

EULER DECONVOLUTION OF TOTAL MAGNETIC FIELDS OF GANDI, NORTH-WEST NIGERIA

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Abstract

Euler deconvolution of the total magnetic field over Gandi in the North-Western part of Nigeria has been carried out to estimate depths to magnetic basement. The study area is bounded by Longitude 5.5 ° E and 6.0 ° E and Latitude 12.5 ° N and 13.0 ° N. The acquired total magnetic field was separated into regional and residual magnetic fields using least square analysis, while twenty five profiles (25) of the residual magnetic fields were subsequently used to estimate depths to shallow and deep magnetic sources in the area. The shallow depth range between 0.04 km and 0.83 km with an average of 0.35 km, while the deeper depth varies from 0.53 km to 2.68 km with an average of 1.54 km. This study utilizing Euler deconvolution would therefore complement the existing geophysical information of the study area.

Keywords: Aeromagnetic data, residual anomaly, basement depth, Euler deconvolution, Gandi, Nigeria

Introduction

Euler deconvolution technique has been applied to estimate the depths to magnetic basement and hence the average sedimentary thickness in Gandi area, north-western Nigeria. The use of Euler deconvolution in magnetic data interpretation has been described by several authors (Thompson, 1982; El-Dawi, 2004; Nabighian *et al.*, 2005). Its implementation started with the work of Thompson (1982) that proposed a scheme for analyzing magnetic profiles based on Euler's relation for homogeneous functions. The procedure uses first-order x , y and z derivatives to determine location and depth for various idealized targets (sphere, cylinder, thin dike, contact), each

characterized by a specific structural index (Nabighian *et al.*, 2005).

The 2D Euler deconvolution equation in relation to magnetic fields is given as (Mushayandebvu *et al.*, 2001) as:

$$(x - x_0) \frac{\partial T}{\partial x} + (z - z_0) \frac{\partial T}{\partial z} = -N\Delta T \quad (1)$$

Where (x_0, z_0) is the coordinate position of the magnetic source, x is the horizontal distance, z is the depth to magnetic source, ΔT is the value of residual field, and N is the structural index. The structural index which can also be referred to as source shape is a measure of the rate of change or fall off rate with distance of a field

and therefore it is a function of the geometry of the magnetic causative bodies (Githiri, 2011).

Previous work done on the Sokoto basin housing the study area shows that the thickness of the underlying sediments varies between 0.6 km and 1.83 km (Chikwelu and Ogbuagu, 2014). Bonde *et al.* (2014) used spectral method

to posit that the basin's depth range from 0.36 km to 2.88 km, while Adetona *et al.*, (2007) obtained depth extents ranging between 0.46 km and 1.96 km. Others are Shehu *et al.*, (2004) and Taufiq *et al.*, (2014) who obtained values ranging from 0.80 km to 1.72 km, and 0.4 km to 2.0 km respectively. This present work would present an estimate of depth extent of magnetic basement of Gandi area and consequently contribute to the geophysical information of hosting the Sokoto basin

Location and geology of the study area: The study area is Gandi, which is situated near

Sokoto in north western part of Nigeria. It is bounded by Longitude 5.5 ° E and 6.0° E and Latitude 12.5 ° N and 13.0 ° N.

The geology of Gandi is characteristic of the geology of Sokoto Basin (Figure 1). The basin is in the dry Sahel, surrounded by sandy savannah and isolated hills (Kogbe, 1979; Kogbe, 1981). It has an annual average temperature of 28.3 °C. Sokoto is, on the whole, a very hot area. However, maximum daytime temperatures are for most of the year generally under 40 °C and the dryness makes the heat bearable. The warmest month are February to April when daytime temperatures can exceed 45 °C. Obaje (2009) stated that the geological structure of the Sokoto Basin is simple as the beds dip between 2.5 to 3.8° per Km in a direction 60° west of North, but around Sokoto, the direction of dip is about 18° NW and has the sedimentary deposits lay directly on the crystalline Precambrian basement.

