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Petrophysical Studies on Upper Bahariya and Abu Roash "G" Reservoirs Using Well Logs in Karama Field, North Western Desert, Egypt

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ABSTRACT **: The present study deals with petrophysical analysis to evaluate the hydrocarbon-bearing reservoirs in the Karama field, East Abu Gharadig basin Northern part of the Western Desert. Some wells which spread around the Karama field are being investigated and studied to determine the different petrophysical characteristics of the Upper Cretaceous Upper Bahariya and Abu Roash "G" reservoirs. This analysis indicates the presence of significant hydrocarbon potential in the Upper Bahariya and Abu Roash "G" reservoirs at different depth intervals. The well log analysis involves data editing, data verification, and lithology, porosity assessment using a density-neutron cross plot. The density-neutron cross plots indicate that the Upper Bahariya reservoir is mainly sandstones with some calcareous cement. Abu Roash "G" reservoir is mostly composed of limestone with some sandstone, shale, and siltstone lithology. The shale volumes are 10-19 % and 11-18 % in the Abu Roash "G" and Upper Bahariya reservoirs respectively, and the effective porosities are 14-20 % at the Abu Roash "G" while reaching 12-16 % at the Upper Bahariya reservoir, implying good reservoirs quality. Petrophysical parameters of the Abu Roash "G" and Upper Bahariya reservoirs are illustrated on iso-parametric maps to delineate the most effective locations with good hydrocarbon potentialities. The iso-parametric maps such as net pay, effective porosity, and hydrocarbons saturation show an increase in the southern parts of the study area especially in Abu Roash "G" reservoir, while the Upper Bahariya reservoir shows an increase in the north-western parts. This analysis gives necessary knowledge about the distribution of fluids within reservoirs.**

KEYWORDS: Petrophysical Evaluation; Hydrocarbon potentialities; Karama Field, Abu Gharadig basin; Western Desert.

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I. INTRODUCTION

The study area is located on the southeastern side of Abu Gharadig Basin which is located in the northern part of the Western Desert of Egypt. Abu Gharadig Basin extends between Qattara Depression to the west and Kattaniya Horst to the east. The area under investigation is located between Latitude 29° 32` 40" N and 29° 34` 37" N and Longitudes 29° 29` 40" E and 29° 31` 45" E (Fig. 1).

The Northern part of Egypt's Western Desert is a location to one of the most productive and promising oil and gas areas. The significance of this aspect stems from the discovery of numerous oil and gas fields by various petroleum organizations, as well as the availability of adequate lithological and structural conditions that play a significant role in hydrocarbon entrapment.

The Northern basins of the Western Desert were created as a single rift, most likely during the Permo-Triassic period, and have since grown into a pull-apart structure, the Jurassic period has records of marine environments (Moustafa, 2008; Barakat et al., 2019).

The study area is located in the Mubarak sub-basin area, positioned in the eastern zone of the Abu Gharadig basin, and this zone is characterized on the south by the NE trending Asala Ridge, which is a part of the regional Kattaniya Ridge, and on the north by a series of large-displacement, south-dipping normal faults that extend as far west as the Badr El-Din fields (Meshref et al., 1988; Barakat& Nooh, 2017).

Four wells (Karama-3, Karama-5, Karama-11, and Karama-17) were selected for estimation of hydrocarbon potentiality of the subsurface reservoir at the area under investigation to delineate the petrophysical characteristics of Abu Roash "G" Mbr which is considered as the main reservoir rocks at Karama oil field.

