Geology and Geochemical investigation for structurally controlled gold mineralization in Mariga, North-Western Nigeria

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Abstract

Aeromagnetic and geochemical investigations were undertaken as a reconnaissance an important component in enhancing the geologic information of Mariga area as it pertains a potential for the extraction of economic gold, gemstones and associated structurally controlled mineralization. This is done with an aim of understanding the structural setting, delineating lithological contacts and possible alteration zones as well as identification of prospective zones for structurally controlled mineralization. The area is bounded between Latitude 9° 50′ to 9° 55′ and Longitude 5° 55′ to 6° 00′. The study area falls within the Schist Belt of north-western Nigeria. The lithological variations include coarse to fine grained, clastics pelitic schists, phyllites, banded iron formation and mafic metavolcanics (amphibolites). For the enhancement and general understanding of the structural geology of the area, the original TMI grid was processed, filtered and transformed to other grids using Oasis montaj software with associated extensions of the package such as MAGMAP, SPI and CET. First Vertical and Second Vertical Derivatives, Analytic Signal, Tilt Derivative and Horizontal Gradient were produced. These were done in order to extract the magnetic lineaments of the area. Density heat map was produced by employing image analysis techniques such as texture analysis and symmetric feature detection algorithms to identify the magnetic anomalies and vector analysis on their line segments to identify structural complexity. Geochemical analysis was done on soil samples and analysed for elements such as gold, silver, manganese, copper, zinc and iron. ArcGIS 10.8.1 was used for weighted overlay thematic maps such as geology, lineaments, feature orientation and geochemical anomaly. Results of aeromagnetic interpretation show that the magnetic signatures vary from -142 nT to 145 nT in the area which is quite appreciable contrasting signature for magnetic anomaly delineation. Several lineaments with major NE - SW trend was identified in the area. Also, major regional faults trending NE-SW and E-W delineated around the north-western part cross-cuts some of the lineaments and lithologic contacts. Feature intersection orientation density heat map showed areas associated contact aureoles and other deposits along with hot spot edges seem to be closely associated with structural complexity, identifiable in the aeromagnetic map. Prospective areas have been identified after the weighted overlay analysis and indicate that the north-western portion of the study area is deemed more prospective. This area recommended for further ground geophysics detailed investigations follow up.

Keywords: Aeromagnetic data, Lineaments, Lithologic contact, Feature orientation, Mineralization

1.0 Introduction

The primary sources of gold and most gemstones in Nigeria are quartz veins and the pegmatites in rocks of the Basement Complex. It can be mined either in the vein or as alluvial deposit. Most primary gold mineralization in the schist belt commonly occurs in quartz veins within several lithologies. Since most of the mineral deposits in the area are structurally controlled, these mineral occurrences are often restricted to structural elements such as faults, shear zones and lithological unconformities. Hence, knowledge of the structure interrelationship and lithologic units are essential for mineral exploration (Adebiyi *et al.,* 2021).

The area falls within the north-central zone of Nigeria which forms part of the Basement Complex intruded by pegmatites known for their economic mineralization potential. They area is also notable to host rich in metallic and industrial minerals such as lead-zinc, gold, tantalite, Niobium and gemstones.

Magnetic measurements and interpretations play important roles in understanding the variations in Earth's magnetic field that resulted from the underlying basement rocks' magnetic properties (magnetic susceptibilities), geological structures and their geometric shapes and sizes (Abdelrahman *et al.,* 2007; Abdelrahman *et al.,* 2012; Abdelrahman and Essa, 2015; Abo- Ezz and Essa, 2016; Biswas, 2016; Biswas and Acharya, 2016; Essa and Elhussein, 2017).

At short wavelengths, magnetic data reflect the susceptibility changes that could be associated with the sedimentary rocks and at long wavelengths the magnetic anomalies could reflect the susceptibility changes in the underlying basement (metamorphic and basic igneous) rocks (Telford *et al.,* 1998). Magnetic data allows for the delineation of the lateral changes in susceptibility associated with the underlying structures and by doing so information about the structural trends and its lithological changes can be inferred. To delineate the subsurface structural features from magnetic data, numerous magnetic edges enhancing techniques have been developed and used effectively by many researchers (Nabighian, 1972; Cordell and Grauch, 1985; Roest et al., 1992; Phillips, 1998; Verduzco et al., 2004; Salem et al., 2007).

Chemical analyses are usually conducted on soil samples collected on anomalous areas within the study area. It is important to note that due to high detection limit of X-ray Fluorescence (XRF), gold is usually not detected directly hence, pathfinder elements may be analysed to have a reliable information on the prospectivity of gold in the area (Steiner, 2021).

