Reservoir Facies of Nahr Umr Formation in Luhais Oilfield, Southern Iraq

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Abstract: ***The current study includes characterization of clastic reservoirs and depositional environments of Nahr Umr Formation in four wells are (Lu-2, Lu-3, Lu-5 and Lu-8) of Luhais Oilfield. Depositional environments of Nahr Umr Formation are represented by; offshore, shoreface, delta (including mouthbar and distributary channel fill), tidal flat, swamp, fluvial channel and floodplain. Reservoir characterization and facies analyses are used to divide the Nahr Umr formation into upper shale member and lower sand member. Upper shale member characterized by low reservoir properties related to high shale content and high water saturation. The sand member divided into ten units are; A, B, C, D, E, F, G, H, I and J. Units A, C, E, G and I are sandstone units and the other are shale units. Units C and E are considered reservoir units in most of studied wells related to large thickness, low shale content and low water saturation and represented by distributary channel fill facies with high effective porosity. Reservoir properties studied are made by using the porosity and permeability (poroperm) readings for studies wells to find the relationships between porosity and permeability in reservoir and non-reservoir units.***

Keywords: Nahr Umr, poroperm, clastic, channel, facies.

1. Introduction

Formation evaluation includes the qualitative and quantitative interpretation of reservoir petrophysical properties such as porosity, fluid saturation and the extensions and thickness of producing zones. These parameters can be estimated from main sources: core analysis, geophysical and well logs data, and pressure test analysis [1]. The lower Cretaceous Nahr Umr Formation includes potential sandstone reservoirs in many oilfields in southern Iraq including Luhais oilfield. The formation consists of thick sandstone units that are characterized by good reservoir properties. This study is based on interpretation of core and wireline logs from 10 wells distributed within Luhais oilfield. The study represents a reservoir evaluation of Nahr Umr Formation, the aims of which are to characterize reservoir facies and to predict areas of best reservoir potential.

2. Location of the Study Area

The Luhais oil field is located in southeast Iraq, approximately 105 Km west of the city of Basra and 350 Km southeast of Baghdad. The oil field lies approximately between (47^{o}, 14' _ 47^{o}, 19') Latitude and (30^{o}, 13' _ 30^{o}, 24') Longitude as shown in Figure (1).

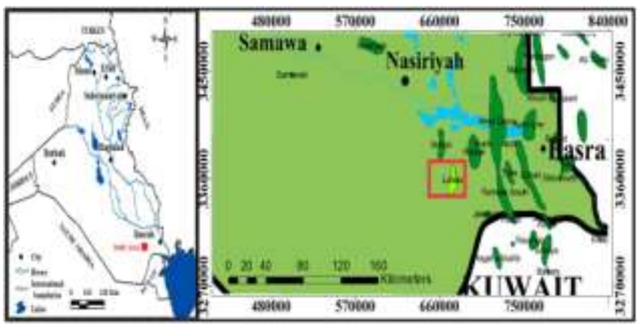

Figure 1: Location map of the study area.

3. Methodology

Reservoir properties studied are made by using the porosity and permeability readings for the wells to find the relationships between porosity and permeability and also to study reservoir quality related to different kinds of facies.

By using full sets of well logging with core samples for four wells are (Lu-2, Lu-3, Lu-5 and Lu-8), Interactive petrophysics (IP) software (v 3.5) is used to calculate the different reservoir parameters such as, shale volume using GR log, porosity (total porosity and effective porosity) by using porosity logs, fluid saturation (oil and water) with calculate the resistivity of formation water (Rw) by using SP log method. In addition to depositional environments are analyzed.

3.1 Porosity and permeability relationship vs. depositional facies

It is widely recognized that grain size and sorting variations are closely associated with facies changes. Several studies showed regular variations of porosity and permeability within successions of different facies [2]–[5]. Besides the changes in porosity and permeability values among different facies, porosity and permeability values change regularly within identical facies as a function of stratigraphic position [6]. [7] ,[8] showed that at the reservoir scale petrophysical attributes of fluvial channel sandstones are stratigraphically sensitive, as are most other attributes of sedimentary facies.

