RESEARCH

54(267), March 1, 2018

Discovery

ISSN 2278–5469 EISSN 2278–5450

Qualitative analysis of Bouguer gravity map of parts of southern Niger delta, Nigeria

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Article History
Received: 5 January 2018
Accepted: 6 February 2018
Published: 1 March 2018

Citation
Ofoha CC, Emujakporue G, Ekine AS. Qualitative analysis of Bouguer gravity map of parts of southern Niger delta, Nigeria. *Discovery*, 2018, 54(267), 88-101

ABSTRACT

Using Bouguer (aerogravity) data, processing and interpretation of structural features covering Oloibiri and Degema was undertaken. Since knowledge about the structural makeup of the subsurface geology within the study area is of great importance considering the fact that the region is economically viable in terms of hydrocarbon exploration, detailed filtering techniques like the directional vertical derivatives, directional horizontal derivatives, upward and downward continuation were carried upon the residual using the oasis montaj software. The residual, which is a true reflection of short wavelength anomalies arising from shallower geological structures was however obtained via regional-residual separation when polynomial fitting of degree one was applied. Low and high amplitude/gravity anomalies were modeled from the Bouguer gravity map. These anomalies have a tectonic trend of E-W, ENE-WSW, WNW- ESE, N-S, NE-SW and NW-SE. These trends are structural and tectonic indicators. The E-W trend could be attributed to be Cameroun Volcanic line that must traversed within the study while the ENE-WSW and WNW-ESE trends possibly indicate the presence of Benin flank that is trending south of the West Africa basement massif. Active Charcot and oceanic fracture zone which cuts far into the West shield exist within the area as this is indicated by the NE-SW and NW-SE tectonic trends. As evidenced by the structural/tectonic trend, the general pattern of the gravity signatures obtained grossly corresponded to the well-known geology of the Niger delta region. Thus, the findings support the fact that the area is geologically significant in terms of hydrocarbon exploration, hence the need for further investigation.

Keywords: Oloibiri and Degema, qualitatively, Bouguer, Oasis Montaj, Residual

Abbreviations: GGF: Geosoft Grid File, NGSA: Nigerian Gelgical Survey Agency, E-W: East west, ENE-WSW: East northeast-west southwest, WNW- ESE: West northwest-east southeast, N-S: North-south, NE-SW: Northeast-southwest, NW-SE: Northwest-southeast.

1. INTRODUCTION

For this study, we aim to add to the understanding of the nature of some structural features of Oloibiri – one of the commercial cities where hydrocarbon was first discovered in Nigeria - and Degema. This was done by analyzing the Bouguer gravity anomalies covering the area and its environs qualitatively. The study area falls within the Niger Delta sedimentary basin. The area lies between longitude $6^{0}0^{i}0^{ii}$ E - $7^{0}0^{i}0^{ii}$ E and latitude $4^{0}30^{i}$ N - $5^{0}0^{i}0^{ii}$ N. The Niger delta basin is one of the basins of the world whose hydrocarbon exploration potential remains ostensible. This basin which contains an effective petroleum system is believed to be an extensional rift basin domiciled within the Niger Delta and the Gulf of Guinea along the passive continental margin beside the western coast of Nigeria. It is a well known fact that the Niger Delta basin is very complex, and it carries high economic value as it contains a very productive petroleum system. In view of this, numerous geophysical techniques have been used by earth scientists to decipher the subsurface geology of the Niger Delta region. Most of the previous studies cover the entire portion or some parts of the area under investigation in this study. Nevertheless, there is a paucity of information as regards to the use of Bouguer data in studying the structural composition/complexity of Oloibiri and Degema. Hence to fill that lacuna, this study tried to investigate the subsurface geology by delineating structural features. This was achieved by interpreting and correlating the gravity anomalies with the geology of the region.

2. GEOLOGY OF THE STUDY AREA

The geologic map, (Figure 1), which falls within Oloibiri and Degema, reveals the area to be swampy and shows the Creeks, with the Benin Formation and Sombreiro Warri Deltaic Plain sands. In Nigeria, many major depositional episodes can be distinguished in Nigeria. These depositional events resulted in the formation of about eight sedimentary basins in Nigeria where petroleum exploration and exploitation activities can be carried out. These basins include the following: Anambra Basin, Benue Trough, Benin Basin, Bida basin, Bornu Basin, Niger Delta basin, Dahomey basin and the Sokoto Basin.

The Niger Delta Basin is an extensional rift basin located in the Niger Delta and the Gulf of Guinea on the passive continental margin near the western coast of Nigeria with suspected or proven access to Cameroon, Equatorial Guinea and São Tomé and Príncipe. This basin is very complex, and it carries high economic value as it contains a very productive petroleum system. The Niger delta basin is one of the largest basins in Africa. It has a subaerial area of about 75,000 km^2, a total area of 300,000 km^2, and a sediment fill of 500,000 km^3 (Tuttle *et al.,* 2015). The sediment fill has a depth between 9–12 km. It is composed of several different geologic formations that indicate how this basin could have formed, as well as the regional and large scale tectonics of the area. The Niger Delta Basin is an extensional basin surrounded by many other basins in the area that all formed from similar processes. The Niger Delta Basin lies in the south westernmost part of a larger tectonic structure, the Benue Trough. The other side of the basin is bounded by the Cameroon Volcanic Line and the transform passive continental margin (Fatoke, 2010).

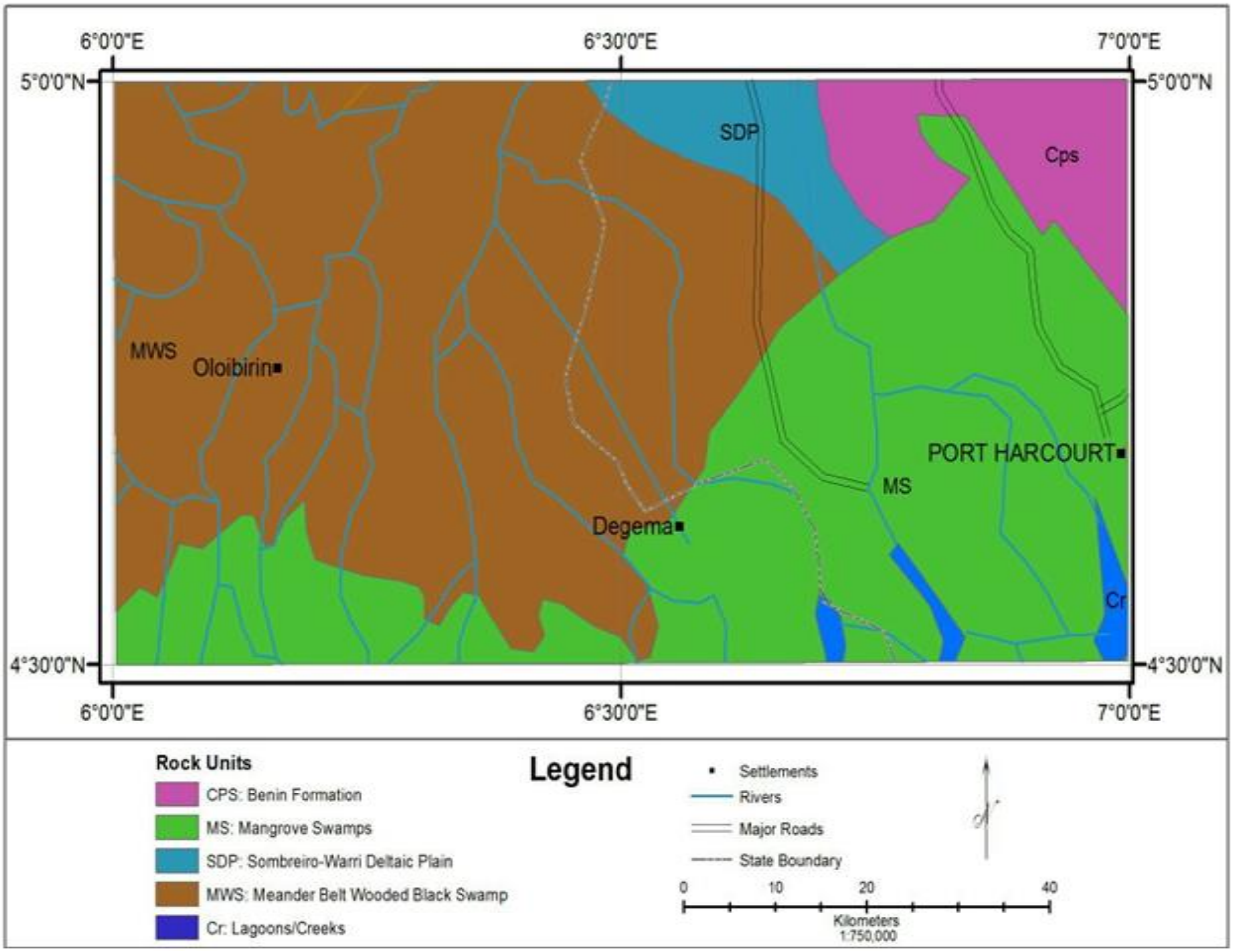

Figure 1 Geological map of the study area (Courtsey: The Nigerian Geological Survey Agency, NGSA, Abuja)

The Tertiary section of the Niger Delta is divided into three Formations representing prograding depositional facies that are distinguished on the basis of sand-shale ratios to Recent, namely: the Akata, Agbada and the Benin Formation. The Akata Formations, which is the potential source rock is estimated to be up to 7000 m thick while the Abgada and Benin Formation are estimated to be 3700 m and 2000 m thick respectively (Michele *et al.,*1999). The three major lithostratigraphic units defined in the subsurface of Niger Delta (Akata, Agbada and Benin Formations) reflect a gross upward coarsening and fluvial environments respectively (Weber and Daukoru, 1975).