1.1 Gold Occurrence in Nigeria

In Nigeria, gold occurs both as placers (alluvial and eluvia) and primary vein deposits within the schist belts of northwest and southwestern Nigeria. Some of the most important occurrences are at Maru, Anka, Kwaga, Gurmana, Birnin-yauri, Okolum, Dogon-Daji and Iperindo areas all associated with the schist belts. It was also stressed that different types of rocks host Nigerian gold with superficially different petrographic characteristics (Fagbohun, 2021). Earlier workers stated that the Nigerian gold can be correlated with common host rocks from other parts of the world and likened their origin to that of the petrochemical characters of the host rocks. Identifying the appropriate structural patterns and hydrothermal processes necessary for gold fluid transport and deposition is important in gold exploration in Nigerian pan African basement (Garba, 1988).

It is concluded that the only controls of gold mineralisation in the Nigerian Pan African basement are essentially structural. These kind of consist of transcurrent fault systems, subsidiary faults along with other penetrative set ups together forming the overdue Pan Photography equipment conjugate fracture system (Garba, 1992). These fault systems were probably the main force that the hydrothermal gold ore essential liquids were later focused into the subsidiary fault along with other structures, along which interactions in the fluids along with suitable walls rocks or even structures induced gold depositing. Furthermore, it was observed that the regional failing structures tend to be largely not mineralized simply because they were areas of best fluid circulation and best fluid/rock quotients, whereas the actual genetically associated subsidiary set ups host the actual deposits for their decreased gold solubility as well as temperature (Darma *et al.,* 2016). The Schist belts are about the best- studied group of rocks in Nigeria because of the known mineralization such as gold, BIF, Marble, manganese and several others are associated with them (Ohioma, 2020).

2.0 Study area

The study area lies within the Akerre Sheet 162 NE of the Federal Survey of Nigeria topographical map sheet. The area covers approximately 38.4 km^2

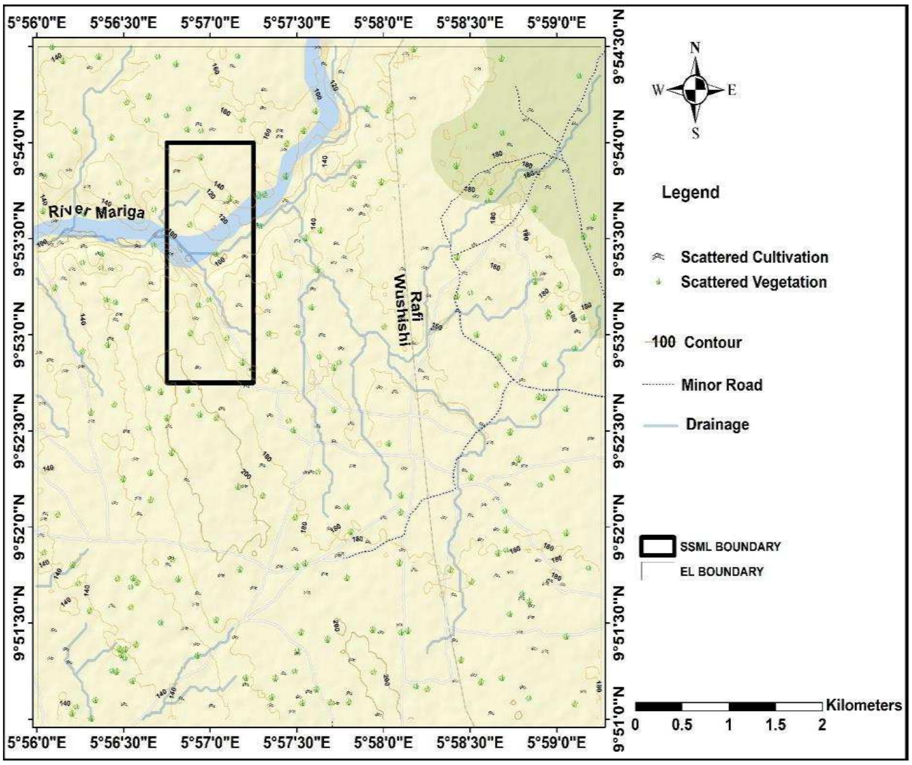

Figure 1: Location of the study area part of Akerre Sheet 162 NE. Black box represents area of geochemical sampling.

2.1 Regional Structural Setting

The schist belts are made up of many rock units such as: schists, phyllites, quartzites, banded iron formations (BIF) and amphibolites. The Older granites are mainly syn-to-late-tectonic Pan-African intrusions, ranging in size from small sub-circular cross cutting stocks to large elongate batholithic bodies emplaced into both the gneiss-migmatite-quartzite complex and supracrustal rocks during or after the main phase of Pan-African deformation (Petters, 1991).

