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Geological Studies on Uranium, Thorium, Potassium Based On Airborne Radiometric Geophysical Data of Wukari And Donga Middle Benue Trough Nigeria

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ABSTRACT
The high resolution aeroradiometric data of Wukari and Donga Middle Benue Trough used for this work were obtained from the Nigeria Geological Survey Agency (NGSA). The analysis of radiometric data revealed concentrations distribution pattern of primary radioelements: potassium (K), thorium (Th) and uranium (U). 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. From the analysis of the maps, the relative lower values of Uranium abundances in Wukari area are roughly related to the presence of sedimentary rocks such as carbonates and sandstones in the study area while higher values of Uranium abundances in Donga area are roughly related to the presence of metamorphic rock such as schist. Results from statistics and map analysis have shown that the concentration of potassium is dominant around southern and northwestern part of Donga and Wukari area respectively and is of great advantage to agriculture in the area. In order to map out the most probable areas of radiometric mineralization, threshold values of U, Th and K% concentrations were determined statistically. The threshold value (the highest activity) for the total count was estimated as 51 cps. The approximate areas with sources of radiation which produce this anomaly (> 51 cps) are dominant in southern part of Donga area. Therefore, only the anomaly in these areas may be significant in terms of radioelement mineralization. The identified area should therefore be considered for further detailed ground spectrometric survey so as to determine the radiometric mineralization potentials of the area.

KEYWORDS: *radiometric, mineralization, spectrometric survey, threshold value*

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I. INTRODUCTION

Airborne Radiometric survey has recently attracted great interests both for economic and environmental reasons. The technique originally targeted for Uranium exploration is now widely used for geologic mapping (Andrson and Nash,1997), mineral exploration and environmental radiation monitoring and control (Hashad,1982). Mapping the surface geology by radiometric survey is based on the fundamental assumption that different rocks are compose of rock- forming minerals which contain specific amount of radioactive elements. Radiometric method produces exceptional radioactive results in the mapping of the various kinds of geological formations (Kearey *et al.,* 2002; Milsom, 2003). According to Telford *et al.* 1990, there are at least 20 known naturally occurring radioactive elements of which only three elements namely, Uranium U, Thorium Th, and Potassium K have isotopes that produce gamma radiation of high energy and intensity to be measured by spectrometry. Among the gamma rays U and Th are of significant interest as sources of fuel for generation of power and heat in nuclear plants (Telford *et al.,* 1990). Variations in U, Th and K respectively contributes to changes in the geologic lithology; therefore airborne radiometric survey can be used as a reconnaissance mapping tool. In Nigeria information on uranium occurrences have been identified by few individuals who have analyzed a few rock samples and uranium ores from some locations around the Nigerian younger granite province. However, the works of Uwah (1984), Dewu (1986), and Ahmed (2006) who carried out detailed investigations of radiometric anomalies in the Sokoto Basin, Bisichi and Jingir areas of Sokoto and Plateau States respectively, form a very important step for a large scale exploration of uranium and allied minerals. Arabi *et al.* (2012) investigated the levels of concentration of uranium in groundwater to ascertain its compliance with the World Health Organization‟s and United State Environmental Protection Agency‟s guidelines for uranium in drinking water in the northeastern part of Nigeria. Recently researchers like (Ayodeji *et al.* (2011); Abdullahi (2013); Taiwo *et al.* (2014) and Arabi *et al.* (2012; 2015)) carried out research in radiometrics in the northern and northeastern part of Nigeria. In this research airborne data were presented and interpreted to map different lithologic units of the area based on the spatial differences in the U, Th and K contents. The aim of this study is to carry out statistical analysis on the data in order to obtain the threshold value and the expected mean activity of the radioelements present in the study area and this will help to delineate the most favourable areas of radiometric anomalies and also areas rich for agriculture.

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, Nigeria. The middle Benue trough links the upper and lower arms of the Benue trough sedimentary basin in Nigeria. It is part of a long stretch arm of the Central African rift system and one of about seven inland sedimentary basins in Nigeria (Fig. 1) originating from the early Cretaceous rifling of the central West African basement uplift. The Benue trough is a unique rift feature on the African continent. It occupies an intracontinental position and has a thick compressionally folded Cretacious supercrustal fill, and divisible into upper, middle and lower Benue (Samuel *et al.,* 2011). The area is characterized by the presence of thick sedimentary cover of varied composition whose age ranges from Albian to Maastrichtian (Obaje, 2004). Fig. 2 is the Stratigraphic succession of the Benue trough (Obaje *et al.,* 2004). The Cretaceous sedimentary succession in the middle Benue trough (beginning from the oldest to the youngest) consists of the Asu River Group, the Awe, Keana, Eze-Aku, Awgu and Lafia Formations. The marine Asu-River group of Abian age commenced the sedimentation in the Middle Benue trough (Obaje, 2004; Obaje *et al.*, 2004).

