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Research Article

INTERPRETATION OF AEROMAGNETIC DATA OF OYO AREA, SOUTHWESTHERN NIGERIA

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Abstract

The study presents aeromagnetic data interpretation which involves the interpretation of aeromagnetic data features. Due to Magnetic properties of the earth crust, aeromagnetic anomalies over Oyo town are evaluated to map the magnetic lineaments and estimate the depth to the basement. The aeromagnetic data, from the study area sheet 241 Oyo, acquired were subjected to various filtering and processing technique which in turn properly displays the magnetic anomalies and magnetic intensities. Butterworth was applied to improve the signal to noise ratio, to reduce magnetic equator to properly position anomalies and to remove grappling effects. Gaussian filter was also applied to remove the regional effects thus leaving only the residual anomalies. Other processing techniques such as Upward continuation of 500m, 1000m, 1500m and 2000m, derivatives in x, y directions, analytic signal to delineate magnetically active zones, averaged power spectrum, Euler Deconvolution. The result shows that the depth to the top of the deepest magnetic source of about 2.3 km, depth to the shallow source ranges from 0.25 to 0.5km The obtained data shows that there is an abundance of positive anomalies that correspond to the migmatite-gneiss complex which is of moderate intensity. Derivatives in x, y and z directions revealed the parallel to sub-parallel lineaments which generally trends NE-SW direction except for major lineament that cuts through the migmatite-gneiss complex which trends in NW-SE direction. All these observations were made from qualitative and quantitative data interpretations, which in turn support magnetic information of the area.

Keywords: Aeromagnetic data, Magnetic intensity, Gaussian filter, Euler deconvolution, Anomaly.

INTRODUCTION

Aeromagnetic interpretation involves the interpretation of features on an aeromagnetic data (Aina and Olanrewaju, 1992). The mapping and interpretation of magnetic anomalies provide a useful and efficient method of studying crystalline basement rocks, basement sedimentary contacts or boundary and sedimentary basins (Ajibade *et al.,* 1987). The wealth of information contained in a magnetic map is usually presented in such a manner that quality of any information extracted from magnetic map is directly proportional to the quality and number of processes through which such information is extracted (Akima, 1970). There is a long history of magnetometers designed and constructed on mechanical principles to measure the direction of the Earth's magnetic field, either in vertical or horizontal planes. The development of magnetometer is effective in exploration which implies the usability for making large numbers of readings over a given area of interest in a reasonably short space of time. The first of such magnetometer, known as the flux-gate, was designed to detect submarines from overflying aircrafts and the sensor measured only the scalar magnitude of the total geomagnetic field (Batterham *et al.,* 1983). This design concept avoided all the complications associated with precise orientation of the sensor that was difficult and time-consuming to achieve and immediately enabled the instrument to be carried by a moving vehicle such as an aircraft. This allowed a very rapid rate of progress over a survey area. It was to be fifty years before the same capability was achieved for effective gravimetric surveys where orientation of the sensor is much more critical. Three fluxgates mounted orthogonally were employed (Beldi, 1993). Two were linked to servo motors each driven by non-zero output from the associated flux-gate, so ensuring that the third flux-gate was aligned with the geomagnetic field. The advent of this new technology, followed by the availability in peace-time of personnel trained in airborne operations during war, produced a business opportunity that set airborne geophysical surveying into motion in the exploration industry (Bello and Lawal, 2015). The technology was progressively refined with time and the capabilities of the initial electronic equipment, rudimentary by today's standards, developed all the while. In the late 1950s, the proton precession magnetometer made its appearance and despite on-going refinement of the flux-gate instrument, eventually replaced it in routine survey operations. These information circulars are intended as a preliminary explanation of the interrelation of distinctive magnetic features with geological features which have been mapped and studied by such correlation data, but that this publication may stimulate exploration and research could lead to discovery and development of new mineral deposits and would greatly further the basic knowledge of the geology of the study area. The magnetic contour lines on the map are lines connecting points of equal magnetic intensity. The shape, position and spacing of the magnetic lines are due to the combined effects of the Earth itself which is a huge magnet, and to local variations in the magnetism of the rock underlying any given area. If only the Earth as a large, uniform body were responsible for the magnetic lines, they would be essentially straight and simple (Bhattacharrya, 1995). It is the local geology, however, which imparts complexities to the pattern or the magnetic lines (Rahaman, 1989). Such complexities or variations from simple pattern are called anomalies (Rahaman, 1989). Local magnetic effects vary from place to place because the magnetic properties of the respective rocks are not alike or because difference in rock structures from place to place varies

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the magnetism measures at the surface. Rocks which have different kinds or different relative amounts of minerals, particularly iron-bearing minerals, have unlike magnetic properties (Collin Reeves, 2005; Reid *et al.,* 1990). In general, the more iron minerals present, the stronger the magnetic effect. The iron oxide mineral, magnetite, has strong magnetic effect even when present in small quantities; when present in large amounts, magnetite is of economic interest as a possible iron ore. If in a given area the rocks have been folded or faulted by internal earth forces, the resulting variation in position of the different rocks will be indicated by the variation in magnetic readings from place to place. Thus, structural complexities as well as mineral variations may be revealed by magnetic data (Sakoma and Martin, 2011; Martin, 2006). Of particular interest are those magnetic variations or anomalies which are circular or tend to enclose a given area; the implication in such cases is that there is a specific, localized causative factor more or less pinpointed by such a pattern (Keating and Pilkington, 2004). An airborne magnetic survey has the advantage of eliminating very minor magnetic features on the ground, thus permitting a better evaluation of larger and deeper magnetic phenomena. It should be borne in mind that the instruments which have measured the magnetic effects in these studies are very sensitive and capable of detecting small changes.

Location and geological information of the Study Area

The study area is Oyo town, Nigeria, and is characterized by major road, minor road, railway and secondary roads. Oyo town lies in the south-western part of Nigeria (Figure 1). Underlain by three lithological units of the crystalline basement complex, comprising: (i) Migmatite-Gneiss Complex (quartzite, gneissic rocks); (ii) Low to medium grade metasediments (Green schists facies, namely quartz schist and mica schist). (iii) The Pan African Granitoids (older granites) which are syncopate tectonic intrusions (MacLeod *et al.,* 1993). With these composite of rocks, Oyo town (Figure 2) has various minerals ranging from metallic, non-metallic, to industrial minerals to various grades of gemstones. Prior discoveries make the northern portion of Oyo town to be predominantly underlain by complex pegmatite, which harbor a lot of gemstones ranging from Aquamarine, Tourmaline, Agate and industrial minerals like Tantalite, Marble, Talc and Granites of various forms. Later discoveries point to Ibadan axis where metallic minerals, e.g. gold, and gemstones like Aquamarine, Amethyst, Tourmaline, and industrial minerals like Tantalite and Sillimante, have been discovered in economic form (Grant *et al.,* 1985).

