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GROUNDWATER POTENTIAL DELINEATION USING AEROMAGNETIC DATA WITHIN SHEET 223 ILORIN NW, SOUTH-WESTERN NIGERIA

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Abstract

The aeromagnetic interpretation of the area was carried out to assess the groundwater potential of the area. This leads to getting information about the subsurface deeper source and the presence of lineaments equivalence of fractures. The aeromagnetic airborne data was used with the software Geosoft of Oasis Montaj v.6.4.2 using the convolution of *Fourier transformation* to obtain magnetic intensities of the area. The Total Magnetic Intensity (TMI) reveals three main types of magnetic anomalies ranging in intensity from -102.68 to 101.40 nT and classified into high, moderate, and low amplitude anomalies. The Regional Magnetic Intensity (RMI) ranges in magnitude from -18.55 to 82.35 nT, the residual magnetic field intensity ranges in intensity from -35.87 to 35.74 nT, Reduction to the equator (RTE) residual magnetic field intensity exhibits values ranging from -99.3395 to 74.7526 nT and the tilt derivative anomalies range from -1.3624 to 1.3634 nT/m. The high magnetic anomalous areas are dominantly found in the fine-grained granite zone; indicating high groundwater potential. The regional structure of the area trends along the NW-SE direction, which conforms to the general structural trends existing in the Basement Complex of Nigeria.

Keywords: Aeromagnetic, delineation, groundwater potential, subsurface deeper source

Introduction

Water is available in many forms such as ice caps, glaciers, ocean water groundwater, etc. Groundwater happens to be a more reliable source of water for over half of the world's population (Alabi *et al.,* 2010, Anomoharan, 2011).

Lineaments that are equivalent to geologic fractures are the main targets for groundwater potential zones in crystalline basement terrain. The magnetic method as a geophysical method gives information about subsurface deeper sources by indicating the high and low magnetic intensity areas and also shows the presence of lineaments; equivalence of fractures for groundwater potential. Researchers such as Adetona *et al* (2007), Labbo and Ugodulunwa (2007), Nwankwo (2015), and Kamba *et al.*, 2016 have all used magnetic methods to delineate groundwater potential zones in different locations.

The study area is a sub-urban settlement within the Basement Complex of southwestern Nigeria. The

area was bounded between latitude 8^0 15' and 8^0 25' and between longitude 4^0 30' and $4^0$37.5' covering an area of 72 km^2(Fig. 1). Locally, the geology of the area consists of migmatite gneiss, porphyroclastic gneiss, banded gneiss, augen gneiss, granite gneiss, quartz mica schist, and fine-grained granite. The area is of a dissected topography, lies within the humid tropical climate with a total annual rainfall of about 1200 mm, and has a dendritic drainage pattern.

Information about groundwater exploration especially at the subsurface deeper source can best be known through the magnetic method which indicates groundwater potential zones accurately. This study aimed to assess the subsurface geology and the associated structures such as lineament, believed to be major determinants and controllers of the groundwater occurrence, quantity, and flow in the area. This is accomplished through the use of part of high-resolution aeromagnetic data (Sheet 223 Ilorin NW) acquired by the Nigeria Geological Survey Agency (NGSA 2007).

