International Journal of Pure and Applied Science Volume 2, Number 2, 2009

RADIOGENIC HEAT PRODUCTION DISTRIBUTION OF SOIL SAMPLES FROM IDI OMO, AKINYELE LGA, OYO STATE, NIGERIA

Adegoke J.A, Layade G.O and Popoola O.I.
Department of Physics,
University of Ibadan, Ibadan Oyo State, Nigeria.

Abstract

The NaI(Tl) gamma-ray spectrometer was employed to determine the concentration of naturally occurring Potassium(K-40), Uranium(U-238) and Thorium(Th-232) vis-à-vis the radiogenic heat production in soil samples from Idi-Omo farmland area of Akinyele Local Government area of Oyo state. The farmland which is at Latitude 07^0 30' 26.3" and Longitude 003^0 57' 21.9" covers an area of about 80,000 square metre, and is at an average elevation of 240m above mean sea level (msl). The samples were pulverized, sealed and activities of the radiogenic isotopes in them were measured for an accumulating period of 7 hours (25200s). The elemental concentrations were determined from the gamma ray spectra. The radiogenic heat determined from activity concentrations on samples from the locality for ^{40}K has on the average 92.86±0.02pW/Kg, while ^{238}U has 251.26±0.61pW/Kg and ^{232}Th has 77.210±0.03pW/Kg. The mean radiogenic heat calculated from the three radionuclides for the whole area under study is 421.33±0.66pW/Kg. ^{238}U contributes 60% to the total heat production, ^{40}K contributes 22% and ^{232}Th contributes 18%. This makes Uranium to be the highest contributor to the total heat production in the area. However observed that the radiogenic heat production distribution in the area is low.

Keywords: *Soil, Radiogenic, Heat, Radio nuclides, Distribution.*

INTRODUCTION

Geothermal energy is, literally, the heat contained within the Earth that generates geological phenomena on a planetary scale. This is the energy that exists in nature as a result of heat from the Earth's core (Ostridge, 1998). The Earth's core lies nearly 6000km below the surface and holds temperatures near 5000°C. These extreme temperatures are enough to heat the *mantle* and cause the rock to melt. The molten magma in the mantle has a lower density than the solid rock around it, so it tends to move upwards towards the Earth's surface. The majority of the time, the magma stays underneath the Earth's surface and heats up the rock and pockets of water that comes in contact with. Sometimes the magma actually finds its way through the Earth's crust and vents through volcanoes as lava.There are three main uses of geothermal energy sources. The first is the direct usage. The water that is heated by the magma beneath the Earth's surface can be pumped to buildings and used in heat exchanging systems. The second is harnessed by using the steam that comes from superheated water. If the steam vents are under sufficient pressure, then they can be used to turn turbines. The third class of geothermal energy is the dry steam; an outside water source (naturally or otherwise) is applied to fractured rock that has been heated to high temperatures, and then the steam that arises can be used to turn turbines (Rybach, 1988). Geothermal energy does not produce any pollution, and does not contribute to the greenhouse effect. The power stations do not take up much room, so there is not much impact on the environment. No fuel is needed. Once a geothermal power station is built, the energy is almost free. It may need a little energy to run a pump, but this can be taken from the energy being generated. Unfortunately, there are not many places where a geothermal power station can be built, and sometimes a geothermal site may "run out of steam", perhaps for decades. Hazardous gases and minerals may come up from underground, and can be difficult to safely dispose of this. Nevertheless, it is a preferred source of energy supply when it is available.Thermal surveys can delimit the areas of enhanced thermal gradient, which is a basic requirement for high-enthalpy geothermal systems, and define temperature distribution. Information on the existence of geothermal fluids in the geological structures can be obtained with the electrical and electromagnetic prospecting, which are more sensitive than other surveys to the presence of these fluids. If thermally excited rocks occur at depths as shallow as 10 to 20 km within the crust, it is almost certain that a partially Molten intrusive is present; the normal depth for thermally excited conductive rocks ranges from fifty to several hundred kilometers. This work attempted to determine the radiogenic heat distribution of soils on a farmland, identifying the major radionuclides that contributed to the radiogenic heat in the locality sequel to the fact that agricultural produce around the area (mostly perennial plants) suffer from underground heat and that often results to witting. Also, the level of geothermal energy prospect in the area under study was considered; knowing fully well that Ibadan is in the neighbourhood of the seismic belt that extends to Ikogosi where we have warm spring in Ondo State area of Nigeria. It is also, to provide meaningful recommendations to Agronomist, crop scientist, Agricultural extension officers and other stakeholders in the field.

