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Hydrocarbon Reservoir Characterization Using Well Logs of Nahr Umr Formation in Kifl Oil field, Central Iraq

Buraq Adnan AL-Baldawi

Department of Geology, College of Science, University of Baghdad. Baghdad, Iraq

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Abstract

This study aims to determine the petrophysical characteristics of the three wells in the Kifl Oilfield, central Iraq. The well logs were used to characterize hydrocarbon reservoirs to assess the hydrocarbon prospectivity, designate hydrocarbon and water-bearing zones, and determine the Nahr Umr Formation's petrophysical parameters. The Nahr Umr reservoir mainly consists of sandstone at the bottom and has an upper shale zone containing a small proportion of oil. The geophysical logs data from three oil wells include gamma-ray, resistivity, neutron, density, acoustic, and spontaneous potential logs. A gamma-ray log was employed for lithology differentiation, and a resistivity log was used to determine the response of distinct zones' productivity. The petrophysical parameters of shale volume, total porosity, effective porosity, water saturation, hydrocarbon saturation, and flushed zone saturation were evaluated using computer processing analyses (CPI). These parameters were plotted by interactive petrophysics (IP) software. The effective porosity (PHE) in the sandstone unit ranges between 3.2 and 31.2%, water saturation (SW) ranges between 6.6 and 100%, and hydrocarbon saturation and (Sh) range from 6 to 65%. The Nahr Umr Formation has moderate to low reservoir characteristics in the lower sandstone unit.

Keywords: Kifl Oilfield; Nahr Umr Formation; petrophysical parameters; CPI; Interactive Petrophysics (IP) software.

الخواص المكمنية الهايدروكاربونية باستخدام المجسات البئرية لتكوين نهر عمر في حقل الكفل النفطي، وسط العراق

براق عدنان البلداوي

قسم علم الارض،كلية العلوم،جامعة بغداد،بغداد،العراق

الخلاصة

الهدف من هذه الدراسة هو تحديد العديد من الخصائص البتروفيزيائية للآبار الثلاثة في حقل الكفل النفطي, وسط العراق تم استخدام المجسات البئرية لتوصيف المكامن الهيدروكربونية من أجل تقييم التنقيب عن الهيدروكربونات في الحقل ، وتعيين مناطق تحمل الهيدروكربونات والمياه ، وتحديد المعاملات البتروفيزيائية لتكوين نهر عمر. في حقل الكفل النفطي ، يتكون مكمن نهر عمر في الغالب من منطقة رواسب من الحجر الرملي السفلي ومنطقة صخرية علوية تحتوي على نسبة صغيرة من النفط. اشتملت الدراسة على بيانات من ثلاثة آبار تضمنت أشعة كاما والمقاومة والنيوترون والكثافة وسجلات الجهد الذاتي والمجسات الصوتية. بالنسبة لتمييز الصخارية تم استخدام مجس اشعة كاما ، وكذلك تم استخدام مجس المقاومة لتحديد استجابة

*Email: buraq.hussein@sc.uobaghdad.edu.iq

إنتاجية المناطق المتميزة. تم تقييم المعاملات البتروفيزيائية لحجم السجيل، والمسامية الكلية، والمسامية الفعالة، والتشبع المائي، والتشبع الهيدروكربوني، وتشبع المنطقة المتدفقة باستخدام تحليلات المعالجة الحاسوبي. تم رسم المعاملات البتروفيزيائية مقابل العمق باستخدام برنامج (IP). بلغت المسامية الفعالة(PHE) في وحدة الحجر الرملي تتراوح بين (3.2 – 31.2٪) ، وتشبع الماء (SW) تتراوح بين (6.6 – 100٪) ، وتشبع الهيدروكربونات وتتراوح (Sh) بين (6–65٪). يمتلك تكوين نهر عمر عن خصائص مكمنية معتدلة إلى منخفضة في وحدة الحجر الرملي السفلي.

Introduction

The most important petrophysical properties to evaluate a petroleum reservoir are porosity, fluid saturation, and the extensions and thickness of the producing zones. These parameters can be estimated from three main sources: core analysis, geophysical and well log data, and pressure test analysis. The ultimate aim of well log interpretation is the evaluation of potential productivity of porous and permeable formations encountered by drilling [1].

