PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (6) 1807-1813 June 2024

Integrated Geophysical and Geochemical Exploration for Gold Mineralization: A Case Study in Lokoja Sheet 247, Ajaokuta L.G.A, Kogi State, Nigeria

[1*]OSISANYA, OW; [2]SHAIBU, OB; [3]KORODE AI; [4]SALEH AS

*[*1]Department of Physics, University of Benin, Benin City, Edo state, Nigeria.*
[2]Department of Earth Sciences, Anyigba, Kogi State University, Nigeria.
[3,4]Department of Petroleum Engineering and Geosciences, Petroleum Training Institute, Effurun, Nigeria

**Corresponding Author Email: wasiu.osisanya@uniben.edu*
**ORCID: https:/orcid.org/0000-0001-7280-9771*
**Tel: +2347036555765*

Co-Authors Email: benjaminshaibu01@gmail.com; geokorode@gmail.com; ahmedsalehkawule73@gmail.com

ABSTRACT: This paper presents an integrated geophysical and geochemical data exploration for assessing the potential presence of gold in Lokoja Sheet 247, Ajaokuta L.G.A of Kogi State, Nigeria by using interpretation of varying derivatives to delineate structural features, with a specific focus on the NE – SW direction, aligning with the regional trend. Additionally, x-ray fluorescence analysis was employed to examine samples from the study area. The interpreted aeromagnetic data unveiled a high anomalous area, prompting further geochemical investigation. X-ray fluorescence analysis indicated gold concentrations ranging up to five parts per million in certain samples, signifying potential high-grade gold mineralization in the study area. Based on the integrated geophysical and geochemical findings, it is recommended that more detailed exploration efforts be concentrated in the eastern half and northwestern portion of the study area. Notably, this research utilized x-ray fluorescence analysis, which proved effective at this stage; however, for more robust information, future exploration endeavors should incorporate advanced geochemical analyses. Moreover, follow-up ground geophysical surveys, including Induced Polarization, ground magnetic, and electromagnetic methods, are deemed necessary.

DOI: https://dx.doi.org/10.4314/jasem.v28i6.20

Cite this Article as: OSISANYA, OW; SHAIBU, OB; KORODE AI; SALEH AS (2024). Integrated Geophysical and Geochemical Exploration for Gold Mineralization: A Case Study in Lokoja Sheet 247, Ajaokuta L.G.A, Kogi State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (6) 1807-1813

Dates: Received: 21 February 2024; Revised: 22 March 2024; Accepted: 20 April 2024 Published: 09 June 2024

Keywords: Aeromagnetic data; Gold mineralization; geochemical analysis; Geophysical investigation; Lokoja.

Solid Minerals are an economic commodity, mined for their potential use or intrinsic value and they constitute a wide range of natural resources. Gold is a noble metal, an indispensable, social, political significance and non-substitutable strategic resource due to its broad applications in industries as well as national economy according to Tong *et al*., (2013). Studies have been conducted on the geochemical characteristics of primary (lode) gold mineralisation near Tsohon Birnin Gwari (Garba, 2002), Orle district within the Igarra schist belt (Adepoju and Adekoya 2011), gold-bearing quartz veins in Maru schist belt (Oke *et al*. 2014) and Iperindo in Ilesa area (Oyinloye 1997, 2002; Oyinloye and Steed 1996). Akinlalu *et al*. (2018) also conducted an aeromagnetic mapping of basement structures for mineralisation characterisation in the Ilesa Schist Belt. Although gold production in Nigeria began in 1913 and peaked in the 1930s (Ministry of Mines and Steel Development (MMSD) 2004). Integration of geophysical and geochemical investigation is vital and of paramount importance in delineating mineralized zone. Hence, the objective of tis paper was to presents an integrated geophysical and geochemical data exploration for assessing the

