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Preliminary studies on uranium content of some rocks at Biakpa, Volta region of Ghana

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ABSTRACT

As part of the nuclear power project envisaged during the period of the first republic, attempts have been made to prospect for uranium as raw material for the nuclear reactor. The Biakpa area in the Volta region had been known by the indigenes to be a potential source of this raw material. A field survey had been carried out using a Fieldspec radiation survey meter and the uranium content of some rock samples taken from the area has been determined. The uranium content determined by comparison with an IAEA uranium standard S-13 lot 370 using the track etch technique gave a mean value of 0.018%. The dose rate obtained during the survey ranged from 1.22 - 2.25 µSv/h.

Introduction

Uranium is primarily used as a fuel in nuclear power generation. The current concern over energy supply and excessive CO_2 production is likely to be an increased in demand for uranium in the near future. There is no uranium production in Ghana. However, within West Africa, there are important uranium mines and deposits and moreover, uranium exploration in this region is increasing. The increasing uncertainties in global energy supplies make this commodity likely to become more important in global commodity marketplace. In addition, many uranium deposits previously considered uneconomic, e.g. pegmatites, may become economic as demand increases. In Ghana, the search for uranium deposits has been a joint collaboration between the Geological Survey Department (GSD) of Ghana and the Ghana Atomic Energy Commission (GAEC). The first attempt to prospect for energy minerals in Ghana began in 1952, when D. Ostle, a geologist of the Atomic Energy Division of the United Kingdom Geological Survey, P. H. Hale, an engineer of the Atomic Energy Research Establishment at Harwell, U.K. and one geologist of the then Gold Coast (now Ghana) Geological Survey, carried out a radioactive reconnaissance survey using car-borne equipment. The results of the survey covering about 7,270km on all motorable roads in Ghana showed that the thorium content in most of the rocks was only about 0.1% and that the uranium content was not remarkable. In 1953, K.E. Beer and J. Taylor investigated about 10,000 samples for radioactivity. The richest deposit, which carried 570g of monazite per cubic metre, was found at Agona Nsaba about 40km north of Winneba in the Central Region. They concluded that the probability of finding exploitable alluvial monazite placer deposits seemed to be very poor. In 1957, J. Mitchell, Senior Geologist of Geological Survey Department carried out radiometric surveys, mainly over intrusions of syenite in the Dahomeyan rocks near the Akwapim-Togo range. The syenites showed considerable radioactivity in places and were shown to contain small quantities of thorium and uranium minerals probably in the form of allanite and pyrochlore. The grade was found to be extremely low. In the same year, W.B. Tsvendale, Senior Geologist of GSD investigated another anomalous area east of Volta near Kpong. He found out that the areas with higher radioactivity were situated on top of syenite and nepheline-syenite of the Dahomeyan. They were found to contain small and insignificant quantities of thorium and uranium minerals. In 1960, Hunting Surveys Limited of U.K. undertook geophysical exploration for minerals by the use of airborne magnetic and radiometric surveys covering an area of 17,092 sq. km. One significant important result of the surveys was that the well-known (and worked) reefs in the mineralized zones were located at, or very near, the intersections of shear zones and faults. In November, 1967, a West German Mining Company, Uranerzbergbau applied for a prospecting license for energy minerals, manganese and oil in Ghana. They found out that uranium containing pegmatites of the Central Region east of Cape Coast appeared to have other minerals which could be mined with little uranium they contained, but at that time, the products to be mined had low prices and were not economical to mine. Based on Uranerzbergbau's work in the Abandzi area and at the request of the Ghana Government, the International Atomic Energy Agency (IAEA) in Vienna sent Dr. P. K. Adamel, a Technical Assistant Expert of the Agency to Ghana. The pegmatites were analyzed in situ with a portable gamma ray spectrometer D25A-400A (Explorarium). Their radioactivity were measured with a broadband gamma-ray scintillometer BGS-IS (Scintrex).

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A German team was reported to have also prospected for uranium at the Biakpa area in the Volta Region of Ghana. This has prompted people in the town to provide assistance to any team that plans to prospect for uranium in the area. Various other surveys were carried out by geophysicists from the GSD and scientists from the GAEC. The GSD used scintillometers and radon gas counter measurements. The GAEC complemented their effort by using the track etch method. Difficulties with the track evaluation and logistical problems hampered the work in that direction (Oppon and Aniagyei, 1988; Adu, 2012). The Survey and uranium content study at Biakpa is a preliminary study to look at the feasibility for a long term prospection in that area.

