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Research Article

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Determination of the Petrophysical Parameters using Geostatistical Method in One of the Hydrocarbon Reservoirs in South West of Iran

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Abstract Description of the reservoir characteristics is one of the most important topics in petroleum engineering. Petrophysics is the study of the rock properties and its interaction with fluids. Petrophysical interpretation describes laboratory techniques to investigate data and measurements inside the well in order to infer the reservoir properties such as shale volume (Vsh), porosity (Ø), permeability (K), the net to gross thickness of reservoir (net / gross), water saturation (Sw) and determination of the productive zone (pay zone). In this paper, these parameters have been calculated for one of the oil reservoirs in south west of Iran. Multimin is the method which was used to conduct this study. After acquiring the data and making corrections on the data the logs were interpreted using statistical method of multimin which is a powerful interpretation technique. This method has been chosen because of its advantages compared to the determine method. In the determine method, interpretation is step by step and the results of each step will affect the results of the next step. Whereas, in Multimin method the whole unknowns (shale volume, porosity, etc.) can be calculated simultaneously. The core analysis for lithology confirms the Multimin analysis. According to the results for the average porosity and average permeability were 0.3 and 13.25 md respectively.

Keywords Porosity, Saturation, Permeability, Well log, Geostatistics

Introduction

In formation evaluation and exploration of hydrocarbon resources, data and information can be obtained from different exploration methods [1-3]. Nowadays, well log methods have developed and their application is evident in all fields related to the earth sciences. Almost all well logs can be used in all stages of exploration, drilling, and development of oil fields reservoirs. These applications vary from a simple adaptation to different methods of determining saturation in shale formations. Well logs can be used at the all scales of geology such as geological and sedimentary structures and rock contexture [4-6].

The purpose of this paper is to obtain the petrophysical parameters for one of the oil reservoirs located in south west of Iran. The logs were interpreted after loading and making corrections on the data, by using the statistical methods of Multimin. This method has some advantages compared to the deterministic method. In the determininistic method, interpretation is step by step and the results of each step, will affect the results of the next step. Whereas, in multimin method, the whole unknowns are calculated simultaneously. Finally, parameters such as porosity, shale volume, fluid saturation, permeability and lithology are determined.

Methodology

Numerical data obtained from well logs of layers containing hydrocarbons can be interpreted by the method. Moreover, the amount of fluids (water and hydrocarbons) contained in the reservoir, lithology, and porosity of the drilled formations can be modeled and calculated by this method. The method is able to import data such as well log, core, seismic, and petrographic to calculate the desired parameters. The outputs are illustrated as the visual results (chart and plot types) and reports [7, 8].

Multimin Method

Multimin method is designed to offer an integrated petrophysical evaluation by using the geological information, core analysis, and log analysis. Multimin is an integral part of the geology application along the other applications and acts as a flexible optimum evaluation method. In fact, it is a method to compare a modeled or predicted collection of answers or measured values. Thus, it can converge the data and improve the analysis. If the well logs are comprehensive, the probabilistic method can be used which is more accurate. Therefore, optimal response is achieved. The total and effective porosity, the total and effective saturation, shale volume, the volume of fluids and minerals in assessed areas can be determined by this method [9]. Multimin assessment process is as follows:

- Model Maintenance
- Log Uncertainties
- Radial Geometrical Factors
- Run Analysis
- Assign Set to Layout
- Inverse Analysis (NIMBLE)

The input data is displayed in three different stages:

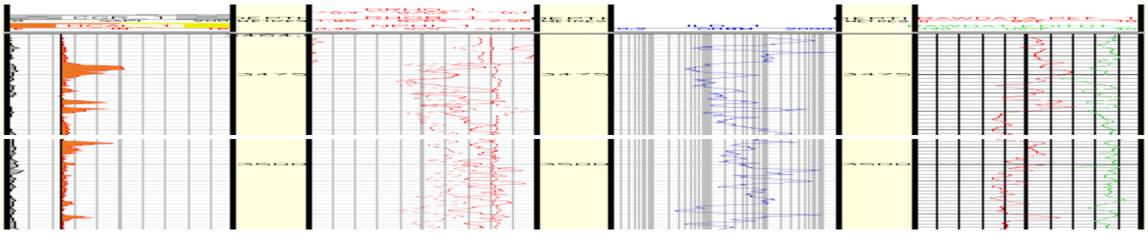
1. Digitally displayed.

Table 1: Different types of logs are acquired in the wellbore

Name	Units	Type	Minimum	Maximum	Top	Bottom	SR	Count	Miss	Mean	StdDev
DEPTH	METRES	DOUBLE	3464.357	3733.952	3464.357	3733.952	0.152	1770	0	3599.155	77.892
CGR_1	GAPI	REAL	0.175	127.057	3465.119	3733.952	0.152	1765	0	29.810	27.704
DRH0_1	K/M3	REAL	-1.309	100.000	3465.119	3733.952	0.152	1765	0	18.617	13.400
DT_1	US/M	REAL	154.535	444.778	3464.357	3733.952	0.152	1770	0	228.205	42.428
GR_1	GAPI	REAL	5.915	158.731	3465.119	3733.952	0.152	1765	0	51.845	30.139
HCAL_1	MM	REAL	209.845	287.259	3465.119	3733.952	0.152	1765	0	216.547	11.346
ILD 1	OHMM	REAL	0.148	1950.000	3465.119	3733.952	0.152	1765	0	49.570	160.395
ILS 1	OHMM	REAL	0.153	1803.413	3465.119	3733.952	0.152	1765	0	38.563	104.221
NPHY_1	V/V	REAL	-0.013	0.308	3465.119	3733.952	0.152	1765	0	0.155	0.065
PEF_1		REAL	1.771	7.949	3465.119	3733.952	0.152	1765	0	3.424	1.408
POTA_1	0.01	REAL	-0.053	3.954	3465.119	3733.952	0.152	1765	0	1.010	0.897
RHOB_1	K/M3	REAL	2177.900	3008.500	3465.119	3733.952	0.152	1765	0	2488.622	202.768
SFL_1	OHMM	REAL	0.179	551.083	3465.119	3733.952	0.152	1765	0	28.597	54.898
THOR_1	PPM	REAL	-0.399	15.877	3465.119	3733.952	0.152	1765	0	3.294	3.332
TKRT_1		REAL	-55.651	104.597	3465.119	3733.952	0.152	1765	0	3.351	4.105
URAN 1	PPM	REAL	0.329	9.397	3465.119	3733.952	0.152	1765	0	2.453	1.563

