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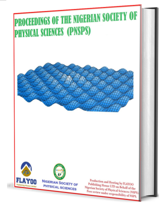

Delineation of structural features and hydrothermal alteration zones using integrated geophysical data of part of North-central Nigeria

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ABSTRACT

Delination of possible structural features in part of Nigeria Northcentral region has been performed using high-resolution aeromagnetic and aero radiometric data. The objectives of this work are to identify and harness the factors responsible for alteration zones which can serve as a potential mineralized sources for exploration purpose in the area. To achieve this purpose, mathematical techniques such as First Vertical Derivative, Analytic Signal, and Centre for Exploration Targeting (CET) grid were performed on the aeromagnetic data analysis and interpretation; in addition, ratios of radioelements were obtained to support the mapping process. The results obtained showed that the area is dominated by structures trending Northeast-Southwest, Northwest, Northeast, Eastwest and Northsouth directions, although the structures trending Northeast-Southwest were found to be most predominant and considered as orientations of mineral deposits in the area. Also, aero radiometric analysis based on the concentrations of Potassium, Uranium, Thorium and their ratios revealed lithological units and hydrothermal alterations of the area. However, this study concluded by identifying and harnessing the factors responsible for alteration zones which can serve as a potential mineralized sources for exploration purpose in the area.

Keywords: Structural features, aeromagnetic data, aero radiometric data, lineaments, RHP, CET.

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1. INTRODUCTION

Airborne magnetic data has been used widely in the search for subsurface information which signals as anomalies that can be found within the field of the earth's magnet resulting from the properties of susceptibility disparity of the fundamental rocks [1]. The applications of magnetic technique are not limited to investigations of geothermal and hydrocarbon signatures [2] but has been used in detections of sources of hidden ores in the investigation of minerals [3] and reconnaissance survey for studying of joints, veins etc. [4]. One of the objectives of interpreting aeromagnetic data is to determine the depth to the top of the source magnetics which is equal to the thickness of the sediment when considering an inland basin and the most significant is detection of source magnetics that can be because of source intrusive in the underlying rocks. The intrusive displays more properties of

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magnetics than the underlying lava flow [5]. Lawal *et al.* [6] reported that intrusive rocks reveal high magnetic intensities because of the existence of strong magnetic mineral contents and that higher wave number magnetic anomaly are characterised by low intrusions which is as a result of igneous rock while low wave number anomalies are associated with intrusions covered by thick basins. The mineral potential in the Northcentral region is made up of abundance of rocks which house metallic, non-metallic minerals, rare metals etc. Some of the rocks include quartzite, amphibolites schist, and quartz schist. Their economic importance cannot be over emphasized. Therefore, this paper is focused on updating the existing information on the structural information of the area using high-resolution aeromagnetic and aero radiometric data.

2. GEOLOGY OF THE STUDY AREA

The study area is found in the basement complex of Nigeria with three major lithologies. These lithologies are migmatite-gneiss complex, the syntectonic to late tectonic granitic rocks and the low-grade sediments- dominated Schists. These lithologies make up the geology of Nigeria. Obaje [7] observed that the study area makes up part of the Pan-african mobile belt and lies between the West Africa and Congo cratons: this complex is made up of four lithologies. They are migmatite – gneiss complex, the Schist Belt which comprise of metasedimentary and metavolcanic rocks, phylites, schists, pelites, quartzites, marbles, amphibolites, the Older Granites that consists of pan african granitoids granites, granodiorites, syenites, monzonites, gabbro, charnockites and lastly undeformed acid and basic dykes which has muscovite-, tourmaline- and beryl-bearing pegmatites, applites and syenite dykes; basaltic, doleritic and lampropyric dykes respectively [6]. Fatoyinbo et al. [8] reported that from the lithological units mentioned, the area of study lies within the migmatite-gneiss complex and the schist belt of the southern basement complex with variations in lithology (Figure 1). In term of landmass, the area is made up of 55 km by 55 km with an elevation which ranges from < 258.44 m in the valleys to > 590 m on the hills as revealed in Figure 2. The lowest value occupies (light blue to dark blue in colour) North and South-western part of the area and highest values (green to magenta in colour) are found in the North and South-eastern part of the area. The topography in the area is generally hilly and consists of ridges of gravel, lateritic soil, alluvial soil, clay, sandy clay, and top-soil and low-lying outcrops at the lowland area. Climatically, the area is marked with two distinct conditions, namely, rainy season which start from March to mid-November with an average temperature of 34° which depends on the pattern of rainfall in the year and the dry season, which is characterized by the dryness, dusty Harmattan wind that blows off the Sahara Desert.

