URANIUM DEPOSITS AND RESOURCES POTENTIAL IN PAKISTAN: A REVIEW

Shamim Akhtar*, Yang XiaoYong, Wang Fang Yue
[1, 3] School of Earth and Space Sciences, University of Science and Technology of China, Hefei, 230026, China.
Email:- shamim@mail.ustc.edu.cn.

ABSTRACT: *We present a review study which deals the uranium deposits in Pakistan by describing their regional distribution, formation of deposits, source and the host rock, alterations in host rocks and the resource potential of uranium deposits in Pakistan on the basis of previous studies.*

Keyword*:* *- review study, U-deposits, resource potential*.

1.0 INTRODUCTION

Uranium is a radioactive, whitish, silvery color trace element, having a great importance for nuclear reactor and weapons. Its overall concentration in rocks is about 1-6 parts per million. Total production of uranium in the world is about 5 902 900 t U per year but Pakistan produce less than 1% of this annual production [1]. As in Pakistan uranium research is very restricted for safety of nuclear power so very less data is available to study uranium deposits in Pakistan. During last seven years, the Pakistan Atomic Energy Commission (PAEC) identified domestic uranium by exploration program at nationwide. But unfortunately, no authentic reports are available on this filed to keep continue further research. Although a number of radioactive sites have identified in igneous rocks, pegmatites and schists but main uranium deposits are sandstone type deposits of sedimentary rocks. Sandstone type uranium deposits fulfill 30% of total world uranium requirement [2] so the study of such type of deposits is very important.

2.0 ROLE OF TECTONIC OF PAKISTAN FOR URANIUM DEPOSITS:

As formation of uranium deposit takes millions of years so during this time if a mega tectonic event interrupts this process then its may cause the dissipation or loss of uranium to the environment, so tectonic constancy of a deposit area is very important. But as we know that tectonically Pakistan lies in an active collision zone and Indo-Pakistan plate is subducting under Island Arc along Main Mantle Thrust which is further subducting under Eurasian plate. So the northern areas of Pakistan are geologically very unstable but this tectonic activity is helpful in preservation of uranium deposits. For example tectonic of Pakistan plays important role in Bannu Basin because tectonically repeated upheavals became the reason of lowering of water table which caused the leaching of uranium and further re-precipitation of uranium below the water table.

3.0 REGINAL DISTRIBUTION OF URANIUM DEPOSITS:

Regionally uranium deposits are located in central and southern part of Pakistan such as in Bannu Basin, Sulaiman Range, Dera Ghazi Khan, Issa Khel, Mianwali District and Kirther Range. First uranium deposit was discovered in Sulaiman Range in 1959 then in 1970 many small deposits discovered in Dera Ghazi Khan district[3,4] and recently in 2000/2001 Taunsa was also discovered in this district[4]. So the area of Dera Ghazi Khan is important regarding uranium production and this area lies in Sulaiman Range. Similarly in Bannu Basin and in Salt Range small deposits Qabul Khel and Kalar Kahar respectively were also discovered.

In north of Dera Ghazi Khan District dozen of small uranium deposits discovered such as Baghal Chur, Rakuchur, Rakhi Munh, Nangar Nai, Kaha Nalo, Rajanpur and Taunsa.

4.0 SOURCE ROCKS:

Source of uranium comes from continental sediments of Siwalik group which is divided into three divisions, Upper Siwalik Division (1800-2400m thick), Middle Siwalik Division (1800-2400m thick), and Lower Siwalik Division (1500m thick)[4]. This Siwalik Group spread along Himalayan foothill from Asam to Kashmir and covers the area of Potwar Plateau, Balillu Plains, Bannu Basin and Sulaiman Range.

5.0 FORMATION OF URANIUM DEPOSITS IN HOST ROCKS:

Formation of uranium deposit occurs when source rock discharge leachable uranium elements and these elements start to move from source rock to host rock but when come in contact with ground water (mostly carbonated water) makes a uranium bearing solution than different geological processes take part in mobilization of this solution and finally these uranium elements start to deposit due to geochemical and geophysical traps but all this procedure may takes millions of years to form a productive uranium deposit. Uranium deposits in Pakistan formed in reducing environment [5] or in other words we can say that these deposits formed in absence of oxygen. Infect uranium minerals are more stable in oxidizing environment as compared to reducing environment so when uranium bearing solution come in contact with reducing environment having organic matter or oil heaps then start to deposit as shown in figure 2.