Methodology

The acquired data was based on both the field work and laboratory measurement of the soil samples collected from a farm land which is at Latitude 07^0 30' 26.3'' and Longitude 003^0 57' 21.9'' covering an area of about 80,000 square metre, and at an average elevation of 240m above mean sea level. Twenty-six soil samples were collected from different geographical coordinates on the site. Each soil sample was collected at the dept of 30cm (0.3m) below the surface of the earth with their geographical latitude and longitude recorded respectively with the aid of a Hand-held GPS (eTrex Garmin 2000). Sample were collected at about 40m intervals from one point of collection to the other; which were later packed inside polythene container and labeled according to their respective coordinates. Samples collected were sun dried, weighed and sealed with label in an 1000ml plastic container for the period of at least four weeks for it to attain secular equilibrium between ^{226}Ra and ^{222}Rn and its decay products. Also each sample collected was counted for the accumulating period of 7 hours (25200s) with NaI(Tl) gamma-ray spectrometer Multi-Channel Analyser. The concentration of 40-K, 238-U and 232-Th varies systematically in many geologic materials. Thus for this various soil materials the total g-radiation arising from these aforementioned radioactive decay processes is sufficient to determine the nature of the soil type and to ascertain the heat production distribution in the soil materials. The NaI(Tl) g-ray spectrometer was used to obtain the net areas under photopeak for 40-K, 238-U, and 232-Th radionuclides present in the soil samples collected having taken care of the background radiation. Thus, the activity concentration was calculated.

CALCULATION OF ACTIVITY CONCENTRATION (Bqkg^{-1})

The calculation of elemental concentration of the detected radionuclide basically depends on the fact that the secular equilibrium was reached. Since this is so between ^{238}U and ^{232}Th and their decay products, the ^{238}U concentration were then determined from concentration of ^{214}Bi decay products in the sample and that of ^{232}Th was determined from the concentrations of ^{208}Tl decay products (Hamby and Tynybekov, 2000). The net count rate N_{Ei} in a particular region of interest of a calibration standard is proportional to the activity A_{Ei} of the investigated Nuclide (*Chiozzi et al., 2002*).

The relation is given as:

$$N_{Ei} = \gamma_E A_{Ei} \quad (1)$$

Where ε_E is the counting efficiency at the energy E

The specific activity in $BqKg^{-1}$ A_{Ei} of a nuclide for a peak at energy E given by (Tzortzis et al 2003)

$$A_{Ei} = \frac{N_{Ei}}{(\varepsilon_E * t * \gamma_d * M_s)} \quad (2)$$

Where N_{Ei} is the net peak area of a peak energy E, t is the counting life-time, ($_d$ is the gamma ray yield per disintegration of the specific nuclide for a transition at energy E and M_s is the Mass of the measured sample in *kg*.

The above relation was further narrowed down to:

$$C_s = KA_s \ (Bq/Kg); \quad (3)$$

Where

C_s is the concentration of the sample under study, A_s is the Net area of the sample under photo peak at energy E, K is the conversion factor given as: the ratio of the concentration of the standard sample to its

Net area under the same condition of energy. Thus the conversion factors were used. The result is shown in Table 2

CALCULATION OF UNCERTAINTY

The uncertainty σ_i, for a radionuclide of the calculated activity values (Table 4) is composed of counting statistics $\sigma_{i_{st}}$ and weighted systematic errors $\sigma_{i_{sysi}}$ of the nuclide calculated by the formula (EG & ORTEC, 1999)

$$\sigma_i = \left[\sigma^2{}_{st} + \sigma^2{}_{sysi}\right]^{1/2} \tag{4}$$

The systematic uncertainties considered include: the uncertainty of the source activity; the uncertainty in the efficiency fitting function, and the uncertainty in the radionuclide.

DERIVATION OF CONCENTRATION IN PARTS PER MILLION (PPM)

In this work, the activity of the radionuclides were calculated in part per million. The conversion relationship between Curie per Kilogram ($CiKg^{-1}$) and part per million (ppm) for radionuclides K-40, U-238, and Th-232 was used (Frame 2003). Consequently, the result of the activity concentration of the radionuclides is shown in table 3.

CALCULATION OF RADIOGENIC HEAT PRODUCTION

The quantity of heat generated per second and per kilogram (:Wkg-1) by K-40, U-238; Th-232 are natural Uranium 95.2; Thorium 25.6; Potassium 0.00348 (Rybach 1988). The heat Q_r produced by radioactivity in soil that has concentrations C_U, C_{Th}, C_K (in ppm) was computed using equation.

$$Q_r = 95.2\, C_U + 25.6\, C_{Th} + 0.00348\, C_K \tag{5}$$

The results are shown in Table 4.