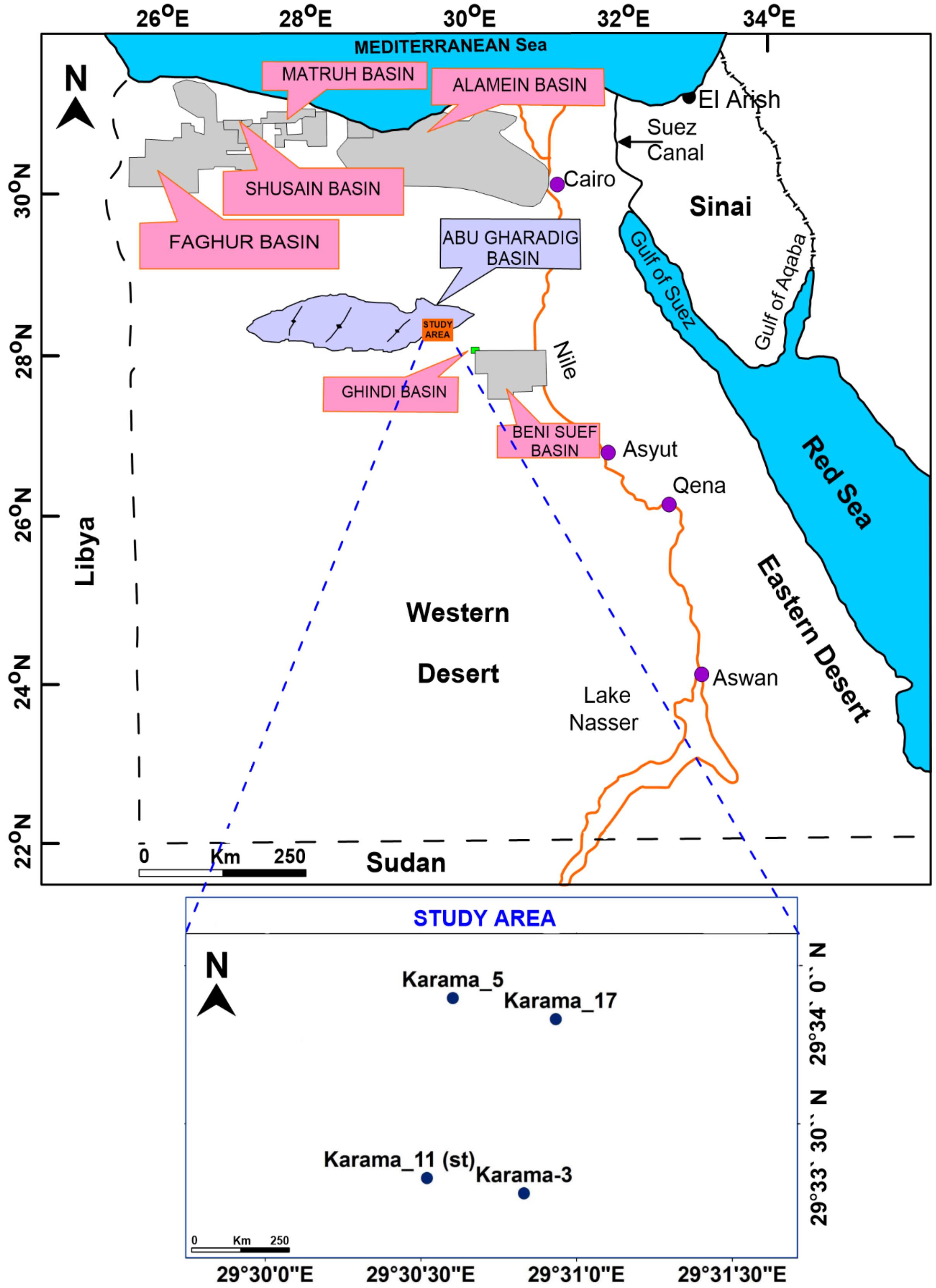

Figure (1): Location map of the study area.

This region is structurally complex, having undergone many stages of expansion in the Jurassic and Cretaceous, as well as at least one phase of compression in the Late Cretaceous-Tertiary. Trap sizes are limited, but they add up to be a powerful resource (Pivnik et al., 2007).The overlaying series' litho-stratigraphic column inside the unstable shelf area of the North-Western Desert is separated into three sequences. To begin, the lowest clastic component is dated from the Cambrian to the Cenomanian.

Second, the intermediate carbonates vary from the Turonian to the Eocene, and third, the upper clastic part ranges from the Oligocene to the Recent (Khalifa et al., 2005).The stratigraphic succession of the Abu Gharadig basin noticed several source rocks (e.g., Khatatba Fm., Alam El Bueib Fm., Alamein Fm., and Abu Roash F Mbr.). Reservoir and source rock lithology and maturity differ; the Abu Gharadig basin spotted Khatatba sand as a reservoir rock, as well as Alam El Bueib Fm., Alamein Fm., Kharita Fm., Bahariya Fm., and Abu Roash (C, E & G) Mbrs.

Multiple rock units play a significant role in sealing the hydrocarbons and retaining them in reservoirs throughout the entire stratigraphic column; these seal rock units comprise Khatatba shale, Alamein carbonates, Bahariya shale streaks, Abu Roash G shale and carbonates, Abu Roash F carbonate, Abu Roash (B&D) carbonates, Khoman chalk, and Apollonia carbonate.

The stratigraphic succession (Fig. 2) facilitated in demonstrating geological ages with the rock unit for each one, as well as explanations of hydrocarbon (oil and/or gas) origins, reservoirs, and fields where the components are of concern (Schlumberger, 1984 and 1995; EGPC, 1992). The Western Desert's sedimentary portion covers from the Paleozoic to the recent time. There were four major sedimentary cycles, with the highest southward transgression occurring during the Carboniferous, Upper Jurassic, Middle and Late Cretaceous, Middle Miocene, and Pliocene eras (Schlumberger, 1984). In this study, the main outlined Stratigraphy will be focused on the Cretaceous period.

This succession begins a significant marine transgression in Egypt, resulting in the accumulation of a mostly carbonate stratum in the Northwestern Desert (a middle calcareous division of (Said, 1962), the Late Cretaceous' significant calcareous formations are particularly well improved in the Abu Gharadig and El Gindi basins, where they provide several oil reserves (Hantar, 1990).

Abu Roash "G" Mbr un-conformably overlies Bahariya Formation and conformably underlies Abu Roash "F" Unit, it's mostly light grey shale, partially silty, and somewhat glauconitic; it's intermixed with milky to greyish white Limestone, coarsely crystalline, and calcareous shale chunks and organic remnants.

Bahariya Formation is divided into the bottom and the top litho-stratigraphic units, with the top unit (L. Cenomanian) being marine-managed facies with laminated Sandstone inter calcareous bands with less marine and has more prevalent fluvial influence, resulting in a finer channelized sand structure (lower Cenomanian to Albian). According to Meshref (1990), two main historical tectonic features guided Egypt: one with NW-SE trending that occurred during the Jurassic period and is known as Jurassic Trend, and the other with NE-SW trending that occurred during the Cretaceous time and is known as Cretaceous Trend.

The northern part of the Western Desert appears to have undergone various stages of deformation in the Late Cretaceous, post-middle Eocene, and middle Miocene, with subsurface data indicating an early Mesozoic phase of normal faulting as a result of the tectonic transformation of the northern Western Desert, where several hydrocarbon fields have been observed (Moustafa et al., 2003; Barakat et al., 2022).

According to (Waly et al., 2001), the Abu Gharadig basin is an extended E-W basin with main fault patterns that include significant NE-SW and NW-SE oriented faults that are antithetical to the dominant trend.

