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Evaluation of Mishrif Reservoir in Abu Amood Oil Field, Southern Iraq

Ahmed Hussain[1]*, Medhat E. Nasser[1], Ghazi Hassan[2]

[1]Department of Geology, College of Science, University of Baghdad, Baghdad, Iraq
[2]Ministry of Oil, Oil Exploration Company, Baghdad, Iraq

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Abstract

The main goal of this study is to evaluate Mishrif Reservoir in Abu Amood oil field, southern Iraq, using the available well logs. The sets of logs were acquired for wells AAm-1, AAm-2, AAm-3, AAm-4, and AAm-5. The evaluation included the identification of the reservoir units and the calculation of their petrophysical properties using the Techlog software. Total porosity was calculated using the neutron-density method and the values were corrected from the volume of shale in order to calculate the effective porosity. Computer processed interpretation (CPI) was accomplished for the five wells. The results show that Mishrif Formation in Abu Amood field consists of three reservoir units with various percentages of hydrocarbons that were concentrated in all of the three units, but in different wells. All of the units have high porosity, especially unit two, although it is saturated with water.

Keywords: Mishrif Formation, Abu Amood Oil field, Well logs, Reservoir, petrophysical properties. Formation Evaluation

دراسة تقييمية لمكمن المشرف في حقل ابو عامود النفطي, جنوب العراق

أحمد حسين علي[1]*، مدحت عليوي ناصر[1]، غازي حسن مطلك[2]

[1]قسم علم الأرض، كلية العلوم، جامعة بغداد، بغداد، العراق

[2]وزارة النفط، شركة الاستكشافات النفطية، بغداد، العراق

الخلاصة

تهدف الدراسة الحالية الى تقييم مكمن المشرف في حقل ابو عامود النفطي, باستخدام المجسات البئرية المتوفرة للابار AAm−1, AAm−2, AAm3,AAm−4 and AAm−5 . يتضمن التقييم تحديد الوحدات المكمنية وأحتساب الخصائص البتروفيزيائية لكل وحدة. تم حساب هذه الخصائص بأستخدام البرنامج الحاسوبي Techlog حيث احتسبت المسامية الكلية باستخدام طريقة ال Neutron−Density ومن ثم صححت تلك القيم من محتوى السجيل لاحتساب المسامية الفعالة. تم عمل تفسير المعالجة الحاسوبية CPI للابار الخمس, أظهرت النتائج ان تكوين المشرف في هذا الحقل يتكون من ثلاث وحدات مكمنية مع نسبة من الهايدروكاربونات التي

*Email: Ahmed.Hussain7767@gmail.com

توزعت في الوحدات الثلاث في ابار مختلفة, جميع الوحدات المكمنية تحتوي على نسبة عالية من المسامية بالأخص الوحدة المكمنية الثانية.

Introduction

Petrophysics can be defined as the investigation of the characteristics of rocks and their interactions with fluids (e.g. liquid hydrocarbons, gases, and aqueous solutions). Mishrif Formation is among the major oil reservoirs in the Southern Iraq. It was deposited during the Cretaceous period in the second sedimentary cycle (Cenomanian-Early Turonian). This formation is a sequence of carbonates that is rich in rudists and benthic foraminifera [1]. The reservoir units are characterized by shallow open marine and rudist biostrom facies associations. Formation evaluation, also termed well log analysis or petrophysics, is the crossroads of several disciplines, including, but not restricted to, geology, geophysics, and reservoir engineering. Each of these disciplines analyses well logging data from its own perspective. This approach is applied to determine the occurrence of reservoir rocks and hydrocarbons potential reserves [2]. In this study, the essential data used for the evaluation of the formation include the wireline well log data. The tested petrophysical properties include shale volume, effective porosity (corrected to shale effect), water saturation, water bulk volume, and Archie's parameters, which are all necessary for the interpretation process. Five wells, namely AAm-1, AAm-2, AAm-3, AAm-4, and AAm-5, that penetrate Mishrif reservoir were selected for this study. For wells AAm-1, 2, and 3, the full set of logs is available and covers the whole succession of Mishrif Formation, while for wells AAm-4 and 5, the set of logs covers only intervals within the Mishrif succession.

Study Area

Abu Amood field is located in Dhi Qar Governorate, 250 km to the southeast of Baghdad and 23 km to the southwest of Dujaila field. The area of Abu Amood field is about 120 km^2 and the structure direction is northwest-southeast. The field is located between longitudes 45.30-46.30 E and latitudes 31.00-32.00 N [3]. Abu Amood Oil Field lies within the Mesopotamian basin in the Euphrates subzone of the stable shelf, on the basis of the tectonic classification of Iraq [4].

