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Determinations of The Depths to Magnetic Sources Over Al-Ma′aniyah Depression Area-Southwest Iraq Using The Aeromagnetic Data and Their Tectonic Implication

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Abstract

Tectonically, the location of the Al-Ma'aniyah depression area is far from active boundary zones, their tectonic features have to reflect the original depositional environments with some horizontal movement due to rearrangement of the basement blocks during different actives orogenic movements. So, the analysis of aeromagnetic data were considered to estimate the thickness and structural pattern of the sedimentary cover sequences for this area. The aeromagnetic data, which are derived from Iraqi GEOSURV to Al-Ma′aniyah region is analyzed and processed for qualitative and quantitative interpretations. The process includes reducing the aeromagnetic data to pole RTP, separation the aeromagnetic data to regional and residual using power spectrum techniques and derivatives methods to delineate the anomalies boundary. The delineated anomalies from magnetic data are dependent for quantitative interpretation using 3D forward and inverse modeling. The depths of magnetic sources are 7-8 km at north and northeastern parts of study area and is about 8-10 km at south and southwestern parts of study area.

Keywords: Al-Ma′aniyah depression, basement blocks, aeromagnetic data, 3D forward and inverse modeling, depth magnetic anomalies.

تحديد الاعماق لأجسام مغناطيسية لمنطقة منخفض المعانية–جنوب غرب العراق باستخدام البيانات المغناطيسية الجوية وتحديد اثارها التكتونية

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الخلاصة

تكتونيا، تقع منطقة منخفض المعانية بعيدا عن المناطق الحدودية النشطة، ولهذا فأن خصائصها التكتونية يجب أن تعكس البيئات الترسيبية الأصلية مع بعض الحركة الأفقية بسبب إعادة ترتيب كتل القاع أثناء مختلف الحركات الأورجوجينية. وعليه، تم اعتماد تحليل البيانات المغناطيسية الجوية لتقدير سمك والنمط الهيكلي لتتابعات الغطاء الرسوبي في منطقة منخفض المعانية. بيانات المغناطيسية الجوية المأخوذة من المسح الجيولوجي لمنطقة المعانية تم تحليلها ومعالجها للتفسير الوصفي والكمي.تم تحليل البيانات المغناطيسية الجوية من خلال تحويل بيانات المسح المغناطيسي الجوي الى بيانات مغناطيسية مقربة الى القطب وتم فصل الشواذ المحلية عن الإقليمية باستخدام طريقة تحليل طيف الطاقة واستخدمت المشتقات لتعين الشواذ المغناطيسية وتم الاعتماد عليها في التفسير الكمي باستخدام نماذج ثلاثية الابعاد. عمق المصادر المغناطيسية هي سبعة الى ثمانية كيلومتر في الجزء الشمالي والشمال الشرقي من منطقة الدراسة وعمقه ثمانية الى عشرة في جنوب وجنوب غرب منطقة الدراسة.

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1. Introduction

The aim of interpretation potential field data is to elicit geological information, [1]. Magnetic prospecting is oldest method of geophysical exploration. It is used to explore for oil, minerals and even archaeological artifacts. In oil prospecting, it gives information from with can determine the depth to basement rocks and thus locate and define the extent of sedimentary basins [2]. The aim of a magnetic survey is to investigate subsurface geology based on anomalies in the Earth's magnetic field resulting from the magnetic properties of the underlying rocks. Surveys carried out to investigate regional geological structure. Applications, from small-scale engineering or archaeological surveys to detect buried metallic object, [3]. The shape of the magnetic anomaly depends upon the shape of the causative body as well as the orientation of polarization vector, which can be changed through the filtering operation, [4]. The depth to source interpretation of magnetic field data provides important information on basin architecture for petroleum exploration and for mapping areas where the basement is shallow enough for mineral exploration. All methods used to estimate depth to magnetic source benefit from discrete, isolated source of bodies of appropriate shape and moderate to strong magnetization. Many magnetic field data sets contain only a few such suitable anomalies. High computing speeds now available to model such sparse resource, it is feasible to replace automated processes with interactive inversion of user selected the anomalies. Inversion produces fewer depth solutions than batch methods, but these should be of greater reliability, and they include estimates of source susceptibility, width, and dip and depth extent, [5].

In Iraq, many areas are left without considerable 3D seismic survey due to bad reflection seismic sections. One of these locations is Al-Ma'aniya depression area, which is located in southwestern part of Iraq. The 2D seismic sections show very bad data and need to extensive work for corrections; these sections could not reflect the images of strata in the area. Al-Ma'aniya depression area is announced for foreign investment for that reason and others. So that, analysis of magnetic data of the area could help to give information about basement depth and relieve beside determine locale anomalies to be in the first priority for extensive seismic work.

2. Location of study area

Al-Ma'aniyah depression area is located in the stable shelf at the southwestern part of Iraq within Al- Najaf province, within Rutba- Jezira Zone and Salman Zone. Tectonic map Figure-1 shows the general trend of transversal fault systems is NE – SW. The transversal fault systems formed during Latest Precambrian by Nabitah Orogeny and re-activated repeatedly during the Phanerozoic. Al-Ma′aniyah depression that lies above the Nukhaib Graben is over 100 km long, 20 km wide and 20 m deep. Paleocene rocks outcrop on both sides of the depression; Middle Eocene limestone occur in isolated outcrops protruding through -20 m of gravel (Nukhaib Gravel) in the middle of the depression,[6].

