Formation evaluation of Zarzaitine Formation for Uranium mineralization in western part of Murzuk Basin SW Libya

Dr. Saleh Elalawi[1], Abraheem Mohamed Jabouda [2 (*)]

[1, 2] Dept. of Geological Engineering, Faculty of Engineering. Nalut University

Abstract

Globally, there has been an ever increasing demand for uranium. This generates need to adopt unique methodologies in order to explore the mineral to its full extent. This paper highlights an integrated approach that is adopted to explore uranium occurrences in western part of Murzuk Basin SW of Libya.

The process of Uranium mineralization exploration composed of several stages which starts with small scale and develops into larger

(*) Email: salehelalawi@gmail.com[1], i.gobouda@nu.edu.ly[2]

scale. In every stage, geological and geophysical information are collected, processed and integrated. Then, after finishing every stage produced Uranium mineralization potential map and the study area becomes smaller

In this the study Spatial integration of various data sets such as geological map, and airborne radiometric data are applied to show the distribution and intensities of uranium (U) within the studied area. Also, used logging Gamma ray to evaluate Zarzaitine Formation in study area. Geographic Information System (GIS) model has been designed and implemented based on the intersection of the buffering zones of each input layer.

The result of the geological map matching the airborne radiometric map by GIS technology, revealed that there are 5 uranium anomalies concentrated on the Zarzaitine Formation , while the results of the logs show that the well D1-155 has recorded the highest values of uranium ranging between 5 to 10 PPM

***KEY WORDS**: Uranium mineralization's, Airborne radiometric data, Radiometric, Gamma ray log, GIS*

Introduction

The Zarzaitine Formation was first described by Lapparent and Lelubre (1948) in the Zarzaitine field area of eastern Algeria. Most of this formation is located in the Illizi Basin in Algeria and smaller part of it is in Libya. According to Protic (1984) the lithological characteristics indicate that the Zarzaitine Formation was deposited in a fluvial environment. Previous studies (e.g., Protic, 1984; Dahoumane et al., 2016) showed that the possible age of this formation is the Triassic. The uranium minerals were first discovered by Assaf et al., (1976) in the Zarzaitine Formation at Al Awaynat- Serdles area, Murzuk Basin, SW

Libya. Since that time the whole area has been considered as potential for uranium and became the subject of extensive geological and geophysical exploration. The geology of these

uranium occurrences, together with their postulated genesis, has been described in detail elsewhere (Pejatovic, 1979; Obrenovic, 1981; Assaf et al., 1988; Assaf et al., 1994).

Due to the nature of the process of Uranium mineralization exploration, geologists deal with a variety of data from different sources to explore the mineral deposits. The main objective of this study is to link geological data with geophysical data to assess the potential presence of uranium in the study area.

In the Uranium exploration, well logging is a basic tool in the exploration. Gamma-ray logging is recognized for detailed exploration in the western part of Murzuq basin to provide additional information on the stratigraphy, lithology and distribution of gamma. The study area was investigated by airborne gamma – spectrometric of an area about 25000 km² and ground follow up recognized 5 anomalous on the surface detected by airborne survey This study was also supported by subsurface investigation using well logging of three borehole in the area .

Methodology

Spatial integration of various data sets such as geological map (1:100,000 scale), and airborne radiometric data are applied to show the distribution and intensities of uranium (U), within the studied area. Geographic Information System (GIS) model has been designed and implemented based on the intersection of the buffering zones of each input layer.

Data obtained from three boreholes (k1-155 , L1-155 , D1-155) in concession (NC155) western part of Murzuk basin as shown in fig (1) , The study was concentrated on Zarzaitine Formation, The measured gamma ray log converted to digital values for calculation of radioactive concentration in deferent formation using software and using gamma ray index IGR equation (1) for determination of radioactive variation of IGR and formation correlation on three boreholes to show a depth interval of radioactive mineralization .

$$I_{GR} = (GR_{log} - GR_{min}) / (GR_{max} - GR_{min}) \qquad \text{Eq. (1)}$$

Where

IGR is Gamma ray index (API) - GR log is Gamma ray reading (log)
GRmin minimum reading (log) - GRmax maximum reading (log)

