DJS Vol. 49(2)(2024) pp. 1-15 ISSN: 1012-5965

Delta Journal of Science
Available online at
https://djs.journals.ekb.eg/

Research Article **GEOLOGY**

Reservoir Quality Determination Through Petrophysical Evaluation of Alam EL-Bueib Formation in Kenz Oil Field, North Western Desert, Egypt

Abd Elhamed E. Fouda[a], Abd Elhady M. A[a], Ahmed Z. Noah [b], Kamel S. A.[a], Marwa Z. Elsawy[b], Ahmed Diab[c*]

[a] Geology Department, Faculty of Science, Al Azhar University, P.O. Box 11884, Nasr City, Cairo, Egypt.
[b] Egyptian Petroleum Research Institute (EPRI), P.O. Box 11727, Nasr City, Cairo, Egypt
[c] Geology Department, Faculty of Science, Alexandria University. Moharram Bey – Alexandria, P. O.: 21511
[*]**Corresponding author:** Ahmed Diab **e-mail**: *ahmed.diab@alexu.edu.eg*

Received: 8/11/2024 **Accepted:** 1/12/2024

KEY WORDS

Petrophysical evaluation; AEB Formation; Kenz Oil Field; Egypt

ABSTRACT

This study examines the reservoir characterization of the Kenz oil field in the Khalda Ridge area of Egypt, specifically targeting the Alam El-Bueib sandstone reservoir from the Lower Cretaceous period. The analysis encompasses data from five wells, involving meticulous data editing, correction, and lithological determination. Density-neutron cross plots indicate that the reservoir is predominantly composed of sandstone, with minor constituents of siltstones and grey shales. The findings reveal effective porosities ranging from 5% to 36%, shale volumes between 9% and 36%, hydrocarbon saturations from 32% to 87%, and water saturation levels from 13% to 68%. Notably, the study highlights increased net pay, effective porosity, and gross sand toward the northeastern and southeastern sections of the field, suggesting favorable structural conditions for petroleum accumulation. These promising regions are identified as key targets for future exploration efforts, with the potential for significant economic petroleum discoveries that could enhance the region's energy resources.

Introduction

The Kenz Oil Field, located in Egypt's Northern Western Desert between latitudes 30° 39' 12" N to 30° 40' 48" N and longitudes 26° 56' 30" E to 27° 00' 30" E, is part of a series of hydrocarbon discoveries (Fig. 1). The field faces challenges due to resource depletion, necessitating advanced exploration and extraction techniques to develop and exploit the region's hydrocarbon potential. The Kenz Oil Field is strategically located within the Khalda Ridge province, which is a prominent geological feature in Egypt's Western Desert. This region is known for its complex geological history and significant hydrocarbon potential, primarily due to its stratigraphic and structural settings. The Khalda Ridge is part of a larger tectonic framework that influences the sedimentary basins in the area, including the Shushan Basin to its west. The Shushan Basin is recognized for its prolific oil fields and plays a crucial role in Egypt's oil production landscape (Khalda Petroleum Company, 2022). The structural configuration of the Khalda Ridge is crucial for trapping hydrocarbons. The ridge acts as an uplifted block that influences the migration pathways of hydrocarbons from source rocks in deeper formations to reservoir rocks in shallower strata. This structural uplift creates potential traps where oil can accumulate, making fields like Kenz economically viable **(Mahgoub et al., 2005).**

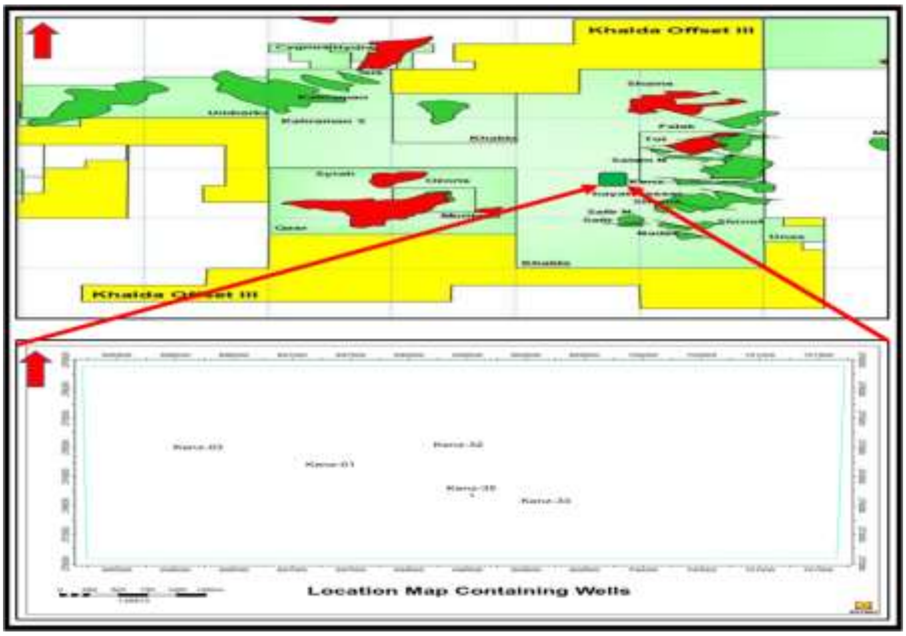

Fig. (1): Location map, showing the wells in the study area (Modified after Khalda Petroleum Company 2022).

The AEB Formation is a key contributor to oil production in the Kenz Oil Field and the Western Desert region. Its lithological composition, consisting of white to yellow sandstones, siltstones, and gray shales, enhances its capacity as a productive reservoir. The formation's exploration and development are crucial to address global oil demand, which is expected to reach 101.6 million barrels per day in 2023. The Kenz Oil Field, with its rich geological formations, is a key player in this endeavor. However, sustainable practices and environmental impact must be considered during exploration and production activities **(Ali et al., 2024)**.

The study aims to create a detailed geological and petrophysical model of the Kenz Oil Field in the Western Desert, focusing on the Upper Cretaceous Sequence, AEB Formation. The field covers 165 km² and is crucial for hydrocarbon recovery and extraction techniques. The study focuses on the hydrocarbon-bearing sand intervals of the AEB Formation, which is the primary productive layer in the Kenz Oil Field. The study includes evaluating reservoir porosity and lithology, identifying key reservoir factors, and developing isoparametric maps to pinpoint optimal sand zones. The AEB Formation is predominantly composed of sandstone units, shale layers, and limestone beds **(Said, 1990)**. The formation originates from the Barremian to Aptian period and is characterized by white to yellow sandstones, siltstones, gray shales, and carbonate strata.

