Sudan University of Science and Technology

College of Graduate Studies

Uranium and Vanadium mining and ore processing at Sudan.

تنقيب ومعالجة اليورانيوم والفاناديوم في السودان

A thesis submitted in partial fulfillment for the requirements
of PhD degree in physics

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الاستهلال

قال تعالي

)

وَإِذْ تَأَذَّنَ رَبُّكَ لَيَبْعَثَنَّ عَلَيْهِمْ إِلَىٰ يَوْمِ الْقِيَامَةِ مَن يَسُومُهُمْ سُوءَ الْعَذَابِ ۗ إِنَّ رَبَّكَ لَسَرِيعُ الْعِقَابِ ۖ وَإِنَّهُ لَغَفُورٌ رَّحِيمٌ)

(الأعراف) (167)

Dedication:

To the spirit of my mother

To My Father

To MY All breather All Sister

To My All tetchier

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First and foremost , I would like to express my deepest gratitude to

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Deep thanks to my family for their consistent mental support finally ,

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ملخص البحث

اجرية هذة الدراسة لحساب تراكيذ عنصر اليوراينوم في مناطق جبال النوبة بمنطقة جنوب كردفان في منطقتي جبل اورو وجبل كرن حيث تم جمع 40 عينة صخرية من المنطقتين 20 عينة من كل منطقة وتم طحنها وتحويلها الي بودرة حيث استخدمنا في التحليل جهاز حيث تم اخز كل واحد جرام من البودرة و وضعه في الجهاز وحساب تركيز كل عنصر في العينة حيث وضح من التحليل ان متوسط تركيز عنصر اليورانيوم في عينات منطقة كرون 103.27بينما متوسط تركيز عينات منطقة اورو 985.13 وذلك بعد عمل العملية الاحصائية للنتائج واخذ متوسط القيم وهي نسبة معتبرة في الاسواق العالمية .حيث نتج من عملية التحليل التراكيز العالية لعنصر الفينديوم ذو الاهمية الاقتصادية التي تفوق 80% في معظم العينات حيث تم عمل تحليل احصائي لنتائج الفنيديوم حيث كان متوسط تركيز الفينديوم في عينات منطقة كرون 2793 بينما متوسط تركيز الفينديوم في عينات منطقة اورو 3667.45 وهي نسبة ممتاذة جدا . حيث تم عرض اسعار كل من اليورانيوم والفينديوم في الاسواق العالمية حيث يري ان هذة التراكيذ معتبرة جد ويمكن ان تسهم في الاقتصاد لو استغلت بالوجه الصحيح.

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 analysed 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 s amples 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 indicate 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 with 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.

Content:

CHAPTER TWO: (XRF) technique used to identify elemental contents in samples

CHABTER THEREE: URANIUN DEPOSITES AT SUDAN

CHAPTER FOUR: Evaluation of vanadium Deposits in Sudan

CHAPTER FIVE: Result and Discussion

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CHAPTER ONE

Introduction

1.1. Uranium in Africa Compared to Worldwide Uranium Deposits

Today, the global nuclear power generation is over 350 Gigawatts electricity with 30 countries possessing nuclear power programs. Out of this value Africa produces only 1.8 Gigawatts at South-Africa, which is only 0.5% of the total world production [1].

In Africa, a lot of effort is required in various nuclear technologies need to be developed. In the present study, one of the main fields is "Uranium Deposits and Mining". The nuclear incident in Fukushima, Japan might slow down, but will not stop attempts to find and develop Uranium deposits all over the world [2].

Presently, exploration is being carried out in 30countries on the continent of Africa. However, Operating uranium mines in Africa are found only in four countries: Namibia, Niger, RSA and Malawi [3]. The present study aims to focus at the possibility of developing a project for "Uranium Mining and Ore Processing at Sudan.

1.2 Literature Survey

1. Survey of the Worldwide Uranium Deposits [3-8]

- **Uranium Deposits Types:** "Unconformity Related, Sandstone, Hematite Breccia Complex, Quartz-pebble conglomerate, Vein type (granite related U deposits), Black shale deposits and other deposits"
- **World Distribution of Uranium Deposits**
- **World Market for Uranium**
- **Natural Uranium Production Related to The Market Requirements**
- **Supply of and demand for Uranium.**

1.3 Uranium Production:

Basically, there are two uranium production methods: the conventional production and the production via in-situ leaching or rather in-situ recovery (ISR). The exact mining method depends on the properties of the ore body, (like depth, shape, ore content, tectonic) and the type of country rock as well as other factors.

1.4 Conventional Production:

The majority of the uranium is mined in underground mines. The deposits are developed via shafts, drifts, ramps or spiral declines. Ingressing groundwater and the ventilation of the mine often pose problems. The exact production method is chosen according to the characteristics of the deposit. The form of the ore body and the distribution of the uranium in it are especially pivotal. An ore body can be specifically mined by underground methods where less waste material is produced as by open pit methods. Ore bodies near the surface and very large ore bodies are primarily mined by

Open pit mining methods. This enables the use of low cost large equipment. Modern open pit mines can have a depth from a few to over 1,000 m and a diameter of several kilometers. Open pit mines often produce large amounts of waste material. Like in underground mines, large amounts of water have to be drained from the open pit however the ventilation is less problematic.

1.5 ISR Mining:

The ISR method uses injection wells to pump water and small amounts of CO2 and oxygen into the sandstone horizons to leach out the uranium. From recovery wells, the pregnant solution is pumped to the surface for processing. The whole method takes place completely underground. The advantages of this method are obvious: there are no large earth movements like in open pit mines, no waste rock stockpiles or tailings ponds for heavy metals and cyanide. At the surface only the wells are visible and the area around the wells can be used without constraints for farming. With the ISR method low grade deposits can be economically mined, the capital costs for the mine development is significantly reduced. The whole method can be implemented with a minimum of manpower which reduces drastically the operating costs. According to a study of the World Nuclear Association, 25% of the produced uranium outside of Kazakhstan comes from ISR mines.

1.6 The current status of the Uranium Market:

But how does today’s uranium market look like? It is certain that the lack of investments into the procurement structure of the past 40 years – in the infrastructure of mines and processing plants – will very likely prove to be a windfall for the uranium investors in the future! Nevertheless, despite opposition against nuclear energy since the catastrophe in Chernobyl and even more after the events in the nuclear plants in Fukushima (Japan) the number of plants worldwide is at a record high. Only 30 countries currently operate (as of September 1st, 2017) 448 nuclear reactors with a total electrical net output of around 392 Gigawatts. Most of these reactors (99) are located in the USA. But this is only half the truth because emerging countries like China and India need more and more energy and have been focusing on a massive expansion of their nuclear power capacities for some time. It is of no surprise that currently 57 additional nuclear reactors are under construction. The planning was completed for an additional 170 reactors and 372 reactors are in the planning phase. After a 20 year stop a renaissance of the uranium sector is pending – especially in China.

1.7 Demand situation:

China is only at the beginning of the nuclear age:

While many self-appointed experts have predicted the end of the nuclear age, it is only in the development phase in the most populous country in the world. China is operating 38 reactors where most of the electricity is generated by coal power plants. Since the beginning of 2015, 15 new nuclear reactors were put into service. The expansion of the nuclear energy sector in China is enormous and occurs with breathtaking speed! Over two thirds of the Chinese energy consumption is still met by coal power plants. Although China is mining its own coal deposits on a large scale, it is, besides India, one of the biggest coal importers of the world. 30% of the globally produced coal is imported by these two countries. A certain dependency from these coal imports is obvious. This is the point China’s leadership wants to avoid. The obligation to implement climate friendly and clean possibilities for energy generation is only secondary

Matte.

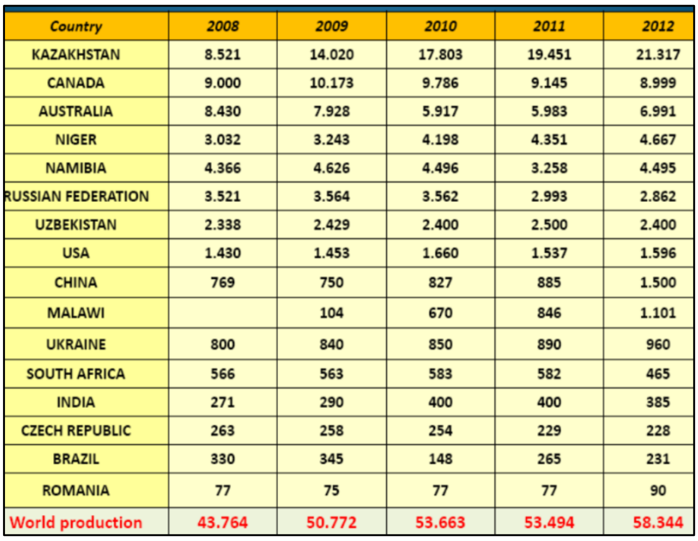
In the fall of 2015 the state-owned power plant manufacturer Power Construction Corporation of China (Beijing) predicted the rise of its country among the biggest user of nuclear energy worldwide the Chinese government is planning the construction of more than 80 nuclear reactors in the coming 15 years and more than 230 new nuclear reactors until

2050. According to information from China Power the new five-year-plan for the energy sector whose approval by the National People's Congress has been planned in March 2016 provides for a faster expansion of the nuclear capacity: to date the capacity was to increase to 58 gigawatts during the coming 5 years, but now over 90 gigawatts are under discussion. In the year 2005 the planning was 40 gigawatts until 2020. Until 2030 110 reactors should be in operation. In the year 2016 alone China started the construction of 6 new reactors. In total 19 nuclear reactors are in the construction phase. According to concepts for the energy sector initial US$ 75 billion are budgeted for the nuclear expansion. In a second step China's nuclear power generation should be expanded to 120 – 160 gigawatts by 2030! While in Germany the elimination of electricity generation from nuclear energy was decided after the events in Fukushima, China has decided the opposite and will do everything possible to produce electricity by nuclear fission. In light of the rising energy demand – due to the increasing prosperity – and a catastrophic carbon footprint China's approach seems only logical.

1.8 World Uranium Production:

Uranium is a naturally occurring radioactive element and its radioactivity is a normal part of the natural background of the environment. Uranium ore is usually mined using open-cut or the underground techniques depending on the location of reserves.

Table 1.1: International Uranium Production by country Country



Country	*2008*	*2009*	*2010*	*2011*	*2012*
KAZAKHSTAN	8.521	14.020	17.803	19.451	21.317
CANADA	9.000	10.173	9.786	9.145	8.999
AUSTRALIA	8.430	7.928	5.917	5.983	6.991
NIGER	3.032	3.243	4.198	4.351	4.667
NAMIBIA	4.366	4.626	4.496	3.258	4.495
RUSSIAN FEDERATION	3.521	3.564	3.562	2.993	2.862
UZBEKISTAN	2.338	2.429	2.400	2.500	2.400
USA	1.430	1.453	1.660	1.537	1.596
CHINA	769	750	827	885	1.500
MALAWI		104	670	846	1.101
UKRAINE	800	840	850	890	960
SOUTH AFRICA	566	563	583	582	465
INDIA	271	290	400	400	385
CZECH REPUBLIC	263	258	254	229	228
BRAZIL	330	345	148	265	231
ROMANIA	77	75	77	77	90
World production	43.764	50.772	53.663	53.494	58.344

Uranium production worldwide [7] is shown in Figure 1. However the given figures are changing rapidly since it is characterized by New Uranium Mining projects in several European countries including Bulgaria, Italy, Poland, Portugal, Russia, Slovakia, Spain, Sweden, Ukraine, and Ireland [4]. As mentioned earlier exploration in Africa is covering 30 countries in the continent.

Deposits of Utility Mineral (DUM) including uranium deposits represent non-renewable natural resources are considered irreplaceable in the economic development of a specific state. Natural and geological portion of DUM determines the technical and technological conditions of its rational use.

1.9 Precious study a bout Uranium in Africa:

- **Namibia:** Two mines produces 10% of the world production[9-10], complete survey studies of the deposits is required, Can Sudan make use of the Namibian expertise
- **Niger:** 1,200 employees, 98% are Nigerien, producing 3,065 tons U annually [11]. Second-largest underground uranium mine in the world, currently the world's fourth largest uranium producer [12].

- **Malawi:** The mine's capacity was 1,500 t/yr of U_3O_8 at 2011, Uranium accounted for nearly 9% of Malawi's exports [13].

- **Republic of South Africa**: In South Africa, uranium is most usually associated with gold or copper ores [14-15].

- **Sudan [16-17]**: Uranium has been discovered in the area of the Nubba Mountains and Hufrat EL Nahas in Darfur, by USA

Company in 1977. Brinkman in 1986 discovered two types of phosphate deposits in Kurun and Uro areas in the center of eastern Nubba Mountains contain uranium

1.9.1 Uranium in Africa.

Africa holds 18% of the world’s uranium resources. Interest in African uranium initially stemmed from the US’s military nuclear ambitions. Exploration and mining began in the DRC (The Democratic Republic of Congo). However, expanding demand for energy, rising global oil prices and increased concern for climate change have revived interest in uranium mining and exploration in general. Much of this interest has focused on Africa because of its relatively accessible uranium, flexible regulations and low labour costs. Most uranium mining companies concentrate their efforts on the largest available uranium deposits, in Namibia and Niger. Others are looking into smaller; untapped potential uranium fields (e.g. in the Central African Republic). There is growing demand from nuclear energy worldwide; interest in Africa’s uranium is set to grow. Africa should welcome this demand provided that it fits into stronger local and regional political frameworks.

Uranium deposits are found throughout Africa and currently exploration is being carried out in 30 countries on the continent, 10 of which are members of the southern African Development community (SADC). However, there are only a few mines in a Chula operation at present.
The future is bright for mining in the Africa. In Africa, over 30% of the world’s global mineral reserves are found [6] . Yet less than 5% of the total global mineral exploration and extraction budget is invested in the continent.

In Africa building infrastructure is critical for the continued growth of the mining sector. Reports by leading global advisories suggest that African governments are presently unable to meet demand for key infrastructure including rail-roads, ports and energy projects. Private participation and investment is being actively encouraged.

The opportunities for mining resource and infrastructure companies are impressive. However, there are also many obstacles. As a part of the quest the mineral rich countries have to realize the need for modern open and transparent regulatory frameworks. Many countries in the Africa have either recently introduced or are working on hew mining laws that seek to encourage investment.

In Africa, support has been offered by international institutions: including the World Bank and the International Finance Corporation to develop transparent and investor-focused mining laws. At the government level Many African countries have planned mining allowances and specific import duty exemptions to encourage foreign investment in infrastructure building.

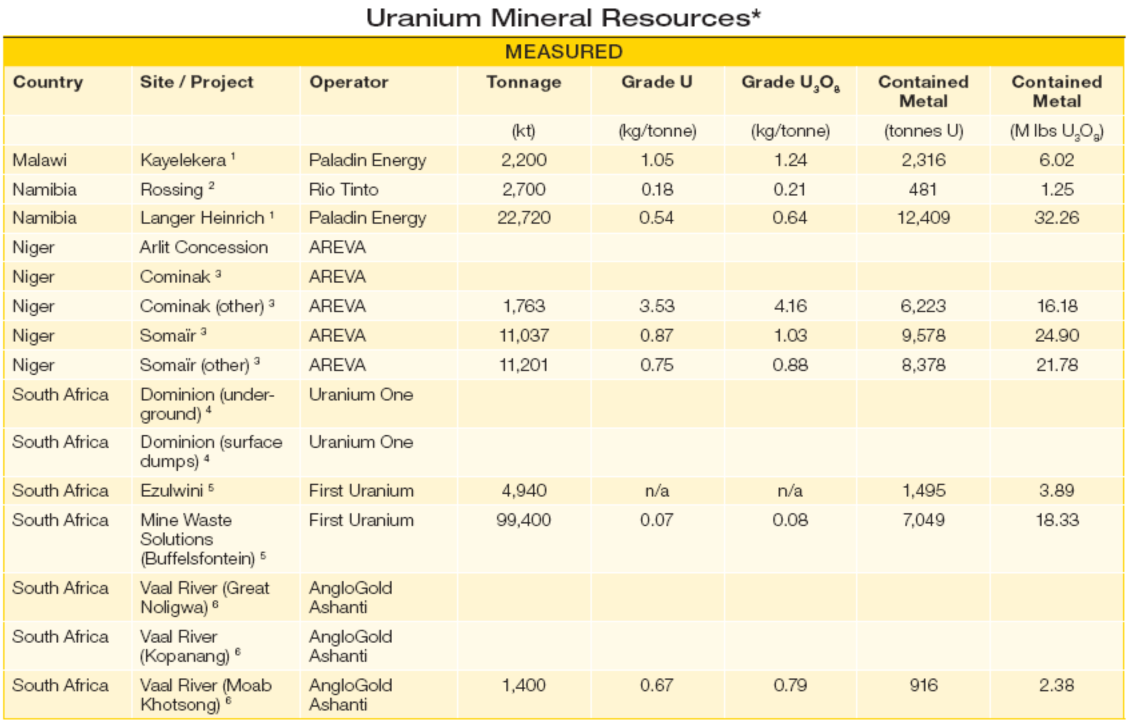
With the worldwide increase in the demand for uranium there are number of projects throughout the continent, which are an advanced stage of development especially in Niger, central Africa Republic, Namibia, South Africa, Tanzania Malawi, and Zambia.

At the moment the market price of uranium has put a number of projects on hold. This creates an opportunity to review and strengthen measures to reduce proliferation risks associated with uranium extraction in Africa [8].

Mining in south Africa more than 120 year 73,000 tones as uranium leaves south Africa Besides , since 1980 the south Africa government did not sell its uranium but deposited the uranium on tailing storage facilities contained between450,000 tones and 600,000 tons of uranium [10].

Uranium both presents a dust out as well as water pollution risks uranium in the gold tainting contains higher uranium levels than tailings of uranium mines.

