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THE ROLE OF SUBSURFACE TECTONIC FAULTS IN SHIFTING THE COURSE OF THE NILE VALLEY BETWEEN EL-MINYA AND BENI SUIEF AREA, EGYPT, USING POTENTIAL DATA

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دور الفوالق التكتونية التحتسطحية المكتشفة فى انجراف مجرى وادى النيل بين منطقة المنيا وبنى سويف، مصر، باستخدام معطيات الجهد

الخلاصــة: إن صورة التصدع عند المستويات المختلفة ربما تمثل السلوك الأرضى التكتونى المؤثر على القشرة الأرضية فى حالة إذا كانت المظاهر المميزة لمجموعة معطلة من الانحرافات دالة للجهد الكلى المؤثر. تم تطبيق تقنية Euler Deconvolution فى الدراسة الحالية لتتبع المظاهر التركيبية لوادى النيل بين المنيا وبنى سويف . يتراوح العمق بين ٠,٢٩ كم الى ٢,٦٣ كم. والمظاهر التركيبية أساساً هى فوالق تتجه تقريبا شمال – جنوب (الخف الافريقى الشرقى) اتجاه خليج السويس . تم تطبيق تقنية نموذج القشرة ثلاثى الأبعاد بامتداد بعض القطاعات المختارة وكذلك تقنية تحليل ثلاثى الأبعاد. سجلت ثلاث نقاط إلتواء بالنسبة لاتجاه المجرى الرئيسى لوادى النيل؛ تقع نقطة إلالتواء الاولى جنوب سمالوط (حيث تغير المجرى من شمال غرب الى شمال شرق تقريبا عند بنى مزار) وتقع نقطة الالتواء الثانية عند بنى مزار حيث تغير الاتجاه الى شمال – جنوب تقريباً (حتى مغاغة) وتبدأ النقطة الثالثة من مغاغة إلى الفشن حيث غير النيل مجراه نحو الشرق باتجاه شمال شرق (عند بنى سويف). توجد كتل صدعية مرتفعة كبيرة تقع الى الشرق من مدينة الفشن باتجاه شمال شمال شرق – جنوب جنوب غرب حيث عملت كحاجز طبيعى أو شبع حاجز وكانت مسئولة عن تغير مجرى وادى النيل نحو الشرق باتجاه شمال شرق (عند بنى سويف). تم الكشف عن ستة نطاقات قصية كبيرة لفوالق مضربية منزلقة وكذلك سبعة عشرة فالقاً عميقاً. وتعد مناطق القص هذه المسئولة عن الصخور البازلتية المنحوتة التى تقع غرب بنى مزار ومسئولة عن الينابيع الواقعة غرب الفشن وعين الريان البحرية وعين الريان الوسطانى وعين الريان القبلية. يبدو أن المجرى الرئيسى لنهر النيل قد تأثر بثلاث فوالق عميقة وكبيرة يقع أحد هذه الفوالق نحو الشرق من النهر ويتواجد الثانى عند الجهة الغربية بينما يحتل الفالق الثالث الجزء المركزى لوادى النيل . ويبرهن هذا على ان المجرى الرئيسى لنهر النيل محكوم بقوة بالفوالق التكتونية التحتسطحية الموازية له.

ABSTRACT: *The faulting picture at different levels might represent the geotectonic behavior affecting the earth's crust in a manner that the characteristic features of a given set of anomalies are related to certain function of the total affecting stress. In the present study, the Bouguer gravity and the reduced to the pole (R.T.P.) magnetic maps are analyzed using second vertical derivative method for clearing the shallow local structures. The depth to the regional and residual components are determined using power spectrum analysis technique and 2.5-D modeling program. Magnetic anomalies are analyzed into regional and residual components using Geosoft program. Both Bouguer gravity and R.T.P. magnetic maps are structurally analyzed for revealing subsurface faults. The structural features are mainly faults having E-W (Tethyan trend), N-S (East African Rift Trend), ENE-WSW (Syrian Arc Trend), NW-SE (Gulf of Suez) and NNE-SSW (Gulf of Aqaba trend) are prevailed. 2.5-D modeling technique was applied along one selected profile on the Bouguer map. Finally, the interpreted structural map of the studied area is intensively analyzed showing different subsurface elements affecting the studied area. Three inflection points along the main course trend of the Nile Valley are recorded; the first lies at south of Samalut (changed from NW to nearly NE to Beni Mazar), the second lies at Beni Mazar where the trend changes to nearly N-S direction (to Maghagha), and the third point started at Maghagha and El-Fashn where the Nile changes its course toward the east with NNE trend (at Beni Suief).*

Six major shear zones of strike-slip faults and about seventeen deep faults were revealed. These shear zones are responsible for the erupted basaltic rocks west of Beni Mazar. The spring located at west of El-Fashn and Ain El-Rayan El-Baharyia, Ain El-Rayan El-Wastanya and Ain El-Rayan El-Qeibliya. The main course of the Nile River seems to be affected by three major deep faults, one of them lies to the east, the second is present at the western side while the third fault occupies the central part of the Nile Basin. The surrounding uplifted igneous and hard sedimentary rocks play also an effective role in detection Nile River course. This proves that the main course of the Nile River is strongly controlled by subsurface tectonic faults parallel to it.

INTRODUCTION

The present study is mainly devoted to the investigation of subsurface structures affecting the studied area that located between lat. 28.00 to 29 05 N and long 30. 00 to 31 30 E. Fig (1). Comprises, a part of the Nile Valley between El-Minya and Beni Suief.

Integration of the available geophysical data in the form of Bouguer and aeromagnetic anomaly maps as well as surface geological and drilled boreholes information portrayed the main structural features prevailed the subsurface of this area.

The Nile Valley represents a very important source of hydrocarbons accumulations as it contains many oil basins as, El-Gendy Basin, Assuit Basin and Dyrut Basin. These basins have very thick sedimentary successions since Eocene to Tertiary ages. The Nile River runs in a zigzag line since very long time having a potential effects for oil and minerals explorations.