RESULTS AND DISCUSSION

The net count of the radionuclides is shown in Table 1 while Table 2 is the activity concentration in Bq/kg. It is also expressed in part per million (ppm) in Table 3. This was converted to radiogenic heat generated using equation (5) and the result is in Table 4. The contour and the surface maps were produced from Table 4 for the heat distribution of the site suing the following parameters: elevation of each point above mean sea level, distance apart from one point of collection to the other, the geographical latitude and longitude and the total heat generated in each point by the three radio nuclide considered. Figure 1 and 3 represents the contour maps showing the altitude, longitude, elevation and heat produced respectively while figures 2 and 4 shows their corresponding surface maps. Figures 5 and 6 represents the contour and the surface maps respectively for elevation, distance apart and heat produced. However, it is clear to see that the heat generated by the presence of the radionuclide is unevenly distributed, needless to say that the peaks indicate relatively higher production of heat. It is alsop necessary to note that the heat produced as indicated in figure 6 is the average heat produced by the three radionuclides considered. It is apparent that the heat produced by 238U is the highest while ^{232}Th produced the least. This is as a result that in natural uranium the percentage heat contributed by ^{238}U is about 99.28%. The mean heat produced in the whole area under study was found to be *421.33*±0.66 pW/kg It is however observed that, the heat produced follow the trend of the topography , that is comparing figure 2 and 4. Some notable peak of heat generated were noticed at some elevations lower than the average msl, this might be as a result of their closeness to the core on a relative term. Conversely, in some areas where the elevation is a bit higher than the averaged msl, the heat generated is lower, this suggest that the heat produced is partly dependent on the distance of the location to the core and partly the presence of the radionuclide.

Table 1: NET AREA OF RADIOACTIVE NUCLIDES K-40, U-238 & Th-232 UNDER PHOTOPEAK

S/N	Coordinates (*mm*'ss"		Mass(Kg)	Elevation (m) above msl	*K-40*	*U-238*	*Th-232*
1	23.5 Lat.	19.9 Long.	0.192	242	106±0.29	940±0.69	877±0.19
2	19.6 Lat.	20.8 Long.	0.143	236	190±0.27	995±0.61	1213±0.16
3	23.2 Lat.	24.2 Long.	0.181	228	69±0.20	916±0.91	616±0.31
4	22.1 Lat.	21.5 Long.	0.151	236	412±0.21	1078±0.51	1249±0.15
5	22.8 Lat.	26.2 Long.	0.199	241	5±0.30	1086±0.51	984±0.18
6	24.6 Lat.	19.9 Long.	0.185	226	534±0.17	14±0.57	541±0.15
7	22.7 Lat.	20.6 Long.	0.116	230	4500±0.15	58±0.52	331±0.15
8	22.5 Lat.	22.0 Long.	0.201	242	264±0.17	1±1.34	398±0.15
9	20.8 Lat.	31.8 Long.	0.186	231	161±0.18	18±1.04	350±0.15
10	16.3 Lat.	27.1 Long.	0.175	229	5852±0.15	1±0.59	354±0.15
11	21.4 Lat	22.9 Long.	0.201	229	311±0.17	11±0.84	312±0.15
12	24.1 Lat.	24.5 Long.	0.183	233	8±0.19	156±0.40	339±0.15
13	23.4 Lat.	19.8 Long.	0.164	227	446±0.17	3±0.84	312±0.15
14	25.6 Lat.	22.9 Long.	0.185	227	418±0.17	0±0.0	357±0.15
15	18.7 Lat.	30.1 Long.	0.117	230	2653±0.16	16±0.57	370±0.15
16	23.5 Lat.	24.4 Long.	0.179	229	814±0.24	0±0.0	37±0.17
17	24.7 Lat.	20.5 Long.	0.198	243	875±0.18	7±0.92	207±0.16
18	23.6 Lat.	19.7 Long.	0.186	242	54±0.17	78±0.78	353±0.15
19	20.3 Lat.	31.4 Long.	0.138	230	6085±0.15	74±0.54	142±0.16
20	23.9 Lat.	24.7 Long.	0.191	227	725±0.20	0±0.0	142±0.16
21	22.4 Lat.	26.8 Long.	0.163	228	2955±0.16	956±0.40	93±0.17
22	26.3 Lat.	21.9 Long.	0.187	229	99±0.17	3±0.73	497±0.24
23	21.0 Lat.	22.3 Long.	0.206	234	564±0.17	67±0.67	152±0.16
24	21.2 Lat.	22.7 Long.	0.175	234	104±0.18	25±0.47	367±0.14
25	22.4 Lat.	21.2 Long.	0.295	236	150±0.18	94±0.53	364±0.15
26	25.4 Lat.	21.0 Long.	0.191	242	286±0.17	7±0.40	60±0.23

Table 2: ACTVITY CONCENTRATION OF THE RADIONUCLIDES (Bq/Kg)

