Residual Magnetic Interpretation over Numan and Guyuku of the Upper Benue Trough , Northeastern Nigeria

O. Maxwell1 and N. Ibrahim2, P.E Ugwuoke

[1,2]PHYSICS DEPARTMENT Universiti Teknologi Malaysia

[3] Centre for Energy Research, University of Nigeria Nsukka

Abstract: The magnetic data over the upper Benue trough were generated from maps of Numan, Guyuk, shelleng, and Dong of the Trough, N-E basement complex of Nigeria. The data were obtained by digitalizing the maps of the above areas, picking the contour values along the flight line and combined the maps to form a digital composite map. The composite map was analyzed qualitatively by applying Polynomial fitting method in regional -residual separation. The result of the residual separation exercise revealed that the area is underlain by a NE-SW regional trend, which shows that they are in agreement with Benue trough, presumed that they have the same structure control. The result of the trend analysis also showed that the area is characterized by faults. From the 3-D residual magnetic anomaly map of the study area, Dong and Numan are likely to be sedimentary basin, which is W-E trending. It shows that the magnetic field there is smoother which is masked off the affects of the stronger magnetic basement. The high amplitude of the anomaly along the S-W features of the Numan area presumed to be Ngurore Basalts. This work could not identify the depths and thickness of the intrusions within the area.

Key Word: Geologic Map, Composite Map, Regional Field , Residual and 3-D Residual Field

1.0 Introduction

The magnetic method of exploration is the oldest of the geophysical methods. In mineral exploration, it is used for prospecting magnetic minerals (E.g. magnetite's, llmenite, e.t.c) or non-magnetic minerals where structures controlling their acumination can be mapped because of associated magnetic minerals (Dobrin , 1976). In oil exploration, it is ordinary used to determine thickness of sedimentary section or to map structure on the basement surface. This is because sedimentary rocks are non-magnetic for all intents and purposes, compared to the igneous or metamorphic rocks below them, such that practically all the magnetic variations measurable at the surface are associated with topographic or lithological changes at the basement.

The aeromagnetic method is one of the geophysical techniques, which is commonly used in all exploration programs. The magnetic method is particularly useful in exploration for asbestos because of its occurrences in ultra basic intrusive rocks reached in magnetite. The cost of geophysical data acquisition has forced mineral and petroleum exploration companies to rely on the aeromagnetic techniques as an economical method for both reconnaissance and detailed determination of subsurface geological structures. This interest generated an active search for better techniques to process and interprets the volume of data that is being accumulated.

One important goal in the interpretation of magnetic data is to determine the type and the location of the magnetic source. This has recently become particularly important because of the large volumes of magnetic data that are being collected for environmental and geological applications. To this end, a variety of semiautomatic methods, based on the use of derivatives of the magnetic field, have been developed to determine magnetic source parameters such as locations of boundaries and depths (Nabighian et al., 2005). As faster computers and commercial software have become widely available, these techniques are being used more extensively .In this work, we have studied the magnetic data by using computer algorithm technique in which so many geological features were exposed. This approach has allowed us to define the disturbance caused by induced magnetization of some magnetic minerals and the nature of the structures and the control of underlying geological formations and correlate the features obtained with the previous work in the study area.

1.1 Statement of the Problem

The ambiguity in magnetic data interpretation has caused so many problems in interpreting the rocks of magnetic properties and its effect. Several factors can lead to level shifts in the magnetic field between adjacent flight lines. These include elevation differences between flight lines, inadequate compensation for the magnetic field of the aircraft, and inadequate removal of time-varying (diurnal) magnetic field variations. Although performing standard compensation and diurnal corrections and leveling, the rugged terrain and widely spaced tie lines prevents complete removal of flight line noise.

To remove the residual flight line noise from the gridded aeromagnetic map, a matched band pass and azimuthally filtering approach is always needed (Syberg, 1972). Under this approach the power spectrum of the aeromagnetic map is "matched" to the power spectrum of a model consisting of several equivalent magnetic layers at different depths (using programs MFINIT and MFDESIGN from Phillips, 1997). For each equivalent layer a corresponding band pass filter will be applied to the aeromagnetic data to extract the magnetic field of the equivalent layer (using program MFFILTER from Phillips, 1997). One of the bands passed fields was found to contain nearly all of the flight line noise.

A similar matched filtering procedure can be applied to the radar altimeter data, which could also show significant flight line noise. The filtered radar altimeter data will be used to correct the various magnetic depth estimations for the height of the aircraft.

In this study, computer algorithm was used to detect rocks or minerals possessing unusual magnetic properties, which revealed themselves by causing disturbances or anomalies in the intensity of the earth's magnetic field, the structural control of the underlying geology, magnitude of the anomalies and their sources.

1.2 Geographical Location of The Study Area

The Trough is a northeasterly structured of about 1000 km long, and between75 to 150 km wide. The Yola arm is an easterly branch of the Trough. The study area covered lies between latitude $9^0\,30^/$ N and $10^0\,00^/$ N and longitude $11^0\,30^/$ E and $12^0\,30^/$ E, which are Numan, Guyuk , Shellem and Dong.

1.3 The Geology of the Study Area

Important geological features of the region comprise of Upper Cretaceous/ Quaternary sedimentary rocks and Tertiary volcanic rocks. These overlie the Precambrian crystalline basement consisting of mainly granitoids and gneisses (Cater et.,al, 1963).

1.3.1Basement Complex

The basement rock units in the north and south parts of the study area are made up of Older granites, gneisses and migmatites. Basic extrusives (basalt) and intrusive also occur. Whilst sedimentary rock units comprising mainly sandstones, limestone, clays and shales outcrop within the central portion of the study area (Cater et al., 1963).

1.3.2The Volcanic Rocks and Igneous Intrusion

The extensive igneous activity which took place on the lower cretaceous of Nigeria and was probably most intense during the late Albian time (Ofoegbu 1985a). The intrusions are widely distributed through the area, and the younger intrusive are represented by volcanic plugs, dyke, silts in the study area. Smaller dykes are of basic masses, occasionally produce contact metamorphism in the sediments, as well as characteristics suggestive of a close interval of time between segmentation, folding and intrusion (Cratchely and Jones 1965).

