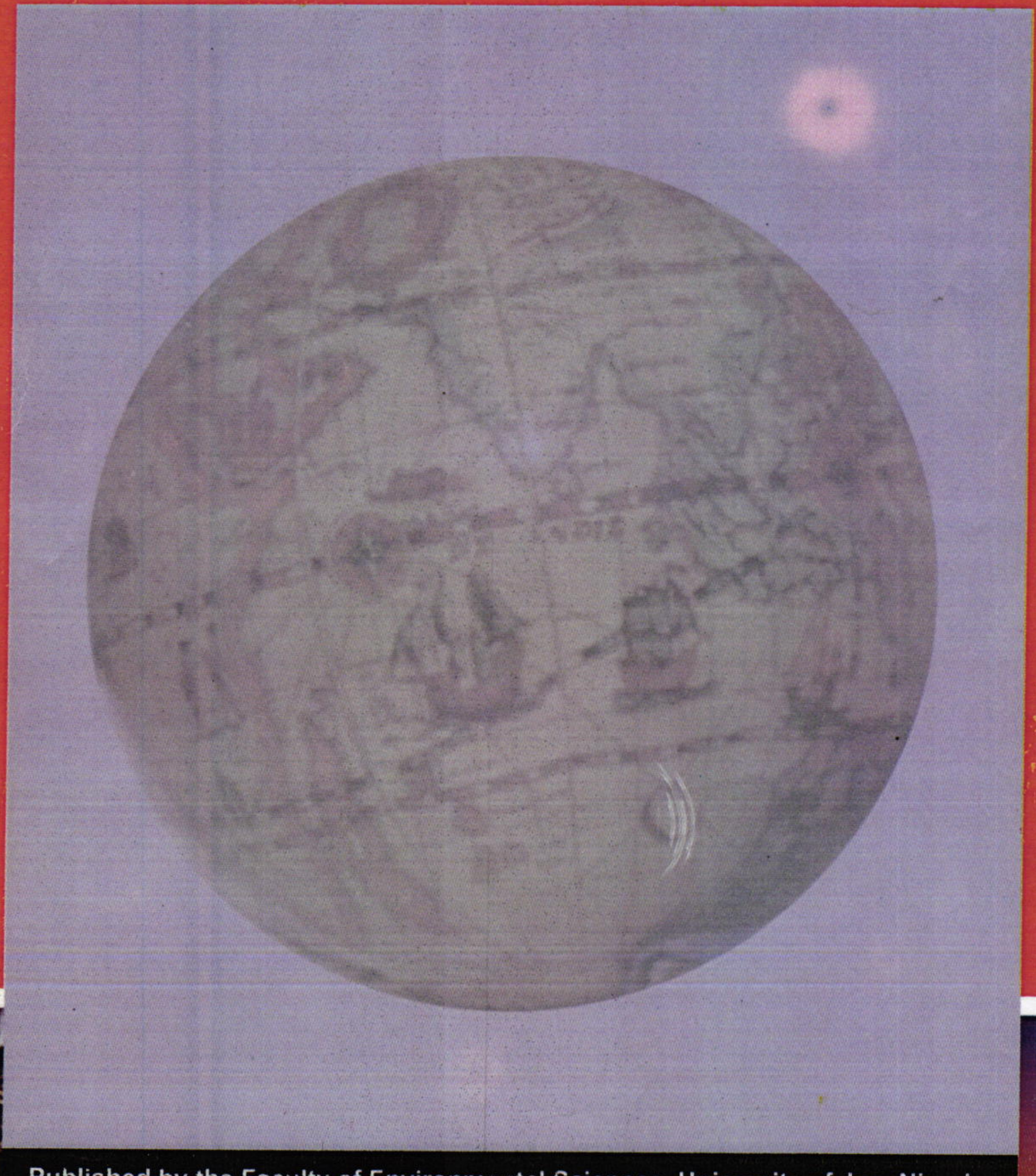
Journal of Environmental Sciences

JOES

Vol.14 No.I/II Jun./Dec. 2010

ISSN 1118-8936



Published by the Faculty of Environmental Sciences, University of Jos, Nigeria.

Journal of Environmental Sciences Volume 14, Number (2) 2010 pp.72-82

ISSN 1118-8936

LITHOLOGIC DELINEATION USING RADIOMETRIC MAPPING: A CASE STUDY OF SOUTH-WESTERN NIGERIA.

Okoye, N. O. and Amadi, A. N.
Department of Geology, Federal University of Technology, Minna

ABSTRACT *The survey area covered a total traverse distance of about 91km taken primarily across the general trend of the strike and or bedding plane of rock formations in the area. The traverses which included: Ibadan-Lagos expressway (29km); Shagamu-Ijebu-Ode road (28km.); Oru-Ijebu-Ode road (13km) and Ore-Benin road (21km) were made mainly across the sedimentary formations of Southwestern Nigeria. Two gamma radiation detecting instruments: scintillometer and spectrometer were used. At intervals of 1km, gamma radiation values as reflected by each instrument were noted. Results were tabulated and plots of gamma radiations in counts per second (cps) against distances (km) were plotted for each traverse and for the two instruments for the same co-ordinates. Although each instrument had its peculiar gamma radiation values, they show the same graph trend which reflects the differences in gamma radiation. It is a reflection of the concentration of Uranium (U), Thorium (Th) and Potassium (K) in the rock formations traversed. From the radioactivity graphs, various rock formations traversed were delineated. Comparison was made with the geological maps of the area. These were found to march approximately and in some cases almost exactly with the corresponding formations delineated on the radiometric graphs. It was also found that the rise and fall on the graphs reflected the radioactive content of the formations. The survey also established variability in radioactive elements content in Ewekoro and Abeokuta formations and this led to the production of radioactivity maps of the area.*
Keyword: Lithologic delineation, Radiometric mapping, Southwestern Nigeria.