In general, the behavior or the direction of the relationship between porosity and permeability depends on many factors, but the main one is the type of pore system. According to the Figure (2) from [9] shows that there are many trends between the porosity and permeability relationship such as the fractures which increases the permeability dramatically for any type of reservoir more than porosity. In sandstone reservoir such as Nahr Umr Formation with almost negligible percentage of secondary porosity and the primary porosity controls reservoir quality. The porosity and permeability have a linear relationship Figure (2). Factors such as sorting, compaction, cementation, grain size and clay mineral will affect on both of porosity and permeability.

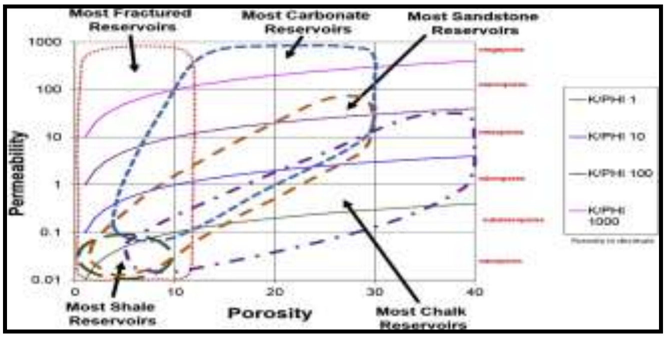

Figure 2: Relationship between porosity and permeability for the different types of reservoirs show the behavior of the relationship in sandstone reservoir [9].

The porosity and permeability of Nahr Umr Formation vary according to facies diversity. Figures (3 to 6) show that each type of facies has different values of porosity and permeability. Distributary channel fill and fluvial channel shows high porosity and permeability related to almost free shale content, well sorting, spherical and rounded grains and medium to fine grain size. The distributary channel fill show low porosity and permeability and that related to the decline of sorting with presence of cementation and/or compaction.

Tidal flats facies show different reservoir properties Figures (3 to 5). The sand-prone facies show high porosity and permeability due to well sorting, low shale content and medium grain size. However, mud-prone facies have low porosity and permeability which is related to very fine grain size with moderately to poorly sorting with high shale content. The swamp facies show similar low reservoir properties because of high clay content.

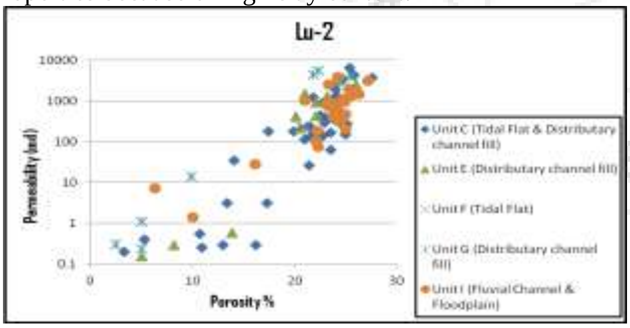

Figure 3: Relationship between porosity and permeability in well Lu-2 in Luhais Oilfield.

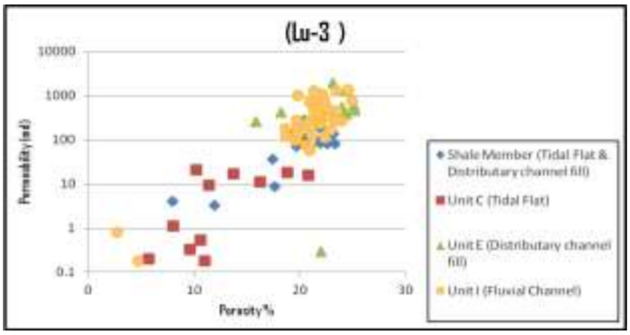

Figure 4: Relationship between porosity and permeability in well Lu-3 in Luhais Oilfield.

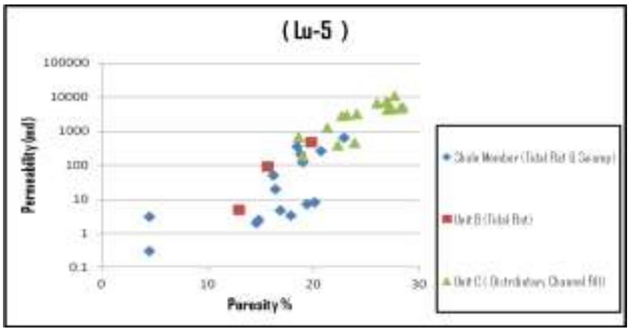

Figure 5: Relationship between porosity and permeability in well Lu-5 in Luhais Oilfield

