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Aeromagnetic data analysis of tafawa balewa area using second vertical derivative and analytic signal techniques

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Abstract: *Aeromagnetic data over Wase and its adjoining areas were obtained and analysed for assessing the mineral potential of the area. This study is situated in northern Nigeria Basement Complex The area includes parts of Bauchi and Plateau states. These parts include: Maijuju, Tafawa Balwa ,Wase , and Pankshin covered by four . The study area covers an estimated area of about 18150 Km^2 between latitudes $9^0 00^1$ to $10^0 00^1$N and longitudes $9^0 00^1$ to$10^0 00^1$E the area has a balance of geographical features as well as climatic conditions. The entire western and northern parts are generally mountainous and rocky. This is as a result of the closeness to the Jos Plateau. The data were analyzed using the second vertical derivatives and analytic signal techniques. Result obtained showed the high density contours of the Second Vertical Derivative were found to correlate with exposed basement intrusion in the area. The analytic signal result highlighted areas of high magnetization contents which could be sites for possible mineralization.*

Key words: *Aeromagnetic data, Second vertical derivatives and Analytic signal*

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I. Introduction

Geophysics is a physics of the Earth and its environment in space, also the study of the earth using quantitative physical methods. The term geophysics sometimes refers only to the geological applications, Earth's shape, its gravitational and magnetic field, its internal structure and composition, its dynamics and their surface expression in plate tectonics, the generation of magmas, volcanism and rock formation. However, modern geophysics organization's use a broader definition that includes the hydrological cycle including snow and ice, fluid dynamics of the oceans and the atmosphere, electricity and magnetism in the ionosphere and magnetosphere and solar-terrestrial relations. And analogous problems associated with the moon and other planets (Reynolds 2011). Geophysical modelling provides generalized and no-unique solution to questions concerning the concerning the geometry of the subsurface geologic structures (Reeves, 2005).Most economic minerals, oil, gas, and groundwater lie concealed beneath the Earth surface, thus hidden from direct view. The presence and magnitude of these resources can only be ascertained by geophysical investigations of the subsurface geologic structures in the area.

Aeromagnetic Studies

The Earth and its contents have long been of concern to mankind. Man has tried to unravel its complexity and develop into its origin via various geophysical methods. The subsurface has been of particular concern to geoscientists, who seek to investigate it using diverse means, some for the purpose of having knowledge, while others do it for exploration of economic resources such as minerals and hydrocarbons. With the advances in technology and the need to have a clearer picture of the earth subsurface and its contents, the earth scientists have deemed it necessary to utilize the properties associated with earth's interior. Geophysics involves the application of physical principles and quantitative physical measurements in order to study the earth's interior. The analysis of these measurements can reveal how the earth interior varies both vertically and laterally, and the interpretation of which can reveal meaningful information on the geological structures beneath Dobrin (1976).By working at different scales, geophysical methods may be applied to a wide range of investigations from studies of the entire earth to exploration of a localized region of the upper crust for engineering or other purposes (Reeves, 2005) A wide range of geophysical methods exist for each of which there is an operative physical property to which the method is sensitive. The type of physical property to which a method responds clearly determines its range of application. Thus, for instance, magnetic method is very suitable for locating buried magnetic ore bodies because of their magnetic susceptibility. Similarly, seismic and electrical methods are suitable for locating water table, because saturated rock may be distinguished from dry rock by its higher seismic velocity and higher electrical conductivity. Aeromagnetic surveys are now used to perform reconnaissance mapping of unexploded ordnance (UXO).The aircraft is typically a helicopter, As the sensors must be close to the ground (relative to mineral exploration) to be effective.

Location of the Study Area

This study is situated in northern Nigeria Basement Complex .The area includes parts of Bauchi and Plateau states. These parts include:Maijuju, TafawaBalwa ,Wase , and Pankshin covered by four aeromagnetic Mapsnumbered 169 , 170, 190 and 191 respectively (Fig. 2). The study area covers an estimated area of about 18150 Km^2 between latitudes $9^0 00^1$ to $10^0 00^1$N and longitudes $9^0 00^1$ to$10^0 00^1$E (Fig. 3).The area has a balance of geographical features as well as climatic conditions. The entire western and northern parts are generally mountainous and rocky. This is as a result of the closeness to the Jos Plateau.