3. MATERIALS AND METHODS

Digitized Bouguer (aerogravity) covering the study area was utilized for this study. The Bouguer data was obtained from the Nigerian Geological Survey Agency, NGSA, in half degree sheet and in Geosoft file format. The Bouguer data is of high resolution in that the data was acquired at a terrain clearance of about 100 m, flight line pattern of NE-SW and tie line spacing of 500 m. The Oasis Montaj Modeling software was used for the processing, analysis and interpretation.

For the research, the qualitative method in other words called the inverse method was implemented on the acquired Bouguer data. By the qualitative method, regional-residual separation was applied on the Bouguer data so as to obviate the influence of unwanted deep seated regional's on the significant shallow seated residuals. Further filtering was then applied on the residual data and as a result other qualitative maps like the first vertical derivative, second vertical derivative, first horizontal derivative, second horizontal derivative, upward continuation and the downward continuation maps were generated. Thereafter, visual inspection and correlation of the various contour maps with the subsurface geology done. Tectonics of the study area was examined by analyzing the structural trends of the contour maps. Analysis was performed on the contoured map on the basis of amplitude of the anomalies and identification of anomalous boundaries, volcanic zones, lineaments, folds, faults, dykes, seals, and other regional structures that, perhaps, assist in hydrocarbon and other mineralized fluid migration and entrapment.

4. RESULTS

Obtained in Geosoft Grid File (GGF) format is the bouguer gravity map (Figure 2) expressed in raster style. Colour variations highlighting gravity field values are evident on the map. To further ascertain structural disposition of the study area, the raster map was transformed into its contour format (Figure 3). Contours of distinct architecture can be discerned on the map. Regional-residual separation was applied on the residual bouguer map in order to attenuate the effect of the deeply seated structures masking the shallow seated structures. This gave rise to the regional and residual bouguer map (Figure 4 and 5).Further qualitative analysis was performed on the residual bouguer map by applying one dimensional Fast Fourier Transform. Consequently, first vertical derivative (Figure 6), second vertical derivative (Figure 7), first horizontal derivative (Figure 8), second horizontal derivation (Figure 9), upward and downward continuation at 40 km and 10 km (Figure 10-13) maps were generated.

5. DISCUSSION

The Bouguer gravity anomaly map covering the study area was produced on a scale of 1:393103 by the Nigerian Geological Survey Agency (NGSA). Colour variations depicting low and high amplitude anomalies are apparent on the Bouguer gravity raster map (Figure 2). The map shows two distinguishable areas: a predominant gravity lows trending ENE-WSW, N-S to E–W around the northern area and ostensible trending ENE-WSW to E-W gravity highs found in the southern side of the map. The gravity high is found to be located within Port Harcourt and Degema region while the gravity low is observed within Oloibiri area of the geologic map. Underlain within Degema and Oloibiri area are the Mealder Belt Wooded Black Swamp and Mangrove Swamps respectively. Beside the map is a label which accentuates the gravimetric values of, perhaps, distinct lithology and structures with the aid of colour differences. These differences in colours partitions the study area into gravity high (yellow, red and mangenta colours) and gravity low (green and blue colours). Maximum and minimum gravity values revealed by the label are 38.21 mgal and 7.47 mgal respectively.

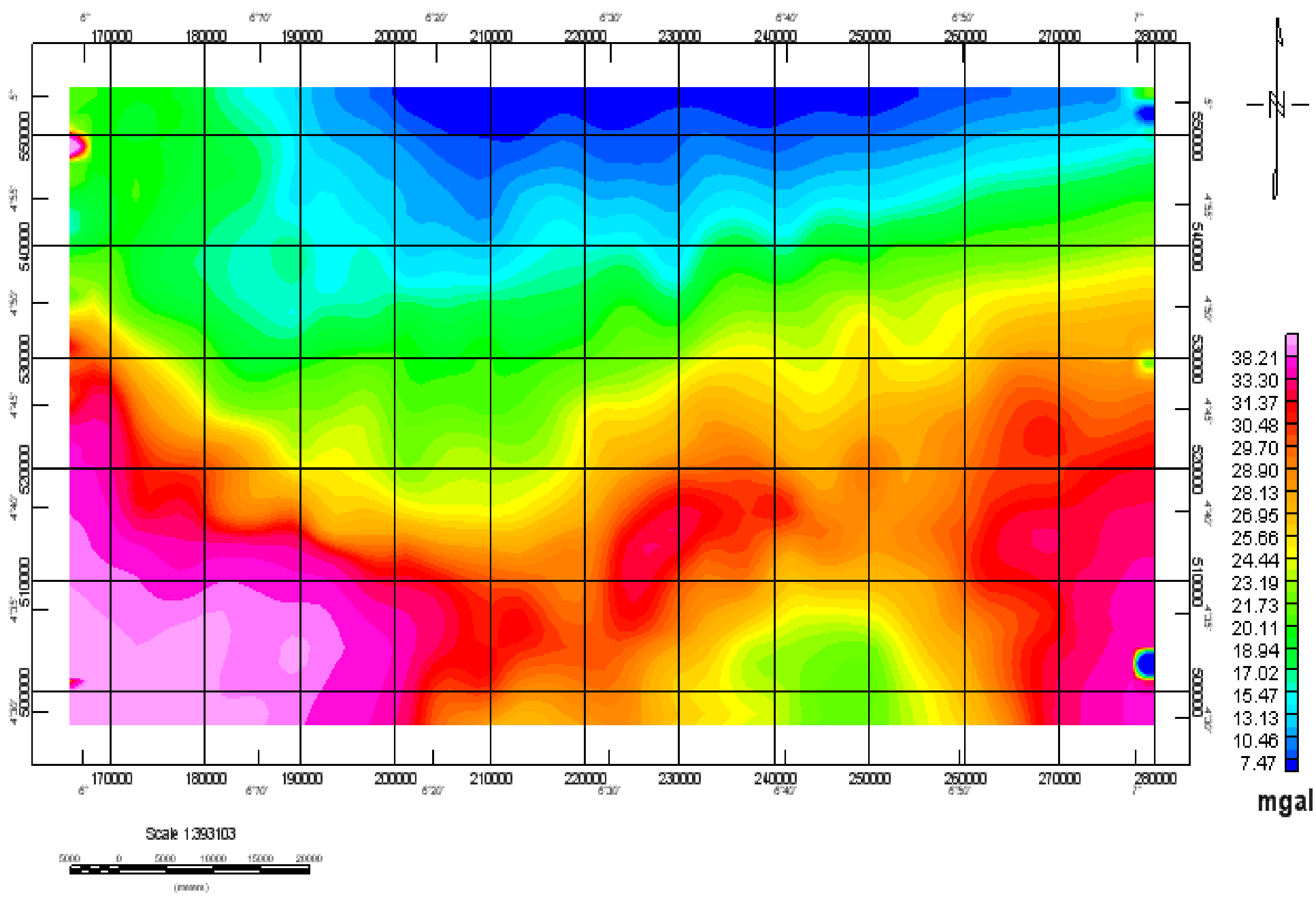

Figure 2 Bouguer gravity map of the study area (mgal)

The colours on the map varies from blue and green at the northern end of the map to yellow, red and magenta at the southern end of the map. The colour contrasts reflect summation of gravitational effect of all subsurface rocks within the study area and as such horizontal variations of rock densities are revealed. Close inspection of the Bouguer gravity raster map reveals sharp gradients found within geological domain of Oloibiri and Degema area of Niger Delta, Nigeria. As evidenced by the label, gravitational field which generally increases from the northern end to the southern end of the map can be observed. The blue and green colours found at the north are associated with possible rocks with low gravity values. On the other hand, high gravity values obviously dominate the southern end of the map. It can therefore be deduced that higher density rocks and/or structures occur at the southern portion of the study area while low density rocks and/or structures are seen at the northern end of the map. Hence, this is a clear indication of dense rocks decreasing southwards within Oloibiri and Degema area. Zahra and Owesis (2016) stated that the southwards decrease of rock densities usually observed in Bouguer gravity maps may indicate that the crust-mantle boundary is deeper within the southwest than the center and north. Gordon et al. (2006) suggested that such decrease in gravity represents increasing thickness of the continental crust. According to Yves and Jean (2012), gravity high regions are associated with basement rocks while gravity low regions are associated with sedimentary rocks. Nevertheless, gravity high within the study area ranges between 23.19 mgal to 38.21 mgal while gravity low varies from 21.73 mgal to 7.47 mgal.

