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AEROMAGNETIC DATA INTERPRETATION OF ABU DABBAB-G.NUWEIBI, CENTRAL EASTERN DESERT, EGYPT

BY

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ABSTRACT

The current study aims to assess the subsurface tectonic patterns in the Abu Dabbab-G.Nuweibi area, Central Eastern Desert, Egypt utilizing aeromagnetic data. Different interpretation techniques have been applied, these techniques are as follows: reduction to northern pole, power spectrum, regional and residual separation, upward continuation, vertical derivative and structural interpretation. The investigated area was subjected to different tectonic movements, giving rise to some complex structures. Several fault trends and fractures have been identified, which include the following; NW-SE (Gulf of Suez - Red Sea trend), NE-SW (Gulf of Aqaba trend).
Keywords: Aeromagnetic, Power Spectrum, and Structural Interpretation.

INTRODUCTION

Abu Dabbab-G. Nuweibi area is located in the Central Eastern Desert and covers an area of 1116 km^2 and lies between latitudes 25° 10′24.45′′& 25° 25′25.71′′ North and longitudes 34° 49′16.03′′& 34° 25′22.29′′ East (Fig. 1). The area of study is 20 km from the Red Sea.

The objectives of this research are mainly including the following: 1) Conversion of the airborne magnetic surveys conducted over the study area to a common image format by standard digital image processing technique, 2) Analyze the aeromagnetic data by various analytical techniques as the reduction to the north magnetic pole (RTP), isolation of the regional and residual magnetic components using Gaussian filtering technique and determine depths of magnetic sources using power spectrum, vertical derivative and other techniques, 3) Interpret the magnetic data to clarify the subsurface structure of the study area.

1. Litho-Stratigraphy

A- Late Proterozoic rocks: comprise the following:

1) Ophiolite Group: The study area contains metagabbro, metavolcanic undifferentiated, basic metavolcanics, and intermediate to acid metavolcanics, metapyroclastics and metamorphosed shelf sediments. 2) Hammamat Clastics: are essentially unmetamorphosed conglomerate, greywackes, sandstone, siltstone, mudstone, tuffstone and rare andesite covered by gabbroic rocks which consist of fresh olivine gabbro, northite and troctolite. It’s covered by gabbroic rocks. 3) Older Granite: Calc-alkaline usually foliated quartz dioritic granodioritic rocks deeply weathered. 4) Younger Granite: which represented by calc-alkaline weakly deformed granitic rocks deeply weathered.

B- Cenozoic Rocks are composed of the following units from bottom to top:

1) Umm Mahara Formation: is made up of a lower sandy limestone member and upper gypsiferous fossiliferous limestone member. The beds are massive, partly dolomitic, and mostly coralline reefs. The unit is shallow marine origin and the fossils are of Mediterranean aspect. 2) Umm Gheig Formation: it consists of hard dolomite bed that seems to be deposited in shallow water above

the wave base. 3) Shagra Formation: is composed of sandstone, bioclastics and some siliciclastics that are underlain by fine and course grained siliciclastics and lacustrine limestone. 4) Quaternary deposits: are represented by raised beaches, wadi gravel deposits, silt, sandy bands and coral reefs

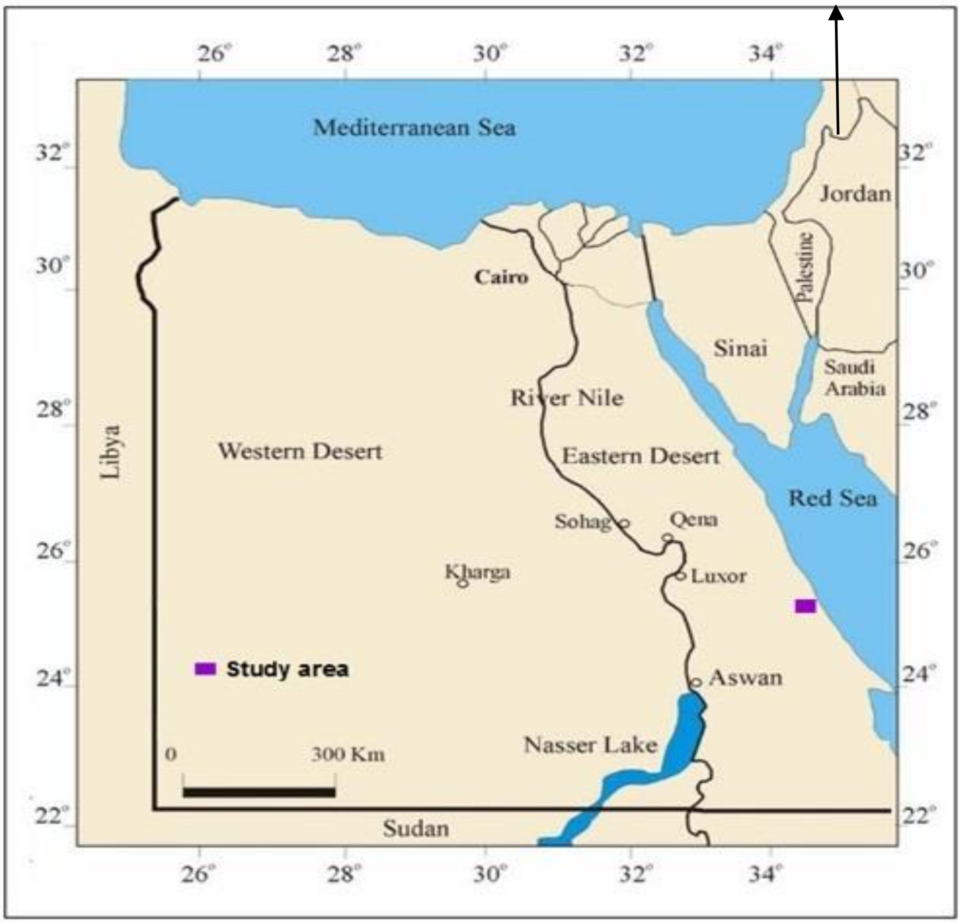

Fig. 1: showing the location map of the study area.

GEOLOGIC SETTING

The regional rock units and the observed structures investigated in the study area are shown (Fig. 2).

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2. Structural Setting

Several types of unconformity have been recorded in the area under investigation;

1) Late Proterozoic-Tertiary unconformity (Non-conformity type) which separates between the basement and sedimentary rocks.

2) Disconformity type between Miocene rocks and Quaternary deposits (Conoco, 1987).

Abu Dabbab stock: seems to be emplaced along a NW trending shear zone affecting the basic – ultrabasic rocks and the volcano-sedimentary sequence. In part, granitic outline follows this tectonic alignment. NNE to NE striking faults are the most developed ones in the apogranite mass a country rocks. Some are associated with quartz veins suggesting that these faults may be the most recent ones.

Older structures are represented by NNW to N striking faults. These underwent later reactivation, and this is probably the case of faults affecting the Abu Dabbab granite.

Nuweibi deposit: The apogranite mass is situated in the zone of the conjunction of the Dabr and Mubarak tectonic blocks. It is localized in the marginal part of the Nabi dome –shaped structure, at the intersection of sub – latitudinal disturbance with the Dabr fracture (Naim, 1996).

