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A method for determining fluids contact and identifying types of reservoir fluids in the F3-sandstone reservoir, field case study in Libya

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ABSTRACT

This research study focuses on the use of tools for well X05-NC169a in (X field) in Libya. Tools such as reservoir saturation tool and repeat formation tool used in this study. F3-Sand Stone is the main reservoir and has a gross thickness ranging from 130 to 187 feet. The aim of this study is to identify the type of fluid and to determine fluid contacts in the F3 - Sand Stone Reservoir. The study was based on a petro-physical evaluation on the well X05-NC169a by using log data (Gamma Ray Log, Resistivity Log, Neutron Log and Density Log). The Techlog software was used to analyze the log data, while the Surfer software was used for mapping. The results indicate that it has a hydrocarbon and water column. Apart from combining the petro-physical results of well tests (RFT data and RST) is to define the reservoir fluids type. The fluid contacts changed when the hydrocarbon fluid level decreased. The most dominant Hydrocarbon in the reservoir, according to RFT, RST, and Petro-physics data, is predominantly two phases. Zones of gas and oil.

طريقة لتحديد مستوى تماس السوائل وتحديد نوع السوائل في مكمن الحجر الرملي ,دراسة حقلية في ليبيا

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الكلمات المفتاحية:
أنواع السوائل
برنامج Technolg
سجلات الابار
تماس السوائل
RST
RFT

الملخص

هده الدراسة تركز على استخدام معدات في البئر، مثل معدة تشبع الخزان (RST)، ومعدة التشكيل المتكرر (RFT) المستخدمة في هده الدراسة. مكمن الحجر الرمي F3، وهو الخزان المنتج الرئيسي الذي يتراوح سمكه الإجمالي من 130 قدم إلى 187 قدم. تهدف هده الدراسة إلى تحديد نوع السوائل في المكمن وتحديد نقاط التماس اعتمادا على التقييم البترو فيزيائي للبئر النفطي X05-NC169a باستخدام بيانات سجل الآبار (سجل شعاع قاما، سجل المقاومة، سجل النيوترون وسجل الكثافة)، حيث تم استخدام برنامج Techog لتحليل بيانات السجل ، بينما تم استخدام برنامج Surfer لرسم الخرائط. تشير نتائج تقييم البيانات البتر وفيزيائية ذات الصلة بالمكمن الخاضع للدراسة إلى وجود عمود هيدروكربوني وعمود مائي. بصرف النظر عن الجمع بين النتائج البتر وفيزيائية واختبارات الآبار) بيانات RFT وبيانات RST (لتحديد نوع سوائل الخزان، فعند انخفاض مستوى السوائل الهيدروكربونية تتغير نقطة التماس بين السوائل. أكثر الهيدروكربونات المسيطرة في المكمن وفقا لبيانات RST , Petro-physics , (RFT) ، هي في الغالب منطقتان : منطقة النفط ومنطقة الغاز.

1. Introduction

The fluids in (X field) are a gas, oil and water. Production fluid perturb the fluid contacts in the F3-sandstone reservoir. The problem of logging *not* being perfectly described exactly the fluid contacts. The field after a time of development, t*he pressure gradually begins* to *decrease* and water begins to appear during production due to the change in fluid contacts. The crossover plots between density and neutron logs cannot give an indication about the type of hydrocarbon, unclear, so that cannot detect new contacts. RFT tool requires detecting new contacts in open-hole wells, and RST tool is for wells that have cased hole [1].

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The main goals of this research are to define reservoir fluid types in main reservoir F3-sand, which represent the primary target in (X field) and to detect the fluid contacts (Gas Water Contact - Oil Water Contact - Gas Oil Contact). The results of Repeat Formation Test and Reservoir Saturation Test are to enhance and improve production in this well and enabled defining the reservoir fluid [2].

The most difficulty in log interpretation of old gas fields lies in the limited data onto old logging series, the well logging quality is not high, lacks of enough well. Sometimes, logging tools cannot record correct readings. If there is no proper contact between the logging tool and the wall of the bottom-hole, logging tools may be unable to record accurate readings. In this case, the data become unreliable [3].

Density measurements are exaggerated due to inadequate contact between the tool and the borehole wall. For high-quality data, tight contact between the tool and the borehole wall is essential. The condition of the borehole walls has the greatest impact on the

logging data quality. If the diameter of the borehole varies over short time intervals due to washouts during drilling, clay swelling, or ledges generated by layers of tougher material [4].

Good contact between the tool and borehole wall is essential for high-quality data. Poor contact results of underestimation of density value. The principal influence on logging data quality is the condition of the borehole wall. If the borehole diameter is variable over short intervals, resulting from washouts during drilling, clay swelling, or ledges caused by layers of harder material, the logs from those tools that require good contact with the borehole wall (i.e. density, and porosity tools) no doubt degraded. Deep investigation measurements such as resistivity and sonic velocity, which do not require contact with the borehole wall, are less sensitive to borehole conditions. Very narrow ("bridged") sections will also cause irregular logging results. The most difficulty on log interpretation of old gas fields lies in the limited data onto the old logging series, well logging quality is not high, lacks of enough well logging information [3, 5].

In 2013 SanazJavid analyzed petro-physical log data from the Skalle well in the Hammerfest Basin, in the

Barents Sea's southwestern region. The aim at their research was to interpret lithology and diagnosis and

their effects on reservoir quality, as well as to compare the reservoir properties of different reservoir units. In the absence of core content, petro-physical log data have been calibrated for reservoir definition [6].

The study by B Tokhmechi et.al, in 2014, estimated well logs of more than 100 wells of Iranian south and southwest oil fields. The results showed the estimated well logs have more variability, which confirms a fundamental deficiency in current well log processing methods [7].