INTRODUCTION

One major duty of a geologist in the field is to delineate as correctly as possible, the various rock units. This task however has not been so easy to carry out owing to certain field problem arising from obscured rock units caused by deep weathering and also thick vegetation cover. Therefore, apart from areas of definite outcrop content, most of the boundary demarcation between rock units are subjective, which depend on personal experience and judgement of the individual geologist. Radioactivity is the process by which atoms of natural element emits radiation as a result of the spontaneous disintegration of its atomic nucleus. Radioactivity was first discovered by Becquerel in 1896, shortly after Roentgen had announced the discovery of X-ray in 1895. Becquerel found that minerals containing uranium emits radiation which affects photographic emulsion in a manner similar to X-ray. Although, about 20 naturally occurring elements are known to be radioactive, only Uranium (U), Thorium (Th) and an isotope of Potassium (K) are of importance in geological mapping and exploration. Rubidium (Rb) is useful in determining the ages of rocks. The rest such as lead (Pb), cesium (Cs) and strontium (Sr) are either so rare, or weakly radioactive or both, as to be of no significance in applied geological studies.

STUDY OBJECTIVE

The radiometric survey undertaken was aimed at establishing the importance of gamma radiations emanating from radioactive elements contained in rock formations in delineating different rock types. This is possible because different rocks contain different proportions of potassium, thorium, uranium and other radioactive elements.

STUDY AREA DESCRIPTION.

The area of the survey lies in the South-western part of Nigeria. It is between longitudes $3^{o}\ 00^{I}$ E to $6^{0}\ 30^{I}$E of the Meridian and latitudes $6^{0}\ 30^{I}$N to $7^{0}\ 30\ ^{I}$N of the Equator. This area forms part of the federal survey sheets (59, 62, 68. 260 and 261) on a scale of 1:250,000. Within the area, the traverses made for the survey include (Fig.1):

1. Ibadan-Lagos expressway, covering a distance of 29 km and readings were taken at regular intervals of 1km.
2. Shagamu- Ijebuode covering a distance of 28 km and readings were taken at intervals of 1km.
3. Oru- Ijebuode, a distance of 13km and readings were taken at an interval of 1km.
4. Ore-Benin, a distance of 21km and readings were taken at intervals of 1km.

The accessibility to the survey area was good having been traversed by motorable roads.

Geology of the area

The survey area consists partly of Basement Complex rocks and partly of sedimentary rocks of Cretaceous and Tertiary age of the Dahomey Basin. The Basement Complex consists of three principal rock types, the ancient Meta-Sediments, the Migmatites-Gneiss complex and the Older Granites. The ancient meta-sediments consist of schist, granulites and calc-silicates. They represent the oldest rocks. The gneisses appear to have been largely derived from these meta-sediments by migmatization, involving essentially the introduction of microcline and quartz interstitially into the schist and granulites. The igneous and metamorphic rocks cover over half of the surface of Southwestern Nigeria and are collectively known as the Basement Complex. A contact-zone between the Basement Complex and the Sedimentary terrain was discovered along the Oru-Ijebuode area (Fig.2). The Dahomey Basin is an extensive sedimentary basin on the continental margin of the Gulf of Guinea. It runs parallel to the coastal margins of Ghana, Togo, Benin Republic and Southwestern Nigeria (Fig. 2). It is separated from the Niger Delta basin by the Benin hinge line and the Okitipupa ridge (Adegoke, 1972, Bankole et.al., 2006). The basin is a marginal pull-part (Reyment, 1965) or marginal sag basin (Whiteman, 1982) while developed in the Mesozoic era when the African and South American plates separated and the continental margin was founded (Jones, 2002). The Benin hinge line is part of the chain oceanic fractures while the Okitipupa ridge is a submarine basement ridge (Adegoke, 1972). The sedimentary rocks were studied along Lagos-Abeokuta road (Fayose, 1970). The sediments are generally poorly exposed except at the escarpment. The stratigraphic succession of rocks in the area are contained in Table 1.