2. Graphically display.

This step illustrates the data in the graphical form or curve track is shown in figure (1)



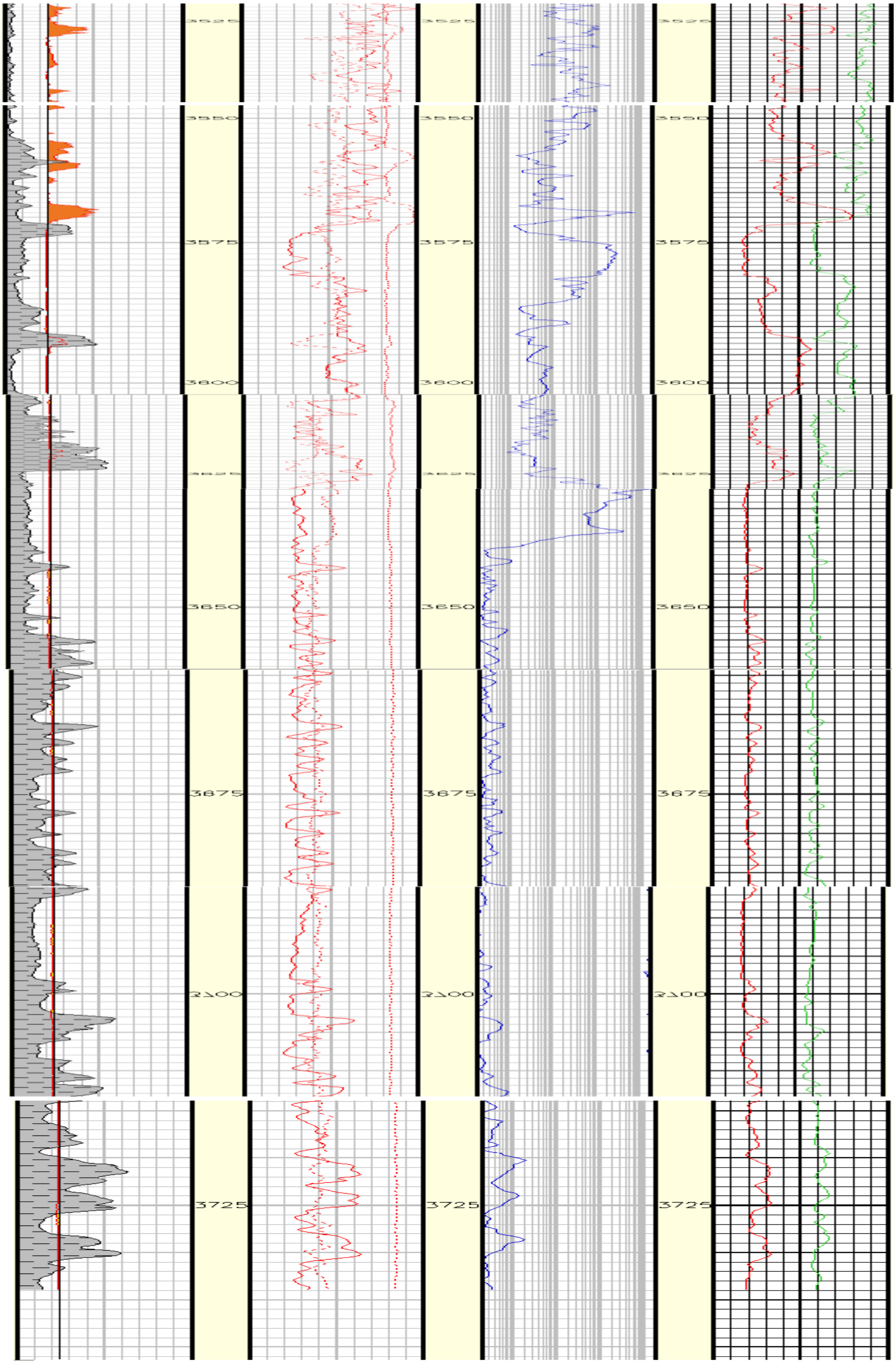


Figure 1: Graphical display of logs

3. Cross plot

This step (Fig. 2) displays and evaluates the logs relative to each other in crossover charts. Also it is widely used for selecting petrophysical parameters, such as porosity, lithology and etc.

