Increasing Oil Production by Improving The Method of Hydrocarbon Zone Determination: A Case Study of Using The Pulse Neutron Logging Application in "B" Field, East Java

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Abstract— The purpose of this research is used to provide a formation assessment using a Pulse Netron Logging (PNL) tool that can work in the casing or in the tubing. In the effort of enhancing hydrocarbon recovery, this study is done to apply an improved method of determining thickness of Hydrocarbon Zone (net pay) by using the Pulse Neutron Logging (PNL). This tool is usually used in old wells that have been producing for a long time and the purpose of this tool is to look for potential for unproduced hydrocarbons Pulse Neutron Logging (PNL) is one of Porosity measurements in formation evaluation are intended to measure the hydrogen index found in rock formations. The hydrogen index is defined as the ratio of the concentration of hydrogen atoms per cubic cm of rock to the content of pure water. PNL logs do not measure the actual porosity of rocks, but what is measured is the hydrogen content found in rock pores. And the other word the more porous rocks the more hydrogen content and the higher the hydrogen index. Thus, shale which contains a lot of hydrogen can be interpreted as having high porosity.To anticipate this uncertainty, in practice, porosity interpretation can be done by elaborating log density logging. Cased Hole Logging - Sigma Saturation and Carbon Oxygen, it can be seen that several zones that are still zones of the prospect of Hydrocarbons. This study has shown that the Pulse Neutron Log is able to improve the reading of the net pay, so the Pulse Neutron Log is able to improve the reading of the net pay 20 - 40 % Oil and Gas in formation. Production before before Pulse Neutron Logging (PNL) job is 180 bopd and after Pulse Neutron Logging (PNL) job will increase estimate 220 bopd

Index Terms— Pulse Neutron Logging, CarbonSat

1 Introduction

Neutron logs are used to distinguish porous formations and determine their porosity. This log detects the presence of hydrogen in the formation. In clean formations the pores have been filled with water or oil, the log neutron reflects porosity filled with fluid. Neutrons are part of an atom that has no charge but its mass is equivalent to a hydrogen nucleus. Neutrons interact with other materials in two ways, namely through collision and absorption. Collision generally occurs at high energy levels and absorption occurs at lower energy levels. The amount of energy lost every time a collision occurs depends on the relative mass of the nucleus that collides with the neutron. The greatest energy loss occurs when neutrons collide with another material that has the same mass as, for example, a hydrogen core. Collisions with heavy nuclei will not slow the rate of neutrons too much. So, the biggest decrease in the number of neutrons returned is determined by how much water content in the rock formation. Within a few microseconds, neutrons that have been slowed through collisions will move spread randomly without losing a lot of energy. The new neutron will stop when captured by the nucleus of atoms such as chlorine, hydrogen, or silicon.

In this paper the author wants to provide a formation assessment using a Pulse Netron Logging (PNL) tool that can work in the casing or in the tubing. This tool is usually used in old wells that have been producing for a long time and the purpose of this tool is to look for potential for unproduced hydrocarbons.

2 Literature Review

Carbon / Oxygen (Carboxsat)

Pulse Neutron is a device for measuring Carbon content in oil and Oxygen in water. When this device captures water, the levels of O atoms will be high and C atoms are low. If this device captures hydrocarbons then C atoms will be high and O atoms will be low. The ratio of carbon and oxygen presented between water and hydrocarbons depends on the salinity of water. In the C / O process this time it is specifically only for oil.

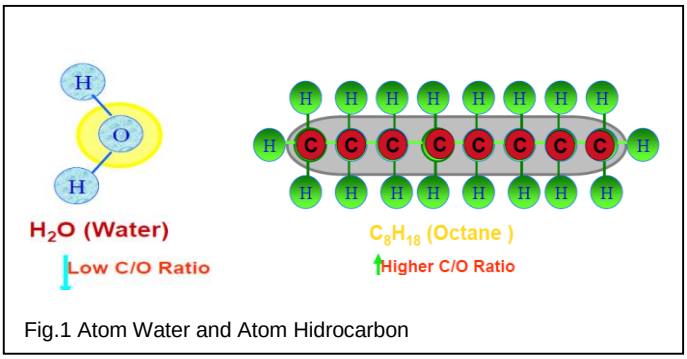

Fig.1 Atom Water and Atom Hidrocarbon

When inside a well, this tool will fire at Energy. The energy shot is 14 Mev. From each energy level emitted by Pulse Neutron we will get a ratio of several minerals and atoms C, O, Ca and Si.