The plugs outcrop in the area occurs as circular to oval features entirely surrounded by the Alluvium and Bima sandstones. Generally, they show sharp contact with the surrounding sedimentary deposits

1.3.4 Qaternary-Recent Alluvium

The Quaternary alluvium is a superficial deposit, comprising mainly argillaceous stuff called Benue valley alluvium. The soil is black to dark gray clayey sediment formed by the weathering of volcanic (basaltic) and shaley rocks. It is marshy and covered by shrubs. They form stripes of 500m to 1kn radius range, beyond which they are intercalated with poorly sorted sands and gritty clays (typical of the Benue valley Alluvium). In the study area, the Quaternary Alluvium uncomformably overlies the Bima formation and obscures it in most sections. The Bima sandstone is classified into three layers: the lower, middle and upper Bima.

The upper Bima (B3): It consists of medium to coarse grained feldspathatic sandstone. In the Lamurde anticline, the maximal thickness reaches up to 1,700m but may vary considerably elsewhere. The sequence was deposited under fluvaital to deltaic environment (Cater et al, 1963). A late Albian/Cenomanian age was assigned to such event .

Middle Bima (B2): It composed of very coarse grained, feldspathic sand stone with these bands of clay, shale and occasional calcareous sandstones. In the Lamurde anticline, the thickness is 800m but may vary elsewhere. This sequence was laid down in fluvaital and the deltaic environment (Carter et la 1963). A tentative middle Albian age has been assigned to it.

Lower Bima (B1): It is the oldest sediment known in the area which appear in the core of the Lamurde anticline which consist of coarse grained feldspathic sandstone alternating with red, purple shale and occasional band of calcareous sandstones and silts stone. The visible thickness in the Lamurde anticline is 390m (Cater et al, 1963).this basal sequence was deposited in lacustrine environment with a brief marine incursion (Cater et al, 1963). An upper Aptian/ Albian age has been recently assigned to this part of Bima sandstone on the basis of palynological date. Figure 1.0 shows the geologic map of the study area.

2.0 Material and Method

Data Acquisition

The datasets used in this study were compiled from four aeromagnetic maps with index numbers of 174,175,195 and 196, for Numan, Guyuk, Shelleng and Dong. These maps were obtained from Geological surveys Agency, Kaduna, Nigeria. The contour lines in all the maps were dense; therefore it was easy to adopt the flight line digitization used with very minimal errors of human judgment. The magnetic values were plotted at 10nT (gamma) interval. The maps were numbered and named according to the places covered for easy reference. A total of 340 maps covered the entire country. The actual magnetic values were reduced by 25,000 gammas before plotting the contour maps (Huntings, 1976). This means that the value of 25,000 gammas should be added to the contour values so as to obtain the actual magnetic field at a given point.

The maps were digitized on a 1x1 system. This spacing imposed a Niquisit Frequency of ½ km-^{1} so that the narrowest magnetic feature that can be defined by the digitized data has a width of “2” km. The anomalies are much wider than 2km and therefore lie in a frequency range from aliasing which do not occur with a 1km digitizing grid.

Having digitized each aeromagnetic map, the data were stored in 55x 55 coding sheets, each of which contains records of the boundary longitudes and latitudes, the map number, and name of the town overflow. The data were entered into a computer file, thereafter became the input file for a computer program, which picked all the data points row by row, calculate their longitude and latitude and the magnetic value for coordinates respectively. Each output file for this operation was given a meaningful name for easy identification. The three dimensional coordinates from x, y, z, is made to be acceptable to a contouring package “SURFER 7.0”. The SURFER is a menu-driven interactive computer programme, which places each magnetic data point according to their longitude and latitude bearing and thereafter produces contour maps to ensure that they correspond with their respective original maps. The maps are Fig.2, 3, 4 and 5

The compilation of the aeromagnetic maps of Numan, Dong, Guyuk and Shelleng form a composite map. The composite aeromagnetic map of the study area was produced by joining the four maps covering the study area together. The computer program used to determine the longitude and latitude for each small map was also used to determine the longitude and latitude for the composite map was also used to determine the longitude and latitude of the composite map. This map would be the subject of analysis and interpretation in other section of this work. Fig.5 shows the total magnetic field map of the study area.

2.1 Regional-Residual Separation

The polynomial Fitting Method

In this work, the polynomial fitting method which is the most flexible and most applied of the analytical methods for determining regional magnetic field (Skeels, 1967, Johnson, 1969 and Dobrin 1976) was used. In this method, marching of regional by a polynomial surface of low order express the residual features as random error. This treatment is also based on statistical theory. The observe data are used to compute, usually by least square, which is the mathematical describable surface giving the closest fit to the magnetic field that can be regional field and the residual field is the difference between the magnetic field values as actually mapped and the regional field thus determined.

2.2 The Least-Square Method

The least square method was applied to the study area. Because the study area seemed adequate and reasonable to assume that the regional field is a first polynomial surface. All the regional were therefore calculated as a two dimensional first – degree polynomial surface. To eliminate the regional field, a plane surface was fitted to the data by multiple regression least-squares criteria established by the mathematical concept of (Dobrin 1976, Skeels, 1967 and Johnson, 1969)

The polynomial coefficients were used to compute the regional map of the study area. The resultant map is shown in Fig. 7. A Computer program was used to subtracting values of the regional filed from the total magnetic field value at grid points. The residual values were contoured using computer software (SURFER 7.0). The data were inputted into the contouring software programme, which automatically generated the residual field map of the area. The residual magnetic anomaly contour map is shown in Fig. 8a. Further analyses of the residual field map in fig 8a with the help of software (Surfer 7) generated 3-D residual anomaly field, Fig. 9

3.0 Result:

The qualitative analyses of the composite map using Polynomial fitting method in regional -residual separation produced the residual magnetic anomaly map. The result of the residual separation exercise revealed that the area is underlain by a NE-SW regional trend, which shows that they are in agreement with Benue trough, presumed that they have the same structure control. The result of the trend analysis also showed that the area is characterized by faults. . From the 3-D residual magnetic anomaly map of the study area, Dong and Numan are likely to be sedimentary basin, which is W-E trending. It shows that the magnetic field there is smoother which is masked off the affects of the stronger magnetic basement. The high amplitude of the anomaly along the S-W features of the Numan area presumed to be Ngurore Basalts. This work could not identify the depths and thickness of the intrusions within the area.