3. ACQUISITION OF DATA

The airborne magnetic and radiometric data (Figures 3 and 4) used in this research work were acquired from the Nigeria Geological Survey Agency (NGSA). NGSA acquired the data via an air plane flown at a height of 80 m with 500 m line spacing, 80 m mean terrain clearance and the tie line spacing of 500 m. Correction such regional correction via the IGRF 2010 was isolated from the data. Also, RTE correction was executed on the magnetic data so that the crests of total magnetic anomalies due to subsurface are shifted from directly over the source and the anomalies becomes highly asymmetric [6], On the other hand aeroradimetric data which comprises of Potassium (K), Thorium

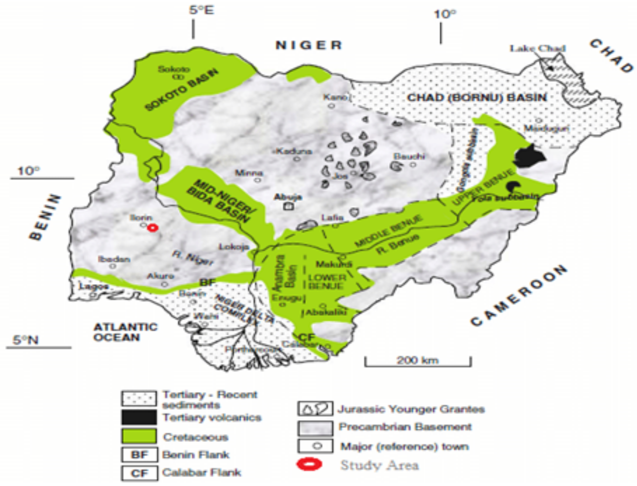

Figure 1. Location and geological map of study area [7].

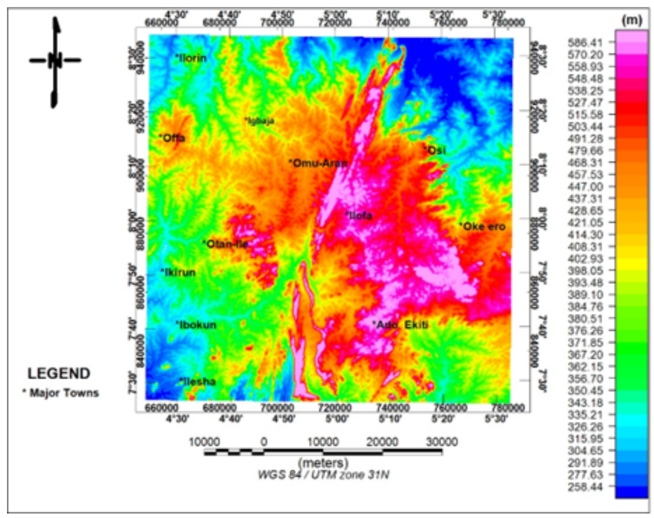

Figure 2. SRTM elevation model of the area.