Geological Setting

The AEB Formation is a complex geological formation, from the Lower Paleozoic to Recent periods Fig. (2), with a diverse lithology, including sandstone, siltstone, calcareous shale, limestone, and coal streaks. This reflects a complex depositional environment likely influenced by shallow marine conditions during the Early Cretaceous period. The presence of carbonates in the northern regions enhances the formation's geological complexity, making it a potential hydrocarbon reservoir **(Schlumberger, 1992)**.

The formation is affected by a network of normal faults, resulted from the extensional tectonics during the Mesozoic era in the Northwestern Desert of Egypt. These faults shape the geological landscape and play a crucial role in the formation of multiple oil-bearing sandstone reservoirs, creating potential traps for hydrocarbon accumulation. Four primary reservoir intervals have been identified, with the AEB-6 unit being the most promising for hydrocarbon production.

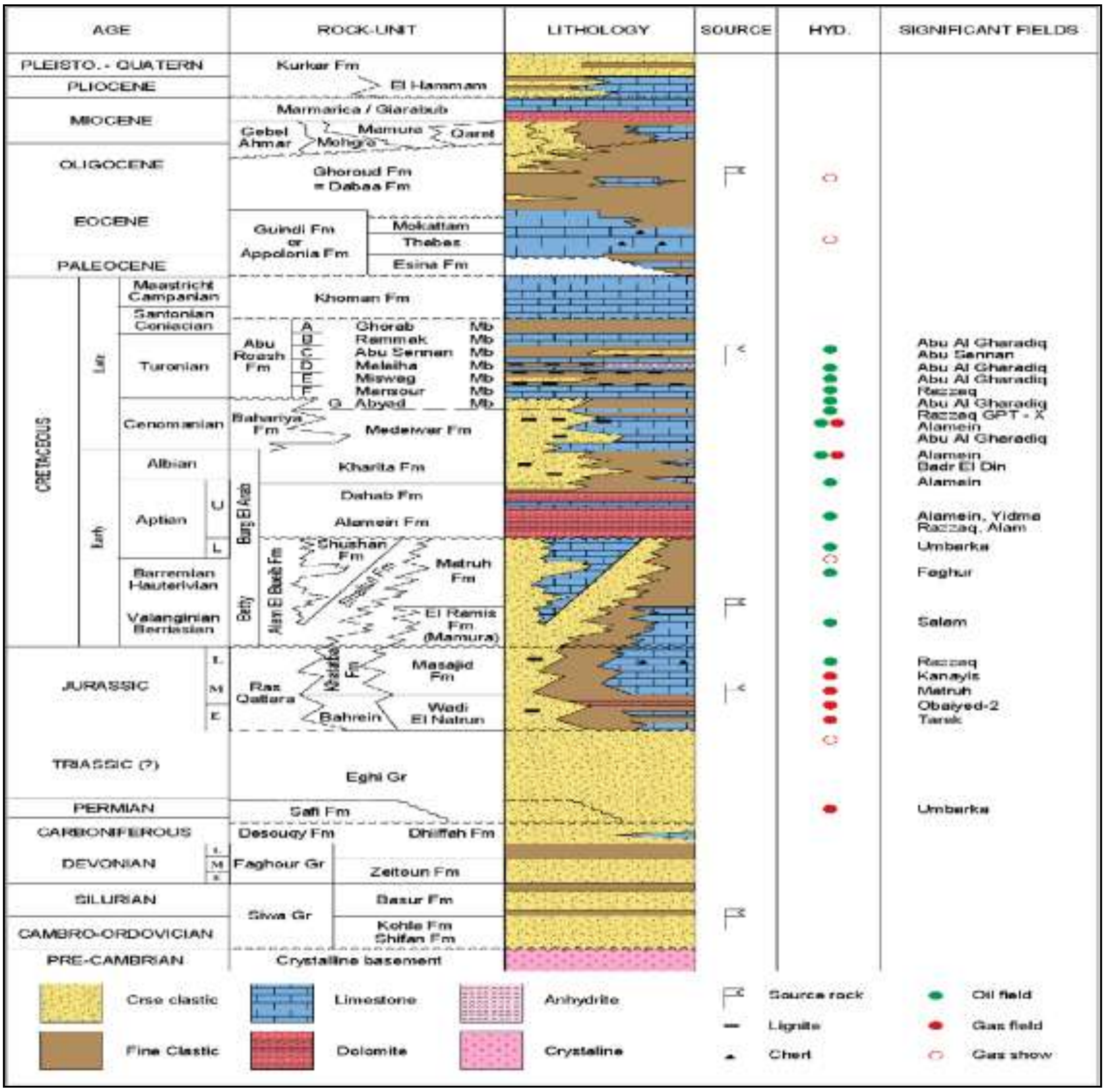

Fig.(2): Northwestern desert's stratigraphic column, compiled from sources including EGPC (1992).

The shale volume within the clastic units varies significantly, ranging from 6.5% to 56.1%, affecting the reservoir's overall hydrocarbon potential. Understanding these variations is essential for developing effective exploration and production strategies **(Badawy et al., 2023; Hagras et al., 1992; Abdel-Fattah et al., 2019)**.

The tectonic history of the AEB Formation is marked by significant extensional events during the Mesozoic, particularly associated with the opening of the Atlantic Ocean. This tectonic activity led to the formation of E-W trending normal faults, which have since influenced the formation's structural integrity **(Diab and Khalil, 2021; Nashaat et al., 1994).**

The AEB Formation, dating from the Barremian to Aptian period, is a significant petroleum source bed in the Shushan and Matruh basins. Petrophysical analysis of clastic reservoir rocks in the Northwestern Desert is based on data from five wells. The region is characterized by a graben system, formed due to pre-existing structural features in basement rock and the Tethyan rifting process. The sedimentary strata exhibit a distinct thickness pattern, with Paleozoic sediments thickening in the southwest and Mesozoic and Tertiary sediments thickening towards the north. The geological narrative of the Northern Western Desert begins with Early Paleozoic continental deposits, with the first transgression occurring during the Cambro-Ordovician epoch. The region is characterized by a NE to ENE folding trend and reverse faulting, with most faults originating from the Late Cretaceous to Early Tertiary period **(El-Dakak et al., 2021; Abdel-Fattah et al., 2015; EGPC, 1992)**.

