Using Reservoir Saturation Test (RST) With Repeat Formation Test(RFT) For Improve Well Production In Wafa Field Case Study Ghadames Basin West, Libya

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Abstract: This study is focused on the using the new tools in reservoir-Petroleum section, Reservoir saturation test (RST) with result of Repeat Formation test (RFT) in production well for enhancement and increasing well production in the F3-sandstone member of the Aouinet – Ouenine Formation of Middle Devonian, which represents the main reservoir producing in the Wafa field with gross thickness ranges from 130 to187feet, with identifies the Hydrocarbon zone. The gathered data that were utilized in performing this study are the Petrophysical analysis of five wells using well log data such as (Gamma Ray Log, Resistivity Log, Neutron Log and Density Log). The applications that were used are Techlog software for analyzing the log data, whereas the Surfer software for mapping. From analyzing the Petrophysics data of the subjected reservoir, the results identify the reservoir contain column of hydrocarbon and water. Besides by integrating the results of Petrophysics with well test (RFT data and RST) for defining the reservoir fluid type and the hydrocarbon will be decrease due to the change of fluid contacts, gas oil contact and oil water contact change, is go- up. the contacts. Moreover, the pressure profiles of F3-sandstone reservoir in subjected wells (X5, X10, X37, X 38 and X39NC196) were constructed. Through the RFT data, RST data and Petrophysics data, most dominated hydrocarbon in the reservoir are mainly two phases Gas and oil zones.

Keywords: Repeat formation test, Reservoir saturation test, Petrophysical analysis

1. Introduction

Wafa Field belongs to Mellitah gas Company, it's located along the Libyan-Algerian border in the south-western part of the Libyan side of the Ghadames Basin, about 100 Km to the south of the city of Ghadames. The first discovery well, D1-52, was in 1964 by shell Libya, the field produce both oil and gas from main Reservoir F3-Sandstone only and the average daily production is 10,290 BOPD. Of crude oil and condensate, 7,600 BB.and Gas, 601MMScf per Day.

Field problem

Wafa Field produce the hydrocarbon since 2004, Some wells in Wafa field contains three phases of fluid: Gas –oil and water phase, during time of producing with normal production and pressure, but due time the well will be decrease production and die due to the contacts of fluid change, gas oil contact and oil water contact change, and pressure of the well decrease).

The main objective of study is to defining the reservoir fluid type in F3-sand which represent the main target in Wafa Field and to know the fluid contacts (Gas Water Contact/Oil Water Contact/Gas Oil Contact) and the major target of this study by integrate Petro physics evaluation of main reservoir F3-sandstone. Results with Repeat Formation Test and Reservoir saturation test (RFT &RST).

Materials and Methods

The method used in this study were applied Petrophysical analysis for five selected wells content electrical logs, include Gamma-ray, Neutron, Resistivity, and density logs, by using new software as Techlog 2015 for Petrophysics analysis in order to determine the quantity of the reservoir properties for such as Porosity, Permeability, water saturation and net pay, and combined them with the Repeat Formation Tester (RFT&RST) data wells were used in this study.