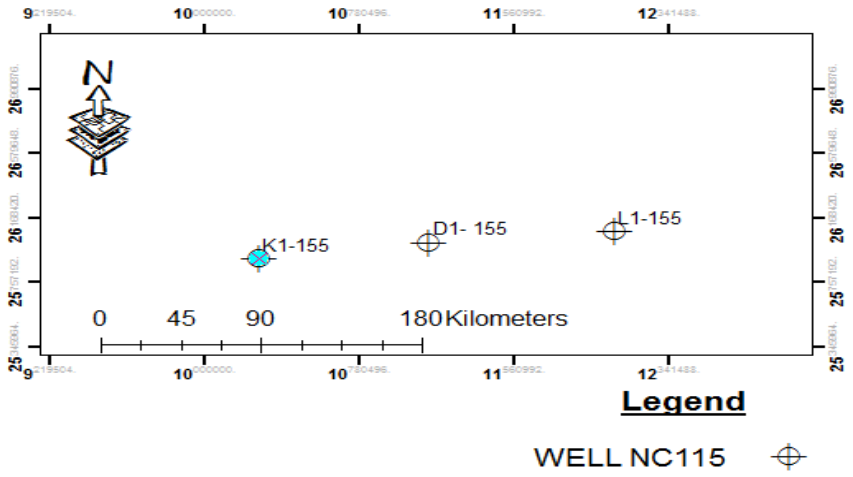


Figure (1) shows the distribution of wells in the study area (using GIS technology)

The relationship between the concentration of the three radioactive components and the total gamma ray signal in API units (γAPI) is given approximately by:

$\gamma API = 4\ Th + 8\ U + 16\ K$

when thorium (Th) and uranium (U) are measured in ppm and potassium (K) in percent by weight.

Geology of Uranium Deposits

Uranium occurs in trace amounts nearly everywhere on the planet, even in seawater, but only rarely is concentrated as ore deposits. There are more than 200 different uranium-bearing minerals known and many other minerals that contain minor or trace amounts of uranium, such as zircon and feldspar. Uranium ore deposits can contain a number of different ore minerals such as uraninite, carnotite, tyuyamunite, coffinite, and several others although usually only a few dominate a given deposit. There are three main types of uranium ore deposits: 1) conglomerate paleoplacer deposits, 2) unconformity deposits, and 3) sandstone-hosted deposits. A pale placer is a sedimentary accumulation of sand, gravel, and cobbles deposited by ancient stream and river systems (figure2). Most uranium deposits of this type were formed nearly 2 billion years ago when Earth's atmosphere contained no appreciable oxygen, and uranium could exist at the surface without becoming oxidized as it would today. These conglomerate hosts are usually very well lithified and resistant rock units. They can be quite rich deposits and are found in numerous locations around the world, including some of the mountain ranges in Wyoming, although such deposits in Wyoming have to date not been economical. There are several economic deposits of this type in Ontario, Canada and South Africa.

Facies and Depositional Environment Analysis

The gamma ray log is often used to measure the shaliness of a formation. In reality the shaliness often does not change suddenly, but

occurs gradually with depth. Such gradual changes are indicative of the litho-facies and the depositional environment of the rock, and are associated with changes in grain size and sorting that are controlled by facies and depositional environment as well as being associated with the shaliness of the rock. Figure 3 shows the shape of gamma ray log responses for various depositional environments. All possible combinations of these shapes may be encountered.