S/N	Coordinates (*mm*'ss"		Mass(Kg)	Elevation (m) above msl	*K-40*	*U-238*	*Th-232*
1	23.5 Lat.	19.9 Long.	0.192	242	77.70±0.21	119.38±0.09	25.43±0.01
2	19.6 Lat.	20.8 Long.	0.143	236	139.27±0.21	126.37±0.08	35.18±0.00
3	23.2 Lat.	24.2 Long.	0.181	228	50.57±0.15	116.33±0.11	17.86±0.01
4	22.1 Lat.	21.5 Long.	0.151	236	301.99±0.15	136.91±0.06	36.22±0.00
5	22.8 Lat.	26.2 Long.	0.199	241	3.67±0.22	137.92±0.06	28.54±0.01
6	24.6 Lat.	19.9 Long.	0.185	226	391.42±0.12	1.78±0.07	15.69±0.00
7	22.7 Lat.	20.6 Long.	0.116	230	3298.5±0.11	7.37±0.07	9.60±0.00
8	22.5 Lat.	22.0 Long.	0.201	242	193.51±0.13	0.13±0.17	11.54±0.00
9	20.8 Lat.	31.8 Long.	0.186	231	118.01±0.13	2.29±0.13	10.15±0.00
10	16.3 Lat.	27.1 Long.	0.175	229	4289.52±0.11	0.13±0.07	10.27±0.00
11	21.4 Lat	22.9 Long.	0.201	229	227.96±0.13	1.40±0.11	9.05±0.00
12	24.1 Lat.	24.5 Long.	0.183	233	5.86±0.14	19.81±0.05	9.83±0.00
13	23.4 Lat.	19.8 Long.	0.164	227	326.91±0.12	0.38±0.11	9.05±0.00
14	25.6 Lat.	22.9 Long.	0.185	227	306.39±0.13	0±0.00	10.35±0.00
15	18.7 Lat.	30.1 Long.	0.117	230	1944.65±0.11	2.03±0.07	10.73±0.00
16	23.5 Lat.	24.4 Long.	0.179	229	596.66±0.18	0±0.00	1.07±0.00
17	24.7 Lat.	20.5 Long.	0.198	243	641.38±0.13	0.89±0.02	6.00±0.00
18	23.6 Lat.	19.7 Long.	0.186	242	39.58±0.13	9.91±0.10	10.24±0:00
19	20.3 Lat.	31.4 Long.	0.138	230	4460.31±0.11	9.40±0.06	4.12±0.00
20	23.9 Lat.	24.7 Long.	0.191	227	531.43±0.15	0±0.00	4.12±0.00
21	22.4 Lat.	26.8 Long.	0.163	228	2166.02±0.11	121.41±0.05	2.70±0.00
22	26.3 Lat.	21.9 Long.	0.187	229	72.57±0.13	0.38±0.09	14.41±0.01
23	21.0 Lat.	22.3 Long.	0.206	234	413.41±0.12	8.51±0.11	4.41±0.01
24	21.2 Lat.	22.7 Long.	0.175	234	76.23±0.13	3.18±0.06	10.64±0.00
25	22.4 Lat.	21.2 Long.	0.295	236	109.95±0.13	11.94±0.07	10.56±0.00
26	25.4 Lat.	21.0 Long.	0.191	242	209.64±0.13	0.89±0.05	1.74±0.01

Table 3: CONCENTRATION OF THE RADIONUCLIDES in Part Per Million (ppm)

