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I. Introduction

The present study area (Fig.1) is located at the central part of the Eastern Desert of Egypt (covering an area of 9460 Km^2). This area is mainly covered by basement rocks. However, there are parts covered by sedimentary rocks ranging in age from Upper Cretaceous to Quaternary.

For better understanding of the subsurface structural features; magnetic method could be used as a good tool for delineation of the basement surface, and better definition of the geometry of complex bodies. Magnetic data can 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 the magnetic method reflects spatial variations in the magnetic field of the Earth. These variations are related to the distribution of structures, magnetic susceptibilities, and/or remnant magnetization. Sedimentary rocks, in general, have low magnetic properties compared with igneous and metamorphic rocks that tend to have a much greater magnetic content. Thus, many aeromagnetic surveys are useful for mapping basement and igneous intrusions.

In this work, high resolution magnetic data have been aided with all available geological information to produce multiple attribute maps in order to reveal the complex structural setting of the area under study.

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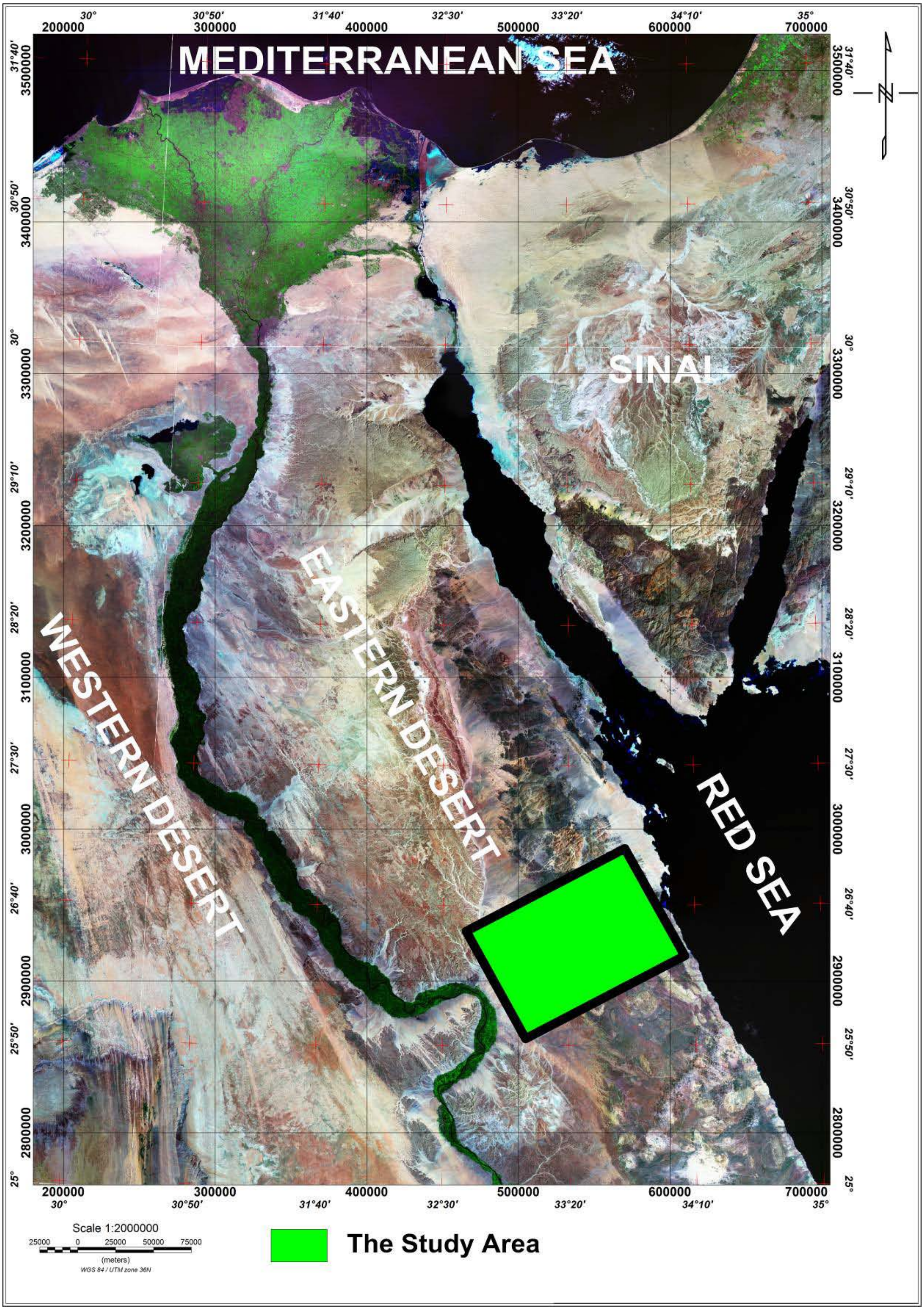

Figure 1: Satellite image showing location of the present study area

II. Geological Background

Based on the geologic map of Egypt (Elramly, 1972), Stern and Hedge, 1985, identified three distinct basement domains in the Eastern Desert; these are the North, Central, and South Eastern Deserts. These areas were divided by two fault zones, and are abbreviated NED, CED, and SED. The present study area located at the transfer zone between NED and CED (Qena-Quseir shear zone). There is a much higher concentration of granitic rocks in the NED and SED than in the CED. The CED exposes, by far, the greatest concentration of rocks with strong oceanic affinities, such as ophiolites and Banded Iron Formation (BIF) (Sultan et al., 1988). The area is covered at the western side by sedimentary rocks ranging in age from upper Cretaceous to Quaternary (Fig. 2).

The rock units exposed in the study area could be arranged into four main groups; from older to younger units (Schandelmeier et al., 1983 & 1987; Greiling et al., 1988):

1) Pre-Pan-African rocks (gneisses and migmatites).
2) Pan-African ophiolites and island-arc assemblage (serpentinites, metagabbros, metavolcanics and metavolcaniclastics).
3) Cordilleran-stage associations (different types of granites).
4) Quaternary sediments

The Eastern Desert of Egypt lies within the fold and thrust belt of the Pan-African continental margin orogeny (El- Gaby, 1983). It consists of relatively thin and imprecated thrust sheets overlying an attenuated Early Proterozoic continental margin.

Greiling, 1988 believe that the Pan African belt was created by compression from an easterly direction, while Shackleton et al. 1980, Ries et al. 1983, and Habeib et al. 1985) consider that the direction of tectonic transport was towards the NNW.

According to the constructed structural map (Conoco and EGPC, 1987), the fracture lineaments including faults have four main trend sets; NW - SE, NE – SW, ENE – WSW and E-W.