To further interpret the crustal structure of the study area, the need to transform the Bouguer raster map into contoured Bouguer gravity map (Figure 3). The contoured Bouguer gravity map is contoured at a stable 1.2 mgal contour interval. Distinct positive contour configurations are evident on the map. Strong positive gravity anomalies with contours trending in the E-W and ENE-WSW direction are observed at the southern portion. However, little NE-SW directional contour trends can be seen at the south eastern end of the map. These strong positive anomalies whose gravimetric values range from 23.19 mgal to 38.21 mgal are irregular and spaced.

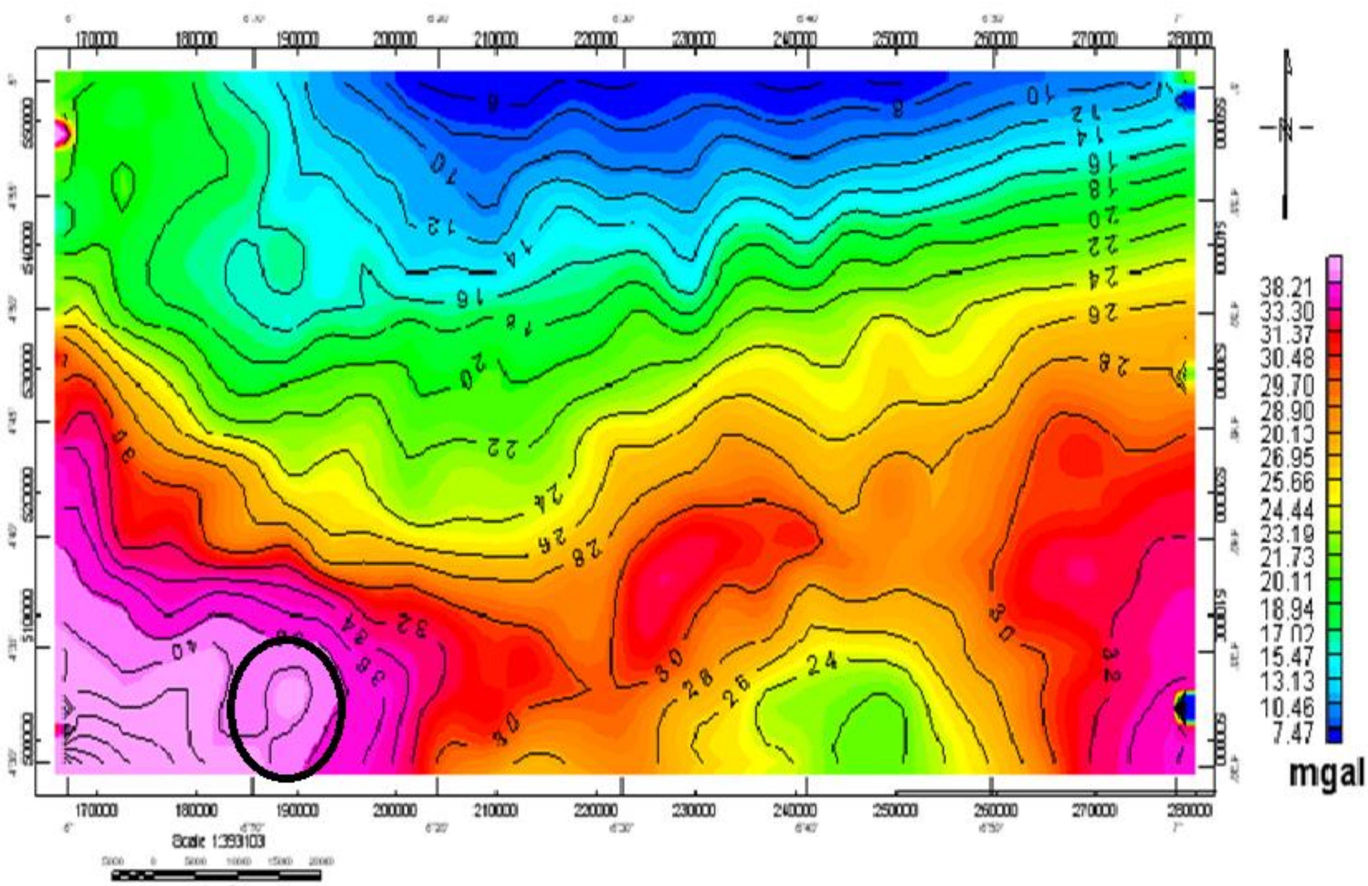

Figure 3 Contour Bouguer Gravity Map of the study area (mgal)

The irregularity observed could be attributed to high differentiation of the basement while the observed spacing pattern between the contours is an indication that the anomalies are of deeper origin. It is apparent that maximum gravity high with a tectonic trend of NW-SE direction occurs at the south western portion and slightly at the south eastern portion. Within the NW-SE region, an anomalous structure circled with a thick line is visible. It could be inferred that the circled anomaly is a salt dome intruding vertically into surrounding rock strata. Hemispheric shape like structure with a contour value of 3.0 mgal is noticeable at the northern part. At the northern end is gravity low with E-W and ENE-WSW trending contours. Subtle gravity low is also observable at the southern part of the map The tectonic trends found within the gravity low region are relatively close except for the trends at the North western part. The closeness of the tectonic trends is an indication that the gravity low regions are shallower unlike the gravity high region.

As shown by the gravity values in the label, sharp but little gravity changes can be seen with contours having 1.6, 1.8, 2.0 and 2.2 mgal contour values. Sharp gradient is also noticed within the north western portion of the map where gravity high appears to be most. Yves and Jean (2012) stated clearly that these sharp gravity gradients are possibly due to upwelling of the mantle associated with high temperature. Thus, it can be extrapolated that melting of the basement rocks had occurred in the lower crust of the study area. The E-W and ENE-WSW tectonic trends are sets of faults induced possibly by gravity tectonics within the study area. Attenuated trends, expressing active Charcot and oceanic fault zones, can be seen within the study area. These trends are subtle and they trend in the NW-SE direction.

The Bouguer gravity sourced from the Nigeria Geological Survey Agency (NGSA) is the sum of all gravitational effect of underground sources. The Bouguer map consists of the effect due to deeply and shallow seated gravity sources but with the deeply seated or the regional superimposed on the shallow seated or the residuals. To give a better interpretation of the desired feature, highlight some salient features and hidden tectonics, regional-residual separation was carried out by using polynomial fitting technique of degree one. The choice of polynomial degree is, however, arbitrary. The regional-residual separation is based on the subtraction of the regional from the Bouguer. The resultant effect is the anomaly of interest which is called residual anomaly.

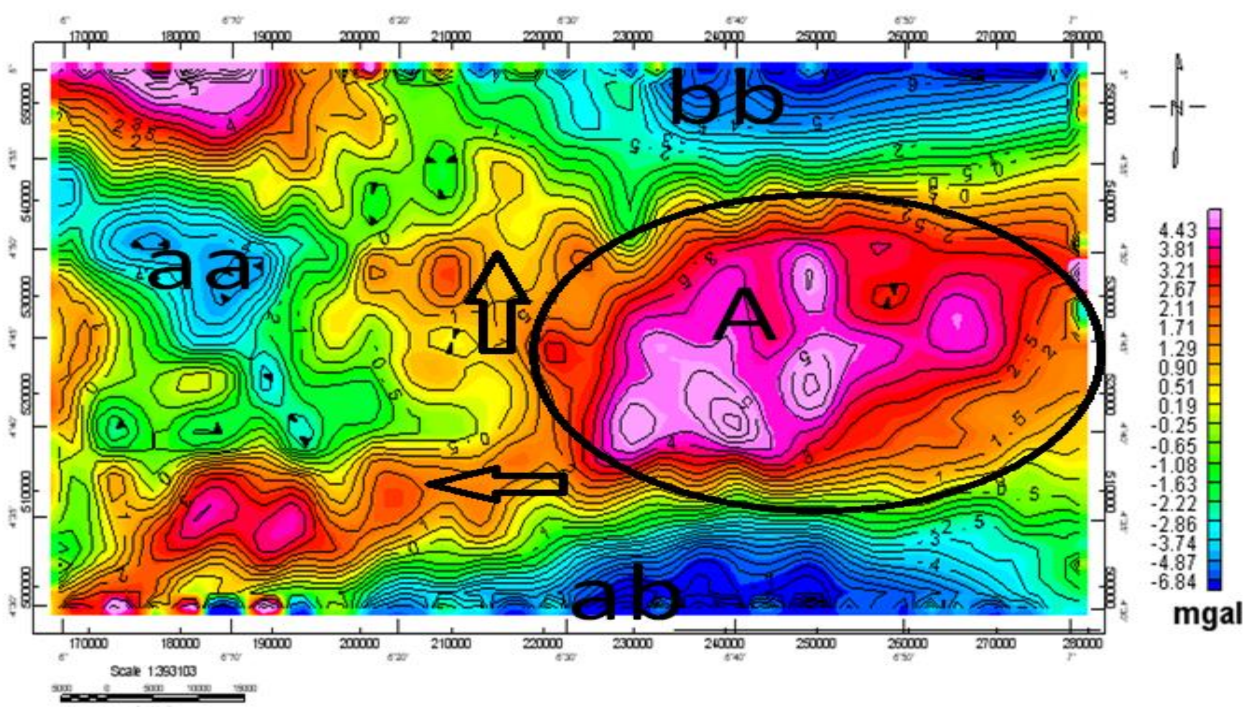

Figure 4 Residual Bouguer gravity map (mgal)

