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Analysis of Lineaments Pattern over Azare and Its Adjoining Area using Aeromagnetic Data

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Abstract

Aeromagnetic data over Azare and its adjoining areas were obtained and analysed for assessing the mineral potential of the area. The data were analyzed using polar plot technique which showed the presence of subsurface lineaments trending predominantly along NE-SW, WNW-ESE and NNE-SSW direction with minor trends along NW-SE and N-S directions. Comparison between these lineaments and the surface lineaments suggested that the majority of surface lineaments were structurally controlled. The research conducted evaluates the economic minerals potential of the study area which is highly encouraged as the economy of the country need to be diversified.

Keywords: Aeromagnetic Data, Lineaments, Pattern, Polar Plots.

Introduction

Aeromagnetic Studies

Aeromagnetic surveys are widely used to aid in the production of geological maps and are also commonly used during mineral exploration. Some mineral deposits are associated with an increase or decrease in the abundance of magnetic mineral and occasionally the sought after commodity may itself be magnetic (e.g. iron ore deposits), but often the

elucidation of the subsurface structure of the upper crust is the most valuable contribution of the aeromagnetic data.

Aims and Objectives

This research is aimed at the interpretation of the aeromagnetic field data over the study area in the following objectives.

1. To determine the trend of the major features in the study area.
2. To delineate the possible mineralization zones in the area

Justification of the Study

The study would generate and upgrade the existing geophysical database of the study area. The study area is within the younger granite province area, where important minerals bearing rocks such as basalts, and Gabboro are present. The structural lineaments (fractures, faults, shear, zones and veins) usually serve as potential hosts for minerals or migration paths for ground water. Thus the assessment of the minerals potentiality of the area is justified as it succeeds it will contribute in the enhancing the economy of the area and country in general.

Geology of the Study Area

It is generally not possible to make a meaningful interpretation of the hydrogeological petrophysical aspects of an area without having first examined the geological framework. Different rock formations exist within the study area. Each formation generally has different petrophysical properties, which will give different capabilities to store and transmit a fluid (in this case water). On top of differences in lithological units, the capacity to store and transmit fluid is further modified by the geological history and structural development of the area. Thus, this will discuss the various rock formations, their distribution and the structural pattern, which controls much of the hydrogeological characteristics of the area. B.S.A.D.P (1983) and Udo (1981) ascertained that Bauchi state is divided into basement complex and tertiary sedimentary environment (Kerri-Kerri and chad formation), which occurred at almost 50-50 (figure 2 and 3).

The geology of Bauchi state can be described in three main categories; Figure 2.

i. The Basement Complex

This complex, mainly of granitic rocks, outcrop over the western half of Bauchi state and is found beneath sedimentary rocks further east. The granite is often porphyritic and pegmatitic veining occurred widely. Granite gneisses and migmatities are commonly found, and an area of diorite was found at Dass. The basement complex is extensively fractured, some of the tectonic lines being traceable over great distances.

The complex, which is known collectively as the older granite, is of pre-Cambrian to Paleozoic age.

The Jos Plateau, which extend in to southwest Bauchi state contains a number of younger granite ring complexes, which are of Jurassic age (Carter, et al, 1963).

ii. Kerri - Kerri formation;

The formation is continental in origin and is generally considered to be Paleocene in age. It consist of a sequence of flat lying sediments made up of central Bauchi state, resting on both cretaceous and the basement complex. In the north of its outcrop the based member of formation is a conglomerate (Adegoke et al, 1978).

iii. Chad Formation;

This is a sequence of lacustrine and fluviatite sand and clays of Pleistocene age. It extends across the northern part of Bauchi state resting on both Kerri-Kerri and cretaceous sediments. It dips gently east toward the Chad basin.