Study Area

Biakpa is a village located in the Ho municipality of the Volta region of Ghana (eastern area). It is situated in Yingor with a geographical coordinate of 6° 51' 0" North and 0° 25' 0" East (http://goinggoingghana.com/about/). The geological formation of Volta region comprises of Buem, Dahomeyan and the Togo formation which are three of five geological formation of Ghana as shown in Fig. 1. The Togo formation are rocks forming the Akwapim range of hills trending northeast ward from the coast west of Accra through Kpong, Anum, into the republic of Togo. Rocks formed here are phyllites, schists and quartzite, whereas in some places exist unaltered shale and sandstone. Phyllonites has been found in many excavation pits along the Togo and Dahomeyan formations. The Dahomeyan occurs as four alternate belts of acid and basic gneisses trending South South West (SSW) to North North Earth (NNE) from the coastal plains east of the Togo formation. The common rocks are quartz-schists, metamicrogabbros forming dykes and sills. They may be massive, black and coarse-crystalline, or may be present as greenish mottled plagioclase-amphibole rock. These consist mainly of feldspar and amphibolites and have clear foliation which gives it a gneiss character. Migmatite, granulites and marble also occur in the Dahomeyan. The Buem outcrops at the northern and north western part of the Togo series. It consists of calcareous, argillaceous, sandy and ferruginous shales, sandstone, arkose, grey wack and trachytic lavas, agglomerates, tuffs and jaspers. The volcanic group, as so often happens in the history of geosynclinals basins of deposition of whatever age, is at or near the top of the formation. Normally, the Buem formation is unmetamorphosed but in the fault tose. Small masses of basic igneous rocks (dolerite and gabbro) intrude the formation particularly, in the vicinity of the Buem-Togo contact (Kesse, 1985; http://www.ghana-mining.org/GhanaIMS; http://unesdoc.unesco.org/images/0013/001385/138581m.pdf; http://www.uoguelph.ca/~geology/rocks_for_crops/28ghana.PDF; http://www.fdi.net/documents/WorldBank/conferences/mining2000/Africadata/Ghana/Maps; Geological map of Ghana, 2009)

Materials and Methods

The equipment that was used for the field survey was a Fieldspec radiation survey meter manufactured by Micron as shown in Fig. 2.This equipment works in three modes:

1. Activity (counts per second);
2. As a dose rate meter and
3. As a field spectrometer with the capability of radioactive element identification.

The activity and dose rate modes were used for the identification of the radiation field and the rocks of interest. The survey was started from the Biakpa township. The activity and the dose rate values recorded at this place were taken as the background radiation. The fieldspec in the activity and dose rate modes was moved up towards the prospective site of the prospection. At the site three rock samples were selected due to their high activity and dose rate values. The mode of the Fieldspec was changed to particle identification and a spectrum was recorded showing a peak.

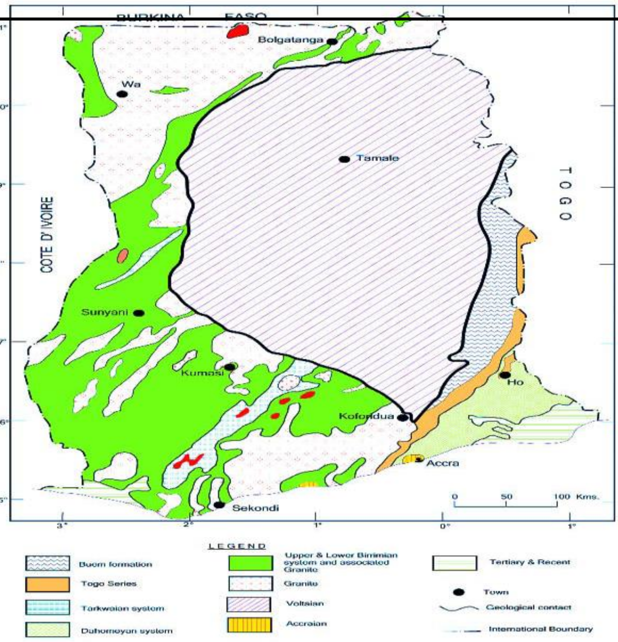

Fig. 1 Map of Ghana showing the various geological formation of each region of Ghana

The selected rock samples were taken to the Solid State Nuclear Track Detection Laboratory, of the Ghana Atomic Energy Commission for further analysis. In the laboratory the rock samples were crushed into fine powder for the determination of the uranium content. There are two techniques for the determination of the uranium content in samples using the track etch method, these are the absolute and the comparison methods (Fleischer et al., 1975; Monnin, 1977).The absolute involves the determination of the fundamental values in the equation 1, below

$$\rho = kC\Phi t \qquad (1)$$

where ρ is the track density, C, the concentration of the element of interest, Φ the flux of thermal neutrons in the reactor and t, the time of irradiation in the reactor. The determination and the errors in these parameters affect the final results in the evaluation of the concentration of the uranium content. The comparison method therefore seeks to reduce these errors due to the determination of the parameters, the geometric factors and the constant of proportionality used. In this method the concentration value of a known sample is compared to the concentration of the unknown sample assuming that the matrix does not interfere. Using the equation above and assuming the same flux for both samples and time of irradiation and geometric factors, the evaluation of the concentration is given by the equation 2. The solid state nuclear track method is more accurate and has been used in several studies on uranium in different types research (Hoffman et al., 2008; Ullah et al., 2005; Kumar et al., 2003).

$$\frac{\rho_s}{\rho_u} = \frac{C_s}{C_U} \qquad (2)$$

, where the parameters are the same as in equation 1.