The residual map (Figure 4) reveals random and smoothened gravity anomalies with gravimetric values ranging from -6.84 mgal to -0.19 mgal for low gravity regions and 0.51 mgal to 4.43 mgal for high gravity regions. Two distinct gravity lows exist within the study area; they are the gravity low with blue colouration and that with green colouration. Gravity low indicated by the blue colours is located within the north eastern, western and southern portion of the map while the gravity low expressed by the green colour is evenly distributed within the study area. Gravity anomalies labeled 4, 5 and 6 are the gravity lows. At the edges of these gravity low anomalies, the blue colouration faints to light blue. The change in colour could be as a result of weathering of gravimetric rock units involved. Anomalies with high gravity values are noticeable at the eastern, central, south western and north western portion of the map. These anomalies with high gravity values are labeled 1,1a, 1b, 2 and 3. Ayala *et al.* (2016) opined that the gravity highs are associated with basement rocks like migmatite and granite while the gravity lows are due to sedimentary rocks like shale, sandstone and/or limestone. The contoured residual map highlights varying degrees of contours that are closely packed. The closeness of the contour can be related to shallow related gravity bodies. These contours vary from being circular, elliptical to being elongated linear contours. At the southeastern portion of the map, closely packed and elongated linear contours with low relief are conspicuous. These linear elongated contours forms fault belt zone. Dobrin and Carl (1988) believe that this anomalous pattern results from subsurface faulting that have displaced gravimetric rocks. The elongation of the contour depicts faults that serve as conduit for economic deposits while the closeness of the contours shows that the faults are of shallow origin. Hence, faults of shallow origin exist within the study area. Nevertheless, the contour architecture found in the residual is quite different from the contours observed in the bouguer gravity. This is attributed to the regional-residual separation performed on the bouguer map. The circled anomaly found on the bouguer map shows anomaly similar to that of a salt dome. This anomaly is unrelated to anomalies of interest as the anomaly is no longer discernible on the residual map. This is an indication that such anomaly is of deeper origin. Emplaced at the eastern portion of the map are high gravity anomalies indicated with a thick circle.

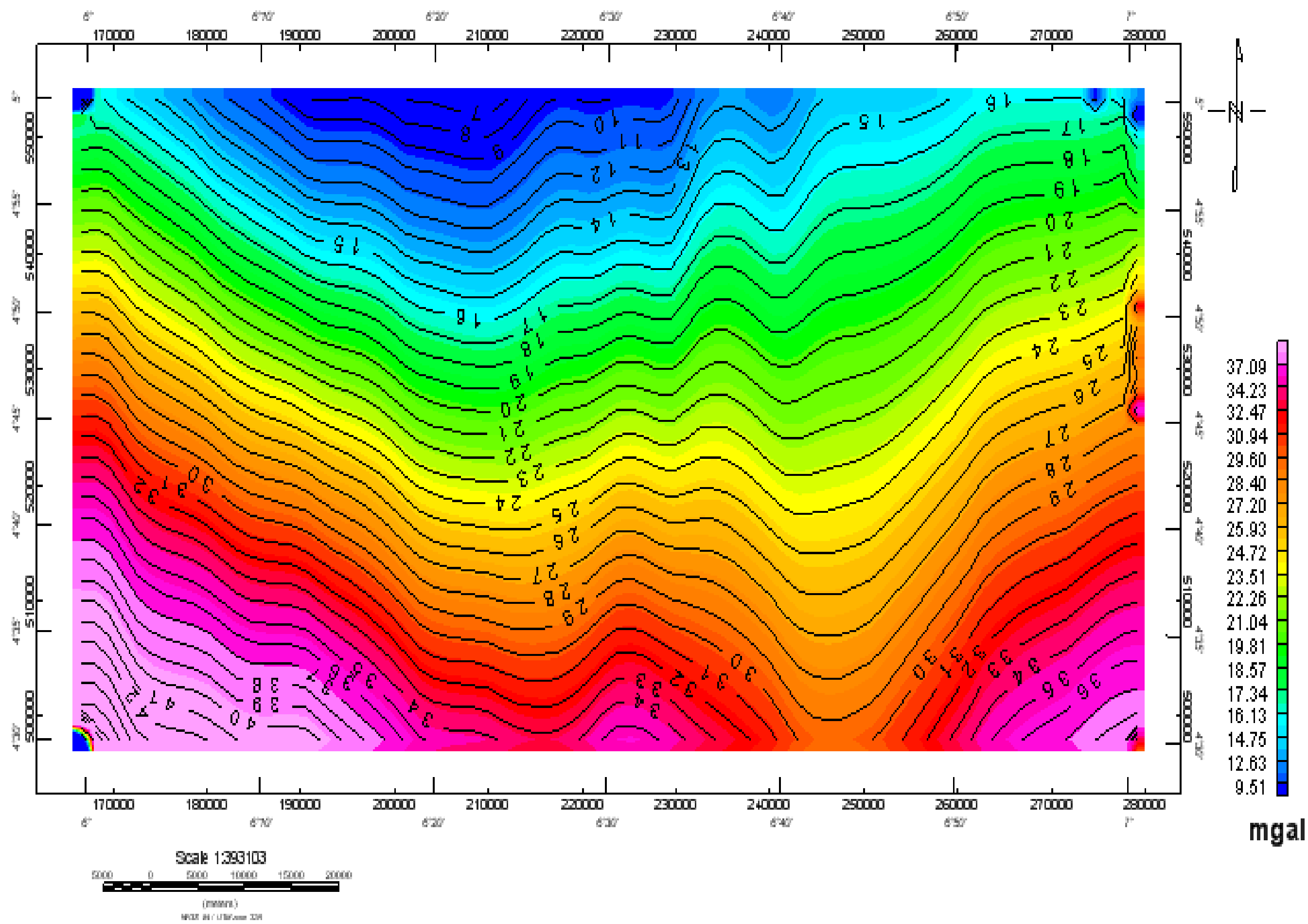

Figure 5 Regional Bouguer Gravity Map of the Study Area (mgal)

These anomalies lie within the Port Harcourt region of the geologic map. However, this region is underlain by the Mangrove swamps. Within the anomalies indicated with a thick circle, are higher anomalies of high gravity values labeled A. The anomalies are of short wavelength. These anomalies are of wide areal extent also. They anomalies consist of edges protruding towards the northern and south western portion of the map. The direction of protruding anomalies is indicated with the arrows. Towards the western side of the map, high gravity values can be seen. The western part of the Bouguer residual map falls within Oloibiri town of Bayelsa state, Nigeria. This region is predominated by the Meander Belt Wooded black swamp. Similar colour of the anomalies labeled A can be noticed at the north western and south western portion. Moving northwards (which is occupied by the Meander Belt Wooded black swamp) and immediately above the circled anomaly is an extended linear anomalies with a relatively high relief. These gravity signatures are almost synonymous to the signatures found immediately below the circled anomalies. At the southern part of the bouguer residual map falls within the degema region and within such region low gravity signatures that are closed and linear can be seen. However, similar type of feature can be seen within the eastern, northern part of the map. These signatures are marked aa, ab and bb. The gravity signatures generally trend in the ENE-WSW, N-S, E-W and WNW- ESE directions but with the ENE-WSW tectonic trend dominating. Smoothened long wavelength effect (Figure.5) known as regional trends was subtracted from the bouguer anomaly data. These longer wavelength effects are due to the deeply seated gravity sources. The deeply seated gravity effect obscures the shallow seated anomalies of interest known as the residual. The long wavelength regional effect therefore makes it difficult to interpret the short wavelength residuals. Manifested on the regional map are parallel and linear elongated regional trends running from east to west. These extended linear trends are curvy in the eastern, northern, southern and south western portion of the map. Krutikhovskaya *et at*. (1972) enunciated that the parallel and curved anomalies are to be a reflection of large tectonic feature of ancient geosynclines. Showed on the map is a southwards increase in the density of gravimetric sources within the area. The gravity values of the deep seated sources vary from 9.51 mgal to 37.09 mgal.

