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Research Paper

IMPLEMENTATION OF AEROMAGNETIC DATA ANALYSIS AT WADI ZEIDUN AREA, CENTRAL EASTERN DESERT, EGYPT

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Wadi Zeidun area is located in the central part of the Eastern Desert of Egypt. The aeromagnetic data is widely used for delineation of a basement surface, and better definition of the geometry of complex bodies. It can also be analyzed in a number of ways, with enhanced techniques and imaging making it an increasingly valuable tool. The basic geophysical concept behind this is that different rock types have different magnetic responses. Source parameter Image (SPI) and analytic signal (AS) methods are applied for depth calculations. In addition to 2-D magnetic modelling were applied to confirm the depth calculation and to give simple view of the basement configuration in the subsurface.

Keywords: Geophysics, Aeromagnetic, Wadi Zeidun, Central Eastern Desert, Egypt

INTRODUCTION

The aeromagnetic method, as used in geologic exploration, is possibly a versatile approach in geophysics, as it can be applied to both shallow and deep features. Also, relative to other methods, the measurements can be cheaply obtained for both, local and regional studies (Bouger, 1992).

The aeromagnetic method, on the other hand, is based on measurements of small variations in the magnetic field, which may be caused by in homogeneities in the composition of the basement rocks or by structural or topographic relief of the basement surface. These variations may be measured at the ground surface or more commonly by suitable instruments carried in an aircraft. The measured variations are, then, interpreted to determine the depth to basement and, thus, defining the thickness of sedimentary cover (Nettleton, 1976).

The shape of aeromagnetic anomalies varies dramatically with the dip of the earth's field, as well as with the changes in the shape of the source body and its direction of magnetization. By this way, the area under study is surveyed by aircraft measurements and the produced values are corrected and plotted on a base map and contoured. The resulting picture presents a preliminary total intensity magnetic map. This map is reduced to the magnetic pole later, and then subjected to qualitative interpretation through

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the magnetic separation and filtering techniques. Then, interpreted quantitatively to define the basement relief and the related fault and dyke system.

LOCATION

The study area is located at the Central Eastern Desert of Egypt between latitude ranges from 25° 30¢ to 26° 00¢ N and longitude ranges from 32°50¢ to 33° 30¢ E. The area looks like a triangle its vertex is in the direction of the Red Sea and its base is in the direction of The Nile River. The area occupied 2286 km^2 and bounded by Qena from the North, Luxor from the West, Idfu and Aswan from the South and the Red Sea from the East (Figure 1).

GEOLOGICAL OUTLINE

The Eastern Desert of Egypt approximates a triangular area bounded by the Red Sea and the River Nile valley from the east and west respectively, with its base as the Egyptian-Sudanese border. Stern and Hedge (1985) divided the belt of basement rocks of the Eastern Desert of Egypt into northern, central and southern domains according to the percentages of gneisses, granites, serpentinites and rocks with strong oceanic affinities. And the study area consider a part of the Central Eastern Desert.

The general geology of the investigated area (Figure 2) is a portion of the Qena Quadrangle Map published by the Egyptian Geological Survey and Mining Authority (EGSMA) in 1978. The area is occupied with sedimentary rocks mainly of Cretaceous, Tertiary and Quaternary periods.

The Lithology of the area during the different ages is:

(i) Cretaceous (Upper Turonian): The Taref Formation (Kut), comprises a sandy facies

Figure 1: Egypt Map Showing the Location of Wadi Zeidun Area, Central Eastern Desert, Egypt

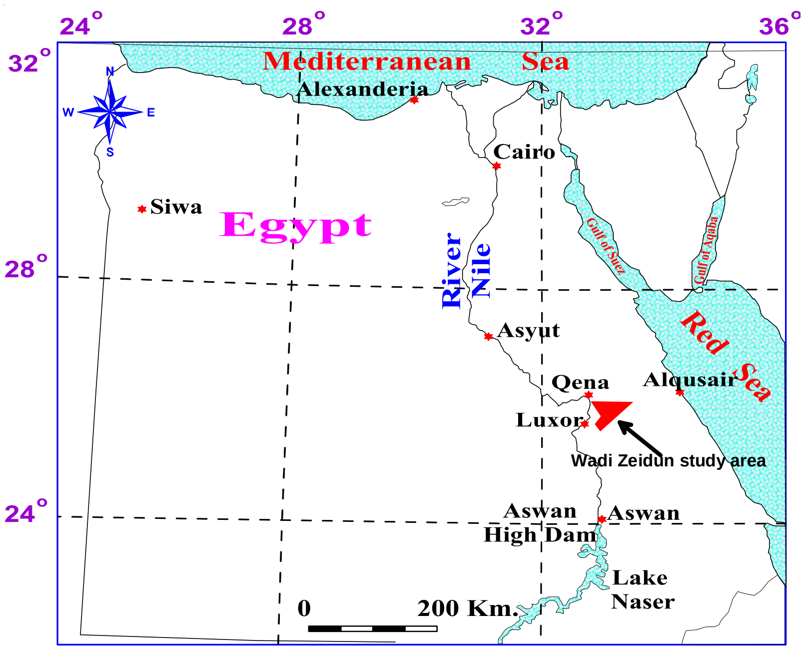
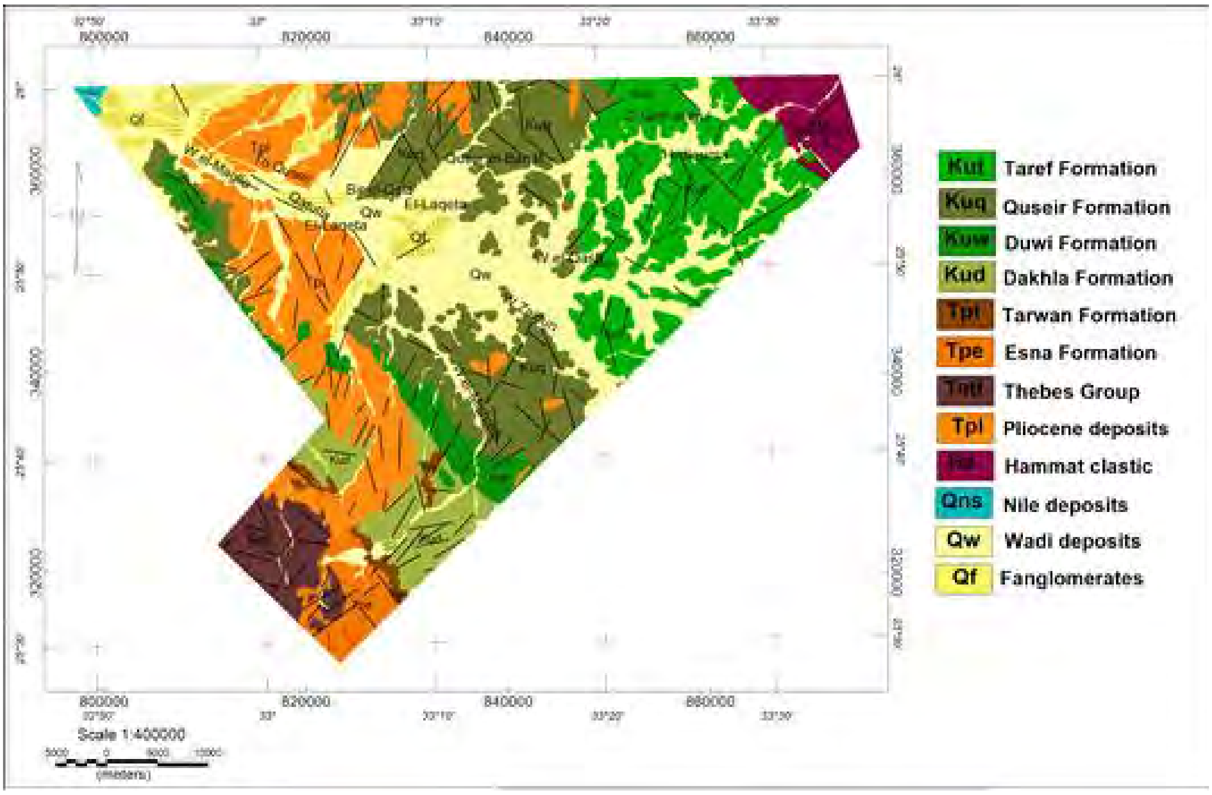