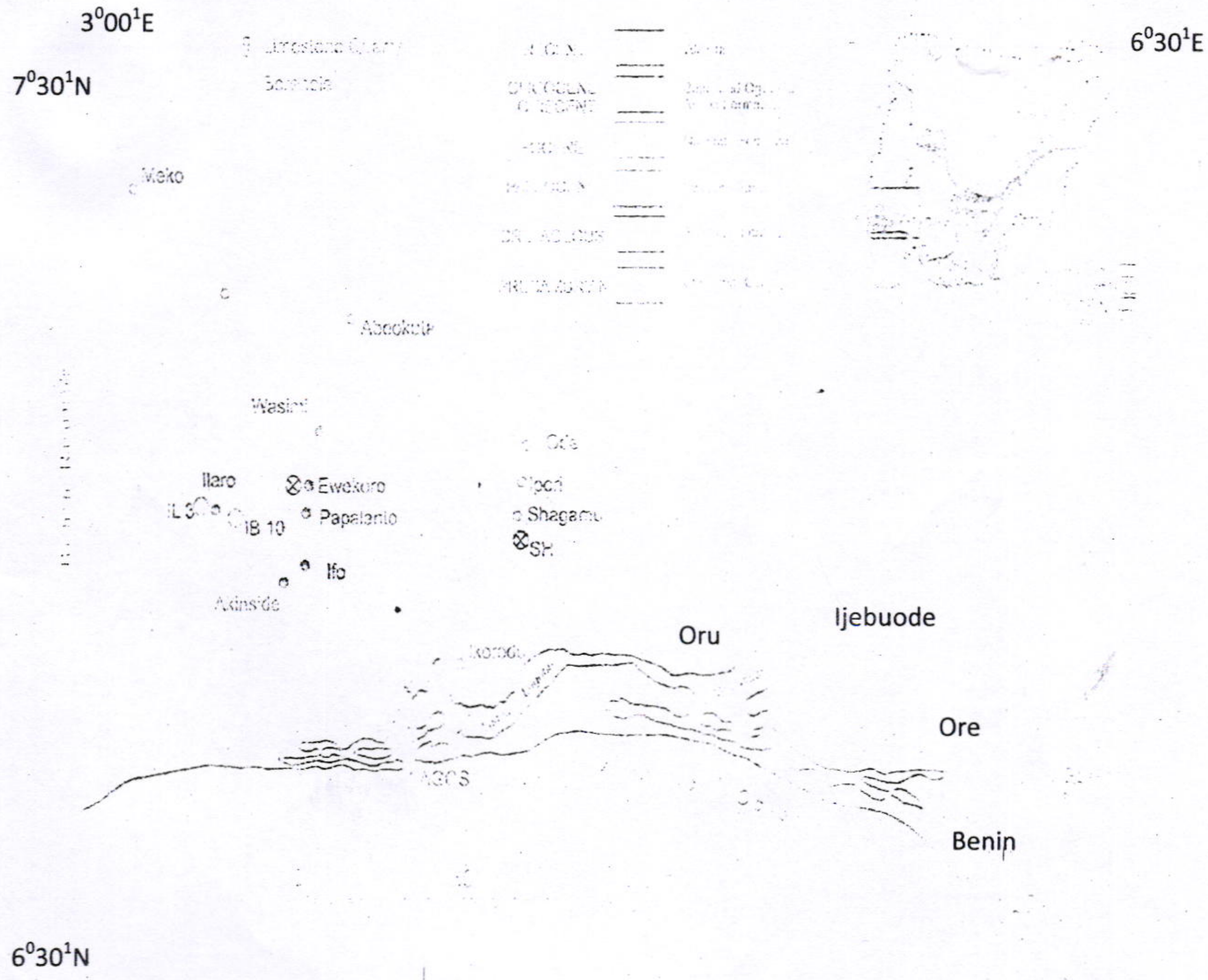


Fig. 1: Map of the study area showing the major town used for traversing (After Bankole et.al., 2006).

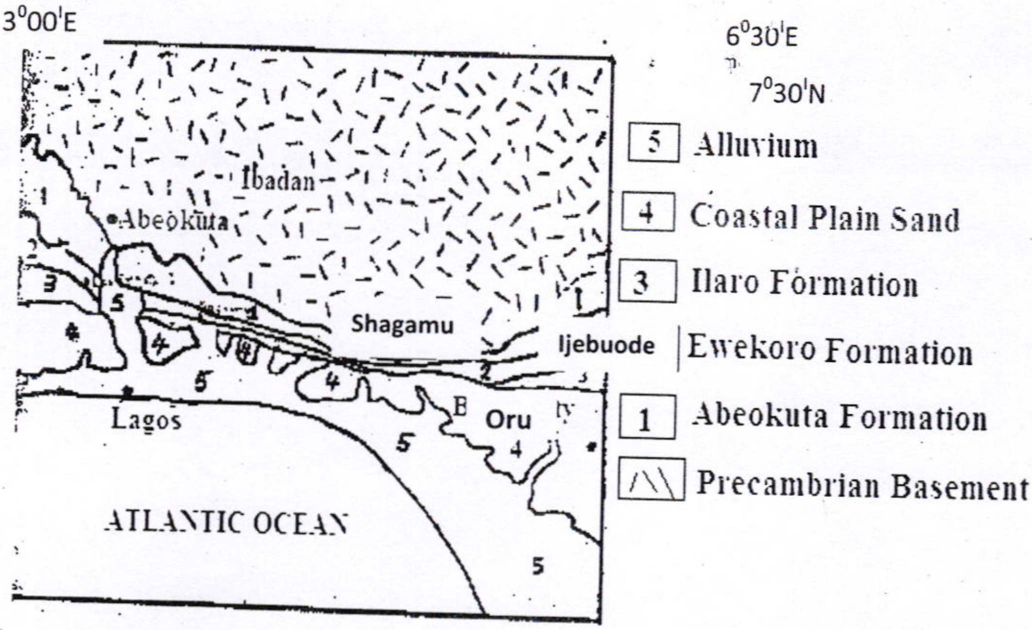


FIG.2 GEOLOGICAL MAP OF SOUTH WESTERN NIGERIA (NGSA.2004)

Table1: Stratigraphic Correlation of Dahomey Basin.

Age	**Jones and Hockey (1964)**	**Adegoke and Omatsola (1981)**
Recent	Alluvial Littoral/Lagoonal Deposit.	---------------
Miocene Oligocene	Coastal Plain Sand	Coastal Plain Sand
Upper Euocene-Oligocene	Baro Formation	Ilaro Formation
Lower Euocene-Middle Eocene	Oshosun Formation	Oshosun Formation
Lower Eocene-Upper Paleocene	Akimbo Formation	Akimbo Formation
Paleocene	Ewekoro Formation	Ewekoro Formation
Mastrician	Araromi Formation	Araromi Formation
Turonian	Afowo Formation	Afowo Formation
Neocomian Albian	Ise Formation	Ise Formation
Precambrian	Basement Complex	Basement Complex

Climate, Drainage System and Vegetation of the Area

The vegetation of the area surveyed is typically deciduous with luxuriant forest. Agricultural activities break the continuity of these forests. The climatic condition of the area falls into the sub-equatorial type with characteristic heavy rainfall, mainly between the months of April and September. The dry season takes off from October to March. The mean annual rainfall is between 150cm to 187cm while the mean annual relative humidity is over 80% and the mean annual temperature is greater than 21°C. The area is drained by 3 main rivers: Ogun, Ona and Yewa, which flows into the Lagos lagoon. These rivers in addition to Ogogoro river in Benin area cut deep as they precipitate the upper slope of the sedimentary escarpment (fig. 3).

