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URANIUM AND VANADIUM CONCENTRATION IN SOME SUDANESE ORES

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ABSTRACT

The results of this study were carried out to determine the composition of the uranium element in the Nuba Mountains area in Southern Kordofan region in the regions of Mount Uro and Mount Kurn. Forty samples were collected from the two regions, 20 samples from each region were grinded and converted into powder, and analyzed by XRF spectrometer, to find the concentration of each element in the sample. The analysis showed that the average concentration of the uranium element in the samples of Kurn is 103.27ppm, while the average concentration of samples of the euro area is 985.13ppm, after the operation of the statistical analysis of the results and the average values shows a significant proportion in the global markets. The meta-analysis process shows High concentration of Vanadium with an economic importance of more than 80% in most samples. A statistical analysis of the results of the Vanadium was performed. The average concentration of Vanadium in the samples is Kurn 2793ppm, while the average concentration of Vanadium in the samples of the Uro area is 3667.45ppm. Where the prices of both uranium and Vanadium have been shown in the world markets, it indicates that these concentrations are very important and can contribute to the economy if used properly. It is very interesting to note that the concentration of uranium and vanadium are proportion to each other. This conforms to the hypothesis that these elements may be produced from molten magma which causes heavy elements to reside at the bottom. The percentage of uranium and vanadium agrees with the radioactive decay law, where the decrease of uranium amount, increases vanadium amount.

I. INTRODUCTION

Sudan has a very unique geographical location in Africa. Bordering seven African countries, and also distinguished by its fertile land, heavy rains and the availability of water resources River Nile, Blue Nile, White Nile, and underground water. Surface area of Sudan is almost 1 Million square miles before the separation.

Sudanese land is rich in mineral resources such as gold, silver, chrome, gypsum. etc. Uranium has been discovered in the area of the Nuba Mountains and Hufrat EL Nahas in Darfur by USA Company in 1977[1] During 1978 and 1979, uranium exploration activities were performed in Sudan by two companies; Azienda General Italiani S.p. A. (AGIP) and Wyoming Minerals Corp., a subsidiary of Westinghouse (USA). The results of these activities were not announced. However, from fragmentary information given by the Sudanese Government it was evident that Minex Corp. was successful in discovering an important deposit of uranium and other radioactive elements in Jebel Dumbeir and Jebel Ed Dair, near Rahdad in west-central Sudan [2]Brinkman in 1986 discovered two types of phosphate deposits in Kurunand Uro areas in the center of eastern Nuba Mountains containing uranium[3].In the recent years, many studies concerning uranium deposits in Sudan have been conducted in various areas [4,5]The result of most studies has revealed without doubt that the Uranium and Thorium concentrations are lower than world wide data. However, a study published at 2014 gave detailed information concerning uranium recovery from

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Sudanese phosphate ores [6].This study was carried out in a laboratory scale to recover uranium from Uro area phosphate ore in the eastern part of Nuba Mountains in Sudan. Phosphate ore samples were collected, and analyzed for uranium abundance. The results showed that the samples contain a significant concentration of uranium with an average of 310.3µg/g, which is 2.6 times higher than the world average of phosphate. The green phosphoric acid obtained from the samples was found to contain uranium in the range of 186–2049 µg/g, with an average of 603.3µg/g. More than 98% of uranium in the green phosphoric acid exists as uranyl- tricarbonate complex. The obtained results proved that uranium from Uro phosphate ore was successfully recovered as uranium trioxide with an overall recovery percentage of 93%.