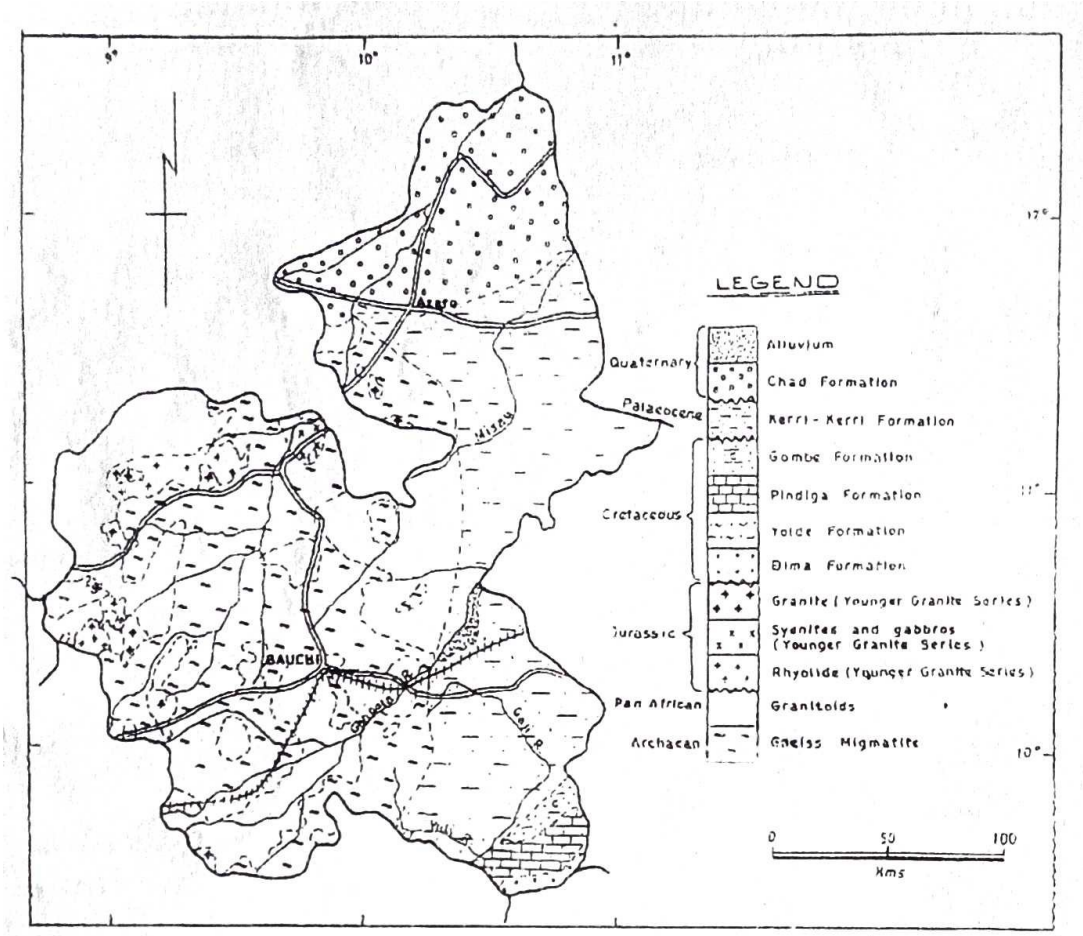


Figure 2 Map of Bauchi State Showing different rock types and drainage pattern (Source: B.A.S.D.P, Bauchi)

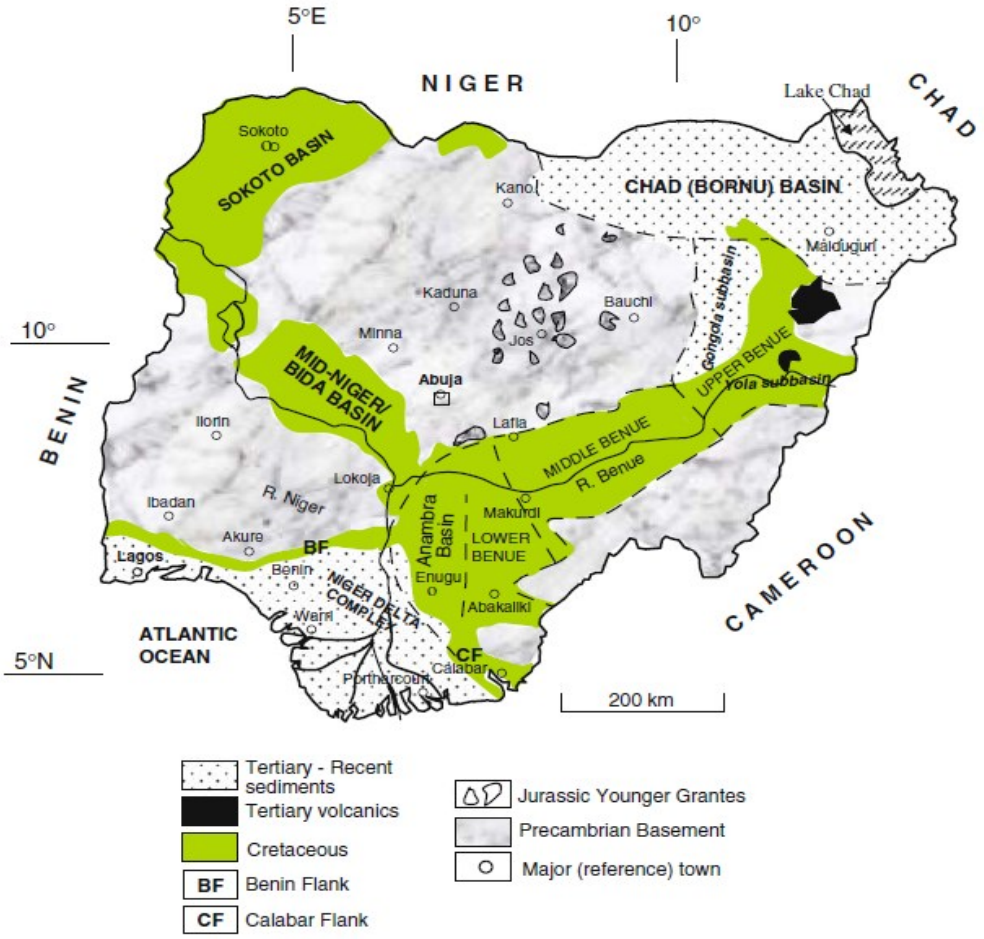


Figure 3 Geological map of Nigeria (Source: Obaje, 2009)

Location of the Study Area

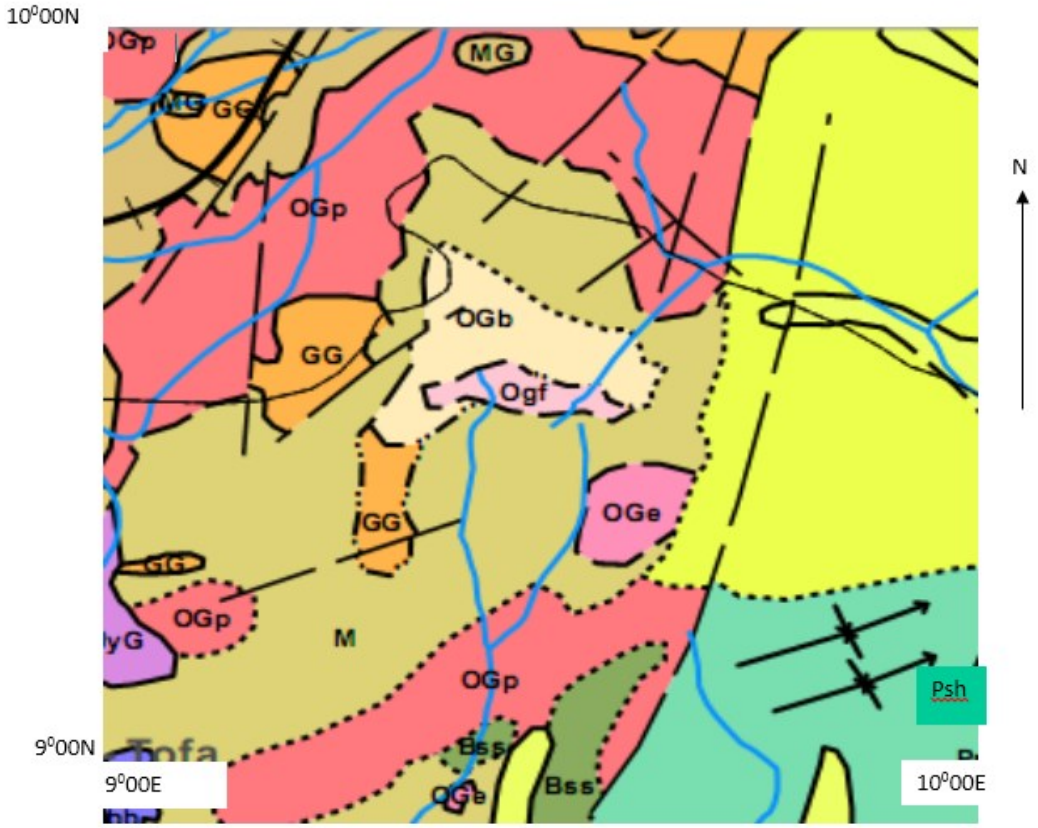
The study area is located between latitude 11.68^0N and longitude 10.19^0E of elevation 436m in the part of Bauchi state of Nigeria.