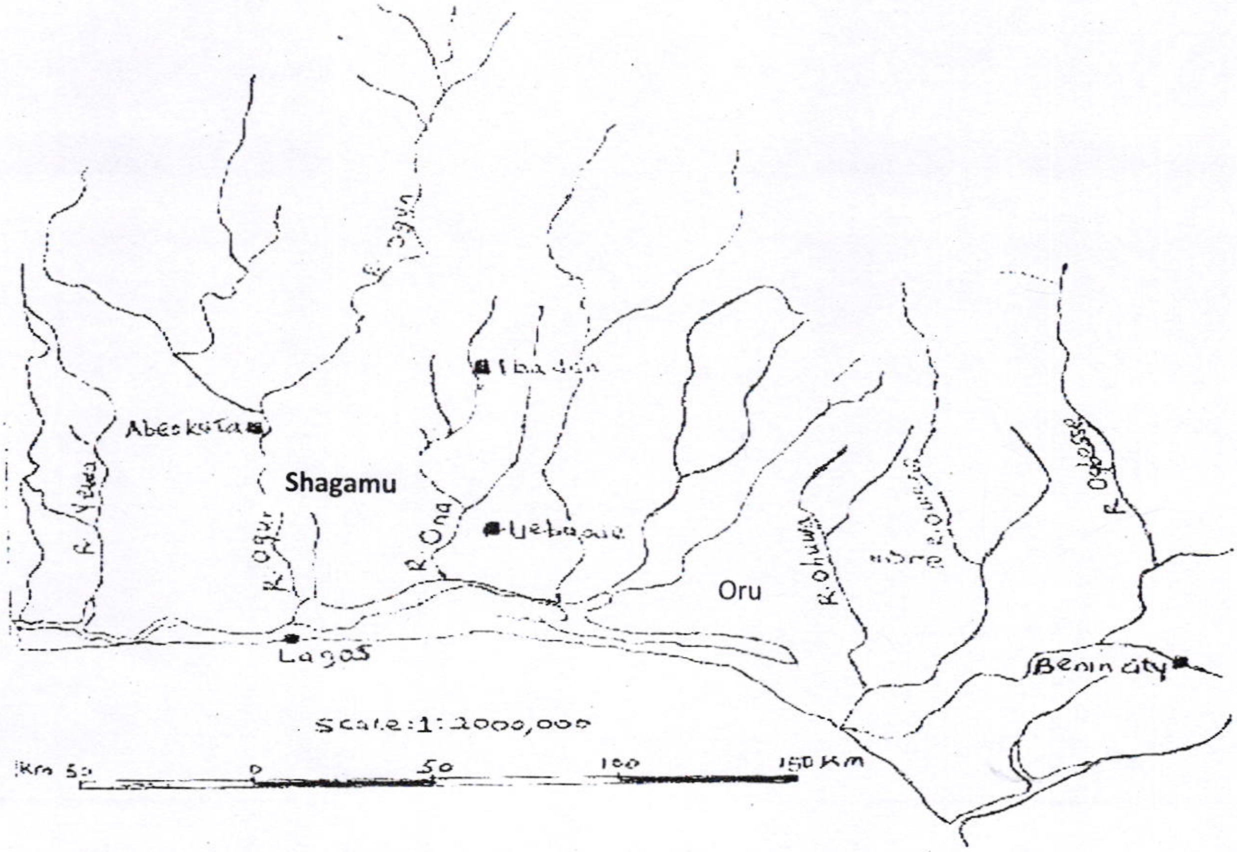


FIG.3 DRAINAGE SYSTEM OF THE STUDY AREA

Source: (Julia, 1985)

ANALYTICAL TECHNIQUES

Gamma ray spectrometer model DISA-300 and Broadband gamma ray scintillometer BGS-ISL were the gamma radiation counting instruments used for this study. The BOS-ISL gamma-ray scintillometer is a highly portable, transistorized instrument used for locating gamma ray emitting material. The design has a crystal-photomultiplier assembly which is shock mounted and which involves 1.5^{II}x 1.5^{II} thallium-activated sodium iodide crystal. The audio output circuit included gives an aural indication of the presence of radiation. This circuit complements the metre readout of the same radiation levels and does this by pitch change, proportional to the radiation level. A sound threshold allows for the adjustment of level above the background at which the sound is activated. Similarly, the Gamma-Ray Spectrometer (Model DISA-300) has basically the same principles and builds up as the scintillometer described above. It transforms incident gamma ray radiations into visual read out of radioactive intensities, as a function of the natural gamma ray energy present in geological phenomena. The sodium iodide crystals (2^{II} x 2^{II}) convert's gamma rays into faint flashes of light whose brilliance is proportional to the energy level of the gamma radiations measured. The frequency or signal readout rats displayed is the intensity of all gamma ray energy above a selected threshold setting. The digital readout therefore is essentially a summation of integral measurement. The operational energy range of the instruments is 0.1 to 2.62 Mev.

Field Observation

Readings of the gamma radiations were by from each instrument at every location, at an interval of 1km. While the Total Count (T/C) in Counts Per Second (CPS) is noted for the scintillometer, four readings, facing different directions at the same location were taken using the spectrometer and at total count per two seconds. Caution was taken to take these readings away from vehicle, rock-ships and asphalt used from road construction. Readings were also net taken near towns where human made materials such as electrical installations etc. are likely to bring about unnecessary background count. It was observed that at each location the Total Count (T/C) in Counts Per Second (CPS) of the gamma radiations were higher in the scintillometer than the average read out in the spectrometer. This might be attributed to the scintillometer being more sensitive and broad based in picking gamma radiations from any emitting materials. Traverses were made across the general trend of the rock formations in the study area with a view to monitoring the changes in the gamma radiation values of the various formations and subsequently delineate them. On this basis, radioactivity maps delineating the various formations were prepared and comparison made with equivalent sections of the geological maps of the areas traversed which have been prepared in the conventional way. By this study, useful deductions and conclusion were drawn on the relevance and importance of this type of survey to geological mapping.