Two major transcurrent fault systems with dextral displacements are known in the Precambrian basement. They trend in the NE-SW direction displacing earlier structures in the order of tens of kilometres. The two fault systems are known as the Anka-Yauri-Iseyin (AYI) and the Kalangai-Zungeru-Ifewara (KZI) faults and are often associated with locally developed subsidiary (NW-SE) sinistral faults (Turner, 1983). These are considered to be conjugate system of late Pan- African brittle deformation that occurred after about 530Ma on a continental scale (Ball, 1980). The close association of ultramafic and related rocks with the fault systems suggests that they might be crustal sutures. A collision-type orogeny has been suggested, involving the Pan- African region and the West African craton, in which a subduction zone dip eastward beneath the Pan-African region. Deformation and metamorphism followed the continental collision at around 660 Ma which was considered to be basement *sensu stricto*, and most radiometric ages lie in the range 600+150 Ma dating the imprints of the consequent crustal thickening in the Nigerian region. The period 650-500 Ma was characterized by extrusion of post-tectonic alkaline to calc-alkaline volcanics and brittle deformation, as the last manifestation of the Pan- African orogeny (Garba, 2002).

2.2 Data Acquisition

A high resolution airborne magnetic data of 1:100,000 Akerre Sheet 162 was used for this interpretation with other data set such as SRTM data, satellite imageries and regional geological map of Nigeria. The survey parameters of the aeromagnetic data are: Flight line spacing (500 m), Tie line spacing (2 km), Terrain clearance (80 m), Flight direction is NW-SE while the Tie line direction NE-SW. The total magnetic intensity field has been International Geomagnetic Reference Field (IGRF) (2015) corrected and super regional field of 32000 nT was deducted from the raw data. The magnetic data was further processed to investigate the presence of buried structures and lineaments that might be relevant in the mineral exploration project development.

2.3 Processing and Interpretation methodology

The original TMI grid was processed, filtered and transformed to other grids using Oasis montaj software with associated extensions of the package such as MAGMAP, SPI and CET. For the purposes of data presentation and interpretation the total field magnetic data are gridded using the minimum curvature gridding method (Briggs, 1974) with a cell size of 125 m, which represents about one quarter of the 500 m average line spacing. A 3x3 convolution filter was passed over the final grid to smooth the grid image.

This data is required for the enhancement and general understanding of the regional geology of the area. In this regard, the data can also be used to map contacts and structural features within the property. It also improves definition of the potential of known zones of mineralization, their geological settings and identifying new areas of interest. The ArcGIS software by ESRI was used to relate and overlay various layers of information, such as geology, magnetic data and extract structural features of the interpretation. The interpretation was performed on screen in the ArcMap. Aeromagnetic Data Analysis and processing was done in three major ways for simple and efficient interpretations of the subsurface structure in a qualitative and quantitative manner by implementing: Reduction to Equator (RTE), filtering and depth analysis

2.3.1 Reduced to Equator

Reduction to Equator method was implemented to position the anomalies vertically above their sources. The filtering process would serve to aid qualitative interpretation of the anomalies, while the depth analysis technique would aid the interpretation of the subsurface magnetic anomalies quantitatively. RTE was implemented on the acquired aeromagnetic data with the objective of accurately positioning anomalies directly above their causative bodies (Luo et al., 2010). The geomagnetic declination and inclination of -4.27° and -2.10° respectively at the central location of the study area was used for the RTE process.

2.3.2 First Vertical Derivative

The partial derivative of magnetic data in the vertical direction defined what is referred to as the vertical derivative. This derivative emphasis the local anomalies by enhancing the high frequency (or short-wavelength) anomalies and suppresses the low frequency (or long- wavelength) anomalies in potential field data (Dobrin and Savit, 1988). The first and second order vertical derivatives can be calculated respectively using equation 1 The equation of the wavenumber domain filter to produce nth derivative is:

$$F(\omega) = \omega^n \qquad (1)$$

where: F = vertical derivative ω = wavenumber (radians/ground unit) n = order of differentiation
Note: $\omega = 2\pi k$ where k is cycles/ground unit.

2.3.3 Analytic Signal (AS)

The interpretation of magnetic field data at low magnetic latitudes is difficult because the vector nature of the magnetic field increases the complexity of anomalies from magnetic rocks. The analytic signal also known as the total gradient (Nabighian 1972, 1974 and 1984) is formed by integrating the horizontal and vertical gradients of the magnetic anomaly. The amplitude A of the analytic signal of the total magnetic field T is calculated from the three orthogonal derivatives of the field (Roest *et al.*, 1992) (Equation 2).

$$|A(x,y)| = \sqrt{\left(\frac{\partial T}{\partial x}\right)^2 + \left(\frac{\partial T}{\partial y}\right)^2 + \left(\frac{\partial T}{\partial z}\right)^2} \tag{2}$$

where A = amplitude of the analytic signal T
= total magnetic field
x, y and z = orthogonal directions

Modelled grid of analytic signal was calculated by applying finite differences to the total intensity magnetic anomaly field computed from the formulas of Singh and Sabina, (1978). Vertical derivative of the magnetic field was obtained by computation at depths of $(z + \Delta x)$ and $(z - \Delta x)$ dividing the difference in the depths by $2\Delta x$. The x and y derivatives are calculated in the same manner. However, contacts on analytic signal are often more discontinuous than that of its horizontal derivative.

