Nigerian Journal of Applied Physics (NJAP)
ISSN Print: XXXX-XXXX
ISSN Online : XXXX-XXX
DOI: https://doi.org/10.62292/njap-v1i1-2025-18
Volume 1(1), September 2025

Depth to Basement Mapping using Source Parameter Imaging (SPI): A Case Study from Federal University of Agriculture Abeokuta

[1]Layade, Gideon Oluyinka, *[2]Ogunkoya, Charles Olubunmi, [1]Edunjobi, Hazeez Owolabi and [1]Philip, Alex Israel

[1]Department of Physics, Federal University of Agriculture, Abeokuta, P.M.B. 2240, Abeokuta, Ogun State, Nigeria.
[2]Department of Physics, Ajayi Crowther University, Oyo, P.M.B. 1066, Oyo, Oyo state, Nigeria.

*Corresponding author's email: co.ogunkoya@acu.edu.ng Phone: +2348078744201
ORCID iD: https://orcid.org/0009-0006-6061-0478

ABSTRACT
This research focuses on mapping the depth to the basement and delineating subsurface geological structures within the Federal University of Agriculture, southwestern Nigeria, using Source Parameter Imaging (SPI), a potential field technique. The research leverages ground magnetic data acquired using a Proton Precision Magnetometer, with measurements taken at 5 m intervals across a 100 m × 100 m study area. Data processing, including Total Magnetic Intensity (TMI) mapping, regional-residual separation, and analytical signal analysis, was conducted using Oasis Montaj software to enhance subsurface interpretation. The TMI map revealed magnetic anomalies ranging from 31,814.3 nT to 37,052.5 nT, with high-intensity anomalies in the southwestern and northwestern regions suggesting magnetically susceptible mineral concentrations, while low-intensity zones in the central and northeastern areas indicated sedimentary cover. The residual magnetic map further highlighted intrusive bodies and lithological variations, with anomalies between -2,359.7 nT and 2,712.8 nT. The analytical signal map, unaffected by magnetization direction, identified NS–SE trending discontinuities, likely fault zones, with intensities from 5.2 nT to 859.4 nT. SPI depth estimates ranged from 1.6 m to 9.5 m, revealing shallow magnetic sources (1.6–3.6 m) in the southeastern and northwestern regions and deeper sources (3.6–9.5 m) in the northeastern and southern areas. These findings underscore the undulating basement topography and structural complexity of the study area, which are critical for groundwater exploration and agricultural planning. The study demonstrates SPI's efficacy in high-resolution basement mapping, offering valuable insights for resource management and environmental sustainability in geologically complex terrains.

Keywords:
Source Parameter Imaging (SPI),
Basement depth,
Ground magnetic survey,
Magnetic anomalies,
Subsurface structures.

INTRODUCTION

The determination of the depth to the basement is a cornerstone of geophysical exploration, providing critical insights into subsurface architecture and resource potential. In sedimentary basins, the basement interface, which separates crystalline rocks from overlying sedimentary layers, plays a pivotal role in hydrocarbon exploration, groundwater studies, and tectonic investigations. Traditional seismic reflection and magnetic surveys have been extensively employed for basement depth estimation. However, these approaches often face limitations in resolution, cost, and applicability, particularly in regions with complex geological frameworks. Source Parameter Imaging (SPI), a cutting-edge geophysical technique, has emerged as a powerful tool for depth-to-basement mapping due to its ability to generate high-resolution subsurface images using potential field data (Reid et al., 2014; Akinlabi et al., 2023).

SPI is a potential field method that leverages magnetic or gravity data to estimate the depth and geometry of subsurface sources. By analyzing derived parameters such as tilt angle, horizontal gradient, and curvature, SPI offers a computationally efficient and minimally assumption-dependent approach to subsurface imaging (Zhang et al., 2019; Eze et al., 2017). Unlike conventional methods, SPI does not require prior knowledge of density or magnetization contrasts, making it particularly advantageous in areas with limited geological data. Recent advancements in SPI algorithms have enhanced their precision and applicability in complex geological environments (Adetona et al., 2013). These advancements have made SPI a preferred method for delineating basement topography and identifying subsurface features such as faults, intrusions, and sedimentary thickness variations (Okwesili et al., 2020).

The Federal University of Agriculture Abeokuta (FUNAAB), located in southwestern Nigeria, lies within the Precambrian basement complex overlain by sedimentary formations of varying thickness. This geological setting influences groundwater accumulation, mineralization, and structural stability, making it an ideal location for SPI application (Umeh et al., 2024). The area is characterized by a network of fractures, faults, and lineaments, which play a crucial role in groundwater movement and mineralization. Understanding the depth and distribution of these subsurface features is vital for sustainable resource management and environmental planning (Ekwok et al., 2024). The application of SPI with other geophysical methods can enhance the accuracy of basement depth estimation and improve the understanding of the study area's geological framework (Odidi et al., 2020).