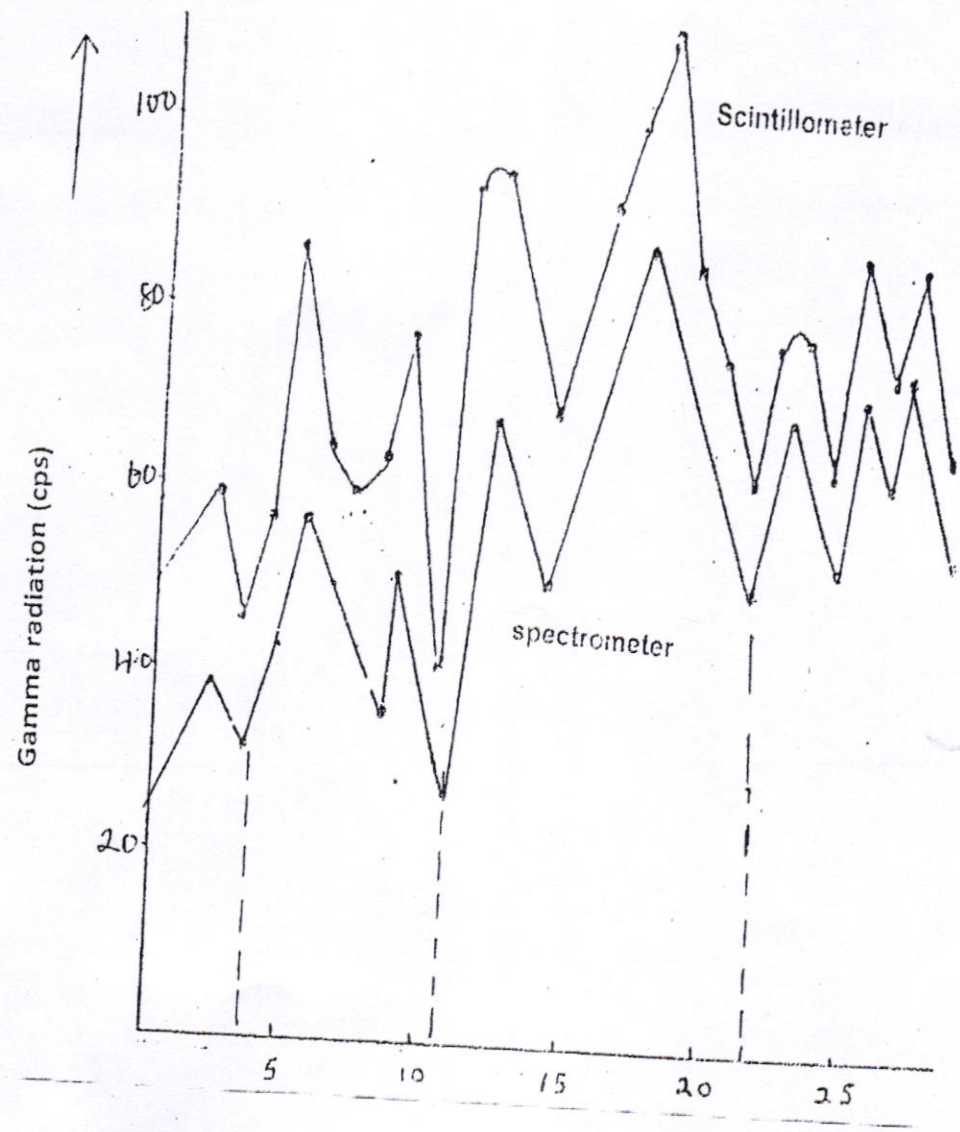
PRESENTATION AND DISCUSSION OF RESULTS

The summary of the statistical results of the radiometric Survey along Ibadan-Lagos expressway, Ore-Benin, Ore-Ijebuode and Shagamu-Ijebuode are tabulated in Tables 2, 3, 4 and 5 respectively while their corresponding radioactivity graphs are shown in Figures 4, 5, 6 and 7 respectively. The close relationship in the radioactivity curves from both instruments used in delineating the different facies has given credence to the usefulness of radiometric survey as an alternative tool in geological mapping. By this study, it has been established that radiometric mapping can provide an invaluable aid in geological mapping of terrains with poor rock exposures.

Table 2. Gamma Radiation Readings in Counts per Second (CPS)
Traverse: Ibadan- Lagos Expressway

Dist. Km	Scintillometer T/C (cps)		% S.D	Spectrometer T/C (		% S.D
0	80	8.9	11.1	28.69	5.4	18.8
1	85	9.2	10.8	27.88	5.3	19.0
2	80	8.9	11.1	25.63	5.1	19.9
3	65	8.1	12.5	25.00	5.0	20.0
4	60	7.9	12.8	21.00	4.2	22.0
5	65	8.1	12.5	23.75	4.9	21.0
6	75	8.9	11.6	32.38	5.7	17.6
7	60	7.7	12.1	26.38	5.1	19.3
8	65	8.1	12.5	24.75	5.0	20.2
9	65	8.1	12.5	25.63	5.1	19.9
10	100	10.0	10.0	29.88	5.5	18.4
11	70	8.4	12.0	19.75	4.4	22.3
12	85	9.2	10.8	33.38	5.8	17.4
13	80	8.9	11.1	34.32	5.9	17.2
14	75	8.9	11.6	30.50	5.5	18.0
15	80	9.5	10.6	27.38	5.2	19.0
16	80	8.9	11.1	29.75	5.5	18.5
17	80	9.5	10.6	33.50	5.8	17.3
18	100	10.0	10.0	35.88	6.0	17.7
19	100	10.0	10.0	38.88	6.2	16.0
20	105	10.2	9.6	31.88	5.6	17.6
21	90	9.5	10.6	29.13	5.4	18.5
22	70	8.4	12.0	25.50	5.0	20.0
23	80	8.9	11.1	29.32	5.4	18.4
24	75	8.7	11.6	29.75	5.5	18.5
25	80	8.9	11.1	25.88	5.1	19.7
26	80	8.9	11.1	32.13	5.7	17.7
27	70	8.4	12.0	25.75	5.4	18.8
28	90	9.5	10.6	32.10	5.7	17.6
29	90	9.5	10.6	26.25	5.1	19.4

SD = Standard Deviation   T/C = Total Count



Distance (km)

Fig .4. Plot of gamma radiation (cps) against distance (km).
Transverse: Ibadan-Lagos expressway.

Table 3. Gamma Radiation Readings in Counts per Second (CPS)
Traverse: Ore-Benin.