In the interior of the African–Nubian Shield, steep vertical movements are accepted for the Precambrian rocks and the Phanerozoic rocks. These faults are often regenerated with quite steep graben borders intersecting the uplift in the Miocene age, in connection with the variations and oscillations in the vertical pattern of faulted areas on the plunges of old massifs, (Schurmann, 1974).

The orientation of the Late Paleozoic to Mesozoic large-scale undulations indicates that the reason for the SE–NW compression in the rotation tendency of Africa start in Carboniferous and culminate in Tertiary regions of Africa separated from Asia (Schurmann, 1974).

Being of epi-Hercynian age, they are generally filled with Triassic and Jurassic series. They are often thick, containing such volcanics such as andesite, basalt, and related tuff. Unlike the aulacogens of ancient platforms, scientists have suggested calling these depressions taphrogenes. The second stage in the young platforms is characterized by the generation of gentle uplifts, similar to shields, and by extensive and long-developing depressions looking like synclines and pericratonic down-warps of ancient platforms. The depressions were initiated in the Jurassic time and then developed during the Cretaceous, Paleogene, and Neogene times; some of them are subsiding at present.

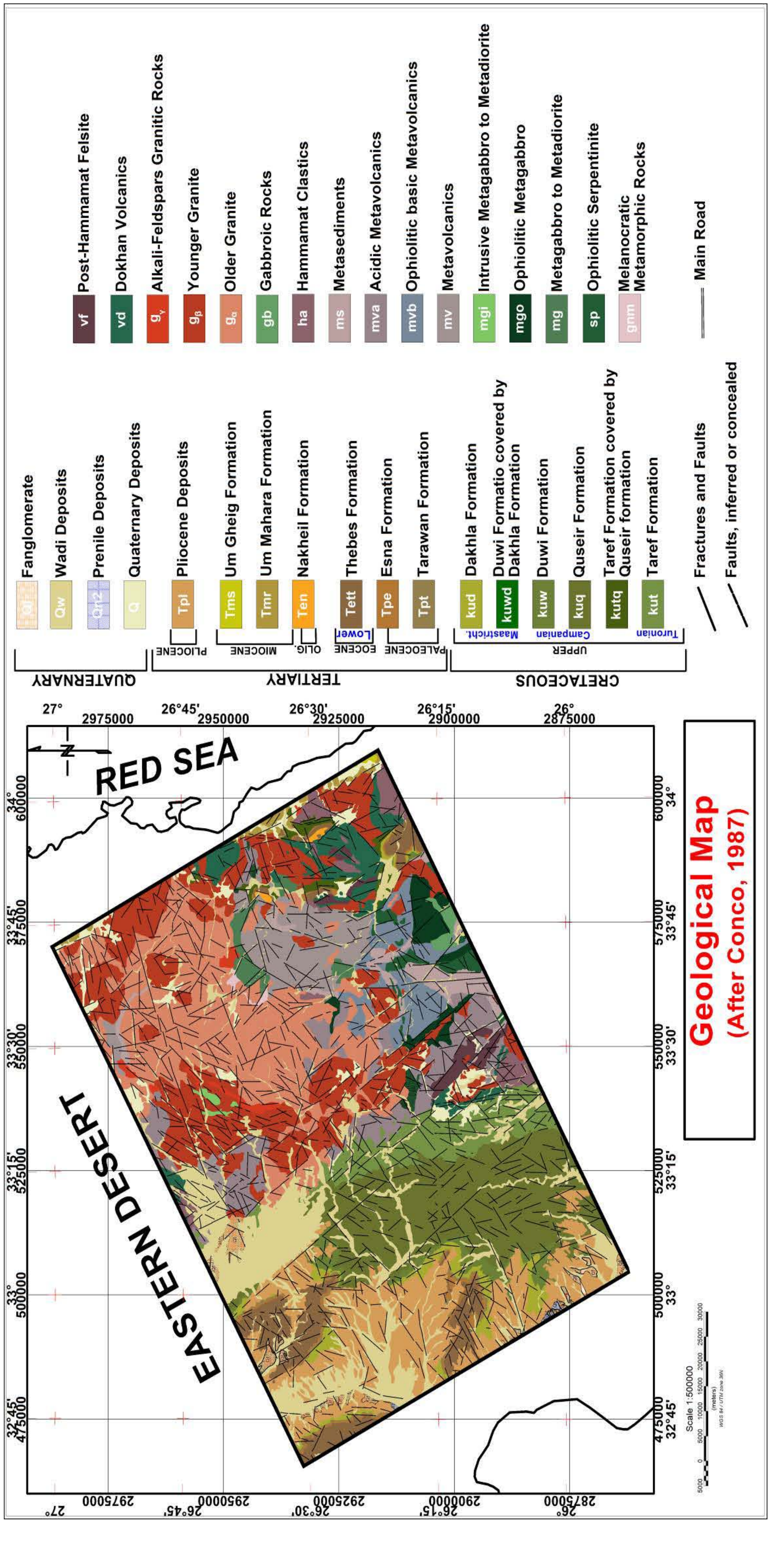

Figure (2): Geologic Map of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt, (After Conco, 1987)

III. Aeromagnetic Data

In 17th December, 1984, Aero-Service Division, Western Geophysical Company of America conducted high resolution magnetic survey covering an area of 9460 km^2 over Qena-Quseir shear zone area, Central Eastern Desert, Egypt (Fig. 1). The data were acquired along flight-lines oriented in NE-SW direction using 1.5 Km line spacing and along tie-lines oriented in NW-SE direction using 10000 m line spacing. Nominal flying elevation was 120m above ground surface (Aeroservice Report, 1984) (Fig. 3).

The Aero-Service aircraft, registration number N80DS, twin-engine Cessna-Titan, type 404 was used for the data acquisition. A 35 mm path-recovery camera was used to record the ground track of the aircraft. 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.