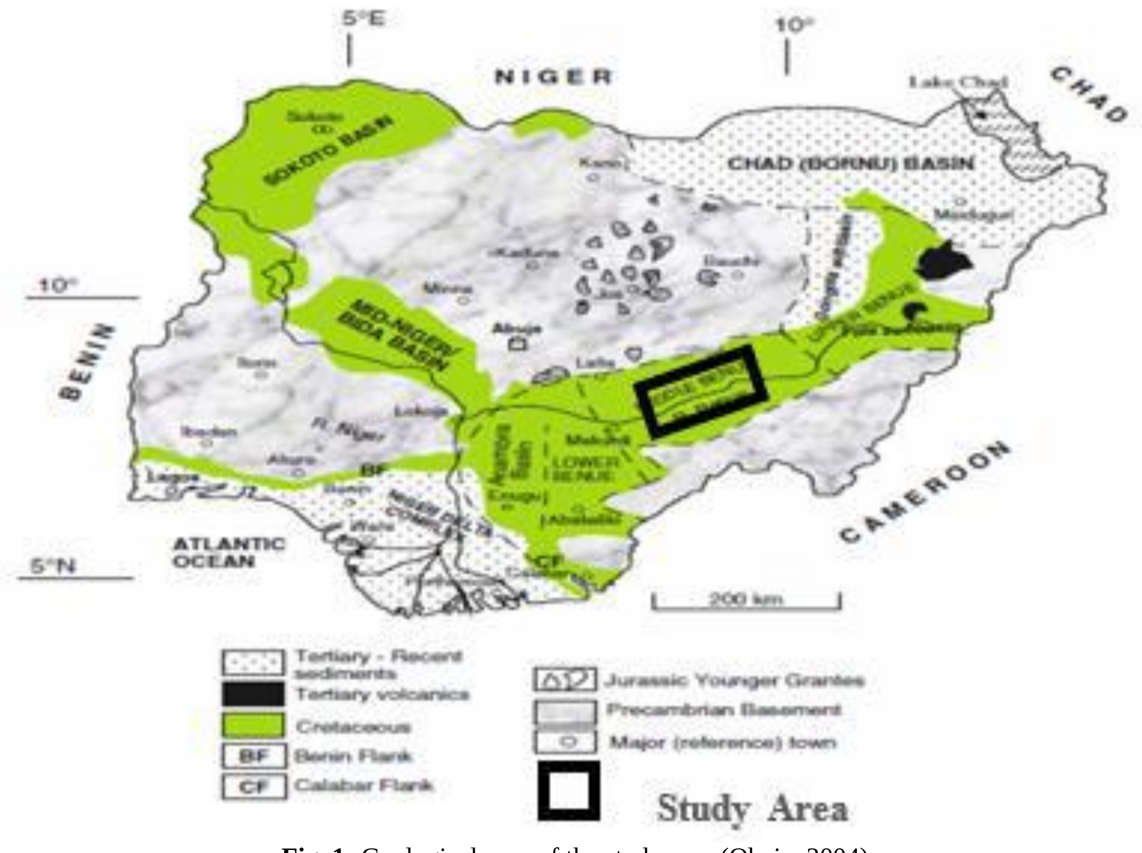

Fig. 1: Geological map of the study area (Obaje, 2004)