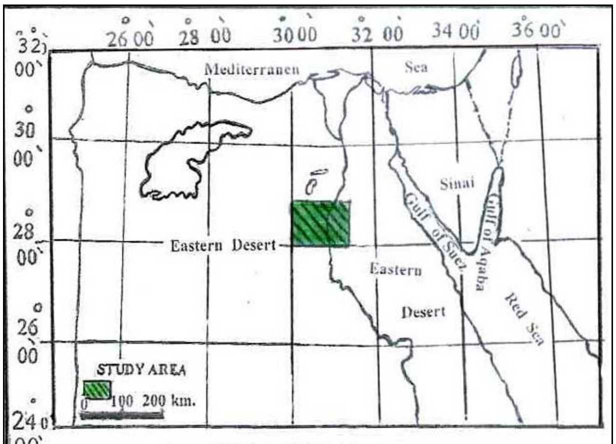


FIG. (1) : LOCATION MAP OF THE STUDY AREA.

The present study try to answer the question which is why the Nile River changes its course more than one time, from nearly N-S, NNW-SSE, N-S, NNE- SSW and N-S trends? For answer this question, the potential aeromagnetic and Bouguer gravity maps are used as a main geophysical source. The aeromagnetic map was transformed into reduced to north (R.T.P) magnetic map using Geosoft program. Both Bouguer and R.T.P. magnetic maps are structurally traced for detection main subsurface structures. For more clearance of residual effects, both, these maps are analyzed using second vertical technique. The R.T.P magnetic map of the studied area was separated into regional and residual components using Geosoft technique.

Depth determination to the shallow, local structures and deep, large-seated elements was achieved using power spectrum analysis technique.

The 2.5-D modeling technique also applied along three selected profiles A-A, B-B and C-C, on the Bouguer and R.T.P. magnetic maps for depth determination to shallow and deep structure and detection the average densities of subsurface formations.

Finally, the interpreted subsurface tectonic structures map was analyzed showing various structural elements as faults, horsts, grabens (sedimentary basins) and shear zones.

THE GEOLOGICAL SETTING

1-Stratigraphy:

The geological map of the studied area, Fig. (2) shows the distribution of different geological formations present in the studied area from Eocene to Tertiary ages which represents a part of the Nile graben. The clastic Jurassic, Cretaceous and Tertiary rocks are the main rock units encountered in some deep- drilled wells as WD57-1 (Western Desert), WD38-1 and El-Nashfa-1 wells. WD57-1 (lat. 29 27 42 and long. 29 31 03 E.), The depth to the basement is 9809 feet. WD38-1 (latitude 29 38 45 N and longitude 30 05 36 E), it has a thickness 9715 feet. The productive succession is the Jurassic sediments in both wells. The discovered oil company is the "FAPCO". The Nashfa-1 well lies at lat. 28 29 30 and long. 30 11 00 with the total depth to the basement about. 2404 feet. AMOCO oil company has discovered the last well.

The outcropping faults are appear at the eastern side of Nile River. The Jurassic rocks represent the oil productive source in the previous mentioned wells, which can be subdivided into four formations as follows from base to top.

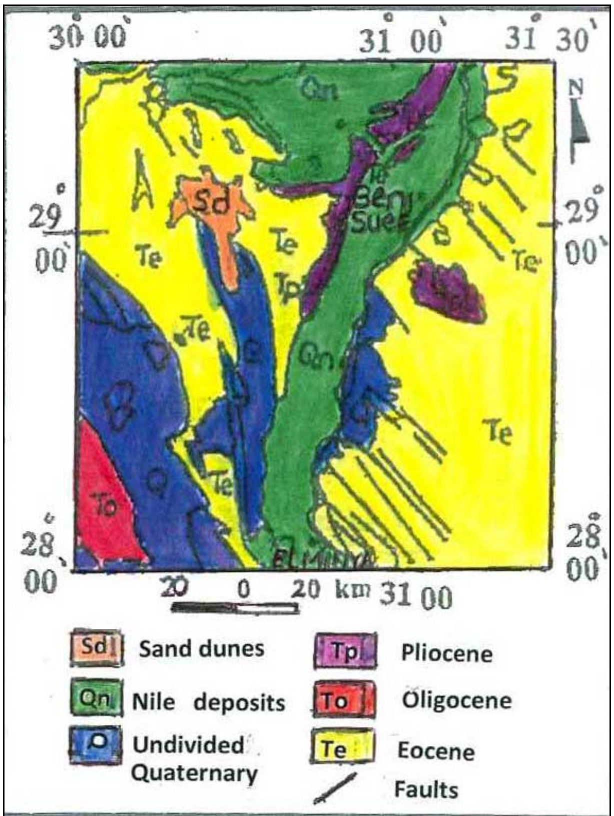


FIG: (2) : GEOLOGICAL MAP of THE STUDY AREA.
After El- Shazly et. Al., 1980

a) The Rass Qattara Formation.

b) The Wadi El-Natrun Formation

c) The carbonate Khatattaba Formation.

d) The Mssajid Formation.

The majority of Cretaceous rocks are unconformity overlying the Jurassic rocks. These Cretaceous units include; Shaltut, Alamein and Kharita formations. The Eocene limestone covers the major parts of the plateau on both sides of the Nile valley.

2- Structural setting:

Beadnell (1900) and Hume (1910) believed that the Nile Valley development as an erosional feature running in N-S gentle syncline. However, Suess (1904) and Lawson (1927) related the parallelism of the Nile to the Gulf of Suez and the clear cut nature of the scarps boardering the Nile Valley as indicators of trough- faulting. Said, 1962 and 1982 revealed that, the Nile Valley course is a graben structure bounded by numerous cliffs and Eocene plateau at the middle part of its course. Gorskov, 1963 mentioned that the Nile Valley lies along a seismo active belt.

Youssef (1968) stated that the studied area was affected by three sets of faults with ENE-WSW, E-W and NW-SE trends. Abdel Razik, and Rasvaliv, 1972 revealed that, the Nile Valley course is surrounded by many cliffs at the middle part of it.

Omara and El-Tahlawi, 1972, recorded four types of sedimentary dykes: NW-SE, NE-SW and less- degree E-W and N-S affected the Eocene limestone plateau. Meshrif,. 1990 mentioned that, the studied area was affected by three sets of faults with ENE-WSW, E-W and NW- SE trends, with northern stress force due to interaction between the Arabian and Europian plates. Iraqi, (1993) studied the eastern opposite area to the studied area, and concluded that, the eastern area was cut by an E-W uplifted structure separates two deep sedimentary basins lie at the north and south parts of it.

Youssef et al. (1994) reported that the NW-SE faults affecting the Eocene rocks around Assiut were developed by the post Eocene movement and added that the studied area became important region for oil and gas exploration especially in the presence of deep- seated and large sedimentary basins.

