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Geophysical Interpretation of Magnetic Data over Mineralized Zone of Itagunmodi, Southwestern Nigeria

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Abstract

This study analyzed measured ground and airborne magnetic data sets. These were with a view to providing information on the depth to basement rocks, the subsurface geologic layers, and essentially how these geologic structures serve as indicators for the occurrence of minerals and also its possible contribution/influence to the deposition and disposition of minerals in Itagunmodi town. The ground magnetic profiles from the ground magnetic data revealed a great deal of inhomogeneity in residual magnetic intensity values. The magnetic anomaly value ranged from -34.4 to +284.5 nT. The 2D subsurface images also revealed a deformed underlying rock. The minimum and maximum overburden thicknesses from the 2-D subsurface image were obtained as 5 m and 70 m respectively. The inferred structural map obtained from High-resolution aeromagnetic data of Ilesa area revealed some major and minor inferred faults. The lineament analysis of the inferred structures using the Rose diagram revealed two main tectonic episodes in the area. These were the NE-SW and the ENE-WSW structures among which the NE-SW trend dominates. Also, notable were the NNE-SSW trends and few E-W trends. The Ifewara and other major fault zones were delineated. Itagunmodi, the study area was observed to be associated with two minor faults that offset the Ifewara fault at about 30° and 45°. This suggested possible migration of minerals from the Ifewara fault into the deformed structures via the Itagunmodi area inferred faults over geological time.

Keywords

Magnetic, Minerals, Lineament, Itagunmodi, Fault

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1. Introduction

Geophysics utilizes varied methods to measure the physical parameters of the earth´s sub-surface, to determine the presence, or otherwise, and location of minerals and geological structures [18]. The gravity and magnetic methods constitute the commonly measured geophysical methods. The present study employed the magnetic methods i.e. the ground and airborne surveys.

The study of geologic structures such as fold, fractures, foliation, and dyke present in rocks can be used as clues to delineate the subsurface, understand the structural patterns, identify elements present in the rocks, unravel the type and nature of deformation that has affected these rocks, determine the geologic history of an area and most especially geologic structures which may serve as indicators for the occurrence

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of minerals.

Local variations of the main field emanate from the local changes in concentration of magnetic minerals and/or the presence of geological structures such as fold, fractures, foliation, dyke, etc. in the near-surface rocks. The field due to these local variations (magnetic anomalies) are obtained from the difference between the total fields and the main fields. These are the target of magnetic exploration.

Several works have been done in Ilesa and its environs, most of which have provided information on the subsurface, structural patterns, depth to source bodies, geologic structures, and many others but none has majorly dwelt on the study of geologic structures that may serve as indicators for the occurrence of minerals in Itagunmodi town. Study on the Ilesa area has been indicative of sulphide mineralization [7]. However, the study area is mainly underlain by Amphibolite rock around the Iwara fault, unlike Itagunmodi which is known to be underlain by the Epidiorite rock. Previous studies [1, 2, 5, 6, 11, 12, 16] adopted the magnetic method to provide information on geologic structures such as fold, fractures, foliation, dyke, etc. present in rock, structural patterns, elements present in the rocks, type and nature of deformation that has affected rocks, geologic history of an area, depth to a magnetic source, subsurface geologic layers, shear zones, possible extension of known faults, e.t.c. in Ilesa area and some parts of Southwestern Nigeria. These studies however did not provide or provided little information on the Itagunmodi area. This magnetic method (ground and airborne) geophysical research was carried out to provide information on the depth to basement rocks, the subsurface geologic layers, and essentially how these geologic structures serve as indicators for the occurrence of minerals and also its possible contribution/influence to the deposition and disposition of minerals in Itagunmodi town.

2. Geologic Setting

The study area is located in Itagunmodi, a gold-mining town in Ilesha area, Southwestern Nigeria. It is located within geographic coordinates of latitude 07° 32′ 00″ - 07° 33′ 00″ and longitude 04° 39′ 00″ - 04° 41′ 00″ with an altitude at an average of 339 meters. The main rock types found in the Itagunmodi area are; Gnesis and Migmatite undifferentiated, Granite-gnesis, Pegmatite, Schists-pegmatitised, Amphibolite (Epidiorite), and Schists undifferentiated (Figure 1) [3, 9, 10]. The study area is underlain mainly by the Epidiorite rock. The epidiorite rock is one of the major rock units of the precambrian basement of South-western Nigeria [15].

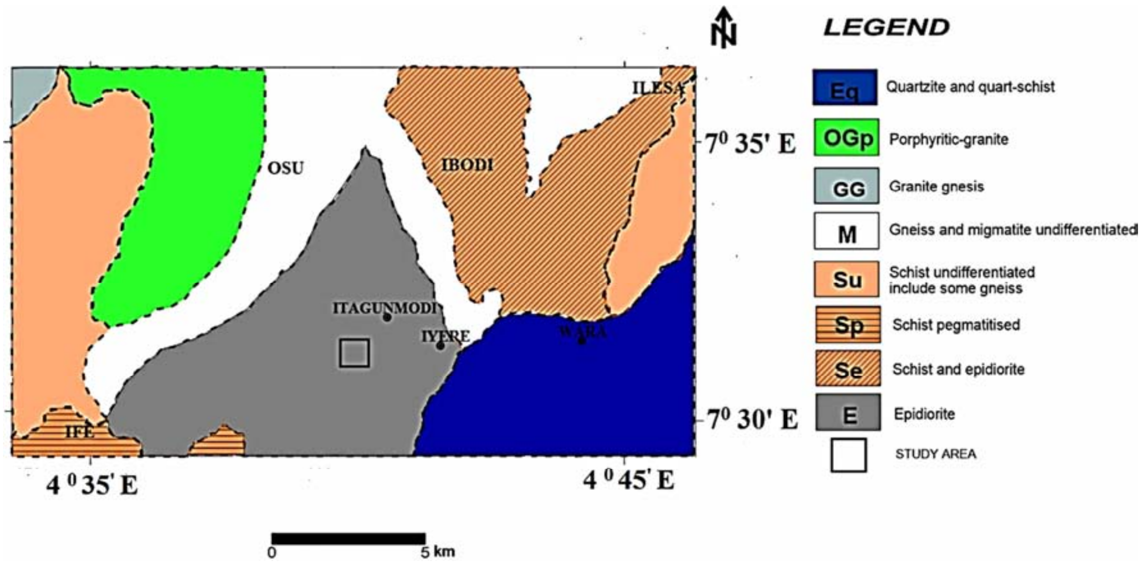

Figure 1. Geological Map around Itagunmodi Area.

3. Methodology

3.1. Ground Magnetic Survey Procedures and Processings

The ground magnetic survey was performed using a proton precession magnetometer along three magnetic traverses (with lengths 500 m, 500 m, and 350 m) on the mineralized area. The survey involved measurement of the total field component of the Earth's magnetic field along these traverses. This technique required the measurements of the magnetic intensities at discrete points along traverses. The traverses were regularly distributed (Figure 2) within the study area to cover enough segments to determine the geological structure and of the study area. The total field magnetic measurements were obtained with 8 PPM along the three (3) traverses at 5 m station intervals. Coordinates of the measurement location were taken at each station interval. The traverse orientations were taken differently. A set of readings were taken at an established base station close to each traverse before the commencement and immediately after data acquisition at a one-hour interval. The base station readings were used for diurnal and offset corrections using three points moving average. To obtain the magnetic values for interpretation, the earth's main field contributions to the measured magnetic field values were removed. Data corrected for the main field was also corrected for the regional gradient using the first-order polynomial trend line. The equations for the trend lines for traverses AB, CD, and EF are given in equations 1, 2, and 3 respectively;

$$Y = 0.25X + 30.3 \quad (1)$$

$$Y = 0.25X + 48.1 \quad (2)$$

$$Y = -0.18X + 134.2 \quad (3)$$

Where Y and X represent the regional gradient magnetic value correction and station distance from base station respectively.

The magnetic data was also upward continued to remove short-wavelength features (aliasing) which are usually due to cultural noise. The resultant corrected magnetic data were plotted against station positions. A SIGNPROC magnetic software was used to produce profiles after the data reduction procedures.

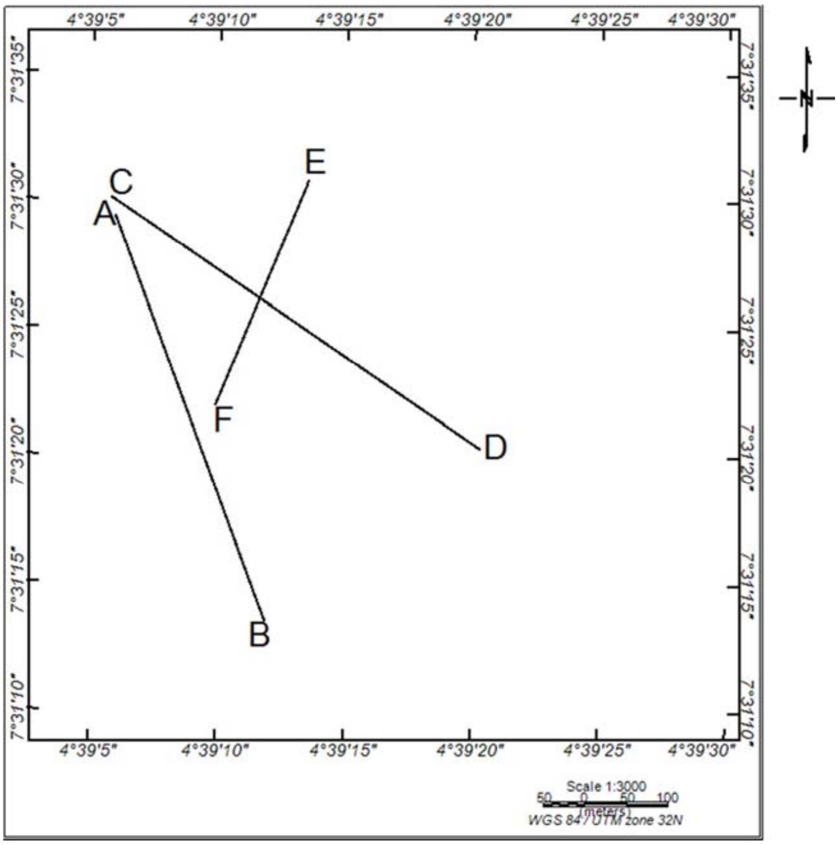

Figure 2. Data Acquisition Map Showing Traverses AB, CD, EF.