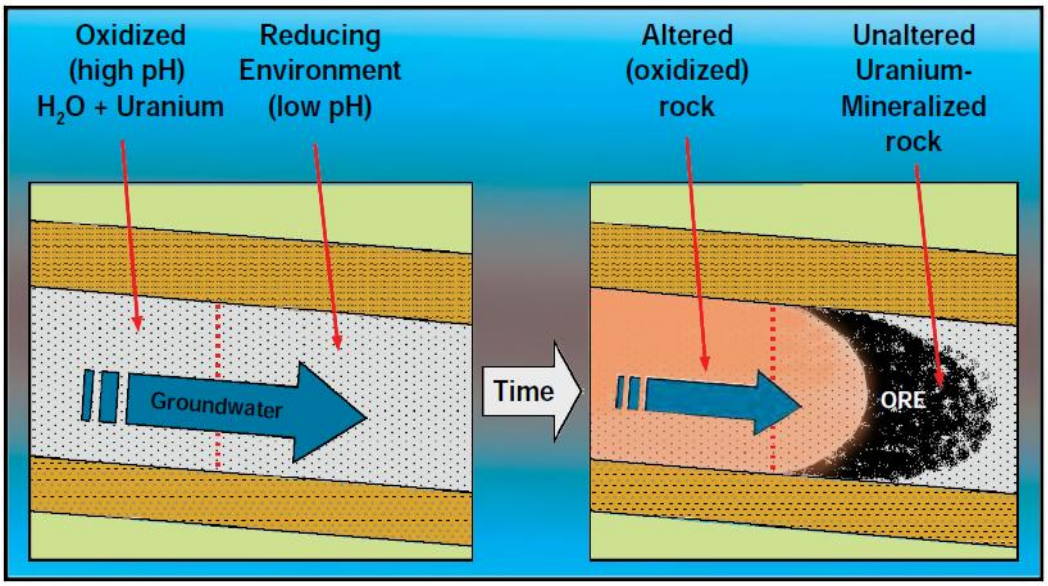


Figure 2 .Simplified cross- section diagram of the development of a roll front uranium ore body . oxidized water carries uranium in solution and precipitates uranium minerals in a reducing environment (Graphic by Roberr W. Gregory and James R. Rodgers.2016)

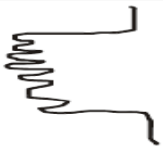
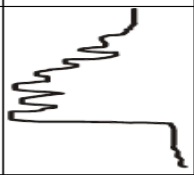
Shape	Smooth	Environments	Serrated	Environments
Cylinder Represents uniform deposition.		Aeolian dunes Tidal sands Fluvial Channels		Deltaic distributaries Turbidite channels Proximal deep-sea fans
Bell Shape Fining upwards sequences.		Tidal sands Alluvial sands Braided streams Fluvial channels Point bars		Lacustrine sands Deltaic distributaries Turbidite channels Proximal deep-sea fans
Funnel Shape Coarsening upward sequences.		Barrier bars Beaches Crevasse splays		Distributary mouth bars Delta marine fringe Distal deep-sea fans

Figure3 The gamma ray log and depositional environments (Prson 1963)

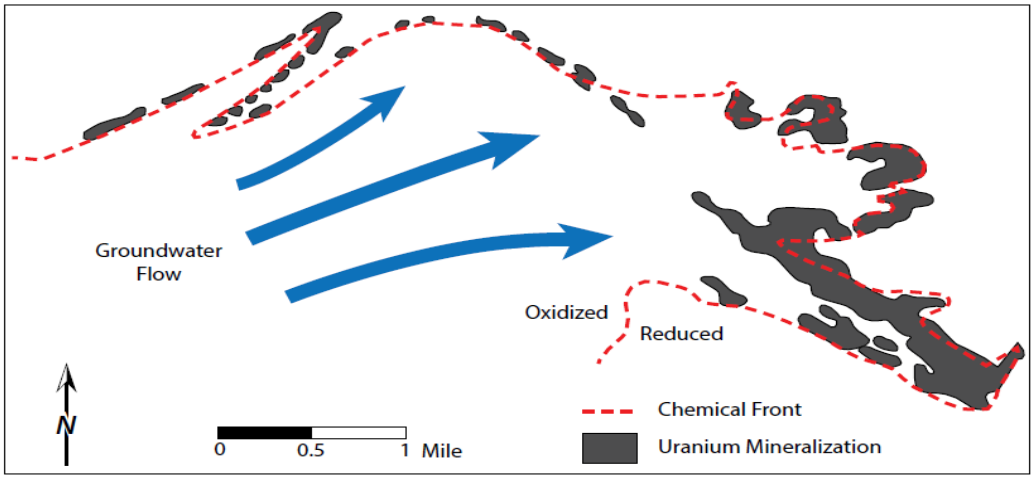


Figure 4 . Diagram of uranium roll front mineralization in plan view southern powder river Basin

(Graphic by James R. Rodgers, 2016, modified from Dahl and Hagmaier, 1976).

