Search For Solid Minerals in Some Parts of Nigeria Using Gravity Method

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DOI: https://doi.org/10.51584/IJRIAS.2025.100700054

Received: 10 June 2025; Accepted: 16 June 2025; Published: 07 August 2025

ABSTRACT

In this study, gravity method have been used in prospecting for solid minerals in Lafia and Akiri parts of Nigeria. The gravity data were acquired from Nigerian Geological Survey Agency (NGSA), the data were grided, separated into regional and residual fields. The residual field ranges from - 30.5 to 27.7 mGal. First and second vertical derivatives and horizontal derivative were applied to the residual field data, which helped in locating the boundaries of the anomalous bodies and faults respectively. From the forward and inverse modeling method, it was observed that Lafia has limestone that is seated at about 2943 m with density of 2.55 g/cm^3 and granite with a density of 2.63 g/cm^3 at the depth of 1156 m, while Akiri parts showed abnormal response to forward and inverse modeling which could be due to either inconsistency in the data or the minerals in the area are more susceptible to magnetic field.

Key words: Bouguer anomaly, Derivatives, gravitational field and minerals

INTRODUCTION

The search for solid minerals in Nigeria has gained significant attention in recent years due to the country's vast mineral potential and the need to diversify its economy. Among the various geophysical methods employed in mineral exploration, the gravity technique has proven effective in identifying subsurface mineral deposits (Oladunjoye et al., 2020). In Nigeria, the gravity method has been successfully applied in several regions, including the Jos Plateau and the Benue Trough (Adeleye et al., 2019). This method involves measuring the gravitational attraction of the Earth's mass to identify variations in density, which can indicate the presence of mineral deposits (Telford et al., 1990). By leveraging the gravity method, researchers and mining companies can efficiently identify areas with potential for mineralization, reducing the need for costly and time-consuming drilling and excavation (Reynolds, 2011). Recent studies have demonstrated the efficacy of the gravity method in detecting mineral deposits, such as iron ore and gold, in various parts of Nigeria (Ehirim et al., 2022; Nwankwo et al., 2020). This paper aims to explore the application of the gravity method in searching for solid minerals in specific parts of Nigeria, highlighting its effectiveness and potential for future mineral exploration.

Geology of the Study Area

Lafia and Akiri are located in the central and southeastern parts of Nigeria, respectively (Latitude: 8.2°N to Latitude: 8.5°N and Longitude: 8.5°E to Longitude: 8.7°E). Geologically, both areas fall within the Precambrian Basement Complex of Nigeria (Obaje, 2009).

The Precambrian Basement Complex in Lafia and Akiri comprises migmatites, gneisses, and schists, which were formed during the Pan-African orogeny (ca. 600-500 Ma) (Rahaman et al., 1983). These rocks were subjected to high-grade metamorphism, resulting in the formation of complex structural patterns (Furnes et al., 2006).

In Lafia, the dominant rock types are quartzites, phyllites, and schists, which are intruded by pegmatites and granites (Ekwueme, 2003). Akiri, on the other hand, is characterized by gneisses, migmatites, and amphibolites, with minor occurrences of quartzites and schists (Adekoya, 2003).