2.3.4 Magnetic Tilt Derivative

The magnetic tilt derivative (TDR) combines all three gradients (X, Y and Z) to produce what is a called a tilt angle. The distance between the zero contour at the 45° contour is called the tilt-depth method and can give an approximation of the depth of the host body Salem et al., 2008).

The magnetic tilt derivative is calculated by the following equation:

$$\mathrm{TDR} = \tan^{-1}\left[\frac{{}^{\mathrm{dT}}/_{\mathrm{dz}}}{\sqrt{\left({}^{\mathrm{dT}}/_{\mathrm{dx}}{}^{2} + {}^{\mathrm{dT}}/_{\mathrm{dy}}{}^{2}\right)}}\right] \tag{3}$$

where dT/dx is the calculated in-line gradient, dT/dy is the measured cross-line gradient and dT/dz is the measured vertical gradient of the total magnetic field. By using measured gradients in the tilt calculation, additional details can be extracted from the data that would typically be lost in a TMI grid-based tilt calculation.

2.3.5 Source Parameter Imaging (SPI)

The SPI method (Thurston and Smith, 1997) estimates the depth from the local wavenumber of the analytic signal using the MAGMAP extension of oasis Montaj software. Thurston and Smith, (1997) and Nabighian (1972) showed that the analytic signal of the magnetic anomaly due to a 2D magnetic source can also be expressed by the complex number.

$$A_1(x,z) = \frac{\partial B_T(x,z)}{\partial x} - j\frac{\partial B_T(x,z)}{\partial z}, \tag{4}$$

Where: BT (x, z) is the total magnetic anomaly observation point at a distance x along the principal profile and a vertical distance z above the source

j is the imaginary number ($= \sqrt{-1}$).

The estimated depth results are interpreted in terms of the magnetic basement and shallow (intrusive) basement. could be interpreted as the depth to top of intrusions at various location. The SPI depth Grid (Figure 10) was computed in order to estimate depth to magnetic sources. The SPI depth Grid show that most magnetic sources are not deeply seated which indicate a lower cost of exploration and exploitation.

2.3.6 Shuttle Radar Topography Mission (SRTM) DEM

Hill shade Digital elevation Model (DEM). This was achieved by combining the Shuttle Radar Topography Mission (SRTM) of the area and sun shading at 45^0. The DEM is then correlated with the magnetic Grids to isolate those anomalies that were suspected to be induced by the topography from the real ones. Most of the anomalies within this area of interest are not topographic anomaly; hence its worthy of further ground verification but the central portions are not influenced by the topography (USGS, 2021).

2.3.7 Magnetic Lineaments

Magnetic lineaments are linear, continuous features on a map, possibly related to deformation zones and/or lithologic contacts. In the following, the deformation zones are discussed mainly from the geophysical point of view, focusing on their magnetic properties.

In geological processes, magnetic properties of bedrock may change, depending on prevailing physical and chemical conditions and mineralogy (Airo 2005). In general, the properties of a deformation zone may vary in the following ways, when the primary magnetic mineral in bedrock is magnetite (McIntyre 1980; Henkel and Guzman 1977; Johnson and Merrill 1972).

i) Oxidizing fluid intrude into the rock material during the metamorphism.
ii) Deposition of magnetite: magnetic susceptibility increases.
iii) Reducing metamorphic fluids intrude into rock material, thus, magnetite is decomposed, thereby decreasing susceptibility.
iv) Low temperature (< 250 °C) weathering in fracture zones. This causes magnetite to be decomposed, thus, decreasing magnetic susceptibility.

It is known that increased pyrrhotite content (especially the pyrrhotite-pyrite ratio) is related to the metamorphic grade of the bedrock (Craig and Vokes 1991). Pyrrhotite in the study area is inferred to originate from the primary sedimentary protolith of the migmatitic gneisses. Geological observations suggest that pyrrhotite has been mobilized first by regional tectonic movements and subsequently by hydrothermal episodes. Accordingly, the fracture and fault zone system of the area has been one factor controlling the emplacement of pyrrhotite.

According to the discussion above, a deformation zone may induce a magnetic minimum or maximum. Brittle zones commonly carry fluids allowing different chemical and physical weathering processes to take place within the zone, resulting in decomposition of magnetite to haematite and pyrrhotite to goethite and elemental Sulphur (Steger and Desjardins, 1978). Since low-temperature weathering is supposedly the most recent chemical process in the brittle zones, it is therefore justified to assume that most linear magnetic minima represent their surface expressions. At the bedrock surface, a deformation zone may be accompanied by a topographic bedrock depression filled by soil, which may also slightly decrease the measured magnetic field. However, in some areas, a number of brittle zones are also related to high susceptibility. In addition to magnetic minima/maxima, also a sharp discontinuity or a displacement of magnetic anomalies may be an indication of a potential brittle deformation zone. A deformation zone is typically highly fractured and are characterized by concentrations of conducting minerals such as sulphides and clay.