This study is concerned with estimating various petrophysical characteristics, a synergistic approach that combines many disciplines to define rock, pore, and fluid systems by evaluating the physical and chemical qualities that explain the occurrence and behavior of rocks and fluids. A comprehensive knowledge of basic reservoir characteristics is necessary to study any well log input data for reservoir modelling and characterization in the discovery and development of hydrocarbon resources **[2]**. Exploratory wells were drilled through promising geological features. They are helpful in assessing the hydrocarbon potential; however, some fundamental petrophysical criteria must be examined to determine the amount of hydrocarbon accumulation in reservoir rocks (sandstone, limestone, or dolomite). Porosity, formation thickness and extent, hydrocarbon saturation, and permeability. These factors have been calculated using a variety of logs, including electrical, nuclear, and acoustic. Well logs were used to correlate zones suited for hydrocarbon accumulation, identify productive zones, measure depth and thickness of zones, discriminate between gas, oil, and water in an reservoir, and estimate hydrocarbon saturation**.**

The Study area

The Kifl oil field is located in the south of Baghdad approximately 35 km and south-west of Hilla city. The study area lies in the middle of Iraq between Najaf and Karbala governorates (west of the Euphrates River) as shown in the Figure 1. It limits from east the Euphrates River to the north Karbala city and to the north-west Razaza lakes. Figure 2 shows the sturcture countor map of Nahr Umr Formation in Kifl oil field.

Geology of Nahr-Umr Formation

Kifl oil field lies tectonically within the stable Mesopotamian basin between the Zagros fold belt and the Arabian shield. The Nahr Umr Formation is distributed in the subsurface along the northeastern ridge of the stable shelf and some parts along the unstable shelf, especially the Mesopotamian zone. It is up to 360 m thick in the Southern parts of the Salman and Mesopotamian zones. [3].The formation deposited during the Early Cretaceous period is considered one of the main reservoirs in southern Iraq and neighbouring regions **[4]**. The stratigraphic column of the Nahr Umr Formation of an Albian clastic unit is characterized by the massive clean basal sands overlain by a mixture of silt, shale, and massive clean sand interbeds. The sandstone reservoirs of the Nahr Umr Formation are Tidal and fluvial **[5].** According to Al-**Dabbas et al. [6],** multi-depositional environments were recognized, prodelta, distal bar, distributary channels, over a bank and tidal flat.

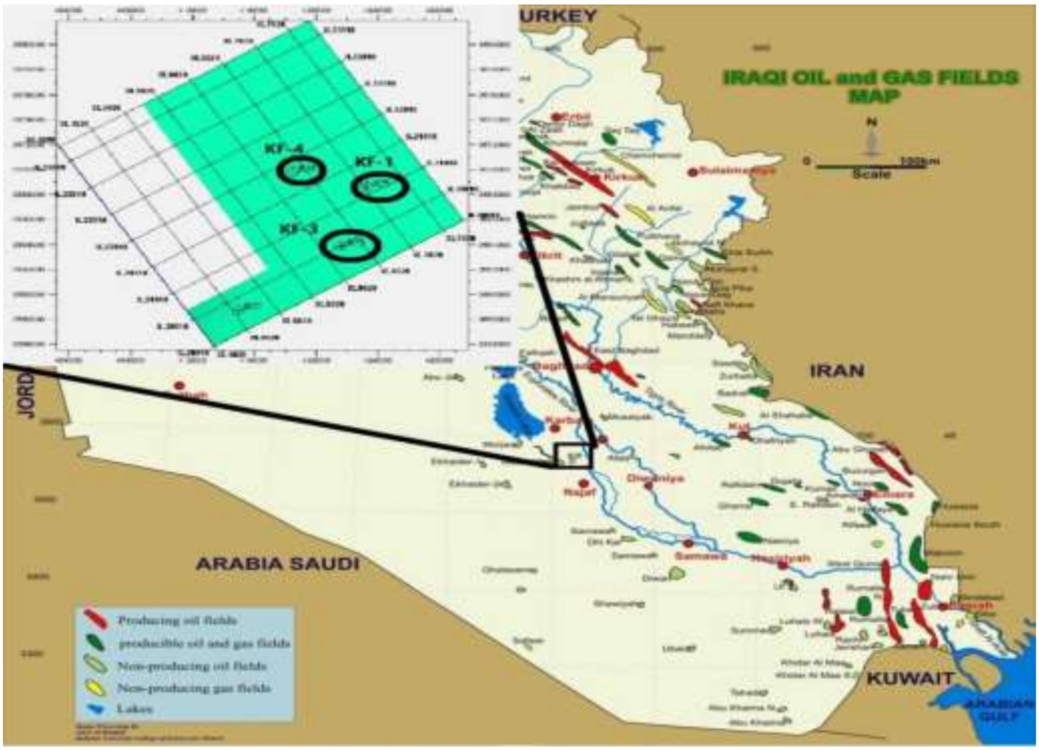

Figure 1-Location map of the study area with a base map of 3D Kifl Survey. (Combined from Al-Khafaji et al. [7]).

