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FULL LENGTH ARTICLE

Inferring the subsurface basement depth and the structural trends as deduced from aeromagnetic data at West Beni Suef area, Western Desert, Egypt

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Abstract The present work aimed to delineate the subsurface structures and to estimate the magnetic source depth at the selected area lying in West Beni Suef area, Western Desert, Egypt, following different geomagnetic techniques. The analysis of aeromagnetic data demonstrates five significant tectonic faults trending to NW-SE, ENE-WSW, NE-SW, E-W and NNW-SSE directions constructed using Euler deconvolution techniques. The execution of this study is initiated by transformation of the total intensity aeromagnetic data to the reduced to pole (RTP) magnetic intensity. This is followed by applying several transformation techniques and various filtering processes through qualitative and quantitative analyses on magnetic data. The reduced to the northern magnetic pole (RTP) data are separated spectrally into regional and residual magnetic components using the computed power spectrum of the magnetic data. The estimated mean depths of both regional and residual sources are found to be 5.27 km and 2.78 km respectively. Also, depth estimations have been conducted by application of the Euler deconvolution and 2-D modeling techniques. The results indicate that the eastern and northern parts of the study area discriminate deeper basement relief and the depth of basement surface reaches to 5095 m. While the southern and western parts of the study area discriminate shallower basement relief and the depth of basement surface

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reaches to 227 m. This study has given a clear picture of the geologic structures beneath the study area.

1. Introduction

Magnetic method represents one of the most useful available tools that help in the recognition of the surface and subsurface geology. The purpose of the application of the aeromagnetic interpretation is to help in solving the problems of regional geological mapping and structure, delineation of buried contacts, site of the probable areas of rock differentiation, mineralization and thickness of sedimentary cover (Domzalski, 1966). It is also used to delineate the basement depth and the subsurface structures around Beni Suef area. Meshref et al. (1980) analyzed magnetic trends in the northern part of Egypt and stated that the basement rocks in the Western Desert have been affected by two fault systems having large vertical and horizontal displacements. The oldest E-W and ENE faults are intersected by the youngest N-W and NNW. Abu El-Ata (1990), based on seismic and gravity data, outlined three structural highs and two lows:

(a) Abu Roash high that strikes first NNE–SSW and then ENE–WSW.
(b) El-Sagha high which is oriented NW–SE.
(c) El Faras-El Fayoum high that is oriented first ENE–WSW and then NNW–SSW.

Tectonically, the area under consideration is a part of the unstable shelf of North Africa and the Mediterranean region (Said, 1962) and is related to the mobile belt (Weeks, 1952), which is characterized by a complex subsurface structural pattern. It is characterized by major and minor faultings originated by action period of prevailing tensional relief. Many fault trends (E–W, WNW, ENE, NW and NNE) have been deduced from the different geological and geophysical studies, which were carried out by many investigators (e.g., Riad, 1977; Meshref, 1982). A folding system was also recorded in the area as a result of the compression forces.

The area under investigation is located at Beni Suef Governorate in the eastern portion of the northern Western Desert of Egypt, immediately to the southwest of Cairo and situates about 150 km south of Cairo. It is bounded by longitudes 30° 26′ 11″E & 31° 21′ 45″E, and latitude 28° 49′ 33″N & 29° 11′ 12″N (Fig. 1), occupying an area of about 4000 km^2.

2. Lithostratigraphy

The stratigraphic column of the Beni Suef Basin (Fig. 2) represents a part of the Northern Western Desert which extends from the Pre-Cambrian granitic basement through the Jurassic clastics of Eghi Formation followed by the Cretaceous sequence which represents the main stratigraphic column of the study area and up to the Eocene Apollonia carbonates and Oligocene shales of the Dabaa Formation (Zahran et al., 2011). Late Tertiary to recent deposition is also recorded within the ancestral Nile valley and along its margins (Zahran et al., 2011). The Cretaceous sequence is divided into lower units made up primarily of clastics and the upper units made up mainly of carbonates (Hantar, 1990). The Lower Cretaceous sequence is divided into five rock units from bottom to top: Betty, Alam El-Bueib, Alamein, Dahab and Kharita formations, but Alamein Formation may not be deposited or eroded in the study area. Betty Formation consists of a shale bed with sandstone interbeds. Alam El Bueib Formation is represented by a sandstone unit with frequent shale interbeds. Dahab Formation is a shale unit with thin interbeds of siltstone and sandstone. Kharita Formation consists of a fine to course grained sandstone with subordinate shale and carbonate beds. The Upper Cretaceous marks the beginning of a major transgression which resulted in the deposition of a dominantly carbonate section (Said, 1962). The Upper Cretaceous sequence is divided into three rock units from bottom to top: Baharyia, Abu Roash and Khoman (Hantar, 1990). The Baharyia Formation comprises medium- to coarse-grained sandstone with calcareous silty shale interbeds. Abu Roash Formation is divided into seven members designated from bottom to top: G, F, E, D, C, B and A (Said, 1962). Members B, D, and F are relatively clean carbonates whereas members A, C, E and G are largely fine clastics with minor carbonate interbeds. The Khoman Formation consists of chalky limestone which is deposited in open marine outer shelf conditions.

3. Aeromagnetic survey

The studied area was surveyed by Egyptian General Petroleum Cooperation using airborne magnetic, the total magnetic intensity measurements were carried out using the high-sensitivity (0.01 nT) airborne proton free-precision magnetometer (Varian, V-85), mounted in a tail stinger. In addition, the Varian (VIW 2321 G4) single-cell cesium vapor was used as base station magnetometer. The flight lines of the survey were flown along parallel traverse lines in a NE-SW direction, with an azimuth of 45° and 225° from the true north. Meanwhile, the tie lines were flown in a NW-SE direction at right angles to the main flight line direction with an azimuth of 135° and 315° from the true north (Aero-Service, 1984). The traverse flight lines of the studied area were oriented in a northeast-southwest direction at 1.5 km spacing, while the tie lines were flown perpendicularly in a northwest-southeast direction at 5 km intervals. For safety reasons, the flight altitude was 3000 Feet (Aero-Service, 1984). A crystal-controlled time-of-day clock was synchronized to international time signals using a short-wave radio, so that correlation with the airborne data is assured (Aero-Service, 1984). In addition, a micro-processor based digital recording system using a 9-track, 800-BPI tape system and analog display recorded the total magnetic intensity resolved to 0.01 nano-Tesla (nT) at one second intervals during the periods of flight and generally on a 24-h basis.