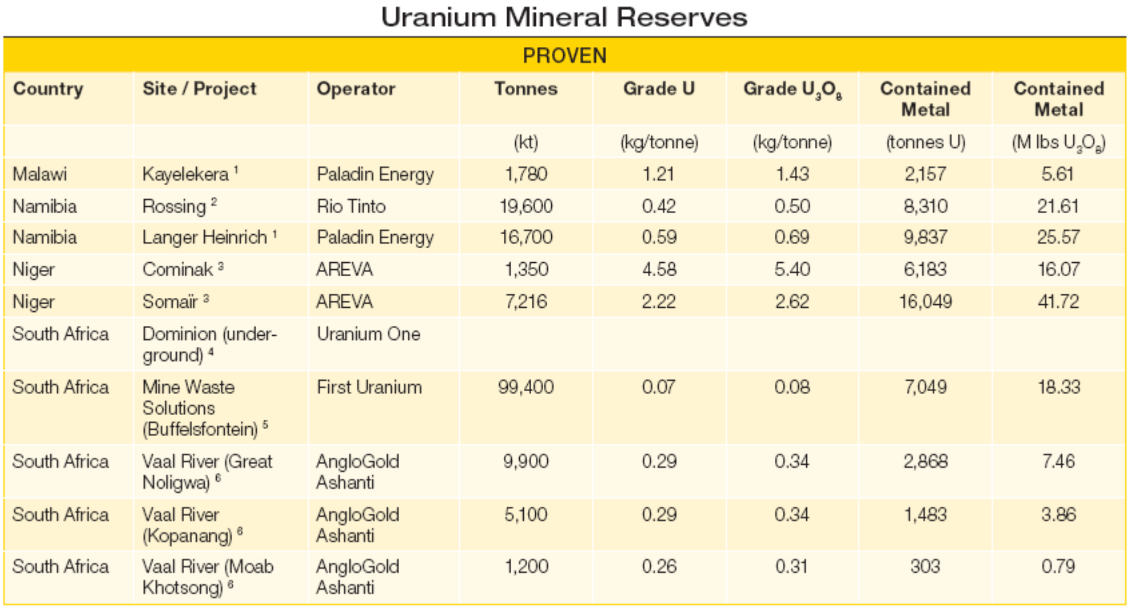
Table 1.2.1 Uranium Mineral Resources



Uranium Mineral Resources*

MEASURED							
Country	**Site / Project**	**Operator**	**Tonnage**	**Grade U**	**Grade U_3O_8**	**Contained Metal**	**Contained Metal**
			(kt)	(kg/tonne)	(kg/tonne)	(tonnes U)	(M lbs U_3O_8)
Malawi	Kayelekera [1]	Paladin Energy	2,200	1.05	1.24	2,316	6.02
Namibia	Rossing [2]	Rio Tinto	2,700	0.18	0.21	481	1.25
Namibia	Langer Heinrich [1]	Paladin Energy	22,720	0.54	0.64	12,409	32.26
Niger	Arlit Concession	AREVA					
Niger	Cominak [3]	AREVA					
Niger	Cominak (other) [3]	AREVA	1,763	3.53	4.16	6,223	16.18
Niger	Somaïr [3]	AREVA	11,037	0.87	1.03	9,578	24.90
Niger	Somaïr (other) [3]	AREVA	11,201	0.75	0.88	8,378	21.78
South Africa	Dominion (under-ground) [4]	Uranium One					
South Africa	Dominion (surface dumps) [4]	Uranium One					
South Africa	Ezulwini [5]	First Uranium	4,940	n/a	n/a	1,495	3.89
South Africa	Mine Waste Solutions (Buffelsfontein) [5]	First Uranium	99,400	0.07	0.08	7,049	18.33
South Africa	Vaal River (Great Noligwa) [6]	AngloGold Ashanti					
South Africa	Vaal River (Kopanang) [6]	AngloGold Ashanti					
South Africa	Vaal River (Moab Khotsong) [6]	AngloGold Ashanti	1,400	0.67	0.79	916	2.38

Table 1.2.2 Uranium Mineral Resource



Uranium Mineral Reserves

PROVEN							
Country	**Site / Project**	**Operator**	**Tonnes**	**Grade U**	**Grade U_3O_8**	**Contained Metal**	**Contained Metal**
			(kt)	(kg/tonne)	(kg/tonne)	(tonnes U)	(M lbs U_3O_8)
Malawi	Kayelekera [1]	Paladin Energy	1,780	1.21	1.43	2,157	5.61
Namibia	Rossing [2]	Rio Tinto	19,600	0.42	0.50	8,310	21.61
Namibia	Langer Heinrich [1]	Paladin Energy	16,700	0.59	0.69	9,837	25.57
Niger	Cominak [3]	AREVA	1,350	4.58	5.40	6,183	16.07
Niger	Somair [3]	AREVA	7,216	2.22	2.62	16,049	41.72
South Africa	Dominion (underground) [4]	Uranium One					
South Africa	Mine Waste Solutions (Buffelsfontein) [5]	First Uranium	99,400	0.07	0.08	7,049	18.33
South Africa	Vaal River (Great Noligwa) [6]	AngloGold Ashanti	9,900	0.29	0.34	2,868	7.46
South Africa	Vaal River (Kopanang) [6]	AngloGold Ashanti	5,100	0.29	0.34	1,483	3.86
South Africa	Vaal River (Moab Khotsong) [6]	AngloGold Ashanti	1,200	0.26	0.31	303	0.79

1.9.1.1 Uranium in Namibia:

Uranium was discovered in the Namib Desert in 1928, but was not until intensive exploration got under way in the late 1950s that much interest was shown in Rössing. Rio Tinto discovered numerous uranium occurrences and in 1966 took the rights over the low-grade Rössing deposit, 65 km inland from Swakopmund.

Namibia has two significant uranium mines capable of providing 10% of world mining output. During the last decade a rapid increase occurred in uranium exploration activities in Namibia. This has been driven by the global commodities boom, record-high uranium prices, increasing global liquidity and Namibia's perception as an exploration-friendly country [8].

Table1. 3: Namibia Uranium Production during the period 208-2016, Tones of Uranium

Year		**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Rössing	Rio Tinto	3449	3519	3083	2641	2289	2043	1308	1057	1569
Langer Heinrich	Paladin	919	1108	1419	1437	1960	2098	1947	1937	1903.5
Trekkopje	Areva	0	0	0	0	251	186	0?	0?	0?
Total					4078	4500	4327	3255	2994	3472

Table 1.2 shows the development of uranium production in the main mines in Namibia during the tears 2008 to 2016. Namibia's Rössing Uranium Mine is the third largest uranium mine in the Western world, producing around 7.8% of the world's uranium. Paladin Resources Langer Heinrich mine has been commissioned within four years without any major administrative hassles. Further, Namibia is home to a number of known uranium deposits for which extensive data is available. Most of the companies active in uranium exploration have, in fact, focused on uranium deposits previously explored.

Rio Tinto owns 68.6% of Rössing Uranium Mine, which was discovered in 1928 and started operations at the large scale open pit mine in 1976. In 2006, Rössing was the third largest uranium mine in the western world, producing 7.8% of world uranium [9]. Yellowcake from Rössing Uranium is sold to European, Chinese, USA and Asia–Pacific electricity producers.

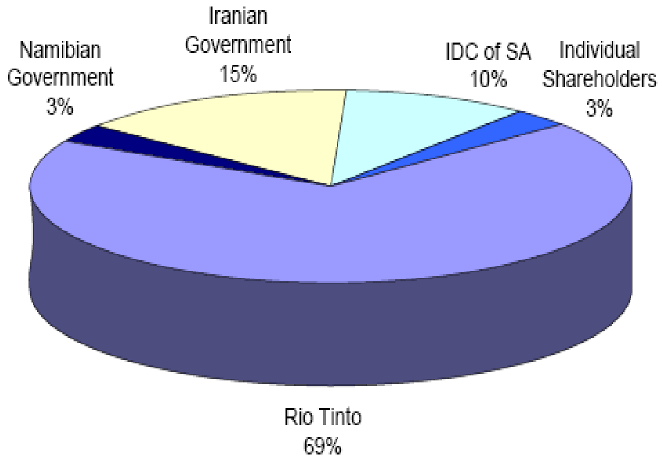


FIG 1.1: Rsossing's Shareholding

1.9.1.2 Republic of Niger:

The search for uranium in Niger began in the 60s and its mining in the 70s. As given the drop in uranium prices in the 80s, these activities decreased significantly. The exploration activities took place in 2006 when many mining companies were very interested in the research of this radioactive metal (uranium).

In 2007, Niger had more than 150 exploration licenses (all minerals included) whose more than 100 uranium exploration permits. It had two (2) uranium operating mining companies (COMINAK and SOMAIR) till 2008 and it passed to four (4) mining companies in 2009,

Three uranium mining companies are operating since 2011 (SOMAIR, COMINAK, SOMINA). 4275 tU are produced in 2013. The forecast 2014 uranium production is 4 254 tU. • SOMAIR and COMINAK mining Contracts are expired on 31st December 2013; • on 27 December 2013, the Niger Government extended SOMAIR and COMINAK mining Contracts till the end of the negotiation of new contracts.

In 1964 the coal deposit of Thirozerine was also discovered. It is currently operated by SONICHAR and produces electricity for the northern Agadez region, including the uranium mines [10].

Historically, uranium mining in Gabon has been closely linked with Niger due to the role of the French Atomic Energy Commission and Cogema (now Areva NC).

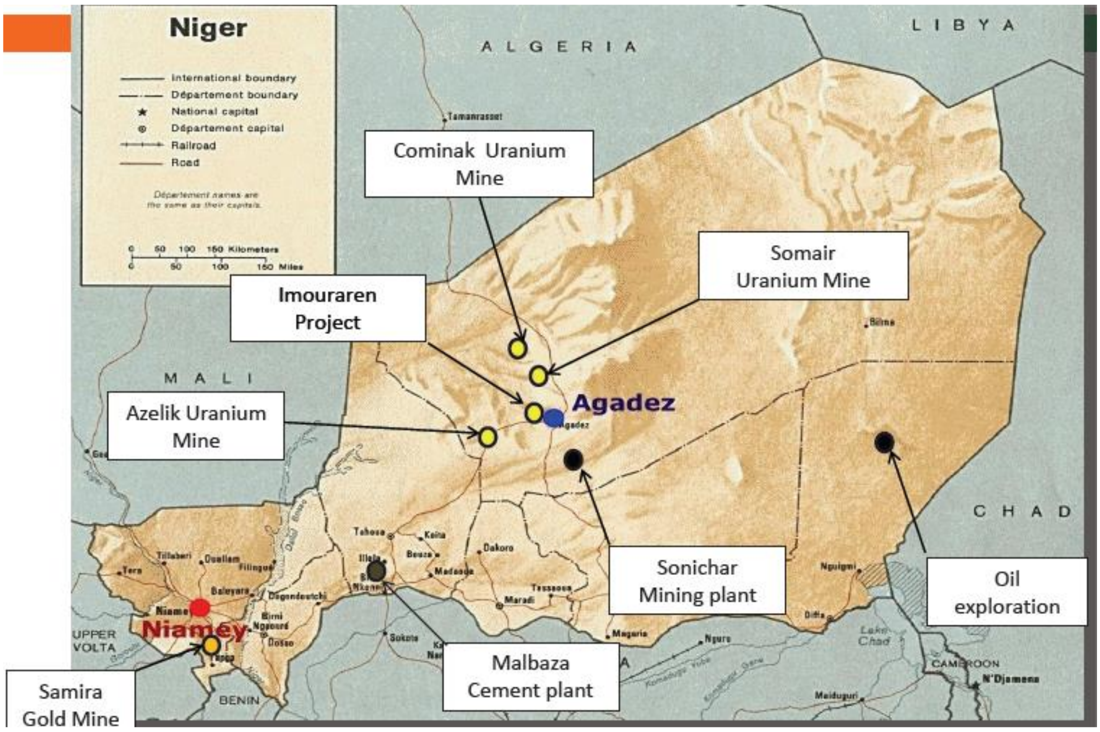


FIG 1.2: The Main Uranium Mines at Niger

Niger is the world's fourth-ranking producer of uranium. In 2011 it produced 4351 tU, and cumulative production from the country was 114,346 tU to the end of 2010. About 62,000 tU of this was from underground, and 52,000 t from open pit mining.

Uranium is mined close to the twin mining towns of Arlit and Akokan, 900 km north-east of the capital Niamey (more than 1,200 km by road) on the southern border of the Sahara desert and on the western range of the Air mountains. The concentrates are trucked 1600 km to Parakou in Benin, then railed 400 km to Cotonou port and exported for conversion, mostly to Comurhex in France.

Production is first sold to the partners in proportion to their equity at an 'extraction price' determined by the government, notionally based on operation costs, but somewhat higher. From February 2012 the extraction price is CFA 73,000/kgU ($145/kgU), paid in Euros. The partners then sell or use it, in the case of the government, through a trading company.

Areva’s SOMAIR and COMINAK were licensed to the end of 2013, and in mid-December 2013 both were shut down for maintenance, pending resolution of negotiation on licence renewal. The Niger government has been seeking a new deal to be based on the 2006 mining law, which raised royalty taxes from 5.5% as set in the 10-year licence to between 12% and 15%, depending on profits. However, current low uranium prices limited the economic scope for higher taxes, and negotiations were protracted. The mines resumed operation at the end of January 2014 under the terms of a government decree.

In May 2014 the government and Areva signed a new five-year agreement for the two mines based on the 2006 mining law and expressing what both sides said was a balanced partnership. The royalty rate will increase potentially to 12% of market value, but depending on profitability. The deal includes for the first time that the firms' boards will include Nigerien managing directors – appointed this year for SOMAIR, and in 2016 for COMINAK. Also, Areva will provide €90 million ($122 million) to support constructing a road from Tahoua to Arlit, near the uranium developments, as well as a further €17 million ($23.1 million) for development in the surrounding Irhazer Valley. Areva will also build a new headquarters building for the two operations in the capital Niamey at a cost of €10 million ($13.6 million). The government expects more than $39 million in additional tax revenues annually from the new agreement. In October 2014 the government formally approved the agreement.

Areva's Niger website [11] documents some of the wider issues involved with its long-term activity in the country. Areva claims that "in 2013, 90% of the direct revenue from the mines went to the state of Niger."

1.9.1.3 Uranium in Malawi:

Deposits are allocated as sandstone-hosted uranium within the Permian Karoo Sandstones. Uranium occurs as Coffinite U (SiO_4) $(OH)_4$ and minor Uraninite (UO_2). Six principal mineralized lenses form bulk of mineralization. Hosted within distinct arkose units and occur to a depth of 100 m from surface Mudstone layers sandwiched, between arkose layers some of which are mineralized. Resource contains approximately 13 600 tonnes of recoverable U_3O_8 with a grade of approximately 800 ppm U_3O_8.

1.9.1.4 Uranium at South Africa:

The Karoo Uranium Province is located in the south-western part of South Africa, while the Springbok Flats Basin is located in the northern part of South Africa. The surface deposits of the Namaqualand region occur in the north-western part of South Africa. Uranium has been produced in South Africa since 1952. The highest uranium production in the country was attained**.**

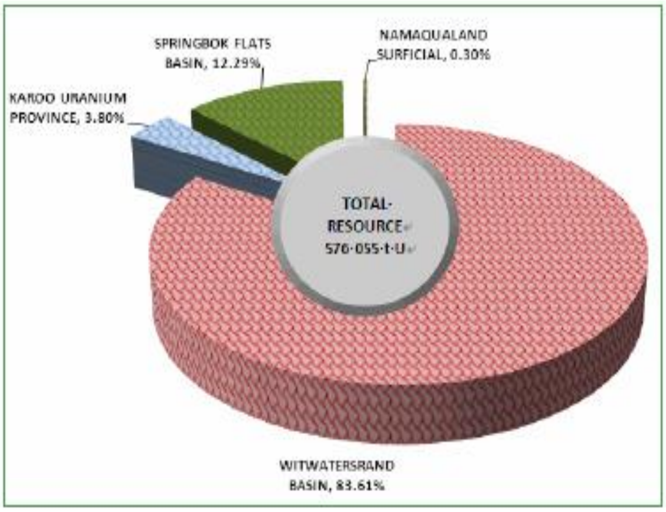


FIG.1.3: Proportions of South Africa's uranium resources in the major deposits

The total contained in-situ uranium resources in South Africa is about 679,310 t U_3O_8 (which is equivalent to about 1820 million troy pounds (Mlb) U_3O_8 or 576,055 tU) as summarized in Table 1. The largest proportion of South Africa's identified in-situ uranium resources (about 84%) are hosted by the quartz-pebble conglomerate of the Witwatersrand Basin and their associated tailings. About 12% of the nation's in-situ resources are hosted by coal and carbonaceous shale of the Springbok Flats Basin, 4% in the sandstones of the Karoo Uranium Province, and less than 1% in the Namaqualand surface deposits.

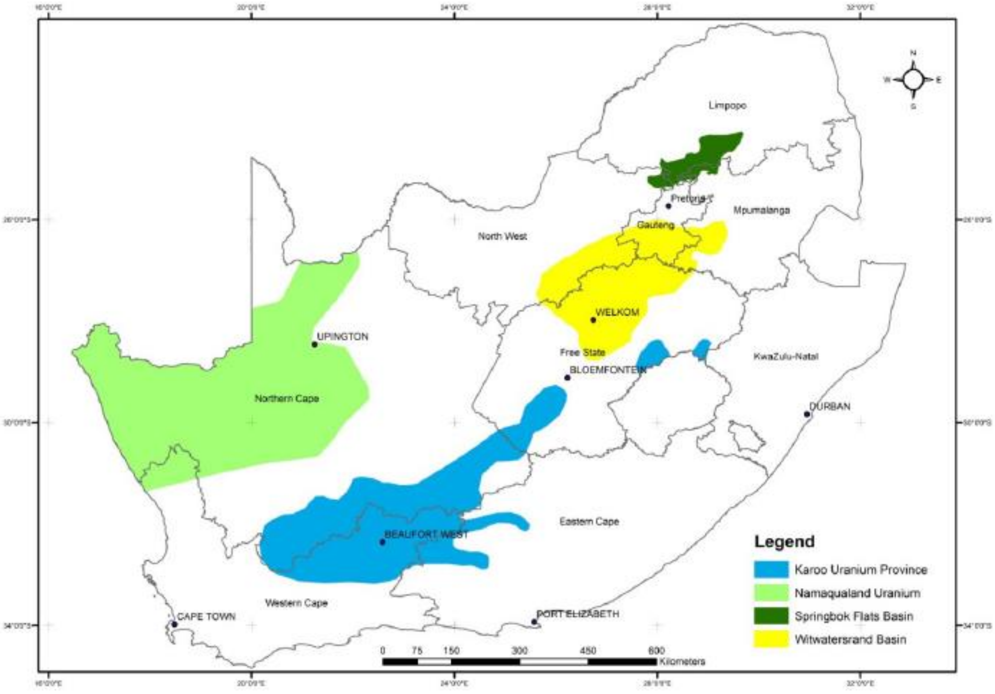


FIG 1.4: Map showing major uranium deposits in South Africa

1.10 Research problem: The research problem is related to the lack of study abundance of uranium and vanadium in some areas in Sudan

1.11 Aim of the Work

The study could be divided into two main parts. The first part will focus on Uranium (the only used nuclear fuel till now) presently and prospective deposits at Sudan compared to that of other African countries. The second part will be a proposed project for Uranium Mining and Ore Processing at Sudan.