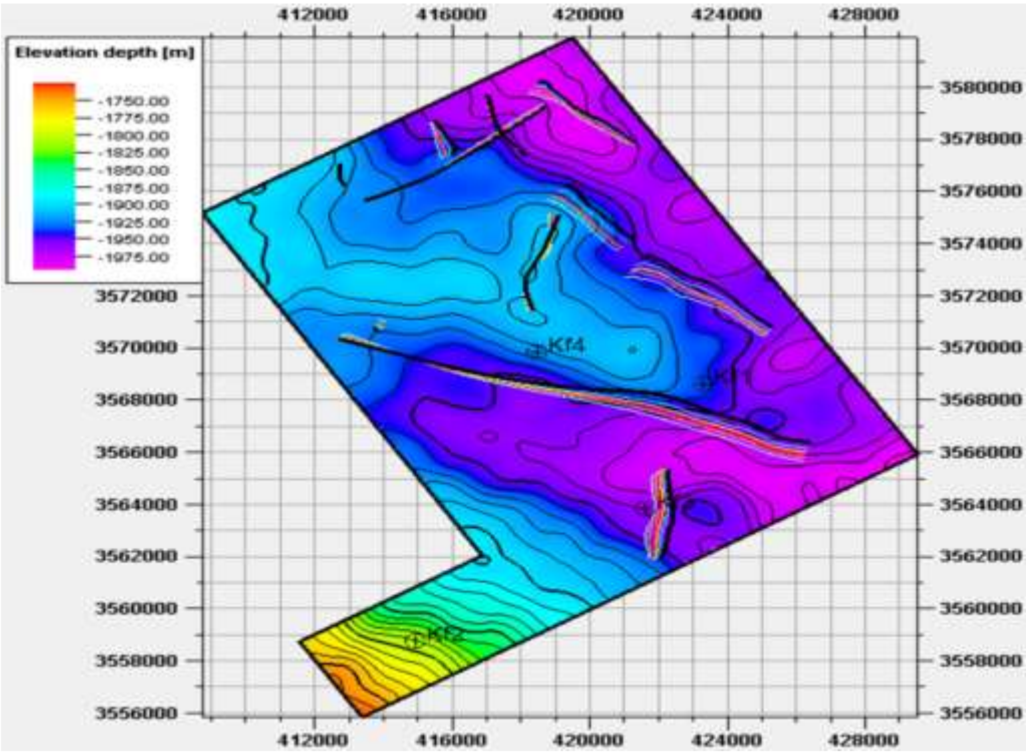

Figure 2- Structure countor map at the top of sandstone Nahr Umr Formation in Kifl oil field.

The upper part of the Nahr Umr Formation is characterized by fining-upwards sediments and intercalations of carbonate, shale and sandstone which indicate the tidal channels deposits influenced of near shore, shallow open marine and the middle and upper parts of the formation are mainly of fluvial and delta with the influence by the inner shelf environment. The basal deltaic platform is characterized by massive clean sands deposited by a series of migrating and amalgamating channels. Thin silts and shales commonly occur at the top of the channel sand packages. The Nahr Umr Formation widespread throughout the Mesopotamian Zone [8]. The lower Cretaceous sedimentary cycle in Iraq is divided into two sub-sedimentary cycles: the first started from the Late Berriasian to the Aptian, the second one is the Alpian covering the Nahr-Umr and Maudud formations. The Nahr Umr Formation in its type locality consists of black shales, interbeded with medium to fine-grained sands and sandstones with lignite, amber, and pyrite **[9].** The depositional environments generally are pro-delta and delta-front which is considered a deltaic environment affected by sea currents **[10].**

Materials and Methods

The Nahr Umr Formation was stuided by wireline well logs. The well logs were digitized using the neuralog programme. For the selected wells (KF-1, KF-3, and KF-4), one reading every 0.25 m depth was chosen. Then, the well logs were subjected to an environmental adjustment. Corrections and interpretation procedures such as hydrocarbon saturation (Sh), porosity (Φ), water saturation (Sw), and bulk volume water (BVW) were performed using the IP software. As illustrated in Figure 3, the petrophysical characteristics were calculated using conventional equations inferred from Asquith and Krygowski **[2]**.