Figure 1. Location of the study area

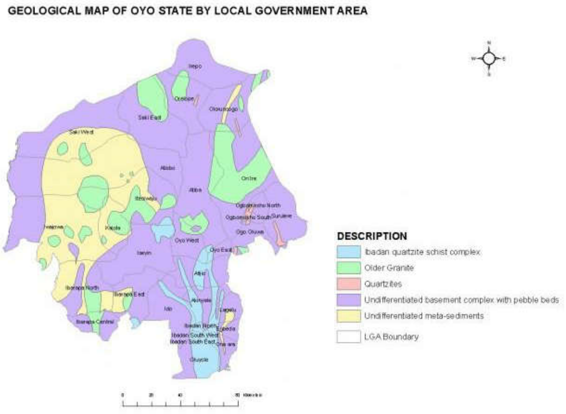


Figure 2. Geological map of Oyo State

Theoretical Background of the Method

From the point of view of Geomagnetism, the earth may be considered as made up of three parts: Core, Mantle and Crust. Convection processes in the liquid part of the iron core give rise to a dipolar geomagnetic field that resembles that of a large bar-magnet aligned approximately along the earth's axis of rotation. The mantle plays little part in the earth’s magnetism, while interaction of the (past and present) geomagnetic field with the rocks of the Earth's crust produces the magnetic anomalies recorded in detailed (e.g. aeromagnetic) surveys carried out to the close surface of the earth surface. Magnetic field in SI unit is defined in terms of the flow of electric current needed in a coil to generate that field. As a consequence, the unit of measurement is volt-seconds per square meter or Weber/meter squared or Tesla. Since the magnitude of the earth magnetic field is only about 5×10^{-5} T, a more convenient SI unit of measurement in geophysics is the nano Tesla (nT = 10^{-9} T). The geomagnetic field then has a value of about 50 000nT. Magnetic anomalies as small as about 0.1nT can be measured in conventional aeromagnetic surveys and may be of geological significance.

MATERIALS AND METHOD

The Geosoft Oasis Montaj 6.3 and Surfer 8 are used for this research. Aeromagnetic Data Correction and Reduction Data Correction are carried out during and after data acquisition stage so as to remove or reduce the effect of anomalies resulting from time variations, height, magnetic intensity of all platform and mechanical noises.

The following methods were used to achieve the objectives of this study; (i) Gathering of information on the regional geology and local geology of the area, principles of magnetic prospecting methods and magnetic properties of the earth materials, data acquisition, processing and interpretation. (ii) Generation of Aeromagnetic data (iii) Aeromagnetic data processing, analysis and interpretation. Airborne magnetometer survey map of contours of total magnetic field intensity of sheet 241 (OYO) was used in this study. The data obtained from the survey were corrected, converted to degrees an UTM values, delivered into Oasis Montaj (x, y, z) file format, gridded, contoured and compared with the original map and aeromagnetic map of previous tear prior further processing. Appropriate filters and enhancement were applied and therefore interpreted to achieve the set of objective of this study.

Compensation for errors caused by the magnetic field platform

All moving platform magnetic measurements are subjected to error caused by the magnetic field of the platform. These effects have been minimized in the past by mounting the sensor on long tow cable of the moving vehicle, by the installation of rigid magneto meters for fixed wing airborne operation, by developing error models, by developing feedback compensatory, by attaching bar magnet and strips of perm alloy to the sensor to cancel the aircraft field. (Akima, 1970) also noted that good compensation was crucial to the usefulness of the magnetic gradiometer systems. He described software compensation system that was eventually commercialized and is now in widespread use, even in single-sensor systems. It is fair to say that along with the introduction GPS, the use of these more sophisticated compensation models has produced the best improvement in data quality over the years.

Elimination of Temporal Variation

Of the time variations, micro pulsations, magnetic storms and diurnal variations occur over period of time that are short compared with the time taken to carry out a typical aeromagnetic survey. The three measures were taken to eliminate base station subtraction, tie-line leveling and micro leveling. The limit set to achievable accuracy by the noise level of modern magnetometer system is about two parts per million of a scalar magnitude of the field being measured and 4 orders of magnitude less than the amplitude of the large anomalies in that field. An almost intractable problem in data reduction is posed by fully eliminating time variations in the magnetic field to this accuracy. It is not practicable to make all the measurement that are necessary to eliminate all ambiguity and the skilled processor engaged in the reduction of data is, as a consequence, ultimately required to make some adjustments which can be justified only on the basis that they make the resulting maps and images look better. Height correction Most often it is not considered necessary to correct the readings of an airborne magnetometer for height, though there is certainly a 'free-air' gradient of the magnetic field at any given locality.
The magnitude of this gradient is 0.04 nT/m. However, high-sensitivity total field surveys flown with less than perfect control on the altitude of the aircraft - particularly where flown over areas of low magnetic relief such as are typical over thick sedimentary successions - are sometimes seen to have variations of fractional nT amplitude in the magnetometer channel sympathetic with variations in the altimeter reading. The magnetic variations can be reduced or eliminated, often by determining a suitable free-air gradient empirically by applying corrections for a range of gradients on a trial- and-error basis. Where height corrections are applied, this should be the first phase of data processing since the implemented corrections will influence the subsequent removal of temporal variations and the micro-leveling of the data. Height correction would be beneficial to a precise scheme of tie-line leveling; a difference between measured and nominal (specified) height of only 3 m would be sufficient to produce a difference in T equal to the 0.1 nT noise envelope on the profile of an optical pumping magnetometer and height differences of several tens of metres will not be uncommon in practice. Application of height corrections would ensure that comparisons of T values made at line-intersections were more valid, though variations of T with h as a result of local anomalies (as opposed to the free-air gradient) would still not be taken into account.