Figure 2: Generalized Geologic Map of Wadi Zeidun (After the Egyptian Geological Survey and Mining Authority "EGSMA", 1978), Redrawn by the Writer



that corresponds to a fluviatile environment that is formed essentially of sandstone (Hermina, 1967). The Formation is assigned to the Turonian age (Klitzsch and Wycisk, 1987).

(ii) Cretaceous (Upper Campanian): The Quseir Formation (Kuq), comprises a shallow marine facies forming a stratigraphic unit of about 90 m thicknesses, that constits essentially of clays, siltstone and sandstone, relaxing on the Taref Formation (Youssef, 1957, Barthel & Hermann-Degen; 1981). The deposits of the Quseir Formation reflect a gradually spreading transgression towards the south.

(iii) Cretaceous (Upper Maastrichian): The Duwi Formation (Kuw), crops out at the Western part of Wadi Zeidun area overlying the upper unit of fine sandstones of the Quseir variegated shales. The Duwi Formation consists of phosphatic sandstones, marls, phosphorites and pelagic chalk (Amstutz et al., 1984). The thickness of the Duwi Formation decreases northwards.

(iv) Tertiary (Paleocne): The Dakhla formation (Kud), is the most recent exposed formation of the Cretaceous sequence in the southern depressions of the Western Desert. It is comprises a clayey facies, correspondent to an open shallow marine environment. The clays of Dakhla based directly on the Duwi Formation and are covered by the calcareous Paleocene deposits.

(v) Tertiary (Paleocne): The Tarwan Formation (Tpt), comprises a calcareous facies deposit that caps the Abu Tartur plateau. It is deposited over the clayey deposits of the Dakhla Formation with an erosional surface. It is composed of locally sandy to clayey fossiliferous reefal calcareous deposits, belonging to the Early Paleocene age (Issawi et al., 1978 and Hermina, 1967).

(vi) Tertiary (Lower Eocene): The Esna Formation (Tpe), passes laterally to a clayey facies that characterize its lateral equivalent which is formed of 50 to 160 m thickness of marls and clays with some carbonate intercalations. It outcrops along the surface of the cliff that surrounds the depressions to the north of Kharga and Farafra plateau.

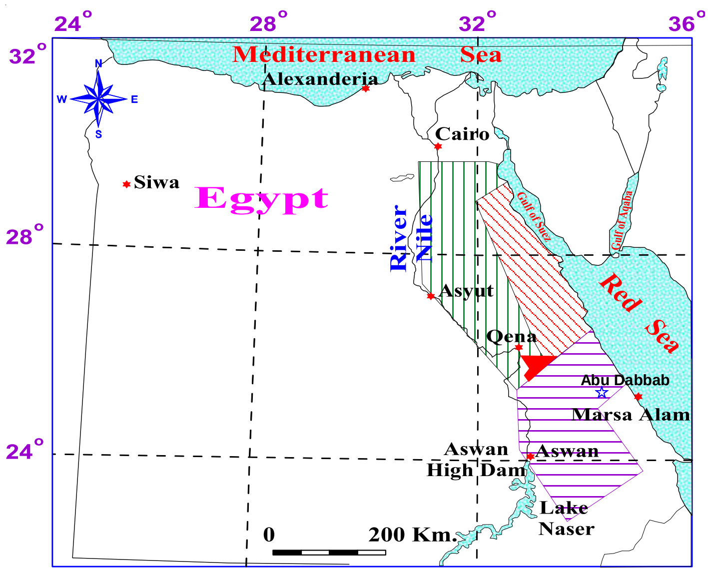
(vii) Tertiary (Lower Eocene): The Thebes Group (Tett), Consist of marly chalk and some chalk layers with flint intercalations. In the upper most portion, a chalky marl shows conspicuous tube-like burrow structures (Bandel et al., 1987). The Thebes Formation overlies the Esna shales (Abdel-Razik, 1970).

(viii) Tertiary (pliocene): The Pliocene Deposits (Tpl), Consists of fluviale siltstone, sandstone and claystone nearer to the valley cliffs lacustrine limestone and capped by thick fangolmertes.

(ix) Tertiary (Upper Miocene): The Hammat Clastic (ha), its molase-type conglomerate to siltstone sequence.

(x) Quaternary: Neonile Deposits (Qns), Wadi Deposits (Qw), Fanglomerts (Qf), they are adjacent to the Nile Valley, raised coral reefs and gravel beaches of the Red Sea coast, and surficial sediments (Geological Survey of Egypt, 1978).

Figure 3: Index Map Showing the Areas Covered by the Systematic Special Radiometric and Aero-Magnetic surveys flowen in 1984 by Aero-Survices, Division Western Geophysical Company, USA, in Relation to Wadi Zeidun, Central Eastern Desert, Egypt



Aircraft

The Aero-Service aircraft, registration number N80DS, twin-engine Cessna-Titan, type 404 was used for the data acquisition. A 35mm path-recovery camera was used to record the ground track of the aircraft. The fiducially number system was recorded directly on the film from a numeric flight emitting diode display. The tracking camera used was Aeropath A5-5, with continuous strip recording. Speed of the camera was controlled by the Doppler Navigation System (Aero-Service Report, 1984).