STRATIGRAPHY OF NORTHERN WESTERN DESERT

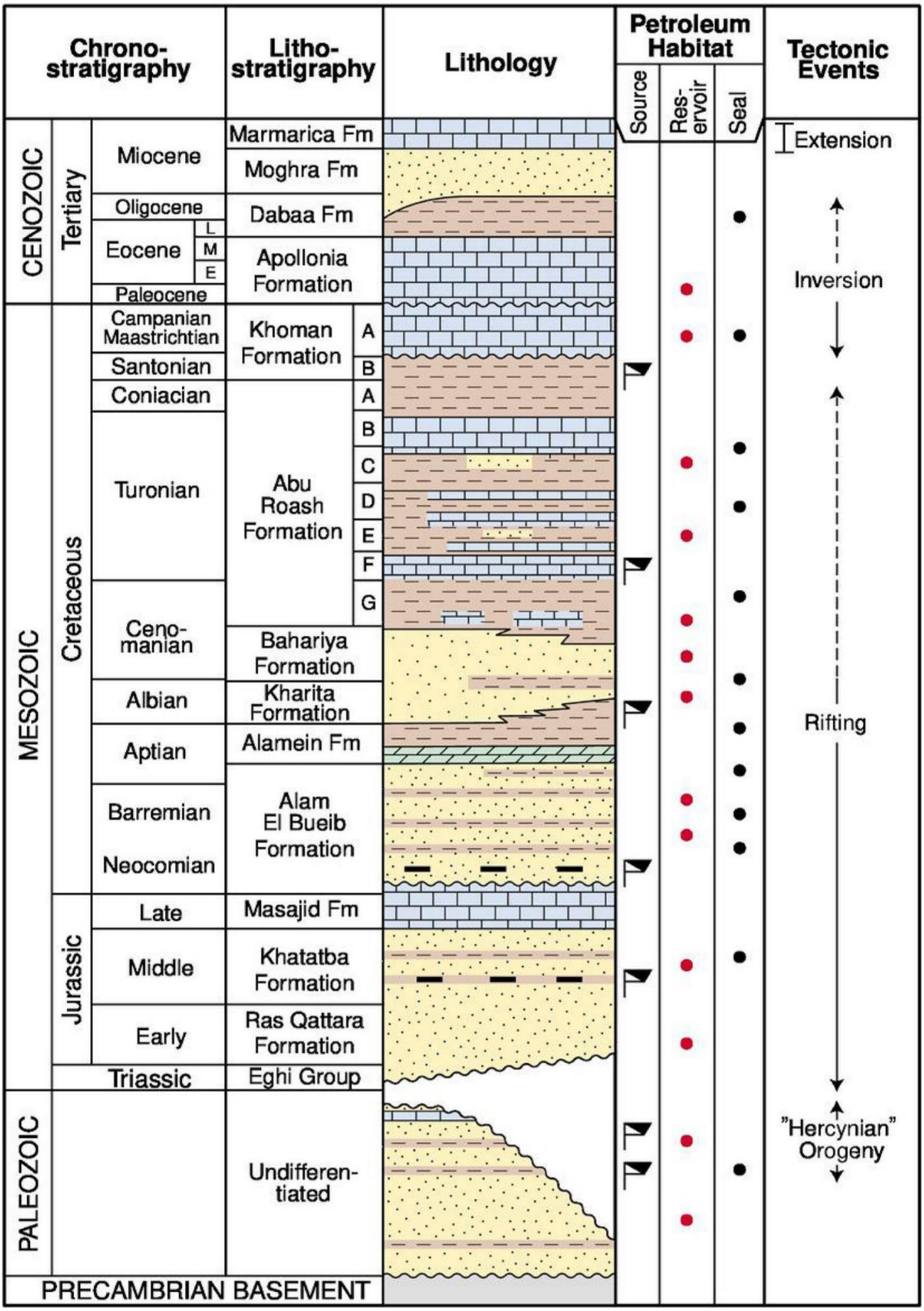

Figure (2): Generalized Litho-Stratigraphic Column of the Northwestern Desert of Egypt, (modified after Schlumberger, 1984 and 1995) and (EGPC, 1992).

Materials and Methods

Various types of well logs for four Karama wells (Karama-3, Karama-5, Karama-11, and Karama-17) were used and interpreted using Interactive Petrophysics software (IP version 3.6TM) for petrophysical parameter analysis. The types of interpreted logs are gamma-ray logs (GR); spontaneous potential logs (SP); Mud Logs; Resistivity Logs; Neutron Porosity Logs; Photoelectric; and Density logs.

The work includes the following principal steps (Abdullah et al., 2021):

1) Determination of reservoir porosity and lithology using of cross plot,
2) Identification of different reservoir parameters characterizing of the pay zones from well log data to spotlight the promising locations for other further exploration,
3) Construction of iso-parametric maps to delineate the most effective sand zones to study the production potentialities of the upper Bahariya, Abu Roash “G” reservoirs in the northern part of the Western Desert of Egypt.

Determination of Lithology and Porosity from the Cross Plot:

The interpretation of lithology of the Upper Bahariya Formation, Abu Roash “G” Mbr was undertaken using all the logs registered through a systematic approach, and lithology was determined from logs using a neutron-density crossplot.

Petrophysical evaluation

The well log evaluation has been achieved using Interactive Petrophysics software (IP version 3.6 TM). The petrophysical parameters of the Upper Bahariya, Abu Roash “G” reservoirs extracted from the well log data are used to display the distribution of shale volume, effective porosity, hydrocarbon saturation, and net pay thickness.

Result:

1-Determination of lithology and porosity from the density-neutron cross plot:

The density-neutron cross plot is commonly used to determine the lithology and accurately evaluate the matrix porosity of rocks.

From the density-neutron cross plot of the Abu Roash “G” reservoir in Karama-3 well in the study area, it is excluded that, the majority of plotted points are scattered closed to limestone line and also between limestone and sandstone lines with porosity ranging from 5 to 13%. This indicates that the reservoir is mainly limestone with some sandstone lithology average grain density (ρ_{mat}) is 2.71 gm/cc (Fig. 3).

From neutron-density cross plots of Upper Bahariya Formation at Karama 3. It shows that the major lithology is sandstone with limestone bands and the average grain density (ρ_{mat}) is 2.65 gm/cc and neutron porosity is 15-25% (Fig. 4).

2-Vertical Distribution of Abu Roash “G” Mbr Petrophysical Parameters in Karama 3 Well:

Abu Roash "G" Mbr was located at a depth of 7208-7611 feet. The Karama 3 well was investigated by varieties of log types that reach a depth of 8285, Abu Roash “G” Mbr contains sandstone, limestone, shale, and siltstone. The data extracted from logs show low gamma-ray, low density, high neutron, and high resistivity separation between shallow and deep ones that reflect low shale content and high sandstone presence (Fig.5).

According to interpreted data, the litho-saturation cross plot of Abu Roash "G" Mbr pay zones reveals that the shale content is % in, effective porosity is %, water saturation is 44 %, hydrocarbon saturation is 56 %, and net pay is about 14 feet.