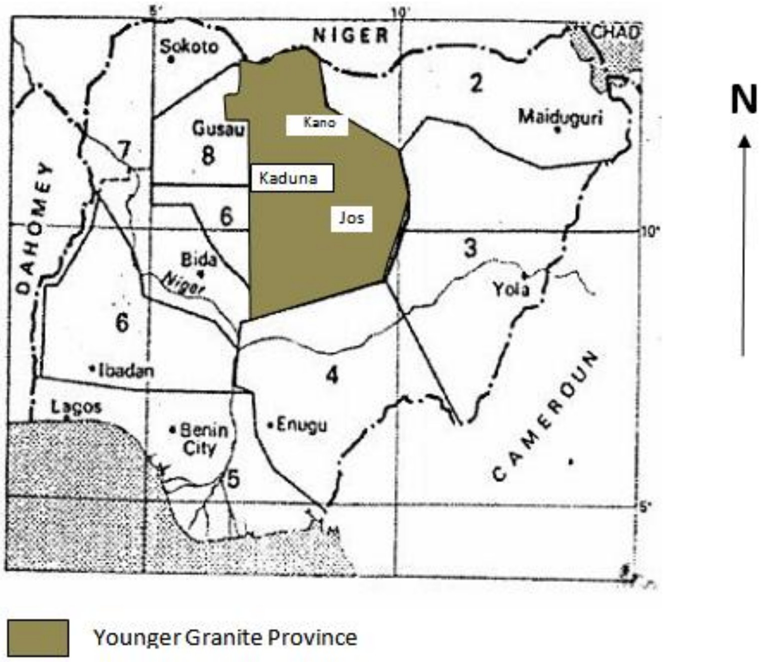

Figure 1. Map of Nigeria showing the Younger Granite Province (after Taofeeq, 2012)