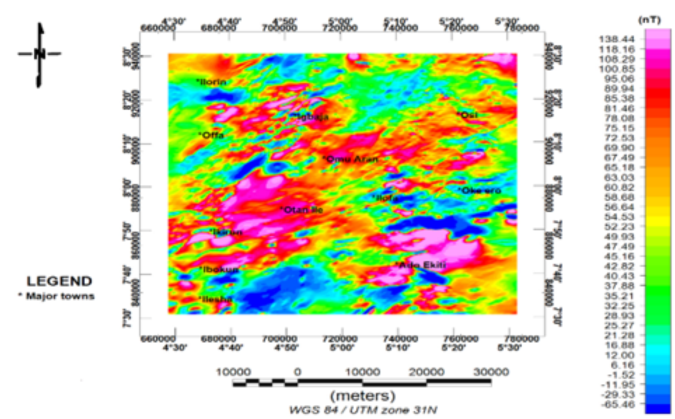

Figure 3. Aeromagnetic map of the study area.

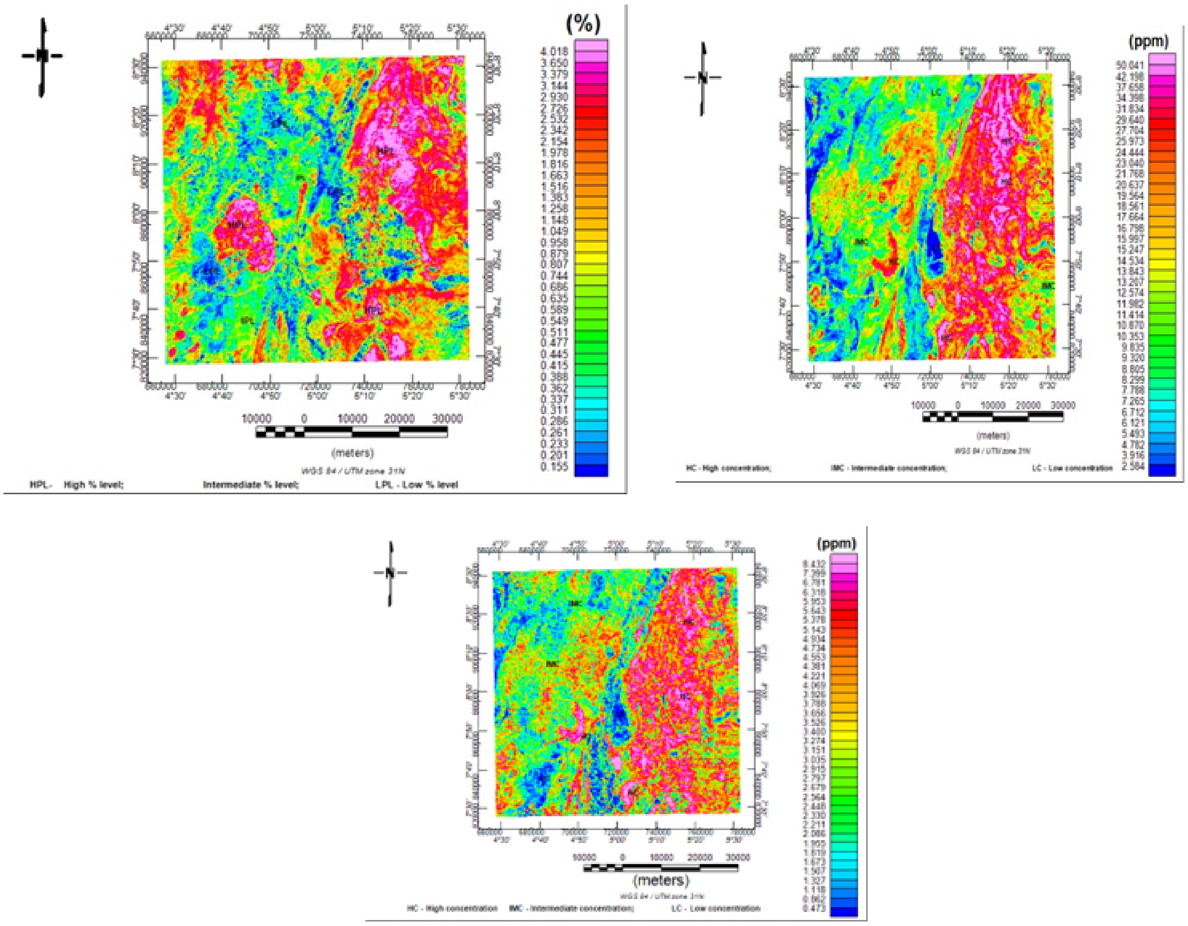

Figure 4. Aeroradiometric data of the study area.