RFT has been first used in the early 1980's , the Early tools suffered poor resolution and accuracy of pressure. The Schlumberger RFT is an open hole wire-line device, showing a continuous recording of the pressure that leads to constructing the pressure gradient; these gradients give information about the fluid density and then the natural of fluids (gas, oil, and water). Also, the depths of contacts between water and hydrocarbon products can be located by the abrupt change in the pressure gradients. The results show pressure profile clearly indicated two distinct areas. The first gradient represents the gas gradient with a density of 0.18 g/cc and the second is the oil gradient with a density of 0.7g/cc. The gas oil contact at a depth 6750 ft, while the other gradients represent the oil gradient with a density of 0.74 g/cc and the second is the water gradient with a density of 1g/cc. The oil water contact is at a depth 7500 ft [8].

The reservoir saturation tool (RST) is a combination of a modern carbon oxygen log and a standard pulsed neutron log. The dual-detector spectrometry system of the through-tubing reservoir saturation tool enables the recording of carbon and oxygen and dual burst thermal decay time measurements during the same trip in the well. The carbon/oxygen (C/O) ratio is used to determine the formation oil saturation independent of the formation water salinity. This calculation is particularly helpful if the water salinity is low or unknown. If the salinity of the formation water is high, the dual burst thermal decay time measurement is used. A combination of both measurements can be used to detect and quantify the presence of injection water of a different salinity from that of the connate water [9].

The methodology

The Stages of the study

- Stage I: Collection Data and input it
- Stage II: Petro-Physical Analysis
- Stage III: Results

The methods and formulas used in the petro-physical results are given in these steps as follows:

Stage I: Data collection and loading:

The first step is to investigate the petro-physical characteristics of the reservoir obtaining a representation data primarily (based on well testing of the understudied well) or secondarily from data in previous studies from an oil company. whether primary or secondary, the data must contain well log data or data from well tests . For this study, the well log was utilized to investigate the petro-physics of the case study. The data that used in this study provided by a Company. The reservoir was categorized into units, a well (X05-NC169a) was used. After that, quality checks (QC) where observed before the data were sorted and loaded into the interpretative software. For this study, the interpretatives software used are;

- Tech-Log Software for petro-physical analysis.

The data including well log data as geological, and Petro-physical data, also some published papers have been used.

The following tables content the data sets used in this study :

Table. 1: Well data sets of Electrical logs used to calculate the physical properties.

Well name	Electrical Log
X05-NC169a	Gamma Ray, Neutron, Density, Resistivity, RFT Data, RST

Stage II: Petro-Physical Analysis

The Petro-physical analysis has done by using Techlog 2015 software for a well X05-NC169a located within (X Field), the electrical logs used to determine the Petro-physical properties such as water saturation, net pay, volume of shale, permeability and porosity, which leads us to understand more about the reservoir quality within the study area.

Table. 2: Well data sets of reservoirs used in the study.

Well name	A	m	n	Rw
X05-NC169a	1	2	2	0.02

Stage III: Results

The final stage Integrate the results of Petro-physical analysis with RFT data result for defining the reservoir fluid type and contacts (Gas Water Contact/Oil Water Contact/Gas Oil Contact) before using the new tool called, Reservoir saturation test (RST).

The methods and formulas used in the petro-physical results are given in these steps as follows:

Step 1. Selection of Zone Interest

The primary objective of well logging is to identify 'zones of interest' from hydrocarbon accumulation by integrating log responses from different geophysical tools. Although, this is not always true and some exceptions can occur but in general the characteristic log responses that will indicate the possibility of the presence of Hydrocarbon (Oil or Gas or both) are;

1. High Resistivity value.
2. Low Gamma ray value.

3. Negative deflection of SP log.

4. Mud cake formation.
5. Low formation bulk density.

Step 2. Calculation of Shale Volume (Vsh)

In our calculations to estimate the volume of shale in F3 sand depends on Gamma Ray log by using Techlog software2015. The gamma ray index (**IGR**) is defined as a relationship between (**GR_{min}**) and (**GR_{max}**), and the formula can be written as:

Shale volume presented in the zone of interest or in the reservoir can be determined by GR log. Vsh from GR log can be calculated using the relation:

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

Where:

- IGR= gamma ray index
- GRlog= gamma ray reading of formation
- GRmin= minimum gamma ray (clean sand or carbonate)
- GRmax= maximum gamma ray (shale)

Gamma Ray Index (IGR) and Vsh are related, but the relationship becomes non-linear for both structured clays and dispersed clays. Wide varieties of non-linear relationships exit from IGR and Vsh. But none is universally accepted. Three common types of this non-linear relationship are illustrated with.

Linear Vsh = IGR
Clavier (1971) proposed an equation for calculating shale volume with a more complex expression compared to other authors, and it looks like this way:

$$V_{sh} = 1.7 - [3.38 - (I_{GR} + 0.7)^2]^{\frac{1}{2}}$$

Where:
- IGR= gamma ray index
- Vsh= shale volume

Steiber (1970) also proposed an equation for shale volume calculation, and it is the following:

$$V_{sh} = \frac{I_{GR}}{3 - 2I_{GR}}$$

Where:

- IGR= gamma ray index
- Vsh= shale volume

Clavier (1971) proposed an equation for calculating shale volume with a more complex expression compared to other authors, and it looks like this way:

$$V_{sh} = 1.7 - [3.38 - (I_{GR} + 0.7)^2]^{\frac{1}{2}}$$

Where:
- IGR= gamma ray index
- Vsh= shale volume

The above equation distinguishes the clean sand from the shaly sand

by fabricating a baseline. From this baseline, any gamma ray reading that exceeds it is shale formation of high Level of radioactivity. The average volume of shale in the study area is summarized in Table 3.0