3. Data of aeromagnetic survey

Aeromagnetic data that have been taken from Iraqi GEOSUR. The aeromagnetic data is derived from aeromagnetic survey of Iraq by C.G.G (Compagine General de Geophysique) in 1974, [7]. The aeromagnetic data covering the study area has motivated the application of a multistate approach for tectonic features identification; [8].The aeromagnetic data is converted to grid data and drown as a total magnetic intensity map for the study area, Figure-2. The magnetic data in map represent total magnetic intensity data. The magnetic anomalies have two parts, positive in the south and negative toward north. This is due to the magnetic inclination, which is near to 45^{o} in the location of the study area. So, all enclosed with red color in map represent the positive part of magnetic anomalies. The magnetic anomalies is concentrated in eastern part of the map with N-S extend then turn toward northwest in the northern part of the maps and surround Al-Ma′aniyah depression area where no magnetic anomalies characterized this area. The positive magnetic anomaly interpret, which is considered as an anticline structure in subsurface, [9].

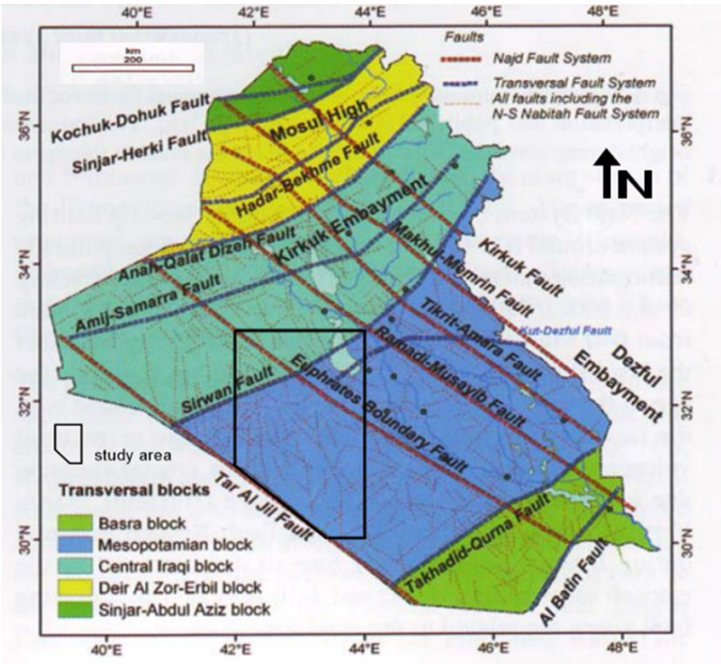

Figure 1- The location of Al-Ma'aniya depression area within the transversal blocks and faults system of Iraq [6].

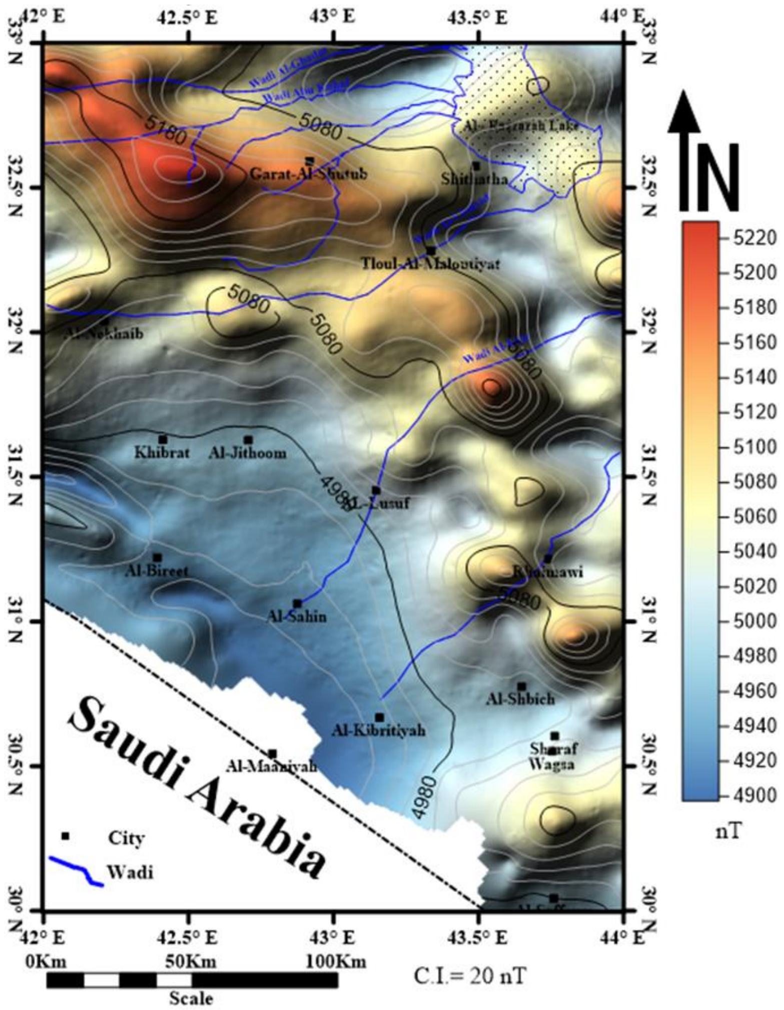

Figure 2-Total intensity magnetic data of the study area (after [7]).

