International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 11 Issue 5 ǁ May 2023 ǁ PP. 375-379

Interpretation of Airborne Radiometric Data of Wukari and Donga Middle Benue Trough, Nigeria

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Abstract — *Qualitative and quantitative interpretation of airborne radiometric data of Wukari and Donga middle Benue trough, Nigeria is here presented. A detailed analysis of the radiometric data has allowed determination of relative abundances of natural radioactive elements (Uranium, Thorium and Potassium) in the main soil types. The count rate range of K (0.11 - 2.75%), Th (6.79 - 27.71 ppm) and U (1.69 - 6.21 ppm) were observed within the study area. The triangular plot of the radio-elements showed a ternary image by combining the three radio-elements. The ternary plots of the radio-elements gave a superior image of the geology. The zones with relative enrichment of Potassium are seen in the southern and northwestern region of the study area, Uranium in Donga parts of study area while Thorium enrichment occurs along the Donga. From the qualitative analysis of the ratio maps, enrichment of uranium to thorium is observed dominantly in northwestern part of Wukari area parts of the study area. The rocks in the Wukari parts were identified as sandstones and shales while the Donga part of the study area consists of Gneiss The identified area should therefore be considered for further detailed ground spectrometric survey in order to identify areas of more prominent radioelement mineralization and geothermal energy explorations.*
Keywords— *Radiometric, Uranimum, Potassium, Thorium.count rate, radioelements, Geothermal energy*.

Date of Submission: 01-05-2023 Date of acceptance: 10-05-2023

I. INTRODUCTION

Amongst the emerging geophysical techniques, airborne radiometric survey presents matchless and incomparable characteristics due to the economical methods of conducting a geophysical reconnaissance study, especially in difficult terrains or in-accessible regions. The amazing characteristics offered unprecedented breakthroughs that have attracted scientific and engineering communities. Nigeria is a major oil and gas producing country in the world mainly by hydrocarbons [1][2].

However, the increasing concern for the exhaust of hydrocarbon byproduct and the associated hydrocarbon environmental pollution has necessitated research toward a cleaner source of energy. One of the sustainable ways of driving this goal is through geothermal energy generation. Geothermal energy is an abundant, and green source of energy, originated from the formations in a sedimentary basin and from radioactive decay of elements within the basement complex rocks [3] The study area was chosen because of the evidence of hot springs located around the Northern part of Benue Trough, near the study area, within a massive tectonic arrangement [4][5][6][7][8]

The method provides useful information for detecting and mapping natural radiometric emanations of gamma rays by measuring the naturally occurring radioactive elements that exists in rock forming minerals [9] Among all detectable radioactive elements only Uranium (U), Thorium (Th) and Potassium (K) produce gamma rays of sufficient energy and intensity to be measured in gamma ray spectroscopy [10][11]. The estimates of the concentrations of the radio elements at the earth's surface is done by measuring the gamma radiation above the ground from low-flying aircraft or helicopters. Changes in lithology or soil types are often accompanied by changes in the concentrations of the radioelements [12][13][14]. Thus the radiometric method is used as a reconnaissance investigation tool. In order to have superior results, ratio maps prepared from the radiometric data shall be subjected to qualitative and quantitative analysis.

This article describes the interpretation of airborne radiometric data of Wukari and Donga located within middle Benue Trough of Nigeria which contributes to a better understanding of the mineral deposits in the area and geothermal energy generation potential.