The application of SPI in basement depth estimation has been extensively documented in various geological settings. For instance, Alao et al. (2024) utilized SPI to analyze high-resolution aeromagnetic data in Esie, North Central Nigeria, revealing depth to magnetic sources ranging from 20 m to 1250 m. Their findings highlighted the potential of SPI in identifying shallow sedimentary basins, which are crucial for geothermal exploration. Similarly, Al-Banna and Daham (2019) applied SPI to gravity and magnetic data in Diyala, Iraq, estimating basement depths between 8 km and 14 km. Their study demonstrated the effectiveness of SPI in delineating deep sedimentary basins, which are potential targets for hydrocarbon exploration. In Nigeria, Abubakar et al. (2019) employed SPI and Euler deconvolution to estimate basement depths in the Sokoto Basin, revealing depths ranging from 1.79 km to 2.39 km. Their work underscored the importance of SPI in identifying areas with significant sedimentary thickness, which are favorable for hydrocarbon maturation.

Furthermore, Eze et al. (2017) applied SPI to aeromagnetic data in the Southern Benue Trough, revealing basement depths ranging from 52.58 m to 11,848.84 m. Their study highlighted the presence of deep-seated magnetic anomalies, which are indicative of significant tectonic activity. In the Niger Delta Basin, Okechukwu et al. (2025) combined SPI with Euler-3D deconvolution to estimate basement depths, revealing significant variations that align with known structural features of the basin. Their integrated approach provided a robust interpretation of the subsurface architecture, supporting ongoing resource exploration. Similarly, Al-Hadithi and Al-Banna (2022) applied SPI to aeromagnetic data in Tharthar Lake, Iraq, estimating basement depths between 6 km and 12 km. Their findings were consistent with previous studies, demonstrating the reliability of SPI in basement depth estimation. In Egypt, Abba et al. (2024) used SPI to estimate basement depths in the Qarun Oil Field, revealing depths ranging from 813 m to 7600 m. Their study demonstrated the effectiveness of SPI in detecting linear features and evaluating subsurface structures, which are crucial for hydrocarbon exploration.

In the context of Nigeria, Nwogwugwu et al. (2017) used SPI and spectral analysis to estimate basement depths in the Middle Benue Trough, revealing depths ranging from 0.05 km to 2.54 km. Their study highlighted the potential of SPI in identifying areas with significant sedimentary thickness, which are favorable for hydrocarbon accumulation.

The delineation of subsurface geological structures and the estimation of depth to the basement are critical in mineral exploration, hydrocarbon prospecting, and environmental studies. Geophysical methods, particularly ground magnetic surveys, have proven to be invaluable tools for mapping subsurface features due to their sensitivity to variations in magnetic susceptibility and rock composition (Layade et al., 2024; Edunjobi et al., 2021). The Federal University of Agriculture Abeokuta (FUNAAB) and its environs, situated within the Dahomey Basin of southwestern Nigeria, are underlain by Precambrian basement rocks and sedimentary formations, making the area geologically complex and economically significant (Layade et al., 2024; Adegoke & Layade, 2019).

Ground magnetic surveys are particularly effective in identifying linear structures such as faults, fractures, and shear zones, which often serve as conduits for mineral accumulation (Layade et al., 2024; Edunjobi et al., 2021). Qualitative interpretation of magnetic data involves visualizing anomalies to infer lithological variations, while quantitative techniques such as Source Parameter Imaging (SPI) and Euler deconvolution provide precise depth estimates to magnetic sources (Thurston & Smith, 1997; Reid et al., 1990). SPI, also known as the Local Wavenumber method, is a robust approach for depth estimation as it leverages the relationship between the local wavenumber of the magnetic field and the depth of the causative bodies (Nabighian, 1972; Thurston & Smith, 1997). This method is advantageous because it does not require assumptions about the magnetization direction or the geometry of the source, making it suitable for complex geological settings (Layade et al., 2020; Nwosu, 2014).

Previous studies in the Abeokuta region have employed ground magnetic and gravity surveys to map subsurface structures and estimate basement depths. For instance, Layade et al. (2024) used Peter's Half Slope Method (PHSM) and 3D Euler deconvolution to reveal shallow intrusive sources with depths ranging from 1.00 m to 14.72 m. Similarly, Edunjobi et al. (2021) applied SPI and Euler deconvolution to aeromagnetic data, highlighting the effectiveness of these methods in delineating geological transition zones. These studies underscore the importance of high-resolution magnetic data in understanding the subsurface architecture of the region.

The accurate determination of basement depth is fundamental in geophysical exploration, providing essential insights into subsurface architecture and resource potential. In sedimentary basins, the basement interface, separating crystalline basement rocks from overlying sedimentary strata, plays a crucial role in hydrocarbon exploration, groundwater assessment, and tectonic studies. While traditional seismic reflection and magnetic surveys have been widely used for basement depth estimation, their resolution, cost, and applicability are often limited in geologically complex terrains. Source Parameter Imaging (SPI), an advanced potential field technique, has emerged as a robust alternative, offering high-resolution subsurface imaging through magnetic or gravity data analysis (Reid et al., 2014; Akinlabi et al., 2023).