4. Processing of aeromagnetic data:

Qualitative interpretation of magnetic data includes anomaly description, anomaly separation, and edge detection to resolve regional/and or local trends in the data. In the current study, regional-residual separation and edge detection are important to isolate the deep and shallow structure and image the geological features related to tectonic settings, respectively, [10].

4.1 Reduce to the pole

The transformation of a magnetic signal into what it would be when the causative body is taken over to the North Pole is known as reduction to pole RTP, [4].The first processing of aeromagnetic data is converting the total intensity magnetic map to RTP, Figure-3.

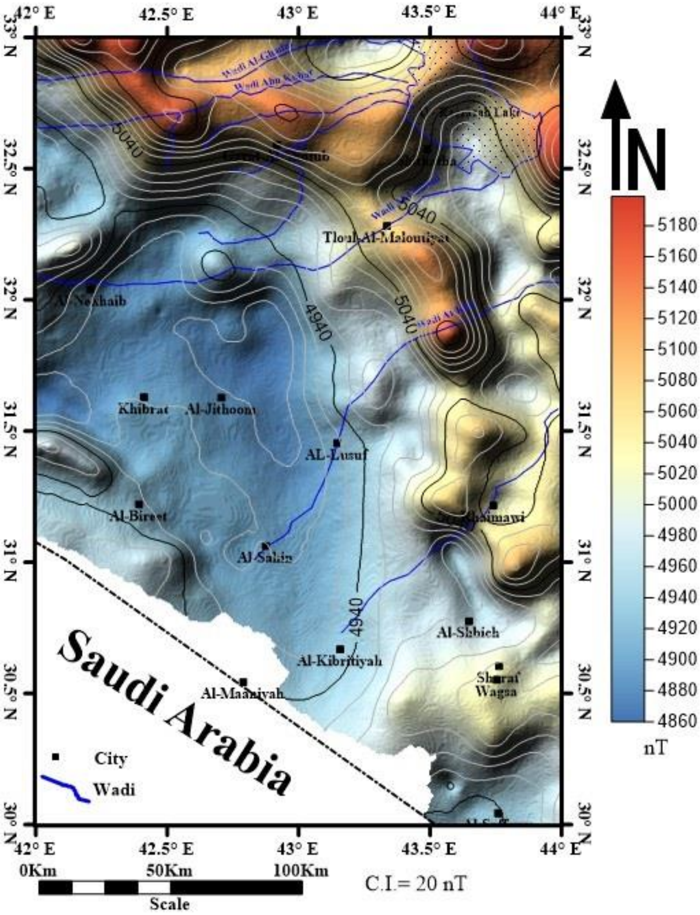

Figure 3- Reduced to pole (RTP) map from total intensity magnetic map of the study area.

4.2 Separation of RTP map to regional and residual:

Using power spectrum method, a low pass filter is applied to RTP data for the study area to get the regional field and high pass filter to get the residual. The chosen cut-off wavelength is from (10000m to 90000m) and results nine spectrum maps for both regional and residual field Figure-4 and Figure-5. As we move from cut-off wavelength 10000m to 90000m the anomalies in the map became smooth and reflect deep regional features as shown in Figure-4.

Figure-5 shows the nine maps results from using high pass filters with above mentioned cut-off wavelength. This map will be depended for naming anomalies letter on. Therefore, that, the power spectrum method can determine the shallow and deep anomalies in study area. From this method of separation, the best residual map is chosen for interpretation, which is high pass filter map that have cut-off wavelength 60000m Figure-6.

Residual magnetic map show the positive magnetic markers by MA, the number of positive magnetic in study area is twenty anomalies distribution in study area, Figure-6. The positive magnetic anomalies related with high magnetic susceptibility and/or shallow depth of basement rocks