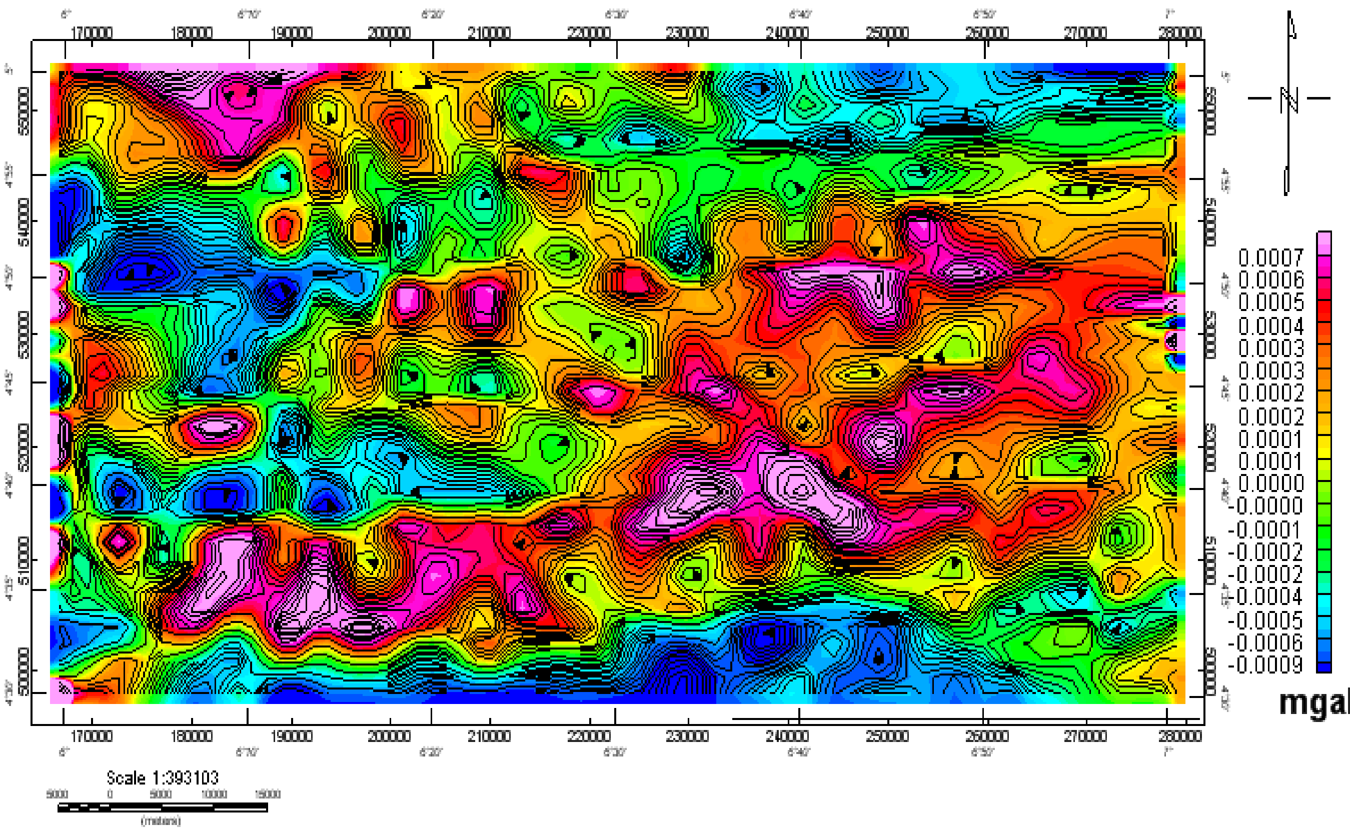

Figure 6 First Vertical Derivative Bouguer Map (mgal)

Colour variations highlighting shallow seated gravity bodies are illustrated in the first vertical derivative map (Figure 6). Unlike the residual gravimetric sources, the gravity values are too small a value. However, anomalous bodies with high and low density are still distinguishable. Sources with high gravity values ranging from 0.0001 mgal to 0.0007 mgal can be seen occurring at the eastern, north western and western side of the map while low values ranging from -0.0001 mgal to -0.0009 mgal. The 0.000 mgal value is a zone with no vertical gravity contrast. The high gravity anomaly existing at the eastern portion is similar to the high gravity anomaly which occurred at the same region in the same Bouguer residual map. They anomaly runs towards the south western and northern portion. Gravity lows appearing apparently on the Bouguer residual map are inconspicuous on the first vertical derivative map. This is owned to the fact that the one dimensional fast Fourier transform - the first vertical derivative filter- recognizes some of the low gravity values as artifact. Unlike the Bouguer residual map, localized and shorter wavelength contours are observable. Dominating on the map are closed gravity contours. Little linear contours that are apparent exist at the southern region. The shorter wavelength contours is an indication that shallower gravity sources are accentuated using the first vertical derivative filter. Embedded inside high gravity contours occurring across the map are contours of higher gravity values. According to Gunn *et al.* (1997), the higher gravitational values that are embedded are distinct lithology from the surrounding. Existent on the map are E-W, N-S, ENE-WSW and WNW- ESE tectonic trends. In contrast to the residual and first vertical derivative map, lateral orientation of anomalies is clear in the second vertical derivative map (Figure 7). However, few anomalies with vertical orientation can be seen. The label beside the second vertical derivative map indicates little or no changes vertically within the map. Gravity values ranging between -0.0000004 mgal and 0.0000003 mgal exist within the map. The gravity anomalies emplaced laterally are noise. This is because the second vertical derivative identifies and visualizes anomalous changes in the vertical direction. Close inspection of the map, reveals gravity bodies with sharp edges. Regions with no vertical gravity contrast are obvious as indicated by the 0.000 mgal values attached to the label. Irregular, circular, localized and short wavelength gravity contours can be seen on the map. The contours have a general trend of E-W, N-S, NE-SW and NW-SE. The E-W trends, however, persist within the study area.

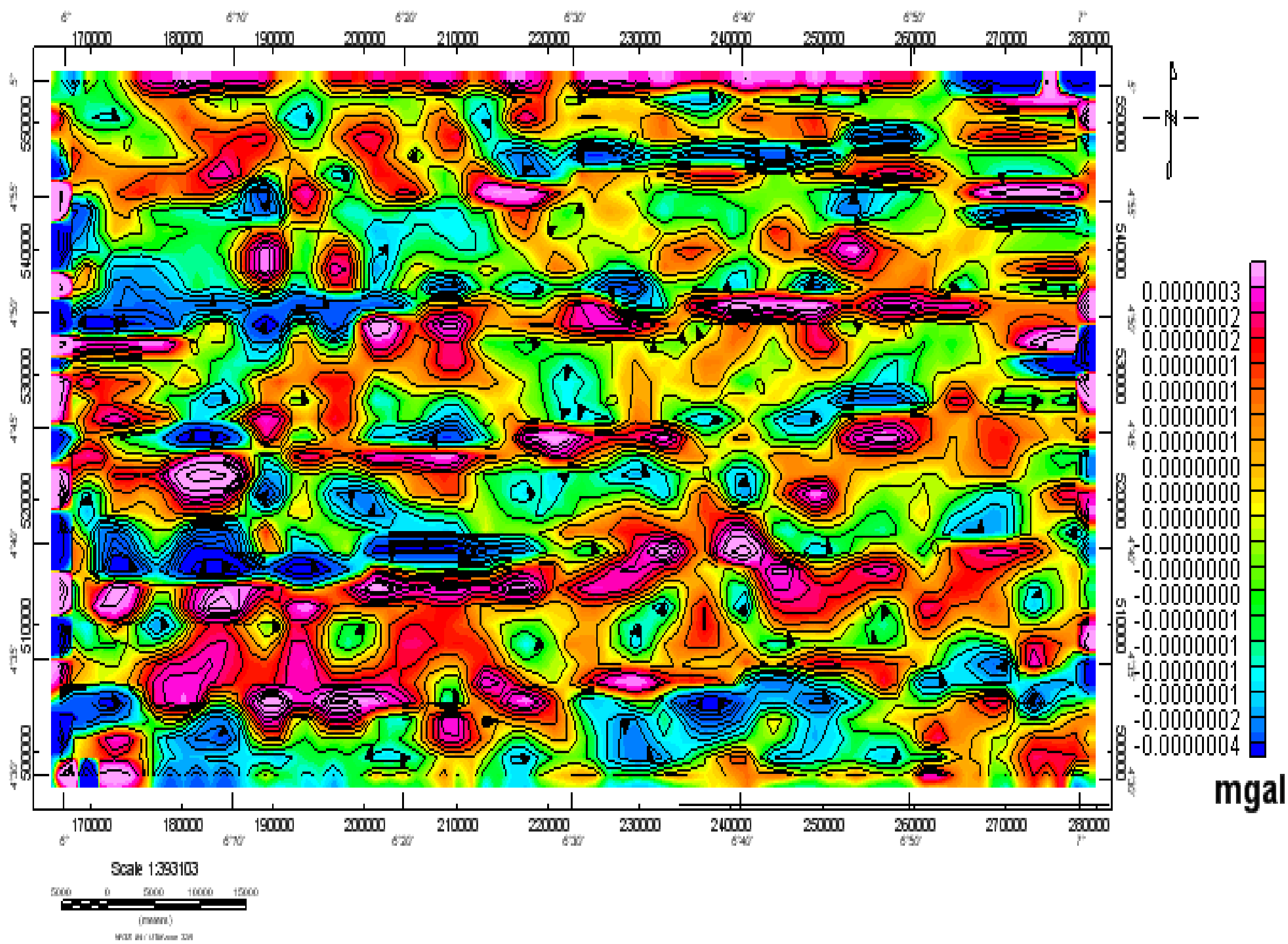

Figure 7 Second Vertical Derivative Bouguer Map (mgal)

The first horizontal derivative map (Figure 8) shows acute predominate high gravity field changes. Gravity sources with large areal extent are visible running from the south eastern side of the map to the southern portion. Gordon *et al. (2006)* stated that sources with such large area extent can be attributed to the homogeneity of the source. They also stated that such anomalous feature is produced by large density contrast. Gravity lows can be seen more at the north eastern portion of the map. Minor circular gravity lows are also noticeable towards the western zone of the map. E-W and N-S tectonic trends are visible on the map but with the former occurring frequently. Dominate E-W directional trend is an indication of less noise within the map. Gravity anomalies within the map have values ranging from 0.00086 mgal to - 0.00081mgal.