Basically in Pakistan uranium is deposited in three types Uraninite, Pitchblende and Coffinite. Uranium mineralization in Pakistan occurs in Middle Siwalik Dhok Pathan Formation. This formation extends from Dera Ghazi khan in Sulaiman Range to Bannu Basin and in some areas of northern Pakistan and also turns toward east in India. Siwalik Sandstone is basically derived from Himalayan Molasses sediments, ranging in age from Pliocene to Pleistocene. Siwalik Group is divided into four formations (Chinji, Nagri, Dhok Pathan and Soan) having radioactive anomalies[5] and their stratigraphic profile is shown in figure 3. Manchar Formation and Kamlial Formation are also host for uranium deposits, table 1.

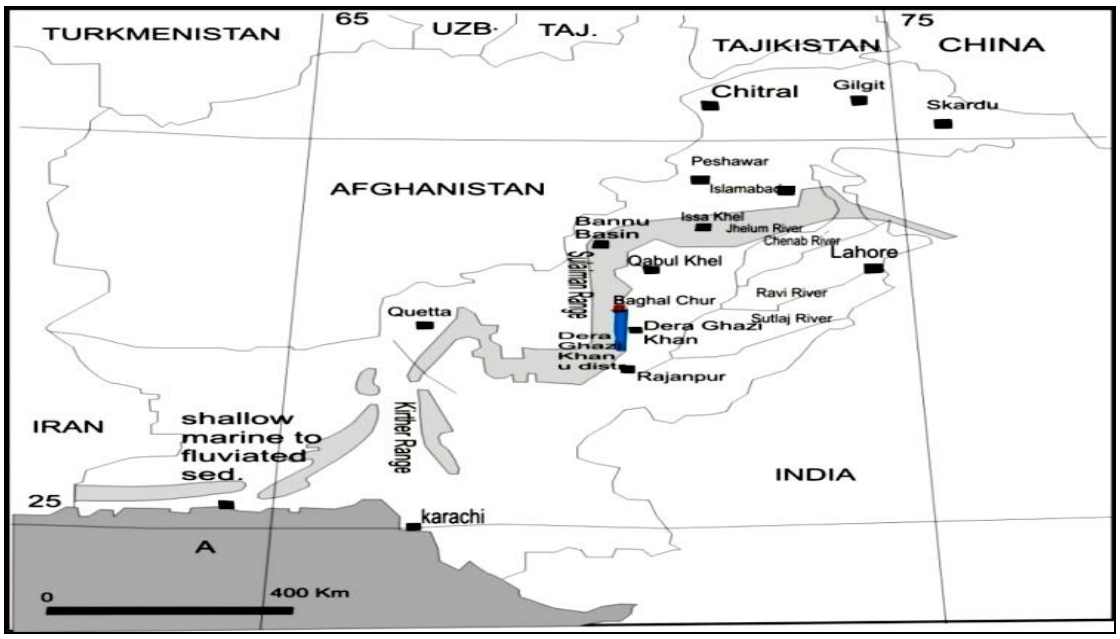

Fig.1: Locality map of Baghal Chur and Qabul Khel uranium deposits in Dera Ghazi Khan and Bannu Basin of Pakistan (after Moghal 2001 and F.J.Dahlkap 2009)

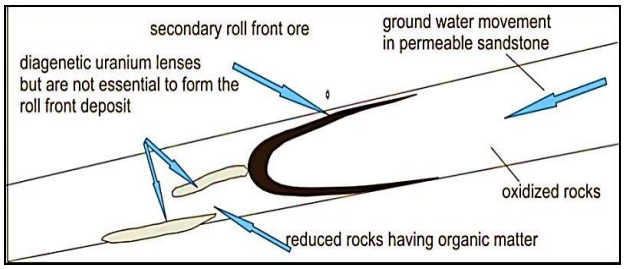

Fig.2: Model for uranium deposit in reducing environment.