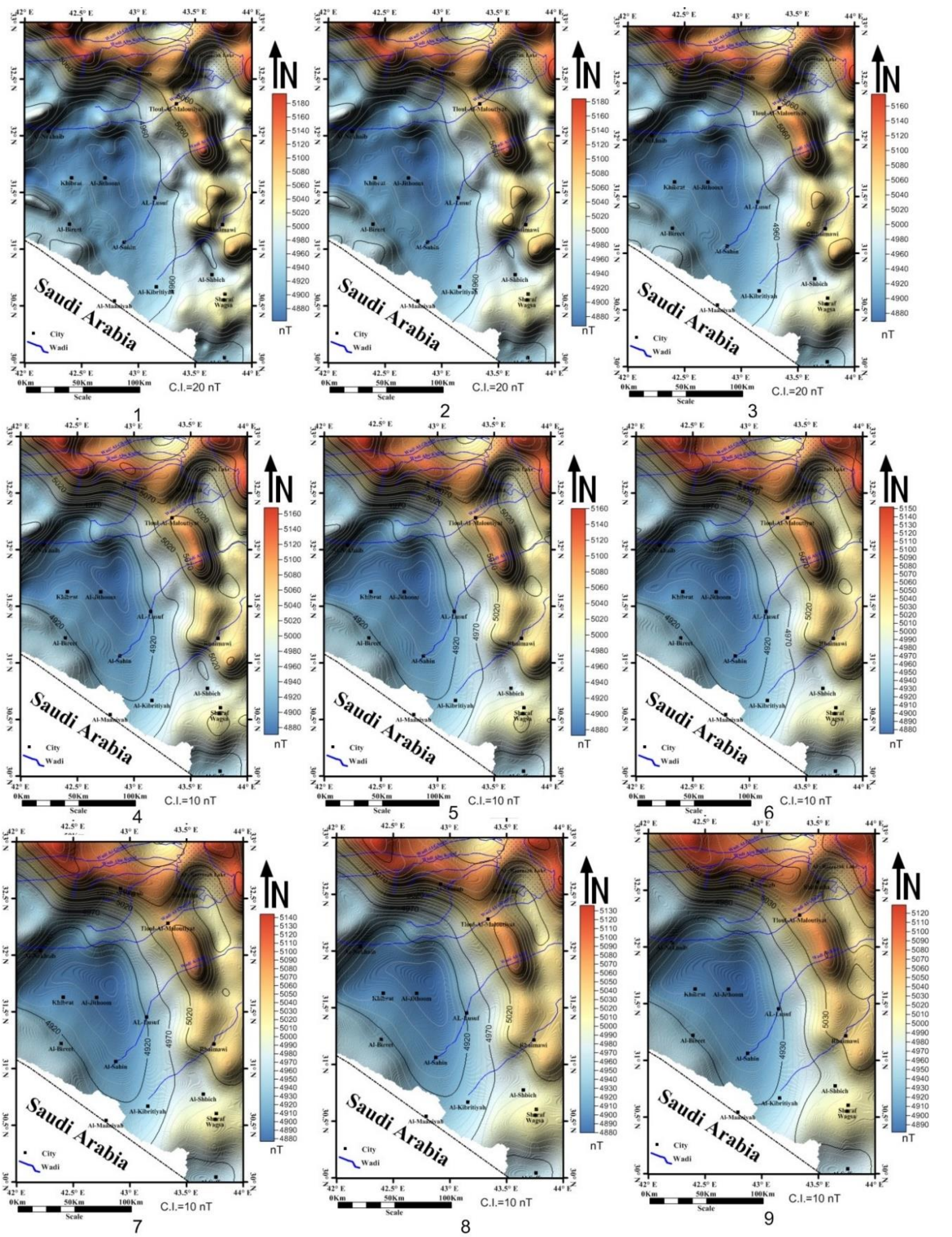

Figure 4- Regional maps created using power spectrum method to RTP data. Low pass filter with cut-off wavelength from (10000m to 90000m) is used. The number in maps determine the cut-off wavelength used. Map 1 to cut-off 10000m and so on.