**Corresponding Author Email: wasiu.osisanya@uniben.edu*
**ORCID: https:/orcid.org/0000-0001-7280-9771*
**Tel: +2347036555765*

potential presence of gold in Lokoja Sheet 247, Ajaokuta L.G.A of Kogi State, Nigeria

MATERIALS AND METHOD

Location, Relief and Drainage of the Study Area: The project area is located in Ajaokuta Local Governments Area of Kogi State (figure 1a). The area falls within Topo sheet 247 NE (Lokoja). It is bounded at the North by Koton Karifi, at the South by Idah, at the West by Kabba and Dekina sheet at the East. It extends from longitude E 6° 37ˈˈ 30’ to E 6° 44ˈˈ 00ˈ and latitude N 7° 38ˈˈ 00’ to E 7° 41ˈˈ 00ˈ. (Figure 1b). The site is spotted with Elaite, Emiworo and Otubi communities in Ajaokuta Local Government Area. It can be accessed from Lokoja town by heading southward through Lokoja-Ajaokuta road for about 21km to Elaite which is one of the host communities. The site is drained by seasonal rivers that feed River Ero. This river and prevailing feeders exploit zones of structural weakness. The pattern of drainage within the tenement reveals the geomorphology, geology and the structural attitude of the area. The property claim is ranging between 350- and 26-meters elevations, cut at the southeastern flank by Num River. The location of study is a summer rainfall area with an annual rainfall of 1,000mm to 1,500mm. The months of December to January coincide with cold and dry harmattan period. The average maximum temperature varies between 30 and 35°C. The project area is located in Ajaokuta Local Governments Area of Kogi State (figure 1a). The area falls within Topo sheet 247 NE (Lokoja). It is bounded at the North by Koton Karifi, at the South by Idah, at the West by Kabba and Dekina sheet at the East. It extends from longitude E 6° 37ˈˈ 30’ to E 6° 44ˈˈ 00ˈ and latitude N 7° 38ˈˈ 00’ to E 7° 41ˈˈ 00ˈ. (Figure 1b). The site is spotted with Elaite, Emiworo and Otubi communities in Ajaokuta Local Government Area. It can be accessed from Lokoja town by heading southward through Lokoja-Ajaokuta road for about 21km to Elaite which is one of the host communities. The site is drained by seasonal rivers that feed River Ero. This river and prevailing feeders exploit zones of structural weakness. The pattern of drainage within the tenement reveals the geomorphology, geology and the structural attitude of the area. The property claim is ranging between 350- and 26-meters elevations, cut at the southeastern flank by Num River. The location of study is a summer rainfall area with an annual rainfall of 1,000mm to 1,500mm. The months of December to January coincide with cold and dry harmattan period. The average maximum temperature varies between 30 and 35°C.