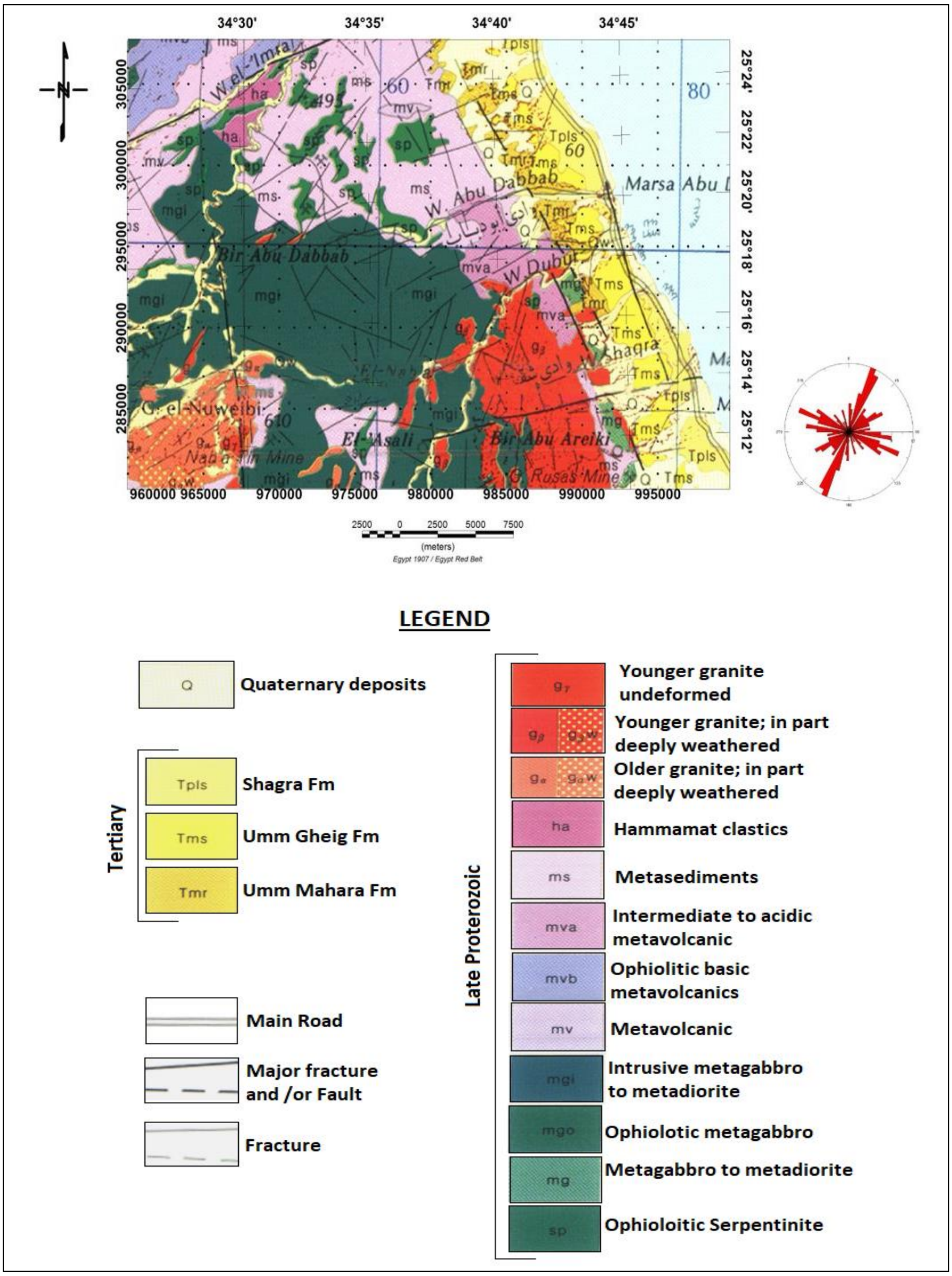


Fig. 2: Geologic map of the study area (Conoco, 1987).

Badawy (2008) noted that, the investigation of the northern part of the Red Sea and surrounded area in Egypt revealed two main directions of the major faults; they are: NW-SE and NE-SW. Both of them influenced the basement rocks as well as the Tertiary rocks lying between the Red Sea hills and the Nile Valley. It is deduced that these faults were formed in the late Tertiary time as a response of the formation of the Red Sea.

AEROMAGNETIC DATA

The aeromagnetic anomaly data of the study area are available through the MPGAP project (cooperation between the Egyptian General Petroleum Corporation (EGPC), the Egyptian Geological Survey and Mining Authority (EGSMA), and Aero-Service Division, Western Geophysical Company of America). In 1982, this collaboration conducted an aerial magnetic survey over a large portion of Egypt's Eastern Desert, as well as some areas of the central Western Desert, to give data to aid in the identification and evaluation of the region's minerals, petroleum, and groundwater resources. (Aero-Service, 1984). The traverse lines took N45° E direction, with a spacing of 1.5 km approximately. The tie lines were perpendicular to the traverse lines (took N135° E direction) and spaced at about 10 km. The station separation was 92.65 m; the average ground speed of the aircraft ranged from 222 to 314 km/h with a mean terrain clearance of 120 m (Fig.3).

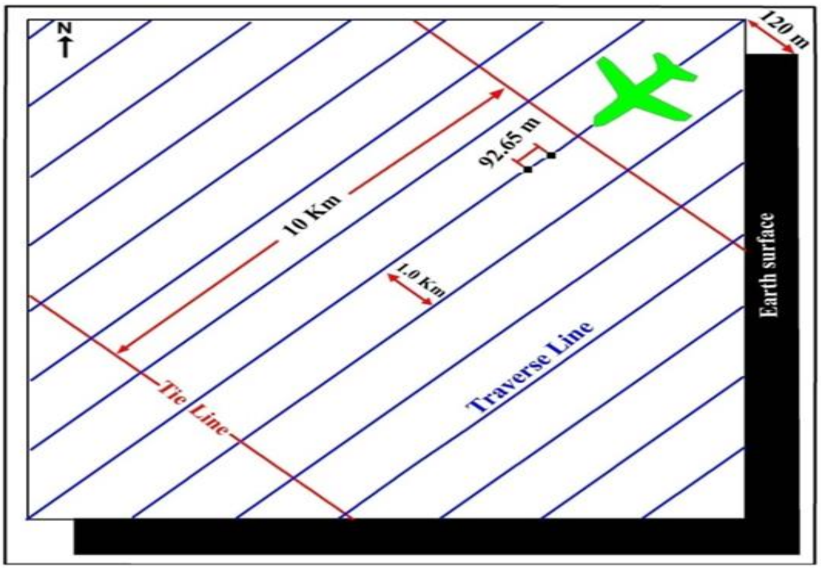


Fig. 3: Flight path of the MPGAP Project (specifications after Aero-Service, 1984).

1. Reduction to north magnetic pole (RTP)

The RTP map (Fig. 4) could be subdivided into three zones. The first zone represents the high amplitude and dense frequency of magnetic field. It is characterized by strong positive anomalies with amplitudes more than 42400 nT. It occupies the southeastern, central and northwestern parts of the area. The second zone has intermediate amplitudes range between 42300 to 42400 nT and scattered over small parts in the area. The Last zone is characterized by low to very low magnetic values of high frequencies, with values less than 42300 nT occupying the northern, southern, northwestern parts of the investigated area.