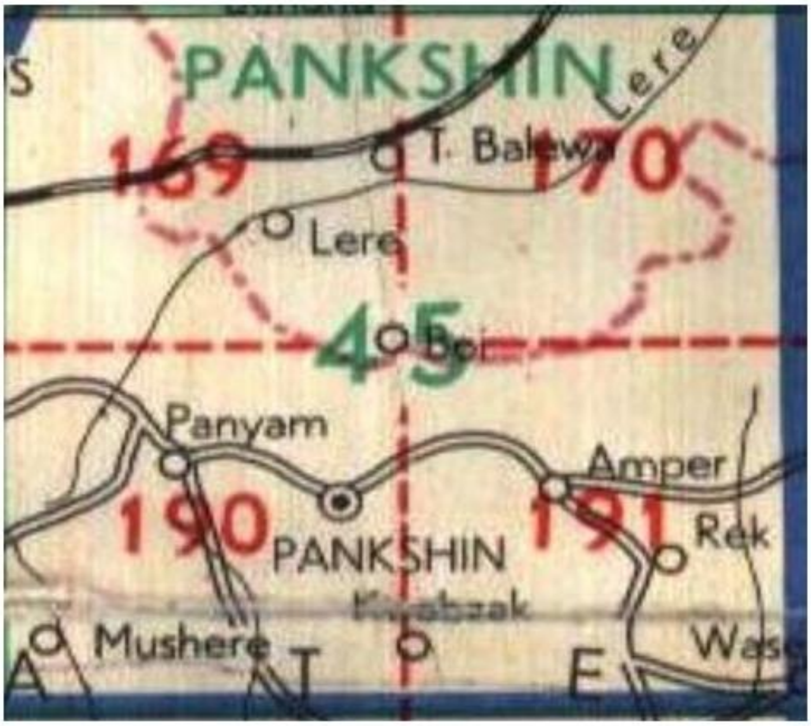

Fig .2 Sheet Map of the Study Area

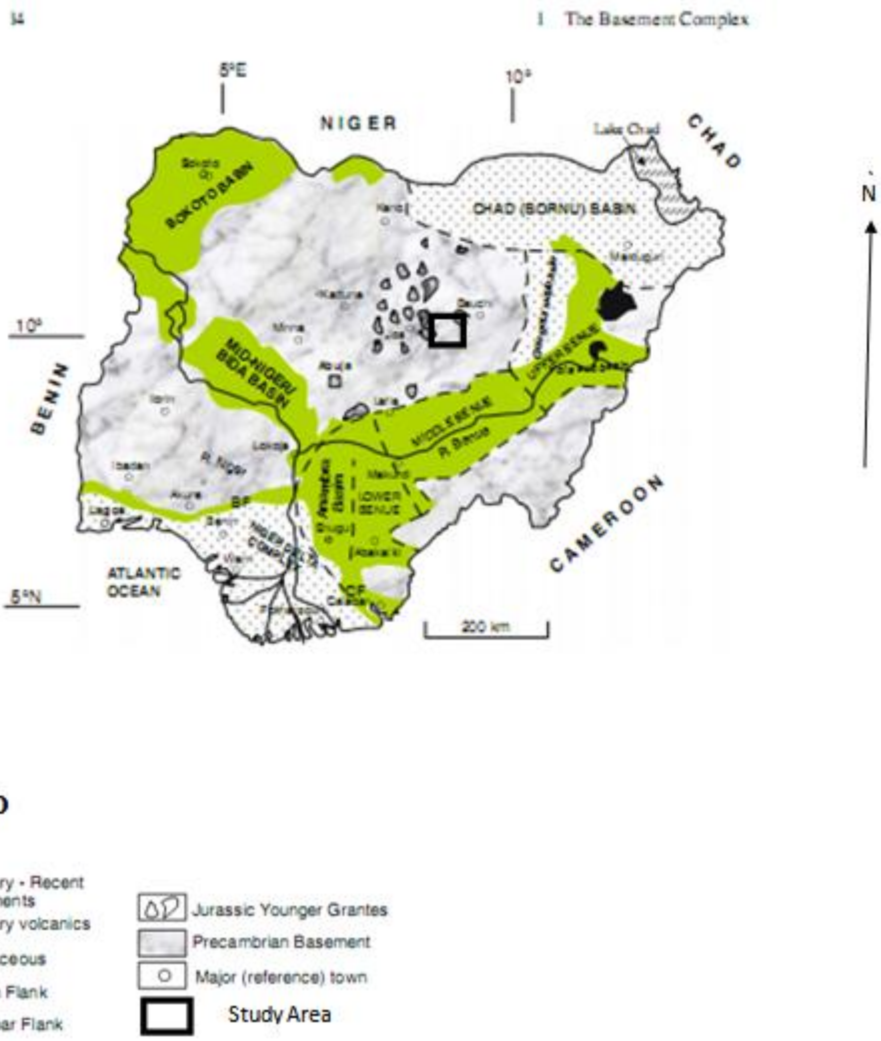

Fig.3. Location Map of the Study Area Modified After Geological Sketch Map of Nigeria Showing the Major Geological Components

Geology of the Study Area

The Geology of Nigeria is generally subdivided into three units. These are as follow:

(i) Basement complex
(ii) Volcanic rocks
(iii) Sedimentary basins

Carter *et al*. (1963) worked in northern Nigeria; They divided the basement complex rocks into three principal groups; the ancient meta –sediments, the Gniess- migmatites and the older granite. The ancient meta-sediments comprise rocks that are however transformed to migmatites and granites. The Gniess- migmatites complex is believed to be part of the basement complex Sensu-strito and account for about 30 - 50% of the Nigerian Precambrian complex.(Carter *et al.*, 1963).

The study area is situated around the Nigerian Basement complex comprising of crystalline rock. Oyawoye (1964) reported that the area consist of gneiss-migmatites, and the older granite (Fig.4). Jacobson *et al*. (1963) also reported that the rock found within the study area comprises of migmatites, granite – gniesses and older granite. This group of rock is believed to be as a result of remobilization during the pan- Africa.