Materials and Methods

The study uses open-hole well log records from five wells (Kenz-03, Kenz-01, Kenz-32, Kenz-33, and Kenz-35) to evaluate petrophysical properties. The shale volume, formation porosities, and permeability of the reservoirs are determined using computer-processed interpretation techniques. Shale volume is calculated using gamma ray logs (eq. 1 and 2), while formation porosities and permeability are calculated using neutron and density logs (eq. 3, 4, 5 and 6). Water saturation is calculated using Archie's Indonesian equation (eq. 7 and 8), and the study evaluates the petrophysical properties of the AEB Formation using Interactive Petrophysics version 3.5 software. The characteristics are represented laterally through iso-parametric maps and vertically via litho-saturation cross-plots. The study examines the lateral distribution of these properties through gradient and saturation maps, analyzing net pay, effective porosity, shale content, water saturation, and hydrocarbon saturation. Cut-off values of 35% for clay volume, 8% for effective porosity, and 50% for water saturation were applied to estimate reservoir net pay intervals.

Asquith and Gibson (1982)

$$V_{sh} = 0.33 * [2^{(2*IGR)} - 1] \quad (1)$$

$$I_{GR} = \frac{(GR_{log} - GR_{min})}{(GR_{max} - GR_{min})} \quad (2)$$

Where, GR_{log} is the gamma ray reading, GR_{min} is clean sandstone, and GR_{max} refer to pure shale.

Tiab and Donaldson (1996)

$$\Phi N_{corr} = \Phi N - (V_{sh} * \Phi N_{sh}) \quad (3)$$

ΦN_{corr} is the corrected porosity, while ΦN_{sh} is the neutron porosity at shale interval

Wyllie et al. (1958) (eq. 4)

$$\Phi_D = \frac{(\rho_{ma} - \rho_b)}{(\rho_{ma} - \rho_f)} \quad (4)$$

Where ρ_{ma} is the matrix density; ρ_b represents the bulk density; ρ_f signifies the fluid density.

Schlumberger's formula (1998)

$$\Phi e = \Phi t * (1 - V_{sh}) \quad (5)$$

Where Φe = effective porosity and Φt = denotes total porosity

Wyllie and Rose (1950)

$$K = (250 \, x \left(\frac{\Phi 3}{S_{wir}}\right)) \, 2 \quad (6)$$

Where: K is permeability (mD); Φ is porosity; S_{wir} is irreducible water saturation.

$$S_{wir} = [C / (\frac{\Phi}{(1 - Vsh)})] \quad (7)$$

V_{sh} is the shale volume, and C is Buckles's constant.

Archie's equation

$$S_w = [\left(\frac{a}{Fm}\right) * \left(\frac{Rw}{Rt}\right)](1/n) \quad (8)$$

Where S_w is water saturation, Fm is formation factor ($=1/\Phi^m$), R_w is formation water resistivity. R_t is observed deep resistivity, and (a, m and n) are Archie's coefficients which are calculated from Pickett plot.

Results and Discussion

The results are analyzed to identify productive zones, evaluate reservoir quality, and provide insights into the geological conditions of the formations. By integrating log interpretation with quantitative analysis, we aim to enhance our understanding of the petrophysical characteristics of the AEB Formation, thereby informing future exploration and development strategies in this region.

Lateral distribution of Petrophysical Properties

The lateral distribution of petrophysical properties across the various reservoir units of the Lower Cretaceous AEB sandstone can be analyzed through iso-parametric maps showcasing net pay (m), effective porosity, shale content, water saturation, and hydrocarbon saturation. These properties were averaged from well logging data and summarized in Table (1).

Table (1): Petrophysical Analysis of AEB-1, AEB-3D, AEB-3A, AEB-3E Units

Petrophysical Analysis in AEB-1 Unit						**Petrophysical Analysis in AEB-3D Unit**					
Well Name	Shr (%)	Sw (%)	V_{sh} (%)	Porosity (f_e) %	Net pay (ft)	Well Name	Shr (%)	Sw (%)	V_{sh} (%)	Porosity (f_e) %	Net pay (ft)
kenz-0	32	68	31	9	10	**Kenz -03**	57	43	29	8	6
Kenz -01	73	27	18	25	43	**Kenz -01**	63	37	22	11	15
Kenz -32	67	33	14	23	34	**Kenz -32**	71	29	13	18	28
Kenz -35	60	40	11	22	21	**Kenz -35**	68	32	11	15	31
Kenz -33	63	37	9	26	24	**Kenz -33**	87	13	7	24	46
Petrophysical Analysis in AEB-3A Unit						**Petrophysical Analysis in AEB-3E Unit**					
kenz-03	53	47	32	6	12	**Kenz -03**	35	65	36	5	5
Kenz -01	63	37	19	11	16	**Kenz -01**	63	37	19	13	26
Kenz -32	68	32	14	17	45	**Kenz -32**	67	33	16	19	41
Kenz -35	81	19	12	27	76	**Kenz -35**	72	28	13	21	49
Kenz -33	72	28	5	21	53	**Kenz -33**	85	15	12	36	63

Across all AEB units, consistent trends emerge. Specifically, net pay and effective porosity are generally highest in the northeastern and southeastern regions of each unit. In contrast, shale content and water saturation show a clear downward trend in these areas. For instance, in the AEB-1 unit, the analysis indicates significant increases in net pay and effective porosity, coupled with decreases in shale content and water saturation, particularly in the same favorable regions Fig. (3A).

Similar patterns are observed in the AEB-3A unit, where elevated net pay and effective porosity are noted, reinforcing the influence of structural features and facies distribution on petrophysical characteristics Fig. (3B). The AEB-3D unit also aligns with these findings, affirming that higher effective porosity and net pay correspond to lower shale content and water saturation in the northeastern and southeastern areas Fig. (4A).

Finally, the AEB-3E unit corroborates these established trends, further confirming that the distribution of petrophysical properties across the AEB sandstone is fundamentally influenced by the underlying geological structures and the distribution of facies Fig. (4B). Overall, the consistent patterns across the units highlight the significant role of structural features in governing the lateral variation of reservoir characteristics.