Mishrif formation was deposited through the secondary sedimentary cycle of the Cretaceous period (Cenomanin_Early Turonian). Mishrif expresses a heterogeneous carbonate succession, originally characterized as organic detrital neritic shoal and shelf limestone, capped by limonitic freshwater [5]. The formation is a carbonate succession rich in rudists and benthonic foraminifera. Its lower boundary is characterized by the variations from its shallow open marine facies to the deep marine facies of the underlying Rumaila. The top of the formation is represented by an unconformable surface between the Late Cretaceous and Khasib Formation (Upper Turonian-Lower Coniacian) [6].

Methodology

The evaluation process was started by digitizing the available well logs (gamma ray, resistivity, neutron, density, sonic, and spontaneous potential) using the Didger software at one reading per 0.25 m. This was followed by determining shale volume (Vsh) using gamma ray log, calculating total porosity (PHIT) using the neutron-density method, correcting total porosity from shale effect to infer effective porosity (PHIE), and employing the values of PHIE, resistivity logs, and Archie's parameters to calculate water saturation (Sw), which is an indicator of hydrocarbons saturation.

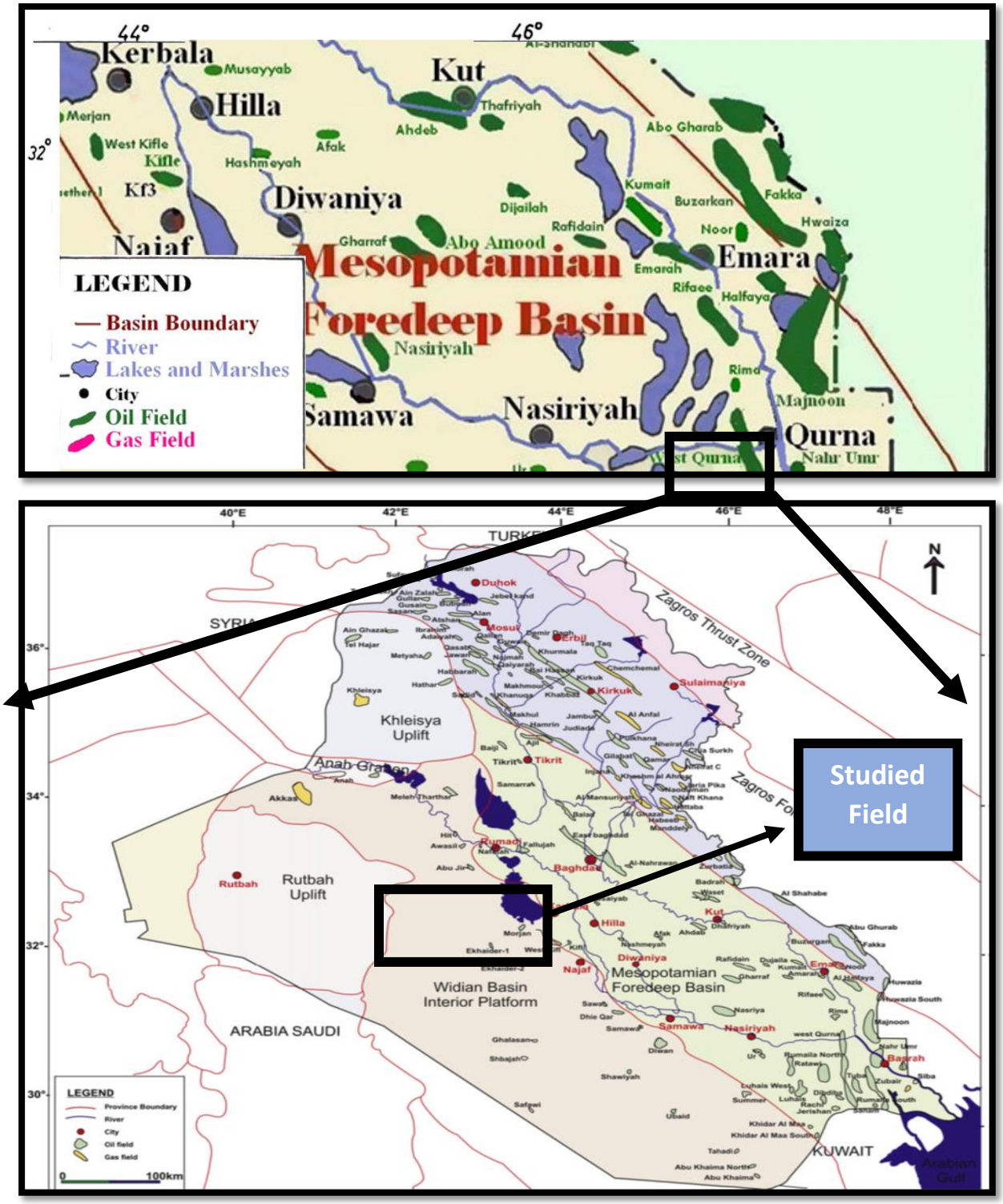

Figure1-Location map of study area [7]