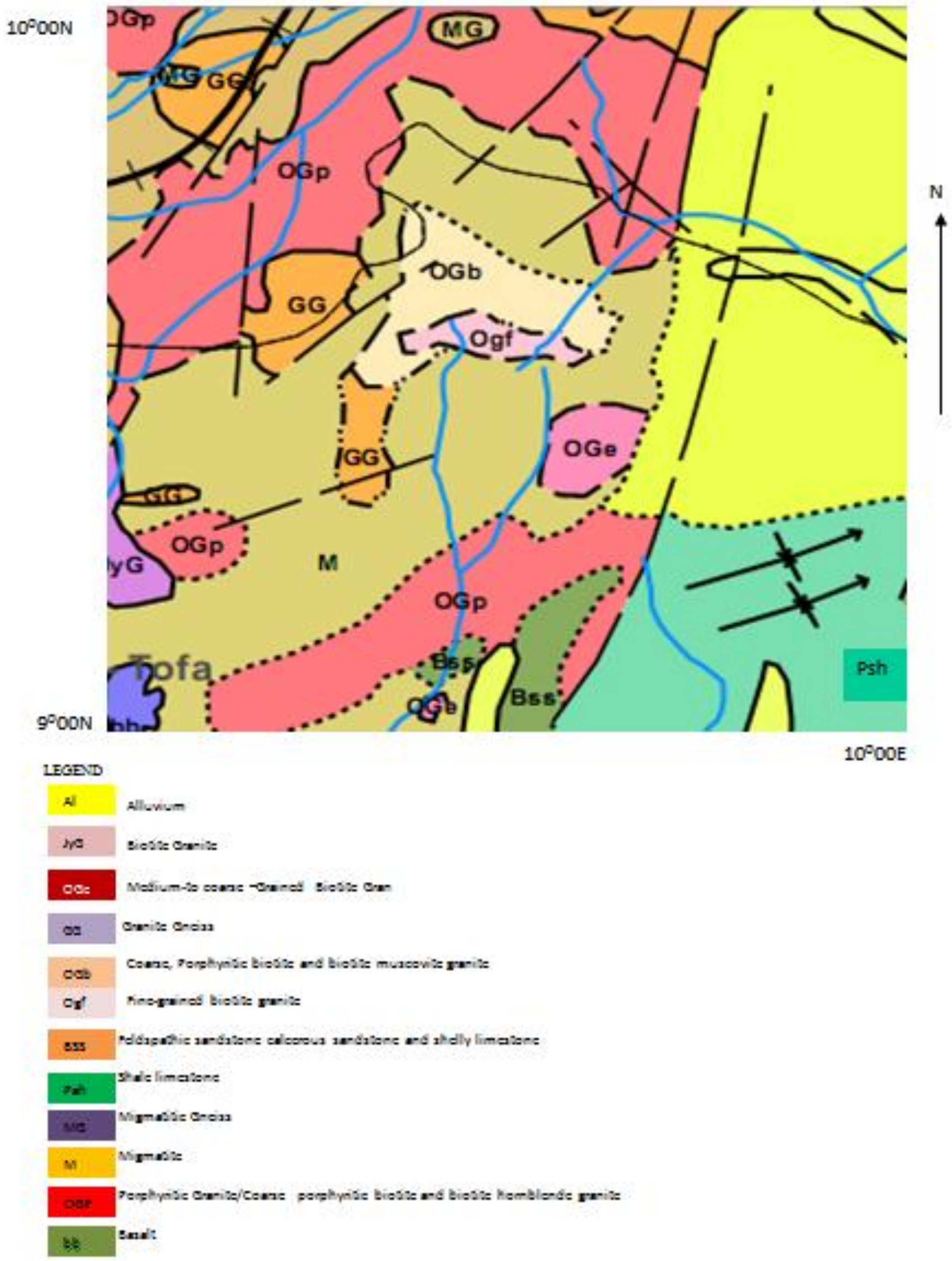

Fig.4 Geologic map of the study Area

Source of Magnetic Data

Magnetic surveying from an aircraft became possible with the development of stable airborne magnetometer used to detect submarines during World War II. The first airborne magnetic survey for geological purposes over land was completed in 1944(USGS 1997). Ship borne magnetic surveys of the ocean floor emerged in the 1950s and satellite magnetic surveys over much of the Earth's surface became available in the 1960s (USGS 1997).

In recent years, airborne magnetic surveying has played a very important role in several fields of earth sciences; examples include the search for mineral resources, seamount mapping and studies of geophysical oceanographic interest. Nigerians land mass has been covered by aeromagnetic surveys, to aid mapping and to indicate areas of potential mineral resources. The aeromagnetic data set used for this study was obtained from the Nigerian Geological Survey Agency (NGSA) as a part of nationwide aeromagnetic survey conducted from 1974 to 1976

The magnetic data were collected at a nominal flight altitude of 154.2m along approximately N-S flight line which is nearly perpendicular to the assumed geologic strike of the area and spaced 2km apart. The study area covers four x aeromagnetic maps published by the geological survey of Nigeria(GSN).