Vertical distribution of Petrophysical Properties

The vertical distribution of petrophysical properties within the AEB formation has been assessed using litho-saturation cross-plots (CPI) **(El-Khadragy et al., 2017).** Across several wells, a consistent pattern emerges in the composition and characteristics of the formation.

In the Kenz-01 well, the CPI plot indicates a total thickness of 1,093 ft, primarily consisting of sandstone and shale. Here, the average net pay is 25 feet, effective porosity is 16%, shale content is 19%, and water saturation is 35%. The sandstone composition increases towards the central and lower regions, where effective porosity and hydrocarbon saturation are enhanced, while shale volume and water saturation decrease (Fig. 5). The Kenz-03 well shows a total thickness of 2,474 feet with a comparable composition of sandstone and shale. The average net pay is 8 feet, with effective porosity at 9%, shale content at 31%, and water saturation at 51%. In this well, sandstone content also increases in the central and lower strata, aligning with heightened effective porosity and hydrocarbon saturation, while shale volume and water saturation diminish.

The Kenz-32 well, covering a gross thickness of 1,596 ft, reveals an average net pay of 37 feet and effective porosity of 19%, with shale content at 14%. Sandstone composition increases throughout the upper, central, and lower sections, with effective porosity and hydrocarbon saturation enhanced across all levels, while shale volume and water saturation decrease, indicating high-quality sandstone Fig.(6). In the Kenz-33 and Kenz-35 wells, both displaying thicknesses of 1,597 ft and 1,300 ft respectively, the average net pay is 42 feet (effective porosity of 25%, shale content of 11%, water saturation of 24%) for Kenz-33, and 44 feet (effective porosity of 22%, shale content of 12%, water saturation of 30%) for Kenz-35. The trend of increasing sandstone content is evident throughout all sections, with both effective porosity and hydrocarbon saturation rising, while shale volume and water saturation decline, further emphasizing the quality of the sandstone.

Overall, the vertical profiles across these wells consistently highlight the significant role of sandstone composition in enhancing porosity and hydrocarbon saturation, while shale content and water saturation tend to diminish, indicating favorable conditions for hydrocarbon accumulation throughout the AEB formation Fig.(7).

Reservoir Evaluation

The petrophysical evaluation of the AEB Formation in the Kenz Oil Field provides good understanding for reservoir's quality and hydrocarbon potential. The study uses well log data from five wells to understand spatial variation in petrophysical properties. The vertical variation in petrophysical characteristics is illustrated using litho-saturation cross-plots, which highlight petroleum-bearing zones and barren zones.

Iso-parametric maps of the AEB Formation units reveal a strong correlation among petrophysical attributes, with net pay and effective porosity increasing towards the southeastern and northeastern sections, while shale content and water saturation decrease in these areas. The study also highlights numerous hydrocarbon reservoir intervals, with hydrocarbon saturation levels reaching up to 87%.

The AEB Formation, primarily composed of white to yellow sandstones, is considered the seal rock in the region, acting as a barrier to prevent hydrocarbon accumulation. Two promising prospective zones have been identified, characterized by increased net pay and effective porosity within the target units of the Alam El-Bueib

Formation. These zones exhibit reduced shale content, lower water saturation, and increased formation thickness, making them favorable for hydrocarbon accumulation.

The analysis suggests that oil accumulation in the Kenz field is influenced by the structural configuration, distribution of lithofacies, and petrophysical characteristics, enhancing the potential for economically viable hydrocarbon reserves.

