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ANALYSIS AND INTERPRETATION OF AEROMAGNETIC DATA OVER PART OF IBADAN, SOUTHWESTERN NIGERIA USING ADVANCED INTERPRETATION TECHNIQUES

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ABSTRACT

The interpretation and qualitative analysis of aeromagnetic data to determine the nature and depth of the magnetic minerals has been on the increase with the use of Euler deconvolution method. In this paper this method was used on the digitized aeromagnetic data of Ibadan (sheet 261) for the purpose of determining the nature and trend of the magnetic minerals, and estimating the depth to magnetic source in five locations within the study area. These locations are: Bare (1), Falansa (2), Ikija (3), Olode (Egbeda) (4), and Olode (Ona-Ara) (5). These locations have been known to have valuable mineral resources, therefore estimating the depth to magnetic source of these locations is necessary for easy exploration. Ibadan which is bounded within Longitude 3.30^{0}E to 4.00^{0}E and Latitude 7.00^{0}N to 7.30^{0}N, is located in present Oyo State, South Western Nigeria and is underlain by basement complex rocks of the Precambrian age. The aeromagnetic anomaly map (magnetic signature map) and the Euler solutions helped in identifying the nature, trend and depth of the magnetic source in these locations. The Euler deconvolution approximated the shallowest and deepest depths to top of the magnetic source as 2.00m and 15.00m respectively. The magnetic signature maps showed the magnetic trends as SW – SE, SW – SE, NW - SW, NW – SW, and Central for locations 1, 2, 3, 4 and 5 respectively. These results have the potential to generate useful information for exploitation and exploration of minerals in Nigeria.

Keyword: Aeromagnetic anomaly map, digitized aeromagnetic data, Euler deconvolution, Ibadan.

INTRODUCTION

The interpretation and qualitative analysis of aeromagnetic data to determine the nature and depth of the magnetic minerals has been on the increase with the use of Euler deconvolution method. Major disadvantages of obtaining ground potential field data are; limited number of acquired data, accuracy, waste of time, inaccessibility of some area and risk of life encountered by field workers. By using aeromagnetic data for geological interpretation one can overcome major disadvantages of ground data collection. The aeromagnetic survey present the comprehensive magnetic contour map of an area and the magnetic data can also be obtained from such map by digitization method in the analytical interpretation [1].

The Euler deconvolution has become a popular choice because the method assumes no particular geological model and has quick means of turning magnetic field measurements into estimates of magnetic source body location and depth [3]. It is the method of depth estimation which is best suited for anomalies caused by isolating and multiple anomalous sources. It could be applied to a long profile of measurements for estimating the location of a simple body, by dividing the profile into the windows of consecutive measurements, each window providing a single estimate of depth and source location. Acceptable solutions for features of interest may involve some trial and error by adjusting the structural index and the window size. When all such measurements are plotted they tend to cluster around magnetization of geologic interest. Some indication of the source type can be gained by varying the structural index for any particular feature. Shallow features can be deconvolved well by using small window to reduce source interference [4].

The aim of this work is to quantitatively analyse magnetic anomalies in order to determine the depth to the magnetic sources. This research covers part of Ibadan metropolis whose digitized total aeromagnetic data has been analyzed using Euler deconvolution enhancement techniques.

MATERIALS AND METHODS

The aeromagnetic data of Ibadan (sheet 261) was obtained from the Nigeria Geological Agency (NGSA), and was digitized using Surfer 10.0 software to obtain magnetic anomalies with their respective coordinates of the study locations. These locations are Falansa (1), Bare (2), Ikija (3), Olode (Egbeda) (4), and Olode (Ona-Ara) (5), Ibadan, Oyo State, Southwestern Nigeria.

The aeromagnetic data of Ibadan (sheet 261) obtained from Nigeria Geological Survey Agency (NGSA) was contoured and digitized to obtain magnetic anomalies of the study locations. Golden Surfer 10.0 software was used to contour the aeromagnetic data of the study area (Fig. 2). The digitized data of the study locations were extracted and saved using the Excel software package. A total of fifty magnetic anomaly values with their corresponding coordinates were established at an interval of 0.2 m.

These magnetic datasets demand automatic interpretation techniques like Naudy, Euler and Werner deconvolution. Of these techniques, the Euler deconvolution has become a popular choice because the method assumes no particular geological model [1]. Therefore, Euler deconvolution enhancement technique was used in this research.

