



ISSN: 0067-2904

Gravity and Magnetic Interpretation to Study Deep Crustal Structures In Karbala and Surrounding Areas-Central Iraq

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Abstract

Gravity and magnetic data were used to study the deep crustal structures in Karbala and surrounding areas in central Iraq. The space window method was used to separate the residual from regional anomalies of gravity and magnetic data, the spaces of window are equal to 48,36 and 24 km. The Total Horizontal Derivative (THD) techniques and local wavenumber of gravity and magnetic are used to identify the faults and their trends with the basement rocks. The N45W, N45E, N-S and rarely E-W trends of faults are detected in the basement rock. It is believed that some of these faults extending from the basement to the uppermost layer of the sedimentary rocks.

Keywords: Bouguer anomaly, Magnetic RTP, Window method, THD, K, Karbala-Iraq

تفسير المعطيات الجذبية والمغناطيسية لدراسة تراكيب القشرة الأرضية العميقة في كربلاء والمناطق المجاورة لها -وسط العراق

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الخلاصة

استخدمت المعطيات الجذبية والمغناطيسية في منطقة كربلاء و المناطق المجاورة لها وسط العراق لدراسة تراكيب القشرة الأرضية العميقة . تضمنت الدراسة استخدام طريقة تغير النافذة (windows) لفصل الشواذ الجذبية و المغناطيسية المحلية عن الاقليمية .فيما استخدمت طريقة الانحدار الافقي الكلي (THD) وطريقة (Local wave number) في معالجة المعطيات الجذبية والمغناطيسية وذلك لتحديد اماكن الفوالق وتعرف اتجاهاتها في القشرة الأرضية وتم تحديد اتجاهات الفوالق في منطقة الدراسة و تبين انها باتجاهات (N45E)، (N45W) واخرى باتجاه (N-S) ونادرات (E-W). ام كن تقسيم المنطقة الى عدة بلوكات اعتماداً على حدود الفوالق الرئيسية في المنطقة .

Introduction

The potential methods (gravity and magnetic) are considered as an important geophysical survey method to delineate faults in the subsurface structures, also they are used to determine the thickness of the sedimentary cover in the sedimentary basins [1]. The crustal structures of the study area can be inferred from the gravity and magnetic data. The magnetic anomalies are related to the source depth or the change in rock lithology(susceptibility change). The gravity anomalies reflected the change in depth or density of rocks (variation in lithology). The total horizontal derivative (THD) is developed by many authors to enhance the magnetic and gravity fields. This technique is used to detect the tectonic boundaries and faults, the source edge caused the gravity and magnetic anomalies [2]. The

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source parameter imaging (SPI) technique usually used to introduce the basement rock map from magnetic data [3]. The depth and faults within the basement detected in many areas in Iraq [4] and [5]. The aim of this study is the interpreting of available gravity and magnetic data, in order to study the crustal structures of the study area.

Location of the study area

The study area is located in the central Iraq between Longitudes 44 ° 45' - 43° 09' East and latitude 33° 32' 42" _ 31° 47' 24" North as shown in Figure-1 , the area has square shape with length of 193km, width equals 148km and area of 28817 km .