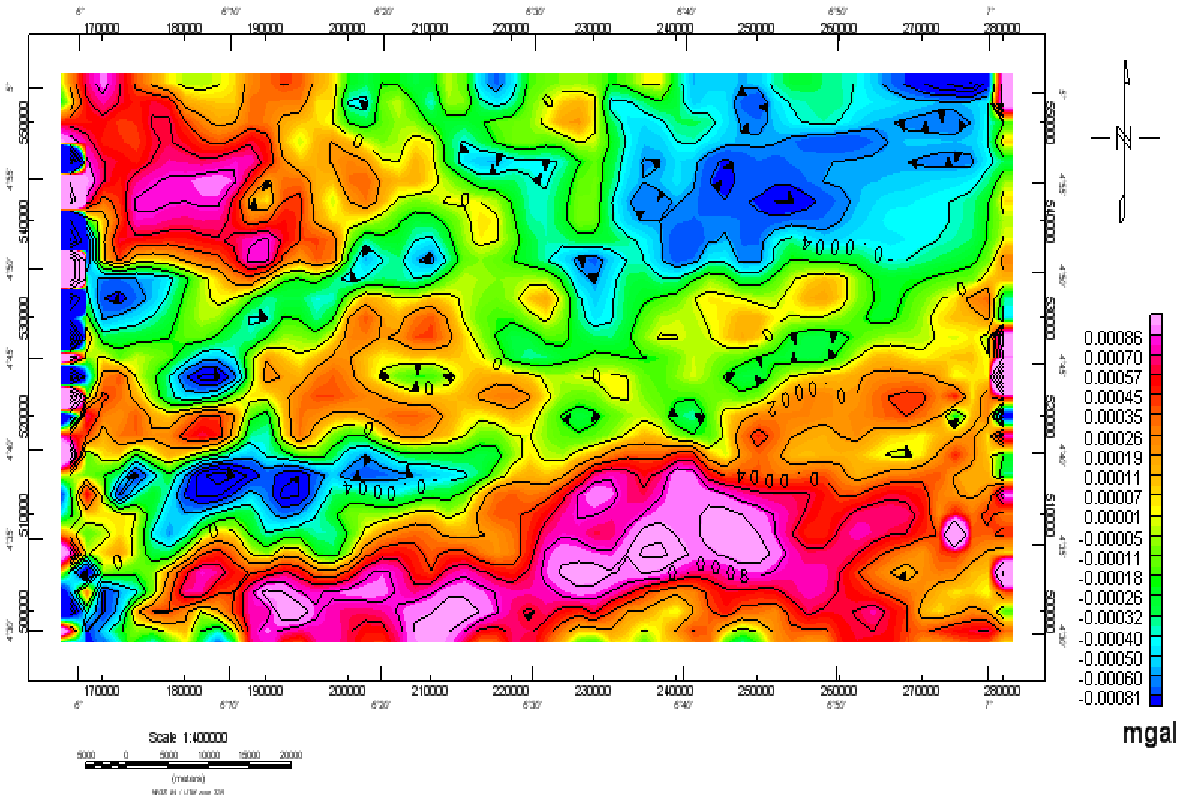

Figure 8 First Horizontal bouguer gravity map (mgal)

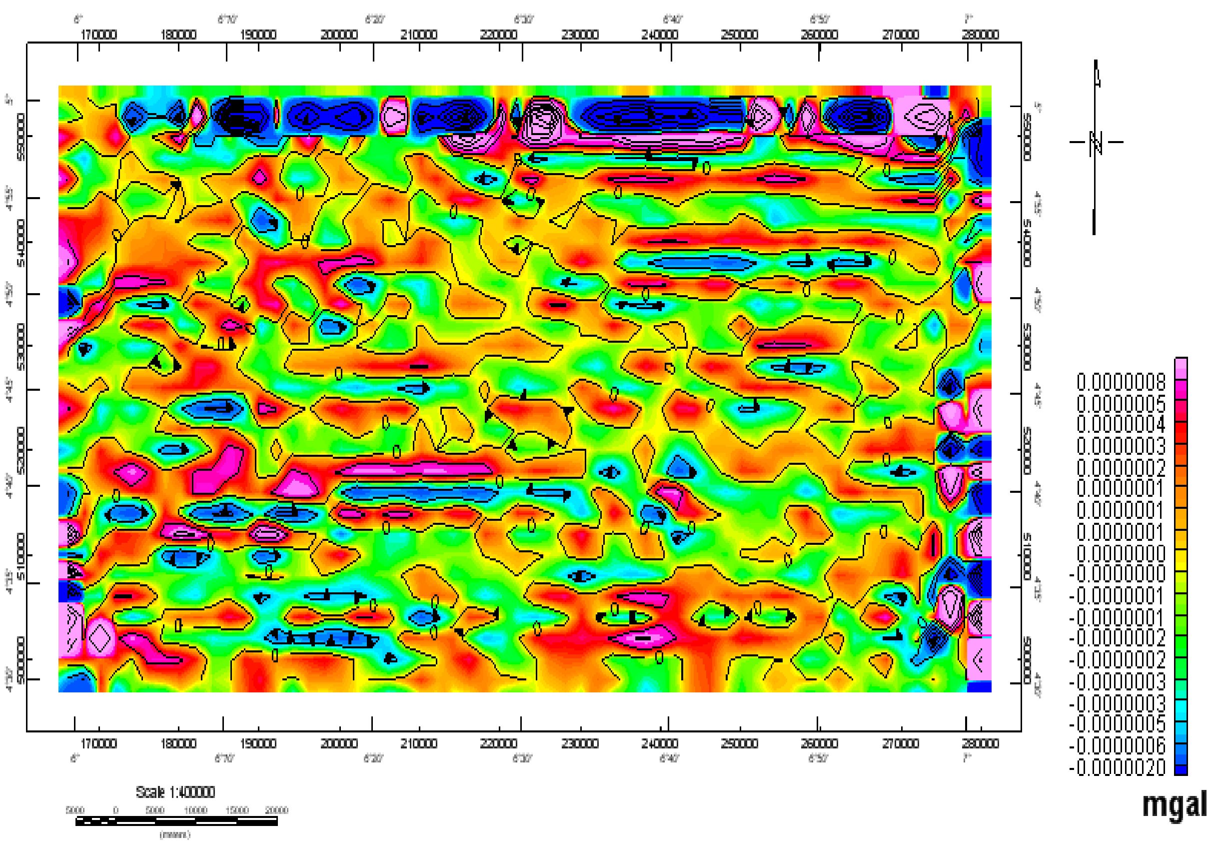

Figure 9 Second Horizontal bouguer gravity map (mgal)

