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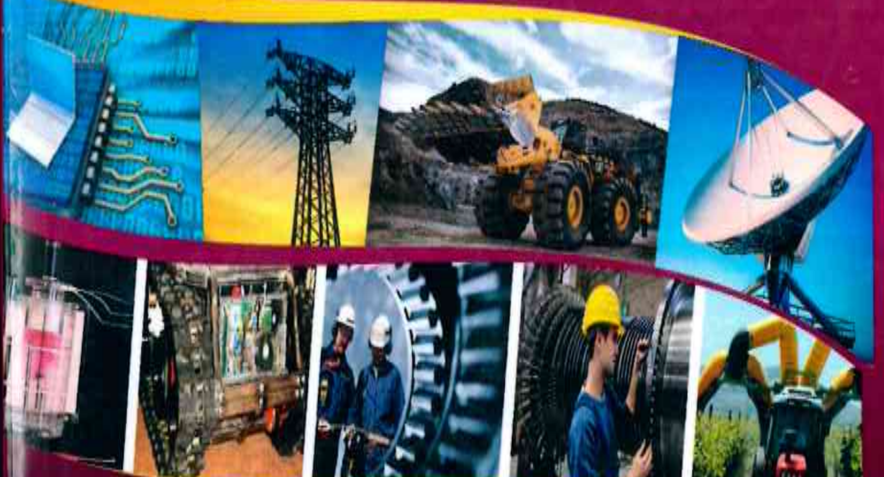

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MAGNETIC AND GEOELECTRICAL PROSPECTING FOR GOLD MINERALISATION WITHIN TSOHON-GURUSU AREA, PART OF SHEET 164 MINNA, NORTH-CENTRAL NIGERIA

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ABSTRACT

Total magnetic intensity (TMI) measurements were combined with 2D electrical resistivity measurement in Tsohon Gurusu, with the objective of delineating the subsurface gold mineralisation. The TMI measurements data was acquired by the ground magnetic technique, using Geometric 876X. The traverses for the measurements were eleven, aligned North-South, 500 m long and uniformly spaced 50 m apart. The measurement stations were position East-West, across the traverses at 10 m apart in the mineral foliation direction. The acquired TMI was processed and analyzed using Euler and Analytical signal techniques. The ERT data was collected along two traverses of anomalously high TMI values (30 – 86 nT) and low TMI value. Low electrical resistivity values were found to associate with the high TMI values in an East-West pattern. This anomaly pattern confirms with the major East-West fracture pattern captured in the rose diagram of fracture and joint measurements on the outcrop. This indicates that these fractures are potential mineralization zones for conductive minerals. Local miners have been pitting all over the place in the hope of intercepting gold bearing veins, their effort has occasionally been rewarded. .

Keywords: *Analytical, Electrical, Euler, Geometrics, Resistivity, Tomography*

1 INTRODUCTION

The Basement Complex has been described as undifferentiated assemblage of rocks underlying the oldest stratified rock. Within the Basement Complex of Nigeria four major petro-lithological units are distinguishable, namely; Migmatite-Gneiss-Quartzite Complex, Schist Belt (metasedimentary and metavolcanic rocks), Older granites (Pan African granitoids) and the Undeformed Acid and Basic Dykes (Obaje,2009). These assemblages of rock host various minerals of economic importance for industrialization and development for which the Schist belt is of prime importance for hosting gold mineralization (Fig 1). Gold is a precious earth metal found in alluvial, eluvial placers and primary veins from several parts of schist belts in the northwest and southwest of Nigeria. The most important occurrence is found in the Anka, Bin yauri, Gurmana, Iperindo, Malele, Maru, Okolom-Dogondaji and Tsoho Birni Gwari-Kwaga. There are six world class settings for magmatic and hydrothermal gold deposits; Orogenic gold deposits, Carlin-type gold deposits, Epithermal deposits,