SPI operates by analyzing derived parameters such as tilt angle, horizontal gradient, and curvature to estimate the depth and geometry of subsurface sources without requiring prior knowledge of density or magnetization contrasts (Zhang et al., 2020; Eze et al., 2023). This computational efficiency and minimal assumption dependency make SPI particularly advantageous in regions with sparse geological data. Recent algorithmic improvements have enhanced its precision in resolving complex basement structures, such as faults, intrusions, and sedimentary thickness variations (Adetona et al., 2021; Oladunjoye et al., 2023). Such advancements underscore SPI's growing preference in basement mapping and structural delineation (Okwesili et al., 2020).

The study area, the Federal University of Agriculture Abeokuta (FUNAAB), is situated within southwestern Nigeria's Precambrian basement complex, overlain by sedimentary formations of variable thickness. This geological setting significantly influences groundwater dynamics, mineralization patterns, and structural stability, making it an ideal location for SPI application (Umeh et al., 2024). The region is characterized by an intricate network of fractures, faults, and lineaments, which govern groundwater flow and mineral deposition. Precise mapping of these subsurface features is critical for sustainable resource management and environmental planning (Ekwok et al., 2024).

Globally, SPI has been successfully applied in diverse geological environments. For example, Alao et al. (2024) employed SPI on high-resolution aeromagnetic data in Esie, North Central Nigeria, revealing magnetic source depths between 20 m and 1250 m, highlighting its utility in shallow basin identification for geothermal exploration. Similarly, Al-Banna and Daham (2019) utilized SPI on gravity and magnetic data in Diyala, Iraq, estimating basement depths of 8–14 km, demonstrating its efficacy in deep sedimentary basin delineation for hydrocarbon exploration. In Nigeria, Abubakar et al. (2019) integrated SPI with Euler deconvolution in the Sokoto Basin, resolving basement depths of 1.79–2.39 km, reinforcing SPI's role in identifying hydrocarbon-prone sedimentary thicknesses.

Further applications include Eze et al. (2017), who applied SPI in the Southern Benue Trough, revealing basement depths of 52.58 m–11,848.84 m, correlating with deep-seated tectonic anomalies. In the Niger Delta, Okechukwu et al. (2025) combined SPI with Euler-3D deconvolution, detecting basement depth variations that align with known structural trends, thus enhancing subsurface architectural models. Similarly, Al-Hadithi & Al-Banna (2022) utilized SPI in Tharthar Lake, Iraq, estimating basement depths of 6–12 km, validating SPI's reliability. In Egypt, Abba et al. (2024) applied SPI in the Qarun Oil Field, resolving depths of 813–7600 m while detecting critical linear features for hydrocarbon exploration.

Nwogwugwu et al. (2017) integrated SPI with spectral analysis in the Middle Benue Trough, estimating basement depths of 0.05–2.54 km, emphasizing its effectiveness in sedimentary thickness assessment. Given the geological complexity of the FUNAAB environs within the Dahomey Basin, ground magnetic surveys are indispensable for mapping subsurface structures due to their sensitivity to magnetic susceptibility variations (Layade et al., 2024; Edunjobi et al., 2021). Qualitative magnetic anomaly interpretation aids in lithological discrimination, while quantitative techniques like SPI provide precise depth estimates (Thurston & Smith, 1997; Reid et al., 1990). SPI's robustness stems from its reliance on local wavenumber analysis, eliminating assumptions about source geometry or magnetization direction (Nabighian, 1972; Thurston & Smith, 1997), making it ideal for complex terrains (Layade et al., 2020; Nwosu, 2014).

Previous studies in Abeokuta have demonstrated SPI's efficacy. Layade et al. (2024) employed Peter's Half Slope Method (PHSM) and 3D Euler deconvolution, identifying shallow intrusive sources at 1.00–14.72 m depths. Similarly, Edunjobi et al. (2021) applied SPI to aeromagnetic data, successfully delineating geological transition zones. These findings underscore the importance of high-resolution magnetic surveys in deciphering the region's subsurface framework.

This study intends to apply SPI to aeromagnetic data over the COLMAS area of the Federal University of Agriculture Abeokuta, to differentiate and characterize regions of deep and shallow magnetic basements and to determine the depth to magnetic sources. By employing ground magnetic data and source parameter imaging techniques, this research aims to produce a detailed map of the basement topography and provide a structural interpretation of the subsurface geology. The findings will contribute to ongoing efforts in geophysical exploration, resource management, and environmental sustainability in the university environment, particularly in supporting groundwater exploration and sustainable agricultural practices vital for the university community and surrounding areas (Okwesili et al., 2019).

Location and Geologic Setting of the Study Area

The study area was conducted in the COLMAS area within the Federal University of Agriculture, Abeokuta Ogun State, Southwestern Nigeria. It is situated between latitudes 7° 14' 4.80" N and 7° 14' 4.89" N, and longitudes from 3° 26' 45.43" E to 3° 26' 45.28" E, covering an approximate area of 100m by 100m. The regional geology is typically characterized by the Precambrian Basement Complex, composed of igneous and metamorphic rock formations. These ancient rock units are known to host a variety of mineral resources, including precious and base metals, as well as industrial minerals.