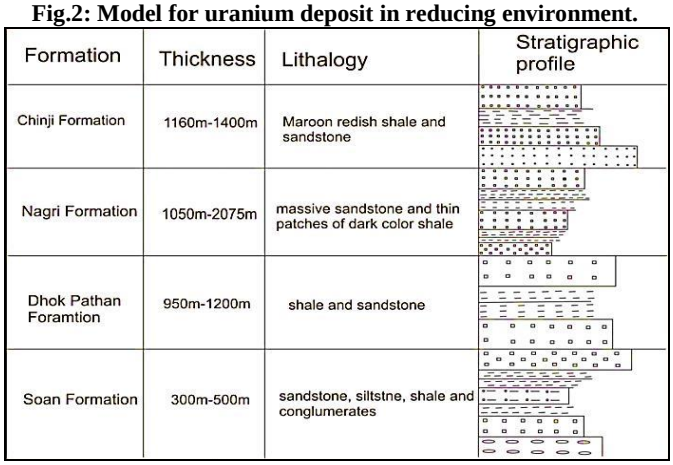

Fig.3: Uranium bearing formations and their stratigraphic profile.

Table.1: Uranium bearing formations and their locality areas.

Host Formation	Area	Uranium concentration
Dhok Pathan Formation	Dera Ghazi Khan in Sulaiman Range	High concentration of uranium
Manchar Formation	Kirther Range in Sindh	4.5% of natural uranium
Kamlial Formation	Kohat, Potwar, Azad Kashmir and Kallar Kahar	High concentration of uranium

6.0 ALTERATIONS IN HOST ROCK:

As uranium start to deposit in reducing environment so the plant remains in host rocks are replaced by iron oxides and other minor alterations like argillization, sericitization, calcitization, sulfidization, zeolitization, baritization etc. some common alterations are as follow: feldspar change to sericite or calcite. Heulandite or calcite replaces the schist fragments. Quartz grains are discolored. Bones and rocks are somewhat silicified. Volcanic tuffs also show alterations and plant remains show pyritization. At the site of uranium mineralization no color or mineral change occurs[4].

7.0 INSPECTION, TECHNIQUES AND EXPLORATION METHODS FOR URANIUM DEPOSITS:

Before the recommendation of a site for progressive drilling, the area is systematically examined for evaluation of reasonably assured reserves (RAR) and for estimated additional reserves (EAR). Such assessment includes the following steps, as shows in Fig.4.

In 1961 radiometric surveys using hand held Gieger Muller gamma counters scintillometers were used for uranium exploration. In 1964 aero-radiometric surveys were used in Dera Ghazi Khan area (Sulaiman Range). Fixed airplane and helicopters were also used. Carbon gamma spectrometric survey was used for radiometric anomalies along roadside. Radon probes analysis was used in 1974 in Baghal Chur then Satellite Imageries were used in 1977. In 1983 Radon on Activated Charcoal was proved to be much better than radon probes, then in 1987 Resistivity and Electromagnetic techniques were used at Qabul Khel deposit[6].

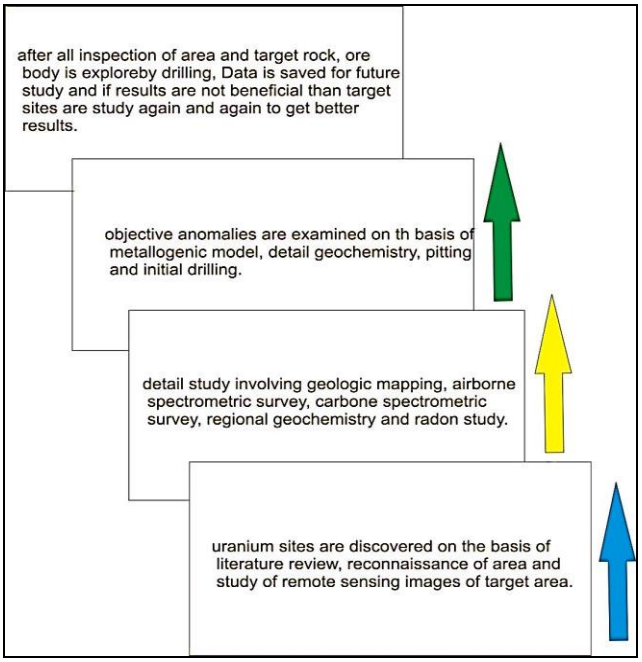

Fig.4: Inspection method for uranium bearing sites.