3.1Discussion

Looking at the residual map, there are noticeable NE-SW & E-W trending features. On the residual Fig.8a, the situation looks different because the contour lines of the total residual magnetic field are concentrated more in the Northern & Southern portion of the study area. This may be explained that the basement complex outcropping here is not homogeneous mineralogically in addition to the presence of faults in the area which are mainly basement faults, while others are grannitic and pegmatetic dyke.This inferred zone may be interpreted as major fracture zones of the weakness within the trough. The NE-SW lineaments are found more towards the northeast and southwestern part of the study area with some extension in the southwestern part. They mainly affect the pan Africa granite. The NE-SW structures are found to be faults and foliation. This structural direction is related to the West African rift system made up of the north easterly Benue Trough and Cameroon volcanic line (Flitton, 1983) (Bassey, 2006). Some features trend NW-SE. These features are foliation and shear zones. The lineaments are among the longest and invariably are of deep crustal origin (Odeyemi et al, 1999). E-w lineaments are the youngest as they cross cut structures of all other directions. They are mainly basement normal faults, while others are granites.The high amplitude of the anomalies which out crop across Dong area is likely to be lunguda basalt.. Area of occurrences of zero or negative residual anomalies in the study area could be the presence of granite-gneiss in the area. They may also be due to the susceptibility variations in the lithologic or a combination of both. There are three areas of positive residual anomalies. They occur to the NE of Dong and SE of Numan

3.2 Conclusion

The regional field has thrown some light on the geology and structure of this part of Nigeria basement complex. The study revealed NE-SW trending which correlate with the geology of the area showing that the Benue trough trends NE-SW, indicating that they have the same structural control. The study which revealed NE-SW structures as the youngest in the Nigerian Basement (Olumide 1988; Ene and Mbono, 1988; Ekwueme, 1994,).The major lineaments observed at Numan and Dong have been accounted for in terms of faults and foliation. The lineaments have regional extension into Niger, Chad and Cameroon.

In this study, it is assumed that the anomalous magnetic field of the crustal rocks is due to induced magnetization in the area. It could be the fact that some locations have a high component of remnant magnetism in the anomalies field.

High-sensitivity aeromagnetic data over the area contain both low-amplitude, linear anomalies produced by structurally deformed magnetized layers near the top of the sedimentary section and high amplitude ,broad anomalies produced within the basement.

Matched-filtering has been successful in separating the anomalies produced by these two source regions.

3.3 Recommendation

The present study throw some lights on the geological and structural formation in this part of Nigeria's Basement complex, further study for geochrological dating of rocks and structural events in the area for a better understanding of the geologic history and the rock susceptibility is needed.

Reference

Bassey N.E (2006): Structuer of Madagali hills NE Nigeria from Airborne magnetic and satellite data over Hawal basement complex. Global journal of geological science volume 4 No 1.pg

Cratchely C.B and Jones. G.P. (1965). An interpretation of the Geologic and gravity anomalies of the Benue Valley, Nigeria Geophysics paper. Overseas Geological Survey. London.

Dobrin, M (1976): Introduction to Geophysical Prospecting. McGraw-Hill book co(Third Edition) New York.

Ekwueme, B.N. 1994. Structureal features of southern Obudu Plateau, Bamenda Massif, SE Nigeria:
preliminary interpretations. J. Min Geol, 30(1) pp.45-49

Ekwueme, B.N.2003. The Precambrian geology and evolution of the
Southeastern Nigerian Basement Complex. University of Calabar Press, 135p.

Ene, K.E and Mbonu. W.C 1988: The metasedimentary belts of Nigerian
Basement Complex, facts, fallacies and new frontiers. In: P.O. Oluiyide (coordinator), Precambrian geology of Nigeria. Geol. Sur.Nigeria Pub... pp53-67

Fitton J.G 1983 Active versus passive continental rifting: evidence from
The West African Rift system. Tectnophysics: 94:473-481

Huntings Geology and Geophysical Ltd (1976):Aieborne Magnetometer survey Map of
contour of Total Magnetic field intensity Geological survey of Nigeria.
Airborne Geophysical series.

Johnson, W.W.(1969).The least-squres method of interpreting magnetic anomalies
caused by two-Dimensional structures.Geophysics, 34: 65-74.

Nabighian, et al, 2005, The historical developmentof the magnetic method in
exploration: Geophysics, **70**, no. 6, 33ND–61ND

Nur, A. (1991): Analysis of Aeromagnetic data over Yola arm of the upper Benue
Trough, Dept. of Geology, Federal University of Technology, Yola,
Nigeria.

Nur, A.2001. Spectral analysis and Hilbert transformation of gravity data
Over southwest of Chad Basin, Nigeria.J.M.Geol.37 (2) pp.9-98

Odeyemy, I.B, ANIFOWOSE, Y.B. AND ASIWUJA-BELLO Y.A.1999: Multtechnique graphical
analysis of fractures from remote sensing images of Basement regions of
Nigeria.J.MIN.GEO.35 (1) PP.9-21

Ofuegbu .C.O. (1985). Interpretation of a linear Magnetic features near Mutum Biyu,
Nigeria Revister Brasiteria Geoscience 3, pg 91-95.

