*IOSR Journal Of Applied Geology And Geophysics (IOSR-JAGG)*
*E-ISSN: 2321–0990, P-ISSN: 2321–0982.Volume 12, Issue 2 Ser. I (Mar. – Apr. 2024), 09-15*
*Www.Iosrjournals.Org*

# Use Of Airborne Radiometric Data For Bitumen Exploration In Agbabu Area, Southwestern, Nigeria

O.F. Ogunlana[1], H.T. Akande[2], T.A. Ojuola[1] And A.T Agbele[1]
[1]*Department of Physics, Bamidele Olumilua University Of Education, Science and Technology, Ikere-Ekiti, Ekiti State, Nigeria.*
[2]*Department of Physics, Applied Physics and Astronomy, Rensselaer Polytechnic Institute, Troy, New York, USA.*

***Abstract***
*Airborne radiometric data was used to define the targets of bitumen deposit in Agbabu area, southwestern, Nigeria. The aero-radiometric maps were processed using Oasis Montaj software to obtain grids of uranium (U), thorium (Th), potassium (K), ratio-grids and ternary (composite) images. The radioelement concentrations of potassium (K), thorium (Th), and uranium (U) varied spatially, with the highest values found in the basement complex (0.6–2.5%), 7.9–28.0 ppm, and (1.9–5.1 ppm), respectively, and the lowest concentrations in the sedimentary terrain (0.0–0.6%), (1.8–9.2 ppm), and (0.3–1.9 ppm), respectively. These findings were based on the interpretation of radiometric datasets. Around lithological borders and hidden linear features, the ternary picture exhibits moderately high radiometric intensity, while areas with bitumen deposit show very low radiometric intensity. From the result of the airborne survey, potential areas for bitumen deposit were denoted by low radiometric concentration.*
***Keywords:****Agbabu;Radiometric; Potassium; Thorium; Uranium; Bitumen.*

---

Date of Submission: 14-03-2024 Date of Acceptance: 24-03-2024

---

## I. Introduction

The research site, Agbabu, is in the Odigbo local government region of Ondo State, southwest Nigeria. It is situated between latitudes 6o35'16.3'N and longitudes 4o49'29.0'E. In southwest Nigeria, this region is a part of the sedimentary Dahomey basin.Three thousand meters or more of Mesozoic and Cenozoic sedimentary strata are contained in the Dahomey basin, an Atlantic margin basin. Its stratigraphy is divided by several authors into distinct units, such as the Abeokuta Group, Imo Group, Oshosun Formation, Ilaro Formation, and Coastal Plain sands and Alluvium. It stretches from southeast Ghana to the western flank of the Niger Delta (Jones and Hockey, 1964; Adegoke and Omatsola, 1981; Agagu, 1985).

The Imo Group's sediments specifically underlie the Agbabu region. Researchers have deciphered geological structure patterns to identify possible mineralization zones by using airborne radiometric datasets (Wemegah et al., 2015). Based on color variations, the composite image of radioelement concentrations offers insights into lithological variances. The maps, which indicate areas with significant radioelement richness, emphasize concentrations of uranium, thorium, and potassium (Elawadi et al., 2004).

Airborne radiometric surveys are commonly used in mineral exploration worldwide, with the goal of identifying mineralization zones and metalliferous deposits (Rajesh et al., 2006; Keating, 1995). By evaluating naturally existing trace elements in rocks and soil profiles such as potassium (K), uranium (U), and thorium (Th), these surveys quantify differences in mineral composition and soil qualities.

The distribution of materials is correlated with the gamma-ray responses from radioelements (K, U, and Th) in rocks that are collected from radiometric surveys. Researchers create images by collecting data in a grid window using mini-curvature gridding, and then link those images with geological units, patterns, and trends.

The potassium picture specifically shows areas with high potassium concentrations. Although thorium is generally thought to be stable, gold deposits frequently show increases in both potassium and thorium, indicating that thorium may have moved during hydrothermal activity (Silva et al., 2003). In most ore deposits, decreases in thorium and increases in potassium signify alteration signs (Ostrovskiy, 1975), which led to the creation of the thorium image map.

