BENIN JOURNAL OF PHYSICAL SCIENCES
BJPS Vol. 2(2), December, pg. 106-114 (2025)
ISSN 3043-6931(Print)
3043-694X(Online)
www.bjps.org.ng

Structural Mapping in North West Nigeria Using Aeromagnetic Information

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Received: 27/08/2025 ***Accepted:*** 02/12/2025

Abstract

Regions that have numerous geological structures are likely zones that are mineralized. With the aim to map the numerous geological structures dependent on familiar responses shown by various structural units, magnetic data set (aero) of Kabo and its environment was acquired. The magnetic data (aero) was subjected to filtering algorithm with enhancement formula such as the Total or general Magnetic Intensity (TMI). Also, we applied Reduction to The Equator (RTE) which assisted in the mapping of numerous geological structures making use of Geosoft Oasis Montaj Software. To identify and present the revealed identified structural units Golden Software Surfer was employed. From the interpretation of the geophysical information, it is observed that the research area has numerous structural complex features like, minor faults (F4- F7), dykes (D1 and D2), folds (Fo1-Fo2) and possible fractures (F1-F3) that are aligned in the North East (NE), South West (SW) axis. The regions have covered the locations of; Shanono, Southern part of Kabo, Rimin Gado, Madobi, Garum Mallam, Bunkure and Rano LGAs of Kano State. The zones exhibit substantial magnetic anomaly.

Keywords: *Structural Mapping, Kabo, Aeromagnetic Data, Gesosoft Oasis Montaj Software, Sheet 80*

1. INTRODUCTION

Structural geology is the analysis of the three-dimensional distribution of huge portions of rocks, their outlook, and the composition within the rock units to acquire knowledge about their tectonic movement's history, previous geological events and area that could have deformed them. These data can be dated to know when exactly the structural features were formed. If the nature of these rocks can

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be known, petroleum geologists can uncover if oil or natural gas are caged within the rocks. Ohioma et al. (2019) made use of geophysical method (aeromagnetic) to identify hydrothermally altered structures which favour the inflow of hydrothermal fluid that usually brings about gold mineralisation in Egbe-Isanlu Schist Belt Area, North Central Nigeria. The application of data enhancement filtering algorithm such as reduction to the pole to the magnetic data aided in mapping of various hydrothermally altered structures that may favour gold mineralization. Ohioma et al. (2017) stated that upward continuation analysis of magnetic data of the Schist belt of North-Central Nigeria is used to see the deep-seated structures with respect to higher altitude. The availability of geophysical Information about the presence of magnetic minerals can further showcase the location and depth of suspected minerals, the use of aeromagnetic data over a study area for Investigation of magnetic mineral can provide more information about subsurface geology of the area (Akinlabi et al. 2023). Magnetic signatures are usually employed alongside with the geological settings in characterizing the structures that may host gold mineralization (Augie and Sani 2020). In the Obudu Plateau, Ikom Mamfe embayment, and Oban Massif, aeromagnetic data was acquired and analyzed to evaluate the study area's structural pattern and sedimentary thickness (Eze et al., 2025). With the objective to delineate the geological structures of Kabo and environs, this research attempts to use magnetic data (aero) to map and characterize the numerous structural units in the study area. Aero- geophysical survey metrics are mainly gotten from aero planes flying at low altitudes along near spaced, equidistant flight lines. More flight paths are flown in the orthogonal axis to aid in information analysis. These huge volumes of logs are then refined into a computerized aero-data map. The rule is close to geophysical survey done on the ground but permits wider areas of the lithosphere to be covered swiftly for territorial survey. The airplane generally flies in a latticed way with line and height spacing being a function of the resolution of the information (also cost of the survey per unit area) (Ohioma and Ikponmwen 2020). The research zone is placed within the central area of Kano State between longitudes 8°0′0″E - 8°30′0″E, and latitudes 11°30′0″N - 12°0′0″N. The research zone encloses Kabo LGA and the other adjoining LGAs such as; Shanono, Gwarzo, Rimin Gado, Tofa, Ungongo, Gwale, Kano Manucipal, Tarauni, Kumboston, Karaye, Madobi, Kiru, Kura, Garum Mallam, Bunkure, Bebeji and Rano areas (Figure 1). As regards geology, research zone falls under the Basement Complex rocks of northern Nigeria, which divide into three groups of rocks, which are; the Upper Proterozoic of the Younger Meta-sediments, first-class gneisses obtained from the Birri major sedimentary rocks via premium metamorphism and granitization, and migmatites (Bagare et al, 2018). These includes Laterites, Granite, Rhyolite, Migmatite, Metaconglomerate, Older Granite, Marbles, Quartz-Mica schist, Ironstones, Gneiss and Sandstones.