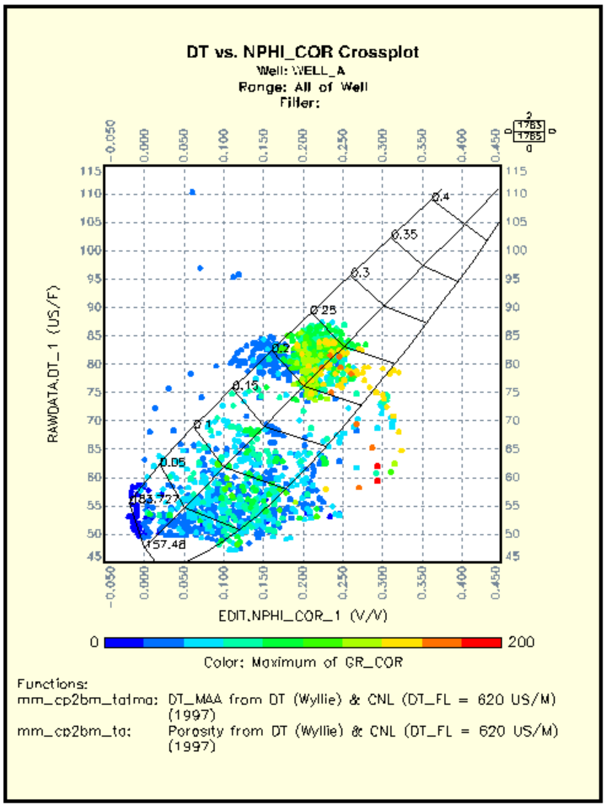


Figure 2: Cross plot of data

Data Preparation and Editing Step

In the step 2 the data are reviewed to find any needed corrections. There are three steps for data preparation, which are described below.

1. After displaying the log data, the distances which identify the slump or swelling in wells are determined by caliper log (Fig. 3). As known, the slump may affect the information of some logs such as PEF, RHOB.

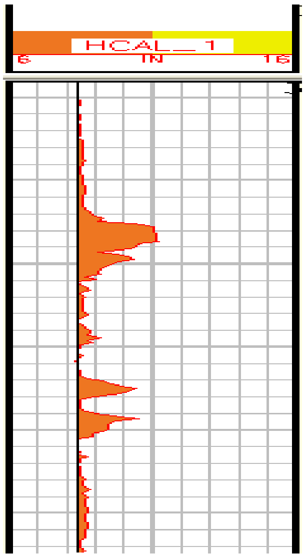


Figure 3: The chart of bit diameter and caliper together which is an indication of slump or swelling of well bore

As shown in figure 3, the vertical black line is the bit diameter and red log is the caliper log. The difference between these two logs represents the slump of wellbore.

2. The next step is despiking, which diminish the unwanted peaks or the jumping points of the sonic (DT) log. These unwanted peaks may be due to the presence of gas, small fractures, a very dense formation and etc. These factors weaken the sound wave and may cause a springboard cycle.

3. Depth Shifting is done in the next step so that one of the logs which has a determined sharp peak is considered as a basis. Then, the point with the specific peak of this log is compared with the other logs to see whether they show the same peak at the same depth or not. If not, the logs must be adjusted to the same depth. During the well logging the operation is performed in several stages to measure different logs. Hence, an amount of displacement is possible during tool calibration or the tools may be stuck in the well.

Precalculation

At this step, the time-related parameters of well logs such as the depth of the beginning and the end of logging, temperature, and the parameters of drilling mud are input data. Finally, a series of output information related to the well conditions are obtained and used in the next step (environmental correction). It should be noted that the *Precalc* module is an essential part of any petrophysical analysis. Many properties of the fluid which are used by Multimin are dependent on the well pressure, temperature (Fig. 4), and especially the contained rocks.