The proposed study will include the following:

1. Survey of the worldwide Uranium deposits
2. Uranium deposits in Africa
3. Studies on the Uranium exploration and deposits at Sudan
4. A proposal for development of a project for uranium mining and ore processing at Sudan including [18].

a. Exploration and methods of area selection
b. Resource estimation: Calculation of volume, tonnage, average grade and uranium content of ore blocks; Conventional resource appraisal methods, Statistical and geo-statistical methods
c. Pre-Feasibility Study: Basic technical studies: Mining, Processing, Infrastructure,
d. Licensing: Environmental Impact, Legal and Social Aspects, Radiation Protection
e. Detailed Feasibility Study

CHAPTER TWO

(XRF) technique used to identify elemental contents in samples

2.1 Introduction:

X-ray fluorescence (XRF) technique is one of the important physical techniques used to identify elemental contents in samples. So this chapter is concerned with the physics. Instrumentation and measurement techniques of (XRF).

(XRF) analysis is a powerful analytical tool for the petrochemical determination of almost all the elements present in a sample.

The method is fast, accurate and non-destructive, and usually requires only a minimum of sample preparation. Applications are very broad and include the metal, cement, oil, polymer, plastic and food industries, along with mining,

mineralogy and geology, and environmental analysis of water and waste materials. (XRF) is also a very useful analysis technique for research and pharmacy.

(XRF) radiation is induced when photons of sufficiently high energy, emitted from an X-ray source, impinge on a material. These primary X-rays undergo interaction processes with the analyte atoms. High-energy photons induce ionization of inner shell electrons by the photoelectric effect and thus electron vacancies in inner shells (K, L, M,) are created. The prompt transition of outer shell electrons into these vacancies within some 100 fs can cause the emission of characteristic fluorescence radiation. Not all transitions from outer shells or subshells are allowed, only those obeying the selection rules for electric dipole radiation. The creation of a vacancy in a particular shell results in a cascade of electron transitions, all correlated with the emission of photons with a well-defined energy corresponding to the difference in energy between the atomic shells involved. The family of characteristic X-rays from each element including all transitions allows the identification of the element.

FIG 2.1 shows tow type of XRF used in sample analyzed

Spectrometer system s can be divided into two main groups: energy dispersive systems (EDXRF) and wavelength dispersive systems (WDXRF), explained in more detail later. The elements that can be analyzed and their detection levels mainly depend on the spectrometer system used. The elemental range for EDXRF goes from sodium to uranium (Na to U). For WDXRF it is even wider, from beryllium to uranium (Be to U). The concentration range goes from (sub) ppm levels to 100%. (14).

Generally speaking, the elements with high atomic numbers have better detection limits than the lighter elements.

The precision and reproducibility of (XRF) analysis is very high. Very accurate results are possible when good standard specimens are available, but also in applications where no specific standards can be found.

The measurement time depends on the number of elements to be determined and the required accuracy, and varies between seconds and 30 minutes. The analysis time after the measurement is only a few seconds.

Figure 1 shows a typical spectrum of a soil sample measured with EDXRF – the peaks are clearly visible. The positions of the peaks determine the elements present in the sample, while the heights of the peaks determine the concentrations.

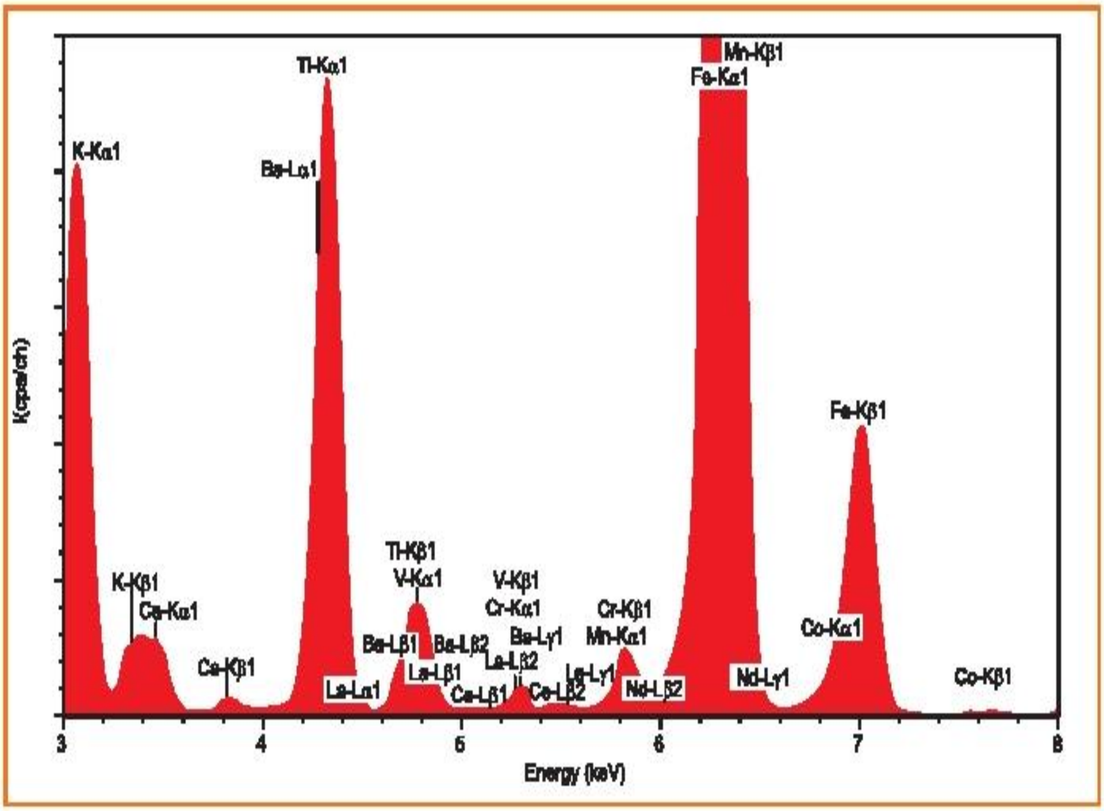


FIG 2.2 shows a typical spectrum of a soil sample measured with EDXRF Spectrometer (14).

2.2 Interaction of X- ray with matter

There are three main interactions when X-rays contact matter: Fluorescence, Compton scatter and Rayleigh scatter. If a beam of X-ray photons is directed towards a slab of material a fraction will be transmitted through, a fraction is absorbed (producing fluorescent radiation) and a fraction is scattered back. Scattering can occur with a loss of energy and without a loss of energy. The first is known as Compton scatter and the second Rayleigh scatter.

When X-ray beam passes through matter, some photons will be absorbed inside the material or scattered away from the original path, as illustrated in Fig. 2.2 The intensity I0 of an X-ray beam passing through a layer of thickness d and density ρ is reduced to an intensity I according to the well-known law of Lambert-Beer:

$I = I_0\, e^{-\mu\rho d}$ (1)

The number of photons (the intensity) is reduced but their energy is generally unchanged. The term μ is called the mass attenuation coefficient and has the dimension cm2/g. The product μL = μρ is called the linear absorption coefficient and is expressed in cm-1. μ(E) is sometimes also called the total cross-section for X-ray absorption at energy (15).

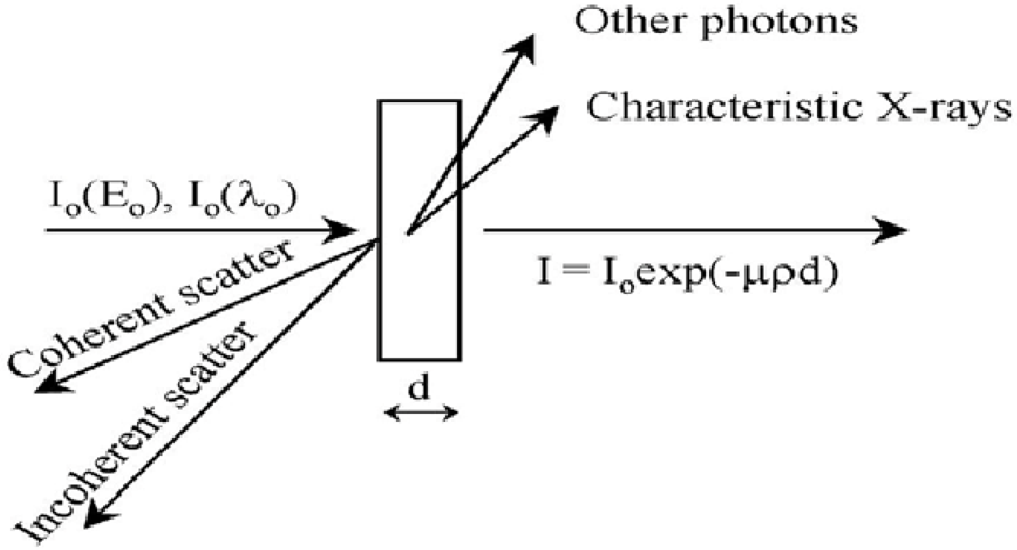


FIG 2.3 Interaction of X-ray photons with matter.

Figure 2.3 shows a log-log plot of the energy dependence of the mass attenuation coefficient of several chemical elements in the X-ray energy range between 1 and 100.

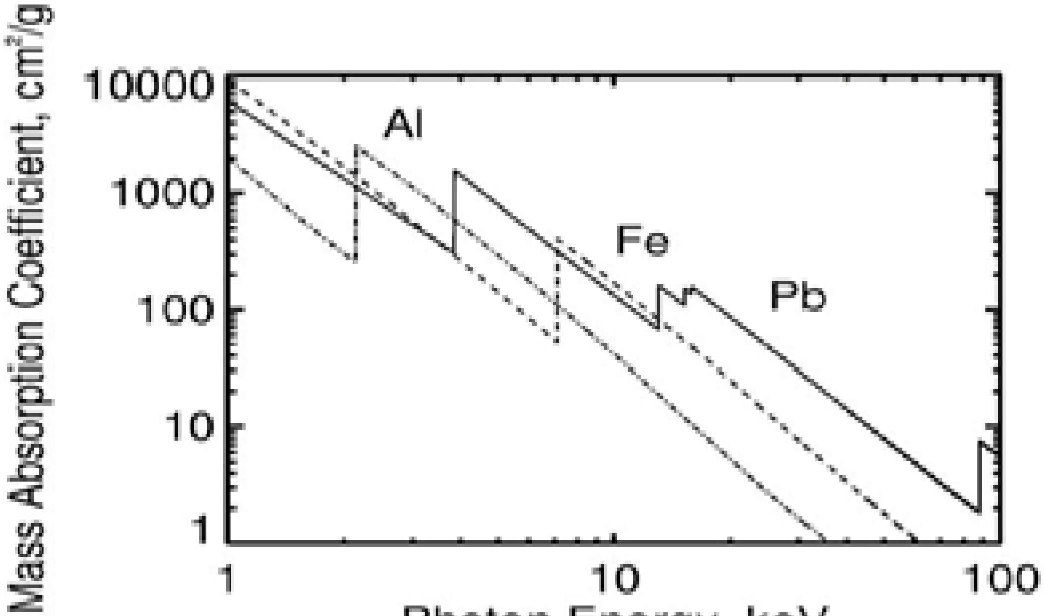


FIG 2.4 Energy dependence of the mass absorption coefficient μ of several elements.

The mass absorption coefficient μ(M) of a complex matrix M consisting of a mixture of several chemical elements (e.g., an alloy such as brass), can be calculated from the mass attenuation coefficient of the n constituting elements:

$\mu(M) = \Sigma w_i \mu_i$ **(2)**

where μ_i is the mass attenuation coefficient of the ith pure element and w_i its mass fraction in the sample considered. This is called the mixture rule.

The mass absorption coefficient μ plays a very important role in quantitative XRF analysis. Both the exciting primary radiation and the fluorescence radiation are attenuated in the sample. To relate the observed fluorescence intensity to the concentration, this attenuation must be taken into account.

As illustrated in Fig. 3, the absorption of radiation in matter is the cumulative effect of several types of photon-matter interaction processes that take place in parallel. Accordingly, in the X-ray range the mass attenuation coefficient μ_i of element i can be expressed as:

$\mu_i = \tau_i + \sigma_i$ (3)

where τ_i is the cross-section for photo-electric ionization and σ_i the cross-section for scattering interactions [16].

2.3 Natural Decay Series of Uranium

Uranium, radium, and thorium occur in three natural decay series, headed by uranium-238, thorium-232, and uranium-235, respectively. In nature, the radionuclides in these three series are approximately in a state of secular equilibrium, in which the activities of all radionuclides within each series are nearly equal. Two conditions are necessary for secular equilibrium. First, the parent radionuclide must have a half-life much longer than that of any other radionuclide in the series. Second, a sufficiently long period of time must have elapsed, for example ten half-lives of the decay product having the longest half-life, to allow for ingrowth of the decay products (see the companion fact sheet on Ionizing Radiation). Under secular equilibrium, the activity of the parent radionuclide undergoes no appreciable changes during many halflives of its decay products. The radionuclides of the uranium-238, thorium-232, and uranium-235 decay series are shown in Figures (2.5) N.1, N.2, and

N.3, along with the major mode of radioactive decay for each. Radioactive decay occurs when an unstable (radioactive) isotope transforms to a more stable isotope, generally by emitting a subatomic particle such as an alpha or beta particle. Radionuclides that give rise to alpha and beta particles are shown in these figures, as are those that emit significant gamma radiation. Gamma radiation is not a mode of radioactive decay (such as alpha and beta decay). Rather, it is a mechanism by which excess energy is emitted from certain radionuclides, i.e., as highly energetic electromagnetic radiation emitted from the nucleus of the atom. For simplicity, only significant gamma emissions associated with the major decay modes are shown in Figures N.1 through N.3; that is, radionuclides listed are those for which the radiation dose associated with gamma rays may pose a health concern. The gamma component is not shown for those radionuclides whose gamma emissions do not generally represent a concern.

Of the two conditions noted above for secular equilibrium, the first is generally met for the uranium-238, thorium-232 and uranium-235 decay series in naturally occurring ores. While the second condition may not be met for all ores or other deposits of uranium and thorium (given the extremely long half-lives for the radionuclides involved and the geological changes that occur over similar time scales), it is reasonable to assume secular equilibrium for naturally occurring ores to estimate the concentrations of the various daughter radionuclides that accompany the parent. The state of secular equilibrium in natural uranium and thorium ores is significantly altered when they are processed to extract specific radionuclides. After processing, radionuclides with half-lives less than one year will reestablish equilibrium conditions with their longer-lived parent radionuclides within several years. For this reason, at processing sites what was once a single, long decay series (for example the series for uranium-238) may be present as several

Smaller decay series headed by the longer-lived decay products of the original series (that is, headed by uranium-238, uranium-234, thorium-230, radium-226, and lead-210 in the case of uranium-238). Each of these sub-series can be considered to represent a new, separate decay series. Understanding the physical and chemical processes associated with materials containing uranium, thorium, and radium is important when addressing associated radiological risks.

In the fact sheets developed for uranium, radium, and thorium, the contributions of radionuclides having half-lives less than one year were included in the risk coefficients. (Each fact sheet identifies which radionuclides are included in these coefficients.) In some situations, it may be necessary to add the radiological risk identified for a given radionuclide to that of its parent radionuclide to properly represent the total risk. For example, the radiological risk for thorium-232 is comprised of the risk for thorium-232 plus the risk for radium-228. Decay series information should be used together with the information in these fact sheets to ensure that the radiological risks associated with uranium, radium, and thorium areproperly estimated and represented.

2.4 The decay chain starting with U-238 is called the uranium decay chain.

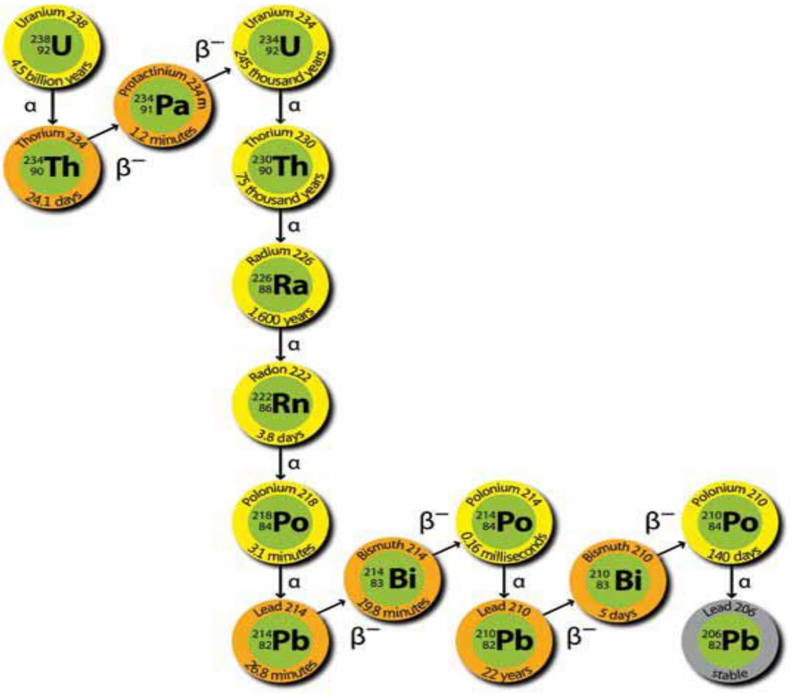


FIG: 2.5 The decay chain starting with U-238 is called the uranium decay chain.