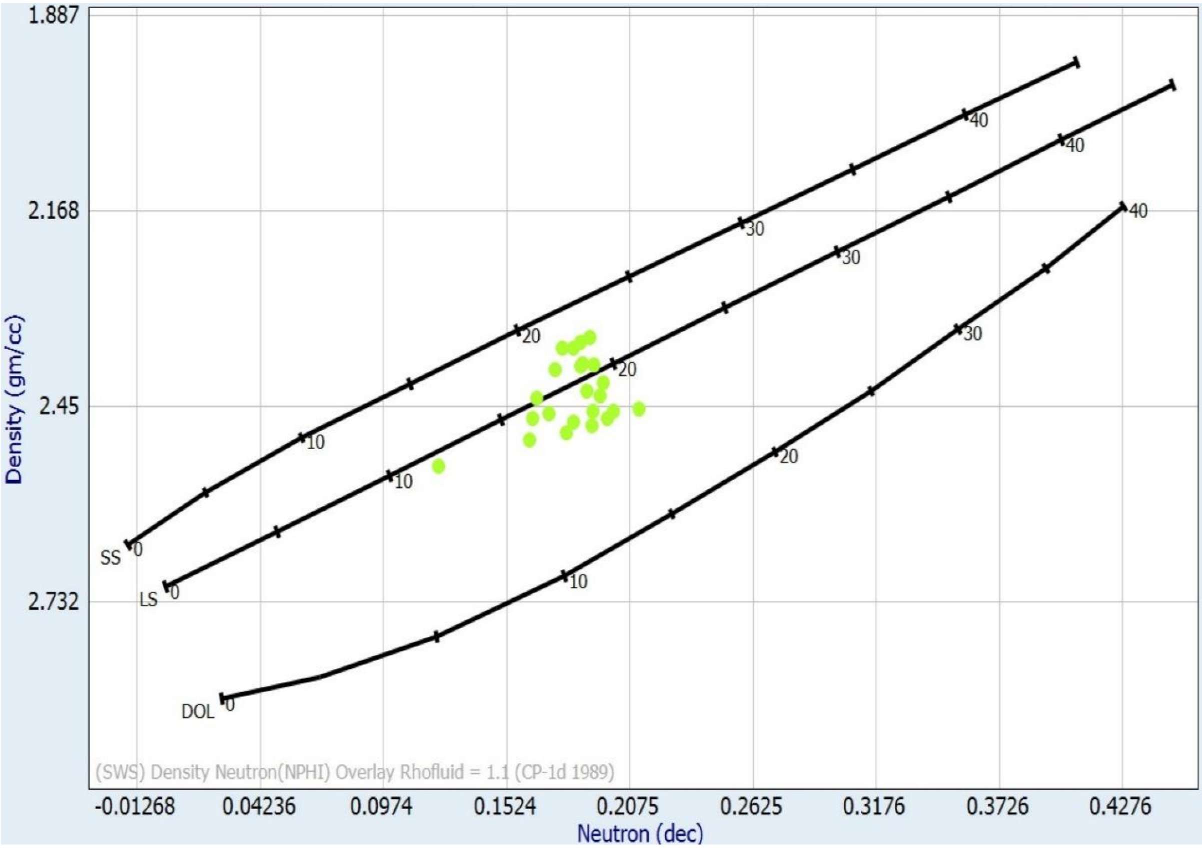

Figure (3): Density-neutron cross plot of Abu Roash “G” reservoir in Karama-3 well.

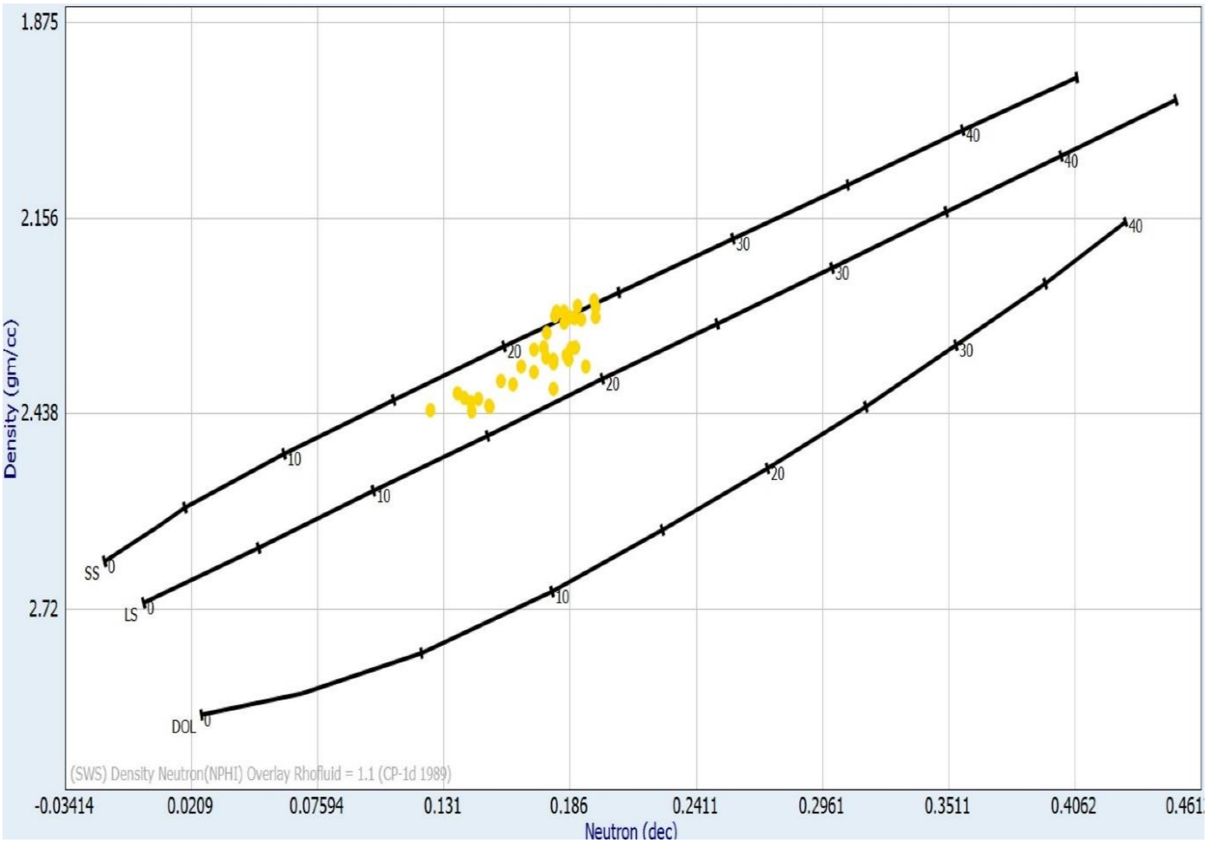

Figure (4): Density-neutron cross plot of Upper Bahariya reservoir in Karama-3 well.