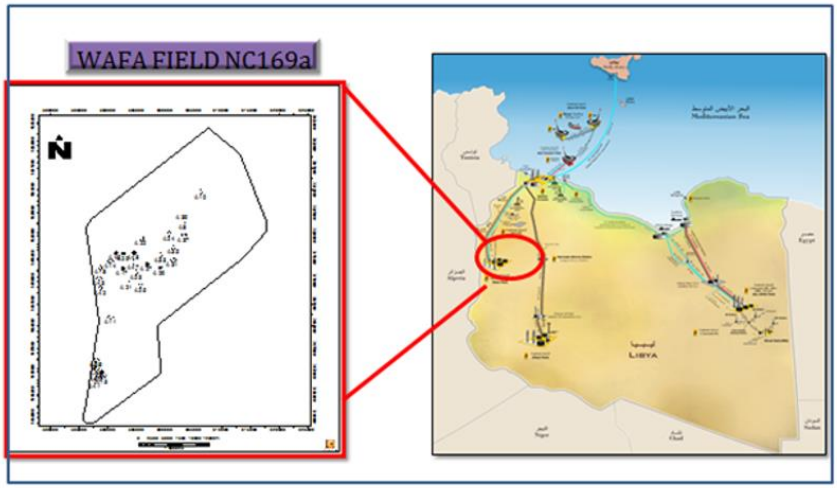


Fig (1) Location map of Wafa Field in Ghadames Basin

2. STRATIGRAPHY

The Paleozoic section is composed of a sequence of alternating sandstones and mudstones with occasional Interbedded carbonate beds Figure (2). The Aouinet-Ouenine deposited on the peneplained surface. Transgression onto the eroded surface was gradual in some areas. Sandstone is described as quartzose, clear, transparent, off white, light brown to grey, medium hard to friable, medium fine to coarse grained, sub-angular to sub-rounded, and moderately sorted with silica cement. The Aouinet-Ouenine has been sub divided into A, B, C, the Aouinet-Ouenine B has been divided to B shale and B F3 Sand which represent the main reservoir (Sakmo, 2012).

2.1 Aouinet-Ouenine B' F3 sandstone Member

Sandstones (Quartzose), clear, colorless, light brown to light gray, hard to moderately hard, medium to fine grained, sub-rounded to sub-angular, poor to moderately sorted, siliceous cement, poor to fair intergranular porosity, with traces of oil shows. Shale, gray to light gray, soft, to poorly indurated sub-flacky, non-calcareous silty. This formation has a thickness range from 134 to 184 feet.

2.2 Aouinet Ouenine B' Shale: Shale, dark gray to dark brownish gray, soft to moderately firm sub-fissile to sub-blocky, micaceous, pyretic in part Sandstone, light brown to light yellow to off-white, soft, quartzose, moderately hard to hard, fine to very fine grained, sub-angular to sub-rounded, moderately sorted, with minor silica and calcareous cement, no visible porosity, no shows Limestone, (traces), off-white, light gray moderately hard, cryptocrystalline, and slightly calcareous. Siltstone, dark brown to brown, moderately firm to sub fissile, micaceous, argillaceous, pyritic, slightly calcareous, becoming dolomitic and micaceous in part. This member has a thickness range from 245 to 247 feet.