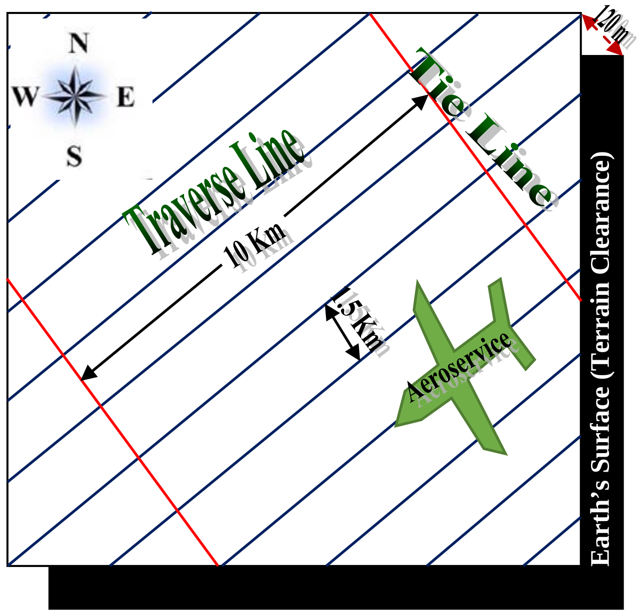

Figure 3: Flight Path Specifications of the Study Area (After Aeroservice, 1984)

IV. Interpretation

The total aeromagnetic map was reduced to the north magnetic pole of the earth by applying spectral analysis technique to overcome the Di-Polarity problem. The reduced to pole (RTP) magnetic map (Fig. 4) was separated into two magnetic components named the regional and residual magnetic components (Figs. 5&6). The RTP regional magnetic-component map (Fig. 5) resembles –to a small extent- the aerial RTP magnetic map. This similarity is shown in the major anomalies, which reflect the magnetic response of the basement rocks, which exposed in the study area. This similarity also means that the sedimentary cover in the western part of the study area possesses low or negligible magnetization. Therefore, the deep-seated structures play the major and important role in defining the general tectonic framework of the area under consideration. The RTP residual magnetic-component map (Fig. 6) shows to a much lesser extent the same general features as the aerial RTP magnetic and regional magnetic-component maps. Nevertheless, it can demonstrate more about the magnetic-rock types, their contacts and their over-all relationships including faulting, folding, etc., particularly at the near-surface shallow level. The estimated mean depths of both the regional and residual magnetic sources were found to be 1000 and 200 m respectively.

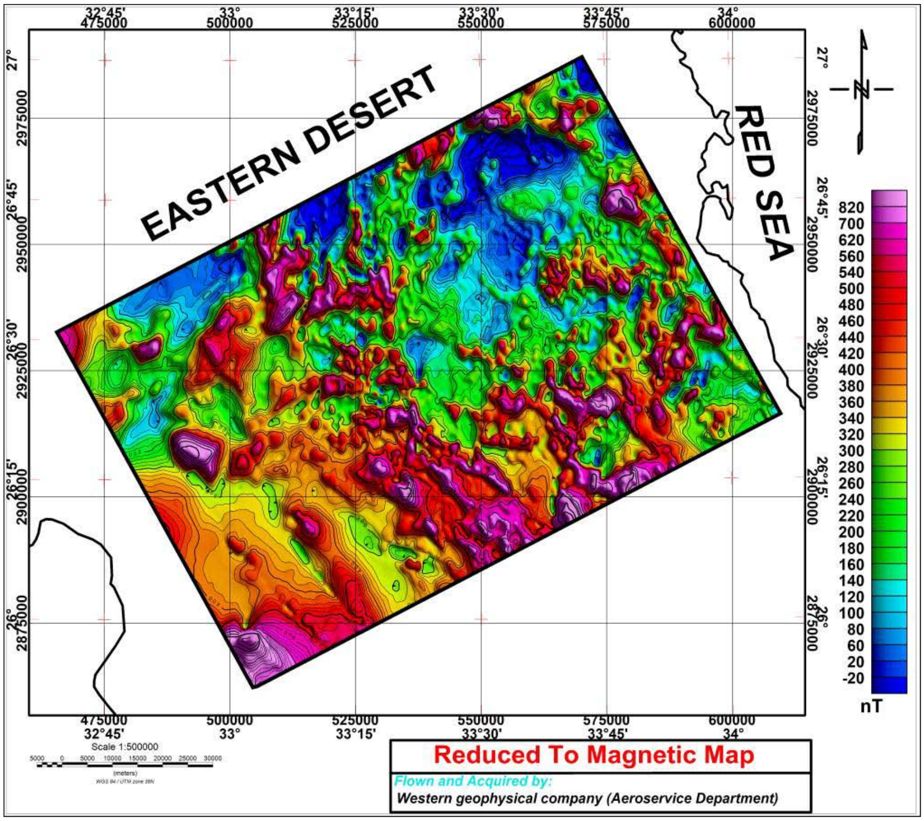

Figure 4: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Aerial Total Intensity Magnetic Field of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

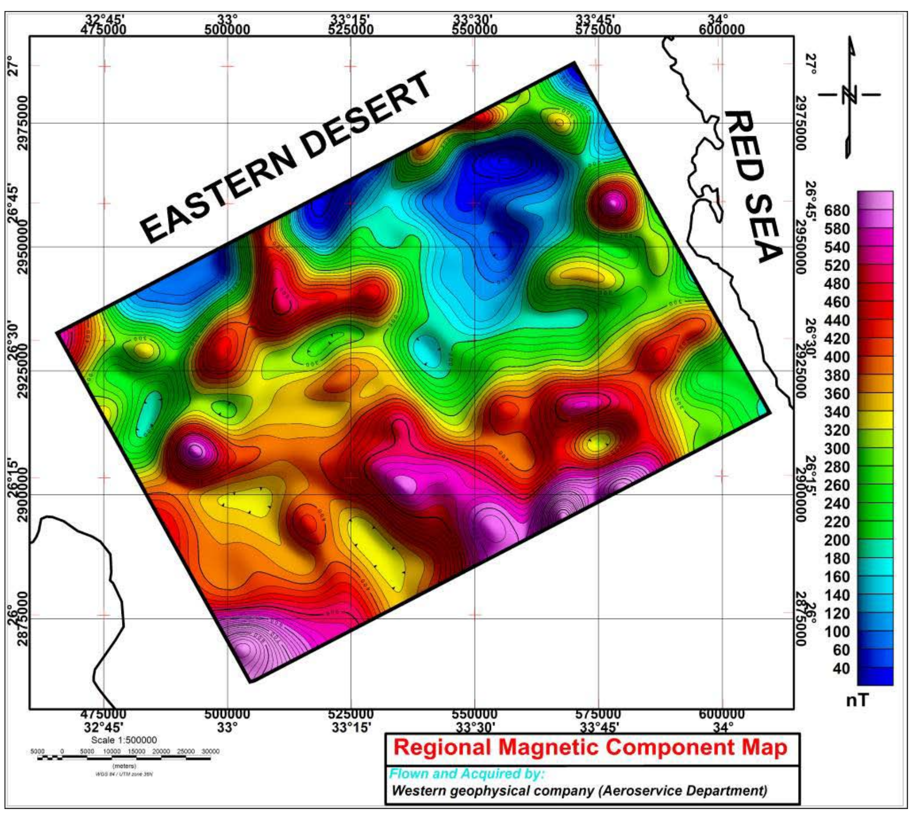

Figure 5: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Regional Magnetic Component of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

