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Thorium Normalization Application on Six Wells in North Nile Delta, Egypt

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***ABSTRACT* : Based on observations of surface or aerial spectrum gamma ray, petroleum prospecting in stratigraphic and structural traps can be established. The most abundant and promising gas and condensate province in Egypt is the Nile delta basin. The three spectrometric radioactive gamma ray-logs (eU, eTh, and K% logs) were used to determine the hydrocarbon potentialities zones on the sandstone reservoirs in the area. Applying this technique to the Kafr El-Sheikh Formation's recorded gamma-ray spectrometric logs from Egypt's Nile delta.**

The different reservoir parameters and the net pay zones in the research region were determined by analyzing the conventional well logs (gamma-ray, resistivity, neutron, density, and sonic logs). The application of the thorium normalization technique can be used as a quick guide for hydrocarbon accumulation zones in the study reservoir rocks because the agreement ratios between the results of the well log analysis and those of the thorium normalization technique range from 67% to 73%, with an average ratio of 71% in six different studies.

KEYWORDS: Thorium Normalization , Nile Delta, Structural Traps, Kafr El-Sheikh Formation.

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I. INTRODUCTION

El-Wastani concession is located in North Nile Delta. This study is applied on Kafr El-Sheikh Formation, El Wastani Concession is located approximately between latitude 27°56′10″ to lat. 28°03′38″N and longitude 33°38′41″ to long. 33°50′54″E. The area is represented by six wells namely: Akhen, Happy, Seth, EW-8, Ew-9 and EW-12 wells scattered in the oil field (Fig. 1). The history of radioactivity measurements associated with produced oil dates back to (1). Petroleum explorationists have been experimenting with gamma radiation measurements as a petroleum prospecting method since the early 1950s (2).

Spectral gamma-ray logs were used to calculate the radiogenic heat production values to differentiate between source and reservoir rocks (3). Reservoir parameters were collected to calculate the weighted index of reservoir quality, (4). (5), used the thorium content as a lithologic control to define ‘‘ideal’’ potassium and uranium values. The present study deals essentially with the analysis and interpretation of the aerial gamma-ray spectrometric survey data. These analysis and interpretation are mainly devoted toward prospecting hydrocarbon accumulations in the stratigraphic and the structural traps. A thorium normalization technique was first applied to well logging data by (6) who concluded that the results of thorium normalization agree with the results of well log analysis on the Lower Miocene (Rudeis) Formation in Belayim marine oilfield in 82% of the cases studied. This work applies the thorium normalization technique on sandstone reservoirs to determine the oil bearing zones using only the gamma ray spectrometric log and comparing it to the conventional well log analysis. The new technique was applied on Kafr El-Sheikh Formation in the Nile Delta.