Dist. Km	Scintillomter			Spectrometer		
	T/C (cps)		% S.D	T/C (cps)		% S.D
0	60	7.7	12.8	23.75	4.9	20.6
1	65	8.1	12.5	14.63	3.8	26.0
2	70	8.4	12.0	23.75	4.9	20.6
3	110	10.5	9.5	22.13	4.7	21.2
4	100	10.0	10.0	31.75	5.6	17.6
5	95	9.7	10.2	34.89	5.9	16.9
6	110	10.5	9.3	33.38	5.8	17.4
7	85	9.2	10.8	32.50	5.7	17.50
8	100	10.0	10.0	30.25	5.5	18.20
9	80	8.9	11.1	28.00	5.3	18.90
10	70	8.4	12.0	23.75	4.9	20.60
11	75	8.7	11.6	28.50	5.3	18.60
12	80	8.9	11.1	29.50	5.4	18.30

13	65	8.1	10.1	25.88	5.1	19.70
14	75	8.7	11.6	27.13	5.2	19.20
15	100	10.0	10.0	38.13	6.2	16.30
16	75	8.7	11.6	31.00	5.6	18.10
17	80	8.9	11.1	29.88	5.5	18.40
18	75	8.7	11.6	22.50	4.7	20.90
19	90	9.5	10.6	29.75	5.5	18.50
20	85	9.2	10.8	28.38	5.3	18.70
21	100	10.0	10.0	33.38	5.8	17.40
22	-	-	-	-	-	-

SD = Standard Deviation T/C = Total Count

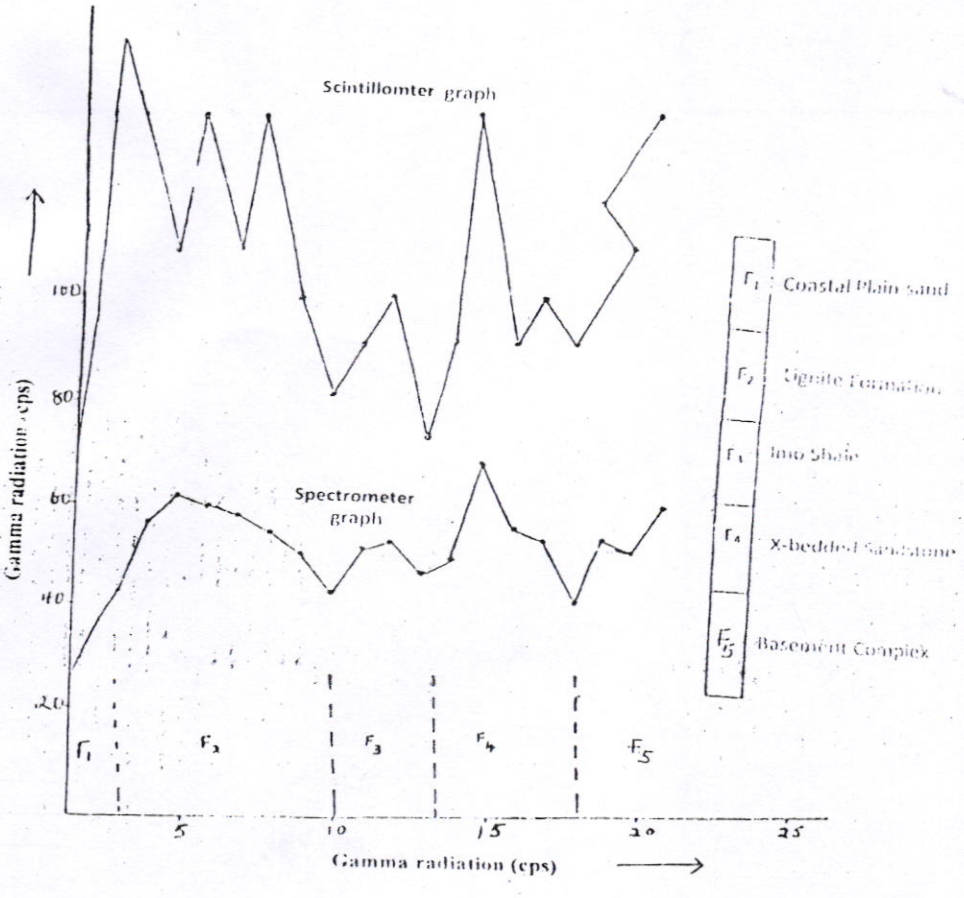


Fig. 5. Plot of gamma radiation (cps) against distance (km).
Transverse: Ore- Benin.

Table 4. Gamma Radiation Readings in Counts per Second (CPS)

Traverse: Oru–Ijebuode

Dist. Km	Scintillometer	.D	% S.D	T/C (c	Spectrometer	% S.D
0	100	10.0	10.0	28.00	5.3	18.90
1	60	7.7	12.8	22.13	4.7	21.20
2	45	6.7	14.9	8.00	2.8	35.33
3	35	5.9	16.9	11.50	3.4	29.60
4	35	5.9	16.9	10.88	3.3	30.30
5	30	5.5	18.8	15.25	3.9	25.60
6	40	6.3	15.8	11.13	3.3	29.60
7	35	5.9	16.9	9.75	3.1	31.80
8	50	7.1	14.2	18.38	4.3	23.40
9	65	8.1	13.5	19.38	4.4	22.70
10	55	7.4	13.5	12.63	3.6	28.50
11	55	7.4	13.5	19.13	4.1	23.90
12	75	8.7	11.6	19.88	4.5	22.60
13	65	8.1	12.5	24.35	4.9	20.20