Geology of study area

The study area is situated on the western rim of the Murzuq basin, where various Paleozoic, Mesozoic, and Tertiary sediments crop out (Fig .5). The older Paleozoic formation that were investigated and radiometric survey were the Akakus formation (Silurian)which consist of an alternation of clastics , coarse to medium grained brown to reddish sandstone with cross bedding in the lower part ,the middle forming fine- grained sandstone , the upper part consist of medium –grained sandstone Devonian Tadrart formation followed upwards by OuanKasa , Carboniferous Marar ,Assedjefar , Dembaba formations .Then follow the Triassic Zarzatine were deposited in meandering river bed and Jurassic – Cretaceous Taouratine and Messak formations are of typical continental origin , deposited in braided river alluvial systems.

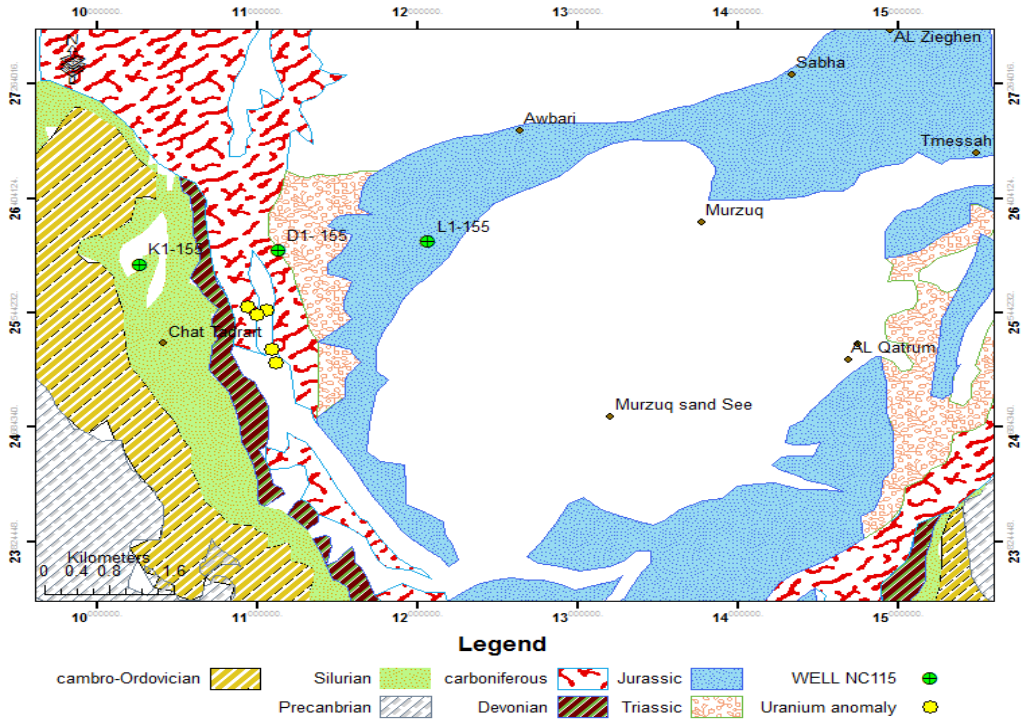


Figure 5. A geological map of the Murzuq Basin showing the main stratigraphic units, well locations and anomalous uranium. Modified after El Chair (1984). (Using GIS technology).