3-Vertical Distribution of Upper Bahariya Formation Petrophysical Parameters in Karama 3 Well:

From well log analysis Upper Bahariya Formation is located at depth interval 7611-8052 ft. the Upper Bahariya Formation is mainly composed of sandstone intercalated by shales, limestone, and siltstone. The separation between shallow and deep resistivity's enhanced the sandstone presence and the value of deep resistivity refers to the liquid type, hence high value indicates hydrocarbons occurrence (Fig.6).

The petrophysical parameters of Upper Bahariya Formation are displayed in Table (1), shale content is 17%, effective porosity is 12%, hydrocarbon saturation is 42%, and net pay is 7 ft.

4- Horizontal Distribution of Petrophysical Parameters for Abu Roash "G" Reservoir:

The shale volume contour map of the Abu Roash "G" reservoir reveals that the reservoir's values decrease in the southwest direction of the research region (Fig 7a). The effective porosity of Abu Roash "G" reservoir in the studied Karama wells, indicate that the effective porosity is increased in the southern part of the study area (Fig 7b).

The hydrocarbon saturation map of the Abu Roash "G" reservoir (Fig 7c) shows the value increases in the southeast direction of the study area. The net pay thickness contour map of Abu Roash "G" reservoir in studied Karama wells, reveals that the net pay increased in the southeast part of the study area (Fig 7d).

Table (1): The Petrophysical parameters results for Abu Roash "G" Mbr and Upper Bahariya Formation (shale content; effective porosity; hydrocarbon saturation; and net pay) in the study Karama well.

Well name	Fm. Name	Petrophysical parameters			
		Shale volume (%)	Effective porosity (%)	Hc. Saturation (%)	Net pay(ft)
Karama 3	A/R/G	14	20	56	14
	U.Bah	17	12	42	7
Karama 11	A/R/G	10	18	52	12
	U.Bah	18	13	45	9
Karama 5	A/R/G	19	15	49	11
	U.Bah	11.5	15.6	48.8	12.3
Karama 17	A/R/G	17	14	47	9
	U.Bah	12.2	14.6	47.2	10.2

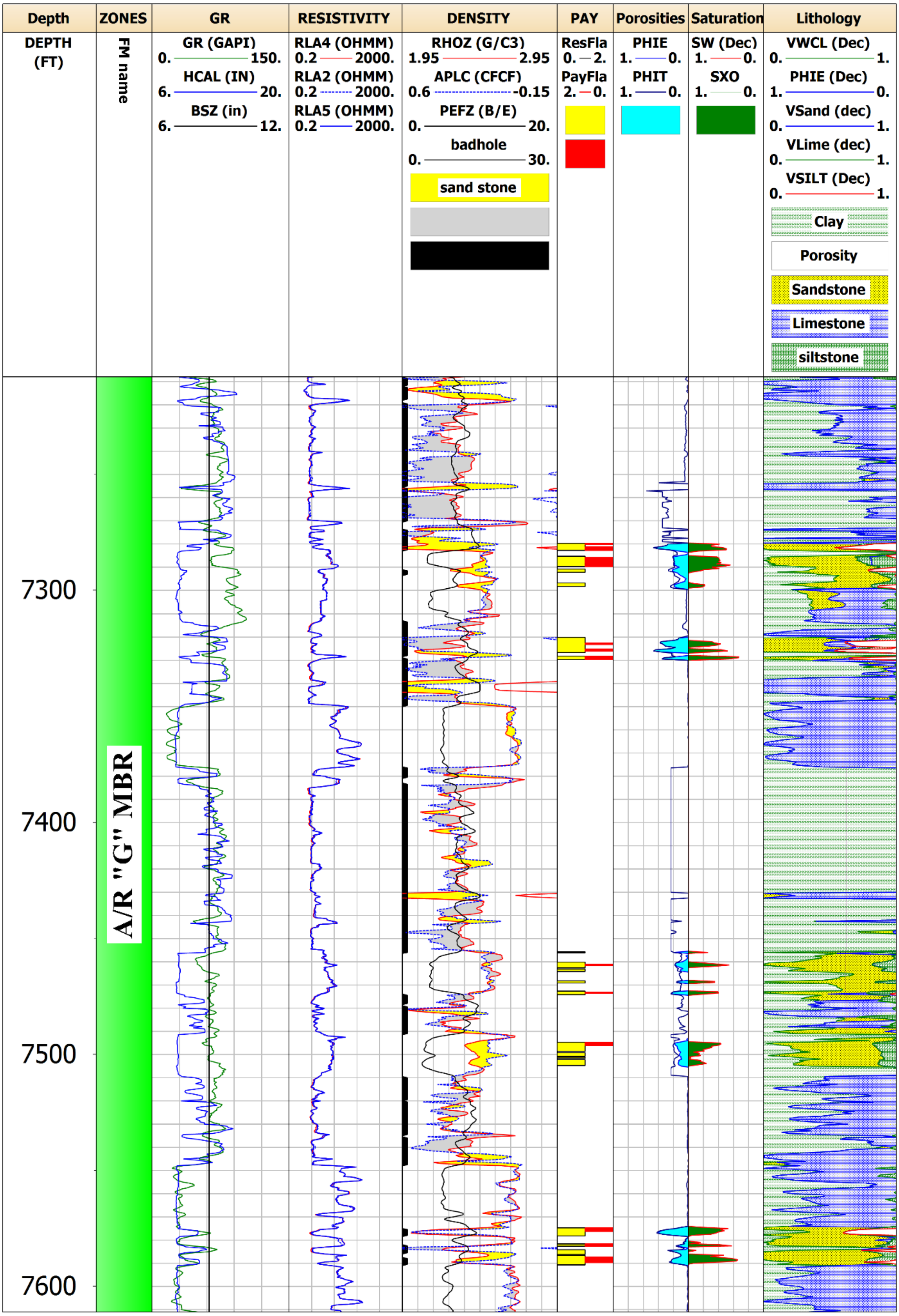

Figure (5): Litho-saturation cross-plot of Abu Roash” G” Mbr for Karama 3 well.