SD = Standard Deviation   T/C = Total Count

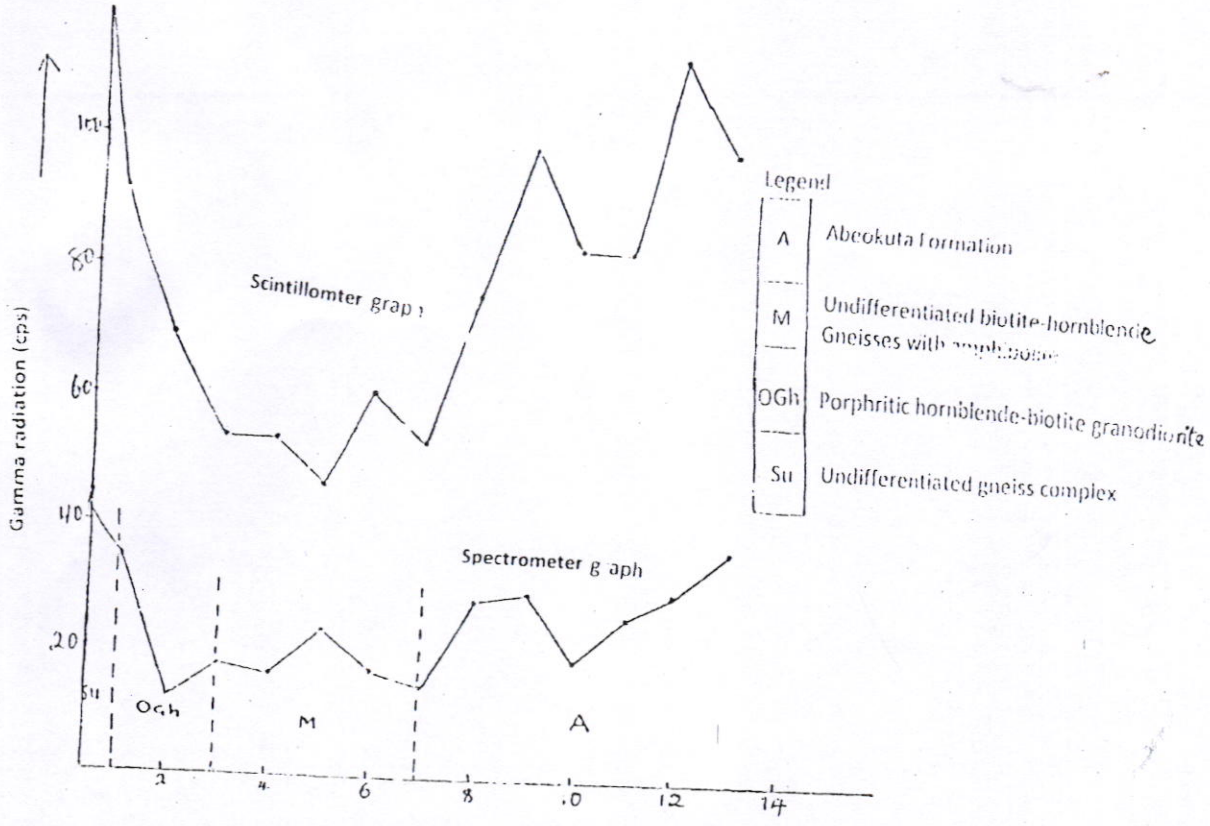


Fig. 6. Plot of gamma radiation (cps) against distance (km).
Tranverse : oru- ijebuode

Table 5. Gamma Radiation Readings in Counts per Second (CPS)
Traverse: Shagamu - Ijebuode

		Scintillomter			Spectrometer	
Dist. Km	T/C (cps)		% S.D	T/C (cps)		% S.D
0	90	9.5	10.6	34.5	5.9	17.1
2	85	9.2	10.8	36.88	6.1	16.5
4	90	9.5	10.6	37.00	6.1	16.5
6	-	-	-	-	-	-
8	90	9.5	10.6	38.13	6.2	16.3
10	100	10	10.0	25.38	5.0	19.7
12	100	10	10.0	33.13	5.8	17.5
14	90	9.5	10.6	22.63	4.8	21.2
16	85	9.2	10.8	25.88	5.1	15.8
18	90	9.5	10.6	37.75	6.1	16.2
20	100	10	10.0	39.88	6.3	15.8
22	95	9.7	10.2	39.00	6.2	15.9
24	100	10	10.0	37.13	6.1	16.4
26	90	9.5	10.6	35.75	6.0	16.8
28	110	10.5	9.5	45.75	6.8	14.9