3.2. Aeromagnetic Survey Procedures and Processings

High-resolution aeromagnetic data (HRAD) of Ilesha area (bounded by longitudes 4° 30' N to 5° 00' N and latitudes 7° 30' E to 8° 00' E) was acquired from Nigeria Geological Survey Agency (NGSA). This survey was carried out along a set of parallel flight lines at 500 m spacing oriented in a NW - SE direction with a flight height of 100 m. The data were recorded at a sampling interval of 100 m. The tie lines were spaced at 2 km directed to NE - SE direction [14]. The recorded magnetic anomalies displayed several trends.

The HRAD was interpolated using the minimum curvature technique at 100 m grid cell size to produce the total magnetic intensity (TMI) map of the study area.

The reduction-to-equator (RTE) of the HRAD was performed before further processing and analysis to accurately situate the anomalies. The RTE was applied because the study area is located in the low latitude region of the world. The RTE transforms the magnetic data recorded at various magnetic field inclinations to what they would be with zero inducing field inclination thereby simplifying interpretation. To cut off cultural noise from the data, the RTE processed data was then subjected to an upward continuation filter to attenuate the high-frequency responses coming from sources on or close to the ground surface.

Residual magnetic intensity (RMI) map, resulting from the removal of the regional field, was subjected to several source edge detection filters such as First Vertical Derivative (FVD), Horizontal Gradient Magnitude (HGM), and Analytical Signal Amplitude (ASA). The Euler plot which reveals the non-uniform depth distribution of the faults/fractures from shallow to deep zone was also applied. A composite map, one which is a result of overlaying the source edge detection methods was used to infer a structural map.

3.3. Modelling

The mineralized area in Itagunmodi was located on the delineated structural map. Magnetic forward modeling was carried out on the reduced ground magnetic data to produce 2D subsurface images of the mineralized area using a WinGLink integrated interpretation software. The modeled structures were interpreted with the lineaments on the structural map to determine the structures confined within and extending beyond the study area.

4. Results and Discussions

Presented here are profiles, 2D models, maps, as well as the discussions of results and their interpretations.

4.1. Ground Magnetic Profiles

In this study, the qualitative interpretation of the reduced magnetic data was performed by plotting the reduced magnetic field values against station distances using the Signproc for Windows Version 1.6 software. The magnetic signature obtained for the residual magnetic intensity plot along each traverse enables the variation of the magnetic values against station points to be evaluated. The profile showed that the study area is characterized by both negative and positive magnetic anomalies.

4.1.1. Magnetic Profile Along the Traverse AB

The profile's orientation is in the NW – SE direction. It was observed to be characterized by magnetic high and low magnetic anomaly values as shown in Figure 3. The magnetic anomaly value of the residual magnetic field varies between -34.4 nT and +239.6nT. Negative magnetic anomaly value observed include -32.30 nT at station 20 (100 m) and -32.52 nT at station 25 (125 m). Stations 13 (65 m) and 29 (145 m) have zero (nT) magnetic values. Similar magnetic anomaly crest of order +67.0nT are observed at station 3 (15 m), station 8 (40 m), and station 33 (165 m). Station 44 (220 m), station 70 (350 m), station 79 (395 m) and station 88 (440m) also revealed an approximate equal anomaly crest of order +120.0 nT. Observed also was a similar trend of anomaly trough of order +105.0 nT at station 48 (240 m), station 66 (330 m), station 73 (365 m), and station 86 (430 m). A prominent high magnetic anomaly crest of +239.7 nT which suggests a possible existence of dyke was observed at station 59 (295 m).

The observed negative anomaly values and the magnetic anomaly troughs could be attributed to dykes/cracks/minor faults/fractured zones in the epidiorite rocks while the high magnetic anomaly crests could be attributed to near-surface intrusions, outcrops, or magnetic material in the epidiorite rock.

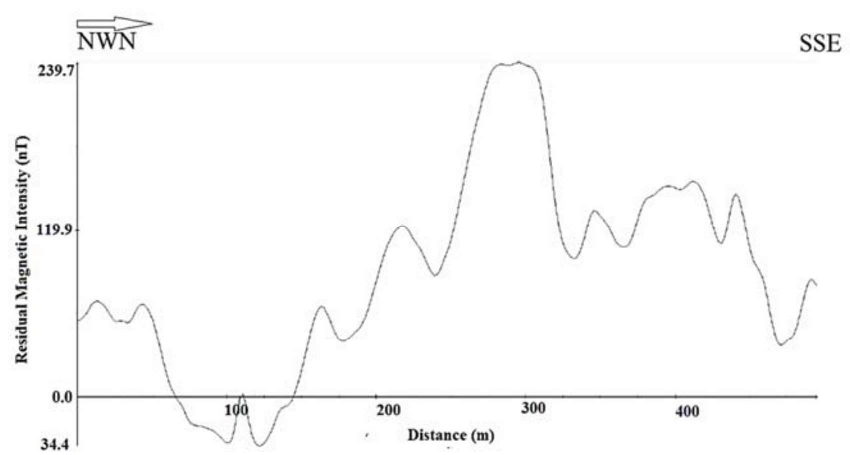

Figure 3. Magnetic Profile along Traverse AB.

4.1.2. Magnetic Profile Along Traverse CD

The profile's orientation is in the NW – SE direction. It was observed to be characterised by only positive magnetic anomaly values as shown in Figure 4. The magnetic anomaly value of the residual magnetic field vary between +8.97nT and +284.5nT. Observed magnetic anomaly crests include +102.45 nT at station 17 (85m), +131.87 nT at station 42 (210 m), +127.72 nT at station 53 (265 m), +187.99 nT at station 79 (395 m) and +196.94 nT at station 86 (430 m). The troughs observed include +8.97 nT at station 25 (125 m), +48.13 nT at station 37 (155 m), +94.15 nT at station 48 (240 m), +45.71 nT at station 64 (320 m), +172.90 nT at station 82 (410 m) and +141.48 nT at station 95 (475 m).

The observed magnetic anomaly troughs could be attributed to dykes/cracks/minor faults/fractured zones in the epidiorite rocks while the high magnetic anomaly crests could be attributed to outcrops, near-surface intrusions, or magnetic material in the epidiorite rock.

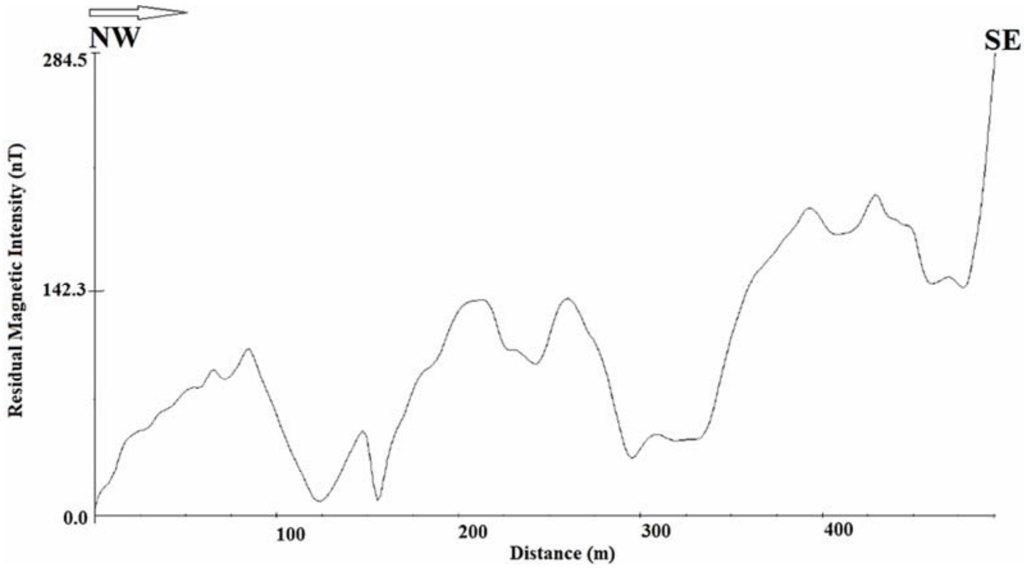

Figure 4. Magnetic Profile along Traverse CD.