S/N	Coordinates (*mm'ss"*)		Mass(Kg)	Elevation (m) above msl	*K-40*	*U-238*	*Th-232*
1	23.5 Lat.	19.9 Long.	0.192	242	2567.76±7.08	9.77±0.01	6.24±0.00
2	19.6 Lat.	20.8 Long.	0.143	236	4602.60±6.52	10.34±0.01	8.63±0.00
3	23.2 Lat.	24.2 Long.	0.181	228	1671.47±4.89	9.52±0.01	4.39±0.00
4	22.1 Lat.	21.5 Long.	0.151	236	9980.37±5.10	11.20±0.01	8.89±0.00
5	22.8 Lat.	26.2 Long.	0.199	241	121.12±7.30	11.29±0.01	7.00±0.00
6	24.6 Lat.	19.9 Long.	0.185	226	12935.72±4.09	0.15±0.01	3.85±0.00
7	22.7 Lat.	20.6 Long.	0.116	230	109008.89±3.74	0.60±0.01	2.36±0.00
8	22.5 Lat.	22.0 Long.	0.201	242	6395.18±4.22	0.01±0.01	2.83±0.00
9	20.8 Lat.	31.8 Long.	0.186	231	3900.10±4.31	0.19±0.01	2.49±0.00
10	16.3 Lat.	27.1 Long.	0.175	229	141760.01±3.72	0.01±0.01	2.52±0.00
11	21.4 Lat	22.9 Long.	0.201	229	7533.73±4.18	0.11±0.01	2.22±0.00
12	24.1 Lat.	24.5 Long.	0.183	233	193.79±4.48	1.62±0.00	2.41±0.00
13	23.4 Lat.	19.8 Long.	0.164	227	10803.99±4.11	0.03±0.01	2.22±0.00
14	25.6 Lat.	22.9 Long.	0.185	227	10125.71±4.13	0±0.00	2.54±0.00
15	18.7 Lat.	30.1 Long.	0.117	230	64266.80±3.79	0.17±0.01	2.63±0.00
16	23.5 Lat.	24.4 Long.	0.179	229	19218.50±5.82	0±0.00	0.26±0.00
17	24.7 Lat.	20.5 Long.	0.198	243	11196.17±4.30	0.07±0.01	1.47±0.00
18	23.6 Lat.	19.7 Long.	0.186	242	1308.11±4.17	0.81±0.01	2.51±0.00
19	20.3 Lat.	31.4 Long.	0.138	230	147404.24±3.72	0.77±0.01	1.01±0.00
20	23.9 Lat.	24.7 Long.	0.191	227	17562.54±4.88	0±0.00	1.01±0.00
21	22.4 Lat.	26.8 Long.	0.163	228	71582.50±3.79	9.93±0.01	0.66±0.00
22	26.3 Lat.	21.9 Long.	0.187	229	2398.20±4.14	0.03±0.01	3.54±0.00
23	21.0 Lat.	22.3 Long.	0.206	234	13662.45±4.08	0.70±0.01	1.08±0.00
24	21.2 Lat.	22.7 Long.	0.175	234	2519.31±4.34	0.26±0.00	2.61±0.00
25	22.4 Lat.	21.2 Long.	0.295	236	3633.63±4.30	0.98±0.00	2.59±0.00
26	25.4 Lat.	21.0 Long.	0.191	242	6928.12±4.21	0.07±0.00	0.43±0.00

Table 4: RADIOGENIC HEAT PRODUCTION IN EACH SOIL SAMPLE (pW/kg)

S/N	Coordinates (*mm'ss"*)		Mass (Kg)	Elevation (m) above msl	*K-40*	*U-238*	*Th-232*	TOTAL HEAT
1	23.5 Lat.	19.9 Long.	0.192	242	8.94±0.02	929.86±0.68	159.81±0.03	1098.61±0.74
2	19.6 Lat.	20.8 Long.	0.143	236	16.07±0.02	984.27±0.60	221.03±0.03	1221.33±0.65
3	23.2 Lat.	24.2 Long.	0.181	228	5.82±0.02	906.12±0.89	112.25±0.06	1024.19±0.96
4	22.1 Lat.	21.5 Long.	0.151	236	34.73±0.02	1066.37±0.51	227.60±0.03	1328.70±0.55
5	22.8 Lat.	26.2 Long.	0.199	241	0.42±0.03	1074.29±0.50	179.31±0.03	1254.02±0.56
6	24.6 Lat.	19.9 Long.	0.185	226	45.02±0.02	13.85±0.56	98.58±0.03	157.45±0.60
7	22.7 Lat.	20.6 Long.	0.116	230	379.35±0.01	57.37±0.52	60.32±0.03	497.04±0.56
8	22.5 Lat.	22.0 Long.	0.201	242	22.26±0.01	0.99±0.13	72.56±0.03	95.77±1.37
9	20.8 Lat.	31.8 Long.	0.186	231	13.57±0.01	17.81±1.03	63.78±0.03	95.16±1.07
10	16.3 Lat.	27.1 Long.	0.175	229	493.33±0.01	0.99±0.58	64.51±0.03	558.82±0.62
11	21.4 Lat	22.9 Long.	0.201	229	26.22±0.01	10.88±0.53	56.85±0.03	93.95±0.88
12	24.1 Lat.	24.5 Long.	0.183	233	0.67±0.02	154.32±0.40	61.77±0.03	216.77±0.44
13	23.4 Lat.	19.8 Long.	0.164	227	37.60±0.01	2.97±0.83	56.85±0.03	97.42±0.87
14	25.6 Lat.	22.9 Long.	0.185	227	35.24±0.01	0±0.00	65.06±0.03	100.29±0.44
15	18.7 Lat.	30.1 Long.	0.117	230	223.65±0.01	15.83±0.56	67.42±0.03	306.90±0.60
16	23.5 Lat.	24.4 Long.	0.179	229	68.62±0.02	0±0.00	6.74±0.03	75.36±0.05
17	24.7 Lat.	20.5 Long.	0.198	243	73.76±0.01	6.95±0.91	37.72±0.03	118.41±0.95
18	23.6 Lat.	19.7 Long.	0.186	242	4.55±0.01	77.16±0.77	64.33±0.03	146.04±0.82
19	20.3 Lat.	31.4 Long.	0.138	230	512.97±0.01	73.20±0.51	25.88±0.03	612.05±0.55
20	23.9 Lat.	24.7 Long.	0.191	227	61.12±0.02	0±0.00	25.87±0.03	86.99±0.05
21	22.4 Lat.	26.8 Long.	0.163	228	249.11±0.01	945.69±0.40	16.95±0.03	1211.74±0.44
22	26.3 Lat.	21.9 Long.	0.187	229	8.35±0.01	2.97±0.72	90.57±0.04	101.88±0.78
23	21.0 Lat.	22.3 Long.	0.206	234	47.55±0.01	66.28±0.83	27.70±0.03	141.52±0.88
24	21.2 Lat.	22.7 Long.	0.175	234	8.77±0.02	24.73±0.47	66.88±0.03	100.37±0.51
25	22.4 Lat.	21.2 Long.	0.295	236	12.65±0.01	92.99±0.52	66.33±0.03	171.96±0.56
26	25.4 Lat.	21.0 Long.	0.191	242	24.11±0.01	6.93±0.40	10.93±0.04	41.97±0.46
		Total			2414.36±0.42	6532.77±15.75	2007.58±0.80	10954.71±16.96
		Mean			92.86±0.02	251.26±0.61	77.21±0.03	421.33±0.66

