BASEMENT DEPTH INVESTIGATION IN G.ABU HAD-G.UMM QARAF AREA, SOUTH EASTERN DESERT, EGYPT, USING AEROMAGNETIC DATA

By

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Abstract

The aeromagnetic survey is important to delineate the relationship that is usually present in survey areas, between magnetic anomalies and tectonic pattern. This is primarily based on the fact that the tectonic history of the rocks is recorded in the magnitude and pattern of magnetic anomalies. Thus, any extensive magnetic survey will contain anomalies whose pattern is not random. G.Abu Had-G.Umm Qaraf area is located in the southern part of the Eastern Desert of Egypt. It is about 100 km southwest Marsa Alam City. This approach utilized interpretation techniques that independent of magnetization direction such as source parameter imaging, Euler deconvolution and analytic signal to estimate body location and depth. The estimated parameters were further used to image the basement rocks using modeling techniques.

Keywords: aero magnetic-depth calculation- Eastern desert - Egypt.

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1. Introduction, Location and Morphology

The present study deals essentially with the analysis and interpretation of aerial spectral gamma-ray survey data. The data interpretation would be supplemented by the consideration of all available previous geological and all information works in this area. In brief the proposed study has the following main objectives:

1- Analyzing gamma-ray spectrometric data for lithologic and geologic refinement.

2- Studying radioactive data to delineate the economic locations associated with ground field check.

Area is located in the southern part of the Eastern Desert of Egypt. It is about 100 km southwest Marsa Alam City. The surveyed area is bounded by latitudes 24° - 25°N and longitudes 34°- 35° E with 1221 km^2 area (Fig.1). More than 95% of the area is covered by crystalline basement (igneous and metamorphic rocks). Sedimentary rocks and wadi sediments cover small region. Quaternary sand and gravel extensively cover plains and wadis. The compiled geological map shows the available information about the surface geology.

Faults, joints and foliation, in addition to lithologic boundaries, are the main features controlling the dendritic drainage pattern of the area.

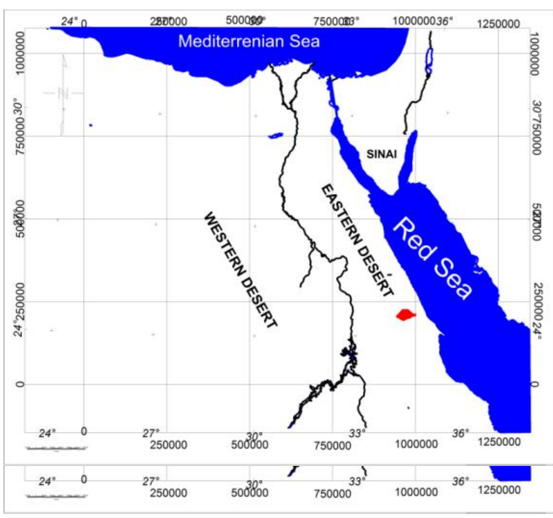

Figure 1: location map.

2. Geological Outline

The study area is a part of the Precambrian belt in the south Eastern Desert of Egypt. Proterozoic igneous and metamorphic and Phanerozoic rocks are exposed within a geological map of the area illustrated in Figure 2 from Conoco map (1987).

2.1. Older Granites (ga)

They are exposed as wide outcrops located at the around Wadi Hafafit at north east part and represented a wide exposure of G. Umm Qaraf at south. The older granites in the study area crop out in the NE side of mapped area and occupy the extreme eastern side of the G. El Faliq itself. Also they have a wide exposure around G. Umm Qaraf. It occurs intruding along the contact between the ophiolitic mélange and the younger granites.

2.2. Weathered Older Granites (gaw)

These rocks represent large wide area from central to southwestern parts. These are weathered quartz diorites rock. They have a very wide exposure G. El Nukharia, G. Umm Qaraf and at the centre of the area.

2.3. Younger Granites (gb)

The younger granitic rocks are outcropping in the upper part (alkali feldspar granites). They are of limited distribution in the area. The majorities of these intrusions is rounded or elongate parallel to the direction of the Red Sea and possess relatively sharp contacts with the surrounding rocks. The younger granites in G. El Faliq area exposed in the east side of the G. El Faliq, Naslet Abu Gabir as well as northeast W. Abu Gherban (Stern,1979).