Ghazala (2001) studied the potential data for the area lies directly to the north of this area for revealing the ancient branches of Eonile. He concluded that the Eonile branches are filled with sediments that increase toward the north and occupy the normal faulting courses.

Abdel Monem et al. (2004) studied the middle part of the Nile Valley directly to the south of this area using the GPS technique measurements for studying the different parameters of crustal deformation especially the two recent earthquakes (December, 1998 & June, 2003) affecting the studied area. They provided available information about the present state of the crustal deformation and its relationship to seismicity and tectonics in the middle part of the Nile Valley.

Lies Loncke et al. (2009) revealed that the accumulated sediments at the Nile deep sea fan represents an instabilities area especially at the Nile-Mediterranean coast. The Nile Valley graben is filled with sedimentary rocks of low density contrast with respect to bed rocks, so, the study depends mainly on gravity and aeromagnetic data.

PROCESSING OF GRAVITY DATA

1- Bouguer gravity map:

The Bouguer gravity anomaly map of the studied area, Fig. (3), was prepared by the Egyptian General Petroleum Company(EGPC) in 1986; scale of 1: 250,000 and 1 mGal contour interval.

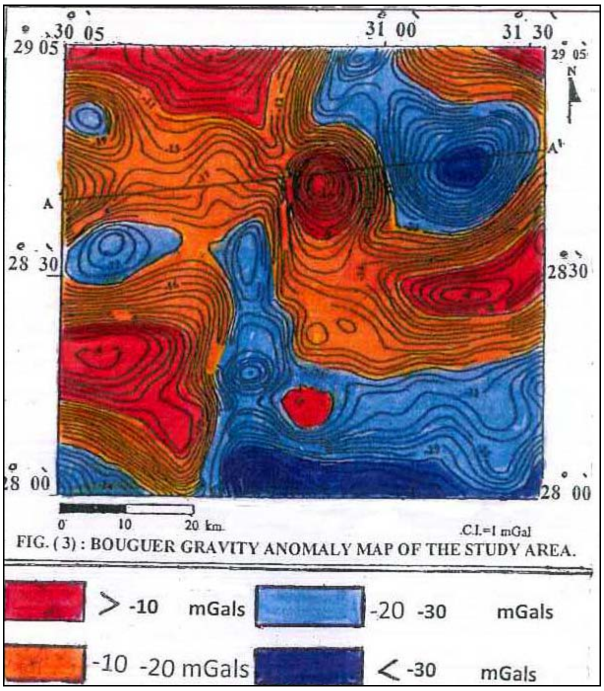


FIG. (3) : BOUGUER GRAVITY ANOMALY MAP OF THE STUDY AREA.

This map shows four strongly positive anomalies (red color) > -10 mGals which lie at the northwestern part with E-W trend; near the southwestern part with E-W trend; at the central part of the northern side of the map and an elongated anomaly located at the central part of the eastern side of the Bouguer map with E-W trend. The highly positive gravity anomaly lies at the eastern side of the Nile River course (east of El-Fashnand south of Beni-Suief areas) represents a highly density contrast values of a large uplifted hard structure which lies very close to the Nile course and may be it is responsible for the shifting of its course from N-S to NNE-SSW trend.

Another three positive gravity anomalies (brown color) with moderate intensities (-10 to -20 mgals) are present at the central part of the eastern side of the studied area with E-W trend (as an effect of East Maghagha High). The second anomaly lies at the southwestern part of the map with E-W trend and the third positive gravity anomaly locates at the northwestern part with E-W trend.

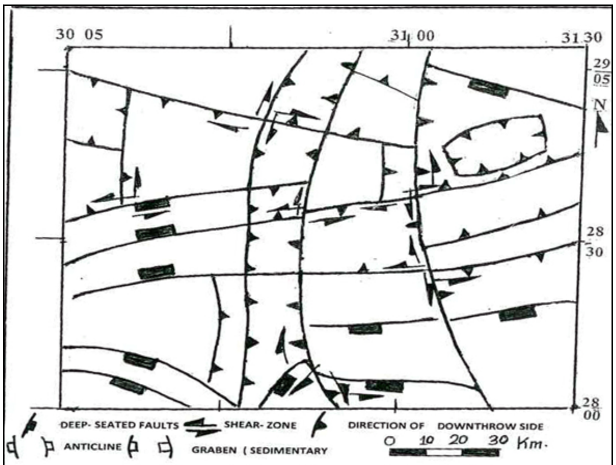


FIG. (4) : INTERPRETED SUBSURFACE STRUCTURES DEDUCED FROM BOUGUER GRAVITY MAP OF THE STUDY AREA.

Two strongly negative areas are separated by E-W elongated uplifted structure of positive anomaly of East Maghagha High,; this result was formed by Iraqi, 1993.

These strongly negative gravity anomalies (< -30 mGals) appear as a deep blue color reflecting an important areas as a deep large sedimentary basins of hydrocarbons accumulation. These two areas lie at the northeastern part of the studied area; with NW-SE trend. The second anomaly lies at the southern part of this area constituting a large sedimentary basin covering the Nile River course at the south with E-W trend (- 40 mGals at El- Minya to zero mGals at El-Fashn area).

Another two large moderately negative anomalies (-20, -30 mGals) are present at the northeastern part of the studied area with NW-SE trend, and thesecond anomaly presents at the south part of the studied area. This negative anomaly occupies the Nile River basin from El-Minya to Beni Suief areas with N-S trend. Another two small areas with moderately negative gravity values present at the southwestern corner and at the central part of western side of the studied area, with WNW and E-W trends respectively.

2- Interpreted Subsurface Structures:

The structural analysis of the subsurface faults deduced from Bouguer gravity map of the studied area (fig. 4) shows that the studied area seems to be affected by two strong tectonic movements during Paleozoic and Early Mesozoic Eras from northern and eastern sides leading to the formation of E-W and N-S subsurface tectonic structures respectively. The main affecting faults are arranged according to their a predominance as follows: E-W , N-S, NW-SE, NNE-SSW and ENE-WSW trends.

The oldest subsurface faults of E-W trend seem to be intersected by N-S tectonic faults of younger ages, constituting alternative groups of horsts and grabens.

This structural analysis map also shows that the set of N-S (or NNE- SSW) faults runs parallel to the Nile River course from both sides.