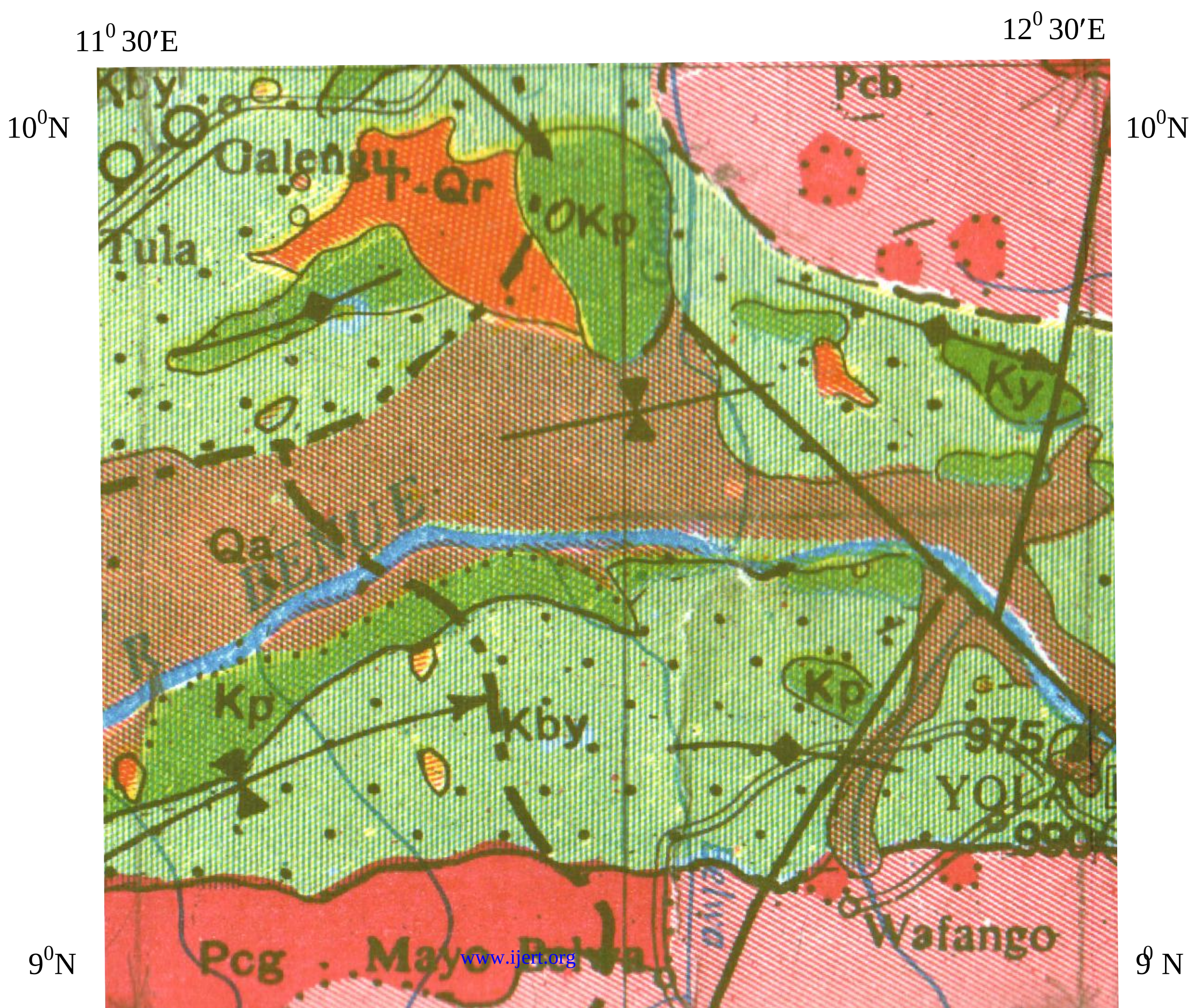
Olumide, P.O.1988.Structural trends in the Nigerian Basement Complex. In: P.O

Oluiyide. (Coordinator), precambrian Geology of Nigeria, Geological Survey of Nigeria, Kaduna, pp.93-98.

Phillips, J.D., 1997, Potential-field geophysical software for the PC, version 2.2: U.S. Geological Survey Open-File Report 97-725, 34p. (online at http://greenwood.cr.usgs.gov/pub/open-file reports/ofr-97-0725/pfofr.htm

Syberg, F.J.R., 1972, A Fourier method for the regional-residual problem of potentiafields: Geophysical Prospecting, v.20, p.47-75.

Telford et al; 1972, Applied Geophysical Cambridge University Press.


11° 30′E
12° 30′E
10°N
10°N
9°N
9°N
Kby
Galengu
Tula
Pcb
Ky
Qa
Kp
Kby
Kp
975
Wafango
Pcg

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

Fig. 1: Geologic Map of the study area after Nigeria Geolog. Surv. Agen:2005

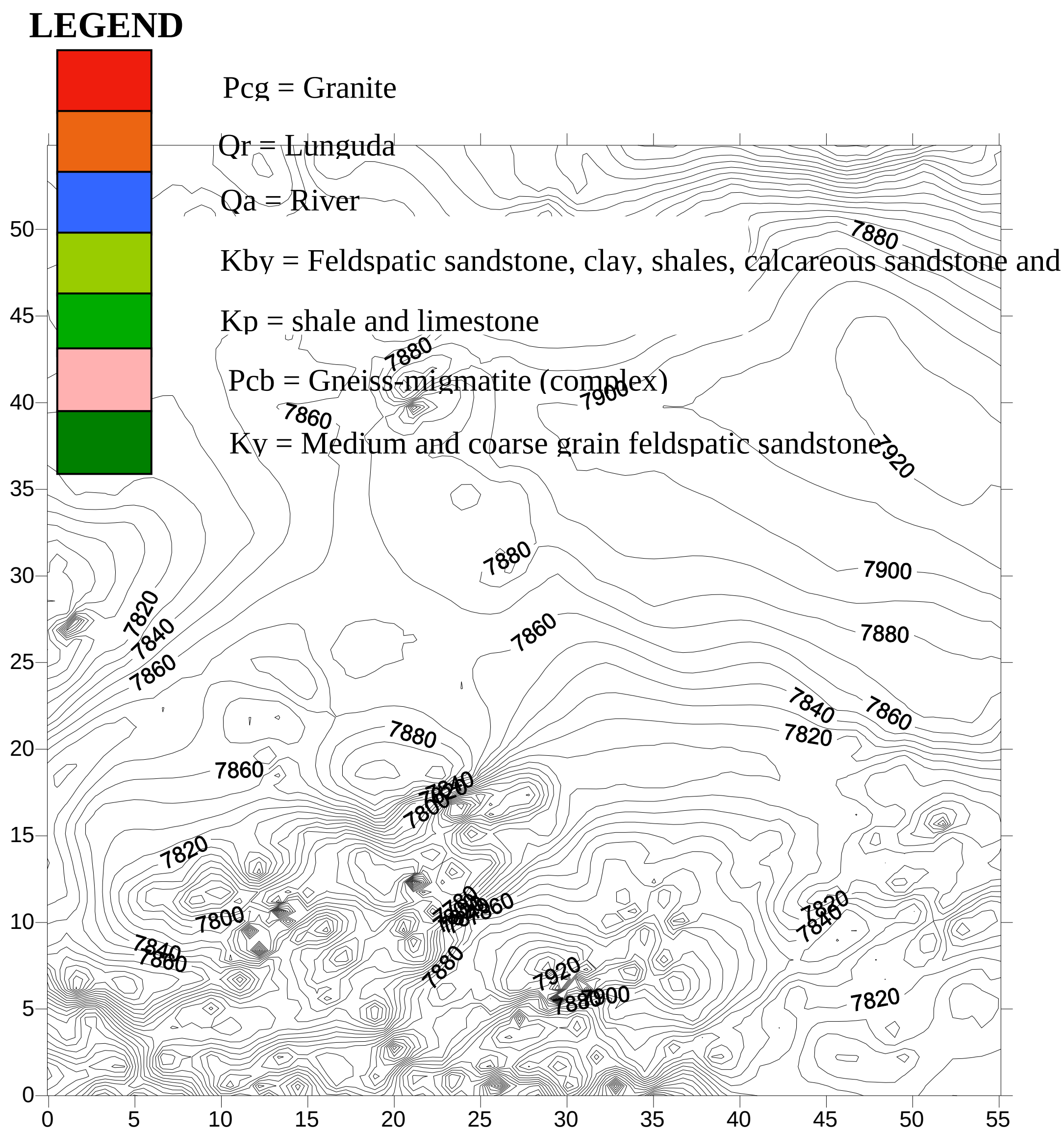


Figure 2: Aeromagnetic map of Numan (contoured at 10nT)