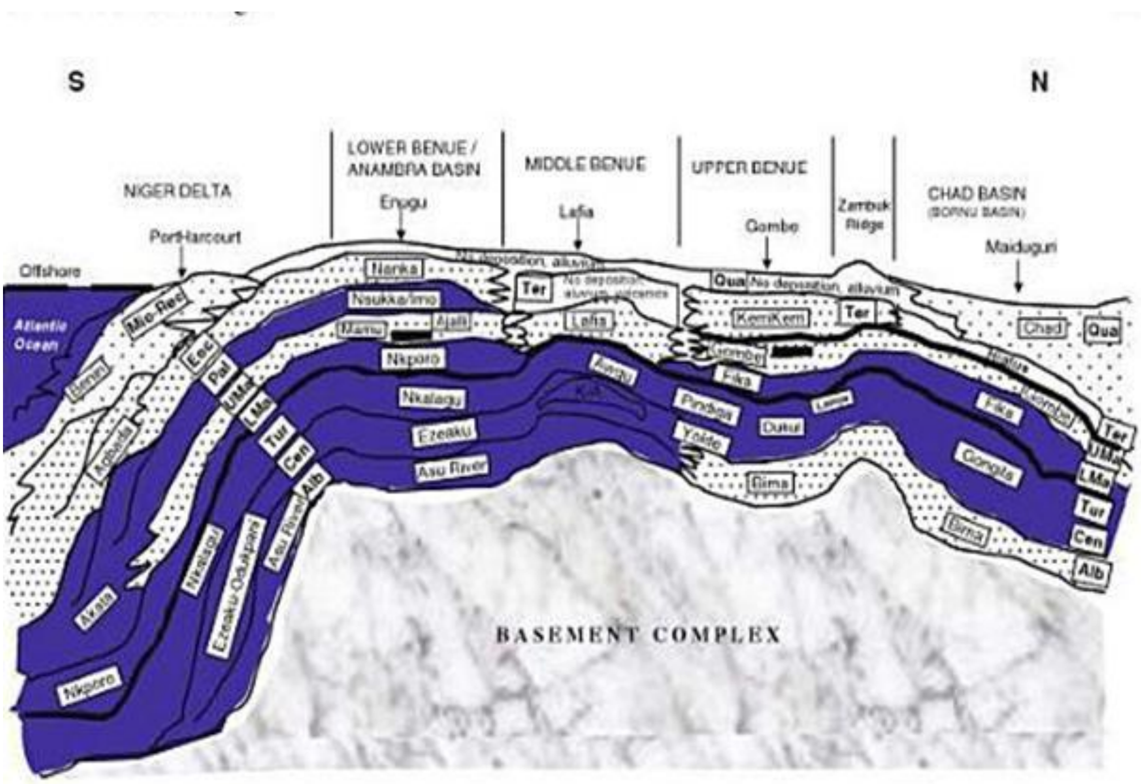

Fig. 2: Stratigraphic succession in the Benue trough (Obaje *et al.*, 2004)

III. SOURCE OF DATA

The high resolution airborne radiometric data of Wukari (sheet 253) and Donga (sheet 254) used for this study were acquired from Nigerian Geological Survey Agency, Abuja (NGSA). The high resolution airborne survey were carried out by Fugro Airborne Survey between the years 2002 - 2009. The data obtained from the airborne survey was presented in digital form as a composite grid of 1:100,000 sheets covering the study area. The data were acquired at a flight elevation of 80 m, line spacing and tie-line spacing were 500 m and 5000 m respectively.

IV. METHOD OF DATA ANALYSIS

Gridding of the aeromagnetic data was one of the first steps adopted in the data analysis because imaging, processing and interpretation require the data to be converted to an evenly spaced two dimension (2D) grid. The data was gridded in order to produce the Total count, uranium, thorium and potassium maps (Figs. 4-7) of the study area using Oasis Montaj software (www.geosoft.com).

The statistical analysis on the airborne radiometric data were carried out using the geostatistical tool of Oasis montaj 8.4 software (Figs. 3(a-d)). The statistical parameters such as the mean, standard deviation (SD), standard error of mean(SEM), skewness, kurtosis, geometric mean (GM), mode, minimum and maximum values, median, threshold value and expected mean activity (EMA) for the measured gamma radiation were calculated. The normal or expected mean activity (EMA) is determined from the mode and standard deviation (SD). The SD gives an idea of how close the entire set of data is to the mean value (Mammoth Geophysical Inc., 2007). According to Duval (1979), the SD is given as:

The EMA value is then given by:

EMA = Mode ± SD 1

The threshold values of eU, eTh and K% concentrations were determined statistically as described in equation 2 in order to map out the most probable areas of radiometric mineralization. Statistically, the threshold value is the sum of the mean and standard deviation and any value above the threshold is considered anomalous (Mammoth Geophysical Inc., 2007; Yusuf, 2016):