Second Vertical Derivative

The second vertical derivatives are the measure of curvature, and large curvature is associated with the shallow anomalies (Telford *et al.,* 1998)). The second vertical derivative is often used to enhance localized near- surface features, i.e. weak anomalies arising from the sources that are shallow and limited in depth and lateral extent. SVD is expressed as

SVD = (1)

The use of second vertical derivatives can be understood by noting the magnetic potential field, T which satisfies the Laplace`s equation

i.e.

(2)

(3)

Thus the second vertical derivative effect is a measure of curvature(the rate of change of non linear magnetic gradients. Since the magnetic anomalies due to shallow localized features have greater curvature than those due to broader regional deep sources, the former will enhance on second derivative map. In addition to enhancing weaker local anomalies, the second vertical derivative zero contour map can often be used to delineate the contact lithologies with contrasting susceptibilities.

SVD is obtained by transforming the residual values into frequency domain, using first Fourier transform (FFT) method, The (FFT) data is multiplied in the frequency domain, with the SVD filter ,, where K is the wave number and n is the order of the derivative, For SVD , n is two. Finally, the result obtained was inverse Fourier transformed back to the space domain.

Analytic Signal Method

The analytical signal method is very important to this research by which it suggests the location of magnetic source is coming from. Analytical Signal Method: (Nabighian1972, 1974) developed the concept of two dimensional analytical signal, or energy envelope of magnetic anomalies. Roest*et al.* (1992) Showed that the amplitude of the three dimensional analytical signal at location (x,y,z) can be expressed as

(4)

Where is the amplitude of the analytic signal at(x,y,) and T is observed total magnetic field at(x,y,)

The greatest advantage of the analytic signal method is that its amplitude is independent of magnetization direction and hence can be used in low latitude regions without the need to apply the reduction for equator filter.

The derivative along x,yorthogonal directions were estimated in space domain, using finite difference method (Blakely,1996) while the FVD was obtained as earlier described Finally the Analytic Signal Amplitude (ASA) were estimated using equation (4)

II. Discussion

Second Vertical Derivative (SVD) Map

The second vertical derivative (SVD) map indicates the existence of several anomalies in the subsurface. The anomalies are shown by the curvatures in Figure 5. To correlate SVD with geologic map, The SVD zero contour mapwas superimposedon the geologic map of the study area shown in Figure 6. The high density of contours at SE and NE parts of the study area, correspond to Quartz feldspathic granulite and gneiss and also migmatiticGneiss complex respectively. A small closure at the North-central**A**conside with the presence of Syenite, Quartz and Gabbro. Two other closures at the North-central below the above mentioned correspond with the presence of Biotite Granite. Also high densities of contour lines at the NNW correspond with the presence of medium to course – Grained Biotite granite. The NE-SW and E-W trend of the anomalies in the image map of the SVD superimposed on geologic map also correlated with the trend of the geologic map.