2.4. Gabbroic rocks (g)

They contain fresh olivine gabbro, norite and troctolite. They are exposed as two small outcrops at west. The gabbroic rocks are associated with ultramafic rocks, due either to differentiation in situ or due to multiple intrusions. The gabbro intrusion comprises olivine-plagioclase hornblendite, plagioclase hornblendite and peridotite.

2.5. Natash volcanics (vn)

These volcanics are well exposed west of the area. They are basic to acidic alkaline, undeformed volcanic rocks. Wadi Natash volcanics acquired their name from the type locality, Wadi Natash, located at the western border of the basement complex at the South Eastern Desert of Egypt (Hashad, et al., 1982).

2.6. Trachyte plugs (vt)

They are represented by trachyte plugs and sheets. They have exposure like spots at the west of the area. These trachyte plugs are located at El-

Nuhud; they are fine-grained, massive and vary in coulor from dark grey to grayish brown.

2.7. Acidic metavolcanics (mva)

It is Intermediate to acidic metavolcanics and metepyroclastics. It is exposed in a small part in the area at the south.

2.8. Undifferentiated Metavolcanic (mv)

The metavolcanics constitute a pile of regionally-metamorphosed submarine lava flows of alternating basic, intermediate and acidic compositions. It is represented at small exposure part at the south of the surveyed area.

2.9. Metagabbro to metadiorite (mg)

It is undifferentiated Intrusive metagabbro to metadiorite. It is exposed as small area at the southern part. It is composed of heterogeneous assemblage of rock types. They are mainly metamorphosed basic rocks including gabbro, norites, delorites, and basalts, in which the igneous textures are partly preserved.

2.10. Undifferentiated metagabbro to metadiorite (mgi)

It is a very small rock unit which is exposed at the south eastern part. It is an intrusive of undifferentiated metagabbro to metadiorite.

2.11. Ophiolitic Serpentinite (sp)

The ophiolitic rock in the area under study represented by Serpentines (sp), talc carbonates and related rocks. Serpentinite, essentially formed after harzburgite and to a lesser extend after dunite and lherzolite, are frequently transformed into talc-carbonates particularly along thrust fault and shear zone. Outcrops are located as few masses at the west.

2.12. Leucocratic Medium Metamorphic Rocks (gni)

A term of leucocratic used is denoted as a light colour in igneous or metamorphic rocks, due to a high content of felsic minerals, and a correspondingly small amount of dark, heavy silicates. These rocks are exposed in west and the north-west.

2.13. Melanocratic Metamorphic Rocks (gnm).

This rock unit is related to Pre-Pan-African rocks is mostly melanocratic medium to high grade metamorphic rocks (gnm). A term of melanocratic applied to rocks which are abnormally rich in dark and heavy ferro-magnesian minerals to the extent of 60% or more. These rocks are found in several parts in the northeastern corner of the area which cover parts of G. el- Faliq and G. Abu- Had.

2.14. Phanerozoic Sediments

They are of limited distributions which are represented as follows:

2.14.1. Upper Cretaceous rocks [Abu Aggag Formation (ku)]

They are exposed at the western part. Abu Aggag Formation stretched in NW–SE large belt of horizontal beds covering the western part of the Garara graben forming Gabal Abu Hashim. The surrounding area is bordered in the west by structural contact with metasediments El Sayed, et., al, 2013.

2.14.2. Quaternary Sediments (Q.Qw)

Detritus, sands, gravels, pebbles, cobbles and boulders are distributed all over the area and constitute the surficial cover in the main Wadis.

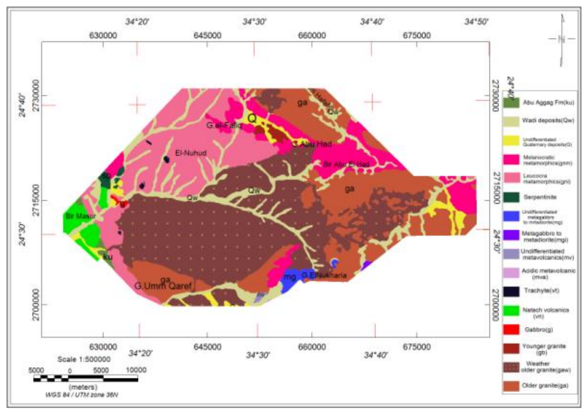

Figure (2): Compiled geologic map of G.Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt (, after Conoco & EGPC, 1987.