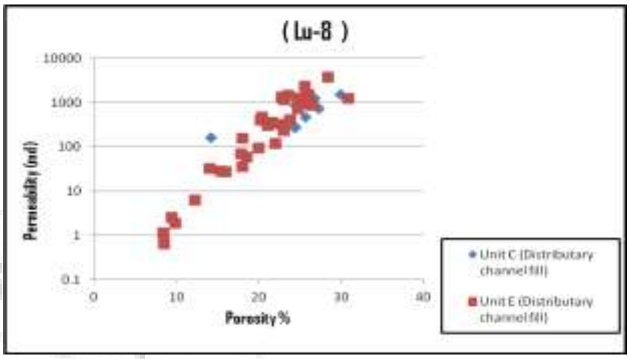

Figure 6: Relationship between porosity and permeability in well Lu-8 in Luhais Oilfield.

3.2 Porosity and Permeability Trends in Sandstone Reservoir:

Several studies have established relationships among porosity, permeability and texture. Grain size, shape and sorting have a strong influence on porosity and permeability [10]–[13]. Theoretically, porosity is independent of grain size for uniformly packed spheres of uniform size [12]. In practice, however, coarser sands tend to have higher porosity than finer sands [14], probably reflecting variations in sorting and non-spherical grain shape. Permeability declines with decreasing grain size because pore and throat diameters decrease and capillary pressure increase [10], [15]. Porosity and permeability increase with improved sorting [12], [13], [15], [16] & [17]. In Nahr Umr Formation, all the statistical parameters for grain size, sorting and grain shape (sphericity & roundness) are computed with facies analysis. The effect of texture parameters and diagenetic processes are predicted for each facies by using the porosity-permeability relationship by [18]. Generally, the porosity and permeability trends are controlled by grain size, sorting, cementation and clays Figures (7 to 10). Figures (7 to 10) show that the Distributary channel fill and fluvial channel display an increasing in porosity and permeability related to well sorting with increasing grain size and both of these channel facies are composed of almost free shale sandstone with high sorting. However they can show low porosity and permeability because of cement, clay content and compaction Figures (7 to 10). Tidal flat, floodplain and swamp show low porosity and permeability related to finer grain size with mostly poorly sorting, but the tidal flat facies sometimes show good porosity and permeability related to coarse grains and good sorting of sand-prone facies.

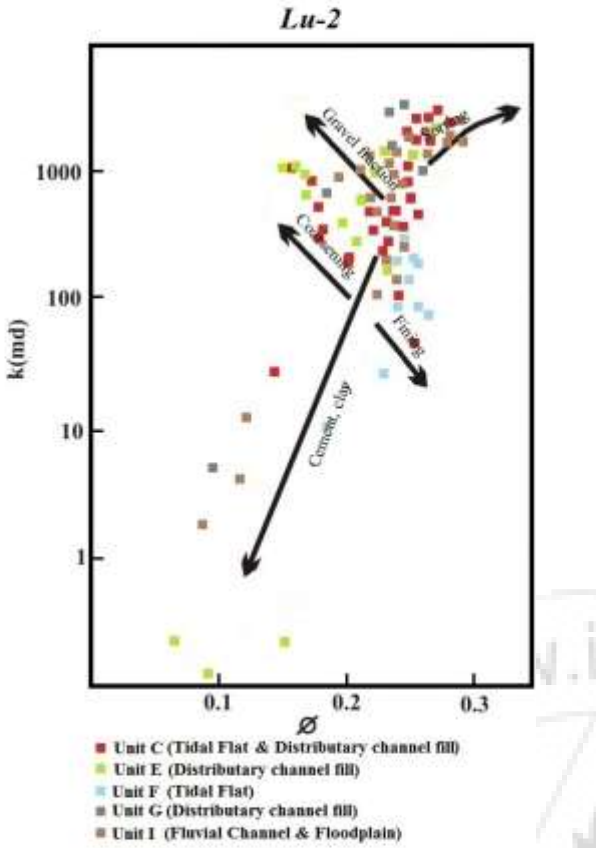

Figure 7: The relationship between porosity and permeability related to depositional facies of reservoir units in well Lu-2 in Luhais Oilfield.

