Bull. Nat. Inst. Oceanogr. & Fish., A.R.E. 1994. 20 (2): 67 - 84

TECTONIC-SETTING AT MANZALAH AND BARDAWIL LAKES AS BASED ON GRAVITY AND MAGNETIC DATA

BY

M. B. AWAD*, H. H. FARES, AND E. M. ABU-SHAGAR

***National Institute of Oceanography and Fisheries, Anfoushy, Alexandria, Egypt.**
Key Words: Tectonics, Geophysics.

ABSTRACT

Lake Manzalh is situated at the eastern boarder of the Nile Delta. It is the largest of the Egyptian lakes. Along the southern shore of the lake, a number of bays and lagoons are present, some of them are connected by narrow straits.

Lake Bardawil is located at the northern part of the Sinai peninsula in an active tectonic area.

The regional structural framework of the two lakes had been delineated using aeromagnetic and gravity data as the main source of information. Both Bouguer gravity and Reduced To Pole (RTP) magnetic maps were separated into their regional and residual components to reflect shallow sources and to reveal the broad anomalies of deep sources. Moreover, wave number filtering of potential field data, using Fast Fourier Transform (FFT), was carried out. Depth to the basement and structures, as well as the lithology of different formations were estimated over lake Bardawil using 2D-model profile.

The results were integrated with subsurface geologic information to get a clear picture about the two lakes:-

Lake Manzalh has originated as a result of a subsidence dominated in that area and initiated from the direct tectonic activities that was prevailing during the Post-Miocene time and/or indirect from structures formed through the activities prevailed during the Pre-Miocene time.

Lake Bardawil has a shallow origin and has been caused by a local quiet tectonic movement causing subsidence and/or uplifting of different parts beside the presence of many faults.

INTRODUCTION

The two lakes under study are generally situated at the eastern border of the Nile Delta (Fig. 1). Linant de Bell et al (1973) concluded that the advance of the sea is clearly seen in the area of the lake Manzalah, which was previously called lake Tanis and crossed by three distributaries from east as (Pelusiac, Tanitic and Mendesian) and from the west by Phatnitic. Lake Bardawil is situated in an active tectonic area (El Sayeda, 1993).

Geophysical studies have been carried out to delineate the shallow and deep subsurface geologic setting of the eastern side of the northern part of Egypt. Bouguer gravity and reduced to pole magnetic data, kindly supplied from Egyptian General Petroleum Company "EGPC", were used for the study. The processing techniques on potential field data were carried out in the wave number domain (Naidu, 1969; Black and Scollar, 1969 and Read, 1990). Figure (2) shows a block diagram for processing and convolving the data with a special domain filter, using Fast Fourier Transform techniques (FFT) (Cooley and Tukey, 1965).

METHODS

In order to achieve the goal of the present work, the Bouguer gravity data and aeromagnetic data were subjected to different qualitative analytical techniques:

1- Reduction to a Pole:

This technique was applied to the graded total magnetic field intensity data, using Fourier Transformation, (Dean, 1959; Cooley and Tuky, 1965) in order to remove the effect due to the variations in construction of reduced to pole magnetic map.

2- Isolation of Magnetic and Gravity Anomalies:

Regional-residual separation of potential field anomalies was performed using orthogonal polynomial technique , (El-Sayeda, 1993). This technique was applied to both Bouguer gravity maps and reduced to pole magnetic map. This separation resulted in the construction of a set of regional and residual magnetic and gravity maps of different orders and thus the choice of the best order is depending on the value of the correlation coefficient and the goodness of fit.

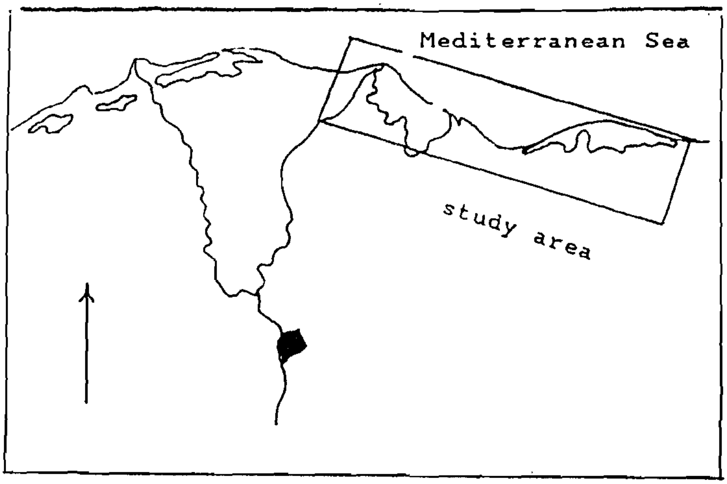


Figure 1: Location map of the study area.