3. <u>Airborne Survey Specification</u>

Airborne Geophysics Department of the Egyptian Nuclear Materials Authority (NMA, 2012), Exploration Division conducted a comprehensive airborne high resolution magnetic survey, over G.Abu Had-G.Umm Qaraf, South Eastern Desert, Egypt,. Along flight-lines oriented in NE-SW direction using 250m line spacing for central and east area but 1000 m for the north and west area meanwhile the tie-lines oriented in NW-SE direction using 1000 m line spacing for all the area. Nominal flying elevation was 100m above ground surface. The airborne geophysical department (AGD) of the nuclear materials authority began operations by the beginning of 19 Jan, 2012 until March 2012.

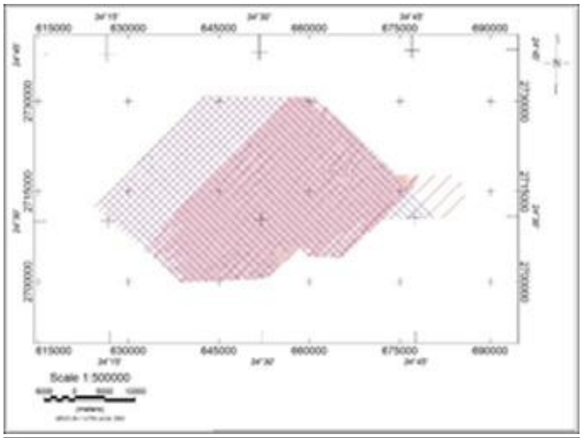

Figure (3): survey lines over South Eastern Desert, Egypt.

4. Reduction to North Magnetic Pole(RTP)

The careful examinations of the RTP map (Fig.4) showed that, the investigated area is characterized by the presence of numerous groups of shallow positive and negative magnetic anomalies of varying wavelengths, amplitudes, sizes, as well as magnitudes. Meanwhile, the differences in sizes of the anomalies reflect sizes of various intrusions. According to the magnetic characters, frequencies and amplitudes of the magnetic anomalies, the RTP map could be subdivided into three zones.

The first zone (Zone-1) is characterized by low to very low magnetic values of high frequencies. It ranges from -594 to -224 nT at the southwestern and western parts of the map. Zone-1 is recorded over some wadi sediments and parts of weathered younger granites. The main trend of this level is North-South (Fig.5).

The second zone (Zone-2) occupies the southern and eastern portion of the study area. It has irregular intermediate magnetic anomalies in different directions, reflecting different magnetic sources. The intermediate amplitudes range between -200 and -123nT. Geologically, this zone is covered by some wadi sediments, granites, metavolcanics and melanocratic medium to high grade metamorphic rocks (Fig.5).

The Last zone (Zone-3) represents the high amplitude and dense frequency of magnetic field. It characterized by strong positive anomalies with amplitudes ranging between -72 nT to 843 nT, with large variation between them. It occupies the western, centre of the area. Geologically, this zone is covered by the granites and leucocratic, melanocratic medium to high grade metamorphic rocks (Fig.5).

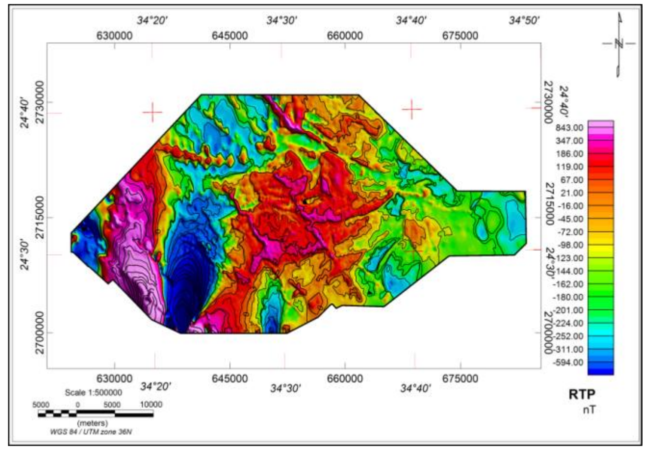

Figure (4): Reduced to North Pole Total Magnetic Intensity Field, G.Abu Had-G.Umm Qaraf area, South Eastern Desert, Egypt.