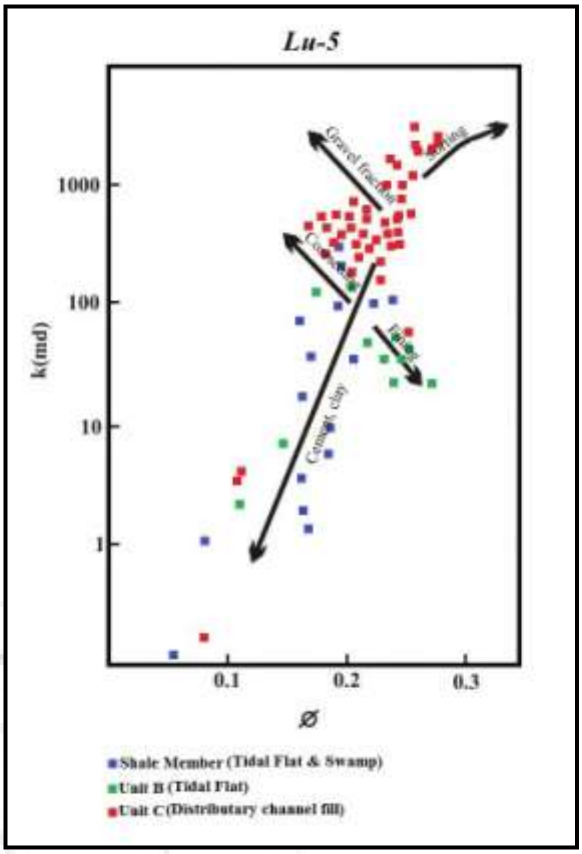

Figure 9: The relationship between porosity and permeability related to depositional facies of reservoir units in well Lu-5 in Luhais Oilfield.

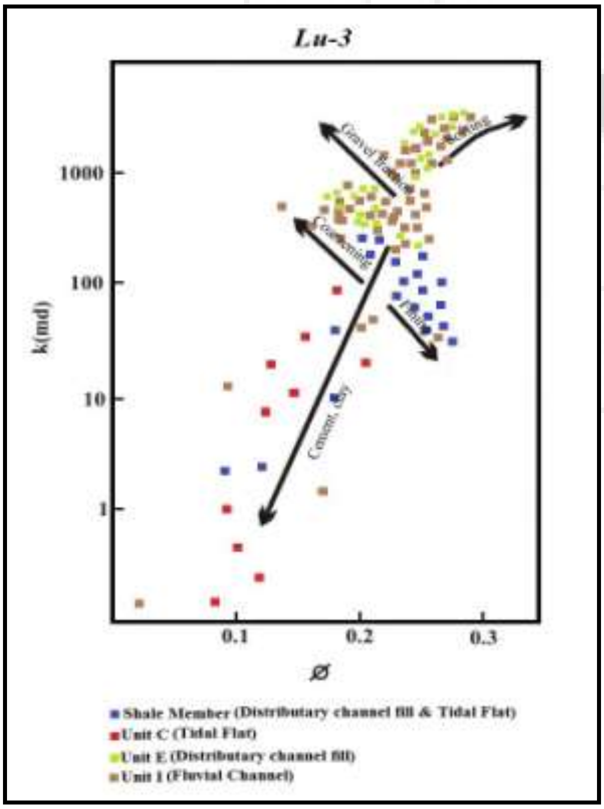

Figure 8: The relationship between porosity and permeability related to depositional facies of reservoir units in well Lu-3 in Luhais Oilfield.