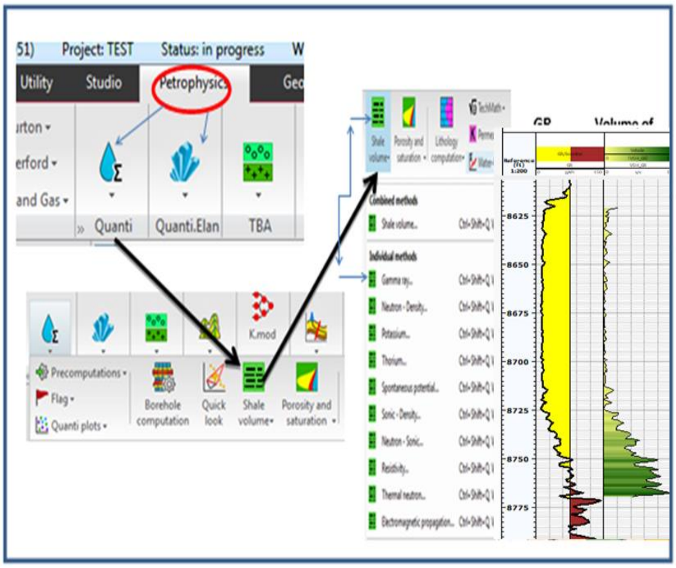


Fig. 1: Flow chart of calculating volume of shale using Techlog software

Table. 3: The average volume of shale in the F3-sand Reservoir in the studied well

Well name	Shale volume(%)
X5-NC169a	5.3

Step 3. Determination of Porosity

The porosity of the formation can be obtained from the bulk density if the mean density of the rock matrix and that of the fluids it contains are known. The bulk density ρb of a formation can be written as a linear contribution to the density of the rock matrix ρma and the fluid density ρf, with each present is proportions (1- ϕ) and ϕ respectively.

ρf

ρb= (1 − *Φ*) *ρma*+ *Φ*

$$\rho_b = (1-\phi)\,\rho_{ma} + \phi\,\rho_f$$

where:
ϕ = porosity of the rock
ρ_{ma} = the density of the rock matrix
ρ_b = bulk density recorded by the log
ρ_f = the density of the fluids occupying the porosity

Determination of Neutron Porosity and Density Porosity

Formation bulk density is a function of matrix density, porosity, and fluids contained in the pore space. Formation bulk density measured by the log must be corrected for borehole irregularities. Convert bulk density of porosity using charts in a log interpretation chart book, or calculate porosity from bulk density using this equation:

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

where,

ρ_b= bulk density of the formation
ρ_{ma} = density of matrix of the formation
ρ_f = density of formation fluid in the vicinity of borehole (mud filtrate)
▲ Effective porosity (Φe) is calculated by combining Neutron Porosity and Density porosity.
▲ Neutron Porosity can be read directly from log.
▲ Density porosity needs to be calculated from Density log using the formula as below:
Neutron porosity as read from the log and density porosity as calculated need to be corrected for the volume of shale presented in the formation.
1. Corrected Neutron porosity is given by ΦNC as follows.
$\Phi NC = \Phi N – V_{sh}\Phi Nsh$
2. Corrected density porosity is given by ΦDC as follows
ΦDC = ΦD – VshΦDsh
Where:
Φe = effective porosity.
ΦN = neutron porosity log (NPL),
ΦNsh = NPL of shale rock with the highest gamma ray log (GRL),
ρ = density log (DL), ρsh = DL of shale with the highest GRL,
ΦDe= porosity calculated using only DL values.
ΦNe = NPL without contribution from the shale fraction.
Vsh = shale fraction.
GRL_{max} is the highest value of GRL in all shale rocks drilled.
The porosity values achieved using the Techlog software are shown in Figure 2.

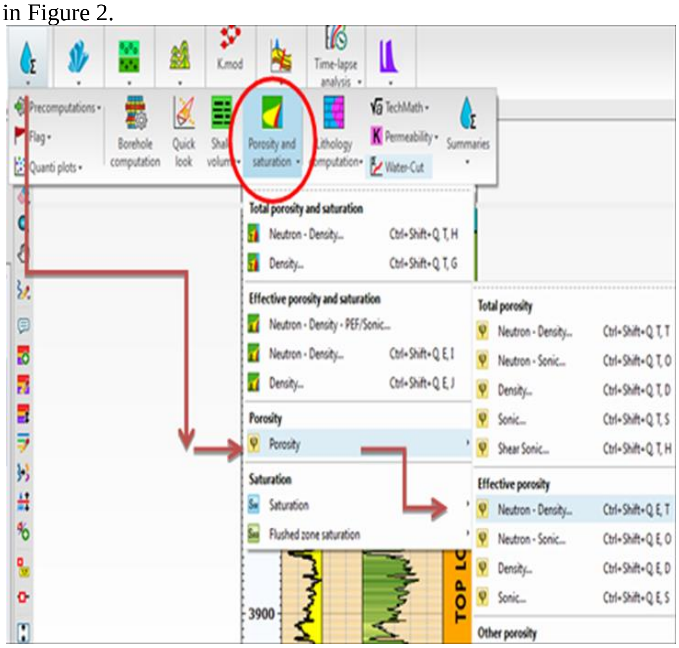


Fig. 2: Flow chart of calculating the average porosity by using Techlog software

Table. 4: shows the average porosity of reservoir in the studied wells

Well name	Average porosity(%)
X5-NC169a	10.8

Step 4.: Determination of Water Saturation (S)

for clean formation, it can be easy to determine water saturation using "**Archie's Equation**"

Archie's law assumes that *m* = 2 and *a* = 1.

Archie's equation for the invaded zone is

$$S_i^2 = \frac{F R_z}{R_i},$$

$$S_w = \frac{R_i / R_t}{R_z / R_w}.$$

Where: R_z is the resistivity of the water in the invaded zone. Because of incomplete flushing, R_z is a mixture of mud filtrate, R_{mf}, is a resistivity of *mud filtrate*, R_w is a water resistivity.

The **Humble formula** assumes that *m*=2.15 and *a* = 0.65.

Flushed zone method

$$S_w = \left(\frac{R_{xo} / R_t}{R_{mf} / R_w}\right)^{0.625}.$$

A particular relation proposed by G.E. Archie between the formation factor (F) and porosity (*phi*), in which F = 1 / *phi*^{m}, where:

Porosity exponent, *m*, is a constant for a particular formation or type of rock. In the original work, Archie proposed that *m* lay between 1.8 and 2.0 for consolidated sandstones, and close to 1.3 for loosely consolidated sandstones. *m* was named the cementation exponent shortly afterwards. This relation is also known as the Archie II equation.