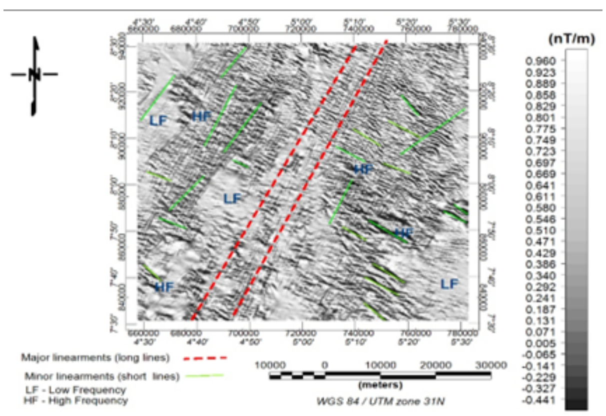

Figure 5. FVD map of the study area.

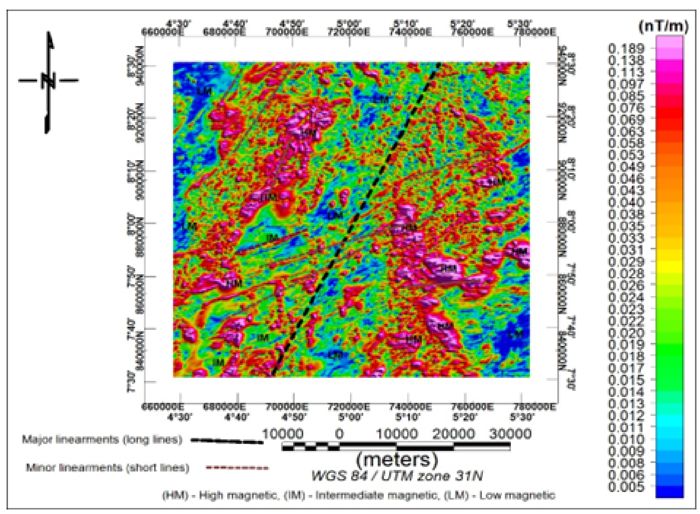

Figure 6. AS map of the study area.

(Th) and Uranium (U) were also obtained in grid form and processed using geosoft sotware.

4. DATA ANALYSIS, RESULTS AND DISCUSSION

In order to delinate possible structural features and hydrothermal altration zones concealing mineral deposits in the area, mathematical methods were applied on the airborne magnetic data (Figure 3). The methods include First Vertical Derivative (FVD), Analytic Signal (AS), and Centre for Exploration Targeting (CET). The FVD has been used extensively in the enhancement of shallow features with their boundaries and associated lineaments [9]. This derivative has the ability of amplifying high wave number anomalous features at the expense of the

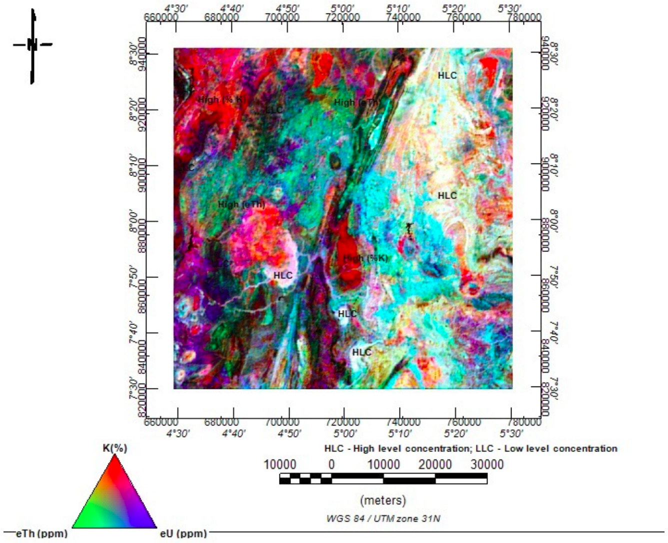

Figure 7. The ternary map of the area.