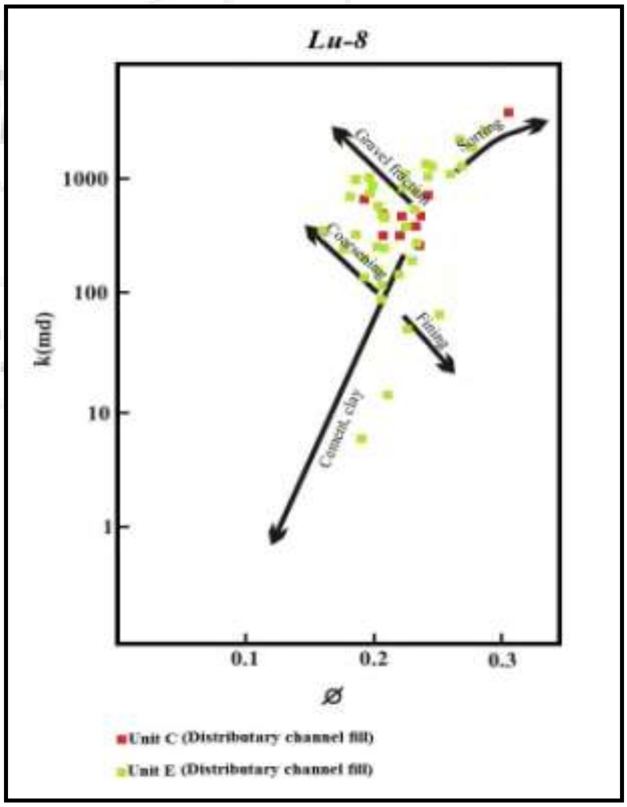

Figure 10: The relationship between porosity and permeability related to depositional facies of reservoir units in well Lu-8 in Luhais Oilfield.

3.3 Evaluation of Reservoir Units

Nahr Umr Formation in Luhais Oilfield consists mainly of thick porous sandstone units overlain by shale units. Figures (11 to 14) show the computer process interpretation (CPI) of Lu-2, Lu-3, Lu-5 and Lu-8 that are deduced by using Interactive Petrophysics (IP) software (v3.5). The CPI figures show the petrophysical properties and Fluid analysis with depositional environments of reservoir units.

The Nahr Umr Formation is divided into upper shale member and lower sand member according to the shale volume and reservoir characteristics Figures (11 to 14). The upper shale member includes by clay-rich units interbedded by sandstone units. The sandstone units within shale member contain residual hydrocarbon especially in well Lu-8, with high amount of water and sometimes contain uneconomic amount of moveable hydrocarbons Figure (14). Also good reservoir properties with high hydrocarbon saturation can be observed in the upper part of this member in well Lu-2 represented by mouthbar sandstone facies Figure (11).

The lower sand member is divided into ten units A, B, C, D, E, F, G and H. Units B, D, F, and H are shale units or seals, and usually non-porous represented by tidal flat facies. In addition, they may contain very low percentage of residual hydrocarbon Figures (11, 13 and 14). Units A, C, E and G represented by sandstone units with good reservoir properties due to high value of porosity and hydrocarbon saturation. They are represented by distributary channel fill facies in addition to tidal flat sandstone facies. The units From A to H reflect deltaic environment. Units A and G have poor reservoir properties due to their limited thickness and distribution within studied wells such as Lu-5, although they contain moveable hydrocarbon. In contrast Unit C and E in wells Lu-2 Figure (11), and Lu-8 Figure (14) this related to large thickness, high values porosity and hydrocarbon saturation. However they may have low reservoir quality due to low hydrocarbon saturation such as unit E in well Lu-5 Figure (13).

Unit I is the thickest sandstone unit in the sand member. It characterized by clean sand with high porosity. However, it may represent water bearing unit as in wells Figures (13 and 14). In the other wells this unit contains good volume of moveable hydrocarbon only in upper part. Unit J is the lowermost unit of the sand member and lies in the base of Nahr Umr Formation. It characterized by high shale percentage but sometimes shows very low hydrocarbon saturation Figure (11).