4.1.3. Magnetic Profile Along Traverse EF

The profile's orientation is in the NE – SW direction. It was observed to be characterised by magnetic high and low magnetic anomaly values as shown in Figure 5. The magnetic anomaly value of the residual magnetic field vary between +16.9 nT and +143.6nT. Observed magnetic anomaly crest include +139.2 nT at station 6 (30m), +126.56 nT at station 21 (105 m), +142.56 nT at station 18 (90 m), +142.06 nT at station 23 (115 m),+121.36 nT at station 86 (430 m), +118.04 nT at station 42 (210 m), +79.27 nT at station 51 (255 m), +99.95 nT at station 62 (310 m) and +123.12 nT at station 67 (335 m). The troughs observed include +115.18 nT at station 1 (5 m), +63.55 nT at station 13 (65 m), +120.05 nT at station 20 (100 m), +57.88 nT at station 33 (165 m), +97.47 nT at station 41 (205 m) and +39.44 nT at station 47 (275 m). Station 46 (230 m) is observed to zero (nT) magnetic value.

The observed sandwiched magnetic anomaly troughs could be attributed to dykes/cracks/minor faults/fractured zones in the epidiorite rocks while the high magnetic anomaly crests could be attributed to near-surface intrusions, outcrops, or magnetic material in the epidiorite rock.

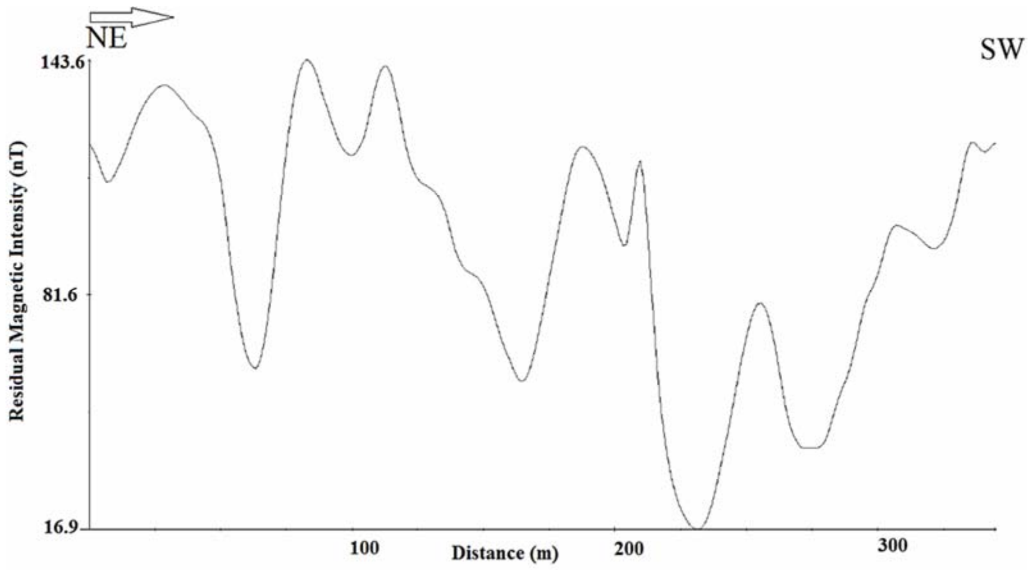

Figure 5. Magnetic Profile along Traverse EF.

4.1.4. Summary of Magnetic Profiles

The magnetic profiles revealed a great deal of inhomogeneity in residual magnetic intensity values. The values range from -34.4 to +284.5 nT. The observed magnetic anomaly troughs and crests were interpreted as possible dykes/cracks/minor faults/fractured zones and near-surface outcrops/intrusions and dyke or magnetic minerals respectively.

4.2. Ground Magnetic 2-D Subsurface Models

In this study, the quantitative interpretation of the magnetic profiles was performed with the 2.5D modeling algorithm of the WingLink software program (Version 1.62.08). The magnetic profiles along the three traverses were modeled to investigate the linear features, basement depth (and topography), and the basement tectonic framework along the traverses. Sedimentary rocks are considered to have low magnetic susceptibility values, hence magnetic anomalies observed in the study area indicate that they might have emanated from the basement as well as from magnetic materials present within the fractured/faulted zones in comparison to the fresh massive bedrock. The modeling of these profiles showed a very reasonable fit between the measured and the computed magnetic profiles.

4.2.1. 2-D Model for Traverse AB

Figure 6 shows the measured and the computed anomaly for the magnetic profile along traverse AB and the interpreted geologic section. Two model bodies are involved in the computation and these include the Epidiorite (s = 4.000 SI unit) and the overburden (s= 0.002 SI unit) mostly of clay composition.

The subsurface model showed inhomogeneous overburden thickness/infills. The overburden thickness range between 10 m – 70 m and prominent deformation is observed between stations 40 – 100. The overburden thickness is deepest between station 35 (175 m) and station 95 (475 m) and shallowest between station 0 (0 m) and station 20 (100 m). An overburden width of 40 m and thickness of 70 m (greatest observed width and thickness) is observed at regions neighborhood of station 62 (310 m). This is indicative of great depths and width at which miners can dig up. Station 35 (175 m) to station 95 (475 m) are observed to be associated with prominent outcrops/ intrusions while an averagely flat underlying rock is observed between station 0 (0 m) and station 35 (175 m). The overburden infills are prominent between stations 36 and 100. Disposition of such overburdened infills in deformed underlying rocks is possible natural conduits for materials and small rock units. These rock units may undergo abrasion, attrition, and solution, consequently releasing minerals in the rock foliations into the deformed structures.

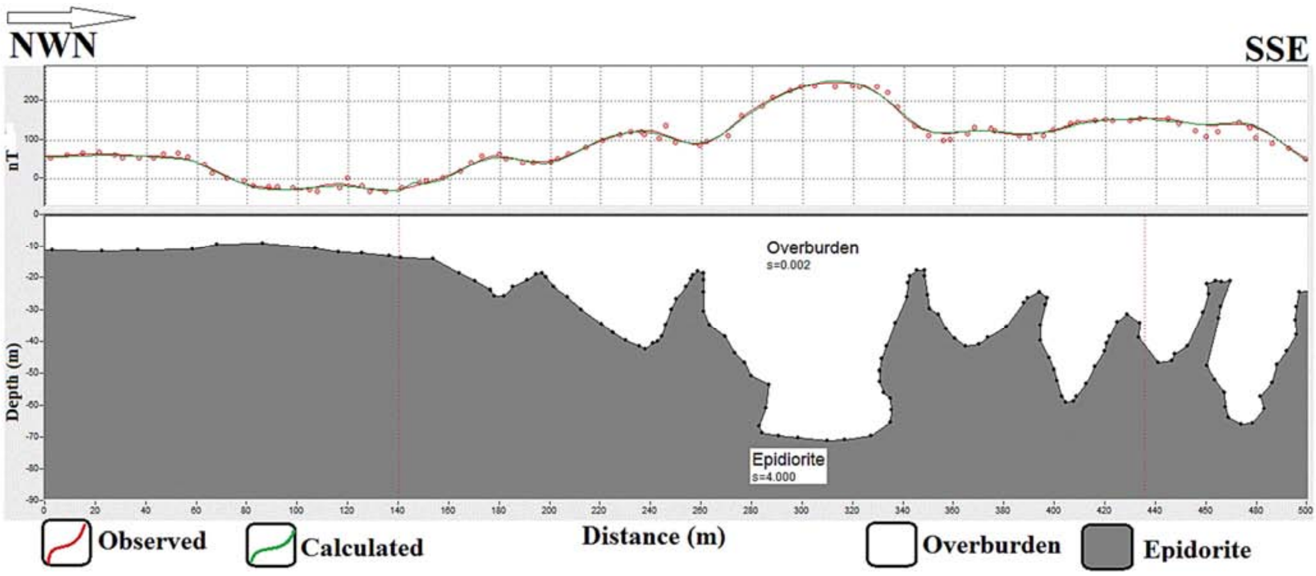

Figure 6. 2-D Magnetic Model for Traverse AB.

4.2.2. 2-D Model for Traverse CD

Figure 7 shows the measured and the computed anomaly for the profile along traverse CD and the interpreted geologic section. Two model bodies are involved in the computation and these include the Epidiorite (s = 4.000 SI unit) and the overburden (s = 0.002 SI unit) mostly of clay composition.

The subsurface model also shows an inhomogeneous overburden thickness/infills. The overburden thickness range between 5 – 70m. Prominent deformation is observed between stations 34 – 100 while station 0 (0 m) to station 20 (100 m) is associated with less deformation. An overburden thickness of 75 m and a width of 40 m (greatest observed thickness and width) is observed at regions neighborhood of station 42 (210 m). This revealed that miners can dig to great depth and width within this point. Prominent outcrops of similar peaks at an average of 10 m are observed at station 32 (160 m), station 48 (240 m), station 61 (305 m), and station 78 (380 m).