Granitoid rocks with a low uranium content but a high potassium concentration can be effectively mapped using the uranium image, particularly the uranium to potassium ratio map (U:K). The deep understanding of the Agbabu research area's geological features and possible mineral resources is facilitated by these extensive imaging techniques.

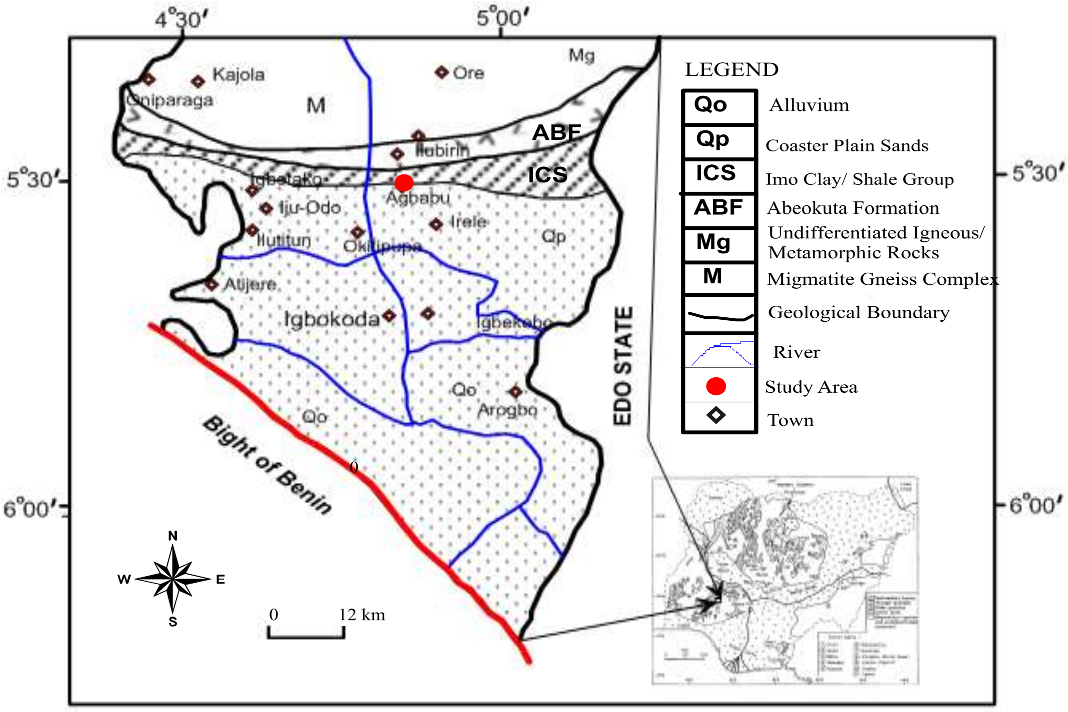


**Figure 1: Geological map of Ondo State's southern region to show the study area, modified from PTF, 1997.**

Basic Radioactivity

Equally numbered protons and varying neutron counts distinguish isotopes from other atoms of the same element. While their physical characteristics differ, isotopes share the same chemical characteristics. To stabilize themselves, unstable nuclei release strong ionizing radiation.Radioactive isotopes, or radioisotopes, are the name given to these isotopes. According to the IAEA (2003), unstable nuclei break down into radionuclides.

The radioactive decay of the nuclei of each radioactive isotope is associated with a unique possibility. The total time taken for any nuclei of radioactive nature to reduce to half of their initial value remains the half-life. Therefore, half of the original radioactive isotope remain after one half-life, one quarter remain after two half-lives, and so on (Minty, 1996). According to the decay law of radioactivity, the number of unstable nuclei's atoms decreases over time and can be stated as (IAEA, 2003).

$$N = N_O exp(-\lambda t)$$

Where $N_O$ is the original number of atoms, λ is the unstable nuclei's decay constant ($s^{-1}$), and N is the number of atoms following decay with time t(s).