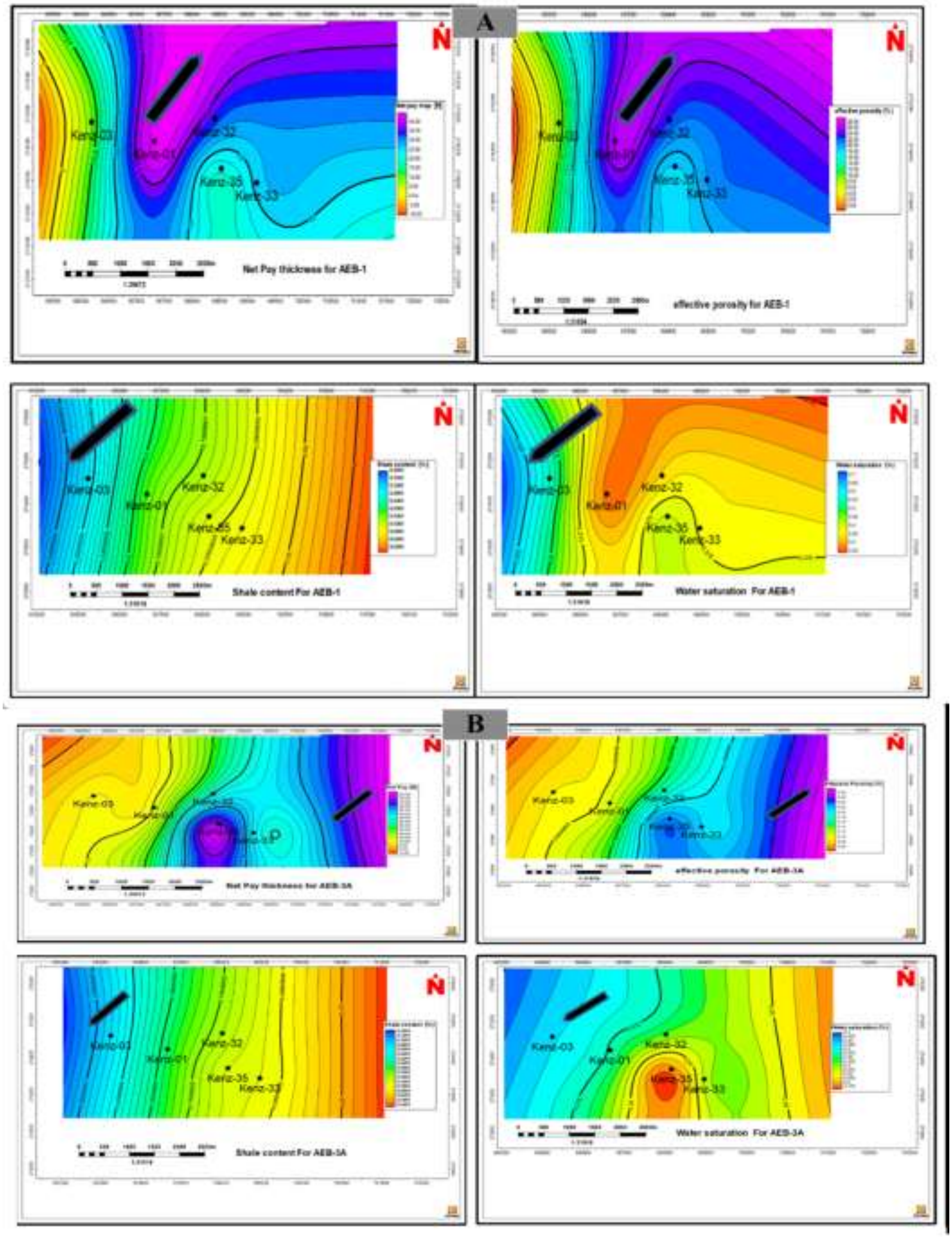

Fig.(3): A) Combined petrophysical parameters of AEB-1 unit, showing that the central, northeastern and southeastern parts B) Combined petrophysical parameters of AEB-3A.

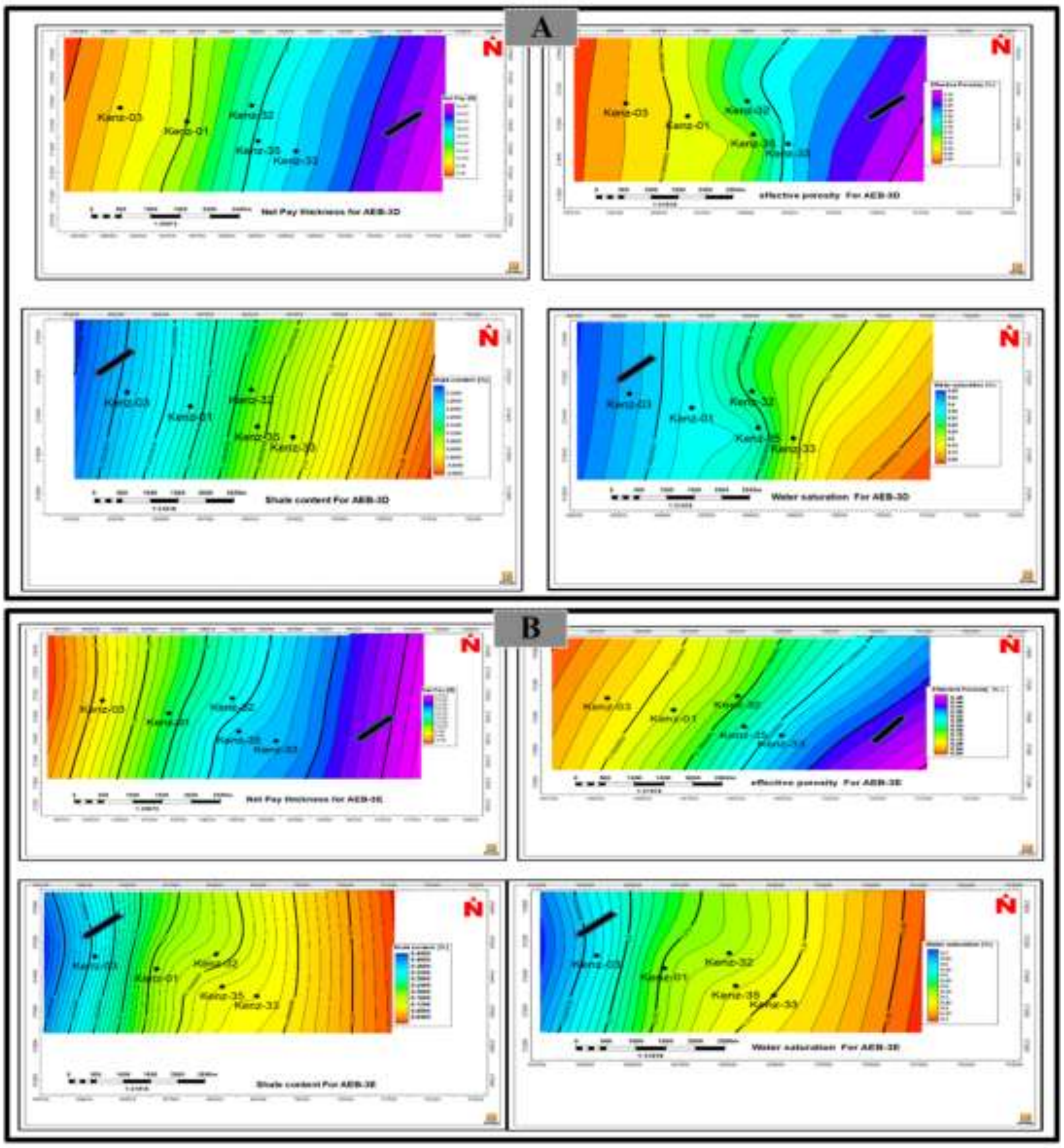

Fig.(4): A) Combined petrophysical parameters of the AEB-3D unit, B) Combined Petrophysical Parameters of the AEB-3E Unit.

Conclusions

This study provides a comprehensive petrophysical evaluation of the Alam EL-Bueib Formation in the Kenz Oil Field, highlighting its potential as a hydrocarbon reservoir. Through detailed analysis of well log data from five wells, we have identified critical petrophysical parameters, including effective porosity, shale volume, water saturation, and hydrocarbon saturation, offering insights into the reservoir's quality and distribution.

The results indicate significant lateral and vertical variations in reservoir characteristics, with higher effective porosities and net pay zones concentrated in the northeastern and southeastern regions of the study area. This trend correlates with reduced shale content and lower water saturation, signifying favorable conditions for hydrocarbon accumulation. The creation of iso-parametric maps has further illustrated these patterns, supporting the notion that structural features and facies distribution play a pivotal role in shaping the reservoir's characteristics.

The findings underscore the importance of targeted exploration efforts in the identified prospective zones, where the potential for economically viable hydrocarbon reserves appears most promising. Additionally, the study reinforces previous research on the hydrocarbon potential of the Alam EL-Bueib Formation, establishing a clear link between petrophysical evaluations and exploration strategies.