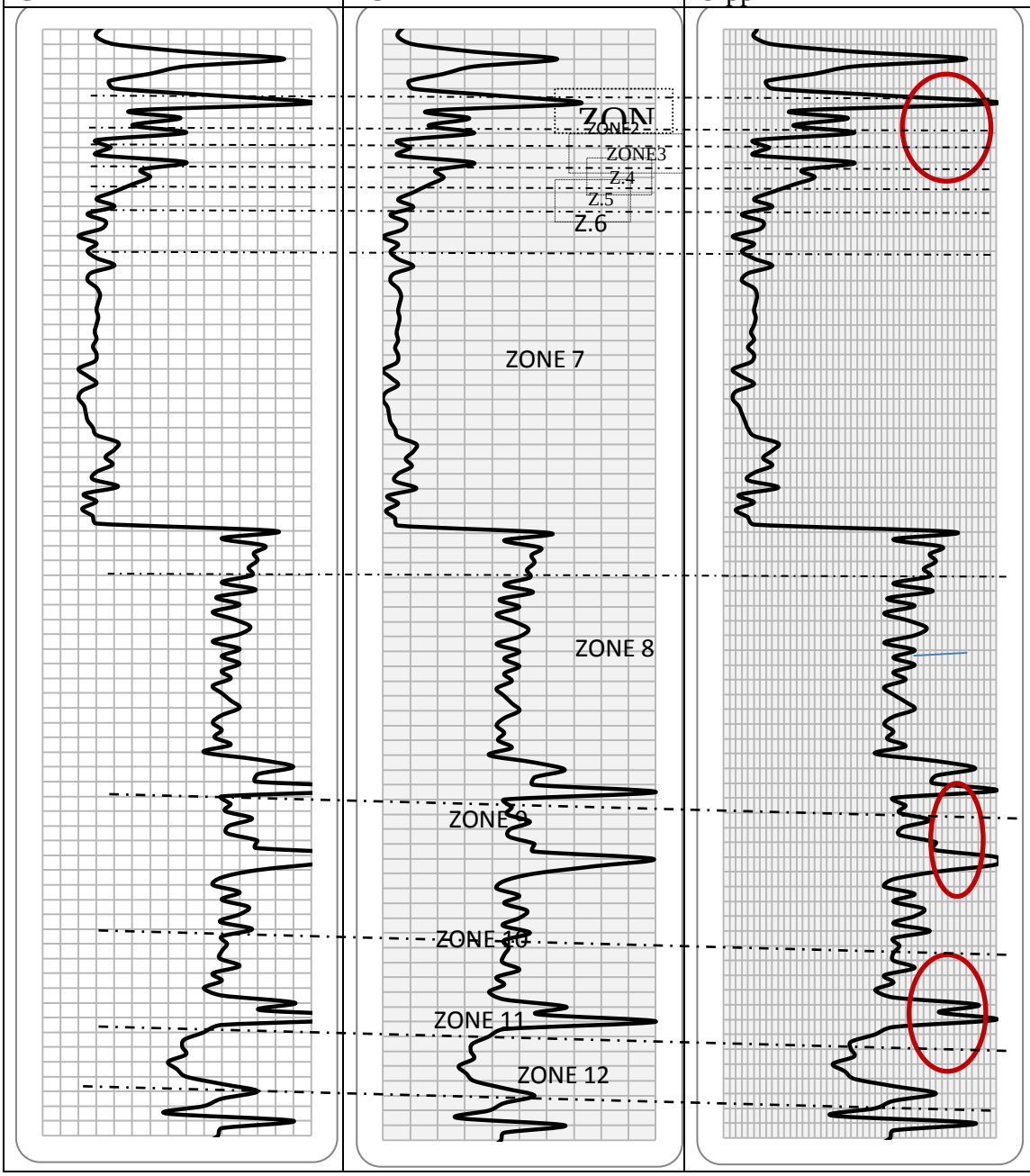
Tectonic activity in the western part of Murzuq basin forming the faults trending N-S and NW-SE , with vertical displacement and folds anticline in the Carboniferous strata plunging toward north-west.ring structure composed of an outer ring about 1.5 km in diameter .

Well logging Results

Calculation, analysis and interpretation of the results obtained from the well L1-155 and D-155 as show in the table 1 and 2.