The time required for $N_O$ to fall by half is known as the element's half-life.

$$t_{1/2} = \frac{0.693}{\lambda}$$

The activity of the unstable nuclei is given by the product of λ and N. Additional physical variables are not necessary for the disintegration of an unstable nucleus (IAEA, 2003).According to Minty (1996), radioactivity often results from a series of daughter products that break down the mother elements to produce stable isotopes.The decay series' radioisotopes exhibit the same behaviors currently. So, the amount of any daughter nuclei may be estimated to some extent, which can help determine the amount of other radio nuclei in the breakdown series. The quantity of radionuclide in the top 30 to 40 cm of soil determines how much radiation is emitted from the Earth's surface, although there are many other variables at play. Elawadi et al. (2004) state that the amount is dependent on the main rock and the degree of weathering.

## II. Materials And Methods

Materials

The contents consist of: a soft copy of the aerial geophysical datasets (Aeroradiometric map) covering Agbabu sheet 282 (1:100,000) and Okiti-Pupa and Mahin sheets 282 (1:100,000); a hard copy of the geological map covering Agbabu sheet 282 (1:100,000); and a geologic assessment covering the Agbabu area produced by NGSA in 1998.

Software

Surfer 10.0 by Golden Software and Geosoft Oasis Montaj (2010) are among the programs included. Golden Software created the mapping and spatial analysis program Surfer 10.0, whereas Geosoft Oasis Montaj is a geoscience software for data analysis, visualization and interpretation. These programs are frequently used for data visualization, modeling, and mapping tasks in the domains of geology, geophysics, and related sciences.

Methodology

The investigation of differences in mineral content in surface geology is much improved by the application of the survey data for radiometric, which also makes the lithologicalmapping easier. These surveys of radiometric, which are carried out by air, are essential for estimating the amount of gamma radiation that comes from rocks that have the potential to create minerals (Telford et al., 1990). The elements "Th, K and U, that appear in minute quantities inside the soil and decay naturally to release gamma radiation, are the main sources of these radiations from gamma.A spectrometer was used to quantify these gamma emissions and gather more detailed information. In addition to measuring total gamma-ray emissions, the device also determines the specific energy levels linked to the various radionuclides. The mapping of lithologies that follows is made attainable by the insightful information obtained from these energy levels. Through close examination of the geographical relationship between the radiometric data and lithological rocks, scientists can identify trends that go toward providing a full picture of the mineral content of the examined region. Broadly speaking, the combination of gamma ray spectrometry and airborne radiometric surveys provides a methodologically sound way to reveal the finer points of surface geology and lithological differences.

## III. Results And Discussion

Potassium (K) Channel

The radiometric study found a few abnormalities pertaining to thorium (Th), uranium (U), and potassium (K). According to Boadi et al. (2013), potassium feldspar, especially in micas like muscovite and biotite, appears to be the main source of potassium radiation. These elements are abundant in the brecciaof the felsic metasediments (MS), although Manu (1993) pointed out that they are less common in the mafic-metavolcanic (MV) series. In the metavolcanics MV, this accounts for the weak K anomaly. Within the basement complex, which consists of metavolcanic deposits, potassium (K) concentrations are often high, ranging from 0.6% to 2.5%). However, it is comparatively low (between 0.0% and 0.6%) in the metasediment, which is the sedimentary strata that contains the bitumen deposit.

