Interpretation of Aeroradiometric Data of Part of Lower Benue Trough of Nigeria for Mineral Deposits

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ABSTRACT

Aeroradiometric data of part of Lower Benue Trough of Nigeria was interpreted in order to ascertain the mineral potentials of the area. The four half-degree radiometric data sheets used for this study (sheet 288, sheet 289, sheet 302 and sheet 303) were acquired from the Nigeria Geological Survey Agency (NGSA). The radioelement composite map, radioelement equivalent ratios and ternary maps were generated from the radiometric data using Oasis Montaj 8.4 and ArcGIS software. High Potassium concentration (0.0861-0.5175%), equivalent Uranium (4.0077-5.5034 ppm) and equivalent Thorium (16.0104-19.8929 ppm) were observed in the study area, especially around Nkalagu, Igumale and Abakaliki areas. Result of the radiometric data interpretation also indicates the presence of a number of magmatic centres around Ejekwe and Igumale areas, and at the southeastern part of Abakaliki, which suggests that the area is potentially mineralized. Key minerals revealed by the study in these areas include feldspar, granite, dolerite, basalt, plead and zinc. The distribution and target extent of these zones of mineralization fall within a broad NE-SW trending axis.

Keywords: Mineral Potential, Radioelement Equivalent Ratio, Radiometric Data, Ternary Map.

I. INTRODUCTION

Airborne radiometric survey has become increasingly popular in the past few decades following advancement in acquisition, processing and interpretation techniques, thereby expanding its application from traditional use in direct detection of mineral deposit to indirect exploration for minerals. Such mineral substances can be easily detected by measuring the energy and intensity of the emitted radiations. The method entails measuring the naturally occurring radioelements that are present in the rock and soil. These elements are known to be unstable and as a result they disintegrate to form other elements while emitting radiations. The elements Uranium (U), Thorium (Th) and Potassium (K) occur as trace elements in rocks and decay naturally to give off gamma rays. Hence the basic objective of radiometric surveys is the determination of relative or absolute abundance of U, Th and K in the rocks and soil by measuring the percent of Potassium (%K), equivalent Uranium (eU) and equivalent Thorium (eTh) [1], [2].

The usefulness of the technique hinges on the supposition that the distribution of gamma rays in rocks or soil relates to the different lithologies and may be capable of identifying zones of mineral alteration. This application to regional geologic mapping and mineral exploration in most parts of Nigeria have however not been fully exploited. This could be due to lack of high-resolution digital data and inadequate supporting technology in the past, as majority of the geophysical analyses carried out were based on the old airborne geophysical data acquired between 1974 and 1978 which produced low resolutions. At present, the Nigerian Geological Survey Agency (NGSA) has high resolution airborne radiometric and magnetic data from the surveys carried out by Fugro Airborne Surveys Limited in 2008. The availability of the high resolution airborne radiometric data and advanced radiometric interpretation software have generated more interest in the Benue Trough of Nigeria to clearly define the extent of mineralization in this mineral belt and delineate prospective zones of mineralization.

This work therefore aims at using the high resolution airborne radiometric data over some southern parts of the Lower Benue Trough of Nigeria to identify the lithologic formations at the study area and their implications to ore mineralization. An in-depth understanding of the relationship between the mineralized veins with the basinal structures will be of immense benefit to ore mineral explorations in the basin.

A. Geology of the Study Area

The study area lies within the southern portion of the Lower Benue Trough of Nigeria and comprises Igumale (sheet 288), Ejekwe (sheet 289), Nkalagu (sheet 302) and Abakaliki (sheet 303). The area is bounded between latitudes 6° 0’00" and 7° 0’00" North and longitudes 7° 30’00" and 8° 30’00" East, covering an area of about 12,100 km². The geology and evolution of the Lower Benue Trough has been well documented [3]-[6]. The Lower Benue Trough is underlain by a thick sedimentary sequence which was formed as a result of series of tectonics and repetitive sedimentation in the Cretaceous time.
Its depositional history is characterized by series of marine regression and transgression [7]-[9]. The major component units of the Lower Benue Trough include the Anambra basin, the Abakaliki anticlinorium and the Afikpo syncline. The stratigraphic sequence of the Benue Trough is shown in Fig. 1. The oldest sediment of the sequence belongs to the Asu River group which unconformably overlies the Precambrian basement complex that is made up of granitic and magmatic rocks [10]. The Asu River group whose type outcrops in Abakaliki area has an estimated thickness of 2000 m [5] and is Albian-Cenomanian in age. It comprises of argillaceous sandy shale, laminated sandstones, and minor limestones with an interfingering of mafic volcanics [3]. The shale is fissile and highly fractured. Deposited on top of these Asu River group sediments is the Upper Cretaceous Eze-Aku shale. The Turonian Eze-Aku shale consists of nearly 1000 m thick calcareous flaggy shale and siltstones, thin sandy and argillaceous limestone and calcareous sandstones [7].

The Nkporo shale is the youngest unit of the sequence and overlies Eze-Aku shale unconformably. It is Campanian-Maastrichtian in age and mainly marine in character, with some intercalations of sandstones. Fig. 2 shows the geological map of the study area.

Fig. 1. Stratigraphic succession in the Lower Benue Trough [4].