3- Gravity anomaly separation:

3-1- Second vertical derivative method:

This technique leads to the removal of the regional component of higher order and equivalent to a filter which passes only the anomalies higher than the order concerned. So; this method magnifies the gravity or / and magnetic effects of the shallower and smaller structures at expense of large- scale regional features of greater depth. The advantages of this technique arises from the fact that; the successive differentiation of the normal component of potential data with respect to depth tend to emphasize more clearly the smaller and shallower geological anomalies at the expense of larger deep- seated regional features.

The second vertical derivative method by Henderson et al. (1949) and 1960 was carried out for the Bouguer gravity and reduced to pole magnetic maps of the studied area using different spacing intervals. Fig. (5) shows the obtained filtered gravity anomaly map that considered the most optimum and applicable for gravity anomaly interpretation.

The Second vertical derivative map of the studied area, strongly supports locations of very shallow density contrast within the sedimentary section. The filtered map (Fig. 5) shows the presence of linear strip of negative closured gravity anomalies inside the Nile valley zone referring to fault planes, representing the occurrence of low density sediments filled the Nile graben at shallow depths.

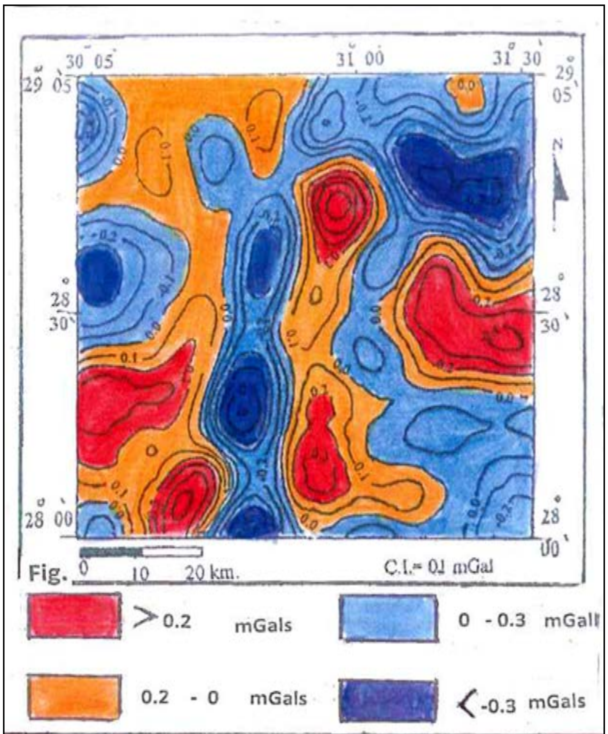


FIG. (5) : SECOND VERTICAL DERIVATIVE GRAVITY MAP OF THE STUDY AREA.

4- Depth determination technique:

4-1- Power spectrum analysis:

The fast Fourier transformation technique was carried out on the gravity and magnetic data for calculating the energy spectra curves and determine the shallow local and deep regional anomalies depth.

This filter depends on the cut- off frequencies that pass or reject certain frequency values. A typical energy power spectrum calculation is illustrated in Fig. (6) For gravity data using Geosoft Program, 2007.

The power spectrum analysis technique is applied on the Bouguer gravity map of the studied area to estimate the average depth of the anomalous sources. The power spectrum analysis curve characterizes by two main segments, the steeper segment that has high slope and refers to regional gravity component and the gentle- slope segment that denotes to near- surface, shallow structures.

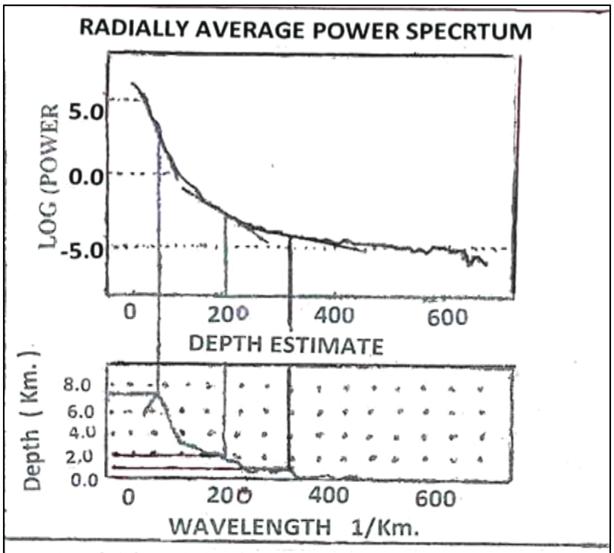


FIG. (6) : ENERGY SPECTA OF THE GRAVITY DATA FOR THE STUDY AREA

4-2- The 2.5-D gravity modeling:

The 2.5-D gravity modeling is an effective tool for studying subsurface conditions with good approximation particularly in case of more geological and / or geophysical information. The parameters of subsurface structure needed to this model are; depths, densities and deep drilled well's data. Therefore, 2.5-D gravity modeling is carried out along A-A` selected profile (Fig. 7) that passes across the Bouguer map from northern part nearly E-W direction.

The long selected gravity profile (A-A`) is interpreted using Geomodel program developed by Cooper (1998) for calculating the theoretical anomaly over 2 1/2 – D bodies and to modify the shape and other attributes of the model in order to improve the fitness of the calculated and observed curves. The observed profile shows as a solid line, while the calculated one is drawn as a dashed line.

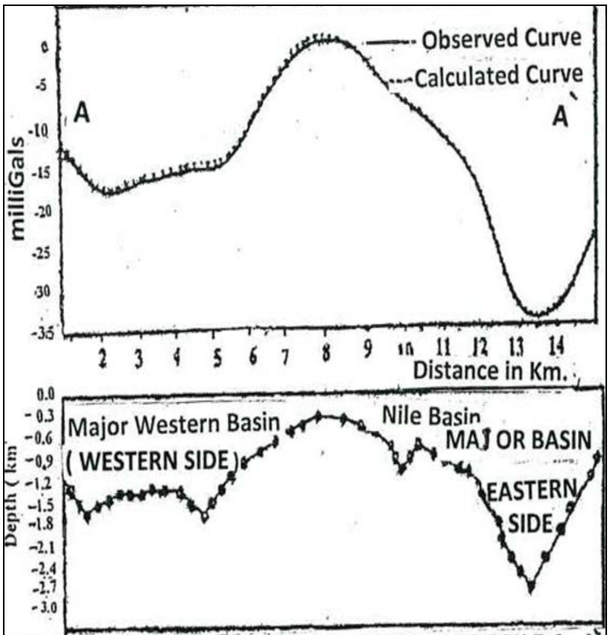


FIG. (7) : CRUSTAL MODLE ALONG THE PROFILE A- A`

(SEE PROFILE LOCATION IN FIG. 3)

This figure illustrates the presence of three sedimentary subsurface basins, which are; a large and more deeper basin lies at the northeast part of the studied area, the second basin locates at the northwestern part of the map and has a large area with moderate depth and the third basin is a small and a shallow one that occupies the Nile River basin.