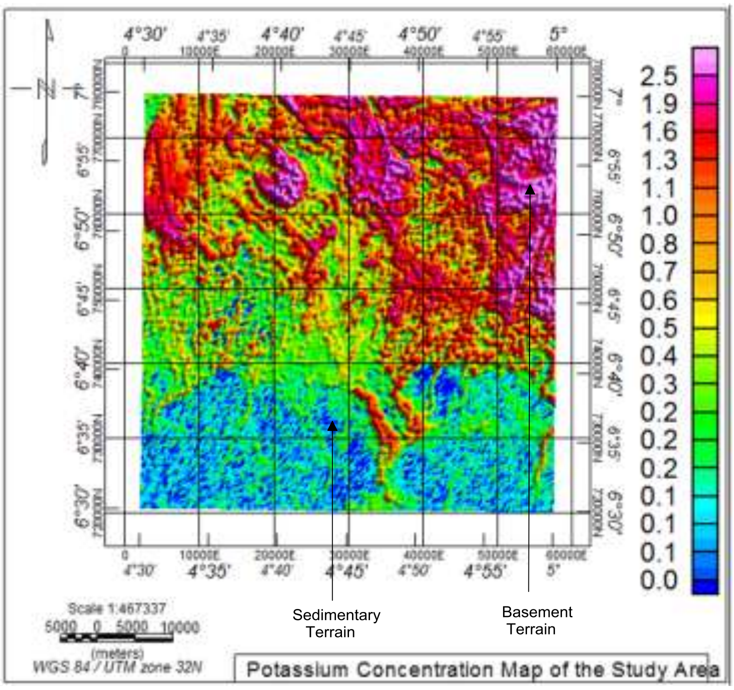


**Figure 2**: Map showing Concentration of Potassium (K) in the Radiometric Data

Thorium (Th) Channel

Determining the borders between sedimentary and basement terrains was made possible in large part by analyzing the thorium data in Figure 3. Notable abnormalities were found, especially in the study area's northern, northwest, and northeast sectors, where thorium concentrations peaked between 7.9 and 28.0. It was discovered that there was some correlation between these elevated concentrations and the basement regions.

On the other hand, the sedimentary basin's southern, southwestern, and southeast sections showed lower intensities for the immobile and mobile Thorium (Th) (Silva et al., 2003). Looking at the map, you can see that there is a clear pattern: the southeast has very low thorium concentrations (1.8 – 9.2). This observation implies a significant depth of the basement rock in that area, indicating a higher likelihood of bitumen deposits. As the study shows, there is a positive association between thorium concentrations and geological features that sheds light on the makeup of the subsurface and the possibilities for exploring natural resources.