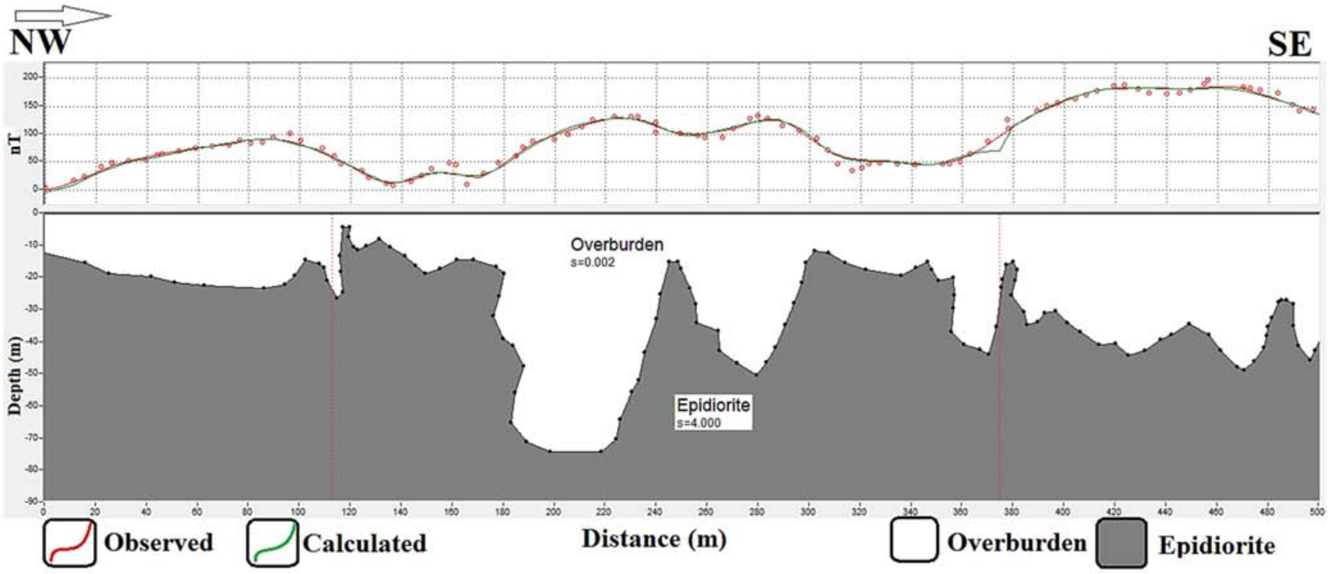

Figure 7. 2-D Magnetic Model for Traverse CD.

4.2.3. 2-D Model for Traverse EF

Figure 8 showed the measured and the computed anomaly for the profile along traverse EF and the interpreted geologic section. Two model bodies are involved in the computation and these include the Epidiorite (s = 3.000 SI unit) and the overburden (s= 0.002 SI unit).

Just like the earlier two models, the subsurface model showed an inhomogeneous overburden thickness/infills. However, the model showed the shallowest overburden thickness. This revealed a shallow depth to which miners can dig before reaching the underlying rock. Outcrops of similar peaks at an average of 10 m are observed at stations 12 (60 m), 32 (170 m), and 46 (230 m).

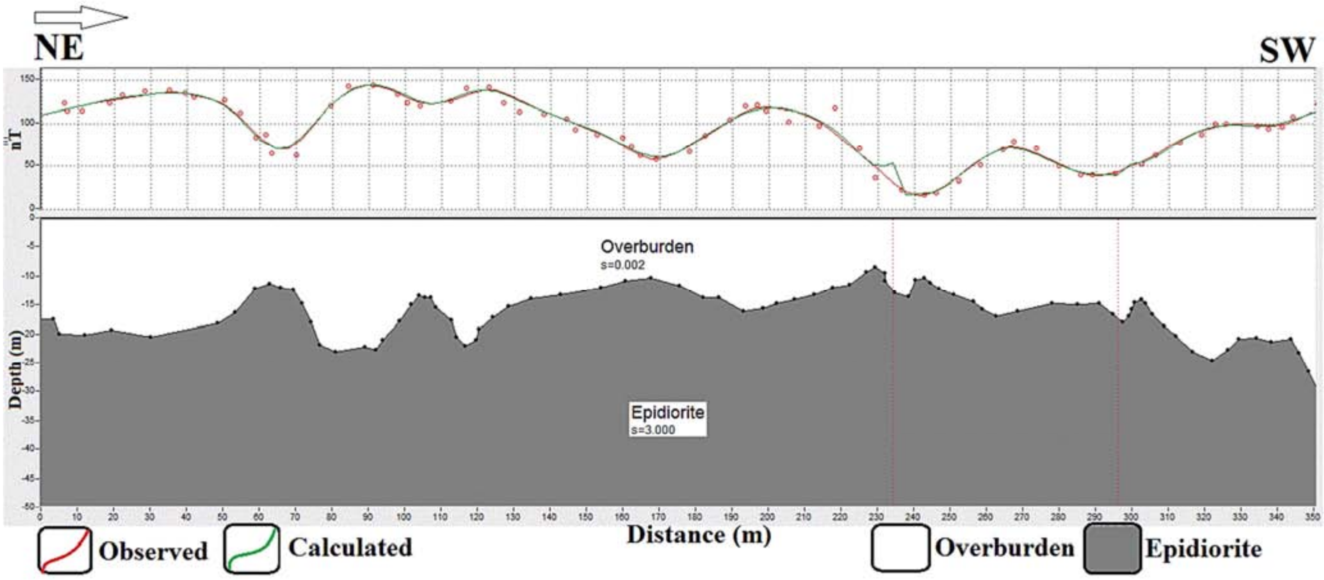

Figure 8. 2-D Magnetic Model for Traverse EF.

4.2.4. Summary of Ground Magnetic Models

The 2-D subsurface images revealed a deformed underlying rock with prominent outcrops within overburden infills. The minimum and maximum overburden thickness/infills were obtained as 5 m and 75 m respectively. This result correlates well with the results of Ariyibi [4] who obtained a depth range between 0 to 65 m for a modeled magnetic profile along Itagunmodi to Aiyetoro. Kayode and Adelusi [12] also obtained depth range between 20 – 130 m in the Ilesa east schist belt. The depth results obtained for this study signifies shallow depths to the magnetic source, as expected in most areas of the basement complex of Nigeria. The traverse was observed to be associated with a pronounced disposition of depressions/overburden infills. Disposition of such depressions in underlying rocks is possible natural conduits for minerals materials and small rock units.

4.3. Aeromagnetic Survey Data Analysis and Interpretation

Results from the processing of the HRAD of Ilesa sheet 243 were presented hereafter as maps for the total magnetic field intensity (TMI), RTE, residual magnetic intensity (RMI), HGM, ASA, Euler deconvolution (ED), FVD and lineaments. The anomalies expressed by the magnetic contours are dependent on the variable magnetic intensities of the underlying rocks and may also be due to conditions near, or at unknown depths below the surface. By the means of the magnetic anomalies and various changes in the separation of contours, useful information could be provided for the delineation of important structural features.

4.3.1. Total Magnetic Intensity (TMI) and Filtered TMI Maps

The TMI map of Ilesa sheet 243 was presented as a 2D map in Figure 9. The map was observed to be characterized by magnetic anomaly values ranging from -79.4nT to 161.1nT.

The map revealed a NE-SW trending high magnetic anomaly value. Significant high magnetic anomaly values are associated with the central part (Osogbo, Ororuwo, Otan-Ile, Ibokun, Esa-Odo, and Esa-Oke areas) of the map. Other towns with similar high anomaly values include Ikirun and Iragbiji. Prominent on the bottom- right (Iloko, Ilesa, Erin Jesa, Efon Alaaye, and Iperindo areas) of the map are low magnetic anomaly values.

The study area was observed to be attributed to both high and low magnetic anomaly values. The high-value magnetic anomaly was observed to be prominent in the central part and the north-west flank of the Itagunmodi area while low-value magnetic anomalies are associated with the south-east flank. High and low-value magnetic anomalies in low latitude areas are qualitatively interpreted as signatures of subsurface rocks having low and high magnetic susceptibilities, respectively.

The TMI map is characterized by anomalies of varying values, some of whose sources are cultural features constituting noise in the data. Figure 10 shows a filtered TMI map resulting from an upward continuation of the TMI map to 100 m. This filtered TMI map revealed well-defined and resolved anomalies with magnetic anomaly value distribution similar to the TMI map.

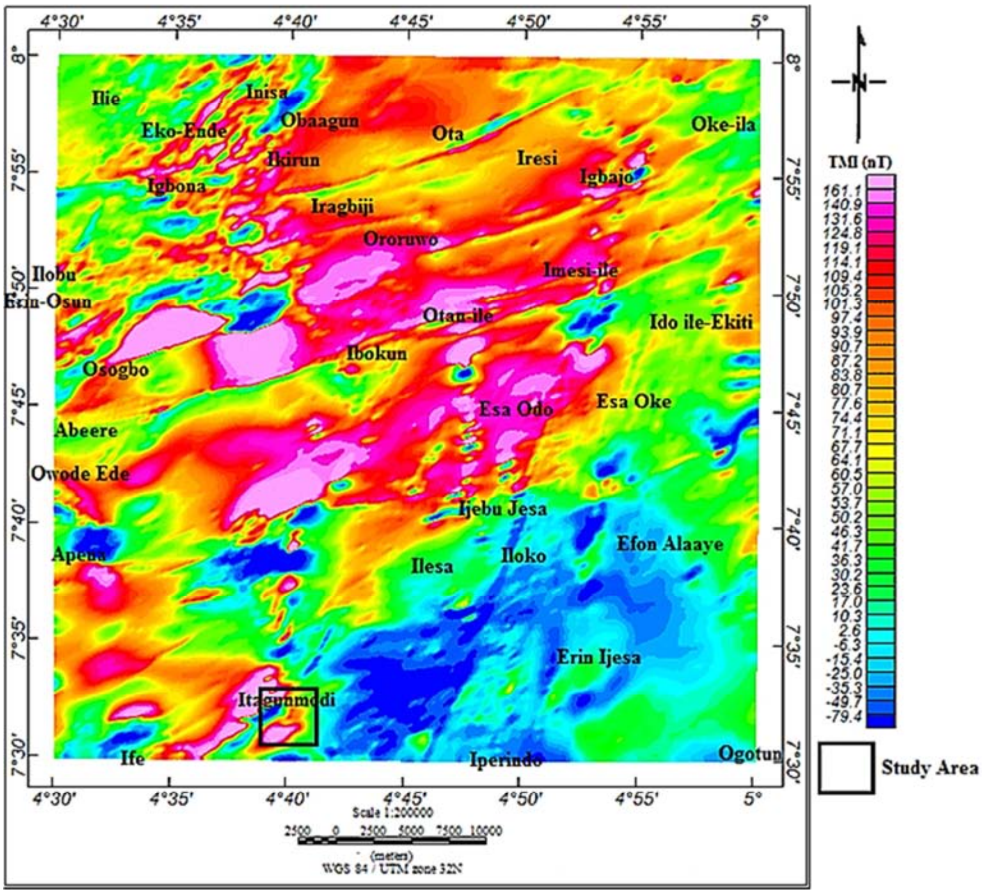

Figure 9. Total Magnetic Intensity (TMI) Map.