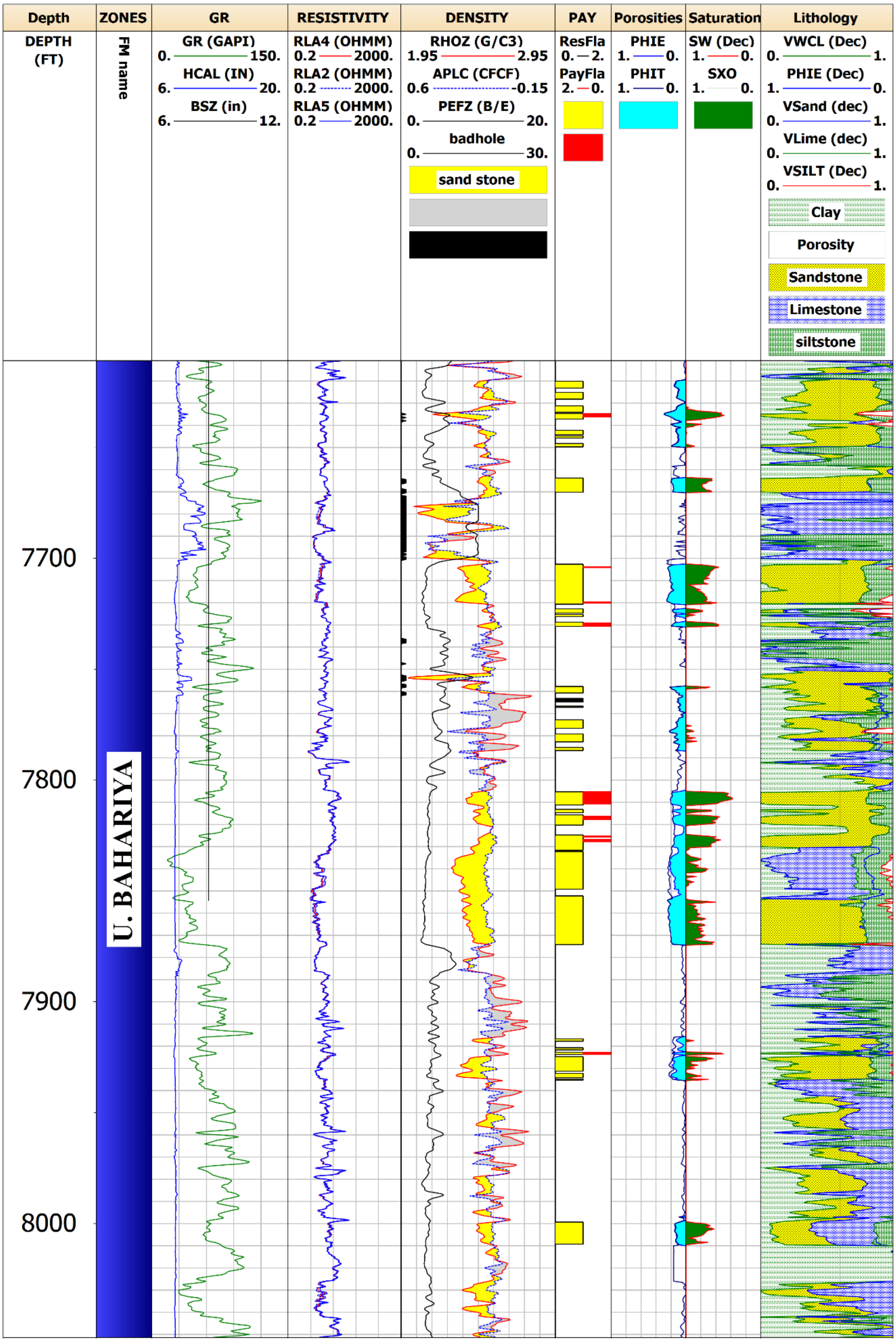

Figure (6): Litho-saturation cross-plot of Upper Bahariya Formation for Karama 3 well.