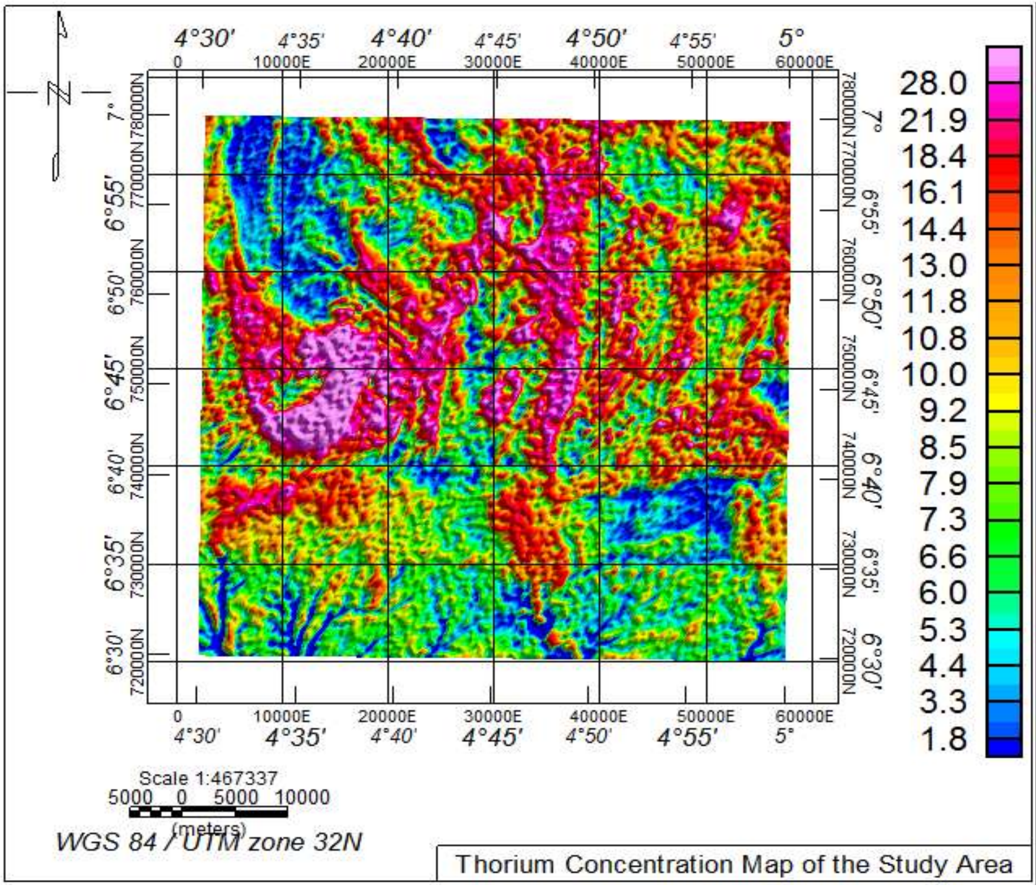


**Figure 3:**Radiometric Data's Map of Thorium (Th) Concentration

Uranium (U) Channel

In addition to offering a visual depiction of the distribution of uranium, the uranium concentration map (Figure 4) highlights the geology of the area aspresented in the corresponding map for thorium. By defining the limits of the basement including that of the sedimentary basins, this detailed map provides important information on the makeup of the research area.

One important finding from the uranium concentration map is the clear geographical differences in uranium concentrations. Higher quantities between 1.9 and 5.1 parts per million (ppm) are seen in the north, northwest, and northeast regions. Basement rocks are present in those places, which is one reason for this phenomenon. Conversely, lower uranium concentrations, ranging from 0.3 to 1.9 ppm, are found in the south, southwest, and southeast, with sedimentary terrain being a major factor in this fluctuation (Silva et al., 2003).

The extremely low uranium intensity in the southeast indicates a considerable depth of basement rock in that area, which is an especially intriguing discovery. Given that the deep basement rock is suggestive of geological conditions favorable to bitumen deposits, this result is consistent with suspicions regarding the existence of bitumen deposits.