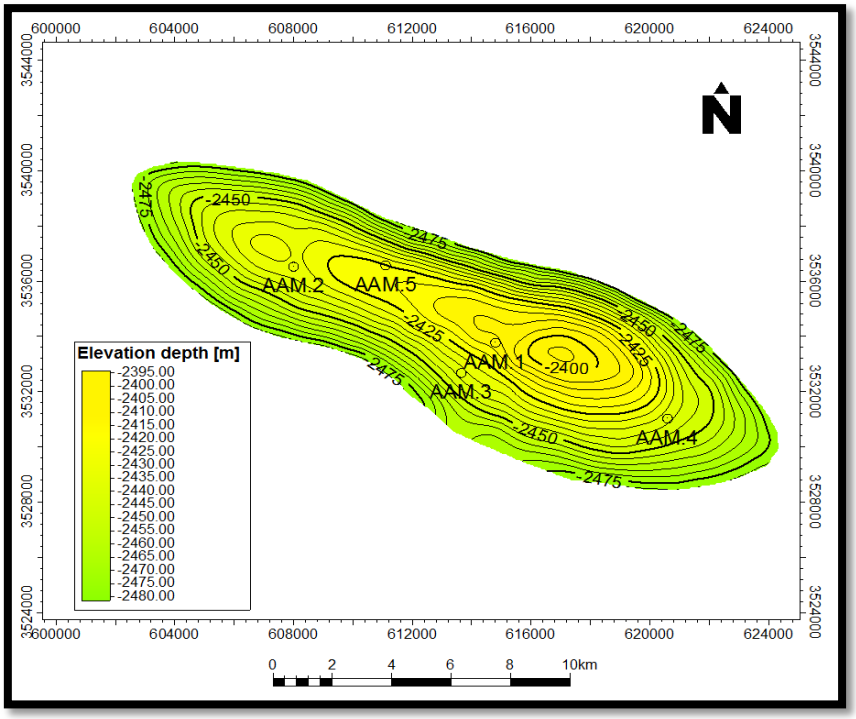

Figure 2-Top of Mishrif Formation in the study area

Evaluation of Mishrif Formation

- The process of evaluation included the calculation of several parameters. Shale volume was calculated using gamma-ray index (I_{GR}) based on gamma ray log, as follows:

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad (1)$$

$$V_{sh} = 0.33[2^{2*I_{GR}} - 1.0] \quad (2)$$

where I_{GR} = gamma ray index, GR_{log} = gamma ray reading for the formation, GR_{min} = gamma ray minimum (carbonate or clean sand), GR_{max} = gamma ray maximum (shale), and V_{sh} = shale volume [8].

Total porosity was determined based on the neutron and density porosities, as in the following equation of Wyllie *et al*., (1958) [9]:

Density porosity (φ_D) is derived from clean liquid bulk density of filled formations in the case that the matrix density (ρ_{ma}) and saturating fluid density (ρ_f) are known, using the following equation [9]:

$$\boldsymbol{\varphi_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_{fl}}} \quad \textbf{(3)}$$

where φ_D = density porosity, ρ_b= formation bulk density (from the log), ρ_{ma} = matrix density (for limestone = 2.710 gm/cm^3), and ρfl = fluid density (for drilling fresh water mud = 1 gm/cm^3, for drilling salty water mud = 1.1gm/cm^3).

$$\Phi N_{Corr.} = \Phi N - V_{Sh} * \Phi N_{Sh} \quad \textbf{(4)}$$

where φ Ncorr. = corrected porosity derived from neutron log for unclean rocks and φ Nsh = Neutron porosity for shale [10].

$$\Phi N - D = \frac{(\varphi_N + \varphi_D)}{2} \quad (5)$$

where: $\Phi N - D$ = total porosity, φ_N= neutron porosity, φ_D= density porosity.

Effective porosity is calculated by the correction of the total porosity from the volume of shale:

$$\varphi_e = \varphi_{N-D} * (1 - v_{shale}) \quad \textbf{(6)}$$

To calculate the S_W of the un-invaded and invaded zones water saturation (S_{XO}), the following equations [11] were used:

$$S_W = \left(\frac{a \,.\, Rw}{\varphi^{m} \,.\, Rt}\right)^{\frac{1}{n}} \quad (7)$$

where Sw =water saturation, Rw = water resistivity, Rt = formation resistivity, Φ = porosity, a = cementation factor, m = cementation exponent, and n = saturation exponent.

$$S_{Xo} = \left(\frac{a.Rmf}{\varphi^{m}.Rxo}\right)^{\frac{1}{n}} \quad (8)$$

where S_{xo} = flushed zone water saturation, R_{mf} = mud filtrate resistivity, and R_{xo} = resistivity of the flushed zone.