The threshold value = mean + Standard deviation 2

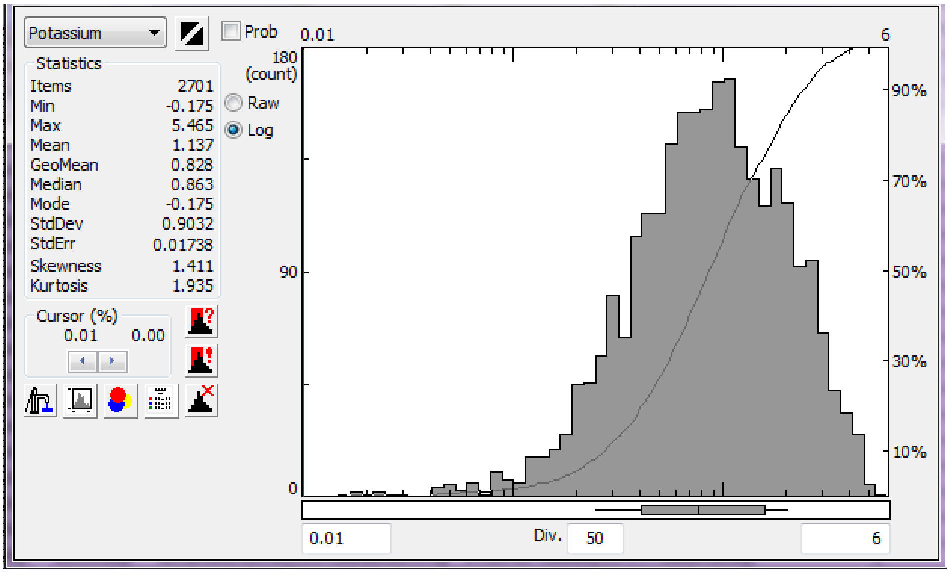

Fig. 3a: Statistical analysis of potassium

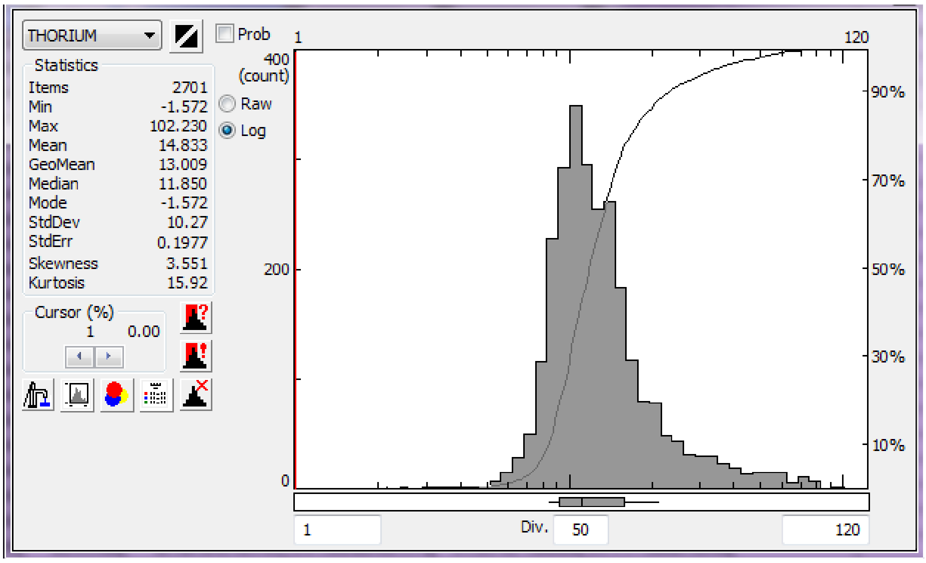

Fig. 3b: Statistical analysis of Thorium

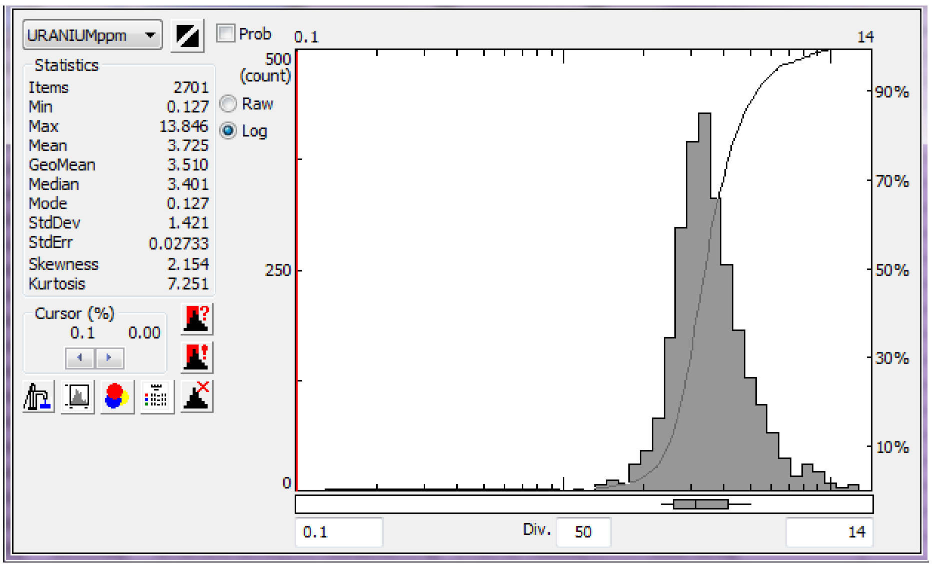

