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Application of Gravity Method in El-Maseed Area

*This dissertation is submitted as a partial requirement of B.Sc. degree in
Exploration Engineering*

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الآية

بسم الله الرحمن الرحيم

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صدق الله العظيم

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Dedication

We dedicate this work to:

Our Fathers

*The one who taught us the
Meaning of principles and give.*

Our Mothers

*Our power resource and the candle
That lighting our darkness*

Our teachers

Our prideness icon

Acknowledgment

After thanks Allah

We would like to send best wishes to supervisor,

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For his gaudiness and support to help us in generating

Perfect work, that by the will of Allah become

A beneficial study.

We would like to thank Dr. Eman abdAllah, Ustaza. Hanan

Mohamed Eng. Migdad Hassan for helping us.

Finally we would like to thank Ministry of Mineral.

May Allah bless them all.

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Chapter One

1. INTRODUCTION

1.1 Location of the Study Area:

The study area lies in Middle Sudan and is situated in the Jazeera State. It is bounded by latitudes (14° _ 15.5° N) and longitudes (32° _ 33.5° E). Almost the whole area covering the Study area can be accessed through al-Maseed village, which is connected to Khartoum by a main asphalt road heading to Wad Madani.

1.2 Geology of the study area:

Geological column consists in Al maseed area:

- Basement complex
- Nubian sandstone
- Gezira formation
- Superficial deposits

Basement complex

Oldest rock in geologic column and non-specific depth in region, no porosity and permeability in basement rocks, and no water, if had exist water it's not good chemically.

Nubian sandstone:

Sandstone formation deposited in non-compatible on basic rock (cretaceous), containing from koonjloret, gravel sand and characterized by homogeneity.

Gezira formation:

The lower Gezira formation is composed of interbedded sand and clays, rarely consolidated to form poorly sorted sandstone and clay stone. the stable heavy minerals reache 70% and the unstable ones reach 30% zircon is remarker mineral and identified assemblage stems from metamorphic, igneous and less probably from poly cyclic sediments. this formation contains about 60% detrial smectite and up to 40% authogenic kaolinite.

-The upper Gezira formation is composed of unconsolidated sands, clays and gravels which are poorly sorted and display lateral facies changes.

They contain considerable amount of carbonitic material and volcanic rock fragments. The unstable heavy minerals are dominant (60%) among which hornblende is remaker while the stable ones reach (40%).

Superficial deposits:

Modern sediment , transported by wind and rain and creeks, represent deposit of sand and gravel and mud from remnants of rock units disintegrating and these sediments formed in Pliocene(Modern era).

1.3 Hydrological region

Of the hydro geological study area is characterize by the presence of two reservoirs:

- Al Jazeera aquifer: the aquifer is the highest in the region and is characterized by the presence of two reservoirs upper and lower, the upper characterized by salinity.
- The lower contain fresh water, formed of cretaceous sand stone (Nubian sand stone).



Fig 1.1: Location of study area.

1.4 Problem Statement

From a water well drillings in Al-massed area a thick layer of clays observed which force them to go deeper to go deeper up to 1400-1300ft to reach the aquifer while the pervious observation lead us to think why the clay is thick , and there are two Assumption :

-there is the basin Depocenter

-structural controls (basin fault boundary) to have information regarding the geometry of basin.

And the availability of gravity data suggest, applying of gravity method since the gravity can give us clues about the presence of basin, and aerial extension which can be extended to sub basin definition and the depth of basin in varied area.

1.5 Objectives of the Study

Using gravity data provide better understanding of the subsurface geology .this objective can including:

- Whether is there a basin?
- Extents of basins geometry.
- (Major Structures), location of faults
- Is there any sub basins that controlled the sedimentation processes.
- Thickness of sediments (Basin depth).

Chapter Two

2. Method and Technique:

2.1. Introduction

Gravity data could be acquired as terrestrial data or airborne data of satellite data.

Gravity method is geophysical Method based on a natural gravity field study over the earth surface.

The gravity method is a nondestructive geophysical technique that measures differences in the earth's gravitational field at specific locations. The success of the gravity method depends on the different earth materials having different bulk densities (mass) that produce variations in the measured gravitational field.

These variations can then be interpreted by a variety of analytical and computers methods to determine the depth, geometry and density the causes the gravity field variations.

The data are processed to remove all these predictable effects. The most commonly used processed data are known as Bouguer gravity anomalies, measured in mGal.

Most gravity surveys currently carried out in the search for oil are designed for reconnaissance of, previously unexplored areas. It answer the first question is whether a sedimentary basin large enough and thick enough to justify further investigation is present.

The interpretation of Bouguer gravity anomalies ranges from just manually inspecting the grid or profiles for variations in the gravitational field to more complex methods that involves separating the gravity anomaly due to an object of interest from some sort of regional gravity techniques including graphical smoothing and polynomial surface fitting. The interpretation of separated (residual) gravity anomalies commonly involves creating a model of the subsurface density variations to infer a geological cross-section. These models can be determined using a variety of methods ranging from analytical solutions due to simple geometries (e.g., sphere) to complex three dimensional computer models.

2.2. Theoretical background:

2.2.1. Newton's Law of gravitation

The physical basis of the Method is law of universal gravitation by Isaac Newton, in accordance with which rocks having different densities make different changes to the gravity field.

Geophysical interpretations from gravity surveys are based on the mutual attraction experienced between two masses, as first expressed by Isaac Newton.

Newton's law of gravitation states that the mutual attractive force between two point masses, m_1

And m_2 , is proportional to one over the square of the distance between them. The constant of proportionality is usually specified as G , the gravitational constant.

Thus, we usually see the law of gravitation written as shown where:

F= is the force of attraction

G= is the gravitational constant

R= is the distance between the two masses, m_1 and m_2 .

$$f = Gm_1m_2/r^2$$

mass is formally defined as the proportionality constant relating the force applied to a body and the acceleration the body undergoes as given by *Newton's second law, usually written as*

$$f = am$$

Therefore, mass is given as $m=F/a$ and has the units of force over acceleration. A point mass specifies a body that has very small physical dimensions. That is, the mass can be considered to be concentrated at a single point.

2.2.2. Acceleration of Gravity:

When making measurements of the earth's gravity, we usually don't measure the gravitational force. Rather we measure the gravitational acceleration g . The gravitational acceleration is the time rate of change of a body's speed under the influence of the gravitational force

In addition to defining the law of mutual attraction between masses, Newton also defined the relationship between a force and acceleration.

Newton's second law states that force is proportional to acceleration. The constant of proportionality is the mass of the object. Combining Newton's second law with his law of mutual attraction, the gravitational acceleration on the mass m_2 can be shown to be equal to the mass of attracting object, m_1 , over the squared distance between the center of the two masses, r .

$$g = Gm/r^2$$

Units of gravity: $1 \text{ gal} = 1 \text{ cm/s}^2 = 1 \times 10^{-2} \text{ m/s}^2$

$1 \text{ Gal} = 10^2 \text{ m/s}^2$, μGal , mGal , $1 \text{ g.u (gravity unit)} = 0.1 \text{ m.gal}$

2.2.2. Gravitational Potential

The potential at any point in gravitational field is defined as the work required for gravity to move a unit mass from an arbitrary reference point “usually at an infinite distance” to the point in question .if the force per unit mass equals acceleration at distance(r) = Gm_1/r^2

The work to move the unit mass through the distance ds in the direction of P

The work= Gm_1dr/ r^2

The work U done to move the unit mass from infinity to O in the field of m_1

$$U = Gm_1 \int_{\infty}^R \frac{dr}{r^2}$$

$$U = Gm_1 \frac{1}{r} = \frac{Gm_1}{R}$$

2.3. Rock densities

Gravity anomalies result from the difference in density, or density contrast.