In the preliminary stages of the development of the formation evaluation technique, Archie (1942) proposed a set of equations establishing the quantitative relationship between porosity (*f*), rock resistivity (Ro) and hydrocarbon saturation of reservoir rocks. Based on Archie's experimental work, it is shown that the resistivity of clean formation is inversely proportional to the resistivity of the brine saturating the rock. At this moment, Archie comes out with a set of promising equations to determine the water saturation present inside the formation (Archie 1942, 1952)

$$SW_{\text{Archie}} = \left(\frac{a}{\phi^m} \cdot \frac{Rw}{Rt}\right)^{(1/n)}$$

$$SW_{\text{Simandoux}} = \frac{a \,.\, Rw}{2 \,.\, \phi^m}\left[\sqrt{\left(\frac{Vsh}{Rsh}\right)^2 + \frac{4\,\phi^m}{a \,.\, Rw \,.\, Rt}} - \frac{Vsh}{Rsh}\right]$$

Where:

- a = Tortusity factor = 1
- m = Cementation factor = 2
- R_t = Formation resistivity (Ω.m).
- n = Saturation exponent = (2).
- R_w =Water Resistivity = (0.02 Ω.m).

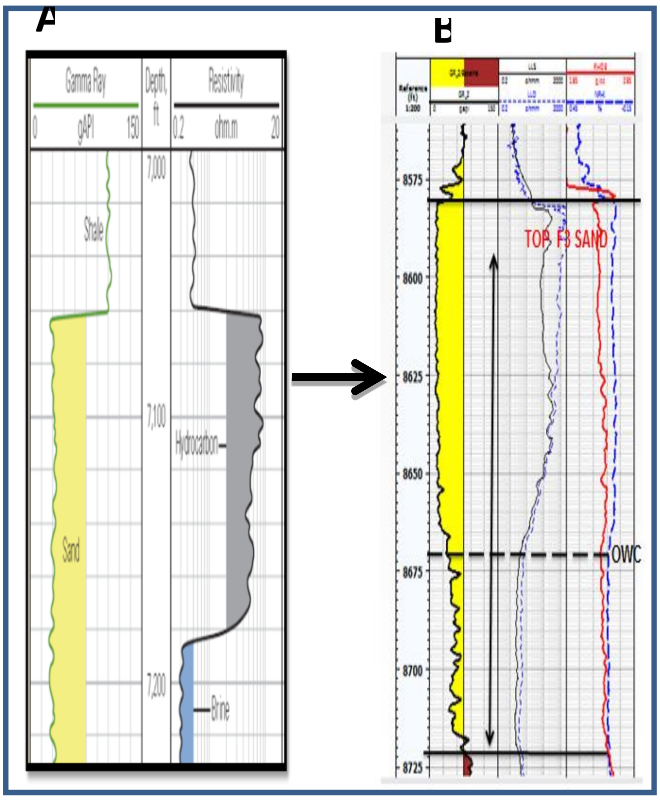
The water saturation is shown in Table 5. below shows the water saturation.

Table. 5: shows the average water saturation of the F3-sand Reservoir

Well name	Average Water Saturation (%)
X5-NC169a	14.4

Step 5. : Oil water contacts

To define the oil water contact can be using wire line logs in any producing well, which using resistivity log with neutron density crossed plot as shown in Fig 3. It shows high resistivity with clean formation which is indicated for hydrocarbon zone, but where the resistivity starts to decrease that means the water saturation increasing as seen in the Fig 3A and 3B.



contact between hydrocarbon zone and oil

Fig. 3A: shows the clear contact between hydrocarbon and water saturation and Fig. 3B: shows hydrocarbon zone and oil water contact (owc) in the study area

Fig 3.A and 3.B have shown the clean zone of sand within a clean reservoir section with high resistivity is indicated for the present of the hydrocarbons, but type of hydrocarbon cannot defined. Contact between water and hydrocarbon, a clear contact can be observed where the resistivity becomes low. We should know the hydrocarbon types in the study area.

Integrate Repeat Formation Tester With Petro-physics Result

To indefinite the type of hydrocarbon in the well X05-NC169a, we used the RFT data to discriminate the type of hydrocarbon, moreover, the contact between fluid in the reservoir. The Repeat Formation Tester (RFT) data and well logs used for interpreting the reservoir fluid type and contacts between fluids such as gas oil contact and oil water contact for F3-sandstone reservoir through the well X05-NC169a in X Field in Ghadames Basin - South of Libya . Defining fluid contacts (Oil Water Contact/Gas Oil Contact) is one of the major variables for estimating the initial hydrocarbons in place as well as in planning redevelopment strategies [10, 11].

Logging data:

Logging data through well X38-NC169a, which used in this study, such as caliper log, Later log shallow (LLS), Later log Deep (LLD), Gamma Ray (GR) log, Neutron log, Formation Density Log. Qualitative analysis of well log includes the determination of porous zones, sand and shale base line, water bearing formation, hydrocarbon zone, and oil water contact (OWC). Quantitative analysis obtains porosity, water and hydrocarbon saturation, shale volume, , and calculation of the formation temperature. Effective Porosity values obtained from density – neutron logs and corrected from shale volume (Vsh) and hydrocarbon fluids. Hydrocarbon saturation is estimated from water saturation which are calculated from true resistivity (Rt), shale volume (Vsh) corrected from porosity parameters. The result of petro-physics analysis for the well X38-NC169a shows the contact

between hydrocarbon and water at depth 8712 feet, this contact between hydrocarbon and water nevertheless what type of hydrocarbon is the main target of this study ,consequently we used RFT to discriminate between hydrocarbon type.

1-Pressure data: The raw data that shown in Table 2: Pressure data sheet from RFT test was obtained in main reservoir F3-sandstone in well X38-NC169a. Petro-physics analysis has shown in Figure 4.0 to recognize the type and contact of hydrocarbon.