Airborne Magnetometer

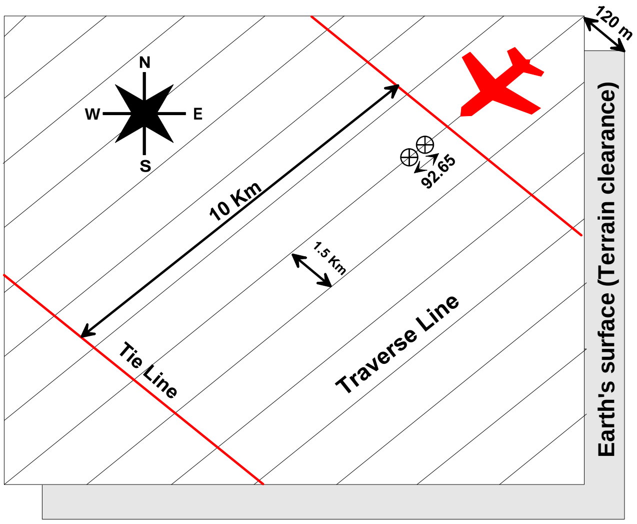
The airborne magnetometer used during the survey was a Varian V-85 proton free-precession magnetometer, with a sensitivity of 0.1 nT. The magnetometer was placed in a fiberglass tail stinger in the aircraft. The base station magnetometer was a Varian VIW 2321 G4, single cell Cesium Vapour (Aero-Service Report, 1984). The important advantages of the proton magnetometer are that it measures the absolute magnetic field of the earth and its sensitivity is higher than any of the instruments considered so far. In addition, it does not require any type of orientation or leveling, which makes it very attractive for airborne operations. Furthermore, there are essentially no mechanical parts in the detector elements to cause trouble, although the electronic components are relatively complex (Telford et al., 1987).

DATA PRESENTATION

Gridding of the Geophysical Data

The airborne magnetic measurement locations are irregularly distributed. This is mainly due to the intensive sampling along flight lines in comparison with the relatively low sampling density between the flight lines. A consequence of this is that gridding (interpolation) procedures may lead to serious degradation of the data. The data were gridded to a very fine grid interval (250m) using cubic-spline interpolation. Without this interpolation, the resulting images would have blank spaces between the flight lines. These spaces hamper color perception and make interpretation more difficult (Duval, 1983 and Geosoft, 1995).

Figure 4: Flight Path of the MPGAP Project, Specifications after (Aero-Service, 1984)



Reduction to North Magnetic Pole

In the RTP magnetic map (Figure 5) the high magnetic response is at the eastern, western and also the southern part of the study area represented by the yellow, red and magenta colors and ranges from 57 to 86.90 nT and have directions of NE-SW, NW-SE and N-S. The low magnetic response is at the central and south western part of the study area represented by the blue and green color and ranges from 17.62 to 57 nT. There is a contact appear clearly at this map is located at the eastern part of the study area and discriminate between the area of the high magnetic response and the area of the low magnetic response. This contact represented by a black colored contact at the map (Figure 5). From the geology map (Figure 2) this contact discriminate between Taref Formation and Quseir Formation.

The RTP map is compatible with the geology and we could divide it into two zones (Figure 6):

(i) The first zone is encountered in the eastern and western portion of the study area. It is characterized by anomalies of strong amplitudes, and very high frequencies. They vary in color from red to magenta and ranges from 57 to 86.90 nT and have directions SW-NE, NW-SE and N-S. And they are related in geology to Hammat Clastic, Taref Formation and Pliocene Deposites.

(ii) The second zone is encountered in the central part of the study area. The anomalies of this zone are characterized by their relatively low amplitudes, and low frequencies. They vary in color from blue, green, to yellow and ranges from 17.62 to 57 nT and related in geology to Quseir Formation, Thebes group, Nile Deposits, Wadi Deposits and Fanglomerats.

Figure 5: Filled-Color Contour Map of the Reduced to Pole Aerial Total Magnetic (RTP), of Wadi Zeidun Area, Central Eastern Desert, Egypt

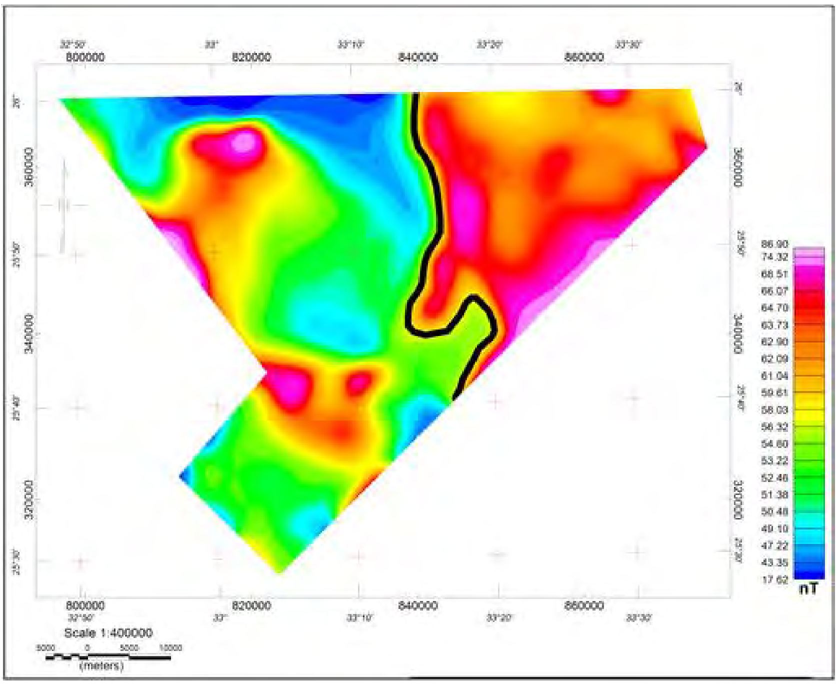
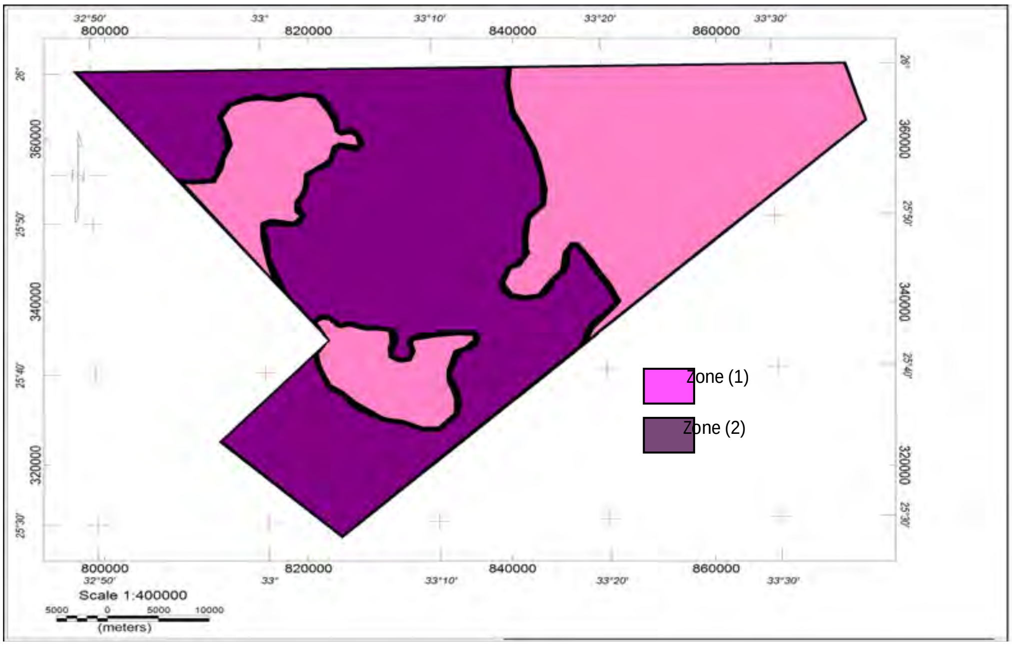