When we get C, O, Ca and Si from this tool. We can already calculate from the ratio of C/O which we usually call RMT C/O and the ratio of Ca/Si which we usually call LIRI. The ratio of C/O and Ca/Si is used to determine the Saturation of oil obtained by comparing the Porosity of the Open Hole.

Neutron Porosity measurements in formation evaluation are intended to measure the hydrogen index found in rock formations. The hydrogen index is defined as the ratio of the concentration of hydrogen atoms per cubic cm of rock to the content of pure water. Neutron Porosity logs do not measure the actual porosity of rocks, but what is measured is the hydrogen content found in rock pores. Simply put, the more porous rocks the more hydrogen content and the higher the hydrogen index. Thus, shale which contains a lot of hydrogen can be interpreted as having high porosity.

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This paper wants to provide a formation assessment using the Pulse Netron Logging (PNL) tool that can work in the casing or in the tubing. This tool is usually used in old wells that have been producing for a long time and the purpose of this tool is to look for potential for unproduced hydrocarbons. Below is a type of Pulse Netron Logging tool used by Halliburton,

The limitation of the problem in this study is to look for the potential of unproduced hydrocarbons by using a Pulse Neutron Logging tool from inside the Tubing.

3 METHOD

The methodology of this study is:

1. Data collection

Data collection this time can come from the field. The data is in the form of LAS, NTI, Open Hole Log data, Cased Hole Log, Well Diagram and several historical files from the well.

2. Data Processing

- Depth Match is aligning or equalizing GR open Hole data with GR Cased Hole data.

- Calibration of each Pass. Calibration aims to make the data we have corrected with the well environment.

- Gain Stabilization

In this process all curves will be aligned to the Hydrogen Peak Window.
- Pulse Neutron Interpretation

In this process, it will enter some data that is needed into the system such as data Vshale, RhoOil, RhoGas, Litology, Bit Size, TPor and others. Usually we can get the data through Open Hole data.

On the Flow Chart above we can see the workflow in this PNL data processing. In the final process we can see three columns, namely Carboxsat, Sigmasat and Triplesat. For Carboxsat it is intended to look for Oil saturation. Sigmasat to find saturation of Gas and Triplesat in search of Oil and Gas.

To get Oil Saturation, you can also use a formula

$$S_{oil} = 1.53 * \frac{1-0.35\,\phi_T}{\phi_T} * \frac{\Delta C/O}{\Delta C/O + 0.27\rho_{hc}} \quad (1)$$

In the above calculation must include several parameters,

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namely Total Porosity, Hydrocarbon Density and. obtained from calculations.

$$\Delta \ C/O = C/O_{meas} - C/O_{wet} \quad .. (2)$$

Below is the flow for working on Carboxsat data

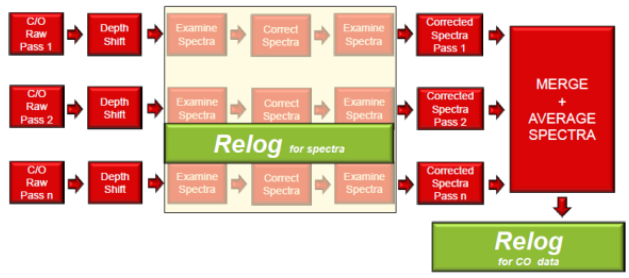


Fig. 2 Carboxsat Chart Flow

Sigma (∑) (SigmaSat)

Sigma is one of the processes of interpretation in determining oil from the formation. With this Sigma process we can distinguish between salt water and oil, vapor and water, oil and vapor. The Vapor here consists of Methane, Carbondioxide, Nitrogren and Steam.