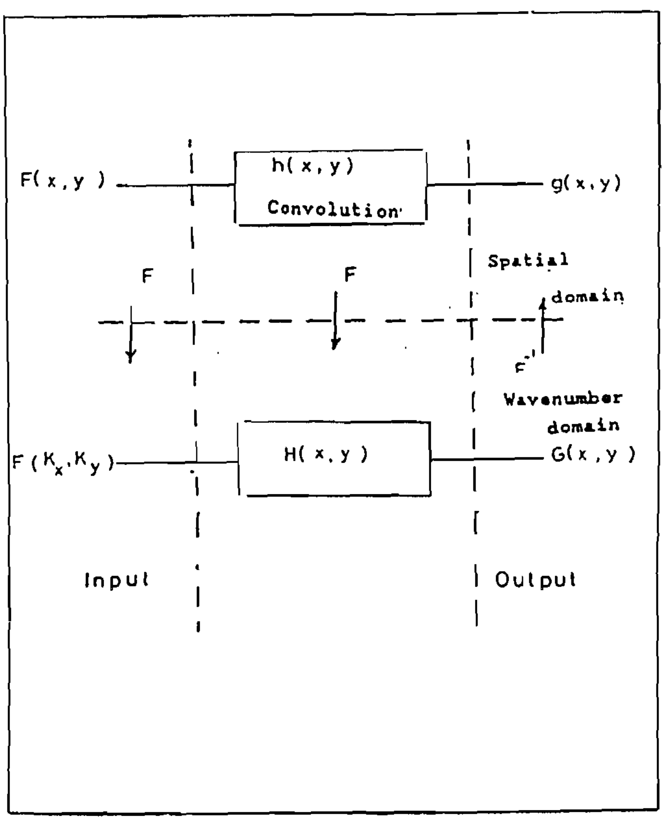


Figure 2: Filtering procedure in spatial and wavenumber domain. F and F' indicate Fourier and inverse Fourier transfer (after Kulhanek, 1976)

3- Continuation Filter:

Continuation filtering in the wave number domain is a powerful isolation and enhancement technique which is widely used in the potential field interpretation (Fares, H., 1990). According to Dean (1958) the equation of transforming a wave number value at a known elevation (Fo) to different elevations up or down (Fw) is:

$$F_h(K_x,K_y) = F_o(K_x,K_y) \exp (2h(K^2_x,K^2_y))^{1/2}$$

where K_x and K_y are the scale factors coordinates in x and y directions.

The available geophysical data of these two lakes, in the form of gravity and magnetic maps were used together to delineate the geological setting of the two lakes.

RESULTS

A- Gravity Data:

The Bouguer gravity map of lake Manzalah is shown in figure 3. It is characterized by a negative anomaly, with its centre matching the southern extended part of the lake. The zero contour line trending nearly E-W and separates the southern part of the lake from its northern and northwestern sides, having steep gradients. From figure 4, it is noticed that Bardawil lake is located on the flank of a highly negative anomaly with its centre towards the northern side of the anomaly. The zero line contour of the anomaly is found to coincide with the southern shore of the lake.

B- Continuation Maps:

Concerning upward continuation levels 2 km, 4 km for both lakes , as shown in figures 5 to 8 respectively, the following can be remarked:-

1- The sharpness and the gradient of the main negative circular over lake Manzalah decreased when going up to a higher level of continuation.

2- The zero line contour coincides always with the lake Bardawil shoreline.

3- The zero line still cuts lake Manzalah into two parts (the southern and the north).

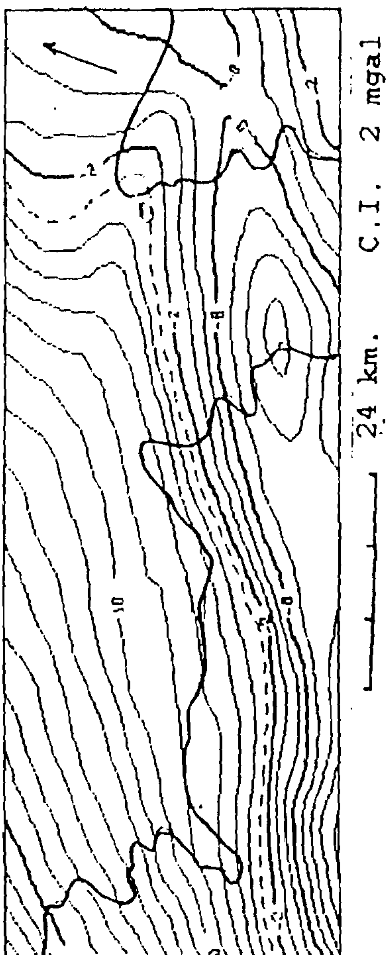


Figure 3: Bouguer gravity map of Lake Manzalah.

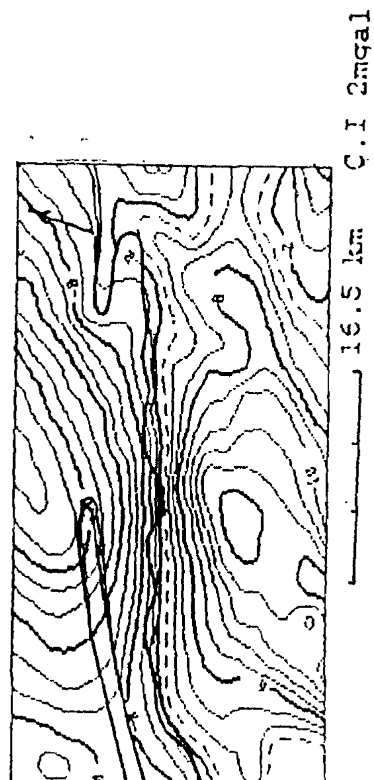


Figure 4: Bouguer gravity map of Lake Bardawil.