Results and Discussion

Identifying the promising zones (i.e. clean sand with a significant amount of hydrocarbons and/or gas) is the first step in evaluating the petrophysical parameters. The lithology (sandstone and shale) was determined using the gamma-ray log and a sand/shale baseline. The Nahr Umr Formation was divided into two lithological units based on the calculation of shale volume. These two units were the upper shale unit and the lower sandstone unit. The correlation section of the Nahr Umr units was built along three studied wells (Figure 4) using lithological interpretation track, which consists of shale volume calculated from the gamma-ray log and density and neutron logs are used to calculate total porosity, and then corrected by clay volume and hydrocarbon fluid content to calculate the effective porosity. Water saturation was calculated using the Archie equation. The CPI figures of KF-1, KF-3 and KF-4 wells were derived from well logs using the Interactive Petrophysics software and are shown in Figures 5,6 and 7. These figures depict the steps of the complete interpretation process. The components of effective porosity (PHIE), water-filled porosity in the invaded zone (BVWXO), and water-filled porosity in the non-invaded zone (BVW) were illustrated by the fluid analysis track, which includes:

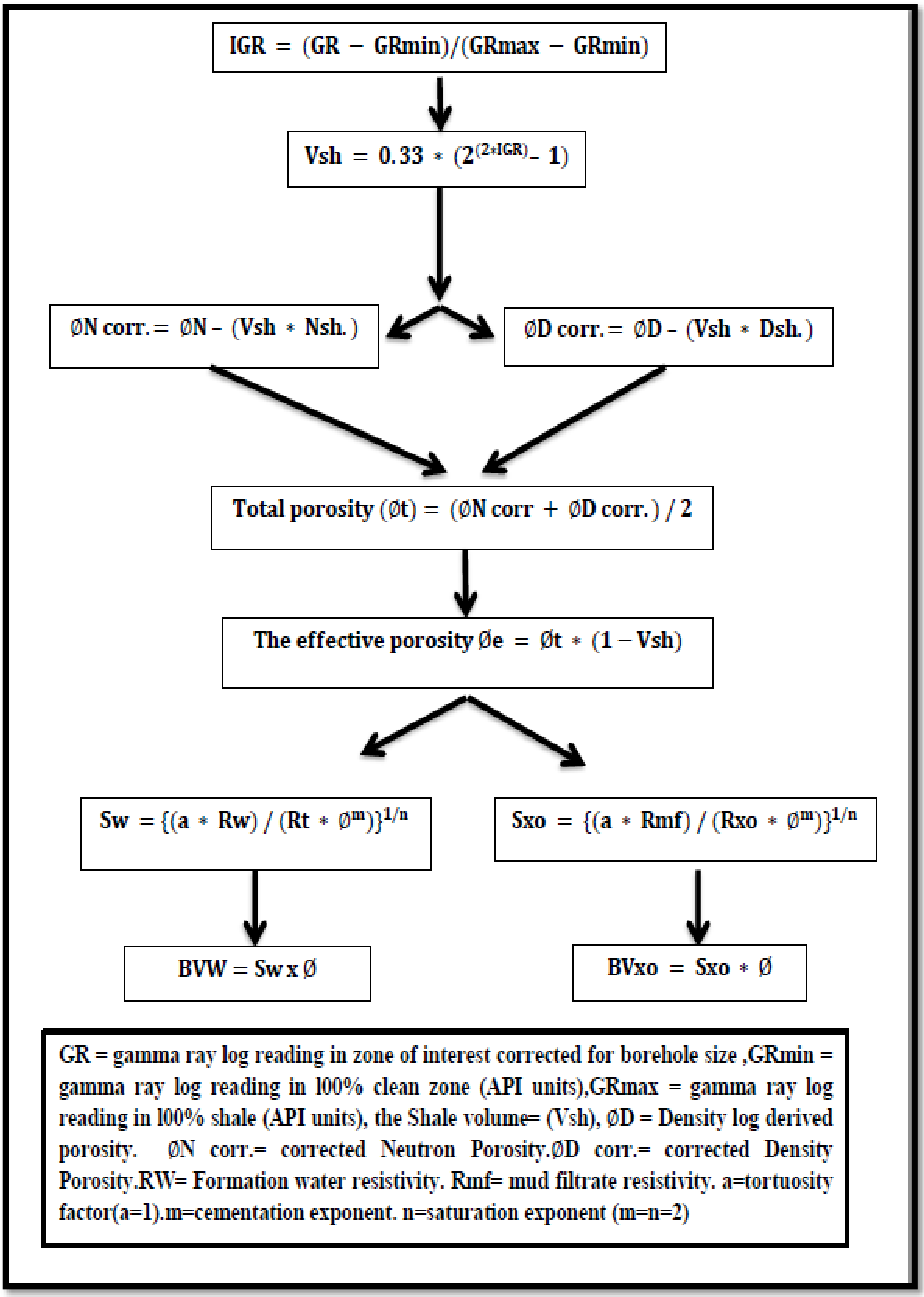

Figure 3-Diagram illustrates steps and parameters of petrophysical properties **[11]**.

A- The residual hydrocarbons are expressed in the area between PHIE and BVWXo.
B-The zone of the moveable hydrocarbons is between BVWXo and BVW.
C- Total hydrocarbons in the area are between PHIE and BVW.