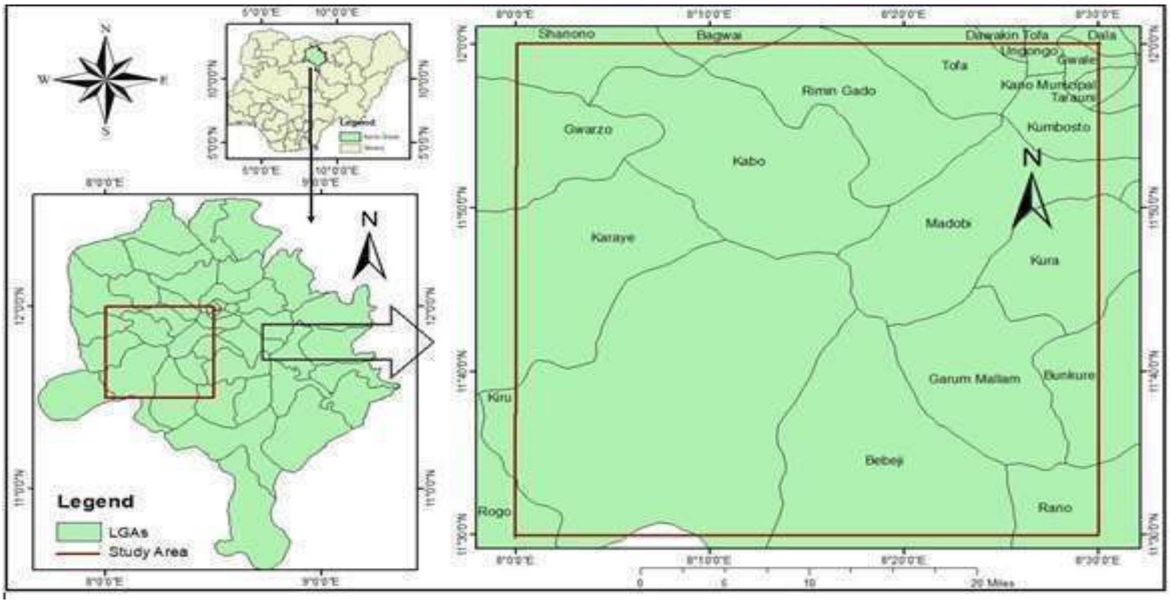

Figure 1: *Placement Map of the Study Area (Augie and Sani 2020)*

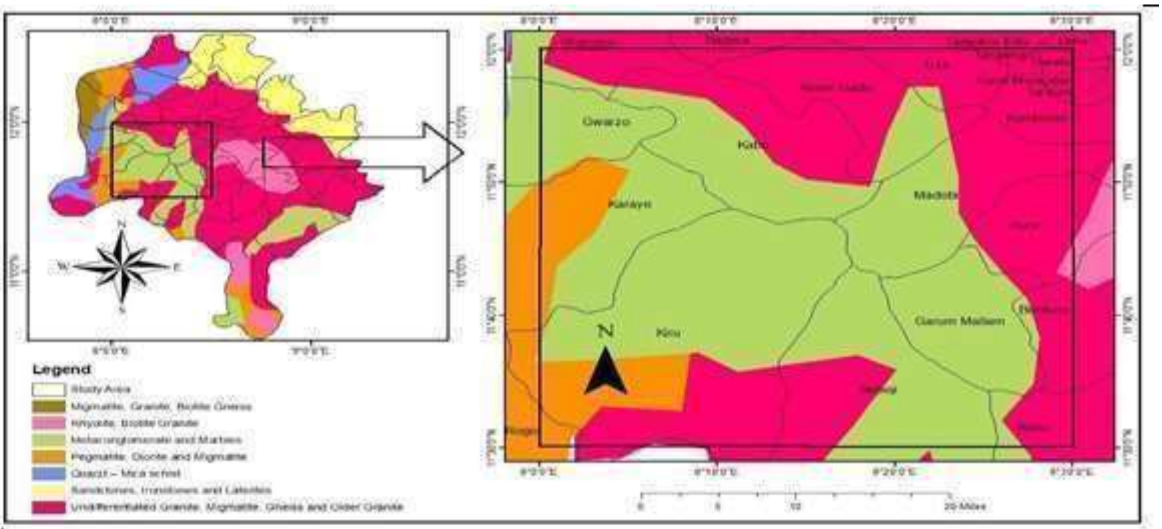

Figure 2: *Geological Map of the Research Zone (Augie and Sani 2020)*

2. MATERIALS AND METHOD

Enhanced aeromagnetic interpretation offers a viable solution to address these challenges by identifying anomalies indicative of mineralization beneath the thick sedimentary cover (Abubakar et al., 2025). The magnetic (aero) data interpreted for this research was gotten from the NGSA (Nigerian Geological Survey Agency). The information collection was part of the national aero geophysical survey program. The information possession was done by static wing airplane. Total coverage kilometers of 36,500 was surveyed. The metered parameter was magnetic gradient. The information was gotten along a series of North West – South East flight lines with a distance of 500meters and an average flight altitude of around 100 meters. Tie lines came at about 2000 meters interval in the North East – South

West (NE-SW) axis. At a rate of 0.1 sec, the magnetic information was sampled with a proton precession magnetometer. Data processing comprised of gridding the airborne data (magnetic) with the help of a plethora of software. A salient software used to process and improve the data is called the Geosoft Oasis Montaj. Another software that was used to improve the data in a variety of forms like Golden Software Surfer 10. Aero geophysical magnetic data are often used as a strong tool to assist in mineral exploration. This is done by visual observation of the map. In this research, sheet number 80 was used covering Kabo LGA its environs of Basement Complex