Fig 1a: Map of Kogi State showing the study area

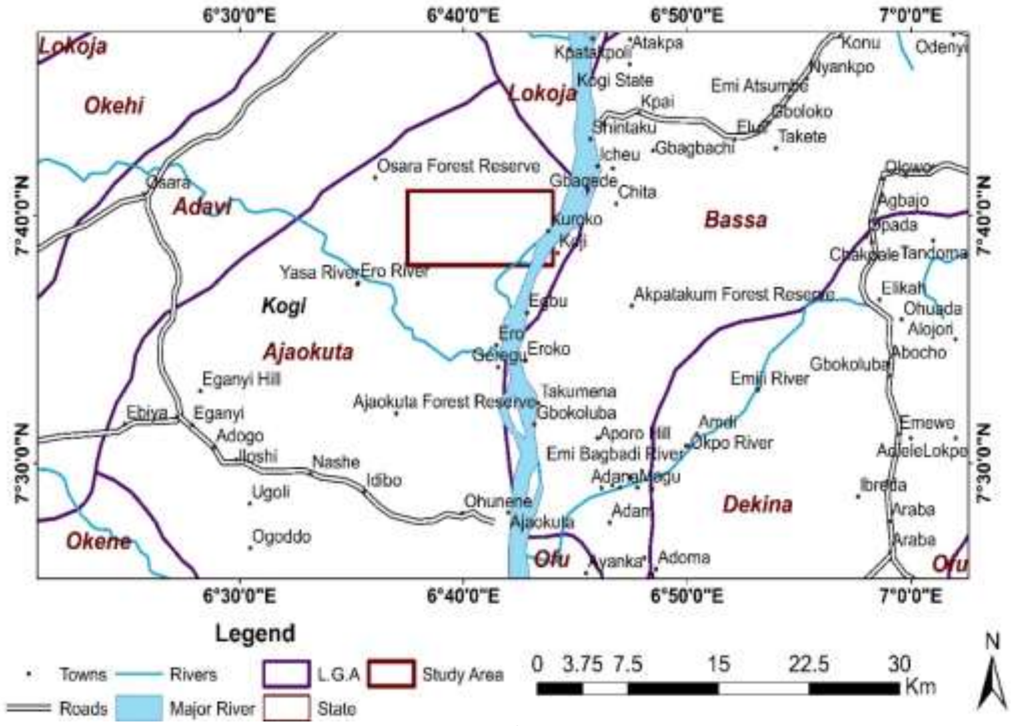

Fig 1b: Topography Map of showing the study area.

Geology of the study area: Kogi State has two main rock types, namely, the basement complex rocks of the Precambrian age in the western half extending slightly eastwards beyond the lower Niger Valley and the sedimentary rocks in the eastern half. The various sedimentary rock groups extend along the banks of River Niger and Benue and Southeast wards through Enugu and Anambra States, to join the Udi Plateau. The geology of Ajeokuta and environs has been severally discussed to be part of the geology of south-western Nigeria which has been well described by Oyawoye (1972), Grant (1978), Rahaman (1988) and others. The geology of the study area comprises of porphyroblastic granite, feldspathic sandstone and siltstone, and Quartzite, Quartz Schist as seen in figure 2

Materials: Materials used in this research such as the remote sensing data (Shuttle Radar Topographic Mission) dataset was sourced from the United State Geological Survey (USGS), the geophysical (aeromagnetic) data was from Nigerian Geological Survey Agency (NGSA) and geochemical (X-ray fluorescence) data was from field investigation and analysis.

Methods: For the Shuttle Radar Topographic Mission, Spacecraft Radar the elevation of the earth's surface is described by 90 m-resolution topographic mission data. The data will be processed and interpreted in order to understand the Geomorphology of the project area. For the aeromagnetic data, NGSA, Abuja, obtained the most recent airborne data flown by Furgo Airborne. The 3x Scintrex CS2 Cesium Vapour magnetometer was used to collect the airborne magnetic data, which was projected using the Universal Transverse Mercator (UTM) projection technique and flown at 500m flight line spacing.

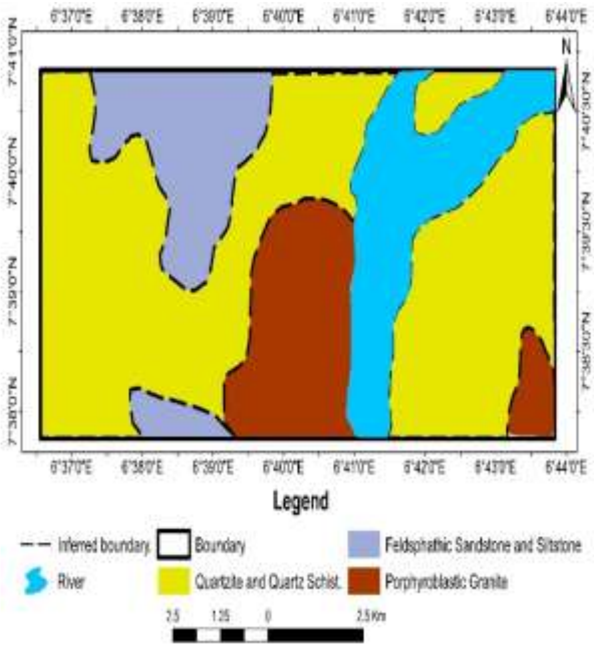

Fig 2: Geology Map of the Study Area.