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume X Issue VII July 2025

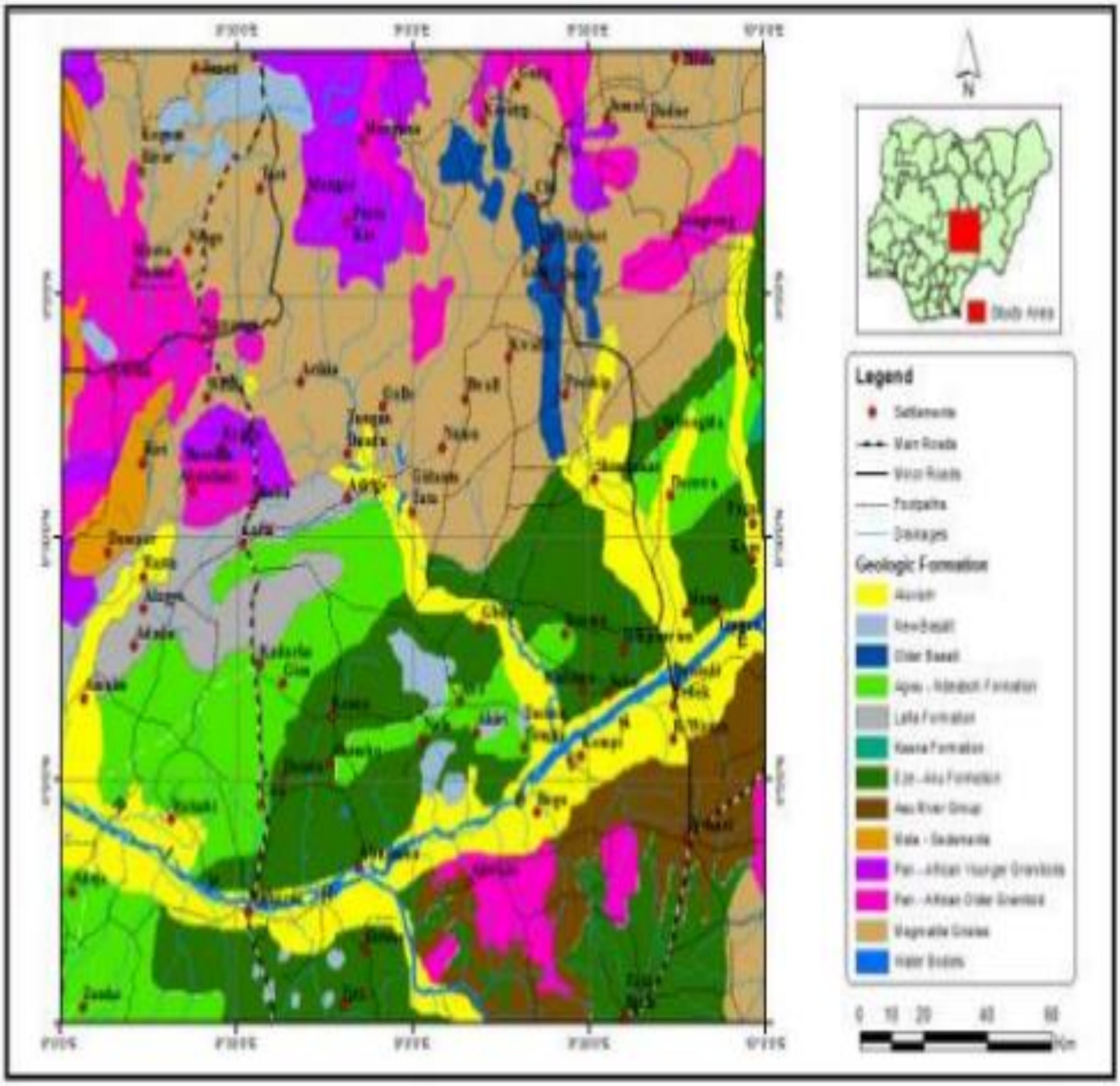

Fig. 1: Geologic map of Nasarawa State showing Lafia and Akiri (Adapted from Ayuba and Nur 2019).

METHODS OF DATA ANALYSIS

The data for this work were provided by the Nigerian Geological Survey Agency (NGSA) of Nigeria in digitize format xyz, where x represents latitude in metres, y represents longitude in metres and z Bouguer anomaly in mGal. The data were acquired by a gravimeter onboard aircraft flown at a speed of 50 to 100 km/hr and 80 m elevation along flight lines spaced 500 m apart. The flight line direction was 135° while the tie line direction was 225°. The data were processed and digitised in xzy format before releasing to the authors.

The following processing methods were applied to the data to further enhance it for interpretation; griding, polynomial fitting, derivative and forward and inverse modeling methods.

Griding is an interpolation process that helps in estimating the values of intermediate points between data points that were not occupied during survey. Polynomial fitting is a mathematical function that separates regional field from potential field anomaly to produce residual field. Derivative methods help to clarify the boundaries of the anomalies. Forward and inverse modeling is applied in estimating the quantitative properties of the anomalous body; such as depth, density etc.

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RESULTS AND DISCUSSION

Figure 2 shows the result of the Bouguer anomaly which ranges from about -66.0 to 28.4 mGal.