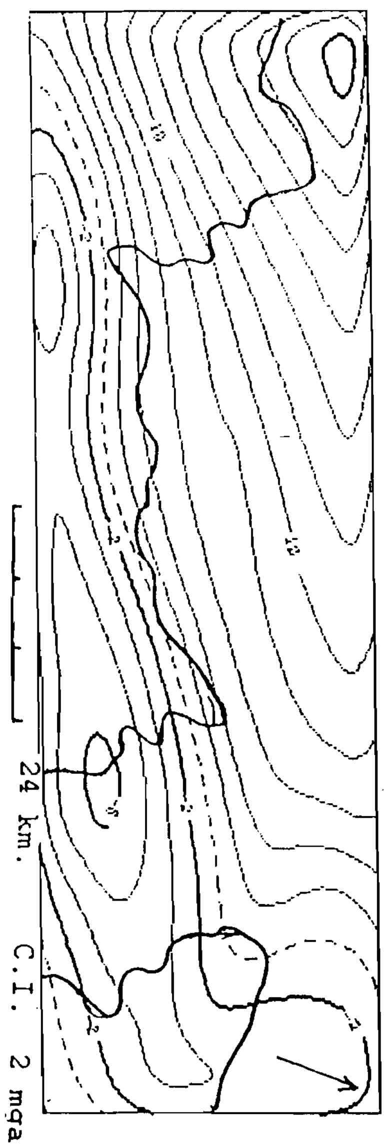


Figure 5: Upward Continuation gravity map 2 km level, (Lake Manzalah).

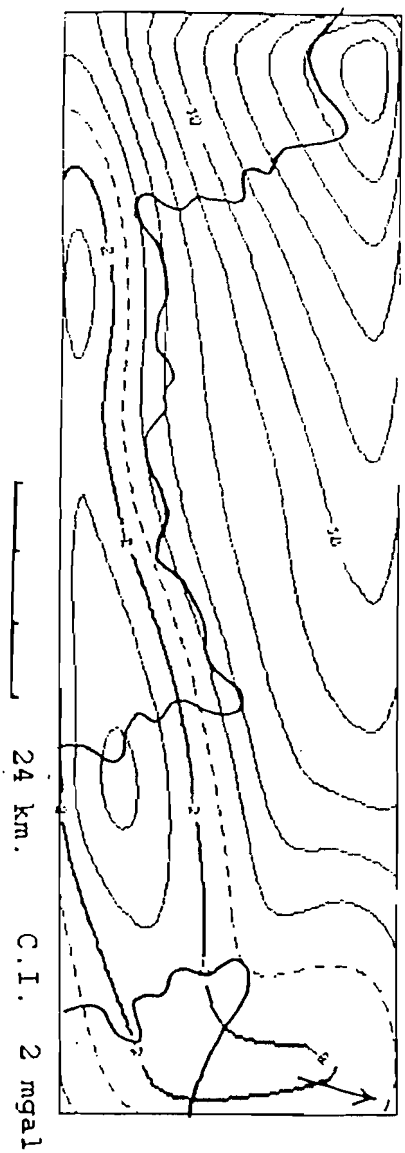


Figure 6: Upward continuation gravity map 4 km level, (Lake Manzalah).

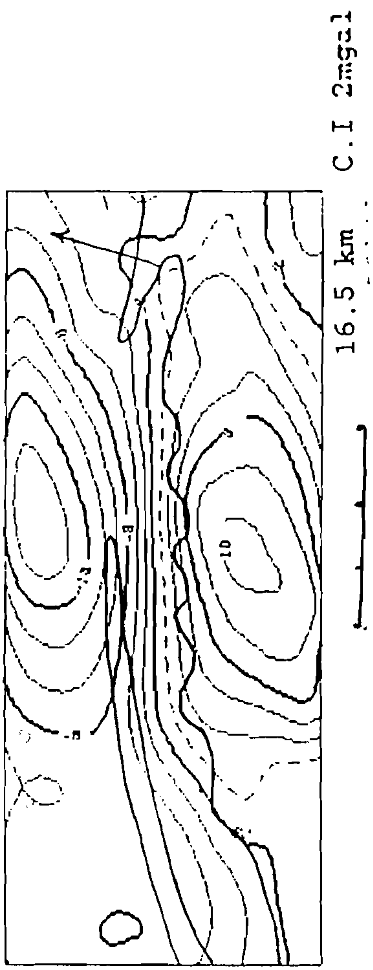


Figure 7: Upward continuation gravity map 2 km level, (Lake Bardawil).

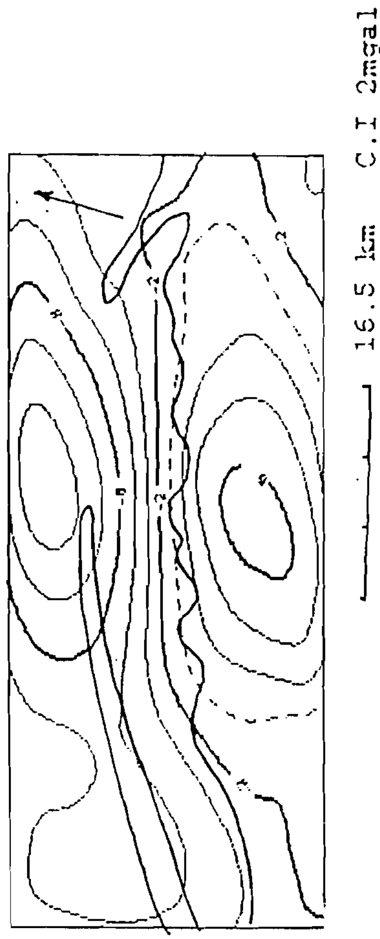


Figure 8: Upward continuation gravity map 4 km level, (Lake Bardawil).