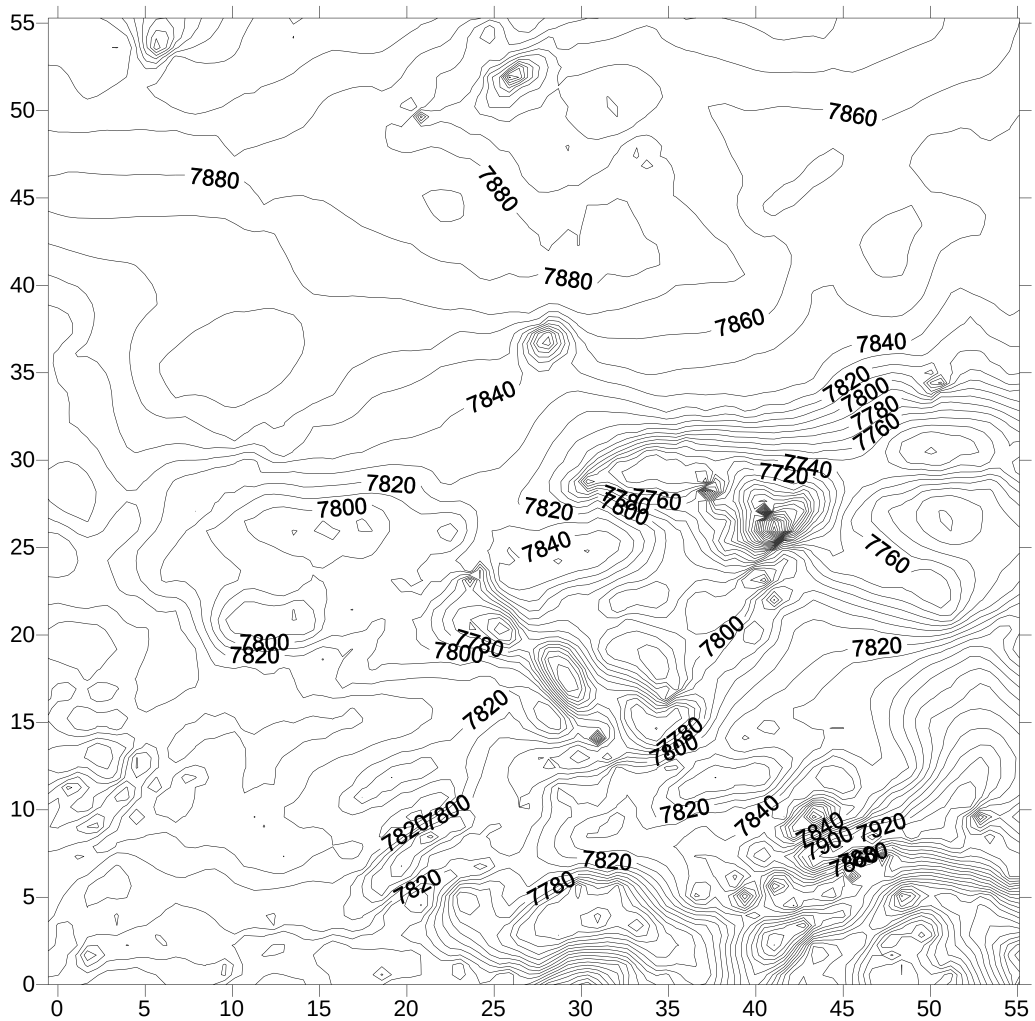


Figure3: Aeromagnetic map of Dong (contoured at 10nT)