The following equations were applied for estimating residual hydrocarbon saturation and movable hydrocarbon saturation, respectively [12]:

$$S_{hr} = \varphi * (1 - Sxo) \quad (9)$$

$$S_{hm} = \varphi * (Sxo - Sw) \quad (10)$$

Results and Discussion

The results of the computer processed interpretation show that the succession of Mishrif Formation in Abu Amood field contains three reservoir units, all of which having high porosity and a percentage of hydrocarbons. Figures 2-6 show the results of computer processed interpretation for AAm-1, AAm-2, AAm-3, AAm-4, and AAm-5 wells, respectively, which can be described as below.

1. **Saturation track**: it represents the effective porosity (PHIE) curve and the water saturation of the non-invaded zone.

2.**The model track**: it represents the shale volume (Vsh), effective porosity (PHIE), bulk volume of water in the non-invaded zone (BVW), and bulk volume of water in the invaded zone (BVWXO).

- **Reservoir unit 1**

This is the upper reservoir unit of Mishrif Formation in Abu Amood oil field. This unit is varying in thickness in Abu Amood wells (AAm-1, AAm-2, AAm-3 and AAm-4), having values of 32.5, 7.5, 25.5, and 6.5 m, respectively. The unit is characterized by reasonable to good petrophysical properties and considered as hydrocarbons-bearing unit in wells AAm-2 and AAm-4. It shows porosity range of 0.02-0.23% with an average of 0.12%. Water saturation ranges 0.33-1% (average 0.75%). The unit has poor reservoir properties at AAm-1 and AAm-3 due to deep marine facies associations. Thus, these wells are not included in the previous statistics.

- **Reservoir unit 2**

The second unit in the studied formation is characterized by rudist biostrom and shallow open marine depositional environments. This unit varies in thickness in the three wells of AAm-1, AAm-2, and AAm-3 (150.5, 148.5, and 152.5 m, respectively). It is considered as a water saturated unit in wells AAm-2 and AAm-3, whereas it is oil-bearing in AAm-1. The three wells have a porosity range of 0.00001-0.26%(average 0.13%) and water saturation range of 0.22-1% (average 0.97%).

- **Reservoir unit 3**

This reservoir unit can be considered as the main reservoir unit in Mishrif Formation in Abu Amood oil field because of the good reservoir properties. It is also considered as oil-bearing unit in the two wells of AAm-2 and AAm-5, being saturated with water in AAm-1 and AAm-3. This unit is characterized by a porosity range of 0.001-0.26% (average 0.12%) and water saturation range of 0.3-1% (average 0.87%).