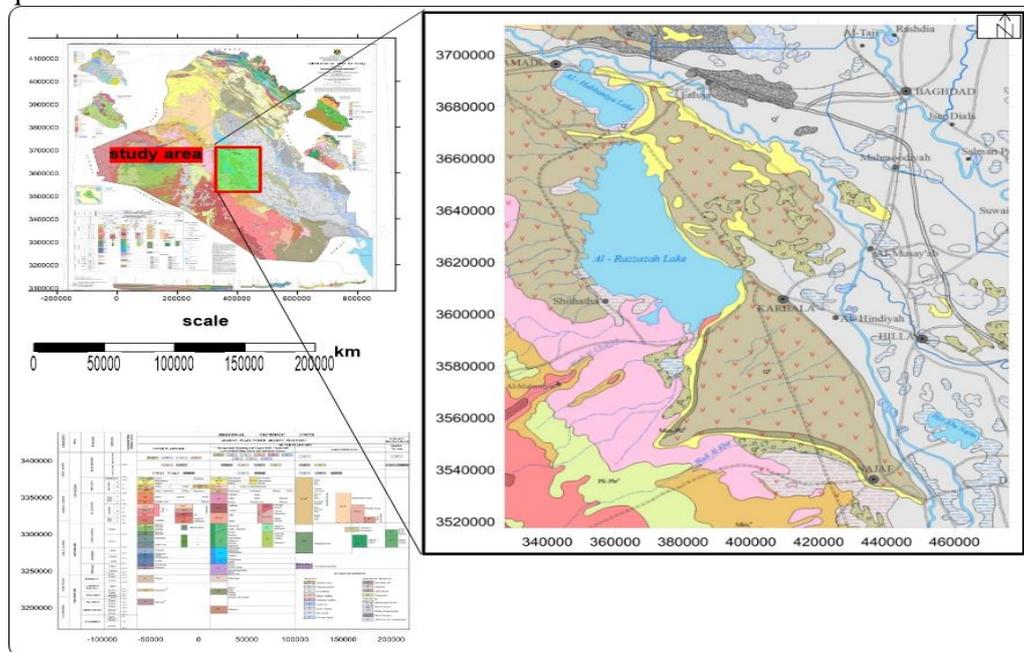


Figure 1 Shows the location of the study area.

Geology of the Study Area

The Sedimentary rocks of some Tertiary and Quaternary deposits were outcropped formation Figure - 2, the outcropped formation in the study area are described from the oldest to the youngest formation.

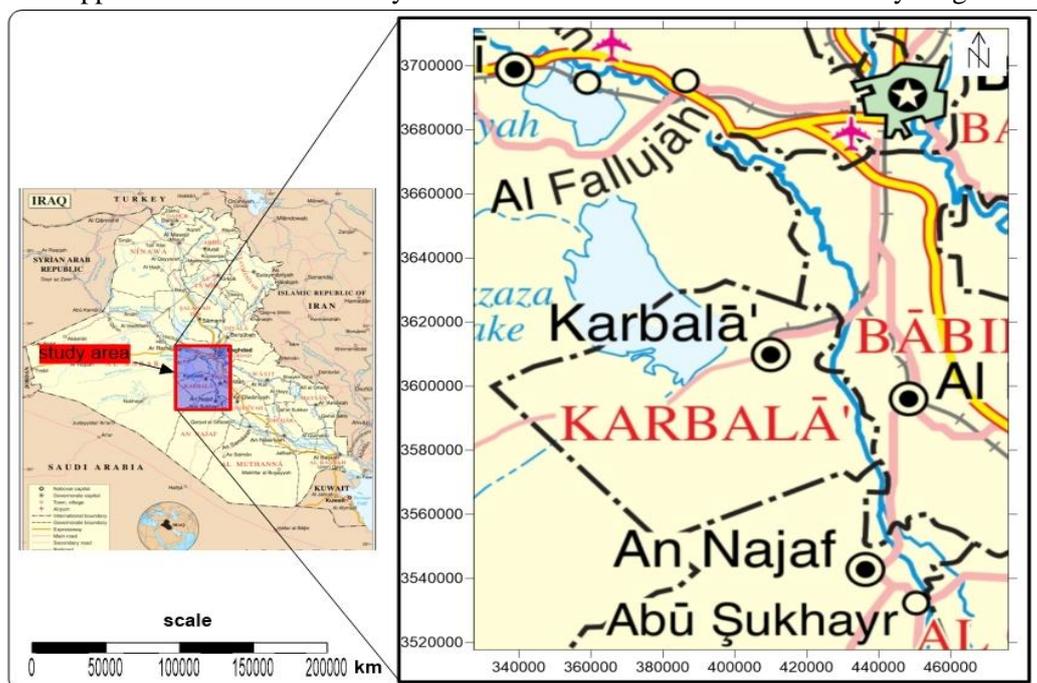


Figure 2- Geological map of the study area

1- Injana Formation (Upper Miocene): this formation outcrops along the eastern coast of Al-Razazah Lake to the west of Karbala city. While in the east of the areas it is either covered with Dibdiba formations deposits or thick layers of recent deposits. This formation is basically composed of sand and clay rocks of different colors (Green, grey, and brown). The contact between the Injana formation and the Diddiba formation appears as a soft layer of gravel. The environment of deposition varies from being marine to continental [6].

2- Dibdiba Formation (Pliocene): this formation is outcrop in the area between Al-Razazah Lake and Karbala city from the north-west and west sides; it is mainly composed of sandstones, gravel sandstones, and lenses of claystone. It is cover Injana formation and the environmental deposition of this formation is continental [7]. There is a Gypcrete layer composed of sand, shale, gravel, and a high percentage of Gypsum in this formation, and they are from the Quaternary. The Karbala area represents a depocenter of the Dibdiba formation along the Euphrates boundary fault [8].

3- Quaternary Deposits: these deposits are outcrop inside Karbala city and extend to the Euphrates River and are composed of sand, shale, clay and there is gravel in some of the areas especially Pleistocene deposits that exist in the northern part of the studied area. The thickness of these deposits varies and increases as we move towards the Euphrates River. The environmental deposit of these continental deposits happened due to erosion and precipitation [7].