The use of gravity for prospecting requires density contrasts to be used in interpretations. Most rocks have densities in the range 1,500-3,500 kg/m³, with extreme values up to 4,000 kg/m³ in massive ore deposits. In sedimentary rocks, density increases with depth and age, *i.e.*, compaction and cementation.

- The density contrast between sedimentary rock and basement rock equal 0.35

2.4. Data reduction

Before the results of a gravity survey can be interpreted it is necessary to correct for all variations in the Earth's gravitational field which do not result from the differences of density in the underlying rocks. This process is known as gravity reduction.

The measurements have to be corrected for the following corrections:

- 2.4.1. Drift correction.
- 2.4.2. Tidal correction
- 2.4.3. Free air correction.
- 2.4.4 .Bouguer correction.
- 2.4.5. Latitude correction.
- 2.4.6. Terrain correction

2.4.1. Drift correction

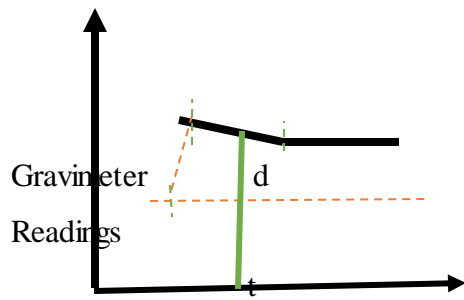
Correction for instrumental drift is based on repeated readings at a base station at recorded times throughout the day. The meter reading is plotted against time

All the gravimeters change null reading with time when set up on the same station, due to:

- 1- Creep in the spring.
- 2- Variation in temperature.
- 3- Earth tide.
- 4- Sudden motion during transportation.

Drift Correction= $(t_{obs} - t_{base}) \times \text{drift rate}$.

Rate of drift= $\Delta R / \Delta t$.



**Fig 1.2 a gravimeter drift curve constructed from repeated readings at a fixed location
The drift correction is subtracted for a reading taken at time t is d**

2.4.2. Tidal correction

Gravity measured at a fixed location varies with time because of periodic variation in the gravitational effects of the Sun and Moon associated with their orbital motions, and correction must be made for this variation in a high precision survey. The tidal effects are predictable and can be computed by a small computer program.

This correction used in ultra – accurate surveys where it is not sufficiently accurate to absorb the effect of the sun and moon in the drift correction.

In modern computer gravity reduction programs, these effects can be automatically calculated.

2.4. (3.4.) Elevation corrections (free air –Bouguer)

Correction for the differing elevations of gravity stations is made in two parts. The free-air correction (FAC) corrects for the decrease in gravity with height in free air resulting from increased distance from the centre of the Earth, according to Newton’s Law. To reduce to datum an observation taken at height h .

The Free-Air and Bouguer effects may be combined as the elevation effect, and written

$$FAC = 3.086h \text{ gu (} h \text{ in metres).}$$

The *Bouguer correction* (BC) removes this effect by approximating the rock layer beneath the observation point to an infinite horizontal slab with a thickness equal to the elevation of the observation above datum.

Hills rising above the station will cause a reduction in gravity

If ρ is the density of the rock.

$$Bc = 2\pi G\rho h = 0.4191\rho h \text{ gu}$$

gu = gal unit

Bc = Bouguer correction

Elevation correction (δge) = (free air-Bouguer) corrections

$$\delta ge = \delta gf - \delta gB$$

$$\delta ge = (3.086 - 0.4191\rho)h \text{ (g.u)}$$

Where ρ is average rock density mg/m^3

All topographic irregularities will cause a reduction in the observed gravity values.

2.4.5. Latitude correction

Gravity varies with latitude because of the non-spherical shape of the Earth and because the angular velocity of a point on the Earth's surface decreases from a maximum at the equator to zero at the poles.

$$\delta gL = -8.108 \sin 2\phi, \text{ Where } \delta gL \text{ latitude correction } \phi \text{ latitude}$$

2.4.6. Terrain Correction (TC)

The Bouguer correction makes the assumption that the topography around the gravity station is flat. This is rarely the case and a further correction, the *terrain correction* (TC), must be made to account for topographic relief in the vicinity of the gravity station.

There are some corrections like Eötvös correction

Study area is flat so we canceled the terrain correction, and continental so we canceled also correct tides.

Gravity value corrected from elevation effect (free air correction) and attract of rock material (Bouguer correction).

3. The Techniques:

Technique applied on this study as follows:

3.1. Bouguer anomaly:

Once free air and Bouguer corrections have been made, the Bouguer anomaly should contain information about subsurface density alone. A map of Bouguer anomaly gives a good impression of subsurface density. Low (negative) values of Bouguer anomaly indicate lower density beneath the measurement point, high (positive) values of Bouguer anomaly indicate higher density beneath the measurement point.

3.2. Separation of Gravity:

The Bouguer anomaly is composed of two components, one is the regional and the other is a residual. The regional anomalies are the effect of the large-scale, broad and deep-seated structures, while the residual anomalies are the effect of small, confined and shallow structures such as basins and ore bodies.

Separation of residual gravity in the study area we apply polynomial fitting in two order.

When separated residual from regional we can have basin signature isolated from the contributions of the deep parts of the crust.

3.2.1. Polynomial fitting:

- This is a pure analytical method in which matching of the regional by a polynomial surface of low order exposes the residual features as random error. This method assumes the residuals to be random errors whose sum is zero. Thus the analytical residual is composed of positive and negative parts. The polynomial equation has the form:

- $y = a + bx + cx^2 + dx^3$

- Where a, b, c and d, are coefficients.