The aeromagnetic data's flight parameters are as follows: flight line spacing of 500 meters; tie line spacing of 2 kilometers; terrain clearance of 80 meters. The samples were collected using shovel at the stone layer and were not sieved into a 2kg of soil into Hubco woven polyester sample bags (Plate 1). Samples were air-dried under a controlled environment to achieve constant weight; after which it was made into powder form using a pulverizer.

Each time a sample is pulverized, the plate inside the machine is washed and dry-cleaned with methylated spirit and tissue paper to avoid cross-contamination of the samples. Sample were ultimately analyzed at the laboratory as seen in Plate 2, for Au and a suite of 35 other elements.

The samples were then analyzed directly through their woven polyester sample bags using factory calibrations. The results of the geochemical analysis were interpreted using statistical analysis and graphical representation.

RESULTS AND DISCUSSION

The Results from Geophysical Investigation by Aeromagnetic Survey are presented in figures 3 to 8 respectively.

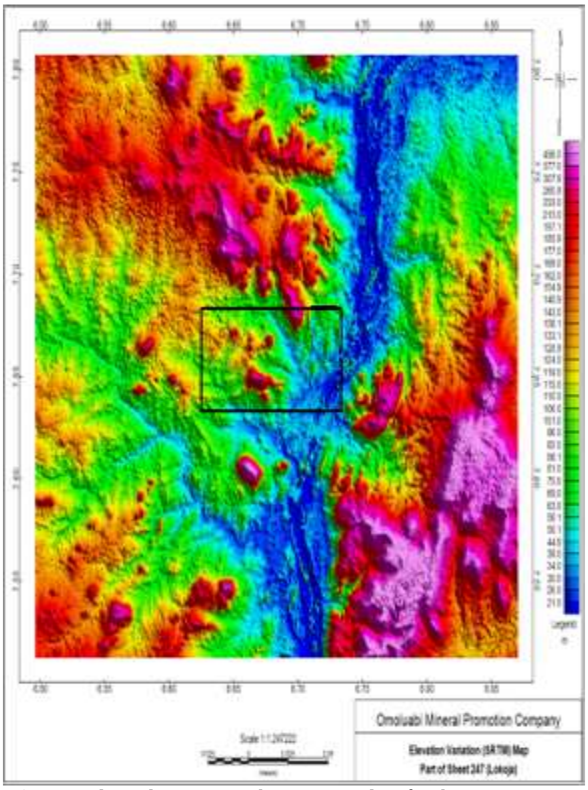

Fig 3: Suttle Radar Topographic Mission data for the project areas beyond

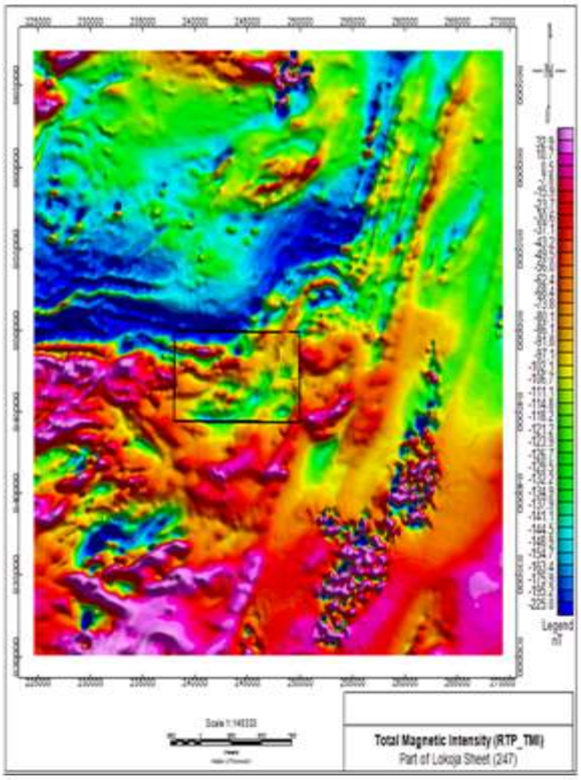

Fig 4: Total Magnetic Intensity (Tenement area in black box)