Tectonics and structure of the studied area

Karbala city and its surrounding areas are located between the stable platform (Al-Salman sub-zone) and the unstable platform (Mesopotamian sub-zone) Figure-3. The unstable shelf or the outer platform represents the eastern and northeastern extension of the stable platform. The thickness of the sedimentary cover is relatively thin at the western part of the study area and it increases toward the east [5]. Many deep and shallow faults were showing on the tectonic map [9]. AL-Razazah considers as a drainage basin, which extended in NW-SE trend with 60 length and 30km width [10]. This lake controlled by many faults and the age of this lake is pilocene-Pleistocene [11].

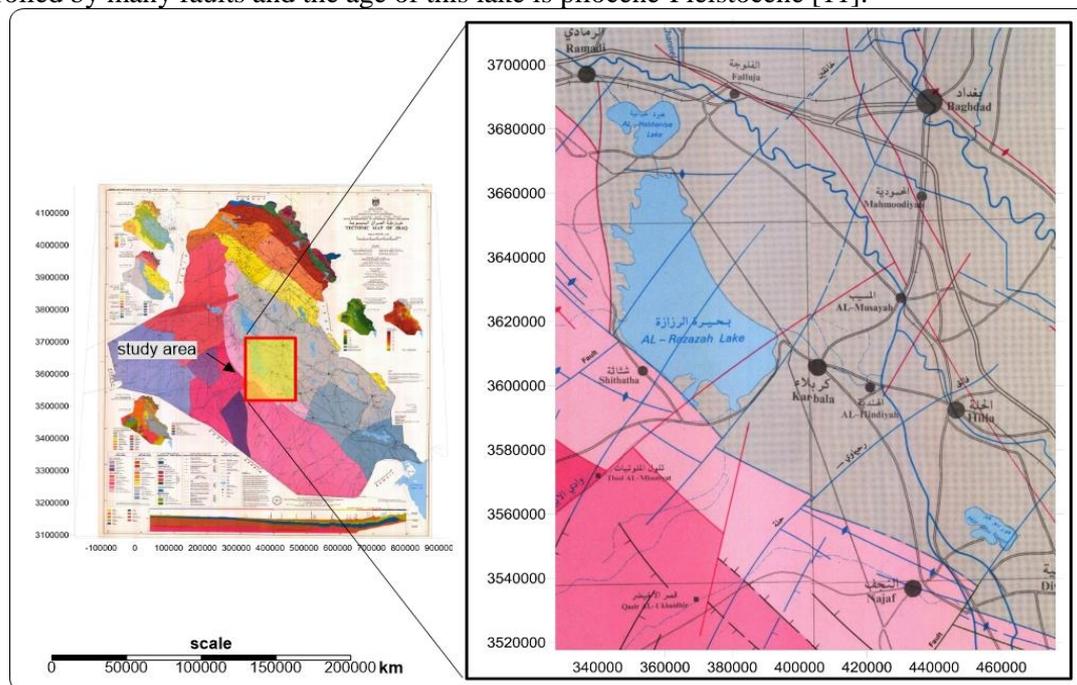


Figure 3- The Tectonic map of Iraq showing study area is affected by the general trend of transversal fault systems is NE – SW, and Najd fault system are NW-S [7].

Data acquisition and processing

The Bouguer anomaly map of the study area Figure(4A) was compiled at a scale of 1: 1000 000 with 2 mgl contour interval. This map is published by GEOSURV and Iraq Petroleum Company (IPC). The Aeromagnetic map total intensity map of the study area is part of the Aeromagnetic total field intensity map of Iraq Figure-(4B). It is constructed by the Company General de Geophysical

(CGG, 1974). The aeromagnetic map used in the current study plotted with one nT. This map digitized with grid interval (1Km²).

A set of gravity and magnetic data were digitized and derivatives designed to highlight subsurface borderlines and structural directions have been calculated and provided as jpeg images in the Surfer project. Figures-(4A) and (4C) show gravity and the Reduction to Pole (RTP) magnetic anomalies maps. The figures were digitized at a grid interval of equivalent (1Km²). These maps show that the western part of the study area characterized by high gravity and magnetic anomalies. The gravity and magnetic value decrease toward the northeast and southeast Figures-(4A) and (4C), this criteria may coincide with the increase of the basement depth toward the east .