2.5 Radioactive half-life is the amount of time it takes for one-half of a given material to undergo radioactive decay.

A long half-life means the element decays slowly, so is weakly radioactive.
A short half-life means the element decays quickly, so is strongly Radioactive.
To illustrate: for 100 apples with a half-life of 1 day,

- After 1 day, 50 apples have decayed,
- After 2 days, another 25 apples have decayed,
- After 3 days, another 12 (or 13) have decayed, and so on.

2.6.1 Uranium-238 Decay Series:

Most common isotope is uranium-238
U-235 (NOT U-238) is the fuel for most nuclear power plants worldwide

U-238 decomposes via a series of spontaneous nuclear reactions

- Ultimate product is lead-206
- Produces a series of radioactive intermediates in its decay series
- One of them is famous: radon-222.

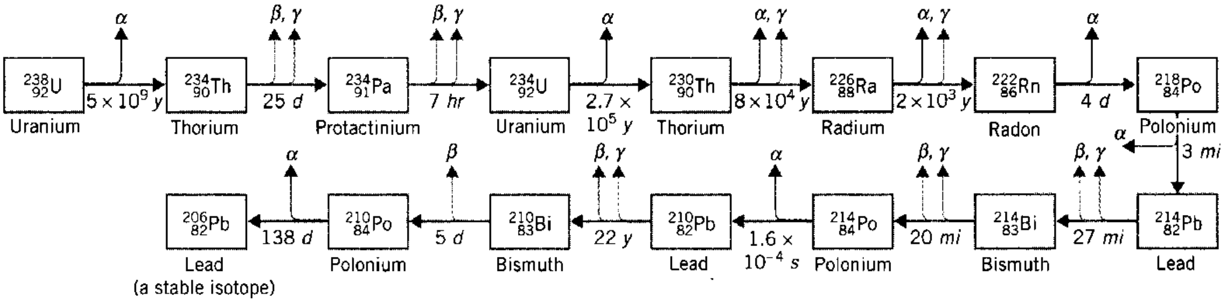


FIG 2.6.1 Uranium-238 Decay Series:

2.6.2 Uranium-238 Decay Series:

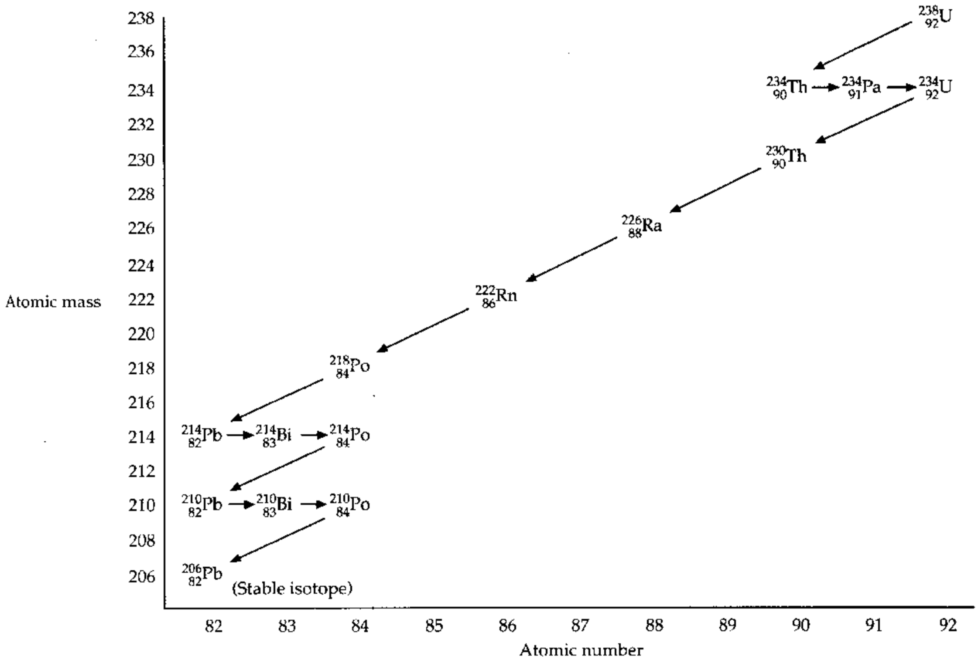


FIG 2.6.2 Uranium-238 Decay Series

2.7 Nuclear Chain Reactions:

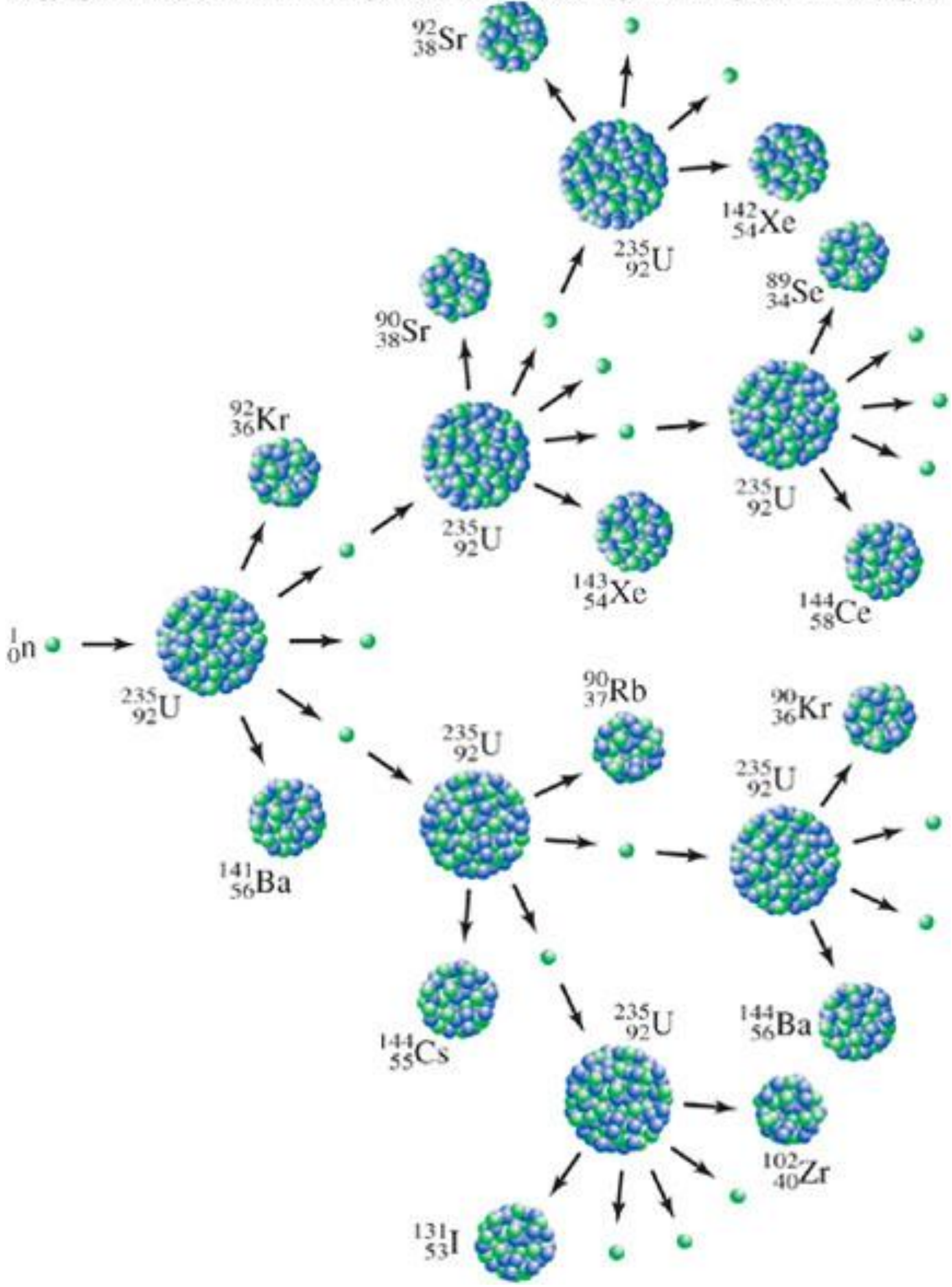


FIG 2.7 Nuclear Chain Reactions

2.7.1 Chain reaction:

Neutron products induce further fission rxns

Daughter reactions produce still more neutrons that can induce reactions, etc

2.7.2 Generation ratio

Defined as the fraction of neutron products that can induce a further (neutron-producing) fission rxn

Needs to be controlled at exactly 1.00000 (etc)

- 2.7.3 Too small: rxn is rapidly quenched
- 2.7.4 Too large: boom! (It “goes critical”)

CHABTER THEREE

URANIUN DEPOSITES AT SUDAN

3.1 Literature Review:

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 have been discovered in the area of the Nuba Mountains and Hufrat EL Nahas in Darfur by USA Company in 1977 [17].

During 1978 and 1979, uranium exploration activities were performed in Sudan by two companies; Azienda Generale 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 [18].
Brinkman in 1986 discovered two types of phosphate deposits in Kurun and Uro areas in the center of eastern Nuba Mountains contain uranium [17].

Previously, many studies concerning uranium deposits in Sudan have been conducted in various areas [19-21]. The result of the most studies has revealed without doubt that the Uranium and Thorium concentrations are lower than world wide data.

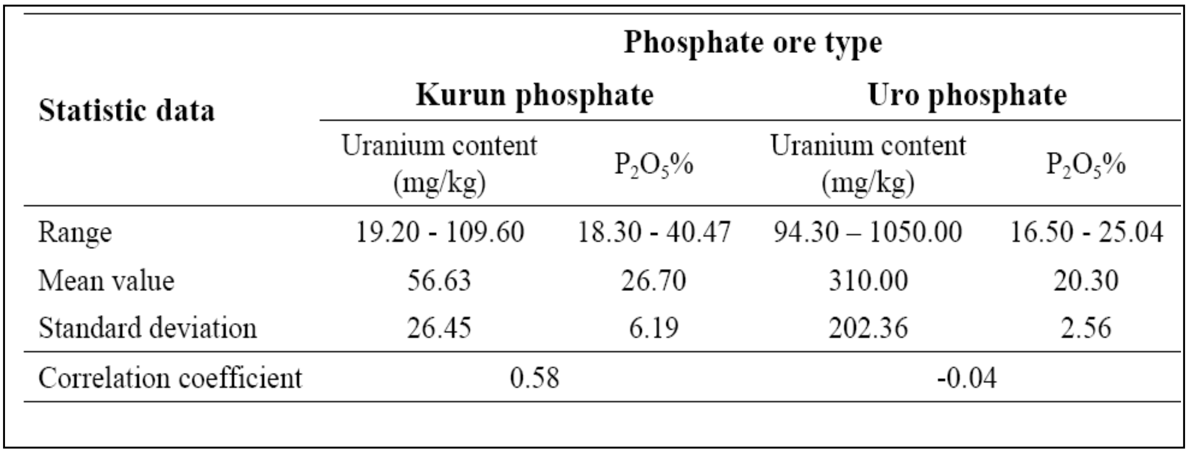
However, a study published at 2014 [22], gave detailed information concerning uranium recovery from Sudanese phosphate ores. This study was carried out in a laboratory scale to recover uranium from Uro area phosphate ore in the eastern part of Nuba Mountains in Sudan. Phosphate ore samples were collected, 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 603.3 µg/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%.

FIG 3.1: Map of Sudan showing the location of the study area.

Moreover, in a published study by Abdel Majid and Eltayeb [23], where several phosphate samples were collected and analysed, it was shown that that uranium content is very high in all of the collected samples relative to the average uranium content in the earth's crust and shale rocks which is 2.7 and 3 mg/kg, respectively [24-25]. On the other hand, the Uro phosphate samples show very high contents relative to the average of the word phosphates (120 mg/kg) [26].

The next Table shows the summery of Abdelmajid and Eltayeb work:

Table3.1: Summary of the statistics of the uranium content results obtained by Abdelmajid and Eltayeb.



Statistic data	Phosphate ore type			
	Kurun phosphate		Uro phosphate	
	Uranium content (mg/kg)	$P_2O_5\%$	Uranium content (mg/kg)	$P_2O_5\%$
Range	19.20 - 109.60	18.30 - 40.47	94.30 – 1050.00	16.50 - 25.04
Mean value	56.63	26.70	310.00	20.30
Standard deviation	26.45	6.19	202.36	2.56
Correlation coefficient	0.58		-0.04	

It was concluded that Kurun and Uro areas are areas of trace level of uranium content in the range from 27.7 to 310 mg/kg. Uro phosphate ore shows high significant differences in uranium concentrations than Kurun phosphate. The mean uranium content in Kurun and Uro phosphate ore are 56.6 and 310 mg/kg, respectively. Moreover, the results have evidenced that Uro phosphate is considered as secondary uranium source, and is more suitable for uranium recovery. The phosphate ore of Kurun is more suitable for phosphate fertilizer industry.

3.1.1 Uranium in Sudanese phosphate:

The phosphate deposits, which are the prime source of phosphate used in the manufacture of phosphate fertilizers and phosphoric acid, contain low concentrations of uranium in fine-grained apatite. This type of deposit is considered to be an unconventional source of uranium; this offers the phosphate industry an attractive opportunity to recover uranium as a by-product of fertilizers and, therefore, has greatly renewed interest in the wet-process phosphoric acid as a significant source of uranium (IAEA, 1990; Becker, 1993) [27]. In Sudan, there is a great need to obtain cheap and safe sources of phosphoric acid and phosphate fertilizers. The need to fertilizers increases annually with the increase of Sudan population

And the global demand of grains. Brinkman (1986) .Discovered two types of phosphate deposits in Kurun an Uro areas in the center of eastern part of Nubba Mountains. Presently, phosphate ores from Kurun and Uro areas became the subject of intensive studies by several Investigators. The natural radionuclide content of phosphate has been documented by several works (Sam and Holm, 1995; Sam et al, 1999) [20] .Sam reported that Uro area phosphate ores generally have a high concentration of U, and he found that 238 U and its decay products are the principle contributors of radioactivity in these phosphate deposits, with activity concentrations ranging from 1225 to 13745 Bq/kg. Adam and Eltayeb investigated uranium abundance in Kurun and Uro areas; they found that uranium abundance in Uro phosphate is five time higher than in Kurun phosphate (Adam and Eltayeb, 2009) [23]. Due to its significant concentration of uranium, we must show more interest to Uro phosphate.

The main objectives of this work are to,

(i) Apply uranium extraction technology in a laboratory scale on phosphate ore samples from Uro and kurun area,

(ii) Investigate in a systematic manner the behavior of theuranium extracted from Uro and kurun phosphate ores,

(iii) Study the correlation and association between uranium and metallic impurities in uranium concentrates using multivariate statistical methods, such as single and bivariate analysis, and cluster analysis,

(iv) Provide basic data for the evaluation of the economic feasibility Study of the extraction of uranium from Uro and kurun phosphates ores, and for the development of metallurgical process and pilot-plant scale.

3.2 Material and methods:

3.2.1 Area description:

The present work is confined to the center of the eastern part Of the Nubba Mountains in the state of Kordofan, (Sudan)between Abu Giubiha and El Rashad towns at the intersection of North east of the coordinate 11450north and 3122east (Whiteman, 1971). The Uro deposits consist of volcanic sedimentary rocks, 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 (Sam et al., 1999) [28].The major phosphate rock constituents in Uro deposits are high-grade gneisses andlow-grade volcanic sedimentary rocks. The ore mineralogy in these deposit is characterized by open space-fillingtexture and structure. The identified minerals include aluminophosphate, hydrated phosphate, limonite goethite, quartz, kaolinite, and zeolotes. The phosphate minerals include apatite, turquoise, crandallite, wave lite, woodhouseite, and variscite (Brinkman, 1986).

The survey has resulted in discovery radioactive anomalies in a number of geological ranging from the pre-Cambrian basement complex to recent unconsolidated.

The radioactivity on the environment is mainly due to extra-terrestrial and terrestrial radionuclide, this type of radiation is produced from radionuclide as Uranium (238U), Thorium (232Th), and radioactive families together with Potassium (40K) [29].Globally the terrestrial radiation level was considerable variation in their soil and rock composition with each region in the world and depends on geological and geographical conditions [30]. This list of radionuclide is responsible for the majority of radiation exposure of the vast majority of people.

The study aimed to determine the radioactivity concentration and Radiological assessment in Soil samples around kurn and Uro Nuba Mountains was made by gamma spectrometry technique equipped with NaI (Tl). The result of activity concentration of 226Ra, 232Th and 40K were varied from 23.58 ±7.86 (18.02-29.14), 36.14 ± 5.17 (32.48 -39.79) and 381.88± 127.43 (291.78 - 417.99) Bqkg-1 respectively. Absorbed dose rate and annual effective dose were estimated to evaluate radiological hazards and were varied from 39.47±8.6 (33.38-45.55) nGyh-1and 38.43±10.56 (40.97-55.9) μSvy-1, respectively .Upon comparing the results with global data, they were found to be within the recommended limits. The result will be serving as a base line for future studies. GIS apocalyptic map was originated and has shown that there were some hot spots with high activity distribution and concentrations of the measured radionuclide and similarly Dose Rate.

The result showed some locations with high concentration of uranium in phosphate rock.

Table (4.1) presents the statistical summary of 238U concentration calculated from the average of the daughter 214Bi and 214Pb. The result shows some locations with high concentration of uranium in phosphate rock. This may lead to radiation hazard from 222Rn (half-life 3.8 days) that result from the decaying of 226Ra through progressing of the uranium decay series. The hazard is exceeded in mining and fertilizer processes in the phosphate rock due to alpha particle emanating from radon, since radon is known to associate with lung cancer. Furthermore, 226Ra as a main component of the gypsum in the form of fine powder may result in dust blowing when stockpiled in the exterior to cause other radiological hazard.

3.2.2 Sites for Sample collection:

Rock phosphate samples collected from Uro and Kurun phosphate deposits located in the eastern part of Nubba Mountains, in southern Kurd fan State.

Sample 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.

. FIG 3.2 sample collection from Uro area

FIG 3.3 sample collection from Krun area

3.2.3 Sample preparation:

After collecting, the samples that were taking the silver color, when the samples were grinded and converted to powder, and take every 1 gram of the sample, and placed in the XRF device, and observe the results recorded on the results table on the device.

- Sample color silver.
- The sample weight 1 g.
- Type of sample powder.

FIG 3.4 sample preparation

CHAPTER Four

Evaluation of vanadium Deposits in Sudan

4.1 Introduction:

After analyses proses More than 80% of the samples were found to be a highly used 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.