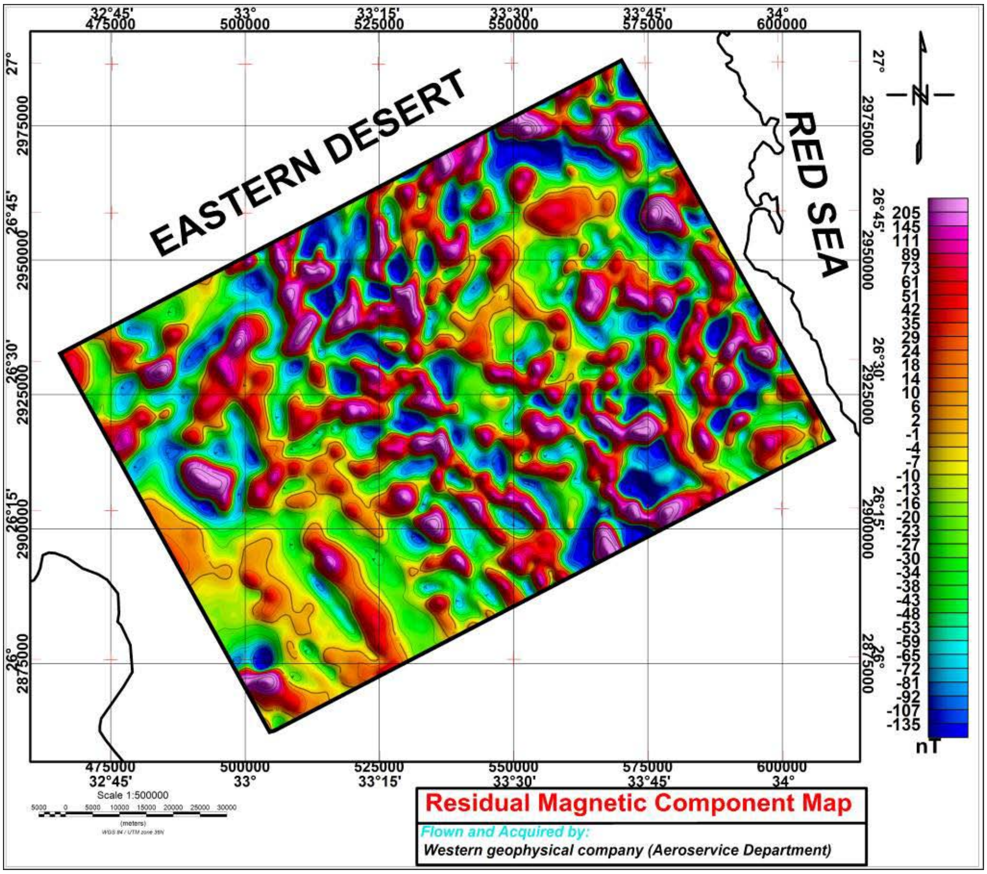

Figure 6: Colour Contour Map of Reduced to the North Magnetic Pole (RTP) Residual Magnetic Component of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

a) *Discussion of Depth Calculation*

The maps of the depths help us very much in delineate the general structures of basement surface. Two techniques of magnetic depth calculations are applied in the study area. The results of Analytic Signal (AS) and Source Parameter Imaging (SPI) are shown in figure (7) and (8) respectively.

The first look to the two maps show that the AS and SPI results are much closed to each other. At the two maps, the western part of the area shows more deeper depths representing the sedimentary rocks. The depths of this part is ranging from 600 m to more than 1000 m. The two maps show that the eastern part of the area is very shallow and has depths ranges from 152 m to less than 10 m because of the outcropping of the basement rocks in this part of the study area. This area is related mainly with the granitic and Metavolcanic rocks.

b) *Interpreted Magnetic Basement tectonic Map*

Magnetic method is used to give information from which one can determine the depth to the basement rocks and, thus, locate and define the extent of the sedimentary basins. Such information is of particular importance in previously unexplored areas such as the continental shelves newly opened for prospecting. It is also employed to map topographic features on the basement surface that might influence the structure of overlying sediments. Another application is the delineation of interasedimentary magnetic sources, such as shallow volcanics or intrusives that disrupt the normal sedimentary sequence (Dobrin, 1990).

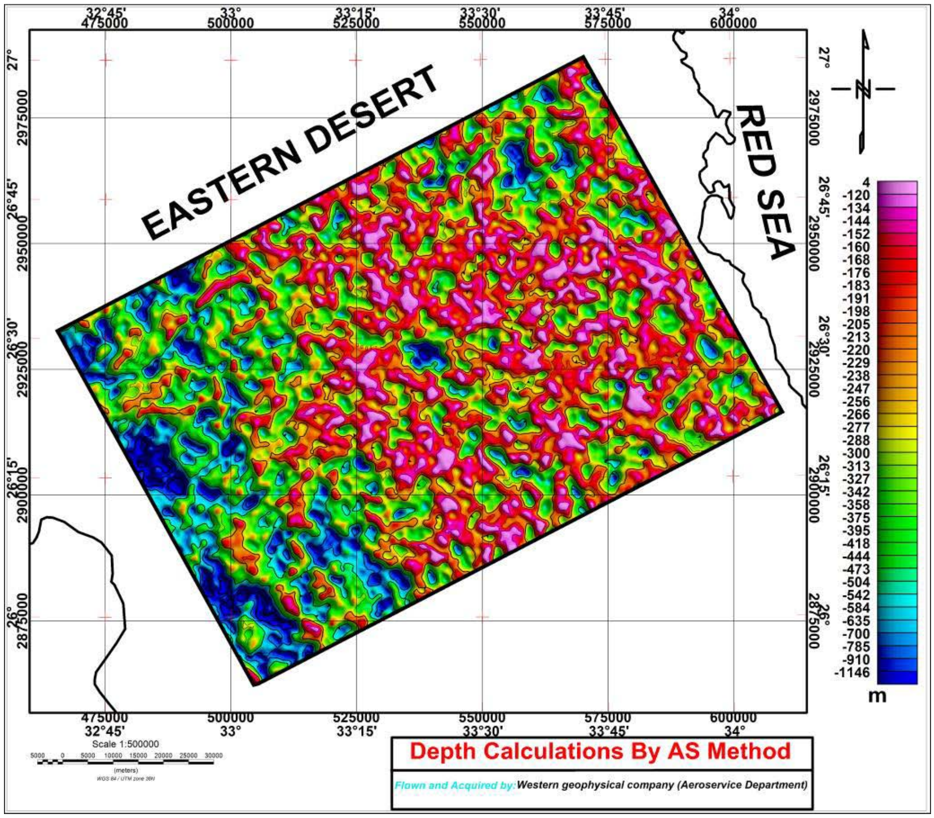

Figure 7: Colour Contour Map of Calculated Depths using Analytic Signal (AS) Technique at Qena - Quseir Shear Zone Area, Central Eastern Desert, Egypt