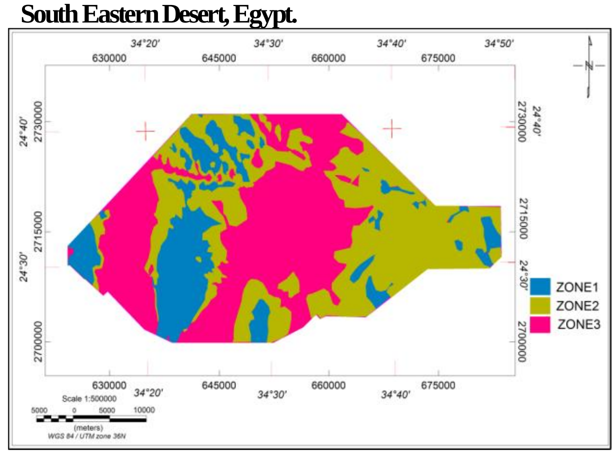

Figure (5): Magnetic Zones Map G.Abu Had-G.Umm Qaraf area, South Eastern Desert, Egypt.

5. spectral analysis and Regional-Residual Separation

There are many techniques to separate regional and residual magnetic component from RTP map. Spectral analysis is the best of these techniques which is based theoretically on a Fast Fourier Transform (FFT). The method of frequency analysis is most appropriate, since it provides better resolution of shallow sources. Fourier spectral analysis has become a widely used tool for interpretation of potential field data, especially for depth estimation. This approach has been developed by many workers (Spector and Grant 1970). The energy decay curve (Fig.6) includes linear segments, with distinguishable slopes, that are attributed to the contributions in the magnetic data from the residual (shallower sources), as well as the regional (deep sources). The presentation of the method depends on plotting the energy spectrum against frequency on a logarithmic scale. Figure.6 shows two different components as straight-line segments, which decrease in slope with increasing frequency. The slopes of the segments yield estimates of the average depths to magnetic sources. Regional-residual separation was done at 0.25 frequencies. The depth of deep-seated (regional) magnetic component maps range from 420m to 500 m and that of near-surface (residual) magnetic component ranges from 100m to 250m.

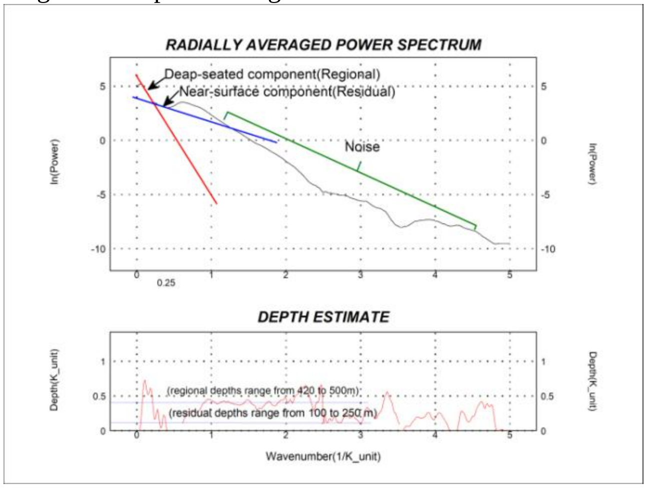

Figure (6): Power spectrum of magnetic data showing the corresponding averaging depths, of G.Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

5.1. Residual Magnetic Component Map

Qualitative and quantitative interpretation can be made more objective by constructing the residual maps of the observed field. Residual maps have been used by geophysicists to bring into focus local features, which tend to be obscured by the broader features of the field (Ammar et al., 1988). The construction of the residual map is one of the best known ways of studying a potential map quantitatively, where the measured field includes effects from all bodies in the vicinity (Fig.7). The residuals focus attention to weaker features that are obscured by strong regional effects in the original map (Reford and Sumner, 1964).