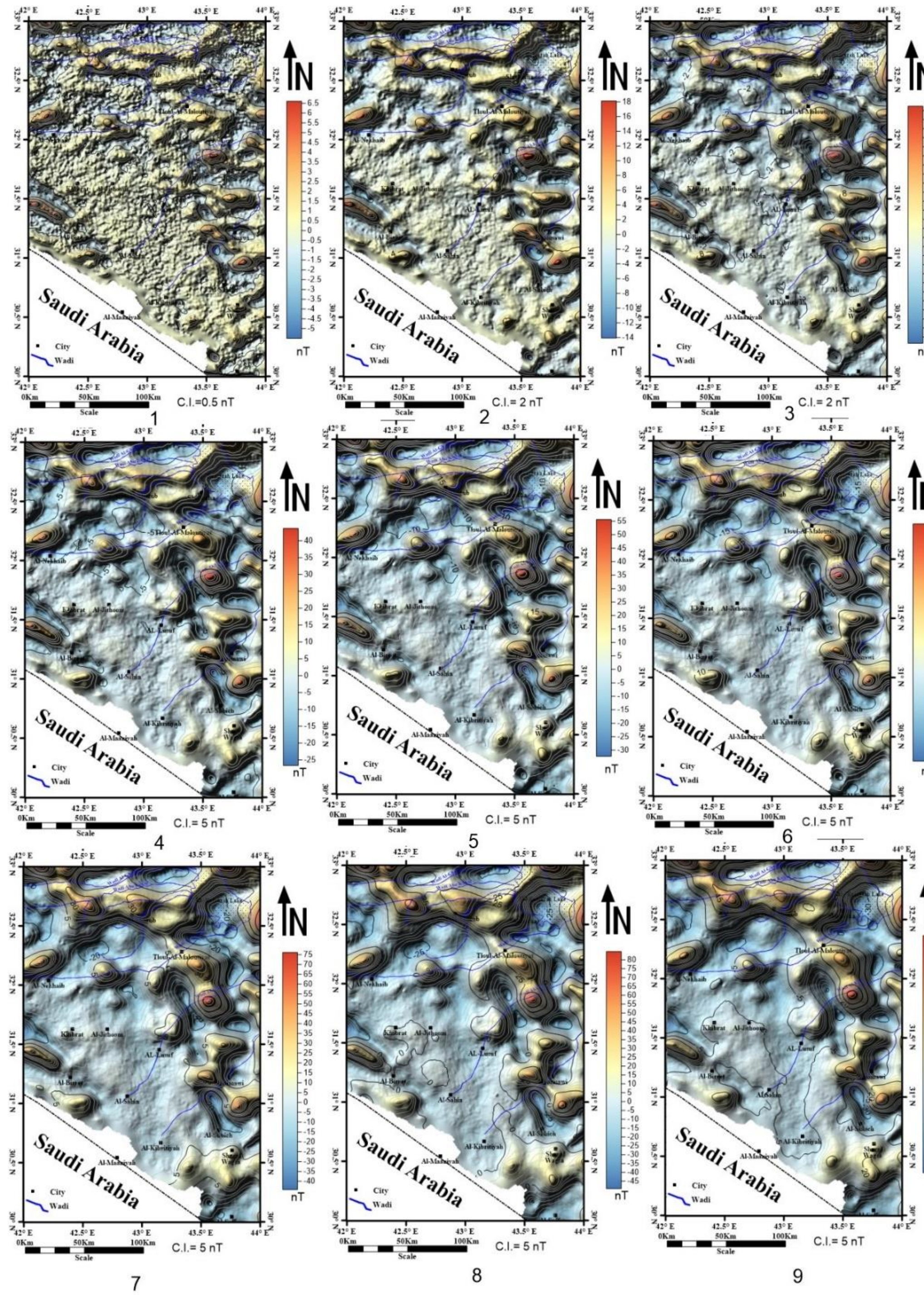

Figure 5- Residual maps created using power spectrum method to RTP data. High pass filter with cut-off wavelength from (10000m to 90000m) is used. The number in maps determine the cut-off wavelength used. Map 1 to cut-off 10000m and so on.

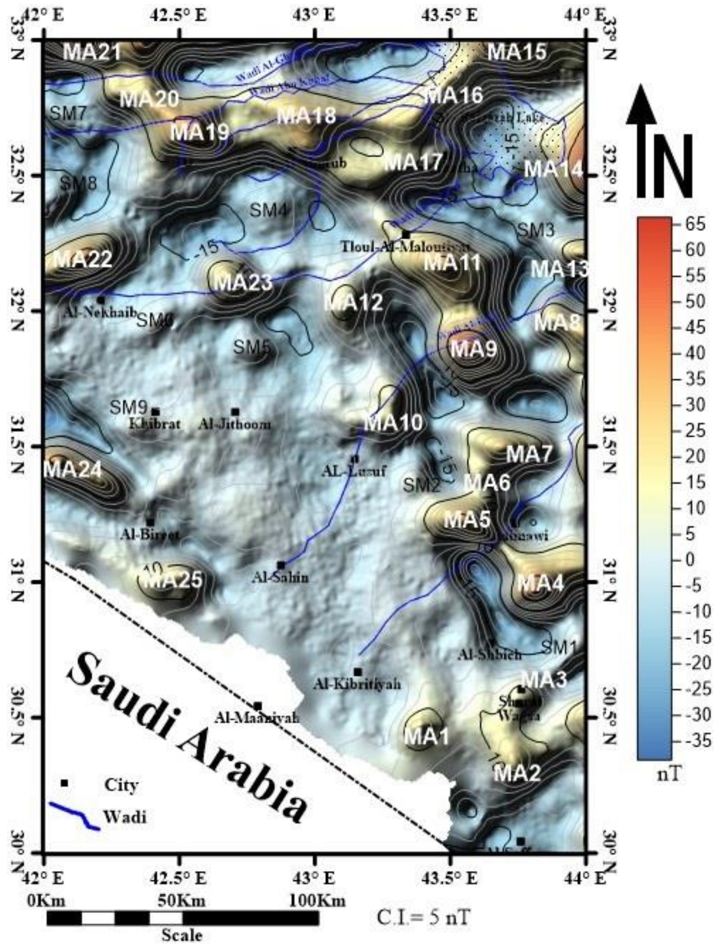

Figure 6-The chosen and interpreted residual RTP map of the study area that represent residual map using power spectrum high pass filter with cut-off wavelength 60000m.

4.3 First vertical derivative (FVD)

FVD is applied to RTP data to enhance the main and secondary anomalies Figure-7. The vertical derivative (vertical gradient) is a good method for resolving anomalies over individual structures in total intensity magnetic data and importantly suppresses the regional content of the data. The first vertical derivative of RTP map shows sharpen of anomalies in all directions of map area. Some anomalies are divided into small anomalies in VDR map of RTP.

4.4 Total horizontal derivative (THDR)

The common used edge-detection filter is the total horizontal derivative where the edges of bodies will be determined and enhanced, but the result is dominated by the response from the shallower and hence larger-amplitude anomaly body, [11].The applied total horizontal derivative to determine edges of magnetic anomalies in study area is shown in Figure-8.

5. Inversion of aeromagnetic data

The modeling of anomaly sources concerning determine a solution of unknown parameters until predictions of the forward model replicate the observed data within a specified margin of error is called forward modeling, while demonstrating the unknown parameters directly from the observed data using an optimization process comparing the observed and predicted data is called inverse modeling, [12]. Magnetic forward modeling solver for large-scale 3D problems, [13]. Magnetic forward modeling and inversion for the study area is derived using Encome Model Vision program. In magnetic, intrusion bodies (prismatic bodies) of different depth, dimension and susceptibility contrast are chosen to estimate the magnetic field in the study area. The locations and boundary of these bodies are determined from qualitative interpretations. The optimized match of the fields computed from the models to the observed field justifies these models as best estimates according to assumptions that sources have homogeneous susceptibility, planar sides, and the simplest geometry required to reproduce the critical characteristics of the anomalies. The assumed bodies that used to estimate the RTP data of the study is shown in Figure-9. Figure-10b shows the magnetic field measured using these bodies (Forward modeling and inversion) and compared with RTP of the study Figure-10a. A 3D prospective presentation for all bodies are shown in Figure-11 and Figure-12 with their magnetic modeled field. At the beginning, all bodies are chosen to be vertical, the inversion with some constrain change the dipping and strike values for these bodies. The locations, dimensions and strikes are distinguished from qualitative interpretation while depth, dip and susceptibility contrast estimations are calculated from modeling. Table-1 shows the properties of assumed bodies. The depths of assumed bodies are ranged between (8-10) km while the changes in magnetic susceptibility are ranged between (0.0018-0.0024) CGS. The magnetic basement depth beneath the study area is determined in order to appraise its hydrocarbon potential find, [14].

