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Forward and Inverse Modeling of Hand Digitized Aeromagnetic Data from Ilesha South West, Nigeria

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Abstract

Results of aeromagnetic data interpretation of Ilesha SW, Nigeria are presented here. The geology of Ilesha which is Precambrian falls under the basement complex of Nigeria. Depths to source rocks in this area are expected to be shallow. The results obtained revealed the presence of rocks such as amphibolites, quartz and schist which are the common rock types present in the study area. An aeromagnetic map of scale 1:50,000 was hand digitized, while forward and inverse modeling was achieved via the use of Potent, version 4.10.02. The field data were qualitatively and quantitatively interpreted and results showed NE-SW trending of the fault zone in the study area and anomalous bodies whose total magnetic intensity ranges from a minimum negative peak value of -625.5 nT to a maximum positive peak value of 179.43 nT. The maximum depth to top of the magnetic source body obtained is 34.2 m and minimum depth is 0.5 m. The results obtained indicate shallow depths to magnetic anomalies, as expected in most areas of the basement complex of Nigeria.

Keywords: Basement complex; Anomaly; Rock units; Schist; Amphibolites; Quartz; Magnetic; Modeling; Susceptibility

Introduction

Ilesha Town is located in Osun State, Southwest Nigeria. It lies within the tropical climate marked by wet and dry seasons. Its latitude is 7.60 N and longitude 4.70 E with an average elevation of 391 m above sea level. Temperature in Ilesha is moderately high during the day and may vary from season to season. The average daily temperature varies between about 200°C for a very cold day to about 350°C for a very hot day. The coldest period is in the middle of rainy season which occurs in July and August [1] (Figure 1). The study area was chosen based on the anomalies observed on aeromagnetic contour map of Ilesha. The geology of Ilesha has been discussed in detail by Rahaman et al. [1-10]. It consists of Precambrain rocks which forms the basement complex. The major rocks associated with the area form part of the proterozoic schist belts in Nigeria as shown in Figure 2. Quartz-schist, quartzite, amphibolites, granite-gneiss, amphibolites schist and migmatite-gneiss complex are the major rocks in Ilesha. Other minor rocks according to Kayode, Folami and Rahaman are garnet, quartz chlorite bodies and dolorites [1,2,6].

Kayode interpreted the vertical magnetic components in Ijebu-Jesa Southwest Nigeria using ground magnetic survey and obtained

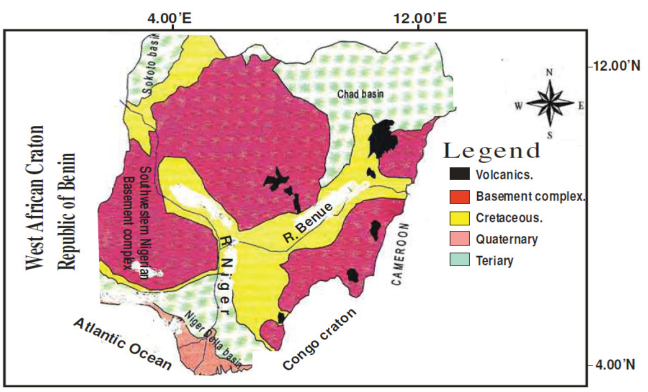

Figure 1: Geologic Map of Nigeria [8].

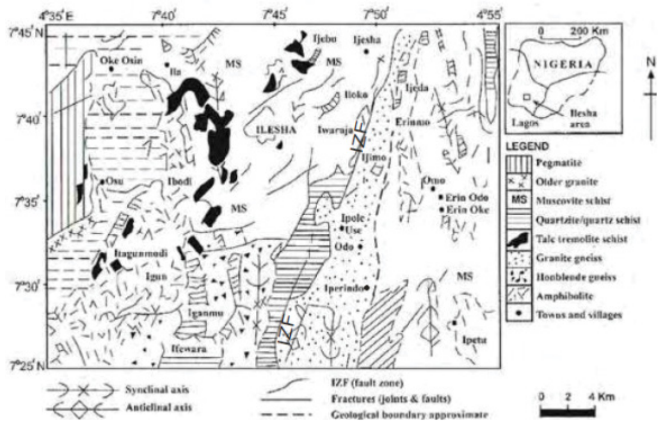

Figure 2: Geological map of Ilesha schist belt Southwestern Nigeria [8].