of north western Nigeria. Filtering utilities (MAGMAP) were then used on the magnetic grids to improve the data for facile interpretation. These filters are a range of nonlinear and linear mathematical algorithm which specifically enhances the anomalies due to one set of geological source relative to anomalies due to another set of geological sources (Milligan and Gunn, 1997). TMI (Total Magnetic Intensity) and the RTE (Reduction to The Equator) were the MAGMAP filter used in enhancing the magnetic data.

3. RESULT AND DISCUSSION

The outcome from the prepared and improved magnetic data were presented in various maps. These said maps are analyzed below and various structures are then mapped from the maps.

3.1 The Total Magnetic Intensity (TMI)

In alignment with the name, the total magnetic intensity is the magnetic field that is seen in a certain region. It is an addition of the Geomagnetic field and the magnetic field gotten from magnetic bodies that are beneath the earth surface. Figure 3 is the Total Magnetic Intensity (TMI) map of the research area. As can be observed from the map, the region has a lot of structures trending North East-South West. The areas showing high magnetic intensity are in the actual sense areas with low magnetic intensities vice versa. This is termed directional noise which is noticed in low magnetic latitude areas because of the inclination of the geomagnetic field at the low latitude. This issue is rectified by reducing the total magnetic intensity to the equator. Directional noise issue if not corrected can lead to data misinterpretation, so there arose the necessity for reducing the data to the equator for facile interpretation of the results.