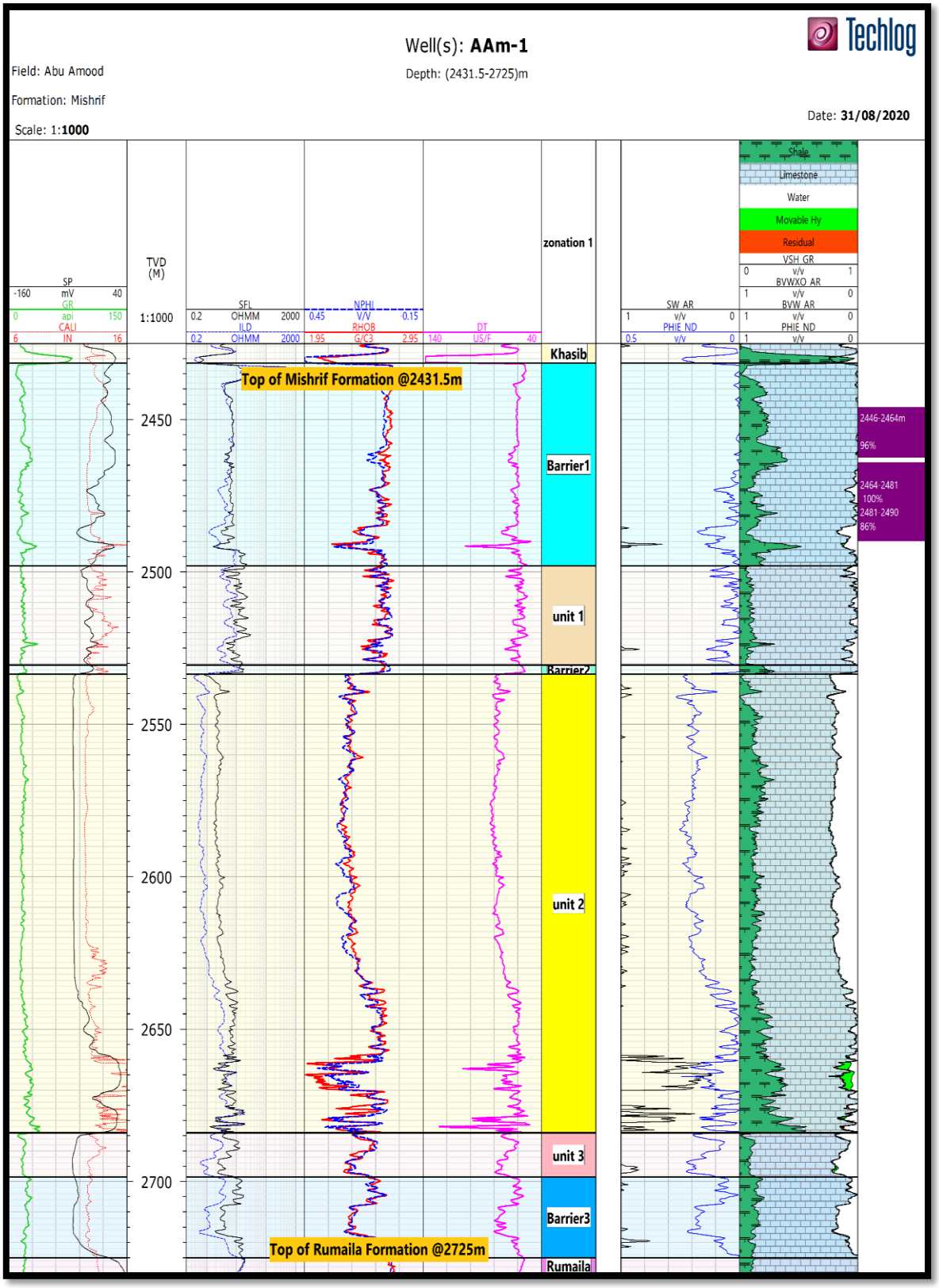

Figure 3-Lithological section, logs, and reservoir characteristics of the Mishrif formation in AAm-1 (using Techlog software)