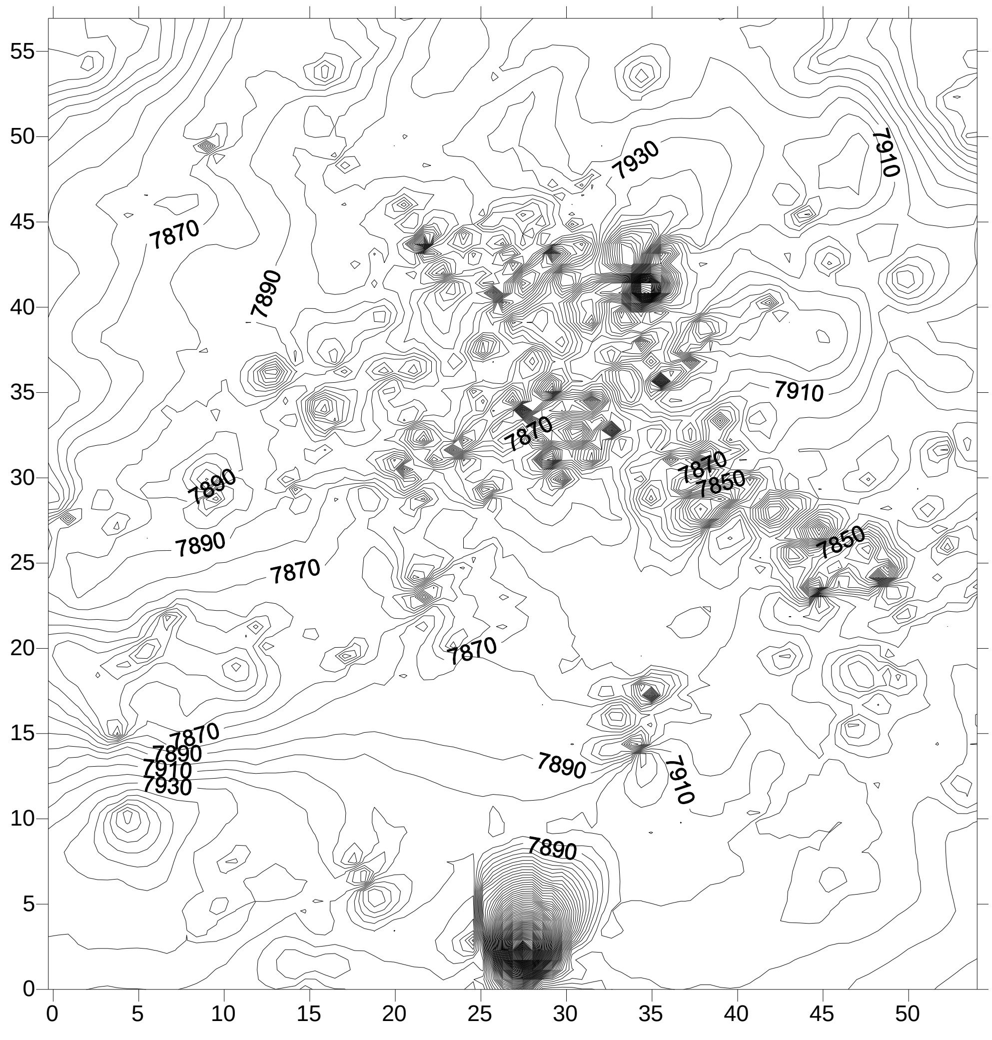


Figure.4: Aeromagnetic map of Guyuk (contoured at 10nT)

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

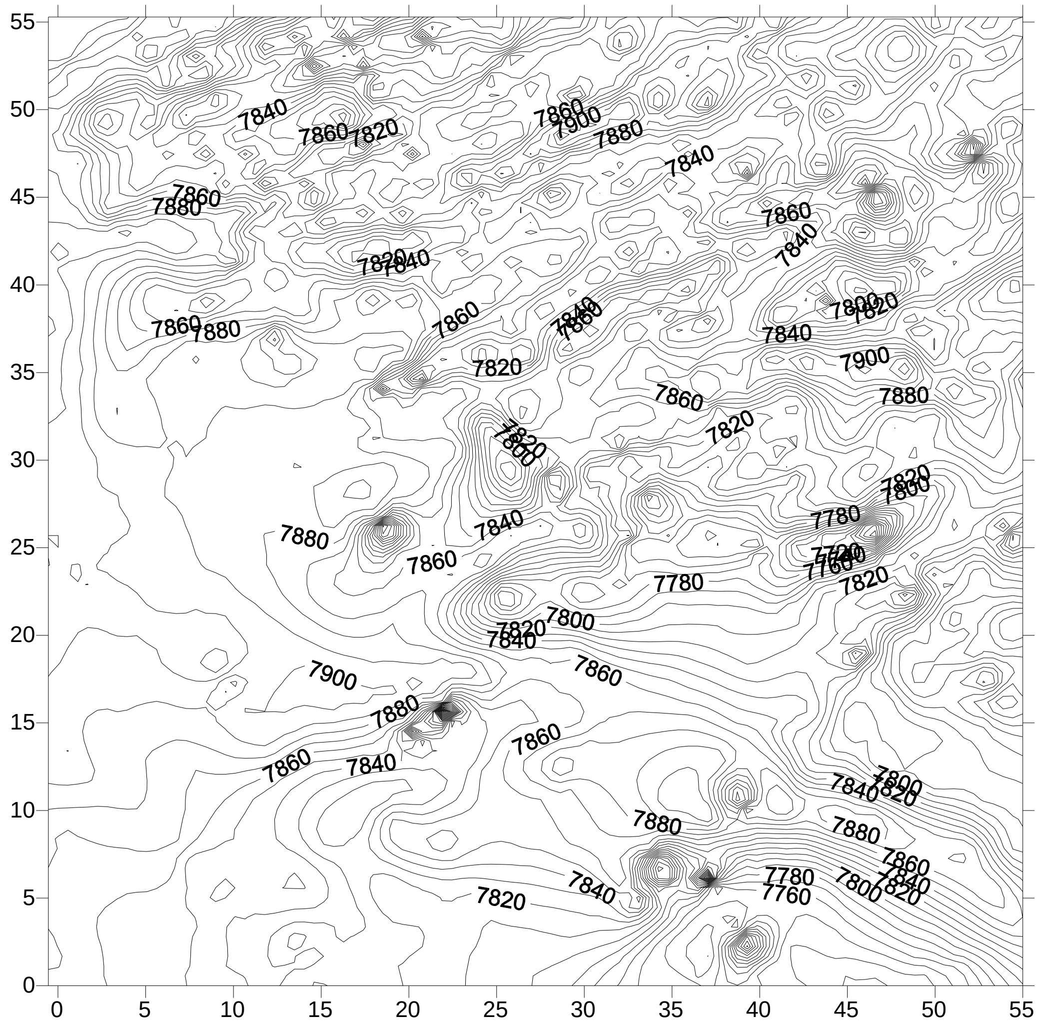


Figure.5: Aeromagnetic map of Shelleng (contoured at 10nT)