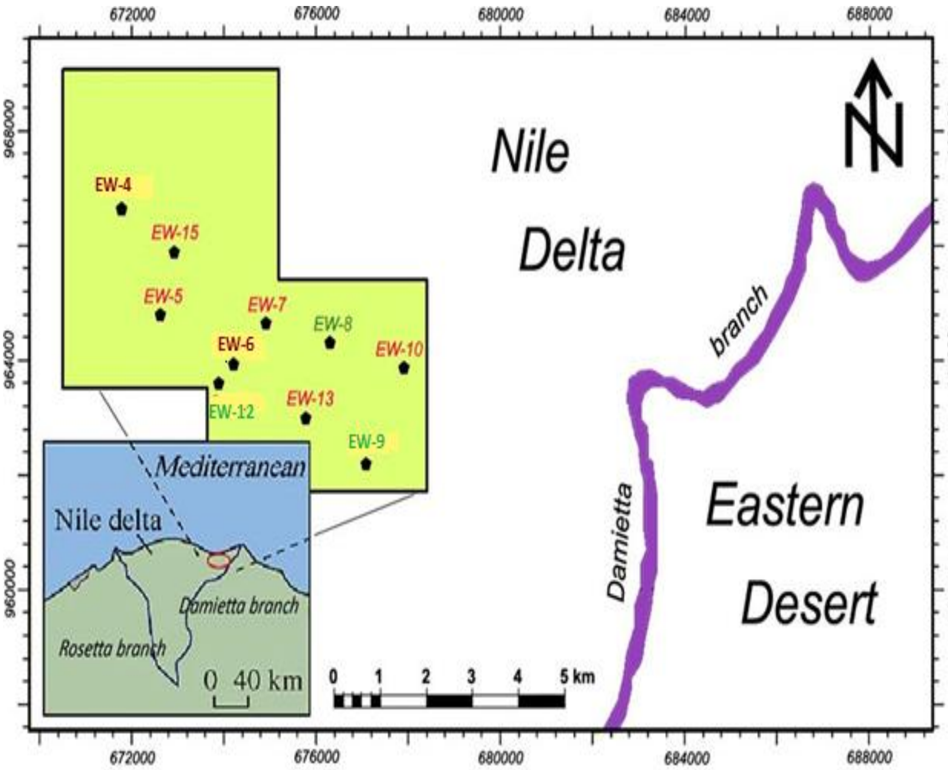

Fig. (1): Location map of the study area

2. GEOLOGICAL SETTING

Due to the Nile Delta's significance to Egypt's daily life and growth, it has attracted comparatively greater attention. Numerous authors including (7, 8 & 9) have searched the Nile Delta province. The lithostratigraphic sequence of Nile Delta, is presented in figure (2).

From bottom to top, the Pliocene sediments in the Nile Delta can be divided into the following formations: Abu Madi, Kafr El-Sheikh, El-Wastani, and possibly the lower portion of Kafr El-Sheikh Formation, which sits congruently above Abu Madi Formation and lies beneath El-Wastani Formation. With a few interbeds of siltstone and streaks of fine-grained sandstone, it is primarily made up of highly fossiliferous marine clayey shales. Its faunal composition is indicative of a habitat on the outer shelf, possibly on the depocenter slopes. According to paleontological evidence, it covers the entire Delta region and has a reasonably permanent characteristic that dates it to the Lower and Middle Pliocene (10 & 11). To the north and northwest of the area, this formation's thickness increases.

3. METHODOLOGY

A new exploration method has been developed by (12) using surface and aerial gamma-ray spectral measurements in petroleum prospection in stratigraphic and structural traps. In Equivalent uranium and potassium data for subsurface gamma-ray spectrometry logs were normalized to equivalent thorium data, using the procedures of (12). Plots were made for the logs of measured Ks versus eThs and eUs versus eThs values for all readings. The simplest effective Eqs. (1) and (2) relating these variables were determined to be linear and pass through the origin. The slopes of the lines were determined by the ratios of mean Ks to mean eThs, or mean eUs to mean eThs. The equations are:-