The local geology consists of sedimentary of tertiary sands of Kerri-Kerri formation, unconformably overlying the Precambrian to early paleozonic basement complex rocks. The kerri kerri formation is a continental sequence of Paleocene age (adegoke etal 1986) deposited under alluvial, fluvial and marginal lacustrine conditions (carfer etal 1963), DU preez and Barber, (1965). Lithologically the kerri kerri formation consist of fine, medium to coarse sandstone and sand, siltstone and silt, claystone and clay as well as ironstone. The sand are usually silly, clayey, occasionally micaceous and even pebbly in some localities. The top of the formation is intensely lateralized. The kerri kerri formation is said to represent molasse deposite following the late cretaceous folding phase that affected the upper Benue through (Benkhelt, 1989). It is known to be 320m metres thick, (Dike 1990). In Azare area, the basement rocks are

encountered at shallow depth uncomfortably underlying the kerri-kerri formation (Dike and Dan Hassan, (1990)

Review of Geophysics Literature

The historical development of geophysics has been motivated by two factors. One of these is the research curiosity of humankind related to Planet Earth and its several components, its events and its problems. The second one is economical usage of Earth resources (ore deposits, petroleum, water resources, etc.) and Earth-related hazards such as earthquakes, volcanoes, tsunamis, tides, and floods. The magnetic method is one of the best geophysical techniques used for determining depth to magnetic source bodies (and possibly sediment thickness) and delineating subsurface structures. Large-scale aeromagnetic surveys have been used to locate faults, shear zones and fractures. Such zones may serve as potential hosts for a variety of minerals and may be used as guidance for exploration of the epigenetic, stress-related mineralization in the surrounding rocks (Paterson and Reeves, 1985). Sediment thickness required for hydrocarbons (oil and/gas) to form or be generated varies from place to place. The minimum sediment thickness required for producing oil usually varies from 2km to 4km,



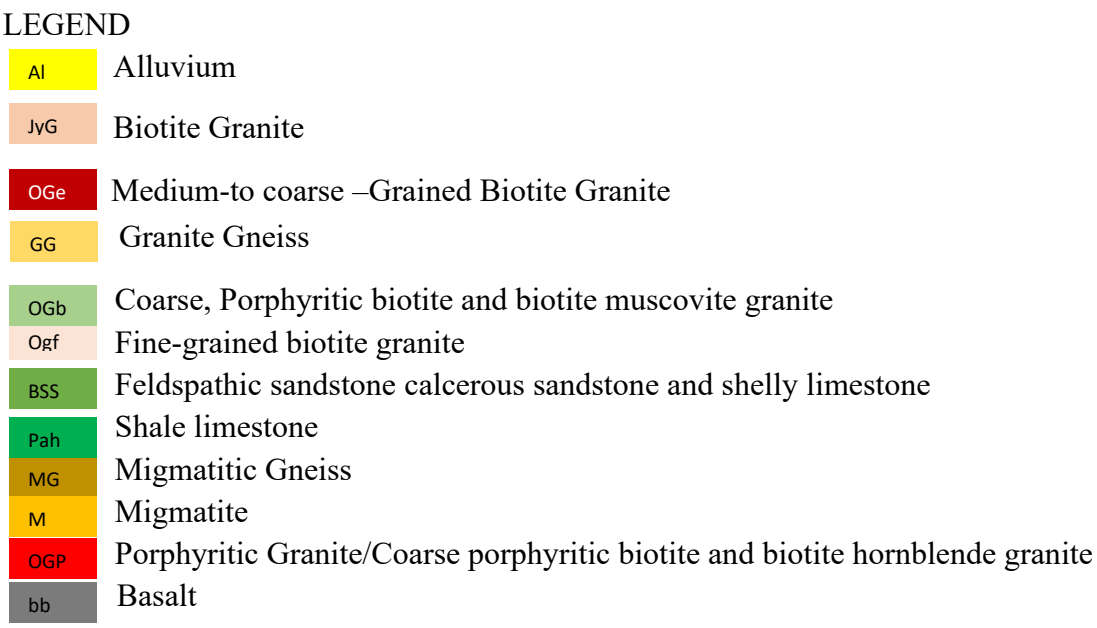


Figure 4 Geologic map of the study Area

MATERIALS AND METHODS

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 1950 s and satellite magnetic surveys over much of the Earth's surface became available in the 1960 s (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

Compilation of Magnetic Data

Aeromagnetic data are geophysical data acquired from aircraft that measure the subtle variations in the earth's magnetic field due to differences in the magnetic properties of the underlying rocks. Although aeromagnetic data are insensitive to the presence of water, differing magnetic properties of certain rock types can be detected and used to

infer many aspects of the subsurface geology that control the presence, quality, and flow of ground water. Knowledge of the magnetic properties as well as volume and depth of rock bodies are important for understanding the geological sources of aeromagnetic anomalies.