lower ones in view of this, shallow features can be properly identified and mapped (Figure 5). Figure 5 shows the filtrated data of enhanced low wavelenght anomalies so that shallower sources could be mapped at the expense of the high-wavelenght ones. The entire area is occupied by these low wavelenght anomalies, indicating shallow depth to causative sources in comparison with some other parts such as Southeast, Northwest and part of North central with deeper sources which have the presence of sedimentary covers.

For the analytic signal technique applied to the aeromagnetic data, the results reveals: (i) a domain of sloped maxima (0.097 – 0.189 nT/m) which can be regarded as outlines of magnetic sources. Some of these maxima are noticeable in the NW, SW and SE portion of the study area; (ii) a domain of intermediate intensities with gradients ranging from 0.020 – 0.085 nT/m; and (iii) a domain of low intensities with gradients located between 0.005 – 0.019 nT/m. In the first magnetic domain, the majority of maxima are trending in the NE-SW direction, while minor maxima are observed to be trending in NW-SE direction. These two groups of maxima can be associated with intruded granite bodies (e.g. porphyritic granite, medium or coarse-grained biotite granite, hornblende granite, granite gneiss) rich in ferromagnesian-bearing rocks with low amount of felsic minerals [10–12].

In order to deduce the linearmnet features in the area, CET grid analysis was applied to the data using the steps described in the work of Ref. [6]. The result of this linearmnet structures is shown in Figure 6. From this figure, it is observed that the majority of the prominent structural features are trending in NE-SW while less ones are trending in NW-SE, E-W and N-S directions. These trends reveal the effects of deep heterogeneity of the earth's crust which represents fractures - faults affecting the Basement Complex or both the basement and the overlying sediments. İn addition, to harness the hydrothermal altration zones in the area, radiometric elements (K, eU and eTh) were interpreted and they show that the area under investigation is covered with rocks of different compositions and the outlines of these radioactive elements are allied in NE-SW trend. Therefore, the NE-SW trend is the most recognized and famous trend from both aeromagnetic, SRTM and aeroradiometric maps and this confirms the role of this trend on the geological map of the study area (Figure 1). Also, mineral deposits reveal increase in % K and concentration in eTh which is an indication of Th mobilized in a hydrothermally altered systems [13] and high % K and low concentration eTh are associated with alterations in many ore deposits [14]. This assertion makes K/eTh ratio map important when searching for signatures associated with hydrothermal alteration zones. And lastly, the ternary map (Figure 7) of the study area was generated by modulating the three colors Red (R), Green (G) and Blue (B) in equal proportion so that their intensities could be revealed. From this map, the lithological contrasts resulting from geological and mineral exploration can be interpreted. Here the white color found in some areas across the study area shows the high level of concentration (HLC) for the radioactive elements which is characterize by strong radiometric response and these area can be associated with metasediments, younger granite, schist felsites and metamorphic rocks.

5. CONCLUSION

The delination of structural features and hydrothermal alteration zones using integrated geophysical data of part of North-central Nigeria has been done and structural and lineament features were obtained upon the applications of FVD, analytic signal, CET grid and porphyry on magnetic data of the area. The structural features are trending more in the NE-SW direction while few once trend SW, NS, WNE, NNW and NW. These directions represent the orientation of the mineral deposits. Zones hydrothermally affected were mapped by on the ternary map.These zones serve as pathways for the movement of fluids which could react with the granitic rocks.

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