Track of saturation represents a flushed and uninvaded area of water saturation. Track of porosity is the tracking of total porosity and effective porosity. In addition to the lithology track in the last track, the raw data of porosity and resistivity logs are shown on tracks 1 and 2, respectively [12]. Depending on CPI figures, effective porosity increases towards well KF-4, it ranges between (3-31%) at sandstone unit whereas shale volume is the least unit at this well which ranges between (0-28%). The water saturation decreases towards well KF-4 which ranges between (6-90%) whereas it increases towards well KF-1, which ranges between (17-100%). The average petrophysical parameters for Nahr Umr Formation in the wells under study are presented in tables 1,2, and 3.

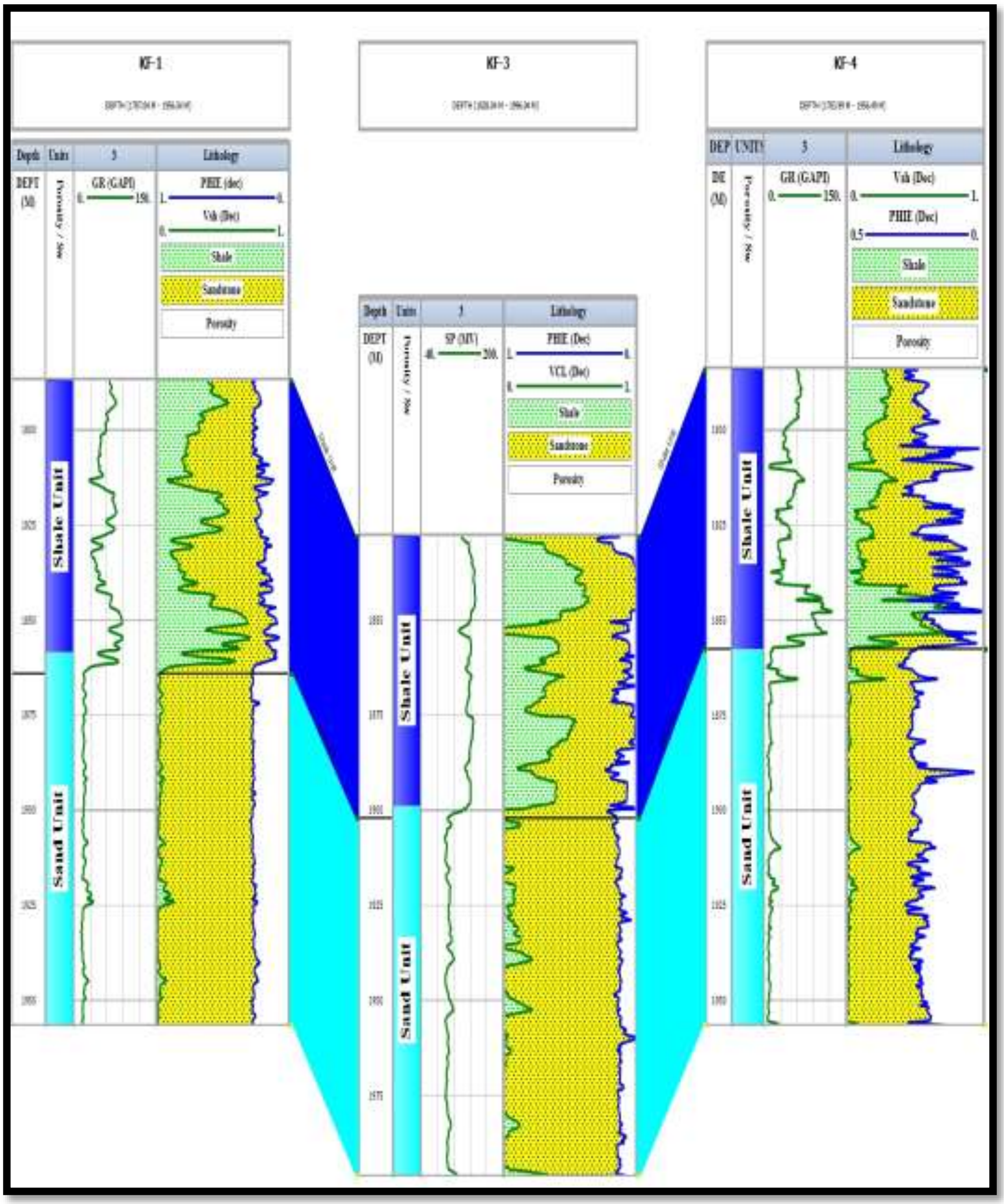

Figure 4-Correlation section along studied wells that shows Nahr Umr Units.