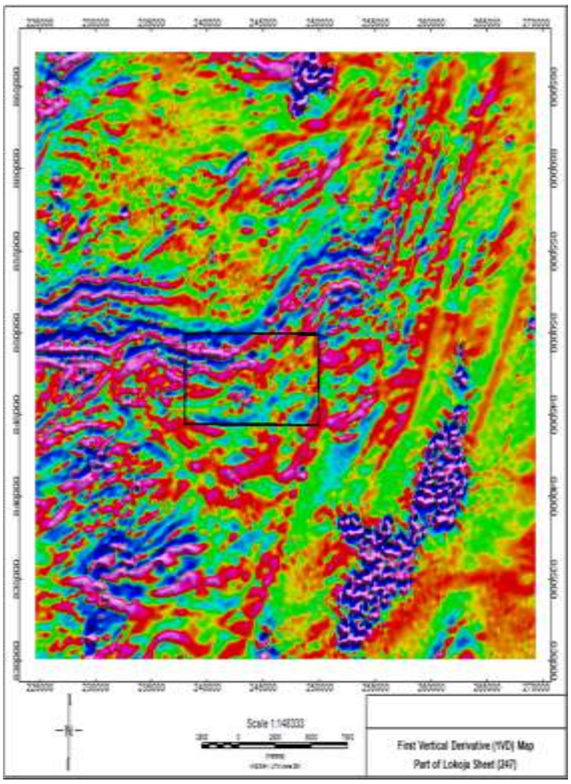

Fig 5: First vertical derivative image of the area of interest showing anomalous geological structures

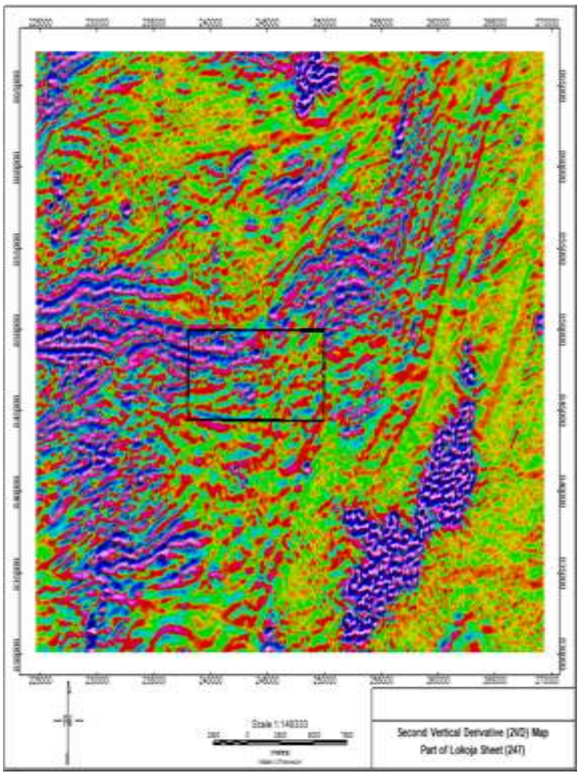

Fig 6: Second vertical derivative image of the tenement area shows near surface structures.