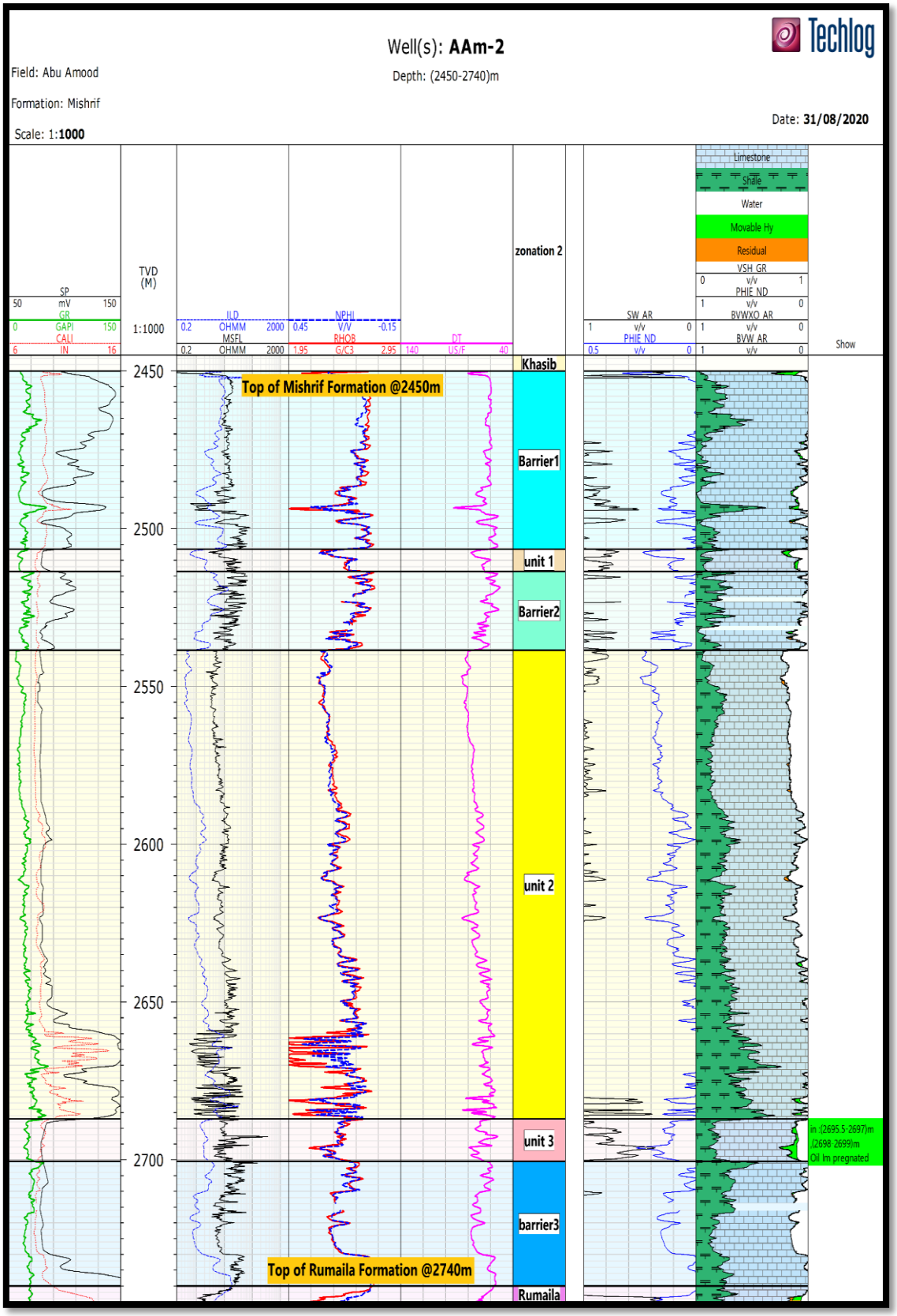

Figure 4-Lithological section, logs, and reservoir characteristics of the Mishrif formation in AAm-2 (using Techlog software)