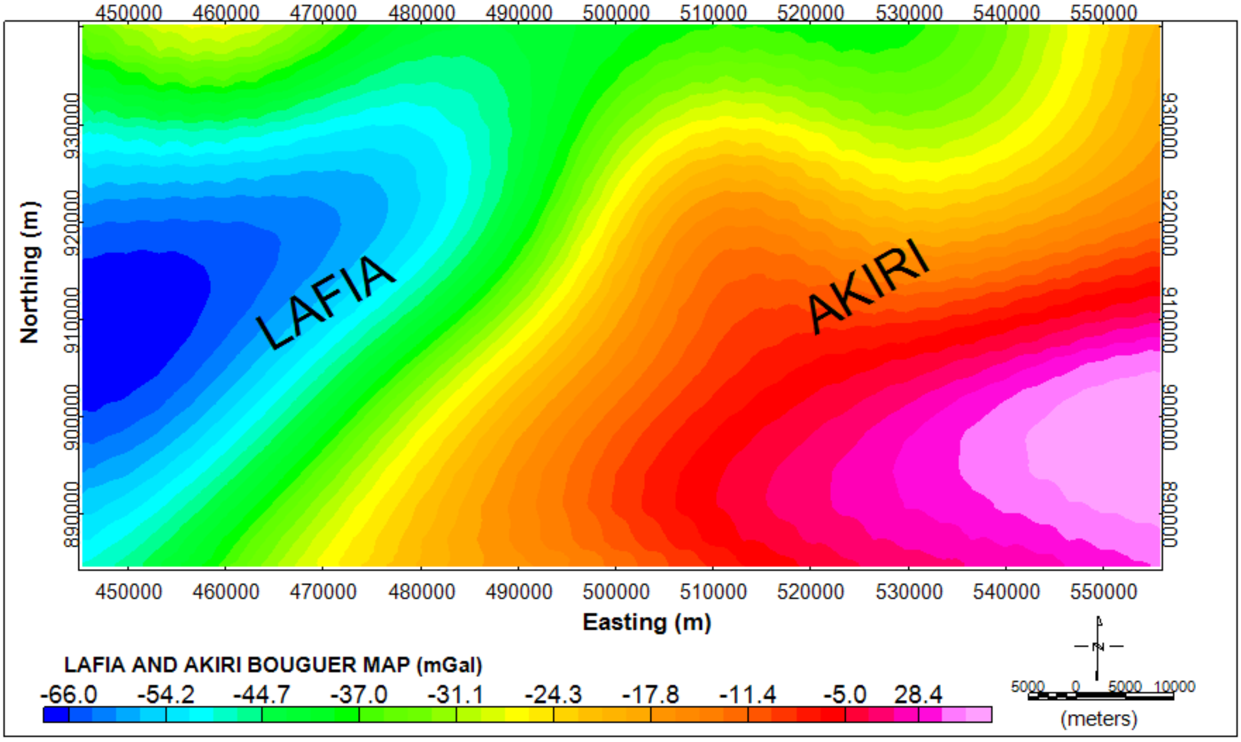

Fig. 2: Bouguer gravity map of the study area.

Residual and Regional Bouguer Gravity Map

The residual Bouguer anomaly of the study area varies from -30.5 mGal to 27.7 mGal (Fig. 3). The colour legend bar identifies regions of gravity high (red and pinks) which corresponds to region with high density contrast beneath the surface; intermediate values (green and yellow) and gravity lows (blue colour) that correspond to regions of low density contrast. Figure 4.3 is the regional Bouguer anomaly map. The values range from -41.9 mGal to -15.0 mGal.