6. Results

The results of qualitative and quantitative interpretation of aeromagnetic data show shallow depth of basement rocks in north and northeastern parts of study area with absent of magnetic bodies in the south and southwestern part of study area (Al-Ma'aniya depression area) Figure-14.

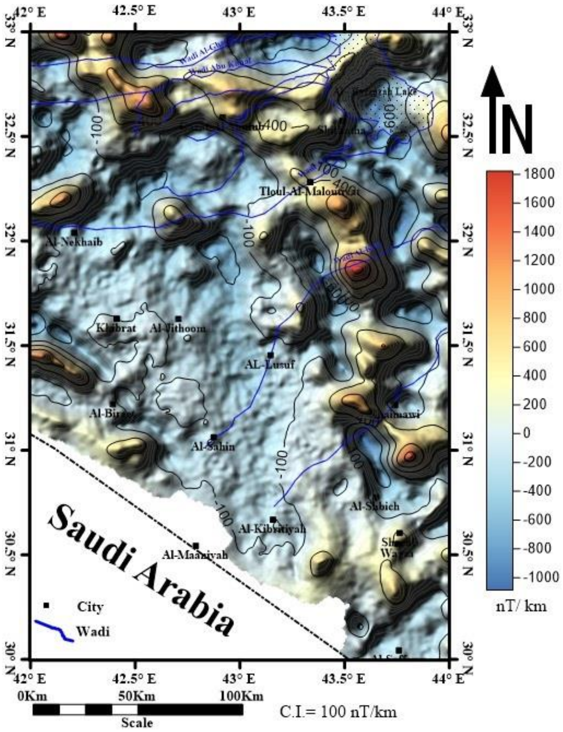

Figure 7- First vertical derivative of RTP map for the study area.

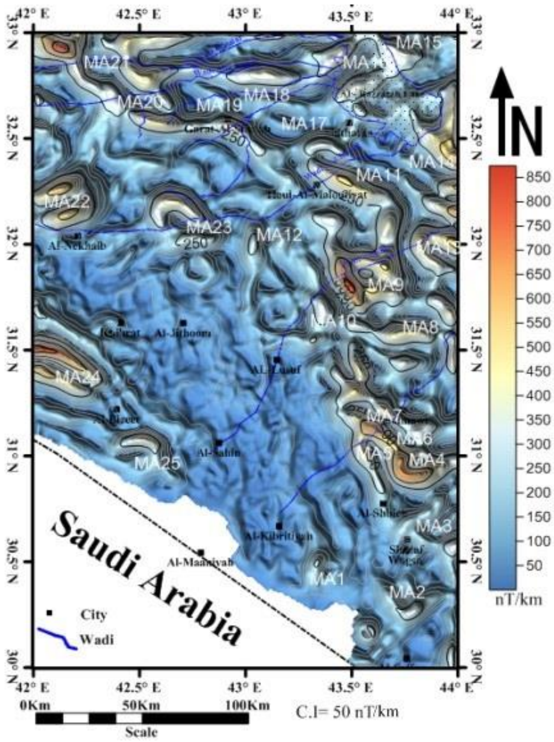

Figure8 - Total horizontal derivative applied to residual RTP data.

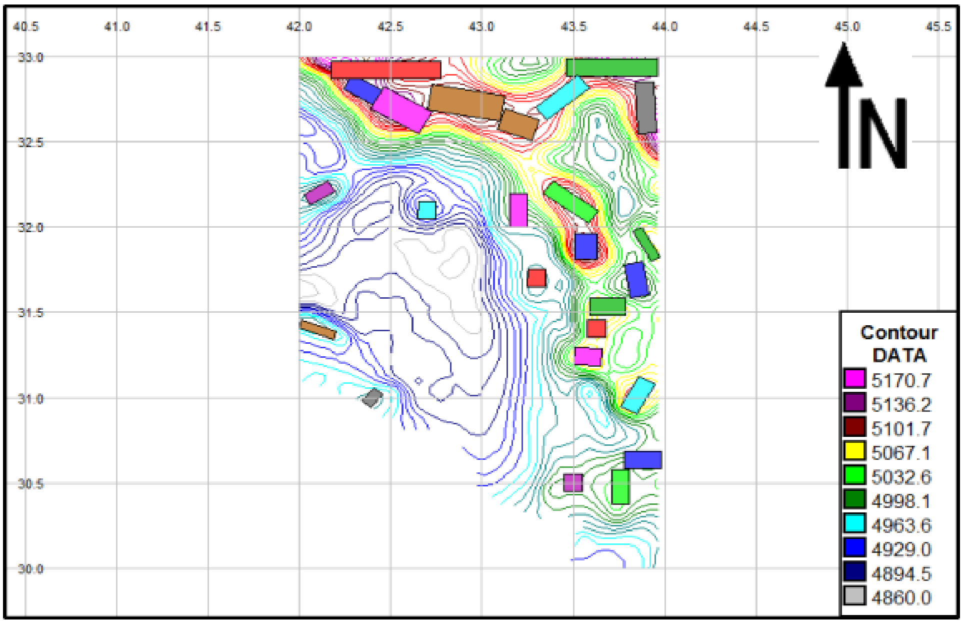

Figure 9-Shows the assumed magnetic bodies posted on RTP map of the study area.