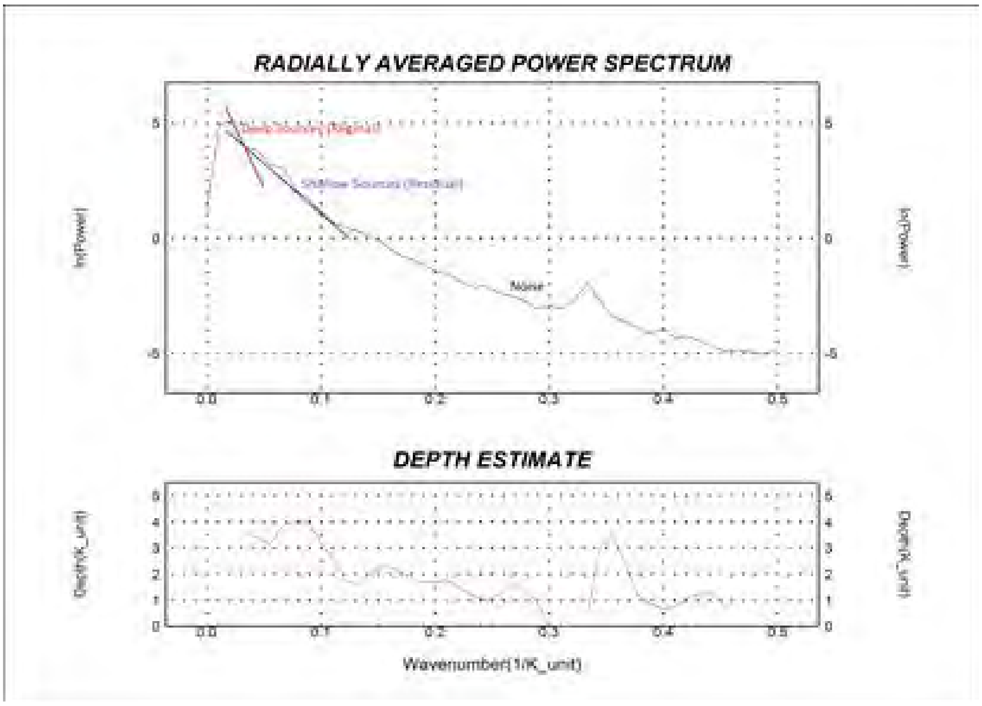
Figure 6: Interpreted Magnetic Zones, According to High Amplitude (Zone 1) and Low Amplitude (Zone 2) of Wadi Zeidun Area, Central Eastern Desert, Egypt



Magnetic Separation Using the Power Spectrum Curve

There are many techniques to separate regional and residual magnetic component maps from a RTP map. One of these techniques is the Spectral analysis which is based theoretically on a Fast Fourier Transform (FFT). The calculated radially-averaged power spectrum for the (RTP) aeromagnetic map is shown in (Figure 7). It could be divided into three segments. The first segment is in the frequency range 0.0 to 0.03 cycle/km. These long wavelengths indicate to regional or deep sources component. The second segment lies in the frequency range 0.03 to 0.1 cycle/km. These short wavelengths denoted to residual or shallow sources component. The third segment, which possesses frequencies exceeding 0.1 cycle/km, represents the noise component. The first and second components have markedly different spectral characteristics. The slope of a line fitted to each of the first and second segments of the spectrum curve are used to estimate the average depths of the regional and residual magnetic sources respectively. The estimated mean depths of both the regional and residual sources were found to be 3.5 and 4 km respectively (Figure 7). It is implicit in the preceding discussion that the slopes of each of the two parts of the spectrum curve are due to differences in depth between the deep-seated (regional) sources and the near-surface (residual) sources. Actually, the slope of the spectral curve, to large extent, is decided by the size or cross-section of the causative sources; the larger the sources the more long wavelength spectral composition and, therefore, the greater the slope of the spectral curve (Spector and Parker, 1979).

Figure 7: Two Dimension Power Spectrum of Magnetic Data, and the Corresponding Averaging Depth of Wadi Zeidun Area, Central Eastern Desert, Egypt