depth to basement complex of 38 m-244 m [4]. Momoh et al. carried out geophysical investigation of highway failure, a case study of the basement complex terrain of South west Nigeria (Ilesha-Owene Highway) [11]. They reported that faults, fractures, joints and buried stream channel were some of the causes of the highway failure. Depths of between 0.3 m and 41.3 m were obtained. Kayode and Adelusi interpreted the ground magnetic data of Ijebu Jesa area and obtained depths to basement complex of between 41 m and 213 m [12]. Integration of surface electrical prospecting methods for fracture detection in Precambrian basement rocks of Iwaraja area, Southwest

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Nigeria, by Adelusi et al. showed a NE-SW trending of faults in that area and obtained depths of 10-55 m [13]. Study on the groundwater accumulation of Oke-Ogba area using ground magnetic survey by Alagbe et al. revealed depths ranging from 3.0 to 21.0 m [14]. This depth range agrees with the depth range of 2.3-21.2 m obtained by Adelusi using electrical resistivity method [15]. This study seeks to obtain depth to magnetic anomalies observed on the aeromagnetic map of Ilesha and to justify the effectiveness of hand digitized data.

Materials and Methods

An aeromagnetic map on a scale of 1:50,000 sheet 243 SW was acquired from the Nigerian Geology Survey Agency (NGSA). The aeromagnetic data was acquired at a nominal flying altitude of 152 m (about 500 ft) with flight lines spaced 2 km in the direction 60/240 (dip/azimuth) degree and contour interval of 20 nT. Magnetic instruments used are air plane, magnetometers, magnetometer stinger and digital data acquisition system track recovering system, recording altimeters, magnetic compensation unit and Doppler navigation system. Regional correction was based on IGRF (1st January, 1974). The map (Figure 3) was hand digitized along flight lines. The regional may be defined as the value of the field which would exist if there were no local disturbance due to the source we are trying to interpret.

The regional is actually unknown and may become quite subjective. It can be treated as an additional variable in an interpretation, but reasonable limits may be set from common sense provided by human intervention [16]. Although hand digitization is the most elementary least efficient method of digitization, its accuracy when carefully done compares favorably with other more sophisticated methods [17].

Results

There are several methods of presenting magnetic data, but only two of these methods were adopted in this study [18]. These methods are as summarized below:

Profiles

This is the oldest form of data presentation, but it has the advantage of being able to show details that cannot be shown in grids based presentations. The aeromagnetic profiles of the study area were generated from the aeromagnetic map of Ilesha SW. A section of the map is shown in Figure 3.

Contour maps

This was used in the presentation of the magnetic data of the area (Figure 3).

Traditionally in potential field measurements, data are displayed in the form of contour maps. Joints and faults are normally represented as elongated closed contours. Faults of regional dimension are characterized by alignments of the contour features [19]. At the eastern part of the map (Figure 3), there is an obvious NE-SW trend and at the western end there is a strong N-S trend. This clearly shows the Ifewara fault zone, which is the dominant feature in Ilesha Southwest [6-8]. Here, most of the lithology boundaries are tectonic [20]. Further confirmation of the N-S trending of the fault is evident in the work of Onyedim, who applied steerable filters in the enhancement of the Ifewara fault zone [19]. Other trending includes NE-SW, NW-SE as evident in the aeromagnetic map (Figure 3).