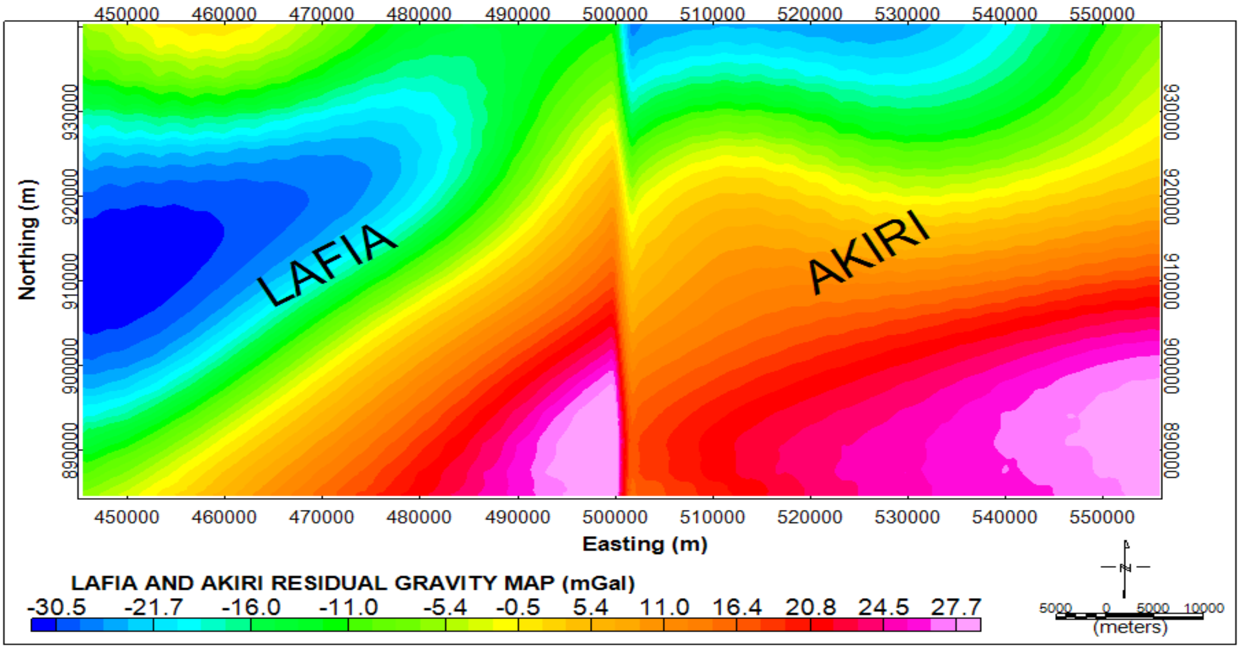

Fig. 3: Residual gravity map of the study area

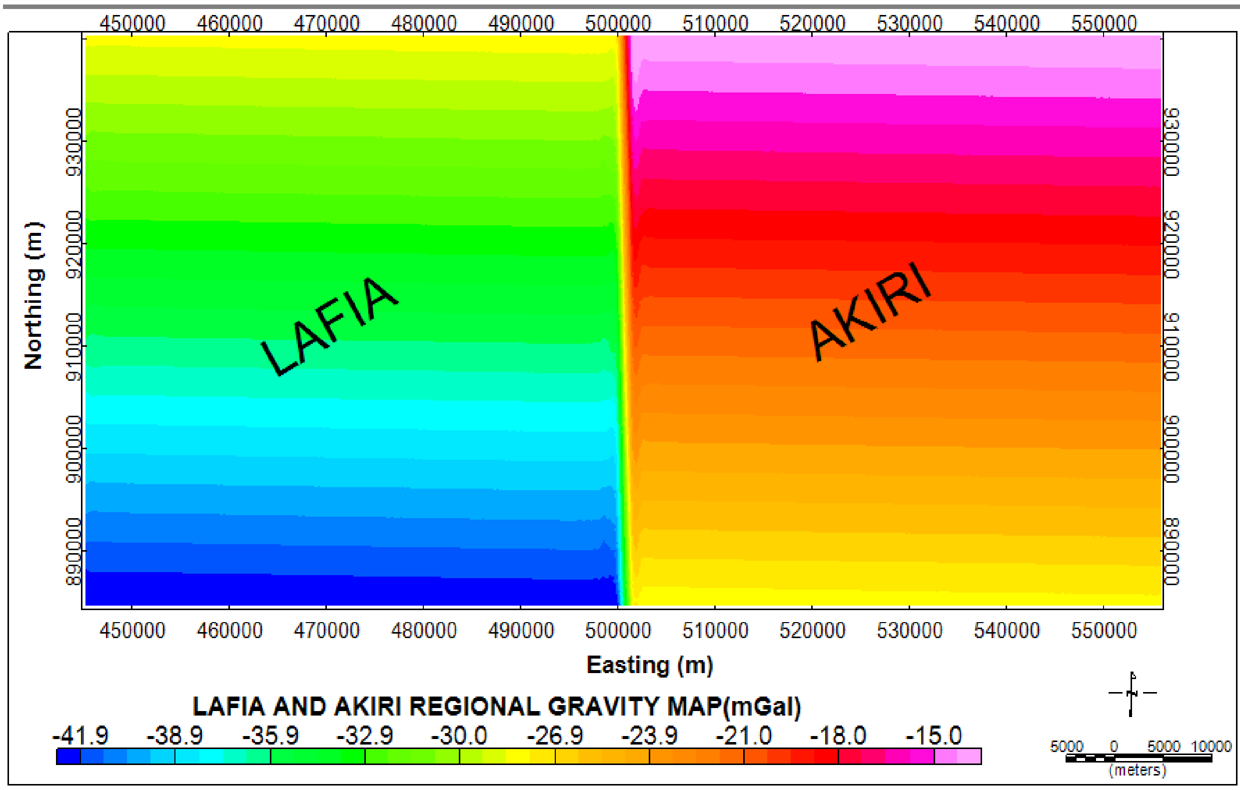

Fig. 4: Regional Gravity Map of the study area

DERIVATIVES

The first vertical derivative computed on the residual data of the study area enhanced the shallow sources by suppressing the effect of the deeper ones, this helped to reveal near surface intrusions in (Figure 5). The second derivative sharpens the effect of the first vertical derivatives and helps to determine the edge of the anomalous body in (Figure 6). The horizontal derivative shows more exact location for faults in (Figure 7).