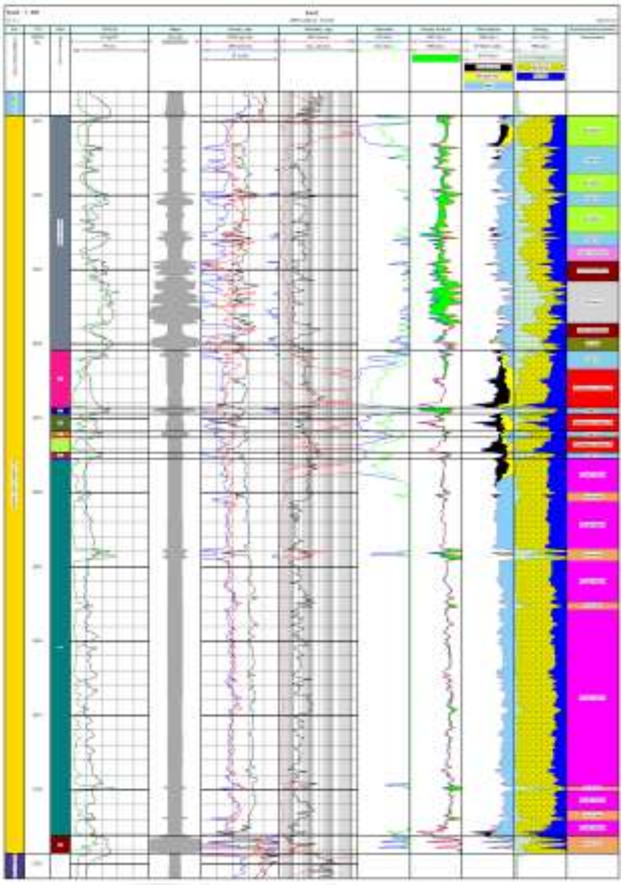

Figure 11: Computer Processes Interpretation (CPI) of Nahr Umr Formation in Lu-2

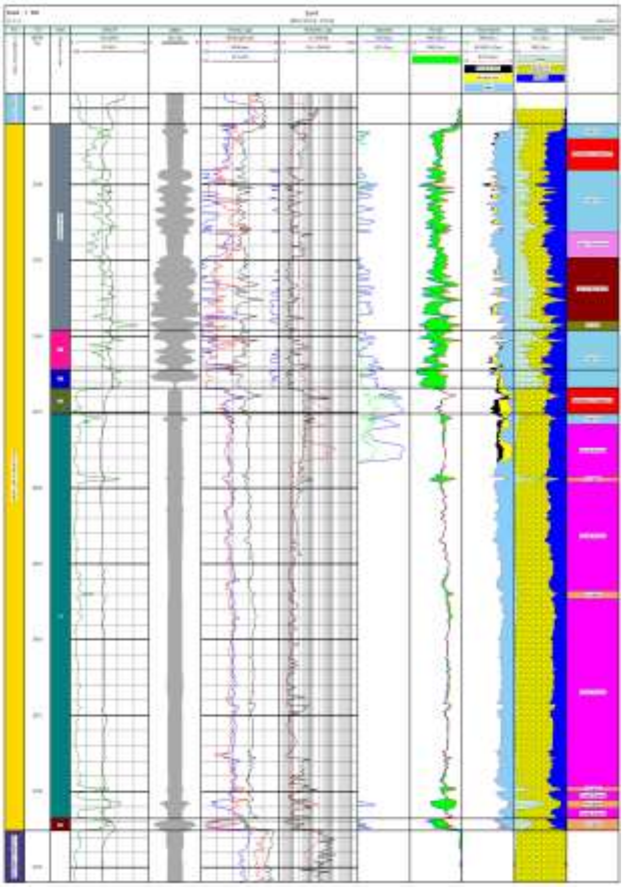

Figure 12: Computer Processes Interpretation (CPI) of Nahr Umr Formation in Lu-3 Well.

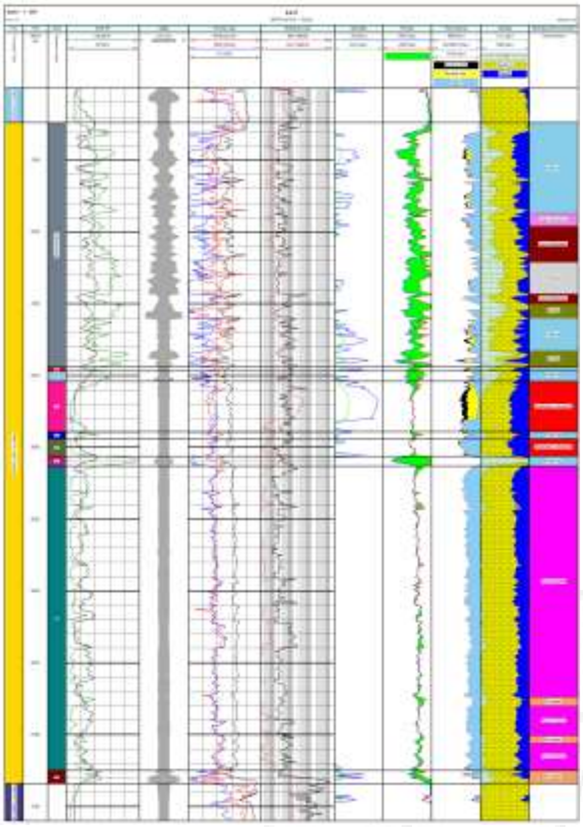

Figure 13: Computer Processes Interpretation (CPI) of Nahr Umr Formation in Lu-5 Well.