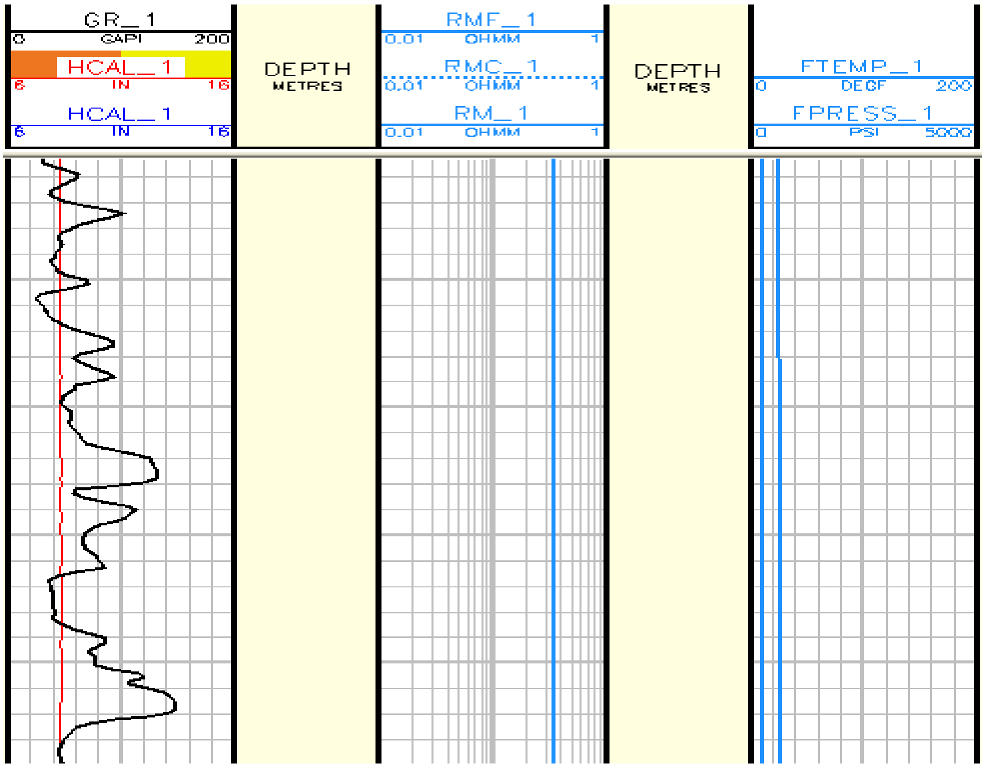


Figure 4: Logs of temperature and pressure profile

Environmental corrections

The output data of the Precalc are used for environmental corrections. In well logging *environment* refers to all the factors around the logging tools which have an impact on the logs. Understanding these affecting factors of logging is necessary in order to correct the evaluation of the graphs of the petrophysical parameters and calculations. When logging tool is sent into the well and records the information from the bottom, some factors such as drilling mud, mud cake, mud filtrate into the formation, temperature, pressure, and well bore instability have affect on recorded data. The log correction can solve this problem. Some of these natural factors are such as temperature, pressure and other factors arise from drilling and logging tools. Therefore, various companies have created certain charts that can be used for corrections.

In this paper, gamma ray, neutron, and density logs are corrected and their final graphs are shown in figures 5 to 7.

Figure 5: Gamma Ray Corrected log

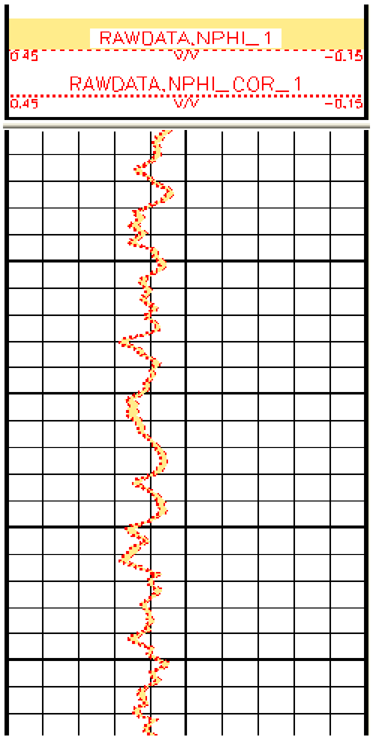


Figure 6: Neutron corrected log

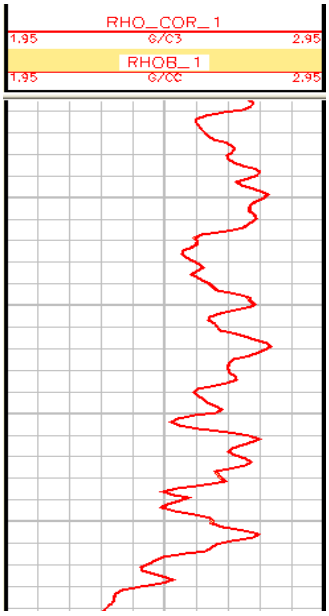


Figure 7: Density corrected log

As it is known the properties of some minerals like quartz, dolomite and calcite are definite but parameters related to shale are not. Therefore, some cross plots are required to show the shale properties. Some of them are described below.

NPHI-RHOB cross plot

Neutron and density logs are function of the porosity and also the rock type. Cross plot of these two graphs illustrates the various minerals of the formation the best among the whole double charts [10]. Figures 8-12 show the different crossplots. In figure 8, the yellow and orange dots represent shale (because of its exceptionally high gamma ray) the density and neutron are read from the axes are 2.6 and 0.3 respectively. According to figure 9 the amount of DT is 80 µ/*ft*. Figure 10 shows that the amount of U is 8. Figure 11 show that shale resistance (R) is 1Ω. And according to figure 12 CGR is 1300 API.