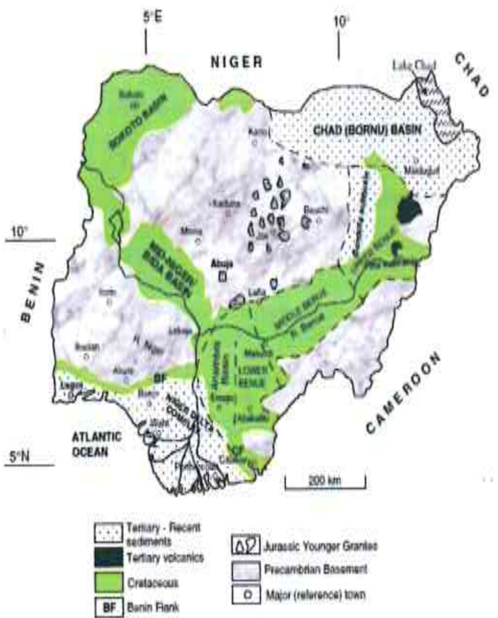

Figure 1: Geological Map of Nigeria, Showing Basement Complex. Source; Lecture Note by Obaje, 2009.

Porphory-copper gold deposits, Iron oxide-copper gold deposits and Gold rich massive Sulphides deposits, (Encyclopedia of life systems). Thus primary gold mineralization is explored for within the neighborhood of igneous intrusions. It occurs in association with pyrrhotite, migmatite and ilmenite. These are rocks with high magnetic susceptibility (Michael, 2009). The magnetic method is commonly deplored to delineate areas with potential for gold mineralization. Also, gold a good conductive element hence electrical resistivity is often engaged to identify areas with magnetic anomaly that are conductive, as such that most likely host gold mineralization. However, the potential revenue accruable from investment in exploration and development of gold and other mineral ores is one of the effective approaches to diversifying Nigeria mono-economy that has been hitch on petroleum for too long.

Tsoho Gurusu is a rural settlement whose major activities is basically subsistence farming (agriculture). The community is about four kilometer from Minna at the South western part of Bosso Local Government Area along Minna-Gwada road. The activities of artisanal mining as observed through pitting and trench excavated for possible minerals necessitated embarking on this research work. The general trend of the area has significant amount of quartz vein exposures and trend of mineralization gave an added impetus to the researching of gold mineralization. The study area lies on latitude 09° **37' 28.4''N and 09° 37'28.6''N and longitude 006° 36' 29.4'' E and 006° 36' 13.1''E on an area extent of** 500×500 m^2 (Figure 2).

GEOLOGY OF THE STUDY AREA

Tsohon Gurusu area lies within the Kushaka Schist Formation of the north-western block of Nigeria basement complex and within the Nigeria metallogeny province, the formation has been intruded by large volumes of granitic rocks that led to extensive migmatization of metasedimentary and metavolcanic rocks carrying substantial gold mineralization (Obaje, 2009). The geology of the area under investigation is underlain by rocks that are typical of the basement complex of Nigeria, some of which shows metamorphic inprints that are quite indicative of various degree of deformation. The rocks include; granodiorite and schist. They exhibit ridge of low laying outcrop extending six to ten meters with greater exposures around stream channels that runs through the study area (Figure 3).

2. METHODOLOGY

Preliminary reconnaissance survey were first carried out to delineate the research study area using the Global Positioning System (GPS); altitude reading, observation of landscape, outcrop trending and drainage pattern. The reconnaissance survey revealed a North-South strike of the rock foliations. Geological mapping was carried out to have a detailed spatial distribution of outcrop and inherent structures (Joint and Fracture) bearings were measured.

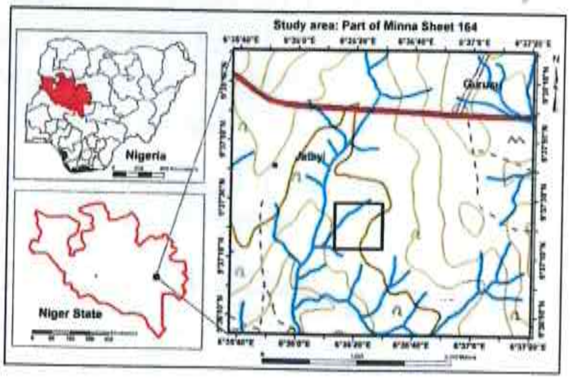

Figure 2. Map of the study area, Tsohon Gurusu.