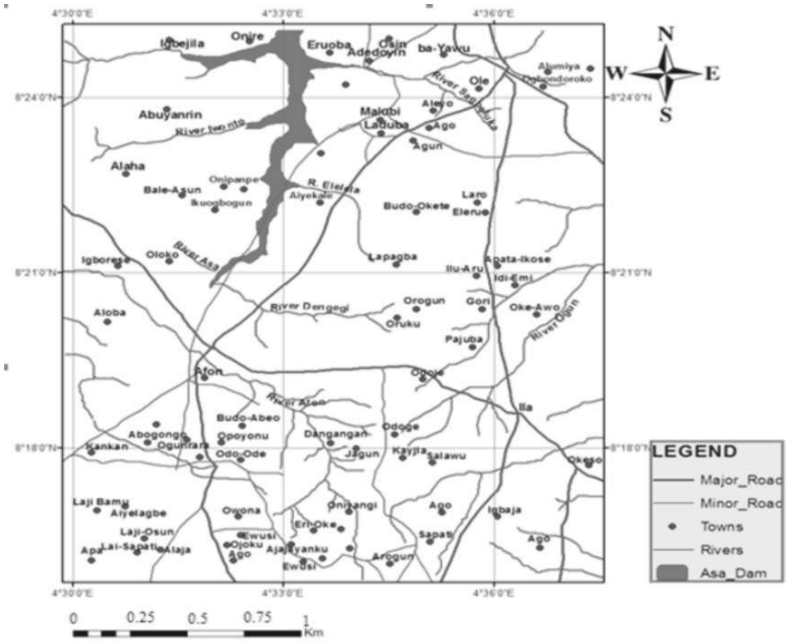


Figure 1: Topographical map of the study area showing its drainage pattern

Materials and Methods

The total-field high resolution digital aeromagnetic airborne data used in this study were acquired from the Nigerian Geological Survey Agency (NGSA), Abuja. The aeromagnetic data set was acquired as part of a nationwide aeromagnetic survey

conducted in two phases by Fugro Airborne Surveys. Phase I data set was acquired in 2007 while Phase II data were acquired from 2007 to 2009. The data set were acquired along with a series of NW – SE flight lines with a line spacing of 500 m and an average of 80m terrain clearance.

Regional-residual separation was made from the total magnetic field using polynomial fitting. In this method, the fitting is based on the statistical theory since the observed data are computed by the least square method to obtain a surface that has the closest fit to the magnetic field. This surface is considered to be the regional field while the residual is the difference between the magnetic field value obtained in the field and the regional field value computed.RTE was applied to transform the anomaly of non-zero inclination into an anomaly that would be observed on the same body with zero inclination. The RTE is mathematically expressed as:

$$RTE = \sin I + i \cos I \sin (D - \theta)^2 \quad 1$$

Where '*I*' is geomagnetic inclination also called Dip, '*D*' is geomagnetic declination, sin *I* is the amplitude component, and $i \cos I \sin (D - \theta)^2$ is the phase component. The tilt angle derivative filter is one of the edge-detection filters normally applied for delineating linear features without necessarily diminishing the long-wavelength anomalies (Salem *et al.,* 2008).

Results

The Total Magnetic Intensity (TMI) anomaly reveals three main types of magnetic anomalies ranging in intensity from -102.68 to 101.40 nT which are depicted in pink, red, yellow, green, and blue colors (Fig. 2). The Regional Magnetic Intensity (RMI) has a magnitude that ranges from -18.55 to 82.35 nT (Fig. 3). The Residual Magnetic Intensity (RMI) ranges in intensity from -35.87 to 35.74 nT and is depicted in red, pink, yellow, green and blue colours (Fig. 4). Reduction to Equator (RTE) residual magnetic field intensity exhibits negative and positive values ranging from -99.3395 to 74.7526 nT shown in red, pink, yellow, green, and blue colours (Fig. 5). The wavelength anomalies of the tilt derivative are circular and elliptical ranging in intensity from -1.3624 to 1.3634 nT/m and depicted in pink, red, yellow, green, and blue colours (Fig. 6a) while the inferred tilt derivative of the area is in Fig. 6b.