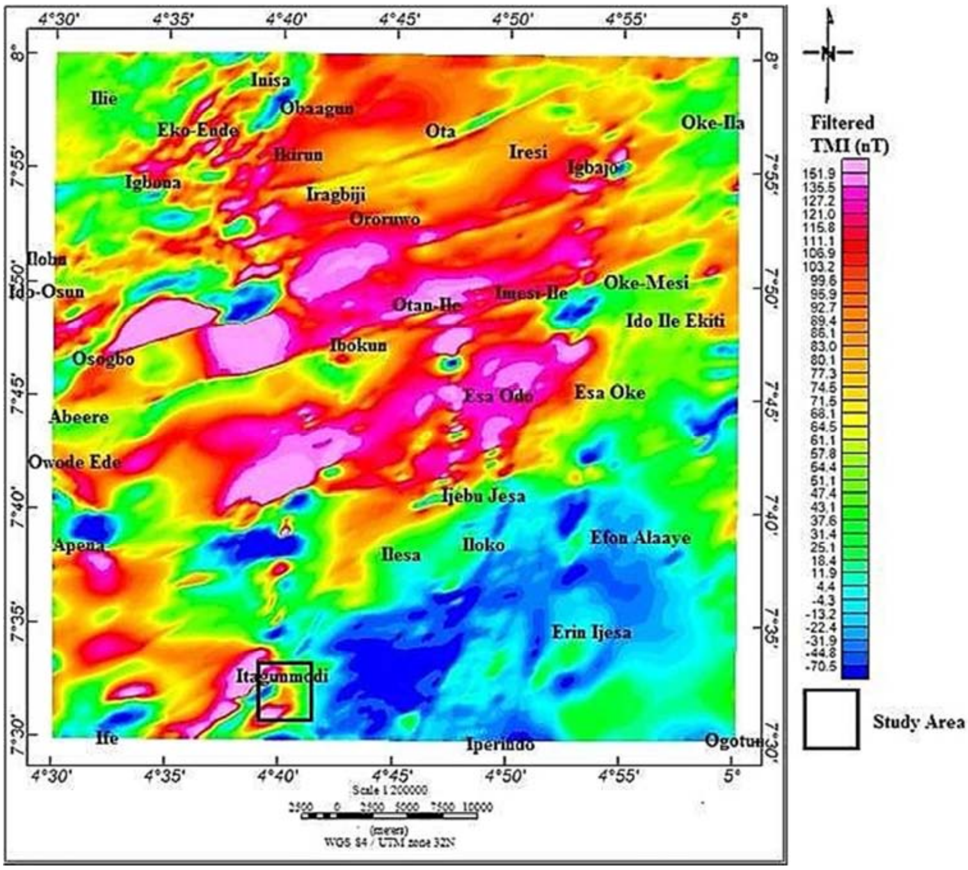

Figure 10. Filtered Total Magnetic Intensity (TMI) Map.

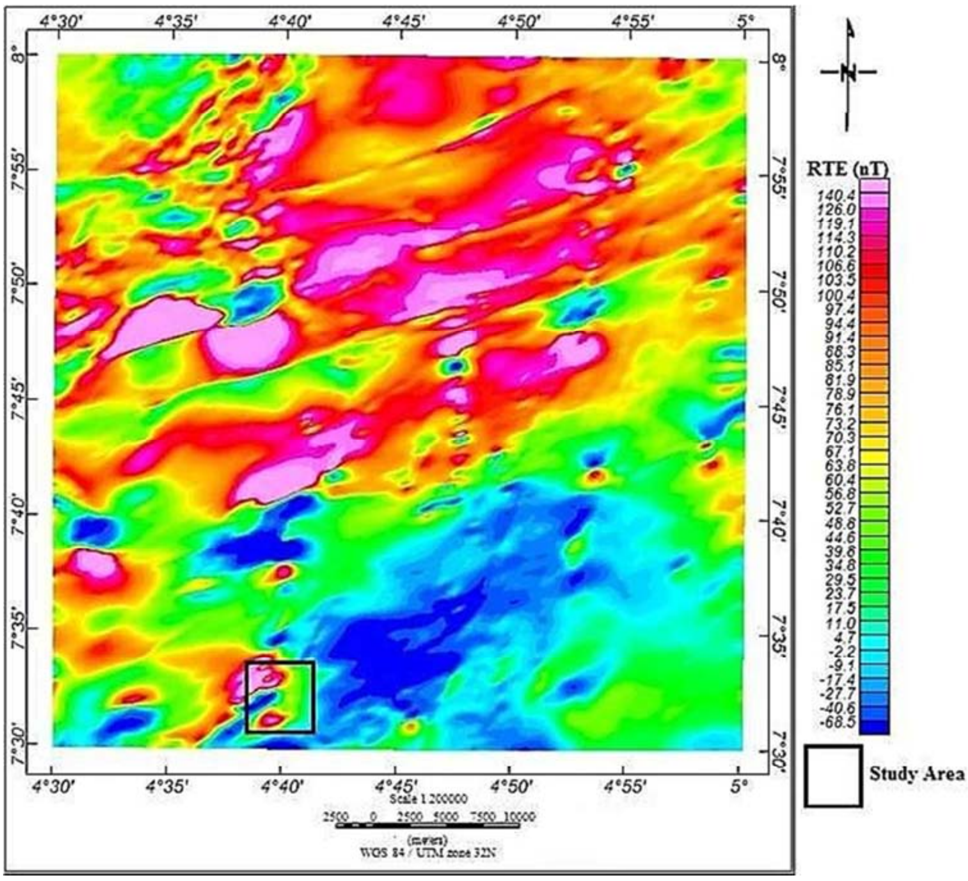

Figure 11. Reduction To Equator (RTE) Map.

4.3.2. Residual Magnetic Intensity (RMI) Map

Due to the low latitude area location of the study area, RTE was applied to the filtered TMI data of Ilesa before further processing. This helped to simplify interpretation by converting magnetic data collected at different magnetic field inclinations to what they would be with zero inducing field inclination. The RTE map is as shown in Figure 11. A comparison of the RTE map with the filtered TMI map revealed a marginal disparity. This is a consequence of the very low magnetic inclination value (about −9.5°) of the study area. Inspection of the values of the anomalies also revealed that the maximum and minimum values in the RTE map had reduced to 140.4 nT and increased to −68.5 nT respectively.

Figure 12 shows the RMI map resulting from the removal of the regional field - an upward continuation of the RTE map to 4 km. The RMI map is characterized by anomalies of varying values ranging from -82.3 nT to 66.4 nT. This RMI map revealed well-defined and resolved anomalies. Similar to the TMI map, the RMI map revealed significant high magnetic anomaly values that are associated with the central part (Osogbo, Ororuwo, Otan-Ile, Ibokun, Esa-Odo and Esa-Oke areas) of the map. Other towns with high anomaly values include Ikirun and Iragbiji. Prominent on the bottom-right (Iloko, Ilesa, Erin Jesa, Efon Alaaye, and Iperindo areas) of the map are low magnetic anomaly values.

As can be observed from the RMI map, the study area is characterized by high magnetic anomalies veined by low magnetic anomalies.