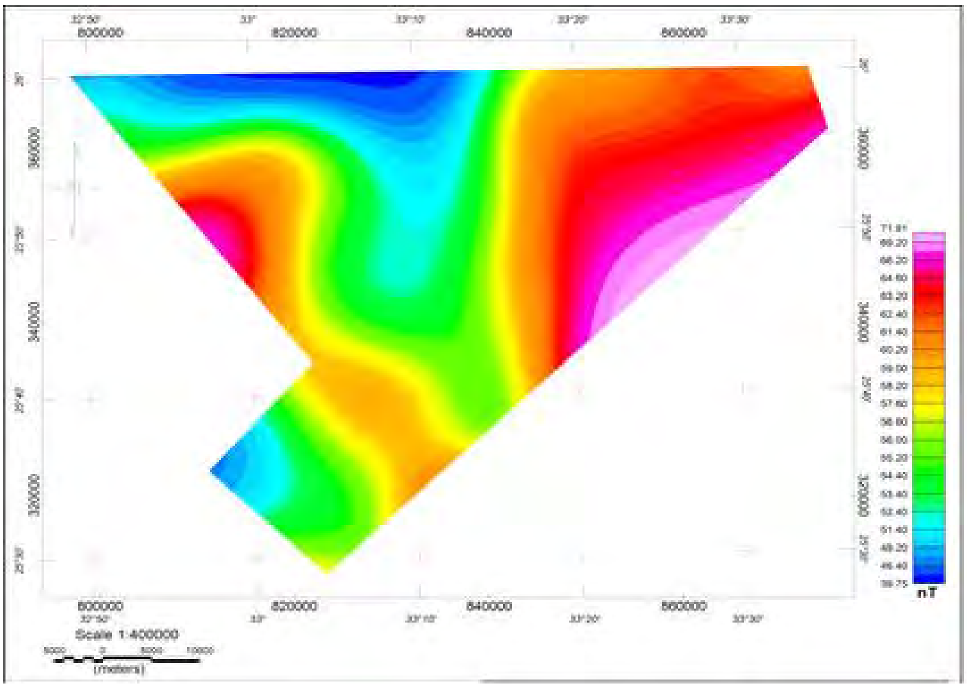
Regional Magnetic Component Map

The RTP regional magnetic-component map (Figure 8) resembles -to a great extent-the aerial RTP magnetic map (Figure 5). This similarity means that the sedimentary cover possesses low magnetization or it could be consider negligible. Therefore, the deep-seated structures play the major role in defining the general tectonic framework of the area under consideration. The magnetic RTP and regional-component maps (Figs. 5 & 8) show the same number of high magnetic anomalies. These anomalies are characterized by their high magnetic amplitudes and could be discriminated by the red and magenta color on the two-mentioned aeromagnetic maps. The shapes of some of these anomalies are somewhat rounded, while others are -to some extent- elongated. These anomalies acquire sharp contacts -in various degrees- with the surrounding magnetic features. The sources of these anomalies may be due to basic or ultrabasic intrusions. There is also, relatively large, negative and relatively broad magnetic anomalies were encountered at Quesir Formation, Fanglomerats, Thebes Group and Wadi Zeidun (Wadi deposits). These anomalies were discriminated by the green and blue colors on the two-mentioned aeromagnetic maps. They may be correlated with subsurface acidic rocks.

Residual Magnetic Component Map

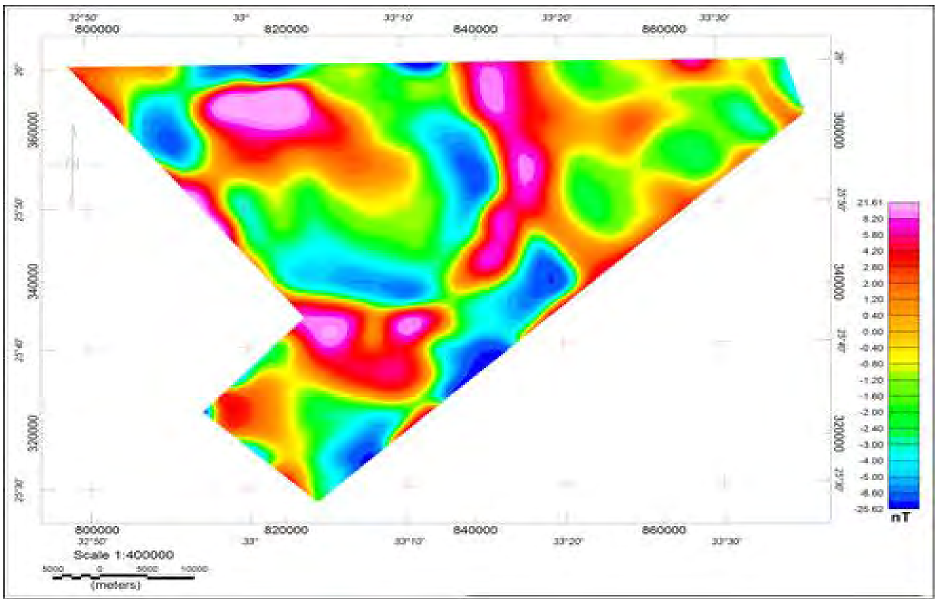
The residual aerial RTP magnetic-component map (Figure 9) shows the sudden changes in the magnetic relief, always accompanying the shallow-seated geological features and/or bodies. There is a number of magnetic anomalies of strong and high amplitudes were encountered at Pliocene Deposits, Dakhla Formation and the contact between Taref Formation and Quseir

Figure 8: Filled-Color Contour Map of the Regional Magnetic Component Map, of Wadi Zeidun Area, Central Eastern Desert, Egypt



Formation and directed in the NW-SE and N-S direction. And, the magnetic anomalies of weak and low amplitudes were encountered at Wadi Zeidun (Wadi Deposits) and Quseir Formation.

Figure 9: Filled-Color Contour Map of the Residual Magnetic Component Map, of Wadi Zeidun Area, Central Eastern Desert, Egypt



Major Structural Trends

The regional anomaly map and residual anomaly map were interpreted to determine the common structural trends affecting the area of study.

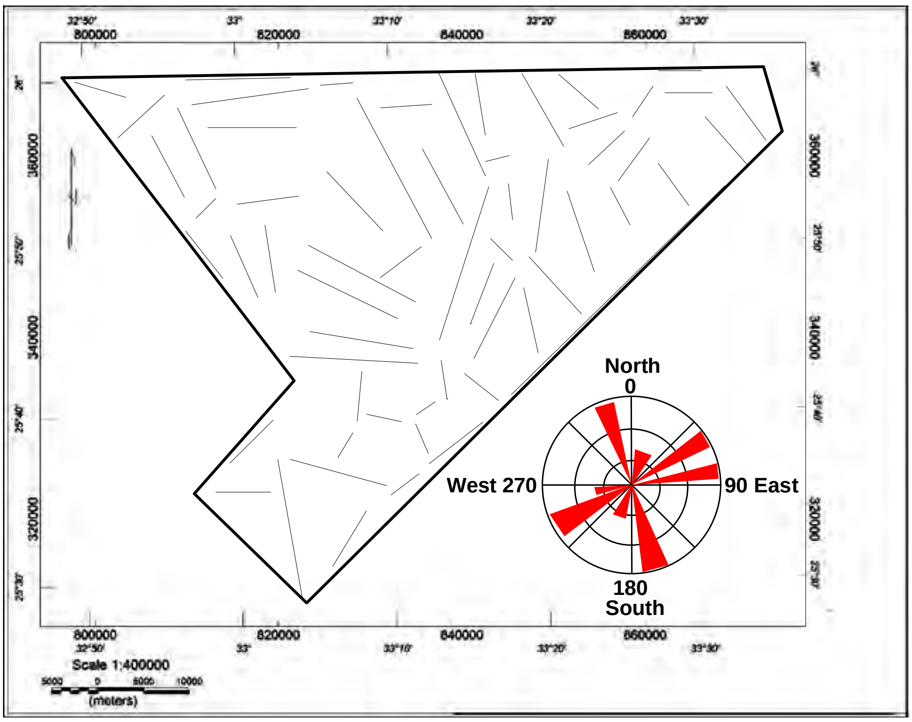
The azimuth and length of each detected lineament on the RTP map represent probably the faults and/or contacts of varied length and directions (Figure 8). These structural systems are statistically analyzed and plotted in a trend map (Figure 10).

The examination of this map showed three predominant structural trends having variable intensities and lengths. These are the NNE to SSW, and ENE to WSW, trends representing the most predominant tectonic trends affecting the investigated area as deduced from the magnetic point of view. However, the other minor structural trends appearing on the trend map such as the N-S, and E-W, are of less significant in this area.