3.0 Results and Discussion

3.1 Local geology

The study area falls within the Schist Belt of north-western Nigeria (Figure 2). The Schist Belts comprise low grade, metasediment-dominated belts trending N–S which are best developed in the western half of Nigeria. These belts are considered to be Upper Proterozoic supracrustal rocks which have been infolded into the migmatite-gneiss-quartzite complex. The lithological variations of the schist belts include coarse to fine grained, clastics pelitic schists, phyllites, banded iron formation and mafic metavolcanics (amphibolites). From the regional geological map of Nigeria, this part of Sheet 162 (Akerre) is predominantly underlain by porphyritic igneous rocks which have intruded large scale intrusions of porphyritic granites/granites/course porphyritic biotite and biotite hornblende granites are also outcropped within the Schist resulting to localised steep dips in the area. They form low strike ridges parallel to those of the schist belts. Mylonites are in contact only with rocks of the schist belts and the older granite plutons which intrude them. There are no unmylonitised basement rocks adjacent to the Mylonitic rocks. The Mylonites have a well-defined lineation or Mylonitic foliation which trends NNE-SSW, parallel to the regional structural grain. Rocks belonging to the Nupe Basin are found in the south-western portion of the map (Ako, 2014).

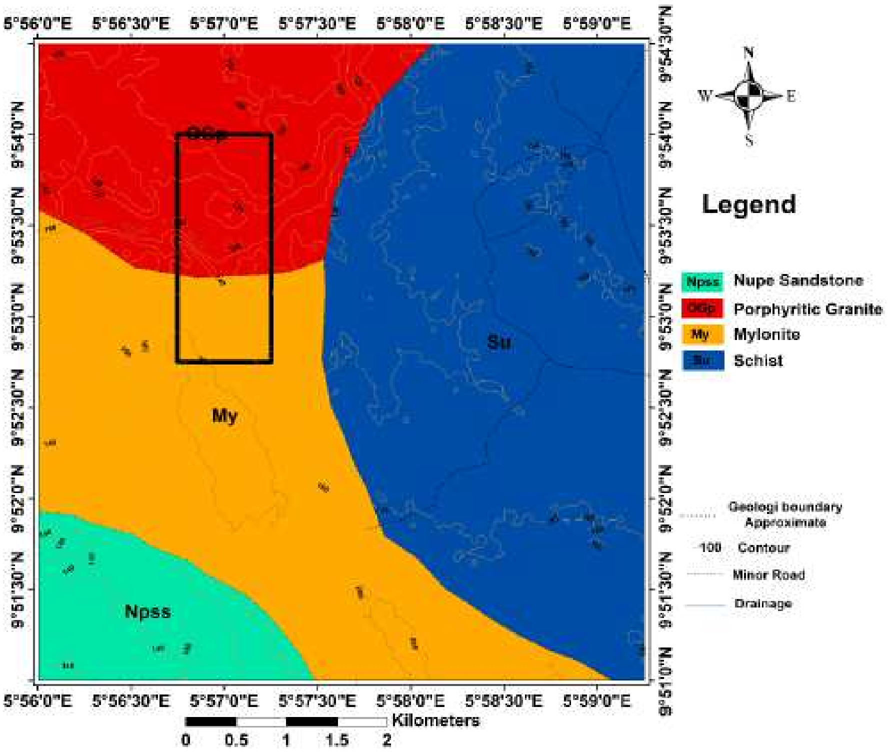

Figure 2: Geologic map of the study. Black box represents area of geochemical sampling.

3.2 Aeromagnetic data interpretation

Figure 3 shows the aeromagnetic data (RTE) for the survey area. Map shows the superposition of perturbations of distinctly different order of sizes. Large features which are visible as trends and continue smoothly over extensive distances are caused by the deeper heterogeneity of the earth's crust. These trends are called the regional trends. In contrast, small local disturbances which have primary importance but are secondary in size are called residual anomalies. These are superimposed on the regional fields and are frequently camouflaged by them. Residual anomalies may provide direct evidence of the existence of structures that are typical to reservoirs or mineral ore bodies. The high values (nT) are purple and orange and indicate appreciably magnetic rocks. The low values are the blues and greens. A gradual change in colour indicates a gradual change in the magnetic field strength. This can be caused by either a gradual change in magnetic susceptibility of rocks near the surface, the gradual burial of a rock unit of relatively constant magnetic susceptibility, or the introduction of a new unit at depth. Conversely, an abrupt change in colour indicates an abrupt change in the magnetic susceptibility.

This is caused by juxtaposing two rock units with very different magnetic susceptibilities such as is the case with faults, volcanic dikes, or some mineralized zones. Faults can be inferred on aeromagnetic maps from linear or curvilinear features composed of discontinuous aeromagnetic highs or lows. This is also an indication that the area has undergone pronounced tectonic activities producing fractures, faults and shears. exhibits zonation and alteration probably in the form of sericite (Juliani et al., 2021). This is an indication of hydrothermal alteration which is usually associated with mineralization probably as a result of intrusion. The amplitude of the magnetic signatures varies from -142 nT to 145 nT within the exploration license which is quite appreciable contrasting signature for magnetic anomaly delineation.