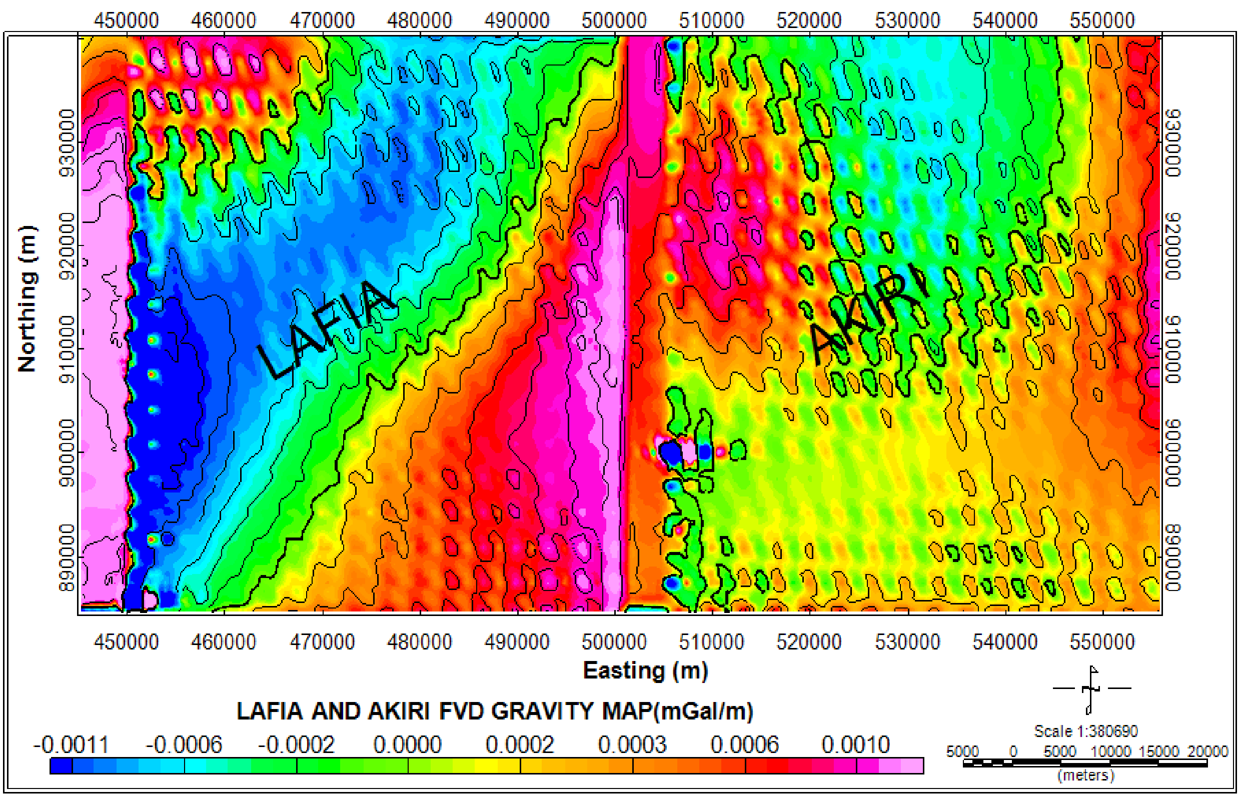

Fig. 5: Aerogravity First Vertical Derivative (FVD)

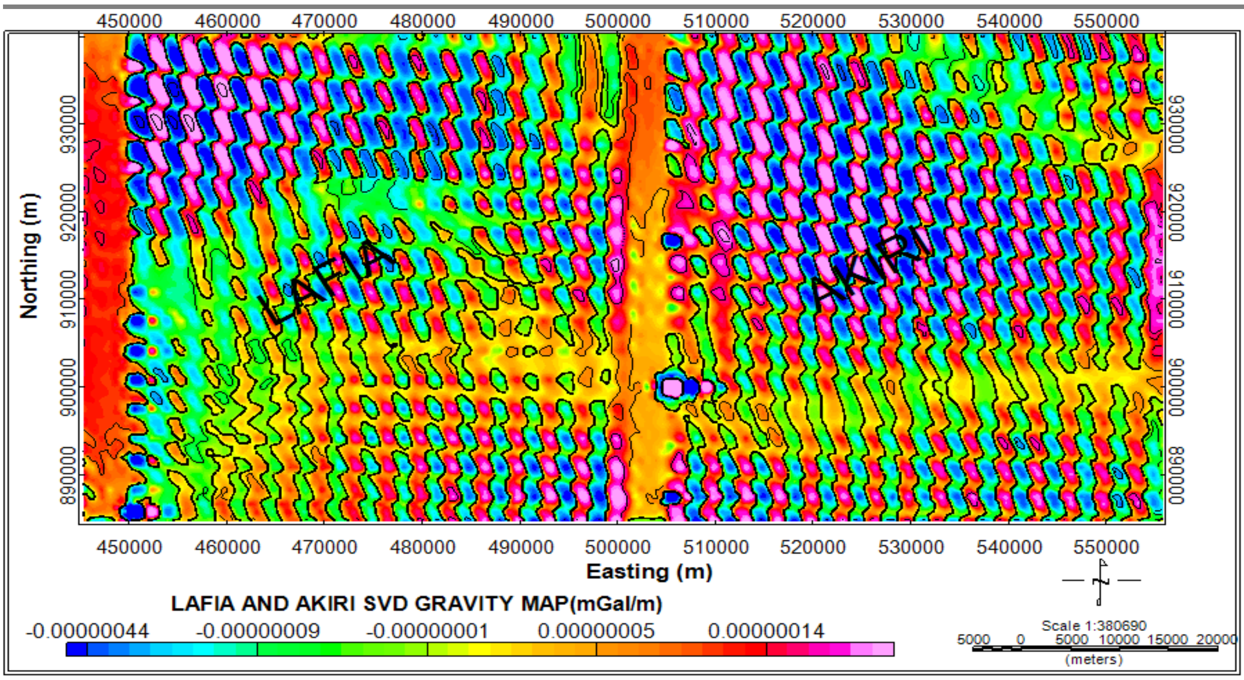

Fig. 6: Aerogravity Second Vertical Derivative (SVD)