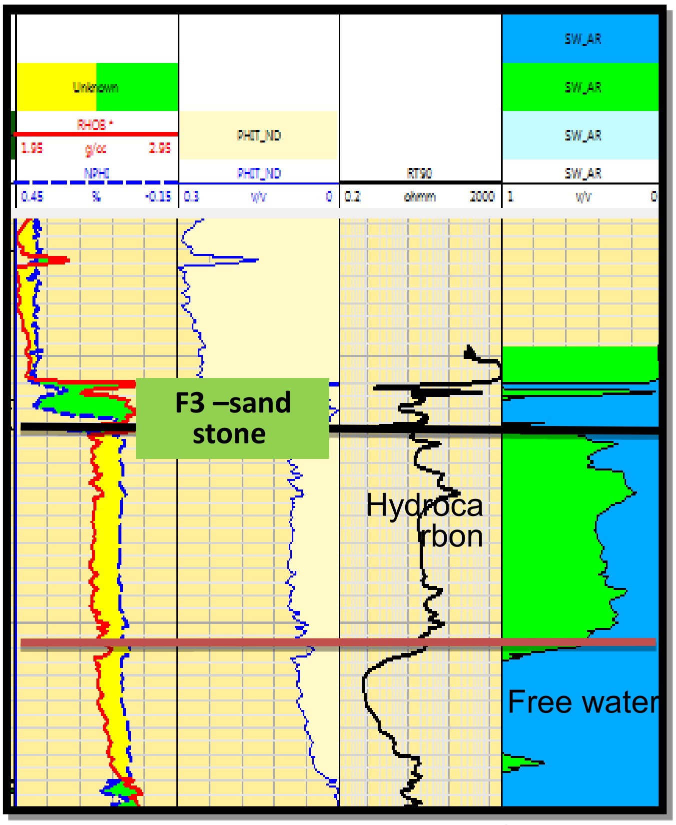


Fig. 4: shows the contact between hydrocarbon zone and free water zone in F3 reservoir by petro-physics analysis in Techlog software

Results And Discussion

This study focuses on selected well (X05-NC169a), which is located in the X field in Libya ,the data including well information, result physical properties of sand formation, following describe the petro-physical analysis for the well:

The Well X05-NC169a analysis:

The well was planned as an Open Hole Development well, producing from the F3 sandstone reservoir of the part of the X-North field area in the top of the *Aouinet Ouenine* Formation “B” F3 sandstone. The primary objective of the well, the reservoir was found at a kb depth of 8590 ft and bottom was found at 8730 feet , thickness of clean sandstone 140 feet ,total depth reached at depth 8852 feet [10, 12].

Main Results:

The Well X05-NC169a resulted in accomplishing the successful gas well in the X–North field area. Major hydrocarbons show existed variably throughout the Devonian section; the petro-physics result of this well were the porosity values cloud average (10.8%), the Net-Pay, it has a thickness of 104 feet, average water saturation is 14.4%, Hydrocarbon Water Contact from petro-physics result found at (8690 ft), shown in Fig 5. and Fig 6.