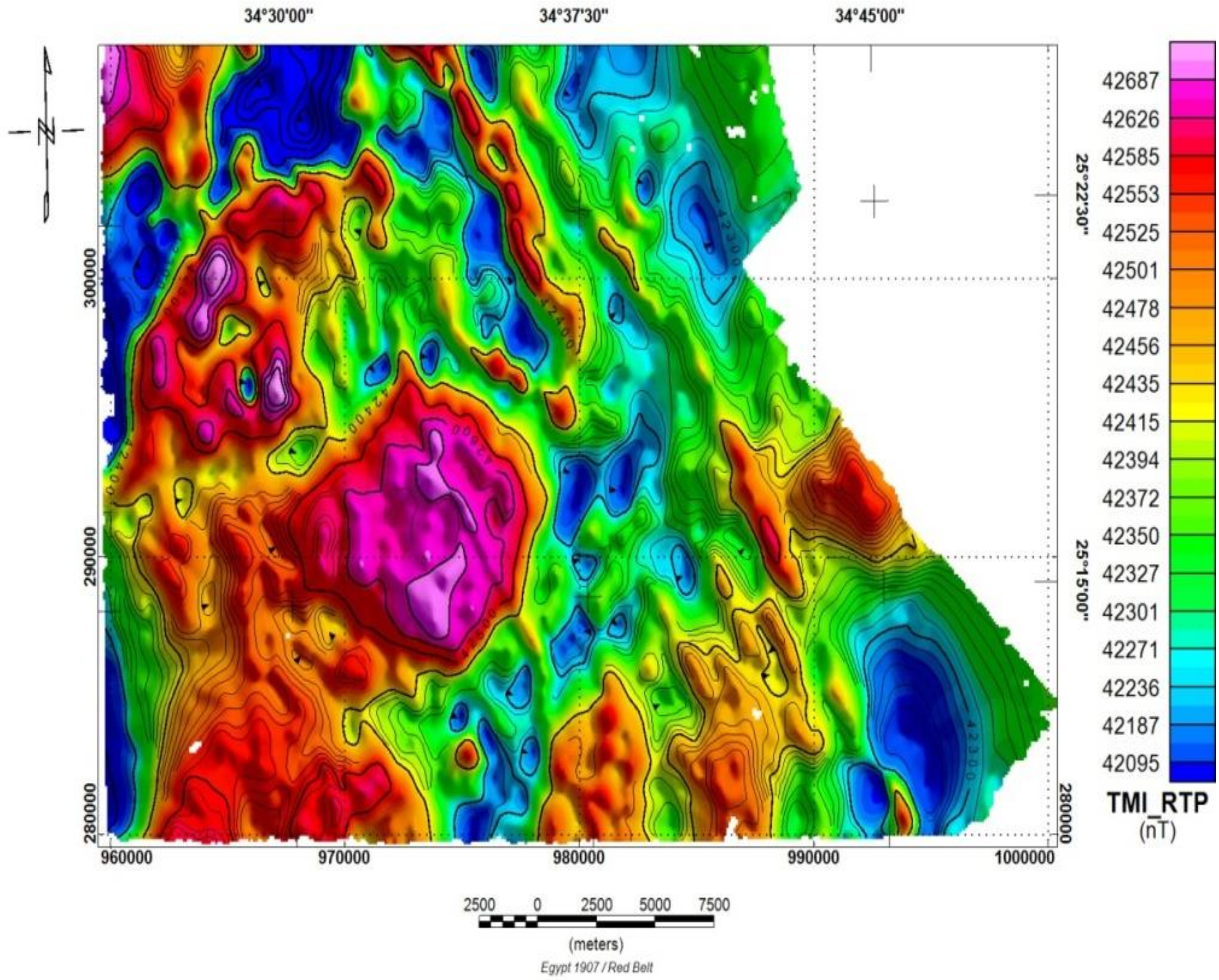


Fig. 4: The reduced to the northern magnetic Pole (RTP) map of Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt. (after Aero-Service, 1984).

2. Calculation of Power Spectrum

The analysis of the power spectrum curve (Fig. 5) revealed that, there are two main average levels (interfaces) at depths 0.5 and 1.2 km below the measuring level. The slope of the line fitted to the low frequency part of the spectrum was used to calculate the average depth of the regional sources, which is estimated as 1.2 km depth, while the slope of the second line fitted to the high frequency part of the spectrum was used to calculate the average depth of the residual (shallow) sources, which is estimated as 0.5 km depth. The analysis of the power spectrum was applied on the RTP magnetic data, using the Oasis Montaj tm software package (version 6.4.2)

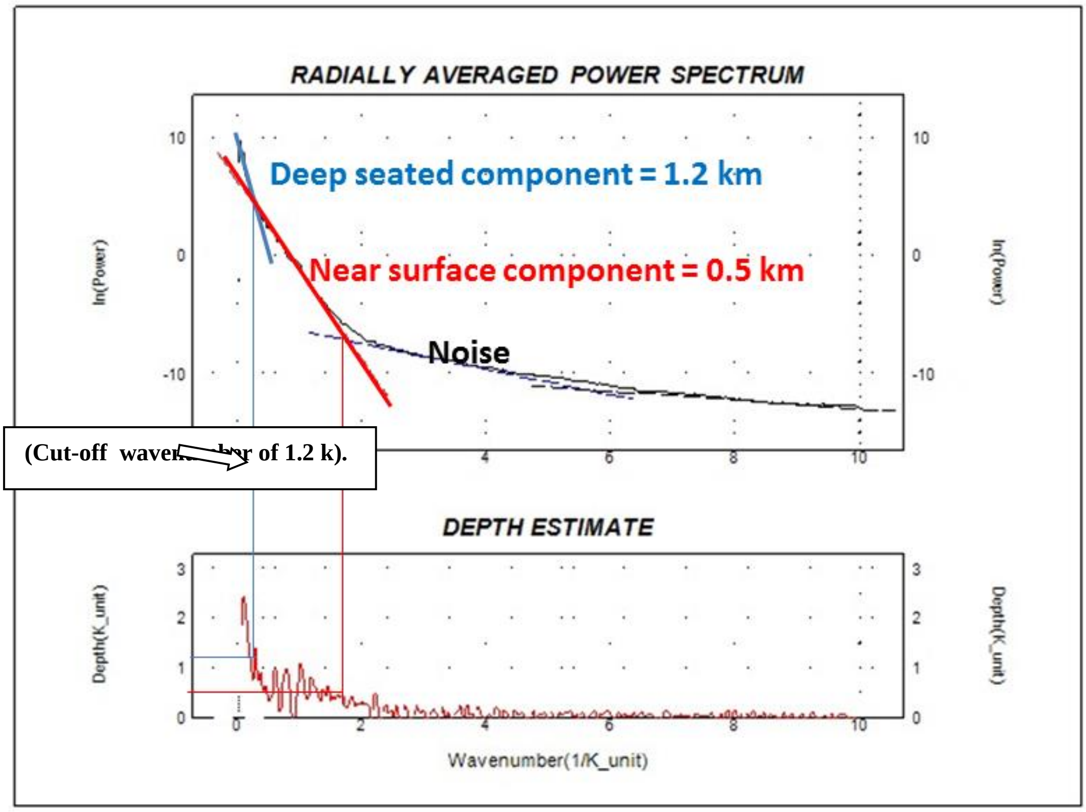


Fig. 5: Radially averaged power spectrum and depth estimate of the RTP magnetic map of Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

3. Regional-Residual Separation

The investigation of the regional (low-pass filtered) magnetic component map (Fig. 6) shows that, it is characterized by the following features:

1) Negative magnetic anomalies (low zones), located at the northern and southwestern parts of the investigated area parts with less than 42300 nT values.