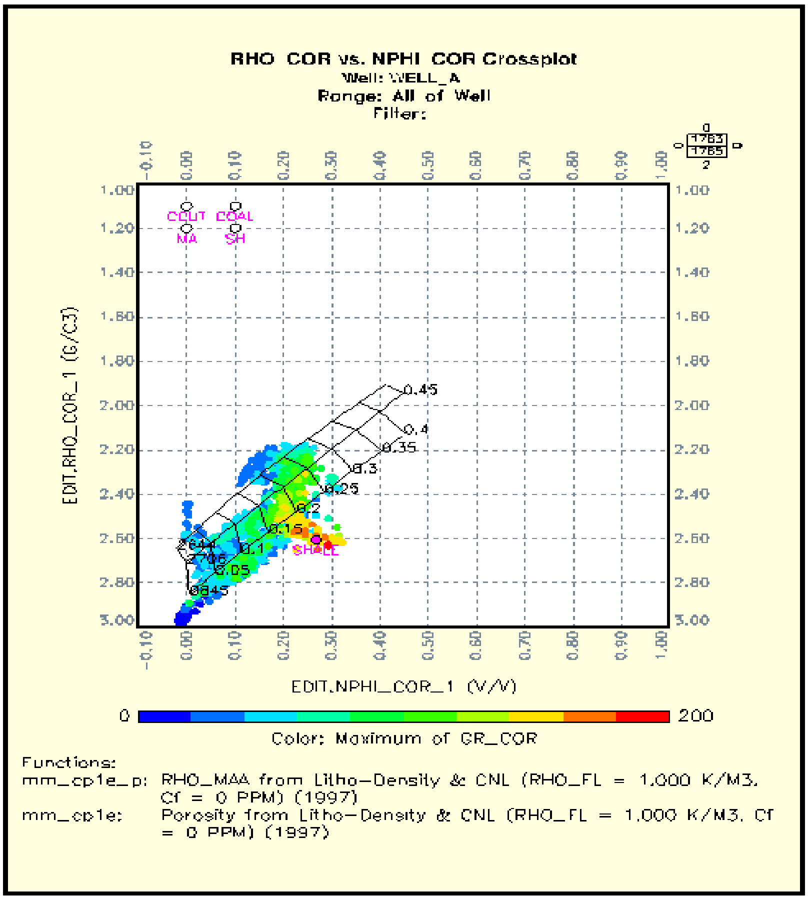


Figure 8: Cross plot of neutron-density logs

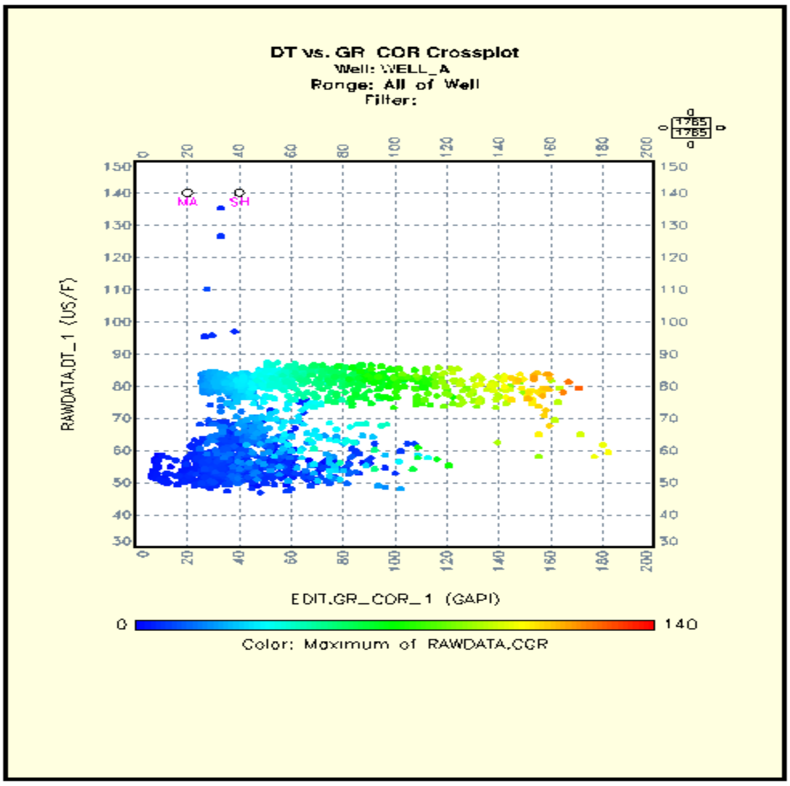


Figure 9: Cross plot of gamma-sonic logs

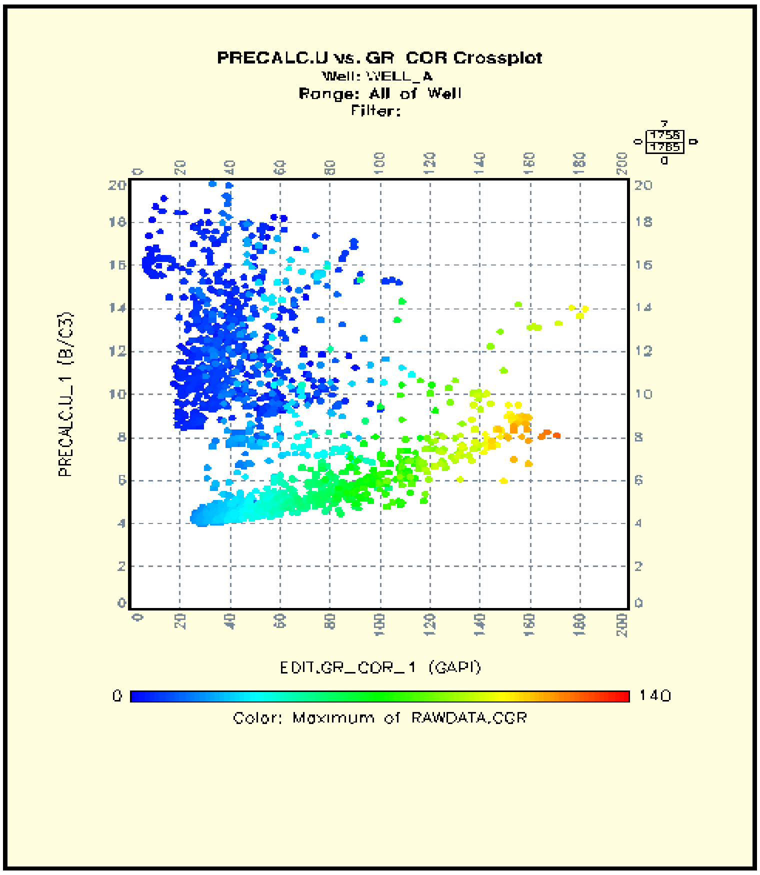


Figure 10: Cross plot of U-GR

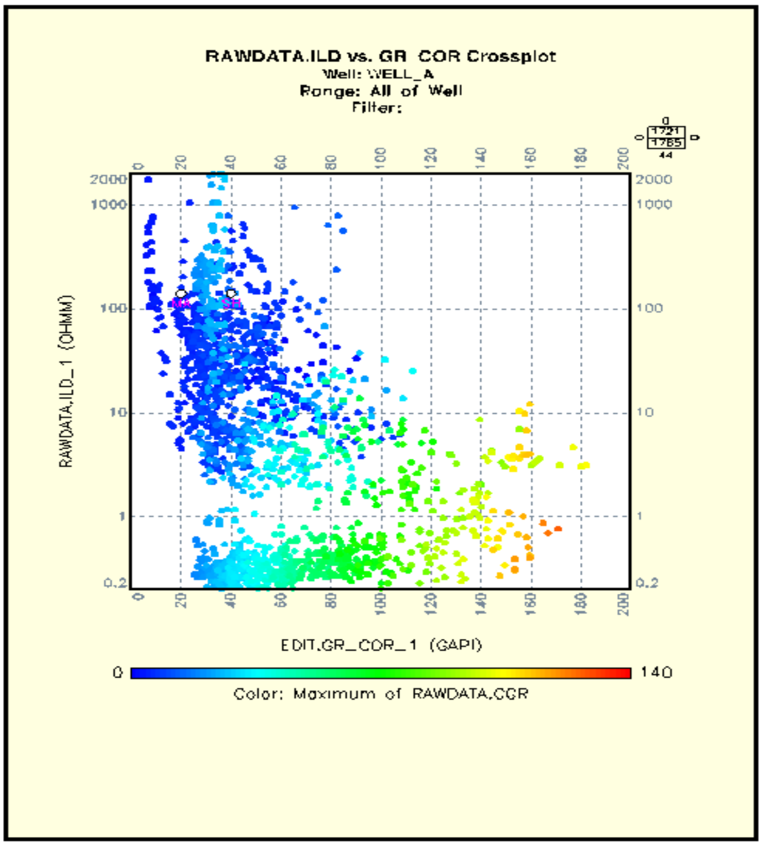


Figure 11: Cross plot of ILD-GR

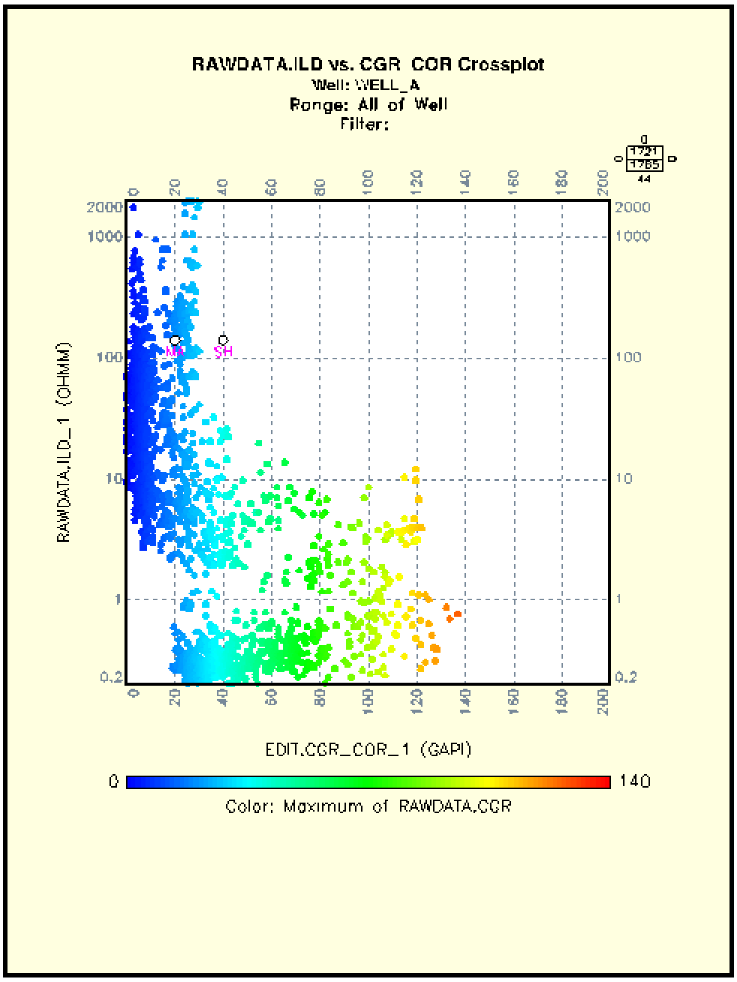


Figure 12: Cross plot of ILD-CGR

Results

The result of the modeling is illustrated in figure 13. Five models were run in the method because of the five zones. In this figure, the first column is related to the lithology which results from Multimin analysis and is compared to obtained lithology from the core in the second column. The third column is related to porosity and the saturation. As shown the porosity is zero in the cap rock and the pore volume filled by fluid elsewhere. Each color represents a special fluid. Oil saturation color is dark green, pale green and gray represent water saturation and bound water saturation related to shale, respectively.

The fourth column is the irreducible water saturation and caliper log is the fifth column. The sixth column is the quality log, the large peaks with pink color indicates high uncertainty. The seventh to thirteenth columns represents the comparison between the real logs and hypothetical logs. As mentioned before in the Multimin method, reservoir characterization and lithology are inputs. Then the method will create a hypothetical well with synthetic well logs and these logs are compared with the original logs.

Since the reservoir has various zones with specific properties, the result is explained for each column to investigate the porosity and the saturation. For permeability calculation Coates Free Fluid Index method was used and the result is illustrated in figure 14. In this figure three tracks contains permeability, lithology, and resistivity log are presented. The permeability is shown in the sandstone and calcite layers. Although the permeability is very high in depth lower than 3640 m, this phenomenon is confirmed with low resistivity beneath this depth.