Base Station Subtraction

It is a relatively straightforward matter to run a recording base station magnetometer at a location on the ground while the aircraft is flying and subtract the time- synchronized magnetic variations at the fixed base from the profiles recorded in the air to give a residual where the temporal dependency has been eliminated and is only a function of space. Unfortunately, this assumes that the geomagnetic variations recorded at the base station are fully representative of such variations over the whole survey area. In fact, it can be shown that such variations are only imperfectly time-synchronous over distances of 50 km or so and individual features - such as micro pulsations - can change phase and amplitude significantly within distances of this order. These effects are exacerbated during magnetic storms when flying operations are, in any case, suspended. The restriction of survey flying to times of low geomagnetic activity is usually defined in a survey contract by the so-called 'diurnal tolerance'. Since most of the processes employed later in the removal of temporal variations assume that geomagnetic variations approach linearity over periods of several minutes, it is necessary to specify an allowable departure from linearity on a recording ground magnetometer (base station) trace. A definition often employed is that non- linearity should not exceed 5 nT over any five-minute period. This is assessed by drawing any 'five minute chord' and measuring the greatest difference in nT between this and the observed magnetic field Some authorities claim that this is unnecessarily stringent, particularly in high magnetic inclinations where storms are more frequent, and leads to needless expensive hours of aircraft idleness. Before subtraction is carried out, great care must be taken to ensure that airborne profiles are not corrupted by any magnetic interference (such as the effect of passing vehicles) recorded only at the base station. Furthermore, the ground profile should be suitably smooth (or be smoothed) to ensure that subtraction of the ground values does not amount to an addition of noise to the airborne profile. Ideally, a ground magnetometer no less precise and accurate than that employed in the aircraft should be used. However, in general, subtraction of base-station readings immediately reduces errors due to temporal variations in an airborne profile to levels less than about 10 nT. For surveys in areas of high magnetic relief, it has been argued that base-station subtraction alone gives adequate removal of temporal variations. In most cases, however, it seems likely the following procedures will further improve the data quality.

Removal of IGRF

Once coefficients are available for the IGRF at the epoch of the survey, it is possible to calculate a value for the IGRF at every point where an airborne magnetometer reading is made in a survey and subtract that value from the observed value to give the 'anomaly' defined as the departure of the observed field from the global model. The global model field over a typical survey area is, in effect, a very low order surface which may even be well-approximated by a linear gradient. There are no significant consequences for the accuracy of processing if this gradient is removed at the beginning or at the end of the data reduction sequence. Of more importance is the fact that the absolute value of the observed field is usually only poorly determined, even though most modern magnetometers record absolute values. After base-station subtraction, the quoted value is simply the difference between the airborne magnetometer reading and the magnetometer reading at an arbitrary point on the ground. The exact relationship between the total field at the ground station and the IGRF at that point is usually still not determined. In theory, the base station values could be compared with magnetometer records at a permanent magnetic observatory from which an accurate absolute value could be derived for the crustal anomaly at the base station and hence the for the airborne values. This is seldom done; the nearest magnetic observatory is often thousands of kilometres from the survey area, adding cost and complexity to survey operations. In Canada, a small number of airborne magnetometer calibration points have been set up at conspicuous cross-roads in areas of low magnetic gradient (Wright, 1985). These points may be over flown in cardinal compass directions with an airborne magnetometer system. The ground points have been carefully linked to nearby magnetic observatories, enabling the value recorded by the airborne magnetometer at the moment of over flight to be related directly to absolute observatory values of T. Often, particularly in the past, the corrected values of T resulting from an airborne survey are added to an arbitrary constant value such as 5000 or 10000. This removes possible confusion consequent upon contouring negative values but has little other merit. Sometimes the arbitrary constant is an estimate of the total field value in the survey area, leaving magnetic values on final maps looking very similar to true total field values except that the horizontal gradient attributable to the IGRF will have been removed. The importance to the user of all these procedures being fully documented by an analyst reducing a survey should be obvious. From the user's point of view, there is clearly a need for caution when reading the absolute values of magnetic field recorded in survey output (map or digital). The need to apply level-shifts and warps to final survey data when attempting to join grids of surveys of adjacent areas 'seamlessly' is a consequence of (a) the lack of rigour in determining absolute values in normal survey practice, (b) the poor control over long wavelength geomagnetic variations which results from large distances between aircraft and ground station and (c) the arbitrary nature of some data- reduction practices applied to remove temporal variations. Leveling at line intersection Aeromagnetic surveys has always been planned with a network of flight-lines and 'tie-lines' or 'control-lines' to provide a method of eliminating temporal variations from the observed anomalies. The principle is that, once heading effects of the aircraft have been eliminated and since the magnetic (anomaly) field we strive to record is essentially time-invariant, any difference observed in the recorded value between two over flights of the same point (i.e. at any intersection in the flight-path) must be attributable to temporal variations, even though neither of the two values is itself necessarily correct. The miss-ties at all intersections may then be examined and adjusted systematically in an attempt to reduce them to amplitude below the noise envelope.

Data Presentation

Aeromagnetic data are presented as maps and presentation form in this study is generally as color-filled maps and contoured maps. The presentation formats varies and this facilitates the assessment and identification of different features of interest. The different presentation formats allows for the identification of anomalies and various quality improvement techniques allows for better identification of the various anomalies in the study area. The ability to carry out qualitative and quantitative interpretation is essential to adequately obtain the information concerning the structural trend, lithology contrast, basement topology etc. Paterson and Reeves color map format facilitates the assessment of regional trends and magnitude variation.

RESULTS AND INTERPRETATION

Interpretation generally involves obtaining of relevant information from the data as possible. The main use of any aeromagnetic and their derivative maps in geophysical prospecting is to make geological deduction from them. The aeromagnetic map has been subjected to various filtering and enhancement processes. In the case of target searches, only high frequency component of the signal is desired. One of the challenges of data analysis is to generate views of the data that will make interpretation straightforward. The task carried out is to enhance the signal of interest and remove the rest.

Qualitative Interpretation

The aeromagnetic data was qualitatively interpreted using grids of total magnetic intensity, Butterworth Filter, Gaussian regional residual filter, horizontal and vertical

Total Magnetic Intensity (TMI)

The total magnetic intensity data was gridded prior to any form of data filtering techniques (Figure 4). The anomalies are well displayed on the total magnetic intensity map. A large anomaly of low magnetic intensity is located in the central section of the area. The black arrows point to the areas of high magnetic intensities represented in purple to red color ranging from 147.0 nT to 79.4 nT located mostly around the North central and North Eastern, South western and South Eastern part of the study area (Figure 3). The anomalies of the low magnetic intensities range from -49.8 nT to -143.8 nT. This appears to be the negative anomalies in the study area noted with the yellow arrows and can be found mostly in the North central and north western part of the study area. The positive anomalies found in the area can be associated with ring complexes and Basement Complex. The variation in magnetic intensities in the area is due to the lithological variations and Basement structures.