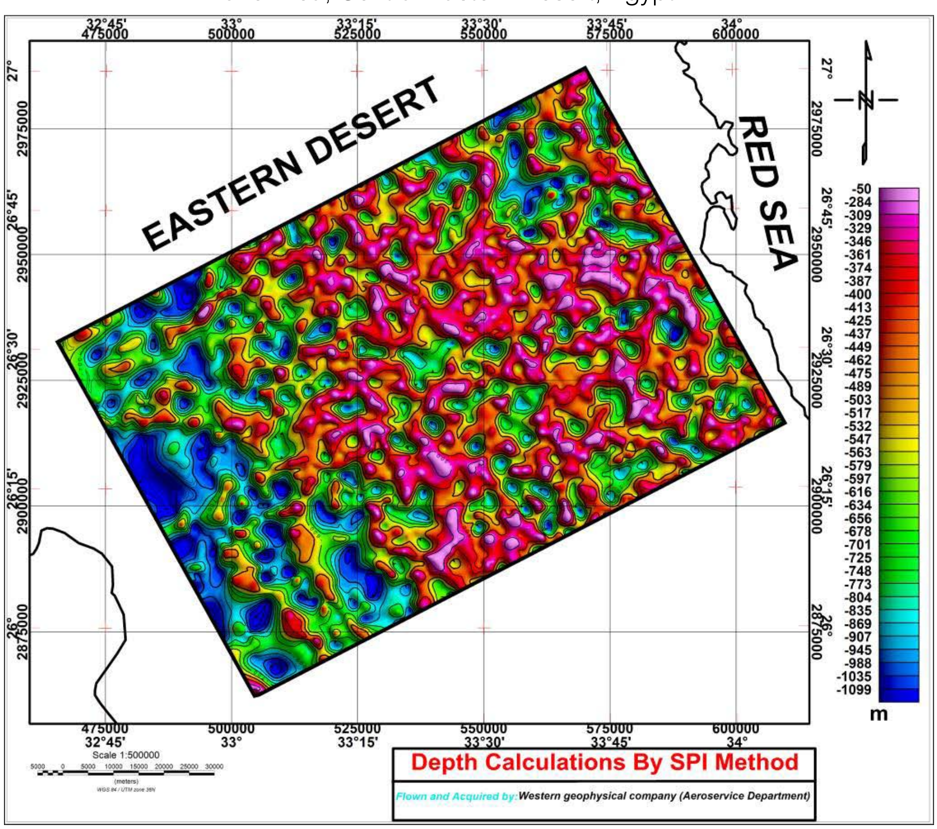

Figure 8: Colour Contour Map of Calculated Depths using Source Parameter Imaging (SPI) Technique at Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

The regional basement tectonic relief map (Fig. 9) was constructed through the integrated interpretation of the magnetic maps. Regional basement tectonic map shows three systems of faults which trending in NW-SE, E-W and NE-SW directions respectively. These faults also suffered from strike-slip movements trending in NE-SW.

c) *Discussion of the Results of 2D-Magnetic Profile Modelling*

To confirm the interpreted basement structural relief of the study area, 2D magnetic modeling was carried out along four profiles AA′, BB′, CC′ and DD′ (Figs. 10, 11, 12 & 13) oriented in N-S, WSW-ENE, NNE-SSW and NE-SW trends respectively. The magnetic susceptibility values were assumed for all rock units in the four modelled profiles and tabulated in table (1).

By comparing between the modelled profile AA′ (Fig. 10) which trends N-S with the basement tectonic map (Fig. 9), nine normal faults affect the area of consideration along the modelled profile AA′. These faults are denoted on figure (10) as numbers from 1 to 9. These faults are described as follow:

Table 1: Assumed Rock Unit Susceptibilities for the modelled Profiles

Rock Unit	Assumed Susceptibility (c.g.s)
Gβ	0.004
Gα	0.005
mgo	0.004
mvb	0.003
mva	0.003
vd	0.008
vf	0.007
mv	0.005
Basic Rocks	0.01
Acidic Rocks	0.015
Basement Rocks	0.01

1. *Fault (1):* trending in NW-SE direction and cutting in younger granitic rocks with 74 m fault throw.
2. *Fault (2):* trending in WNW-ESE direction and cutting in older granitic rocks with 21 m fault throw.
3. *Fault (3):* trending in NW-SE direction and cutting in older granitic rocks with 34 m fault throw.
4. *Fault (4):* trending in WNW-ESE direction and cutting in older granitic rocks with 264 m fault throw.
5. *Fault (5):* trending in ENE-WSW direction and cutting in older granitic rocks with 70 m fault throw.
6. *Fault (6):* trending in ENE-WSW direction and cutting in basic metavolcanic rocks with 69 m fault throw.
7. *Fault (7):* trending in ENE-WSW direction and cutting in younger granitic rocks with 48 m fault throw.
8. *Fault (8):* trending in NW-SE direction and cutting in basic metavolcanic rocks with 35 m fault throw.
9. *Fault (9):* trending in NW-SE direction and cutting in acidic metavolcanic rocks with 57 m fault throw.