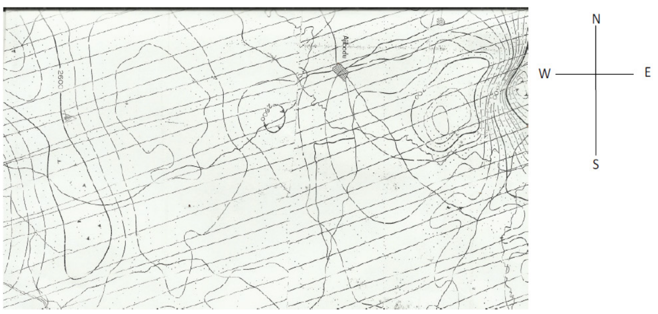

Figure 3: A section of Aeromagnetic map of Ilesha sheet 243 SW, Nigeria.

Profile 1

The total magnetic intensity obtained for this profile has a minimum negative peak value of -59.93 nT to a positive maximum peak value of 61.12 nT. Two rock units were delineated near Ajibodu and Itagunmodu axis. Depths obtained for the two rock units are 0.5 m and 16.7 m respectively.

Profile 2

The magnetic signatures along this profile shows minimum negative amplitude of -45.36 nT and maximum amplitude of 62.70 nT. Rock units delineated are amphibolites schist, quartz schist. Amphibolites schist forms the first and second rock unit along this profile. The depth to top of magnetic anomaly is 13.1 m and 34.2 m. Quartz schist forms the third rock unit. It has depth of 7.4 m.

Profile 3

A total magnetic intensity with minimum negative peak value of -106 nT and maximum positive peak value of 75.3 nT were obtained. The modeling bodies are two dyke-like bodies in nature, thus one rock unit was delineated with depths of 0.9 m and 2.2 m.

Profile 4

Two bodies were used in modeling this profile; dyke and slab. The magnetic intensity here shows a minimum negative amplitude of -266.7 nT and maximum positive amplitude of 169.9 nT. The rock unit found here is quartz schist with depths of 8.4 m and 1.0 m.

Profile 5

The magnetic signature observed here are similar to those of profile 2. The major feature delineated here is the Ifewara fault zone. It has a negative minimum total magnetic intensity of -84.35 nT and a positive maximum total magnetic intensity of 179.43 nT. Three dyke-like bodies were used to model this profile. Two rock units were delineated in this area which are quartz and schist whose depths to top of magnetic anomaly are 2.3 m and 23.9 m respectively.

Profile 6

This profile cuts across Ilesha town, Irekete and Iregun areas. It has a minimum negative total magnetic intensity of -625.5 nT and maximum positive peak value of 71.8 nT. The depth to magnetic source here is 11.5 m. The nature of the magnetic signature shows that this area is characterized by a fault fracture trending NE-SE.

Discussion

In this work, forward and inverse modeling technique is applied

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in analyzing hand digitized aeromagnetic data of Ilesha Southwest, Nigeria. Six profiles where taken across the study area for easiness of interpretation. Profile one (Figure 4) reveals two distinct bodies with susceptibilities of 0.004 and 0.07 and depths of 0.5 m and 16.7 m respectively. Thus two rock units where delineated based on the geology of the study area; quartzite and amphibolite. These rocks had undergone a polycyclic metamorphism which is mostly pervasive in eburnean and Pan-African tectonothermal events [21]. In profile two, (Figure 5) susceptibilities obtained reveals three rock units namely amphibolites schist and quart schist. Amphibolite occurs widely in southwestern Nigeria in Ile-Ife area, Ibodi, Itagunmodi in Ilesha area. Most outcrops of the massive melanocratic amphibolites are exposed in streams and river channels in these areas [21]. Others rock units obtained from profile 3, 4, 5 and 6 include schist and quartz. The linear nature of the anomalies in this part of the schist belt suggests that the rocks may be bounded and offset by faults which serve as