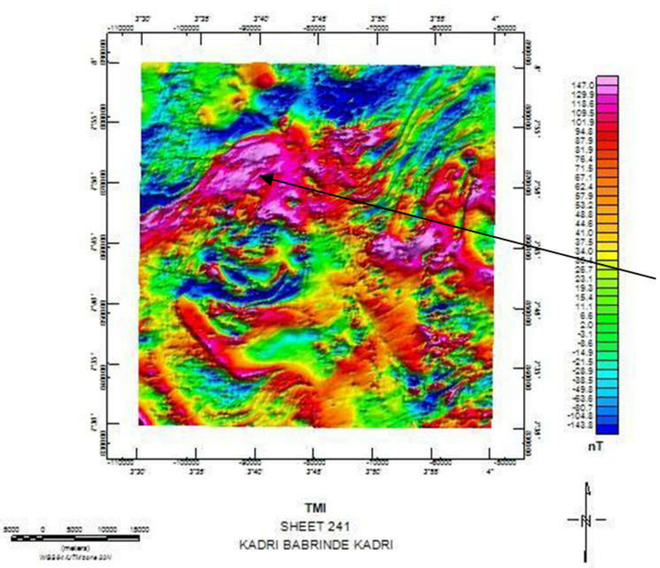


Figure 3. Color Shaded shows Total Magnetic Intensity of the Study Area

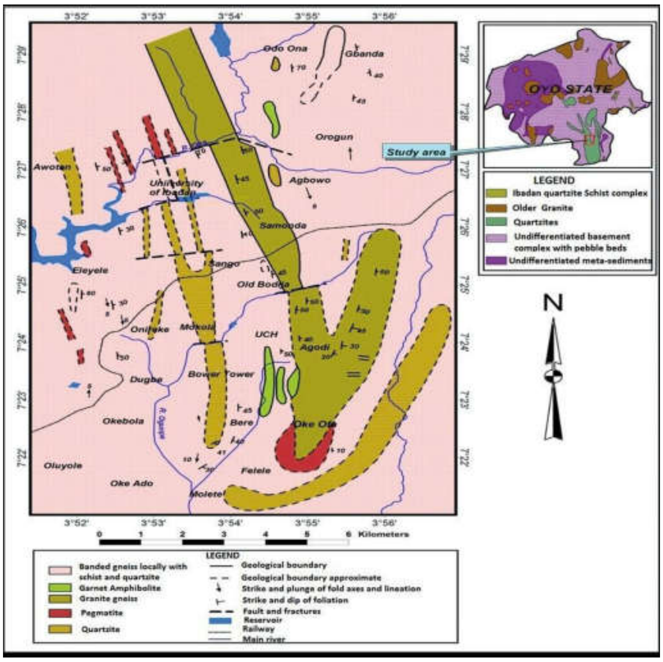


Figure 4. Total Magnetic Intensity and Geological Map of the Study Area

Reduction to Magnetic Equator and Residual Magnetic Intensity (RMI)

The reduction to Magnetic Equator filter was applied to correct the effect of latitude and the place the anomalies on their respective sources. Geomagnetic field inclination and declination of -28.7255758° and – 6.46895158° representing the geomagnetic field parameter of the central location of the study area were used as indicated from IGRF at a point. Figure 4 showed the reduced to equator map of the area. High Magnetic Intensity is indicated as purple and red while low magnetic intensity is indicated as blue. The magnetic highs with intensities ranging from 159.8 nT to 64.8 nT indicates the presence of high .magnetic materials of high susceptibility around the North central and North Eastern, South western and South Eastern part of the study area. The magnetic lows which have intensities ranging from -130.4 nT to 24.1 nT are well pronounced in the North central and North western part of the study area which indicates low magnetic susceptibility. The examination of the map with geology of the area reveals that the region with low intensity coincides with part of the area underlain by banded gneiss locally with schist and quartzite while the area with high intensity is uncertain with migmatite-genies and quartzite. Residual Magnetic Intensity (RMI) The residual magnetic intensity map of the study area is applied through High Pass Gaussian filter. The filter was applied to the regional effect thus leaving only the residual anomalies of the area. The residual magnetic intensity map (figure 4) shows that the total magnetic map has been reduced drastically in which unwanted noises has been filtered off after the application of Gaussian filter. The Butterworth Filter was initially applied. In comparison with the total magnetic map, the highs and lows magnetic intensity values has been slightly reduced from 147.0 nT and 81.9 nT to 146.9 nT and 81.8 nT, -143.7 nT and -49.8 nT to -143.8 nT and -49.7 nT. Apart from the effects of magnetic intensities, the filter also increased the extent of positive anomaly in the North central and North Eastern part of the Total Magnetic Intensity Map. Comparison of The Reduction to the magnetic equator map and Residual Magnetic Intensity Map shows a significant amount of reduction in the intensities from 146.9 nT and 87.9 nT to 159.8 nT and 76.0 nT for the magnetic highs and -143.7 nT and -49.7 nT to-103.4 nT and -37.4 nT but little to no difference in the extent of anomalies on the map.

Horizontal and vertical derivative

These filtering techniques are used to sharpen the edges of magnetic anomalies and better locate their position. The reduced to the equator residual magnetic intensity map contains all the anomalies representative of both shallow and deep sources. This technique is applied to suppress unwanted sources and to sharpen the edge of the anomalies.

Correlation of the Aeromagnetic data

Anomalies are located in the southwestern part of Nigeria and underlain by three lithological units of the crystalline basement complex which wholly belong to the Pre Cambrian- Cambrian Basement Complex. This results in the variation of the intensities of the two areas from application of some filters and extent of anomalies on different filters.