2) A huge zone of broad and high magnetic anomalies presents at the central, southeastern, northwestern parts of the area suggesting the existence of major deep-seated faults bounding this zone from the NW-SE and NE-SW directions.

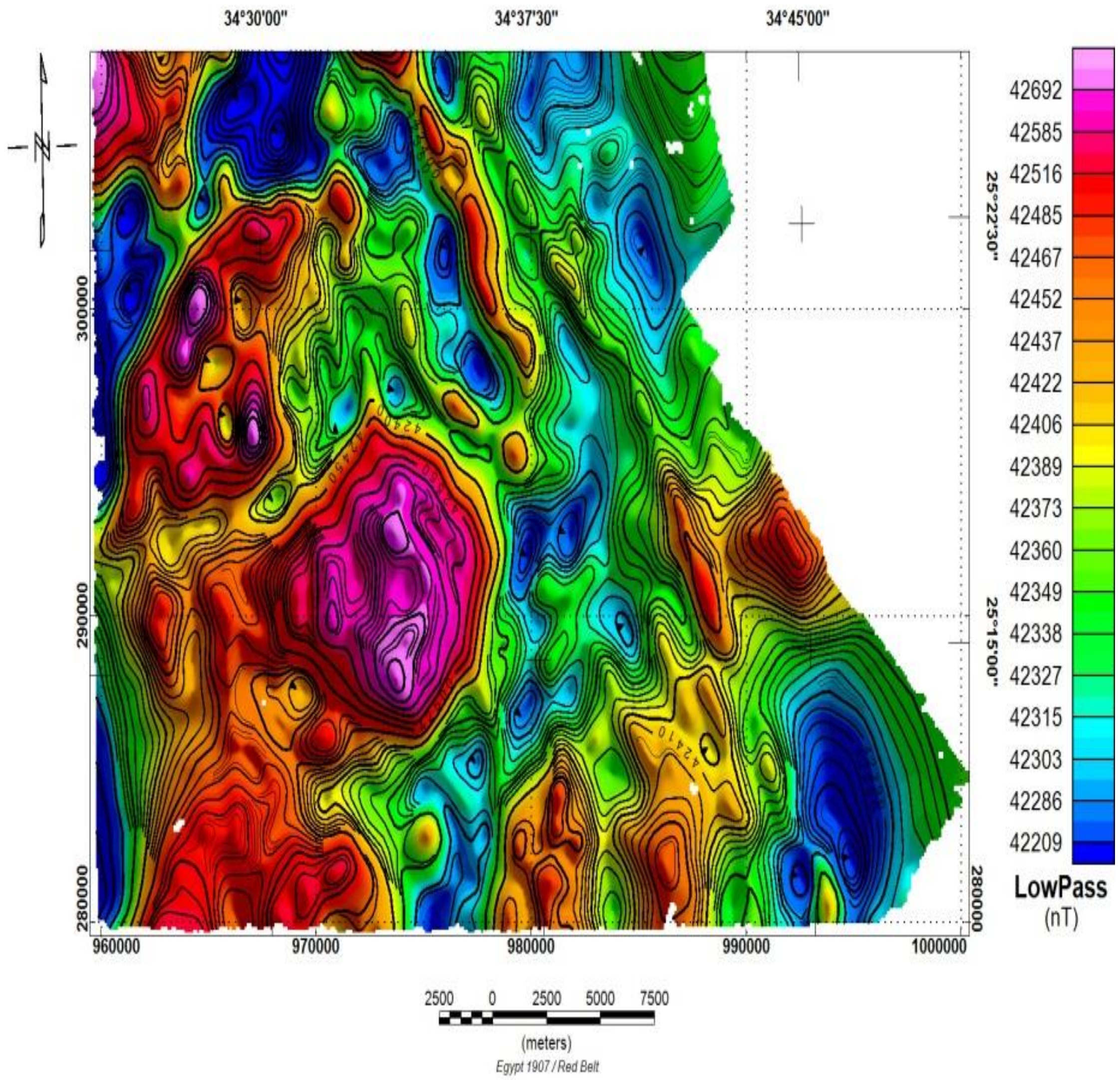


Fig. 6: Low-pass filtered of regional magnetic map of Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

The construction of the residual maps 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. The residuals focus attention to weaker features that are obscured by strong regional effects in the original map (Reford and Sumner, 1964). The residual (high-pass filtered) magnetic component map (Fig. 7) could be described as follows: 1) Some of the magnetic anomalies of large details areal extent are present such as; northern, central, southeastern, northeastern parts of the study area with high magnetic values.2) Presence of broad negative magnetic zones differing in shapes and trends. They may reflect different compositions of the basement rocks at the subsurface or shallow basins due to subsiding.3) Some magnetic anomalies disappear from the regional magnetic component map (such as; northern parts) and are found in the residual component map (as example: the linear high magnetic and deep-seated basic dykes). This phenomenon shows that, these magnetic anomalies originate from shallow depths and are near surface anomalies having shallow roots.