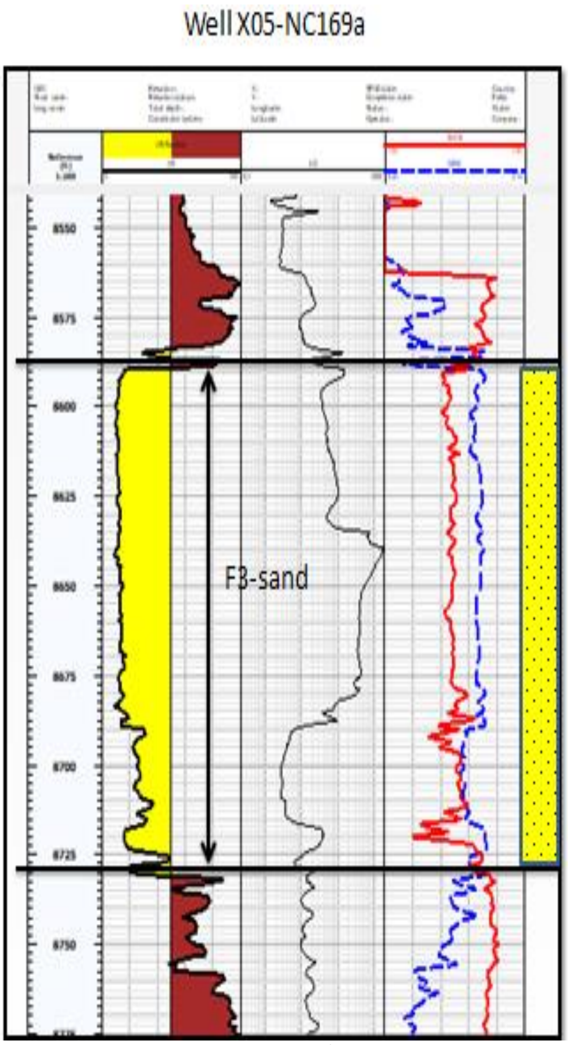


Fig. 5: shows well logging of well X05-NC169

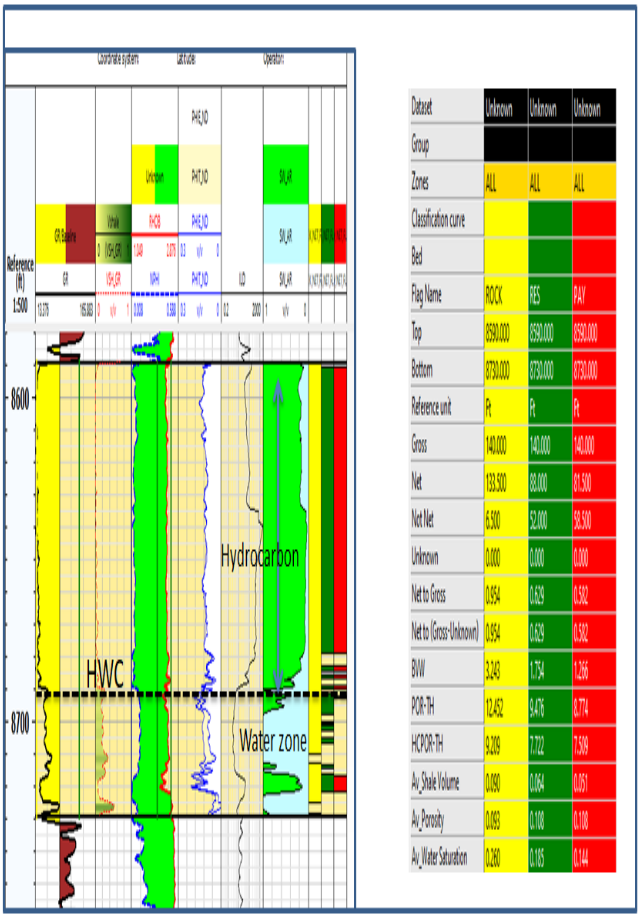


Fig. 6: shows Result of petro-physics of well X05-NC169a

The results of petro-physics analysis of the well present of gross thickness of hydrocarbon zone about 104 feet with 44 feet in water zone, to know the type of hydrocarbon, repeat Formation Test (RFT) were run to identity type of fluid. The Repeat Formation test was applied to the well, and selected 24 RFT (Repeat Formation Tester) pressure measurements have been taken across the Aouinet-Ouenine-F3, have shown in Table 6.

Table. 6: shows Repeat Formation Tester in well X05-NC169a

TEST NO.	FILE	Depth (TVD) ft	Mud Pressure		Last Read Build-Up. Pres.	Form. Pres.	Mobility MD/CP	
			I.H.P. psi	F.H.P. Psi	Psi	psi	psi	Remarks
3	61	8600.10	3892.52	3892.52	2977.15	2977.15	2.35	Normal pretest
4	62	8608.94	3896.68	3896.44	2977.81	2977.81	30.53	Normal pretest
5	63	8620.85	3901.69	3901.66	2978.49	2978.49	32.16	Normal pretest
7	65	8635.01	3907.99	3907.90	2979.14	2979.14	354.05	Normal pretest
8	66	8640.01	3910.22	3910.08	2979.83	2979.83	31.08	Normal pretest
9	67	8649.08	3914.27	3914.09	2980.47	2980.47	1.39	Normal pretest
11	69	8664.11	3920.92	3920.77	2981.82	2981.82	0.39	Normal pretest
12	70	8672.03	3924.26	3924.22	2983.21	2983.21	77.87	Normal pretest
13	71	8679.06	3927.52	3927.42	2984.96	2984.96	3.80	Normal pretest
15	73	8687.93	3931.42	3931.13	348.55		171.21	Dry Test.
16	74	8688.92	3931.60	3931.62			60.38	Lost Seal
17	75	8687.03	3930.86	3930.67	183.32		1.06	Dry Tes
18	76	8684.03	3929.38	3929.35	2985.97	2985.97	466.17	Normal pretest
19	77	8693.91	3933.75	3933.77	121.57		170.74	Dry Test.t.
20	78	8692.53	3932.94	3932.96			14.71	Lost Seal
21	79	8695.84	3934.48	3934.43				See Remarke
22	80	8700.10	3936.28	3936.21	80.35			Dry Test
23	81	8701.08	3936.77	3936.74	61.31			Dry Test
24	82	8705.14	3938.62	3938.59	91.35			Dry Test
25	83	8713.59	3942.38	3942.26	45.80			Dry Test
26	84	8698.04	3935.37	3935.28	42.77			Dry Test
27	85	8697.14	3934.86	3934.82	40.71			Dry Test
28	86	8659.99	3918.18	3918.23	2981.18	2981.18	30.39	Normal Pretest
29	87	8675.10	3924.97	3924.92	2983.67	2983.67	74.32	Normal Pretest

After running 24 points of RFT, pressure measurements have been taken across the Aouinet-Ouenine - F3 Sandstone from 8600.10 ft to 8675.10 ft. The 11 points were good test points and 13 points were unsuccessful test due to different reasons as dry test or lost test. After estimating a pressure gradient by using the equation below according to the difference in fluid densities. A difference in the pressure gradient occurs in the measurement. Obtain by inverse slope from plot formation pressure versus depth. The ranges which have been used are: The different measured formation pressure opposite the reservoir is plotted against the depth, and from this plot the flowing fluids (oil, gas or water) can be identified from their gradients. If this analyzed gradient gives the value of the density of water then, the continuous phase is water, while if the measured densities are that of oil or gas, the continuous phase will be oil or gas, Also, the depth of free water level can be estimated by studying the abrupt change in pressure on the pressure gradient. The relationship between fluid density and the pressure gradient can be expressed as follows:

1- Gas gradient range from (0.08-0.18) psi/ft.
2- Oil gradient range from (0.23-0.39) psi/ft.
3-Water gradient from (0.433-0.465) psi/ft.
4-Fresh water gradient = 0.433 psi/ft
5-Saline water gradient = 0.465 psi/ft

Pressure gradient can be calculated by used this equation

Gradient = (P2 - P1)/(MD2-MD1)

Where
p1= pressure bed number 1

p2 = pressure bed below number 2
MD1 = measured depth bed number 1

MD2 = measured depth bed number 2

The pressure vs. depth plot shows a gas gradient value of 0.071 psi/ft and oil gradient value of 0.243 psi/ft. The result was 81 feet of gas zone and 18 feet oil zone Fig 7. and Fig 8.