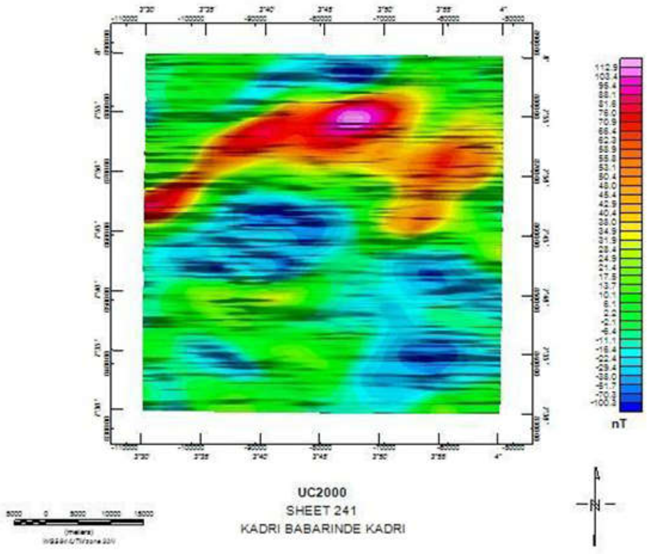


Figure 5. Upward continuation of 2000m

Basement analysis

According to (Wright, 1985), structural analysis of the basement can advance the understanding of overlying structures of the petroleum system of an area. Therefore, the integrated interpretation starts in the basement, proceeds to the Sedimentary section and leads directly towards the risk assessment of specific project site. The processed and enhanced total magnetic intensity map of the study area was further filtered with an upward continuation of 500m, 1000m, 1500m, and 2000m to accentuate the response from the basement and attenuate responses from the sediments. The most important effects of this filtering technique on this map is that it makes them to be smoother, more regional thereby reflecting the general basement anomalies. Figure 5, as sample, showed the upward continuation of 2000m. When the map was upwardly continued towards positive anomalies of high magnetic intensities are recognized, the positive anomaly towards the southern section was enhanced and the major negative anomalies are recognized too. When upwardly continued towards 1000m, significant enhancement of the anomalies is observed. Local positive and negative anomalies in the southern section became enhanced and positive and negative anomalies in the Northern section disappear. When continued to 1500m disappearance of some anomalies are observed in the Northern section. More positive anomalies disappeared while less negative anomalies disappeared. The boundary of the regional negative anomaly in the central section became well defined; the positive anomaly also appeared well defined. Traces of green anomaly begin to appear after disappearance of the positive and negative anomalies in the Northern section. When continued to 2000m, three prominent anomalies are observed which the green, blue and red anomalies are. The red anomaly became prominent in the North central section while the blue anomaly is noticed prominently across the southern section and the green anomaly sub rounded the whole study area. (Figure 5) From the observations stated above, it is clear that the magnitude of anomalies decreases with increase in continuation distance. Three prominent anomalies were recognized in Figure 5 based on size shape, trend and the variation of intensity of magnetic response. The shorter wave length negative magnetic intensity with a large spatial scale is noticed at the central portion of the study area. The green portion of the anomaly around the study area is of moderate intensity. The red positive anomaly in the North central of the map is of high intensity and corresponds to an intrusive body (ring structure). Figure 6 showed the correlation of the geological map with upward continuation of 2000m. This shows that the centrally placed anomaly of high magnetic intensity corresponds to the area underlain by migmatite gneiss basement and coarse grained prophyritic biotite/ Biotite-hornblende granite which are represented by red to purple color

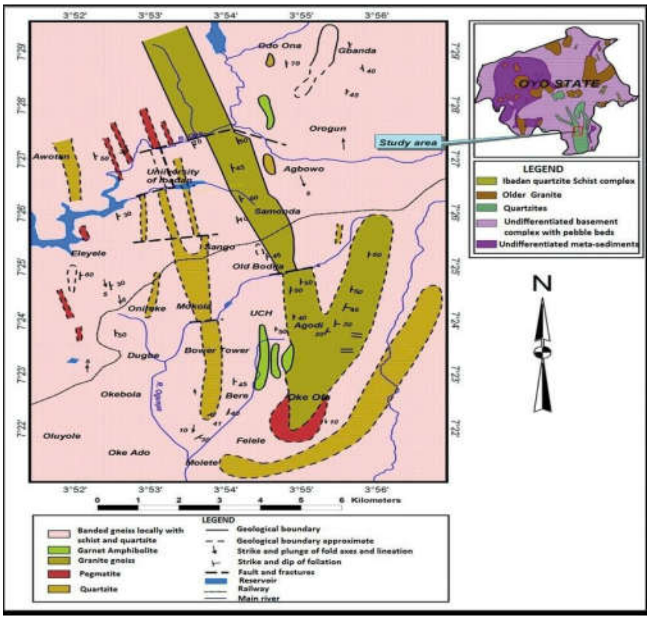


Figure 6. The correlation of the geological map with upward continuation of 2000m

Structural Interpretation

First order horizontal and vertical derivatives filters were applied in the processed aeromagnetic data. Figure 7 showed color shaded derivative maps of the study area. Horizontal derivatives usually provide a more exact location for faults than first vertical derivatives (Figure 8). The horizontal derivative method involves only horizontal derivatives and is relatively insensitive to noise. The pink and red in the color shaded derivative maps shows high positive shallow anomalies indicating the presence of high magnetic susceptibility material in the near surface. Lineaments are zones of structural deformation which are related to faults, joints or even geological contacts. Magnetic minerals are usually concentrated along or aligned with some structural features such as faults. The derivative maps (Figure 7) showed parallel to sub-parallel in North Eastern – South western (NE-SW) orientation of magnetic lineaments which may represent the faults or fracture zones and some occurs within the basement. Almost all this linear anomalies in the study area is within the basement complex terrain. Linear anomalies within the area trend in NE-SW direction. Presence of a particular lineament is observed in the NW-SE direction which cut across centrally located regional anomaly of low magnetic intensities. The pink and red colored anomalies present in the Northern part of the map indicate the presence of minerals of high magnetic susceptibility which results from ring complexes in the area.

Delineation of magnetization contrast within the basement analytic signal

The analytic signal map of the study area is presented in Figure 9. Analytic Signal indicates the variation in the magnetization contrast of the magnetic source in the study area. The map reveals the anomaly texture and highlight anomaly pattern discontinuities. The area is divided into zones of high and low values of magnetic intensity. The magnetically active zones constitute the North central and North Eastern part of the study area and the South western part of the study area. This area is characterized by intrusive suite of rocks, basement terrains. The region of low magnetic intensities is located around the Northern and South western part of the study area. [15] stated that the analytic signal shows the boundary between the maximum and the minimum magnetic signatures, so that it is a very good tool to map shape and boundaries of rocks. The magnetic active zones could be due to the presence of relatively high magnetic susceptibility rocks in shallow basement while the magnetically quiet zones could be traced to the presence of very low magnetic susceptibility or the effect of depth on the anomaly.