Production of Total Magnetic Intensity, TMI Map

The four aeromagnetic sheets covering the study area were manually digitized at a regular grid spacing 3 km to recover TMI values. The gridded data were then digitally merged to obtain a composite data set of 37 x 37 grid values. The grid interval was found to be adequate for analyzing crustal magnetic anomalies (Udensi *et al*., 2003) The digitized TMI values were imported into the Surfer 8 and Oasis montaj softwares and gridded, using the minimum Curvature method and subsequently colour shaded to produce contour colour aggregate of TMI map. Estimate residual values were used to produce contour and colour shaded maps as earlier described.

Rose Diagrams

Rose diagram sometimes called polar plot which is used in testing the lineaments distribution via direction. Directional analyses of both major and minor orientation of lineament trends are presented on bidirectional diagrams (i.e. rose diagrams or polar plots). The trend direction of the rose diagrams data are organized in class intervals of 15^0. Each class represents the number of occurrences of event that fall within the specified angular region. A family of concentric circles provides scaled control for the number of fracture orientation observations that occupy each class interval. The number of points from the selected data column controlled the bar length within each class interval.

RESULTS AND DISCUSSION

Qualitative Interpretation of Total Magnetic Intensity (TMI) Maps

The colour shaded TMI map Presented in Figure 5 .The variation of the TMI values over the study area. The red and pink portions represent areas associated with strong positive anomalies, suggesting higher concentration of magnetic materials. (e,g magnetite).such areas cover almost the entire NE part of the study area ,and the lower parts of the SE and SW parts of the study area. The TMI values associated with these green vary from 32896 nT to 32942 nT. Similarly, areas with broad magnetic lows, interpreted as areas of low magnetic concentration, and therefore lower susceptibility were represented by blue colour. Such areas cover almost the entire NE part of the study area. Whereas the pale green and yellow colours represent areas of intermediate magnetic field intensity value between 32893 nT – 32892 nT, The magnetic anomaly of magnitude from 32760.0 nT to 32860.0 nT appears to be very dominant and may

likely contain outcrops of crystalline igneous or metamorphic rocks, deep seated volcanic rocks or even crustal boundaries' to be conspicuous in the west, northwest, southwest, south and north-eastern parts of the study area. Closely followed by these in spread are those anomalies ranging between 32700 nT and 32800 nT in magnitude. These are only prominent at the central part of the study area with little traces of it in the northeast, southwest and northwest. Found almost in small quantity are anomalies of very high magnetic intensity value between 32900 nT and 33000 nT which are observed the north and south-eastern parts of the study area. Also found in small quantity in the area are the anomalies between 32600 nT and 32700 nT noticed in the southeast and northeast of the area. Summarily, the TMI map of the area revealed that the area is magnetically heterogeneous. Areas of very strong magnetic values (32760 nT to 32860 nT) may likely contain outcrops of crystalline igneous or metamorphic rocks

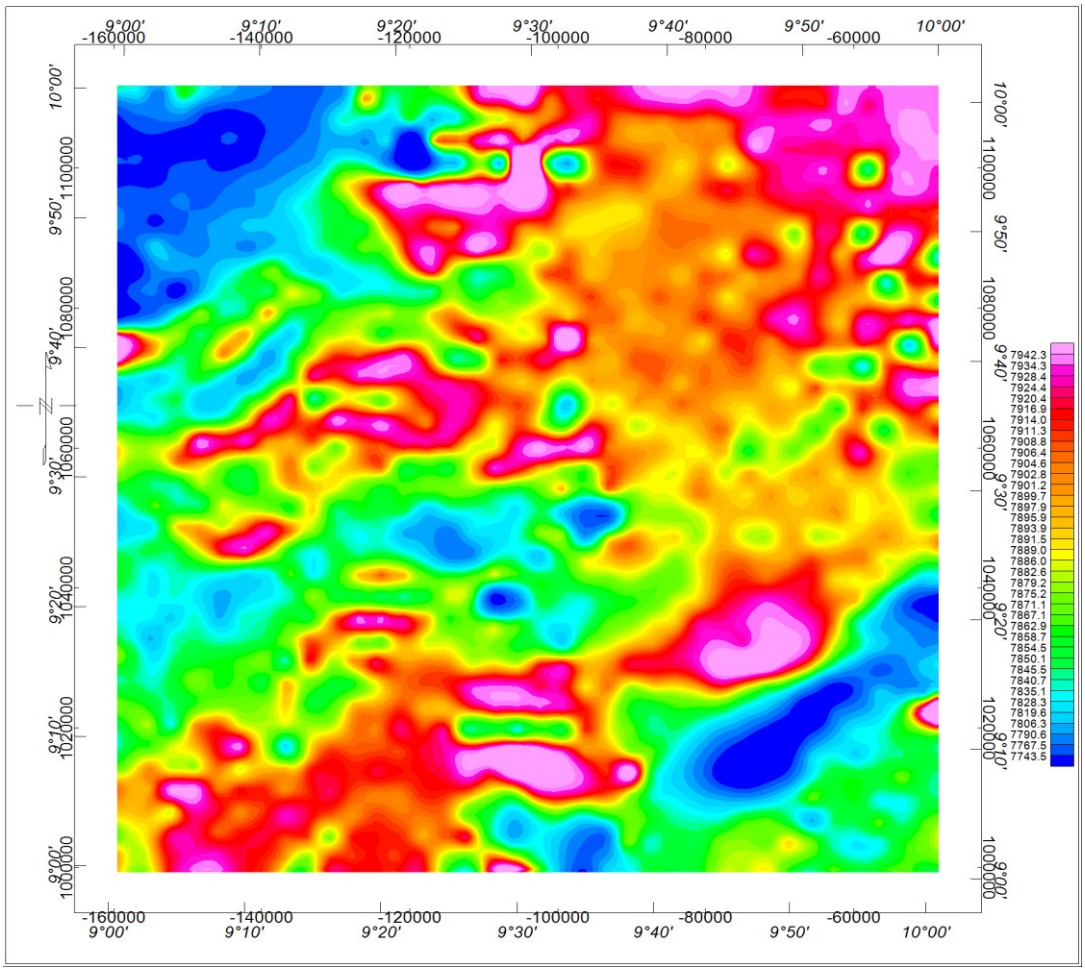


Figure 5a: Total magnetic field intensity (TMI). To obtain the total TMI values, 25,000 nT should be added.