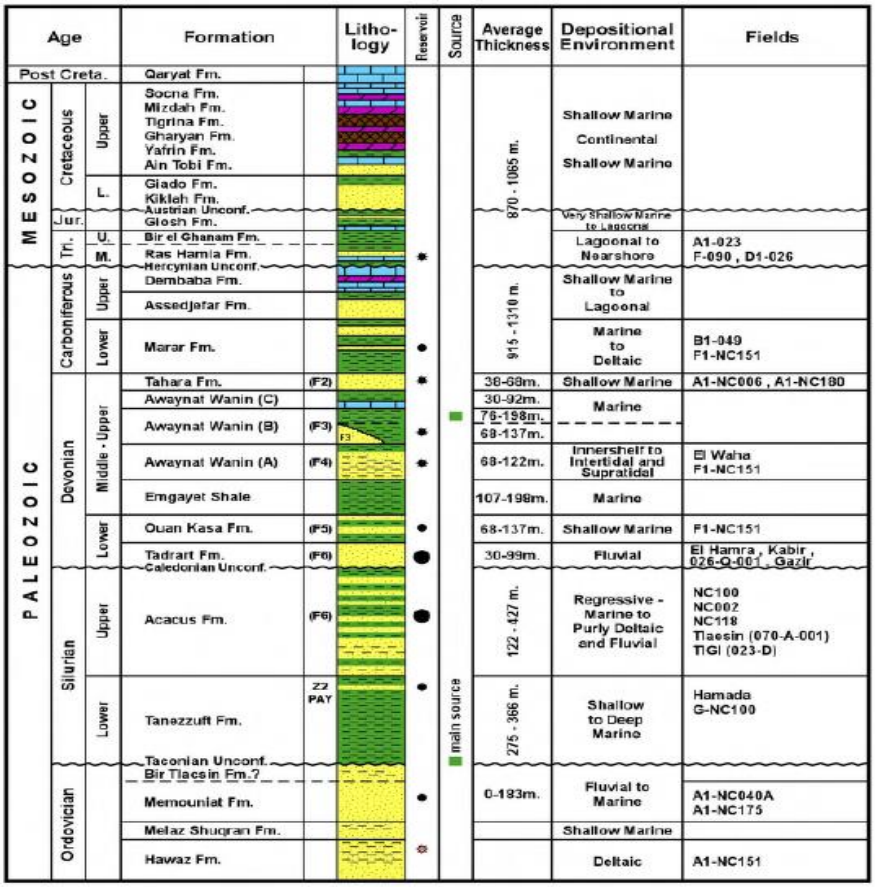


Fig (2) Stratigraphic column (Mellitah 2002)

3- Reservoir in study

The Aouinet Ouenine F3-sand is representing the main reservoir in Wafa Field middle to late Devonian age. The lithology for F3-sand is composed mainly of sandstone interfered with minor amount of Shale, reservoir thickness in study area ranges from 108 to 148 feet show on Fig (3).

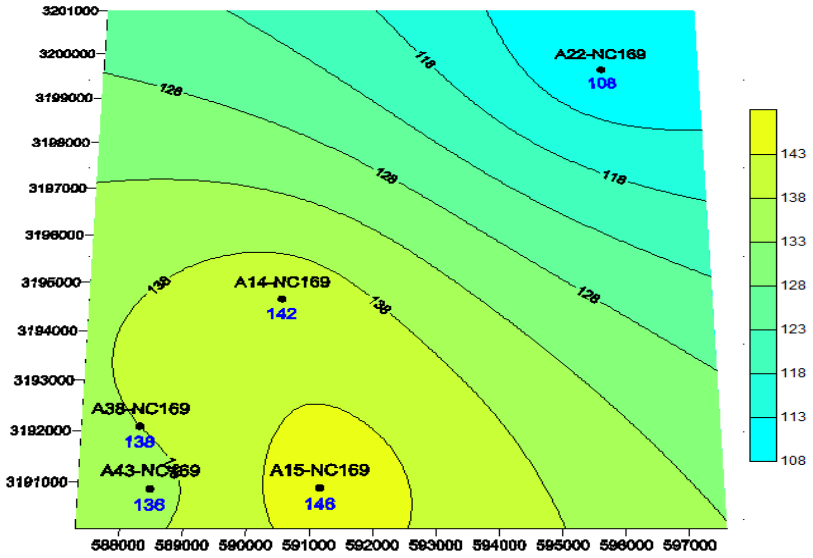


Fig (3) Thickness map of F3- sandstone

4.Petrophysical Study

Petrophysics mean the study of the rock properties; porosity, permeability and fluid distribution, etc. complete package of logs records including gamma Ray , neutron, density, sonic and induction Logs, have been recorded across the Reservoirs. and analysed in detail for porosity, volume of shale, water saturation, and net pay thickness and hydrocarbon pore volume .

4.1 Determination Volume of Shale:

To estimate volume of shale in the Aouinet-Ouenine F3 sand was depended on Gamma Ray log by using Techlog software The (VGR) is defined volume of shale as a relationship between (GRmin) and(GRmax)

V.sh= (GR log-GR clean) / (GR sh-GR clean)

Where: Vsh is volume of shale (API), GRlog is the Gamma ray reading, GRclean is the minimum Gamma ray reading, GRsh is the maximum Gamma ray reading.

4.2-Porosity determine

4.2.1 Density Porosity

The density porosity (ØD) was determined based on type of reservoir rock from Equation

$$\emptyset D = (\rho b\ ma - \rho b\ log)/ (\rho b\ max - \rho\ fl)$$

Where: ρb =bulk Density, gm/cc (log). ρfl =Fluid Density, (equal 1gm/cc). ρb ma =Matrix Density, equal 2.65 gm/cc (for Sandstone). ØD =Density Porosity.