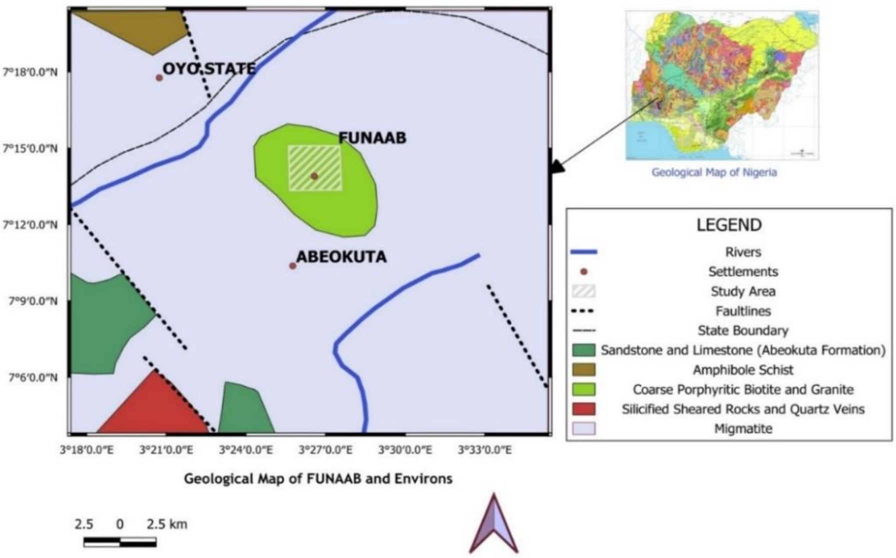

Figure 1: Geological Map of FUNAAB Environs

MATERIALS AND METHODS

This study employs ground magnetic surveys to investigate variations in the Earth's magnetic field, focusing on identifying subsurface geological features. A Proton Precision Magnetometer was utilized for data acquisition, with measurements taken at 5-meter intervals along predefined survey lines. To ensure spatial accuracy, GPS was integrated to record the precise coordinates of each measurement point.

The acquired data were processed using Oasis Montaj Modelling Software, facilitating the generation of a Total Magnetic Intensity (TMI) map. This map was instrumental in delineating magnetic anomalies, providing critical insights into the underlying geological and structural features. Gaussian filtering and Fast Fourier Transform (FFT), were applied to minimize noise and improve data clarity, enabling more accurate interpretation. Additionally, analytic signal analysis was conducted to assess the distribution of magnetic sources, further refining our understanding of subsurface geological configurations. Regional-Residual separation was performed using first-order polynomial fitting in Geosoft Oasis Montaj. This process enabled the derivation of analytical signal (AS) and Source Parameter Imaging (SPI) maps from the TMI data, which were used to estimate the depth and characteristics of magnetic sources.

SPI is a technique based on the extension of the complex analytic signal and calculates the magnetic source depths using gridded magnetic data. This method is particularly effective for estimating the thickness of sedimentary rocks and identifying the edges and dips of magnetic bodies. The SPI approach is advantageous due to its independence of magnetic inclination, declination, and remanent magnetization, as well as its ability to reduce interference from overlapping anomaly features. The SPI method determines the depth from the local wave number of the analytical signal. The analytical signal AS (x, z) is defined as.

$$AS\ (x, z) = \frac{\partial M(x,z)}{\partial x} - j\frac{\partial M\ (x,z)}{\partial z} \qquad (1)$$

Where M (x, z) is the magnitude of the anomalous total magnetic intensity field (TMI), j is the imaginary number, and z- and x- are Cartesian coordinates for the vertical and horizontal direction, respectively. The horizontal and vertical derivatives comprised of real and imaginary parts of the 2D analytical signal are related as follows (Nabighian, 1972):

$$\frac{\partial M(x,z)}{\partial x} = -j\frac{\partial M\ (x,z)}{\partial z} \qquad (2)$$

Where equation 2 represents a Hilbert transformation pair, hence the local wave number k_1 is given by Thurston and Smith (1997):

$$K_1 = \frac{\frac{\partial}{\partial x}\left[Tan^{-1}\frac{\partial M}{\partial z}\right]}{\frac{\partial M}{\partial x}} \qquad (3)$$

RESULTS AND DISCUSSION

This research aims to produce a detailed map of the basement topography, identify fault zones, and provide a structural interpretation of the subsurface geology. The findings will contribute to ongoing efforts in geophysical exploration, resource management, and environmental sustainability in the region, particularly in supporting groundwater exploration and sustainable agricultural practices vital for the university community and surrounding areas. The interpretation of the magnetic data was conducted using both qualitative and quantitative approaches.