II. MATERIAL AND METHOD

Area Description

The present work is conned to the center of the eastern part of the Nubba Mountains in the state of Kurdufan, between Abu Giubiha and El Rashad towns at the intersection of North east of the coordinate 11450north and 3122eastThe Uro deposits consist of volcanic sedimentary rocks[7[, omphiolyte assemblage, and quaternary sediments that include rocks that belong to green schistfacies consisting of a variety of schist's, e.g. chlorite-phyllite, chlorite schist, mica schist, graphite schist, marbles and quartz[8].The major phosphate rock constituents in Uro deposits are high-grade gneisses and low-grade volcanic sedimentary rocks. The ore mineralogyinthese deposits is characterized by open space-fling texture and structure. The identified minerals include ealuminaphosphate, hydrated phosphate, limonite goethite, quartz, kaolinite, and zeolotes. The phosphate minerals include apatite, turquoise, crandallite, wavelite, woodhouseite, and variscite[9]

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Study

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Fig.(1): Map of Sudan showing the location of the study area [6]

Sites of Samples collection

Rock phosphate samples collected from Uro and Kurn phosphate deposits located in the eastern part of Nubba Mountains, in southern Kurdfan State.Samples were crushed and ground to 2mm size, to facilitate Uranium releasing and ending up in the leaching Solution .Sub-samples from bulk samples were taken using quartering technique which consists of piling the ore into conical heap , spreading this out into circles cakes , and dividing the cake into the quarters , taking opposite quarters. This process was repeated until suitable samples were collected.

Sample Preparation

After collecting, the samples that were taking the silver color, when the samples were grinded and converted to powder, and take every one gram of the sample, and placed in the XRF device, and observed the results recorded on the results table on the device.

Sample color silver.
The sample weight 1 gm
Type of sample powder

XRF Analysis Method

Using an XRF (X-Ray Fluorescence) machine where 1 gram of powder sample was taken and put it in the machine to get the concentration of each of the elements in the sample. The main concern here is on the concentration of uranium which is the element required for the present study.

III. RESULTS

The analysis processing by XRF Machine was completed for 40 samples which were taken from two different regions: Kurn and the Uro areas. It was noted that the concentration of uranium in Uro region samples is much higher than the Kurn area samples. The Uro samples gave values more than 1,100 ppm, while the Kurn areas were foun

Concentration of uranium (Bq/kg) in Uro area.

Table1: Concentration of uranium (Bq/kg).

Samples code	Sample location in the mountain(height in m)	^{238}U(Bq/ kg)
K 1	5 7 7	1101.3
K 2	5 8 1	1128.033
K 3	5 8 5	1128.864
K 4	5 8 8	5 . 4
K 5	5 9 2	1 1 . 1
K 6	5 9 8	1166.876

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K 7	5 9 6	1183.897
K 8	5 7 7	1193.456
K 9	5 8 9	1171.332
K 10	5 8 3	1156.890
K 11	5 8 4	1149.996
K 12	5 8 5	1160.876
K 13	5 8 7	1154.042
K 14	5 9 4	1086.32
Max		1193.456
Min		5.4
Average		**985.13**

1. Kurn Samples

Table 2: Statistical Analysis Kurn Samples

Sample/ppm	Tb	Th	Tm	U	V	W	Y	Yb	Zr
1	0.3	0.4	0.6	205	1676	26.3	50.7	4.9	16
3	0.4	0.3	3.9	208.3	7106	1.9	195.8	18.8	24
4	0.3	1.1	0.5	131.7	1425	2	33.5	4.2	30
5	0.4	0.6	3	184.1	3453	2	170.7	27.5	32
6	1.0	0.6	3.9	128.1	2554	3.8	267.5	24.4	25
7	0.8	0.9	3.6	139.7	2713	3.1	235.6	26	24
8	0.6	0.7	2.2	184.9	5015	25.4	132.1	18	19
9	1.3	0.4	1.8	110.6	4895	1.9	130.4	12.3	18
10	1.2	0.3	1.7	110.5	4874	1.8	127.7	14	17
11	1.8	0.1	4.3	174.2	3614	3.9	231.9	32.8	10
12	1.7	0.4	4.8	188.8	1163	4.7	242.7	37.3	22
13	0.7	0.3	3.2	67.9	2093	1.2	211.9	21.9	7
14	0.3	0.4	0.4	90.1	211	1.2	30,7	2.5	16
15	0.1	0.3	0.2	56.3	253	1.1	25.4	1.7	33
16	0.3	0.3	0.4	22,6	181	19	40.4	2.7	44
17	0.2	0.2	2.6	43.0	4220	0.9	112.9	25.1	12
18	0.1	0.4	0.8	29.3	1975	0.9	31.3	7,8	13
19	0.2	0.1	0.7	20.8	1293	0.8	30.6	7.4	8
20	0.3	0.4	2.1	46.2	4353	2.1	76.5	19.4	16
Average $\bar{x}$	**0.63**	**0.43**	**2.14**	**103.27**	**2793**	**5.47**	**125.17**	**16.25**	**20.32**
Standard Deviation σ	**0.53**	**0.25**	**1.51**	**63.98**	**1930**	**8.23**	**85.83**	**10.96**	**9.53**