5.2. Regional Magnetic Component Map

The regional magnetic component map (Fig.8) at the assigned interface is the result of removing the residual effects from the RTP map, where the separation procedures are designed to separate broad regional variations from sharper local anomalies. This map could be described as follows:

1. Negative magnetic anomalies (low zones) located in southwestern corner, northeastern corner and east part. They covered with the quaternary deposits, ophiolitic rocks and metavolcanic rocks, and their amplitudes range from -606 to -21 nT. It could be suggested that, remnant magnetization is associated with this zone, which may be also interpreted as structural lows or synclines.

2. Positive magnetic anomalies (high zones). They covered the northern part trending NW-SE trend and found as mass extend in eastern part and their amplitudes range from -21 nT to 2287 nT. Also positive values are located at the centre part trending NE-SW trend.

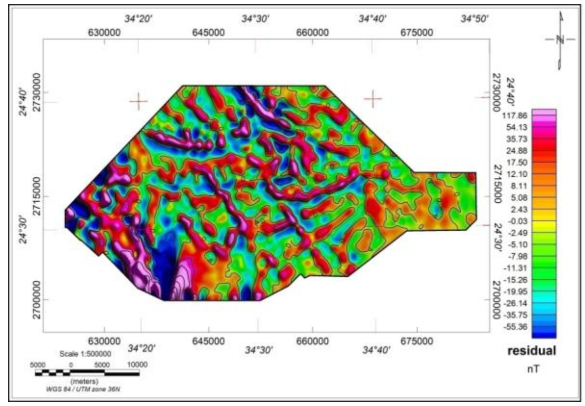

Figure (7): Shaded color contour map of the RTP residual magnetic component, G.Abu Had-G.Umm Qaraf area, South Eastern Desert, Egypt.

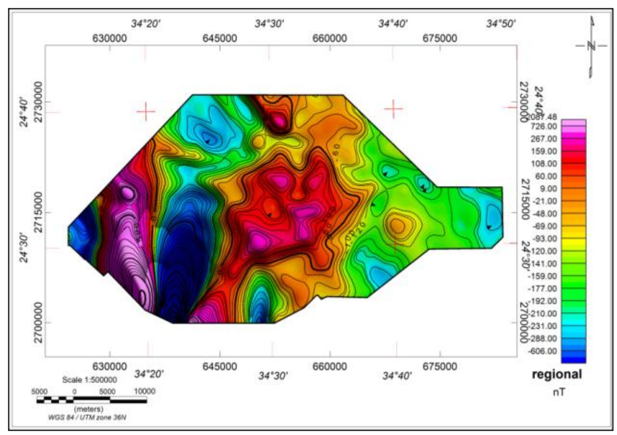

Figure (8): Shaded color contour map of the RTP regional magnetic -component, of G.Abu Had-G.Umm Qaraf area, South Eastern Desert, Egypt.

6. Discussion of the Magnetic Depth Calculations

The SPI and AS result are closed to each other (Figs. 9 and 10). Meanwhile, Euler method shows little difference (Fig.11). The maps of the depths help us very much to lineate the general structures of basement surface. At the three maps, the NE-SW trend show more shallow depth presented at the central to eastern parts. The depths at the two zones are related to the results which are calculated at the three methods. The first zone is characterized by deep depths which ranged from -429 to -278 for SPI method, from -451 to -225 for AS method and ranged from -471 to -360 for Euler method.

The second zone has shallow depths. These low values of depths range from -278 to -110 for SPI method, from -225 to -101 for AS method and from -360 to -129 for Euler method. This zone found from east to central parts. The shallow depths have main trends N-S, NE-SW and NW-SE trends.