C- Regional -Residual Separation Maps:

From the second order polynomial of lake Bardawil figures (9 and 10), there are four anomalous trends separated by three zero contour lines. The central anomaly comprises the shoreline of the lake and it is facing Mediterranean coastal zone. The zero contour lines of the regional anomaly map figure 10 and the residual anomaly map figure 9 coincide with the shore line nearly at the same position. Figures 11 and 12 represent the regional and residual maps of lake Manzalah (third order). The residual map shows two negative anomalies situated inside the southern part of the lake and a positive one located further to the west of the negative anomaly.

D- Reduced To Pole (RTP) Magnetic map:

The RTP magnetic map, figure 13, of lake Manzalah shows a circular negative anomaly trending NE and nearly coincides with the negative gravity anomaly of figure 3. Also the variation of the gradient is noticed. From figure 14, it is noticed that lake Bardawil has no specific pattern with respect to the lake boundary.

E- Continuation Filter:

Concerning the upward continuation maps (Figs. 15 and 16), of levels 2 and 4 km respectively, of lake Manzalah, the zero contour lines are perpendicular to the lake shoreline at the same position as the regional maps. Lake Bardawil maps (Figs. 17 and 18), show that the anomalies became more defined, with a decrease in the contour spacing intervals with increasing level of continuation.

F- Regional-Residual separation:

Inspection of figures 19 and 20 shows that most of the negative anomalies of the Bardawil lake's residual map are located inside the lake boundary, while the zero contour line of the regional map cuts perpendicular to the lake shoreline. The residual and regional maps of lake Manzalah are shown in figures 21 and 22 respectively. The central part of the lake Manzalah is occupied by two anomalies of figure 21. One is positive and is located to the west and one is negative and is located to the southern part of the lake.

G- Gravity Model:

Figure 23 represents a NE - SW profile at lake Bardawil. The lake position is situated inside a negative anomaly. The first body has a density contrast of 0.12 x 10^3kg m^{-3} when compared to basement.

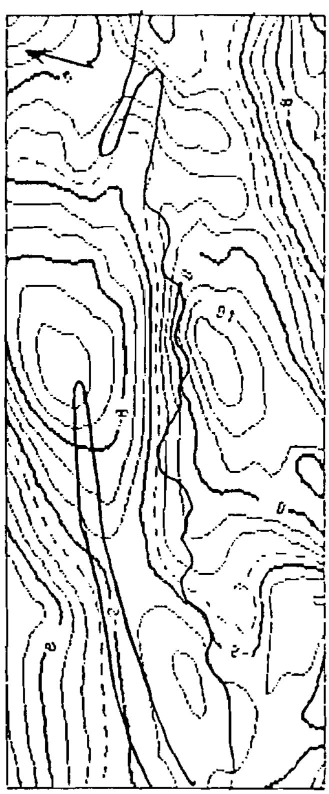


Figure 9: Residual gravity map of second order, (Lake Bardawil).

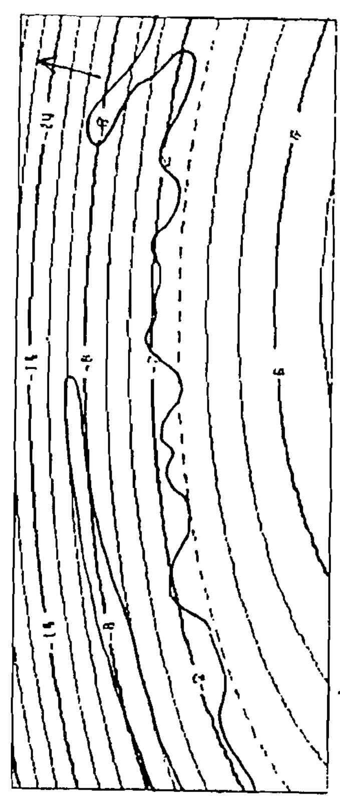


Figure 10: Regional gravity of second order, (Lake Bardawil).

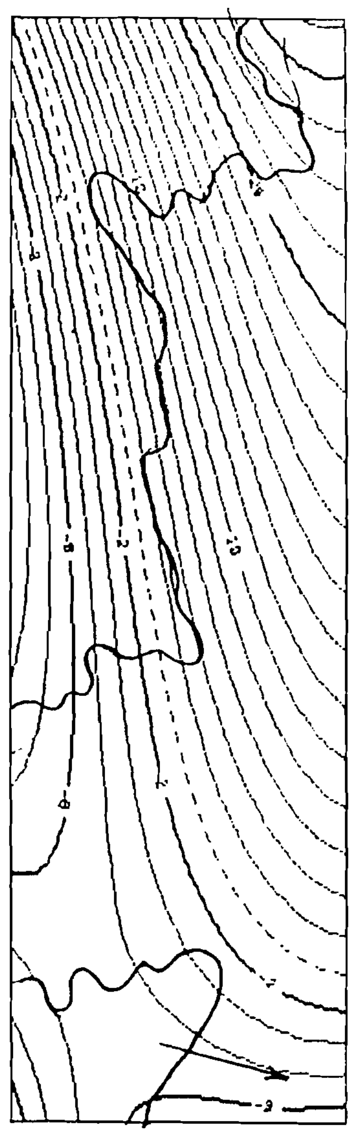


Figure 11: Regional gravity map of third order, (Lake Manzalah).