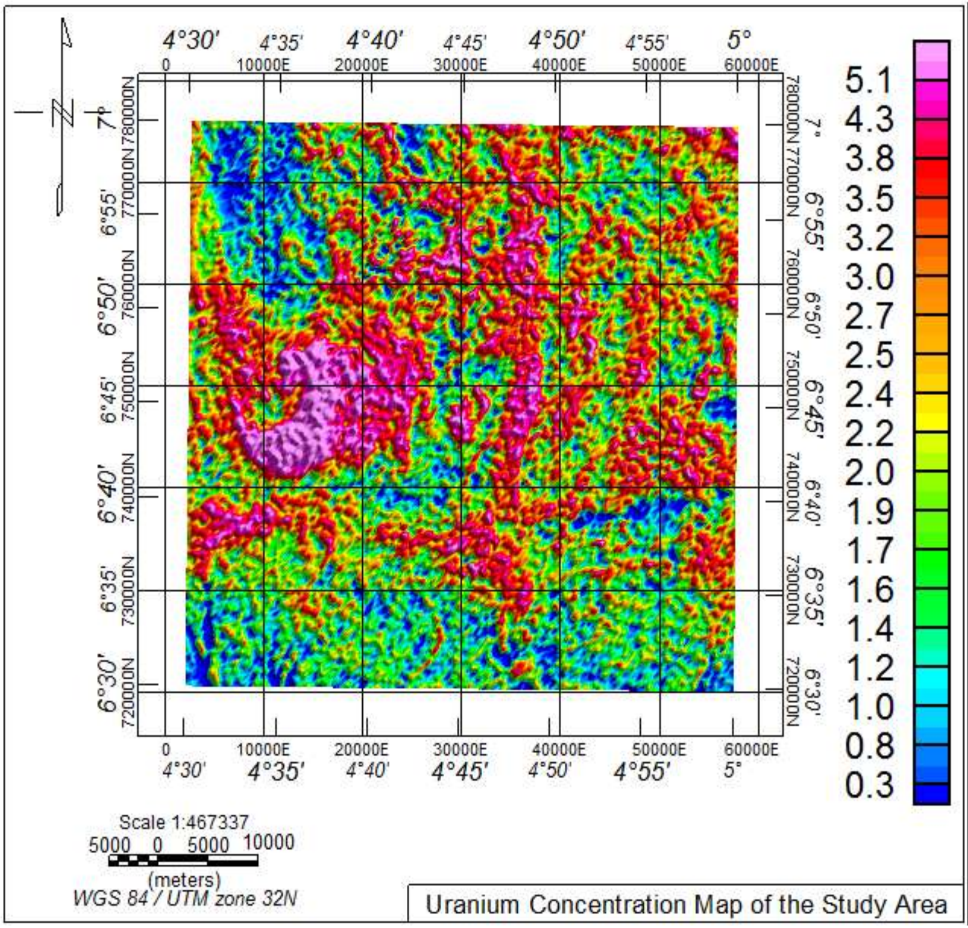


**Figure 4:**Map of Uranium (U) Concentration Using Radiometric Data

Composite Images (Ternary map)

A complex color spectrum resulting from the distinct concentrations of gamma radiation is captured in the Ternary image, which is shown in Figure 5. Slight differences in the proportions of three essential elements are represented by these colors. For cartographic applications, ternary pictures created from radiometric data are quite useful, particularly when it comes to mapping and lithological boundary delineation (Silva et al., 2003).

The Ternary composite image that we see in Figure 4.10 was expertly created using gamma radiation concentrations. The combined graphic displays differences in the proportional abundance of three different radioelements. Interestingly, shifts in the Ternary map's radioelement signature precisely correlate to modifications in the area under study's geological formation.

Rocks rich in quartz and magnetite appear as darker areas on the Ternary picture than they do in the surrounding environment. This blackness denotes reduced Th, U, and K concentrations. On the Ternary map, on the other hand, pale regions indicate higher levels of potassium, thorium, and uranium, which are usually associated with felsic volcanic rocks.

The yellowish spots represent regions with relatively low uranium concentrations but significant potassium and thorium counts. As seen in Figure 5, locations with higher uranium and potassium concentrations but lower thorium counts are represented by magenta-colored portions. Rock weathering, alteration, and shearing are among the geological processes associated with the dark areas in the Ternary picture.

The identification of a region thought to possess a bitumen deposit is a noteworthy component of our investigation. On the Ternary map, this area appears black for two main reasons. It is first classified as a metasediment, which is defined as having little to no radioelement content. Not only that, but bitumen is non-radioactive, making up the largest volume percentage of elements within the rock matrix. Thus, the region appears black on the map in part because bitumen does not contain radioactive.