Table1; This diagram shows the relationship between GR .IGR and U ppm of the well L1-155

MEZOZOIC- Triassic- Zarzatine Formation	
Well	L1-155
Thickens	m150

GR	IGR	U ppm
		

MEZOZOIC- Triassic- Zarzatine Formation	
Well	D1-155
Thickens	m110

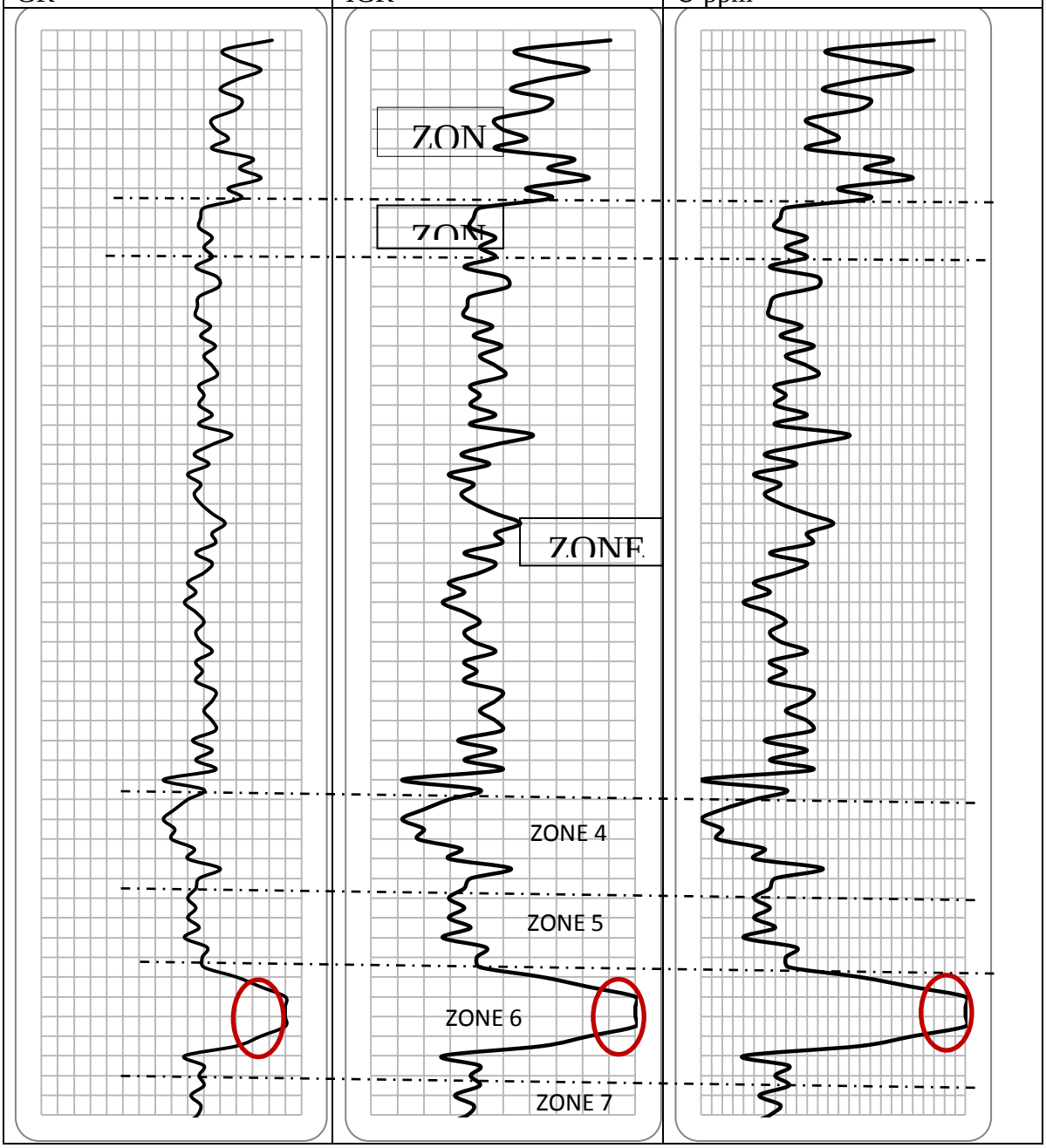


Table 3; illustrates the results obtained from wells log

Age	Formation	Well	Depth	Thickens	GRavg	GRmin	GRmax	IGRavg	IGR %	Uppmavg
	Zarzatine	L1-155	350-500	150m	84.6	20	200	0.35	35	5.6
		D1-155	150-260	110m	104.4	85	150	0.46	46	6.5