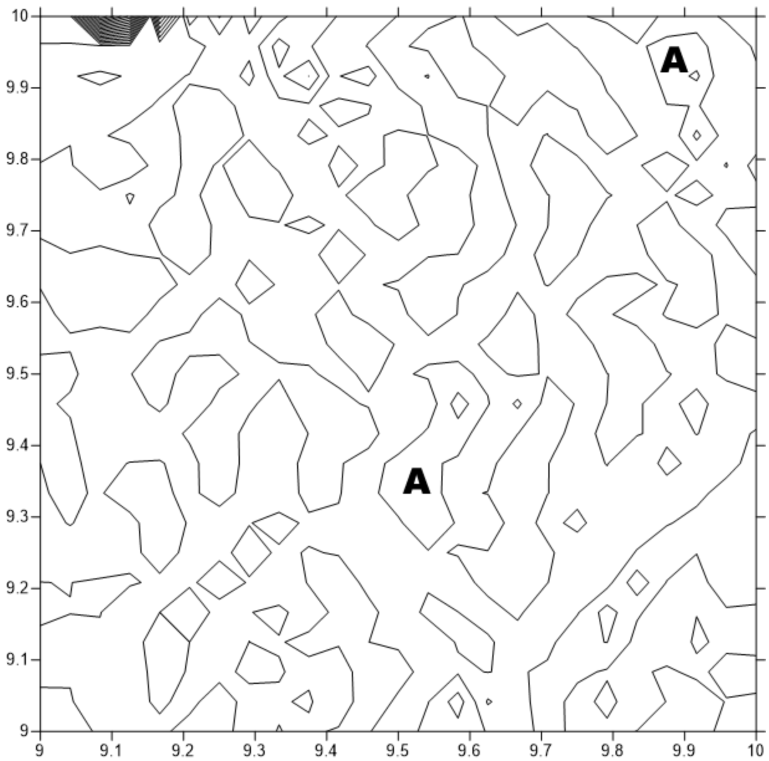

Fig.5 Second vertical derivative (SVD) contour map indicates the curvature of the anomal

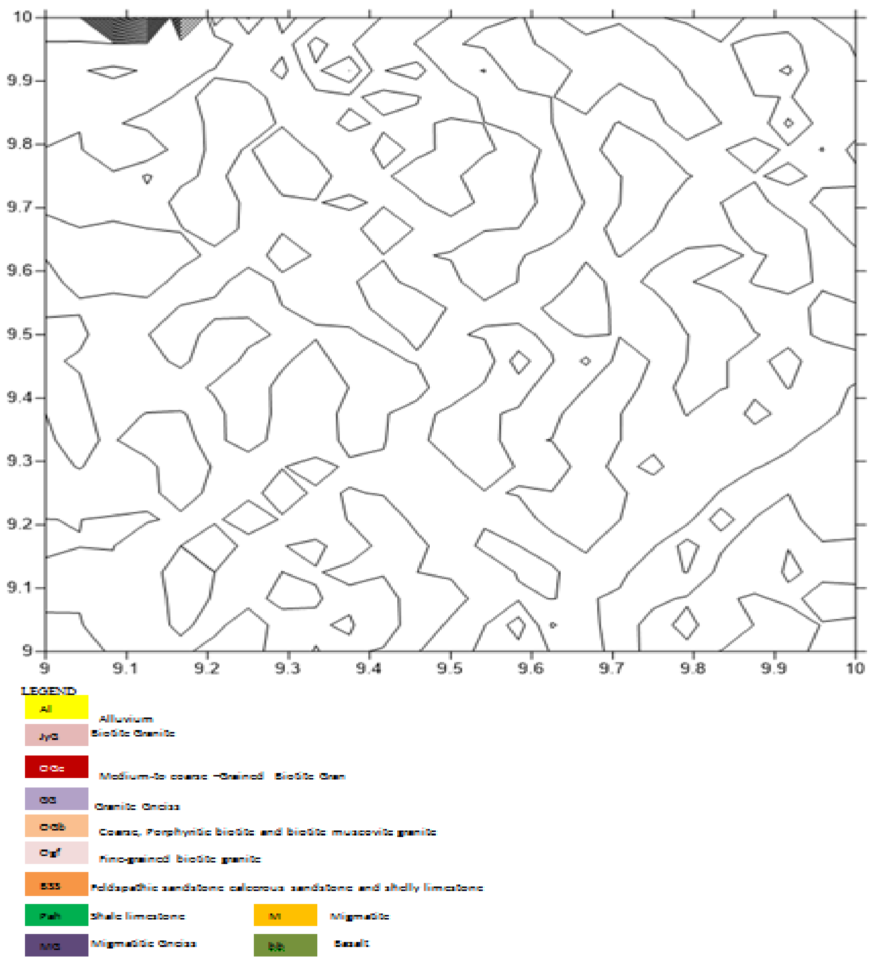

Fig. 6 Superposition of Second Vertical Derivative on Geologic Map

Analytic Signal Amplitude (ASA) Map

The analytical signal amplitude (ASA) map (Figure 7) was produced with Geosoft Oasis Montaj software. The result was correlated with the surface geology. These regions with different magnetization content weredistinguished on the basis of the variations in color of the anomalies, which reflect the variation of magnetic content. The western part of the study area is predominantly correlated with high magnetic content while the eastern part is predominantly correlated with low magnetic content, except at its lower part where high magnetic was noted.