The average Concentration of Uranium in the Krun samples is 103.27 ± 64 ($\bar{x} \pm \sigma$) parts per million. This means that one ton of ore gives 103.27 ± 64 grams of uranium.

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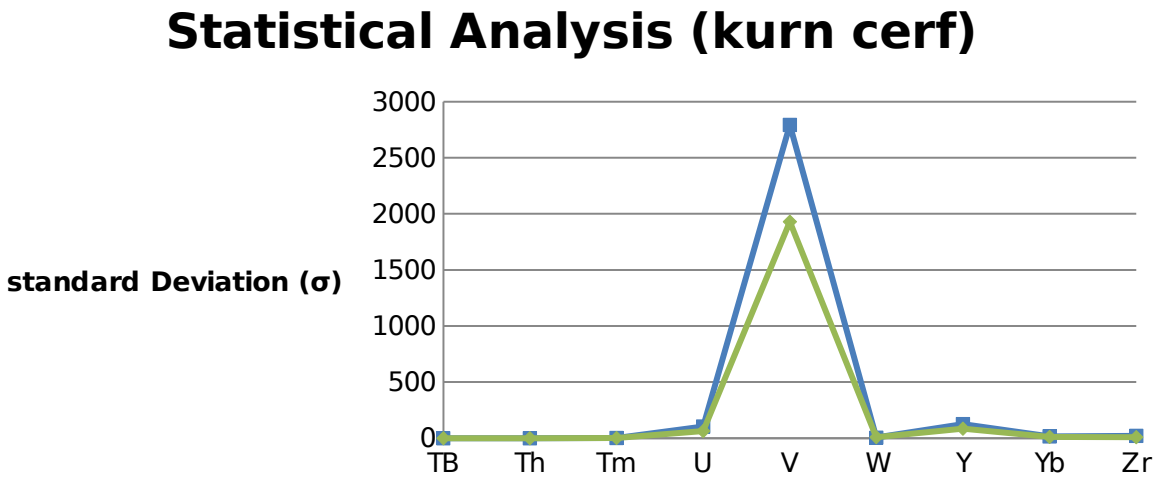

Fig. (2) : Statistical Analysis Cerf (Kurn sample).

This study gives an average of 677 ppm and standard deviation of 597 ppm i.e. 677±597 (See the Table)

More interesting is the same one ton of the ore gives 2793± 1930 gram of vanadium (around 3 Kgm of Vanadium). About 80 percent of the vanadium now produced is used as ferrovanadium or as a steel additive. Vanadium foil is used as a bonding agent when cladding titanium to steel. Vanadium pent oxide is used in ceramics and as a catalyst. Vanadium is also used to produce a superconductive magnet with a field of 175,000 gauss.