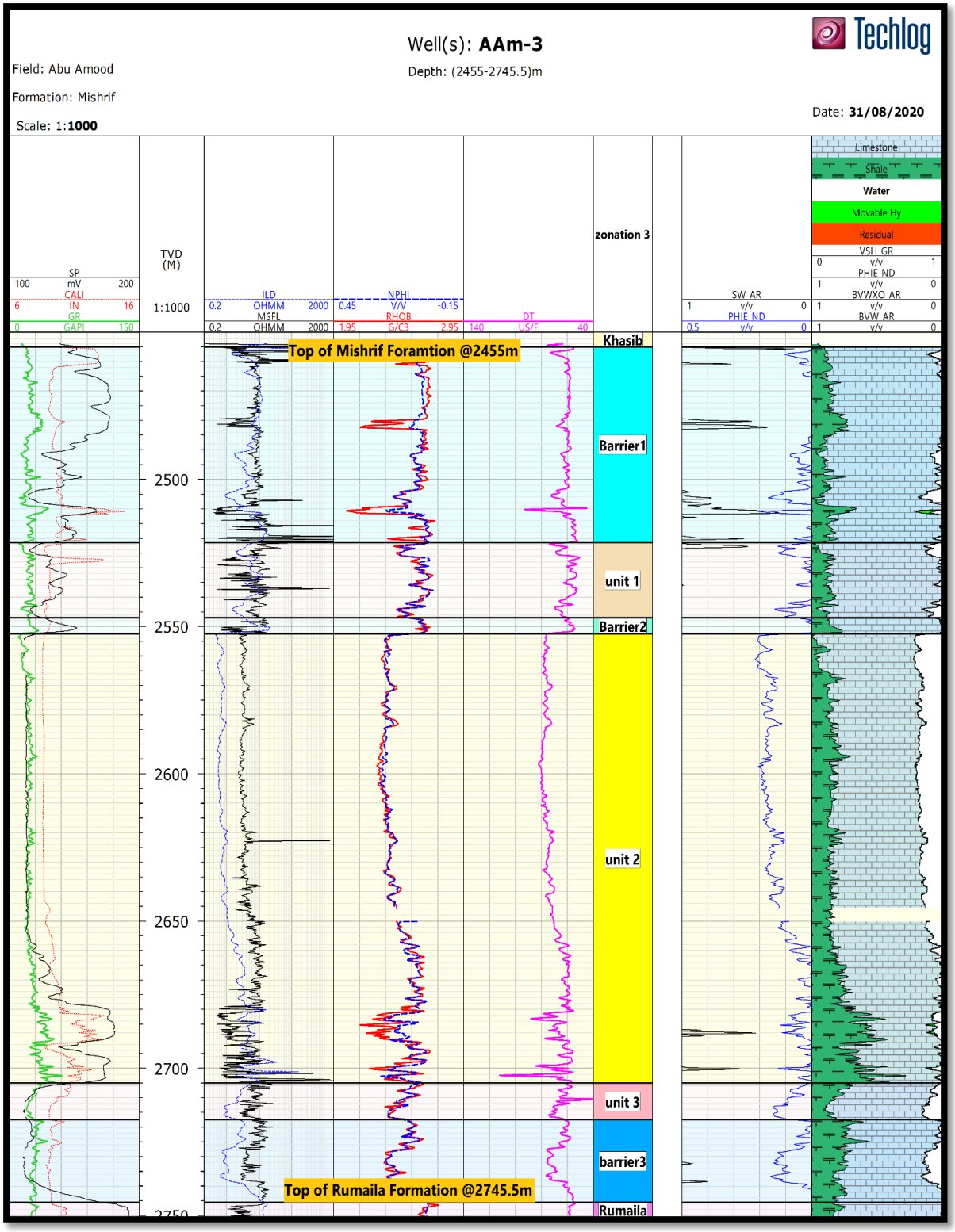

Figure 5-Lithological section, logs, and reservoir characteristics of the Mishrif formation in AAm-3 (using Techlog software)

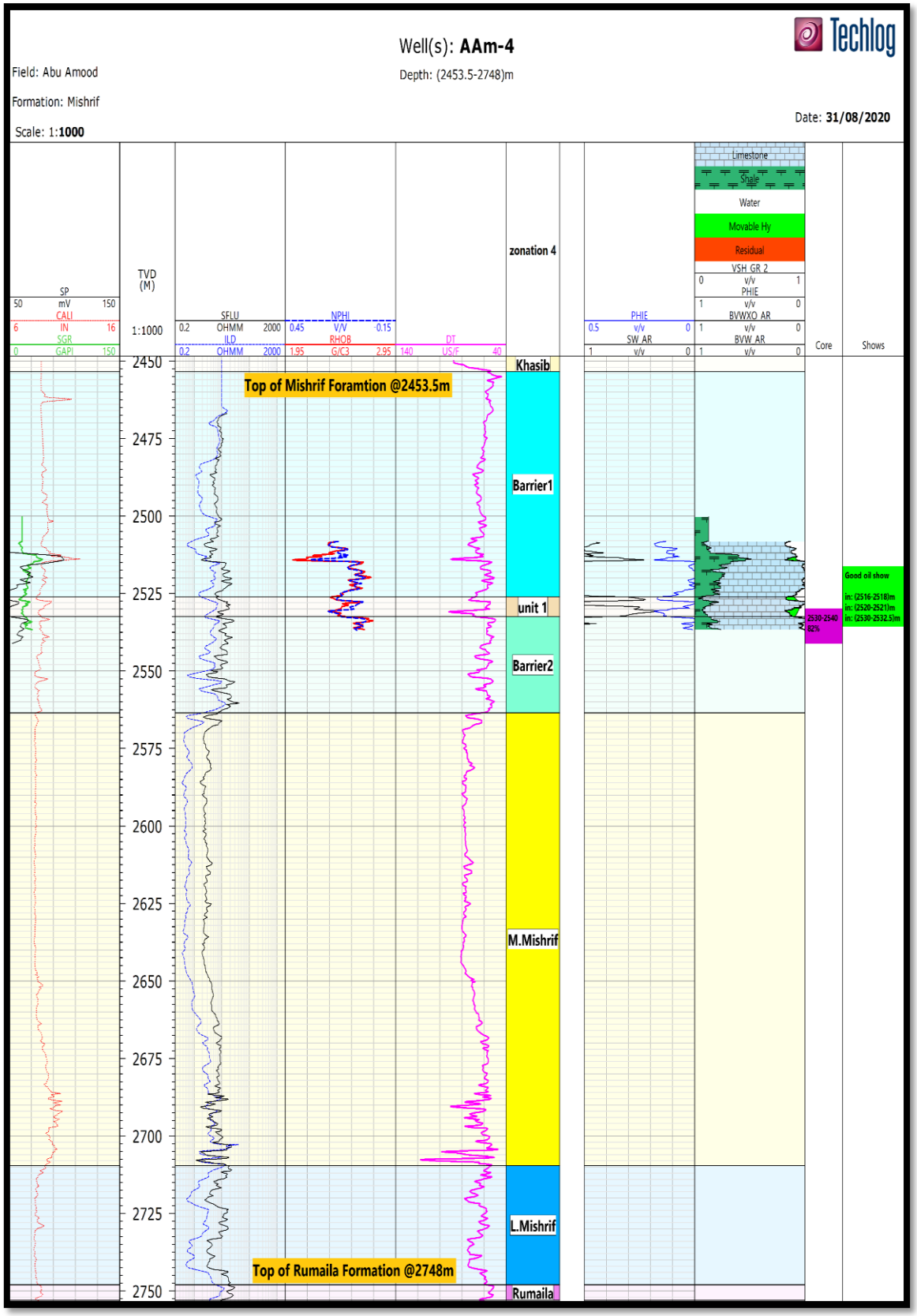

Figure 6-Lithological section, logs, and reservoir characteristics of the Mishrif formation in AAm-4 (using Techlog software)