Fig. 3c: Statistical analysis of Uranium

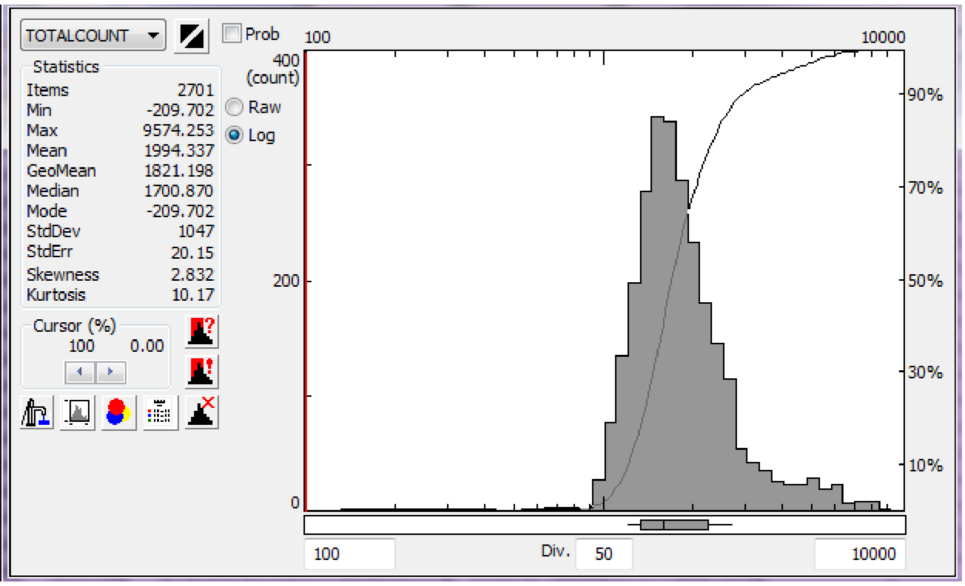

Fig. 3d: Statistical analysis of the Total count

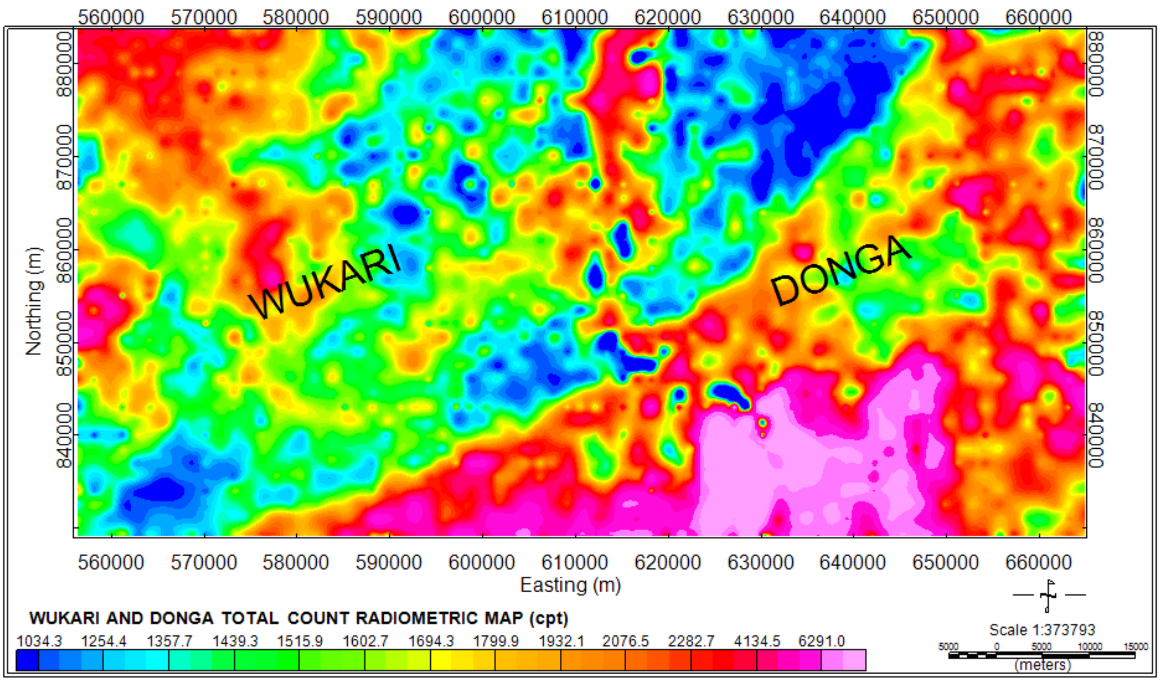

Fig. 4: Total Airborne Radiometric Anomalies count map of the study area.