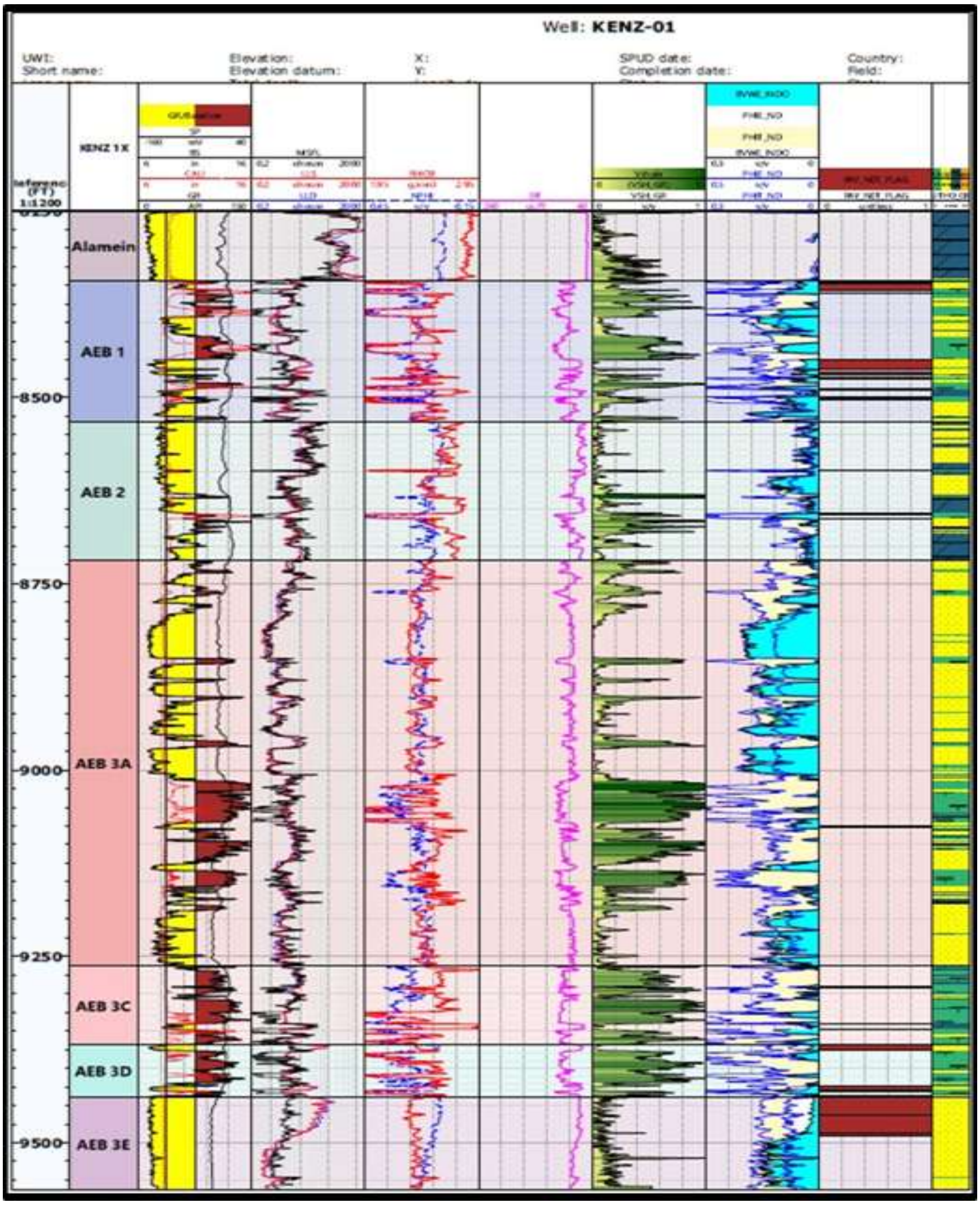

Fig. (5): Petrophysical parameters analysis of Alam EL-Bueib Formation in kenz-01 well.