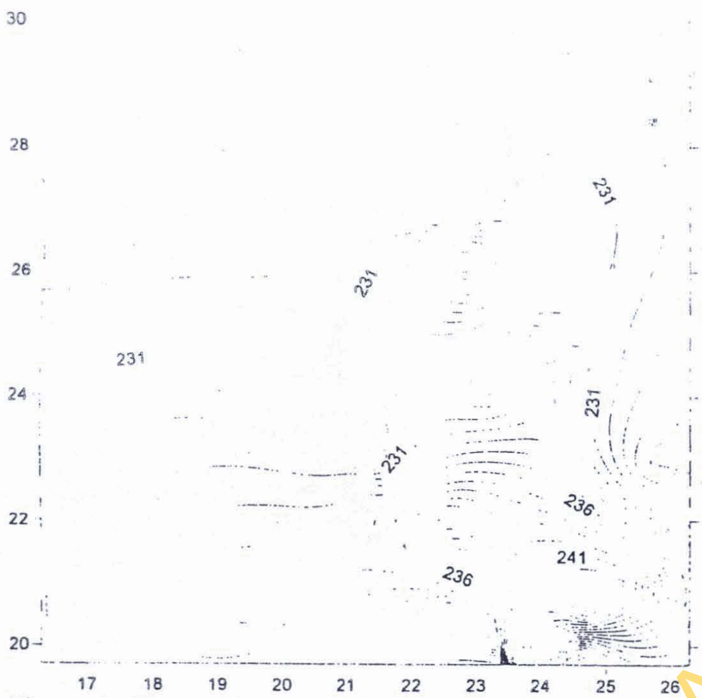

Figure 1: Contour Map showing Latitude, Longitude and Elevation of each point

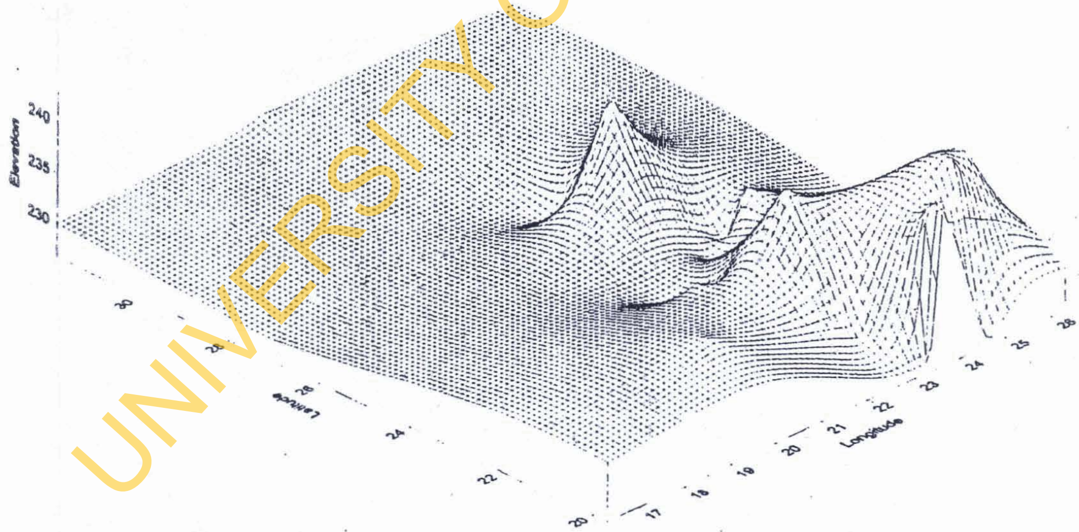

Figure 2: Surface Map showing Latitude, Longitude and Elevation of each point