4.2 XRF showed the presence of high percentage of vanadium:

After 40 samples were collected from the regions of Kurun and Uro and analyzed by XRF, it is noted from the results that a high percentage of vanadium in all samples may reach more than 80% in the sample, indicating that Sudan in general and the regions of Kurun and Uro in particular. With a large proportion of this important element, forcing us to bike within the economic study of the message to benefit In the future.

4.3 V – Vanadium:

Vanadium is one of the lightest members of the first row transition elements, consisting of SC, Ti,V, Cr, Mn, Fe, Co, Ni, Cu and Zn, and belongs to group 5 of the periodic table, along with Nb and Ta. The element has an atomic number of 23, an atomic mass of 51, three main oxidation states (+3, +4 and +5) and two naturally occurring isotopes (50V, and 51V), of which 51V is the most abundant at 99.8% of the total mass[38].

Vanadium is a lithophile metallic element at low pressure, but may be siderophile at the elevated pressures suggested for core formation in the Earth. It is incompatible in most silicate minerals, although it may be moderately compatible in some pyroxenes (Snyder1999). It forms several minerals including magnetite (Fe,V)304, vanadinite Pb5(VO4)Cl, and carnotiteK2(UO2)2(VO4).3H23O. It is also present as a trace element in mica, apatite, pyroxene and amphibole.

Montroseite VO(OH) occurs across a wide Ph range under reducing conditions, exhibiting V in its lowest valency (V3+), and acts as a source for awide range of V3+, V4+and V5+oxides and hydroxides. Sulphides of V4+are found in ore deposits.

4.4 Properties of vanadium oxides:

Transition metal oxides have been a subject of research in recent years in view of their fundamental and technological aspects. Among these, vanadium creates many compounds with oxygen; these have different structural, optical and chemical properties.

464 K. SIERADZKA et al. Meaningful differences between the properties of different phases of vanadium oxides like VO, VO2, V2O3 and V2O5 depend on their structure, which determines other

properties. Different forms of vanadium oxides can be obtained by changing the deposition process parameters, or by post-process treatment, e.g., additional annealing. From the application point of view, the most interesting vanadium oxides are VO2 and V2O5. Vanadium dioxide is a very good candidate for thermochromic coatings due to the change of properties from semiconducting to semimetal at 68 °C. Vanadium pent oxide (V2O5) is a thermodynamically stable form which exhibits electrochromic

Properties. V2O5 thin films can also be used in optical filters, reflectance mirrors, smart windows and surfaces with tunable emittance for temperature control of spacevehicles [31]. It can be received by selecting deposition parameters or by the annealing

Of VO2 above 350 °C. Thin films of vanadium pent oxide can be prepared by various methods, such as sputtering [32].thermal evaporation [33].pulse laser deposition [34], sol–gel [35], e-beam

Deposition, etc. Properties of the V2O5 films are strongly dependent on the method of their synthesis, due to the fact that V2O5 loses oxygen when is heated in vacuum or in reductive atmosphere. This causes partial dislocation and oxygen removal from the V2O5 lattice, which results in the formation of defects or in a reduced phase in the resulting layers. In this work we have studied the structural and optical properties of V2O5 thin films [36].

Deposited onto glass substrates by d.c. reactive magnetron sputtering. The results obtained from X-ray diffraction (XRD), Raman spectroscopy and transmission measurements are presented and connected with different O2 partial pressure controlled

During sputtering deposition [37].

4.5 Electrochemical properties of vanadium oxide gels:

Vanadium pent oxide xerogels, V2O5·nH2O exhibit both ionic and electronic conduction. This is due to the partial reduction of V5_ into V4_ and the acid behavior of OH groups. Their electrical conductivity increases as the amount of V4_ increases (s300:4_10_5 V_1 cm_1 for V4__1%, s300:2_10_3 V_1 cm_1 for V4__10%). Anti-static coatings based on vanadium pent oxide gels have then been patented by Kodak. They also exhibit conductivity of thin films increases with the water content, i.e. with the water pressure (s300:3_10_2 V_1 cm_1 for n_1.6, s300:5_10_5 V_1 cm_1 for n_0.5). Humidity sensors have been developed taking advantage of this property. They are made of V2O5 gels mixed with an organic polymer (hydroxyl propyl lthy cellulose). The impedance of these hybrid films decreases meby about two orders of magnitude when the relative humidity increases from 80 to 97%. Vanadium oxide xerogels have been extensively studied as reversible cathodes for lithium batterie [38] s. Chemical bonds between V2O5 ribbons in vanadium oxide xerogels are much weaker than in the crystalline oxide. Water molecules are intercalated in the interlamellar space and ionic species can diffuse easily through the materials. The electrochemical behavior of vanadium pent oxide gels V2O5·nH2O as a reversible cathode for lithium batteries is therefore quite different from that of the crystalline oxide. Moreover, thin layers can be easily deposited onto various substrates allowing the fabrication of micro-batteries. The discharge curve of vanadium pent oxide xerogels exhibits a single plateau around 3.1 V. A faradaic yield close to 1.8 e: V2O5 and a capacity of 250 Ah Kg_1 are obtained at 2 V corresponding to the reduction of all V5_ ions into V4_. Cycling experiments show a good reversibility and almost 70 % of the initial capacity is recovered after 30 cycles for a current density j_0.05 mA cm_2 . The intercalation of metal ions such as Na_ within the layered structure of vanadium pent oxide gels has been used for the low temperature synthesis of Vanadium bronzes. The ordered stacking of the ribbons is preserved during a thermal treatment leading to the crystallization around 350°C of anisotropic films of vanadium bronzes. These sol-gel bronzes exhibit the same structure as the usual b-NaxV2O5 vanadium bronzes obtained via solid state reactions at 700°C.

However, X-ray diffraction suggests that (a,c) planes are preferentially oriented parallel to the substrate, while the tunnels of the bronze structure remain perpendicular to the substrate. This orientation of sol-gel layers enhances the diffusion of Li_ ions into the host lattice and sol-gel bronzes exhibit improve electrochemical properties [39].

4.6 Vanadium price:

According to Ryan's Notes, U.S. ferrovanadium (FeV) prices ranged from $13.750 to $14.281 per pound of vanadium content in January 2013, compared with $12.964 to $14.000 in December 2012. European FeV prices ranged from $30.813 to $31.813 per kilogram in January, compared with $27.000 to $28.000 in December [40].

4.6.1 Vanadium Prices and Price Chart:

4.6.1.1 Vanadium price 2017:

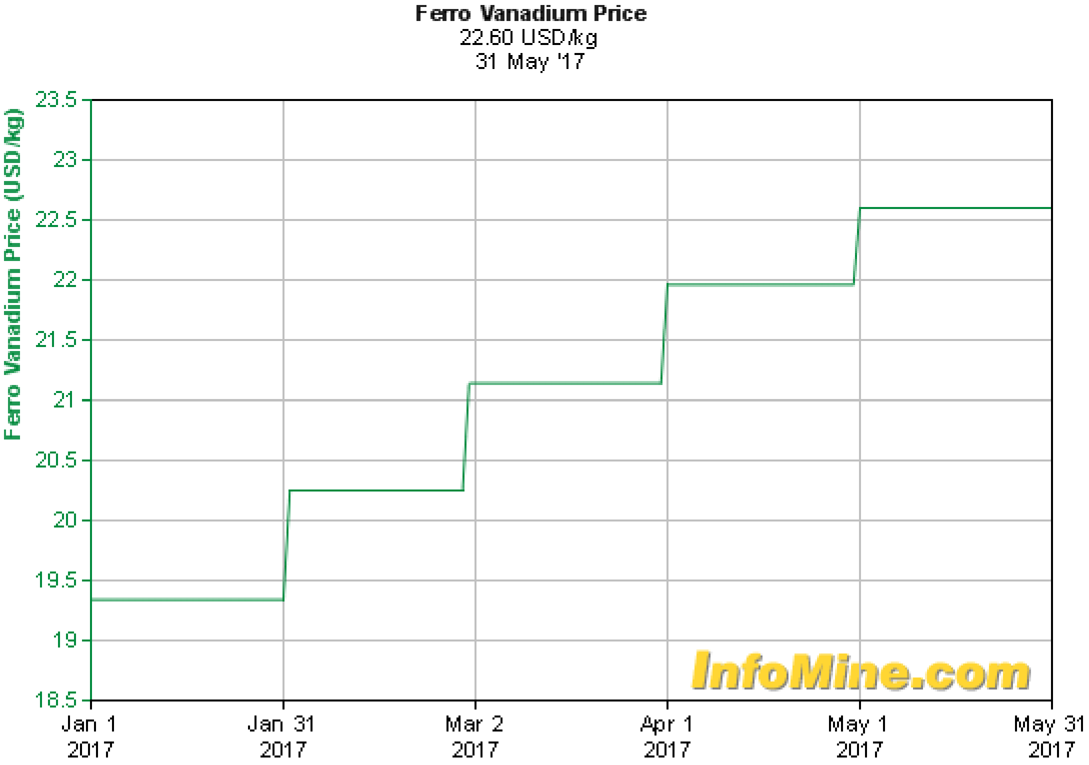


FIG: 4.1 Vanadium price 2017:

4.6.1.2 Vanadium price 2016:

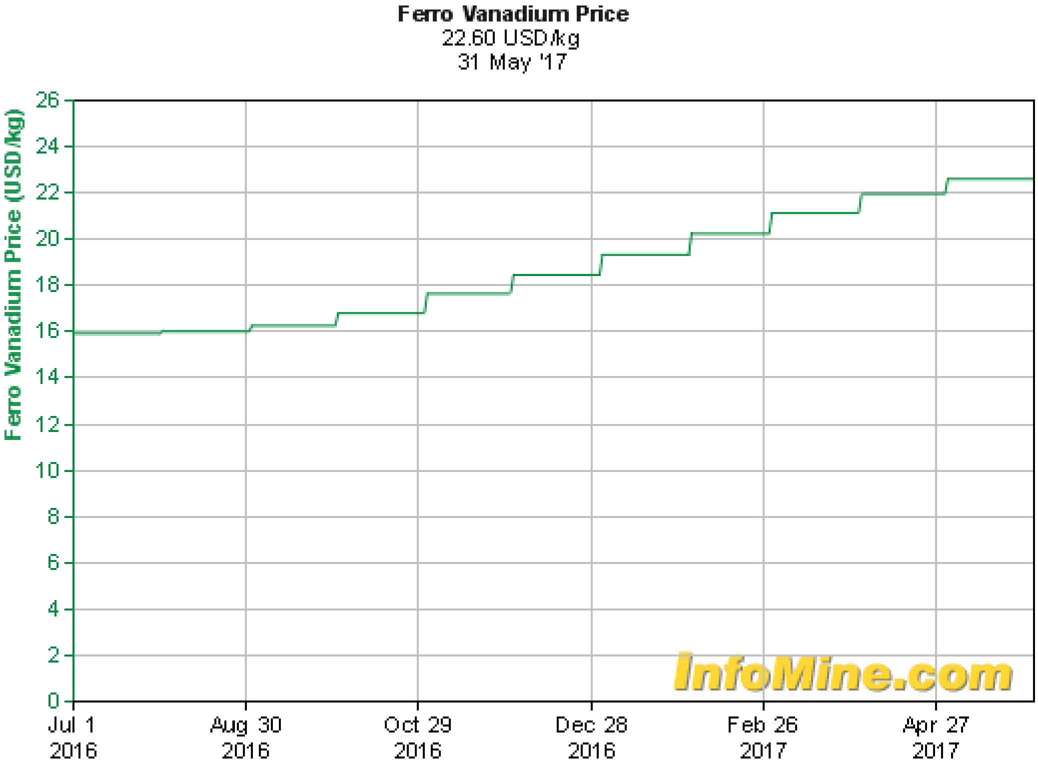


FIG: 4.2 Vanadium price 2016:

4.6.1.3 Vanadium price from 2005 to 2017:

FIG: 4.3 Vanadium price from 2005 to 2017:

CHAPTER Five

Result and Discussion

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

Table 5.1 Concentration of uranium**(Bq/kg).**

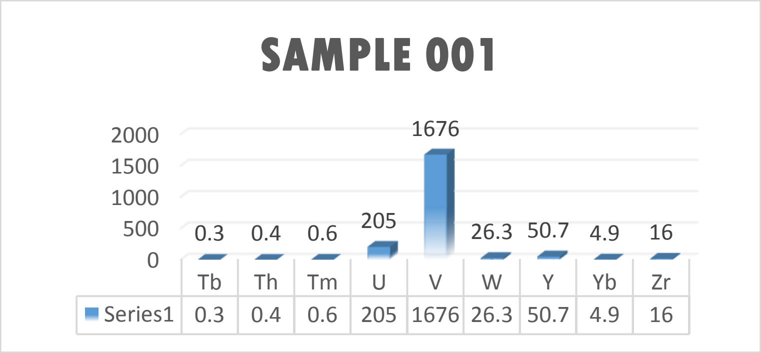
Samples code	**Sample location in the mountain(height in m)**	**^{238}U(Bq/kg)**
K1	577	1101.3
K2	581	1128.033
K3	585	1128.864
K4	588	5.4
K5	592	11.1
K6	598	1166.876
K7	596	1183.897
K8	577	1193.456
K9	589	1171.332
K10	583	1156.890
K11	584	1149.996
K12	585	1160.876
K13	587	1154.042
K14	594	1086.32
Max		1193.456
Min		5.4
Average		**985.13**

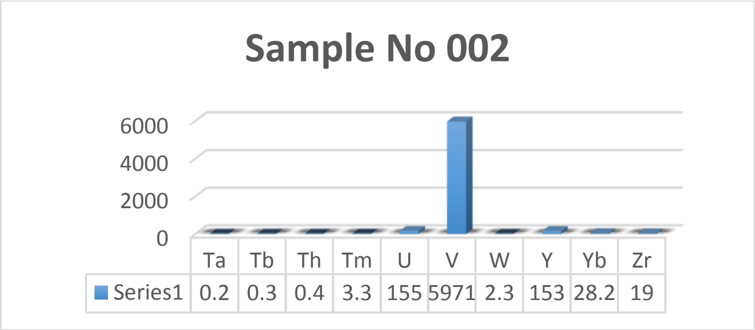
5.2 Samples Analysis method:

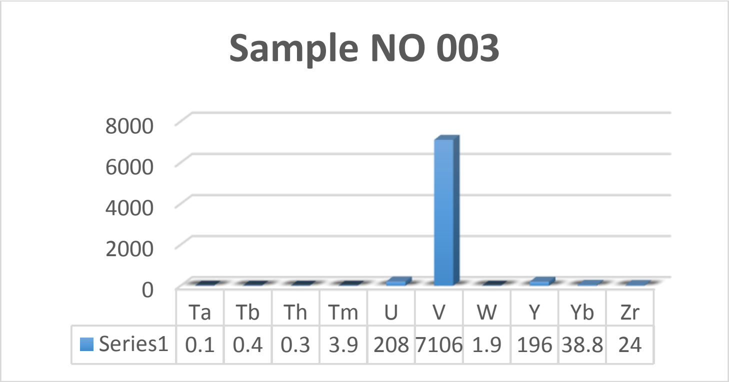
Using in sample analysis XRF machine where were taken every 1 grams of powder sample and put it in the machine and calculate the concentration of each of the elements in the sample and the focus here is on the concentration of uranium required study element.

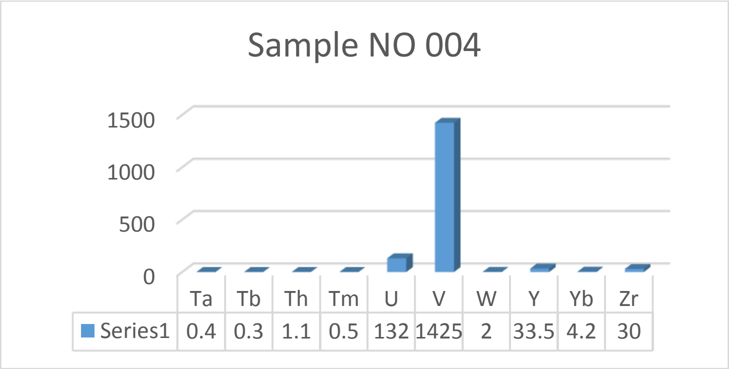
5.3 XRF analysis result:

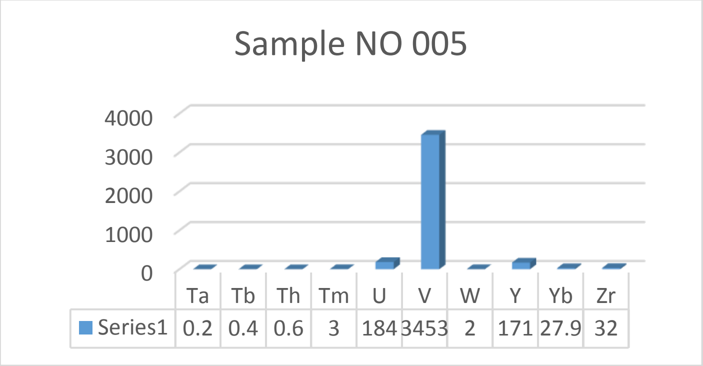
5.3.1 1Kurn Sample:



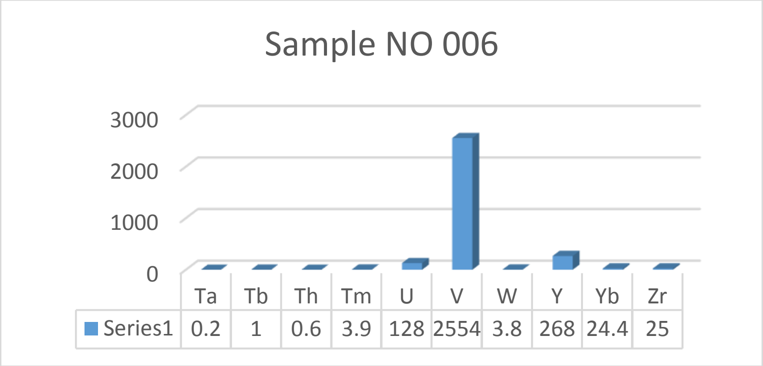




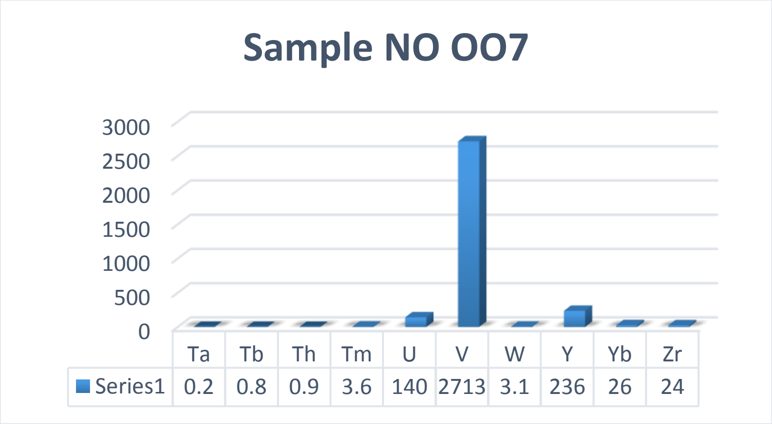




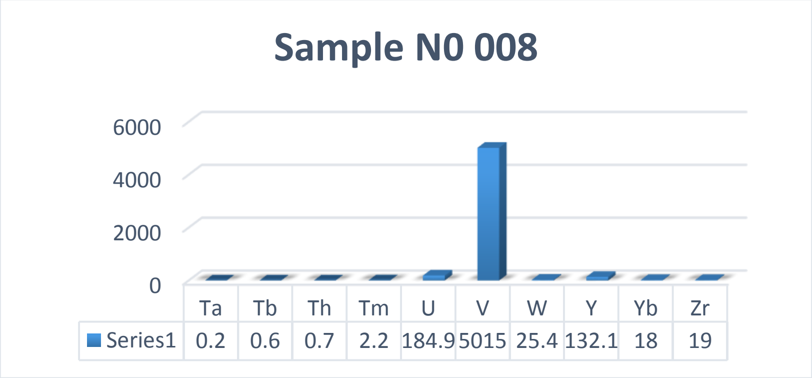
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.4	0.6	3	184	3453	2	171	27.9	32



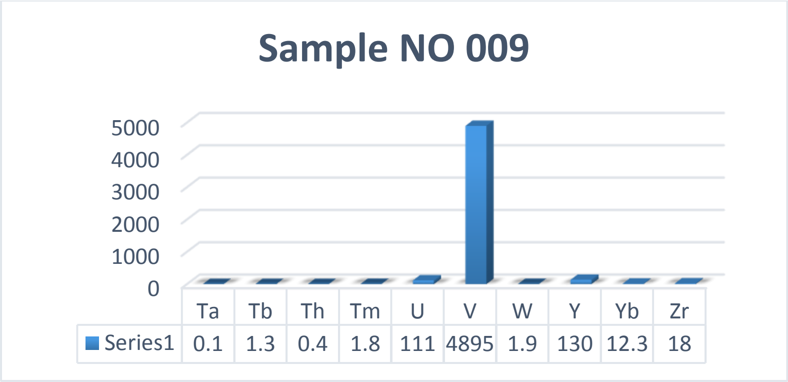
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	1	0.6	3.9	128	2554	3.8	268	24.4	25



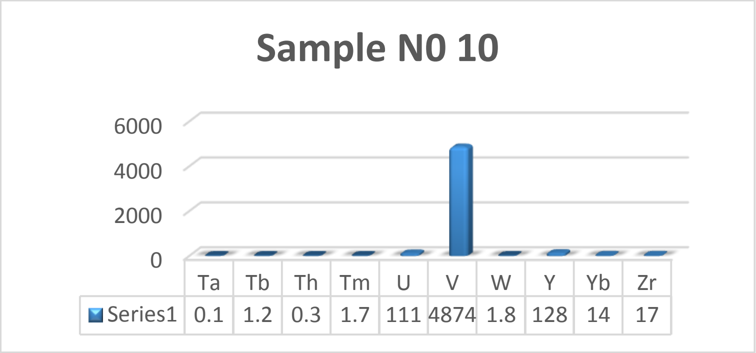
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.8	0.9	3.6	140	2713	3.1	236	26	24



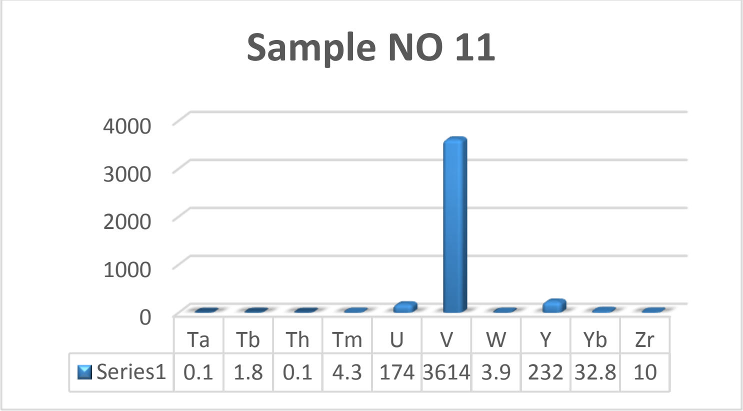
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.6	0.7	2.2	184.9	5015	25.4	132.1	18	19



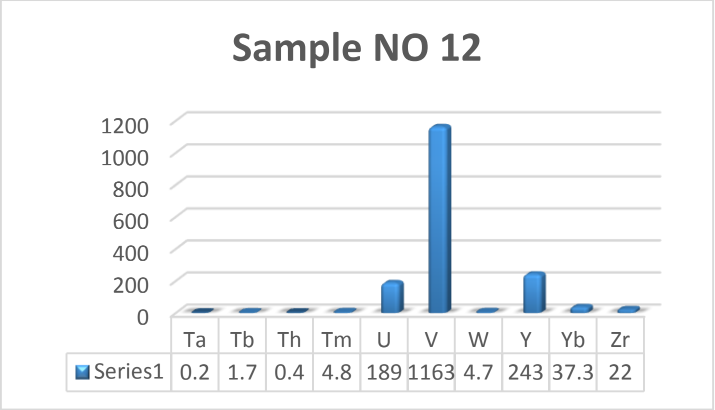
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	1.3	0.4	1.8	111	4895	1.9	130	12.3	18



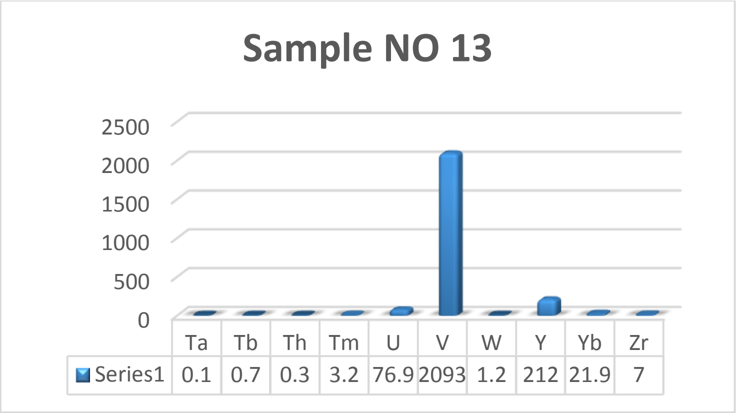
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	1.2	0.3	1.7	111	4874	1.8	128	14	17



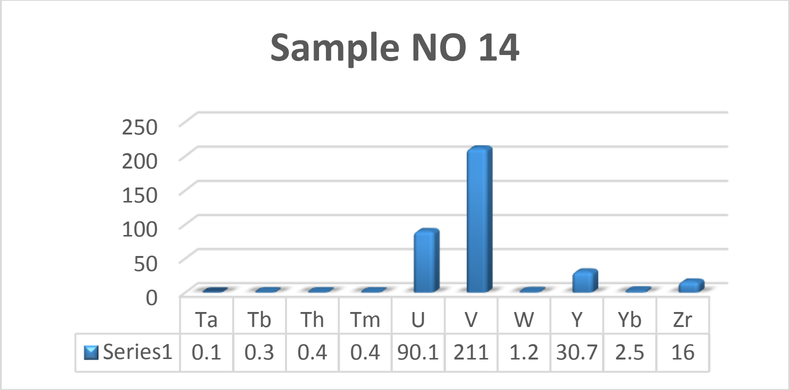
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	1.8	0.1	4.3	174	3614	3.9	232	32.8	10



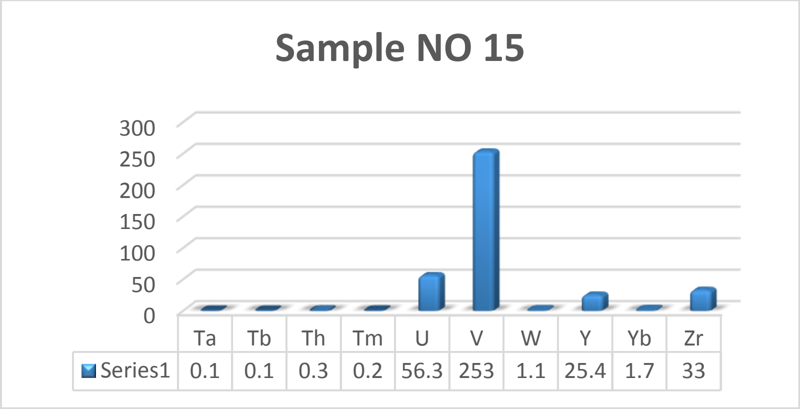
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.2	1.7	0.4	4.8	189	1163	4.7	243	37.3	22


Sample NO 13

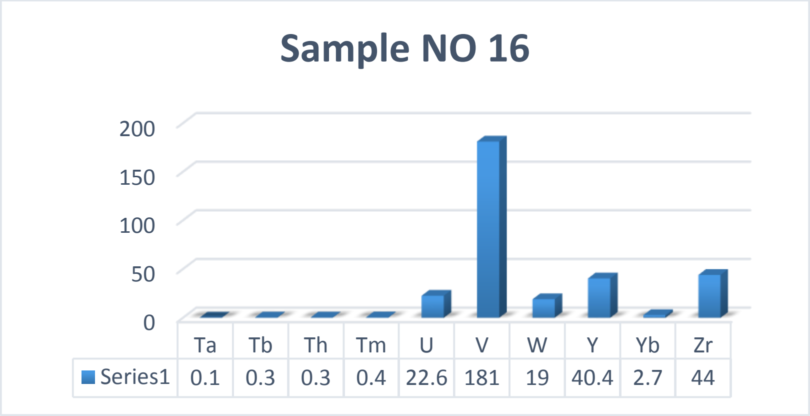
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.1	0.7	0.3	3.2	76.9	2093	1.2	212	21.9	7


Sample NO 14

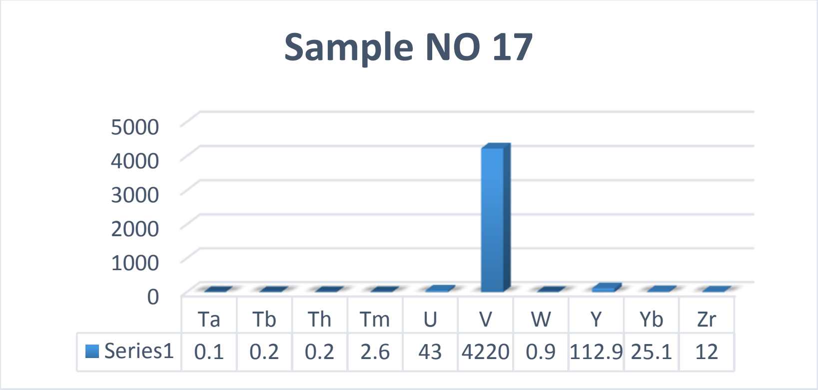
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.1	0.3	0.4	0.4	90.1	211	1.2	30.7	2.5	16


Sample NO 15

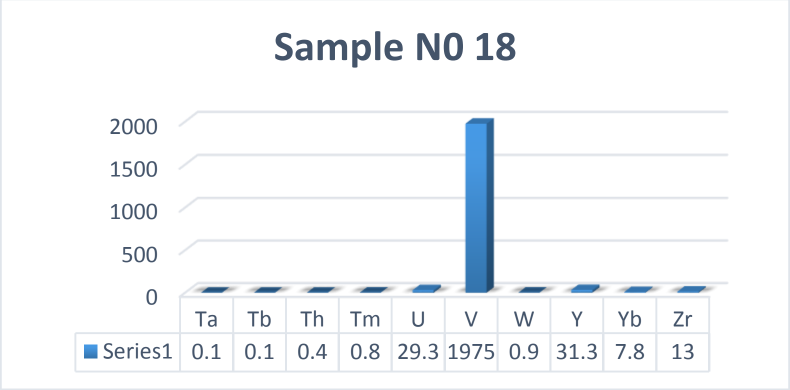
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.1	0.1	0.3	0.2	56.3	253	1.1	25.4	1.7	33


Sample NO 16

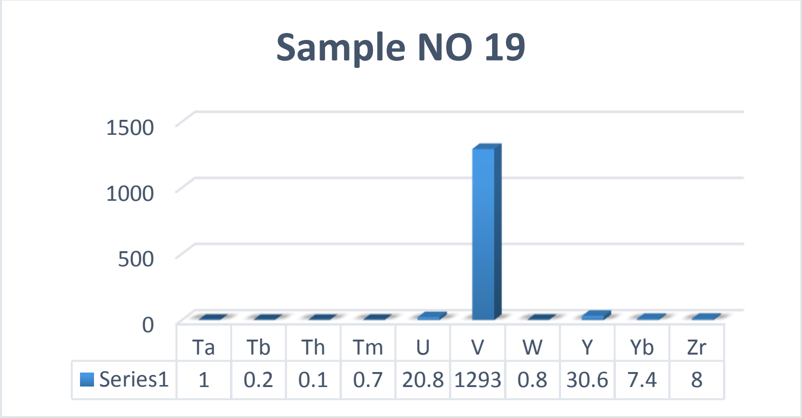
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.1	0.3	0.3	0.4	22.6	181	19	40.4	2.7	44



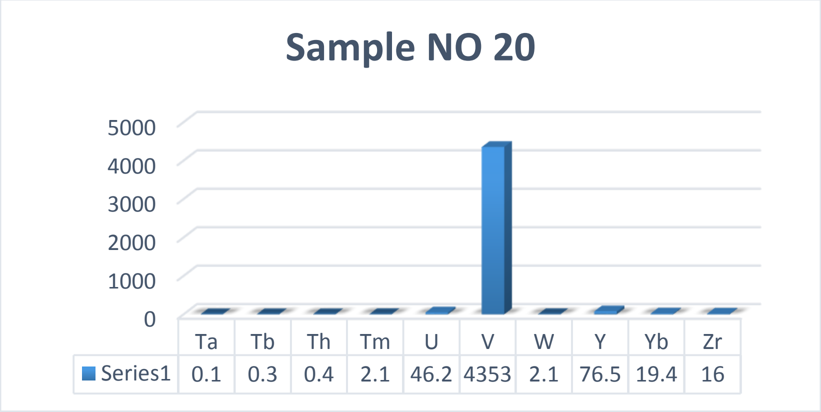
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	0.2	0.2	2.6	43	4220	0.9	112.9	25.1	12



	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	0.1	0.4	0.8	29.3	1975	0.9	31.3	7.8	13

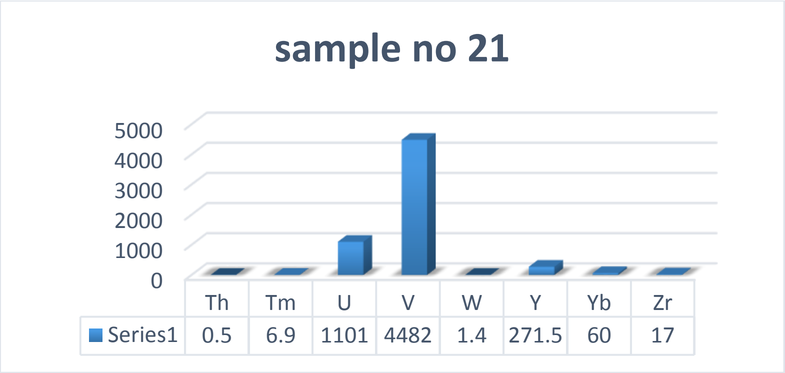


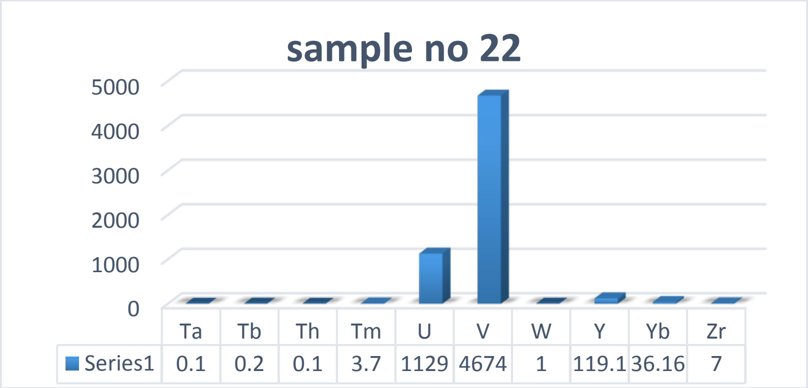
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	1	0.2	0.1	0.7	20.8	1293	0.8	30.6	7.4	8