Fig. 2. Geological map of the study area.
II. MATERIALS AND METHODS

The data used for this study were part of the high resolution airborne radiometric data obtained from Nigeria Geological Survey Agency (NGSA) which were acquired for most parts of Nigeria in 2008. The data were acquired alongside the high resolution airborne magnetic data. The acquisition was carried out by Fugro Airborne Surveys Limited and was essentially aimed at providing geological and geophysical data that would aid the understanding of the solid mineral potentials of the various regions of the country. The data which were presented in a digital form as a composite grid of 1:100,000 were acquired at flight elevation of 80 m, line spacing of 500 m and tie line spacing of 2000 m. For this study, four half-degree radiometric data sheets of Igumale (sheet 288), Ejekwe (sheet 289), Nkalagu (sheet 302) and Abakaliki (303) were used. The acquired four data sheets were merged into a single composite sheet using Microsoft Excel to form the study area, covering about 12,100 km².

The merged data were thereafter imported into Oasis Montaj 8.4 for gridding, using the minimum curvature method, to produce an enhanced radiometric distribution of the count rate of the primary radioelements (Potassium, Thorium, and Uranium). This generated images which are representatives of the radiometric signatures associated with mineralization in the area. Radioelement composite maps of Potassium, Thorium and Uranium were also generated from the radiometric ratios of the nuclides. The Potassium composite map was generated by combining the K map in red, K/eTh map in green and K/eU map in blue while the equivalent Thorium composite map was generated by combining the eTh map in red, eTh/eU map in green and the eTh/K map in blue. To obtain the equivalent Uranium composite map, the eU map in red, eU/eTh map in green and the eU/K map in blue were combined. Finally, a radiometric ternary map which is the composite image of the three primary elements was produced by modulating the red, green and blue in proportion to the radioelement concentrations of the K, Th and U in the study area.

III. RESULTS

The single channel radioelement map of Potassium (K), equivalent Thorium (eTh) and equivalent Uranium (eU) are shown in Fig. 3, Fig. 4, and Fig. 5 respectively while Fig. 6, Fig. 7, and Fig. 8 shows respectively the composite map of Potassium, Thorium and Uranium in the study area. The radioelement ternary map is also shown in Fig. 9.
IV. DISCUSSION

The K-radioelement map (Fig. 3) shows high K-values (0.0861–0.5175 %) in a narrow NE-SW trending strip (white and bright red colour). Intermediate-high K-values are also seen around Abakaliki area which coincides roughly with the main areas of Pb-Zn mineralization [4]. Low K-values, ranging from 0.0006 to 0.0048 % are observed at the northeastern portion of the study area (Igumale). These areas are characterized by feldspar-poor rocks, hence the low amount of Potassium elements in the sediments. The basaltic and dolerite bodies found around Abakaliki [11], [12] also suggest low K-values. In the equivalent Thorium radioelement map (Figure 4), most of the shaly formations indicate high Th values which vary between 16.0104 and 19.8929 ppm. It is noticeable that locations with high Th values (very light green) correspond with areas underlain by Asu River shale, Eze-Aku shale and Nkporo shale. These areas are located around Igumale, the northeastern part of Ejekwe as well as the southwestern part of Abakaliki.

Areas underlain by the Awgu formation (dominated by shale) show intermediate eTh values, whereas the Agbani sandstone located west of Nkalagu, the Ajali and Mamu formations found northwest of Igumale as well as the basaltic intrusive exposures at the southeastern part of Abakaliki all show low eTh values (8.7153–15.8098 ppm) due to their low shale content. It is observed that areas underlain predominantly by shale possess high Uranium value that ranges from 4.0077–5.5034 ppm. These areas include Abakaliki, Igumale and the southern part of Ejekwe. On the other hand, the western axis of Nkalagu (Agbani sandstone), northeastern part of Igumale, southeastern portions of Ejekwe and Abakaliki area depict low Uranium values (2.5256–5.5034 ppm).

The composite maps of K, eTh and eU as shown in Fig. 6-Fig. 8 respectively indicate a NE-SW trending of the radioelements. The distribution of these radioelements falls within a broad NE-SW trending axis in the neighborhood of already discovered mineralizations [11], [12], [14] which coincides with the main axis of the basin on a regional scale. The K-map shows high value of K at the northwestern part of Nkalagu, eastern part of Ejekwe and southwestern part of Abakaliki. With the exception of Nkalagu, these zones correspond to the zones underlain by igneous intrusive rocks and Pb-Zn mineralization [13]. The Nkalagu area also shows high values of eTh and eU. The eU-values vary almost proportionally with eTh-values as indicated in Fig. 4 and Fig. 5. The low eTh and eU values recorded northwest of Igumale and southeast of Abakaliki are attributable to basaltic intrusive exposures [11], [14]. The radioelement ternary map (Fig. 9) shows the relative abundance of K, Th and U in the study area. The map shows that K is relatively most abundant at the southern part of the study area while U is relatively most abundant at the northeastern part of the study area. Of the three radioelements, Th is least abundant as scantily noted at the southeastern part of the study area.
V. CONCLUSION

Radiometric data covering some part of Lower Benue Trough in southeastern Nigeria has been used to reveal the mineral potential of the area. The K-radiometric map shows high K-values in a narrow NE-SW trending strip northwest of Nkalagu, east of Ejeckwe and west of Abakaliki. Basaltic intrusive structures and mineral bearing structural lineaments in Ejeckwe and Abakaliki were indicated by low eU and eTh. The study shows that the southern part of the study area is more favourable to ore minerals. In particular, the mineralization is likely to occur within the igneous intrusions at the northeastern part of the map around Ejeckwe and Igumale, and at the southeastern part of the map, around Abakaliki. The large volumes of igneous bodies may be responsible for the observed close spatial association with the ore mineralization in the study area. Key minerals and rock minerals revealed by the study in these areas include feldspar, granite, dolerite, basalt, pleat and zinc. Host rocks of this mineralization include shales, siltstones, sandstones and intrusive rocks.

CONFLICT OF INTEREST

Authors declare that they do not have any conflict of interest.

REFERENCES