Location of the study area: Ibadan is the capital city of Oyo State, Southwestern part of Nigeria. Ibadan is located within longitude $3^{0}30^{l}$E to $4^{0}00^{l}$E and latitude 7^{0} 00^{l}N to 7^{0} 30^{l}N.It is bounded in the north by Kwara state, in the east by Osun state, in the south by Ogun state and in the west partly by Ogun state and partly by the republic of Benin. Ibadan is the largest indigenous city in West Africa and is located in south-western Nigeria about 120km east of the border with the republic of Benin, 128km inland North-East of Lagos and 530km southwest of Abuja. Its population is 2,550,593 according to the 2006 census result including 11 local government areas. The population of central Ibadan, including five L.G.As is 1,338,659 according to the census result of 2006. The majority of the people are members of the Yoruba ethnic group.

Five different locations were mapped-out from the study area. These locations are: Bare (1), Falansa (2), Ikija (3), Olode (Egbeda) (4), and Olode (Ona-Ara) (5). It has been reported that there are availability of minerals in these locations [2]. Table 2 shows the summary of the type of mineral occurrences in these locations. Also, the contour digitized map of the study area, which shows the study locations is presented in Fig. 2.

Fig. 1: Map of the Location of the study area in street view

Geology of the study area: Geology of Ibadan (Fig. 3) falls within the basement complex of Nigeria, characterized by the basement complex rocks of the Precambrian age which consists of various granites and the metasedimentary rocks [5].

Ibadan area is underlain by biotite granite gneiss, migmatite biotite gneiss, biotite muscovite granite, hornblende granite and schists. These crystalline rocks are composed primarily of banded gneiss in which the hornblende-biotite rich bands alternate with quartz-oligoclase rich bands. The banded gneiss, which originated as part of a sedimentary sequence, contains large lenses of granite gneiss and thin intercolated layers of quartzite and amphibolite [11].

Oyo state is endowed in solid mineral resources which could be developed for the economic benefit of the state and the nation. Prior discoveries make the northern portion of Oyo State to be predominantly underlain by complex pegmatite, which harbor a lot of gemstones ranging from Aquamarine, Tourmaline, Agate and industrial minerals like Tantalite, Marble, Talc and Granites of various forms. Later discoveries point to Ibadan axis where metallic minerals, e.g. gold, and gemstones like Aquamarine, Amethyst, Tourmaline, and industrial minerals like Tantalite and Sillimante, have been discovered in economic form [2]. Therefore, estimating the depth to magnetic source of these locations is necessary for easy exploration of these resources.