PROCESSING OF MAGNETIC DATA

The total intensity aeromagnetic map of the studied area (Fig. 8) was prepared by the Egyptian General petroleum company in 1986 with 1: 250000 scale and 20 gammas contour interval and represents the source of magnetic data in this research.

1- Reduction to the north magnetic pole (R.T.P.) map:

The total intensity aeromagnetic map of the studied area was transformed into the reduced to the north magnetic pole map (R.T.P) Fig. (9) to avoid the distortion in the distribution of geomagnetic field over the Earth's surface due to the effect of changing in the values of magnetic inclination angle. The reduction was performed using Baranov, et al., (1964). This process acts as a filter technique used to align the various magnetic anomalies directly over their sources.

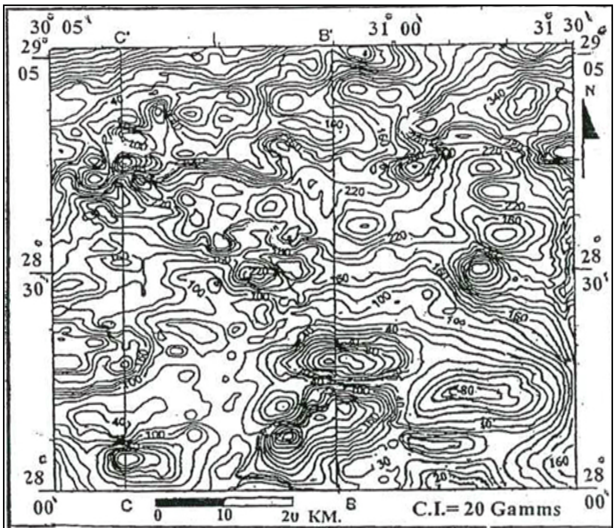


FIG. (8) : THE AEROMAGNETIC MAP OF THE STUDY AREA.

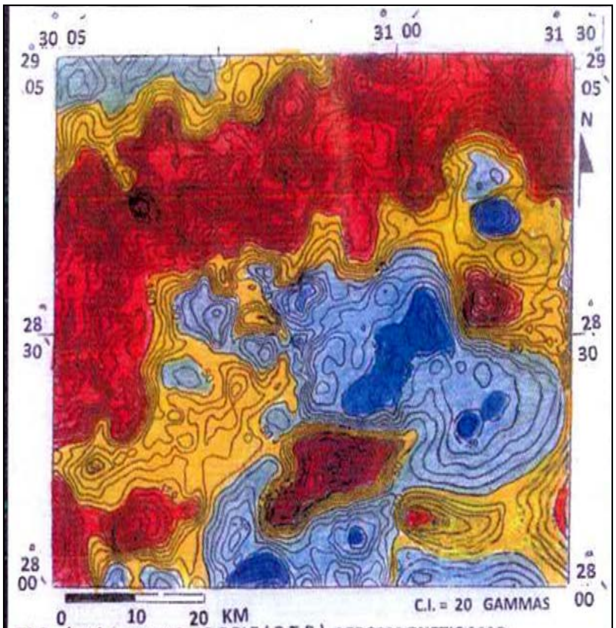


FIG. (9) REDUCED TO POLE (R.T.P.) AEROMAGNETIC MAP OF THE STUDY AREA.

This transformation makes it easy to compare the anomalies of reduced to the north magnetic pole map with the Bouguer gravity anomalies positions. The reduced to north magnetic pole (R.T.P.) map of the studied area characterizes by the followings:

The high magnetic rocks (red colour):

This highly magnetized zone takes the red colour and presents at the north part of the studied area as a large and broad belt of uplifted igneous rocks which takes ENE-WSW trend. This high magnetic zone extends from the west to the northeast corner of the studied area.

There are four highly- magnetized small separate intrusions or uplifted structures, which are presents at the southwestern corner of the area, near the central part of southern side (northeast of El-Minya), and lies very near from Nile course. The third location sites at the central part of eastern side of the studied area. The latest red colours, highly-magnetic location is the igneous intrusion or igneous uplifted structure presents at the southeastern corner of this area.

The moderate intensity magnetic igneous rocks (50 to 150 gammas) are present surrounding the highly magnetic rocks and are concentrated as a belt of ENE-WSW trend. This type of moderate magnetic intensity are present as a relatively shallow depth structures.

The blue and deep blue coloured highly negative magnetic rocks (50 to < - 50) represent a deep – seated sedimentary basins. These deep grabens are concentrated at the southern part and at the central area, of the studied area.

2- The Interpreted Subsurface Structures:

The correct interpretation of subsurface elements depends mainly on the available geological and geophysical information about the studied area, also knowledge the geological history and different tectonic movements affected on the subsurface succession and the experience of the interpreter. Also the applications of modern and available Software programs in data analysis, separation, depth determination and modelling techniques, represents the backbone of right subsurface interpretation.

For the studied area, the interpreted subsurface structures are shown in Fig. (10). The reduced to the north magnetic pole map was traced for extracting the probable subsurface faults, directions of faulting throws, horsts, grabens, shallow and deep sedimentary basins and shear zones. This figure shows that; the studied area had affected by several tectonic movements since Paleozoic to Tertiary eras, causing a great distortions in constituting formations. The main tectonic movements affected the studied area are the Late Paleozoic, Early Mesozoic movement, the Upper Cretaceous; the Oligocene and Miocene tectonic movements. As a result of these tectonic movements; many fault trends had been constituted with varying strengths. The main prevailed faults affecting the studied area are as follow from stronger to weaker faults. E-W (Tethyan trend of Paleozoic age), N-S (East African Rift trend) of Late Paleozoic-Early Mesozoic age, ENE-WSW (Syrian Arc trend) of Upper Cretaceous age, NNW-SSE (Gulf of Suez trend of Oligocene Age) and NNE- SSW(Gulf of Aqaba trend) Oligocene Age. The subsurface sedimentary and / or basement rocks are intersected into successive faulted blocks of horsts and grabens which are illustrated inside the R.T.P. magnetic map as an alternation of positive and negative anomalies.