The crushed samples were filled into vials and weighed. A standard Uranium ore (Pitchblende) S-13 lot No 370 from the

Analytical Quality Control Services of the IAEA prepared by the Junta de Energia Nuclear , Madrid Spain with an average uranium content of 0.044% was used as the standard for comparison. The crushed rock labelled as samples 1, 2, 3 were filled in triplicate into vials and weighed. The average masses for the three samples are 2.1g., 2.3g., 2.6g., respectively. These together with the standard sample and an unknown sample taken from the same field in a previous trip were irradiated in the Miniature Neutron Source Reactor (MNSR) at the GHARR-1 Centre with a flux 5 x 10^{11} n/cm^{2}s for 10s. After irradiation the samples were left to cool. The track detectors which were embedded in the vials were removed and etched in a solution of 2.5N NaOH at a temperature 60 Celsius for a period of 110 minutes. The dried detectors were counted using an optical microscope with a total magnification of 400x. The percentage values of the uranium content for the rock samples were then evaluated from the track densities obtained from the counts.

Fig. 2 Micron fieldSPEC

Results and Discussion

The readings of the Fieldspec for the field survey were as follows. The activity counts per second at the Biakpa Township was 27cps, dose rate ranged from 39 - 47 nSv/h with the lowest being 35 nSv/h. The readings of the Fieldspec in between the trip to the site was 50 - 58 nSv/h and at the spot where the vehicle stopped and the dose rate ranged from 36 - 60 nSv/h. After the stop the dose rate increased to 73 - 82 nSv/h with the counts per sec being 37 cps and the dose rate getting to 90 nSv/h. There was an increase in the cps to 52 cps with the dose rate ranging from 78 - 85 nSv/h. The three rock samples gave the following readings. For sample one the activity count was 780 cps with a dose rate of 1.37 µSv/h. Sample two activity count was 1255cps with a dose rate of 2.25 µSv/h. Sample three gave 766 cps with a dose rate of 1.22 µSv/h. Some smaller rock samples which were not collected gave the readings of count per second ranging from 51-160 cps with a dose rate ranging from 73 - 231 nSv/h. The average activity at the site was 96 cps with the dose rate being 129 nSv/h. There is a three fold increase in the cps value, in that of the field, compared to that of the township. There was a similar three fold increase in the dose rate. This gave an indication that the site should be of interest. High cps may be attributed to the geology of the area which according to existing data has some deposits of uranium. Comprising of the Late Proterozoic to Paleozoic rocks of the Voltaian System, which consist of sandstones, mudstones, conglomerates, limestones and tillites and overlain the Precambrian rocks of Ghana (Geological map of Ghana, 2009; Adu, 2012). The cps values obtained were much higher than value found in uranium prospection conducted in the Afram plains by the GSD using a scintillometer measurement also in cps. The highest reading at Tab8 was 58cps in sector 2 of the field sheet. For the rock samples the following results were obtained, these are shown in table 1 below and graphically represented in figure 3. The mean values for the three rock sample were 0.018%, 0.017%, 0.019%, for the samples 1, 2, 3 respectively. For the unknown sample which was taken from the field on a previous trip the mean value was 0.015%. These values show that though there were variations in the activity and the dose rates of the samples, the variation did not have any correlation with the uranium content of samples. The differences are due to the masses of the rocks found on the field. Although the mean values obtained did not fall within the low grade of uranium which is between 0.03% - 0.05 % that can be mined, a detailed study is necessary since the geology falls in Buem formation which has prospects for deposits of Uranium (Kesse, 1985).

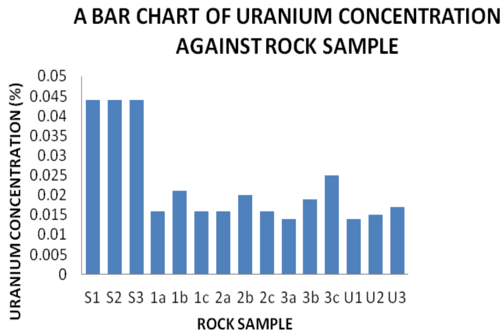

Fig. 3 A bar chart of uranium concentration against rock sample

Conclusion

Uranium content of some rock and field radioactivity of the Biakpa area had been determined using solid state nuclear track detectors and Fieldspec radiation survey meter. Some massive rock samples found in the area had high radioactivity levels with the highest value being 2.25 µSv/h. The determination of the uranium content of the rock sample yielded a mean percentage concentration of 0.018%.

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Table 1. Uranium concentration in rock samples

SAMPLE	COUNT 1	COUNT 2	COUNT 3	MEAN COUNT	CONCENTRATION %
S1	112	110	114	112.0	0.044
S2	76	62	65	67.6	0.044
S3	115	111	112	112.6	0.044
1a	40	41	44	41.6	0.016
1b	51	54	54	53.0	0.021
1c	41	39	38	39.3	0.016
2a	40	41	41	40.6	0.016
2b	52	50	52	51.3	0.020
2c	40	38	41	39.6	0.016
3a	36	37	36	36.3	0.014
3b	43	43	42	42.6	0.019
3c	65	64	63	64.0	0.025
U1	34	34	35	34.3	0.014
U2	36	42	37	38.3	0.015
U3	42	44	44	43.3	0.017

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