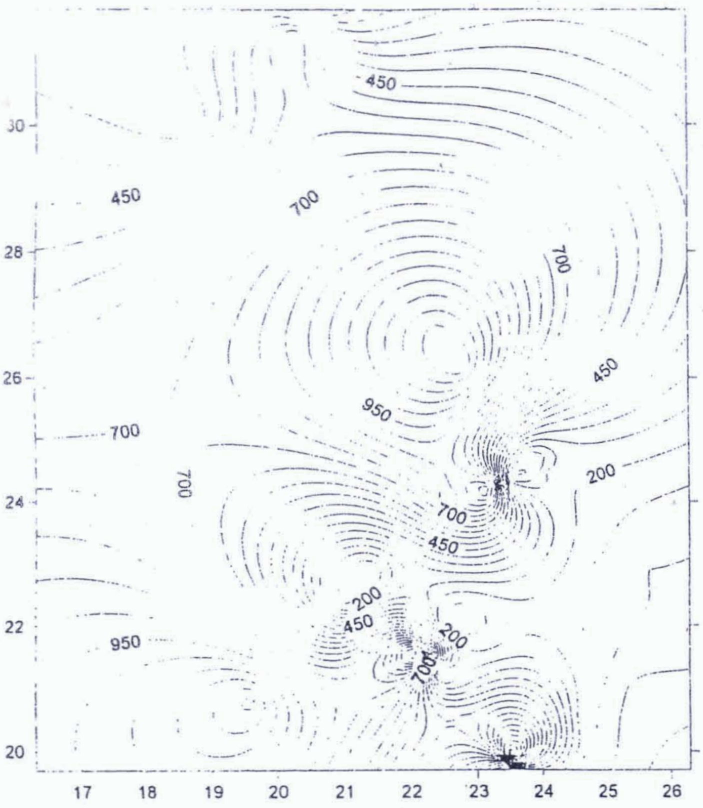

Figure 3: Contour Map showing Latitude, Longitude and heat produced at each point

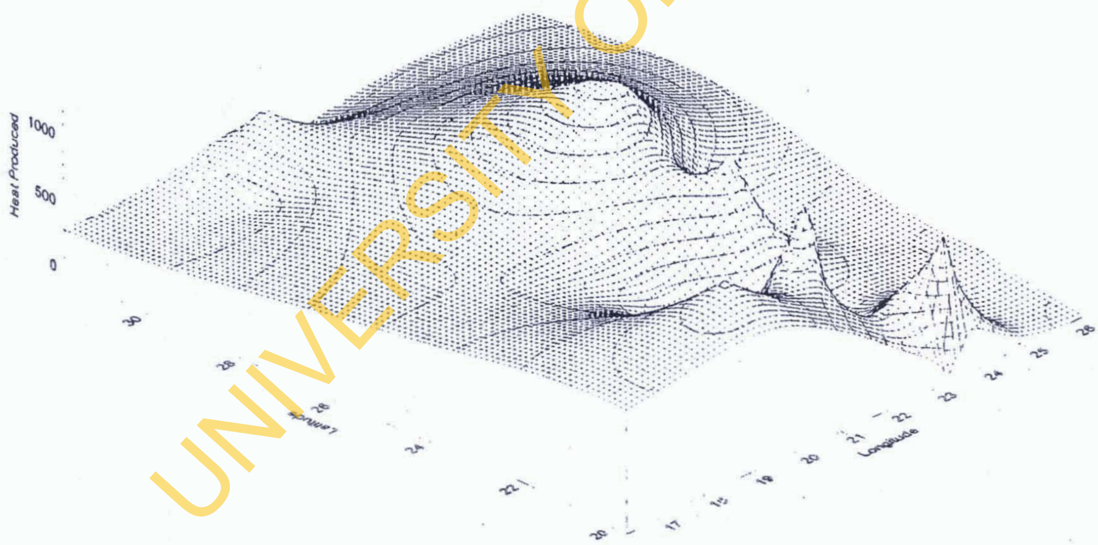

Figure 4: Surface Map showing Latitude, Longitude and heat produced at each point