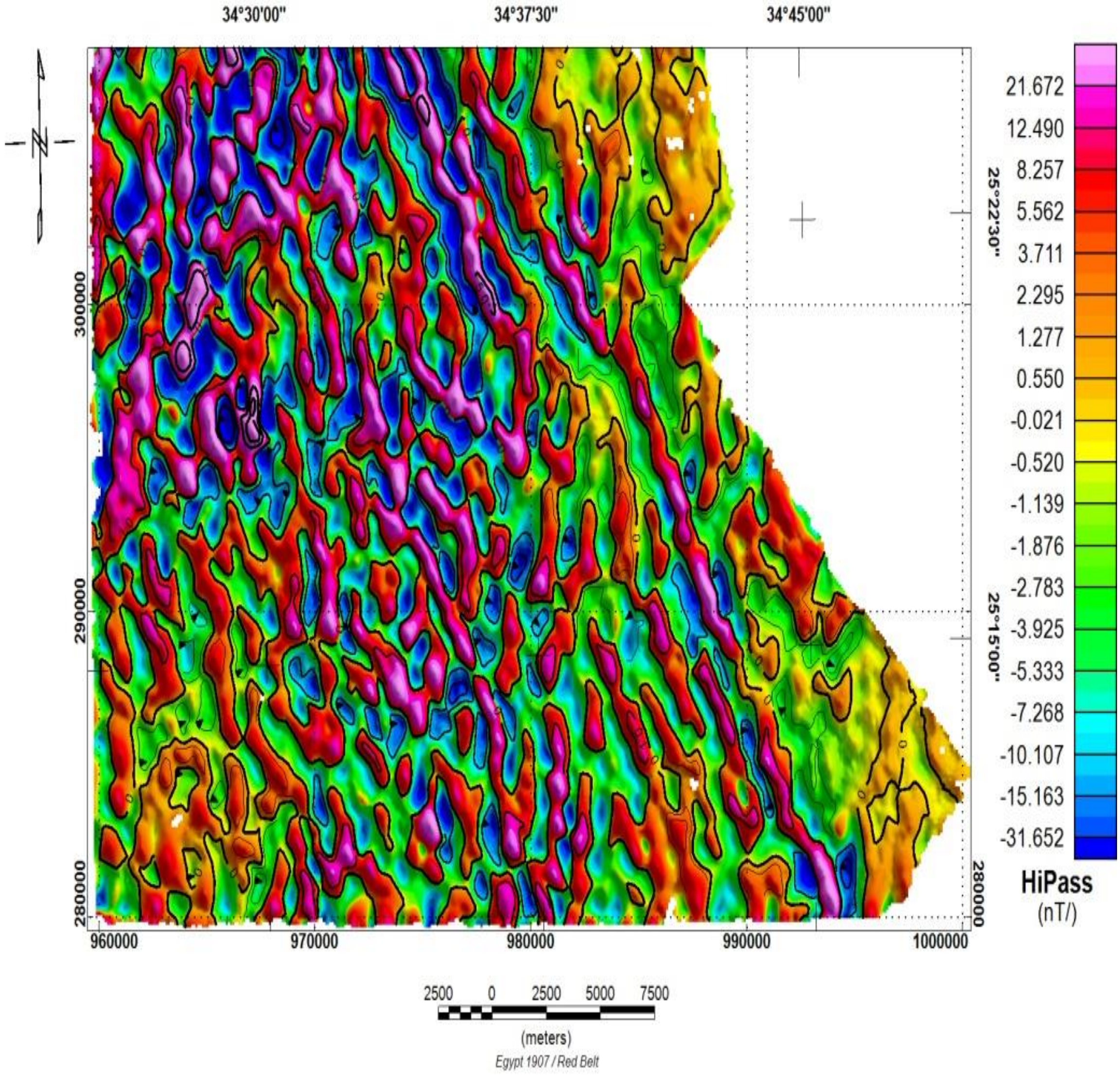
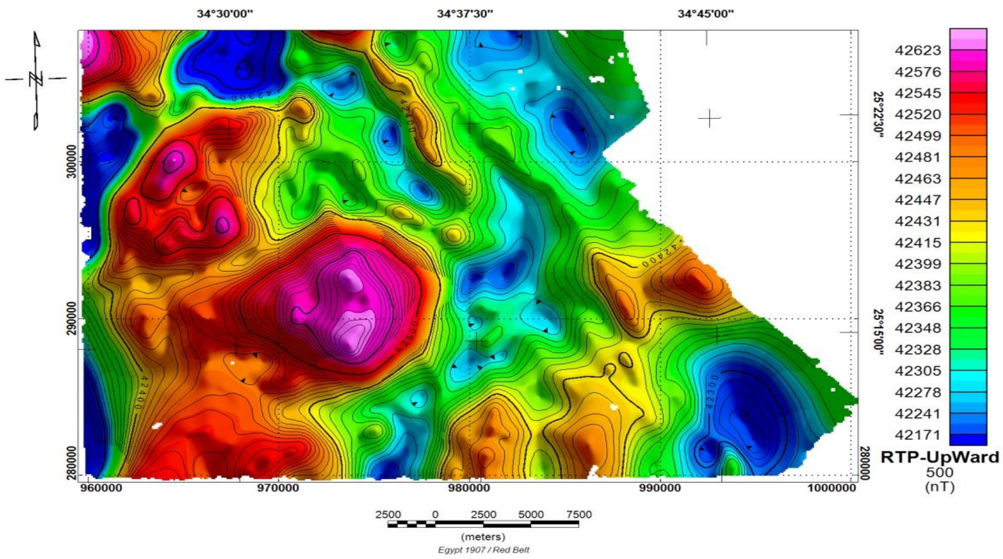


Fig. 7: High-pass filtered of residual magnetic map of Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

4. Upward Continuation Maps

Upward continuation tends to accentuate anomalies caused by deep sources at the expense of anomalies caused by shallow sources (Blakely, 1995). In this study, a series of upward continuation filters were applied on the RTP data.

Six upward maps (at 500 m, 1000 m, 1500 m, 2000 m, 2500 m and 3000 m) were selected (Fig. 8). Inspection of the upward continued map to 500 m shows the most features of the RTP map, while the upward continuation maps or upward 1000 m to upward 2000 m attenuate these shallow source anomalies and emphasize the deeper ones. Inspection of the upward continued maps at 2500 and 3000 m shows high magnetic amplitudes of varying deep roots at central, and southeastern parts of the area where most of residual bodied started to disappear.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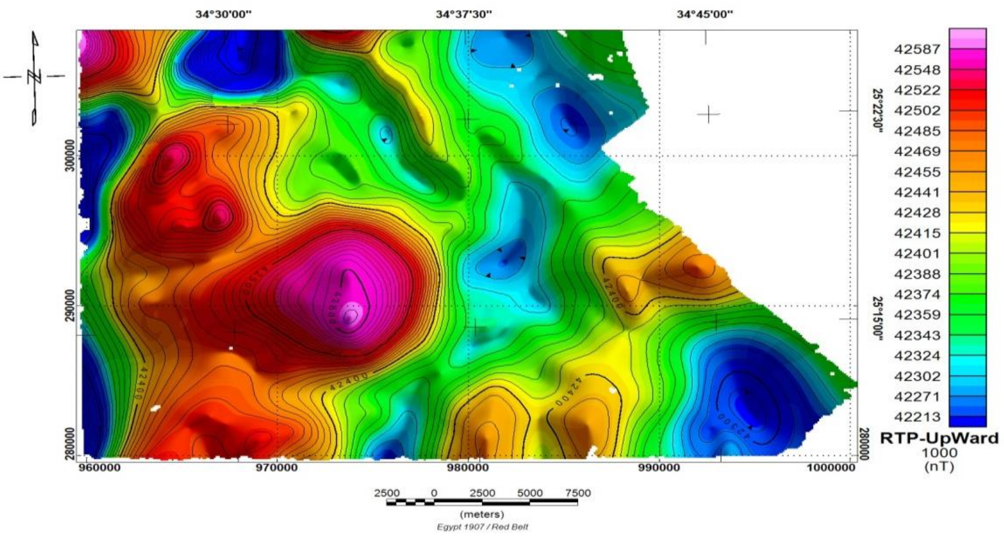
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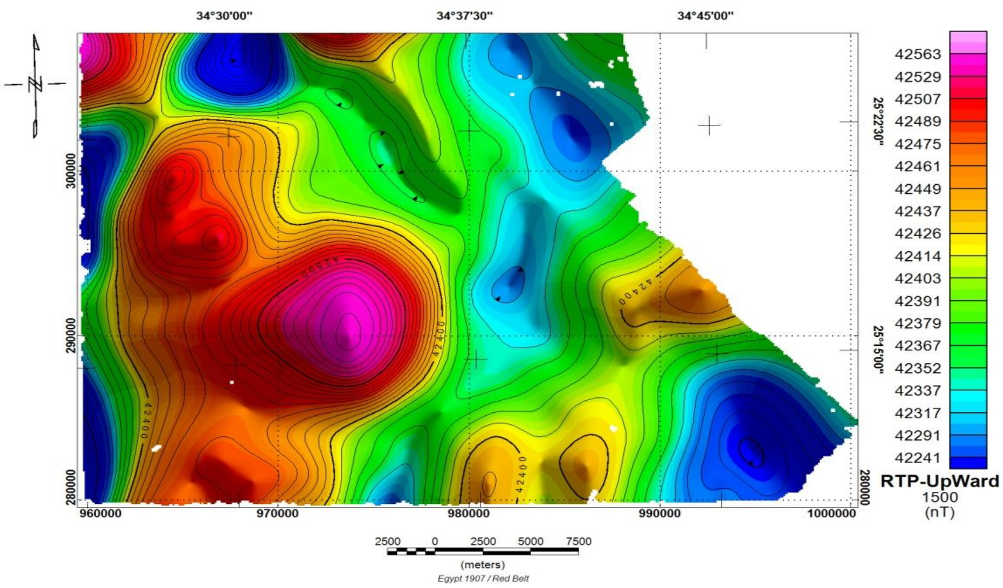
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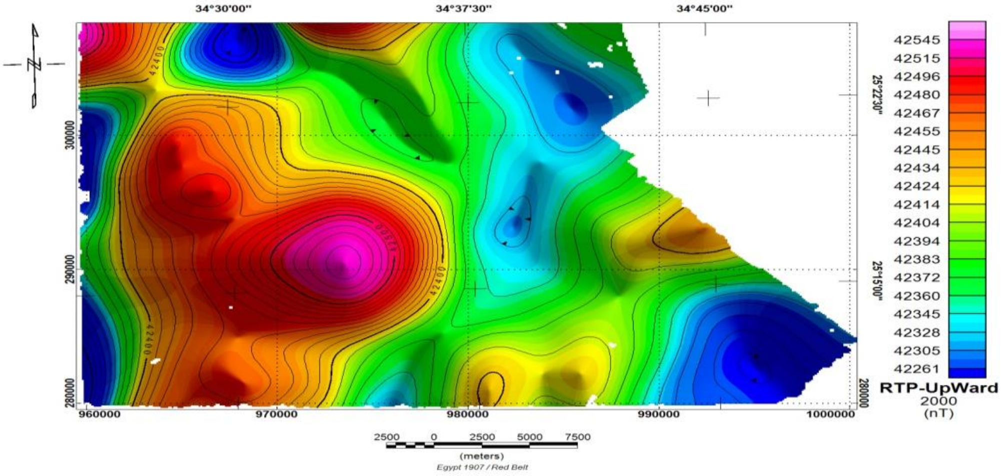

