Comparison of Rock Type Determination Based on Permeability Estimation and FZI Value in Upper Cibulakan Shaly Sand Formation, ASR Field

(Perbandingan Penentuan Jenis Batuan Berdasarkan Perkiraan Permeabilitas dan Nilai FZI dalam Formasi Shaly Sand Cibulakan Atas Lapangan ASR)

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Abstract

Rock permeability is an important rock characteristic because it can help determine the rate of fluid production. Permeability can only be determined by direct measurement of core samples in the laboratory. Even though coring gives good results, the disadvantage is that it takes a lot of time and costs so it is not possible to do coring at all intervals. So that the well log is required to predict the level of permeability indirectly. However, the calculation of permeability prediction using well log data has a high uncertainty value, so rock typing is required so that the calculation of permeability prediction becomes more detailed. This research was conducted in an effort to determine the Hydraulic Flow Unit (HFU) of the reservoir in the well that has core data using the Flow Zone Indicator (FZI) parameter and FZI value propagation on wells that do not have core data so that the type of rock and permeability value are obtained from every well interval. From the results of the study, the reservoirs on the ASR field can be grouped into six rock types. The six rock types each have permeability as a function of validated porosity by applying it at all intervals. After FZI is calculated from log data and validated with core data, it can be seen that the results of the method produce a fairly good correlation ($R^2 = 0.92$). Furthermore, from the permeability equation values for each different rock type, the predicted permeability results are also quite good ($R^2 = 0.81$).

Keywords: Permeability Prediction, Rock Type, Flow Zone Indicator (FZI), MICP, Propagation FZI

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Permeabilitas batuan merupakan karakteristik batuan yang penting karena dapat membantu menentukan laju produksi fluida. Permeabilitas hanya dapat ditentukan dengan pengukuran langsung sampel batuan di laboratorium. Meskipun coring memberikan hasil yang baik, kerugiannya adalah bahwa dibutuhkan waktu yang lama dan biaya besar sehingga tidak mungkin untuk melakukan coring pada semua interval. Sehingga logging sumur diperlukan untuk memprediksi tingkat permeabilitas secara tidak langsung. Namun, perhitungan perkiraan permeabilitas menggunakan data log sumur memiliki nilai ketidakpastian yang tinggi, sehingga melakukan Rock Typing diperlukan sehingga perhitungan prediksi permeabilitas menjadi lebih rinci. Penelitian ini dilakukan dalam upaya untuk menentukan Hydraulic Flow unit (HFU) reservoir di sumur yang memiliki data core menggunakan parameter Flow Zone Indicator (FZI) dan pergerakan nilai FZI pada sumur yang tidak memiliki data core sehingga jenis batuan dan nilai permeabilitas diperoleh dari setiap interval sumur. Dari hasil penelitian, reservoir di lapangan ASR dapat dikelompokkan menjadi enam jenis batuan. Keenam jenis batuan masing-masing memiliki permeabilitas sebagai fungsi porositas dan divalidasi dengan menerapkannya pada semua interval. Setelah FZI dihitung dari data log dan divalidasi dengan data core, dapat dilihat bahwa hasil dari metode tersebut menghasilkan korelasi yang cukup baik ($R^2 = 0.92$). Selain itu, dari nilai persamaan permeabilitas untuk setiap jenis batuan yang berbeda, hasil permeabilitas yang diprediksi juga cukup bagus ($R^2 = 0.81$).

Kata-kata kunci: permeabilitas prediksi, Rock Type, Flow Zone indikator (FZI), MICP, propagasi FZI

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I. INTRODUCTION

Rock permeability is an important rock characteristic because it can help determine the rate of fluid production [1]. Permeability can only be determined by direct measurement of core samples in the laboratory. Although coring produces good results, the disadvantage is that it takes a lot of time and costs, so it is not possible to do coring on all wells. Therefore the well log is performed to predict the level of permeability indirectly [2, 3, 4, 5, 6]. However, the calculation of permeability prediction using well log data has a high uncertainty value, so rock typing is done so that the calculation of permeability prediction becomes more detailed [7].

In wells that do not have core data, it is very difficult to identify rock types.

Through core data and log data, grouping of

shaly sand reservoir quality found in the Upper Cibulakan formation can be done using a petrophysical approach with the Flow Zone Indicator (FZI) method. This method is a method that utilizes calculations based on porosity and core permeability data and can also be used to calculate permeability values through a generalization process at depth intervals that do not have core rock samples [3].

In this study, the problems discussed were analyzing the physical rock properties of shaly sand in zones 28 to 32 in the Upper Cibulakan formation which consisted of 239 RCAL data and 57 SCAL data to obtain permeability predictions at all well intervals using the Flow Zone Indicator (FZI) method at wells that do not have core data so that rocks can be grouped according to their characteristics.