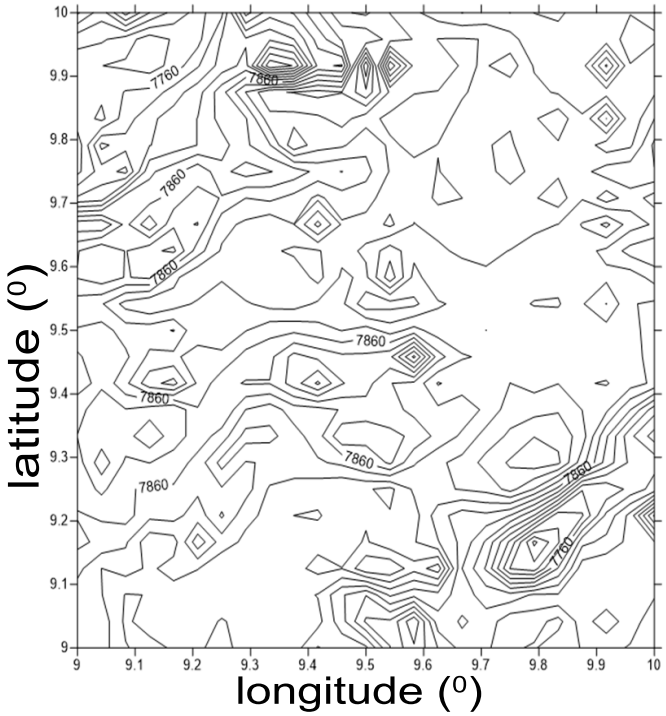


Figure 5b : Total Magnetic Intensity Contour Map of the Study Area (Contour Interval is 20 nT) .To obtain the total TMI values, 25,000 nT should be added

Discontinuities

The discontinuities are indicated by long parallel set of contours and they signify the existence of lineaments- faults. The Magnetic discontinuities normally represent magnetic lineaments which are related to fracture zones. The lineaments represent pre-existing zones of weakness in the pan African crust. The discontinuities of the study area were observed in TMI map of the study area (Fig. 6), which shows two romanche chains noticed to have passed through the study area in NW and SE directions.

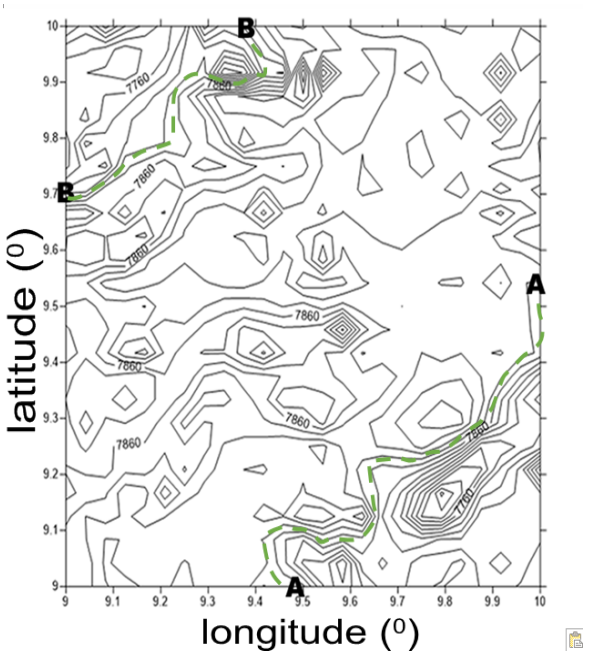


Figure 6. TMI Contour Map Indicating Discontinueties (Contour Interval is 20 nT). To Obtain the Actual Values, 25000 nT Should be Added

Polar Plots (Rose Diagrams)

To quantitatively analyse the trends of the lineaments, arose diagram (i.e. polar plot) was employed, using Grapher (version 8.0) software. As can be seen from the plot the lineaments are oriented along E-W, NE-SW, WNW – ESE, NW – SE, and ENE - WSW in decreasing order of predominance. The major trends are E-W and NE-SW while the minor trends are WNW – ESE, NW – SE and ENE - WSW, (Fig.4.15). Almost all of the trends were earlier delineated except SSW and SSE which

indicated that they reflect hitherto unmapped structures in the study area. The NE – SW and ENE –WSW trends correlate with the general trend of the Benue trough (Ajakaiye *et al.,* 1986) and the WNW – ESE trends correlates with the Yola arm of the upper Benue trough. (Anudu *et al.,* 2014)

However to infer structural control of the surface lineaments by the subsurface (magnetic) lineaments, the rose diagram of the surface lineaments was plotted. The result shows that the surface lineaments were oriented along NE-SW, WNW-ESE, WNE-SSW, NW-SE, and N-S in decreasing order of predominance. Among these trends the NE-SW, WNW- ESE, and the NNE-SSW were the major trends while the NW-SE and N-S were the minor trends. Comparison between the subsurface (magnetic) and the surface (geologic) lineaments trends shows that the NE –SW, WNW – ESE and the NW -SE are common trends between them, thereby, suggesting that these surface trends were structurally controlled by the subsurface lineaments. However, the E-W and ENE- WSW surface trends were not reflected among the subsurface lineaments which suggested that these surface lineaments were devoid by magnetic lineaments and were not structurally controlled. It may be plausible to suggest that they were developed in response to the stress associated with the development of the surface lineaments.