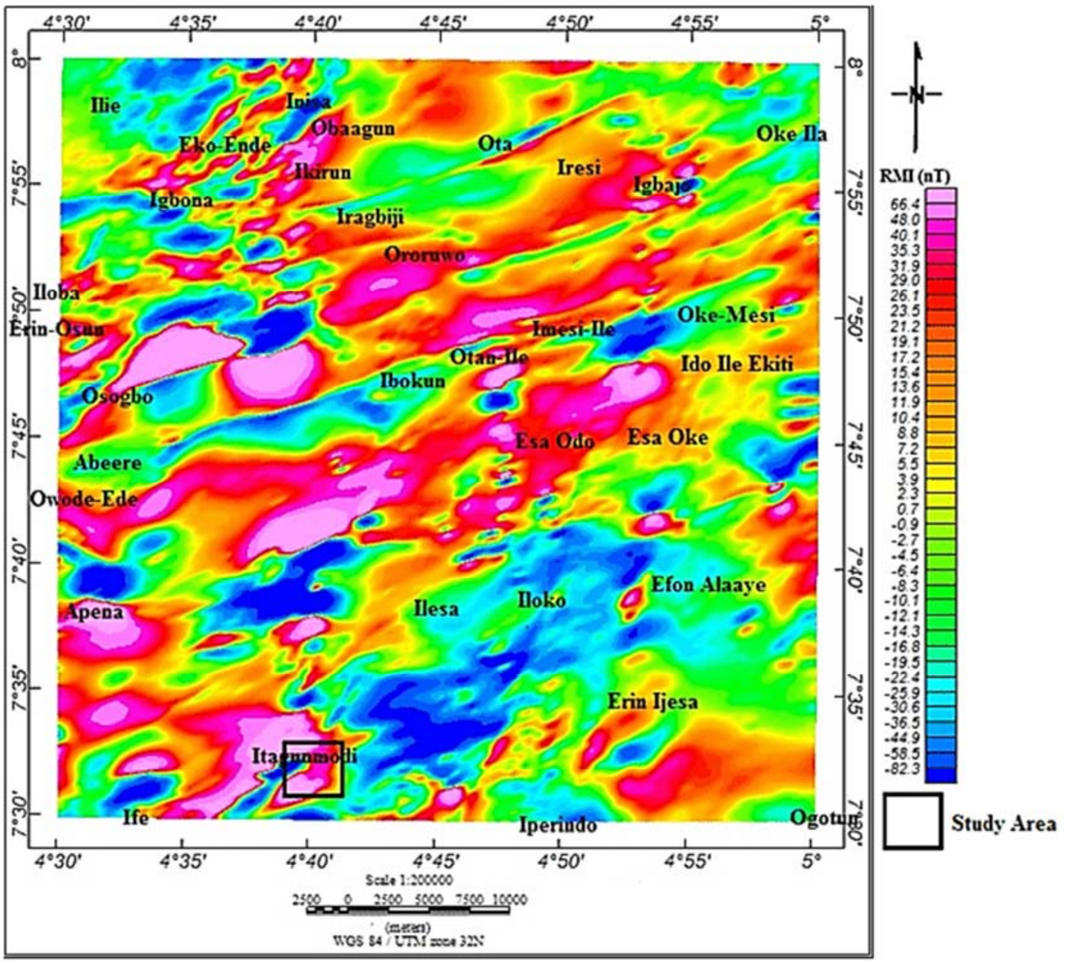

Figure 12. Residual Magnetic Intensity (RMI) Map.

4.3.3. Inferred Structural Map

The FVD, HGM, ASA, and ED geophysical processing techniques were applied to the residual magnetic intensity data to enhance the signals of the subsurface structures and geologic boundaries related to faults, contacts, and fractures.

The ASA and HGM maps of the filtered RMI data are as shown in Figure 13 and Figure 14 respectively. A good correlation was observed in both maps. This is because both maps peak over the source edges. However, the HGM map showed more continuous, thin, and straight maxima than the ASA map.

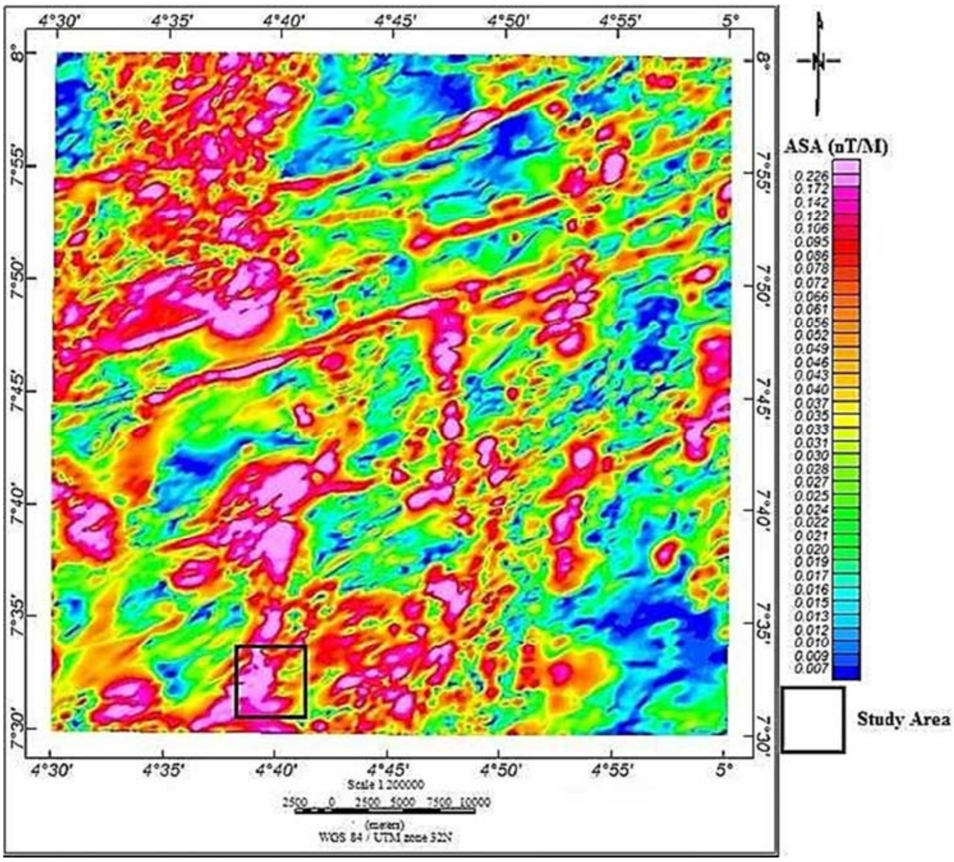

Figure 13. Analytical Signal Amplitude (ASA) Map.

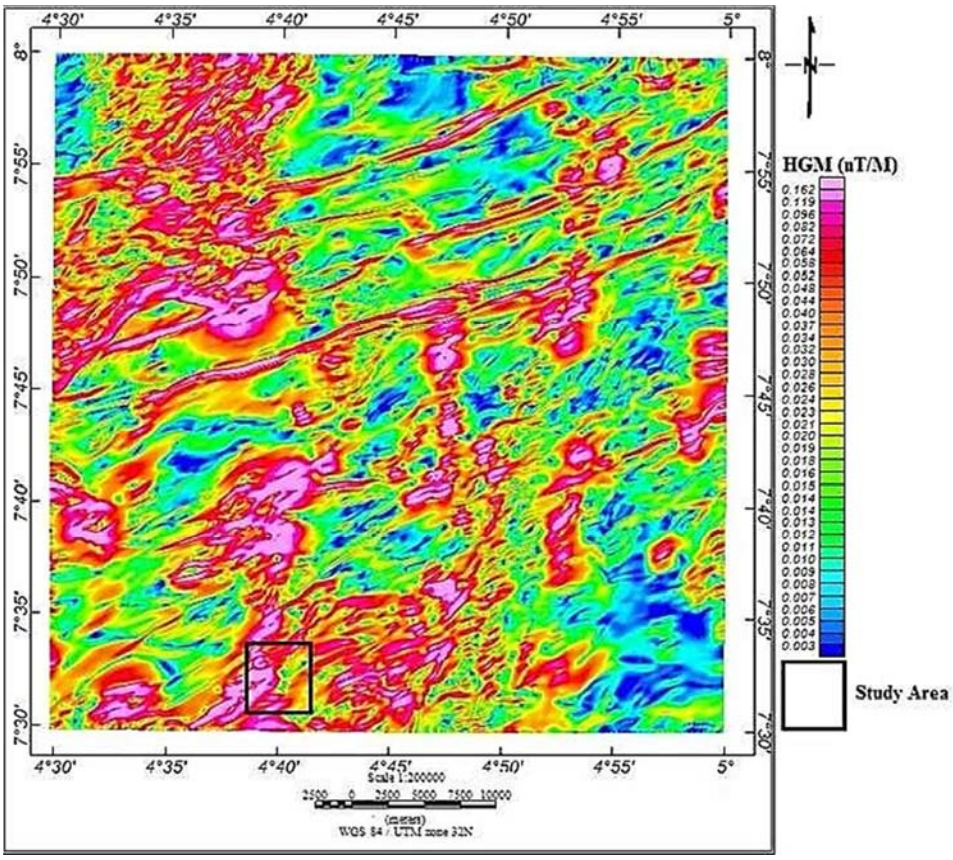

Figure 14. Horizontal Gradient Magnitude (HGM) Map.

Figure 15 and Figure 16 respectively show the source edge locations (maxima) of the ASA and HGM overlain on the RMI map. The figures represent the relationship between the anomalies and their source edges. Most of the peaks identified the edges of anomalies, consequently, lineaments were seen to be in the NE- SW trending pattern. However, fast steep short lineaments are observed to margin the map from the top-left diagonal to the bottom- center.

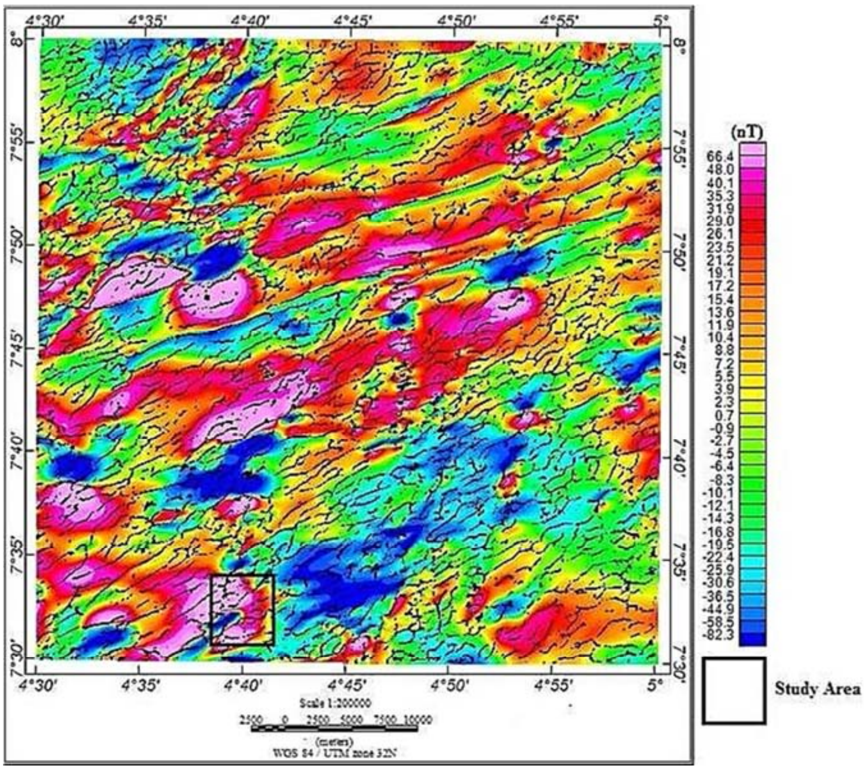

Figure 15. ASA Peaks Overlain on the RMI Map.