Sigma is the ability of an element or element to be able to capture neutrons. To search for gas saturation you can use the formula:

$$\Sigma_{log} = \Sigma_{ma}(1-\Phi-V_{sh}) + \Sigma_{w}(S_{w})(\Phi) + \Sigma_{sh}(V_{sh}) + \Sigma_{hc}(1-S_{w})(\Phi) \quad (3)$$

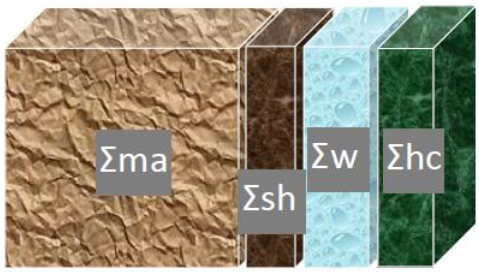


Fig. 3 Rock Model Sigma

To enter the formula requires data from open holes such as porosity and Vshale data. In addition to data from open holes we also have to enter data such as Sigma air, Sigma matrix and Sigma water. We can get these numbers in the table below

If you see Fig. 4 you will see oil and Fresh water on the same line, it is a sign that to process sigma on fresh water there is a limitation because the sigma value in both is almost the same. In the process of obtaining gas saturation by using sigma ideally the fluid in the well must have high salinity. Below is flow to work on Sigmasat data.

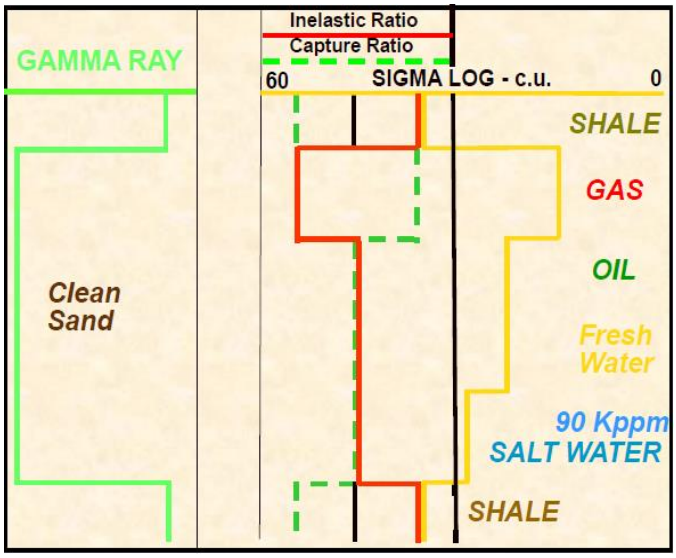


Fig. 4 Log Response on SigmaSat and Carboxsat

4 RESULTS AND DISCUSSION

4.1 Research Flow

The main objective of the Reservoir Monitoring Tool (RMTI) is to identify the remaining hydrocarbon potential in the prospect zone, behind the casing, determine the type of fluid and reservoir pressure before getting updated data reservoirs for evaluating candidates for workover.

4.2 Information on Wells

The RMTI is a tool for evaluating gas and the potential for oil inside. Sumur X is located in East Java

The RMTI (Sigma Mode and C/O Mode) was applied to the X well on 28 November 2014. At this RMTI it was run on the inside 4.5 "liner and at intervals 7860-7650 FT MD. For the

RMTI Sigma mode run on 7 "and 4.5" liners and at intervals of 7850-5600. But for processing only at intervals of 6000-5640 FT.

Environmental Correction has been done for the RMTI which includes

- Case size
- Casing thickness
- Bit size
- Litology
- Salinity of water inside the casing

The SigmaSat Module is used to obtain Gas Saturation by calculating Sigma Intrinsic and Carboxsat Modules. The goal of the calculation is to get Oil Saturation by calculating the C/O ratio from the RMTI.