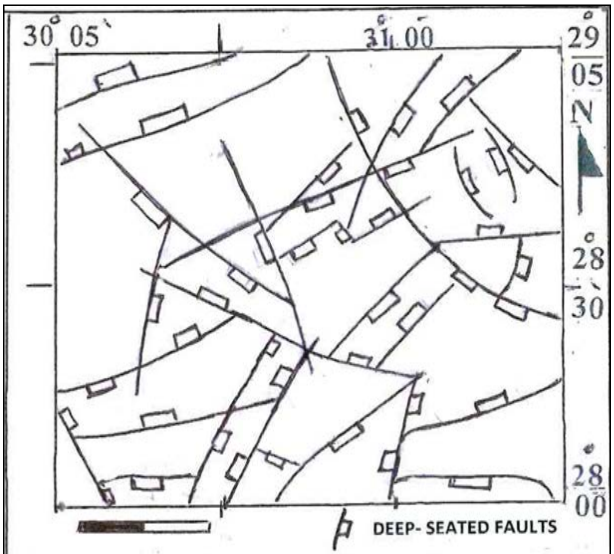


FIG. (10) : INTERPRETED SUBSURFACE ELEMENTS DEDUCED FROM REDUCED TO THE NORTH MAGNETIC POLE (R.T.P.) MAP OF THE STUDY.

This map clearly illustrates the great N-S subsurface faults which surround the Nile Valley Course.

3- Magnetic anomaly separation:

3-1- Regional residual separation:

The magnetic separation process means the decomposition of magnetic anomalies into residual and regional components. This separation aids to remove the broad, gently varying , smooth contours, large wave lengths, deep seated structures and low frequency regional anomalies from, small, irregular contours, short wave length, shallow seated structures and high frequency residual anomalies. This separation of magnetic effects gives a clear picture about, the small size, shallow depths and more interest structures.

The reduced to the north magnetic pole map of the studied area was analyzed into their components by using Geosoft program (MAGMAP) where the Fourier transformation technique was applied, and residual and regional maps are obtained, representing by Fig. (11) and Fig. (12), respectively.

The residual magnetic map of the studied area, Fig (11) shows the following.

A highly magnetized, shallow depth, elongated structure (NE-SW) and perfect closures subsurface anomalies are present at the central part of southern side of the studied area. Another highly magnetized structure was appeared at the central part of eastern side of the studied area, which reflects the highly-magnetic uplifted structure in E-W trend. "East Maghagha High" (See the last figure).

At the south western part of the studied area, there is a high magnetic contours with E-W trend reflecting the effect of known Nshfa Wadi Araba uplift structure. There are also many small sizes, highly magnetic and closed magnetic contours reflecting the shallow depths, high magnetic, uplifted and small size structure. In the residual magnetic map, many positive, small magnetic closures are present representing the presence of many faulted igneous blocks scattered in the studied area at the north western part and around the Nile Course.

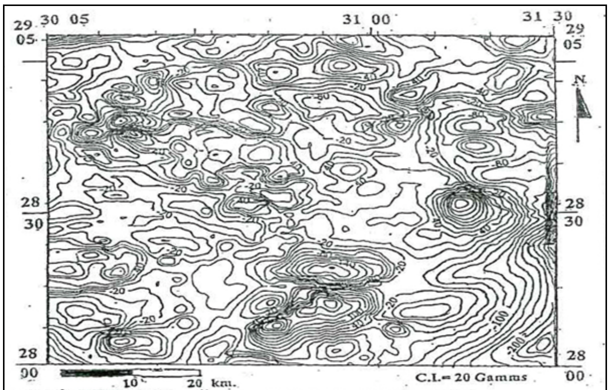


FIG (11) RESIDUAL MAGNETIC ANOMALY MAP OF THE STUDY AREA.

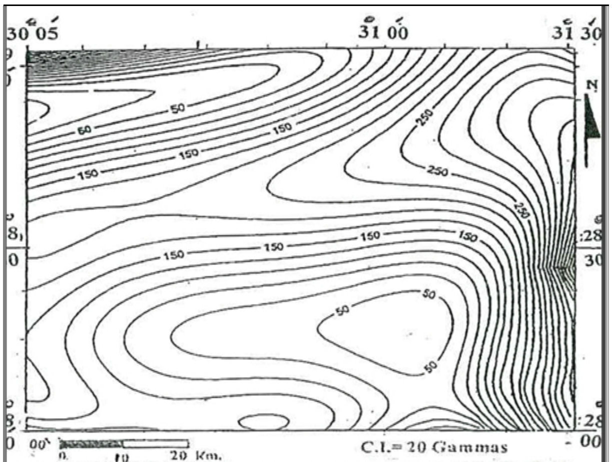


FIG (12) REGIONAL MAGNETIC ANOMALY MAP OF THE STUDY AREA.

This residual magnetic map characterizes by the presence of many low magnetic contours reflecting the areas of low magnetic susceptibility or sedimentary basins, with great thickness, as the area lies to the north of "East Maghagha High" at the north western corner and at the Nile River course (Fig. 11 and 15).

The regional magnetic map of the studied area (Fig. 12) reflects the magnetic intensities arisen from large regional, smooth contours, and deep- seated subsurface structures present in the studied area. The regional magnetic map of the studied area characterizes by low magnetic intensities reflecting the weak magnetic susceptibility of deep sedimentary basins. This regional map has three large sedimentary basins that lie at the southern part of the studied area and seems to be the largest basin covering a great area with E-W axis trend and occupies the southern Nile basin. This basin was tilted toward the west side (toward the Nile Canyon), the second basin is a large basin locates near to the north eastern part of the studied area with E-W trend and lilt toward the Nile course. The previous southern basin and the north eastern one are separated by a high gradient magnetic contours reflecting the presence of uplifted structure, Fig. (12), which named "East Maghagha high". The third sedimentary basin lies at the north western corner of the studied area and has a large area, regional extent, smooth magnetic contours reflecting the presence of large, deep sedimentary basin with ENE- WSW trend. This basin has a great gradient toward the south and separated from Nile course by great ENE-WSW Baharya-Attaqa uplift. which may has an eastern extension represented by El-Wasta Hight.