Furthermore, the comparison between the analytic signal amplitude (ASA) map and geologic map of the study area reveal some correlations. Notably the high magnetization contrasts in NW part correlate with that area. Also the high magnetization contrast in SW part of the area correlates with granite, Migmatites and granite – biotite complex in that area. However the NE part observed to be the predominant low magnetization contrast, which indicates that the basement rocks in that area might have lost their magnetization due to heat associated with emplacement of the younger series of the rocks which destroyed their ferromagnetic content.

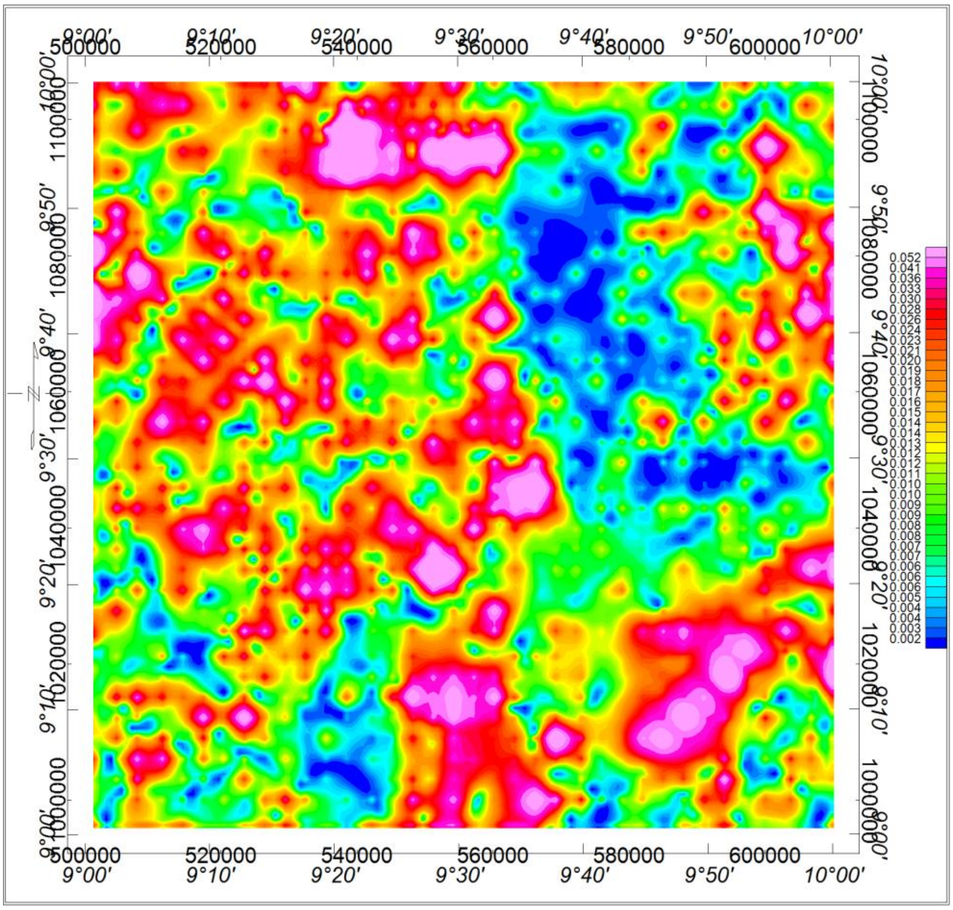

Figure 7 Analytic signal amplitude map of the study Area.

III. Conclusion

The main conclusion that can be drawn from the results obtained in this research are itemized as follows

(1) The rocks in the NW and SW parts are associated with high ferromagnetic content and could be best sites for mineralization with faults as structural traps.

(2) Some of the rocks in the area have probably lost their magnetizations.

IV. Recommendations

The Assessment contributed to the better understanding the region of higher magnetic contrast, which shows the possibility for potential minerals recourses to explore. However, for further studies in the area the following suggestions are recommended

(1) The estimation of depth to magnetic sources along, curie point depth (CPD)

(2) Newly acquired high resolution aeromagnetic (HRAM) data to further analyze the economic potentials of the area.

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