CONSTRUCTION OF BASEMENT DEPTH MAP IN AL-JEZIRA AREA NORTHWESTERN IRAQ USING TWO-DIMENSIONAL SPECTRAL ANALYSIS TECHNIQUE

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ABSTRACT

A basement depth map can be considered as an aiding tool in deducing the structural and stratigraphical features existing in the sedimentary sections overlying basement rocks. Sometimes, structures within the sedimentary cover that affected by basement relief were individually acquired it's geometrical characteristics as a result of compaction occurred in sediments around hills or protrusions carved on an underlying basement, this may caused structural closures on overlying sedimentary formations. In this paper, a basement depth map of Al-Jezira area north western Iraq is constructed from gravity data by applying two-dimensional spectral analysis technique. The estimated basement depth values are ranging between (6) km in the northwestern part of the studied area to about (10.5) km in the eastern part of it.

بناء خارطة لعمق صخور القاعدة في منطقة الجزيرة شمال غرب العراق بأستخدام تقنية تحليل الطيف ثنائي الأبعاد

أمين أبراهيم أمين الياسي 1 عماد حسن رضا الخرسان 2 علي زباري سبتي الخشان 2
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الخلاصة

تعد خرائط أعماق صخور القاعدة كوسيلة مهمة لأستنباط الشواهد التركيبية المتواجدة في المقاطع الرسوبية التي تغطي صخور القاعدة. في بعض الأحيان ، التراكيب الجيولوجية المتواجدة ضمن الغطاء الرسوبي المتأثر بتضاريس صخور القاعدة التي أكتسبت مواصفاتها الهندسية بشكل مستقل قد نتجت بفعل عملية الأحكام الحاصلة للرواسب حول التلال والبروزات المنحوتة تحت صخور القاعدة والتي بدورها قد تسببت في ظهور أنغلاقات تركيبية في التراكيب الواقعة فوق صخور القاعدة ضمن الغطاء الرسوبي. في هذا البحث ، تم بناء خارطة عمق لصخور القاعدة في منطقة الجزيرة شمال غرب العراق أعتمادا على المعطيات

الجذبية من خلال تطبيق تقنية تحليل الطيف ثنائي الأبعاد. أن القيم التخمينية لعمق صخور القاعدة تتراوح بين (6) كم في الجزء الشمالي الغربي من منطقة الدراسة الى حوالي (10.5) كم في الجزء الشرقي منها.

INTRODUCTION

Spectral analysis methods have been used widely in recent years to estimate the basement depth. In these methods, the characteristics of the observed anomalies are studied firstly by transforming the potential data from space domain (areal domain) to frequency domain (wave domain) and then analyzing their frequency characteristics (Båth, 1974).

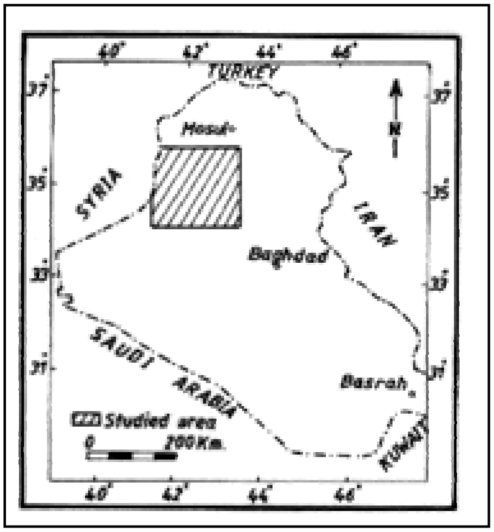
Power spectra almost indicate two distinct depths which will be related to a set of deeper and a set of shallower sources. In some cases, the depth extent of one set of sources can also be estimated (Hahn *et al.,* 1976 and Negi *et al.,* 1984). The errors in source depth prediction are related closely to the window size. For gravity field, a window of six times the source depth is required for <10% information loss (Regan and Hinze, 1976). This condition was verified in this study. The power spectral method is applied to profile data and it is obvious that the same approach can be followed for the solution of two-dimensional data by computing the radial spectrum of all the particular waves falling with a certain frequency range.