Table.2: Techniques for exploration

year	technique
1961	Radiometric surveys
1964	Aero-radiometric surveys
1974	Radon probes analysis
1977	Satellite imageries
1983	Radon on activated charcoal
1987	Resistivity and electromagnetic techniques

In early, uranium deposits were explored by open pit mining and underground mining methods especially till the depth of 150-200m and later on ISL (in-situ leaching) mining method was used[4]. Rakhi Munh deposit was mined by ISL technique in 1995 and after this in 1997 Nagar Nai deposit was also explored by such method[4]. ISL mining method is very helpful in Bannu Basin and this technique is also used on Baghal Chur deposit, Kabul Khel, Nngar Nai, Taunsa and Shawana deposits[7]. In March 2007 Pakistan government present a buget of Rs600 million for uranium exploration in Bannu Basin and Sulaiman Range in Dera Ghazi Khan.

7.0 RESOURCE POTENTIAL OF URANIUM IN PAKISTAN:

In 2005 Pakistan government made an Energy Security Plan (ESP) to fulfill the energy requirement of country with the cooperation of Pakistan Atomic Energy Commission (PAEC). According to this plan it was decided that Pakistan will produce 162,590 MWe till 2030 and 8,800 will be produce by nuclear reactors. So Pakistan government also planned to construct two 600 MWe reactors and seven 1000 MWe reactors. Pakistan Atomic Energy Commission in April 2007 has claimed that there are 1000 sites of uranium deposits have been discovered in Pakistan which would be helpful for nuclear power plants. According to this recent report two nuclear power plants are very important which are producing about 380 MW electricity and AEMC is partially fulfilling their uranium requirement because Atomic Energy Minerals Centre (AEMC) which is based in Lahore is responsible for all uranium deposits exploration.

Table.3: Active nuclear power plants of Pakistan.

Nuclear Power Plant	Year of establishment	Annual production
Karachi (KANUPP)	1971	137MWe
Chashma 1	1992	325MWe
Chashma 11	2005	300MWe

Now a days in Pakistan weapons power and fuel supply for Khushab nuclear reactor depends on Qabul Khel mine, Nangar Nai deposit and Taunsa deposit which produce about 40 tons of uranium per year which fulfill about 70% of total requirements for rector[7]. Shanawa uranium mine was a big project that started in 2009[8] having 0.05% uranium ore grade[9] by in-situ leaching method[10] but because of heavy project cost and insufficient funds this project was suspended in February 2011[11].To estimate Pakistan's weapons power from 1995 to 2005 a chart is prepared that show the increasing rate of uranium ore grade.

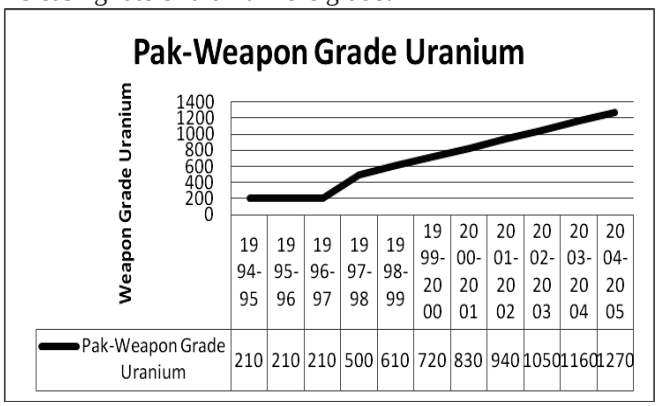

Fig.5: Graphical presentation of weapon grade uranium in Pakistan.

Although uranium weapons grade in increased in Pakistan from 1993-2005 and till now it is increasing but rather than this entire situation, Pakistan is still facing uranium deficit, approximately of 30 tons. This uranium deficiency can be phosphoric acid of fertilizers e.g. di-ammonium phosphate (DAP). Such type of uranium extraction started in Pakistan in 1999[7].

Table.4: uranium deposits of Pakistan.

Uranium deposit	Year	Locality Area
Baghal Chur	1971	Dera Ghazi Khan district (Sulaiman Range)
Qabul Khel	1992	Bannu Basin
Rakhi Munh	1995	Dera Ghazi Khan district (Sulaiman Range)
Nangar Nai	1997	Dera Ghazi Khan district (Sulaiman Range)
Kalar Kahar		Salt Range
Taunsa	2000/2001	Dera Ghazi Khan district (Sulaiman Range)
Shanawah	2009	Karak district NWFP

Table.5: Occurrence of uranium minerals with percentage ore grade in few localities.