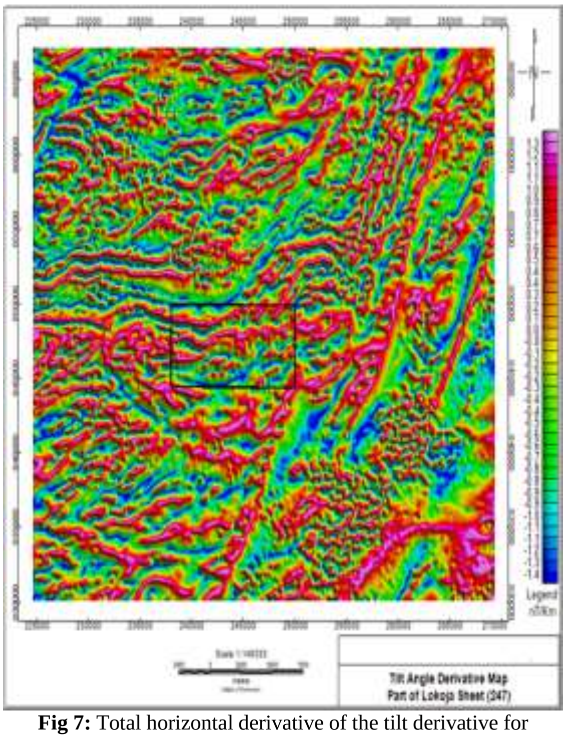

Fig 7: Total horizontal derivative of the tilt derivative for Lineaments of the Project Area

The primary function of any aeromagnetic and their derivative maps in mineral prospecting, by Dobrin and Savit (1988), is to draw geological conclusions from them. Additionally, information on subsurface lithology, trend, and geological structures can be gleaned from the data's range of magnetic intensity values.

Shuttle Radar Topographic Mission (SRTM): The area's Digital elevation Model (DEM) was created from a three-dimensional (3D) perspective of the area's Shuttle Radar Topographic Mission (SRTM). The elevation of the earth's surface is described by data from a Shuttle Radar Topographic mission that were acquired at a 90m resolution. This region lies between 21 and 190 meters above mean sea level. To comprehend the landform of the project area, more processing and interpretation of the data was done. In this regard, it is probable that the research region has both primary and placer gold resources. Therefore, alluvial and elluvial gold mining in the region should place a high priority on the valleys of the area under investigation. The bulk of the payable alluvial workings in the Ife-Ilesha gold field, according to De Swardt (1953), were confined to the valleys draining amphibolite complex which underlain the area. From the map figure 4, there exist areas of high magnetic intensity (0.1 to 0.7 nT) response at the north western part of the study area. This improvement tends to minimize anomaly complexity and sharpen anomalies over bodies, making it easier to image the underlying structures. Since the transformation will amplify short wavelength noise, it may be noisy. The magnetic grid in the research region clearly delineates sections with varying data resolutions (figure 5).

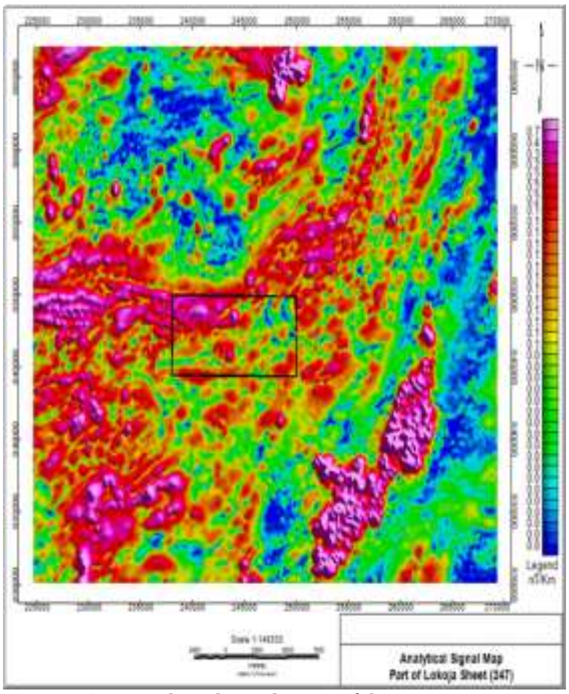

Fig 8: Analytical signal image of the project area

Geochemical Analysis: The Result from Geochemical Analysis.