Many investigators tried to calculate the basement depth in the same region, northwestern Iraq using different available geophysical techniques. Al-Banna, 1992 used gravity and magnetic anomaly maps of Al-Jezira area to predict the average basement depth. Also, Aziz, 1986 carried out seismic reflection surveys in the western parts or Iraq in order to detect basement depth. Moreover, Compagnie General De Geophisque C.G.G, (1974) interpreted the Aeromagnetic map through the application of the Inflection Tangent Intersection (ITI).They found that basement depth of the investigated area is reached about (6.5), (6.5-7.5), and (6-9) km respectively. Consequently, the main task of this research is to determine the basement depth at the same area (which represent one of the suitable locations for searching about hydrocarbon producing structures) by applying much a cute modern technique called (Power spectrum).

A basic program prepared by Dimitriadis *et al.,* 1987, was used for two-dimensional spectral analysis of gravity data to get accurate basement depth, and therefore, to exploit the obtained results in order to make a possible comparison with the basement depth estimations achieved before.

TECTONICS AND STRUCTURAL SETTING

The studied area is a part of Al-Jezira area, northwestern Iraq, (Fig.1). It is a square in it's shape and most of it is located on the stable shelf of the African-Arabian platform, i.e., within Rutba-Jezira zone (Jezira subzone) and Salman zone. The Jezira subzone, which covers most parts of the considerable area, had been stable during Mesozoic-Tertiary times, but was apparently more mobile through Infracambrian and Paleozoic times (Buday and Jassim, 1987).



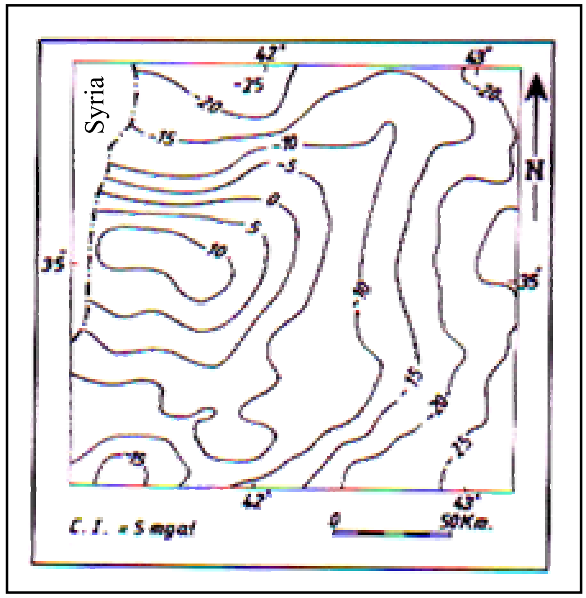
(Fig.1) Location map of the studied area from (Al-Banna, 1992)

The structure of Al-Jezira subzone is characterized by short antiforms and structural noses, arranged in different directions. The blocks within this subzone, which characterized by narrow grabens, are most probably caused by differential movements along the deep faults. Salman zone is not subdivided in any subzone because the zone in it's northern part, though very restricted, has the same characteristic features as the bulk of it in the south. The zone represents the eastern unit of the stable shelf. The basement in the Salman zone had been more stable during the Pre-Mesozoic epochs, but on contrary more mobile through Mesozoic-Tertiary development stages. The depth of the basement, in Salman zone, ranges between (6-7) km (Salomy and Al-khatib, 1982).

GRAVITY MAP OF THE INVESTIGATED AREA

Bouguer anomaly map of the studied area is a part of the Bouguer anomaly map of Iraq, with scale 1:1000000 which compiled by Abbas *et al.*, 1984, (Fig.2). Gravity maps and data obtained from IPC, MPC, BPC, and the S.E. of Geological Survey and Mining (SEGSM) were unified to produce the Bouguer anomaly map of Iraq using statistical and computer techniques. The gravity measurements were carried out along (10x10) km grid profiles with one kilometer spacing between gravity points (Sŭtor and Odestreil, 1977).

