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Geomagnetic Assessment of the Igbebi Marble Deposit (Nigeria)

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Abstract

The Magnetic Intensity data of aeromagnetic survey, as conducted by Nigerian Geological Survey Agency, were acquired from sheets 200 and 201 for qualitative and quantitative interpretation purposes. The area is bounded by latitudes 8.5°N–9.0°N and longitudes 3.5°E–4.5°E covering an area of about 6150.50 km². The data were reduced off the regional field to obtain the residual field. Upward continuation and analytical signal were employed for qualitative interpretations. In addition to Euler and Werner Deconvolutions, spectral depth analyses were carried out to estimate the depth to causative geologic structures and basement of the target marble deposit. The residual field contour shows an intensity ranging from –63.05 to 52.65 nT, indicating series of magnetic highs and lows. The obtained positive residual anomalies could stand as responses to the outcrops common in the area, while the negative field could be associated with the presence of granitoids and felsic volcanic rocks or major fault zones. The reached result prove to reveal minimum and maximum depths of 1.07 and 3.79 km, suggesting an expected thickness extent of the deposit. Further Depth estimate around the current mining appears to range from 2.0 to 2.2 km.

Keywords

Magnetics Upward continuation Residual Spectral analysis

1 Introduction

The magnetic method has proved to be successfully applied to investigate in areas in regard of such purposes as oil exploration, to determine the depth to basement [1], in mineral exploration, for magnetic minerals prospecting ends [2], in gold exploration, to determine gold-bearing structures [3], and, overall, in general structural mapping related studie [1]. In this respect, Theopjile et al. [4] have used aeromagnetic data to locate buried faults lying in Southeastern Cameroon. It has also been used for geothermal exploration purposes, and in the investigation of unexposed granite plutons [5] as well as the subsurface continuity of a rock unit [6]. Besides, it is often integrated with sensing techniques to map out lineaments [7].

The magnetic field, whose amplitude has already been measured, is a vector sum of the following components: the earth's main magnetic field, as originating from dynamo action of conductive fluids in the earth's deep interior [8], induced field caused by magnetic induction in magnetically susceptible earth materials as polarized by the main field [9], field caused by remanent magnetism of the earth's material [9], field caused by solar activities, atmospheric and cultural influences [2]. However, it is the induced and remanent fields that are of particular interest to a regolith geoscientist, as these fields' magnitudes are directly related to the mag-netic susceptibility, spatial distribution and concentration of local crustal materials. Fortunately, a good number of min-erals occur abundantly in nature to make a significant con-tribution to the induced and remanent fields.

The study area, Igbebi (Fig. 1), is a town located in Olorunsogo Local Government Area, in the Northern part of the Oyo State. The area lies between the coordinates 8.5°N–9.0°N and 3.5°E–4.5°E. The aim of this research is to estimate the depth extent of marble reserve in Igbebi, lying between the coordinates 8.5°N–9.0°N and 3.5°E–4.5°E, on a section of the basement complex of Nigeria geology, by processing Total Magnetic Intensity (TMI) data, as acquired from the aeromagnetic sheets 200 and 201.

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Fig. 1 Inset of the Oyo State within Nigeria, showing the study area

2 Materials and Methods

Some marble mining pits sited at Igbeji were visited, and location coordinates at the sites were taken prior to the data acquisition. The purpose is to identify the surface area limit of the data to be extracted from the digitized data sheets 200 and 201, as obtained from the NGSA. The main data source relevant to this work is the aeromagnetic data relating to a specifically set section of the Oyo State (sheets 200 and 201).

The digitized data, as drawn from NGSA are in x, y, z worksheet format. The x values represent the distance of a point from the origin, pointing to the easting (longitude), the y values represent the distance of the point from the origin in the northing direction (latitude), while the z values represent the total magnetic field intensity at a point. The Total Magnetic Field Intensity (TMI) was stripped off 33,000 nT by the NGSA. Hence, a 33,000 nT was added to each value of the TMI to obtain the actual TMI, as measured during the survey. Thereafter, the data were sorted to check for spurious values, likely to result from possible magnetic storms.

The research area was sub-divided into eight square blocks for spectral depth determination ends. Each of the blocks represents a square grid of residual field points, corresponding to a quarter degree by quarter degree

$\frac{1}{4}^0 \times \frac{1}{4}^0$ map. Each of these blocks covered a total area of about 756.25 km², as depicted on Table 1.

3 Results and Discussion

3.1 Residual Anomaly Map

The residual field contour is shown in Fig. 2.

Basically, the magnetic data, as observed from geo-physical surveys comprise the sum of all magnetic fields produced by all underground sources. Hence, the compound or composite map produced on the basis of such data proves to contain two main signal sources stemming from the causative bodies, which are different in order of sizes and generally super-imposed. Super-imposed on the regional field, but frequently camouflaged by them, are the smaller, local disturbances which are secondary in size but primary in importance. These are actually the residual anomalies [9]. Therefore, the residual field contour shows an intensity ranging from -63.05 to 52.65 nT. The positive residual anomalies are considered to emanate from the outcrops common in the area, while the negative field could be associated with the presence of granitoids, felsic volcanic rocks and, possibly, major fault zones. This is likely to constitute the basis for the marble mineralization persistent in the area.