2. ERU Samples

Table 3: Uranium content and P_2O_5% for phosphoric Acid

Sample/ppm	Tb	Th	Tm	U	V	W	Y	Yb	Zr
21	-	0.5	6.9	1101.3	4482	1.4	271.5	60	17
22	0.2	0.1	3.7	1128	4674	1	119.1	36.16	7
24	0.1	0.1	1.7	1128	4801	0.5	64.1	19.5	8
25	0.2	0.4	0.1	5.4	137	0.9	15.1	0.9	21
26	0.9	1.1	0.4	111.1	11.4	0.5	58.7	2.5	20
28	0.6	0.5	2.9	1166	3158	1.5	142.2	27.5	16
29	0.5	0.3	2.7	1183	4568	1.7	121	26.1	24
31	0.2	0.1	8	1193	5735	2.6	245.9	86.3	10
33	0.5	0.7	2.8	1171	4773	2.6	126.6	27.1	24
35	0.5	0.3	3.9	1156	1837	2.5	162.8	40.7	13
36	0.5	1.4	1.2	1149	6740	16.2	61.3	11.8	39
38	2.2	2.9	1.6	1160	3458	1.4	102.6	16.1	20
39	0.3	1.7	54	1154	5161	0.9	75.7	22.7	12
40	0.7	1.3	0.8	1086	1809	0.7	51.2	7	52
Average $\bar{x}$	**1.05**			**985.13**	**3667.45**				
Standard Deviation σ	**1.87**			**414.90**	**2035.8**				

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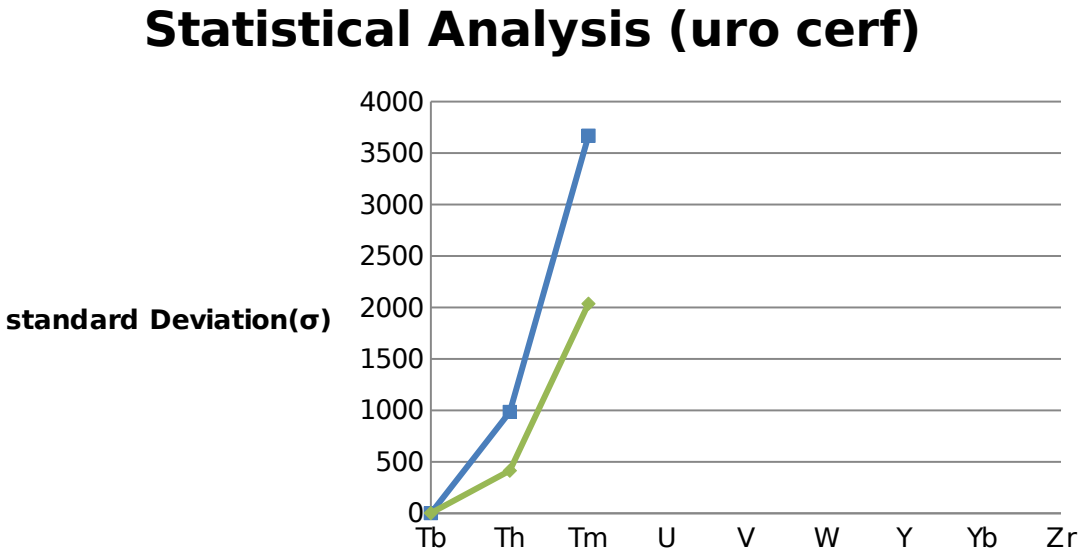

Fig. 3 : Statistical Analysis Cerf (Kurn sample).