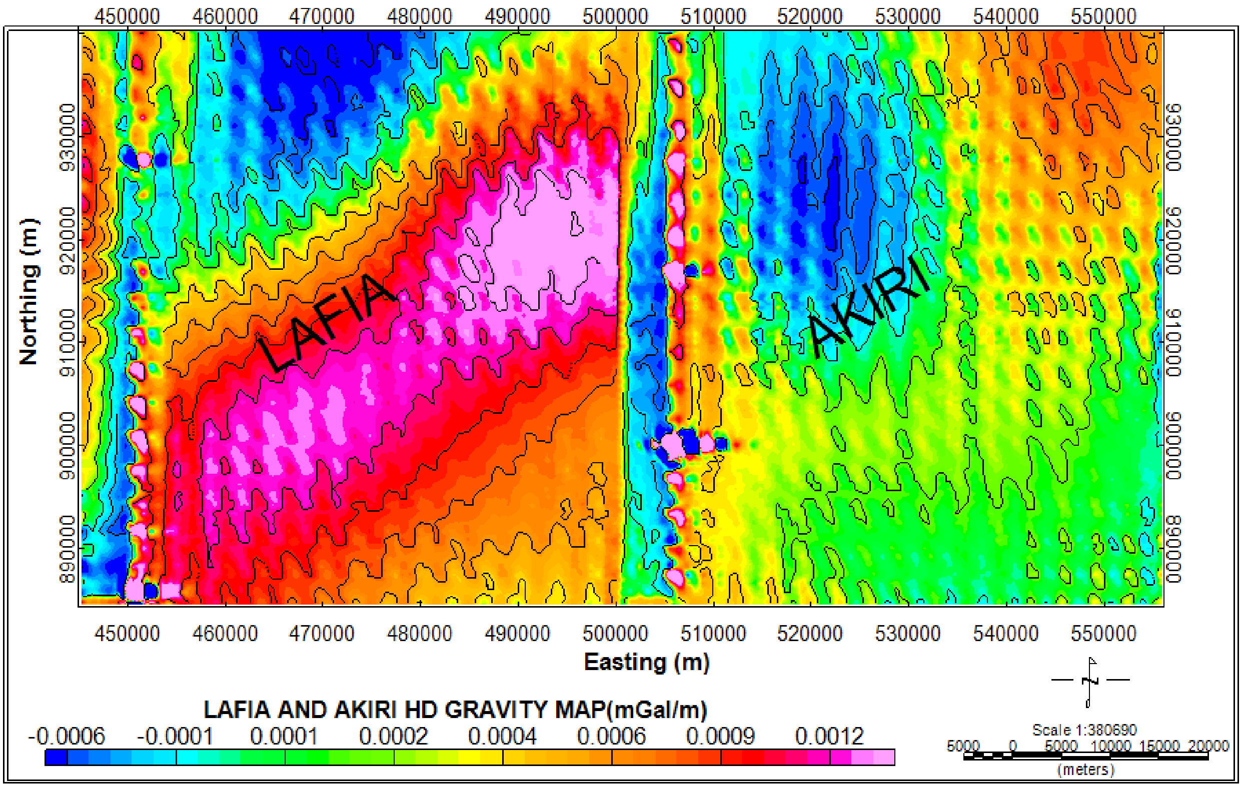

Fig. 7: Aerogravity horizontal derivative (HD)

Forward and Inverse Modelling Results

Three profiles were taken from the aerogravity residual grid (Figure 8) of the study area. Profile 1 and 2 were modeled while profile 3 could not be modeled may be due to no enclosed contour. The modeled parameters are shown in Figure 9(a - c). The results of the forward and inverse modeling are summarized in Table 1. The result from the forward and inverse modeling analysis of the aerogravity data shows that the density values obtained from the modeled profiles 1 - 2 are 2.550 and 2.630 g/cm^3 respectively, with respective depths of -2943 and -1156 m. These density values indicate the presence of rock bearing minerals like Granite and limestone in the study area.