$$\text{Ki} = \frac{mean\ Ks}{mean\ eThs}\ eThs$$

$$\text{eUi}= \frac{mean\ eUi}{mean\ eThs}\ eThs$$

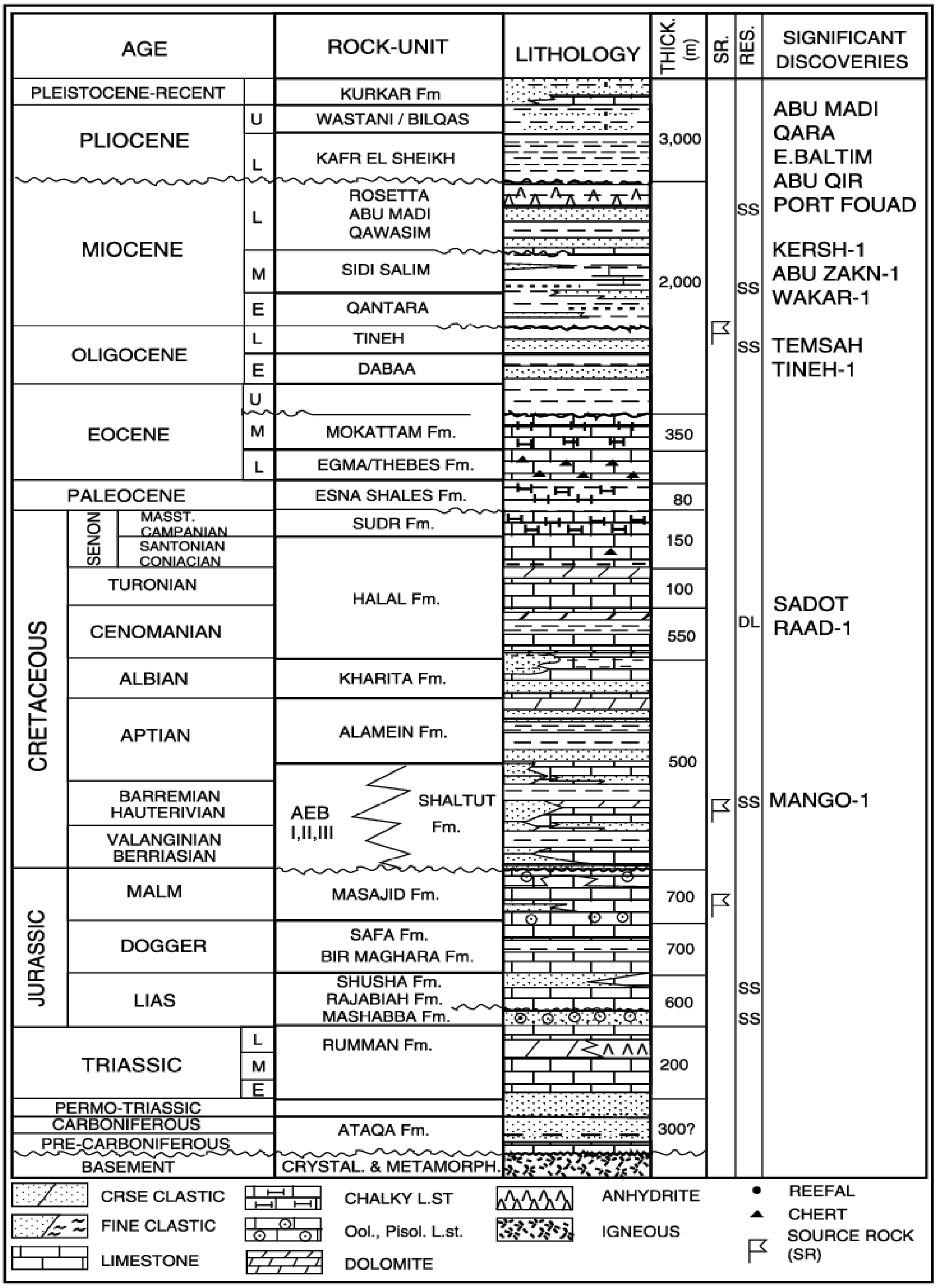

Fig. (2): Generalized lithostratigraphic sequence of the Nile Delta area after (8)

Where Ki is the ideal equivalent thorium defined potassium value for the reading with a real equivalent thorium value of eThs, and eUi is the ideal equivalent thorium defined equivalent uranium value for that reading. Using this approach, the equations were calculated directly from the data and quick field evaluations may be made without preparing the plots and resorting to curve fitting. Deviations of the real values from the calculated ideal values for each reading were obtained using equations of the form

$$KD\%= \frac{Ks-Ki}{Ks}$$

$$eUD\%= \frac{eUs-eUi}{eUs}$$

Where Ks and eUs are the measured values at the reading stations, and KD% and eUD% are the relative deviations expressed as a fraction of the reading values. Experience has shown that KD% yields small negative values and eUD% yields smaller negative or sometimes positive values (12). KD% and eUD% variations can be combined as a single positive number, DRAD, which is the difference between both of them:

DRAD= eUD% -KD%.