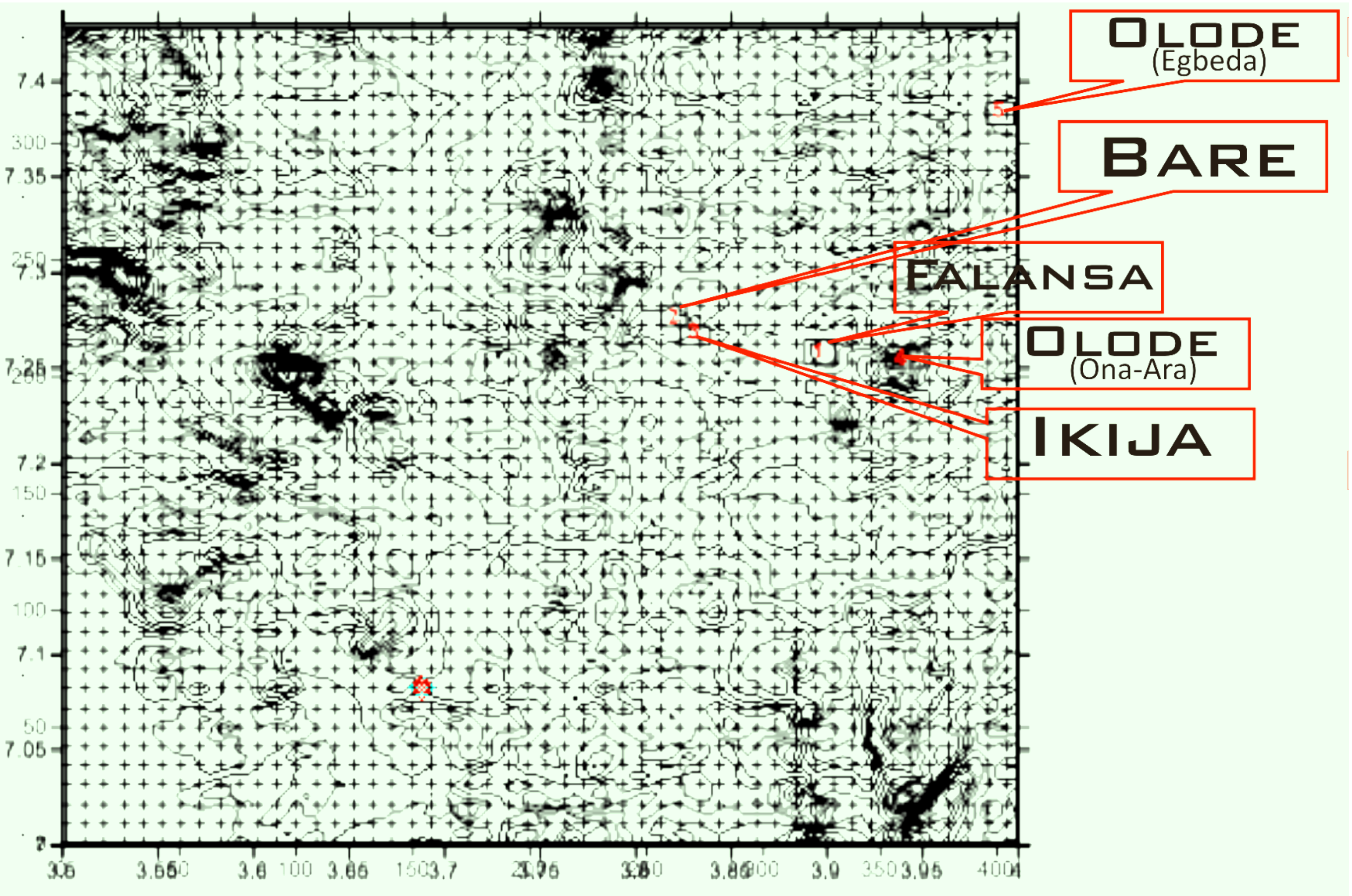

Fig. 2: Contour digitized map of the study area showing Study locations

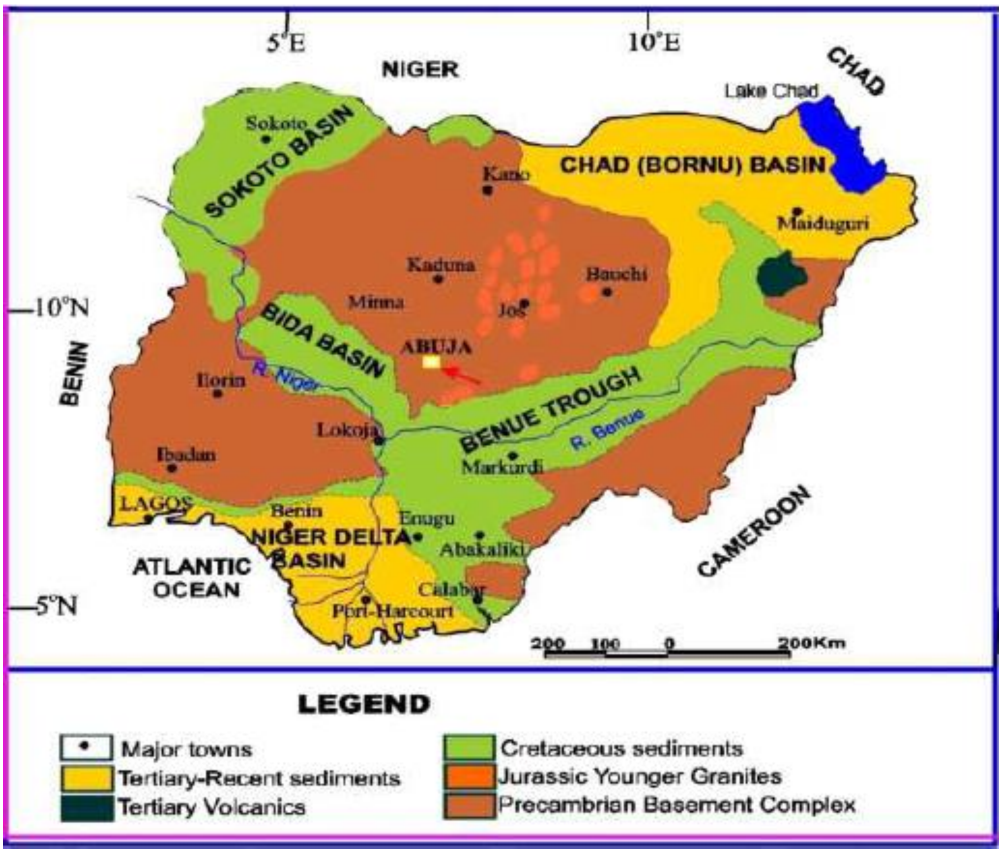

Fig. 3: Geological map of Nigeria (after Obaje, 2009).