24 km. C.I. 2 mgal

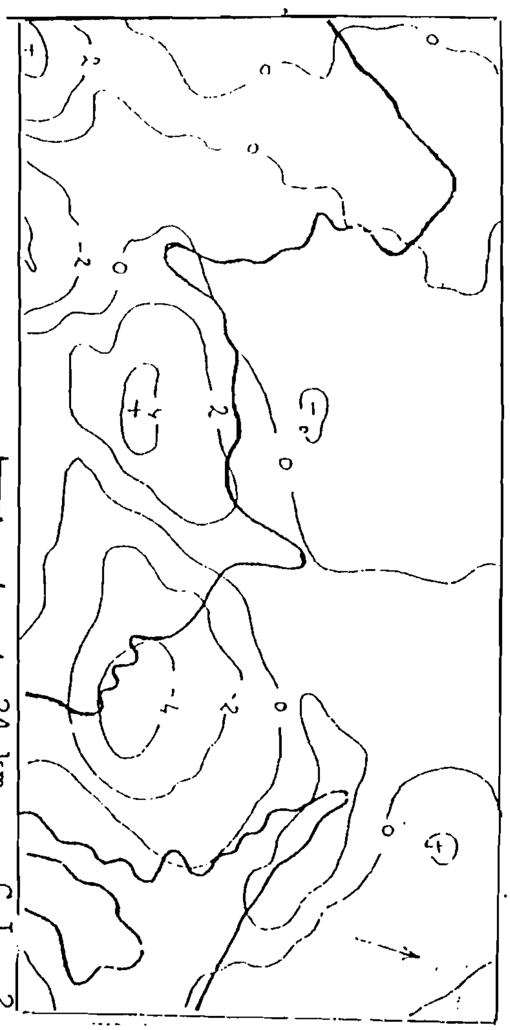
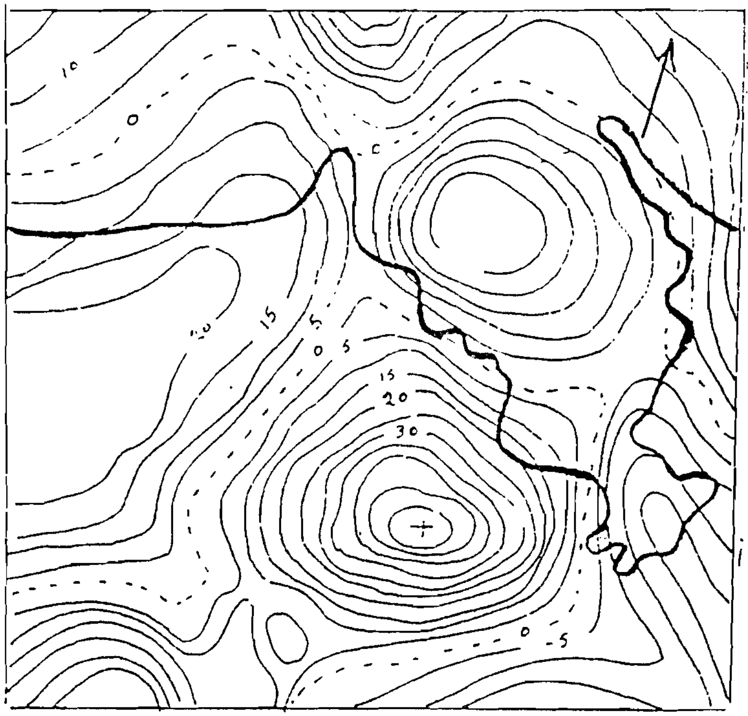


Figure 12: Residual gravity map of third order, (Lake Manzalah).