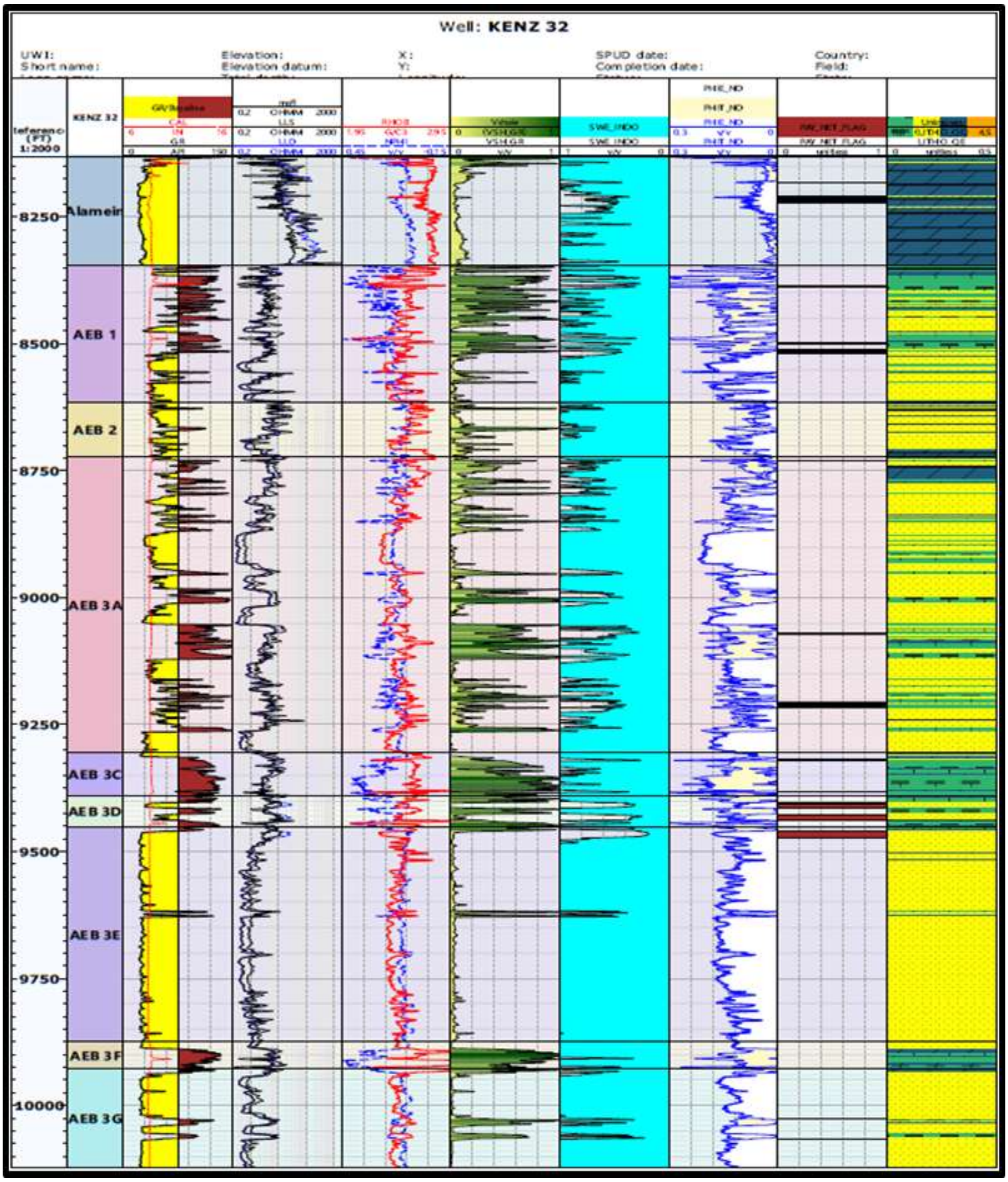

Fig. (6): Petrophysical parameters analysis of Alam EL-Bueib Formation in kenz-32 well.

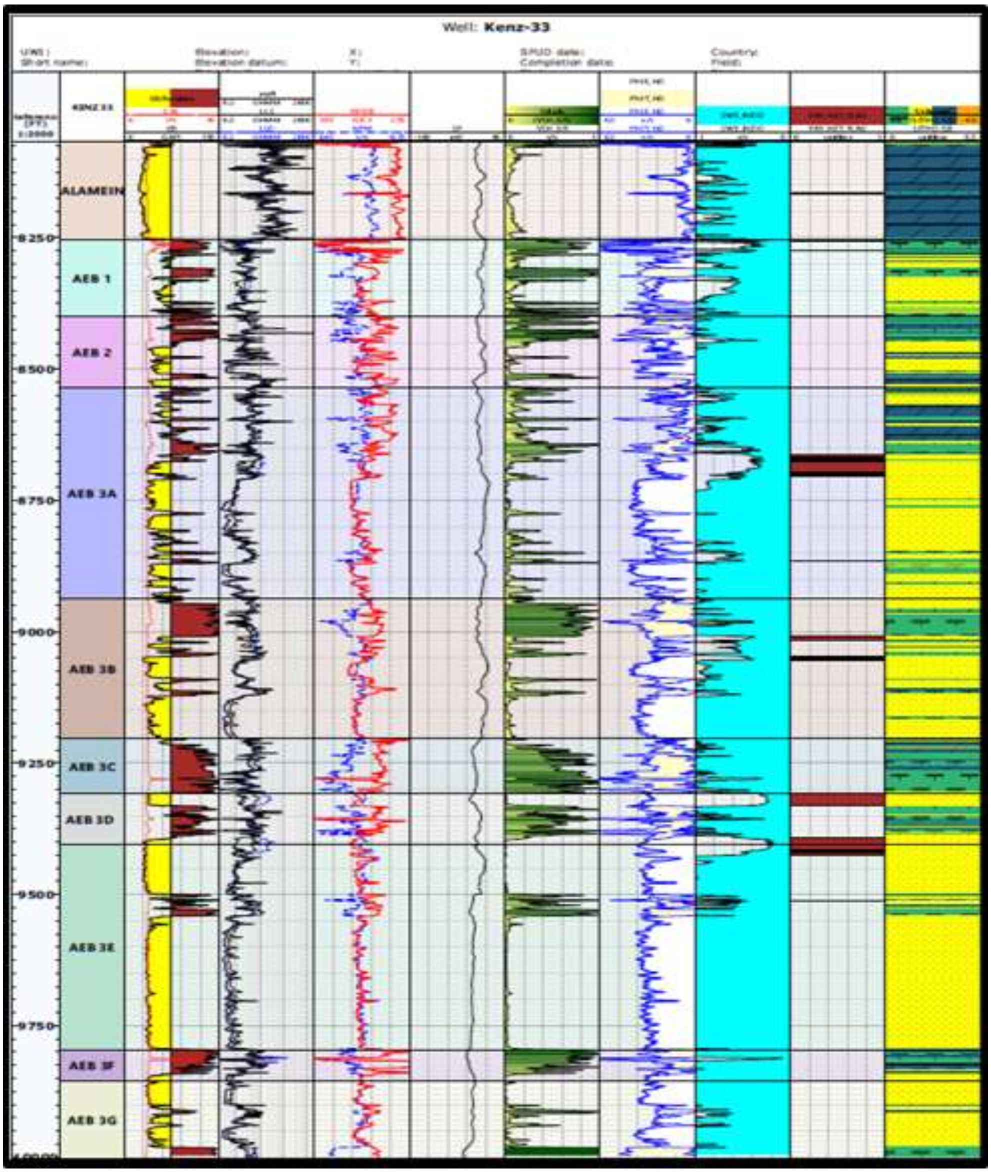

Fig.(7): Petrophysical parameters analysis of Alam EL-Bueib Formation in kenz-33 well.

Acknowledgements

The authors express gratitude to Allah and acknowledge the Egyptian General Petroleum Corporation and Khalda Petroleum Company for providing data and the Department of Geology at Al-Azhar University for accessing laboratories.

References

Abdel-Fattah, M., Gameel, M., Awad, S., & Ismaila, A. (2015). Seismic interpretation of the aptian Alamein dolomite in the razzak oil field, Western Desert, Egypt. *Arab. J. Geosci.*, 8: 4669- 4684.

Abdel-Fattah, T. A., Rashed, M. A., & Diab, A. I. (2019). Reservoir compartmentalization phenomenon for lower Safa reservoir, Obaiyed gas field, North Western Desert, Egypt. *Arab. J. Geosci.*, 12(22): 697.