Euler deconvolution: Euler deconvolution is an automatic technique used for locating thesource of potential field based on both their amplitudes and gradients. The method was developed by Thompson (1982) to interpret 2D magnetic anomalies and extended by Reid *et al.* (1990) to be used on grid-based data [9]. Magnetic field M and its spatial derivatives satisfy Euler's equation of homogeneity.

$$(x - x_o)\frac{\partial M}{\partial x} + (y - y_o)\frac{\partial M}{\partial y} + (z - z_o)\frac{\partial M}{\partial z} = N(B - T) \quad (1)$$

Where, $\frac{\partial M}{\partial x}$, $\frac{\partial M}{\partial y}$ and $\frac{\partial M}{\partial z}$represent first-order derivative of the magnetic field along the x-, y- and z- directions, respectively, N is known as a structural index and related to the geometry of the magnetic source.For example, N=3 for sphere, N=2 for pipe, N=1 for thin dike and N=0for magnetic contact [10]. Also, (x_0, y_o, z_o) is the position of a magnetic source whose total field T is detected at (x, y, z). The total field has a regional value of B.

Assigning the structural index (N), a system of linear equations can be obtained and solved for estimating the location and depth of the magnetic body. Using a moving window, multiple solutions from the same source can be obtained. Good solutions are considered to be those that cluster well and have small standard deviations [4, 10]. Selection of the appropriate structural index is very important to obtain the correct depth solutions. In this paper we applied the method using the structural index (SI = 3) of sphere body[4, 10], since the main objective is to determine the depths and shapes of the magnetic body. For this structural index, cluttered solutions were obtained and the solutions have smaller standard deviations [4, 10].

RESULTS AND DISCUSSION

The results obtained from the aeromagnetic data of the study locations were presented in a quantitative interpretation which involves the estimation of the depth to the top of the magnetic source.

Quantitative Interpretation: Figs. 4 – 8 show Euler solution maps for the study locations. These maps were clustered together very well and revealed that the shape of the magnetic body in these locations to be sphere (SI = 3). For Bare (Fig. 4), the trend of the magnetic signature is NW, NE, and SW – SE directions, and the highest anomaly is obtained at Southern region. The shallowest depth is 3.0m and the deepest depth is 14.5m as obtained from Euler solution map.

Fig. 5 is for Falansa and the magnetic signature follows the trends of SW - SE direction, with highest anomaly at Southwestern region. The shallowest depth is 4.2m and the deepest depth is 14.1m.

Fig. 6 is for Ikija and the magnetic signature pattern is highest in the Western, Northern and Southern regions. For this location, the shallowest depth is 2.7m and the deepest depth is 13.2m.

Fig. 7 and Fig. 8 are for Olode in Egbeda and Ona-Ara LGA respectively. For these locations, the shallowest depths are 3.8m and 2.1m, deepest depths are 13.9m and 14.5m.The magnetic trend for Olode in Egbeda is along NW – SW direction, while for Olode in Ona-Ara the magnetic trend is distributed within the central part of this location.
The summary of the result obtained is given in Table 2.