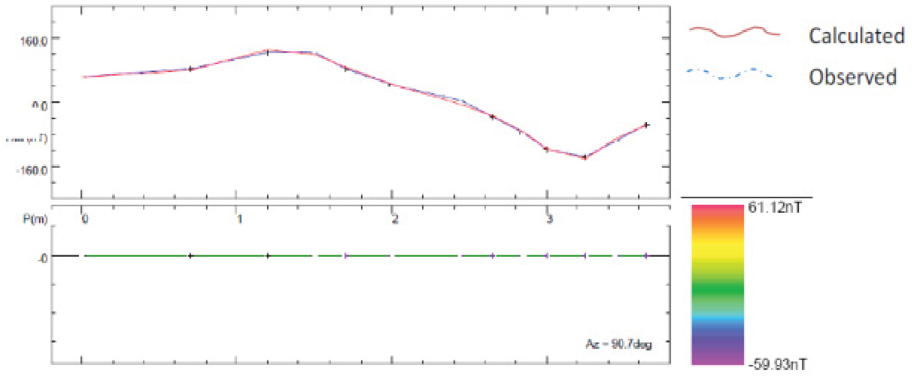

Figure 4: Observed and calculated TMI, Profile one.

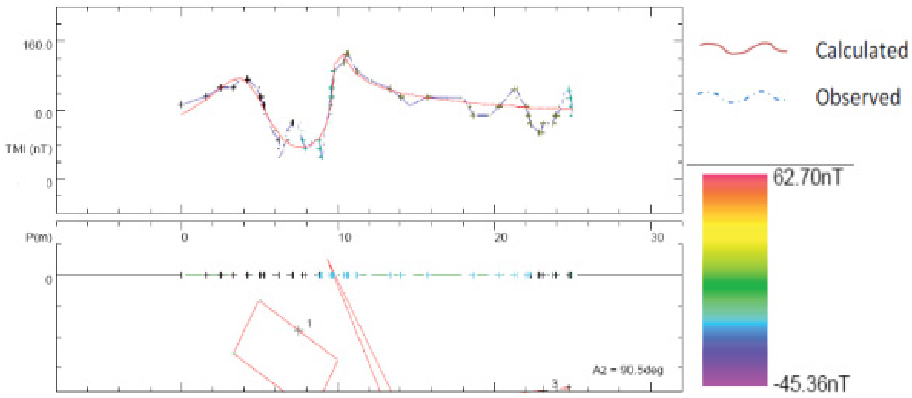

Figure 5: Observed and Calculated TMI, Profile two.

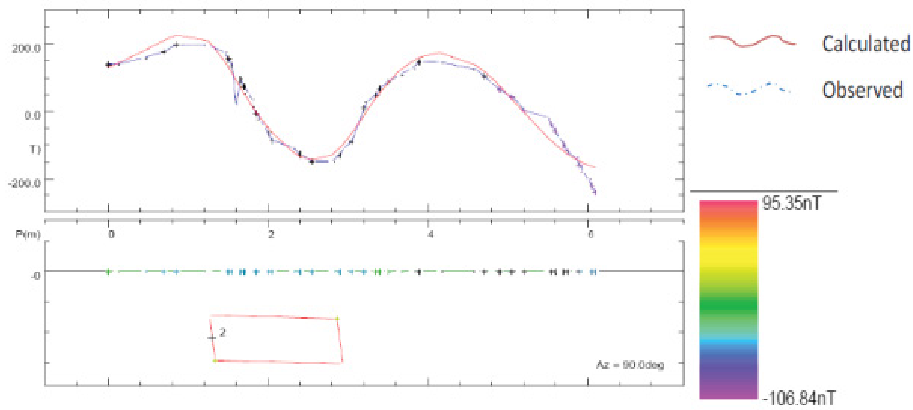

Figure 6: Observed and Calculated TMI, Profile three.