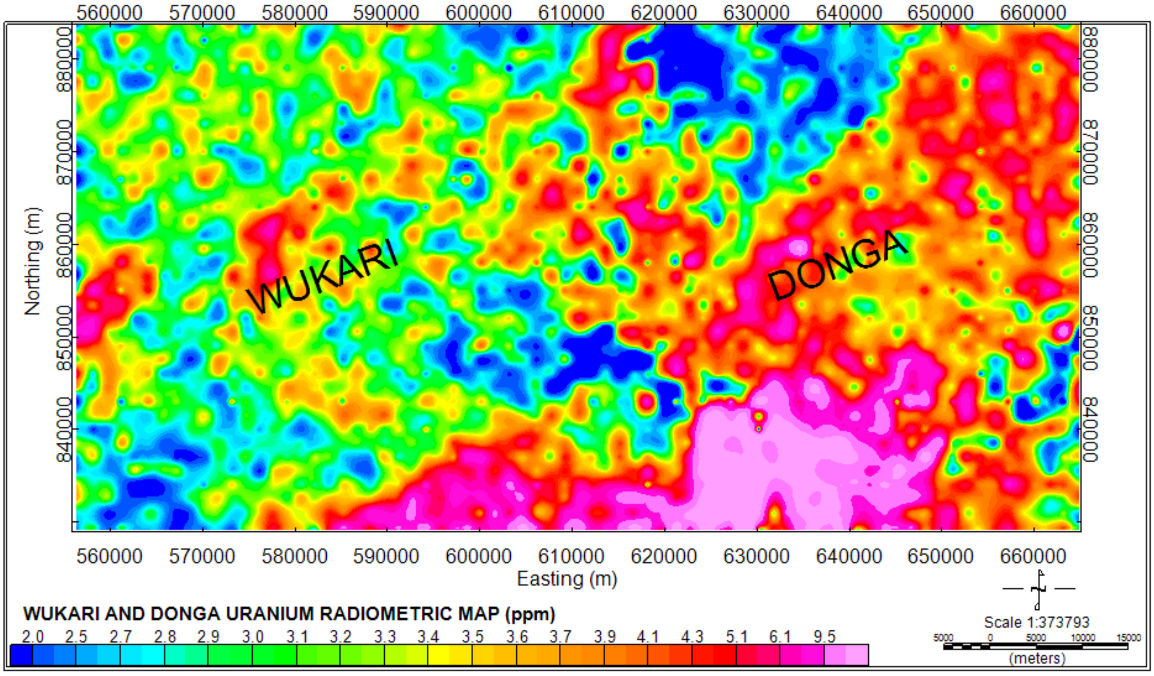

Fig. 5: Geographic distribution of Uranium in the study area.

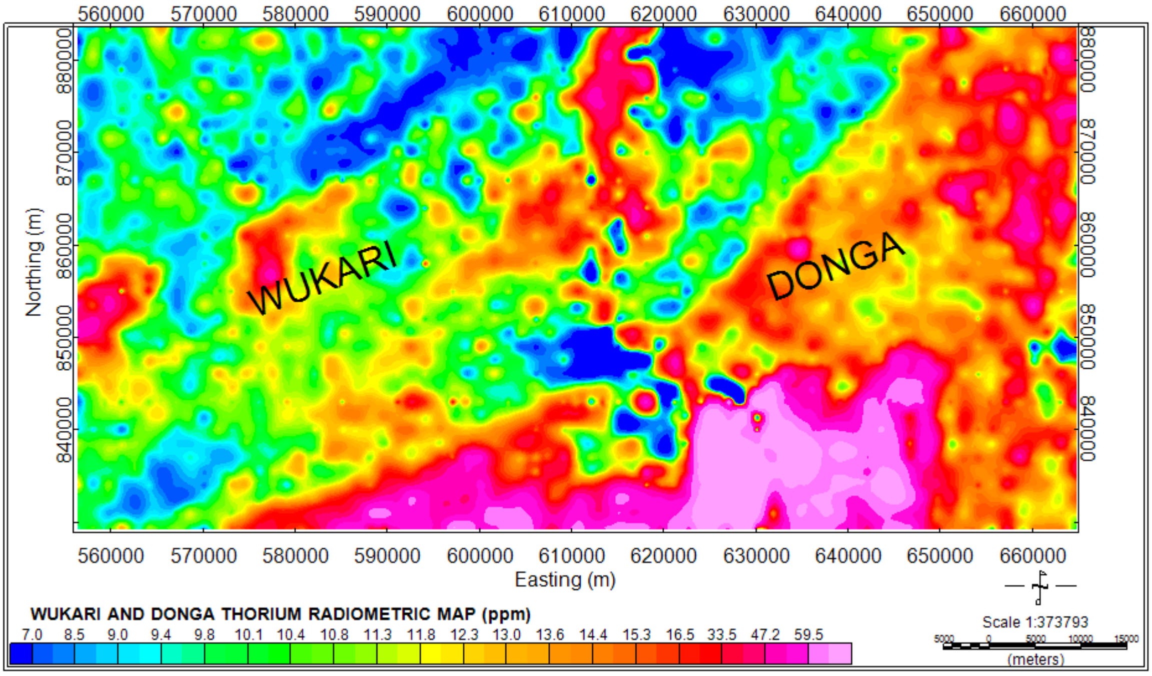

Fig. 6: Geographic distribution of Thorium in the study area.