The polynomial order is the largest power of x in the equation. For fitting a data point (x_i, Y_i) , it assumes that all of the errors occur in the measured y values and there are no errors in the x values. Each value of X_r ($r = 1, 2, 3$, etc.) has a corresponding calculated y for the polynomial, and the difference between this regional and the observed value is called the residual Δr in Y_r so,

$$\Delta r = (a + bx_r + cx_r^2 + \dots).$$

The principle underlying the fitting of the polynomial to make the sum of the residual squares as small as possible by choosing appropriate values for a, b, c , etc. The sum of residual squares E is expressed by:

$$I = n^2$$

$$E = \sum \Delta$$

$$I = 1$$

The best fitting of a polynomial of a given order is found when E is minimized. High order polynomials may produce unwanted spikes between data points and then interpolation is necessary. Increasing the order of the polynomial can decrease the minimum value of E which lessens the smoothing of the data. In extreme cases the order is equal to $n-1$ and the polynomial passes through each of the data points. This is called interpolating polynomial for which $E = 0$ and there is no smoothing of data

- Fit a smooth (polynomial) surface to data to represent regional.
- Subtract calculated regional value from observed value at each point to get residual field.
- In practice the surface is expressed mathematically as a two polynomial of an order that depends on the complexity of the regional geology.
- zeroth-order polynomial (constant, g_0)
- minimize Sum of Squares of Residuals (SSR)

$$SSR = \sum_{i=1}^n (g_i - g_0)^2$$

$$\frac{\partial SSR}{\partial g_0} = - \sum_{i=1}^n 2(g_i - g_0) = 0$$

$$g_0 = \sum_{i=1}^n g_i / n$$

= average of data points

- If the regional field is a simple plane it would be a first-order

Polynomial in x and y

$$g_i = ax_i + by_i + c$$

$$\frac{\partial SSR}{\partial a} = \frac{\partial SSR}{\partial b} = \frac{\partial SSR}{\partial c} = 0$$

- equations
- 3 unknowns (a, b, c)
- The next stage of complexity would involve representation by a

Second-order polynomial in x and y

$$g_i = ax_i^2 + by_i^2 + cxiy_i + dxi + eyi + f$$

- Polynomial of much higher order would probably be necessary for a large areas.
- The residual function R for the observed gravity field G is:
- $R = G - (ax_i + by_i + c)$

$$\text{Residual field} = \text{total field} - \text{regional field}$$

3.3. Second vertical derivative

The Second Vertical Derivative technique was used as two dimensional filters for interpretation of potential field data. This technique was developed by Elkins (1951). If we use the symbol (g) to represent gravity a choose axes so that (z) is vertical downward, then the second derivative is the quantity d^2g/dz^2 .

The importance of the second derivative for potential field interpretation arises from the fact that the double differentiation with respect to depth tends to emphasize the smaller, shallower geological anomalies at the expense of larger, regional feature.

The second derivative of a gravity field can be shown to be a measure of the curvature of the field. Considering a gravity profile, where the curvature of the line is greatest (radius least), the second derivative has its higher value. Where there is no curvature, (radius infinite), the second derivative is zero. If a shallow geological feature of limited lateral extent (like a salt dome) has a gravity anomaly with greater curvature than the regional field on which it is superimposed, the second derivative will be greater over the localized

Feature than over the part of the area where the gravity variations follows the regional trend. The second derivative accentuates shallow anomalies and suppresses deep seated effects. Points of inflections of the second derivatives, i.e. points where the second derivative value changes its sign, are geologically expressed as faults, since the gravity gradient undergoes its most rapid changes from one level to another in the vicinity of faulted area. The second derivative is the quantity explained by Laplace's equation:

$$d^2g / dx^2 + d^2g / dy^2 + d^2g / dz^2 = 0$$

$$d^2g / dx^2 \approx (\Delta g_1 / r - \Delta g_2 / r) = 1 / r [(b_1 - c) / r - (c - b_3) / r]$$

$$\approx (b_1 + b_3 - 2c) / r^2$$

3.4. Forward Gravity Modeling

Forward modeling:

A model that is thought to represent the geology is constructed.

The anomaly due to this model is calculated.

The computed and observed anomaly are compared

The model is adjusted, minimizing the difference between the observed and the computed anomalies.

In indirect interpretation, the causative body of a gravity anomaly is simulated by a model whose theoretical anomaly can be computed, and the shape of the model is altered until the computed anomaly closely matches the observed anomaly. Because of the inverse problem this model will not be a unique interpretation, but ambiguity can be decreased by using other constraints on the nature and form of the anomalous body.

A simple approach to indirect interpretation is the comparison of the observed anomaly with the anomaly computed for certain standard geometrical shapes whose size, position, form and density contrast are altered to improve the fit.

1-assume specific initial subsurface density model

2-calculate gravity (always do-able, at least numerically)

3-compare with data

4-adjust density model as necessary

Repeat steps 2 through 4

3.4.1. Types of forward gravity modeling:

2-D: the body being modeled extends to infinity in and out (at a right angle) of the plane of the model.

2.5-D: as 2-D, but the extent of the body in and out of the plain can be limited.

2.75-D: as 2.5-D but the angle of the body with respect to the plain of the model can be varied.

3-D: modeling of the full three-dimensional extent of the body.

3.4.1.1. Forward modeling with 2D polygons:

Calculate the gravitational attraction of a 2D body with polygonal vertical cross-section using the formula of Talwani et al. (1973).

Applying two dimensional forward modeling by applying line integral method for a semi-infinite slab model as described in Talwani (1973). In this technique, the gravity anomaly of an arbitrary shape 2-D body is obtained by adding the contributions from thin, horizontal, semi-infinite layers defined by the edges of the body. This is illustrated for a simple polygonal shape in Fig, and the gravity contribution from any single interface is given by:

$$U_{12} = a_1 \sin \phi_1 \cos \phi_1 \left[\theta_1 - \theta_2 + \tan \phi_1 \ln \frac{\cos \theta_1 (\tan \theta_1 - \tan \phi_1)}{\cos \theta_2 (\tan \theta_2 - \tan \phi_1)} \right]$$

positions are used to get a_1 , θ_1 , θ_2 , ϕ_1 , etc., for example,

$$a_1 = x_2 - z_2 \frac{(x_2 - x_1)}{(z_2 - z_1)}$$

$$\theta_1 = \tan^{-1} \left(\frac{z_1}{x_1} \right)$$

$$\phi_1 = \tan^{-1} \left(\frac{z_2 - z_1}{x_2 - x_1} \right)$$

Finally,

$$\Delta g = 2G\Delta\rho (U_{12} + U_{23} + \dots + U_{n1})$$

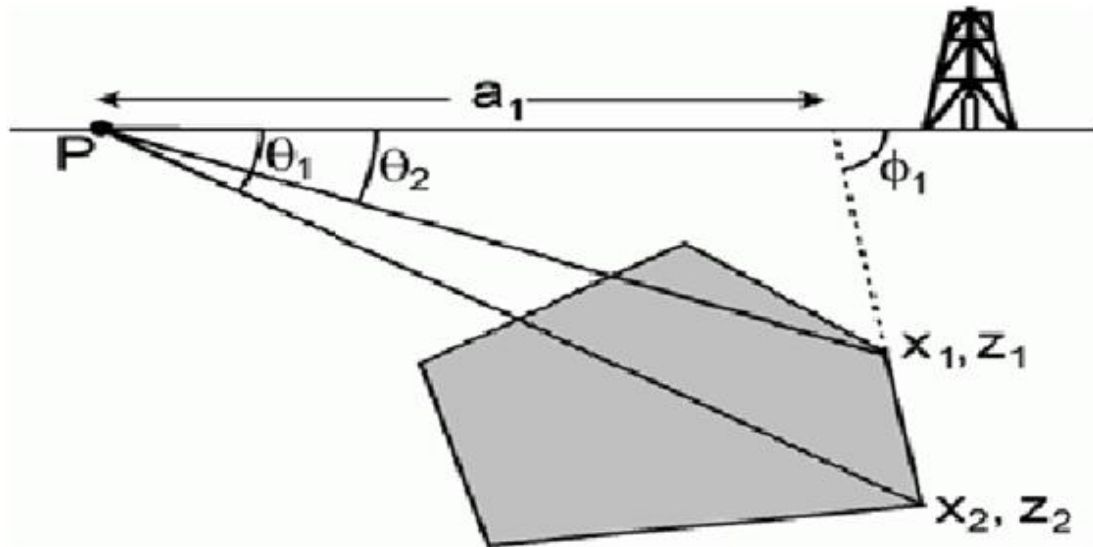


Fig 3.1 simple polygonal shape and gravity contribution from single interface

Chapter Three

4. Methodology

Data used

- The data had been get from San Diego university of California 1 minuet grid in ASCII format, as free air correction.
- Transformed free air data into Bouguer by using Bouguer correction with reduction density 2.67 g/cm³ (Ib. PhD thesis)