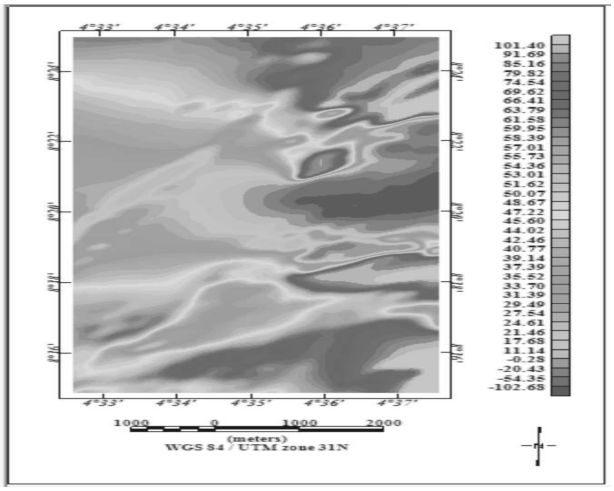


Figure 2: Total Magnetic Intensity Anomaly map

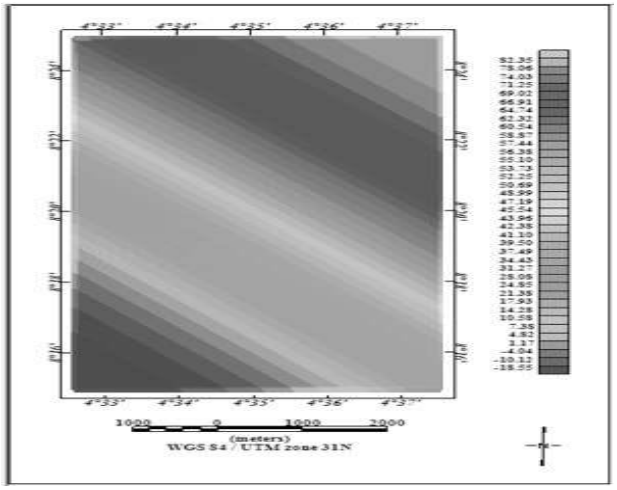


Figure 3: Regional Magnetic Intensity Anomaly map

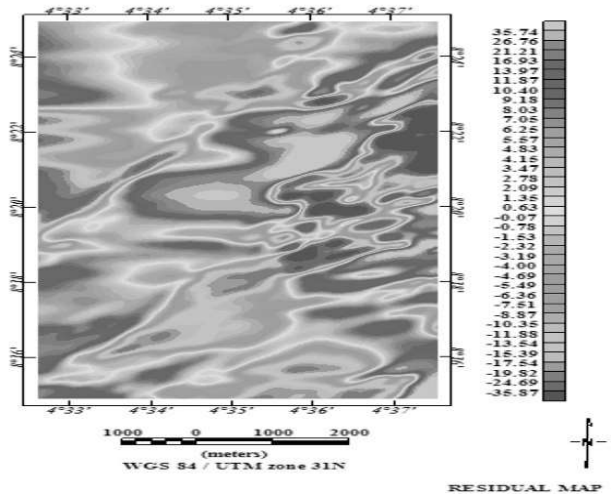


Figure 4: Residual Magnetic Intensity (RMI) map

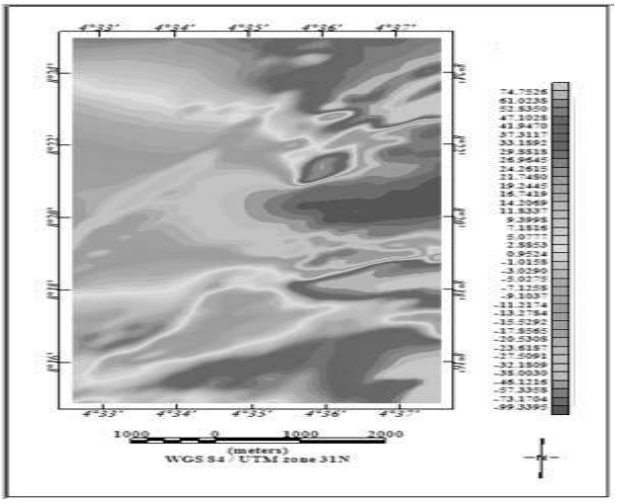


Figure 5: Reduction to Equator map

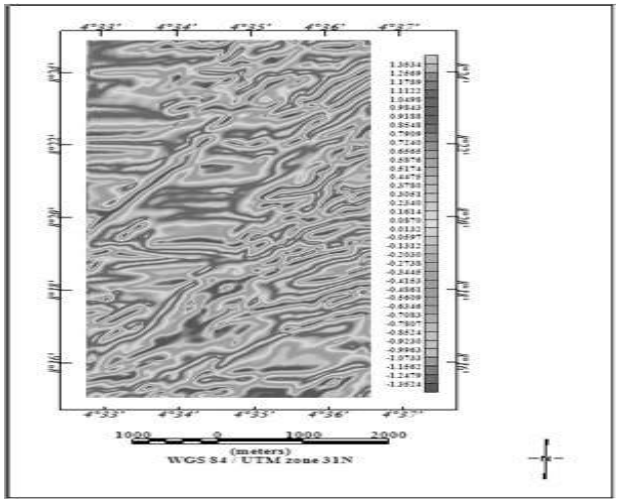


Figure 6a: Tilt Angle Derivative Map of the study area

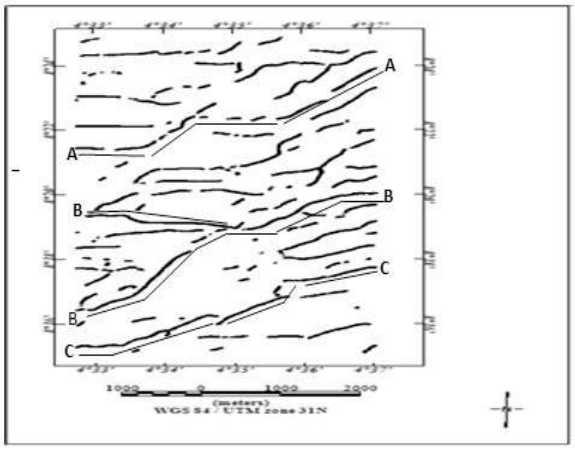


Figure 6b: Inferred Tilt Derivative Map of the Study Area

Discussion

The Total Magnetic Intensity anomalies were classified into high, moderate, and low amplitude anomalies. The high amplitude total-field magnetic anomalies associated with intensity between 54.36 to 101.40 nT, which are shown in pink and red colours, occupied predominant portions of the northern, north-eastern, southern, southwestern, and southeastern of the study area (Figure 2). The portions comprise settlements like Eru-Oba, Alaha, Alomilaya, Ewusi, Kankan, and Okeso respectively in the Augen gneiss, porphyroclastic gneiss, and fine-grained granite zones. The moderate amplitude magnetic anomalies range in values from 24.61 to 54.36 nT and are shown in yellow and green colours. These are predominant in the western part around Aloba and Igborese areas occupied by quartz-mica schist. Also, Parts of the south-western and south-eastern portions of the area were occupied by yellow and green colours. These areas include Odo-Ode and Ila-Oja with Banded and porphyroclastic gneisses respectively. The prominent low amplitude anomalies ranging in intensity from -102.68 to 24.61nT are shown in blue colour. The blue colour is found extending from the eastern part around Oke-Awo, Pajuba, and Apata-Ikose to some western parts which include Oloko and Dangagi of the study area in the quartz-mica schist zone.

Figure 3 shows the contour map representing the estimated regional magnetic field intensities over the study area. The map shows a uniform trend along the NW-SE direction, which conforms to the global structural trend existing in the Basement Complex of Nigeria, as reported by McCurry (1976), Oluyide (1988), and Oyawoye (1964).