We organized the paper in sections as follows. The introduction and detailed background of the study are discussed in section I .Section II provides the location and geology of the study area followed by materials and methods described in section III which deals with the sources of data and method of data analysis. Detailed results obtained have been presented and thoroughly discussed in section IV. Conclusively in section V the observed results are summarized

II. LOCATION AND GEOLOGY OF THE STUDY AREA

The study areas with the geographical coordinates of latitude 9.5^0 to 10.5^0 North and longitude 7.5^0 to 8.0^0 East with an area extent of approximately $6050\ km^2$ are located in the middle Benue trough. The study area is in the middle Benue trough Nigeria. The Middle Benue Trough forms a link between the Upper and Lower Benue Trough (Figure. 1). The Middle Benue Trough passed through two major types of sedimentation cycles. The sedimentation in the Middle Benue area began in the Albian with the deposition of the Asu River Group whose age ranges from Middle Albian to Late Albian [15]. The first sedimentary cycle deposited shales and limestones (Albian - Conomenian) along Wukari and Akwana. These sediments lie unconformably on the Precambrian basement rocks (biotite granites, hornblende gneiss). Along Makurdi areas, Turonian sandstones also overlie the basement directly. The second sedimentary cycles started from the Upper Conancian to late Maestrichtian depositing shales, limestones, sandstones and ironstone around Lafia, Agana and parts of Shendam. Other areas around Wamba, Akwanga, Shendam and Lafia are characterized by undifferentiated granites, migmatites, gneisses and tertiary – recent volcanic [16]. Figure 2 is the Stratigraphic succession map showing the Middle Benue Trough [17].

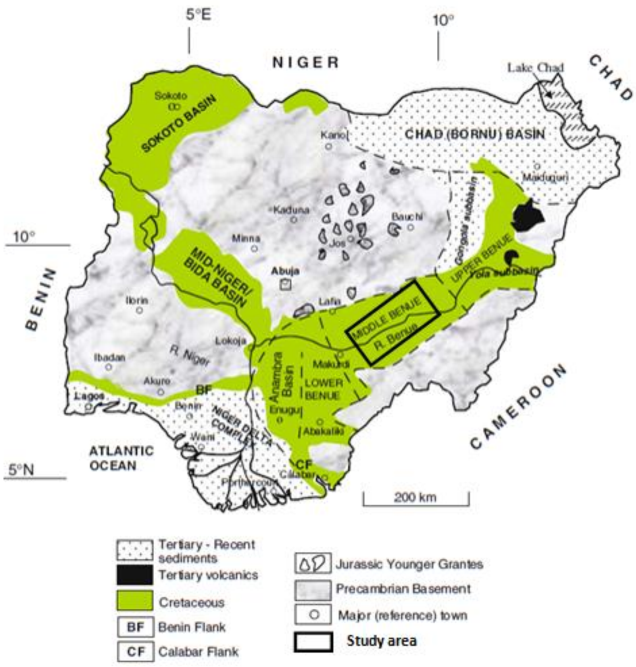

Figure. 1: Map of Nigeria showing the Study Area (Obaje, 2004).

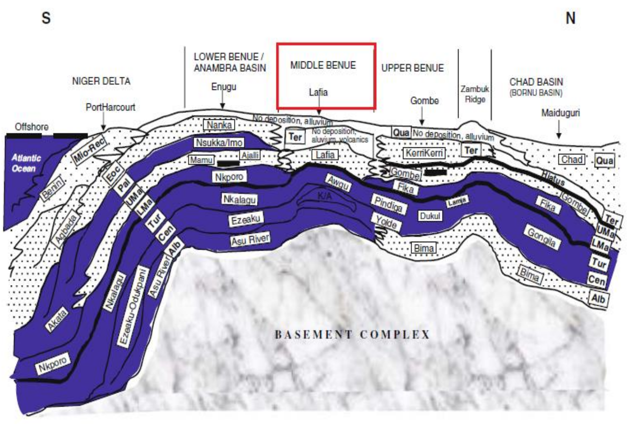

Figure. 2: Stratigraphic succession map showing the Middle Benue Trough (Obaje, 2009).

III. MATERIALS AND METHODS

Source of Data: Aeroradiometric data of high resolution for Wukari (sheet 253), Donga (sheet 254), Takum (sheet 273) and Tissa (sheet 274) were acquired from Nigerian Geological Survey Agency (NGSA) Abuja. The airborne survey was carried out by Fugro Airborne Survey between the years 2002 - 2009. The experimental obtained data from the airborne survey was presented in digital form as a composite grid of 1:100,000 covering the study area. The aeroradiometric data were acquired at a flight elevation of 80 m, line spacing and tie-line spacing were 500 m and 5000 m respectively. A line direction of 135/315 degrees was accepted for the survey.