Total Magnetic Intensity (TMI) Map

The Total Magnetic Intensity (TMI) map of the study area (COLMAS FUNNAB) reveals magnetic anomalies ranging between 31,814.3 nT and 37,052.5 nT (Figure 2). The map is characterized by distinct high (pink and red) and low (blue) magnetic signatures. High magnetic anomalies dominate the southwestern and northwestern regions, while the central part exhibits low magnetic signatures (green and blue). The northeastern area is primarily marked by low-intensity anomalies, with minor patches of high-intensity signatures extending toward the southeastern region. The strong positive anomalies (pink-red) likely indicate a higher concentration of magnetically susceptible minerals, while the broad magnetic lows (blue-green) suggest areas with lower magnetic susceptibility and reduced mineral concentration. These variations are attributed to differences in lithology, magnetic susceptibility, strike orientation, and depth. Additionally, the increasing sedimentary thickness from the northern to the southern part of the study area is evident from these magnetic patterns (Abubarkar et al., 2019). This information is critical for mapping basement topography and identifying potential fault zones.

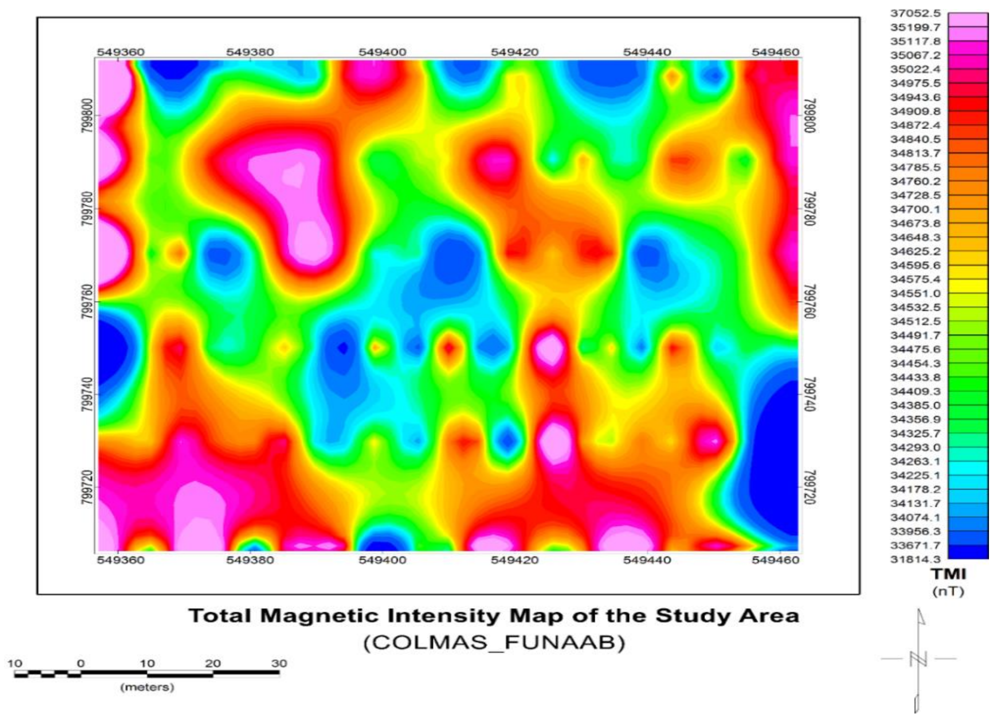

Figure 2: The Total Magnetic Intensity Map of The Study Area (COLMAS FUNNAB)

Residual Magnetic Intensity (RMI) Map

The residual magnetic map of the study area (Figure 3) reveals magnetic anomalies ranging between -2359.7 nT and 2712.8 nT, indicating a predominance of high residual magnetic anomalies with localized zones of low values. Elevated residual magnetic anomalies are predominantly observed in the northern and southern regions, diminishing toward the central and southeastern parts. This spatial distribution suggests the presence of intrusive bodies, likely attributed to near-surface rocks with significant magnetic susceptibility (Okwesili et al., 2019). Conversely, lower residual magnetic anomaly values, primarily aligned in a west-east direction, may result from the presence of weakly magnetic lithologies, such as sedimentary rocks. The close correlation between the residual magnetic map and the total magnetic intensity map underscores the dominance of residual magnetic anomalies over regional trends, further supporting the interpretation of the area's geological composition. These findings are essential for identifying structural features and fault zones that influence groundwater flow and agricultural suitability.