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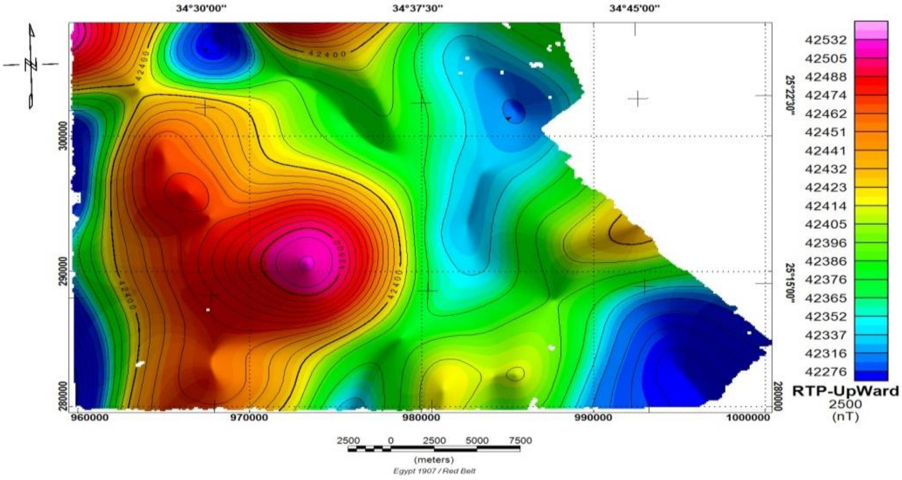

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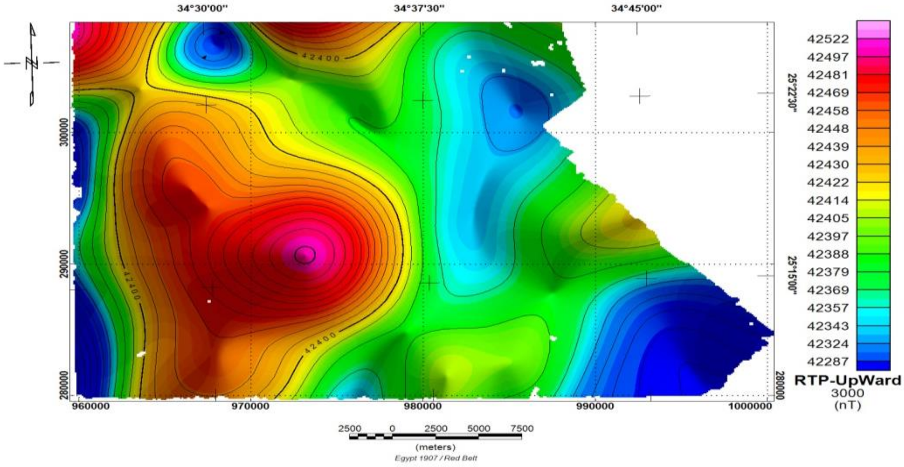

(F)

Fig. 8: Upward continuation contour map at A) 500 m, B) 1000 m, C) 1500 m, D) 2000 m, E) 2500 m and F) 3000 m of magnetic data, Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

5. Vertical Derivative

Vertical Derivative transforms are intended to facilitate the interpretation of reduced to the pole magnetic data. It is an enhancement technique, which amplifies the shorter wavelength anomalies relative to the longer wavelengths. The nth order vertical derivatives for a given potential field $f(x,y,z)$ is calculated as follows:

$\partial^n f(x,y,z) / \partial z^n = F^{-1}[\, K \,|n|\, F(f(x,y,z))$…………….(1)

Where F refers to the Fourier transform operator, $|F^{-1}|$ refer to the inverse Fourier transform operator and $k = \sqrt{k^2x + k^2y}$, where kx and ky are the wavenumbers in the x and y directions, respectively. Clearly, multiplying the transformed potential by k to any power will magnify short wavelength features of the potential field typically associated with near surface sources while attenuating long wavelength components (Blakely, 1995). First vertical derivative field map is often used to detect edges and geologic boundaries in data (Henderson and Zietz, 1949). The vertical derivative is commonly applied to RTP magnetic data to enhance the shallow geologic source in the data. Vertical derivative maps, usually the first or second vertical derivative, accentuate gradients along edges of shallow magnetic sources. Hence, they are used to locate edges of magnetic bodies and to emphasize sources at shallow depths (Dobrin and Savit, 1990).

The main features of the first vertical derivative (FVD) and second vertical derivative (SVD) maps (Fig. 9a and b) are clearly identified. There are edges and geologic boundaries scattered with trends of NW-SE and NE-SW directions.