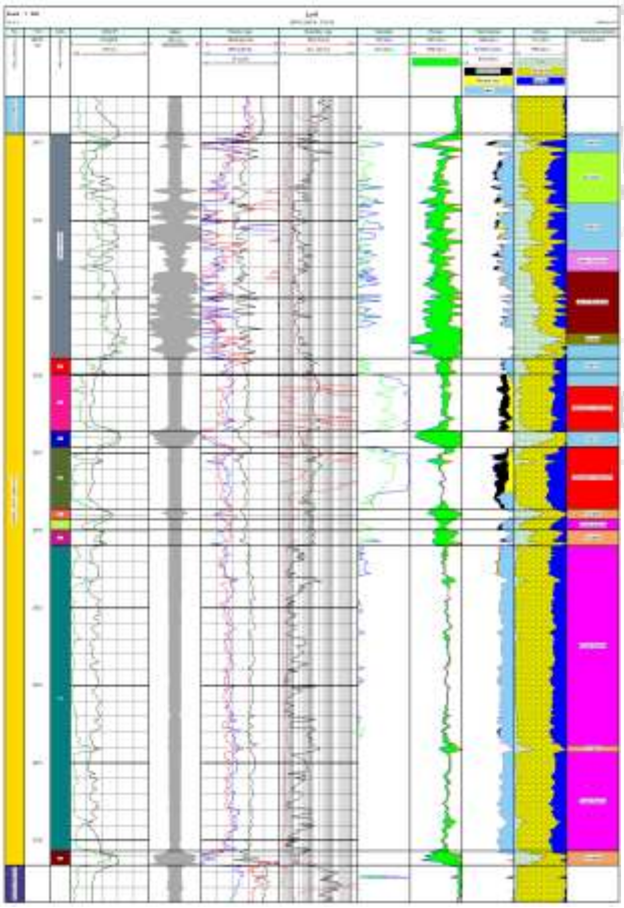

Figure 14: Computer Processes Interpretation (CPI) of Nahr Umr Formation in Lu-8 Well.

4. Conclusion

Facies analysis of Nahr Umr Formation distinguished the existences of seven main depositional environments in Luhais field. These are: offshore, shoreface, tidal flat, swamp, delta (including distributary channel fill and mouthbar), fluvial channel and floodplain environment. Porosity and permeability (core poroperm) data for 4 wells (Lu-2, Lu-3, Lu-5 and Lu-8) were used with facies analysis data to characterize reservoir and non-reservoir units. Units with high porosity and permeability represented by fluvial channel and distributary channel fill facies in contrast tidal flat and floodplain facies. Porosity and permeability data for 4 wells (Lu-2, Lu-3, Lu-5 and Lu-8) were used with facies analysis data to characterize reservoir and non-reservoir units. Units with high porosity and permeability represented by fluvial channel and distributary channel fill facies in contrast tidal flat and floodplain facies. The poroperm data compared with [9] diagram are used and shows a linear relationship between porosity and permeability indicating the control of primary porosity on reservoir porosity of Nahr Umr Formation. Poroperm data also analyzed according to [18] diagram to study the reservoirs unit properties related to different statistical parameters including grain size, sorting, cement and clay. Generally the enhancement in the porosity and permeability for reservoir units related to increasing in grain size with sorting such as in distributary channel fill and fluvial channel facies, whereas the tidal flat and floodplain show low porosity and permeability related to finer grain size and poorly sorting. Well logs analysis and interpretation are made by using Interactive petrophysics IP (v 3.5) software. The computer processes interpretation (CPI) of (4) wells of Nahr Umr Formation in Luhais oilfield have been deduced using IP software. The CPI shows that the formation is divided into upper shale member and lower sand member. The upper shale member considered as non-reservoir related to high shale content, high water saturation and low effective porosity. The upper sand member divided into ten sandstone and shale units are; A, B, C, D, E, F, G, H, I and J. Units A, C, E, G and I are sandstone units whereas the C and E are represented the reservoir units related to large thickness, low water saturation and high value of effective porosity. B, D, F, H and J are shale units. The essential oil-bearing reservoirs in Nahr Umr Formation occur in distributary channel fill facies.

5. Acknowledgements

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