Ground magnetic survey measurements were taken with Geometric 856AX Proton Precession Magnetometer with external GPSMAP 78sc Garmin, (Figure 4). The measurement were conducted along the dip direction of the rock outcrop in order to reveal the lithologic variation i.e perpendicular to strike direction. Eleven traverses and Fifty-one station point per profile were established comprising of 50m inter profile spacing and 10m inter station spacing. These inter profile and inter station spacing was enough to generate a high density data that is comprehensive to reveal the subsurface geology of the area. Base station method for correction of diurnal variations was used while the area selected for base station was magnetically quiet, i.e. free from moving automobiles and is not close or on top of any major outcrop neither under power line. The stored data from the instrument is downloaded on a computer system. The downloaded data is later saved in an Excel Spread-sheet for easy accessibility. All Magnetics Stations were tied to their respective coordinates. Quality Control and Quality Assurance were then applied on the raw data through visual inspection. This is useful in making sure that all survey specifications have been adhered to. Observed geology, cultural features and all possible source of noise aided the execution of Quality Control and Quality Assurance on the data.

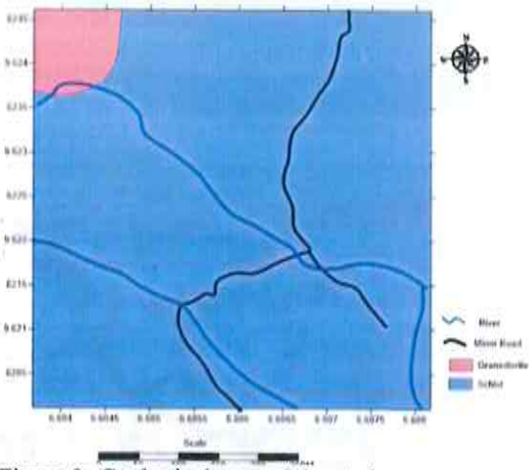

Figure 3: Geological map of the study area

Figure 4: Magnetic data acquisition

A qualitative and quantitative magnetic survey interpretation from the total magnetic intensity anomaly map comprising of high and low intensity. The high and low intensity areas delineated were further explored using 2D Electrical resistivity imaging. Such areas were based on unique Magnetic responses which are diagnostic of potential mineralization. There are many electrode arrays that are used in electrical imaging (*e.g.*, Wenner, Schlumberger, dipole-dipole etc.) depending on the application and the resolution desired. The Wenner alpha array was used for this survey. Two (2) lines of about 200m each were covered with McOHM 2115 resistivity equipment (Figure 5).

Figure 5: 2D Electrical Resistivity Data acquisition

Resistivity values were computed and saved on Excel Spread-sheet for easy access on Notepad. Res2Dinversion was used in plotting pseudo-section which resembles a cross section of the area reflecting high or low magnetic intensity of the profile. This traditional pseudo-section exaggerates the depth of the anomalous materials; therefore 2D inversion of the apparent resistivity data was carried out using finite element (Loke, 2011).

2.1 DATA PROCESSING AND INTERPRETATION

Magnetic Data Processing

The crustal field is the focus for exploration activities. Magnetic field external to the earth has great effect on magnetic measurement and must be removed during data processing. Magnetic data processing involve the removal of **diurnal variations of the earth's magnetic field, which** may be resolved into secular changes, solar-diurnal changes, lunar changes and changes resulting from magnetic storms, Erwan et al, 2010. At every forty minute interval revisiting of base station is achieved to correct for diurnal variation. To estimate the geometry of geologic structures and depths to magnetic source bodies, mathematical functions were applied to the total magnetic intensity grid. These are Analytical signal and Euler Deconvolution. Figures 6 show the colour-shaded map of the total magnetic intensity map of the study area.

The observed magnetic field at every point is a vector sum of various components, such as the regional field and the local field components. The minerals found in the Earth Crust are capable of carrying both remanent and induced magnetisation. (Erwan, 2010). Remanant magnetism is the effect of the primary magnetic field at the time of rock formation. The total magnetic response is proportional to both the induced magnetism as well as remenant magnetism (Erwan, 2010)

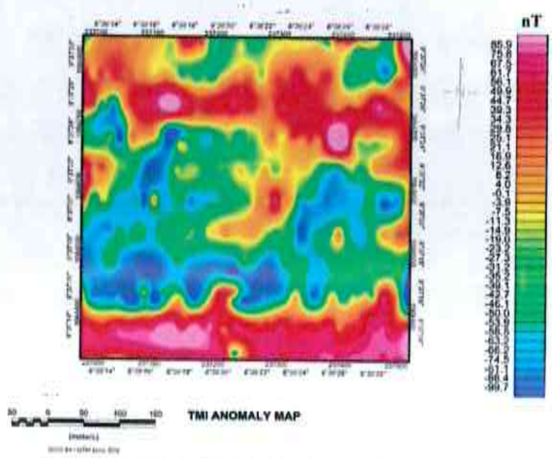

Figure 6: Total Magnetic Anomaly map

Corroborating the TMI anomaly trend and Fracture direction, the trend of structures are principally in the NorthEast-SouthWest direction and East-West inflections. Figure 7.