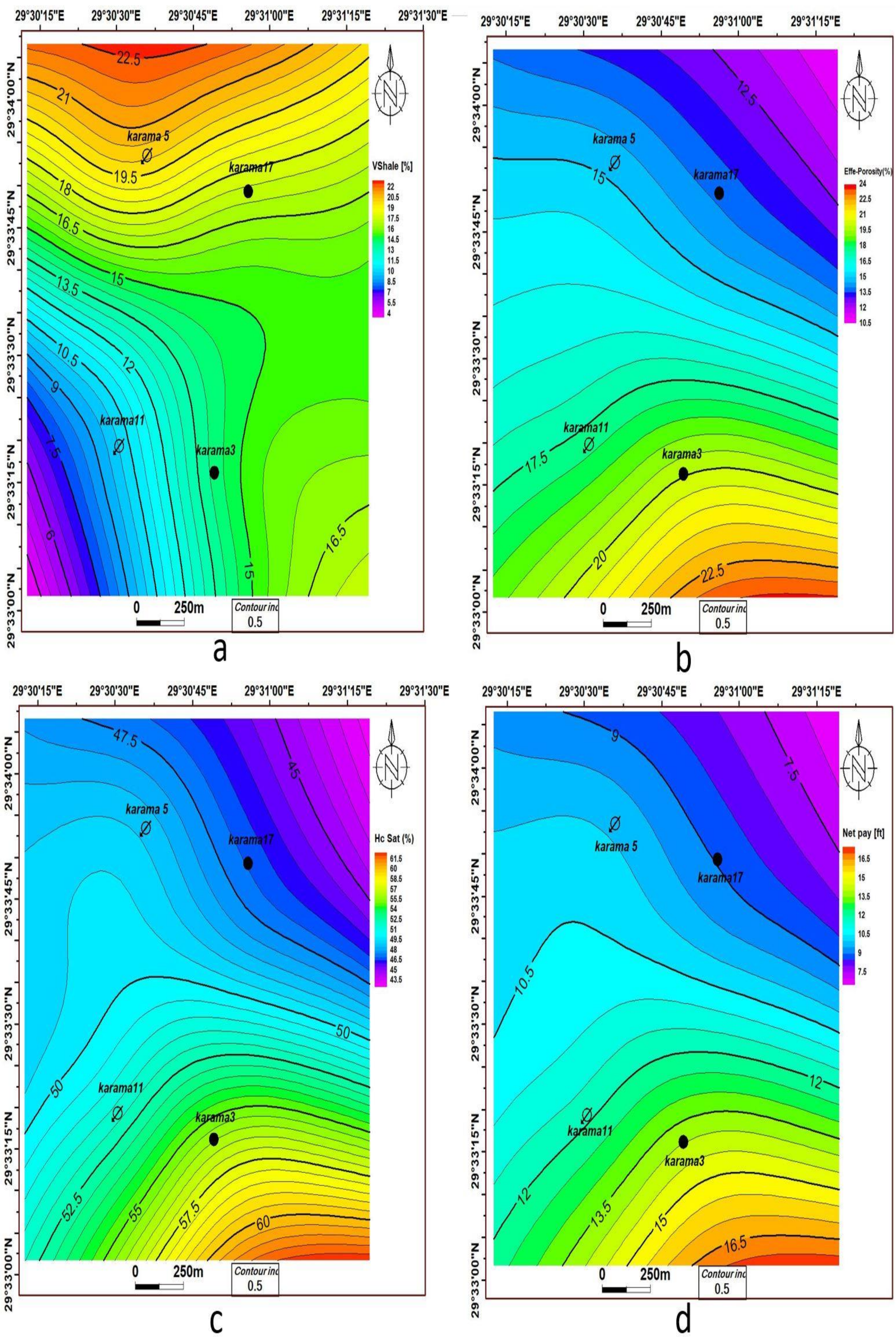

Figure (7): Iso-parametric contour maps for Abu Roash" G" reservoir (map a is shale volume; map b is effective porosity; map c is hydrocarbon saturation; and map d is net pay).

5- Horizontal Distribution of Petrophysical Parameters for Upper Bahariya Formation:

The shale volume contour map for the Upper Bahariya reservoir shows that the values decreasing direction is at the northwestern part of the study area (Fig 8a).

The effective porosity for the Upper Bahariya reservoir shows that its values increasing direction is at the northwestern part of the study area (Fig 8b).

The hydrocarbon contour saturation map for the Upper Bahariya reservoir shows that the increasing direction is in the northwestern part of the study area (Fig 8c).

The pay thickness contour map for the Upper Bahariya reservoir in studied Karama wells (Fig 8d) shows that the net pay direction increases northwestern part of the study area.

From the petrophysical analysis of the Upper Bahariya reservoir in the area of study, it is founded that the shale volume range between 11-18%, effective porosity 12-16%, hydrocarbon saturation 42-49%, and net pay thickness 7-13 feet. While the petrophysical parameters results of Abu Roash “G” reservoir in the study area range as shale volume between 10-19%, effective porosity 14-20%, hydrocarbon saturation 47-56%, and net pay thickness 9-14 feet.