Bouguer anomaly map of the area understudy includes gravity values ranging from less than (-25) mgal in the eastern parts to more than (+10) mgal in the western part. The map is characterized by a broad positive gravity anomaly of more than (+10) mgal in it's center. The anomaly is located near the Syrian borders and it represents the only positive one all over Bouguer gravity map of Iraq. This anomaly may reflect the effects of supra basement bodies, i.e., due to reliefs on the basement surface. This high gravity anomaly also coincides with the locations of Sinjar-Sharaf Divide proposed by Buday and Jassim, 1987. This divide is characterized by numerous high gravity anomalies with positive magnetic anomalies. In the eastern part of the map, gravity values are decreasing gradually to less than (-25) mgal, and this may result from the increase in the depth of basement toward the mesopotamian trough.To prepare data for computer analysis, the Bouguer anomaly map was firstly digitized into grid interval of (2) km, forming a square grid area of (100x100). Then data was interpolated using cubic spline program to form (64x64) square grids with new grid interval equal to (3.13) km (≈3 km). The second process was done to make the dimensions as one of the powers of two (number 2), which is required to be used in the Fast Fourier Transform (FFT) program utilized in this work.



(Fig.2) Bouguer anomaly map of the studied area

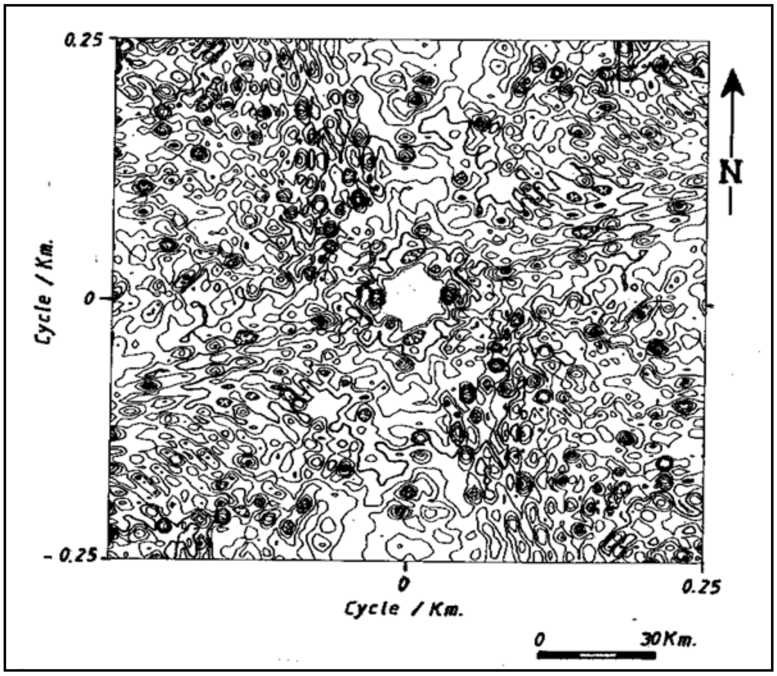
BASEMENT DEPTH ESTIMATIONS

Wavenumber filtering is one of the effective techniques in separating the regional field from local anomalies. To design suitable filters, it is neccesary to get information based upon the two dimensional power spectrum of the gravity data, calculated by direct method using Fourier transform, after removing alinear regional field by fitting a least squares plane to this data. Before the power spectrum computation, gravity data were subjected to cosine tapering to reduce edges effects. Near the center of the contoured map, (Fig.3), the low wavenumber contributions associated with regional components of the gravity field are represented. High wavenumber components associated with local anomalies are represented in the outer parts of the map. These high wavenumber compenents result from many sources of local anomalies, and there are no clear cut or readily identifiable features that can be related directly to specific geological bodies or structures. The two-dimensional power spectrum in this figure has been averaged over circles in the wavenumber domain to produce estimates of two-dimensional power spectrum as a function of wavenumber only (Mishra and Pederson, 1982). Most of the techniques used involve Fourier transformation of the digitized gravity data to compute the amplitude spectrum. This is plotted on a logarithmic scale against wavenumber, and the plot shows straight-line segments which decrease in slope with increasing frequency. The slopes of these segments yield estimates of average depths to the gravity or magnetic sources (Sharma, 1986 and Dimitriadis *et al.,* 1987). The linear segments in the spectrum are identified; these segments are related to differing source depths. Consequently, depth estimates based on the Bouguer anomaly spectral profile are:

h_1=31.2 km. for the thickness of the crust.