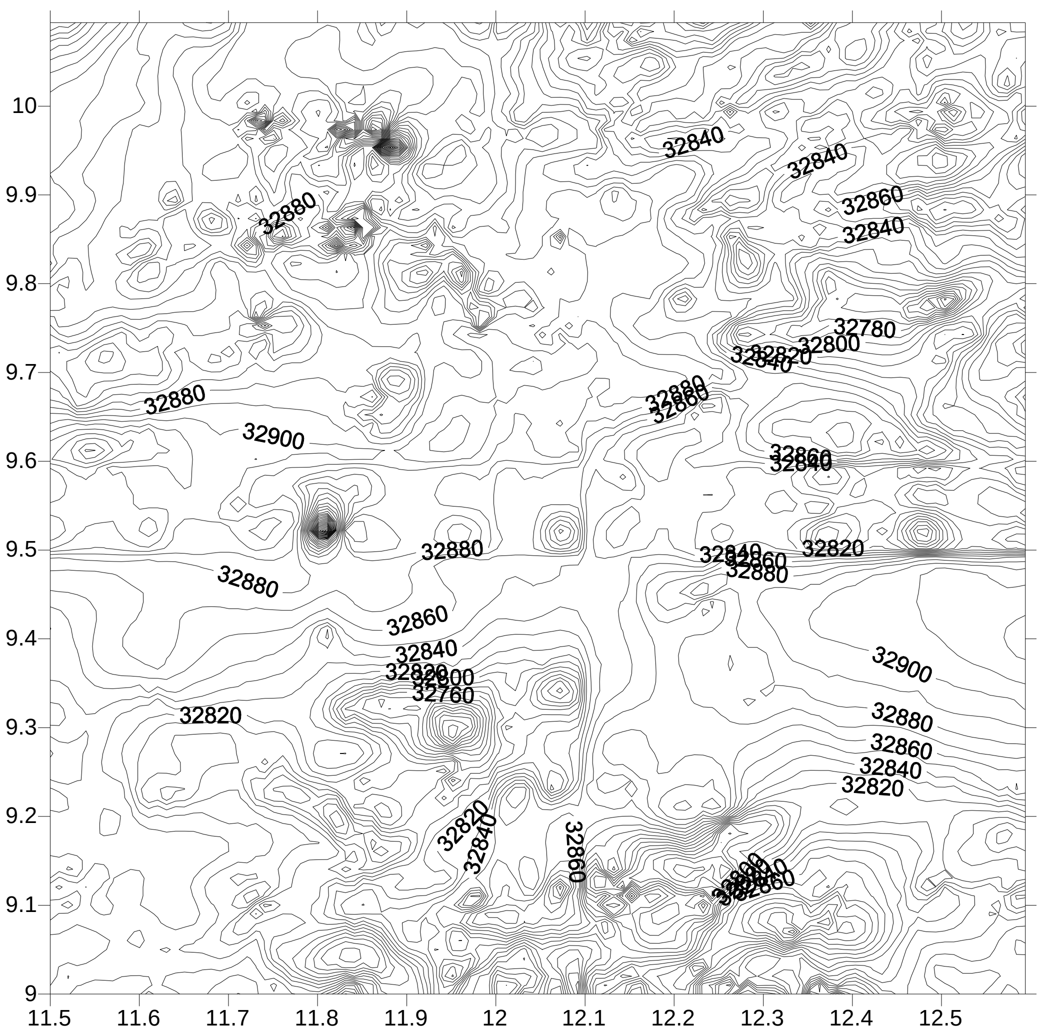
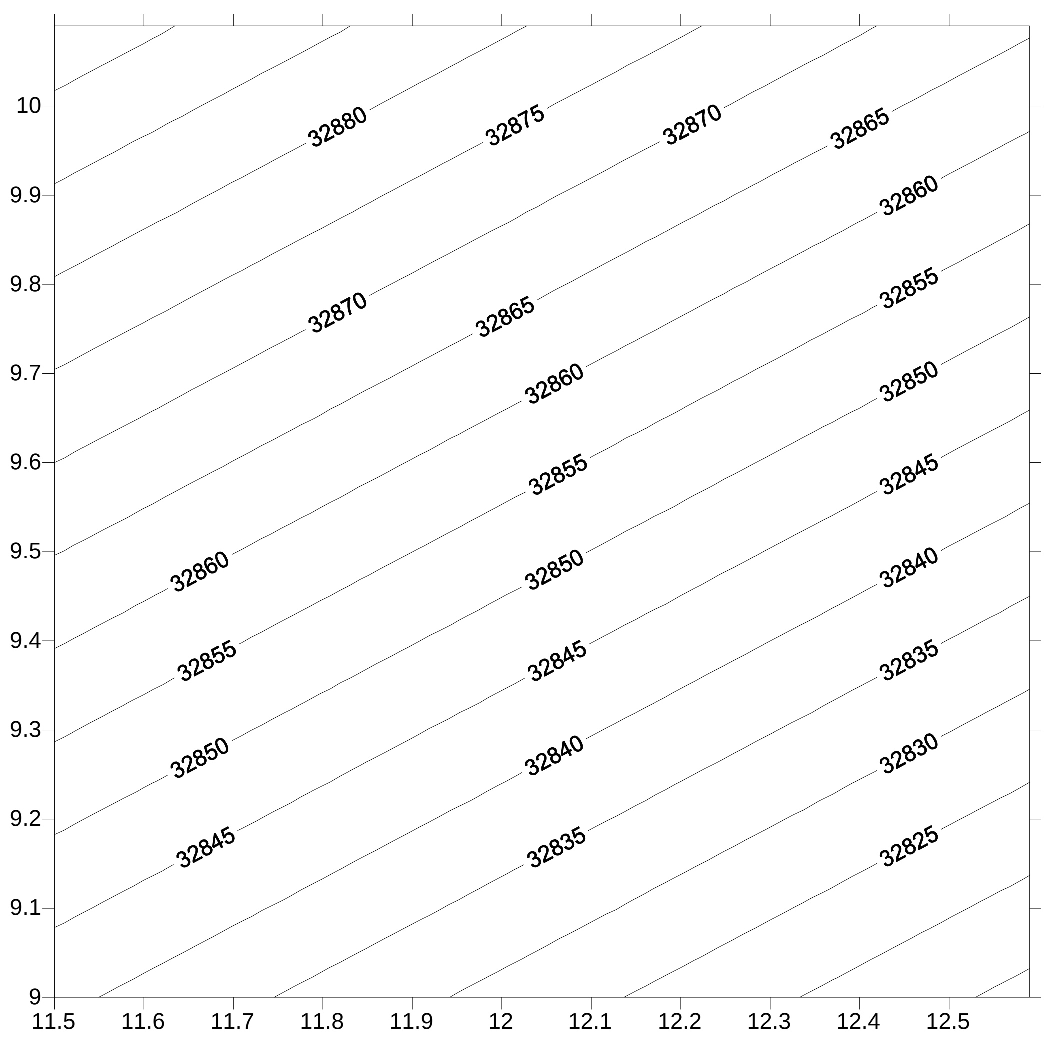


Figure 6: Total Aeromagnetic field of the study area (contoured at 10nT)


32880
32875
32870
32865
32860
32870
32865
32860
32855
32850
32860
32855
32850
32845
32855
32850
32845
32840
32850
32845
32840
32835
32845
32835
32830
32825
10
9.9
9.8
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9
11.5
11.6
11.7
11.8
11.9
12
12.1
12.2
12.3
12.4
12.5

18

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

Figure 7: Regional map of the study area (contoured at 5nT)