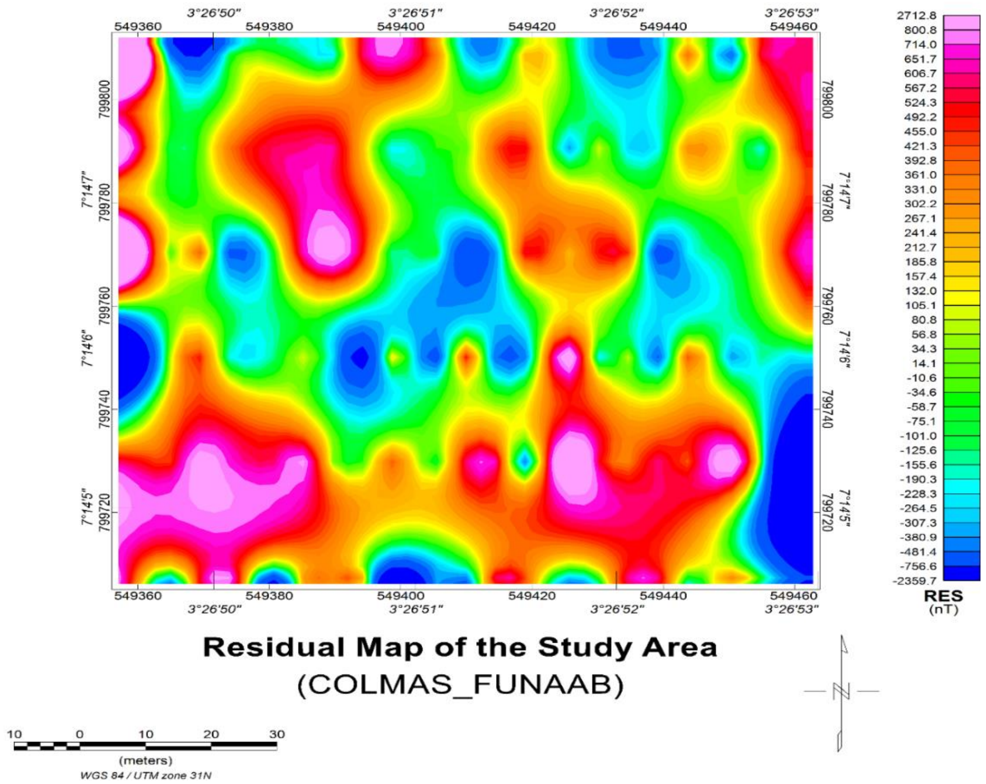

Figure 3: Residual Map of the Study Area

Analytical Signal (AS) Map

The analytical signal map of the study area enhances magnetic intensity over magnetic bodies and their contacts, independent of magnetization direction, with values ranging from 5.2 nT to 859.4 nT. Higher intensities in the northwestern and southeastern regions reflect increased magnetic susceptibility, likely linked to tectonic activities such as faulting, fracturing, and intrusions. The analytic signal technique, unaffected by magnetization direction or ambient fields, peaks over magnetization contrasts, enabling precise delineation of magnetic source boundaries. Maxima on the map, particularly in the northwestern and southeastern extremities, outlines magnetic sources and aligns with NS–SE trending magnetic discontinuities, indicative of fracture zones with potential mineral prospecting (Lawal et al., 2014). These features highlight the utility of the analytic signal in mapping geological structures and identifying exploration targets, which is crucial for understanding subsurface geology and supporting sustainable resource management.

Source Parameter Imaging (SPI) Map

The depth estimates derived from source parameter imaging (SPI) vary between 1.6 m and 9.5 m, reflecting the presence of both shallow and deep magnetic sources within the study area. The SPI grid image and accompanying legend illustrate a spectrum of colors representing varying magnetic susceptibility contrasts, as well as the undulating nature of the basement surface. Analysis of the results reveals that deeper magnetic bodies, with depths ranging from 3.6 m to 9.5 m and an average of approximately 6.55 m, are predominantly located in the northeastern and southern regions, as depicted in Figure 4. In contrast, shallower magnetic sources, with depths between 1.6 m and 3.6 m and an average of about 2.6 m, are more concentrated in the southeastern and northwestern parts of the area. This spatial distribution suggests that the southeastern section is characterized by shallow magnetic anomalies, while the northwestern and southern regions are dominated by deeper magnetic bodies (Akiishi et al., 2018). These depth estimates are vital for mapping basement topography and identifying structural features that influence groundwater availability and agricultural planning.