Discussion of the Magnetic Depth Calculation Maps

The Source parameter image (SPI) and Analytical signal (AS) results are much closed to each other. In SPI map (Figure 11), the eastern part of the study area is the deepest place at the area and represented by blue and green colors and the depths ranges from -3042.87 to -861.40 nT and these depths show low magnetic Reponses. The Western, Southern and South Western parts is the shallow places at the area and they represented by the yellow, orange, red and magenta colors and the depths ranges from -841.20 to -630.80 nT and these depths show high magnetic Reponses. There are some magnetic anomalies represented by symbols A, B, C, D, E

Figure 10: Structural Trend Analysis of the Magnetic Land Survey Data



and F and they have a light magnetic color and its depths ranges from -630.80 to -458.25 nT are the most shallowest places at the area and have the highest magnetic responses.

In AS map (Figure 12), the eastern part of the study area is the deepest place at the area represented by the blue and green color and the depths ranges from -1777.13 to -777.60 nT and these depths show low magnetic Reponses. The Western and Southern parts of the study area show the shallow places at the study area represented by the yellow, orange, red and magenta colors and the depths ranges from -751.00 to -536.40 nT and these depths show high magnetic responses. There are four magnetic anomalies represented by symbols A, B, C and D and have the light magenta color and the depths ranges from -536.40 to -365.45 nT and these depths represented the most shallowest places at the study area which have the highest magnetic responses.

The SPI and AS maps are similar in shape as shown at (Figures 10 and 11) and the anomalies A,B,C and D are exist in both of the maps . The only difference is in the depth calculation.

Figure 11: Map of the Calculated Depths with Source Parameter Image (SPI), of Wadi ZeidunArea, Central Eastern Desert, Egypt

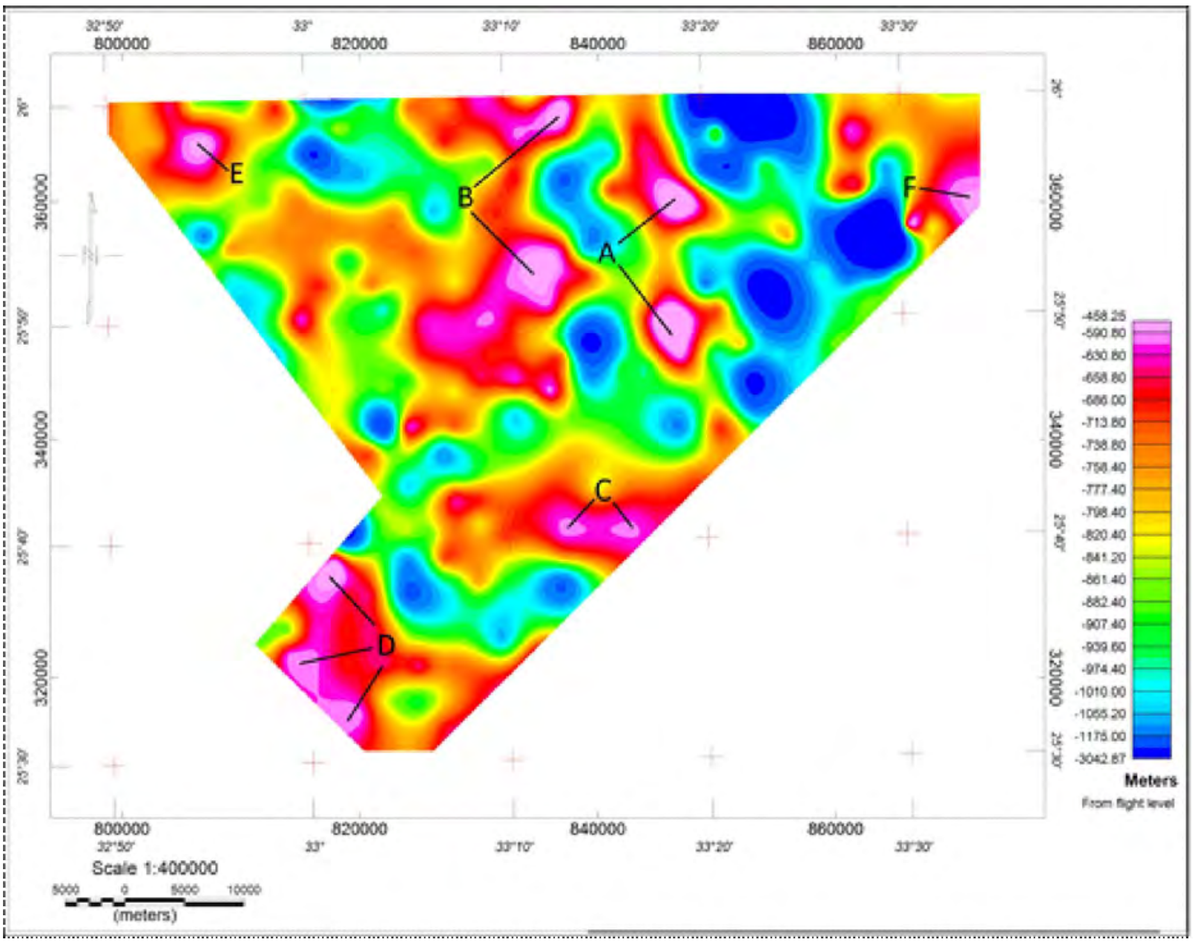
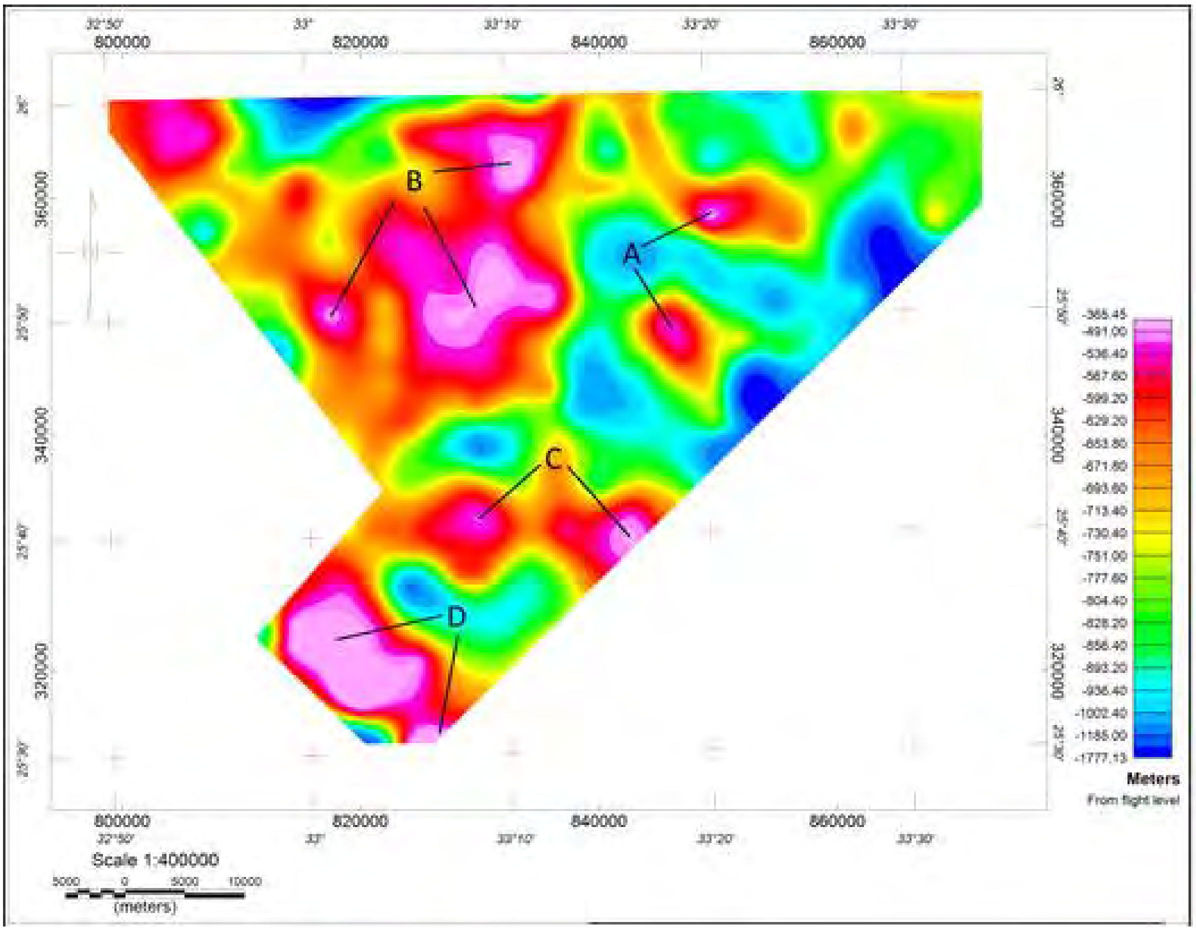