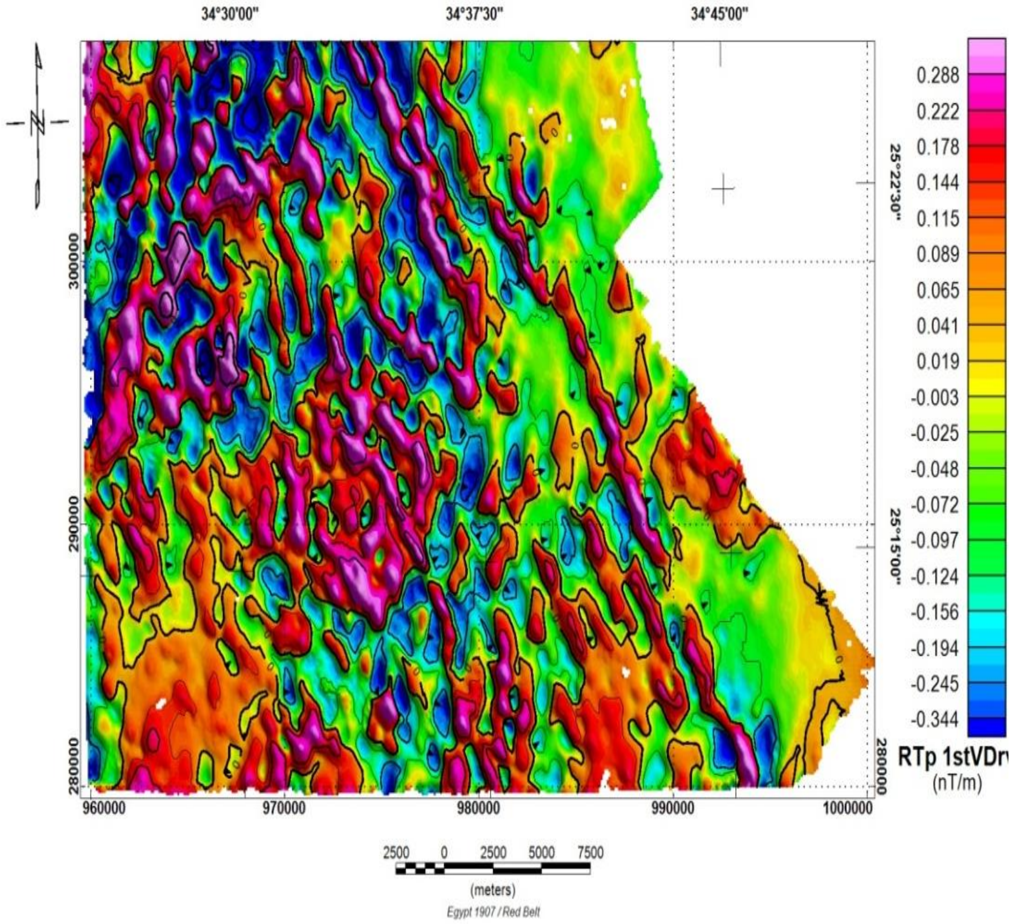

Fig. 9 a: First vertical derivative map of magnetic data, Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

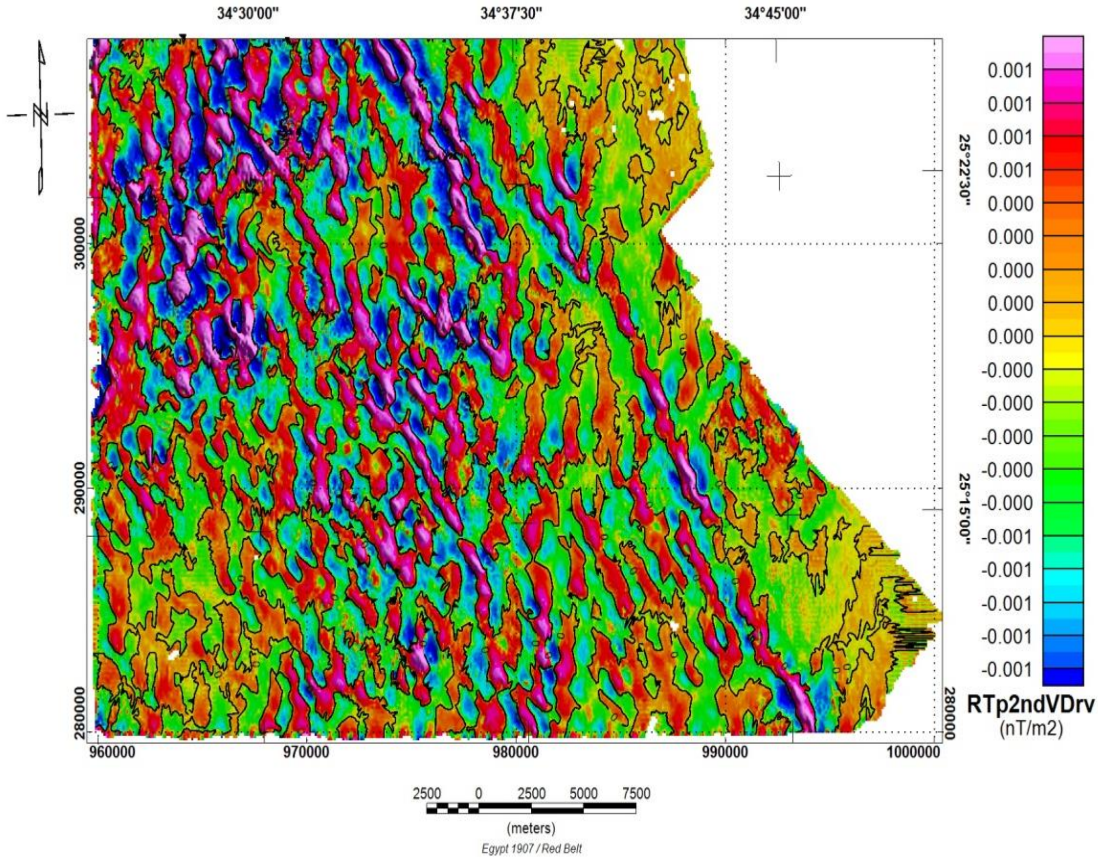

Fig. 9 b: Second vertical derivative map of magnetic data, Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

STRUCTURAL INTERPRETATION

The magnetic signatures of the various magnetic maps show various utilizable structural elements. This significant structural frame is responsible for the tectonic development of the geologic setting of the considered area. The interpreted trends are represented by peaks exceeding the significant frequency of the maps. The aeromagnetic structural lineaments take the NW-SE, NE-SW directions (Fig. 10). Trend analysis has led to two main categories (trends) Red Sea-Gulf of Suez trend (NW-SE) and Gulf of Aqaba trend (NE-SW).

A) Red Sea -Gulf of Suez trend (NW-SE): Meshref and El Sheikh,1973 pointed out that, the stress which produced the conjugate shear fractures (Suez and Aqaba) is different from the stress which gave the east-west (Tethyan) and N 65°E (Syrian arc) trends. The same trend was interpreted also by (Meshref, 1971 and 1990) as one of the fracture systems, which resulted from the force of a couple shear associated with the Red Sea opening.Tealeb, 1979 mentioned that, this trend appears as a predominant trend of both the deep and shallow structures in the Nile Valley, Sinai and the Gulf of Suez. He added that, the great extent of this direction and its appearance on the different depth zones of the crust, give the impression that, it is related to old tectonic movement.