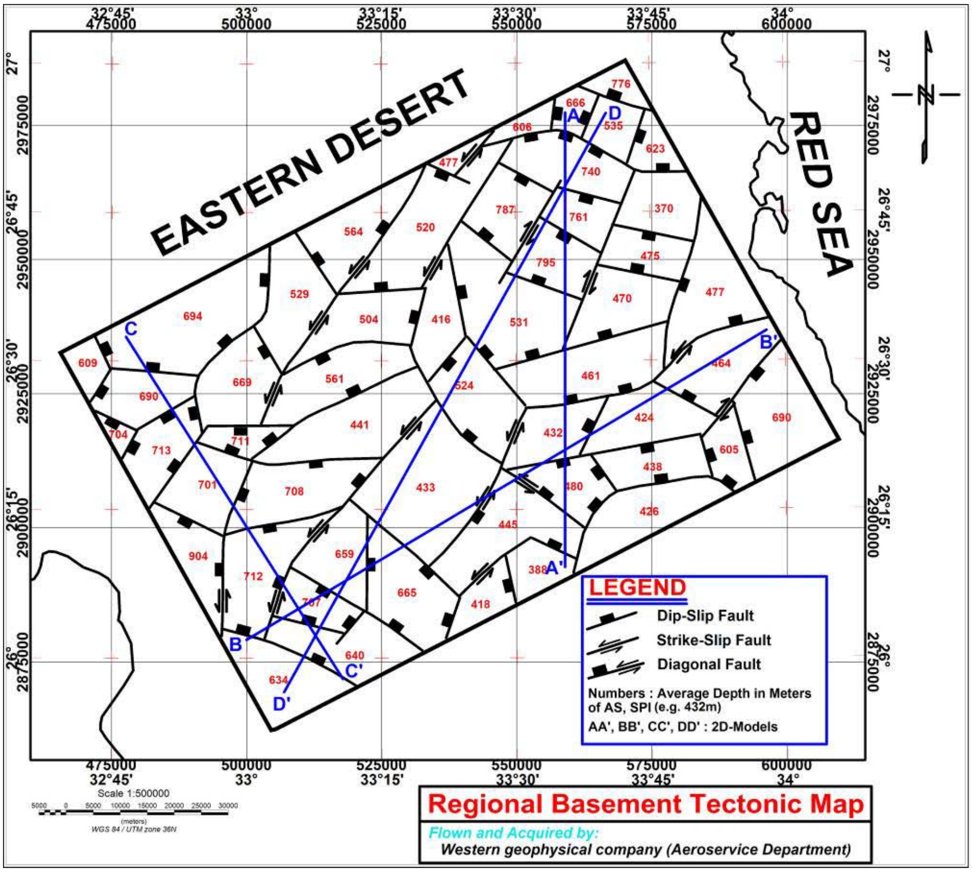

Figure 9: Interpreted Regional Basement Tectonic Map of Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

The profile AA′ intersected with the profile DD′ to the north-east at point DD′ at ground elevation 400 m while it intersected with profile BB′ to the south-west at point BB′ at elevation 300m respectively.

The modelled profile BB′ shows that the area under consideration suffer from nine normal faults which appeared on the basement tectonic map (Fig. 9). These faults are denoted on figure (11) as numbers from 1 to 9. These faults are described as follow:

1. *Fault (1):* trending in NW-SE direction in basement rocks with 127 m fault throw.
2. *Fault (2):* trending in NW-SE direction in basement rocks with 108 m fault throw.
3. *Fault (3):* trending in N-S direction in basement rocks with 6 m fault throw.
4. *Fault (4):* trending in NW-SE direction in basement rocks with 232 m fault throw.
5. *Fault (5):* trending in NNE-SSW direction and cutting in acidic metavolcanic rocks with 12 m fault throw.
6. *Fault (6):* trending in NW-SE direction and cutting in younger granitic rocks with 25 m fault throw.
7. *Fault (7):* trending in WSW-ENE direction and cutting in basic metavolcanic rocks with 48 m fault throw.
8. *Fault (8):* trending in NNE-SSW direction and cutting in basic metavolcanic rocks with 8 m fault throw.
9. *Fault (9):* trending in NW-SE direction and cutting in post Hammamat felsite with 40 m fault throw.

The profile BB′ is intersected with profiles CC′ and DD′ to the south-west at points CC′ and DD′ with depths to basement reached 150 m and 400 m respectively. Another intersection point between the modelled profiles BB′ and AA′ is found at the middle of the profile and has a height above ground level of about 300 m.

The modelled profile CC′ which trends NNE-SSW shows that the profile area is suffered from eight normal faults which appeared on the basement tectonic map (Fig. 9). These faults are donated on figure (12) as numbers from 1 to 8. These faults are described as follow:

1. *Fault (1):* trending in E-W direction and cutting in basic rocks.
2. *Fault (2):* trending in NE-SW direction and cutting in acidic rocks with 23 m fault throw.
3. *Fault (3):* trending in NE-SW direction and cutting in acidic rocks.
4. *Fault (4):* trending in NE-SW direction and cutting in basic rocks.
5. *Fault (5):* trending in WSW-ENE direction and cutting in acidic rocks.

6. *Fault (6):* trending in NNE-SSW direction and cutting in acidic rocks.
7. *Fault (7):* trending in NW-SE direction and cutting in acidic rocks with 67 m fault throw.
8. *Fault (8):* trending in NW-SE direction and cutting in acidic rocks.

The profile CC′ is intersected with profile BB′ and DD′ to the south at points BB′ and DD′ with depths to basement reached 150 m for both of them.

The modelled profile DD′ which trends NE-SW shows that eleven normal faults which appeared on the basement tectonic map (Fig. 9) affect the present study area along this profile. These faults are denoted on figure (13) as numbers from 1 to 11. These faults are described as follow:

1. *Fault (1):* trending in NW-SE direction and cutting in younger granitic rocks with 205 m fault throw.
2. *Fault (2):* trending in NW-SE direction and cutting in older granitic rocks.
3. *Fault (3):* trending in NW-SE direction and cutting in older granitic rocks. with 34 m fault throw.
4. *Fault (4):* trending in NW-SE direction and cutting in older granitic rocks with 264 m fault throw.
5. *Fault (5):* trending in NW-SE direction and cutting in younger granitic rocks.
6. *Fault (6):* trending in NNW-SSE direction and cutting in metavolcanic rocks with 109 m fault throw.
7. *Fault (7):* trending in NW-SE direction and cutting in other basement rocks with 232 m fault throw.
8. *Fault (8):* trending in N-S direction and cutting in other basement rocks.
9. *Fault (9):* trending in NW-SE direction and cutting in other basement rocks with 48 m fault throw.
10. *Fault (10):* trending in WNW-ESE direction and cutting in other basement rocks with 67 m fault throw.
11. *Fault (11):* trending in NW-SE direction and cutting in other basement rocks.

The profile DD′ is intersected with profiles BB′ and CC′ to the south-west at points BB′ and CC′ with depths to basement reached 400 m and 150 m respectively. Another intersection point between the modelled profiles DD′ and AA′ is found at the north-east of the profile and has a height above ground level of about 400 m.