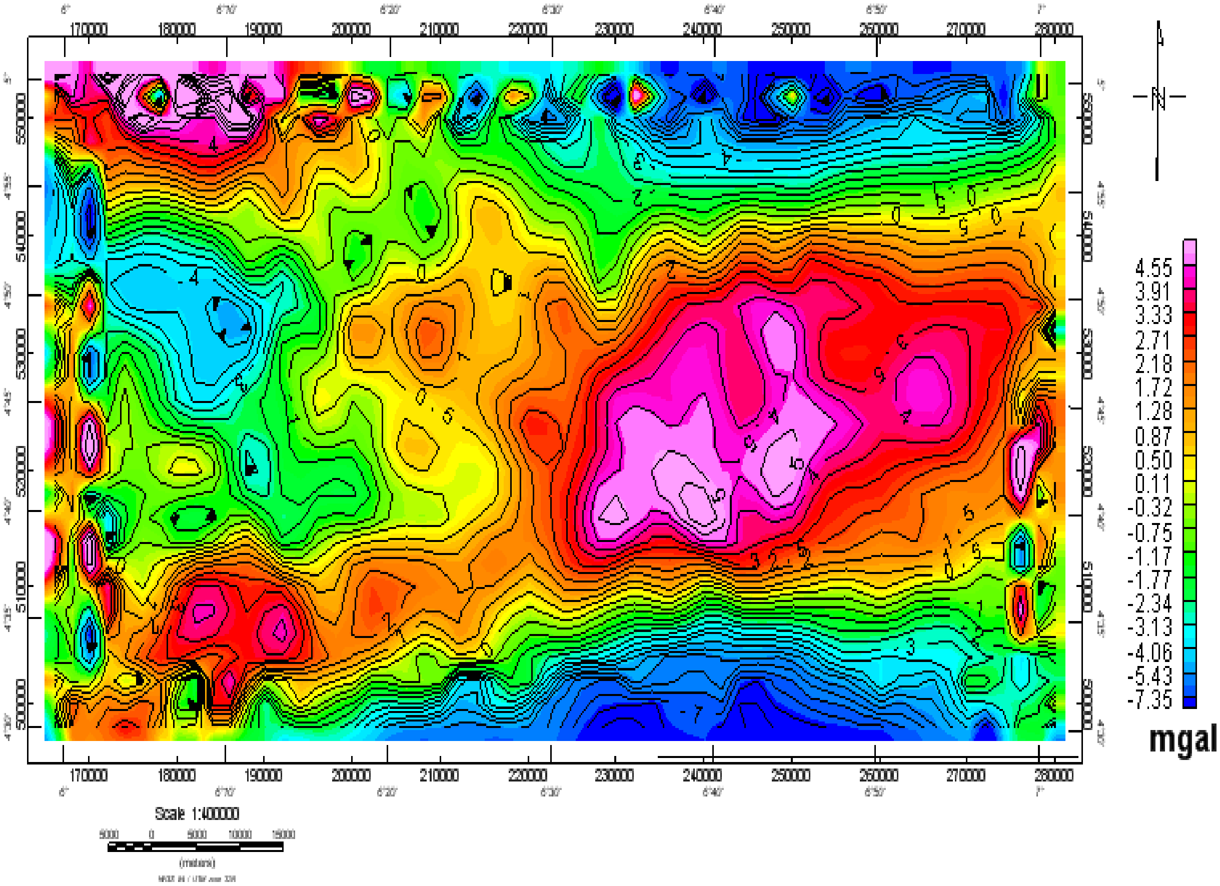

Figure 10 Upward Continued Bouguer Gravity Map at 5 km (mgal

Spatially distributed on the second horizontal derivative map (Figure 9) are structural highs. The structural highs are anomalies with high gravity values. The anomalous gravity values vary between -0.0000020 mgal and 0.0000008 mgal. Structural or gravity lows can be observed within edges of the map. Close examination of the contours reveals contours that are of longer wavelength laterally. The anomalous gravity trends are in the E-W direction. But minor N-S trend at the edges of the map are discernible.

Upward continuation map at 5 km (Figure 10) highlights smoothened anomalies that are true reflection of basement features. The anomalies found when the measurement point was 5 km away from the source are almost similar to that observed on the residual map. They are dissimilar in the nature of the anomalies found around the north western and western part of the study area. The gravity highs appearing at the extreme western part of the upward continuation map are sharpened with their edges pointing upwards. Moving upwards, the structural or gravity lows adjacent to the gravity highs are more pronounced. Isolated gravity low is also observed at longitude $4^0 30^1$- 4^0 35^1 E and latitude 6^0-$6^0 10^1$ of the upward continuation map. The anomaly labeled 4 on the residual are more pronounced on the residual map than a similar anomaly observed on the upward continuation map. Isolated signatures can be seen at the northern end of both maps but with the anomalies found on the continuation map moving away from the edge of the map. Slight difference exists between the contoured upward continuation map and the contoured residual bouguer gravity map. Closed circular and elliptical gravity contours, which are absent on the residual map, are visible at the northwestern, western and northern edges of the upward continued map at 5 km. Gravity signatures trending in the N-S, E-W and ENE-WSW direction are visible on the map.

Prominent on the upward continuation map at 40 km (Figure 11) are structural highs depicting gravimetric sources with high density contrast. Similar type of gravity anomaly with high density contrast is observed both on the upward continuation map at 40 km and the residual map. Slight changes can be seen at the eastern, south western and north western edges of both maps. At the south western portion of both maps, isolated and alternating gravity high and low which is discernible on the residual is absent on the upward continuation map at 40 km. Isolated circular anomalies which is not present on the upward continuation map at 40 km can be identified at the extreme northern portion of the residual bouguer map. However, little circular anomalies regarded as noise can be noticed at the eastern, extreme south-eastern, southwestern and northwestern portion of the upward continuation map at 40 km.

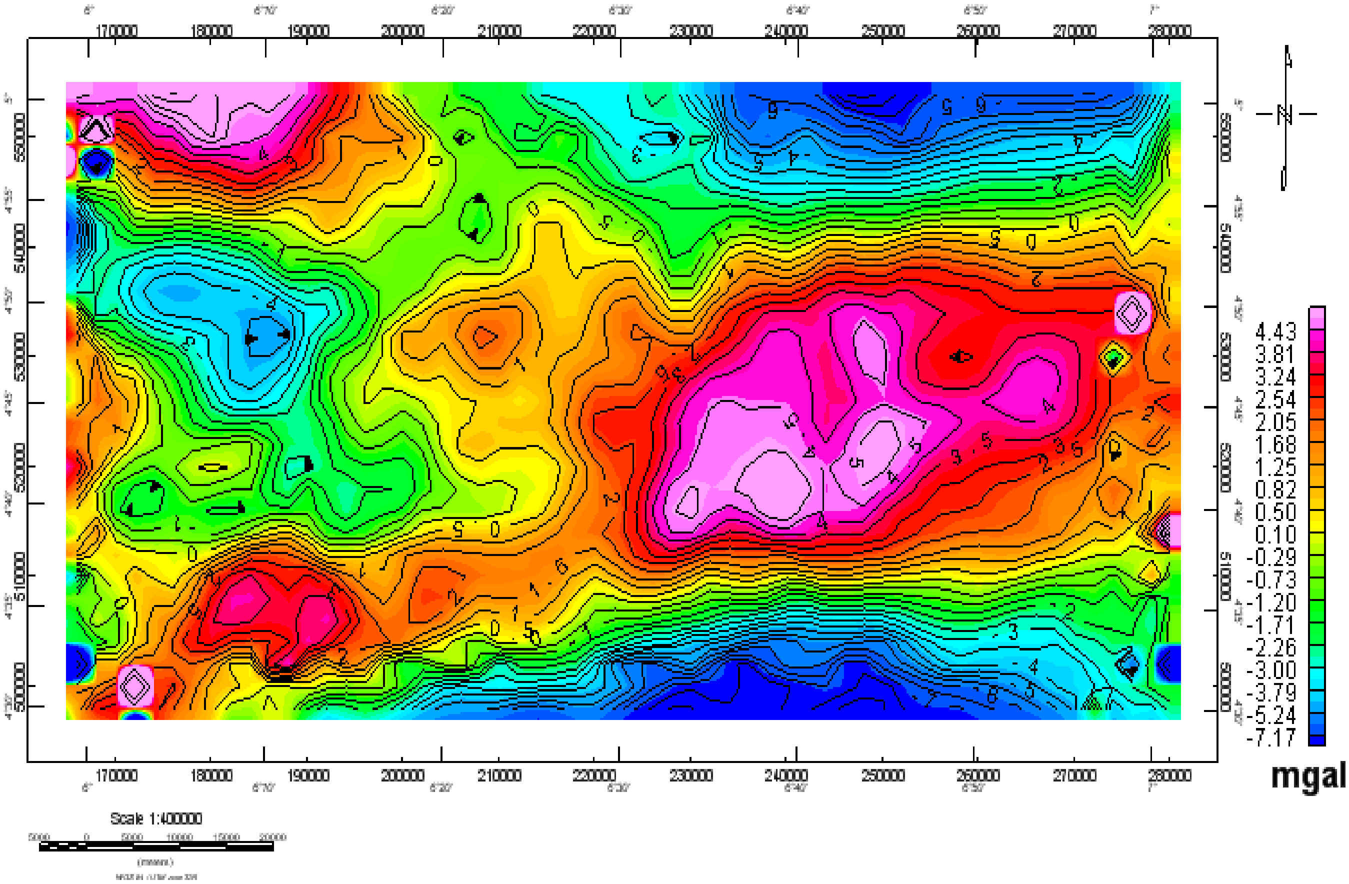

Figure 11 Bouguer gravity Map Upward continued at 40 km (mgal)