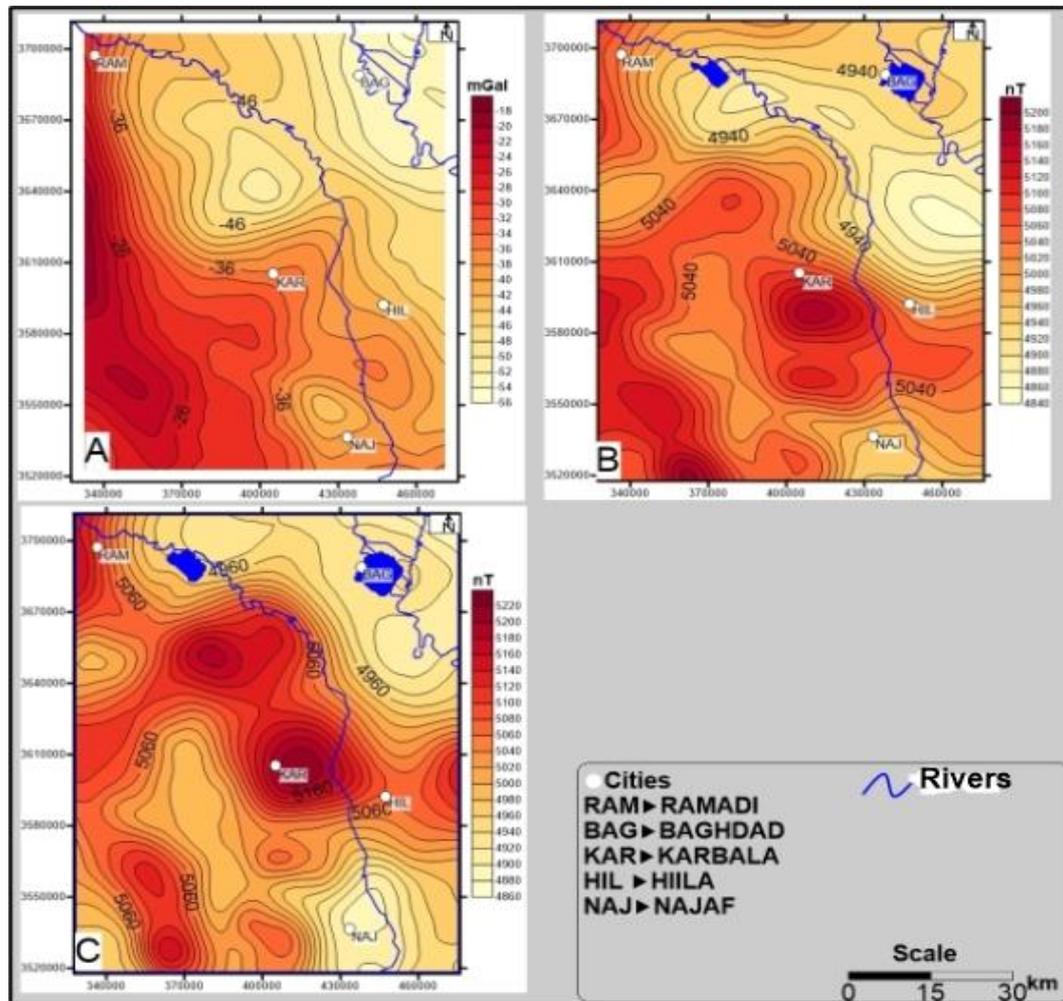


Figure 4- (A) Residual Bouguer Gravity anomaly map, (B) Total Magnetic Intensity anomaly map (TMI) (C) Reduction To Pole Magnetic anomaly map (RTP)

Residual anomaly Separation

The gravity and magnetic anomalies mainly reflect the variation in density or susceptibility which can indicate a structures feature in the crust of the study area. Several local gravity anomalies are also detected. These local anomalies may be related to the features within the sedimentary cover. The separation of the residual gravity and magnetic carried out using three space windows these are (48,36 and 24 km). Effect of deep Crustal structures are obtained from the gravity and magnetic residual maps, using 48, 36km and 24km spacing windows Figure-5, these maps showing a positive residual gravity and magnetic anomalies mostly trending NW-SE and NE-SW.