3-2- Second vertical derivative method:

Second vertical derivative technique leads to the removal of the regional component of higher orders. This means that, the process is equivalent to a filter which passes only the anomalies higher than the order concerned. So, the second vertical derivatives maps are magnifying the magnetic effects of smaller and shallower structures with respect to that of the larger scale features of great depths.

The advantages of this method arises from the fact that the successive differentiation of normal component of potential data with depth, particularly the second vertical derivative, tend to emphasize more clearly the smaller and shallow geologic anomalies at the expense of a larger regional structures.

In the present study, the application of second vertical derivative technique for the R.T.P. magnetic data was computed using special program (Geofsoft, Oasis Montage V. 5.1.7).

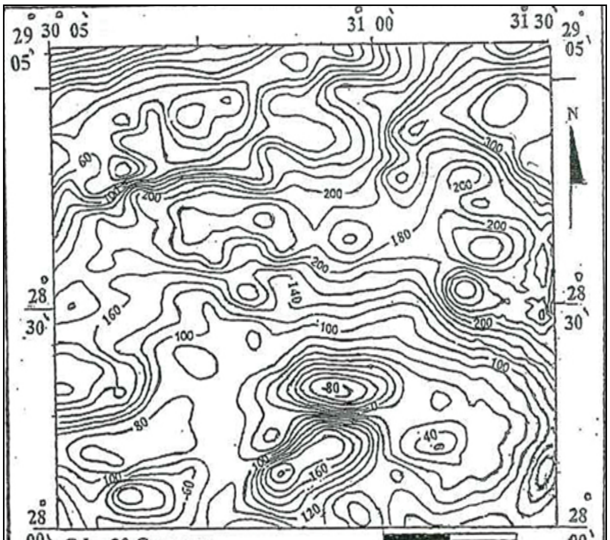


FIG. (13) SECOND VERTICAL DERIVATIVE MAGNETIC MAP OF THE STUDY AREA.

The second vertical derivative magnetic map of the studied area, Fig. (13) shows the residual magnetic anomalies of shallow- seated, small anomalous features present in the area. The magnetic contours take closed or semi-closed shapes and are present in many parts of the map, very similar to the residual magnetic map. These residual magnetic contours express the shape, orientation, aerial extent, strength and polarity of subsurface structure.

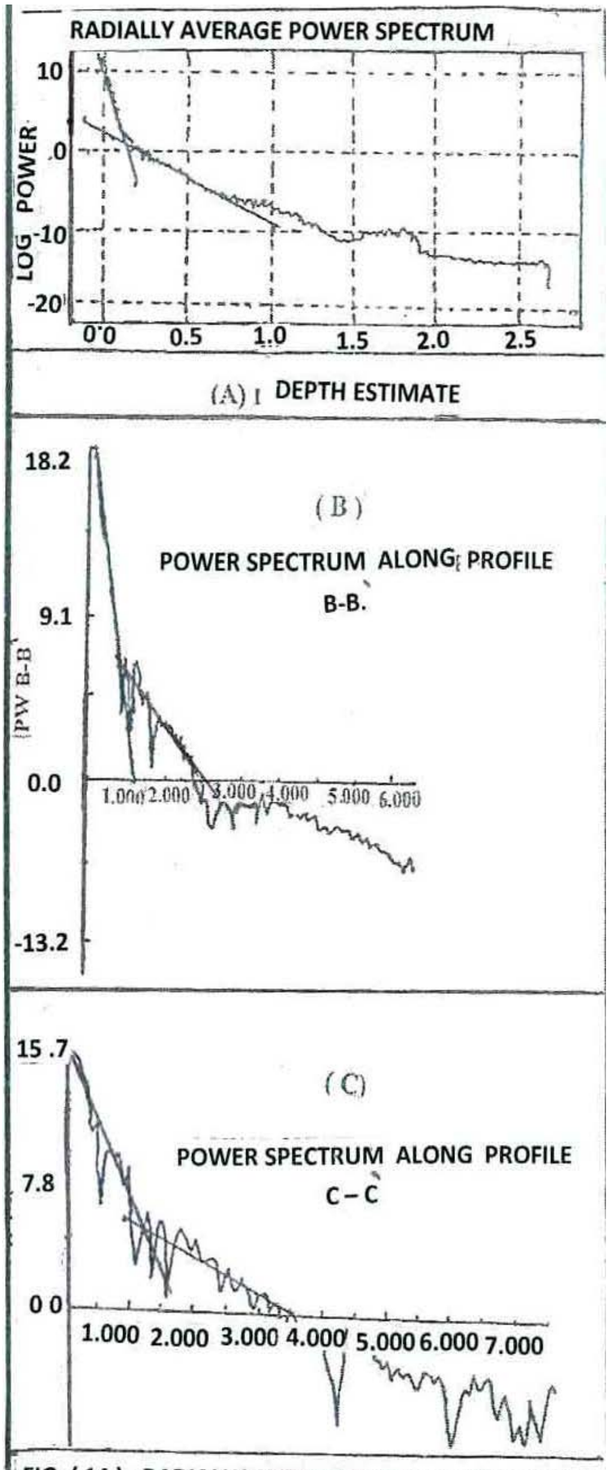


FIG. (14) : RADIALLY AVERAGED POWER SPECTRUM (B-C), POWER SPECTRUM ALONG PROFILES B-B AND C-C RESPECTIVELY.

4- Depth Determination:

Power spectrum analysis technique:

Power spectrum analysis technique is very important process for estimation the depth of burial for deep- seated regional structures and shallow-seated small residual anomalous bodies, which is in low frequency end and in most cases is easier to approximate with a straight line denoting deeper discontinuities (Moho), and a shallow source (residual) component which is in high frequency end denoting shallower sources.

The energy spectrum technique used in interpretation of both gravity and magnetic data is the Geosfot Oasis Montaj, 2007. The application of this program on the magnetic data and also gravity data is shown in Fig. (14), where it illustrates the power spectrum analysis on the gravity data along a selected profile A-A` while this technique is applied on the R.T.P. magnetic data along two selected profiles which are B-B` and C-C`, Fig. (14), shows the depth determination technique for regional and residual components.

INTERPRETATION OF SUBSURFACE STRUCTURES:

1- Subsurface faults:

The subsurface structural map of the studied area, Fig. (15) represents the final result of this work. It conformed that, the studied area had suffered from many tectonic movements affecting on the structural pattern of the studied area.