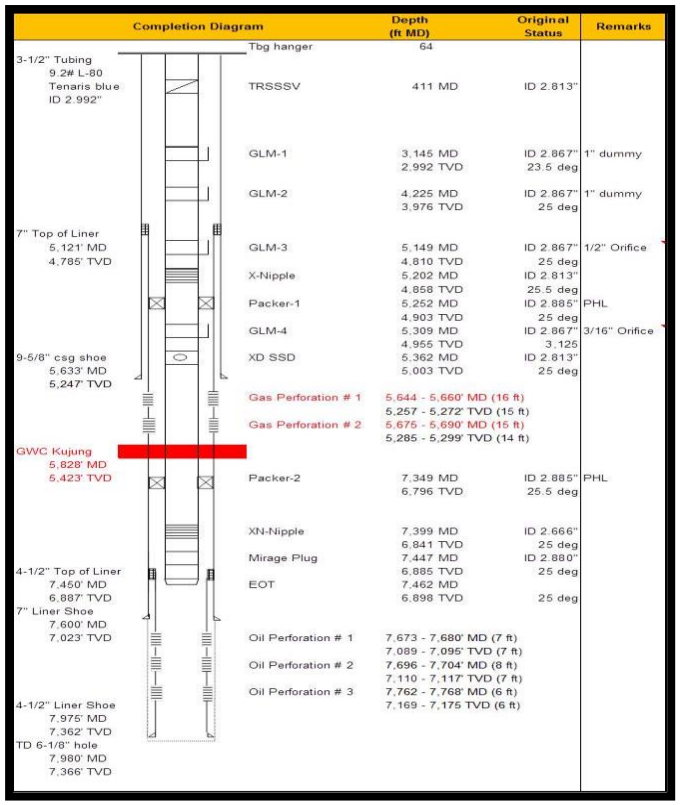


Fig. 5 Well Diagram

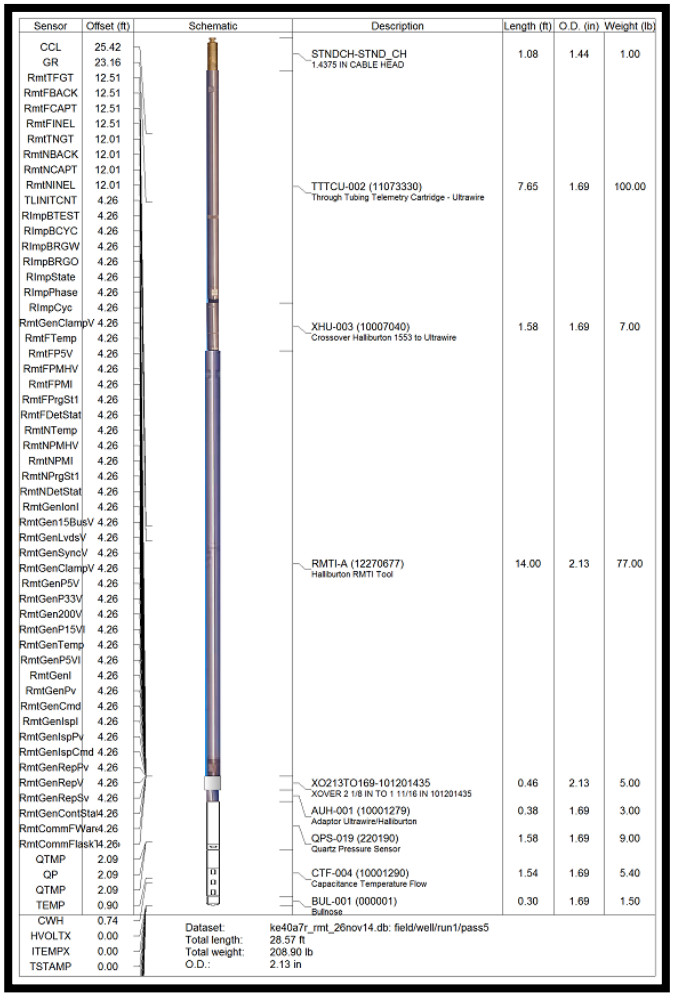


Fig. 6 Tool Diagram

4.2.1 Data Quality Analysis

All data will go through some RMTI Process Modeling for Stabilization Energy Gain windows and environmental correction, with the aim of minimizing the effects of wellbore and tools in the well that might affect the effects of the calculation. Before working on the RMTI data first through the stage, the data is prepared first. In the sub-section below, it will be discussed about data preparation.