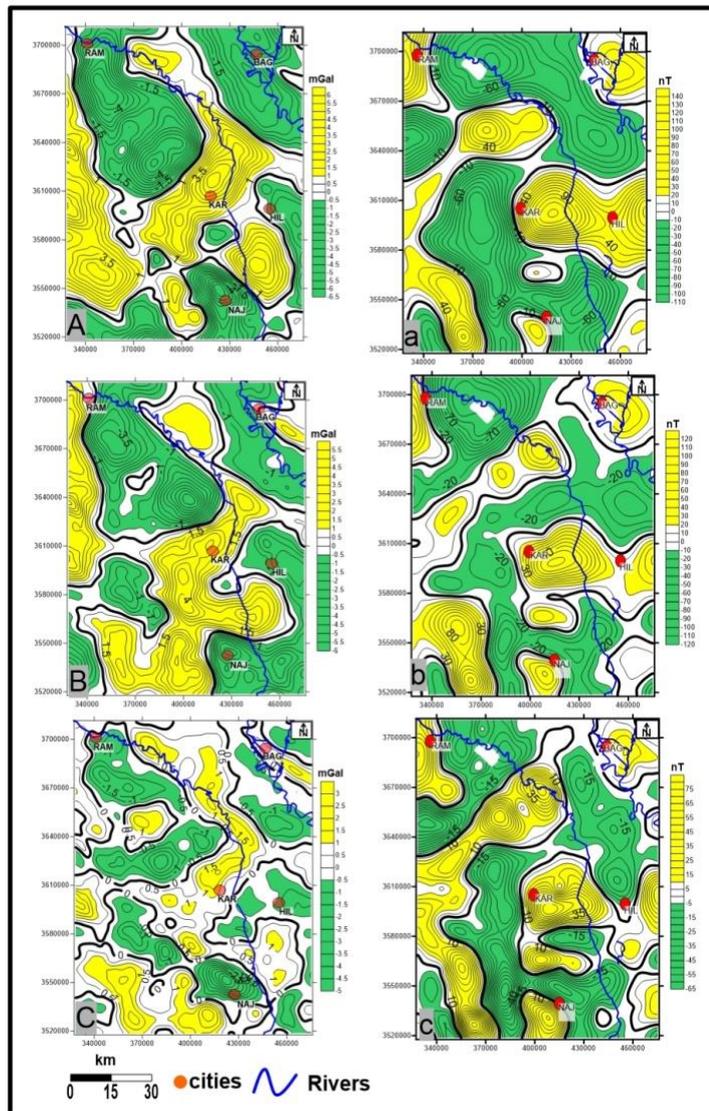


Figure 5- Residual gravity anomaly maps of windows (A): 48 k (B):36 km (C):24 km and residual magnetic anomaly maps of windows (a):48 km (b):36km (c): 24km

Edges detection of gravity and magnetic anomalies

Edges detection and depth estimation techniques are a very important step in the analysis and interpretation the gravity and magnetic data, numerous transform, and enhancement were applied to detect the source boundaries of gravity and magnetic anomalies, the Total Horizontal Derivative (THD), and Local Wave Number method (k) techniques were applied to the gravity and RTP magnetic maps.

Total Horizontal Derivative (THD) of gravity and RTP magnetic data

The Total Horizontal Derivative technique is designed to detect contact or faults features, the maximum values in the mapped derivative indicate source edges. The THD considered as a complementary technique to the filtered residual gravity and magnetic maps[12]. The application of total horizontal derivative used to detect the boundary of the source of the residual gravity and RTP anomalies maps which determined to three space windows: (48Km, 36Km, and 24Km) Figure-6. The total horizontal derivative maps of the study area in the general have the differences trend of the edge contact, these are N-S, NE-SW, and NW-SE. The main trends of the relatively deep gravity source of the residual anomalies are N45W, N55W and N35W (Figure-7). The trends of the deep source of the residual RTP magnetic are N15W, N35W, N 55W and N45E Figure-8.