Table 4 It illustrates the change in uranium values in each zone

Age	Formation	Well	Zone	Uppm	Well	Zone	Uppm
	Zarzatine	L1-155	Zone1	3 to 9	D1-155	Zone1	7 to 9.5
			Zone2	2		Zone2	6.5 to 9
			Zone3	3 to 10		Zone3	6 to 8
			Zone4	2 to 5		Zone4	5 to 7
			Zone5	2		Zone5	6
			Zone6	2 to 6		Zone6	6 to 10
			Zone7	1.5 to 3		Zone7	6.5
			Zone8	7 to 9			
			Zone9	8 to 10			
			Zone10	7 to 8			
			Zone11	5 to 10			
			Zone12	4 to 10			

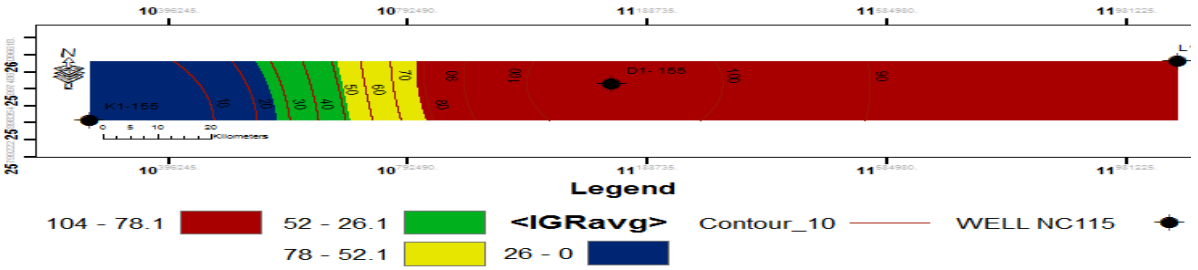


Figure 6. Contour map showing the average IGR of wells in the study area.(using GIS technology)

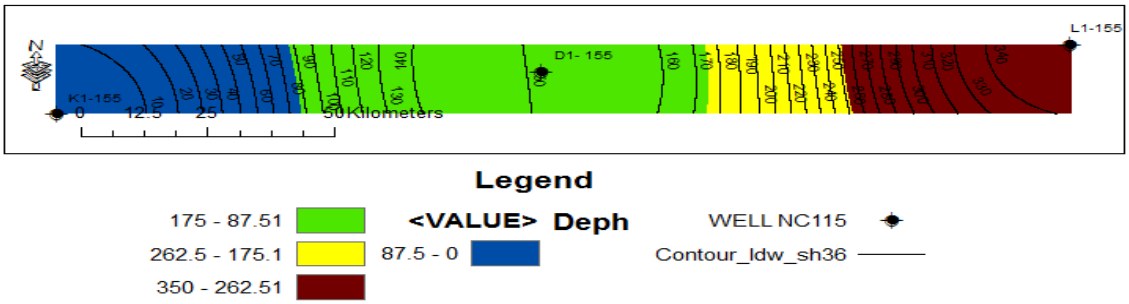


Figure7. Contour map showing the average depths of wells in the study area.(using GIS technology)

Conclusion

In this study, spatial integration is applied to different data sets. Firstly, drawing the geological map using a GIS program where the engineering improvement was carried out and transformed into digital data to make it easier for the computer to deal with it.

Secondly, the airborne radiological data were projected to show the distribution and intensity of uranium (U) on the geological map, and this was done to determine the locations of wells within the studied area. The gamma-ray Log was used to assess the formation of Zarzatine in the study area.

The result of the geological map matching the airborne radiometric by GIS technology revealed that there are 5 anomalies of uranium concentrated on the Zarzatine formation.

Through the results obtained from the calculation and analysis of the gamma ray Logging for the formation of zarzatine, the value of uranium was found in ranges between 5 to 10 ppm in well D-155, and between 2 to 10 ppm in well L-155,while well K – 155 does not contain

the Zarzatine formation because the well is located at the edge of the basin.

According to the results, it was found that the further we went north of the well D-155, there would be better results. Therefore, we recommend using gamma-ray logging for the oil wells located in the north of well D-155 and using remote sensing technology to identify the drainage pattern.

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