Figure 12: Map of the Calculated Depths with Analytical Signal (AS), of Wadi Zeidun Area, Central Eastern Desert, Egypt

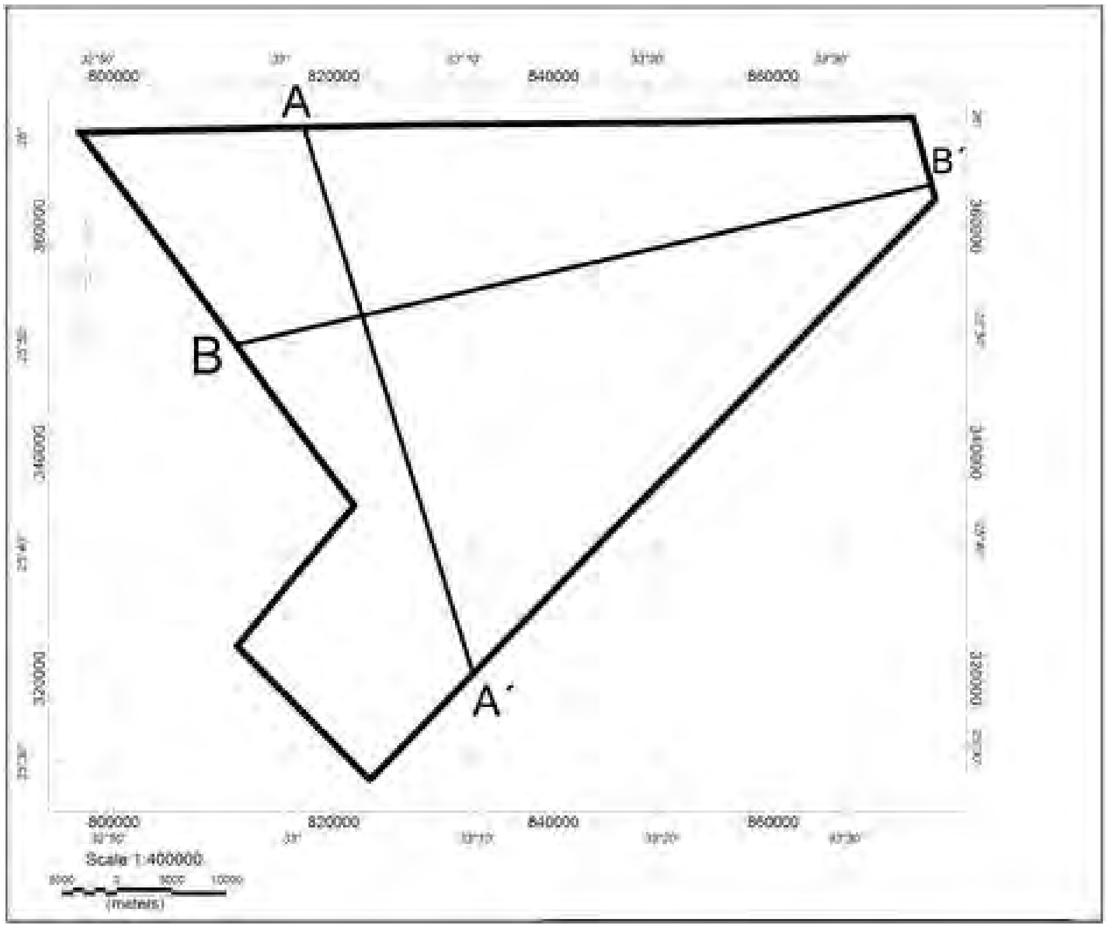


Modelling Technique

The two dimensional modelling is simple way to imagine the subsurface structure. The following 2-D models explain the profiles A-A\ which trended in the NNW-SSE direction and B-B\ which trended in the WSW-ENE direction (Figure 13).

The both profiles (Fig. 14, 15) show more or less the same as the surface of the basement rocks which is not reach the earth's surface. According to the surface geology all the rock units that appear on the earth's surface are sedimentary rocks. As it is known that the sedimentary rocks have low magnetic susceptibility and corresponding the high variation and discrimination for magnetic profile will be due to basement rocks. The two profiles are intersected at depth 1800 and we assumed the magnetic susceptibility of the basement as 0.00047 c.g.s and according to the typical magnetic susceptibilities of the earth materials, the basement may be acidic rock (Granite). This models are considered as one of the solutions which show the subsurface shape because we doesn't have a subsurface data or detailed

Figure 13: Location of the 2-D models drawn at Wadi Zeidun area, Central Eastern Desert, Egypt



geophysical studies. In addition to that, the percentage of the error in the both profiles is too small 0.1 in profile (A-A') and 0.06 in profile (B-B') so it may be good indicator.

The profile A-A' (Figure 14): there are may be two basins and three faults ranges from gentle to steep moving into the NNW direction. The depths of the basement surface ranges from 1100, 1300, 1500 to 2100 km then it is get shallower at 1000 km and then it is get deeper again at 2900 km. From the geology map this model gives high magnetic response at Pliocene Deposits and low magnetic response at Wadi Deposits (Wadi Zeidun) and Dakhla Formation.