The total porosity represents the mean of the combined neutron and density porosities readings for water and hydrocarbon zones. This porosity map in study area above show the range of porosity from 8.7% in the north east part around well A22-NC169a to the high values to up 11.3 % in the central part in well A14-NC169a then

decrease to 8.8 % in the southwest part in well C38-NC169 also in the south part in well A43-NC169a reached 10.9

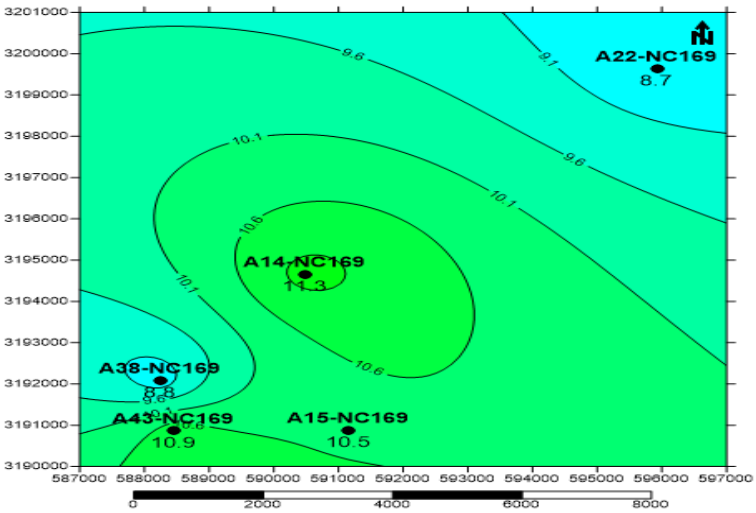
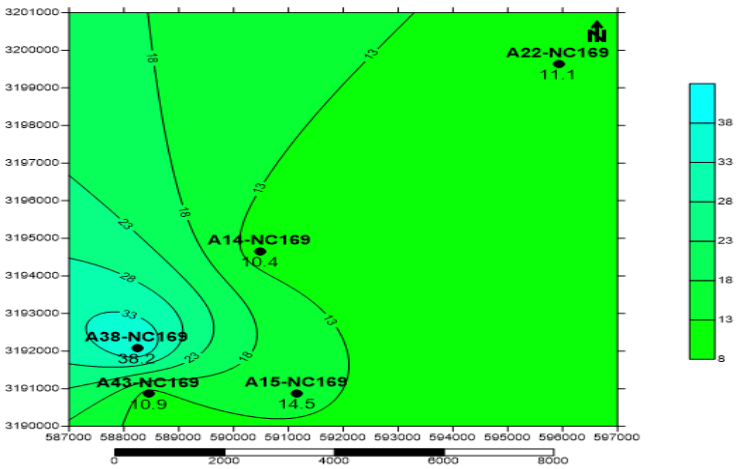


Fig (4) Average porosity map of F3-sand reservoir

4.4- Determination of water Saturation (Sw):

$$Sw= [(a\times RW)/ (Ø^{m}\times Rt)]^{1/n}$$

Where: a = Tortusity factor = (1). ØT = total porosity (ØtN-D)% m = Cementation factor = (2). Rt = Formation resistivity (Ω.m). n = Saturation exponent = (2). Rw =Water Resistivity = (0.02 Ω.m).



Fig(5) average water saturation map of F3-sand reservoir(surfer software)

The water saturation map was constructed to show the water saturation distribution in the reservoir.