And the equation is $\delta g_B = 0.4191 \rho h$ gu

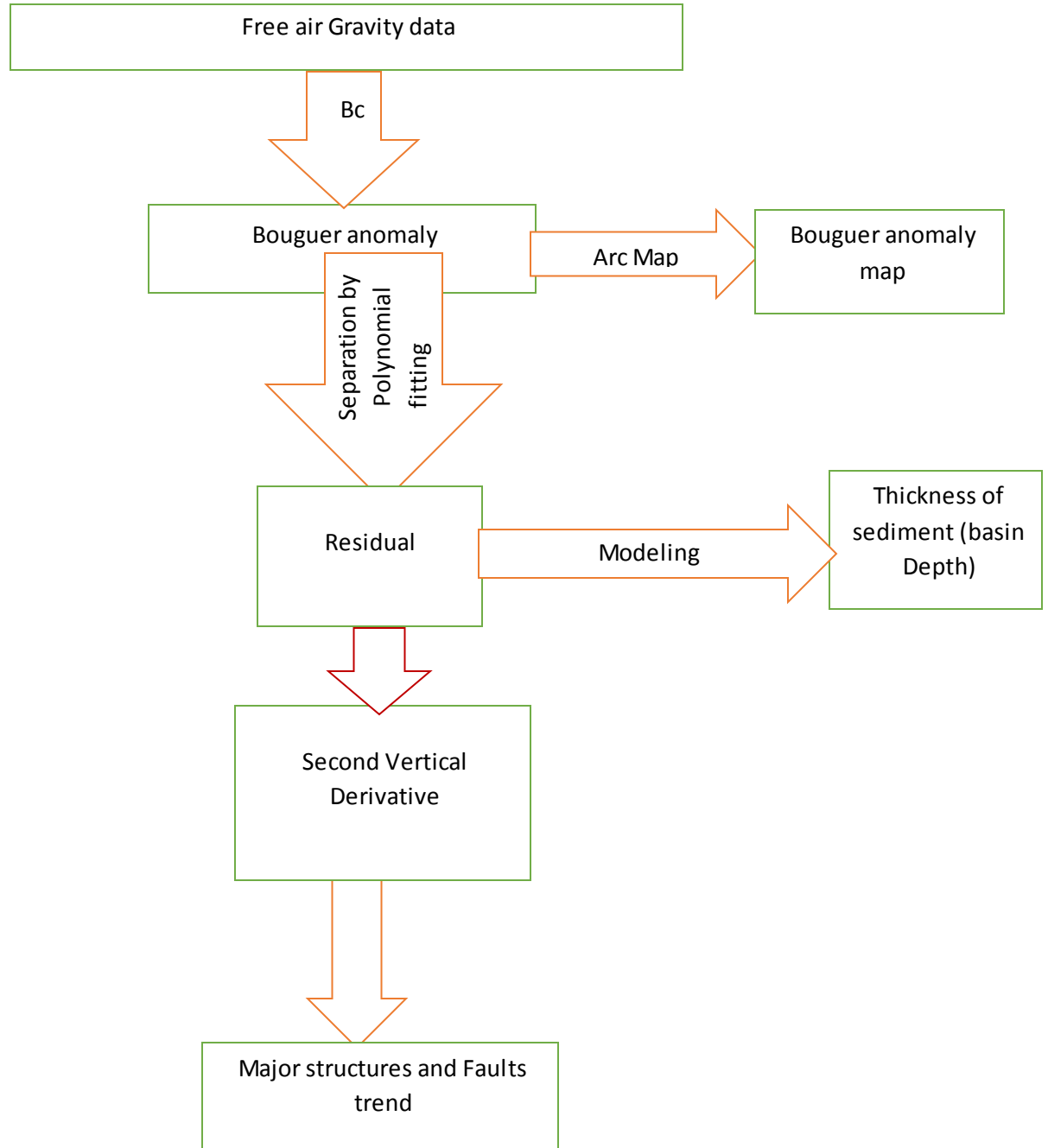
Where ρ density = 2.67

Calculated δg_B (Bouguer gravity data), for all elevation.