Sample analyses in deferent exposure time
ARO-1, 2,3,4,5 five sample in exposure time 1000 second

Table 4: sample no 1 in time 1000 second

ARO-1	[A0(RES)= 10059]			WEIGHT [g/cm^2]:	.205
EL	E [KEV]	INT [C/S]	S	T CONC [FRAC]	ERROR
CA	3.690	0.653	1.62E+02	0.0256 7.65E-01	5.25E-01
TI	4.508	0.037	9.15E+03	0.0069 2.73E-03	2.04E-03
FE	6.400	1.319	2.67E+04	0.0174 1.33E-02	9.10E-03
CU	8.041	0.194	5.56E+05	0.0304 5.37E-05	3.71E-05
ZN	8.631	0.586	1.64E+04	0.0363 4.61E-03	3.16E-03
PB	10.540	0.058	4.30E+04	0.0577 1.11E-04	7.91E-05
SR	14.142	25.498	9.17E+04	0.1071 1.25E-02	8.55E-03
Y	14.933	0.643	8.11E+04	0.1185 3.22E-04	2.21E-04
U	13.600	0.322	4.43E+04	0.0994 3.52E-04	2.43E-04
ZR	15.746	0.808	4.33E+04	0.1301 6.90E-04	4.75E-04

Table 5: sample no 2 in time 1000 second

ARO-2	[A0(RES)= 10059]			WEIGHT [g/cm^2]:	.204
EL	E [KEV]	INT [C/S]	S	T CONC [FRAC]	ERROR
CA	3.690	0.737	1.62E+02	0.0235 8.65E-01	5.93E-01
TI	4.508	0.046	9.15E+03	0.0066 3.59E-03	2.60E-03
FE	6.400	1.400	2.67E+04	0.0167 1.49E-02	1.02E-02
CU	8.041	0.187	5.56E+05	0.0291 5.49E-05	3.79E-05
ZN	8.631	0.649	1.64E+04	0.0347 5.41E-03	3.71E-03
PB	10.540	0.077	4.30E+04	0.0551 1.56E-04	1.09E-04
SR	14.142	26.373	9.17E+04	0.1023 1.37E-02	9.41E-03

Y	14.933	0.569	8.11E+04	0.1131	3.03E-04	2.08E-04
U	13.600	0.304	4.43E+04	0.0949	3.53E-04	2.44E-04
ZR	15.746	0.615	4.33E+04	0.1241	5.58E-04	3.86E-

Table 6: sample no 3 in time 1000 second

ARO-3 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.662	1.62E+02	0.0264	7.64E-01	5.24E-01
TI	4.508	0.041	9.15E+03	0.0069	3.04E-03	2.19E-03
FE	6.400	1.235	2.67E+04	0.0175	1.25E-02	8.56E-03
CU	8.041	0.143	5.56E+05	0.0307	3.97E-05	2.75E-05
ZN	8.631	0.617	1.64E+04	0.0366	4.87E-03	3.34E-03
PB	10.540	0.060	4.30E+04	0.0582	1.14E-04	8.06E-05
SR	14.142	17.926	9.17E+04	0.1085	8.71E-03	5.96E-03
Y	14.933	0.440	8.11E+04	0.1201	2.18E-04	1.50E-04
U	13.600	0.236	4.43E+04	0.1006	2.56E-04	1.77E-04
ZR	15.746	0.445	4.33E+04	0.1319	3.76E-04	2.61E-04

Table 7 : sample no 4 in time 1000 second

ARO-4 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.707	1.62E+02	0.0265	8.04E-01	5.52E-01
TI	4.508	0.043	9.15E+03	0.0067	3.26E-03	-LDL-
FE	6.400	1.310	2.67E+04	0.0168	1.37E-02	9.39E-03
CU	8.041	0.221	5.56E+05	0.0294	6.36E-05	4.39E-05
ZN	8.631	0.688	1.64E+04	0.0350	5.63E-03	3.86E-03
PB	10.540	0.041	4.30E+04	0.0555	8.14E-05	5.98E-05
SR	14.142	25.374	9.17E+04	0.1032	1.29E-02	8.86E-03
Y	14.933	0.507	8.11E+04	0.1141	2.64E-04	1.82E-04
U	13.600	0.289	4.43E+04	0.0957	3.29E-04	2.27E-04
ZR	15.746	0.548	4.33E+04	0.1253	4.87E-04	3.38E-04