4.2.1 Sigma Data Preparation

Below are the steps for preparing data for sigma

- Step 1 Gain Stabilization (Relog for spectra)

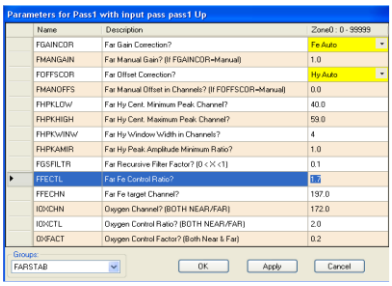


Fig. 7 Parameter input for Far Detector

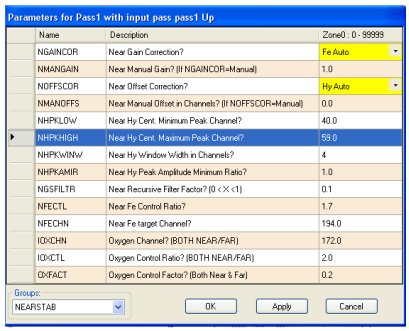
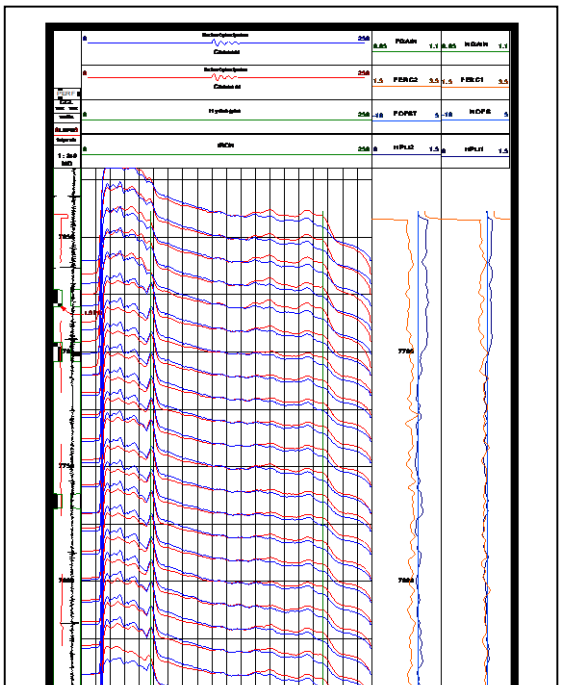


Fig. 8. Parameter input for Near Detector

After entering the Far Parameters (Figure 7) and Near Parameters in (Figure 8), a picture such as the Log below will be obtained (Figure 9). If the log has not gotten good results, then it changes the curves again in Far and Near Parameters.



- Step 2 Environmental Corection

Environmental Correction can enter data from Vshale and Total Porosity. In (Figure 11) is a table for entering the Vshale parameter. In (Figure 12) is a table for the Total Porosity parameter