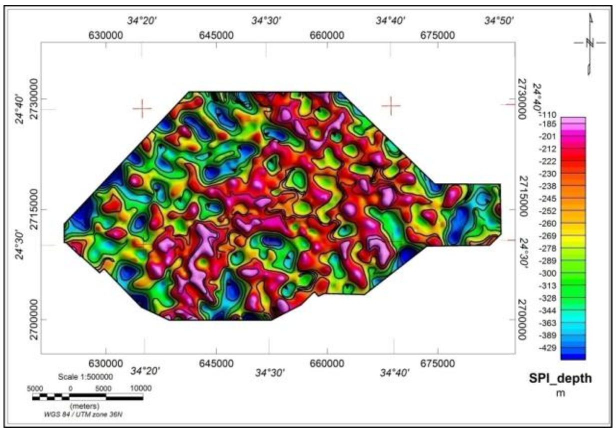

Figure (9): Depth to magnetic basement as calculated using source parameter imaging (SPI), G.Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

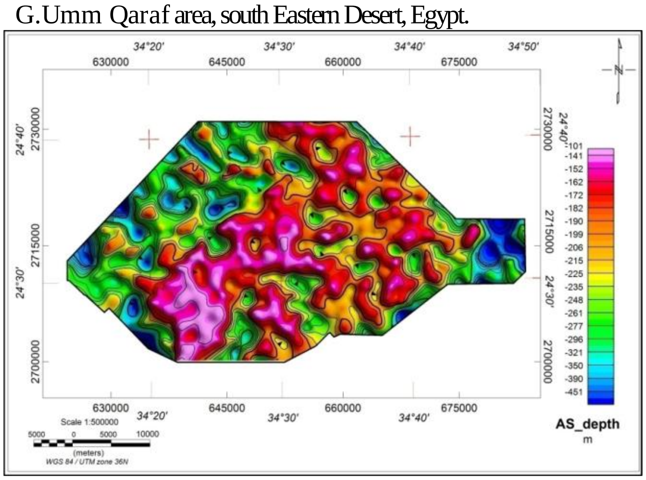

Figure (10): Depth to magnetic basement as calculated using analytical signal (AS), G.Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

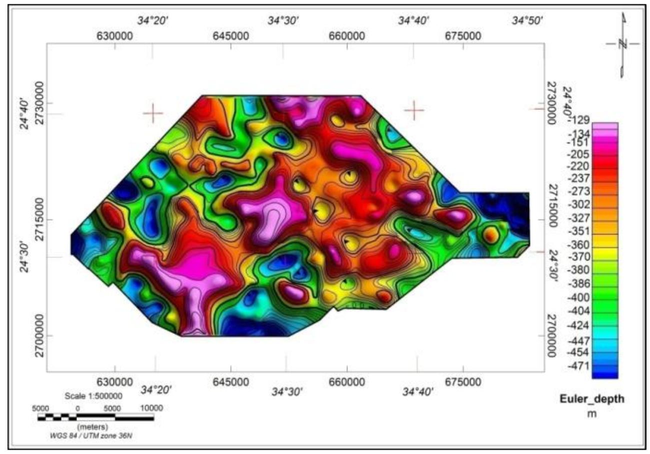

Figure (11): Depth to magnetic basement as calculated using Euler, G.Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

7. Modelling Technique

The two dimentional modelling is simple way to imagine the subsurface structure. The following 2-D model explains profile AA*,BB* and CC* (figure 12).

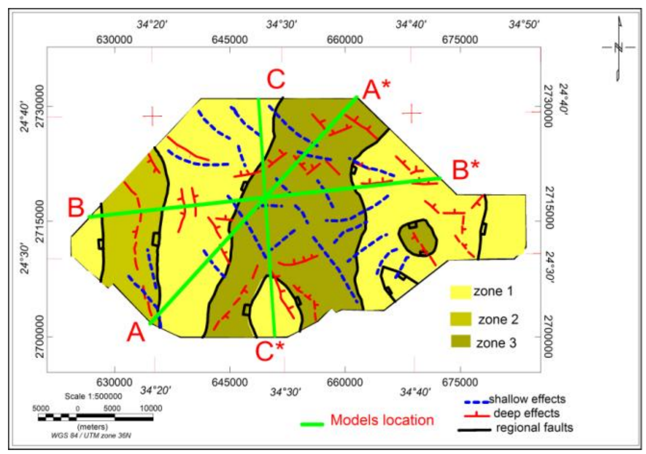

Figure (12): location of 2-D model drawn at Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

7.1. Two-Dimensional Magnetic Modelling of Profile AA*

Model A was taken at southeast-northeast direction. Close examination of the modelled profile AA*show an excellent fit between the observed and calculated anomalies with error reach 2.78. The magnetic susceptibility values were assumed to be 0.035 for weathered older granites, 0.034 for older granites and 0.04 for younger granite for this model (Fig. 13).