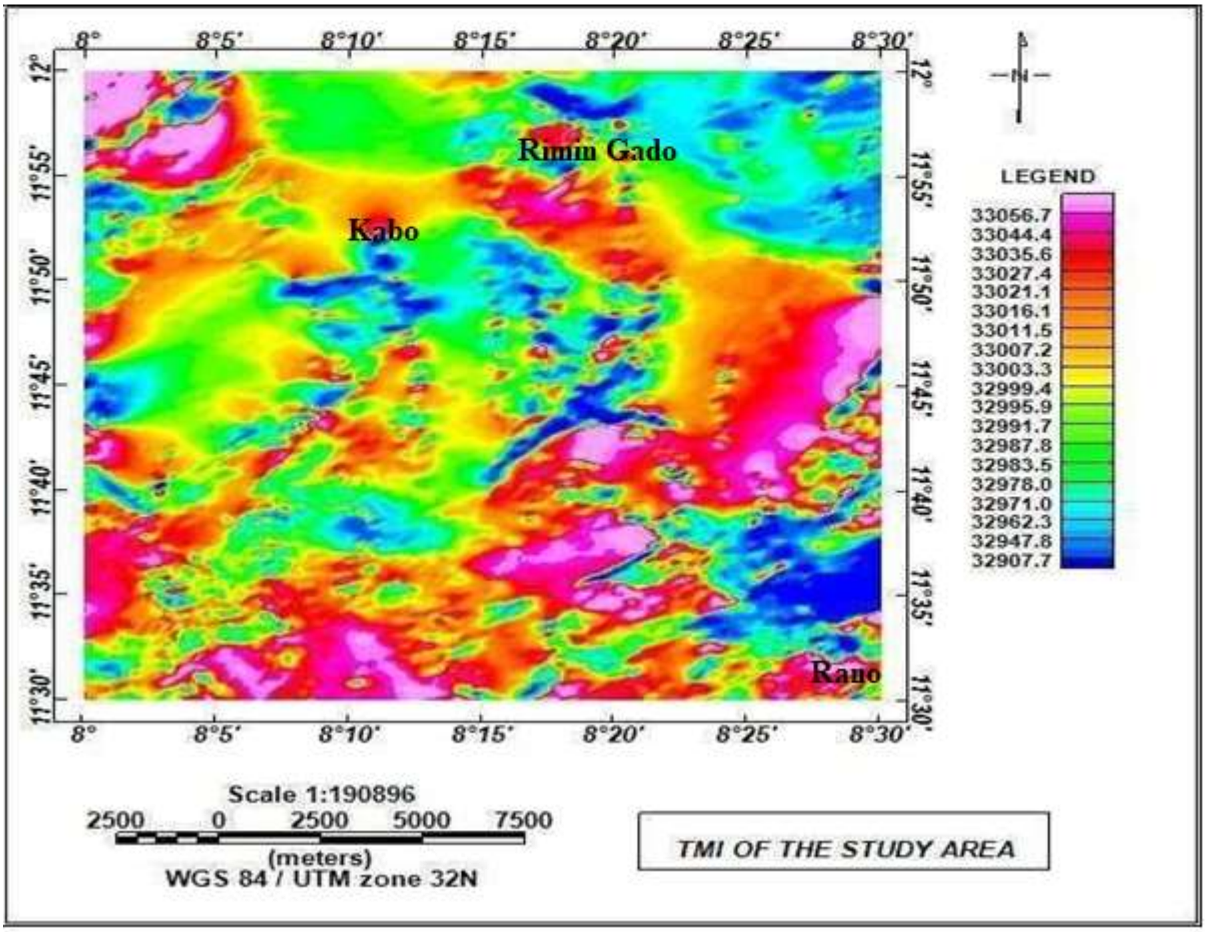

Figure 3: *The Total Magnetic Intensity (TMI) map of Kabo sheet 80*

3.2 Reduction to The Equator (RTE)

The reduction to the equator is used in low magnetic latitudes to center the peaks of magnetic anomalies over their sources. This makes the data easier to interpret while retaining its geophysical meaning. Reducing the data to the pole (REDP) does much the same thing, but at low latitudes, a separate amplitude correction is usually required to prevent North-South signal in the data from dominating the results (Okoroafor and Opara 2025). This research area lies within low inclination (low latitudes) of the magnetic equatorial zones of where Reduction to Pole (RTP) technique will not be optimal this is because the North-South structures have no noticeable induced magnetic oddity at zero geo-magnetic inclination. So therefore, the TMI map were made to undergo an enhancement from the reduction to the magnetic equator to get oddities which rely on the inclination and declination of magnetized body, the local geomagnetic field and orientation of the feature orient horizontally where some of the root magnetizations are flush (Augie and Sani 2020). The resultant composite color portraying the reduced-to-equator residual magnetic anomalies are shown in Figure 4. Regions showing high magnetic signatures are now showing low magnetic responses.