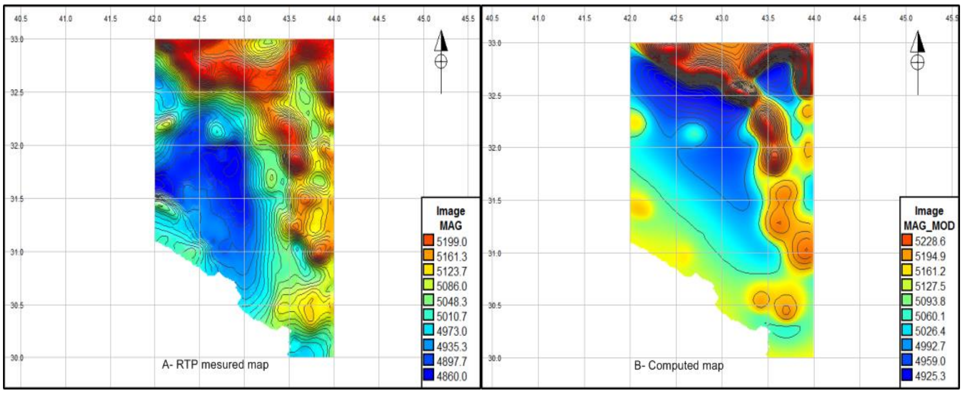

Figure 10-A comparison between A) RTP data of the study area and B) the calculated magnetic field from modeling intrusion bodies as shown in Figure -9

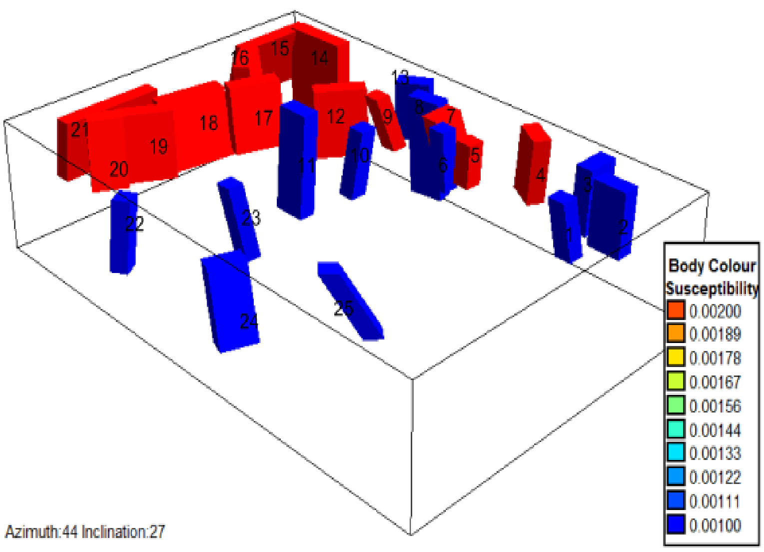

Figure 11-3D prospective of the assumed bodies that reflective The magnetic field of the study area.

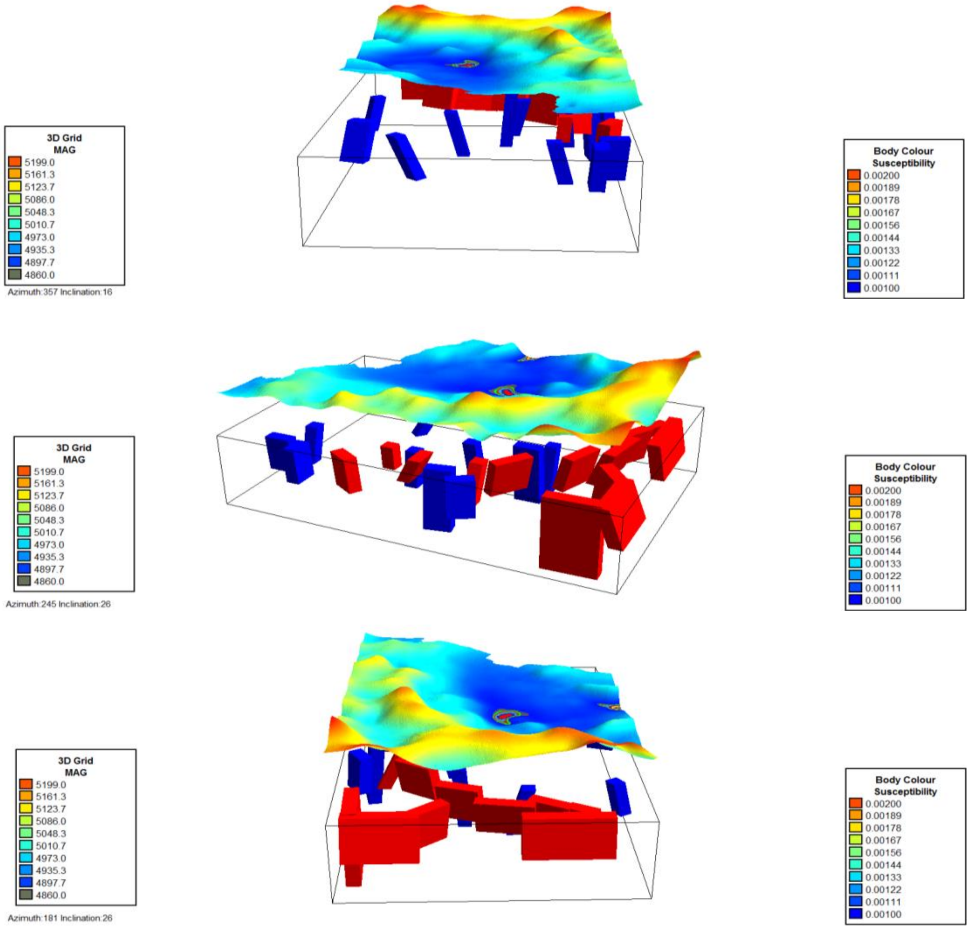

Figure12- 3D prospective view for the assumed bodies with RTP map rotated in different directions.