3.2 Depth-to-Basement Anomaly

Spectral depths were obtained by plotting graphs of logarithms of spectral energies against frequency for various blocks. The spectral plots appear to display clear linear segments due to deeper, intermediate and shallower sources. With respect to the present work's focus of interest, the deep source gradient stands as the most interesting segment. Based on the segments associated gradients, the average depths to the causative bodies were determined through the equation: $z = \frac{1}{4} h \frac{1}{4} 4^m$ p where m designates the gradient and z gives the mean depth of the causative body. The depth-to-basement variation, as obtained via spectral analysis, is displayed on Table 2.

The contour of the depth-to-basement relevant to the study area (Fig. 3) indicates well that, generally, the magnetic basement lying beneath the study area turns out to be shallow. The deepest magnetic depth is of 3.79 km, observed to lie around the SW and SE corner of the area,

Table 1 Table showing block division for spectral analysis

Spectral block	Longitude, °E		Latitude, °N	
	Minimum (x ₁)	Maximum (x ₂)	Minimum (y ₁)	Maximum (y ₂)
Block 1	3.50	3.75	8.75	9.00
Block 2	3.75	4.00	8.75	9.00
Block 3	4.00	4.25	8.75	9.00
Block 4	4.25	4.50	8.75	9.00
Block 5	3.50	3.75	8.50	8.75
Block 6	3.75	4.00	8.50	8.75
Block 7	4.00	4.25	8.50	8.75
Block 8	4.25	4.50	8.50	8.75

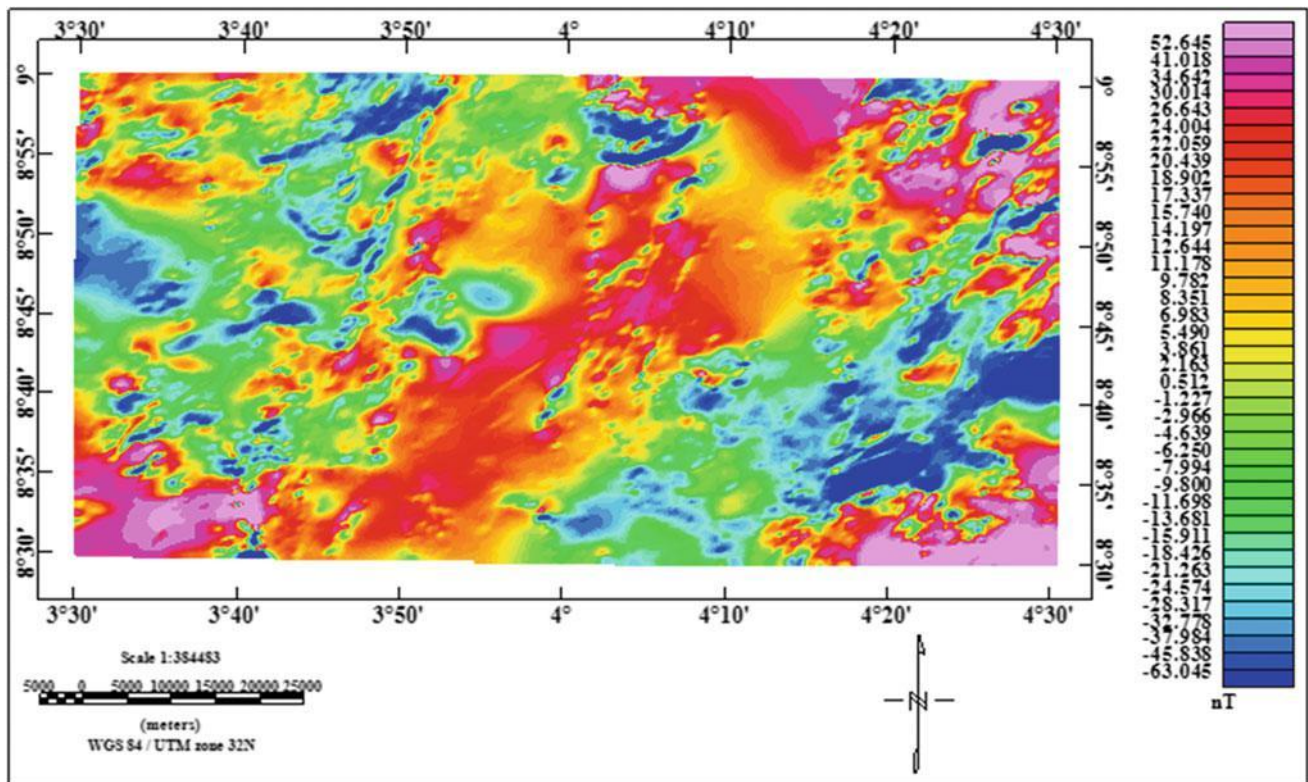


Fig. 2 Residual anomalies of the study area

Table 2 Block division with depth estimate

Spectral block	Longitude °E		Latitude °N		h (km)
	Minimum (x ₁)	Maximum (x ₂)	Minimum (y ₁)	Maximum (y ₂)	
Block 1	3.50	3.75	8.75	9.00	1.49
Block 2	3.75	4.00	8.75	9.00	1.57
Block 3	4.00	4.25	8.75	9.00	1.96
Block 4	4.25	4.50	8.75	9.00	1.07
Block 5	3.50	3.75	8.50	8.75	3.32
Block 6	3.75	4.00	8.50	8.75	1.40
Block 7	4.00	4.25	8.50	8.75	2.32
Block 8	4.25	4.50	8.50	8.75	3.79