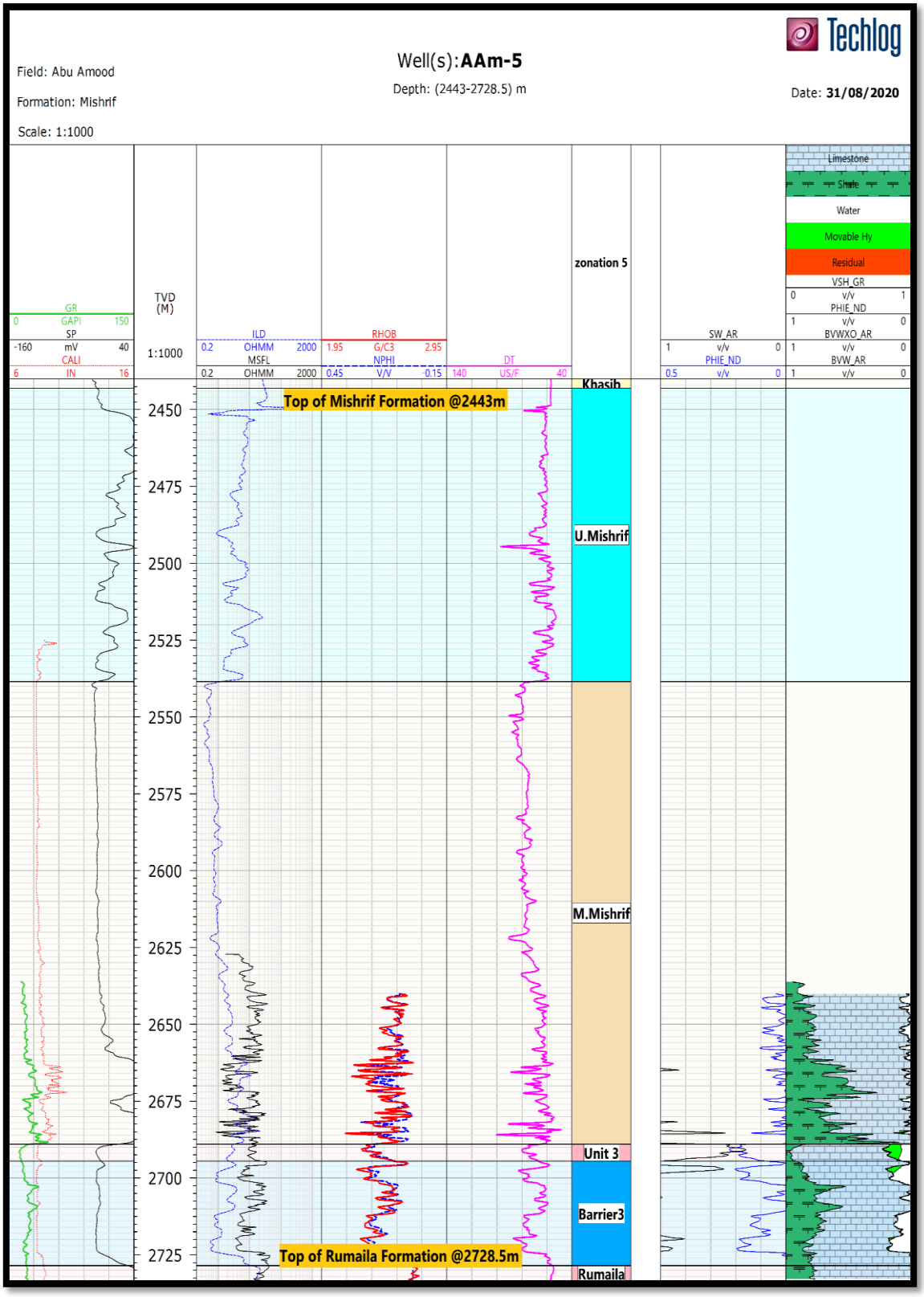

Figure7-Lithological section, logs, and reservoir characteristics of the Mishrif formation in AAm-5 (using Techlog software)

Conclusions

The results of CPI analysis indicate Mishrif Formation in Abu Amood oil field as a reservoir that consists of limestone with some thin beds of shale. Mishrif Formation in Abu Amood oil

field is divided into three reservoir units (Unit 1, Unit 2, and Unit 3), which are separated by three barriers. Reservoir Unit 1 is an oil-bearing unit in wells AAm-2 and AAm-4, while reservoir Unit 2 is oil-bearing only in AAm-1. The main reservoir unit is Unit 3 which is oil-bearing in wells AAm-2 and AAm-5.

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