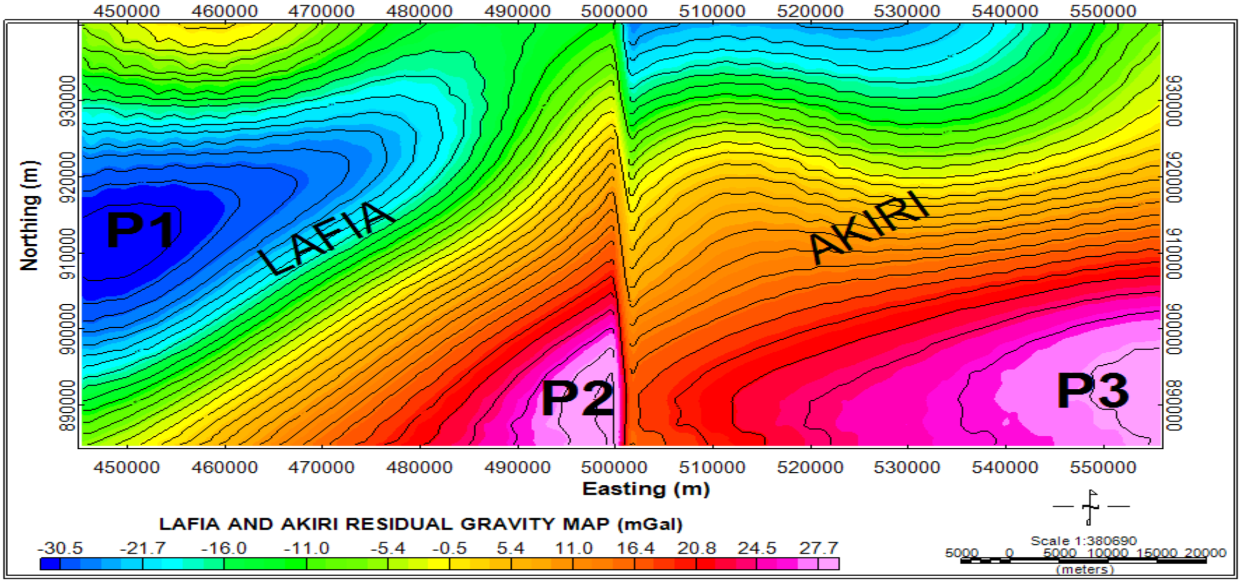

Figure 8: Residual grid of the study area

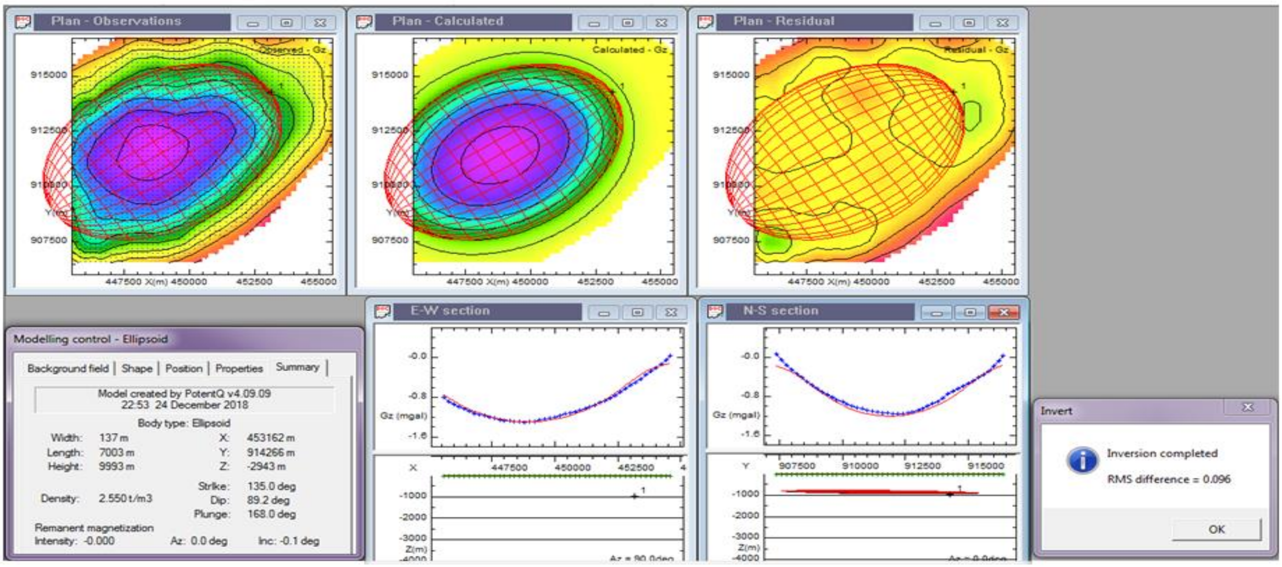

Figure 9a: Profile 1 (P1) modeled

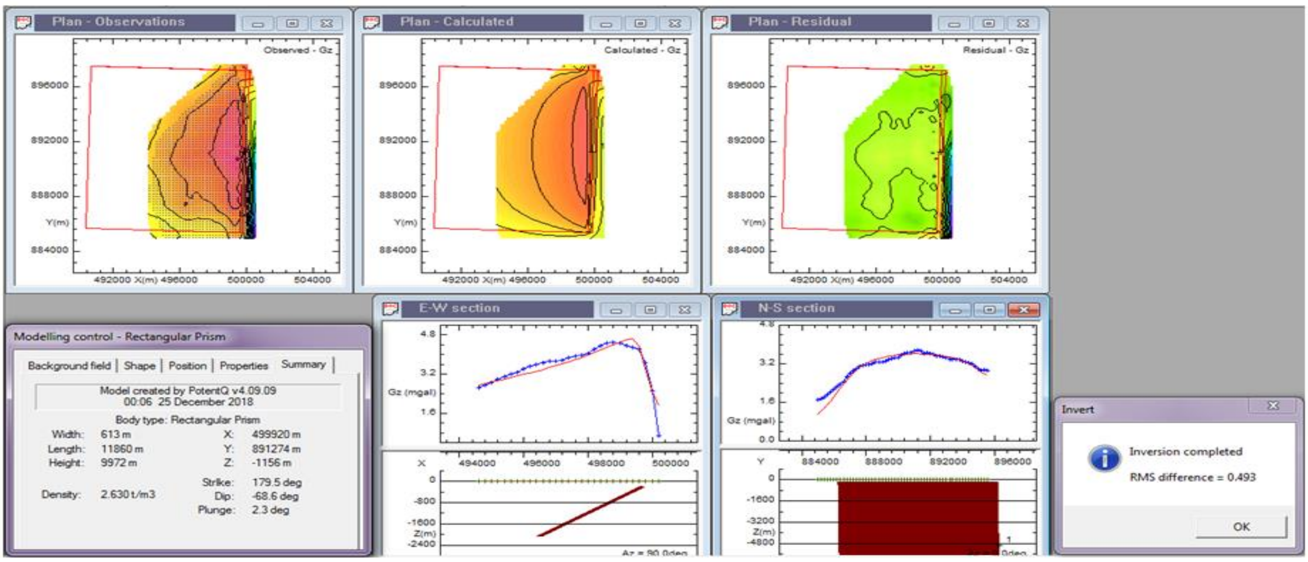

Figure 9b: Profile 2 (P2) modeled

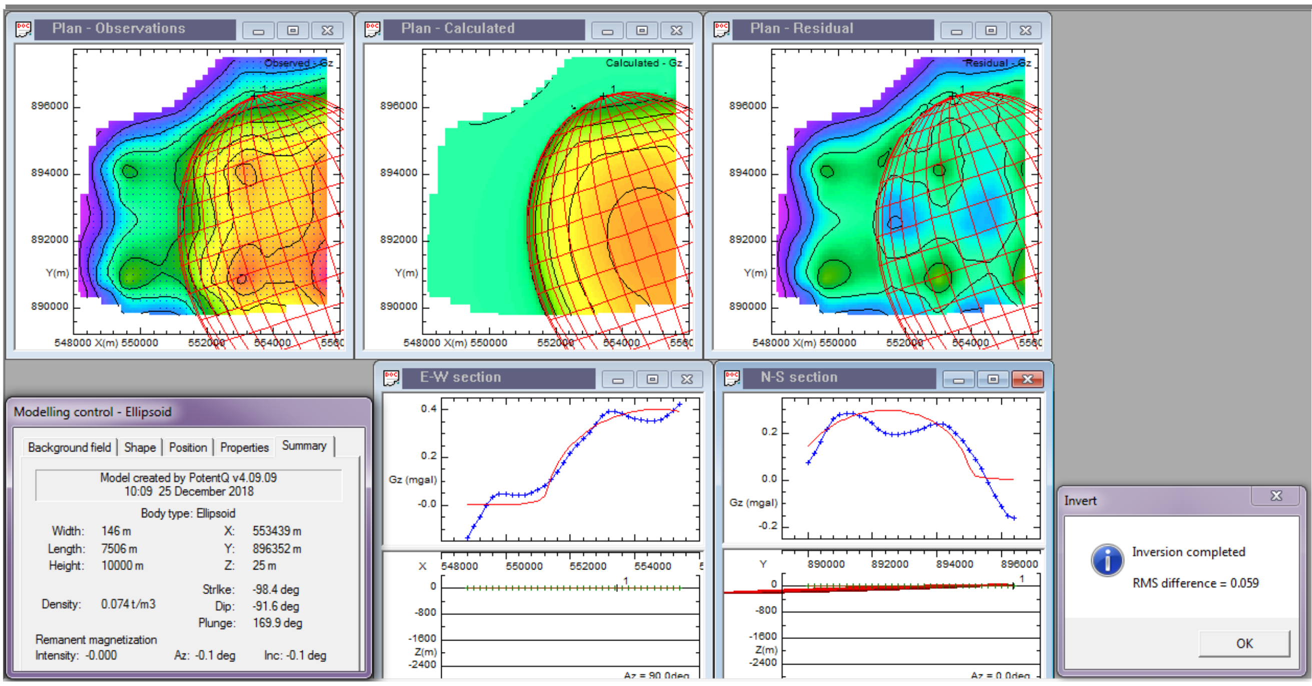

Figure 9c. Profile 3 (P3) modeled

Table 1: Summary of Aerogravity Forward and Inverse modeling results

Model	Model shape	X(m)	Y(m)	Depth to anomalous body (m)	Plunge(deg)	Dip (deg)	Strike (deg)	Density value (g/cm^3)	Possible cause of anomaly
P1	Ellipsoid	453162	914266	-2943	168.0	89.2	135.0	2.550	Limestone
P2	Rectangular Prism	499920	891274	-1156	2.3	-68.6	179.5	2.630	Granite
P3	Ellipsoid	553439	896352	25	169.9	-91.6	-98.4	0.074	-

CONCLUSION

The study has been able to demonstrate that gravity survey method used usually as a recognizance method in most exploration is capable of mapping mineralization. The results of this work show that Lafia region has potential to sustain some industries if sited in the region. The mineralization trends and deposits are characterized by various minerals, particularly: Limestone: Deposits of limestone are prevalent, which is essential for cement production. Granite and Feldspar: There are sizeable granite deposits, along with feldspar, utilized in glass and ceramics. The mineralization in Lafia follows the larger geological trends of the Benue Trough and the Nigerian Middle Belt. Lafia's mineral deposits are vital for both local and national economic development, covering a range of industrial applications. Continued exploration and sustainable development practices are essential to optimize these resources.

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