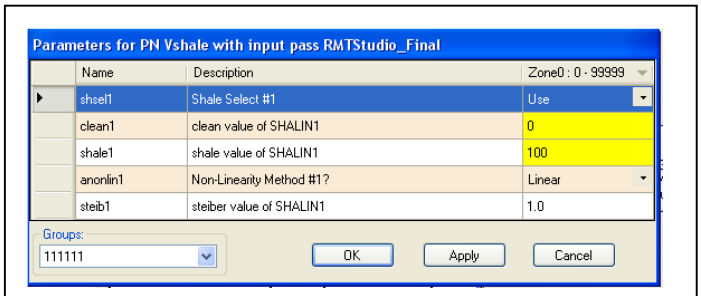


Fig. 11 Input parameters for Vshale

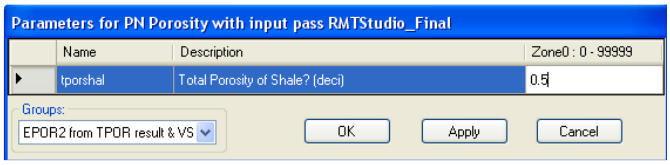


Fig. 12 Parameter input for Total Porosity

4.2.2 C/O Data Preparation

Environmental Corection on C / O is used to correct C / O data against Borehole size, casing / tubing size and borehole salinity. Salinity in the well is corrected by 5000 ppm NaCl.

C/O data has been corrected with an oil column in the casing and tubing. Following are the data preparation steps for C/O

- Step-1 Gain Stabilization (explanation on Sigma data preparation)

- Step-2 Average spectra from multi passes

Different from data preparation in Sigma Log, for C / O Log

data there is one part that is added, namely Average Spectra Log. At this stage, you will collect 3 pieces of data to become 1 pass data. The purpose of this step is to see the average data from each pass. In (Figure 13) and (Figure 14) are the Input Tables to enter several parameters. Results of Average Spectra Log as shown in (Figure 15).

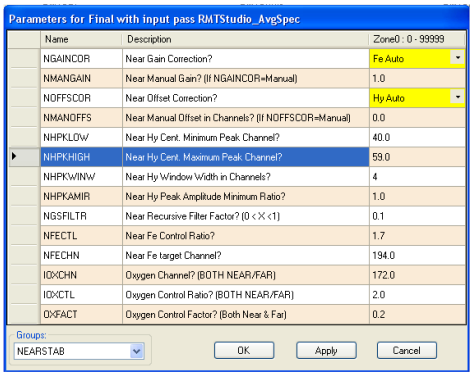


Fig. 13 Input Near Parameters for Log Average

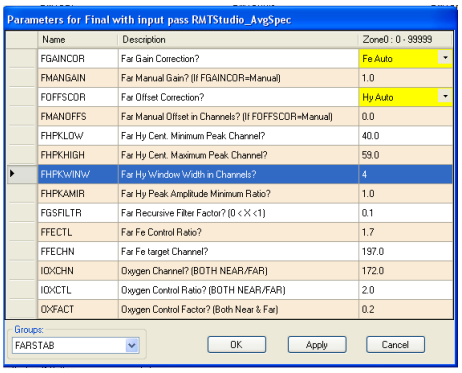


Fig. 15 Input Far Parameters for Log Average

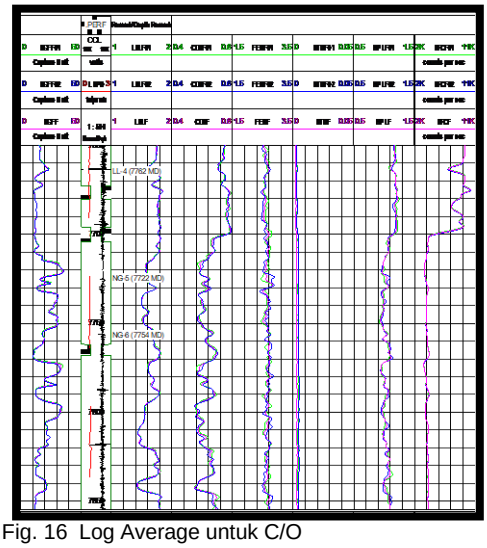


Fig. 16 Log Average untuk C/O

- Step-3 à C / O mode Environmental Corecction (explanation on Sigma data preparation

4.3. Interpretation Model

After going through the above process it is expected that the data that has been generated is data that has gone through several stages of correction. This correction is used so as to minimize errors in reading the tool because there are too many disturbances in the well. In this interpretation there are two models, namely sigma and C / O. Sigma is used to search for gas and C / O the goal is to find oil.