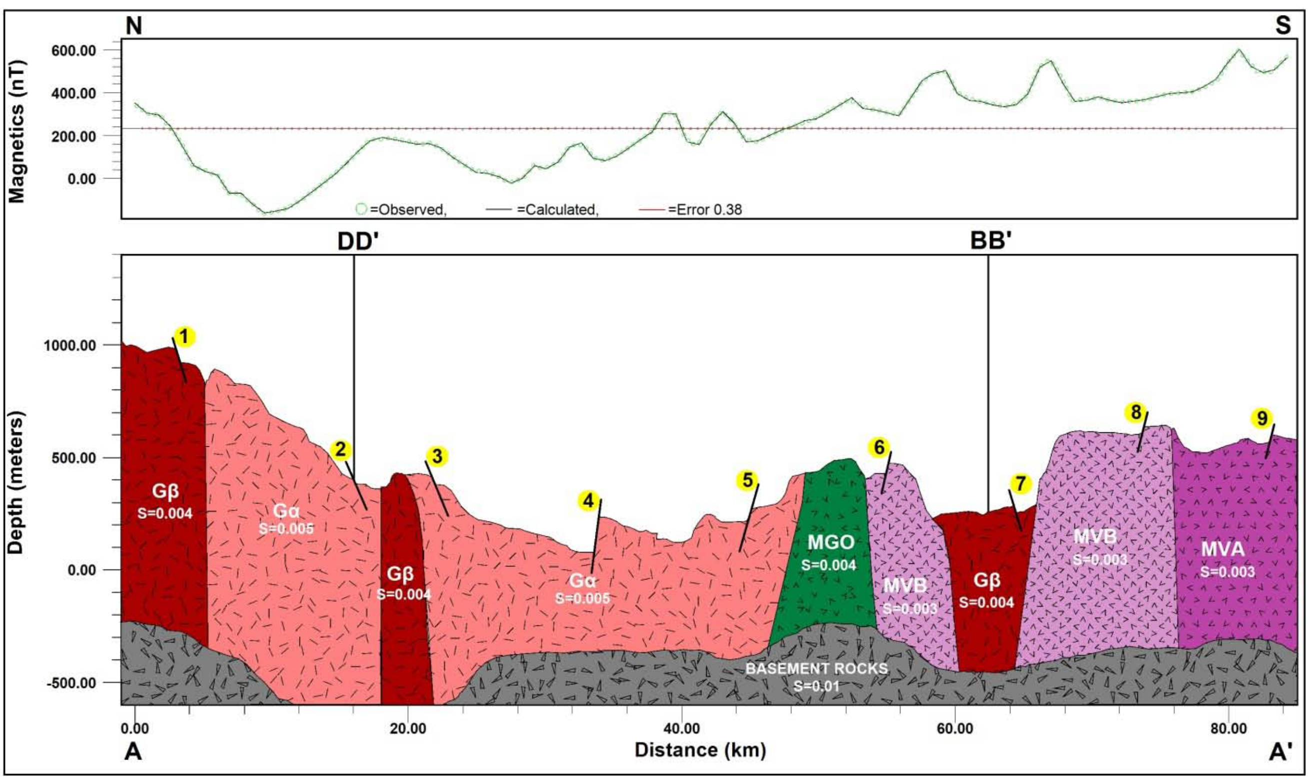

Figure 10: Two - Dimensional (2D) Modelled RTP Magnetic Profile AA′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

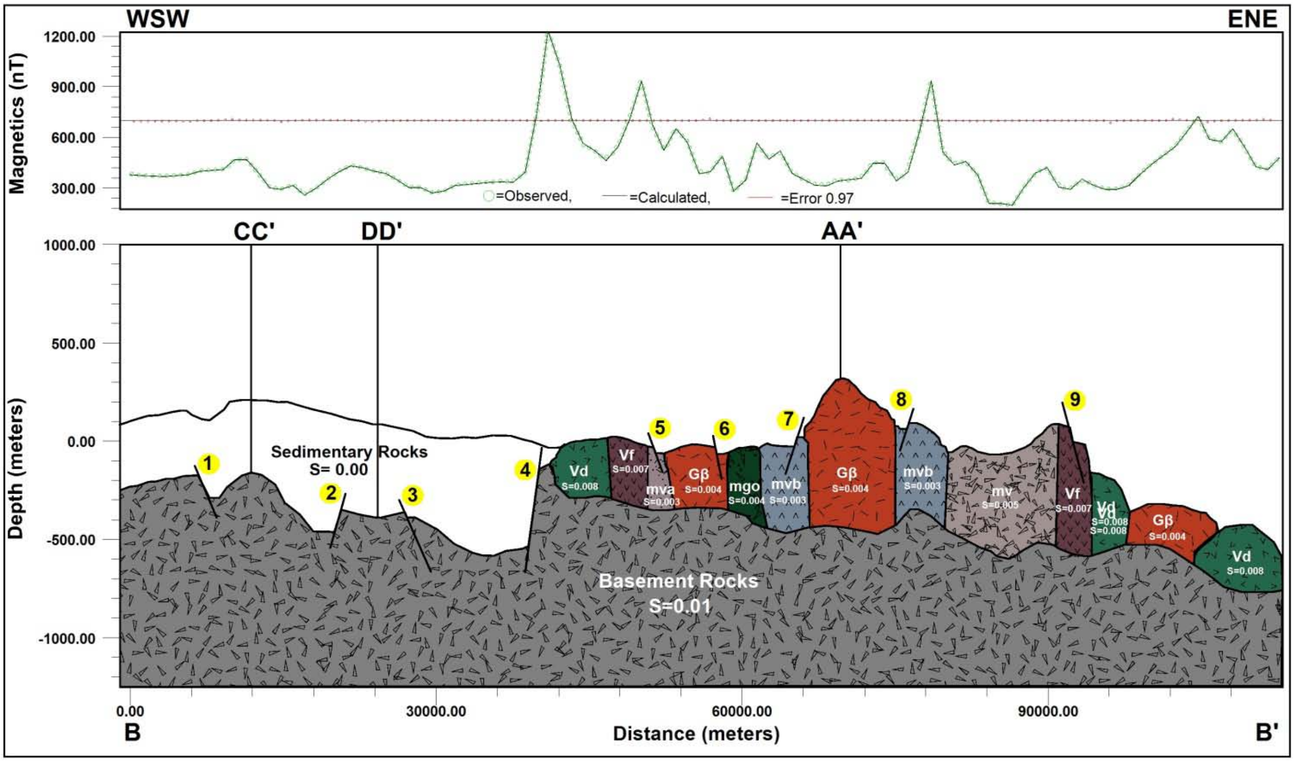

Figure 11: Two - Dimensional (2D) Modelled RTP Magnetic Profile BB′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