7. Conclusions

The total magnetic intensity map shows magnetic anomalies concentrated in north and northeastern part of the map with N-S extend then turn toward northwest in the northern part of the map because of the strike slip fault. The high pass filtered map using power spectrum technique with cut-off wavelength of 60000 m is found to be best residual for magnetic maps. The residual map of RTP data show twenty-five positive magnetic anomalies different in size, directions and positions as shown in Table-1. The derivatives such as THDR and VDR are excellent edges determinations for residual anomalies. This greatly helps in identifying edges dimension later on for quantitative analysis.

In the quantitative analysis, the magnetic picture reveals twenty-five magnetic bodies with high igneous susceptibility in study area interpreted as igneous intrusion. The distribution, dimensions and depths have very good consistency with qualitative analysis. The depth of magnetic bodies are ranged to (7-8) km in northern part of study area and to about (8-10) km in eastern part of study area, while a deep magnetic bodies in southwestern part of at Al-Ma′aniyah depression is about 10km. A shallow depth of magnetic bodies in northern part of study area at Garat-Al-Shutub is about 7km. From the invasion aeromagnetic data and determine of depth of magnetic bodies in study area can investigation the thickness of Phanerozoic increase in south part of study area at Al-Ma′aniyah depression and reduce thickness of Phanerozoic thickness at north of study area.

Due to the location of the Al-Ma'aniyah depression area which is far from active boundary zones, their tectonic features reflect the original depositional environments with some horizontal movement due to rearrangement of the basement blocks during different actives orogenic movements. Al-Ma'aniyah depression is deep without any magnetic features, and could be considered as starved basin continue in subsidence during the precipitation of sedimentary layers, This will create a pinch-out structures at the boundary of the depression. So, it may be considered as a promising area for oil exploration.

Table1-The properties of assumed bodies from modeling.

Bodies No.	Depth km	Magnetic Susceptibility CGS unit	Dip	Azimuth
1	9	0.001	75	-0.37
2	9	0.001	95	0
3	9	0.001	95	0
4	8	0.002	95	30
5	8	0.002	95	2.28
6	9	0.001	85	0
7	8	0.002	65	90
8	9	0.001	85	-10
9	7	0.002	65	0
10	9	0.001	105	0.57
11	9	0.001	95	0
12	7	0.002	103.8	-55
13	9	0.001	85	-30
14	7	0.002	90	-2.09
15	7	0.002	110	90
16	8	0.002	82.5	50
17	8	0.002	105	-70
18	7	0.002	68	100
19	7	0.002	105	-60
20	7	0.002	110	-60
21	7	0.002	100	90
22	8	0.001	105	-30
23	10	0.001	75	0.36
24	9	0.001	65	110
25	10	0.001	55	40

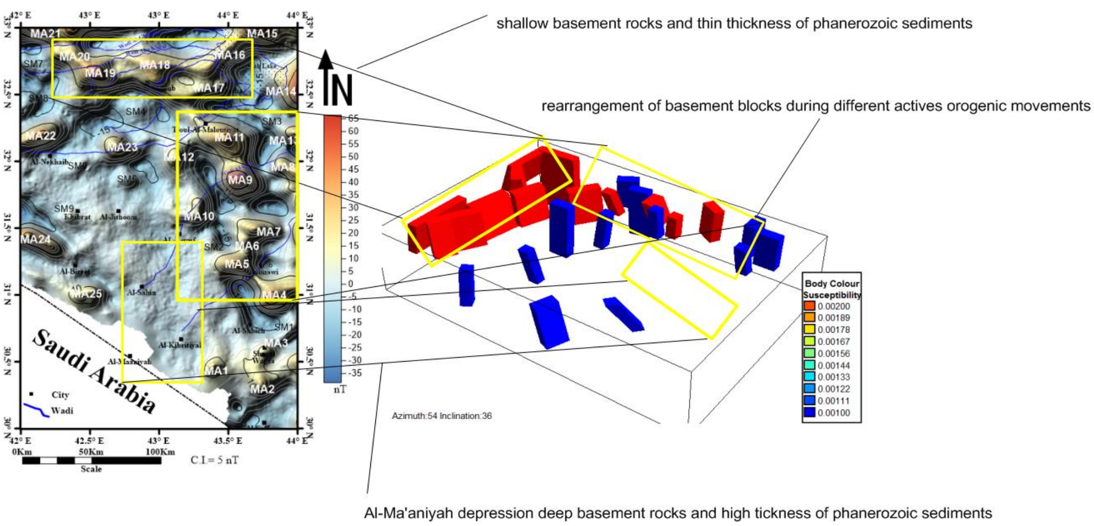

Figure 14-Relationship the positive magnetic anomalies in residual RTP map with depth of magnetic bodies

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