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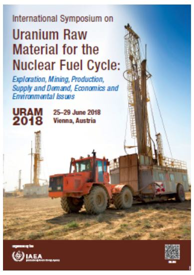

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An overview of geology and occurrence of unconventional uranium resource: potential recoveries from Precambrian basement and Cretaceous sedimentary rocks of Nigeria

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INTRODUCTION

Uranium occurs in Nigeria as conventional and unconventional resource in both Precambrian Basement and Cretaceous Sedimentary rocks. The history of exploration for uranium resources Nigeria started in North-Eastern Nigeria, by three major government Organizations. The Geological Survey of Nigeria (Now Nigerian Geological Survey Agency) in 1973, Nigerian Mining Corporation and Nigerian Uranium Mining Company, (NUMCO) from 1979, 1980, 1981, which was winded up in 2001. The areas discovered for Conventional Uranium deposits in Precambrian basement rocks in Northeastern Nigeria are Mika, (132 tU) at 0.63% U at 130m cut off of 0.03% U, Gumchi with (100 tU) at 0.9 % up to 200 m at cut off of 0.03% U, Gubrunde (60 tU) at 0.7% U and Cretaceous Bima Sandstone hosted Sedimentary rocks of Mayo lope and Zona areas, (130 tU) [9].

This paper is aim at evaluating the Uranium potential in Basement Complex of Central Nigeria as well as in the Sedimentary Phosphate rock, of illlumeden (Sokoto) basin North West Nigeria. This will also discuss an overview of Geology, and Occurrence of prospective Unconventional Uranium resource from intrusive Pegmatites North-central basement complex and Cretaceous (Maastrichtian-Paleocene), Sedimentary Phosphate rock, of North-West Nigeria, involving the integration of Geology, Geochemistry, recently acquired High resolution Airborne Radiometric, Magnetic and processing of remotely sensed Landsat 8 data set to delineate areas of high potential.
The prospect of the Sedimentary phosphate rocks is located about 500km, Northwest of Abuja the capital of Nigeria. This deposits has been reported and studied by several authors [4, 8, 10, and 11].

The phosphate rocks occur in Paleocene Dange formation, Mastrichian Dukamanje, Taloka and Wurno Formation in Sokoto Illumeden basin. The Federal Government of Nigeria in 2016 through the Nigerian Geological Survey Agency as part of policy thrust to diversify its economy through Solid mineral sector and bridge the power supply need of the country commenced the Assessment of Uranium and Rare Earth elements (REE) and the project is ongoing for unconventional source of Uranium from Phosphate rock. The exploration has delineated about thirteen prospective areas [8,].The phosphate rock occur as irregular, cylindrical, sub rounded, elongate, hard, cream reddish concretions nodules interbedded with shales, clays, Siltstone and Gypsiferrous shale. The phosphate rocks resulted from ocean upwelling and high organic productivity during Cretaceous to Eocene. The Sokoto phosphate is linked to Tethys sea incursion during the Paleocene, that extend from Libya, Chad, Niger Republic and Sudan, [15].

METHODS AND RESULTS

In the Sedimentary basin Gamma ray spectrometric measurements of radio-elements and lithologic logging was carried out with a portable hand-held RS-320 spectrometer along exposed sections on two out of the thirteen (13) prospective areas. Chemical analysis of Phosphate samples from Paleocene Dange formation at CETEM Laboratory indicated average Uranium concentration of 73.5U (ppm) and P2O5 34.5(ppm), Uranium radioactivity count gave 16.25U (ppm) on lateritic ironstone (Tertiary Gwandu formation), and Thorium was 20.2(ppm) to 30(ppm) in the Grey Shales (Paleocene Dange formation).The lith-spectrometric log showed increased in Uranium content in the Phosphatic Shale downward which signifies high potential with depth. The presence of pyrite nodule at the basal unit marked a redox condition for Uranium concentration towards the basal Maastrichtian Wurno formation. The phosphates rock in the basin contains uranium and further exploration for the un-conventional uranium resources is ongoing.

Also within the Basement Complex of Nigeria, the identified pegmatite zone has enormous potential for Unconventional Uranium and Thorium resource. The Pegmatite zone is Apaku located about 150km south east of Abuja, the capital of Nigeria. The Ministry of Solid Minerals Development, in 1998, evaluated Pegmatites veins for their technology metal potentials, including, Tantalite (Ta), Columbite (Nb), Lithium (Li). Beryllium (Be) and Tin (Sn). This exploration work has led to the discovery of fourteen pegmatite blocks as prospective sources of unconventional uranium [6]. The Pegmatite area is quite extensive, covering an area of approximately 225km2. The Pegmatites ranges in size from 100m to 2km in length and 100 to 500m width. They are being massively worked by more than 500 different artisanal small scale miners, exploiting tantalite, Niobium, Tin, Lithium, Columbite, Beryl and REE.

Several workers have shown that the Pegmatites are associated with the Pan-African orogeny and reactivation tectonic activity .The Pegmatite zone is part of a well-defined ENE-WSW trending zone of 400km stretched extending from Jos-Wamba-Jemma Central Nigeria extending to Ijero- Ibadan South-western Nigeria [1 6, 10].

The Apaku zone that has Uranium potential is 1.4 by 0.7 km (Length 1.4km X Breath 700m) it is one of viable Mineralized Pegmatite prospect. The work done in theses area by 6] involved interpretation of panchromatic aerial photographs as base map to delineate structures and lithologies, random regional Geological, Geochemical sampling of whole rock, weathered, fresh pegmatites and concentrate on scale of 1:50,000. Chemical analysis for Tantalum oxide (TaO), Niobium Oxide (NbO), Uranium Oxide (U3O8), Thorium Oxide (ThO), and other Major, Minor elements concentrations using Inductively Couple Plasma Mass Spectrometry (ICP-MS) and X-ray fluorescence (XRF).

