azizi et al., 2015; Farhi et al., 2016; and Khashaba et al., 2016). The main objective of this study is to map the basement rocks configuration of the Wadi El Natrun area, Egypt as interpreted from the airborne magnetic data. Basement configuration include depth to the basement surface as well as the controlling structures that may also align the overlying sediments. These information are significant for oil and gas exploration as well as groundwater studies. Prior to interpretation, the magnetic data were subjected to various analyses and interpretation techniques, including reduction to the pole, filters, and derivatives as well as depth estimation methods. The application of these techniques was performed in the wavenumber domain using Geosoft Oasis Montaj package, 2008. An Euler deconvolution method was applied to the magnetic data for estimating the depth to the basement surface and locating subsurface structures such as faults and contacts. The results of depth estimation methods and the interpreted basement structures were used to construct the initial models for three profiles

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crossing the study area. The depth to the basement at one of the boreholes available in the area was used as important constraint for the modeling processes. The 2-D initial models were adjusted and refined by forward and inverse modeling using the GM-SYS modeling program (Geosoft Oasis Montaj, 2008; GM-SYS, 2013). The estimated variations of the depth to the basement and magnetic signatures of the filtered data were used to construct a detailed basement tectonic map for the study area.

2. Study area

The study area (Fig. 1) is located west of the Nile Delta on both sides of the Cairo–Alexandria desert road, between 30°00′ and 30°40′N latitude and 29°40′ and 30°40′E longitude. The name refers to the presence of eight different lakes in the region that produce natron salt. Located near the western boundary of the present Nile delta, the area is one of the areas that have been selected for future agricultural and industrial developments. Moreover, the area is located at the northern periphery of the Mezozoic delta cone (Meshref, 1982) that is considered as promising zone for oil and gas exploration. The study area was included in an aeromagnetic survey in 1964, flown along parallel N–S-oriented flight lines with a line spacing of 3 km at a constant barometric altitude of about 450 m (Awad, 1985).

3. Geology and structural setting

The study area is characterized by a low relief and mild topography with elevations varying from −23 m below mean sea level (MSL) (at the Wadi El Natrun depression) to +233 m above MSL (at Qaret El Haddadein) (Embaby, 2003). The surface geology (Fig. 2) is characterized by Cenozoic sediments. Paleogene and Neogene sediments (Oligocene, Miocene, and Pliocene), composed of sand and sandstone with clay and limestone intercalations, are dominant in the southern and southwestern parts of the study area. A small area covered by Oligocene basalt sheets is exposed southeast of the study area. The northern part is covered by Quaternary sediments composed mainly of clastic material dominated by sand with occasional gravel and clay intercalations. Sand dunes exist in the southern part of the area. To the southeast of the study area, Cretaceous and Eocene sediments are the oldest exposed rocks in the Abu Roash area. In the subsurface, the sedimentary rocks overlying the basement complex reach a thickness of about 4000 m, as recorded by the Wadi El Natrun-1 test well. The base of the sedimentary sequence is formed by Triassic rocks that unconformably overlie the basement rocks. The top of the sedimentary

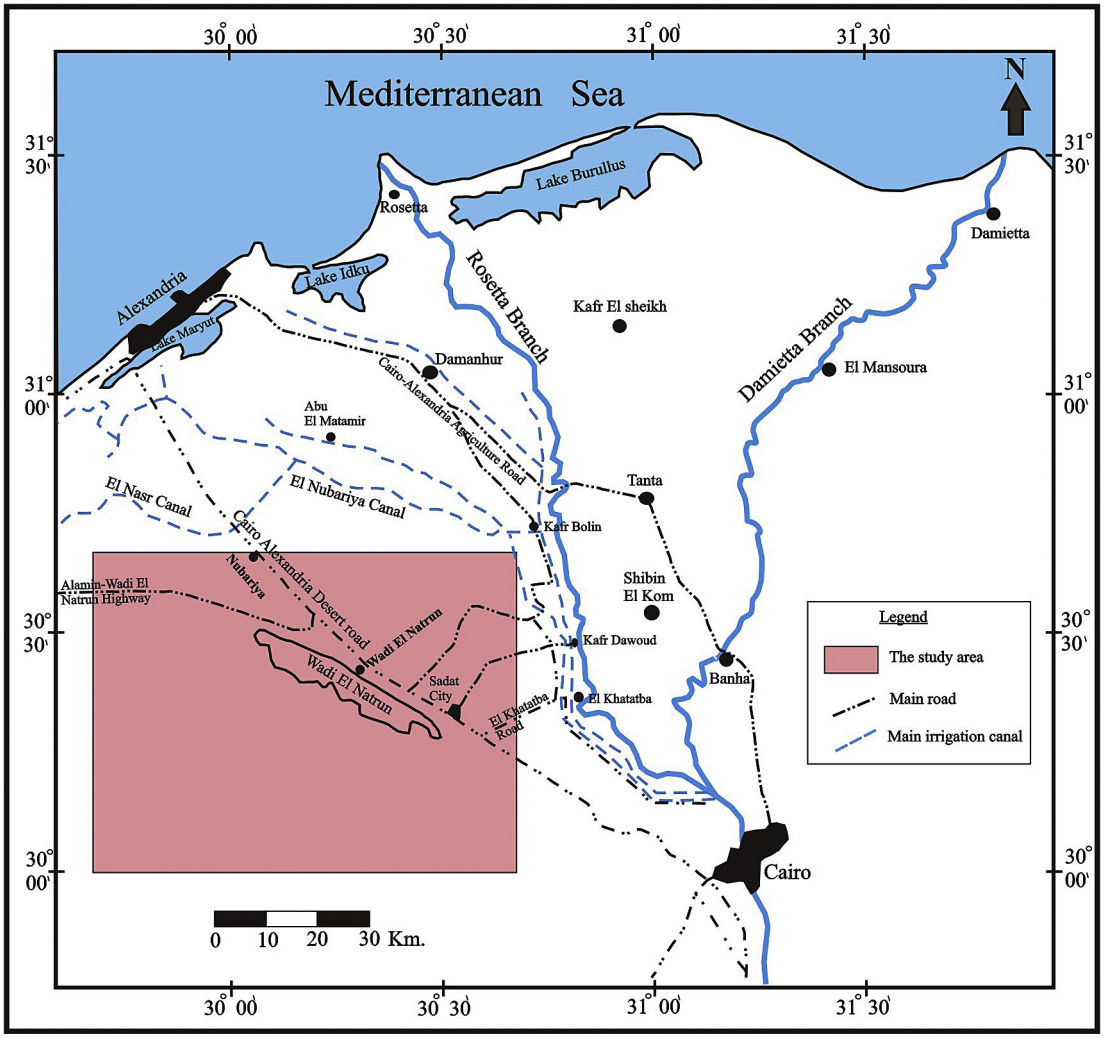

Fig. 1. Location map of the study area.