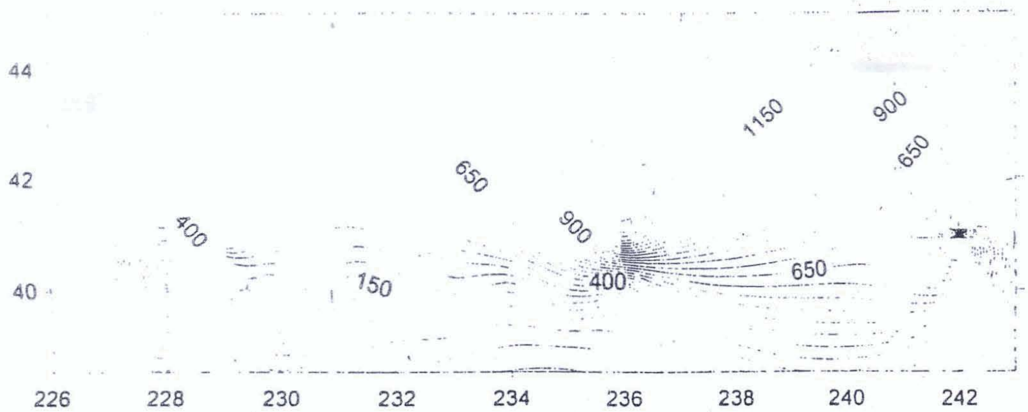

Figure 5: Contour Map showing Elevation, Distance and heat produced at each point

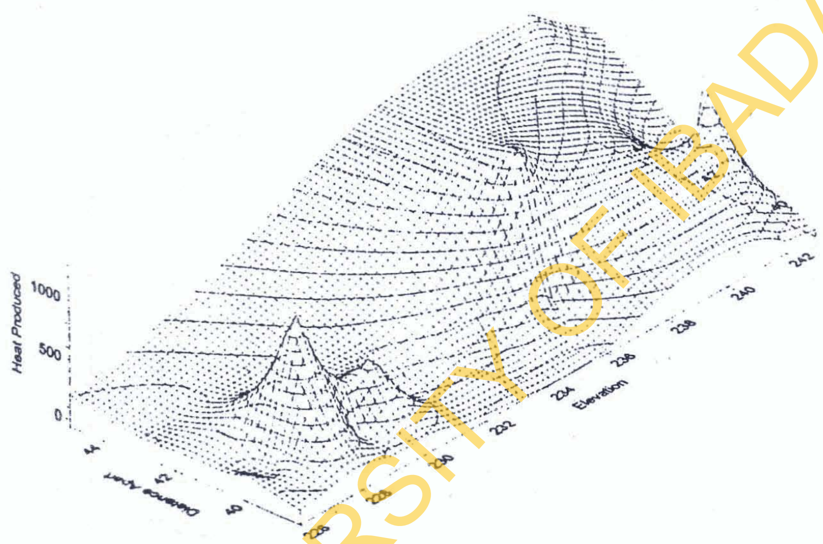

Figure 6: Surface Map showing Elevation, Distance and heat produced at each point

CONCLUSION

Generally, the heat generated by each of the three radionuclide, is of significant value since they all contributed to the geothermal processes. Most of the soil samples studied in this work reveal low values for the activity and elemental concentrations of ^{40}K, ^{238}U and ^{232}Th, thus contributing a low radioactive heat production with an average of 421.33±0.66pW/kg. The results indicate low prospect of geothermal energy production. However, the heat generated in the area has impact on the agricultural produce and vegetation.

REFERENCES

Chiozzi, p., Pasquale, V., Verdoya, M. (2002) Narurally Ocuuring Radioactivity at the alps-Apennines Transition Radiation Measurement, 35, pp. 147-154.

Debertin. K and Helmer, R.G (1988) Gamma- and X-ray Spectrometer with Semiconductor Detectors, Amsterdam.

EG&G ORTEC, (1999) Gamma Vision-32: Gamma-Ray Spectrum Analysis and MCA Emulator. Software User's Manual (V51). EG&ORTEC.

Joshua E.O., Akpanowo M.A. and. Ariyibi E. A. (2006). Radiogenic heat production in crustal rock samples from Cross River State, Nigeria *Global Journal of Pure and Applied Sciences* Vol. 12 (4).

Ostridge R. (1998), Written for Physics 261 University of Prince Edward Island http://www.upei.ca/~physics/p261/projects/geothermal1/geothermal1.htm . Retrieved on July 10, 2007

Rybach, L. (1988) Determination of heat production. In handbook of Terrestial heat flow density determination.

Tzortzis,M., Tsertos, H., Christofides, S., & Christodoulides (2003) Gamma Radiation measurement and dose rates in commercially used natural tilling rocks (granites) UCH-PHY-02/03, Physics/0212104.