SD = Standard Deviation T/C = Total Count

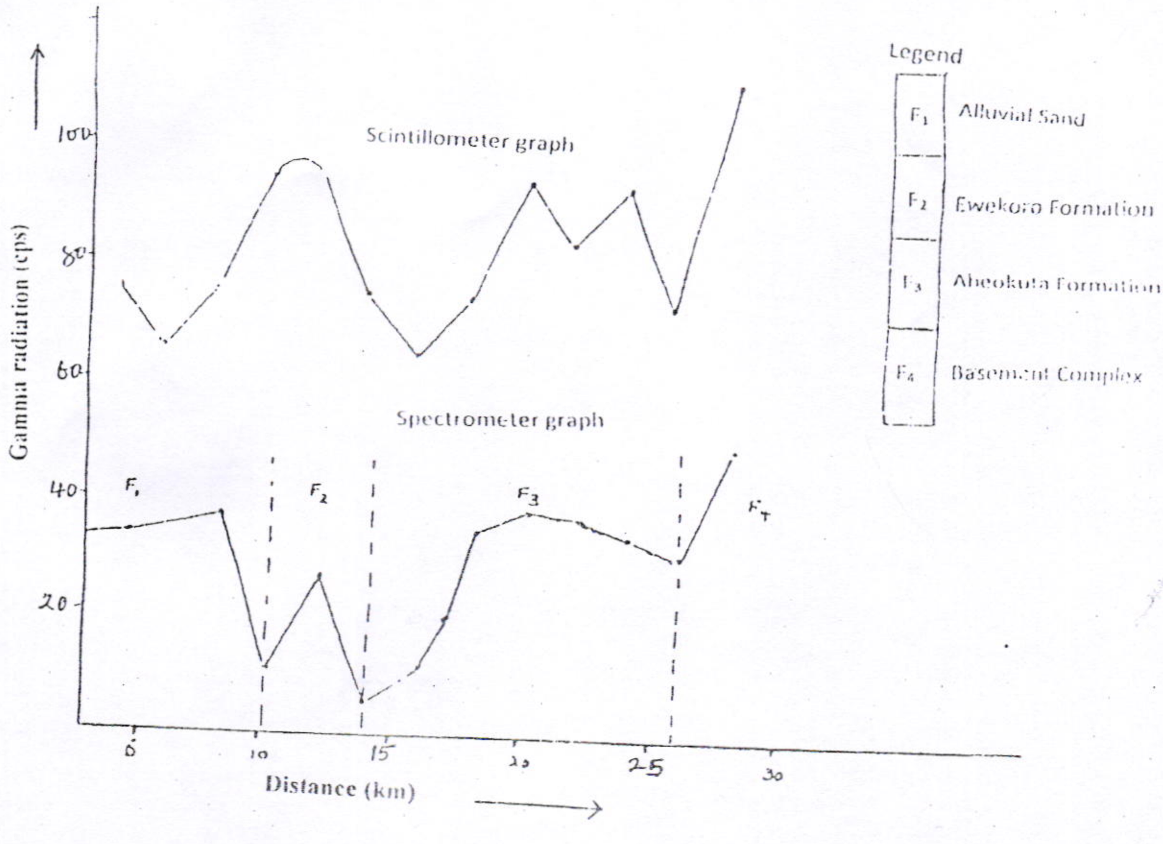


Fig. 7. Plot of gamma radiation (cps) against distance (km).
Transverse: Shagamu-Ijebuode

The radioactivity graph pattern of the two instruments has shown some high degree of consistency in delineating the different rock formation encountered in the transverse. This set pattern has been satisfactorily achieved despite the disparity in the actual gamma radiation values of the two instruments. The range of the count per second (cps) of gamma radiation in the 4 routes traversed are: Ibadan-Lagos expressway (19.75 to 38.88) (cps); Shagamu-Ijebuode traverse (34 to 37) cps; Oru-Ijebuode traverse (35 to 65) cps and Ore-Benin traverse (10 to 19) cps. Analyzing the 4 sets of gamma values and bearing in mind that the traverse was from western to eastern section of the study area, the results shows an increase in abundance of radioactive elements in the formations generally eastward. Different geological section of the traverse routes were produced to compare and contrast with the units delineated using radioactivity graphs. It was observed that the lithological character of each formation reflect the amount of gamma radiation recorded. Such lithologies like shale, clay, granites with high potassium content, coal and metamorphic rocks such like schist have shown ample responses to gamma radiations. For instance, in the traverse along Ore-Benin, the formation containing Shale and Clay indicate an average value of 110 cps for scintillometer and 34.0cps for spectrometer. Similarly, another formation comprising of pebbly coastal plain sand in the same traverse showed rather low gamma counts of between 60 to 70 cps for scintillmeter and 14.5 to 23.5 cps for spectrometer respectively. The granites and the schist rocks endowed with primary radioactive elements during magma crystallization or trapped the mobile radioactive elements has been related to suite of rocks such as syenites and pegmatites contains radioactive elements Uranium (U), Thorium (Th) and K-feldspar. The probable provenance of these radioactive elements has been related to suite of rocks containing K-feldspar which must have distributing these radioactive elements to the later formed sedimentary formations by the processes of weathering, transportation and deposition.. These radioactive elements are distributed to the later formed sedimentary rock through weathering and diagenetic processes.

CONCLUSION AND RECOMMENDATIONS

The similarity (resemblance) in the radioactivity curves from both instruments used in delineating the different facies has given credence to the usefulness of radiometric survey as an alternative to geologic mapping. With the foregoing observations, it can be asserted that radiometric survey has provided invaluable tool in the production of a provisional geologic map by showing continuity of geologic units between widely spaced ground traverse; geologic units obscured by deep weathering can often be mapped by this method. The anomalies obtained via radiometric survey can be further explored through geophysical and geochemical analysis of radioactive element content of the various rock types traversed. It is pertinent to note that best results are obtained in areas with variable lithologies, extensive outcrops and or residual soils.

REFERENCES

Adegoke, O. S., (1972). Paleocene molluscus from Ewekoro Formation, Southwestern Nigeria. Proc. 4th European Malsc. Congress, Geneve, pp71.

Adegoke, O. S. and Omatsola, M. E., (1981). Tectonic evolution and cretaceous stratigraph of the Dahomey basin, Journal of Mining and Geology, vol 18, No.1, pp130-137.

Bankole, S. I., Schram, E., Erdtmann, B. D. and Akande, S. O., (2006). Palynostratigraphic age and paleoenvironments of the newly exposed section of the Oshosun formation in the Sagamu Quarry, Dahomey basin S.W.Nigeria. NAPE Bulletin, vol.19, No. 2, pp25-27.

Adeleye, D. R., (1972). Stratigraphy and Sedimentation of the Upper Cretaceous strata around Bida, Nigeria. Ph.D thesis, University of Ibadan, Unpublished.

Faure, G., (1977). Principles of Isotope Geology. John Willy and sons inc. U.K., pp331.

Fayose, E.A., (1970). Stratigraphical paleontology of Afowo I well. S.W. Niger. Journal of mining and geology, vol.5, No1, pp 28-30.

Heinrich, E. W., (1985). Mineralogy and Geology of Radioactive raw materials. Mcgraw Hill book coy. Toronto, London, pp654.

Jones, H. A. and Hockey, R. D., (1964). The Geology of parts of Southwestern Nigeria. Bull.G.N.S., No. 31, 87p.

Jones, I., (2002). Shrinking and Swelling soil in the UK; assessing clays for the planning process in Earthwise magazine, issue 18. British Geological Survey, pp 22-23.

Julia, L., (1985). Evans Jnr Atlas for Social Studies. Evans Brothers Publishers, Ibadan, 43p

Langmuir, D., (1978). Uranium solution mineral equilibria at low temperatures with application to sedimentary Ore deposits in Kimberley. Short course in Uranium deposits, their mineralogy and origin. Toronto Mineralogical Assoc., Canada, Pp17-55.

Nigeria Geological Survey Agency, (2004). Map of parts of South-western Nigeia (unpublished).

Reyment, R.A., (1965). Stratigraph of some borehole in western region of Nigeria. Journal of mining and geology, vol 2, No. 1, pp11.

Whiteman, A., (1982). Nigeria: its Petroleum Geology, Resources and Potential. London: Graham and Trotman Publishers, pp301-310.