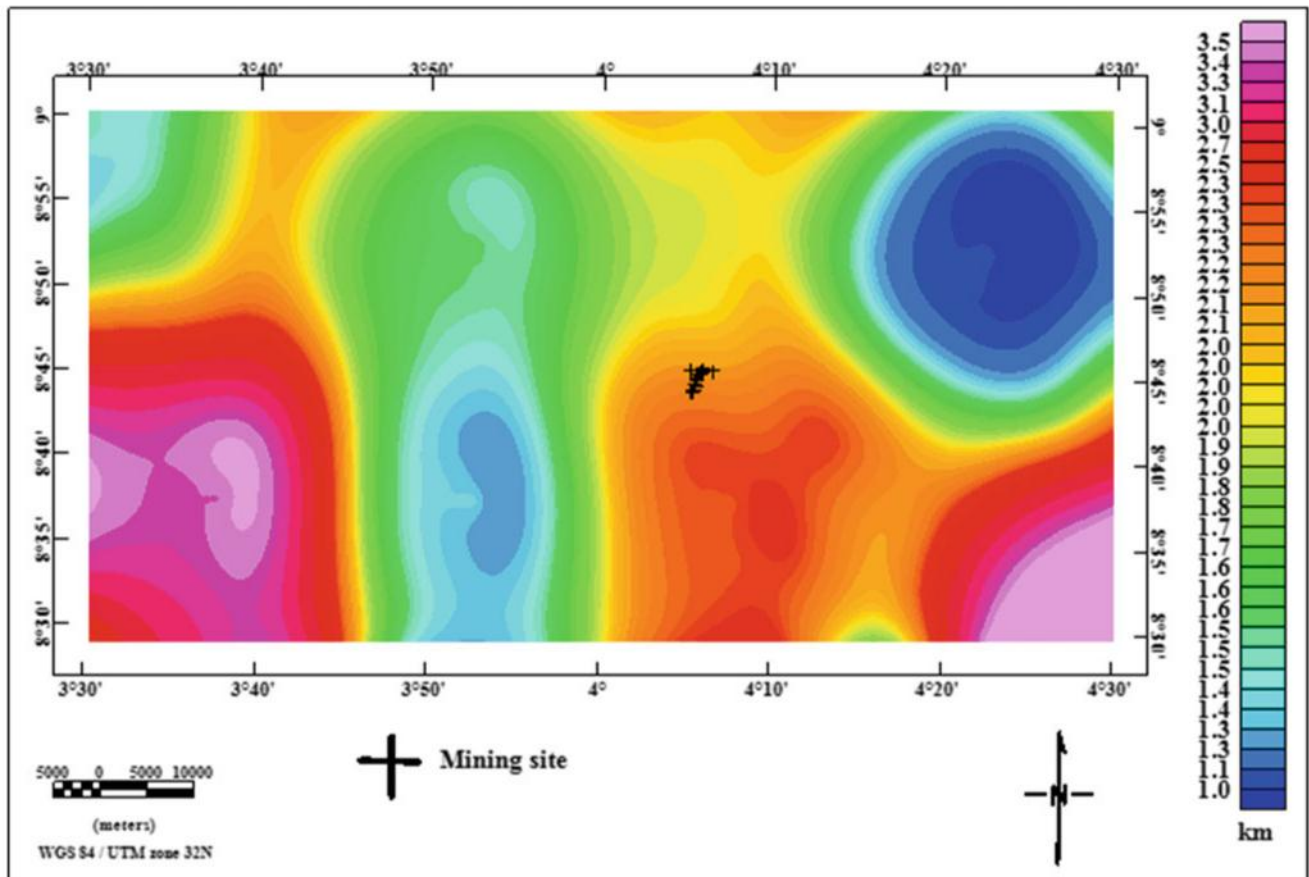


Fig. 3 Basement depth anomaly of the study area

while the shallowest depth (1.07 km) lies around the NE corner of the study area. A depth range of about 2.0–2.2 km is observed around the mining site zone of the study area.

4 Conclusions

The prominent granitic outcrops, common in the area, appears to have a significant influence on the magnetics field responses obtained. Moreover, though the present mining locations are not too poorly sited, a better mine location could still be achieved in the southern part of the area, owing mainly to the availability of greater depth and occurrence of fault zone, as highlighted through the achieved results.

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