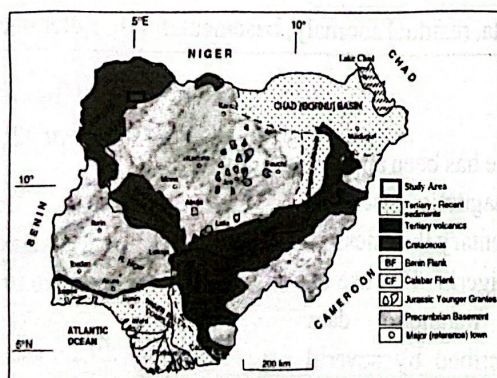


Figure 1: Geological map of Nigeria showing the study area (after Obaje, 2009)

Materials and Methods

The aeromagnetic map (sheet number 30) of the study area utilized in this work was procured from the Nigeria Geological Survey Agency (NGSA). The survey was carried out by the NGSA at a nominal flight altitude of 152m above the ground level, flight lines of 2km in N-S direction and tie-lines of 5km. The data, published in the form half degree aeromagnetic

map on a scale of 1:100000, was corrected using the International Geomagnetic Reference Field (IGRF) by the NGSA before the eventual publication. The procured map was digitized with a spacing of 2 km yielding 27 by 27 data points. The spatial extent of the map is approximately 54 km x 54 km. The re-contoured Total Magnetic Intensity (TMI) map is shown in Figure 2.

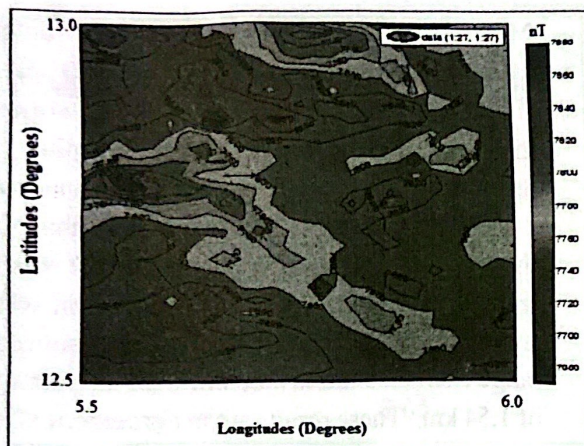


Figure 2: Re-contoured Total Magnetic Intensity (TMI) map of the study area

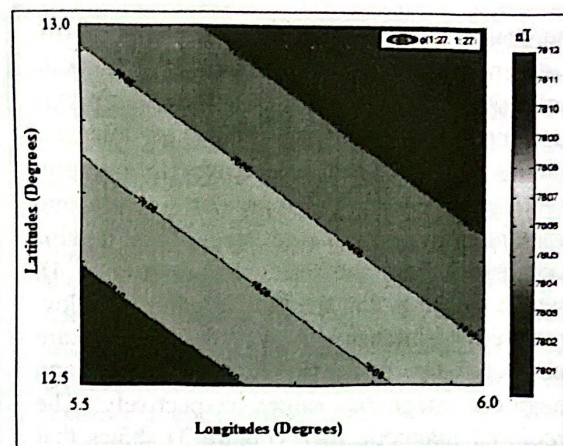


Figure 3: Regional Magnetic Intensity map of the study area

The data was separated into regional and residual fields using least squares plane surface polynomial fit (Nwankwo, 2006) as shown in Figure 3 and 4 respectively. The resulting residual field was afterwards divided into 25

profiles cutting across diverse geologic structures, while each profile analyzed for source depths using Euler Deconvolution method.

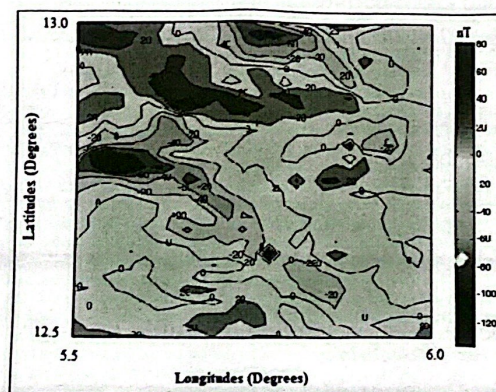


Figure 4: Residual Magnetic Intensity map of the study area

In this study, EULER 1.15 software developed by Cooper (2004) was used for imaging the magnetic sources. In the software, the 2D space defines depth (z_0) positive down and horizontal distance (x_0). For the magnetic Euler solutions, input information includes magnetic inclination, declination and the background normal total magnetic field. The source distribution is assumed to be two-dimensional such that the first derivatives of T (i.e. $\frac{\partial T}{\partial x}$ and $\frac{\partial T}{\partial z}$)

are calculated by the software. When a magnetic profile data is run in EULER 1.15 software, the profile is divided into windows of set of data points ranging from 7 to 27. Source locations (x_0, z_0) are eventually calculated and plotted in a cross-section, which clusters around strong magnetized sources (Githiri, 2011).

Results and Discussions

The Total Magnetic Intensity map of the Gandi (Figure 2) shows that the area could be

separated into main three sections: the north-western part characterized by high magnetic intensity values, the southern and eastern part is dominated by medium magnetic intensity values and lastly a low magnetic intensity section dominating the upper north-central and western portions of the area. This is also confirmed from the residual map (Figure 4), which suggests that the high, medium and low magnetic intensities in the area are characteristic of positive, intermediate and negative magnetic values respectively. The regional magnetic map (Figure 3) shows that the area is characterized with NW – SE regional trending structure.