The profile B-B' (Figure 15): there are may be one huge basin have a steep fault and other three small faults. . The depths of the basement surface ranges from 900 to 700 km and it is get deeper at 900 to 2000 then it is get shallower again at 1700, 1500 to 750 km. From the geology map this model gives high magnetic response at Pliocene Deposits, Taref Formtion and Hammat Clastic and low magnetic response at Wadi Deposits (Wadi Zeidun).

Figure 14: 2-D Modelling (Profile A-A') of Wadi Zeidun area, Central Eastern Desert, Egypt

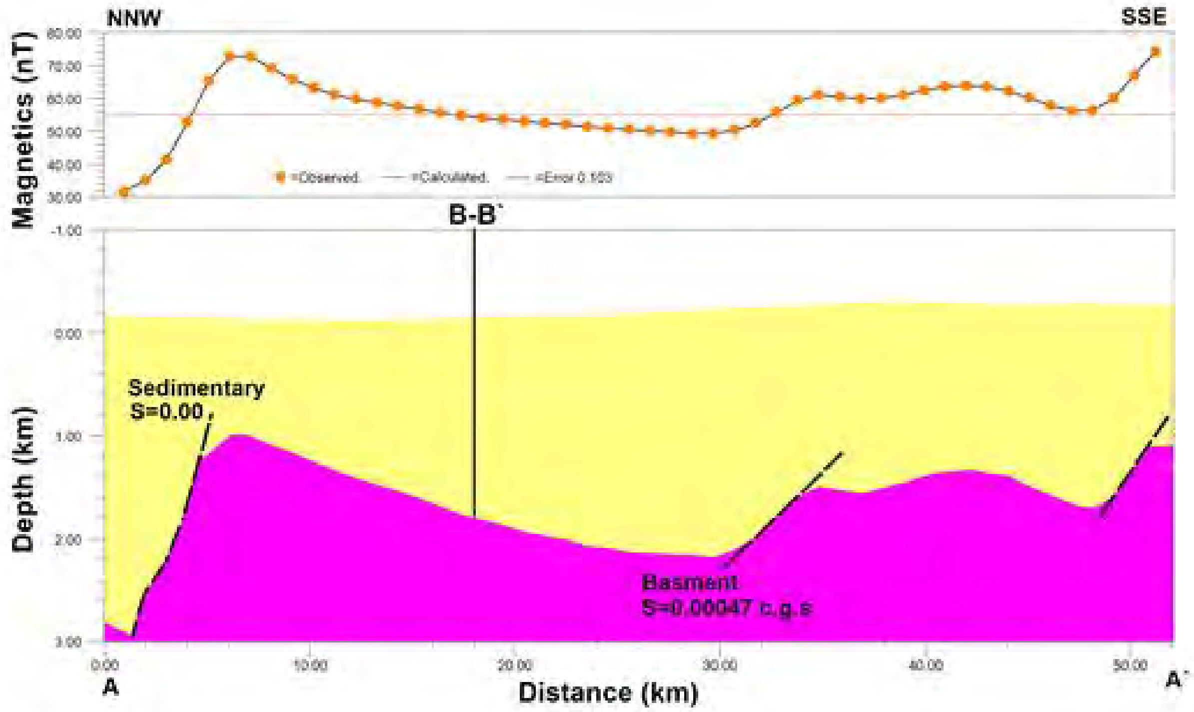
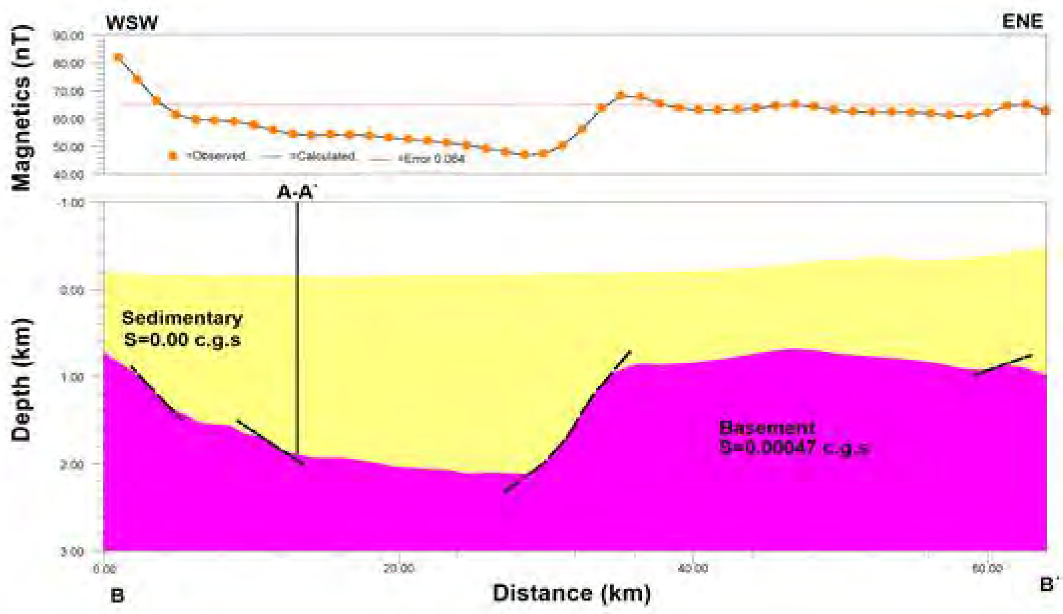


Figure 15: 2-D Modelling (Profile B-B') of Wadi Zeidun Area, Central Eastern Desert, Egypt



CONCLUSION

The structural trend analysis has been applied for the shallow structural elements deduced from the observed and residual land survey magnetic data. The interpreted fault and/or contact system are statistically analyzed. This map showed the major sets of the trends, which are; (i) The NNW to SSE trends (Red Sea-Gulf of Suez trend) expressive the most principal faulting direction in the studied area as the first order, and (ii) The NE to SW trend (Aqab trend) this drift is implication in the residual anomaly trend, (iii) The ENE-WSW trend (Aualitic) is the third order trend.

The oldest tectonic trends appear to be revitalized as interrelated to the opening of the Red Sea and the two gulfs. Depth estimation was carried out for the major selected anomalies of the RTP magnetic maps using spectral analysis, in order to delineate the depths to basement.

Moreover, the 3-D analytical signal, Euler deconvolution and the two-dimensional modeling techniques have been applied to estimate the basement surface, as well as the structural deformations affecting the overlying sedimentary section. The depth results range from 700 to 2900 meter. This means that results were calculated and the basement relief map was constructed for the area of study. It is interesting to mention that, the constructed basement relief map shows great view of depths in the study area. The relief map reflects that the obtained results of depth calculations in this work are of good approximation; particularly the chosen area of study has no deep wells.

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