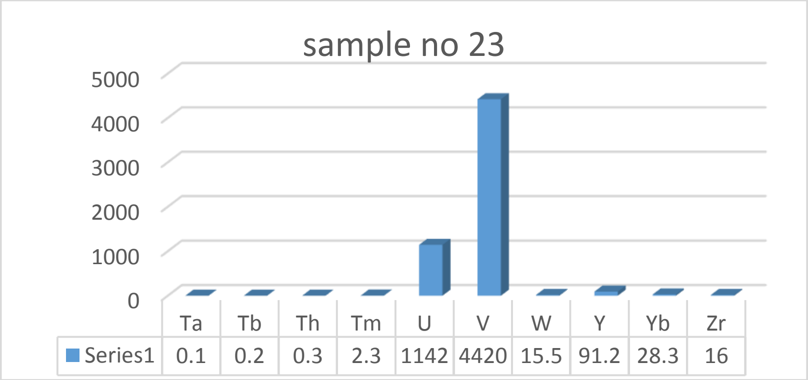


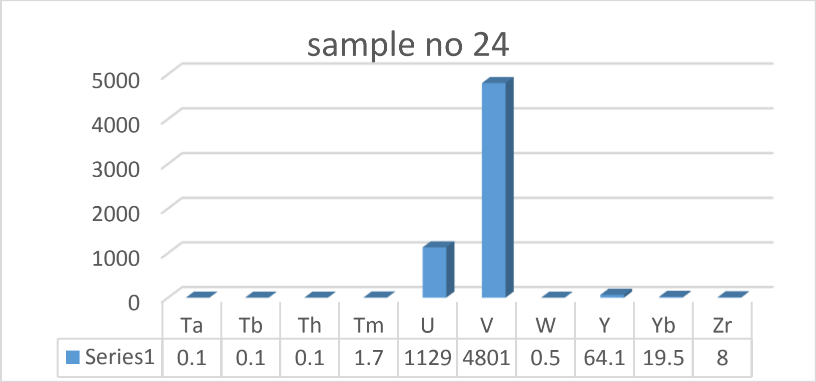
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	0.3	0.4	2.1	46.2	4353	2.1	76.5	19.4	16

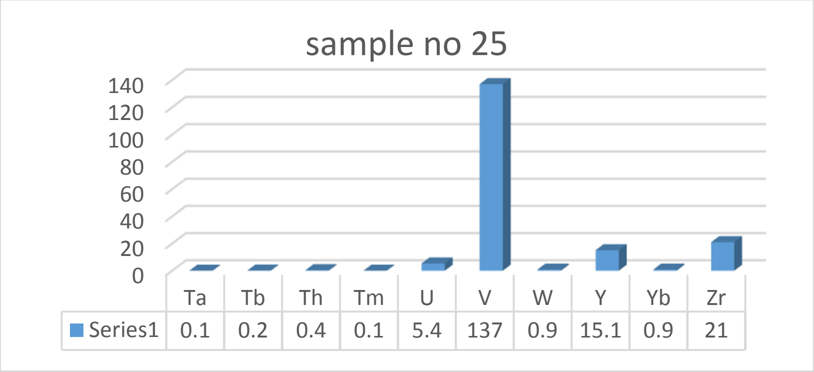
5.3.2 Uro Sample:



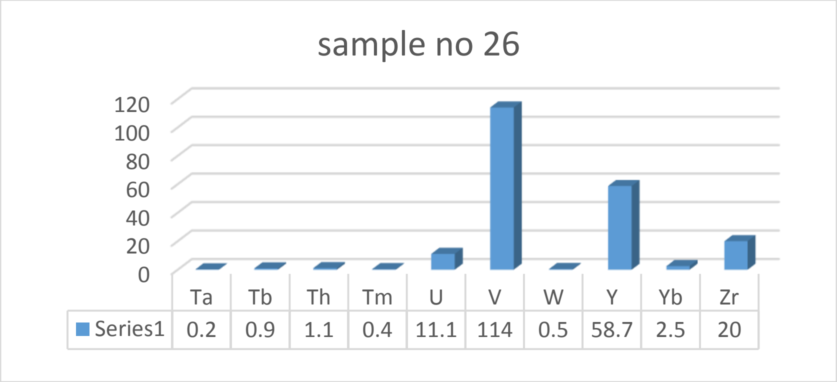




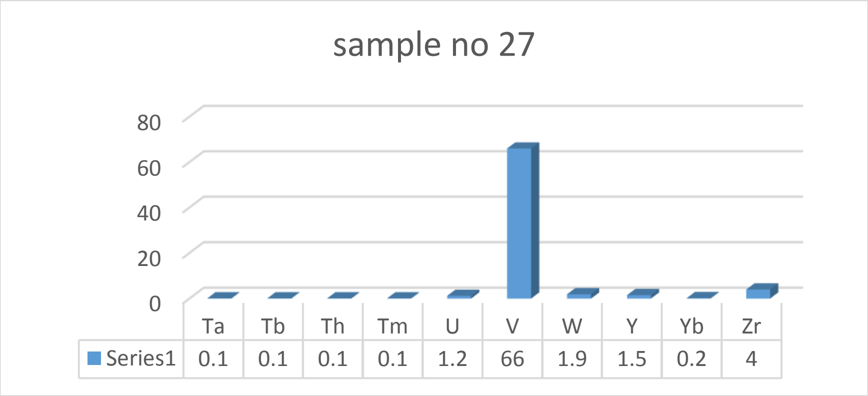




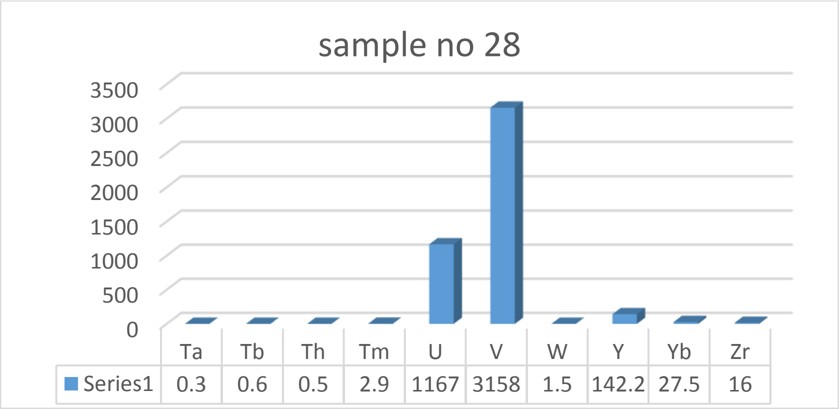
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	0.2	0.4	0.1	5.4	137	0.9	15.1	0.9	21



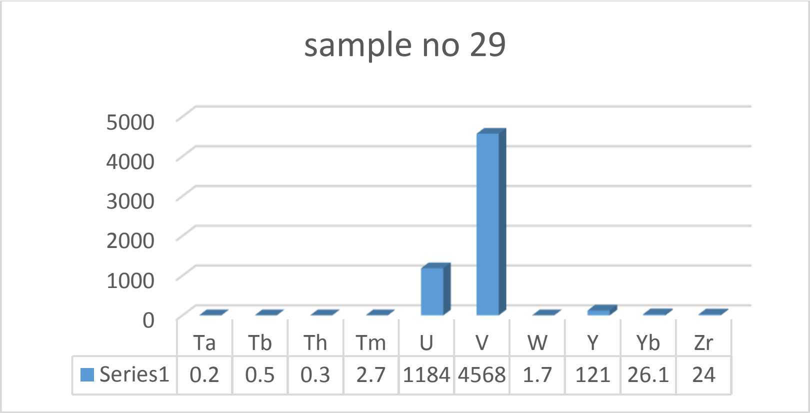
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.2	0.9	1.1	0.4	11.1	114	0.5	58.7	2.5	20



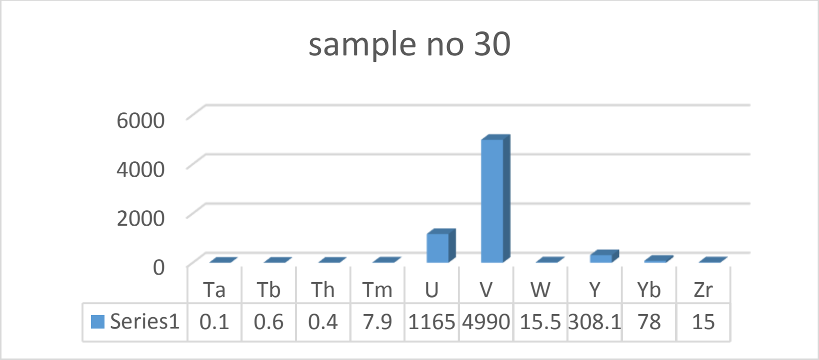
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.1	0.1	0.1	0.1	1.2	66	1.9	1.5	0.2	4



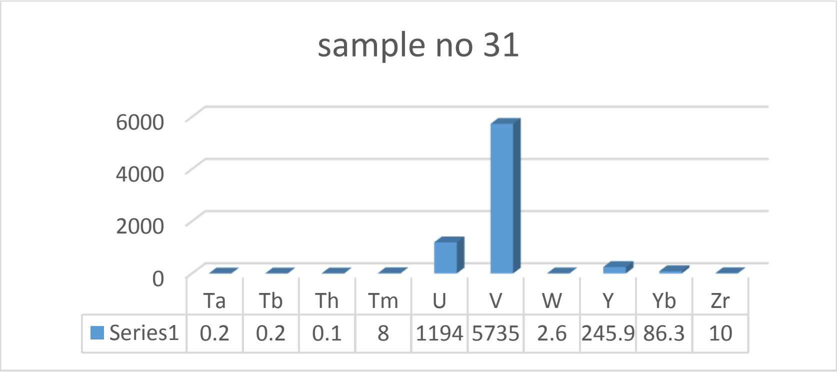
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
■ Series1	0.3	0.6	0.5	2.9	1167	3158	1.5	142.2	27.5	16



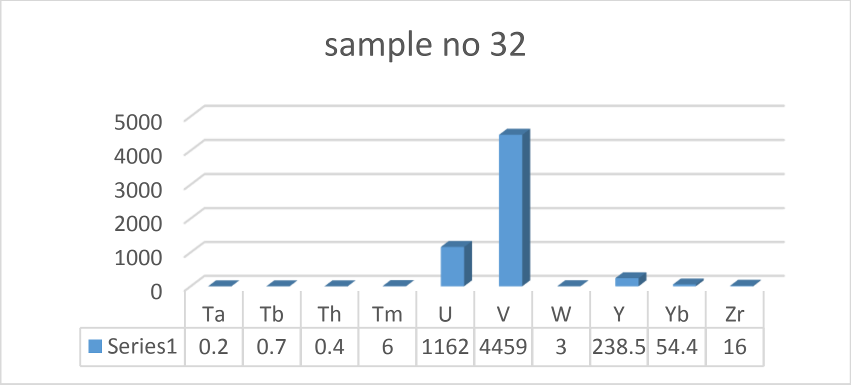
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.5	0.3	2.7	1184	4568	1.7	121	26.1	24



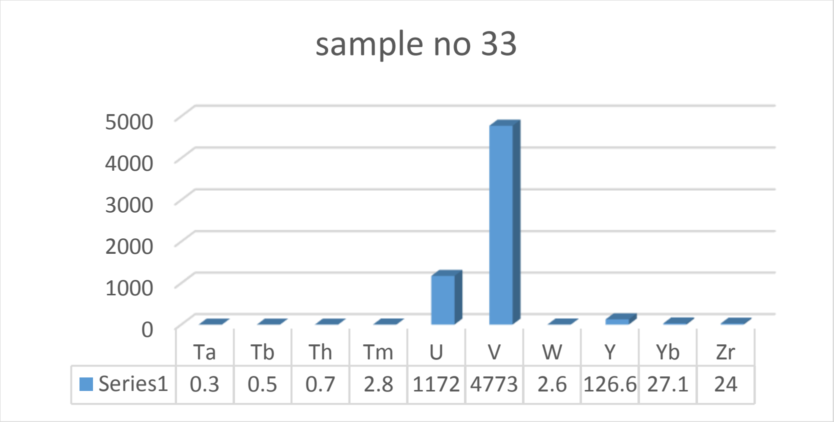
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.1	0.6	0.4	7.9	1165	4990	15.5	308.1	78	15

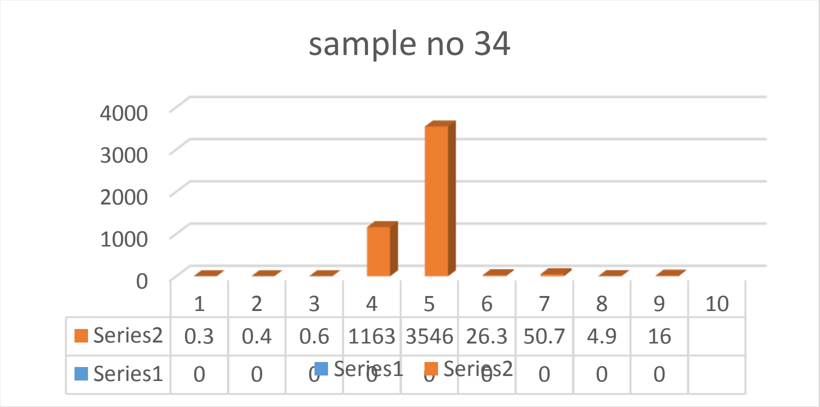


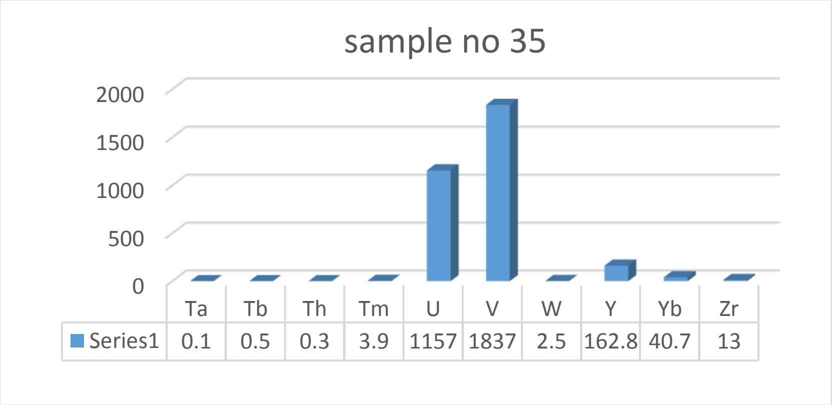
	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.2	0.1	8	1194	5735	2.6	245.9	86.3	10

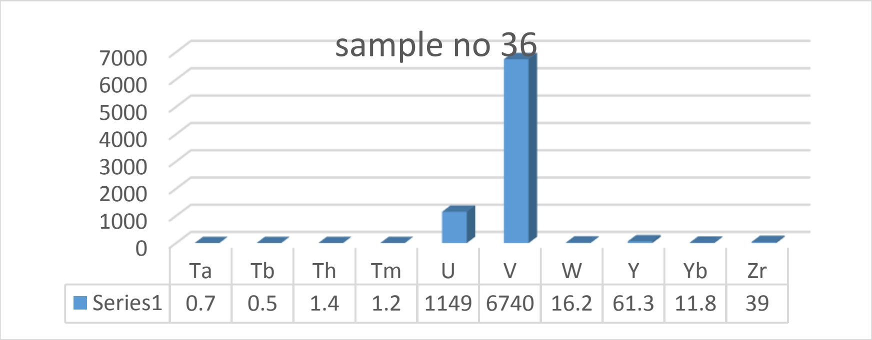


	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Series1	0.2	0.7	0.4	6	1162	4459	3	238.5	54.4	16

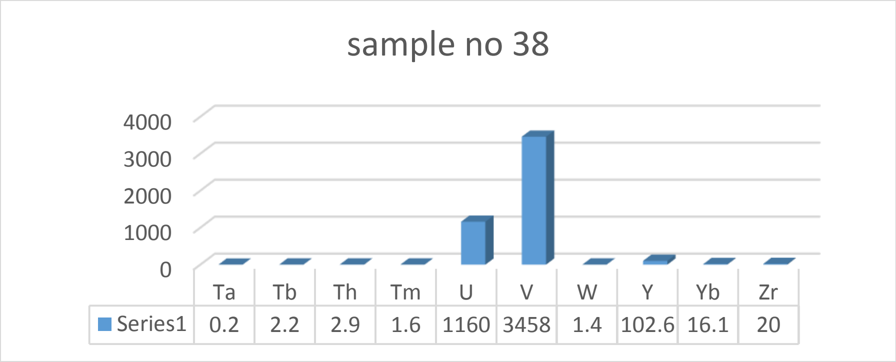

sample no 33
5000
4000
3000
2000
1000
0
Ta Tb Th Tm U V W Y Yb Zr
Series1 0.3 0.5 0.7 2.8 1172 4773 2.6 126.6 27.1 24


sample no 34
4000
3000
2000
1000
0
1 2 3 4 5 6 7 8 9 10
Series2 0.3 0.4 0.6 1163 3546 26.3 50.7 4.9 16
Series1 0 0 0 0 0 0 0 0 0
Series1
Series2

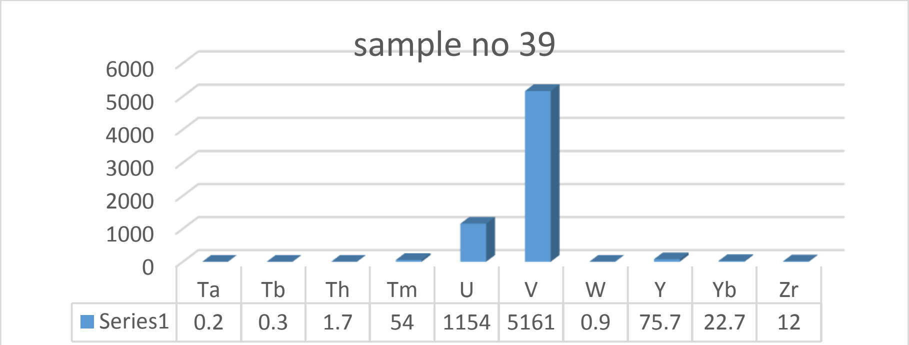

sample no 35
2000
1500
1000
500
0
Ta Tb Th Tm U V W Y Yb Zr
Series1 0.1 0.5 0.3 3.9 1157 1837 2.5 162.8 40.7 13


sample no 36
7000
6000
5000
4000
3000
2000
1000
0
Ta Tb Th Tm U V W Y Yb Zr
Series1 0.7 0.5 1.4 1.2 1149 6740 16.2 61.3 11.8 39

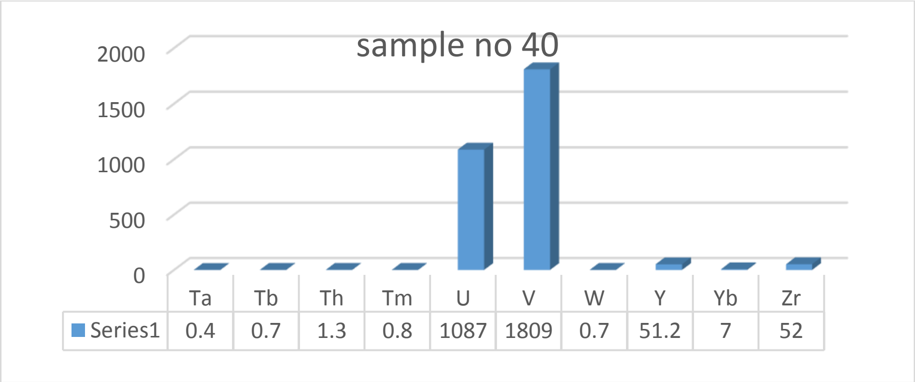
	1	2	3	4	5	6	7	8	9	10
🟧 Series2	0.5	0.6	1.6	3331	10620	1.7	75.4	29.1	28	
🟦 Series1	0	0	0	0	0	0	0	0	0	



	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
🟦 Series1	0.2	2.2	2.9	1.6	1160	3458	1.4	102.6	16.1	20



	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
🟦 Series1	0.2	0.3	1.7	54	1154	5161	0.9	75.7	22.7	12



	Ta	Tb	Th	Tm	U	V	W	Y	Yb	Zr
🟦 Series1	0.4	0.7	1.3	0.8	1087	1809	0.7	51.2	7	52

5.4 Noticeable results:

After the analysis processing by XRF Machine to 40 Samples from two different regions from Kurun and the Uro is noted that the concentration of uranium region in Uro much higher than the Kurun area. More than 1,100 ppm, while the Kurun area focus much lower, reaching between 50 to 250 ppm and this suggests that the deposits of uranium region in Uro it higher than kurun. With high concentrations of the vanadium element, it was found that there was a strong relationship between uranium and vanadium where uranium concentrations were slightly lower in the Kern region, as well as less concentration of vanadium than in the euro area and when uranium concentration increased in the euro region.