7.2. Two-Dimensional Magnetic Modelling of Profile BB*

Close examination of the modelled profile BB* shows an excellent fit between the observed and calculated anomalies with error reach 0.5. The magnetic susceptibility contrast values were assumed to be 0.0302 for leucocratic metamorphic rocks, 0.035 for weathered older granite and 0.03 for melanocratic metamorphic rock. We assumed that the magnetic susceptibility for natach volcanic is 0.029 and 0.025 for Quaternary wadi sediments (Fig.14).

7.3. Two-Dimensional Magnetic Modelling of Profile CC*

Modelled profile CC* was taken at north- south direction. The model passed the same interception point with model AA* and model BB*. The magnetic susceptibility values were assumed to be 0.0302 for leucocratic metamorphic rocks, 0.03 for melanocratic metamorphic rocks, 0.035 for weathered older granites and 0.032 for older granite rocks.

We found that at these models, the intersection point pass the weathered older granite rocks. At this point the magnetic response and the depth are relatively the same at the three models (Fig.15).

The resulted models show that an image that two faults affected this profile and show the lateral change in lithology. At this model we suppose that the effect of magnetic susceptibility was because of the surface basement rock or their changes in composition and structure.

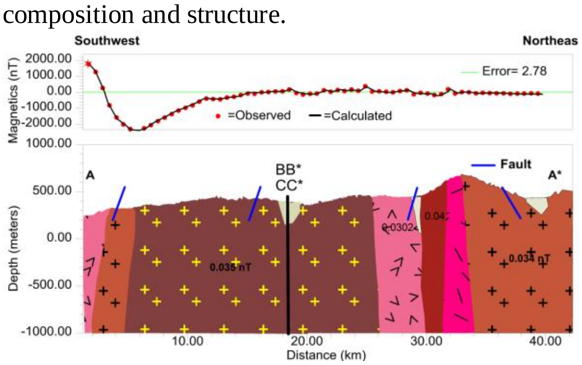

Figure (13): 2-D modelling of profile (AA*), .Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

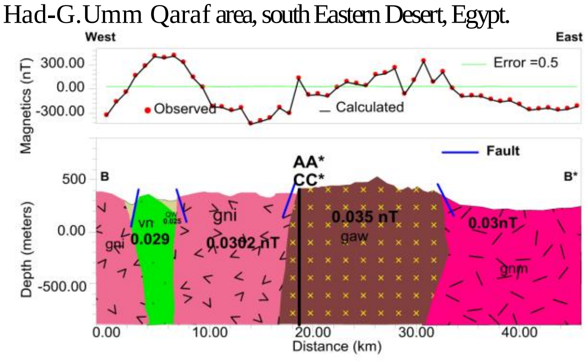

Figure (14): 2-D modelling of profile (BB*), Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

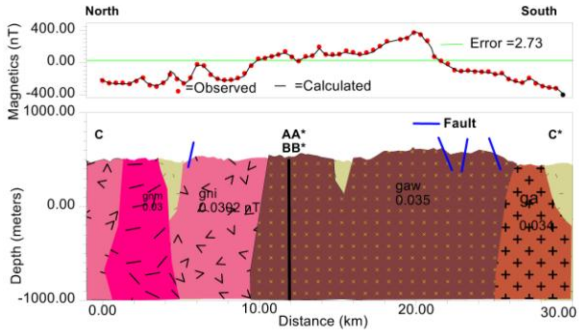

Figure (15): 2-D modelling of profile (CC*).Abu Had-G.Umm Qaraf area, south Eastern Desert, Egypt.

The resulted models show that an image that two faults affected this profile and show the lateral change in lithology. At this model we suppose that the effect of magnetic susceptibility was because of the surface basement rock or their changes in composition and structure.

Conclusion

The reduced to pole (RTP) magnetic map was separated using Gaussian technique into two magnetic components named: regional and residual magnetic components. The SPI and AS result are closed to each other. Meanwhile, Euler method shows little difference. The maps of the depths help us very much to lineate the general structures of basement surface. 2D magnetic modelling was carried out along three profiles AA*, BB* and CC* oriented in SW-NE, W-E and N-S trends respectively.

Acknowledgments

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