Data Analysis: We have merged the four data sheets obtained from NGSA together. The merging was done by combining the four different sheets into one single sheet to form total area of study. The data were then gridded to obtain the Potassium, Thorium, Uranium and Total count grid using the minimum curvature grid method. The merged data was simulated using Oasis montaj 8.4 software for proper analysis.

Methods: We have calculated the map ratios of the radioelement using the grid ratio tool of the Oasis montaj 8.4 software. The ratios were calculated between the radioelement by assigning the values for the $\frac{U}{Th}$ $\frac{U}{K}$ and $\frac{Th}{K}$

The ternary radioelement map presents a single display of the three radioelement concentrations showing areas of rich abundance and sparse abundance of the three radioelements. To produce the ternary map, the ternary analysis tool of the Oasis montaj 8.4 software was used in which standard colours such as blue, green and red were assigned to Uranium, Thorium and Potassium respectively.

IV. RESULTS AND DISCUSSION OF RESULTS

The analysis of radiometric datasets revealed concentrations distribution pattern of primary radioelements: potassium (K), thorium (Th) and uranium (U). The result obtained was used to delineate and characterize bedrock lithology, as well as alteration and rock contacts within the study area. The count rate range of K (0.2 to 3.8 %), Th (7.0 - 59.5 ppm) and U (2.0 - 9.5 ppm) were observed within the study area. The concentration of thorium in Donga parts may likely be due to deposition of mafic minerals in the study area during sedimentation while the Potassium concentration is predominantly observed in the southern and northwestern part of Donga and Wukari area respectively. Figure 3 the U/Th ratio map shows preferential enrichment of uranium to thorium in most parts of the study area. Enrichment of uranium to thorium is observed dominantly in northwestern part of Wukari area parts of the study area. The rocks in the Wukari parts were identified as sandstones and shales while the Donga part of the study area consists of Gneiss).

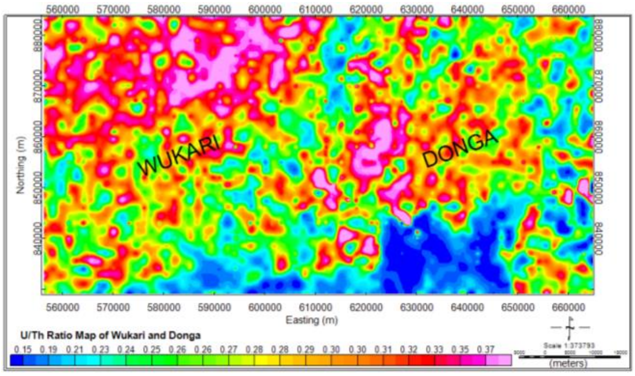

Figure 3: Uranium to Thorium (eU/eTh) ratio map of the study area.

Figures 4. and 5. are respectively the Uranium to Potassium (U/K) ratio map and Thorium to Potassium (Th/K) ratio map of the study area. High Th/K ratio signatures are observed in northern and southeastern Donga and Wukari parts of the study area. Regions with low Th/K ratio indicate preferential enrichment of potassium to thorium. In the U/K ratio map (Figure. 4), there is preferential enrichment of uranium to potassium as most of the area has high U/K ratio values while potassium enrichment is observed in the northwestern and southeastern Wukari and Donga part of the study area.