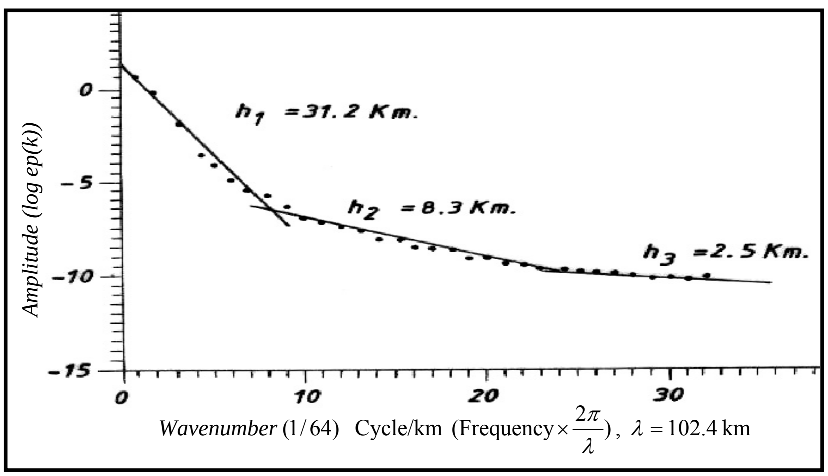
h_2=8.3 km. for the depth of deeper sources (Basement surface).

h_3=2.5 km. for the depth of shallower sources (in the sedimentary cover).



(Fig.3) Two-dimensional power spectrum map of the studied area

Since the gravity map covers a large area including many geological structures at different depths, the depth values estimated can only be explained as an average depth over the whole area, (Fig.4).



(Fig.4) Two-dimensional power spectrum (averaging)

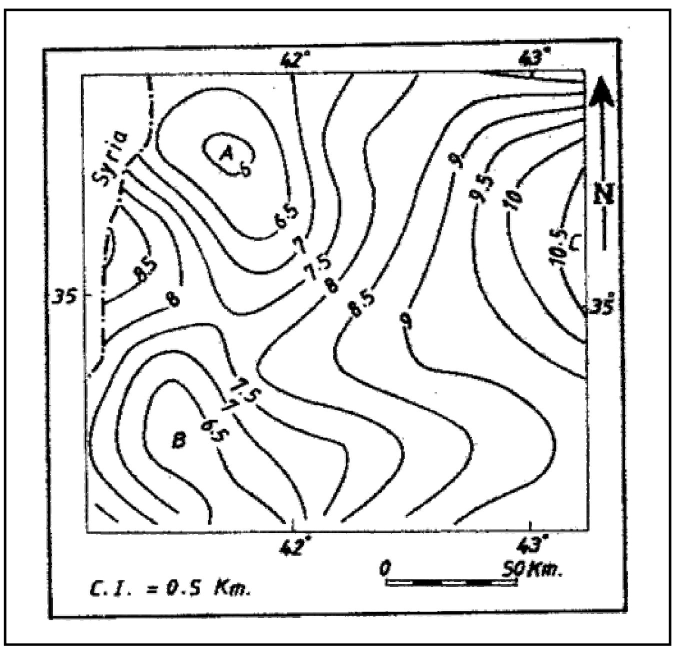
MAP OF THE BASEMENT DEPTHS

The spectral analysis method has been extensively used for determining the average depth to the basement rocks using gravity and magnetic data. Acute modern program prepared by Dimitriadis *et. al.,* 1987 has been used to estimate the average depth to basement rocks. After defining the size and location of the first window, the program automatically scans over at the predetermined step interval. Then depth to the source for the specific window is evaluated.

Care has to be taken in the selection of the lower and upper limits of the wavenumber. The selection of the linear segments is very important in source-depth estimation. Before the measurements of the depth estimates to the basement, it is neccesary to compare some of the measured values with actual depth values because this comparison will help in the correct selection of the linear segments in Iraq. There is no direct information on the crystalline basement, since the basement dose not crop out and no borehole has penetrated the whole sedimentary cover. In this paper, correlation between measured depth values in the west part of the studied area with the basement depth values near Syrian borders (taken from Seber *et al.*, 1993 and Berew *et al.,* 1997) reached more than (8) km. The correlation indicates that these values are comparable.