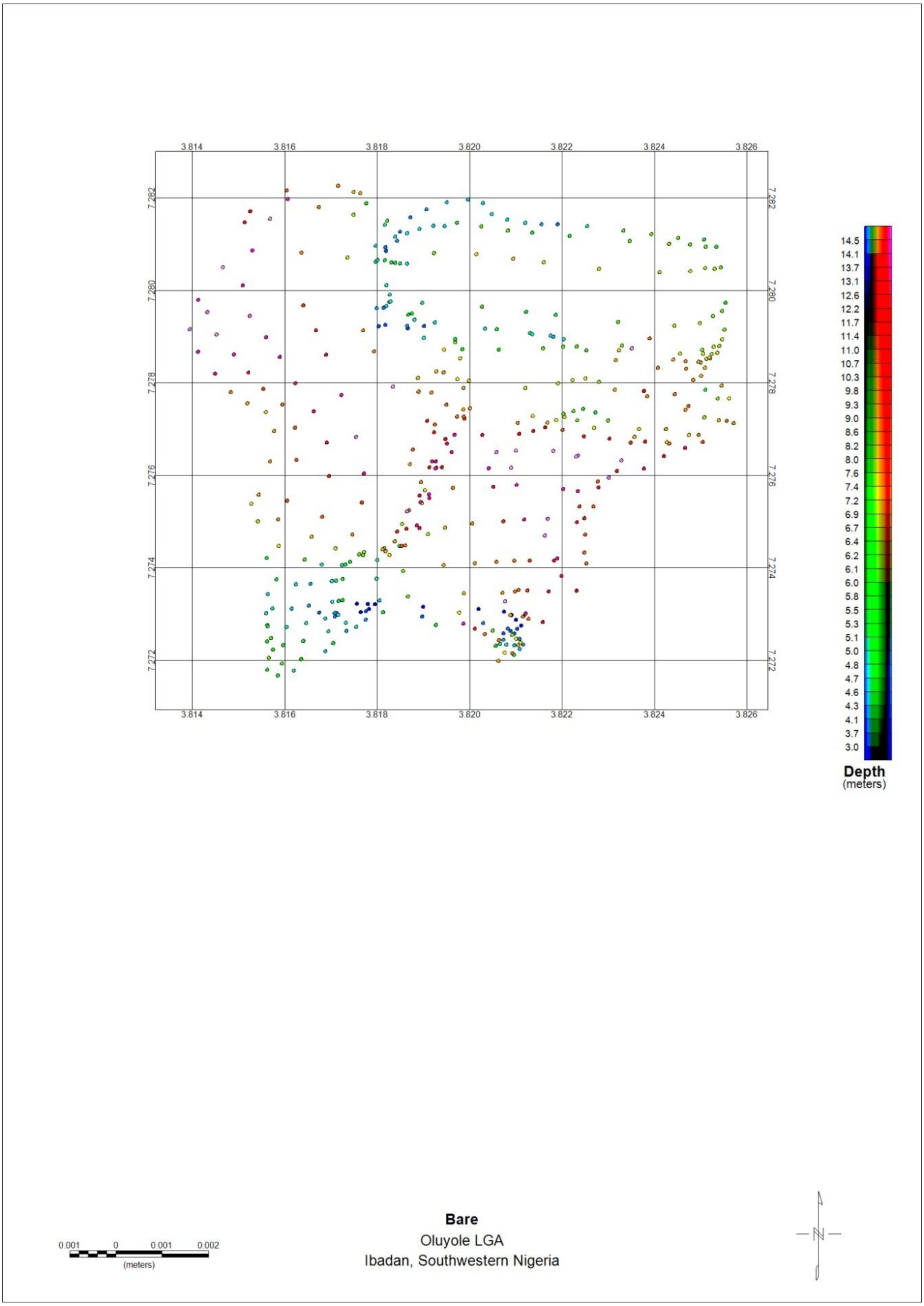

Fig. 4: Euler Solution Map for Bare

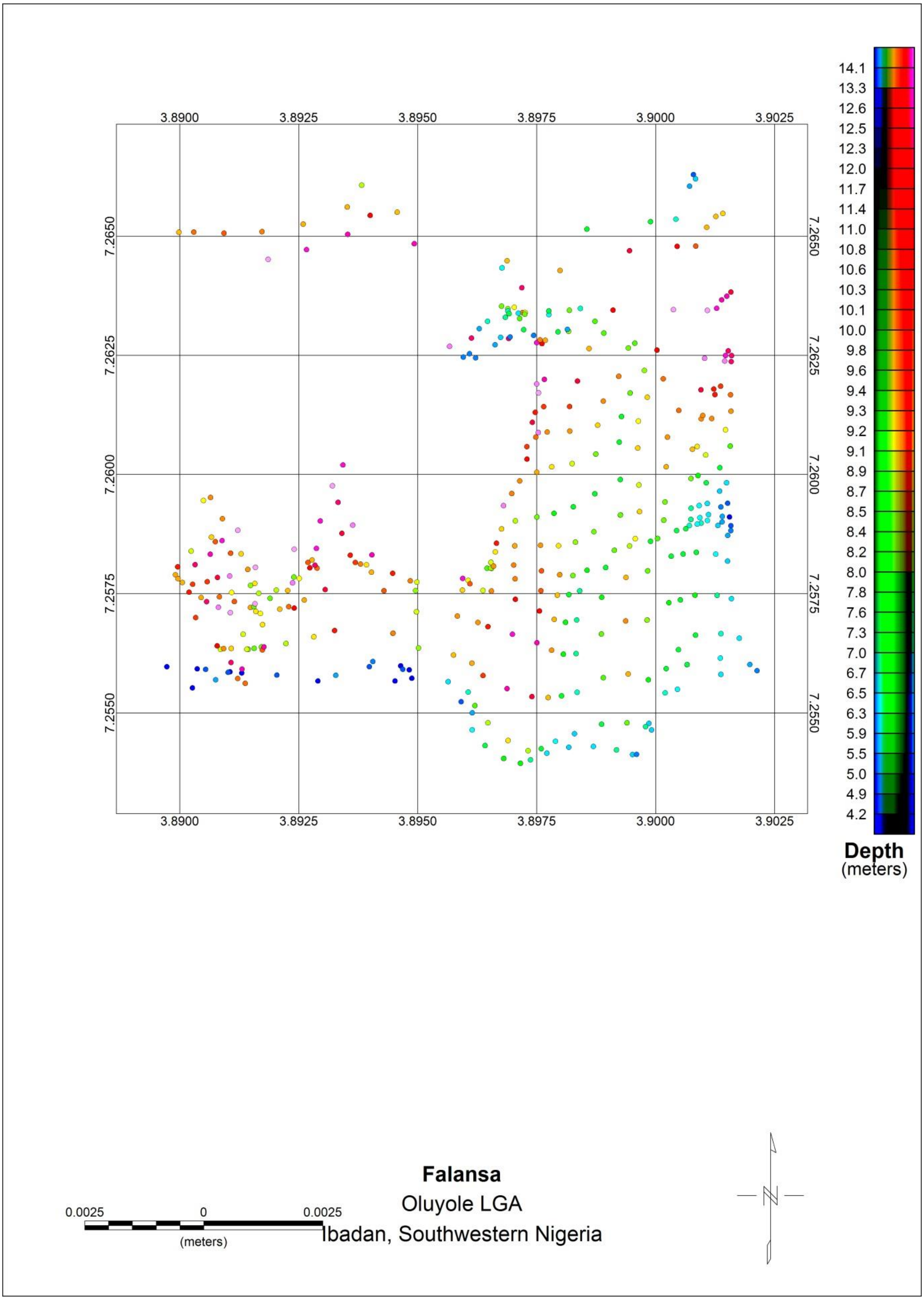