The three variables (eU, eTh and K) registered for six wells in the study area, in the form of three digitized logs along the well depth every 1 m. The DRAD arithmetic mean (X) plus three times standard deviation (3S) for the data set were computed, any single profile value greater than this quantity (X+3S) should have a probability of 99.87% so that it represents a valid anomaly and is not caused by random variations in the background values (13). TechLog software was used to calculate the different reservoir parameters using the different conventional logs (gamma ray, caliper, sp, resistivity, neutron, density and sonic logs).

This work, the well logging data are used to determine the oil bearing zones using this technique in Nile Delta and South Valley areas in Egypt. These areas are selected to apply this technique on the well logging gamma-ray spectrometry.

4. RESULT AND DISCUSSIONS

Comparative profiles of KD%, eUD% and DRAD are plotted for six wells to illustrate the oil bearing zones. The following discussion is devoted only to Kafr El-Sheikh Formation in Happy well, Ras El-Bar oil field. The oil bearing zones determined depend on the values of shale volume (less than 35%), effective porosity (more than 10%) and hydrocarbon saturation (more than 50%). These values are calculated by the analysis of the conventional well logs, thus in this part we will compare the thorium normalization DRAD curve with the curves of the calculated three values in Happy well at offshore Nile Delta. The relation between derived DRAD curve and the reservoir parameters in Happy well are plotted in fig. (3) and can be discussed as:

4.1. DRAD curve

Figure 3 shows plots of processed gamma spectrometry data and DRAD values. Positive DRAD values are expected to represent good oil bearing zones with higher levels of hydrocarbon accumulation, such as zones from 1410 m to 1430 m, 1580 m to 1620 m, and 1660 m to 1685 m. Negative DRAD values, on the other hand, are reported in some zones, such as depths (from 1440 m to 1460 m and 1700 m to 1710 m) that are considered poor hydrocarbon yielding zones.

4.2. Volume of shale curve

Fig. (3) illustrates the high values of shale volume (more than 35%) at many zones along the calculated volume of shale curve as in zones between these depths (from 1440 m to 1460 m, 1510 m to 1560 m and 1700 m to 1710 m). A low volume of shale values (less than 35%) was also recorded in many zones (from depths 1410 m to 1430 m, 1580 m to 1620 m and 1660 m to 1685 m). Thus, the curve of shale volume is inverse the DRAD curve.

4.3. Porosity curves

The total porosity values in this well ranging from the minimum value (about 4%) to the maximum value (about 31%) are illustrated in Fig. 3. The high total porosity values were recorded in many zones along the depth of this well as in the zones (from depths 1660 m to 1690 m, and from 1720 m to 1750 m). On the other hand, the low effective porosity values were also noted in many zones (from depths 1700 m to 1710 m). Thus, the effective porosity curve is mainly in agreement with the DRAD curve.

4.4. Hydrocarbon saturation curve

The net pay zones are the zones which have hydrocarbon amounts more than 50% of all fluids in different zones, thus the zones from 1410 m to 1430 m, 1580 m to 1620 m and 1660 m to 1685m are considered as pay zones as illustrated in Fig. 3. Meanwhile the zones from depths from 1440 m to 1460 m and 1700 m to 1710 m are considered poor hydrocarbon zones because these zones have low hydrocarbon saturation values.