Residual Magnetic Intensity (RMI) represents the responses due to the bodies of interest in the study area. The residual magnetic Intensity map (Figure 4) shows the colour shades of the residual magnetic field intensity over the study area ranging from -35.87 to 35.74 nT and depicted in red, pink, yellow, green, and blue colours The positive residual intensities range from 0.63 to 35.74 nT with the high amplitudes ranging between 4.16 and 35.74 nT and depicted in pink and red colours while the low positive amplitude ranges from 0.63 to 4.16 nT and depicted in yellow colour in the porphyroclastic gneiss, banded gneiss, and fine-grained granite terrain. The negative residual intensities are ranging between –35.87 and -0.07 nT in the Augen and fine-grained granite regions. The high negative amplitudes are depicted in green colour ranging in intensity from -8.87 and -0.78 nT while the low negative amplitudes ranging between –35.87 and -8.87 nT are depicted in blue colour. The high positive

amplitude anomalies are found in the north-eastern (around Alomilaya, Gbagede, and Ogbondoroko) and southwestern(around Kankan, Abogongo, and Laji Bamu) parts while the low positive amplitude is widespread throughout the study area. Similarly, the high negative amplitude anomalies are widespread throughout the study area with dominance in the half northern region. Finally, the very low negative anomalies are dominant in the eastern and western regions.

The colour shaded map of the RTE residual magnetic field intensity (Figure 5) exhibits negative and positive values ranging from -99.3395 to 74.7526 nT shown in red, pink, yellow, green, and blue colours in the gneissic and granitic regions. The positive RTE is broadly characterized by intensities ranging from 0.9524 to 74.7526 nT with a high amplitude ranging from 14.2069 to 74.7526 nT and depicted in red and pink colours. The intermediate positive value is shown in yellow colour with the range between 0.9524 and 14.2069 nT and the negative RTE intensities range between -99.3395 and -1.0155 nT with the high amplitude ranging from -20.5305 to -1.0155 nT and depicted in green colour while the low negative amplitudes are ranging between -99.3395 to -20.5305 nT and depicted in blue colour. The high prominent negative amplitude anomalies, shown in green colour, are widespread throughout the study area with dominance in the half western region while the very low amplitude negative anomalies displayed in blue colour with circular and elongated shapes are dominant in the half eastern region.

The wavelength anomalies of tilt derivative are circular and elliptical ranging from -1.3624 to 1.3634 nT/m and depicted in pink, red, yellow, green, and blue colours (Figure 6). The high positive gradient TDR anomalies which are prevalent throughout the study area are depicted in pink and red colours. The intensities of these anomalies vary between 0.4478 and 1.3634nT/m and are predominantly linear in shape.

The low positive TDR values shown in the yellow colour range between 0.0292 and 0.4478 nT/m are depicted as the boundary separating the high positive and negative TDR gradient values. As the high positive gradient TDR values reflect magnetic sources, the low positive TDR intensities which are close to zero were interpreted to reflect geologic boundaries.

Conclusion

The rate of magnetization of a material depends on the length of its wavelength; the longer the wavelength of the anomalies, the higher the rate of

magnetization because the longer wavelength shows greater amplitude. The regional field increases in magnitude from the northern to the southern portion of the study area. The short-wavelength anomalies of Residual |Magnetic Intensity suggest near-surface magnetized intrusions while the long wavelength suggests deep-seated bodies typical of areas associated with thick sediments. The magnetic survey of geophysical methods adopted revealed that the general trend of rocks in the area is NNW-SSE which conforms to the global structural trend existing in the Basement Complex of Nigeria, reported by Oyawoye 1964.

The work confirmed, in addition to a series of minors, the occurrence of 3 major lineaments; the first spans from NW to NE, the second is oriented in the W-NE direction and the third one extends from SW to SE. Moreover, a high percentage of lineament, equivalent to the subsurface fractures, is concentrated in the southern part of the area. So, the presence of high subsurface fractures, which are considered to enhance the porosity that hosts groundwater, serves as a clue for the high potential in the southern part of the area. Also, the orientations of the major fractures, pointing to the southeastern flank, confirm that the underground water flow is structurally controlled towards the southern part.

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