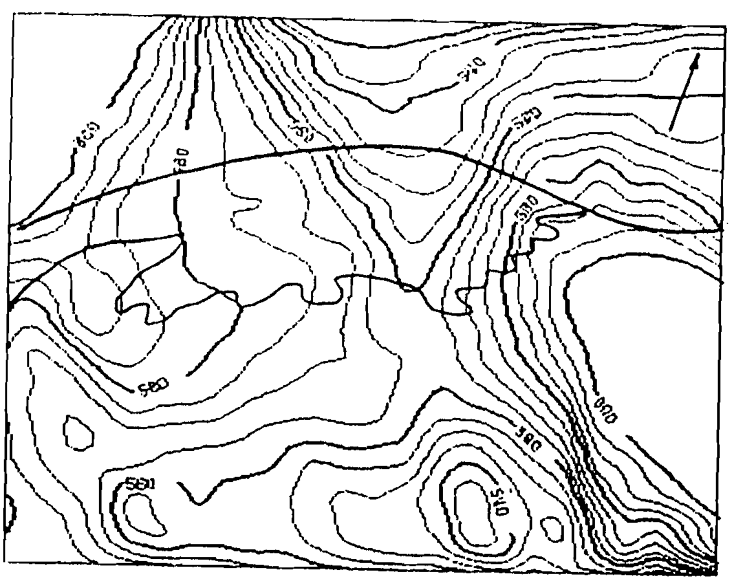
24 km. C.I. 2 mgal

Bull. Nat. Inst. Oceanogr. & Fish., A.R.E. 1994. 20 (2): 67 - 84



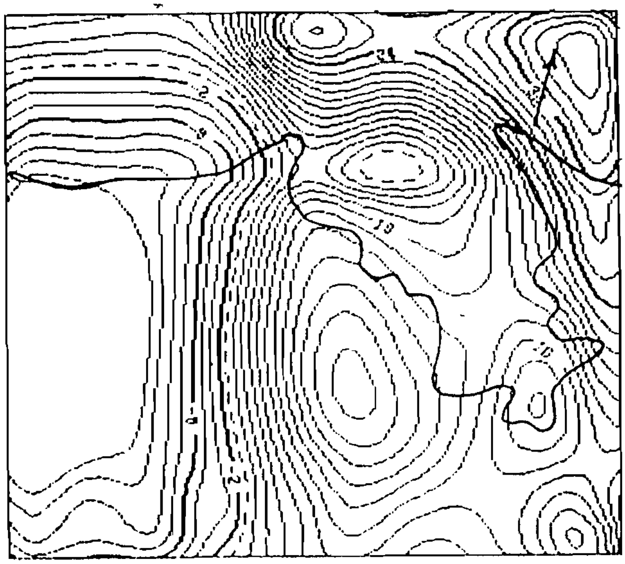
24.3 km C.I 5nt.

Figure 13: Reduced to pole magnetic map of Lake Manzalah).



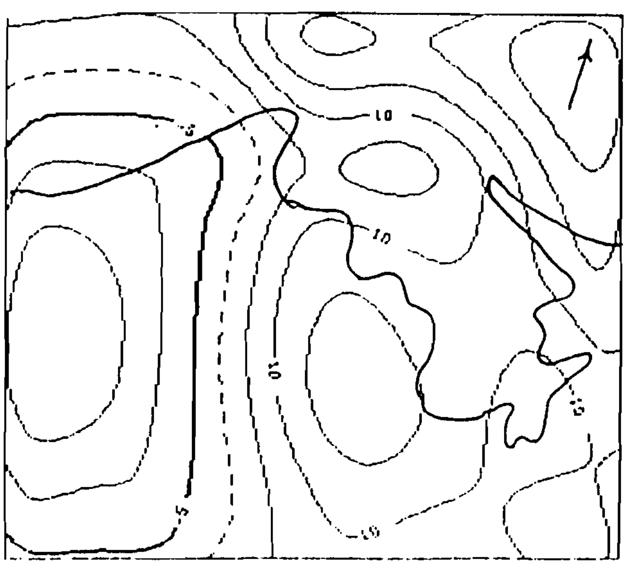
19.7 km C.I.5nt.

Figure 14: Reduced to pole magnetic map of Lake Bardawil.



24.3 km C.I 2.nt

Figure 15: Upward continuation magnetic map 2 km up, (Lake Manzalah).



24.3 km C.I 5nt.

Figure 16: Upward continuation magnetic map 4 km up, (Lake Manzalah).

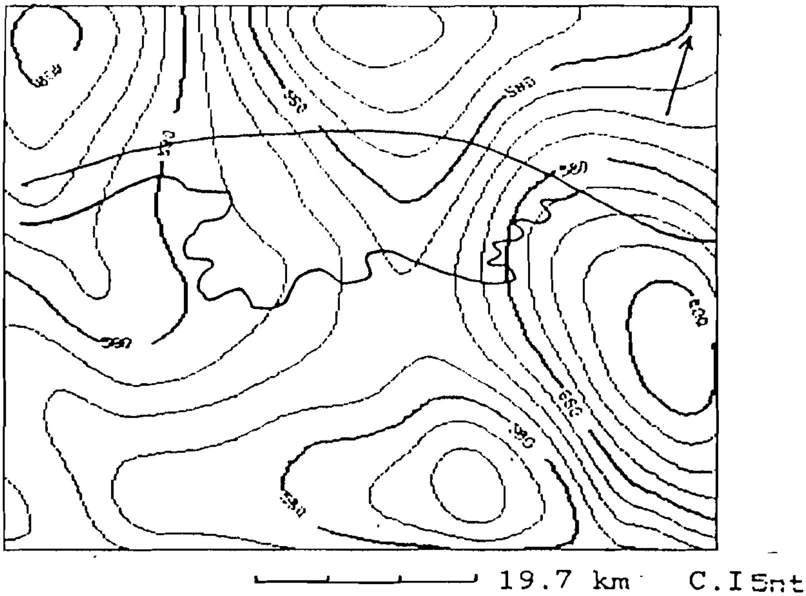


Figure 17: Upward continuation of magnetic map 2 km up, (Lake Bardawil).