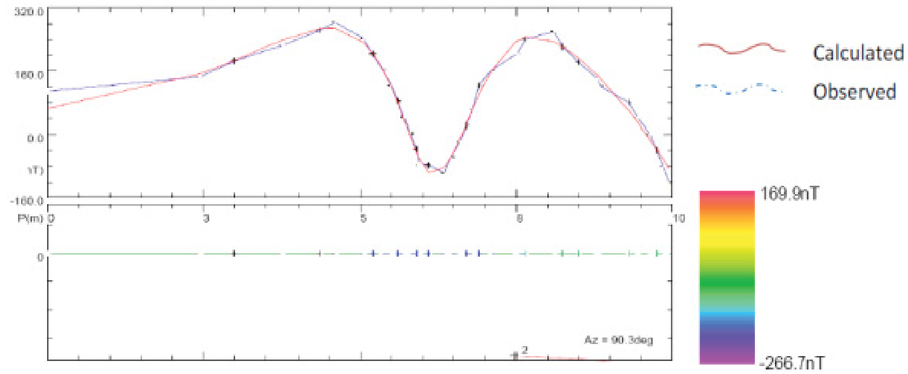

Figure 7: Observed and Calculated TMI, Profile four.

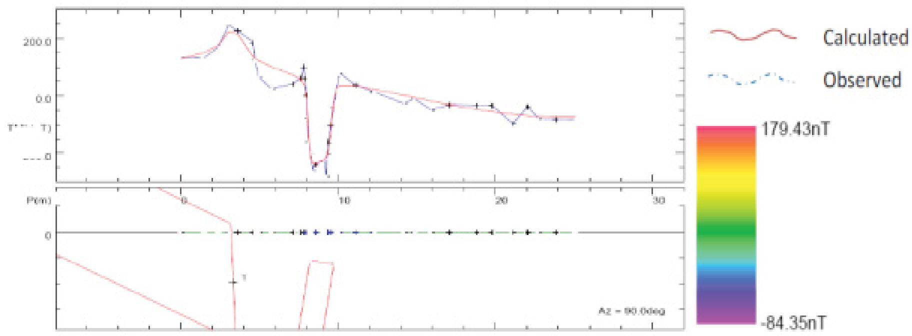

Figure 8: Observed and Calculated TMI. Profile five.

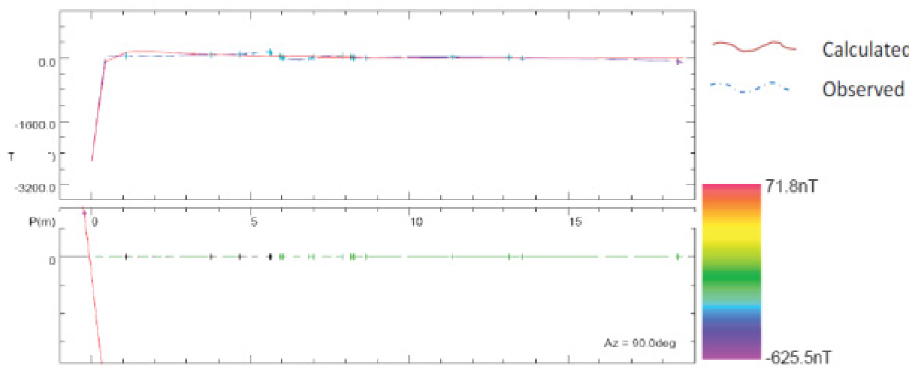

Figure 9: Observed and Calculated TMI, Profile six.

deposits center for mineral resources [4]. This fault is noticeable in profile 6 (Figures 6-9). The area west of the fault comprises mostly amphibolites, amphibole schist, metaultramafites, and meta-pelites. Extensive psammitic units with minor meta-pelite constitute the eastern segment. These are found as quartzites and quartz schist. All these assemblages are associated with migmatitic gneisses and are cut by a variety of granitic bodies Rahaman [2,22]. The results obtained have further confirmed the presence of Ifewara fault zone in the western part of Ilesha, trending NE-SW, as shown in profile 6 (Figure 9). This is in line with the submissions of Onyedim who delineated a major fault trending NNW-SSW in Ilesha SW, using steerable filters [19]. The results have further justified the effectiveness of hand digitized data as submitted by Bath [17]. Quantitatively, results obtained have shown maximum depth to anomalous source of 34.2 m and minimum depth of 0.5 m. This confirms the result obtained by Momoh et al and Alagbe et al [11,14]. While the former obtained depth ranges of 0.3 m to 41.3 m, the later obtained depths ranging from 3.0 m to 21.0 m. The depth range agrees with the result obtained by Adelusi who used electrical resistivity method and obtained 2.3 m -21.2 m [15]. Geologically, it is expected that depths within Ilesha should be shallow since we are dealing with a basement complex. Hydrocarbon search maybe rule out because of shallow depths but ore minerals have potential on account