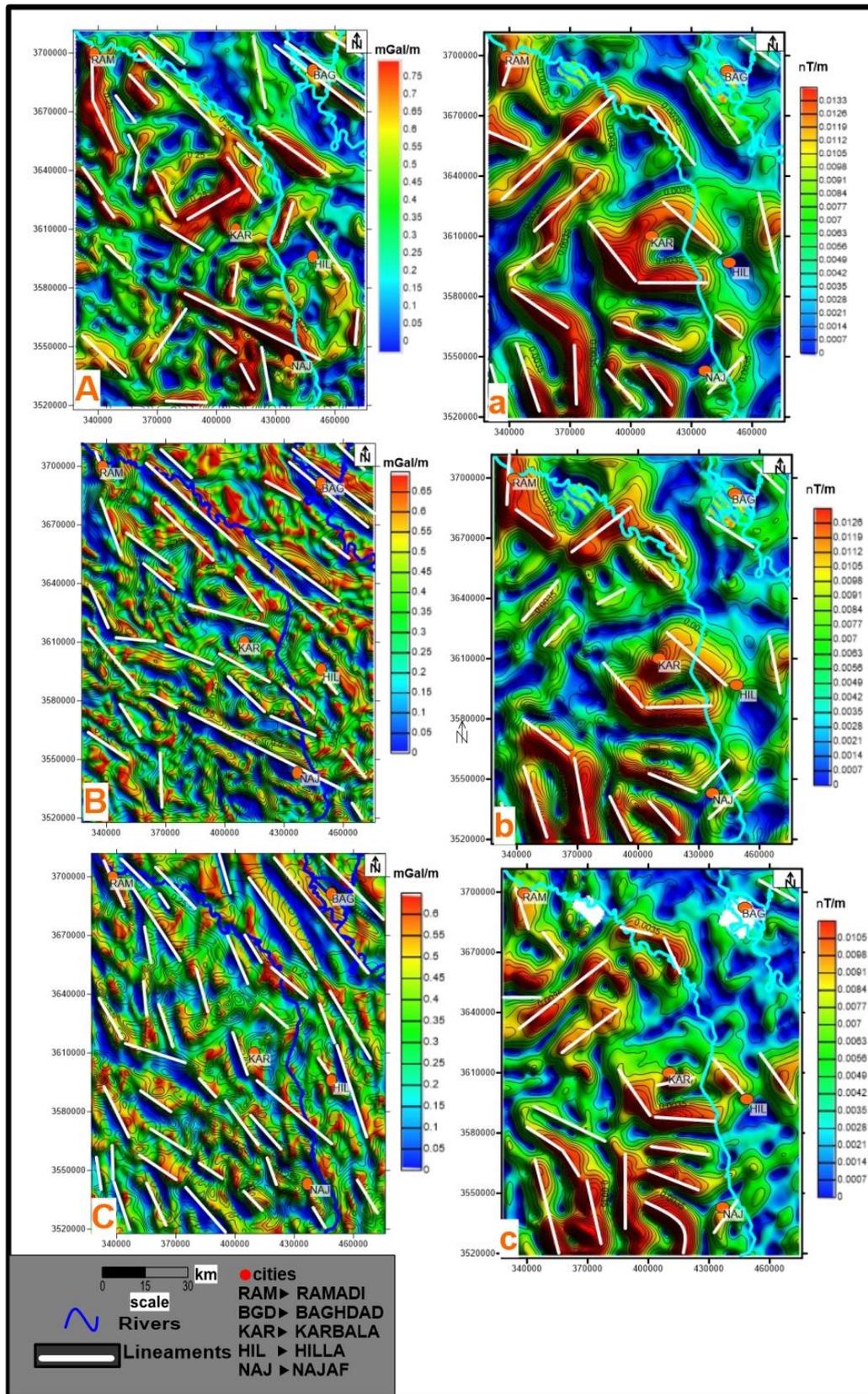


Figure 6 - The total horizontal derivative (THD) and the axes of the maximum values of the residual gravity anomalies of the spacing window: A: 48 km B:36 km C:24 km and magnetic anomalies of spacing Window: a: 48 km b:36 km c: 24 km

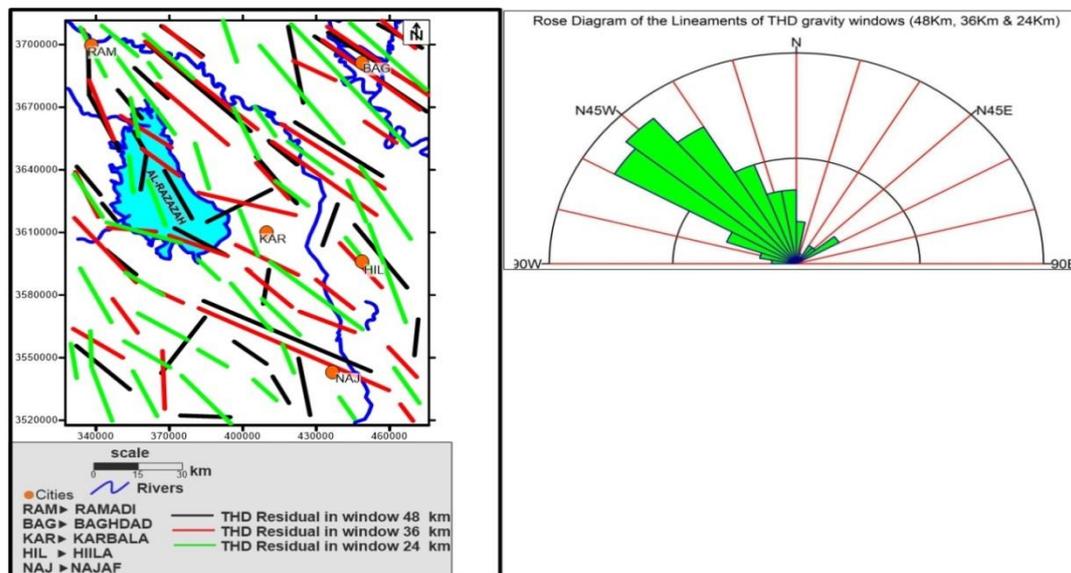


Figure 7- Shows the lineaments obtained from the total horizontal derivative of the residual gravity, for the window spacing 48Km, 36Km & 24Km