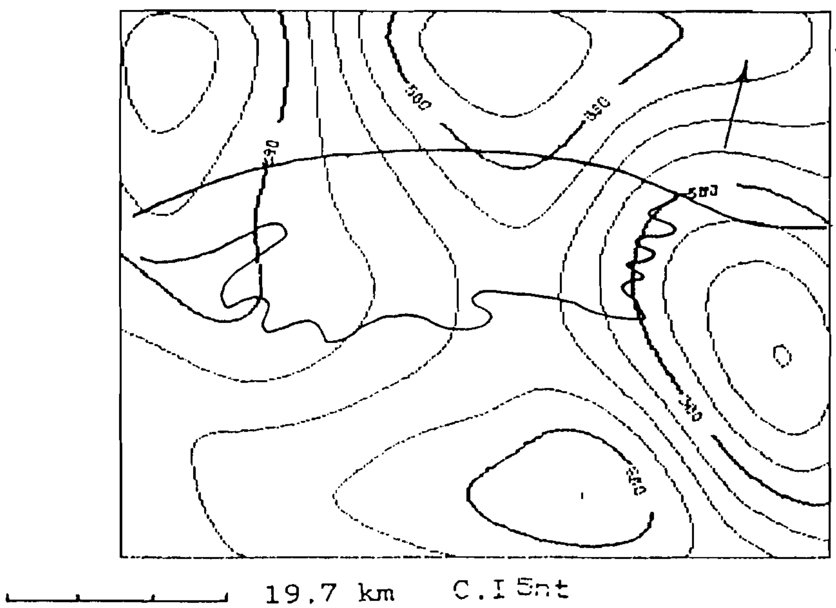
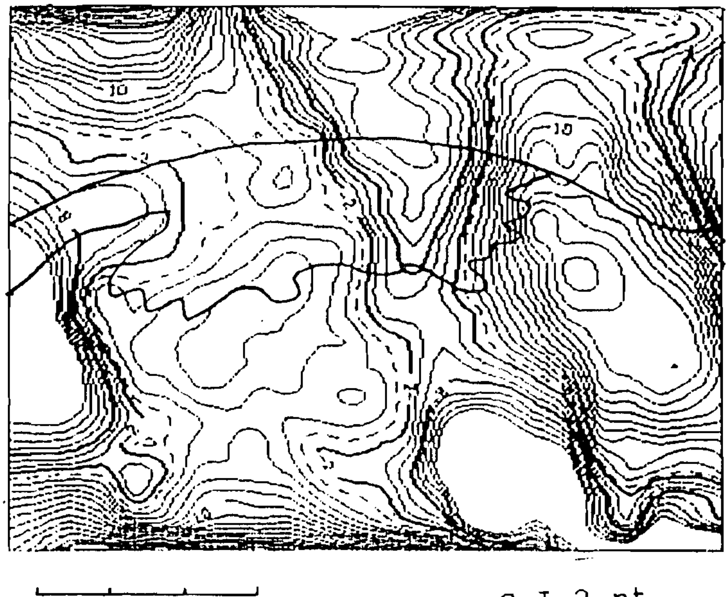
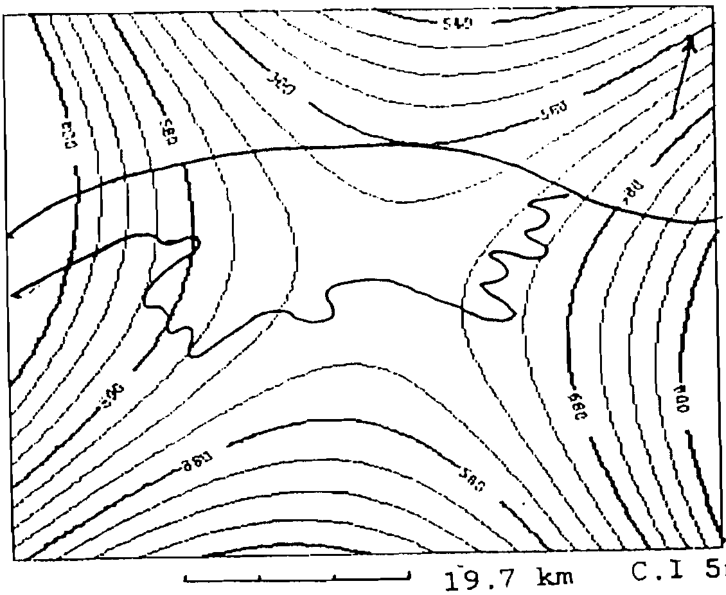


Figure 18: Upward continuation of magnetic map 4 km up, (Lake Bardawil).



19.7 km C.I 2.nt

Figure 19: Residual magnetic map of second order, (Lake Bardawil).



19.7 km C.I 5nt.

Figure 20: Regional magnetic map of second order, (Lake Bardawil).

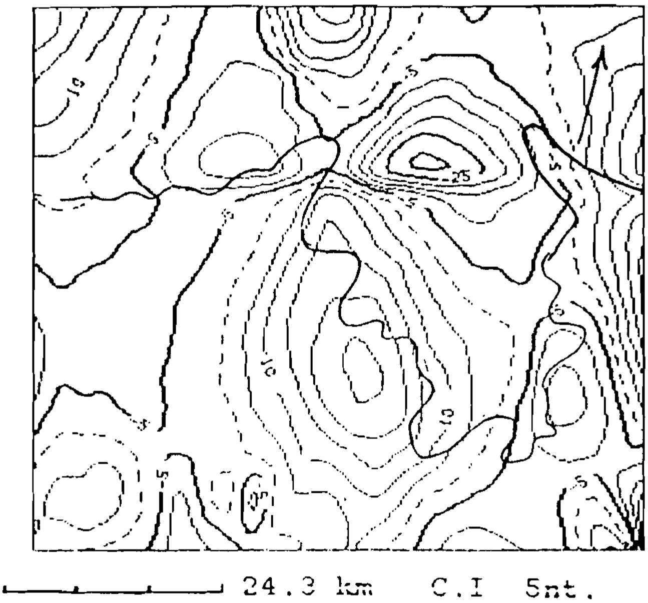


Figure 21: Residual magnetic map of second order, (Lake Manzalah).