5-Integrate Repeat Formation Tester With Petrophysics

Define the oil water contact can be use wire line logs in any produce well which using resistivity log with neutron density cross plot as in figure (6) show high resistivity with clean formation is indicated for hydrocarbon zone but where the resistivity start to decreasing that main the water increasing, To indefinite and recognize the type of hydrocarbon in well apple other tools as Repeat Formation Test(RFT) in open hole .the RFT data can also kbown the contact between fluid in reservoir

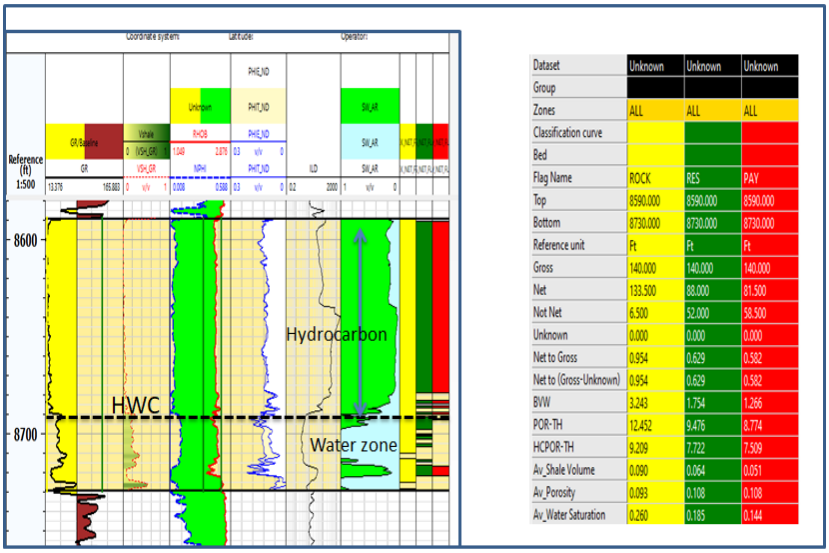
Fig (6) show the clear contact between hydrocarbon and water saturation

6-Results and Discussion

This study run for five selected wells (X05, X20, X37,x38 and X39), which are located in the Wafa Field NC 169a area the data including well information, result physical properties of Awaynat Ouenine sand formation), following describe the petrophysical analysis for each well

THE WELL X05-NC169ANALYSIS:

The well X05-NC169a drilled in the Southwestern corner of Wafa area NC169a, The well was planned as an Open Hole Development well, producing from the F3 sandstone reservoir in the part of the Wafa-North field area, the top of the Aouinet Ouenine “B” F3 sandstone (primary objective of the well) 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. The petrophysics result of this well was the porosity values cloud average (10.8%) the Net-Pay, it has a thickness of 104 feet, and average water saturation is 14.4%, Hydrocarbon Water Contact from petro-physics result found at (8690 ft)



Dataset	Unknown	Unknown	Unknown
Group			
Zones	ALL	ALL	ALL
Classification curve			
Bed			
Flag Name	ROCK	RES	PAY
Top	8590.000	8590.000	8590.000
Bottom	8730.000	8730.000	8730.000
Reference unit	Ft	Ft	Ft
Gross	140.000	140.000	140.000
Net	133.500	88.000	81.500
Not Net	6.500	52.000	58.500
Unknown	0.000	0.000	0.000
Net to Gross	0.954	0.629	0.582
Net to (Gross-Unknown)	0.954	0.629	0.582
BVW	3.243	1.754	1.266
POR-TH	12.452	9.476	8.774
HCPOR-TH	9.209	7.722	7.509
Av_Shale Volume	0.090	0.064	0.051
Av_Porosity	0.093	0.108	0.108
Av_Water Saturation	0.260	0.185	0.144

Fig (7) Result of petrophysics of well X05-NC169

The result of petrophysics analysis of the well show present of gross thickness of hydrocarbon zone about 104 feet with 44 feet in water zone , to know what kind of hydrocarbon was run repeat Formation Test (RFT) for identity type of fluid and hydrocarbon type . The Repeat Formation test was applied to the well. And selected a total of 24 RFT (Repeat Formation Tester) pressure measurements have been taken across the Aouinet Ouenine- F3 sandstone reservoir.