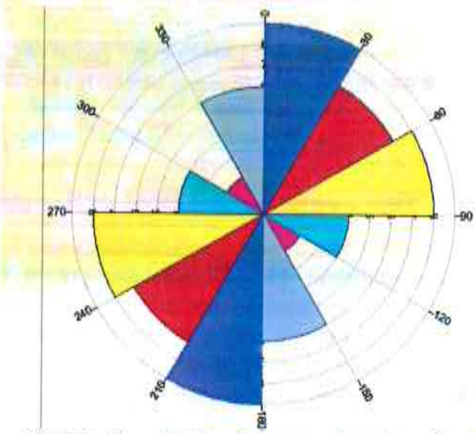

Figure 7: Rose diagram showing fracture and joint direction.

The structural trends as observed from the Rose diagram are the areas that are potential zones for mineralization. The depth of magnetic source were determined using Euler menu of the Oasis montaj, color legend range with highest source is 25m and the lowest source is 8m. Thus edge detection of magnetic body was controlled by Analytical signal which invariable inform the choice location for electrical resistivity (Figure 9). Two points designated as magnetic high and low; South-East and North-East of the map. A traverse of 200m that runs in the East-West direction was measured to detect conductivity of mineralization (Figure 10)

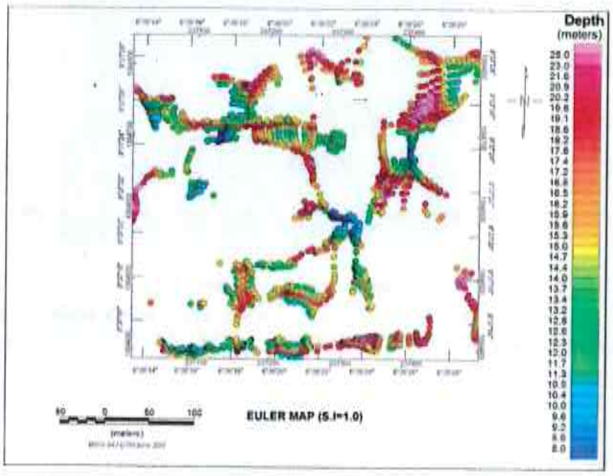

Figure 8: Euler Map for magnetic source detection

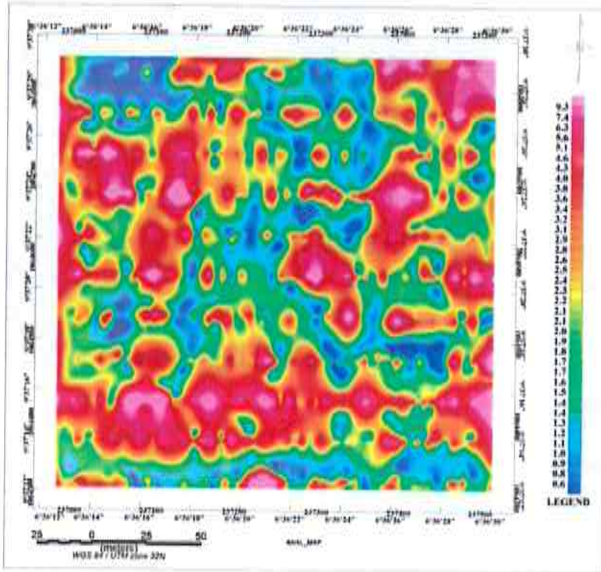

Figure 9: Analytical Signal Map

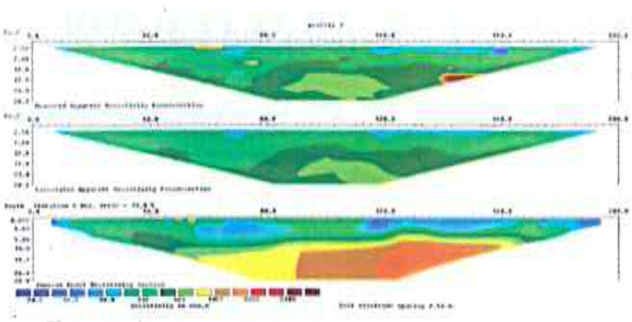

Figure 10: 2-D Resistivity profile on 9° 37' 16.0''N and 6° 36' 28.0''E

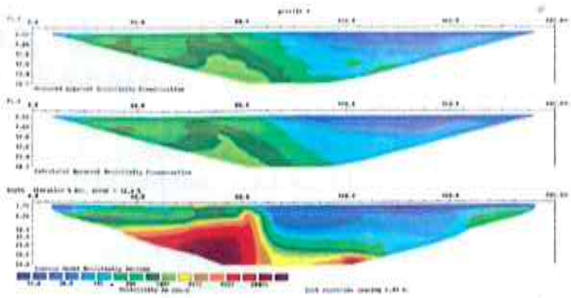

Figure 11: 2-D Electrical Resistivity on 9° 36' 28.0''N, 6° 36' 28.0''E

3. RESULT AND DISCUSSION

The total magnetic intensity map of the area (Figure 6) exhibits zonation and alteration. This indicates hydrothermal alteration which is usually associated with mineralization probably as a result of intrusion. The residual anomaly minima and maxima amplitude signature shows positive magnetic amplitude (maxima) ranging from -54 nT to 51.0 nT (Figure 12). This is quite appreciable for reasonable magnetic anomaly and it suggests that the magnetic susceptibility of the study area is contrasting, hence suitable for mineral exploration. The residual magnetic field intensity map of generally show majorly NE/SE and E/W trending anomalies with few trending in N/S (Figures 12). This shape of magnetic signature obtained in the ground magnetic survey generally suggests