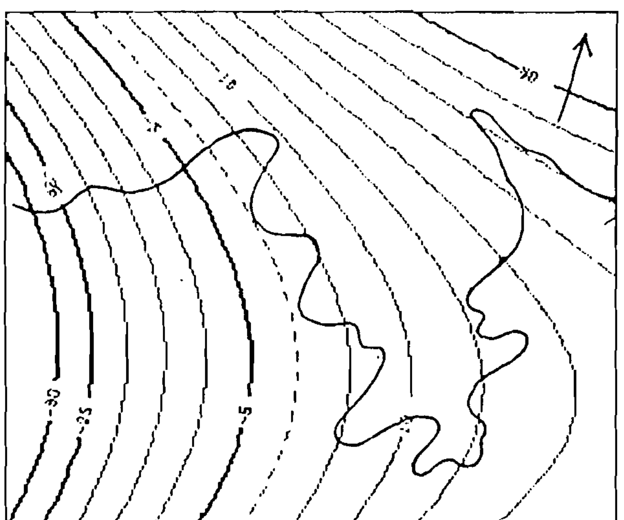


Figure 22: Regional magnetic map of second order, (Lake Manzalah).

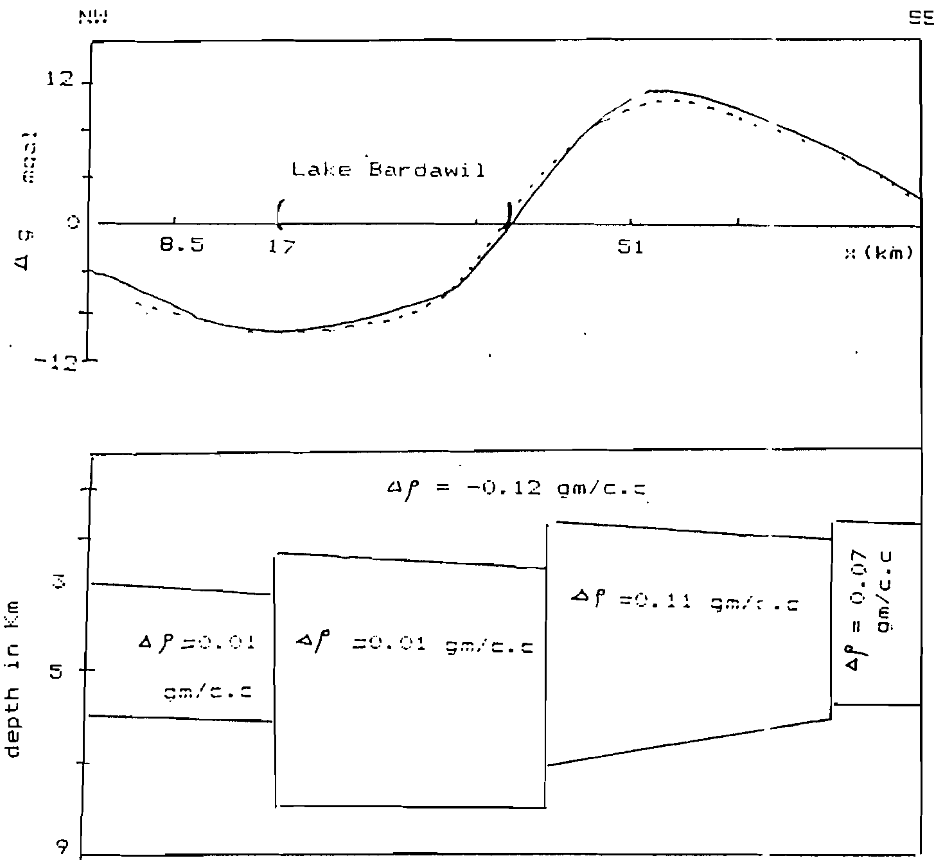


Figure 23: Gravity model of Lake Bardawil profile.

The middle depth bodies have their variable density contrasts which range between 0.01 and 0.11 x 10^3kg m^{-3}. These bodies are affected by many faults which extend to the underneath basement rocks.

CONCLUSIONS

The analysis of the potential field data of Manzalah and Bardawil lakes gave evidence that lake Manzalah has a different formation in its different parts. It is formed by differential subsidence accompanied by uplifting in the neighboring parts. This subsidence may be due to some local tectonic activities prevailed in the area during the Post Miocene time and / or indirect from the structures formed during Pre-Miocene time.

Concerning lake Bardawil area, the interpretation of such anomalies as shown:

-The lake is formed in all its parts simultaneously.

-Shallow tectonic origin, may be responsible for the formation of this lake.

REFERENCES

Cooley, J.W. and Tuky, J.W., 1965; An algorithm for machine calculation of the complex Fourier series; Math. Comp. V. 19, P.237 - 301.

Dean, W.C., 1959; Frequency analysis for gravity and magnetic interpretion; Geophys. V. 23, P. 97 - 127.

El-Sayeda, M. 1993; Comparative geological and geophysical studies on the origin of the Northern Egyptian lakes; Ph. D. thesis submitted to Geoplogy Department, Faculty of Science, Alexandria University, (unpuplished).

Fares, H.H., 1990; Utility of filtering and isolation techniques in evaluation of separate geologic phenomena or structures, using magnetic and gravity data, (unpublished).

Lack, D.I. and Scollar, I., 1969; Spatial filtering in wave vector domain, Geophys. V. 34, P. 916 - 923.

Linant de Bell, Barthout, J. and Daressy, G., 1973; Memoir sur les principaux travaux d'elite publique executis en Egypte depois lasphus hsute, Antique J., Paris, P. 47 - 88.

Naidu, P., 1969; Estimation of spectrum and cross-spectrum of aeromagnetic field using fast Fourier transform techniques, Geophys. Proc., V. 17, P. 344 - 346.

Reed, J. E., 1980; Enhancement and Isolation wavenumber filtering of potential field data, unpublished Purdue University, 205p.