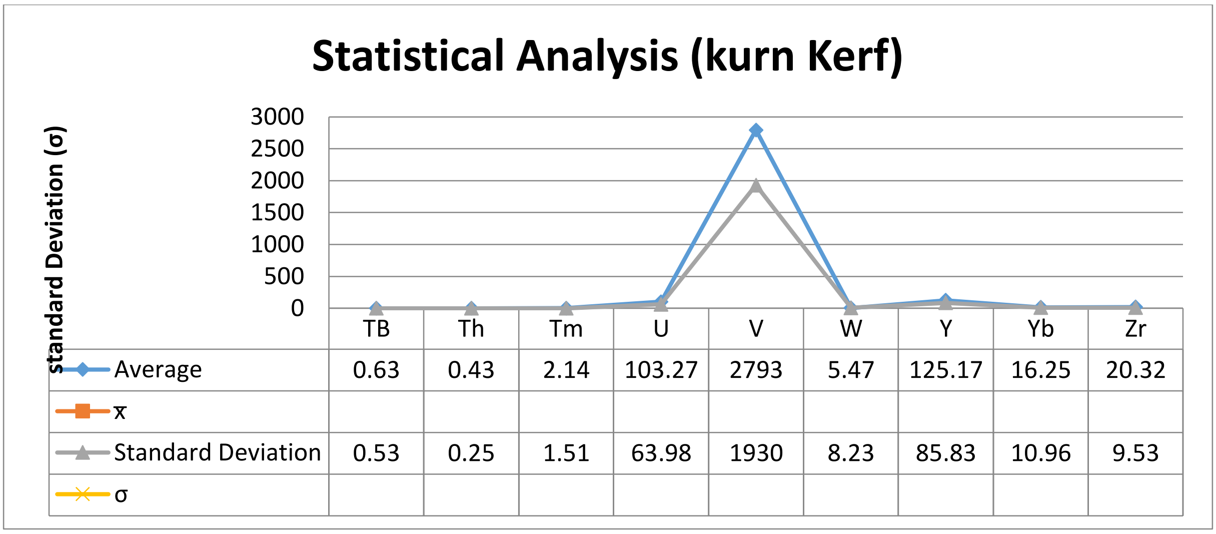
5.5 Statistical Analysis:

5.5.1 Kurn Samples:

Table 5.2 Statistical Analysis Krun 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**



	TB	Th	Tm	U	V	W	Y	Yb	Zr
Average	0.63	0.43	2.14	103.27	2793	5.47	125.17	16.25	20.32
x̄									
Standard Deviation	0.53	0.25	1.51	63.98	1930	8.23	85.83	10.96	9.53
σ									

FIG: 5.1 statical Analysis kerf (Kurn sample).

Table: 5.3 Uranium content and P2O5% for phosphoric Acid

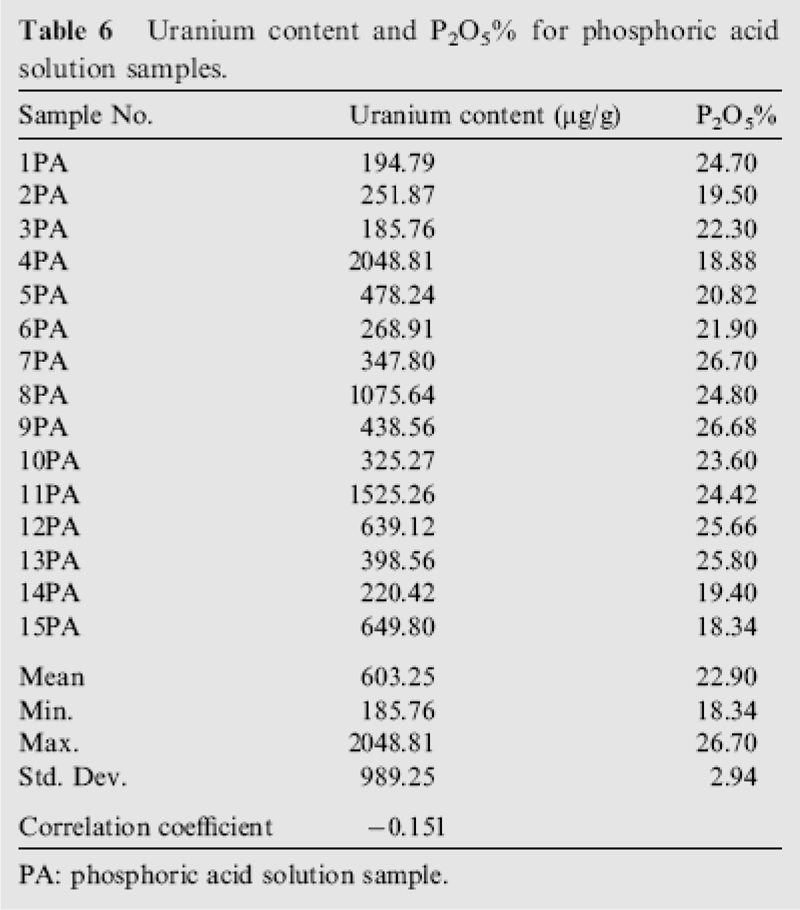


Table 6 Uranium content and P_2O_5% for phosphoric acid solution samples.

Sample No.	Uranium content (μg/g)	P_2O_5%
1PA	194.79	24.70
2PA	251.87	19.50
3PA	185.76	22.30
4PA	2048.81	18.88
5PA	478.24	20.82
6PA	268.91	21.90
7PA	347.80	26.70
8PA	1075.64	24.80
9PA	438.56	26.68
10PA	325.27	23.60
11PA	1525.26	24.42
12PA	639.12	25.66
13PA	398.56	25.80
14PA	220.42	19.40
15PA	649.80	18.34
Mean	603.25	22.90
Min.	185.76	18.34
Max.	2048.81	26.70
Std. Dev.	989.25	2.94
Correlation coefficient	−0.151	

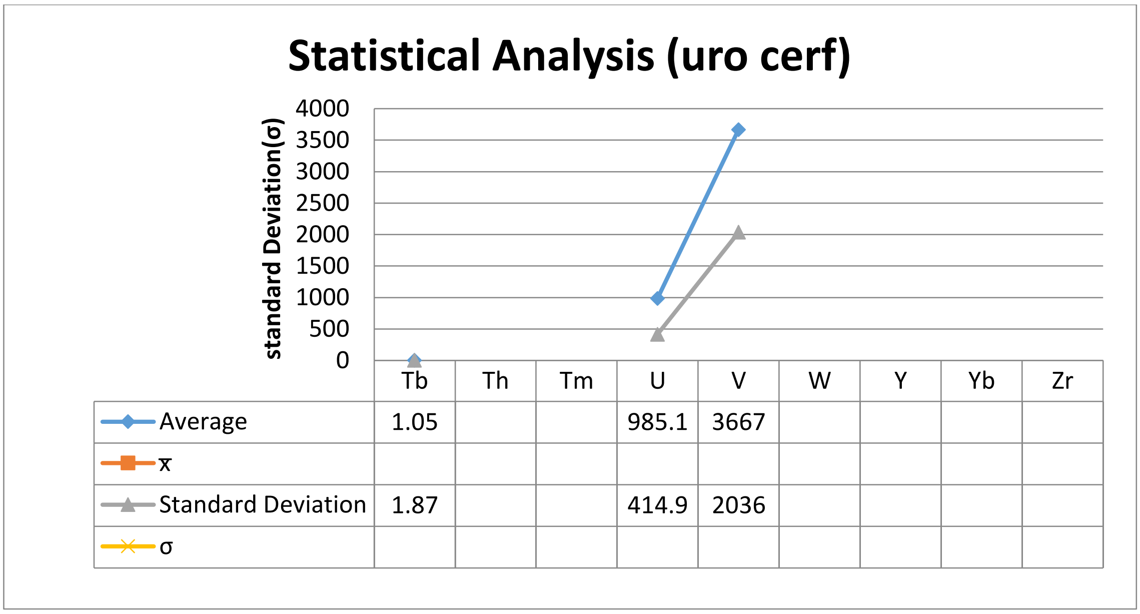
PA: phosphoric acid solution sample.

4.5.2 ERU Samples:

Table: 5.4 Statistical Analysis Uro Samples.

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
23	0.1	0.2	0.3	1142	4420	15.5	91.2	28.3	16
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	11.1	11.4	0.5	58.7	2.5	20
27	0.1	0.1	0.1	12	66	1.9	1.5	0.2	4
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
30	0.6	0.4	7.9	1165	4990	15.5	308.1	78	15
31	0.2	0.1	8	1193	5735	2.6	245.9	86.3	10
32	0,4	0.7	6	1162	4459	3	383.5	54.4	16
33	0.5	0.7	2.8	1171	4773	2.6	126.6	27.1	24

34	0,4	0,6	5	1163	3546	26.3	50.7	4.9	16
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
37	0.6	1.6	0.0	3331	106320	1.7	75.4	29.1	28
38	2.2	2.9	1.6	1160	458	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**				



	Tb	Th	Tm	U	V	W	Y	Yb	Zr
Average	1.05			985.1	3667				
$\bar{x}$									
Standard Deviation	1.87			414.9	2036				
σ									

FIG: 5.2 statical Analysis Cerf (Kurn sample).

4.6 Sample analyses in deferent exposer time:

4.6.1 ARO-1,2,3,4,5 five sample in exposer time 1000 second

Table 5.5 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
```

$ANALYSIS_RESULTS:

Table 5.6 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-
```

$ANALYSIS_RESULTS:

Table 5.7 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

$ANALYSIS_RESULTS:

Table 5.8sample 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

$ANALYSIS_RESULTS:

Table 5.9 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

The average value of uranium in exposer time 1000 second= 3.148 E-04

That mean =314.8ppm.

4.6.2 ARO-11, 22,33,44,55 sample 1,2,3,4,5, in exposer time 2000 second

$ANALYSIS_RESULTS:

Table 5.10 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
```

```
$ANALYSIS_RESULTS:
```

Table 5.11 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
```

```
$ANALYSIS_RESULTS:
```

Table 5.12 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
```

$ANALYSIS_RESULTS:

Table 5.13 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

$ANALYSIS_RESULTS:

Table 5.14 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

The average value of uranium in exposer time 2000 second

=3.39 E-04

That mean =339ppm

That mean find little different in concentration of uranium between two value of exposer time.

4.7 Separation techniques:

The methods for separating, collecting, and detecting radionuclides are similar to ordinary analytical procedures and employ many of the chemical and physical principles that apply to their nonradioactive isotopes. However, some important aspects of the behavior of radionuclides are significantly different, resulting in challenges to the radio chemist to find a means for isolation of a pure sample for analysis (Friedlander et al., 1981) [41].

This section describes the MRT process for the extraction of uranium for value, or for environmental purposes, from uranium solution matrices that may also contain significant amounts of other impurities such as copper and iron. Impurities such as copper may also be recovered for value. Examples of these separations and the primary benefits of the MRT process are given [42].

The use of solvent extraction and ion exchange resins is now the technology of choice for extraction of uranium from clarified mine leach solutions, leached pulp and slurries. The application of MRT to uranium extraction from these feed streams, as well as to evaporation ponds, waste and environmental streams, offers a viable, highly competitive alternative to solvent extraction and ion exchange resins. Due to the extremely high selectivity of SuperLig materials, MRT offers the potential to dramatically simplify the flowsheet for uranium recovery from these solution matrices. The MRT process can selectively separate the uranium directly from the mine leach solution and produce a concentrated, high purity uranium product [43].

There are two MRT SuperLig® materials available for uranium extraction, SuperLig® 171, and SuperLig® 191, as described in Table below.

Table:5.15 SuperLig® Materials Available for Uranium Extraction and Purification

	SuperLig® 171	SuperLig191
Binding Ion	U(VI)	$(UO_2)_2$
Effective pH Range	Acidic (0 – 1)	Neutral pH (6 – 12)
Elution	8 M H_2SO_4 or similar	Any Strong Acid With Concentration of 0.5 M or Higher

4.8 Uranium separation from a uranium solution containing significant iron and other base metals:

There is a need to extract uranium from feed solutions containing significant amounts of iron, as well as copper, cobalt, and nickel, in a sulfate matrix. These aqueous solutions can be, for example, acid mine drainage solutions in which removal of the uranium is desirable for environmental reasons as well as for recovery for value. Separation of U from Fe in the uranium conversion process is also important. IBC’s product, SuperLig® 171, is capable of U separation from matrices containing significant iron and other base metals. provides a detailed review of test results demonstrating this capability. In summary, SuperLig® 171 removes uranium (as $U(SO_4)_4^{2-}$ anion) to detection levels (5ppm) or lower while rejecting the Fe, Cu, Ni, and Co. Fe, Cu, Ni, and Co levels in the eluent solution were less than 1 mg/L [44] .

4.9 Copper and uranium separation from uranium solution:

There is a need to remove copper and uranium from uranium solutions in a sulfate matrix in order to collect the copper and uranium for environmental purposes and for value. These solutions may be, for example, acid mine drainage evaporation pond streams or raffinate streams. IBC has SuperLig® products capable of copper and uranium removal from such solutions. Test work was undertaken at IBC to demonstrate this capability for copper and uranium. Two samples consisting of a higher and a lower concentration solution were tested. The results were similar for both. A summary is provided below [45].

The U was removed (as U $(SO_4)_4^{2-}$ anion) using SuperLig® 171, while rejecting the Cu, Fe, Co, and Ni. The Cu separation was then performed from the raffinate of the U system. The Cu was readily removed to below detection levels using SuperLig® 152. Both the U and Cu are recovered as pure products using sulfuric acid elutions. In a commercial system, the concentrated CuSO4 product could be sent to electrowinning to produce Cu cathode. The concentrated U product solution in dilute H2SO4 would be sent for further treatment to produce a saleable uranium product. As an option, Cu and U can be removed together from the feed stream, utilizing a mixed bed SuperLig system. This would require less system hardware due to the use of fewer SuperLig columns. However, this must be balanced against separate Cu and U recovery, which consumes less acid and produces separate, more highly concentrated and high purity eluant products [46].

4.10 Discussion:

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.
Comparing these with some other values given in a previous study (Uranium recovery from Uro area phosphate ore, Nuba Mountains, Sudan, Abdelmajid A. Adam a,*, Mohamed Ahmed H. Eltayeb b, Omar B. Ibrahim, Arabian Journal of Chemistry (2014) 7, 758–769).

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 th increase when that U decrease. This a greens 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 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.

It is very important to note that tables (4.2) 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 (4.4) 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 element is were famed in egneous 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 concentration 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 Krun 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 exite all atoms in the sample to emit characteristic X-ray. Thus increasing exposure time dose not exite more atoms. This is why increasing exposure time to 2000 second make no significant increase in the concentration of elements. This agrees with the study made by ALfadil (47) which shows that the saturation taken place for exposure time move than 7 second.

CHAPTER Six

Conclusion Recommendation and References

Conclusion:

1. Resent exploration has outlined several new occurrences of uranium.

2. The occurrences of uranium mineralization in pegmatites are of little commercial interest, but serve to outline potential source areas for uranium.

3. surface concentration of secondary uranium in granites, although unlikely to from large deposits, have not been evaluated in depth and warrant further exploration. These occurrences are at Nubba mountains kurun mountain and Uro mountain.

4. The concentration of uranium found in rock samples extracted from the Uro area is much higher than uranium concentration in the samples extracted from the Kurn region, where the concentration of uranium in the Uro area is more than 1,100 ppm, whereas uranium concentration in the Kurn region above 250 ppm.

5. After analyzing the samples with XRF, high concentrations of the vanadium element, an element with a link to the uranium element, have widespread uses. The concentration of the vanadium element in the Kurn area is much higher than the concentration in the Uro region. In some samples, it reached 10,000 ppm to take advantage of this element.

Recommendation:

It is clear from this report that there is considerable potential for the development of deposits of uranium within the sedimentary cover of this region of the Sudan Republic. Also, on the basis of work carried out to data it becomes apparent that the delineation of blind ore bodies within the cover rocks will entail extensive exploration in depth and it is possible , even at this stage, to foresee exploration budgets in the order of us$ 500,000 to 1,000,000 being necessary to fully evaluate the anomalous areas located . Exploration within central Sudan in not easy and severe logistic problems are entailed which are aggravated by difficulties in obtaining water and fuel and by possible difficulties in obtaining appropriate drilling equipment and operators locally. While exploration of the hard-rock occurrences in granites could proceed, in the short-term a considerable project appraisal effort has to be undertaken prior to embarking on the long and costly process of exploring the sedimentary cover. This project appraisal would entail a visit to Khartoum to assess the local availability of suitable drilling equipment and would allow a budget to be established for an exploration programme based on known local factors.

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