Conclusions

The present study deals with the petrophysical characteristics and hydrocarbon potentiality of the Nahr Umr Formation in the Kifl oil field. It is one of the most important subsurface geological formations and one of the productive and promising reservoir oil fields in central Iraq. Nahr Umr Formation was divided into two lithological units based on shale volume. These units are defined as upper shale unit and lower sandstone unit. The CPI figures show that the sandstone unit is a principle oil-bearing unit in the Nahr Umr Formation, which is characterized by high porosity, low shale volume and moderate water saturation, especially at the top of this unit. On the other hand, the shale unit at the upper part of the formation represents cap rock it characterised by very high shale volume and low porosity. The sandstone unit in the Nahr Umr Formation (well KF-4) represents the best oil-production unit in the Kifl oil field. The Nahr Umr Formation in the Kifl oil field has good reservoir properties in the well KF-4, as shown in CPI figures characterized by bad reservoir properties toward well KF-1.

Table 1-Summarized average reservoir characterization for Nahr Umr units in well KF-1.

units	Top	Bottom	Thickness	BVW	BVWSXO	PHIE	PHIT	SW	SXO	Vsh
Shale	1787.5	1864	76.5	0.184	0.194	0.199	0.274	0.926	0.976	0.350
sandstone	1864	1960.5	96.5	0.132	0.183	0.265	0.271	0.921	0.969	0.029

Table 2-Summarized average reservoir characterization for Nahr Umr units in well KF-3.

units	Top	Bottom	Thickness	BVW	BVWSXO	PHIE	PHIT	SW	SXO	Vsh
Shale	1828	1902	74	0.056	0.068	0.073	0.118	0.901	0.974	0.646
sandstone	1902	1996	94	0.098	0.115	0.121	0.129	0.819	0.951	0.108

Table 3-Summarized average reservoir characterization for Nahr Umr units in well KF-4.

units	Top	Bottom	Thickness	BVW	BVWSXO	PHIE	PHIT	SW	SXO	Vsh
Shale	1784	1857.5	73.5	0.098	0.148	0.172	0.234	0.624	0.876	0.252
sandstone	1857.5	1956.5	99	0.194	0.207	0.237	0.243	0.821	0.877	0.023