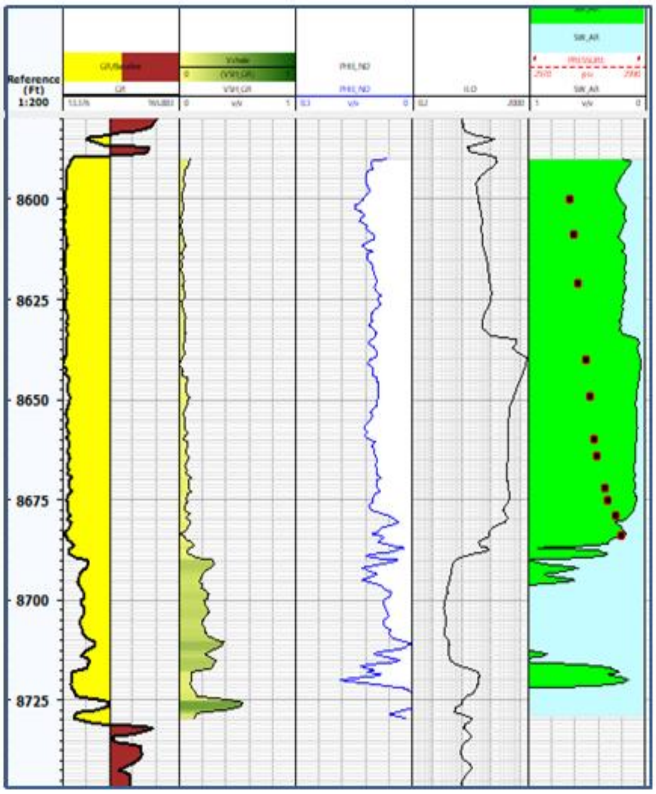


Fig. 7: shows Result of petro-physics of well X05-NC169a & RFT points

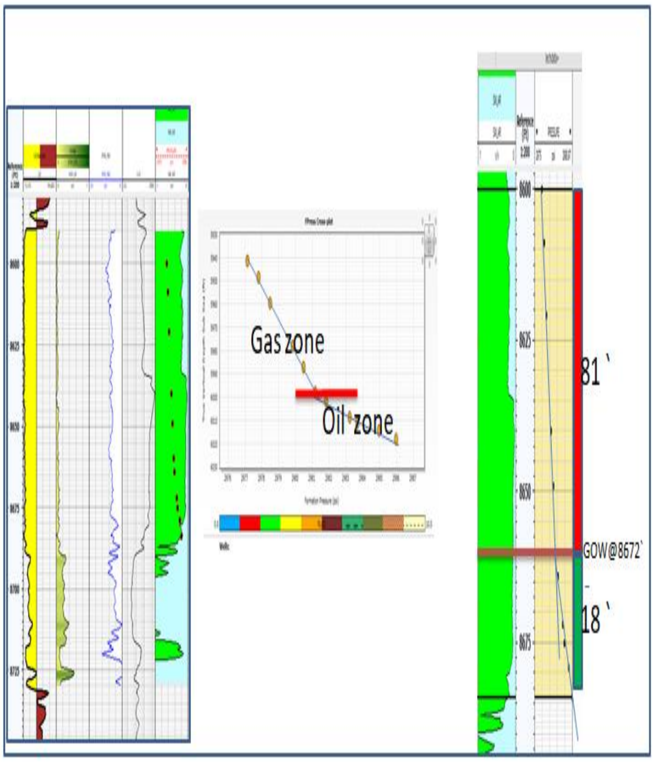


Fig. 8: shows Result of petro-physics and RFT of well X05-NC169a

The well was completed as casing well with tubing 4 ½" from the surface to 8471 ft. The total test sequence and results from the Middle Devonian F3 sandstone reservoir of well (X05-NC169a) are summarized in Table 7. below as follows:

Table. 7: shows the total test sequence and results of the Middle Devonian F3 sandstone reservoir in well (X05-NC169a)

CASING Perforation	8584 ft – 8655 ft
Flowing W.H.P	1794 psi
Chock Sizes	48
Gas Production	20.7 MMSCF /DAY
Oil	589 BBLS/DAY
Water %	8-10% (Recovered as condensate associate water)

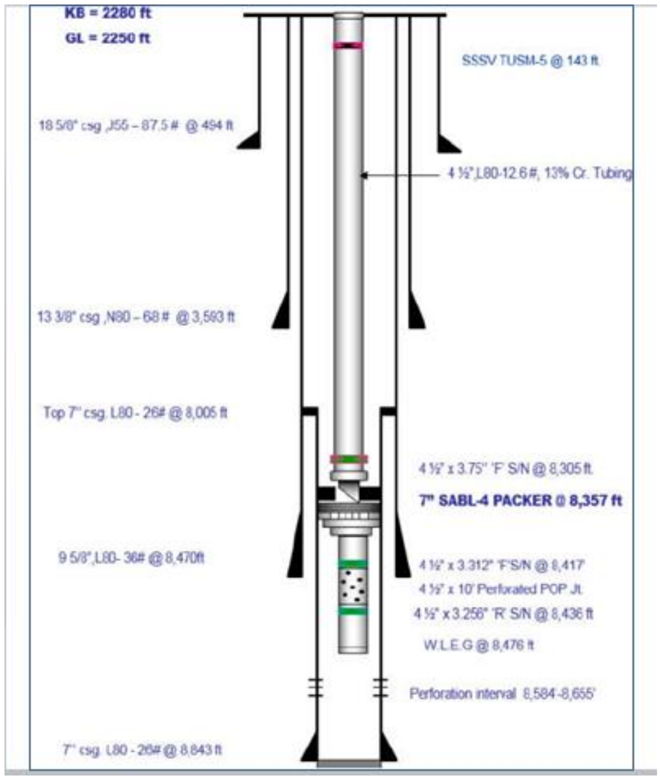


Fig. 9: shows casing design & perforation interval of well X05-NC169

Well History Production

The well was put on the production of 2005 for producing oil after perforation in oil zone with five feet in gas zone the oil rate increased more than 500 BOPD and well pressure 1700 psi after that the oil flow rate decreased up to 2013 reaches to 400 BOPD with 1016 psi and continuous dropping down in 2018 to 150 BOPD with 500 psi , then the well shut in 2018 due to low production.