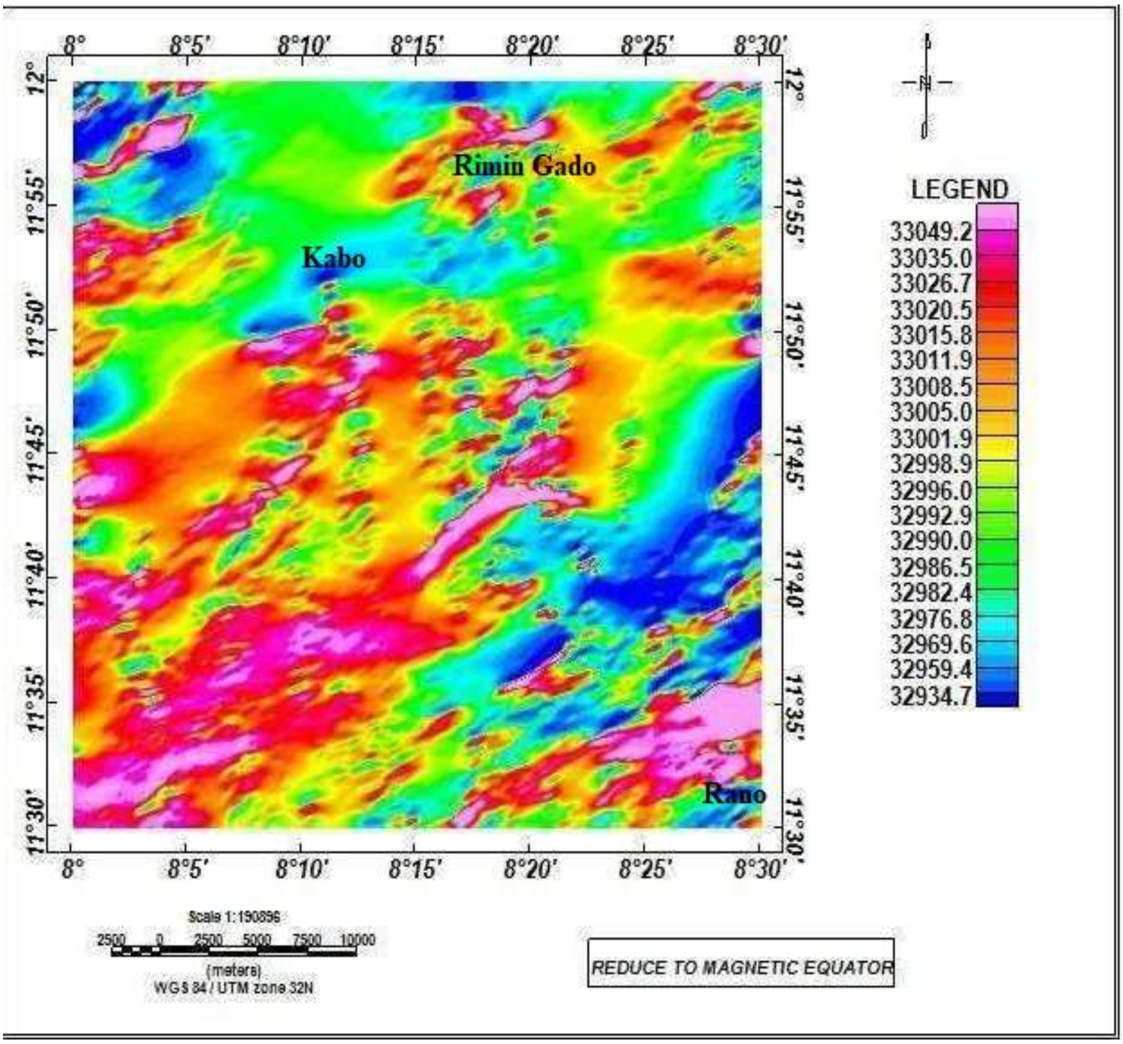

Figure 4: *Reduced to The Equator (RTE) map of TMI of Kabo sheet 80*

3.3 The Interpreted Structural Map

Generally, aero-magnetic data takes note of these magnetic signs which are employed to delineate structures/ features with their associated sequence of occurrence (Amenyoh et al., 2009). According to Nsikak and Udinmwen (2019), this area was subjected to multiple episodes of deformation and there was evidence of reworking of older structures by younger ones. Foliation, folds and dykes/vein data suggests that the metamorphic rocks in this area experienced a predominant E - W compression during the Pan - African Orogeny. Structural evidence and the presence of dominant ductile shear zones also confirm that the deformation in this region is predominantly ductile. The relatively younger granite intrusions show structural trends which are consistent with the closing periods of the Pan-African Orogeny. The TMI map (Figure 3) irrespective of the extent of magnetization, shows the apparent system of the structures prevailing in the area. Having carried out the application of the filters like reduction to the equator, numerous faults and some folds were obviously delineated. As can be observed in the magnetic maps, a structural map from the research area is gotten as seen below in Figure 5. It is observed that the research region has various structural complex attributes such as possible fractures (F1- F3), minor faults(F4-F7), folds (Fo1-Fo2) and dykes (D1 and D2) that trend in the North East (NE) - South West (SW) axis.