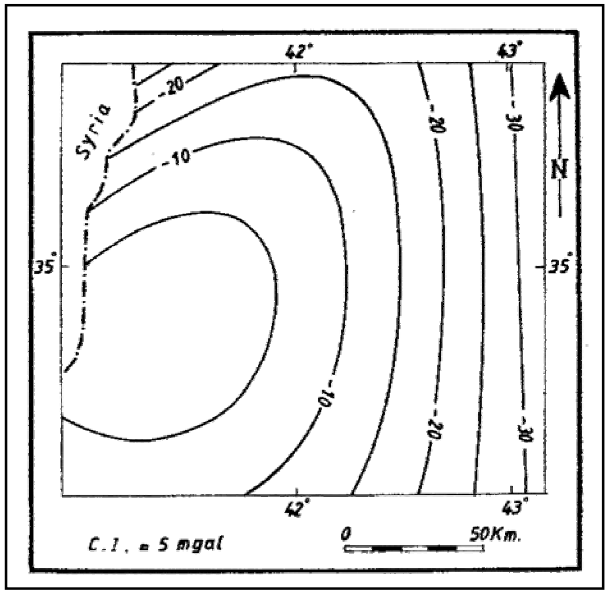
Contour basement depth map measured by spectral analysis of the gravity data had been constructed, (Fig.5). On this map, depth values range from about (6-6.5) km at locations (A) and (B) to about (10.5) km at location (C), these values also reflect the thickness of sedimentary cover in the considerable area. The elevated locations mentioned above, i.e., locations (A) and (B) coincide with the broad positive anomaly of more than (+10) mgals near the Syrian borders, (Fig.2). This anomaly is the only positive one all over the Bouguer gravity map of Iraq and it may reflect the common effect of the supra-basement bodies (A) and (B) shown in this figure. The locations of these two bodies coincide with the location of Sinjar-Sharaf Divide, which is characterized by numerous high gravity anomalies accompanied with positive magnetic anomalies.

In the eastern part of the extracted map, the basement depth values are increasing gradually to more than (10.5) km at location (C) which reflect the increase in the sedimentary cover in that direction.



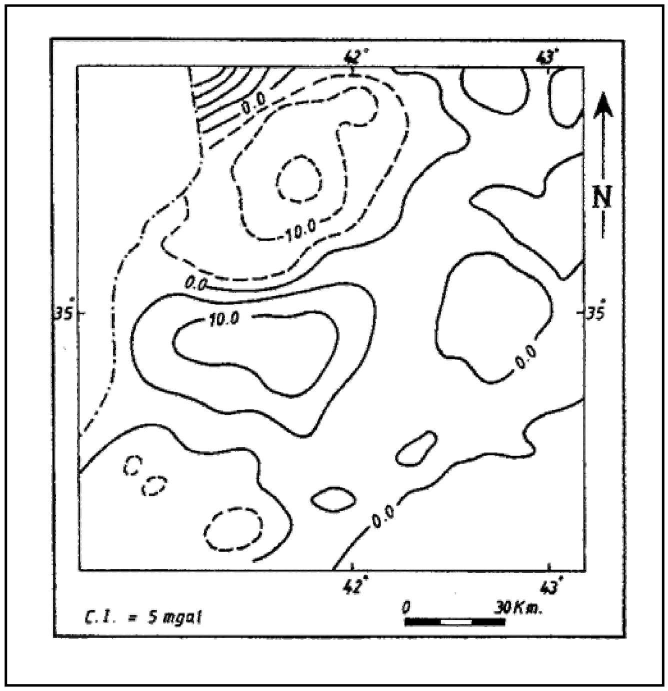
(Fig.5) Basement depth map of the area understudy

Regional gravity map of the mentioned area, (Fig.6), shows that there is a high density basic igneous body embeded in basement rocks and this body may continue deeply in the crust.