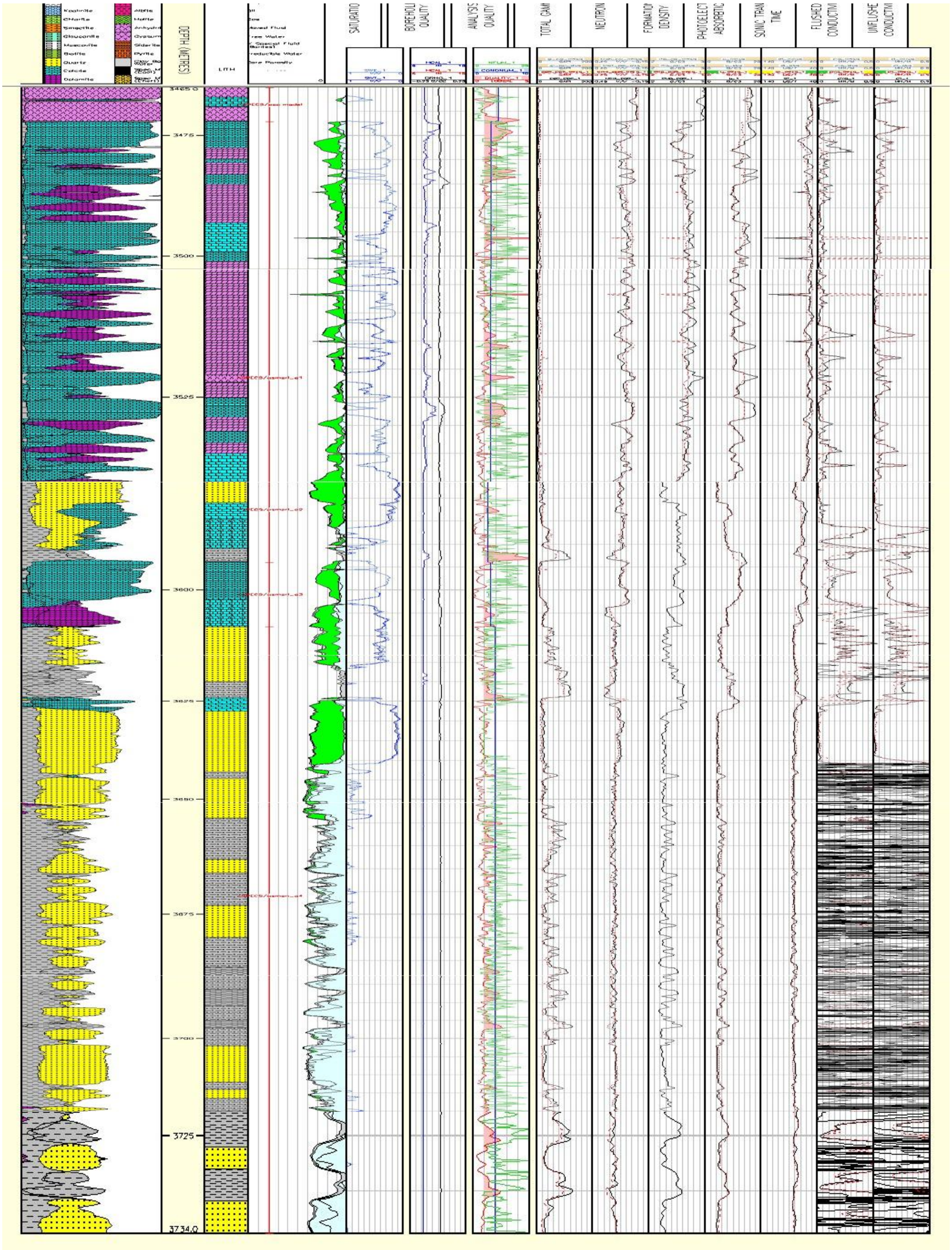


Figure 13: The final result containing the description of logs

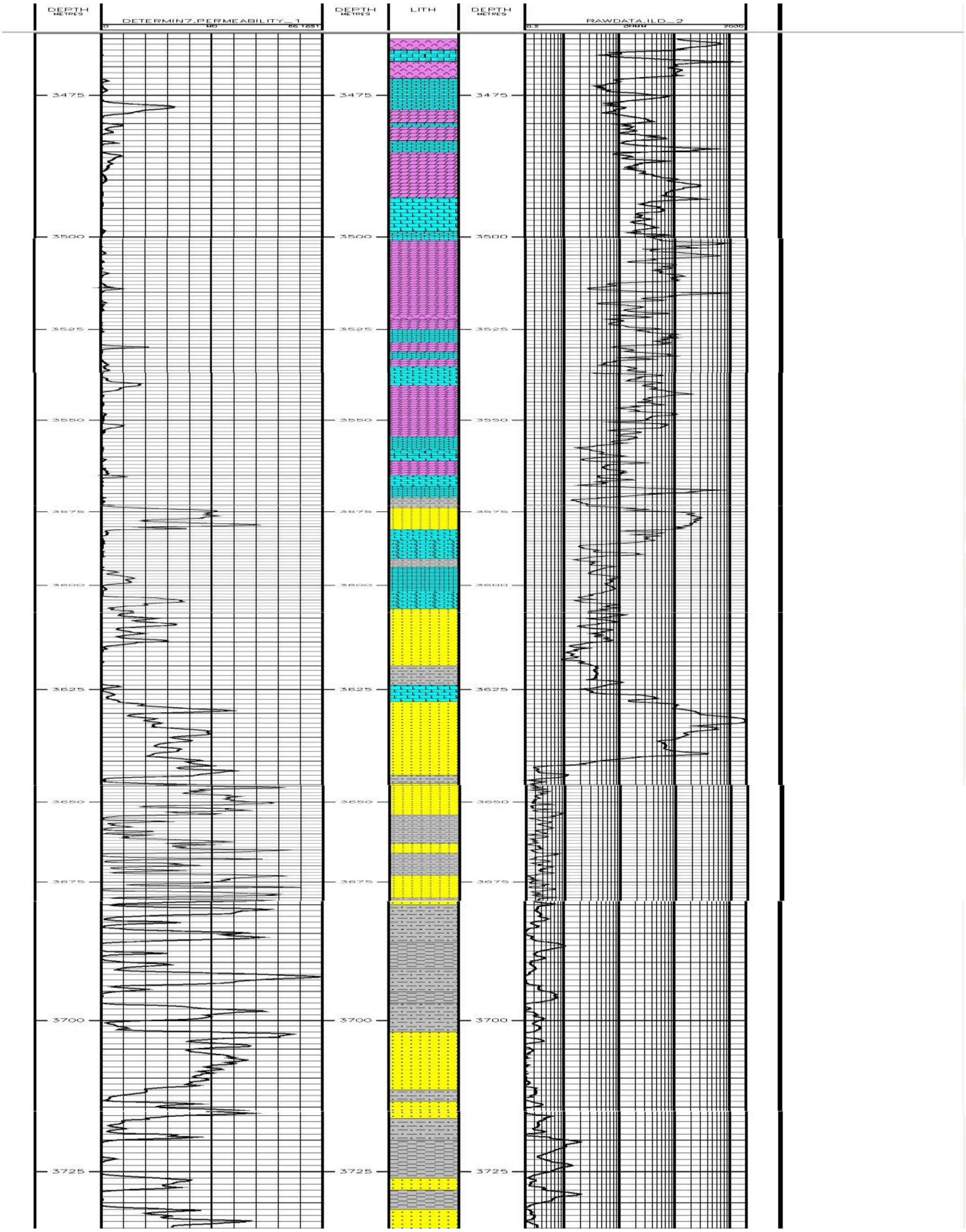


Figure 14: The permeability's of different layers

Conclusions

Physical parameters like porosity, hydrocarbon saturation, hydrocarbon layer thickness, and permeability are important for evaluating a reservoir. The core analysis for lithology confirms the Multimin analysis. Conclusions based on zonation are as follows:

- First zone: this zone is in the depth of 3462 to 3472 and contains anhydrite rocks. The properties of this rock confirm the zero porosity and it can be considered as the cap rock because the permeability of this layer is almost zero.
- Second zone: This zone is at the depth of 3472 to 3571 and contains often dolomitic rocks, and its porosity is approximately 0.2 also its oil saturation is about 0.15. Although the graph shows high distribution of the permeability, approximately 5 mD can be mentioned as the average permeability.
- Third Zone: this zone is at the depth of 3571 to 3594 and often contains sandstone, calcite and dolomite. Its porosity is approximately 0.3 which seems reasonable due to the sandstone formations. The oil saturation is about 0.22. According to the logs permeability has a high distribution but approximately 15 mD can be mentioned as the average permeability attributed to this layer.
- Fourth Zone: This zone is at the depth of 3594 to 3608 and is often contained of calcite and dolomite rocks. This zone has the porosity and the saturation of 0.3 and 0.2 respectively. The permeability shows high distribution with respect to the logs however, 3 mD is the average permeability attributed to this layer.
- Fifth zone: This zone is at the depth of 3608 to 3734 and is often contained of sand stone with the porosity 0.4. According to the logs the whole pore volume is filled by water. The permeability shows high distribution with respect to the logs however, 30 mD can be considered as the permeability attributed to this layer.