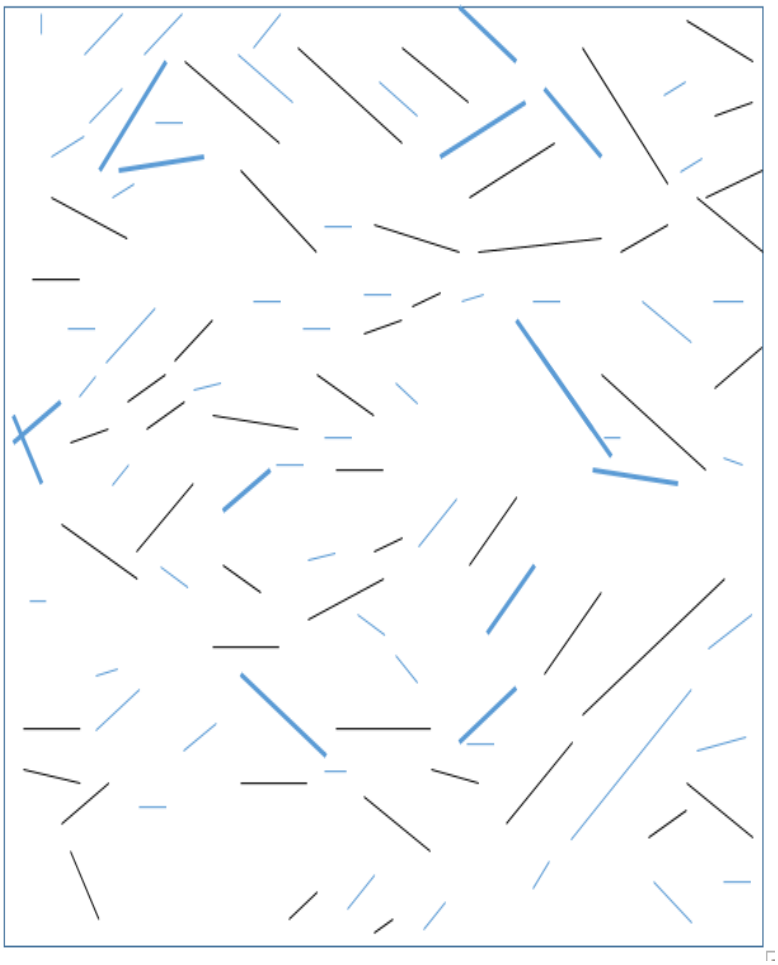


Figure 7 . Magnetic Lineament Map of the study Area

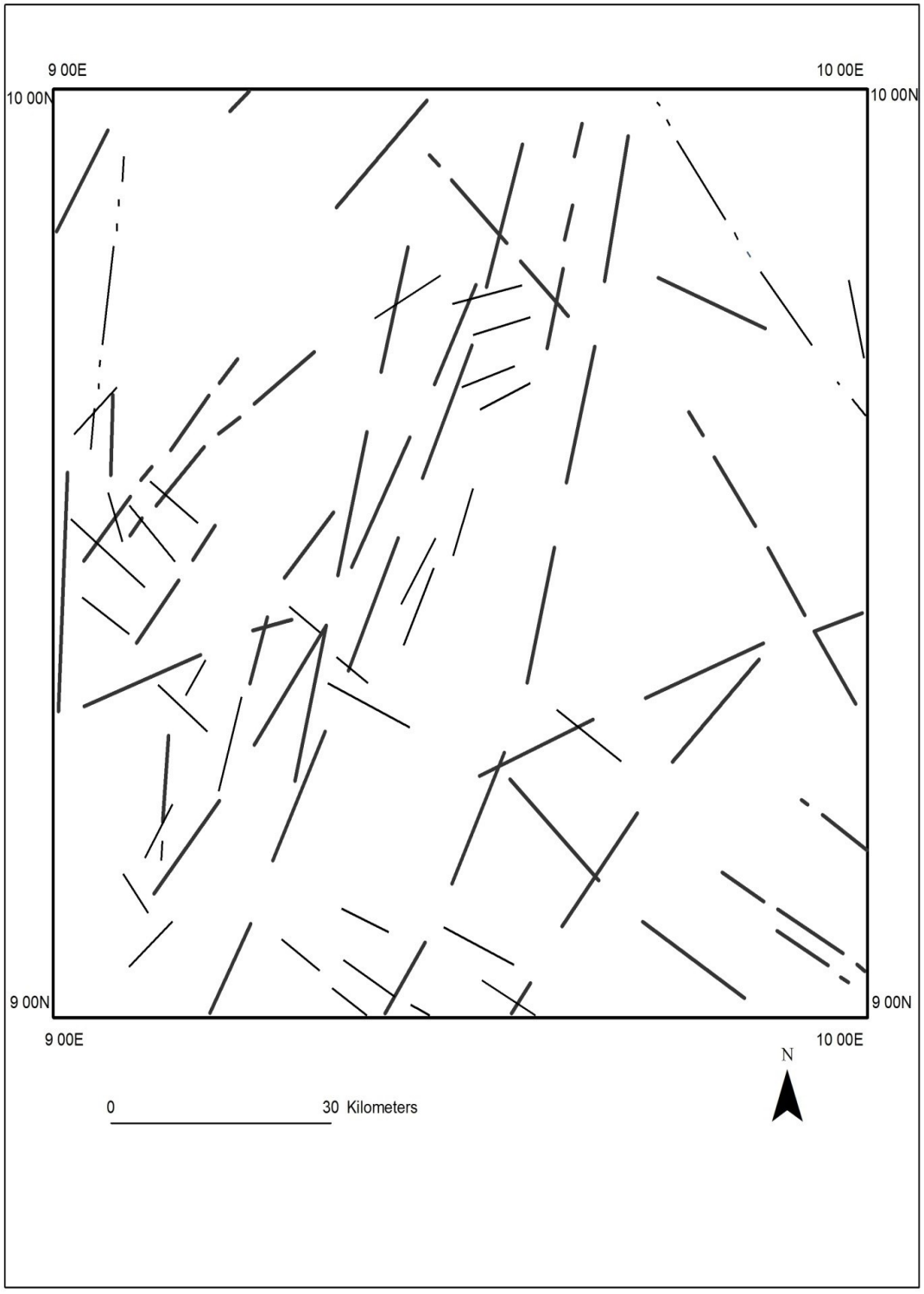