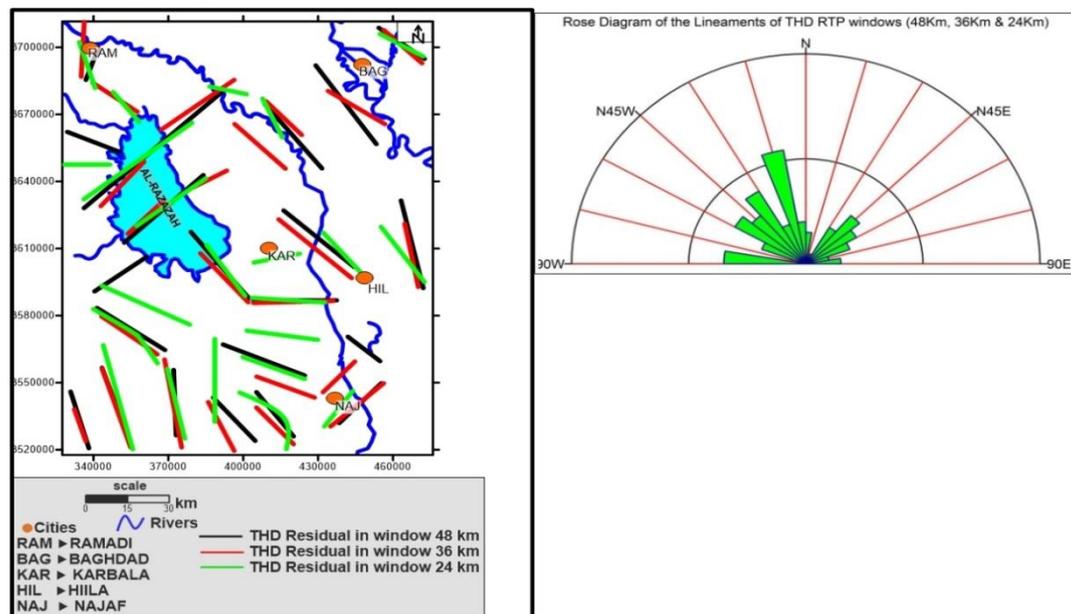


Figure 8- Shows the lineaments obtained from the total horizontal derivative of the residual RTP, for the window spacing 48Km, 36Km & 24Km.

Local Wavenumber (K) of Gravity and Magnetic grid

Source parameter imaging is a grid based on a method for estimating magnetic and gravity source depths, and for some source geometries; dipping, density, and susceptibility contrast. The method utilizes the relationship between source depth and the local wavenumber of the observed field [13]. The practical utility of the method is presented in the current study, uses the traditional and phase-rotated local wavenumbers as a function of the model parameters. The derivative can be solved to determine the horizontal location body without specifying a priori information about the nature of the sources. Using the obtained source-location parameters, the nature of the source can then be inferred. It was able to provide both the location and an index characterizing the nature of the source structure body [13]. The local wavenumber of the gravity and magnetic grids obtained generally the two trends of the maximum edge contact that been (NE - SW and NW - SE), and it indicates the trend direction (N - S) which is limited in the south and southwest part of the study area. These different trend direction supposed for deep (Pre Cambrian) features Figure-9.