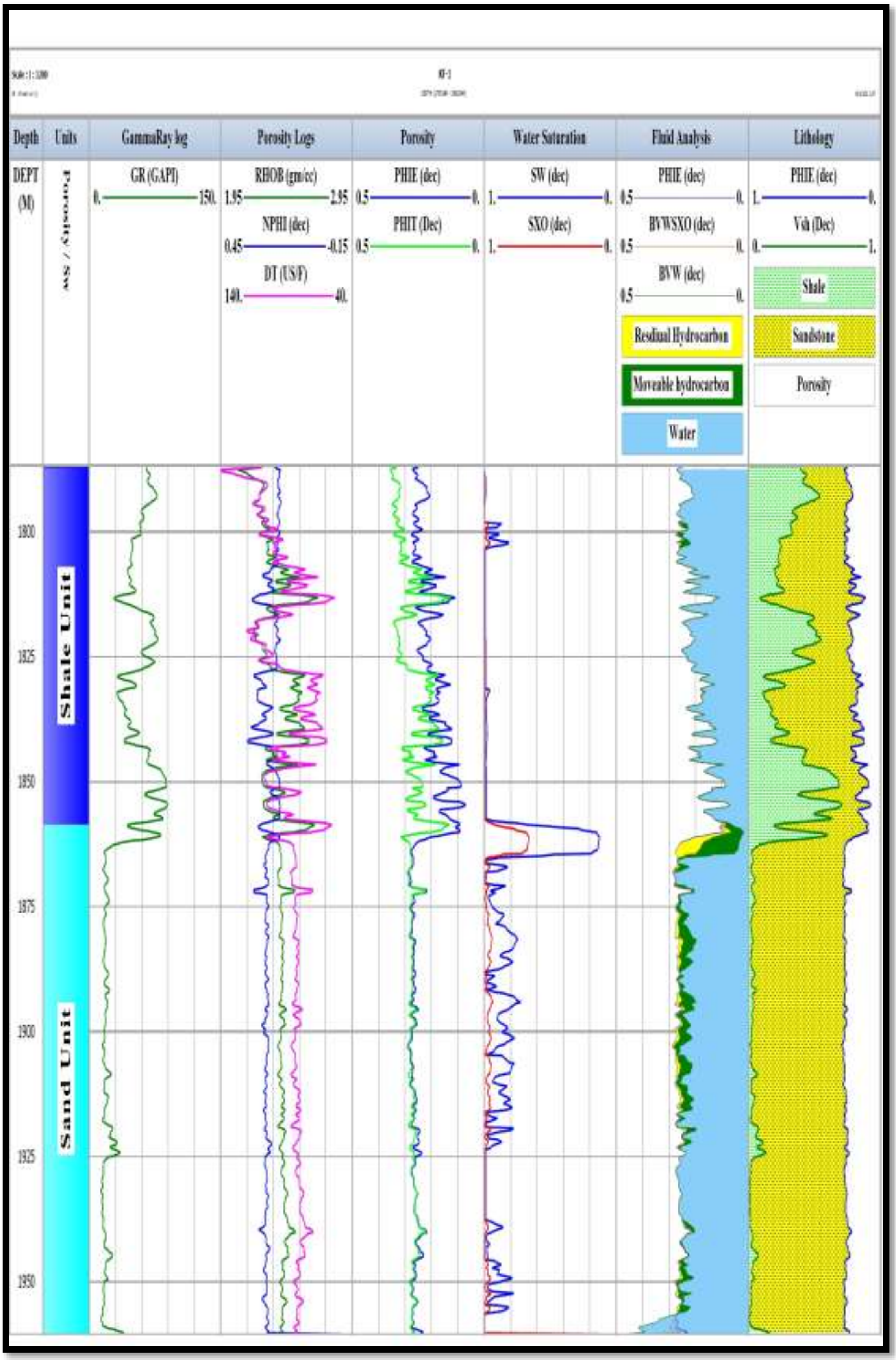

Figure 5-Computer prossesing Interpretation (CPI) for well KF-1.