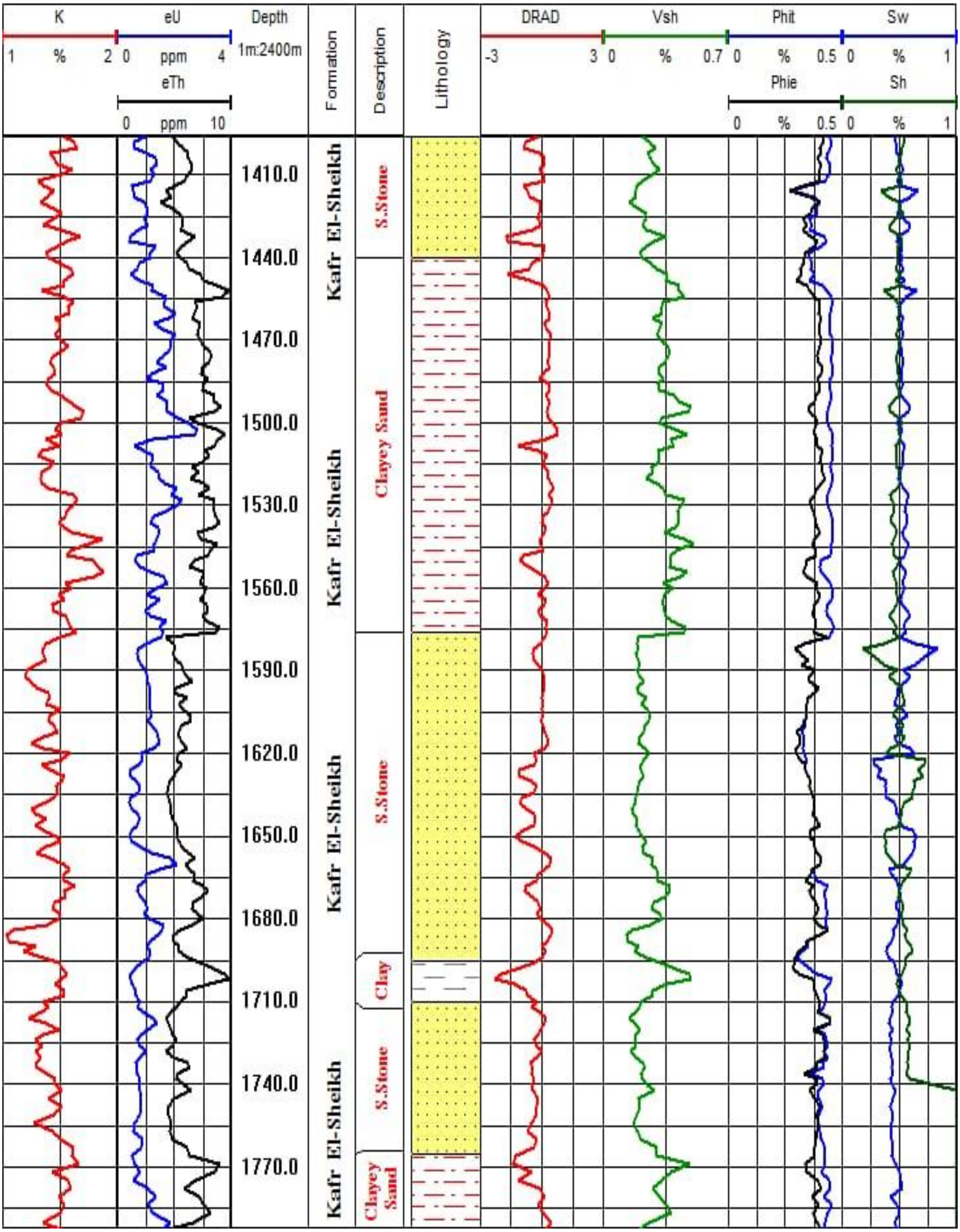

Fig. (3): Relationship between thorium normalization DRAD results and well log analyses results of Kafr El-Sheikh Formation in Happy well, Ras El-Bar oil field, offshore Nile Delta, Egypt.

It is also observed that the hydrocarbon saturation curve frequently agrees with the DRAD curve. From the previous discussion and according to Fig. 3 it can be noted that zones which have positive DRAD values have low values of shale volume, high effective porosity values and high hydrocarbon saturation values. On the other hand, the negative DRAD values zones are recorded in zones which have high values of shale volume, low effective porosity values and low hydrocarbon saturation values. The agreement ratio in Happy well offshore

Nile Delta between the results of DRAD curve and the net pay zones is calculated along the depth of the well as follows:

A. Positive DRAD related to net pay zone is in agreement.
B. Positive DRAD related to non-net pay zone is in disagreement.
C. Negative DRAD related to net pay zone is in disagreement.
D. Negative DRAD related to non-net pay zones is in agreement.