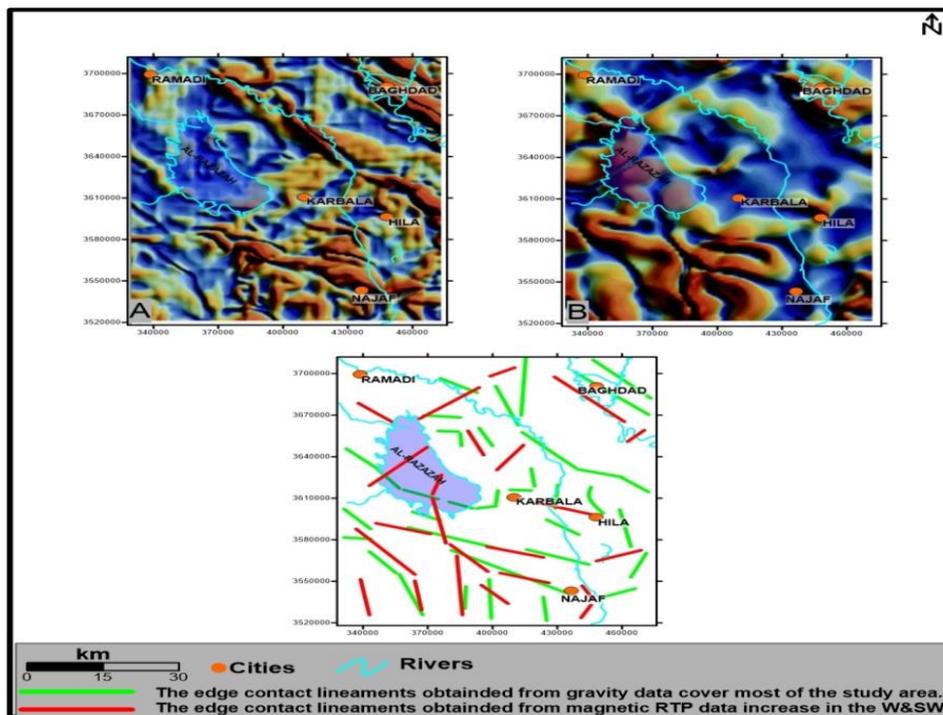


Figure 9- Shows the local wavenumber grid and the traces of maximum edge contact map of the residual (A) gravity and (B) RTP maps, shows the indication and the direction of the edges.

The major tectonic boundaries

Detection of major tectonic boundaries is very important to distinguish the main zones, which have different geophysical and geological characteristic. The potential interpretation using the Total Horizontal Derivative (THD) technique and the residual potential maps of spacing windows(48,36 and 24) are used to obtain the main tectonic boundaries of the study area Figure -10. These boundaries have been adjusted by the boundaries traced according to the results obtained from(THD) of residual potential anomalies of the current study and from previous studies. First major system corre system corresponds to the trend of (NW-SE) Najad faults system, the second major system (NE-SW) Transversal faults system.

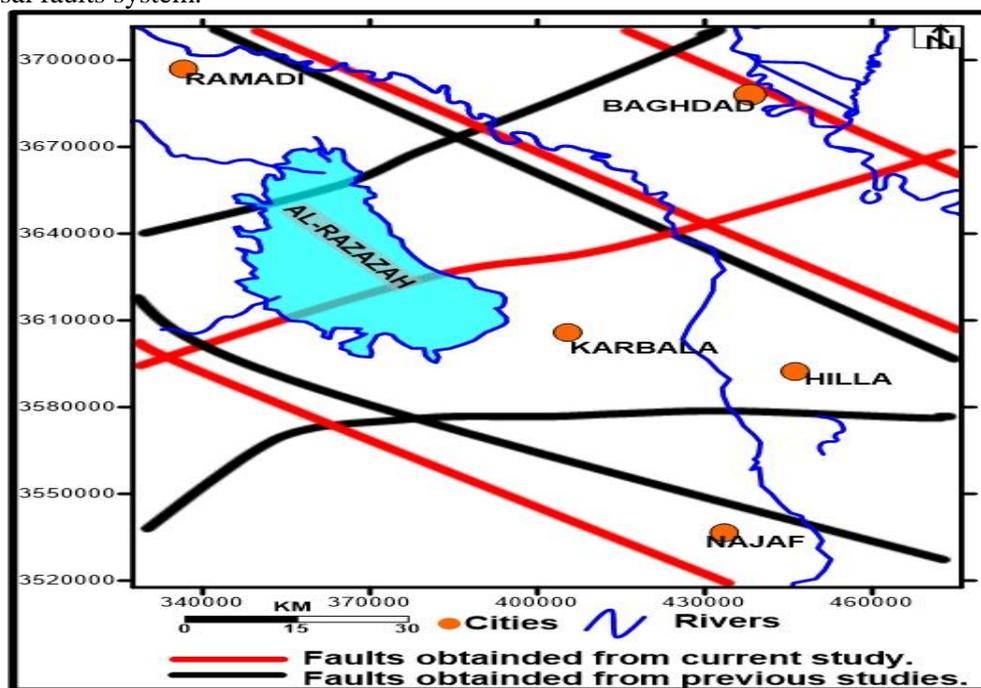


Figure 10- Faults system in the study area.

Conclusions

- 1- The Structural interpretation and analysis reveal three main structural trends. It is represented by (N45W-SE) to (NNW-SSE), (N45E-SW) to (NNE-SSW), (E-W) and less common (N-S) trend
- 2- The Total Horizontal Derivative (THD) and local wavenumber(k) show good results in detection of edge or faults in the study area.
- 3- The residual gravity and RTP magnetic anomalies of spacing 48km, 36km and 24km mostly coincide with each other, This may indicate they belong to same sources.
- 4- Many faults were detected and traced on the tectonic map of the study area.

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