Table 8 sample no 5 in time 1000 second

ARO-5 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.529	1.44E+02	0.0250	7.18E-01	4.93E-01
TI	4.508	0.040	8.15E+03	0.0073	3.16E-03	-LDL-
FE	6.400	0.944	2.38E+04	0.0183	1.02E-02	7.02E-03
CU	8.041	0.160	4.96E+05	0.0322	4.75E-05	3.28E-05
ZN	8.631	0.526	1.46E+04	0.0384	4.43E-03	3.04E-03
PB	10.540	0.048	3.83E+04	0.0611	9.79E-05	7.07E-05
SR	14.142	21.184	8.17E+04	0.1136	1.11E-02	7.59E-03
Y	14.933	0.510	7.22E+04	0.1256	2.73E-04	1.87E-04
U	13.600	0.243	3.95E+04	0.1053	2.84E-04	1.96E-04
ZR	15.746	0.702	3.86E+04	0.1379	6.40E-04	4.41E-04

Table 9: sample no 1 in time 2000 second

ARO-11 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR

CA	3.690	0.753	1.62E+02	0.0236	8.79E-01	6.02E-01
TI	4.508	0.032	9.15E+03	0.0065	2.53E-03	1.84E-03
FE	6.400	1.316	2.67E+04	0.0165	1.42E-02	9.70E-03
CU	8.041	0.203	5.56E+05	0.0289	5.99E-05	4.12E-05
ZN	8.631	0.635	1.64E+04	0.0344	5.34E-03	3.66E-03
PB	10.540	0.068	4.30E+04	0.0547	1.39E-04	9.65E-05
SR	14.142	25.543	9.17E+04	0.1016	1.34E-02	9.17E-03
Y	14.933	0.600	8.11E+04	0.1123	3.22E-04	2.21E-04
U	13.600	0.313	4.43E+04	0.0942	3.66E-04	2.51E-04
ZR	15.746	0.687	4.33E+04	0.1233	6.28E-04	4.32E-04

Table 10: sample no 2 in time 2000 second

ARO-22 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.706	1.82E+02	0.0227	7.71E-01	5.29E-01
TI	4.508	0.027	1.03E+04	0.0072	1.74E-03	1.28E-03
FE	6.400	1.344	3.00E+04	0.0182	1.17E-02	8.05E-03
CU	8.041	0.199	6.24E+05	0.0319	4.76E-05	3.28E-05
ZN	8.631	0.695	1.84E+04	0.0381	4.74E-03	3.25E-03
PB	10.540	0.066	4.83E+04	0.0605	1.09E-04	7.59E-05
SR	14.142	25.598	1.03E+05	0.1125	1.08E-02	7.41E-03
Y	14.933	0.554	9.10E+04	0.1245	2.40E-04	1.64E-04
U	13.600	0.271	4.97E+04	0.1044	2.55E-04	1.76E-04

Table 11: sample no 3 in time 2000 second

ARO-33 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.672	1.62E+02	0.0230	8.09E-01	5.55E-01
TI	4.508	0.026	9.15E+03	0.0069	1.94E-03	1.45E-03
FE	6.400	1.300	2.67E+04	0.0176	1.32E-02	9.02E-03
CU	8.041	0.194	5.56E+05	0.0307	5.42E-05	3.73E-05
ZN	8.631	0.628	1.64E+04	0.0366	4.97E-03	3.41E-03
PB	10.540	0.065	4.30E+04	0.0581	1.26E-04	8.76E-05
SR	14.142	25.475	9.17E+04	0.1080	1.26E-02	8.61E-03
Y	14.933	0.609	8.11E+04	0.1195	3.07E-04	2.11E-04
U	13.600	0.361	4.43E+04	0.1002	3.97E-04	2.73E-04
ZR	15.746	0.618	4.33E+04	0.1311	5.32E-04	3.66E-04