4.3.1. Sigma Saturation Log (Sigmasat)

Sigma Saturation Log (SigmaSat) is one of the interpretation modules for Pulse Neutron which is used to calculate saturation of sigma

In this discussion, the author wants to explain the results of processing Sigma Saturation (SigmaSat) and Carbon Oxygen Saturation (CarboxSat). The Sigma Saturation module is intended to calculate gas from sigma intrinsic. While the Carbon Oxygen Saturation (CarboxSat) is used to determine the oil saturation in the well.

Sigma 5.1 Interpretation

5640 - 5676 ft interval

There is a cross over between RNF and RINC because of the gas in the borehole and in the annulus.

5676 - 5700 ft interval

This smaller cross over between RNF and RINC may be due to gas in the borehole and water in the annulus.

Interval of 5724 - 5742 ft

SGIN values are observed around 10cu and wet Sigma is around 14 cu, this makes the separation between SGIN and Sigma Wet which results in gas saturation. There is a cross over between RNF and RINC where water is in the annulus and gas is in borehole. Effective porosity around 13-25 pu with 1 - 5% vshale and gas saturation around 20 - 40

Interval 5775 - 5788 FT

SGIN value is around 10 cu and Sigma Wet is around 14 cu, there is a separation between SGIN and Sigma Wet which

indicates gas saturation. There is also a Cross Over between RNF and RINC because there is water in the annulus and gas in the borehole. Effective porosity is around 18-25 pu with 1% vshale and gas saturation around 60%.

5800 - 5825 ft interval

SGIN value looks around 10 cu and Sigma Wet is around 14 cu, this makes a little separation between SGIN and Sigma Wet which will produce Gas saturation. Cross Over between RNF and RINC because of the presence of water in Annulus and gas in borehole. Effective porosity around 15-30 pu with 1 - 5% Vshale and gas saturation <20%

5.1 Cabon Oxygen Interpretation

TABLE 6
VALIDATION FOR MODIFIED CONSTANT VALUE

$(kt/\square\square c_t)^{0.5}$	r_i equation, ft	r_i simu-lator, ft	$\square r_i$, %
x	$y=(1/1491)^{0.5}x$		
44946.66	1164.02	1170	0.51
5387.63	139.53	140	0.34
11920.07	308.70	309	0.10
20314.98	526.11	527	0.17
1975.733	51.17	51.2	0.06

7674 - 7686 FT interval

Oil saturation is around 20 - 40% and effective porosity is around 15 - 35 pu. Gas Water contact at 7700 ft

7764 - 7768 FT interval

Oil saturation is around 20% and effective porosity is around 18-25 pu. Water in Borehole

4 CONCLUSION

1. Based on the results of qualitative interpretation, Cased Hole Logging - Sigma Saturation, it can be seen that several zones that are still zones of the prospect of Hydrocarbons, where Residual Gas Saturation is located at the interval:
   - Depth of 5775 - 5788 ft, with Shale Volume prices of 1%, Effective Porosity of 18-25 pu, and Residual Gas Saturation of 60%.
   - depth of 5724 - 5742 ft of gas zone with ambient saturation and effective porosity of around 13-25 pu with shale with Shale Volume prices of 1 - 5%, Effective Porosity of 13-25 pu, and Residual Gas Saturation of 20 - 40%.
   - Depth of 5800 - 5825 ft with Shale Volume prices of 1-5%. Effective Porosity is 15-30 pu, and Residual Gas Saturation is <20%.
2. Based on the qualitative interpretation of the Cased Hole Logging - Carbon Oxygen Saturation, it can be seen that several zones that are still zones of the prospect of Hydrocarbons, where Residual Hydrocarbon Saturation is located at the interval:
   - Depth of 7764 - 7768 ft, with Effective Porosity prices around 18-25 pu and Residual Hydrocarbon Saturation at 20%.
   - Depth of 7674 - 7686 ft with an effective price of Porosity of 15 - 35 pu and Residual Hydrocarbon Saturation of 20 -40%.
3. Limits of Gas - Water (Gas-Water Contact) can be detected through a device that is at a depth of 7700 ft.
4. Production before before PNL job is 180 bopd and after PNL job will increase estimate 220 bopd

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