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

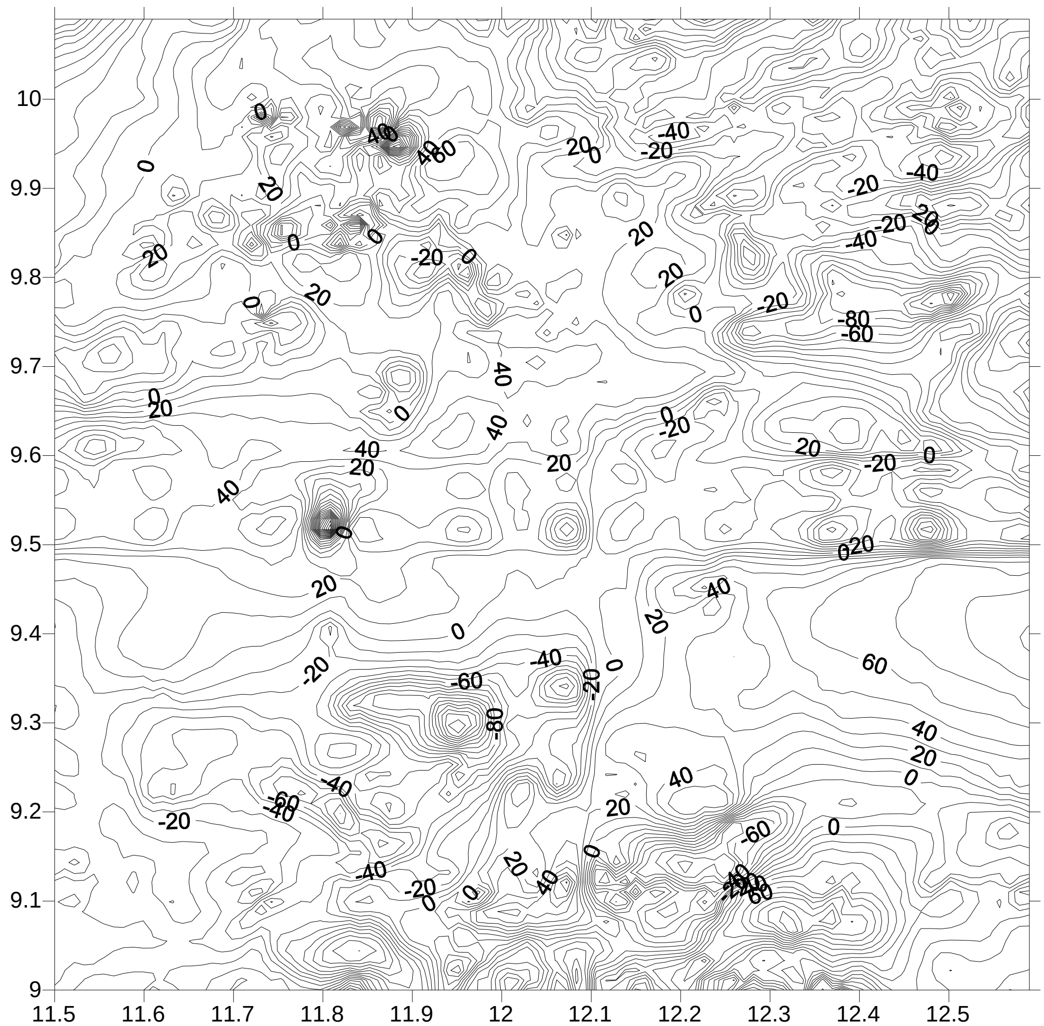
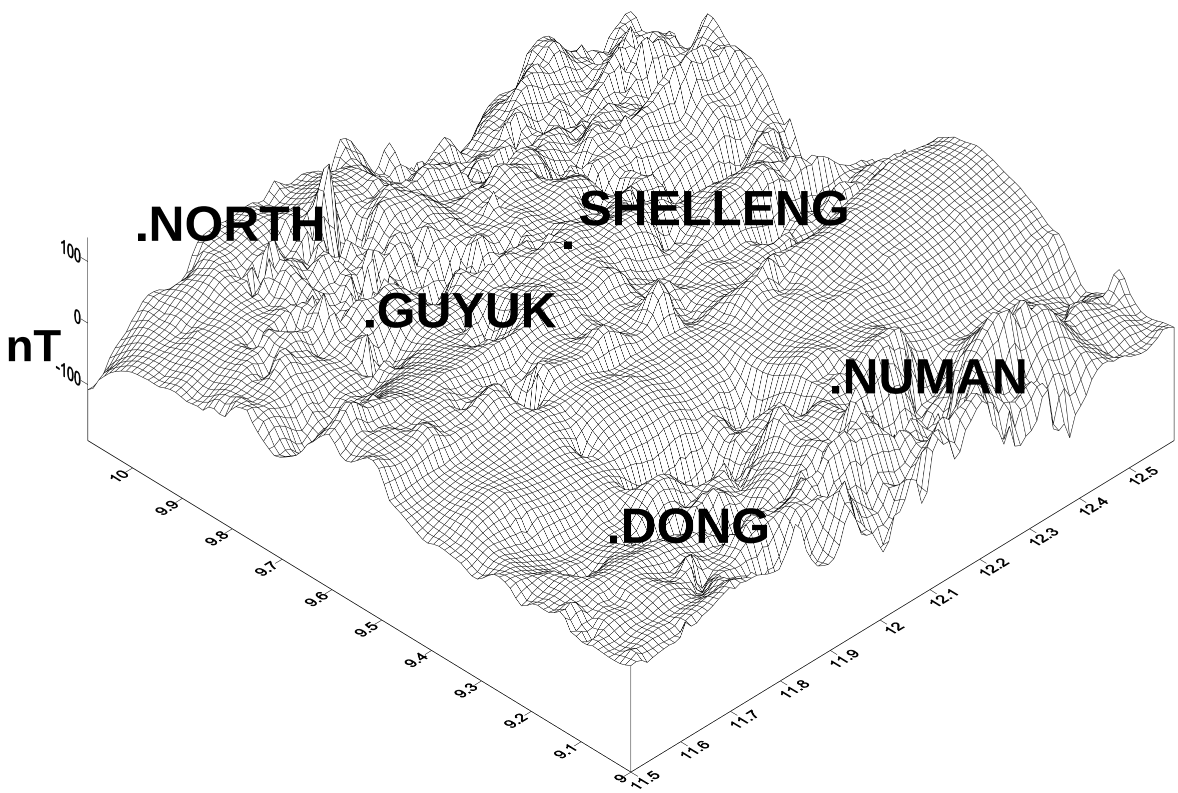


Figure 8a: Residual map of the study area (contoured at 10nT)


.NORTH
.SHELLENG
.GUYUK
.NUMAN
.DONG
nT
100
0
-100
10
9.9
9.8
9.7
9.6
9.5
9.4
9.3
9.2
9.1
9
11.5
11.6
11.7
11.8
11.9
12
12.1
12.2
12.3
12.4
12.5

ISSN: 2278-0181
Vol. 1 Issue 5, July - 2012

Figure 9: 3-D Residual magnetic anomaly map of the study area