Profiles	X(m)	Y(m)	No. of Bodies	k Value (SI)	Types of Bodies	Depth (m)	Dip (deg.)	Plunge (deg.)	Strike (deg.)	Remanent Magnetization Rem.H		
										Rem.H	Rem.Az	Rem.Ic
Profile I	1.6	0.2	2	0.004	Slab	0.5	31	-81	8.2	-0.672	21.1	-43.4
	0.6	0.2		0.07	Slab	16.7	-10.5	-71.1	-1.4	18.915	0.5	2.2
Profile 2	16.9	20.2	3	0.085	Dyke	13.1	26.8	27.8	37.3	-0.619	-15.02	23.7
	21.4	1.2		0.088	Dyke	34.2	-101.2	22.5	32.3	-2.252	1.23	-3.2
	23.6	0.1		0.021	Dyke	7.4	-6.9	-4.8	11.7	0.9	0.1	0
Profile 3	1.6	0.2	2	3	Dyke	0.9	-96.7	21.1	-40.2	58.78	23.9	-43.4
	4.9	-0.3		3	Dyke	2.2	73.8	10	-5.4	26.94	-4.3	-8
Profile 4	4.5	0.5	2	0.0042	Dyke	8	18	98.5	56.6	3	80.34	- 125. 1
	7.1	-0.7		0.0035	Slab	1	-9	39.9	15.3	7.14	-13.5	-19.8
Profile 5	2.7	1.8	3	0.01	Dyke	2.3	42.5	87.2	110.2	0.679	3.7	7.4
	4.4	-0.7		0.01	Dyke	23.9	-11.3	84.I	-48.8	-0.855	10.2	30.1
	19.8	0.8		0.03	Dyke	12	-35.5	14	8.2	19.919	-4.2	-5.9
Profile 6	1.2	0	1	0.3	Dyke	11.5	8.7	-84.2	-107	110.06	-91.1	57.8

Table 1: Summary of result.

of high susceptibilities obtained in the course of this study. Table 1 give summary of the results obtained.

Conclusion and Recommendation

An aeromagnetic map has been hand digitized and analyzed using forward and inverse modeling technique to obtain the depths to top of magnetic anomally and various rock units present in the study area. Total magnetic intensities recorded ranges from a minimum negative peak value of -625.5 nT to a maximum positive peak value of 179.43 nT. The maximum depth to top of the magnetic source body obtained is 34.2 m and minimum depth is 0.5 m. Anomalous bodies recorded include quartzite, amphibolites schist and quartz schist. These bodies are possible centers of mineralization since they are associated with fractures/faults which must have resulted from tectonic activities. Generally, depths to top of magnetic anomalies give important information on petroleum characteristics and mapping of areas for possible mineral exploration. The depths obtained shows good sign of mineral depositions in the study area. It is recommended that further research with advance technology be carried out in the study area to obtain other information that will aid in the understanding of the research area for possible exploration of the mineral resources present there. Rocks such as quartzite, amphibolites schist, and quartz schist have economic importance and uses. For instance schist can be used for flooring ground after building and it can be used for decorating gardens. Quartz schist can be used for decoration purposes, for carving materials, as an abrasive in grinding, sand blasting and cutting softer stones. Amphibolites on the other hand are local host of gold mineralization. Minerals are localized in rocks within the schist belts in southwestern Nigeria. Some of the minerals found within the southwestern Nigeria basement complex include, gold in Oyan and Ilesha schist belts, in Okolom and Gurungaji in Egbe schist belt southwestern Nigeria. Gold is the major metal found in the southwestern Nigeria basement rocks [21].

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