6.1 -Pressure gradient Estimation:

According to the difference in fluid densities, a difference in the pressure gradient occurs during the measurement. Obtained by inversely 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 nature of the flowing fluids (oil, gas or water) can be identified from their gradients. If this analyzed gradient give the value of 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 follow:

1- Gas gradient range from (0.08-0.18) psi/ft.
2- Oil gradient range from (0.28-0.39) 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) / (MD1- MD2)

Where p1= pressure bed number 1, p2 = pressure bed below number 2, Md1 = depth bed number1 Md2 = depth number2 Figures below represents the formation pressure against the depth, for F3-sandsrone reservoir well (RR1). The pressure pro-

file clearly indicates two fluid . Figure (4.3) represent the petrophysics result of well RR1, thickness of F3-sand about 134 feet and hydrocarbon zone thickness about 109 feet.

Table 1 Repeat Formation TesterX05-NC169

TEST NO.	FILE	Depth (TVD) ft	Mud Pressure		Last Read Build-Up. Pres.	Form. Pres.	Mobility MD/CP	Remarks
			I.H.P. psi	F.H.P. Psi	Psi	psi	psi	
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

Schlumberger RST-Sigma mode & PLT was logged in August 2019 the well in flowing conditions in order 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 performed during well in flowing condition on PNX-GSH mode in order to obtain : formation fluid contact change and gas detection also Bottom hole invasion effectThe result of RST indicate the contact is move up 39 feet and all perforation points currently in oil zone ,the well back produce oil after extend perforation base 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 .