Table 12: sample no 4 in time 2000 second

ARO-44 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.734	1.62E+02	0.0234	8.63E-01	5.91E-01
TI	4.508	0.021	9.15E+03	0.0066	1.67E-03	-LDL-
FE	6.400	1.268	2.67E+04	0.0168	1.34E-02	9.19E-03
CU	8.041	0.174	5.56E+05	0.0294	5.05E-05	4.47E-05
ZN	8.631	0.671	1.64E+04	0.0350	5.55E-03	3.81E-03
PB	10.540	0.043	4.30E+04	0.0556	8.73E-05	6.19E-05
SR	14.142	25.555	9.17E+04	0.1032	1.32E-02	9.03E-03
Y	14.933	0.582	8.11E+04	0.1142	3.07E-04	2.11E-04

U	13.600	0.321	4.43E+04	0.0957	3.70E-04	2.54E-04
ZR	15.746	0.607	4.33E+04	0.1253	5.46E-04	3.76E-04

Table 13: sample no 5 in time 2000 second

ARO-55 [A0(RES)= 10059] WEIGHT [g/cm^2]: .204

EL	E [KEV]	INT [C/S]	S	T	CONC [FRAC]	ERROR
CA	3.690	0.518	1.44E+02	0.0243	7.09E-01	4.86E-01
TI	4.508	0.025	8.15E+03	0.0072	1.97E-03	1.47E-03
FE	6.400	0.955	2.38E+04	0.0182	1.02E-02	7.01E-03
CU	8.041	0.147	4.96E+05	0.0320	4.32E-05	2.98E-05
ZN	8.631	0.501	1.46E+04	0.0382	4.17E-03	2.86E-03
PB	10.540	0.063	3.83E+04	0.0607	1.26E-05	8.77E-05
SR	14.142	21.212	8.17E+04	0.1129	1.10E-02	7.50E-03
Y	14.933	0.486	7.22E+04	0.1248	2.57E-04	1.76E-04
U	13.600	0.280	3.95E+04	0.1047	3.22E-04	2.21E-04
ZR	15.746	0.757	3.86E+04	0.1370	6.82E-04	4.68E-04

IV. DISCUSSION

The average Concentration of Uranium in the Kurn samples is 103.27 ± 64 ($\bar{x} \pm \sigma$) parts per million. This means that one ton of ore gives 103.27 ± 64 grams of uranium. This study gives an average of 677 ppm and standard deviation of 597 ppm i.e. 677±597 (See the attached Table). It is very important to note that the concentration of the increase when that U decrease. This agrees with decay law where U decay to Th. More interesting is the same one ton of the ore gives 2793± 1930 gram of vanadium (around 3 Kg of Vanadium).About 80 percent of the vanadium now produced is used as ferrovanadium or as a steel additive. Vanadium foil is used as a bonding agent when cladding titanium to steel. Vanadium pent oxide is used in ceramics and as a catalyst. Vanadium is also used to produce a superconductive magnet with a field of 175,000 gauss.

It is very important to note that tables (2) for Kurn sample the higher concentration of U and V are in the same sample (see sample 3). The lower V and U are proportional to each other. The same proportionality is observed in table (3) for Uro area. I.e. the concentration of V and U are proportional to each other in general. This may be related to the fact that these elements are where famed in igneous rocks which are assumed to be formed from molten magma. In this molten state heavy elements reside at the bottom with high concentration, while their concentrations decrease with distant. Thus are expect higher concentration samples to be collected from deep areas .After the calculation of Uranium and vanadium concentrations in Uro and Kurn regions, 5 samples were analyzed by using deferent exposure time a time exposure of 1000 second and 2000 second to determine the effect of exposure time on the concentration of elements. There was a slight increase in concentrations when the exposure time was increased.This means that exposing samples for 1000 second exited all atoms in the sample to emit characteristic X-ray. Thus increasing exposure time dose not excite more atoms. This is why increasing exposure time to 2000 second makes no significant increase in the concentration of elements.

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