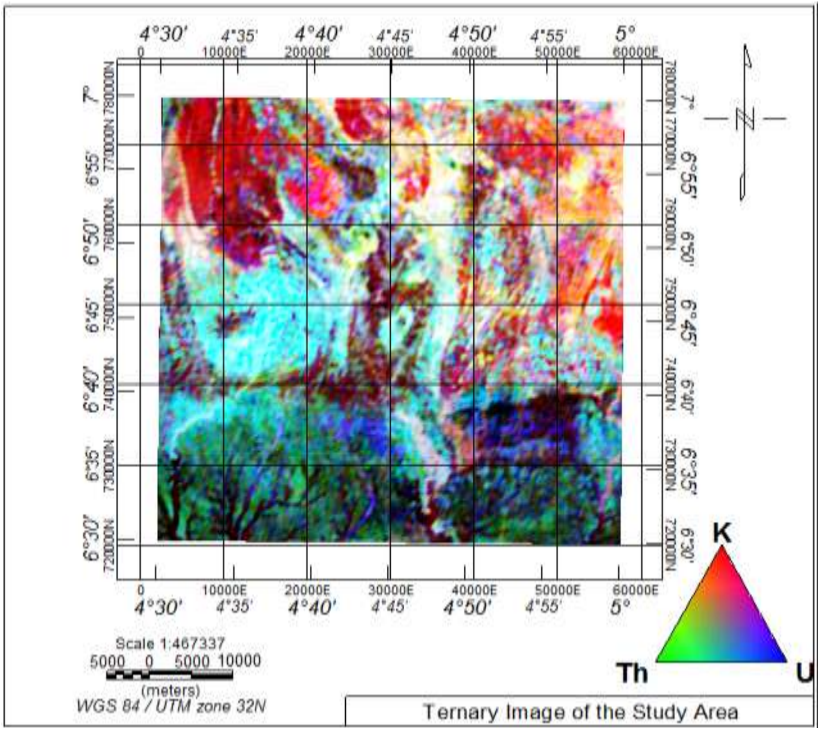


**Figure 5:**The study area's ternary image (K-Th-U/RGB)

Ternary map

As seen in Figure 6, a clear red border line delineates the bitumen aerial distribution throughout the assigned study region. This effort is intended to draw attention to the location of the research area that contains significant and large amounts of bitumen deposits. Significantly, two old exploration wells, designated as Wells 1 and 2, are shown on the map with blue symbols.

The picture does two things in addition to pointing out bitumen-rich areas: it shows where the basement and sedimentary layers divide. Yellow boundary lines show this distinction visually, with the sedimentary layer shown in the southern area and the basement region in the northern section. Knowing the geological makeup of the study sites is made easier with the use of such a representation.

The map also includes important infrastructure and human communities, rather than just concentrating on geological characteristics. An extensive summary of the geographical context is given by the distinct indication of the towns, villages, and highways that are part of the study region. By including both geological and human factors, the map becomes more useful and provides a comprehensive view of the area under study.

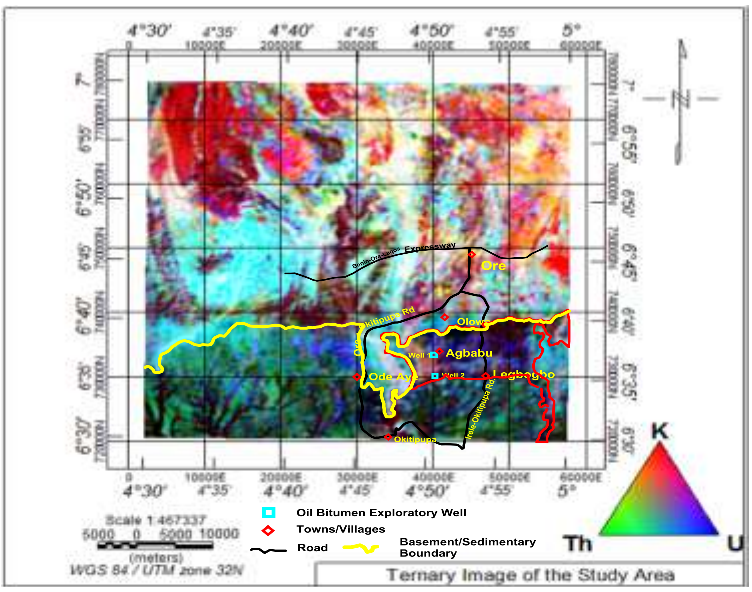


**Figure 6**: Ternary Map showing some Aerial Features

## IV. Conclusion

The deduction made from the aerial radiometric surveys provides important information regarding the concentration of Th, K, and K that are obtained from mineral-forming rocks, but only in trace amounts, in the soil. Geological phenomena such rock weathering, alteration, and shearing within the examined region are responsible for the dark areas on the map.These mysterious black patches, which may contain bitumen deposits, are surprisingly found inside the metasediments. One noteworthy feature of metasediments is that they have very little to no radioelements present at all. This insightful finding supports the idea that metasediments are associated with low levels of radioactive elements. Regions with low radiometric concentration are clearly identified as possible bitumen deposit sites based on the results of the aerial survey. Reduced radioelement levels are positively correlated with the probability of finding significant bitumen deposits, as this connection highlights. Thus, the survey findings are a useful tool for identifying areas that show promise for more research and evaluation of bitumen resources in the investigated region.