$$BA = FAA - BC$$

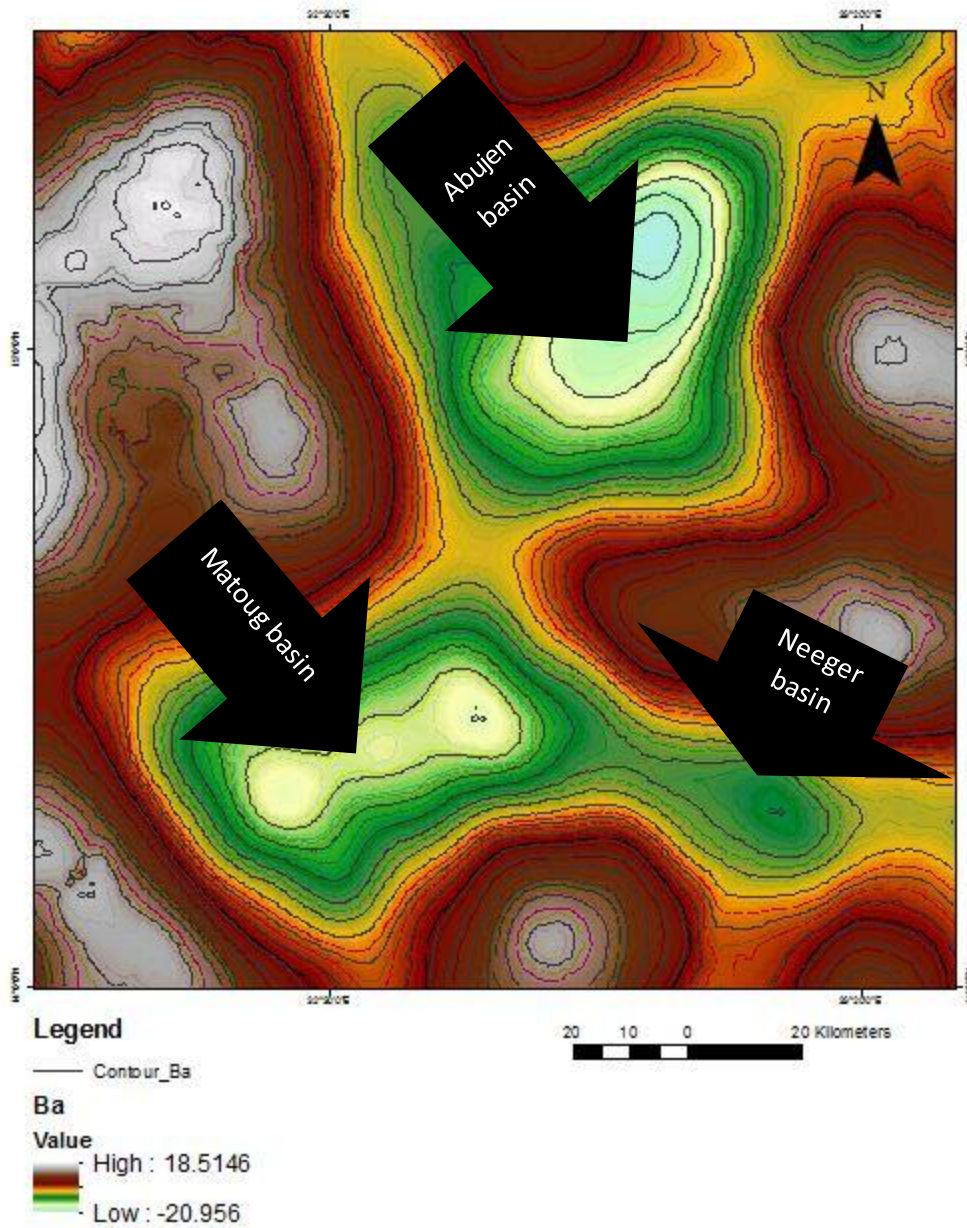
- And then we obtained Bouguer anomaly map by using arc Map Software. After prepared data on Excel sheet form. Added data to the Arc GIS *in x, y data*. Export data , Interpolation of Export data using Inverse Distance Weighted (IDW).
- And with same method which we used to obtained for Bouguer anomaly map, also using to get for Residual map. Added data to arc map, export (x,y) data, and interpolation of Export Data (IDW).
- Used Talwani algorism software for modeling to determine Thickness of the sediments and basin geometry.

Fig 3.2 summarize Data used, method and techniques applied



Chapter Four

5. Data Interpretation and Analysis:



Fig(5.1) showing Bouguer anomaly map for Al- mased area at couture interval 2

Bouguer Map showed three Basins, Abujen basin striking N-S connected with Matoug basin striking (NE-ES) the nomenclature according to study of Dr. Abdalla al-Haj.

The third Basin (alneeger) connected with matoug Basin by study. Ahmed Osman.

The Bouguer contour map shows the basin boundaries are faults.

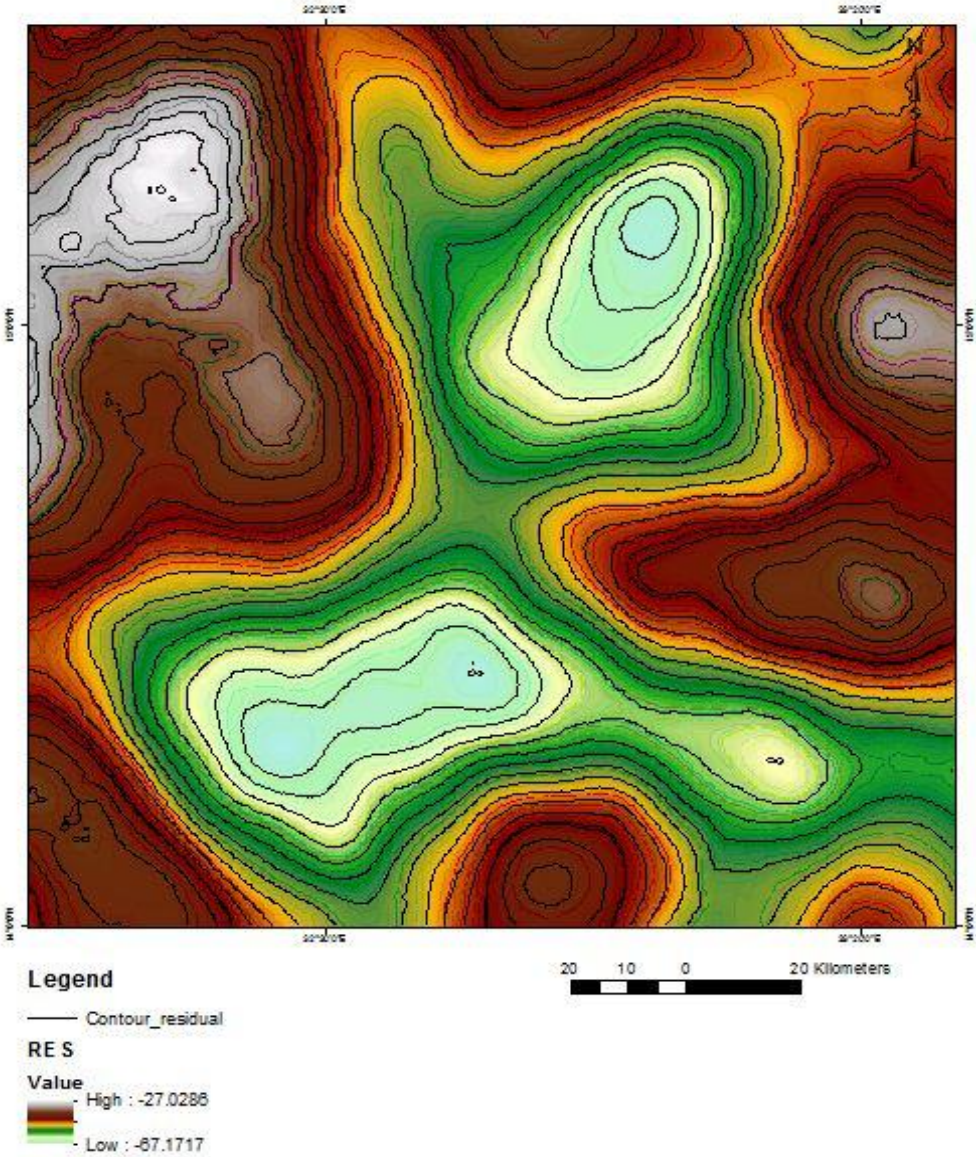


Fig (5.2) showing Residual map for Al- maseed area at couture interval 2

Residual map emphasizes the basins.