Locatity	U grade	U minerals
Baghal Chur deposit	0.05%	Pitchblende and Coffinite
Kirther Range	0.02-4%	Carnotite, Curite, Phurcalite, Saleeite
Shanawa deposit	0.05%	Carnotite and Pitchblende

SUMMARY:

- In Pakistan different types of uranium deposits are identified but the first deposit that was discovered in 1959 in Dhok Pathan Formation of Siwalik sediments was a sandstone type uranium deposit and later on so many other such type of deposits are discovered. So in Pakistan study of sandstone type uranium deposits is very important.
- Such type of deposits are distributed in Bannu Basin, Sulaiman Range, Dera Ghazi Khan, Issa Khel, Mianwali District and Kirther Range. Qabul khel, Baghal Chur, Rakuchur, Rakhi Munh, Nangar Nai, Kaha Nalo, Rajanpur and Taunsa deposits have been discovered.
- Continental sediments of Siwalik sequence are the source of these deposits and this Siwalik Group spread along Himalayan foothill from Asam to Kashmir and covers the area of Potwar Plateau, Balillu Plains, Bannu Basin and Sulaiman Range.
- Manchar, Kamlial and Dhok Pathan Formations are good host rocks for such type of deposits and ISL is a common mining method in Pakistan.
- According to ESP Pakistan will produce 162,590 MWe till 2030 and 8,800 will be produced by nuclear reactors. So Pakistan government also planned to construct two 600 MWe reactors and seven 1000 MWe reactors. To fulfill 70% fuel requirement for these reactors Qabul Khel, Nangar Nai and Tuansa deposits are mined to produced 40 tons of uranium per year.

REFERENCES:

1. A Joint Report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. Uranium 2014: Resources, Production and Demand. NEA No.7209 © OECD 2014. (www.oecd.org/publishing/corrigenda)
2. Kyser, K., Cuney,M., 2009, Sandstone-hosted uranium deposits. In Recent and not-so-recent developments in Canada. Short course series 39, 161-220.
3. Dahlkamp, Franz J. "Uranium ore deposits." (1993).
4. Dahlkamp, Franz J. Uranium deposits of the world. Vol. 2. Springer, 2009.
5. Sami Khan, 2013. Uranium deposits in Pakistan and their formations.
6. Mansoor, Muhammad. "Nuclear minerals in Pakistan." The Nucleus 42.1-2 (2005): 73-83.
7. Tamara Patton, December 2012. Uranium Fuel Constraints for Pakistan's Nuclear Weapon Complex. Source: http://defence.pk/threads/an-analysis-of-pakistans-uranium-supply.223332/#ixzz3Jrol5knN.
8. Global Fissile Material Report 2010, Chapter 10, International Panel on Fissile Materials, December 2010, www.fissilematerials.org.
9. Jack Boureston, "Understanding Pakistan's Energy Security Needs and the Role of Nuclear Energy," South Asian Strategic Stability Institute, Jun 2008, www.sassu.org.uk.
10. "Pakistan to mine 60 Tons of Uranium Annually, "Nuclear Fuel News,29 Aug 2009, www.nuclearfuels.energy-business-review.com.
11. Umar Farooq, "Valentine's surprise: Rosy start to a fiery debate in K-P assemble," Express Tribune, 15 Feb 2011, www.tribune.com.pk; limitiaz Husain, "KPA protest funds transfer to multan, Larkana," Islamabad Weekly Pulse,22 Feb 2011, www.weeklypuse.org.
12. Qureshi, A. A., et al. "Determination of uranium contents in rock samples from Kabul phosphate deposit, Abbotabad (Pakistan), using fission-track technique. "Radiation measurements 34.1 (2001): 355-359.
13. Ahearne, John F. "Prospects for nuclear energy." Energy Economics 33.4 (2011): 572-580.
14. Tauchid, M., and D. H. Underhill. "Uranium deposits of the world." Proceeding of Exploration. Vol. 97. 1997.
15. Rich, Robert A., Heinrich D. Holland, and Ulrich Petersen. "Hydrothermal uranium deposits." (1977).
16. Deffeyes, Kenneth S., and Ian D. McGregor. "World uranium resources." (1980).
17. Muneer, T., and M. Asif. "Prospects for secure and sustainable electricity supply for Pakistan." Renewable and Sustainable Energy Reviews 11, no. 4 (2007): 654-671.