a step or an edge structures like dyke or intrusion, such structures are of interest may hold mineralization at certain depth. RES2DINV software was used for the 2D-inversion of the resistivity data. The revealed apparent resistivity pseudo-section of 2-D inverted resistivity show a qualitative idea of resistivity distribution in the subsurface (Figures 10 to 11) hence maximum depth penetration recorded is 39m which invariably exhaust magnetic source observed in the Euler map which ranges from minima of 8m to maxima of 25m (Figure 8). Thus, investigation reveals vertical and lateral extent of mineralization.

Primary gold occurrences in the northern Nigeria schist belts are associated with sulphide mineralization, hence low resistivity. Quartz veins are characterized by high resistivity (low conductivity). Most primary gold mineralization in the schist belts commonly occurs in quartz veins within different lithologies, therefore geophysical characteristics of the quartz veins is another important factor in mineral prospecting and delineation of gold deposit.

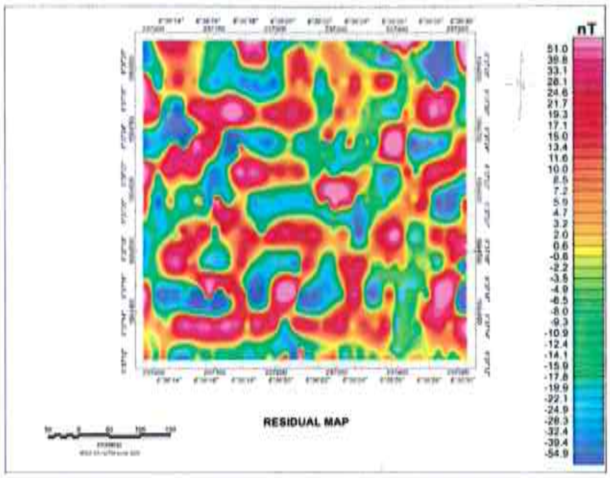

Figure 12: Residual Anomaly Map

4. Conclusion

Combining the results of geologic structures and geophysical methods reveal a wide range of linear structures suspected to be quartz veins which are believed to host ore mineralisation were identified. Careful interpretation and technical assessment of the general results, it can be inferred that some of these structures are probably mineralized veins with varying degrees of characterization. Responses to physical parameters also revealed that some of the structures delineated from the magnetic data are conductive while others are non-conductive, while some are within a resistive host and others are within a conductive host. Several of such structures trending mostly NE-SW, E-W and N-S were identified.

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