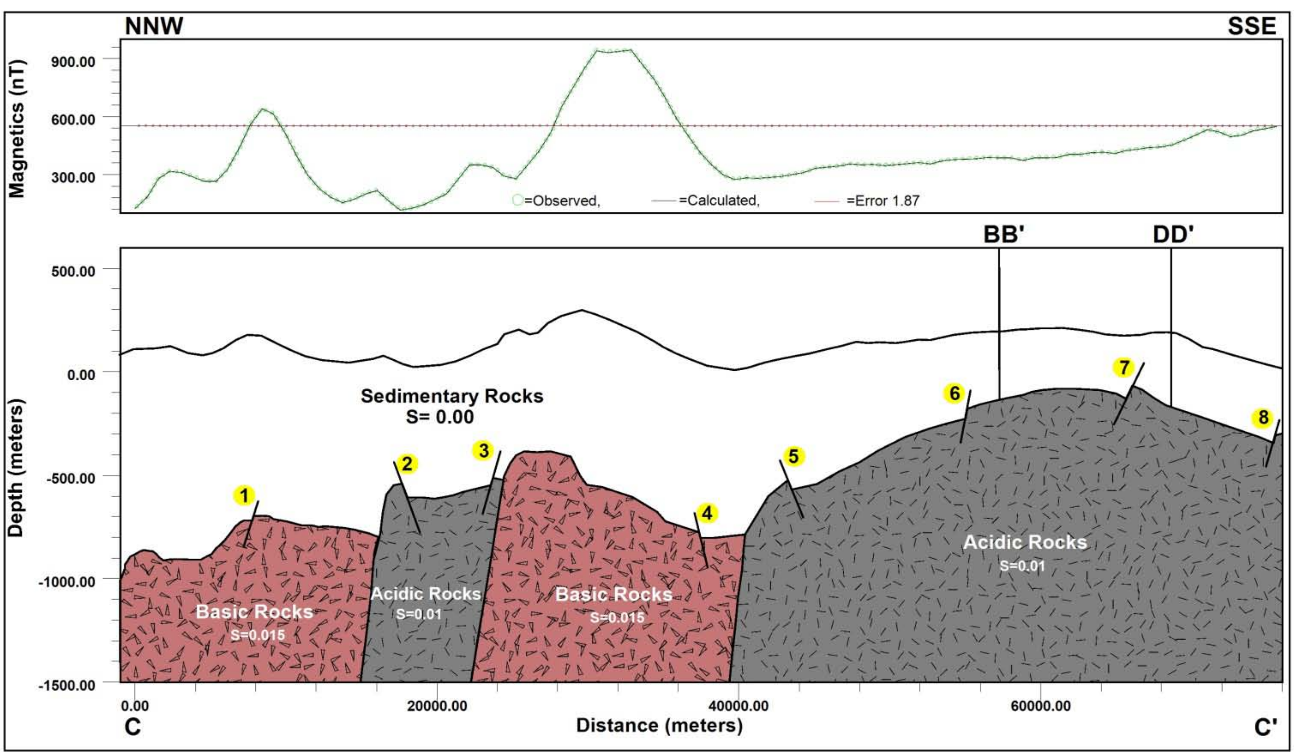

Figure 12: Two - Dimensional (2D) Modelled RTP Magnetic Profile CC′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

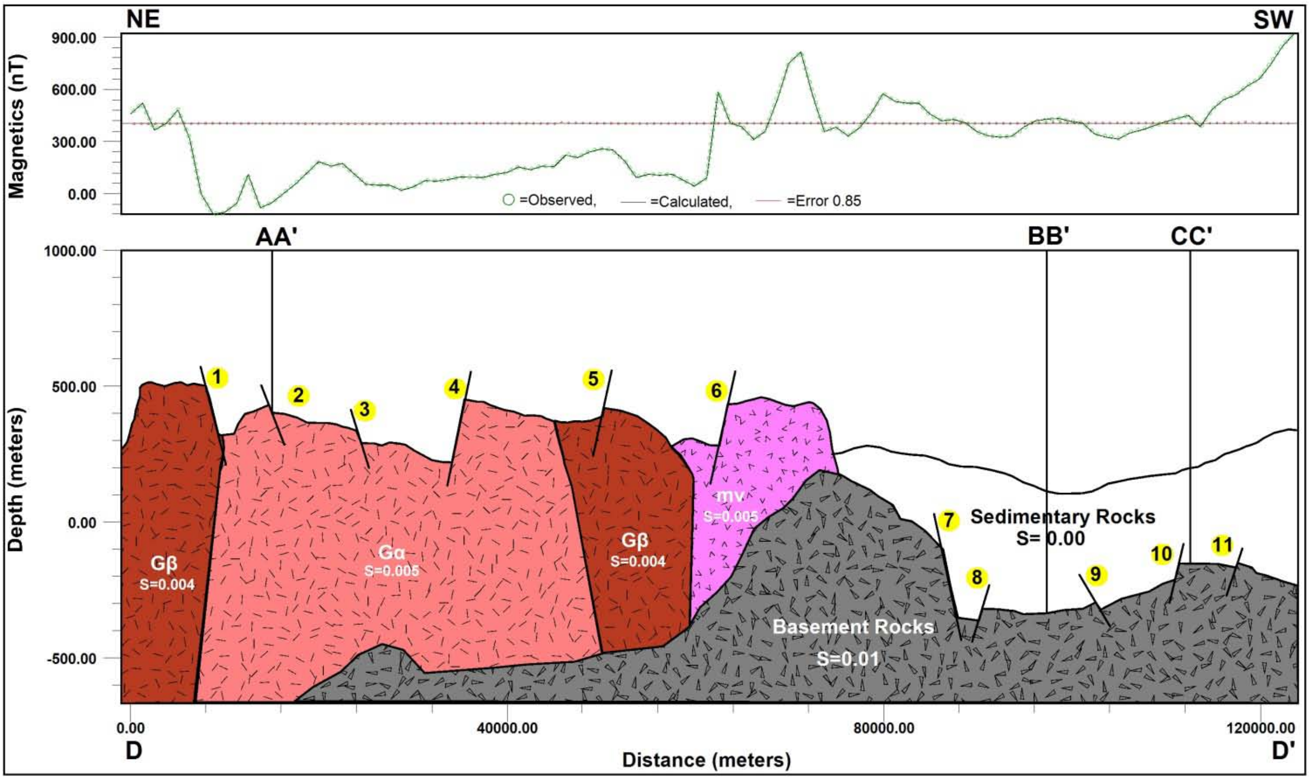

Figure 13: Two - Dimensional (2D) Modelled RTP Magnetic Profile DD′, Qena-Quseir Shear Zone Area, Central Eastern Desert, Egypt

V. Conclusion

The similarity between the regional magnetic component map and RTP map is shown in the major anomalies, which reflect the magnetic response of the basement rocks, which exposed in the study area. This similarity also means that the sedimentary cover in the western part of the study area possesses low or negligible magnetization. Therefore, the deep-seated structures play the major and important role in defining the general tectonic framework of the area under consideration.

The two depth maps (AS & SPI) show that the western part of the area shows more deeper depths representing the sedimentary rocks. The depths of this part ranging from 600 m to more than 1000 m. The two maps show that the eastern part of the area is very shallow and has depths ranges from 152 m to less than 10 m because of the outcropping of the basement rocks in this part of the study area. Regional basement tectonic map shows three systems of faults which trending in NW-SE, E-W and NE-SW directions. These faults also suffered from strike-slip movements trending in NE-SW.

To confirm the interpreted basement structural relief of the study area, 2D magnetic modeling was carried out along four profiles AA′, BB′, CC′ and DD′ oriented in N-S, WSW-ENE, NNW-SSE and NE-SW trends respectively.

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