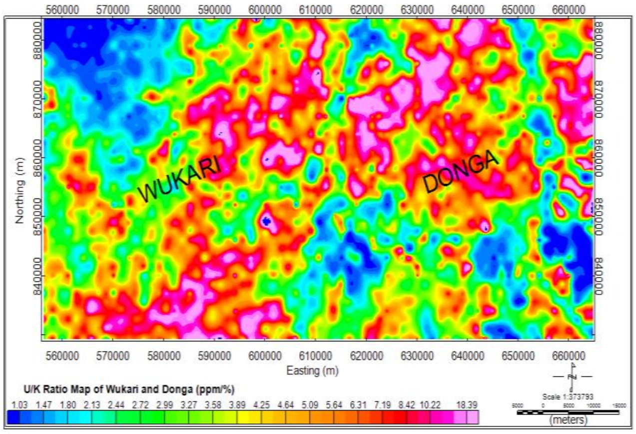

Figure 4: The Uranium to Potassium (U/K) ratio map of the study area

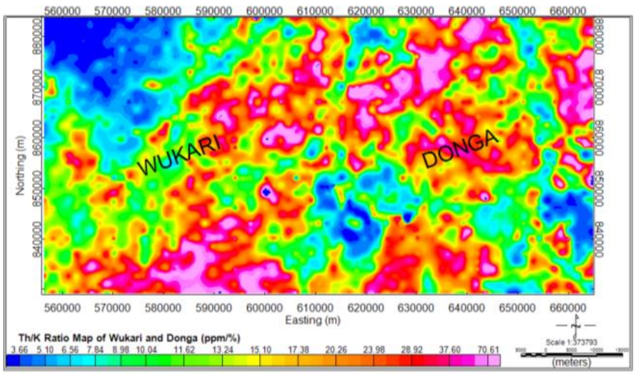

Figure 5: The Thorium to Potassium (Th/K) ratio map of the study area.

The triangular plot of the radio-elements showed in Figure 6 displays a ternary image by combining the three radio-elements. The ternary plots of the radio-elements gave a superior image of the geology. The zones with relative enrichment of Potassium are seen in the southern and northwestern of the study area, Uranium in Donga parts of study area while Thorium enrichment occurs along the Donga part

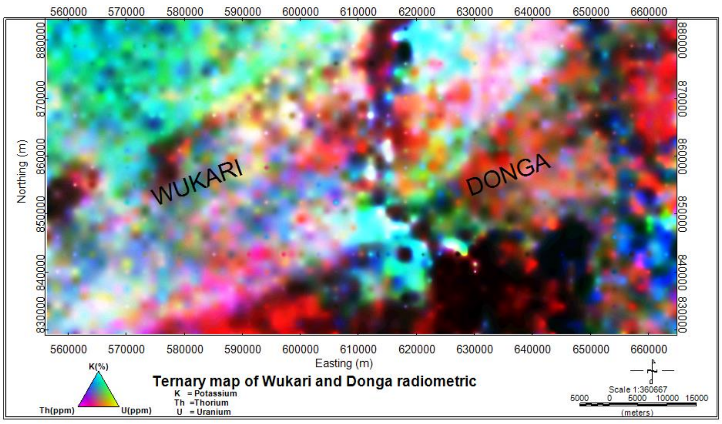

Figure 6. The ternary map of the study area

V. CONCLUSION

The analysis and interpretation of the radiometric data of Wukari and Donga Middle Benue Trough,Nigeria has allowed determination of relative abundances of natural radioactive elements (Uranium, Thorium and Potassium) in the main soil types. The count rate range of K (0.11 - 2.75%), Th (6.79 - 27.71 ppm) and U (1.69 - 6.21 ppm) were observed within the study area. The triangular plot of the radio-elements showed a ternary image by combining the three radio-elements. The ternary plots of the radio-elements gave a superior image of the geology (Salem et al., 2005). The zones with relative enrichment of Potassium are seen in the southern and northwestern regions of the study area, Uranium in Donga parts of study area while Thorium enrichment occurs along the Donga part. From the qualitative analysis of the ratio maps, enrichment of uranium to thorium is observed dominantly in northwestern part of Wukari area parts of the study area. The rocks in the Wukari parts were identified as sandstones and shales while the Donga part of the study area consists of Gneiss which could serve as raw materials. The identified area should therefore be considered for further detailed ground spectrometric survey in order to identify areas of more prominent radioelement mineralization and geothermal energy explorations.

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