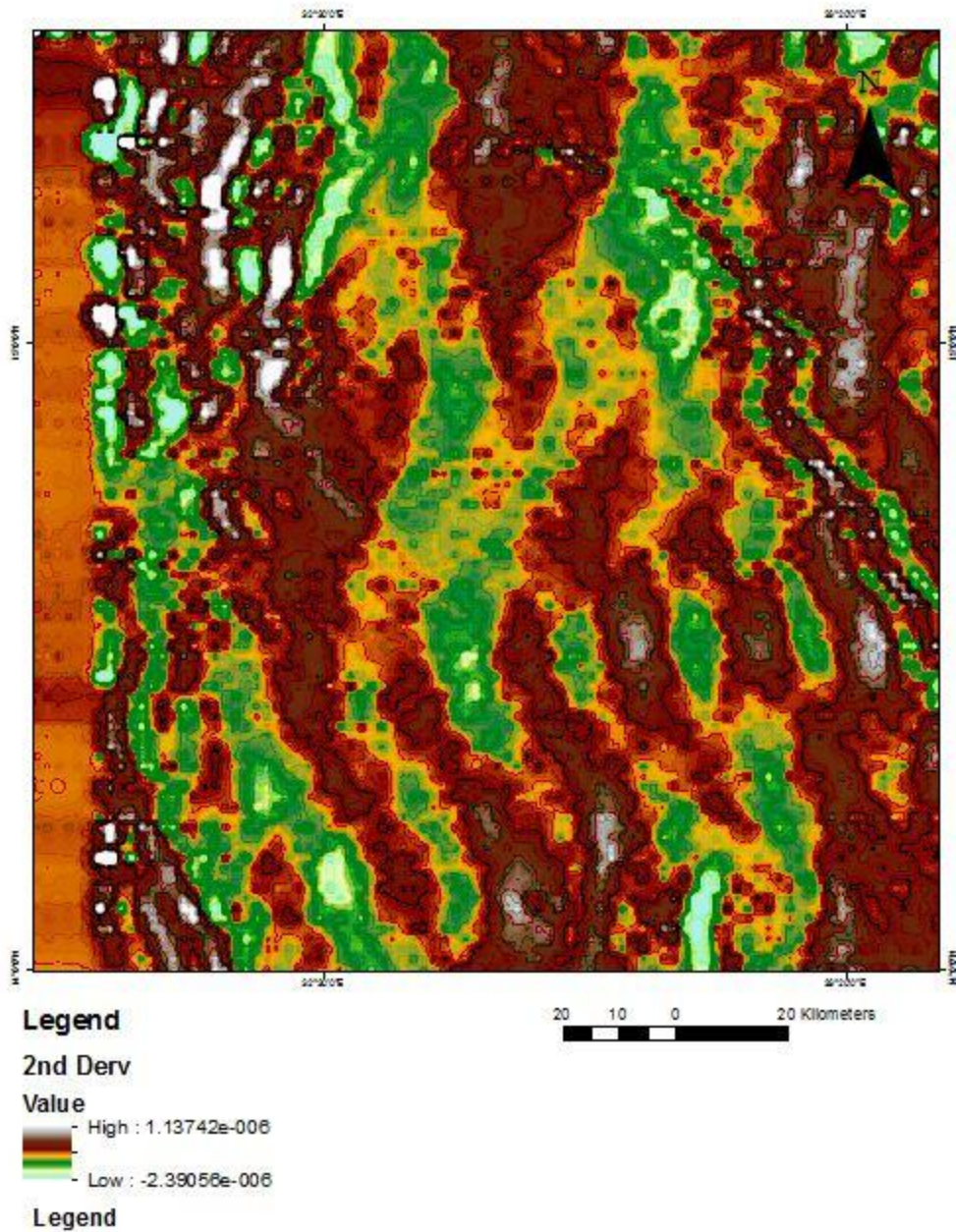


Fig (5.3) showing Second vertical derivative map for Al- maseed area

The second derivative map showed the faults are striking NW-SE. the faults turned the area into grabben and half grabbens which were subtle in the Bouguer gravity map these structures striking NW-SE complying with the central Sudan rift system basins, the high gravity values the horsts are subtle under thick sediments which indicate and intensive erosion which leads to the vast and huge peneplanation (Gazera plain).

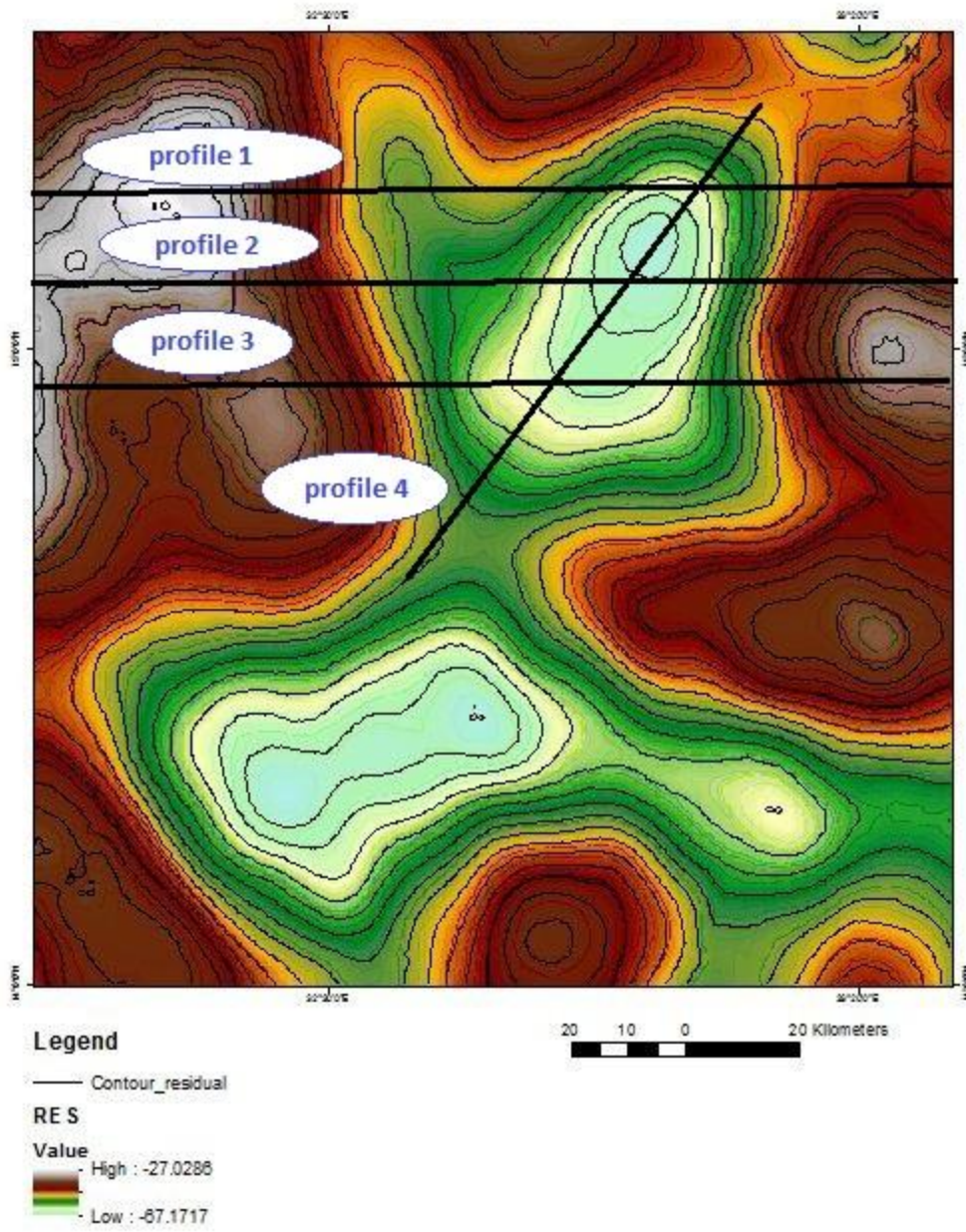


Fig (5.4) Location of Profiles

5.1. Model of Profile-1:

The profile contains 50 points from the residual anomaly map. The distance between points is kept equal to 3km. This profile runs in the West-East direction Fig (5.5) The gravity along profile represent high values in the beginning and increase to very high and decline to low in the center. After that increase and decrease to lowest record along profile, and last increase at the end of profile .basin on profiles shown at Gravity (-14_-15), Depth of Basin equal 3900m. There are many faults defined.