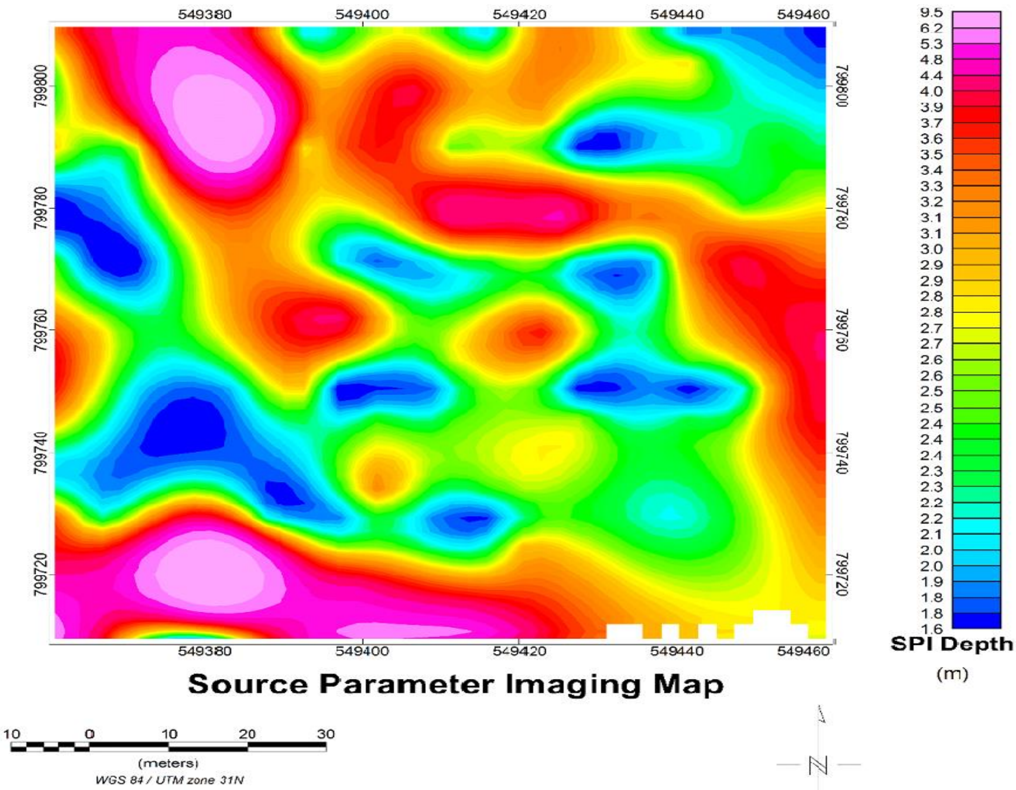

Figure 4: Source Parameter Imaging Map of the Study Area

CONCLUSION

The application of Source Parameter Imaging (SPI) to ground magnetic data in the COLMAS area of the Federal University of Agriculture Abeokuta (FUNAAB) successfully mapped basement topography and identified subsurface structural features, revealing magnetic anomalies ranging from 31,814.3 nT to 37,052.5 nT in the Total Magnetic Intensity (TMI) map, with high-intensity zones in the southwestern and northwestern regions and low-intensity areas in the central and northeastern sections. The Residual Magnetic Intensity (RMI) map highlighted intrusive bodies and sedimentary rock distributions, while the Analytical Signal (AS) map delineated magnetic source boundaries, particularly along fracture zones. SPI depth estimates varied between 1.6 m and 9.5 m, with deeper sources in the northeastern and southern regions and shallower ones in the southeastern and northwestern areas, providing critical insights for groundwater and agricultural planning. The study demonstrates SPI's effectiveness in resolving complex geological structures without prior assumptions, offering a foundation for sustainable resource management. Future research could integrate additional geophysical methods to refine subsurface models, ensuring continued advancements in geophysical exploration and environmental sustainability in the region.

REFERENCES

Abba, M. J., & Danbatta, U. (2024). Source Depth Determination of the Ningi-Burra Younger Granite Complex North-Eastern Nigeria from Aeromagnetic Data. *International Journal of Research and Innovation in Applied Science*, *IX*(X), 451–459. https://doi.org/10.51584/ijrias.2024.910041

Abubakar I, Bonde D. S, Raboh Y. (2019). Basement Depth Estimation Using Euler Deconvolution and Source Parameter Imaging; a Case Study of Northeastern Part of Sokoto Basin, Nigeria. *Saudi Journal of Engineering and Technology*. 7: 387-392.

Adegoke, J. A., & Layade, G. O. (2019). Comparative depth estimation of iron-ore deposit using the Data-Coordinate Interpolation Technique for airborne and ground magnetic survey variation. *African Journal of Science, Technology, Innovation and Development (AJSTID),* 11(5): 663-669. https://doi.org/10.1080/20421338.2019.1572702

Adetona, A., Abbass and Mallam, A. (2013). Estimating the Thickness of Sedimentation within Lower Benue Basin and Upper Anambra Basin, Nigeria, Using Both Spectral Depth Determination and Source Parameter Imaging. *International Journal of Geophysics,* 20 (1): 1-11.

Akiishi, M. (2018). Mapping Of Depth To Basement in Masu Area Of Nigerian Sector Of Chad Basin, Using Aeromagnetic and Aerogravity Data. *IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)* 6.5: 36-45.

Akinlabi, I. A., Oladejo, O. P., Ogunkoya, C. O. (2023). Investigation of Magnetic Anomalies and Depth to Magnetic Sources Over Igboho Area Using High Resolution Aeromagnetic Data. *Nigerian Journal of Physics (NJP).* 32(3): 79-89.

Alao, K. N., Oladejo, O. P., Suleman, K. O., Adedokun, O. M., Adeniyi, E. O., Otobrise, H., & Sunmonu, L. A. (2024). Determination of Depth to Magnetic Sources using Source Parameter Imaging (SPI) of High-Resolution Aeromagnetic Data of Esie, North central Nigeria: An Investigation tool for Geothermal Exploration. *Deleted Journal*, *4*(6), 1091–1094. https://doi.org/10.62225/2583049x.2024.4.6.3559

Al-Banna, A. & Daham, Alaa., (2019). Application of Source Parameter Imaging (SPI) Technique to Gravity and Magnetic Data to Estimate the Basement Depth in Diyala Area, Eastern Central Iraq. *Iraqi Journal of Science.* 60: 601-609.

Al-Hadithi, S. J., & Al-Banna, A. S. (2022). Using Source Parameter Imaging Technique to the Aeromagnetic Data to Estimate the Basement Depth of Tharthar Lake and Surrounding Area in Central Iraq. *Iraqi Geological Journal*, *55*(1F), 151–159. https://doi.org/10.46717/igj.55.1f.12ms-2022-06-27

Edunjobi, H. O., Layade, G. O., Falufosi, M. O., & Olurin, O. T. (2021). Lineament and Depth Evaluation of Magnetic Sources in a Geological Transition Zone of Abeokuta and its Environs, Southwestern Nigeria. *Pet & Coal,* 63(2): 548-560.