Figure 8. Surface Lineament map of the study Area

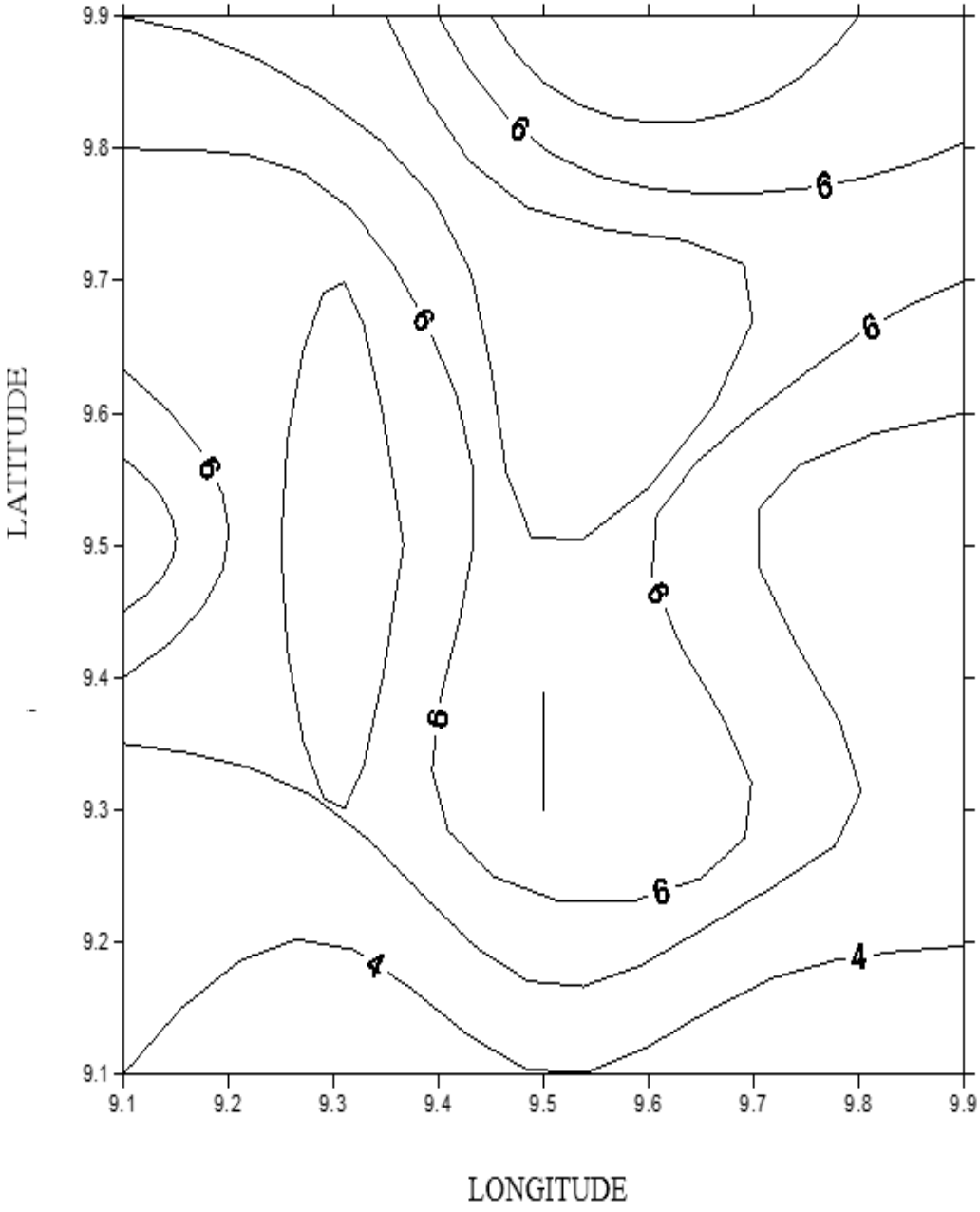
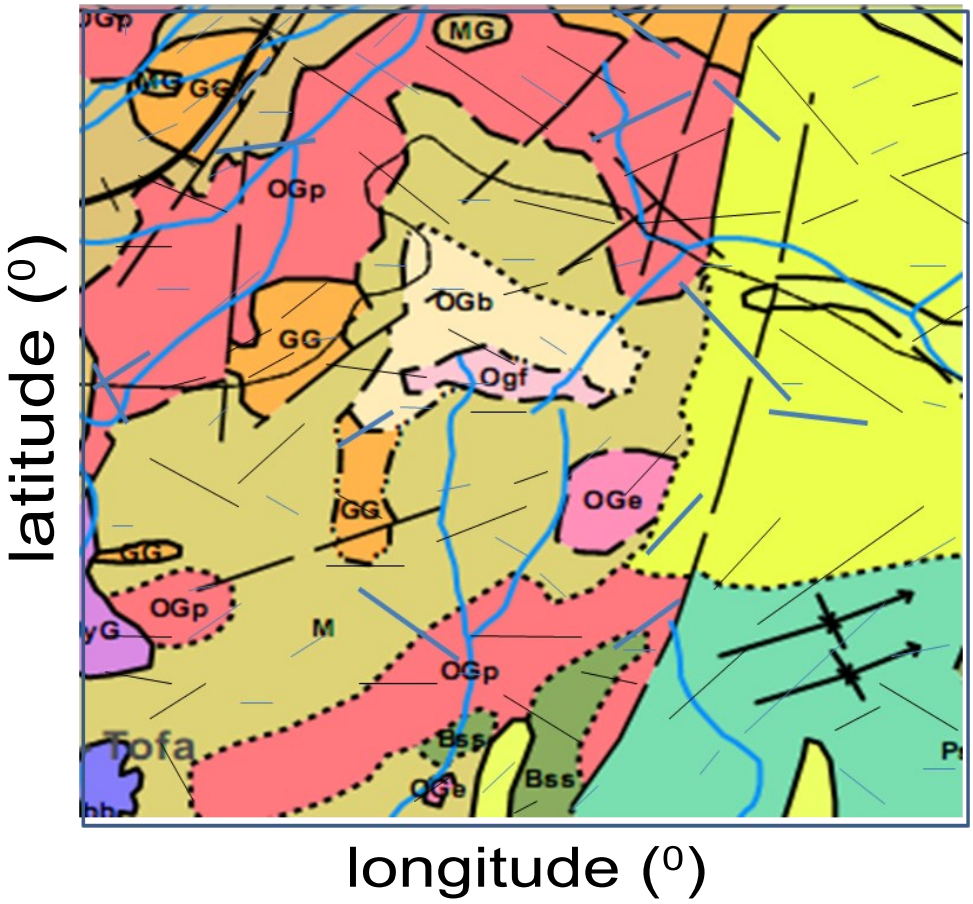