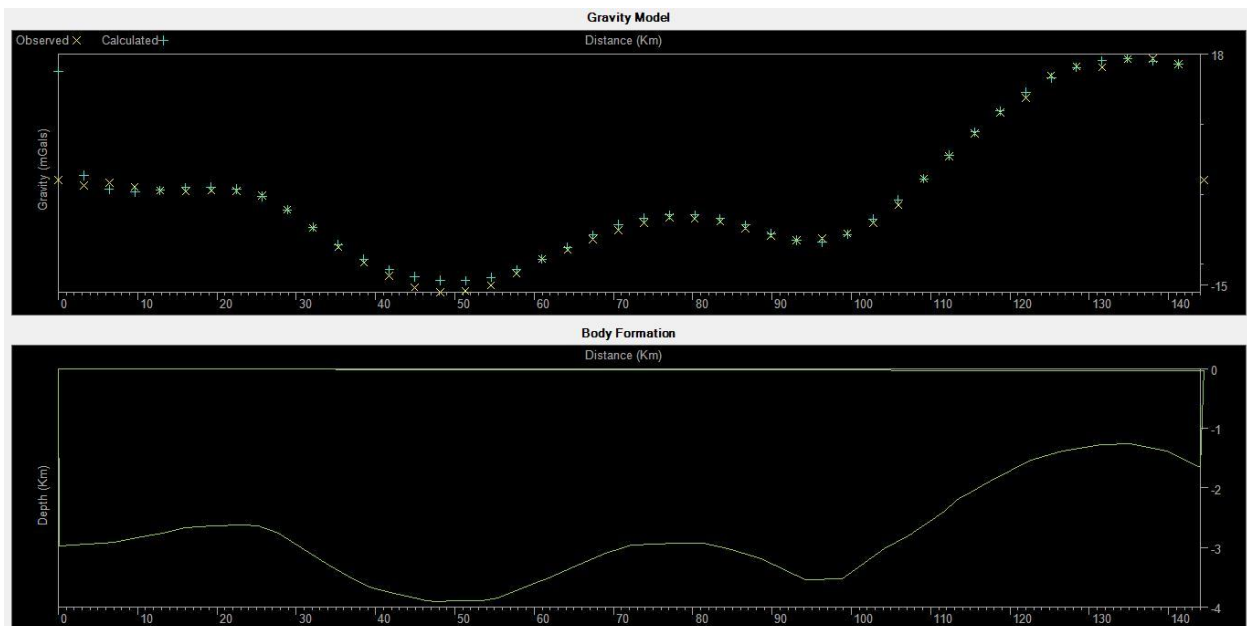


Fig (5.5) shows model of profile (1)

5.2 Model of Profile-2:

The profile runs in the W – E direction and it passes across the center of sedimentary basin. This profile contains 50 points from residual map. The distance between points is kept equal to 3km. We find different readings in this profile explained some geological structures. This difference in values is caused by the density contrasts. There are many faults defined The maximum depth to the basin equal 2800m.

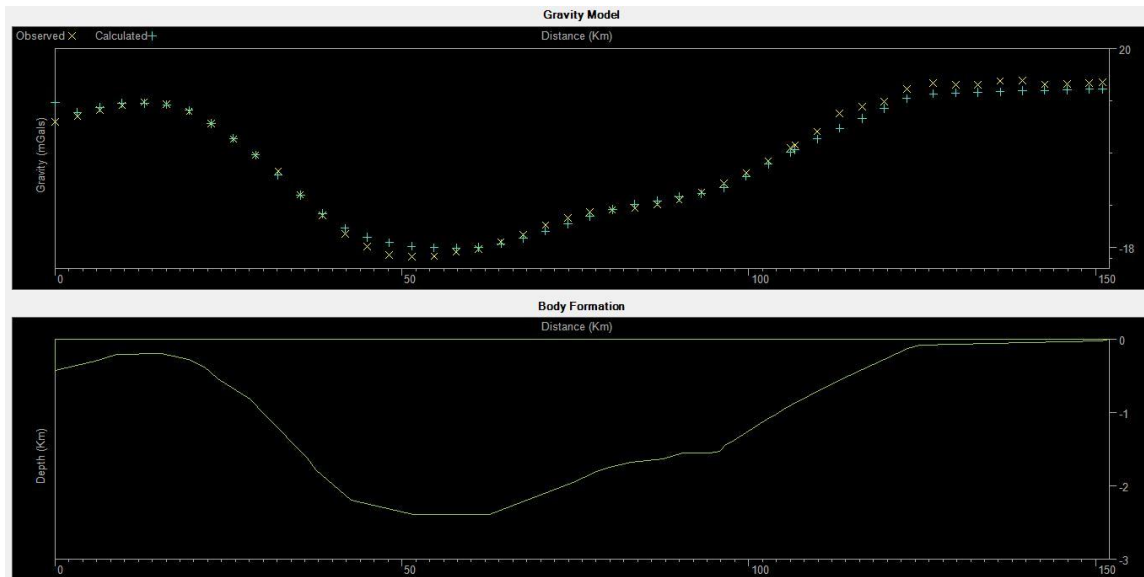


Fig (5.6) shows model of profile (2)