The agreement ratio between derived thorium normalization DRAD curve and the calculated reservoir curves in Happy well is 68 %. While the average agreement ratio in all studied six wells in Kafr El-Sheikh formation in Ras El Bar Oil Field is 71 %.

5. CONCLUSIONS

Thorium normalization was used in various wells in the Ras El Bar oil field to determine the oil bearing zones in sandstone reservoirs, and the results of this technique agree with the results of well log analyses in the studied area (offshore and onshore of the Nile Delta area) with 71% agreement ratios.

The generated DRAD curve can be used as an indicator for oil bearing zones in different wells in the research region because to the high agreement ratios between the thorium normalization approach and the results of the well log studies.

REFERENCES

[1] Bogoyavlenskiy, L.N., 1929. Radioactivity of ashes of some rock oils. Izv. Inst. Prik. Gepfiz. 4, 311-314 (translated in BuMines Inf. Circ. 6224, p. 22).

[2] Armstrong, F.E., Heemstra, R.J., 1973. "Radiation Haloes and Hydrocarbon Reservoirs: A Review. US Bureau of Mines Information Circular", pp. 52–79.

[3] Muhammad Nabih, and Ibrahim M. Al-Alfy. 2021. Differentiation between source and reservoir rocks using statistical analysis of radiogenic heat production: A case study on Alam El Bueib Formation, north Western Desert, Egypt, Applied Radiation and Isotopes 176 (2021) 109868 https://doi.org/10.1016/j.apradiso.2021.109868

[4] Al-Alfy, I. M., El-Hawary, A. M., Mohammad, H. B. E.-D., Shaheen, M. A., & Nabih, M. 2022. 3D Slicing of Weighted Index for Reservoir Quality of Lower Miocene Rocks, Belayim Marine Oil Field, Gulf of Suez, Egypt. Journal of Geoscience and Environment Protection, 10, 55-65.

[5] Saunders, D.F., Terry, S.A., Thompson, C.K., 1987. "Test of national uranium resource evaluation gamma-ray spectral data in petroleum reconnaissance", Geophysics 52, 1547–1556.

[6] Al Alfy, I.M., 2009. Radioactivity and reservoir characteristics of lower Miocene rocks in Belayim marine oil field. Ph.D. Thesis. Faculty of Science, Zagazig University, Gulf of Suez, Egypt, 174 P

[7] Shereef, M.R., 1972. A geophysical study on the Nile Delta area from petroleum prospection. Ph.D. Thesis, Faculty of Science, Cairo University, Egypt, 188 pp.

[8] Schlumberger, 1995. Well Evaluation Conference of Egypt, Schlumberger Technical Editing Services, Chester

[9] Abdel Halim, M., 2001. Future hydrocarbon potential in the Nile Delta offshore and onshore, Delta, modern and ancient, In: Proceedings of the First International Symposium on the Delta, Cairo, Egypt,March 13–19, 1999, pp. 159–174.
https://doi.org/10.4236/gep.2022.108005

[10] Rizzini, A., Vezzani, F., Cococcetta, V., and Milad, G. 1978. Stratigraphy and sedimentation of a Neogene—Quaternary section in the Nile Delta area (A.R.E.). Marine Geology, 27(3-4), 327–348. doi:10.1016/0025-3227(78)90038-5

[11] Barakat, M.G., 1986. Natural gas in Egypt, its occurrence, reserves, and future prospects. Research project on source development and policyt in Egypt. Petroleum and Natural gas. June, Cairo, Egypt, pp 1–78.

[12] Saunders, Donald F, K Ray Burson, Jim F Branch, and C Keith Thompson. 1993. "Relation of Thorium-Normalized Surface and Aerial Radiometric Data to Subsurface Petroleum Accumulations." Geophysics 58 (10): 1417–27.

[13] El-Sadek, M.A., 2002. Application of thorium-normalized airborne radiospectrometric survey data of Wadi Araba area, North-Eastern Desert, Egypt, as a guide to the recognition of probable subsurface petroleum accumulations. Appl. Radiat. Isot. 57, 121–130.