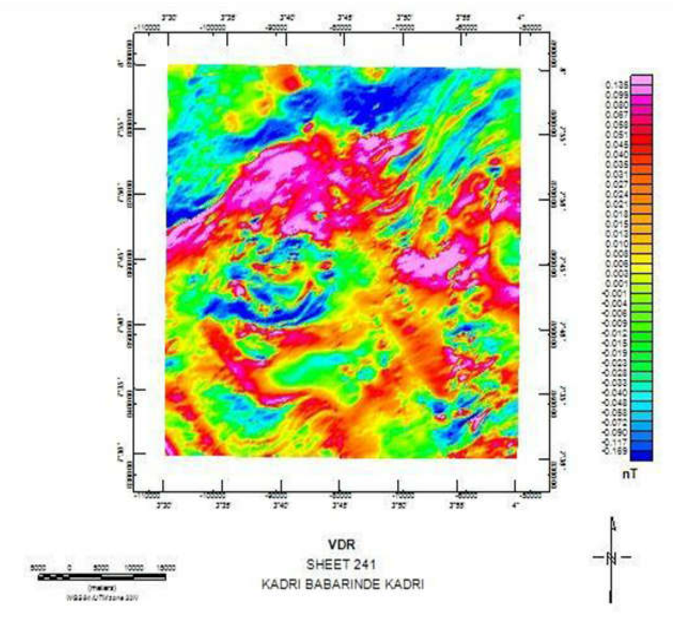


Figure 7. Color Shaded Vertical Derivative Map of the Study Area

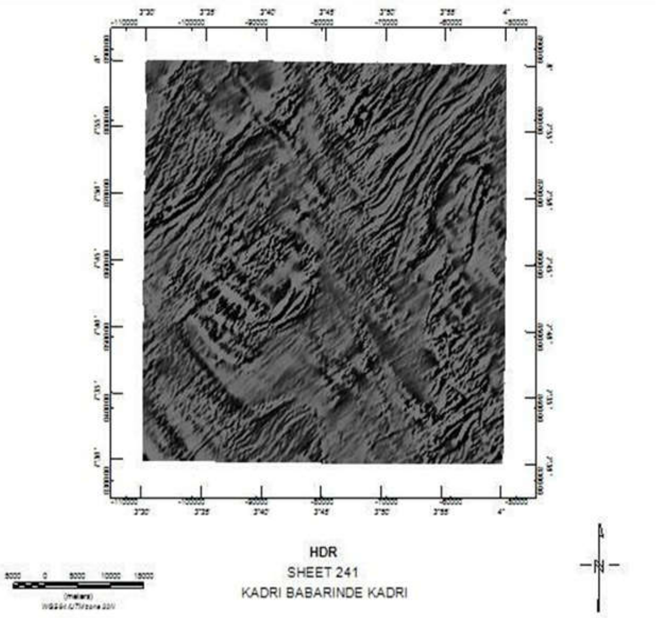


Figure 8. Grayscale shaded Horizontal derivative Map of the Study Area

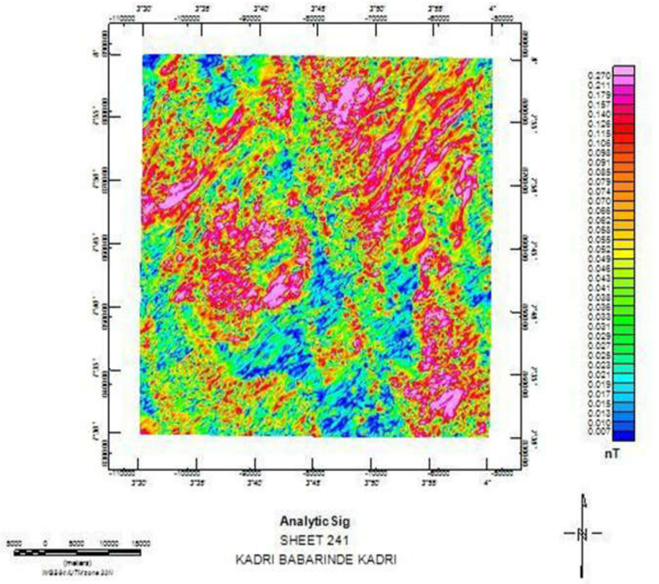


Figure 9. Analytic Signal Showing Magnetically Active and Magnetically Quiet Zones

Quantitative interpretation

A complete quantitative interpretation of potential field data estimates three types of information about the sources of geological interest in the depth, contrast in physical properties and source geometry.

Depth to Magnetic Basement After the realization that aeromagnetic data exhibits scaling behavior, it became apparent that this would have direct effect on the calculation of certain depths.. Depth estimation can be estimated with 7% error . Two depth estimate methods were employed during the study; spectral analysis and Euler Deconvolution.

Averaged Power Spectrum In order to determine the number of magnetic horizon in the study area and their average depths, power spectrum of aeromagnetic data was computed and interpreted. The amplitude of the logarithm power spectrum was plotted against the radial frequency. Best fit least square straight lines were then fitted to the power spectrum. The slopes of linear segment of the spectrum correspond to separate the depth ensemble. Power Spectrum in 2D function of the energy and wave number were used to identify average depth of source assemblages [18]. Figure 10 was the result of computed radial power spectrum and depth to top of the magnetic sources around Oyo town. The result showed that the depth to top of the deeper magnetic source is about 2.3km. Depth to top of the shallow source ranges from 0.25 to 0.5km.