Table 1: Result from X-ray Fluorescence's Analysis

S/N	Longitude	Latitude	ppm	+/-
1	6.629	7.679	1.0	0.3
2	6.647	7.679	5.0	0.7
3	6.664	7.678	4.0	0.6
4	6.68	7.679	2.0	0.5
5	6.695	7.678	5.0	0.7
6	6.713	7.678	4.0	0.6
7	6.729	7.679	5.0	0.6
8	6.629	7.662	N.D	< 3
9	6.646	7.663	N.D	< 3
10	6.663	7.663	1.0	0.3
11	6.678	7.663	N.D	**< 3**
12	6.695	7.662	4.0	0.6
13	6.713	7.663	3.0	0.5
14	6.728	7.663	5.0	0.7
15	6.629	7.646	N.D	< 3
16	6.646	7.645	1.0	0.3
17	6.662	7.645	N.D	< 3
18	6.679	7.646	N.D	< 3
19	6.696	7.646	5.0	0.7
20	6.713	7.646	4.0	0.6

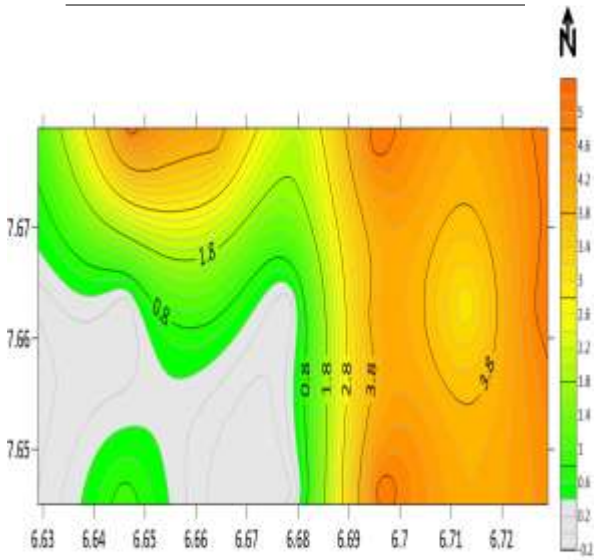

Fig 9: 2-D concentration map showing areas with low, medium to high gold concentration

By removing long wavelength magnetic field features, the first vertical derivative filter significantly improved the resolution of near spaced and superimposed abnormalities. The second vertical derivative (Figure 6) illustrates that structural elements like faults are more visible in comparison to the first vertical derivative map (Figure 5). According to the geologic map of the study area, figure 2, interpreted from the ground truthing, and geologic map adopted from NGSA 2015, the contact zone between the different rock types in the area reveals extensive faulting and shearing. The NE-SW direction is where the fault and fracture system primarily trends. This area is obviously a significant regional-scale fracture system, and it is likely to have been crucial to the formation of gold mineralization. The tilt angle derivative (figure 7) complements the above-mentioned filtered and first vertical derivative improvements. In comparison to the first vertical derivative, it typically yields a more precise position for faults, but for magnetic data, it must be used in conjunction with other transformations, such as reduction to pole (RTP) or pseudo-gravity. The tilt angle derivative is an effective technique due to the fact that it highlights the structures' edges, making them appear like rail lines along little features. NE-SW structural lineament tendencies were predominant. (Figure 7).