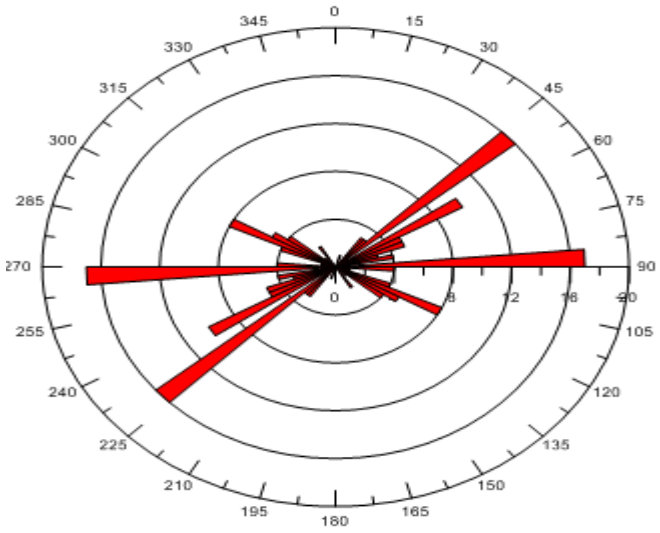
Figure 9. Lineament density map of the study area (Contour interval is 1) for magnetic lineaments



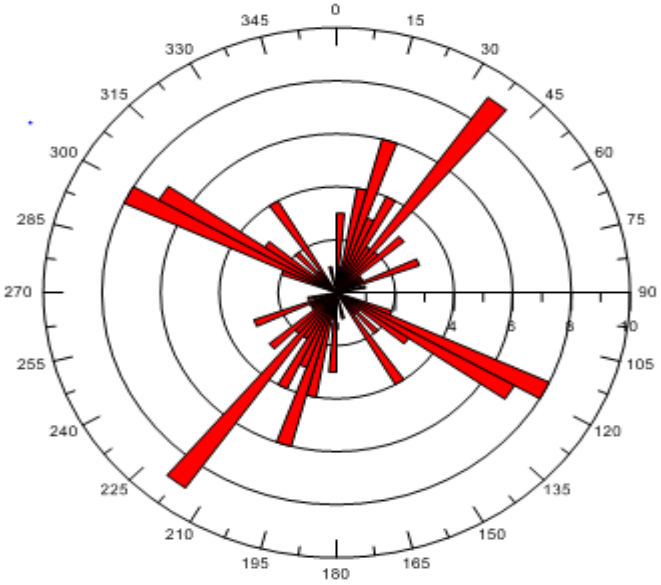
LEGEND

Al	Alluvium
JyG	Biotite Granite
OGe	Medium-to coarse –Grained Biotite Granite
GG	Granite Gneiss
OGb	Coarse, Porphyritic biotite and biotite mus
Ogf	Fine-grained biotite granite
BSS	Feldspathic sandstone calcerous sandstone and shelly limestone
Pah	Shale limestone
MG	Migmatitic Gneiss
M	Migmatite
OGP	Porphyritic Granite/Coarse porphyritic biotite and biotite hornblende granite
bb	Basalt

Figure 9. Superposition of Aeromagnetic Lineaments on Geologic Map



Rose diagram for lineaments Produced from Aeromagnetic Data of the study Area



Surface Lineament Rose diagram for the study Area

Figs. 10&11 Frequency Rose diagram for both Aeromagnetic and Surface lineament of the study Area

SUMMARY CONCLUSION AND RECOMMENDATIONS

Summary

The research conducted evaluates the economic minerals potential of the study area which is highly encouraged as the economy of the country need to be diversified. The

aim of this study mentioned earlier was to determine the trend of the major features, delineate the mineralization zone in the study area

Four aeromagnetic maps were acquired and subjected to data processing and analysis via different methods. The methods applied include polar plots (i.e. Rose diagram) and discontinuity. Super positioning of both TMI contour map of the study area and the surface geology map showed that the basement rocks were structurally controlled. The result obtained from analytic signal analysis highlighted the areas associated high magnetic content which could be favorable for mineralization.

Conclusion

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

(1) The basement of the area is segment by faults oriented along different directions. The major faults were oriented along NE –SW, WNW –ESE, WNE-SSW directions While the minor faults were oriented along NW – SE , N – S directions

(2) The predominant surface faults were structurally controlled by the subsurface faults.

(3) 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.

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

Recommendations

The Analysis of Lineaments pattern over Azare and environs (i.e. study area), 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

- The estimation of depth to magnetic sources along, curie point depth (CPD)
- Newly acquired high resolution aeromagnetic (HRAM) data to further analyze the economic potentials of the area.

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