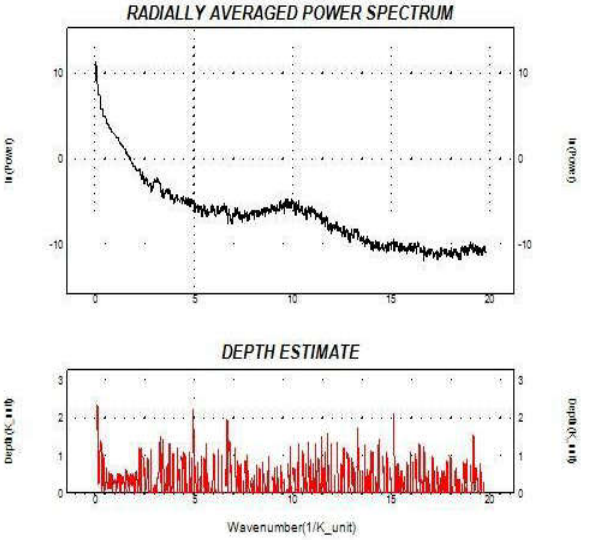
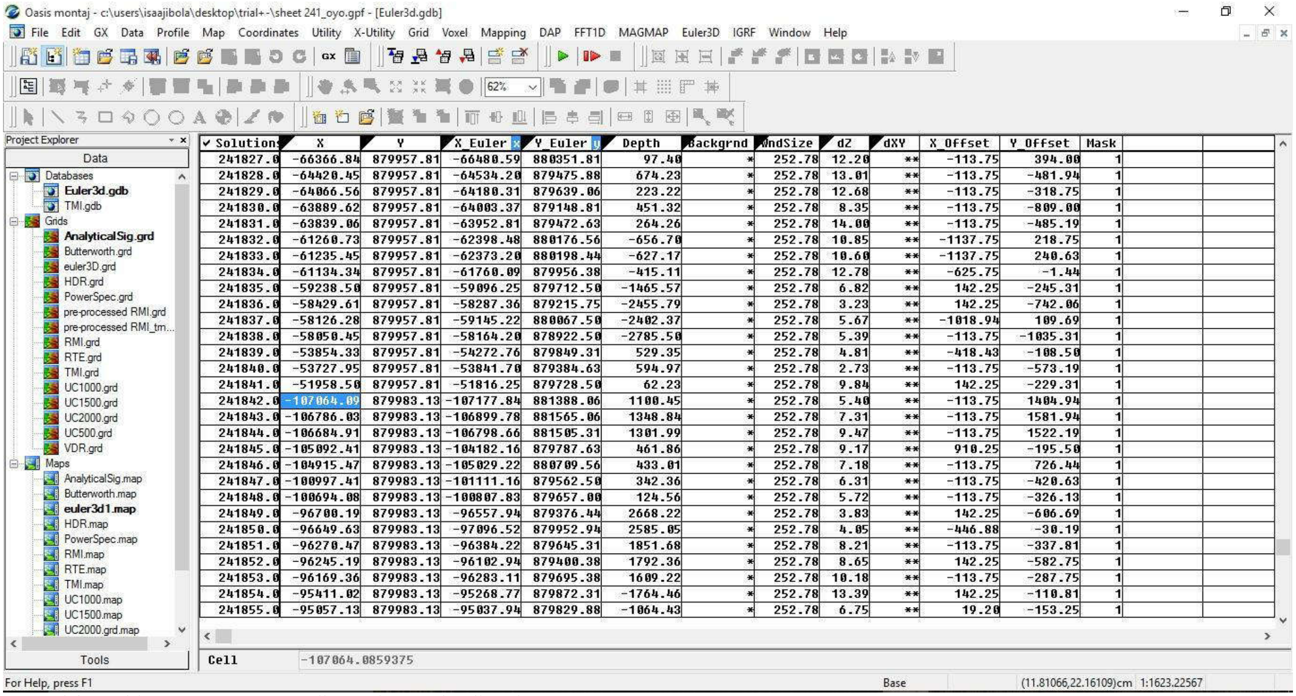


Figure 10. Power Spectrum and Depth Estimate of the Study Area

Figure 10 is a classified depth to source basement solution of the study area. The northern part dominates by depth range of 1000-2000m (migmatite gneiss) and the central section of the study area is characterized by depth range of values less than 1000m. The maximum depth range corresponds to values less than 3000m but greater than 2000m indicated by the light green color, red color indicate color ranges from 1000-2000m and black color predominates the area. The highest depth range indicated by the light green color occurs to be sparsely distributed in thus model. The red color towards the western section of the map indicates the ring complex identified by this model with depth ranges from 1000-2000m. Figure 11 (a-b) is classified depth to source solution of the study area with structural index of 1.0. This is an intrusive body model. The north eastern section of the study area is dominated by depth ranges between 1000-2000m indicated by red color. The central section is dominated by red and light a green color which indicates that depth to source ranges of values less than 3000m but greater than 2000m. The South Eastern section is dominated by red color which indicates depth ranges between 1000-2000m. Indication of green color in the North Eastern section and the South Eastern section indicates the presence of depth ranges. Presence of depth ranges less than 1000m distributed all over appearance of clustering in the North Eastern and South Eastern section which is associated with migmatite gneiss that displays variation in magnetic intensities. Figure 11c is classified depth to source solution of the study area with structural index of 2.0. This is a cylindrical or rod model. Presence of red and green colors clustered in different sections. Few depth ranges less than 1000m is observed in this area.