Fig. 5: Euler Solution Map for Falansa

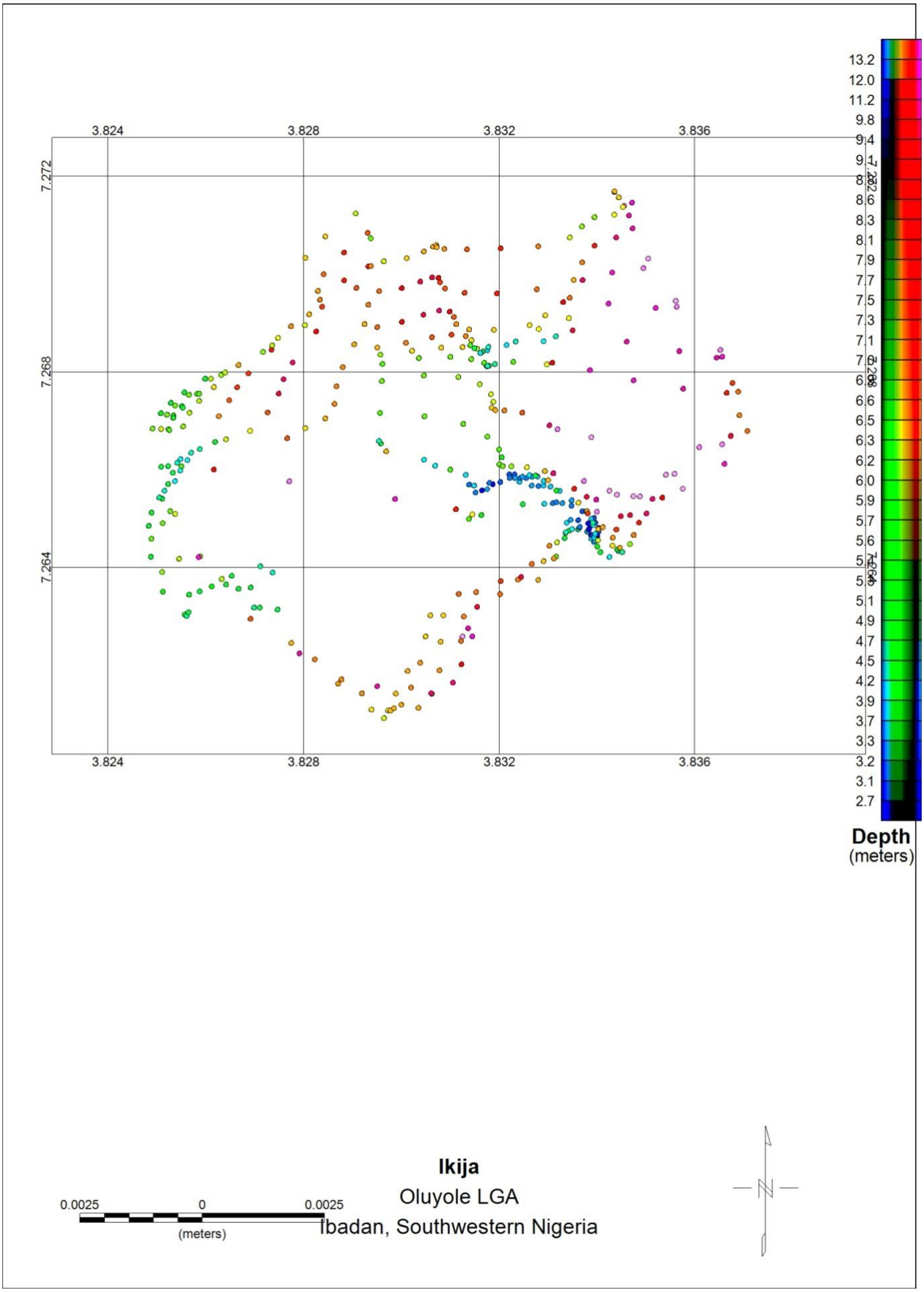

Fig. 6: Euler