The analytical signal (figure 8) has the virtue of producing a maximum both directly over discrete bodies and their edges, although frequently being more discontinuous than the straightforward horizontal gradient. As long as the signal resulting from a single contact can be resolved, the breadth of a maximum or ridge is a good measure of the depth of the contact. Due to the inherent issues with RTP (at such low latitudes), this modification is frequently helpful at low magnetic latitudes (figure 8)

From the geochemical investigation, sample point 2, 5, 14, and 19 had the highest concentration in part per million of five (5). Sample point 3, 12, and 20 were found to be 4ppm, sample point 13 had 3ppm, sample point 4 had 2ppm, and sample point 1, 10, and 16 had 1ppm while the remaining sample point of 8, 9, 11, 15, 17, and 18 were found to be below detection limit. After performing statistical analysis and a graphical result output produced, it was evident that the eastern half of the study area show significantly higher opportunity for further exploration. (Figure 9). It is worthy of north that a river cut across the study area which is also at the eastern half. According to De Swardt (1953), the bulk of the payable alluvial is at the valley area which is the area found to have the high concentration of gold after analysis.

Conclusion: This study employed geophysical and geochemical analyses to assess gold presence in Lokoja Sheet 247, Ajaokuta L.G.A, Kogi State. Structural features and aeromagnetic data revealed a NE–SW directional trend, with concentrations of up to five parts per million. Further exploration, especially in the eastern and northwestern areas, is recommended. While x-ray fluorescence analysis proved effective, integrating advanced geochemical analyses and ground geophysical surveys like Induced Polarization is crucial for comprehensive evaluation. This approach will enhance understanding of gold concentration in soils. The study provides valuable insights into the region's gold potential, highlighting concentration disparities in different areas. It lays a foundation for future, more detailed investigations into gold mineralization in the region.

REFERENCE

Adepoju, MO; Adekoya, JA (2011). Reconnaissance geochemical study of a part of Igarra Schist Belt, Southwestern Nigeria. *Ife. J. Sci.* 13(1): 75–92

Akinlalu, AA; Adelusi, AO; Olayanju, GM; Adiat, KAN; Omosuyi, GO; Anifowose, AYB; Akeredolu, BE (2018). Aeromagnetic mapping of basement structures and mineral characterization of Ilesa Co. Inc. New York. P152-190, 498-578, 691-745

De- Swardt, AMJ (1953). The geology of the country around Ilesa. Bull. Geological Survey of Nigeria. No 23.

Dobrin, MB; Savit, CH (1988). Introduction to Geophysical Prospecting. McGraw-Hill Book

Grant N.K (1978) Structural Distinction Between A Metasedimentary Cover And An Underlying Basement In The 600 My Old Pan-African Domain Of Northwestern Nigeria. *Geol. Soc. Am Bull* 89:50–58

Oke, SA; Abimbola, AF; Rammlmair, D (2014). Mineralogical and geochemical characterization of gold bearing quartz veins and soils in parts of Maru schist belt area. Northwestern Nigeria. *J. Geolog. Res.* 17 pp

Oyawoye, MO (1972). The Basement Complex of Nigeria. In: Dessauvagie TFJ, Whiteman AJ. (eds) African geology. Ibadan University Press, 66–102

Oyinloye AO (1997). Ore petrology and chemical compositions of gold and associated sulphides in the Iperindo primary gold deposit in Ilesha Area, Southwestern Nigeria: implications on stages of mineralization. *Afr. J. Sci.* 1(1):71–81

Oyinloye, AO (2002). Au-Ag, K-Rb-Sr and 34S isotope chemical composition of gold deposit in Ilesa Area, Southwestern Nigeria. *J. Chem. Soc. Nig.* 27(2):162–166

Oyinloye, AO; Steed, GM; (1996). Geology and geochemistry of Iperindo primary gold deposit, Ilesha schist belt, Southwestern Nigeria. *Appl. Earth Sci.* 105:B74–B81

Rahaman, MA (1988). Recent Advances in the study of the Basement Complex of Nigeria. In: Geological Survey of Nigeria (ed) Precambrian Geol Nigeria, 11–43

Tong, Y; Yang, H; Li, J; Yang, Y (2013). Separation and Purification Technology 120: 367-372.