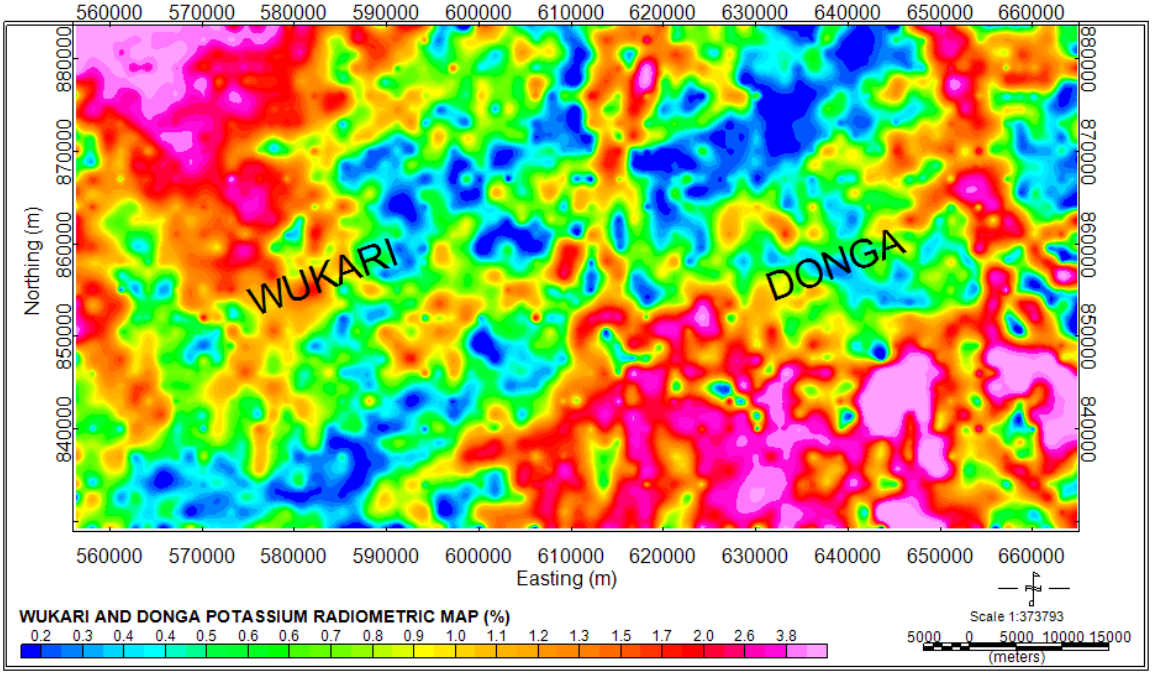

Fig. 7: Geographic distribution of Potassium in the study area.

Table 1: Summary statistics of the airborne radiometric data

S/N	Statistics Analysis	eU_Parts per million (ppm)	K(%)	eTh(ppm)	Total Count (cpt)
1	Min	0.127	-0.175	-1.572	-209.702
2	Max	13.846	5.465	102.230	9574.253
3	Mean	3.725	1.137	14.833	1994.337
4	Mode	0.127	-0.175	-1.572	-209.702
5	StdDev	1.421	0.9032	10.27	1047
6	StdErr	0.02733	0.01738	0.1977	20.15
7	Median	3.401	0.863	11.850	1700.870
8	Skewness	2.154	1.411	3.551	2.832
9	Kurtosis	7.251	1.935	15.92	10.17
10	Threshold value	5.146	2.0402	25.103	3041.337
11	EMA	1.548	0.7282	8.698	837.298

V. 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. Fig. 4 is the total count of the three radio-elements (Uranium (ppm), Thorium (ppm) and Potassium (%)) with a total count of about 1034.3cpt – 6291.0 cpt map of the study area. The map shows high concentration of total count values in parts of the study area mostly around Donga. From the threshold values (Table 1), the maps of Uranium, Thorium and Potassium concentrations (Fig. 5-7) respectively have delineated areas of more prominent radioactive anomalies of the radioelements. The Thorium above threshold map (Fig. 6) shows the concentration of thorium in the Donga part of the study area. Potassium is concentrated in southern and northwestern part of Donga and Wukari area respectively of the study area (Fig. 7).

The threshold value (the highest activity) for the total count was estimated as 51 cps which according to Uwah (1984), all other values higher than the threshold value are considered anomalous. In Fig. 4, the approximate areas with sources of radiation which produce this anomaly (> 51 cps) are dominant in southern part of Donga area. Therefore, only the anomaly in these areas as indicated with pink colour may be significant in terms of radioelement mineralization. Also, According to Levinson (1974), for an activity to be of significance in terms of mineralization, it must be about twice the mean activity of the area. In the study area, activities of more than twice the mean activity (i.e. 28 cps) was dominantly observed at Donga part of the study area as shown in Fig. 4 with pink colour.

The standard deviation were determined statistically as shown in Table 1. The standard deviation of the concentrations of the radionuclides U in this study are lesser than its mean activity concentrations which indicates a high degree of uniformity while Th and K are greater than their mean activity concentrations which indicates a low degree of uniformity (Gupta, 2001). The mean concentration of U, Th and K for the data, are 3.73 ppm, 14.83 ppm and 1.137 % respectively which are within the world average values (UNSCEAR, 2000).

VI. CONCLUSION

The radiometric data of Wukari and Donga has been interpreted quantitatively and qualitatively. The result from the analysis of the radiometric data revealed the concentrations of the radioelements, potassium (K), thorium (Th) and uranium (U) in the study area. 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. Results from statistics and map analysis have shown that the concentration of potassium is dominant around southern and northwestern part of Donga and Wukari area respectively and is of great advantage to agriculture in the area. The mean concentration of U, Th and K for the data, are 3.73 ppm, 14.83 ppm and 1.137 % respectively which are within the world average values. In order to map out the most probable areas of radiometric mineralization, threshold values of eU, eTh and K% concentrations were determined statistically. The threshold value (the highest activity) for the total count was estimated as 51 cps. The approximate areas with sources of radiation which produce this anomaly (> 51 cps) are dominant in southern part of Donga area. Therefore, only the anomaly in these areas may be significant in terms of radioelement mineralization.