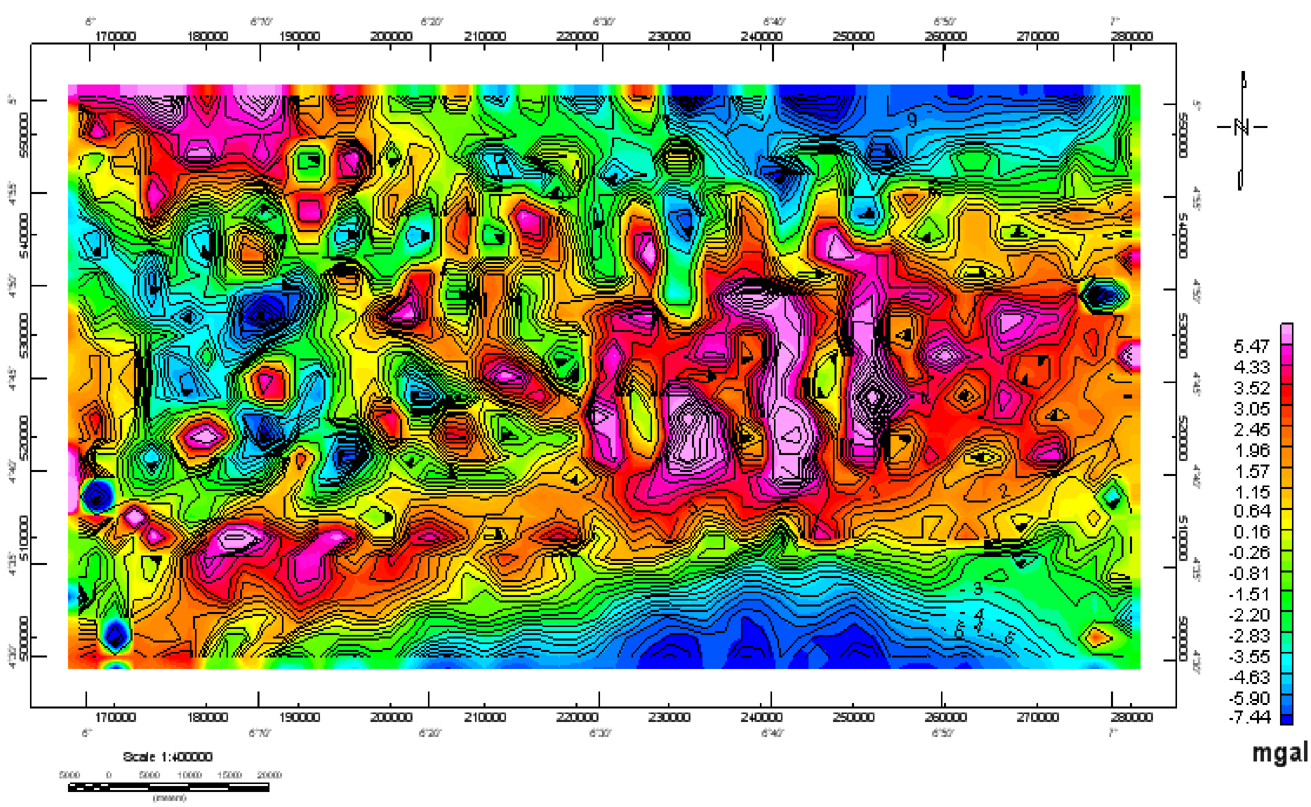

Figure 12 Bouguer Gravity Contour Map Downward Continued at 5 km (mgal)

High and low gravity values are apparent when the measurement point was downward continued at 5 km (Figure 12). However, gravity sources with high values occur frequently within the map. The anomalous sources with high gravity sources can be seen in a similar position with the high gravity sources found on the upward continuation and residual maps. But on the downward continuation map, the dense sources with high values are of shorter wavelength and less broadened. The shorter wavelength and less broadening nature of the gravity anomalies is a reflection of shallow related gravity sources. Low gravity sources with short and relatively long wavelength can be seen at the north eastern, western and south eastern part of the map. Isolated, circular and elliptical gravity contours are noticeable on the downward continuation map. N-S dense gravity signatures are seen visibly at the eastern portion of the map. Moving towards the western portion of the map are gravity contours trending in the N-S and NW-SE directions.

Few gravity anomalies can be seen having a trend of NE-SW, N-S, E-W and NW-SE directions at the western, north western and south western portion of the map. It is pertinent to know that the elongated structural linear trends which appeared at the south eastern portion of the residual map, upward continuation maps at 5 km and 40 km, and downward continuation maps at 5 km and 40 km, are conspicuous on the downward continuation map at 5 km. This consistency can therefore aid in inferring that there is an existence of fault zone at the south eastern side of the study area.

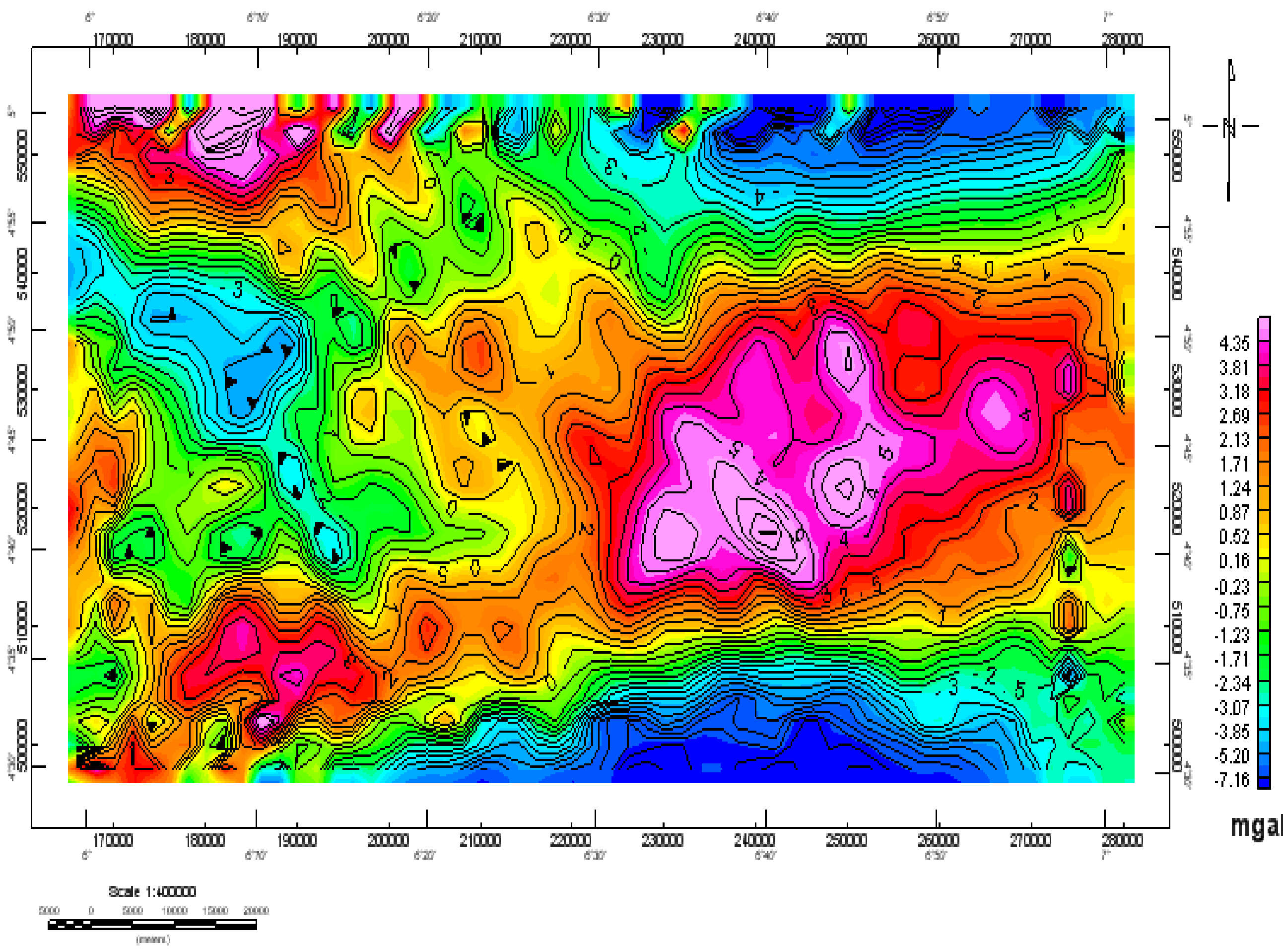

Figure 13 Contour Bouguer Gravity Map Downward Continued at 40 km (mgal)

Downward continuation at 40 km (Figure 13) was carried on the residual map. Like the residual raster map, upward continuation maps at 5 km and 40 km and the downward continuation maps at 5 km and 40 km, colour contrasts are seen clearly. Similar types of gravity highs and lows occur in both the residual and downward continuation maps at 40 km. This implies that shallow related sources can be revealed using downward continuation filter at 40 km, therefore as a result gravity bodies of similar configuration can be detected even when the measurement point is taken 40 km towards the gravity sources. Unlike the downward continuation at 5 km, sources with high gravity values are broadened at the eastern portion of the map. This broad nature can be attributed to large density contrast at that measurement point of the study area. On the downward continuation map, the sanctity of the gravity lows seen on the bouguer residual map structural low is maintained. The contoured downward continuation map at 40 km exhibits similar contour configuration with that of the bouguer gravity residual map. An exception, however, can be seen at the eastern and northern edges of the downward continuation map at 40 km where smaller, irregular and localized contours can be found.

6. CONCLUSION

Analysis of the bouguer gravity datasets indicated the existence of E-W, ENE-WSW, WNW- ESE, N-S, NE-SW and NW-SE trending lineaments but with the ENE-WSW and E-W striking trends dominating. The E-W and ENE-WSW tectonic trends are sets of faults induced possibly by gravity tectonics within the study area. Attenuated NW-SE trends, expressing active Charcot and oceanic fault zones, can be seen within the study area. These trends, however, suggest fracture imprints associated with Pan African Orogeny. So, this research established that different areas of the study area have undergone different geologic histories forming lithotectonic domains with different lithotectonic trends.

SUMMARY OF RESEACH

The qualitative analysis applied on the bouguer datasets revealed lithotectonic trends having NW-SE, NE-SW, NNW-SSE, NNE-SSW, E-W, N-S and ENE-WSW strike orientations. It was also established that different areas of the study area have undergone different geologic histories forming lithotectonic domains with different lithotectonic trends. The study area will be very plausible for hydrocarbon, and perhaps, water exploration. This is evidenced by the presence of echelon of fractures or tectonic lineaments observed.

ACKNOLEDGEMENT

We are highly indebted to the Nigerian Geological Survey Agency (NGSA) for making the datasets available.

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