Table 1. Monte carlo



Solution	X	Y	X_Euler	Y_Euler	Depth	Backgrnd	WndSize	dZ	dXY	X_Offset	Y_Offset	Mask
241827.0	-66366.84	879957.81	-66480.59	880351.81	97.40	*	252.78	12.20	**	-113.75	394.00	1
241828.0	-64420.45	879957.81	-64534.20	879475.88	674.23	*	252.78	13.01	**	-113.75	-481.94	1
241829.0	-64066.56	879957.81	-64180.31	879639.06	223.22	*	252.78	12.68	**	-113.75	-318.75	1
241830.0	-63889.62	879957.81	-64003.37	879148.81	451.32	*	252.78	8.35	**	-113.75	-809.00	1
241831.0	-63839.06	879957.81	-63952.81	879472.63	264.26	*	252.78	14.00	**	-113.75	-485.19	1
241832.0	-61260.73	879957.81	-62398.48	880176.56	-656.70	*	252.78	10.85	**	-1137.75	218.75	1
241833.0	-61235.45	879957.81	-62373.20	880198.44	-627.17	*	252.78	10.60	**	-1137.75	240.63	1
241834.0	-61134.34	879957.81	-61760.09	879956.38	-415.11	*	252.78	12.78	**	-625.75	-1.44	1
241835.0	-59238.50	879957.81	-59096.25	879712.50	-1465.57	*	252.78	6.82	**	142.25	-245.31	1
241836.0	-58429.61	879957.81	-58287.36	879215.75	-2455.79	*	252.78	3.23	**	142.25	-742.06	1
241837.0	-58126.28	879957.81	-59145.22	880067.50	-2402.37	*	252.78	5.67	**	-1018.94	109.69	1
241838.0	-58050.45	879957.81	-58164.20	878922.50	-2785.50	*	252.78	5.39	**	-113.75	-1035.31	1
241839.0	-53854.33	879957.81	-54272.76	879849.31	529.35	*	252.78	4.81	**	-418.43	-108.50	1
241840.0	-53727.95	879957.81	-53841.70	879384.63	594.97	*	252.78	2.73	**	-113.75	-573.19	1
241841.0	-51958.50	879957.81	-51816.25	879728.50	62.23	*	252.78	9.84	**	142.25	-229.31	1
241842.0	-107064.09	879983.13	-107177.84	881388.06	1100.45	*	252.78	5.40	**	-113.75	1404.94	1
241843.0	-106786.03	879983.13	-106899.78	881565.06	1348.84	*	252.78	7.31	**	-113.75	1581.94	1
241844.0	-106684.91	879983.13	-106798.66	881505.31	1301.99	*	252.78	9.47	**	-113.75	1522.19	1
241845.0	-105092.41	879983.13	-104182.16	879787.63	461.86	*	252.78	9.17	**	910.25	-195.50	1
241846.0	-104915.47	879983.13	-105029.22	880709.56	433.01	*	252.78	7.18	**	-113.75	726.44	1
241847.0	-100997.41	879983.13	-101111.16	879562.50	342.36	*	252.78	6.31	**	-113.75	-420.63	1
241848.0	-100694.08	879983.13	-100807.83	879657.00	124.56	*	252.78	5.72	**	-113.75	-326.13	1
241849.0	-96700.19	879983.13	-96557.94	879376.44	2668.22	*	252.78	3.83	**	142.25	-606.69	1
241850.0	-96649.63	879983.13	-97096.52	879952.94	2585.05	*	252.78	4.05	**	-446.88	-30.19	1
241851.0	-96270.47	879983.13	-96384.22	879645.31	1851.68	*	252.78	8.21	**	-113.75	-337.81	1
241852.0	-96245.19	879983.13	-96102.94	879400.38	1792.36	*	252.78	8.65	**	142.25	-582.75	1
241853.0	-96169.36	879983.13	-96283.11	879695.38	1609.22	*	252.78	10.18	**	-113.75	-287.75	1
241854.0	-95411.02	879983.13	-95268.77	879872.31	-1764.46	*	252.78	13.39	**	142.25	-110.81	1
241855.0	-95057.13	879983.13	-95037.94	879829.88	-1064.43	*	252.78	6.75	**	19.20	-153.25	1

Cell -107064.0859375

Legend for Table X, Y = UTM coordinates in x and y directions
X_ Euler, Y_ Euler = Actual location of Euler solutions
Depth = solution depth (z coordinates)
Wind size= An estimates of peak sizes
dz = estimated error in depth

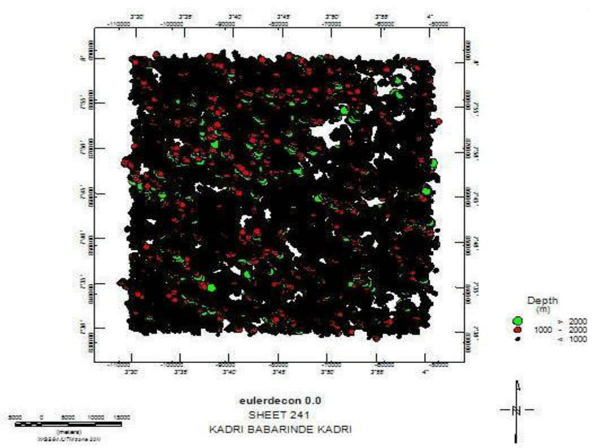


Figure 11a: Classified Euler depth to source (basement) solution (contact model)

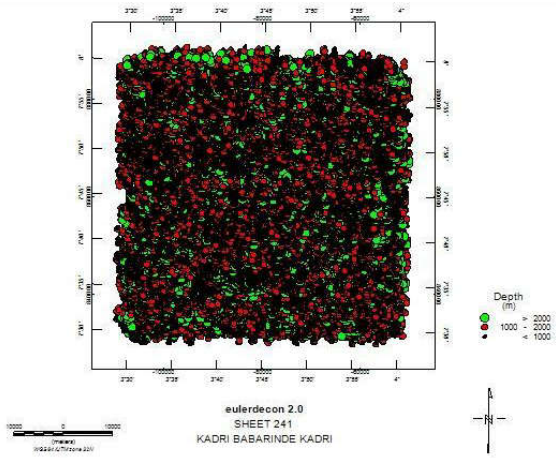


Figure 11c: Classified Euler depth to source solution (Cylindrical model)

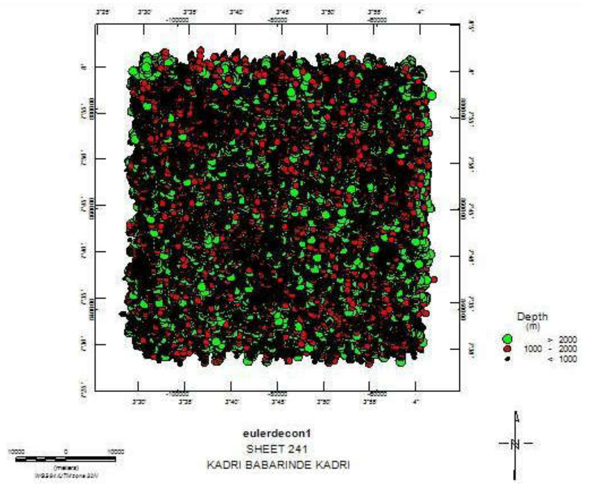


Figure 11b. Classified Euler depth to source solution (Dyke model)

Conclusion

The interpretation of the digitalized aeromagnetic data from sheet 241 Oyo was carried out both qualitatively and quantitatively, by using various processing techniques such as Butterworth, Gaussian filter, Upward continuation of 500m, 1000m, 1500m and 2000m and 2D models. The results of this study established the following: an analysis of the aeromagnetic data; the magnetic definition of the areas with certain geological significance, geographical information and the identification of the alignment of the magnetic field that probably corresponds to fault systems. Majority of the area corresponds to the Migmatite gneiss complex while prominent positive anomaly is also observed in the southern section characterized by coarse-grained prophyritic biotite/ Biotite-hornblende granite and the intensities correspond to Magnetic intensities

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