Examples of analysis of Euler Deconvolution performed on the 25 residual magnetic profiles are shown in Figures 5 and 6 for profile 1 and 3 respectively. The Figures (i.e. 5 and 6) show the

Magnetic profile anomaly (as original data), calculated Reduced to the Pole (RTP) data, Horizontal and Vertical Gradients, and source locations. The magnetic source depths as revealed by the Euler Deconvolution analysis are shown on Table 1. The table shows that the shallow magnetic source depths in the study area range between 0.04 km and 0.83 km with an average of 0.35 km, while the deeper sources range from 0.53 km to 2.68 km with an average of 1.54 km. These results are in agreement with results obtained by diverse workers in the Sokoto basin: 0.6 km -1.83 km (Chikwelu and Ogbuagu, 2014), 0.36 km – 2.88 km (Bonde *et al.*, 2014), 0.46 km - 1.96km (Adetona *et al.*, 2007), 0.80 km to 1.72 km (Taufiq *et al.*, 2014), 0.4 km - 2.0 km (Shehu *et al.*, 2004), etc.

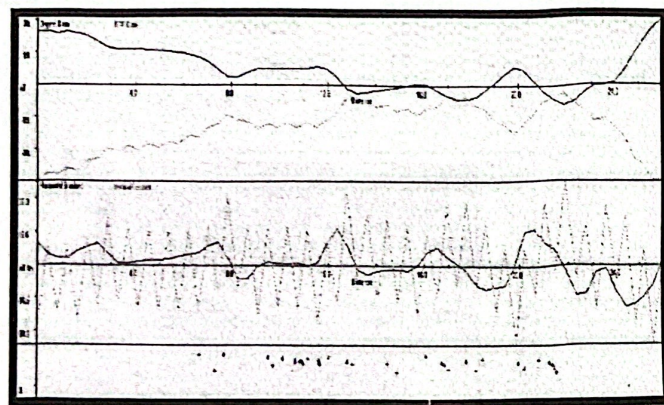


Figure 5: Euler Deconvolution solution of Profile 1

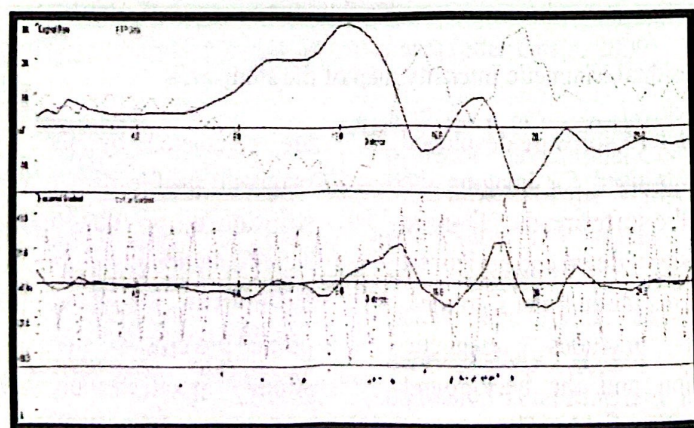


Figure 6: Euler Deconvolution solution of Profile 3

Table 1: Summary of Deeper and Shallow Depth of the Study Area

Profile	Shallow Depth (km)	Deeper Depth (km)
1	0.75	2.10
2	0.83	2.46
3	0.44	1.27
4	0.63	1.29
5	0.14	2.05
6	0.39	1.62
7	0.34	1.52
8	0.04	1.91
9	0.27	0.75
10	0.26	0.84
11	0.40	0.93
12	0.06	1.23
13	0.20	1.48
14	0.26	1.11
15	0.37	1.64
16	0.19	2.68
17	0.07	2.31
18	0.75	1.71
19	0.24	1.95
20	0.12	0.53
21	0.26	0.79
22	0.34	1.00
23	0.38	1.10
24	0.63	2.22
25	0.31	2.13
Average	0.35	1.54

Conclusions

Euler deconvolution technique has been used with the aim of determining the depths to buried magnetic rocks. The results show that the shallow depths obtained ranges from 0.04 km to 0.83km with an average of 0.35 km while the deeper depths of the magnetic source vary from 0.53 km to 2.68 km with an average of 1.54 km along 25 profiles. This confirms that the thickness of the sediments in the basin is less than 4 km. This study utilizing Euler deconvolution would therefore complement the existing geophysical information of the study area.

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