Solution Map for Ikija

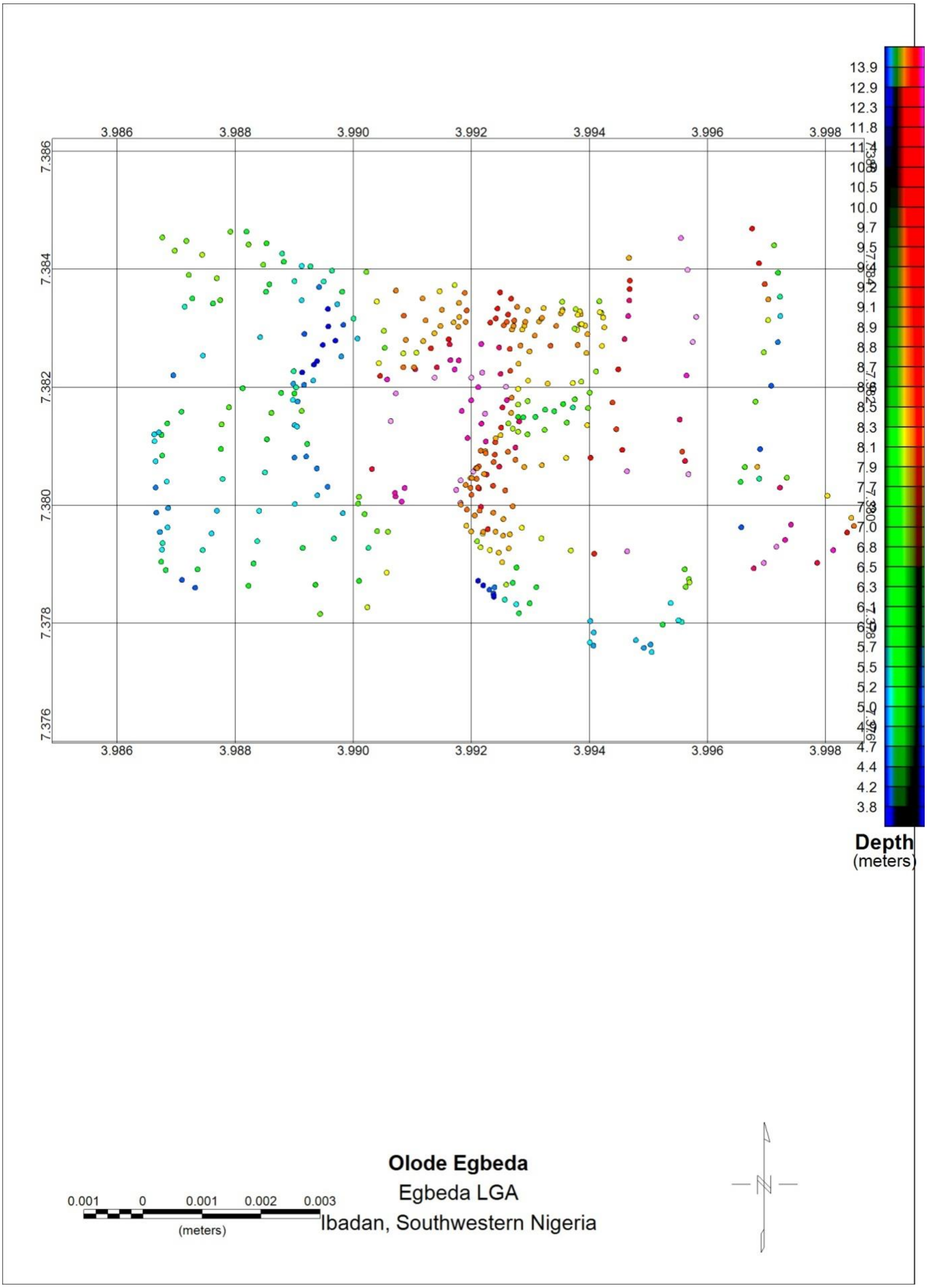

Fig. 7: Euler Solution Map for Olode (Egbeda)