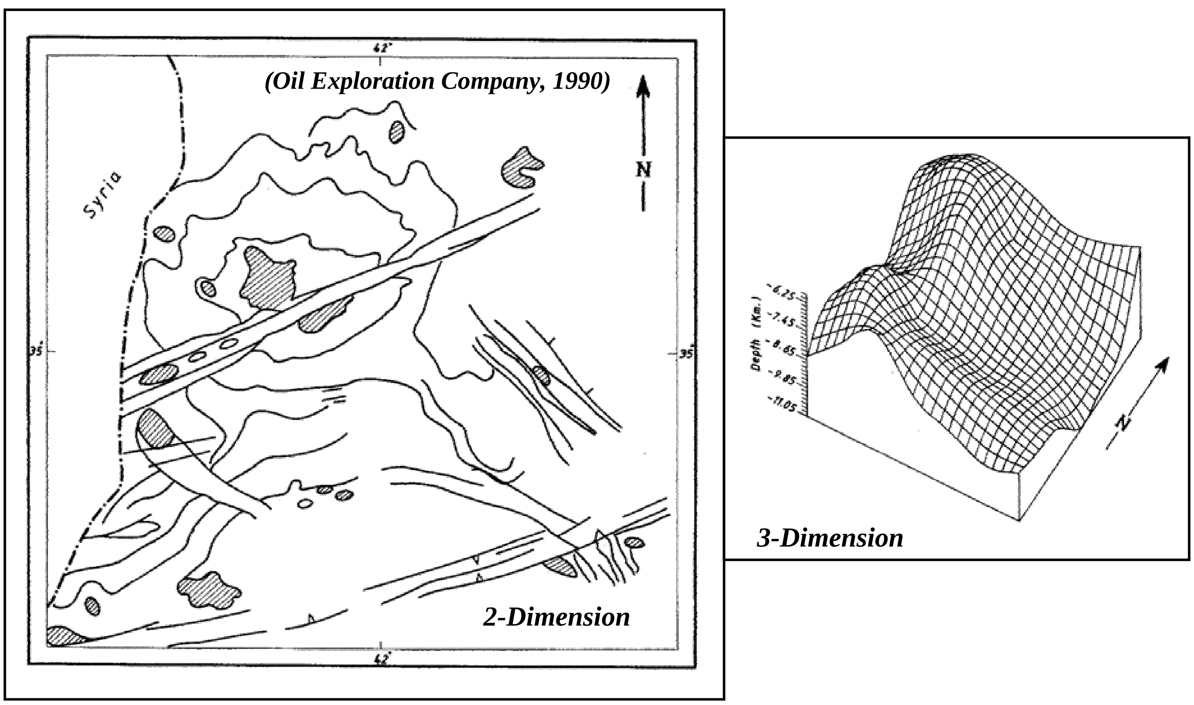


(Fig.6) Regional gravity map of the investigated area.

Residual gravity map of the area, (Fig.7), indicates that, sedimentary cover was affected by the two supra-basement bodies or the two basement protrusions (A) and (B). This was indicated by two positive anomalies nearly coincide with these two protrusions and emphasized by the structural map of the studied area, (Fig.8). In this figure, a large domal structure was separated into two parts, each part may be affected by one of the basement protrusions (A) and (B) mentioned before.



(Fig.7) Residual gravity map of the area understudy



(Fig.8) Structural map of the selected area showing the discovered oil fields

DISCUSSION AND CONCLUSIONS

Depth estimations to the crystalline basement rocks, inside the investigated area using power spectral method, range between (6-10.5) km. These values approximately agree only with the values interpreted by C.G.G. (1974) in the studied area, and with actual basement depth values east of Syria obtained from drilling wells or avaliable seismic data.

A basement depth estimates map can be used in deducing the structures developed in the sedimentary cover overlying basement rocks. The compaction of sediments around protrusions carved on underlying basement could cause structural closures on overlying sedimentary formations. Since compaction mechanism is responsible for a significant percentage of oil and gas producing structures in the world, the area under investigation may be considered as one of a good locations to search for hydrocarbone producing structures, especially over (A) and (B) protrusions.

Litak, *et al.,* (1998) indicated that approximately (30) oil field have been discovered in the Euphrates graben system, in the vinicity of the studied area, since 1984. Recoverable reserves discovered to date reportedly exceed (1) billion barrels of oil and lesser amount of gas. Light oil is primarily found in lower cretaceous sandstone reservoirs. This discovery of oil and gas in the Euphrates graden system (to the west and southwest of the studied area) in addition to the high thickness of sedimentary cover may put this area as one of the important targets in the future.

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