References

[1]. Ozcelik, O., Altunsoy M., Erik, N.Y., Karadirek, S., & Unal, N. *Biomarker Characteristics of Triassic Kasımlar Formation; Akseki–Anamas Platform, Western Taurus, Turkey*. Journal of Scientific and Engineering Research, 2017. 4(6): p. 141-147.

[2]. Adiotomre, E., *Usability of Crystalline Basement Rocks as Construction Materials: Case Study of Ajaokuta Area, Kogi State, Nigeria.* International Journal of Scientific and Engineering Research.

[3]. Kawekwune, N. and M. Oti, *Available online www. jsaer. com.* Journal of Scientific and Engineering Research, 2016. 3(4): p. 219-231.

[4]. Serra, O., *Fundamental of Well–logging interpretation.* Development in Petroleum Science No. 154, 1984.

[5]. Tiab, D. and E.C. Donaldson, *Petrophysics: theory and practice of measuring reservoir rock and fluid transport properties*. 2015: Gulf professional publishing.

[6]. Worthington, P.F., *The petrophysics of problematic reservoirs.* Journal of Petroleum Technology, 2011. 63(12): p. 88-97.

[7]. Blanchet, P. and C. Godwin, *" Geolog System" for Computer and Manual Analysis of Geologic Data from Porphyry and Other Deposits.* Economic Geology, 1972. 67(6): p. 796-813.

[8]. Godwin, C., R. Hindson, and P. Blanchet, *GEOLOG: A computer-based scheme for detailed analysis of stratigraphy, especially as applied to data from drill holes in coal exploration or development.* Inst. Mining Metal. Bull, 1977. 70: p. 123-132.

[9]. Rahim, N. and N. Watson, *Determination of Duvernay Formation Reservoir Properties through Probabilistic Petrophysical Analysis calibrated to Core Studies.* Submission 334S0123) Geoconvention, May, 2015: p. 4-8.

[10]. Fertl, W.H., *Openhole Crossplot Concepts A Powerful Technique in Well Log Analysis.* Journal of Petroleum Technology, 1981. 33(03): p. 535-549.