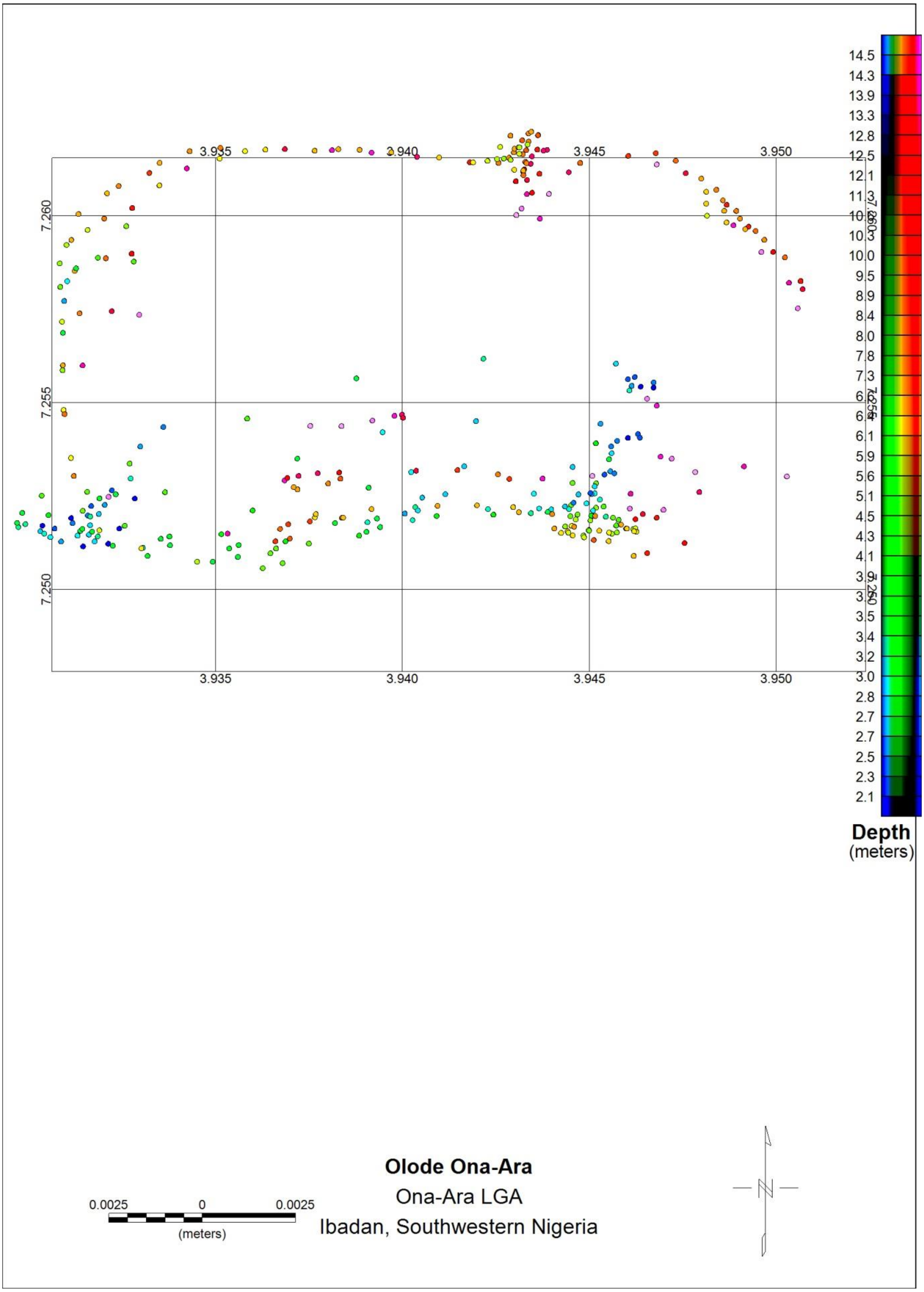

Fig. 8: Euler Solution Map for Olode (Ona-Ara)

Table 3. Summary of the result obtained for the study locations

S/N	Locations	Local Govt. Area	Shallowest depth (m)	Deepest depth (m)	Magnetic Signature Trend
1.	Bare	Oluyole	3.0	14.5	NW, NE, SW – SE
2.	Falansa	Oluyole	4.2	14.1	SW - SE
3.	Ikija	Oluyole	2.7	13.2	Western, Northern, Southern
4.	Olode	Egbeda	3.8	13.9	NW – SW
5.	Olode	Ona-Ara	2.1	14.5	Central

5.0 Conclusion

The quantitative analysis of the aeromagnetic data over part of Ibadan revealed the depth estimate to the magnetic source in the study area. The Euler deconvolution overestimated the shallow sources which help to reveal deeper magnetic anomalies sources. Also, this technique revealed the shape of the magnetic body. This method is fast, accurate, cost-effective and reduces the risk encountered by the field workers when embarking on ground magnetic survey. It is recommended that other relevant geophysical methods be used in the study locations to confirm the predictions in this work.

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