B) NE-SW (Gulf of Aqaba) trend: Meshref, 1971 and 1990 interpreted the NE-SW and NW-SE trends to represent one of the two vertical shear fractures resulting from a northern compression by the end of the mountain building stage and Post Orogenic transitional stage. Ammar et al., 1983 mentioned that, the NE-SW trend was recorded over both the Precambrian basement rocks and the Phanerozoic sediments cover as revealed from the analysis of processed magnetic map. They come to a conclusion that, the NE-SW trend could be valuable, as mineralization of economic importance either radioactive or magnetic or both could be connected with this system of fractures.

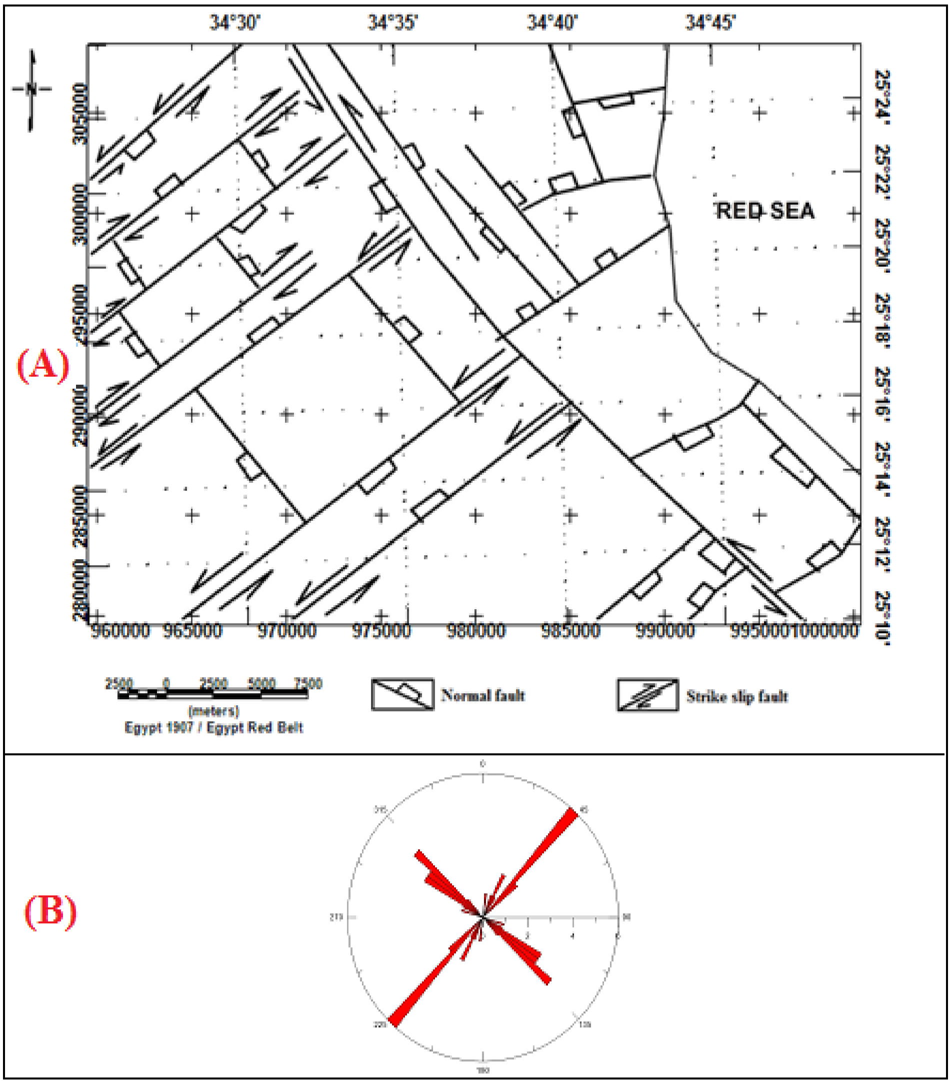

Fig. 10: (A) Sub-surface structure map and (B) Rose diagram of Abu Dabbab-G. Nuweibi area, Central Eastern Desert, Egypt.

CONCLUSION

Several techniques of the aeromagnetic data have been applied, which included; reduction to the northern magnetic pole (RTP) to locate the magnetic anomalies directly above their causative sources, power spectrum, regional-residual separation techniques were applied on RTP magnetic map to separate the shallow anomalies, upward continuation to enhance the signal of deeper sources andvertical derivative todetect edges and geologic boundaries in data. Finally, the analysis and interpretation of RTP map reflect that two predominant structural trends are having variable intensities and lengths. These are the Red Sea-Gulf of Suez trend (NW-SE) and Gulf of Aqaba trend (NE-SW), representing the most predominant tectonic trends affecting the investigated area.

REFERENCES

Aero-Service., (1984): Final Operational Report of Airborne Magnetic/Radiation Survey in the Eastern Desert, Egypt. For the Egyptian General Petroleum Corporation (EGPC) and the Egyptian Geological Survey and Mining Authority (EGSMA), Aero-Service Division, Houston, Texas, USA, Six Volumes.

Ammar, A. A., Meleik, M. L. and Fouad K. M., (1983): Tectonic Analysis of A sample Area, Central Eastern Desert, Egypt, Applying Aeroradiometric and Aeromagnetic Survey Data. Bull. Fac. Earth. Sci., King Abdulaziz Univ., Jeddah, Kingdom of Saudi Arabia, V. 6, pp. 459-482.

Badawy, M. B. M., (2008): Application of Remote Sensing and Geographic Information Systems in Geomorphological Studies: Safaga-El-Quseir Area, Red Sea Coast, Egypt as an Example. Dissertation zurErlangung des Grades “Doktor der Naturwissenschaften” imPromotionsfachGeographie am FachbereichChemie, Pharmazie, Geowissenschaften der Johannes Gutenberg-Universitt Mainz.

Blakely, R. J., (1995): Potential Theory in Gravity and Magnetic Applications; Cambridge University Press, Cambridge, UK.

ISBN:9780511549816 http://doi.org/10.1017/CBO9780511549816.

Conoco., (1987): Geological Map of Egypt, Scale (1:500,000), NG 36 NE-Quseir Sheet and NG 36 SE-Gebel Hamata Sheet.

Dobrin, M. B. and Savit, C. H., (1990): Introduction to Geophysical Prospecting, 4th Edition, McGraw-Hill Book Co., 867 P.

Henderson, R. G. and Zietz, I., (1949): The Computation of Second Vertical Derivatives of Geomagnetic Fields. Geophysics, Vol. 14.

Meshref, W. M., and El Sheikh, M. M., (1973): Magnetic Tectonic Trend Analysis in Northern Egypt; Jour. Geol., 17 (2), 179-184.

Meshref, W. M., (1971): The Application of Magnetic Trend Analysis to the Interpretation of Egyptian Tectonics; Abstracts of Papers Presented at the 9th Annual Meeting of the Geological Society of Egypt, 19-21.

Naim, G. M., El-Miligy, A.T. and Soliman, K., (1996): Tantalum-niobium-tin mineralization in Central Eastern Desert of Egypt. Proc. Egypt Geol. Surv.Centennial conf. (1896-1996), Cairo, Nov. 1996, Spec. Pupl.Pap. No. 75, pp. 599-622.

Reford, M., S. and Sumner, J. S., (1964): Review Article - Aeromagnetics; Geophysics, XXIX (4), pp. 482-516.

Tealeb, A., (1979): Predominant Tectonic Trends in North Egypt; Bulletin No. 189, Helwan Institute of Astronomy and Geophysics, pp. 1-22.

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