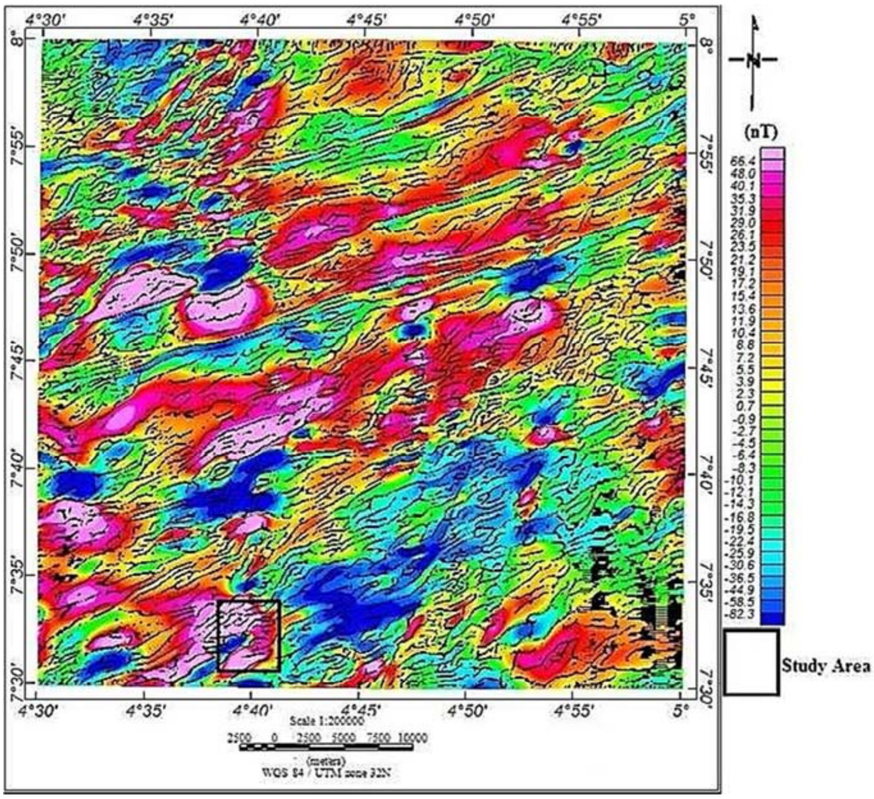

Figure 16. HGM Peaks Overlain on the RMI Map.

These fast steep short lineaments are more significant towards the bottom-center. Such abrupt change in lineament patterns can be attributed to geological linear structures such as contacts, faults, or fractures.

The results of 3D Euler deconvolution for structural indices of zero and one were inspected for the best clustering. A well-clustered solution commonly reflects the suitability of the structural index (SI) used [17]. The SI of one which is a representation of dike/fault (fracture) offers the best clustering solutions and was therefore chosen. The Euler solutions, which are mostly linear, are therefore interpreted as possible faulted block boundaries. The solutions mapped by the ED align well with the source edges that were also mapped by ASA and HGM methods in Figure 15 and Figure 16 respectively. Locations, where the source edges from HGM and ASA methods do not show alignment with the Euler solutions, might have not been faulted or fractured. The most significant clustering was identified using labeled quadrilaterals Q1 and Q2 and are interpreted as the important fault/fracture zones. Q1 suggested a NNE-SSW trending fault and this correlates with the known Ifewara fault zone mapped by Awoyemi et al. [6]. The curved breakage which resembles concentric ripples of a mussel shell illustrated in Q2 suggested conchoidal fractured/faulted zones. This was attributed to the presence of pegmatite rocks that are layered, banded, and veined. The Euler plot (Figure 17) also reveals the non-uniform depth distribution of the faults/fractures from shallow to deep zone.

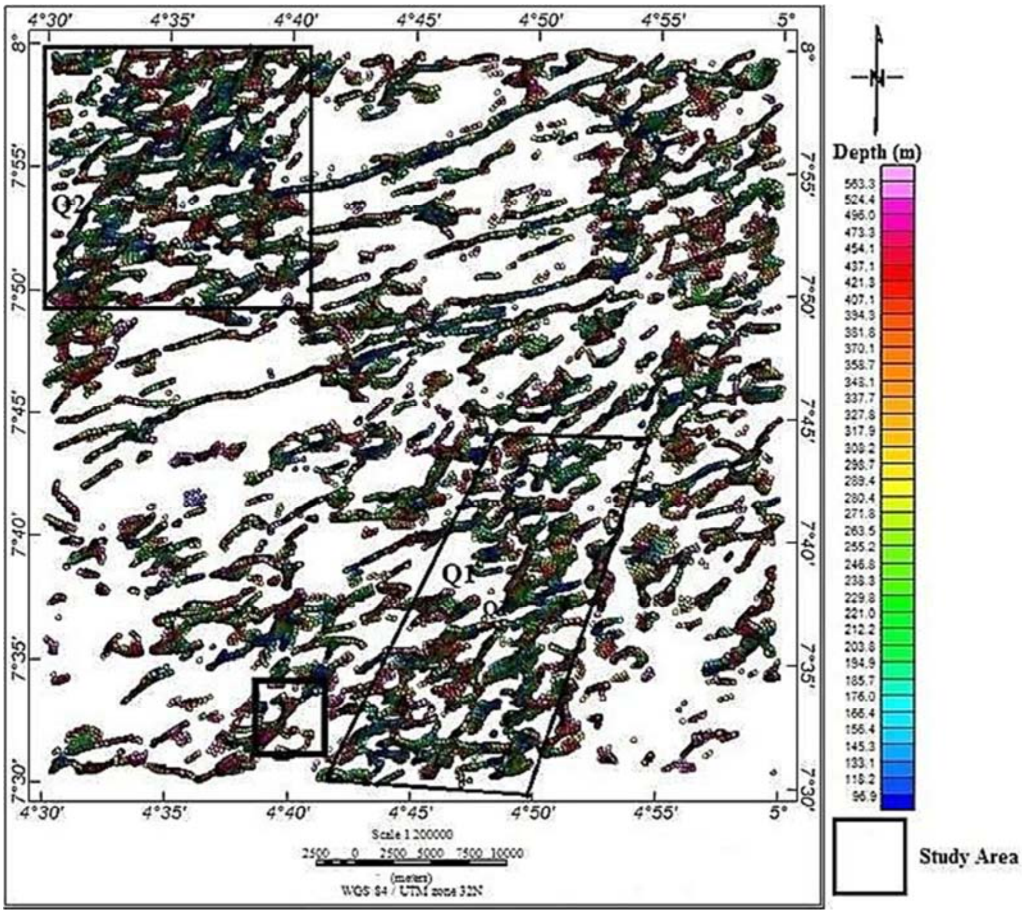

Figure 17. Euler Deconvolution (ED) for Structural Index of 1.

The lineaments mapped from the combined structural analyses of the HRAD by FVD, HGM, ASA, and ED techniques are presented as an inferred structural map in Figure 18. The structural map consists of major and minor inferred faults. The minor faults were found to dominate the structural map. They are found at the top right (Ilie, Igbona, and Eko-Ende areas), bottom right (Apena and Ife areas), and bottom left (Erin-Jesa area) of the map. The thick long lines represent the major inferred faults or faults that showed elongated continuity with adjoining faults. Parts of the inferred major faults (F1 and F2) in the south-eastern part of the map are well known and have been mapped by various authors [2, 6, 8]. The trend and pattern of the structural map generally indicate that the basement rocks are mostly affected by several faults which are oriented in varying directions. The direction of various orientations of the deduced faults was measured (clockwise from the north) taking into account the azimuth. These directions were grouped every 15° and presented using a rose diagram in Figure 19.