The results of chemical analysis indicate elevated values of Niobium oxide(NbO5) concentration of 14%,Tantaliteoxide(Ta2O),40%,ThoriumOxide(ThO)900(ppm),Uranium(U3O8)1900U(ppm),Tin(Sn)1500ppm.

REMOTE SENSING AND GEOPHYSICAL DATA INTEGRATION

The prospecting for uranium has been challenging in Nigeria, therefore remote sensing technology can bridge the gap possibly to discover new potential deposits and enhanced wider coverage of previous areas exploited by [6,9]. Remote sensing technology has been used to directly or indirectly discriminate Uranium bearing rocks and mapping hydrothermal alteration zone [13, 16].

The present study involved the integration of geochemical result, processing and interpretation of high resolution recently 2010 acquired airborne- geophysical data set. Landsat 8 Operational Land Imager (OLI), an enhanced resolution Multispectral image (band) as against the panchromatic aerial photographs used earlier in the study areas. Digital Image processing, (principal component analysis, (PCA, band ratio, (band 5/4 for clay mineral, 5/7 for hydroxyls and 3/1 for iron oxide and Color composite.

The ternary image and composite as RGB based on distribution of the three radioelements, Uranium, Thorium and Potassium (U-Th-K) which reflect composition of the lithologies in the area. U /Th Ratios was used to track the possible host rock of the identified Uranium Anomaly, since Uranium is highly and thorium least mobile. The total magnetic intensity (TMI (1VD) grey scale was used to extract suspected shallow and deep-seated lineaments as possible Subsurface structural traps for uranium accumulation. Ground follow- up or field check was done to confirm the alteration zones. The minerals identified in the area are Kaolinitic clay (kaolinite) and Iron minerals are limonite and hematite, with disseminated pyrite in brecciated quartz.

DISCUSSION

Geologically, the Apaku area is underlain by Precambrian Migmatites, occurring with weathered low-lying Muscovite Schist/Phylites, and Metapellites, quartz veins, Granite-gneiss, and Medium to Coarse grained Granite within the North-eastern segment. Pegmatite veins occur as flat-lying out crops intruding the Precambrian Migmatite, Granite gneiss, Schist, Pan-Africa granite and Younger granites.

The Uranium mineralization is associated with Granitic rocks occurring in the area, this is as a result of Pan-African orogeny, contact metamorphism and thermal effects. Uranium anomaly and Uranium-thorium ratios maps has confirmed the source of the Uranium from the Granites and Gneiss surrounding the study area. A NNE-SSW, NE-SW structural trend extracted from Magnetic TMI (1Vd) data indicate shallow and deep-seated lineaments as possible subsurface structural traps for uranium accumulation. The hydrothermal fluids must have been remobilized, and Uranium concentrated in presence of oxidizing fluids and reducing minerals pyrites [10, 12]. The plagioclase feldspars of the fresh granitic rocks has been hydrothermally altered, to Kaolinite, which form kaolinitic clays. The ferromagnesian mineral biotite's, hornblende, amphiboles, were altered into to limonite and hematite, as observed at the base of grantic rock in the areas. This is enhanced by chemical weathering typical of tropical climatic condition with little to moderate rainfall, surface and groundwater in the presence of oxygen.

The potential for Uranium recovery in Nigeria is very high, with average concentration Uranium in Cretaceous Phosphate Sedimentary rock, and Pegmatites veins. The occurrence of Uranium within the phosphate rock is supported by recent radiometric Airborne Survey in Cretaceous Sandstone (Continental terminae) in southern part of Illume den basin in Niger republic [5]. The Sokoto Basin is part of Southward continuation of Illumiden Basin, where Uranium in hosted in Agadez Sandstone of the Niger Republic. The Sediments in the basins is Surrounded by Precambrian crystalline and volcanic rocks, this are potential host of Uranium mineralization [10]. This uranium is probably source from Carbonaceous to Jurassic Peralkaline Younger Granitic rocks as seen occurring in Paleozoic ring complex of Niger republic, which is Petrological and geochemically associated with Mesozoic (Jurassic) ring complex of Nigeria [2]. The areas with high anomaly and geochemical results from the Cretaceous Sedimentary Phosphate rock and Pegmatites of the present study has shown a NNE-SSW,NE-SW structural trend similar to Niger republic with two major Regional tectonic structure in Alit-in-Azoual fault trending N-S and Madeoula fault trending NNE-SSW hosting most of the discovered uranium deposits [5].

CONCLUSION

In conclusion, the discovery of High concentration of uranium in Apaku one of the Precambrian Pegmatites out of fourteen identified pegmatite blocks and Two out of thirteen prospect of Cretaceous Phosphate rocks in Sokoto Basin is a good development for Uranium investors and prospectors in Nigeria. When these areas are adequately exploited and new remote sensing prospecting techniques is adopted in Nigeria recovery of Unconventional resource is high. Ground follow- up or field check has confirmed, altered Granitic rocks in the Precambrian Basement area and Cretaceous Phosphate rocks correlate with areas of high uranium as shown by U/thorium ratios, Conductivity, Subsurface lineament, Ternary, and Geochemical results. The well-established deposits of uranium in the Niger Republic section of the Illumeden Basin which is contiguous with the Sedimentary Phosphate rock of Nigeria makes the potential of similar occurrence very high. Further work including feasibility studies is recommended in these areas that have good potentials for un-conventional uranium resource.

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