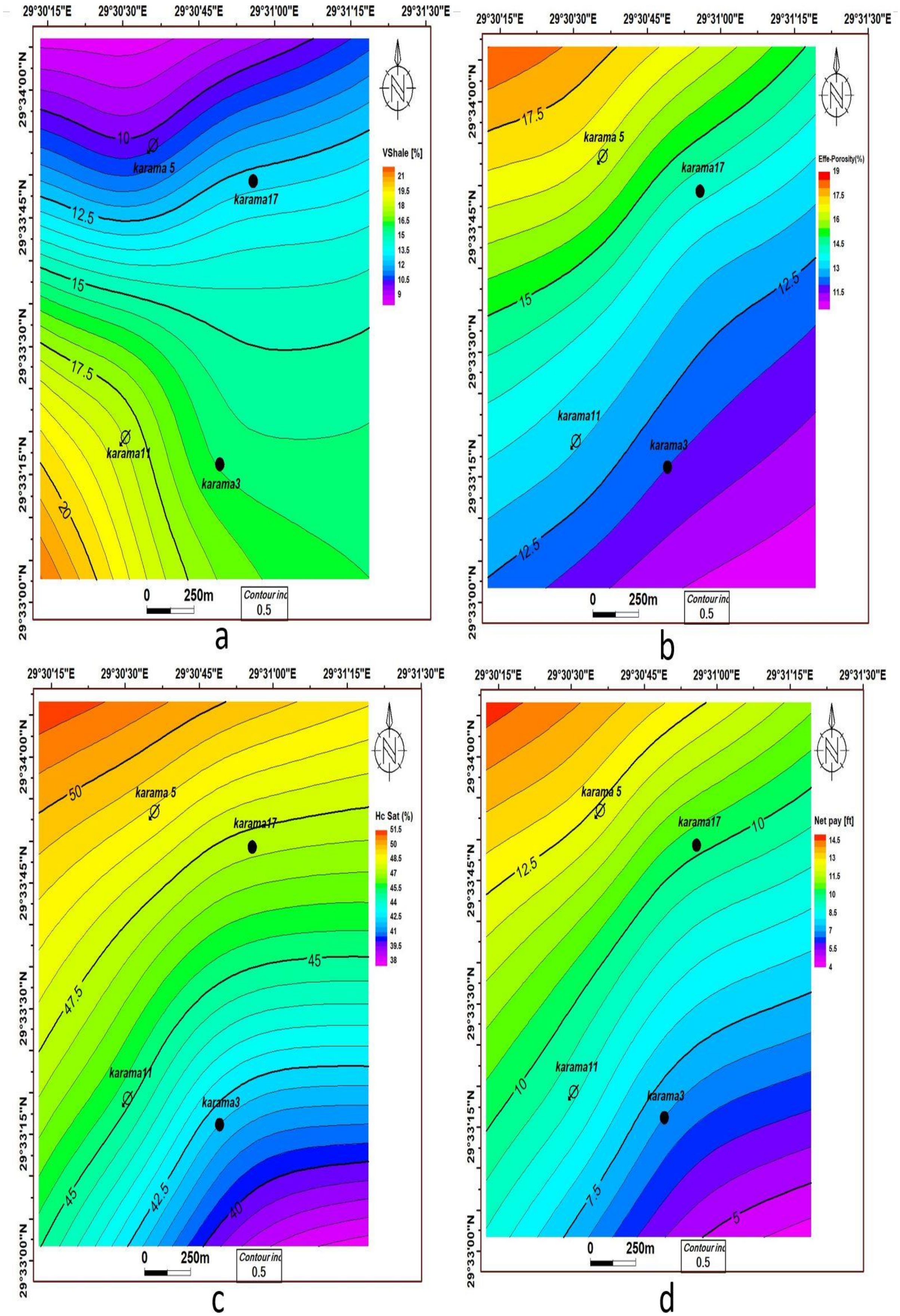

Figure (8): Iso-parametric contour maps for Upper Bahariya reservoir (map a is shale volume; map b is effective porosity; map c is hydrocarbon saturation; and map d is net pay).

6-Conclusion:

Petrophysical parameters data analysis from four wells distributed in the Karama oil field shows the presence of good quality reservoirs in the Abu Roash" G" Mbr and Upper Bahariya formation.

The Abu Roash" G" reservoir density-neutron cross-plot indicates that the lithology is mainly limestone with some sandstone, shale, and siltstone while in Upper Bahariya Formation indicates the sandstone presence with some calcareous cement in all studied wells. The well log analysis results are countered in maps, the petrophysical parameters contour maps show its lateral variation and they are useful to detect new places for more productive wells drilling.

The maps of iso-parametric of the Abu Roash" G" reservoir revealed that the southeast and central parts of the study area are attractive locations to drill other productive wells, due to an increase in effective porosity, net pay thickness, and hydrocarbon saturation.

The Upper Bahariya reservoir iso-parametric maps show that the North-Western part of the study area is the most favorable part for hydrocarbons accumulation and production as the effective porosity, net pay thickness, and hydrocarbon saturation increases toward this part of the study area.

In conclusion, it can be stated that both the Abu Roash" G" and Upper Bahariya reservoirs contain good reservoir zones with a variable lithological composition that reflects the different local depositional environments. Also, both formations have good effective porosity values which are favorable for hydrocarbons accumulation. The present study has proved that there is a good opportunity to drill more wells to develop the productivity of the Karama oil field, particularly in the North-Western and southern parts of the study area.

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REFERENCES

Abdullah, E. A., Al-Areeq, N.M., Al-Masgari, A., and Barakat, M. Kh., (2021): Petrophysical evaluation of the Upper Qishn clastic reservoir in Sharyoof oil Field, Sayun-Masilah Basin, Yemen. ARPN Journal of Engineering and Applied Sciences, 16(22), pp. 2375-2394.

Barakat, M. Kh, and Nooh, A.Z., (2017): Reservoir quality using the routine core analysis data of Abu Roash "C" in Badr El Din-15 oil field, Abu Gharadig basin, Northwestern Desert- Egypt. J. Afr. Earth Sci. 129, 683–691. https://doi.org/10.1016/j. jafrearsci.2017.02.019.

Barakat, M. Kh., El-Gendy, N., and El-Bastawesy, M., (2019): Structural modeling of the Alam EL-Bueib Formation in the jade oil field, Western Desert, Egypt. J African Earth Sci.,156:168–177. https://doi.org/10.1016/J.JAFREARSCI.2019.05.003.

Barakat, M. Kh., Azab, A. A., and Nabil, M., (2022): Reservoir characterization using the seismic reflection data: Bahariya Formation as a case study Shushan basin, north Western Desert, Egypt. Journal of Petroleum and Mining Engineering. 24 (1) p.1-11, 2021.DOI: 10.21608/jpme.2022.110315.1107.

EGPC, (1992): Western Desert, oil and gas fields, a comprehensive overview. 11th Egyptian General Petroleum Corporation Exploration and Production Conference, Cairo, pp. 1-431.

Hantar G., (1990): Northwestern Desert. In: Said R, editor. The Geology of Egypt. Rotterdam: Balkema; chapter. 15: p. 293–319.

Khalifa M.A., H.A. Wanas, H.M., El-Shayeb, and M.A. El-Alfy, (2005): Sequence Stratigraphy and reservoir quality of the middle Jurassic Khatatba Formation, north Western Desert, Egypt. 1st International Conference of the Tethys, pp: 54 (abstract).

Meshref, W. M., Beleity A., Hammouda H., Kamel M., (1988): Tectonic evaluation of the Abu Gharadig basin, AAPG Mediterranean basins Conference, 1988.

Meshref W (1990) Tectonic framework of global tectonics. In: Said R (ed) The Geology of Egypt.

Moustafa, A. R., Ati Saoudi, Alaa Moubasher, Ibrahim M. Ibrahim, Hesham Molokhia and Bernie Schwartz (2003): Structural setting and tectonic evolution of the Bahariya Depression, Western Desert, Egypt. GeoArabia, Vol. 8, No. 1. Gulf Petrolink, Bahrain, pp 91-122.

Moustafa, A. R., (2008): Mesozoic-Cenozoic basin Evolution in the Northern Western Desert of Egypt 2008: Geology of East Libya, Vol. 3, 29-46 p.

Pivnik, D., Bedingfield, J., and Barker G., (2007): Results from a four-year exploration and development effort in the East Bahariya Concession, Western Desert Province, Egypt; AAPG.

Said, R., (1962): Tectonic framework of Egypt. In Said, R. (Eds.). The geology of Egypt. Elsevier publishing company.

Schlumberger, (1984): Well evaluation conference, Egypt. Geology of Egypt, pp: 1-64.

Schlumberger, (1995): Geology of Egypt: 58-66. - Paper presented at the Well Evaluation Conference, Schlumberger, Cairo.

Waly, M., A. Allard, and Abdel-Razek, M., (2001): Alamein basin hydrocarbon expulsion Models, proceeding of the 5thConference on Geochemistry, II: 293-302.