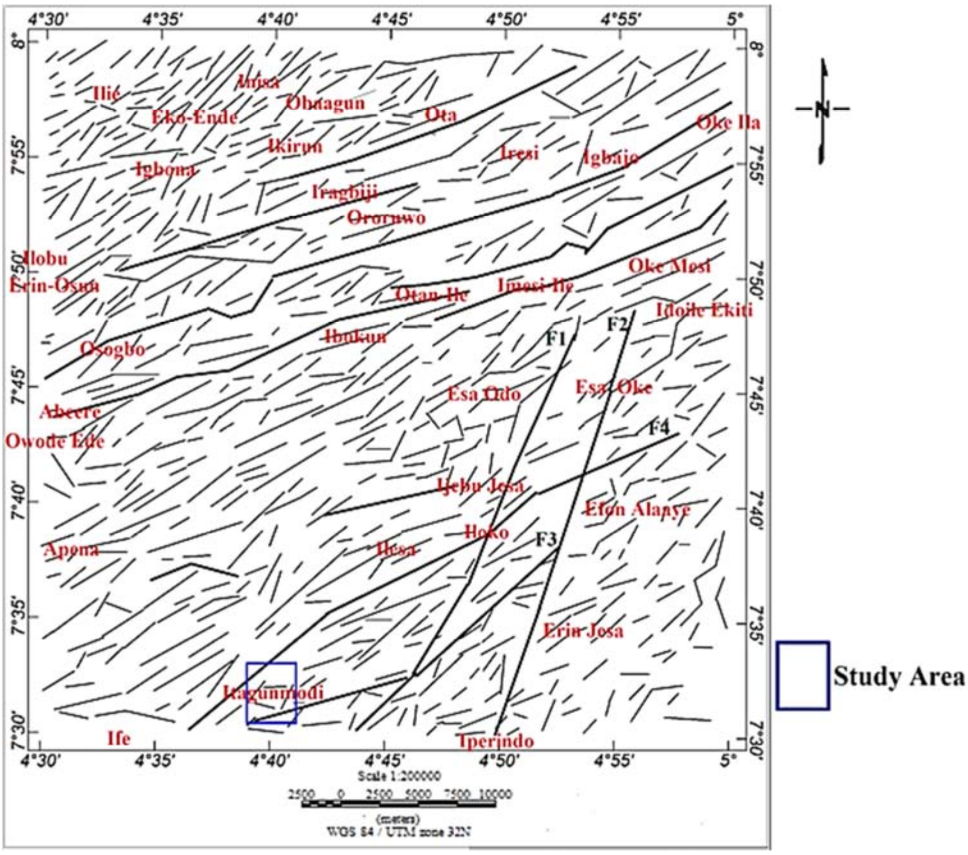

Figure 18. Inferred Structural Map.

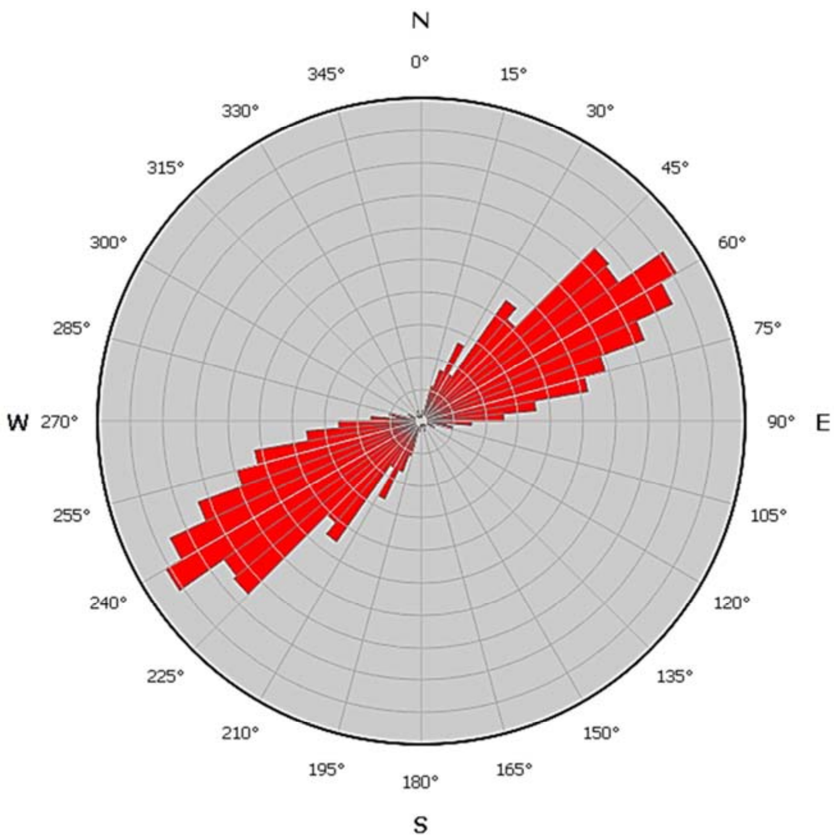

Figure 19. Rose Diagram.

The lineament analysis of the structures using the rose diagram revealed two main tectonic episodes in the area. These were the NE-SW and the ENE-WSW structures among which the NE-SW trend dominates. Also, notable was the NNE-SSW trend. A few E-W trend was also observed in the rose diagram. This correlates well with the results of Awoyemi et al. [6]. From the inferred structural map, it is observed that the occurrence of fractures on the Pegmatite is high while those on the Gnesis/Migmatite Undifferentiated and Epidiorite rocks are moderately high. This result correlates well with the results of the [4, 5].

As can be observed in Figure 16, Itagunmodi is associated with two inferred major faults suggesting that mineralization in this area is structurally controlled.

4.4. Correlation of the Magnetic Survey Results and Its Implication to Mineral Deposition

Epidiorite rock, the main underlying rock in the study area was observed to be associated with deformed structures. The subsurface images revealed the minimum and maximum depths of overburden as 5 – 75 m respectively. These deformed structures with overburdened infills are possible conduits for economic minerals.

Two major inferred faults of the Ilesha area associated with Itagunmodi were offset at about 30 and 45 degrees to the Ifewara fault. This suggests possible migration of materials by erosion or underground water from the Ifewara fault into the deformed structure via the major inferred fault associated with the study area.

The terrain map for the Ilesha area (Figure 20) also revealed that the Itagunmodi area has a low altitude compared to its neighboring settlements. The area was also observed to be veined by lower altitudes. Such disposition of lowlands amidst faulted highlands allows for the suggested migration of materials. These materials through transportation by erosion may disengage economic minerals into deformed structures through a solution, abrasion, or attrition processes or into the foliations of the epidiorite rock underlying the Itagunmodi lowland area over millennia of geological time.

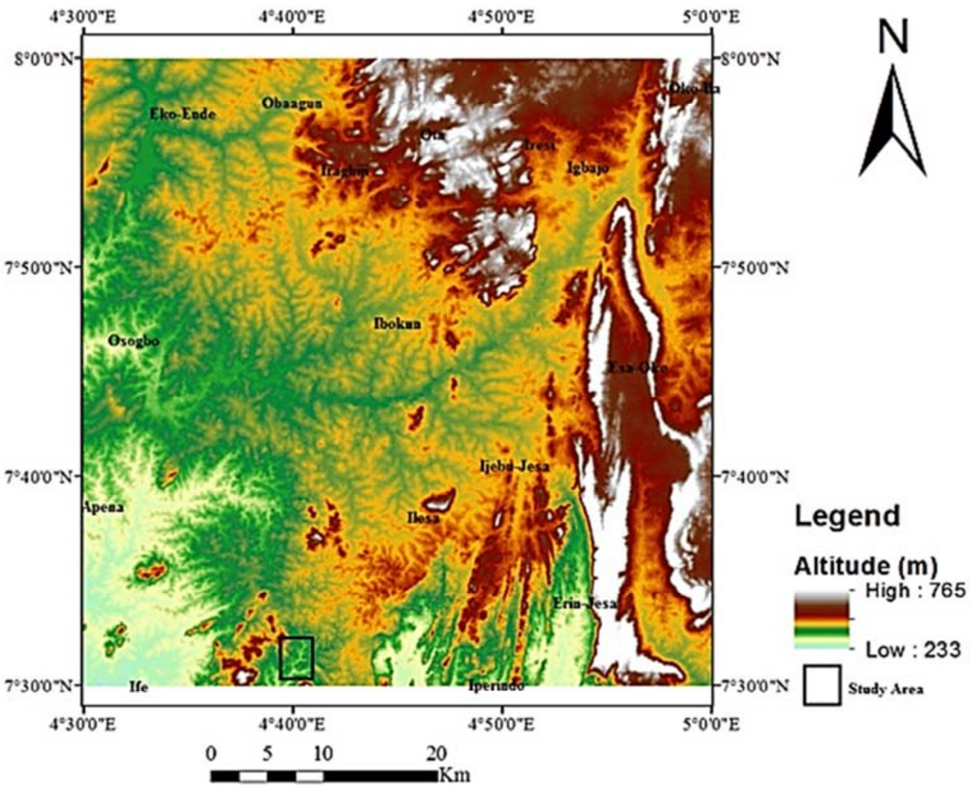

Figure 20. Terrain Map of Ilesa Area.

5. Conclusion

This study analyzed ground and airborne magnetic data sets, delineated magnetic structural features, and also carried out magnetic modeling of the study area. These were to provide information on the geologic structures which are a possible potential target for the accumulation of minerals in the area. The results of the qualitative analysis of the ground magnetic measurements through the ground magnetic profiles revealed a great deal of inhomogeneity in residual magnetic intensity values. The magnetic anomaly value ranged from -34.4 to +284.5 nT. The observed low and high magnetic anomaly values were interpreted as possible dykes/cracks/minor faults/fractured zones and near-surface outcrops/intrusions, or magnetic minerals respectively. The 2D subsurface images obtained from the quantitative analysis of the ground magnetic data also revealed a deformed underlying rock. The minimum and maximum overburden thickness were obtained as 5 m and 70 m respectively. The results obtained indicate shallow depths to magnetic anomalies, as expected in most areas of the basement complex of Nigeria. The inferred structural map obtained from the analyses of the High-Resolution Aeromagnetic Data (HRAD) revealed that the Ilesa area is characterized by several major and minor inferred faults. The lineament analysis of the inferred structures using the Rose diagram revealed two main tectonic episodes in the area. These were the NE-SW and the ENE-WSW structures among which the NE-SW trend dominates. Also, notable were the NNE-SSW trends and few E-W trends. The Ifewara and other major fault zones were delineated. Itagunmodi, the study area was observed to be associated with two minor faults that offset the Ifewara fault at about 30° and 45°. This suggested possible migration of minerals from the Ifewara fault into the deformed structures via the Itagunmodi inferred faults over geological time. The study concluded that the mineralization in the Itagunmodi area is structurally controlled.

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