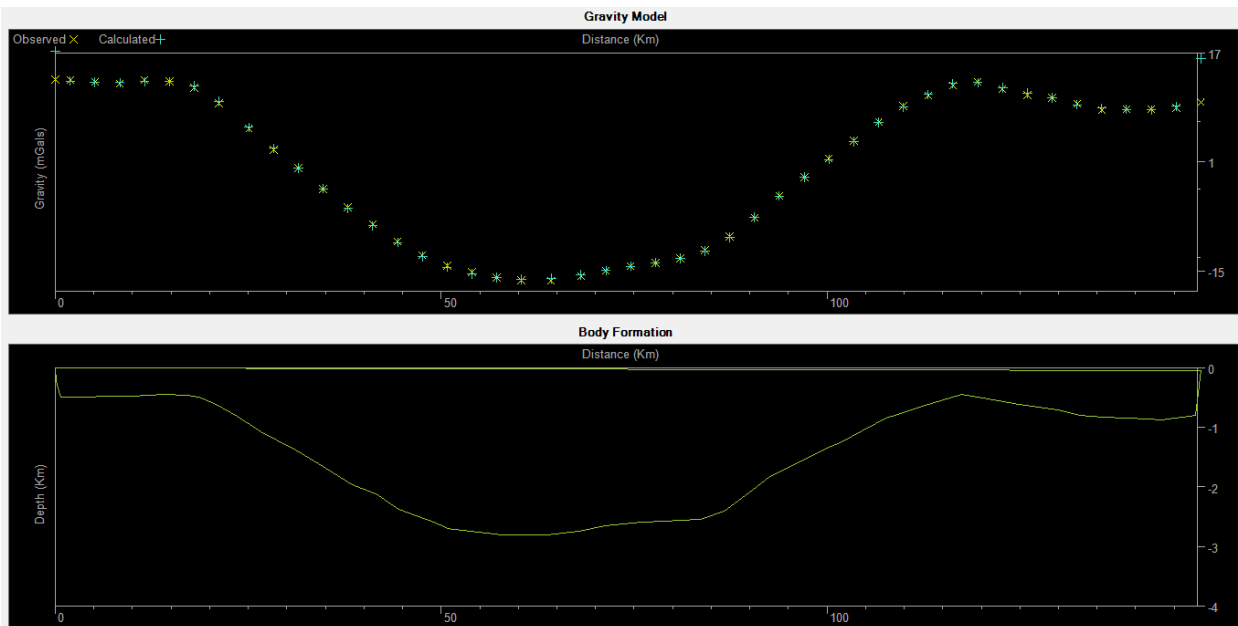


Fig (5.7) shows model of profile (3)

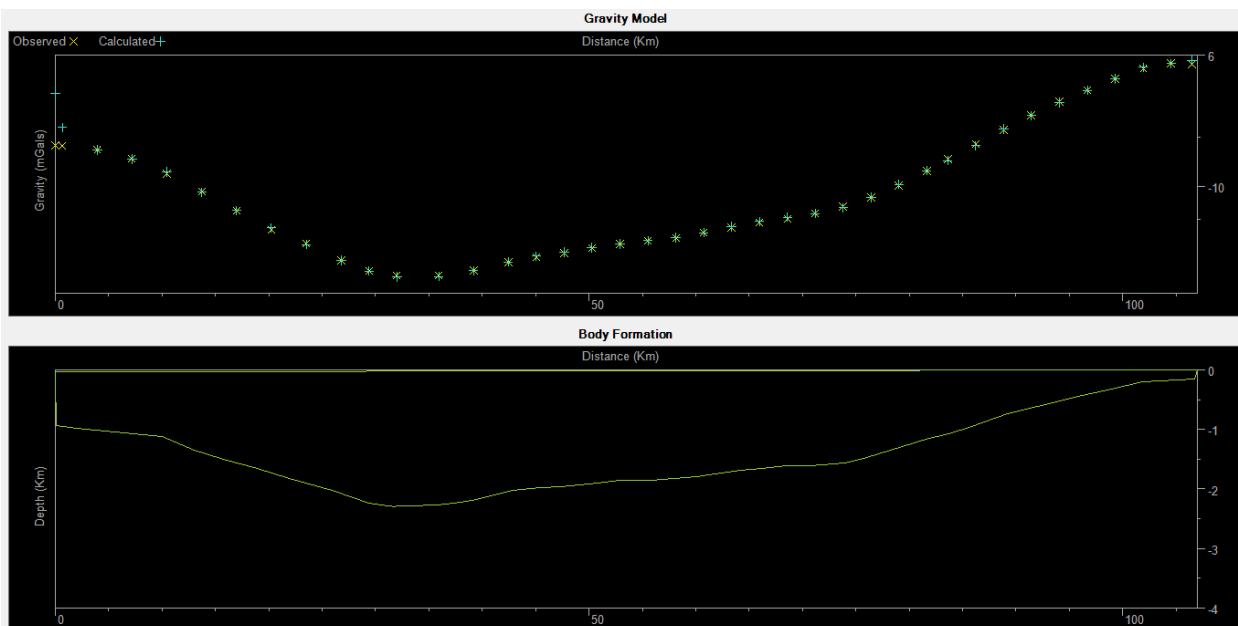


Fig (5.8) shows model of profile (4)

Chapter Five

6. Conclusion and Recommendations

We get free air data and corrected from Bouguer effect and by arc map obtained on Bouguer anomaly map interpretation of map shown three basins, Polynomial fitting was used in order two to separate the regional from the residual component of the gravity by using Oasis Montaj software. The Derivatives of the Gravity were computed in order to study the presence and infer direction of the faults showed that they are striking (NW-SE). Moreover, four profiles were drawn across the residual gravity map in an approximately profile (1, 2, 3) W-E and profile (4) NE-SW directions cutting the most prominent anomalies in the area. Applying 2D forward Gravity modeling technique (Talwani software) showed the geometry and the subsurface structure along these profiles. The results of interpretation maps and profiles defined basins and its peripheries, The Faults in the study area and are striking NW_SE and there is sub basins defined by the fault which are grabbens striking NW-SE subtle under thick sediments. Depth estimations had been made and it found to 3.9Km 2.9Km-2.2Km-2Km. We suggest further studies to have links between the inferred basin geometry and the available borehole data to have more information regarding the lithofacies distribution. The modeling of the gravity showed there are deep areas which can be subject for more studies for oil exploration.

ABSTRACT

The study area lies in central Sudan, situated in the Jazeera State. It is bounded by latitudes (14° _ 15.5° N) and longitudes (32° _ 33.5° E). From a water well drillings in Al-massed area a thick layer of clays observed which force them to go deeper up to 1400-1300ft to reach the aquifer this observation lead us to think why the clay is thick there were two assumptions, the area is a basin depocentre or structure control the sedimentary depositional environment. Applying gravity method varied techniques, Bouguer and residual mapping and the second derivative, recovering the basin geometry using the forward gravity modelling showed that the area is bounded by listric normal fault comprising a half grabben, which lead to sediment segregation in its path way, the wells showed the thick clays are situated in the deeper part of the half grabben (Distal area).

التجريد

- تقع منطقة الدراسة في وسط السودان في ولاية الجزيرة بين خطي عرض (14- 15.5 درجة شمالا وبين خطي طول (32-33.5) درجة شرقا .
- من الأبار التي تم حفرها في منطقة المسيد لوحظ وجود طبقة سميكة من الطين ؛ مما أدى إلى مواصلة الحفر لأعماق بعيدة تتراوح بين (1300-1400 قدم) .
- هذه الملاحظة قادتنا إلى لماذا طبقة الطين سميكة؟ يوجد إفتراضان:
 - إما أنها أعمق منطقة في الحوض
 - أو أن هناك تركيب (فالق) حكم البيئة الترسيبية
- تطبيق طريقة الجاذبية (خرائط بوجير والمتبقي من الفصل والمشتقة الثانية للجاذبية) لتغطية شكل الحوض .
- إستخدام برنامج (Talwani) أظهرت عملية النمذجة أن المنطقة يحدها فالق إعتيادي ,شملت (half grabben) على طول مسار الترسيب .
- أظهرت الأبار أن الطين السميك يوجد في أعماق جزء من ال (half grabben) المنطقة البعيده .

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