Ekwok S. E., Eldosuoky A. M., Thompson E.A., Ojong R. A., George A. M., Alarifi S. S., Kharbish S., Andráš P. and Akpan A. E. (2024). Mapping of geological structures and sediment thickness from analysis of aeromagnetic data over the Obudu Basement Complex of Nigeria. *Journal of Geophysics and Engineering* 21: 413–425 https://doi.org/10.1093/jge/gxae012

Eze M., Amoke A., Aguzie P. C. (2017). Basement and Automatic Depth to Magnetic Source Interpretation of Parts of Southern Benue Trough and Anambra Basin. *IOSR Journal of Applied Geology and Geophysics*. 5 (3): 67-74

Layade, G. O., Edunjobi, H. O., & Ajayi, K. D. (2024). Lineament, Qualitative Interpretation and Depth Evaluation of Potential Field Signatures in the Abeokuta Region, Southwestern Nigeria. *Journal of the Earth and Space Physics,* 49(4): 37-55. DOI: http//doi.org/10.22059/jesphys.2023.358877.1007525

Layade, G. O., Edunjobi, H. O., Makinde, V., and Bada, B. S., 2020, Estimation of depth to Bouguer anomaly sources using source parameter imaging and Euler deconvolution techniques in basement complex-sedimentary formation: *RMZ Materials and Geo-environment,* 67(4), 185-195, doi. https://doi.org/10.2478/rmzmag-2020-0016

Lawal, T.O. and Nwankwo, L.T. (2014). Wave let Analysis of High Resolution Aeromagnetic Data over Part of Chad Basin, Nigeria. *Ilorin Journal of Science* 1: 110-120.

Nabighian, M. N. (1972). The Analytic Signal of Two Dimensional Magnetic Bodies with Polygonal Cross-section: Its Properties and Use for Automated Anomaly Interpretation. *Geophysics.* 37 (3): 507- 517.

Nwogwugwu E., Salako K., Okwokwo I. O. (2017). Determination of depth to basement rocks over parts of Middle Benue Trough, North Central Nigeria, using high resolution aeromagnetic data. *Journal of Geology and Mining and Research*. 9(3): 18-27

Nwosu, O. B. (2014). Determination of Magnetic Basement Depth Over Parts of Middle Benue Trough By Source Parameter Imaging (SPI) Technique Using HRAM. *International Journal of Scientific and Technology Research* 3(1): 262-271

Odidi I.G., Mallam A., Nasir N. (2020). Depth to Magnetic Sources Determination Using Source Parameter Imaging (SPI) of Aeromagnetic Data of Parts of Central and North-Eastern Nigeria A reconnaissance Tool for Geothermal Exploration in the area. *Science World Journal* 15(3): 19-23. https://doi.org/10.47514/swj/15.03.2020.003

Okechukwu, P. N., Ofuyah, W. N., & Oguh, A. M. (2025). Basement depths estimation using the Euler-3D and source parameter imaging methods from the analysis of ground magnetic field data in the Niger Delta Basin. *International Journal of Science and Research Archive*, *14*(1), 218–229. https://doi.org/10.30574/ijsra.2025.14.1.2385

Okwesili, N. A., Okeke, F. N. & Orji, P. O. (2020). Geophysical survey of aerogravity anomalies over Lafia and Akiri regions of middle Benue trough, Nigeria, employing Power Spectrum and Source Parameter Imaging technique. *IOSR Journal of Applied Physics (IOSR-JAP),* 12(5): 58-68.

Okwesili, N. A., Abangwu, J. U. and Igwe E. A. (2019). Spectral analysis and source parameter imaging of aeromagnetic data of Lafia and Akiri Areas, Middle Benue Trough, Nigeria. *International Journal of Physical Sciences,* 14(1): 1-14.

Reid, A. B., Ebbing, J. O., and Susan, S. J., 2014, Avoidable Euler errors—the use and abuse of Euler deconvolution applied to potential fields: *Geophysical Prospecting,* 62: 1162-1168, https://doi.org/10.1111/1365-2478.12119.

Reid, A.B., Allsop, J.M. Granser, H. Millett A.J. and Somerton I.W. (1990). Magnetic interpretation in three dimension using Euler deconvolution, Geophysics, 55: 80-91.

Thurston, J.B. & Smith, R.S. (1997). Automatic conversion of magnetic data to depth, dip, and susceptibility contrast using the SPI ™ method: *Geophysics,* 62: 807-813.

Umeh M. C., Obiekezie T. N. and Akiang F. B. (2024). Using Euler deconvolution and source parameter Imaging (SPI) of gravity data for depth-to-basement Determination in parts of southeastern Nigeria. *Journal of Basic Physical Research* 13: 76 – 90.

Zhang M, Qiao J, Zhao G, Lan X. 2019. Regional gravity survey and application in oil and gas exploration in China. *China Geology*, 2(3): 382–390.