In an attempt to extract meaningful lineaments from the aeromagnetic data, several derivative maps have been calculated and produced. The First vertical derivative (Figure 4) of the data was computed so as to make lineaments identification easier. This is done by observing the trends and amplitudes of the anomalies that matches the geological history of the region.

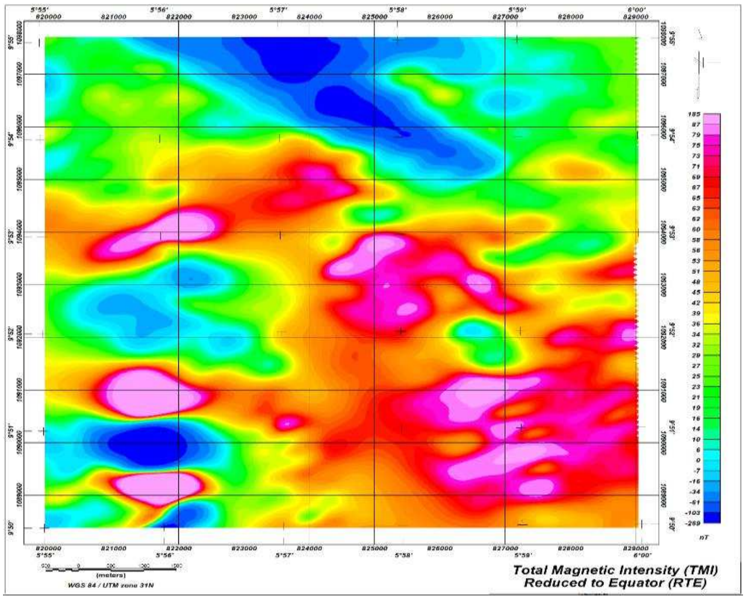

Figure 3: Total Magnetic Intensity (TMI) Reduced to Equator of the study area.

The lineaments were extracted from this map by interpreting the signatures as the edges of geological bodies and directions of structures which might have been in connection with the thermo-tectonic events. The amplitude of the signal peak of analytic signal (Figure 5) is directly proportional to the edge of magnetization. Hence source edges are easily determined. The analytic signal has a form over causative body that depends on the locations of the body (horizontal coordinate and depth) but not on its magnetization direction. This is an important feature of the analytic signal. More so, the amplitude of analytic signal is solely related to the amplitude of magnetization and this feature has been used in locating the contacts of magnetic bodies. Analytic signal is often effective at highlighting geologically meaningful subtle anomalies (Lyatsky *et al.,* 2004).

The Tilt derivative map (Figure 6) pursues the objective of extracting meaningful lineaments a bit further by highlighting very subtle, near surface structures in the dataset where the zero-contour line of the grid is said to represent geology contacts or edges of bodies. Several lineaments with different orientation were identified in the area. The lineaments can be grouped into three on the basis of their orientations. Major trend in the NE – SW direction, some trend in the NW – SE direction. Also, a major regional faults trending NE-SW was delineated within the concession around the north-western part cross-cutting some of the lineaments and the lithological boundaries. Such structures interpreted from the aeromagnetic maps are essential channels for mineralization fluids.

The ENE-SSW trends represent the mega shear zones in Africa called the Central African Shear Zone (CASZ) which resulted from the important tectonic movements that occurred during the Pan-African orogenic cycle (Moreaus *et al.,* 1987). The ENE-SSW is also a dextral shear zone that is related to the wider mylonite belts pre-dating at the Cretaceous times, the opening of the South Atlantic Ocean (Jorgensen and Bosworth, 1989; Djomani *et al.,* 1995). The N-S lineaments are minor trends. Their formation may be associated to either the migration of the African plate over the mantle plume or shear movements along the pre-existing ENE- WSW faults in the Pan-African basement (Djomani *et al.,* 1995).

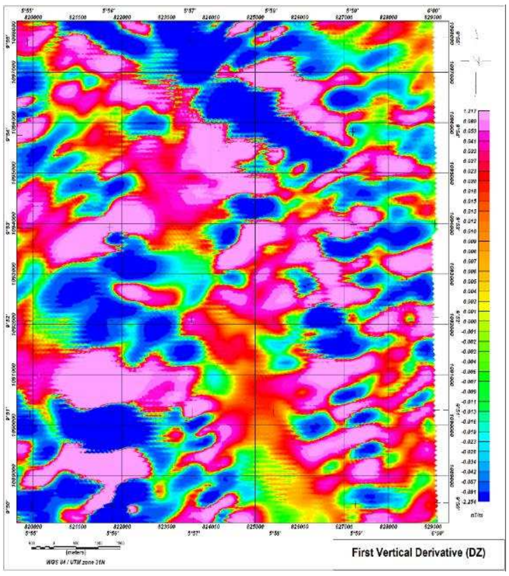

Figure 4: First Vertical Derivative map of the study area.