## Reference


[1] Adegoke, O.S., And Omatsola, M.E., (1981). "Tectonic Evolution And Cretaceous Stratigraphy Of The Dahomey Basin". J. Min. Geol. 18 (1): 130-137.

[2] Agagu, O.K., (1985). A Geological Guide To Bituminous Sediments In South-Westernnigeria: Unpublished Report, Department Of Geology, University Of Ibadan.

[3] Boadi, B., Wemegah, D.D., And Preko, K., (2013). Geological And Structural Interpretation Of The Konongo Area Of The Ashanti Gold Belt Of Ghanafrom Aeromagnetic And Radiometric Data. International Research Journal Of Geology And Mining (Irjgm) (2276-6618), 3(3), Pp. 124-135.

[4] Elawadi, E., Ammar, A., And Elsirafy, A., (2004). Mapping Surface Geology Using Airborne Gamma Ray Spectrometric Survey Data - A Case Study. Proceedings Of Segj International Symposium. Nuclear Materials Authority Of Egypt, Airborne Exploration Dept. Geosoft Inc., (2010): Oasis Montaj Version 4.0 User Guide, Geosoft Incorporated,

[5] Toronto.

[6] Iaea, (International Atomic Energy Agency) 2003. The Use Of Gamma Rays' Data To Define The Natural Radiation Environment, Vienna.

[7] Jones, H.A., And Hockey, R.D., (1964). "The Geology Of Part Of South-Western Nigeria". Geol. Surv. Nigeria Bull. 31: 87.

[8] Keating, P.B., (1995) A Simple Technique To Identify Magnetic Anomalies Due To Kimberlite Pipes. Exploration And Mining Geology, 4, 121-125.

[9] Manu, J., (1993). Gold Deposits OfBirimian Greenstone Belts In Ghana: Hydrothermal Alteration And Thermodynamics. Verlag Mainz, Wissenchaftsverlag, Aachen Herstellung: Fotodruck Mainz GmbhSusterfeldstr. 83. 52072 Aachen.

[10] Minty, B.R.S., (1996). The Fundamentals Of Airborne Gamma-Ray Spectrometry. Agso Journal Of Australian Geology And Geophysics, 17(2): Pp. 39–50.

[11] Ostrovskiy, E.A., (1975). Antagonism Of Radioactive Elements InWellrock Alteration Fields And Its Use In Aerogamma Spectrometric Prospecting. International Geological Review, 17: Pp. 461–8.

[12] Petroleum Trust Fund (1997). Geological Map Of Ondo State. National Rural Water Supply Project. The Petroleum (Special) Trust Fund (Ptf).

[13] Rajesh, V.J., Yokoyama, K., Santosh, M., Arai, S., Oh, C.W., And Kim, S.W(2006). Zirconolite And Baddeleyite In An Ultramafic Suite From Souther India: Early Ordovician Carbonatite-Type Melts Associated With Extensional Collapse Of The Gondwana Crust.

[14] Silva, A.M., Pires, A.C.B., Mccafferty, A., Moraes, R.A.V., And Xia, H., (2003). Application Of Airbornegeophysical Data To Mineral Exploration In The Uneven Exposed Terrains Of The Rio Das Velhasgreenstone Belt. Revista Brasileira De Geociências, 33(2):17–28.

[15] Telford, W.M., Geldart, L.P., And Sheriff, R.E., (1990). Applied Geophysics. Cambridge University Press, Second Edition.

[16] Wemegah, D.D., Preko, K., Noye, R.M., Board, B., Menyeh, A., And Danuor, S.K., And Amenyoh, T. (2015). Geophysical Interpretation Of Possible Gold Mineralization Zones In Kyerano, South-Western Ghana Using Aeromagnetic And Radiometric Datasets. Journal Of Geosciences And Environment Protection, 3, 67-82. Https://Doi.Org/10.4236/Gep.2015.34008