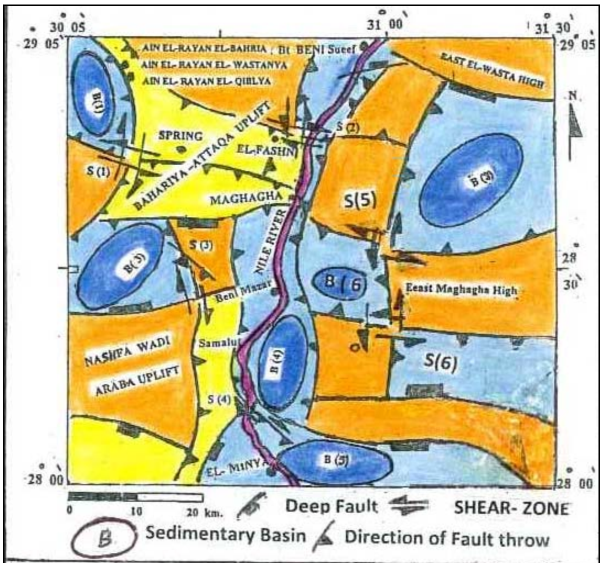
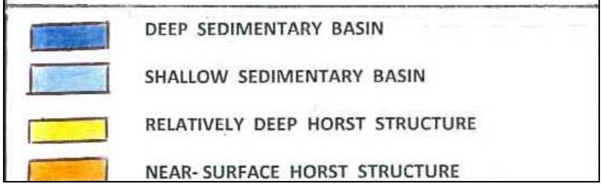


FIG. (15): INTERPRETED SUBSURFACE TECTONIC MAP OF THE STUDY AREA.



The tectonic movements affected on this area include; the Late Paleozoic movement with a N-S stress axis leading to formation of E-W oldest subsurface faults. The second tectonic movement of Late Triassic (Early Mesozoic age) had affected the subsurface formations from E-W compressional force leading to the constitution of N-S (East- African-Rift) Faults. The third tectonic movement had happened at the Upper Cretaceous age forming ENE-WSW (Syran Arc) faults. There are WNW- ESE deep faults affecting the basement rocks- that related to Erythrian tectonic movement of late Paleocene Early Tertiary age. The last tectonic movements and more younger are the NW-SE and NNE- SSW of Gulf of Suez and Gulf of Aqaba trends respectively, with Oligocene age.

The prevailing subsurface faults are as follows from older to younger: E-W, N-S, ENE- WSW, WNW- ESE, NW-SE and NNE- SSW trends.

2- Uplifted subsurface structures:

- The studied area includes many subsurface tectonic uplifts deforming the subsurface strata as :
- "East Wasta High" lies at north eastern corner of the studied area.
- "Barhaya-Attaqa uplift" which presents to the northwest part of the area. This structure seems to be surrounded the Nile River from east and west (as its prolongation to the east may be "East El-Wasta High".
- "East Maghagha High" presents to the east side of the Nile Valley at the central part of eastern side.
- "NashfaWadiAraba uplift", that locates at the southwest part of the studied area and seems to be extended to the eastern side of the Nile Valley.

3- Sedimentary basins:

The studied area is characterized by the presence of many subsurface sedimentary basins as that:

- There is a great sedimentary basin at the north eastern part of the studied area to the east of the Nile Valley and to the North of the "East Maghagha High" with NE-SW trend.
- There are two- medium in size- sedimentary basins present at the north western corner to the west of Ain El-Rayan and at the central part of the western side of the studied area, west of Beni Mazar area.
- To the east of the Nile valley there are two separate moderate basins that lie to the south and west of "East Maghagha High".
- The Nile Valley itself represents a great sedimentary basin, where it includes two large

sedimentary basins to the south and north of El-Minya region.

4: Shear Zones (S):

The studied area may be suffered from deformation by subsurface faults constituting many shear zones which lie at different parts as:

(S1) shear zone lies at the north western corner, S2 sites very near to the Nile valley, north of El-Fashn area. S3 lies to the west of Nile River. The fourth shear zone (S4) lies inside the Nile Valley to the east of El-Minya site. S5 (Shear zone) presents at the south western corner of "East Maghagha High".

5- Relation between subsurface faults and nile valley:

The studied area seems to be highly deformed by many tectonic movements that had formed many sets of faults.

The Nile Valley region in the studied area is bounded by three large subsurface faults, one of which lies to the east side of Nile Valley and the second presents to the western side of Nile Valley, while the third fault locates inside the Nile Valley. All these three faults have N-S or NNE-SSW trend and present surround the Nile River from both sides, and all have downthrown sides toward the centre of Nile valley.

The Nile River course is greatly influenced by the subsurface surrounding uplifted rocks as; the East El- Wasta high at the north eastern part.

The Nile valley is surrounded from the west by a great Baharya-Attaqa uplift" and Nashfa-WadiAraba" uplift at the south western part, west of Samalut.

The Nile Valley course is restricted from the east by the uplifted structure NE of El-Minya area which seems to be a prolongation of Nashfa-Wadi Araba Uplift".

To the north, there is another uplifted structure lies very close to the Nile River and lies to east of El- Fashn area, and this structural high may be the reason of shifting the Nile valley course from N-S to NNE-SSW trends.

CONCLUSIONS

The studied area had affected by many strong tectonic movements since Late Paleozoic to Tertiary eras leading to formation of many sets of tectonic faults.

The prevailing tectonic faults affecting on the subsurface structures are as follows from strongest to weakest, E-W, N-S (to NNE-SSW), ENE-WSW and NW-SE trends.

There are three deep faults cutting the studied area from N to S and present at the central part of the area, one of which lies to east of the Nile valley and the other two faults surround the Nile Valley from east and west with downthrows side toward the Nile basin and seems that, they play an effective role in detecting the direction of Nile River Course.

The uplifted structures present in the studied area as: Baharya-Attaqa uplift, East El-Wasta High, East Maghagha High and Nashfa-Wadi Araba, beside that opposite to Maghagha-El-Fashn area on the eastern side of the Nile River may be a reason of shifting the Nile course.

The studied area is very rich by large, deep sedimentary basins that present inside the Nile basin and surround it. These basins are highly potential basins as it have a great sediments since Paleozoic era.

The deep igneous rocks of ENE trend may be not affected by younger near surface faults.

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