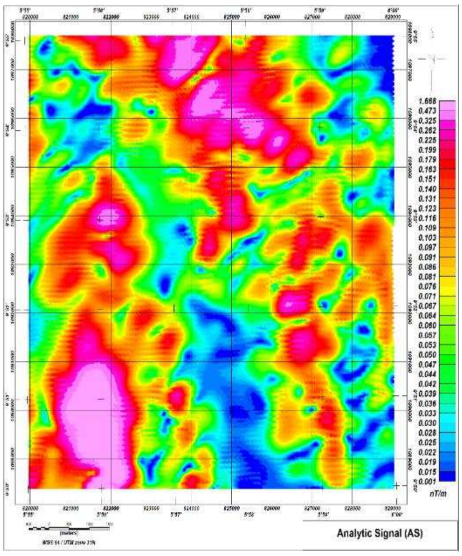

Figure 5: Analytic Signal map of the study area.

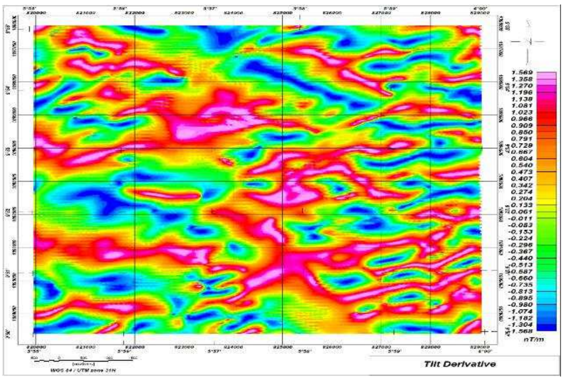

Figure 6: Tilt Derivative map of the study area.

3.3 Feature Intersection Orientation

The feature intersection orientation density heat map (Figure 7) was achieved by employing image analysis techniques such as texture analysis and symmetric feature detection algorithms to identify the magnetic anomalies and vector analysis on their line segments to identify structural complexity. This contribution presents an image processing method to generate maps that highlight regions of geological structural complexity from aeromagnetic data, efficiently and objectively.

An interesting observation is that gold deposits often are located near edges of hot spots. This is not surprising, considering that gold deposits are often located at or near hot spot edges, such as contact aureoles (e.g., Pirajno and Bagas, 2008). Researches have shown that areas associated this and other deposits along with hot spot edges seem to be closely associated with structural complexity, which can be automatically identified from the regional aeromagnetic data.

3.4 Geochemical interpretation

The concentration of gold in the soil samples ranges 0.001 **- 0.0142 ppm**. These values are not very significant for an economic extraction of the resource on a scale. However, a trend as shown on the map below (Figure 8) revealed that the north-western and southern portion of the map could be promising when compared to the feature intersection orientation map. The trends and anomalies of other elements shown in the figure is correlatable to the feature intersection orientation map. These are pathfinders to gold. These anomalies are a pointer to the fact that the economic extraction of gold may be possible in the study area.

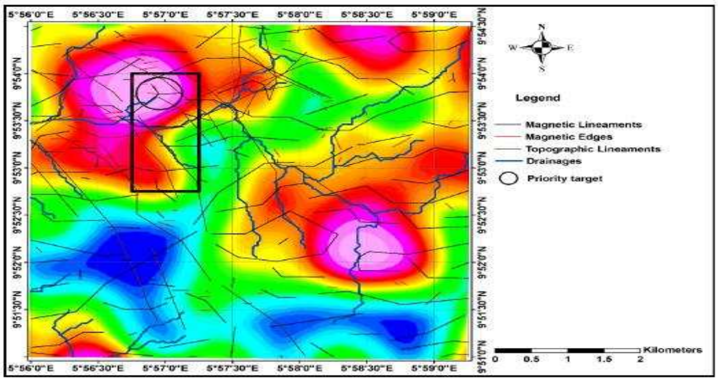

Figure 7: Structural map superimposed on the contact occurrence density heat map of the study area. Black box represents area of geochemical sampling.