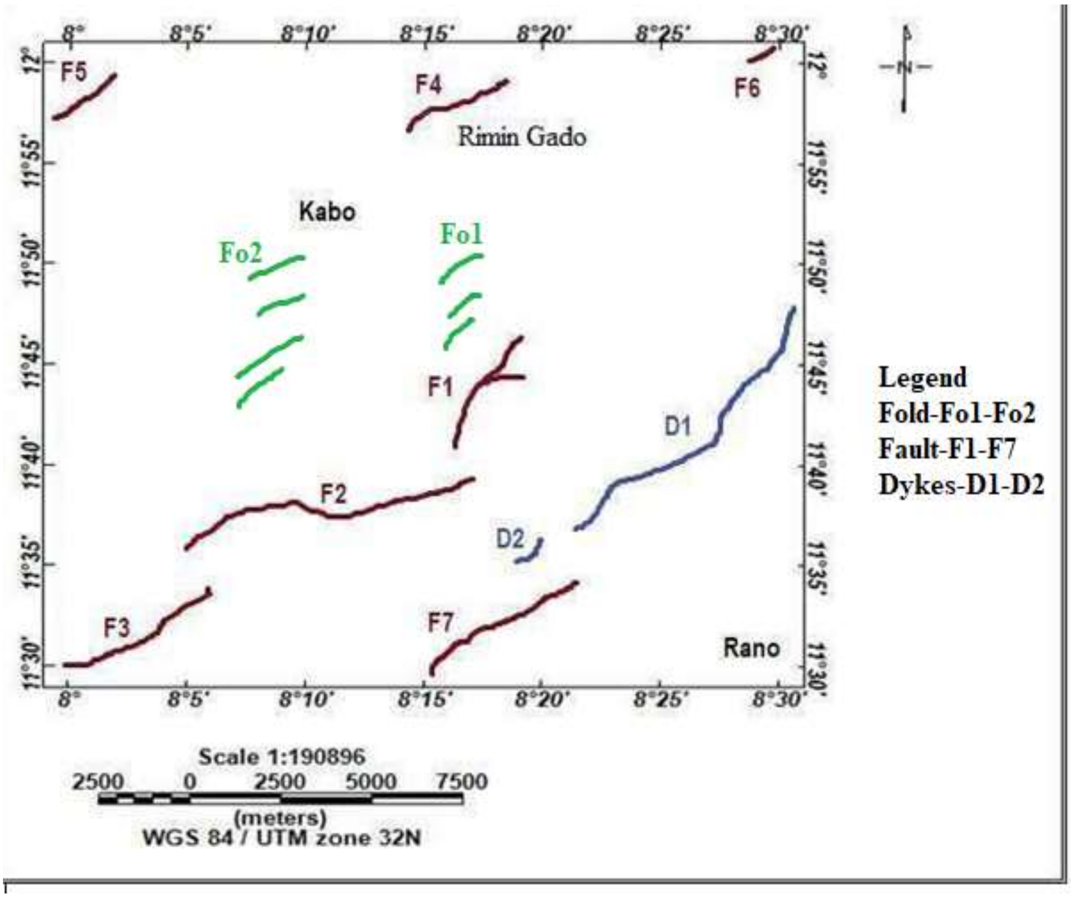

Figure 5: *The Interpreted structural map from the aero-magnetic data of Kabo sheet 80*

4. CONCLUSION

Results from Reduction to The Equator (RTE) map showed the geological structures of basement complex orient in the North East (NE) - South West (SW) axis. In this research study, results have shown that the structural characterization of an area is feasible even without the actual physical contact and visitation to the area. It is seen that the study area possesses numerous structural complex features such as minor faults (F4- F7), dykes (D1 and D2) that orient northeast and northwest, folds (Fo1-Fo2) and possible fractures(F1-F3). The regions have covered the locations of; Shanono, Southern part of Kabo, Rimin Gado, Madobi, Garum Mallam, Bunkure and Rano LGAs of Kano State. The zones show substantial magnetic anomaly.

CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

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