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REFERENCE

[1]. Abdullahi M. (2013). Gamma ray spectrometry of naturally radioactive materials for Birrnin Gwari. Artismal Goldmine of Kaduna State. Unpublished M.Sc Thesis, Department of Physics, Ahmadu Bello University, Zaria.

[2]. Ahmed, A. L. (2006). Detailed Radiometric Surveys of the Albite Riebeckite Granites of Dutsen - Wai Ring Complex, Kaduna State Northern Nigeria. Unpublished Ph.D. Thesis, Department of Physics, Ahmadu Bello University, Zaria.

[3]. Andrson , H., and Nash, C. (1997). Integrated lithostructural mapping of the Rossing Area using high resolution aeromagnetic, Exploration Geophysics, 28, 185-191

[4]. Arabi A. S., Funtua I. I., Dewu, B. B. M., Alagbe, S. A., Kwaya, M. Y., Garba, M. I. and Baloga, A. D. (2012). Activity concentration of uranium in groundwater from uranium mineralized areas and its neighbourhood. Journal of radiological and nuclear chemistry. DOI 10.10007/s1096-012-1957-x

[5]. Arabi A. S., Funtua, I. I., Dewu, B. B. M. and Muhammad A. M. (2015). Background radiological hazard associated with local building materials around Zaria, Nigeria. Radiochemistry, Vol. 57, No. 2, 207-212.

[6]. Ayodeji, A., Adetayo, A., Dauda, A., Omowumi, O., Isiaka, O. O. and Pascal, T. (2011). Basement data of the Terrestrial Radionuclide level of Abuja, Federal Capital Territory (FCT), Nigeria. Journal of Environmental Protection, Vol. 2, 359-364.

[7]. Dewu, B. B. M. (1986). A geophysical Ground Follow – up to an Aeroradiometric Anomaly at Bisichi Area of Plateau State, Nigeria. Unpublished M.Sc. Thesis, Department of Physics, Ahmadu Bello University, Zaria; 1 – 85

[8]. Duval, T.S. (1979). Arial Gamma-ray in Duval, Liveole, Texas. USGS Professional Paper 11220.

[9]. Gupta, S. P. (2001). "Statistical methods", Sultan Chand and Sons, Educational Publishers, New Delhi, pp 54-61.

[10]. Hashad, A. H. (1982). Geophysical and petrological study of wad. Natash late cretaceous volcanic, Egypt. J. Geol., 26, 19-37

[11]. Kearey, P., Brooks, M. and Hill, I. (2002). An introduction to geophysical Exploration third Edition.TJ international. 2-160.

[12]. Levinson, A. A. (1974). Introduction to Exploration Geochemistry. Applied publishing Ltd. Maywood Illinois, p 614.

[13]. Mammoth Geophysical Incorporated (2007). Geophysical Exploration, Oil and Gas Field, Barraackville, West Virginia. Technical Report, (304): 355-1810.

[14]. Milsom, J. (2003). Field Geophysics, the geological field guide series. Third edition. John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, pp. 71

[15]. Obaje, N.G.(2004). Geology and Mineral resources of Nigeria. Springer Dordrecht Heidelbug London New York 10-30.

[16]. Obaje, N., Wehner, H., Scheeder, G., Abubakar, M. and Jauro, A. (2004). Hydrocarbon prospectively of Nigeria's inland Basins: from the viewpoint of organic geochemistry and organic petrology. AAPG bulletin, 88(3): 325 – 353.

[17]. Samuel O. A., Olusola, J.O. and Olabisi, A. A. (2011). Stratigraphic Evolution and Petroleum Potential of Middle Cretaceous Sediments in the Lower and Middle Benue Trough, Nigeria: Insights from New Source Rock Facies Evaluation. Pet. Technol. Dev. J. 1:1595-9104.

[18]. Taiwo, A. O., Adeyemo, D. J., Sadiq, U. and Bappah, I. A. (2014). Determination of external and internal hazard indices from natural occurring radionuclides around a superphosphate fertilizer factory in Nigeria. Archives of Applied Science Research, 6 (1):23-27.

[19]. Telford, W. M., Geldart, L. P., and Sheriff, R. E. (1990). Applied Geophysics. Cambridge

a. University Press, second edition.

[20]. UNSCEAR (2000). United Nations Scientific Committee on Effect of Atomic Radiation. Sources and Effects of Ionizing Radiation. Report to General Assembly, with Scientific Annexes, United Nations, New York.

[21]. Uwah, J. E. (1984). Investigation of radiometric anomalies by nuclear and other methods. (A case study of the Sokoto basin of Nigeria). Unpublished Ph.D Thesis, Department of Physics, Ahmadu Bello University, Zaria, 1-135.

[22]. Yusuf, B. D. (2016). Ground radiometric investigation in the southern part of the Kerri–Kerri formation, Gombe state, Northeastern Nigeria. A thesis submitted to the school of postgraduate studies, Ahmadu Bello university, Zaria in partial fulfilment of the requirements for the award of a degree of doctor of philosophy in Applied Geophysics Department of Physics, Pg 80.