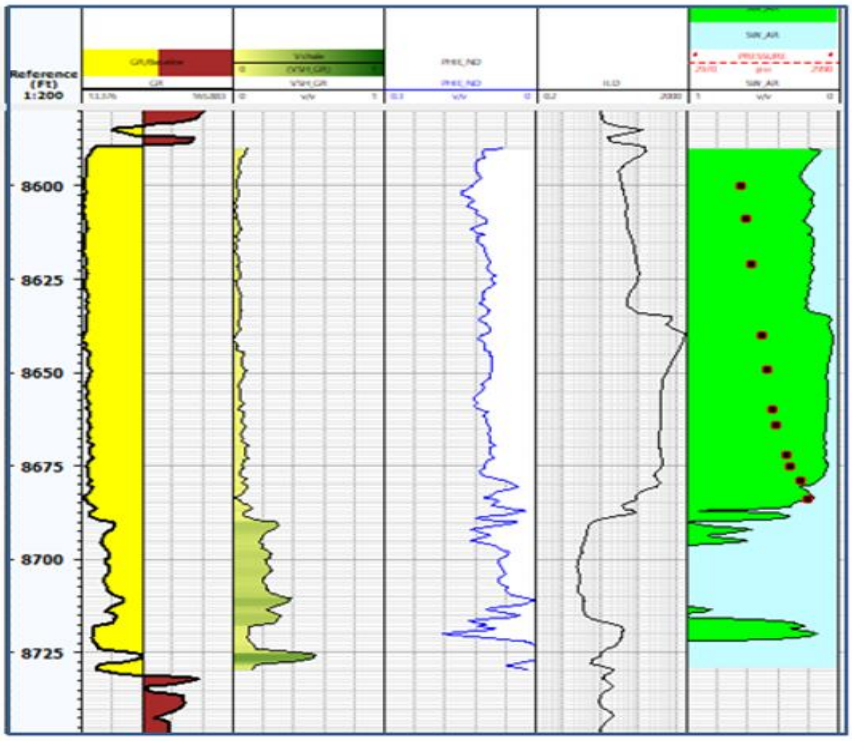


Fig (8) show Result of petrophysics and RFT of well X05-NC169

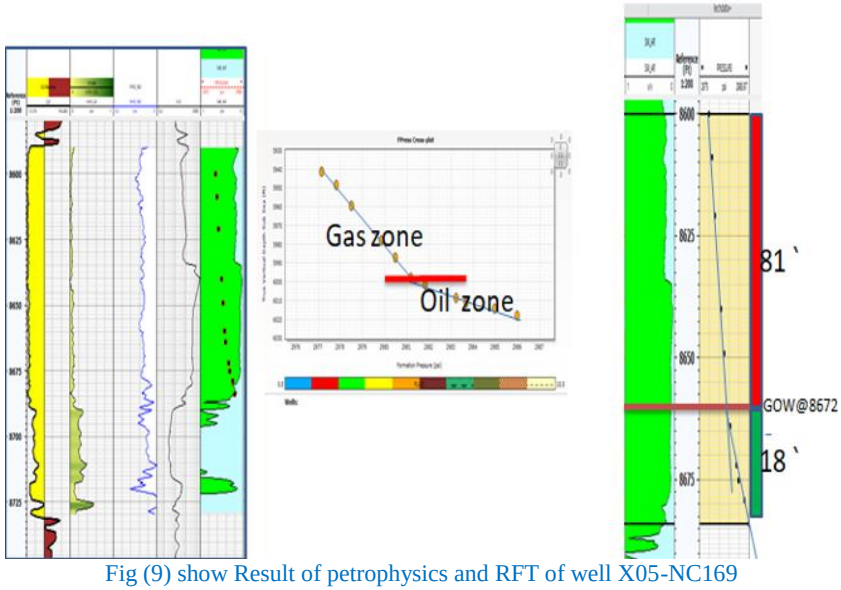


Fig (9) show Result of petrophysics and RFT of well X05-NC169

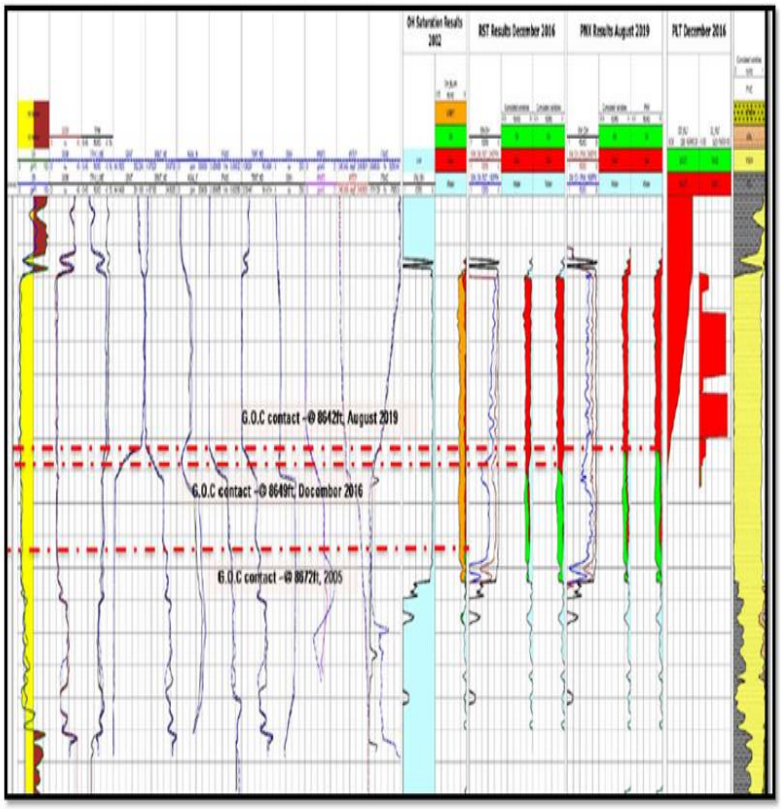


Fig (10) RST result with time of well X05-NC169

CONCLUSION

The well test as Repeat Formation Tester (RFT) and reservoir saturation test (RST) data are an important tools for production wells and reservoir engineering, the well test can be interpreted to enhancement and increasing well production that can be applied for a better understanding of petroleum reservoirs. The application is applied on F3 sandstone reservoir in five wells distributed in Wafa Field in Ghadames Basin South of Libya. The application discussed is based on the analysis of the Petrophysics data of the subjected reservoir, the results identify the reservoir contain column of hydrocarbon and water. Evaluating the gradient of pressure profile provide information about the type of fluids and the contact between them by monitoring the abrupt changes in the pressure gradients.

The pressure profiles of F3- sandstone reservoir in X5, X10, X37, ,X 38and X39) were constructed. Through the pressure profile, most of the dominated fluids are gas ,oil and water ,the contacted gas with oil was distinguished the oil can be extracted from the studied wells.

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