In August 2019, Schlumberger RST-Sigma mode & PLT was logged in during 2019 the well in flowing conditions to evaluate the current saturation and evaluate the remaining hydrocarbon (Oil and Gas) in the CH section. a new Cased-Hole Reservoir Saturation tool was logged to re-evaluate hydrocarbon fluid contact change over the last 2 years ,the objective of this work is to be performed during well in flowing conditions on PNX-GSH mode to obtain: formation fluid contact change and gas detection also Bottom hole invasion effect

Data Available:

❖ Open-hole logs were provided by MOG-Gas. Data available were GR, Caliper, Shallow and Deep Resistivity , RHOZ, and NPHI Customer provided other well data including bit size, casing size, and weight , as required.

❖ OH Evaluation (ELAN Analysis of minerals and
❖ porosity) was done by Schlumberger to be used for RST processing [13].

PNX Data Repeatability Analysis & Results

- Observation & Interpretation Results

 Good GR overlays & depth match between "CH-RST-GR, vs PNX-CH-GR" with no sign of Scale build up due to deposited radioactive over the whole logging interval.

 Borehole fluid salinity (ASAL) showed very high saline water in the well borehole ranging from 320,000 -,340,000ppm below the perforated interval (8655ft -TD), also indicated The present of HC in the wellbore (8655ft and above).

 PNX Borehole Fluid measurement such as (Borehole salinity) (ASAL), with Sigma count rates near & Temperature log in FL conditions showed a clear sign of two hydrocarbon (Oil @ 8652ft & Gas @ 8642 ft) fluid entry.

 Currant G.O.C was detected @ 8642ft, Fig 10.

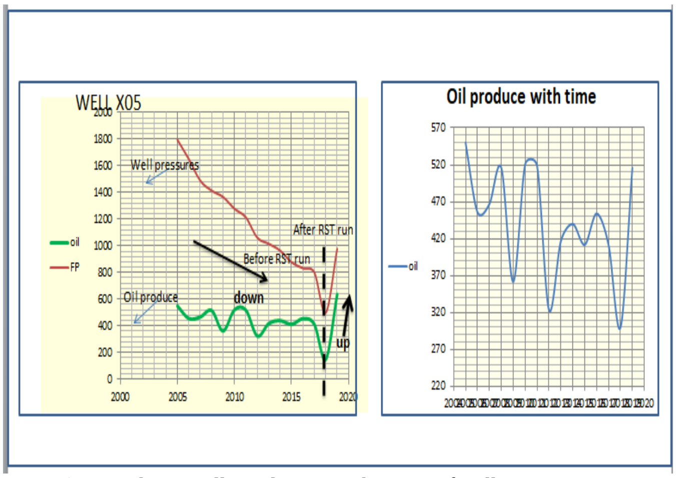


Fig. 10: Shows well production with time of well x05-NC169

The results of RST indicate the contact is move up 39 feet and all perforation points currently in oil zone, the well back produce oil after extended perforation based on new contacts (GOW @8642 in 2019) it was contact at depth 8649, in 2016 and the original Gas oil contact at depth 8672 feet.

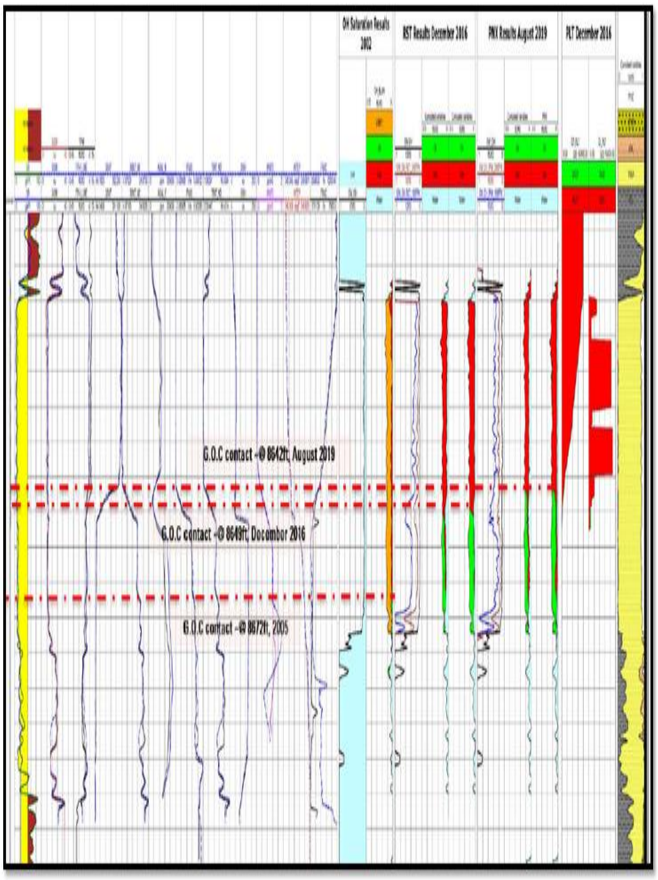


Fig. 11: shows well RST result with time of well X05-NC169a

Conclusion

Well test as Repeat Formation Tester (RFT) and reservoir saturation test (RST) data are an important tool for production and reservoir engineering. Well test can be interpreted to enhance and increase the production well that can be applied for a better understanding of petroleum reservoirs. The application is applied for F3 sandstone of well X05-NC169a in X Field in Ghadames Basin South of Libya.

The application discussed is based on the analysis of the Petro-physics data onto the subjected reservoir, the results identify the reservoir contains a column of hydrocarbons and water.

Evaluating the gradient of this profile provides information about the type of fluid and the contact between them by monitoring the abrupt changes in the pressure gradients.

The pressure profiles of F3- sandstone reservoir of well X05-NC169a were constructed. Through the pressure profile, most of the dominant fluids are the gas, oil and water, the contacted gas with oil were distinguished the oil can be extracted from the studied well.

The most dominant hydrocarbons in the reservoir, according to RFT, RST, and Petro-physics data, is predominantly two phases. Zones of gas and oil. Sometimes, logging tools cannot record correct readings . If there is no proper contact between the logging tool

and the wall of the bottom-hole, logging tools may be unable to record accurate readings. In this case, the data become unreliable.

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