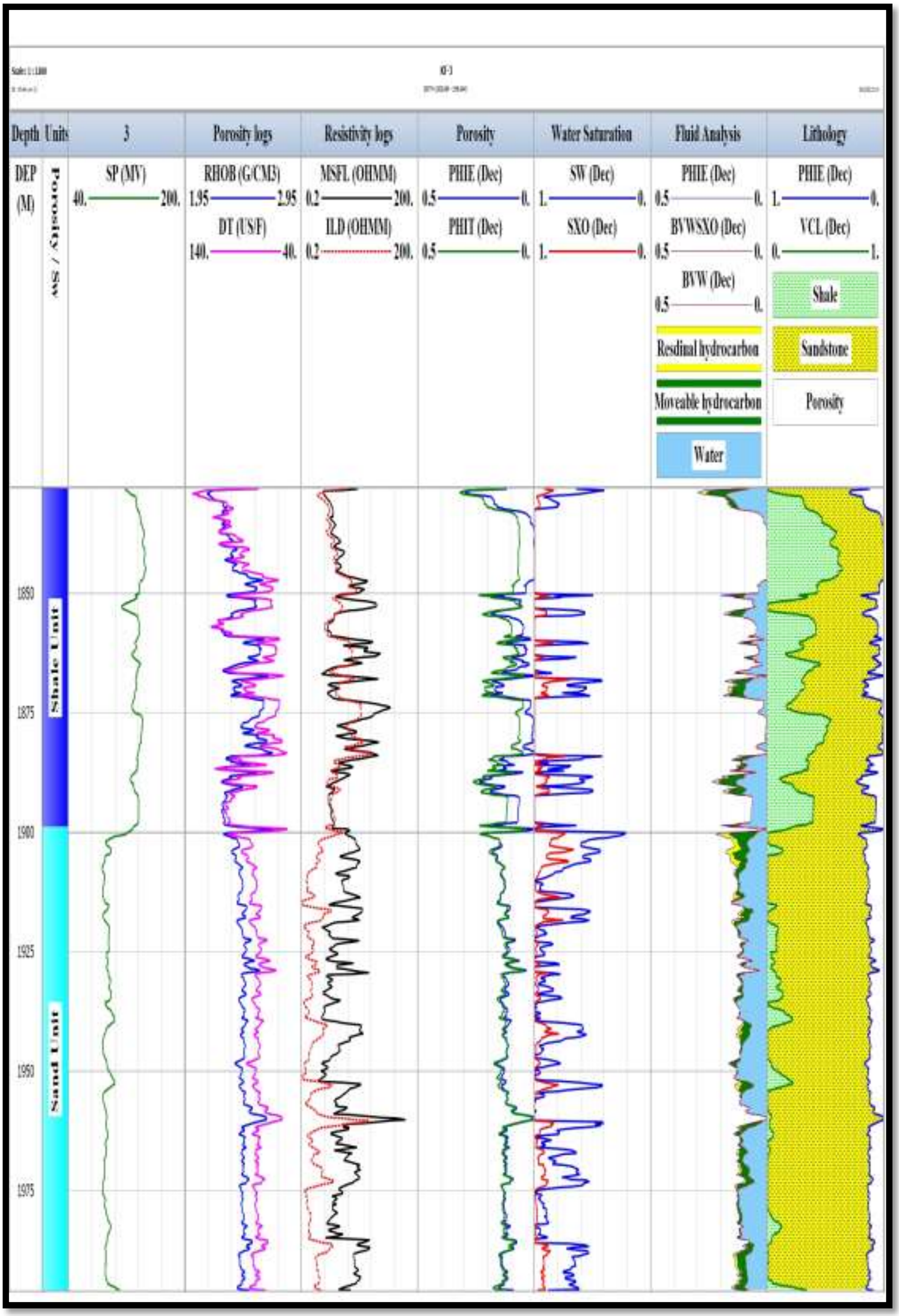

Figure 6-Computer prossesing Interpretation (CPI) for well KF-3.

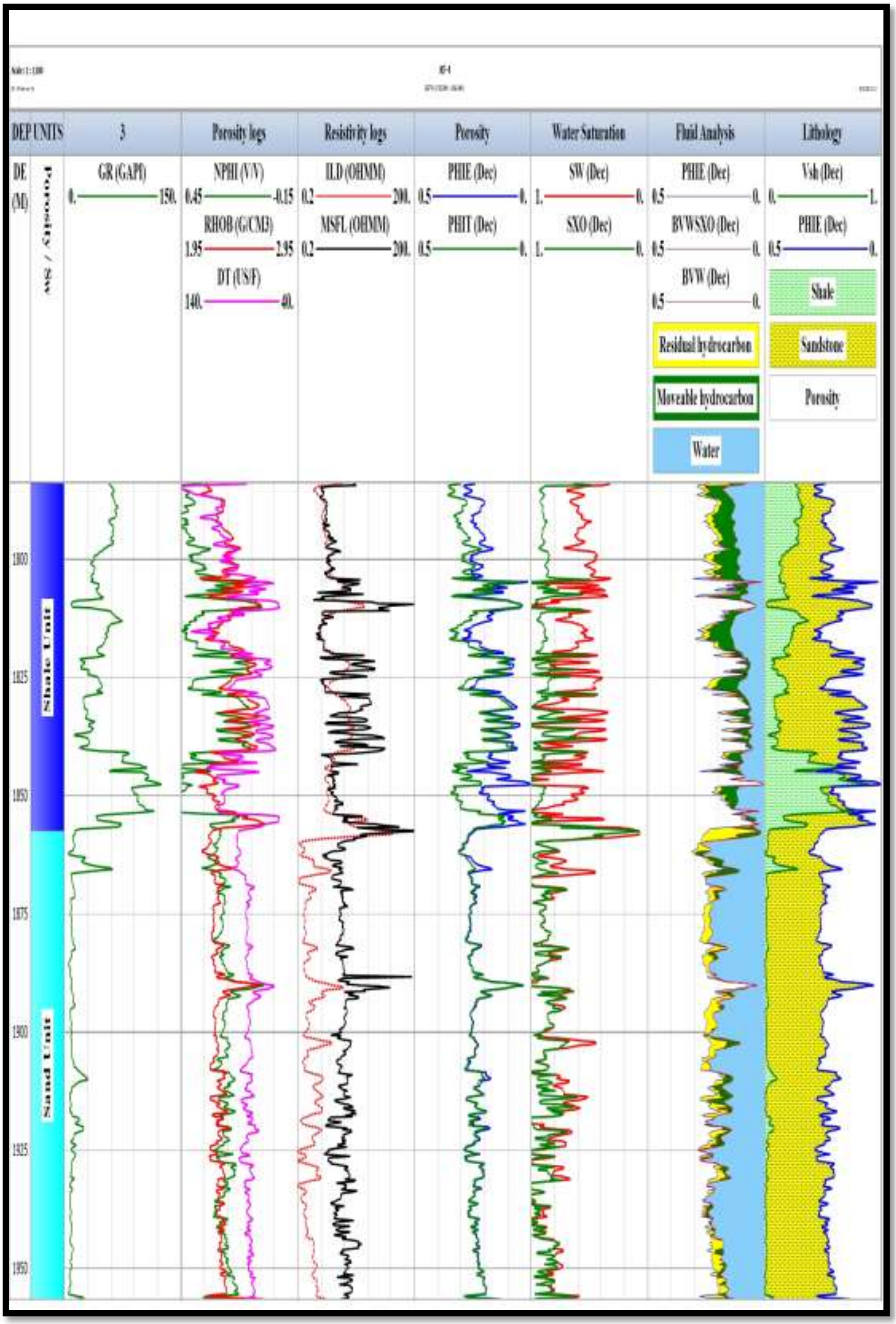

Figure 7-Computer prossesing Interpretation (CPI) for well KF-4.

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