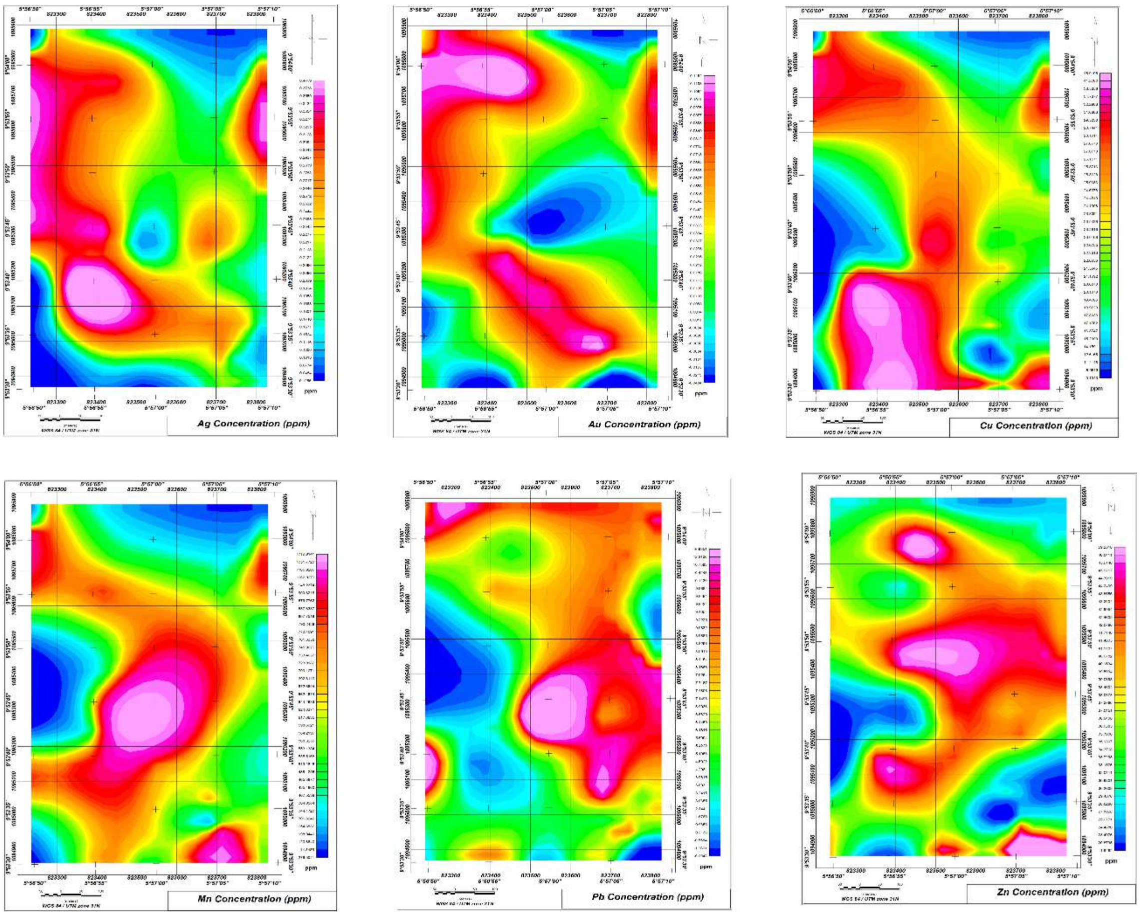

Figure 8: Distribution of Geochemical anomalies of some selected elements in the study area.

3.5 Conclusion and Recommendation

The magnetic data collected over the survey area was complex and defines features that appear related to structures such as faults, folds, and fractures. The magnetic field response varies considerably in both amplitude and character. Broad, low gradient features likely represent deeper seated bodies, whereas the sharp and high gradient responses are more likely to be related to near surface features.

The individual magnetic products have been referenced in order to better define the numerous structures throughout the area. The various gradient and derivative products fully represent the components of the magnetic field and can provide specific information not obvious in the total field data. The vertical gradient product emphasizes all subtle features in the data. In addition, the magnetic analytic signal is produced by calculating the vector sum of all three magnetic gradients to produce a grid that is independent of the effect of orientation from subsurface bodies.

Typically, the orientation of a magnetic target can produce a positive or negative response in the total magnetic field relative to its orientation. The analytic signal produces highs, which are directly over magnetic sources and are independent of the direction of the earth’s magnetization vector. The feature orientation heat map allows for the identification of possible gold deposits in the tenement.

The area has undergone a pronounced tectonic activity resulting in shearing and fracturing. So, the sheared zone and fractures are potential channels for mineralization fluids. The observed zonation and likely alteration in the magnetic data are indication of hydrothermal alteration associated with mineralization. These alteration signatures are broad and laterally extensive in the study area. From the interpreted structural map (Figure 7), zones with regional and localized aeromagnetic anomalies with associated magnetic lineaments/major faults are targets for mineralization. The intersections between linear features (faults/lineaments); sheared and fractured zones are potential traps for minerals and therefore provide a significant exploration vector. These zones extend well into this concession especially the NE-SW trending lineament almost intersecting the NW-SE trending major fault occurring around the alteration zones and the magnetic unit boundary as observed from the interpreted map. Such areas were marked with round box as priority target in (Figure 7).

Geochemical mapping carried out in the area gave credence to the viability of the area for possible gold mineralization. Encouraging pathfinders were found in the geochemical maps. However, ground-truthing, which should be followed with ground geophysical survey inform of Resistivity, Induced polarization and Electromagnetic surveys should be conducted. Results from these surveys may further agree with the results presented in this research.

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