Ali, W.A., Deaf, A.S. and Mostafa, T., (2024). 3D geological and petrophysical modeling of Alam El-Bueib formation using well logs and seismic data in Matruh field, northwestern Egypt. Scientific Reports, 14(1): p.6849.

Asquith, G. B., & Gibson, C. R. (1982). Basic well log analysis for geologists.

American Association of Petroleum Geologists.

Badawy, M., Abdel Fattah, T. A., Abou Shagar, S., Diab, A. I., Rashed, M. A., & Osman, M. (2023). Identifying the hydrocarbon potential from seismic, geochemical, and wireline data of the Sallum intra-basin, North Western Desert of Egypt. *NRIAG J. Astronomy Geophys*., 12(1): 1-8.

Diab, A. I., & Khalil, H. M. (2021). Quantitative assessment of the tight gas reservoirs in the Obaiyed field, Shushan Basin, NW Egypt. *NRIAG J. Astronomy Geophys*, 10(1): 320-332.

Egyptian General Petroleum Corporation (EGPC). (1992). Western Desert oil and gas fields: A comprehensive overview. Cairo, Egypt.

El-Dakak, M. A., Abdelfattah, T. A., Diab, A. I., Kassem, M. A., & Knapp, C. C. (2021). Integration of borehole depth imaging and seismic reflection results in reservoir delineation: An example from the Alam El Bueib 3C field, Northern Western Desert, *Egypt. J. Afr. Earth Sci*., 184:104322.

El-Khadragy, A. A., Shazly, T. F., Ramadan, M., & El-Sawy, M. Z. (2017). Petrophysical investigations of Rudeis and Kareem formations, Ras Ghara oil field, Gulf of Suez, Egypt. *Egyptian J. Petrol*., 26(2): 269-277.

Hagras, M., El Awdan, H., & Gawdat, M. (1992). Hydrocarbon potential of the Alam El Bueib siliciclastics. In 11th Petroleum Exploration and Production Conference (Vol. 2, pp. 144). Cairo.

Khalda Petroleum Company. (2022). Concession maps 2022. Egypt Oil & Gas. https://egyptoil-gas.com/maps/

Mahgoub, I.S., Mowafi, K.M., Hussein, H. and Wehr, F., (2005), November. Applications of sequence stratigraphy and geological modeling to mature field development: Khalda ridge, Western Desert, Egypt. In International Petroleum Technology Conference (pp. IPTC-10137). IPTC.

Nashaat, M., Gamal El Din, A., & Gad, M. (1994). Geochemical material balance and entrapment mechanics in Shusan-Matruh basins, Western Desert, Egypt. In 12th Exploration and Production Seminar (pp. 198-216). Egyptian General Petroleum Corporation, Cairo.

Said, R. (1990). The geology of Egypt. A.A. Balkema.

Schlumberger. (1992). Well evaluation conference, Egypt. Schlumberger Technical Editing Services.

Schlumberger. (1998). Cased hole log interpretation principles/applications. Schlumberger Wireline and Testing.

Tiab, D., & Donaldson, E. C. (1996). Petrophysics: Theory and practice of measuring reservoir rock and fluid transport properties. Gulf Professional Publishing. eBook ISBN: 9780128031896, Hardcover ISBN: 9780128031889.

Wyllie, M. R. J., & Rose, W. D. (1950). Some theoretical considerations related to the quantitative evaluation of the physical characteristics of reservoir rock from electric log data. Transactions of the American Institute of Mining, Metallurgical, and Petroleum Engineers, 189, 105.

Wyllie, M. R. J., Gregory, A. R., & Gardner, G. H. (1958). An experimental investigation of the factors affecting elastic wave velocities in porous media. *Geophys*., 23: 495-493.

تحديد جودة الخزان من خلال التقييم البتروفيزيائى لمتكون علم البويب، بحقل كنز، شمال الصحراء الغربية، مصر

عبد الحميد السيد فوده [١]، محمد عبد الخالق عبد الهادي [١]، احمد زكريا نوح [٢]، شريف احمد كامل [١]، مروة زين الدين الصاوي [٢]، احمد إبراهيم دياب [٣*]

[١] قسم الجيولوجيا كليه العلوم، جامعه الأزهر، مدينه نصر، رقم بريدي ١١٨٨٤، القاهرة، مصر
[٢] معهد بحوث البترول المصري، ص.ب. ١١٧٢٧، مدينة نصر، القاهرة، مصر
[٣] قسم الجيولوجيا، كلية العلوم، جامعة الإسكندرية. محرم بك – الإسكندرية، ص.ب. ٢١٥١١

تبحث هذه الدراسة في توصيف مكمن لحقل كنز في منطقة امتياز خالدة في شمال الصحراء الغربية، مصر، وتستهدف على وجه التحديد خزان علم البويب من الحجر الرملي من العصر الطباشيري السفلي. يشمل التحليل بيانات من خمسة آبار، بما في ذلك تحرير البيانات بدقة وتصحيحها وتحديد الصخور، وتشير التسجيلات المتقاطعة للكثافة النيوترونية إلى أن الخزان يتكون في الغالب من الحجر الرملي، مع مكونات ثانوية من الحجر الجيري والصخر الزيتي الرمادي. كما تكشف النتائج عن نفاذية تتراوح بين ٥% إلى ٣٦%، ويتراوح محتوى الطفلة بين ٩% و٣٦%، ويتراوح نسبة التشبع بالهيدروكربون بين ٣٢% إلى ٨٧%، ومستويات تشبع الماء من ١٣% إلى ٦٨%. ومن الجدير بالذكر أن الدراسة تسلط الضوء على زيادة الطبقة الحاملة للزيت، والمسامية الفعالة، وسمك طبقة الحجر الرملي الموجود بمنطقة الدراسة من الأجزاء الشمالية الشرقية والجنوبية الشرقية من الحقل، مما يشير إلى تركيبات جيولوجية مناسبة لتراكم النفط، وقد تم تحديد هذه المناطق الواعدة كأهداف رئيسية لجهود الاستكشاف المستقبلية، مع إمكانية تحقيق اكتشافات بترولية اقتصادية كبيرة يمكن أن تعزز موارد الطاقة في المنطقة.