II. METHODOLOGY

Hydraulic Flow Unit is a part of a reservoir that can be mapped and has geological and petrophysical properties that are consistent and different from other parts of the reservoir in controlling fluid flow [9]. The Hydraulic Flow Unit concept by using the Flow Zone Indicator parameters [2] was chosen to classify rock types. The first step is to calculate the Rock Quality Index (RQI) value using the equation:

$$RQI = 0.0314 \sqrt{\frac{k}{\phi_e}} \qquad (1)$$

RQI is Rock Quality Index (μm)

$$\phi_z = \frac{\phi_e}{1 - \phi_e} \qquad (2)$$

ϕ_z is ratio of pore volume to grain

$$FZI = \frac{RQI}{\phi_z} \qquad (3)$$

FZI is Flow Zone Indicator (μm).

Each core sample from the same rock type will have a similar FZI value and a similar relationship of porosity and permeability. After all FZI values from core data are calculated, the next task is to determine the Hydraulic Flow Unit in the well that does not have core data. Correlation between log measurements and FZI values from cores is used. Log data used are Gamma Ray (GR), Density (RHOB), and Neutron (NPHI).

A variable regression technique of optimal non-parametric transformation is used. With the regression on each rock type, we get 6 permeability

equations. Where in the equation, permeability is a function of porosity. To search for rock types at all intervals, propagate to several wells whose production is commingle, so that rocks can be grouped according to their character which can be seen from the FZI value. The next thing to do is predict the permeability of the log data that has been obtained based on the division of each rock type against the value of FZI. After obtaining permeability predictions at all intervals, the average permeability prediction in each zone of formation is carried out in zones 28 to zone 32.

III. RESULTS AND DISCUSSION

The probability plot approach used in this study is a mechanism to group core data into the appropriate flow unit groups. In Figure 1. there is a plot between porosity and permeability, but because the permeability range in each porosity is still too large, rock typing is done by grouping the Flow Zone Indicator (FZI) method to obtain more detailed permeability predictions at each well interval. The Upper Cibulakan Formation has porosity ranging from 15% - 38% and permeability values vary from 0.03 mD to 3000 mD. In figure 1. the porosity and permeability values in the data core have been corrected becomes the value of porosity and permeability found in the reservoir.

To divide the rock type with RCAL data on 4 wells, namely 239 porosity data and 239 permeability data, FZI calculations can be performed on each core sample. The distribution of rock types can be done with the FZI graph with the cumulative data available as shown in Figure 2.

In those 4 wells, 6 rock types were obtained with FZI values from the largest, which were 2.98-5.05, 1.45-2.92, 0.65-1.42, 0.3-0.6, 0.16-033, and 0.05-0.17 as shown in Table 1. This rock type distribution has been validated with J-Function curves and MICP data. After calculating the J-Function and making the curve, the results are 6 curves where the specified rock type has the same results. Besides being validated with J-Function, rock types can also be validated with SCAL data, Mercury Injection Capillary Presure (MICP). The following is a table of each rock type with FZI values based on porosity and permeability values on the Routine Core Analysis and Special Core Analysis [10].

After the rock type clustering was obtained and validated with J-Function data and the Mercury Injection Capillary Pressure data obtained 6 rock types along with regression on each type of rock as deicted in Figure 3.

Determinant analysis uses the principle of calculation step by step. This method is a petrophysical analysis with a probabilitic approach. Determined analysis was performed to calculate clay volume, porosity, and water saturation. This

analysis is carried out with data obtained from the picking parameter values as shown below by using a ternary diagram that serves to show the components in the formation. Where on the ternary diagram the shale is chosen because of the

compacting effect, so the shale value varies at each depth.

In Figure 4, there is a triangle between water, wet clay, and quartz. In this graph the value of gamma ray is obtained as well as the density in quartz and wet clay. To find the GR value and density in quartz and wet clay a zone that is matched in a qualitative analysis is needed. Whereas in water, the value has been set, namely gamma ray 0 and its density value 1.

In Figure 5, the value of neutrons and density in wet clay is obtained. At the point of quartz the value that has been set is the NPHI of -0.02 and the RHOB value of 2.65.

In Figure 6, there is a graph to determine the neutron and gamma ray values at the wet clay point that has been matched with qualitative analysis. With the value of this picking parameter, a determinant analysis can be performed.

After obtaining permeability equation values for each rock type and also obtaining log data, FZI propagation can be carried out wherein the input data are 3 models namely GR Log, RHOB Log, and NPHI Log tied to associated logs in the form of FZI core data to propagate to several wells whose production is commingle, so that rocks can be grouped according to their character which can be seen from the value of FZI. With the regression on each rock type, we get 6 permeability equations. Where in the equation, permeability is a function of porosity. After calculating through equations on each rock type at all intervals, get the percentage estimate of the permeability value of 81%.

By obtaining the coefficient correlation predictive value of permeability in the log data on the core data. The following is a research table that produces the value of the average permeability in each zone is from zone 28 to zone 32 as given in Table 2.

IV. DISCUSSION

Calculation of permeability and analysis of rock type on the ASR field using the Flow Zone Indicator method produces different characteristics. From the analysis, six rock types have different characters, including:
1. In the core data, the porosity value ranges from 15% to 38%.
2. In the data core, permeability values vary from 0.03 mD to 3000 mD.
3. Rock type 1 has a FZI value of 2.98-5.05 μm, of which the largest FZI value is rock that has the best rock type.

4. Rock type 2 has a FZI value of 1.45-2.92 μm.
5. Rock type 3 has a FZI value of 0.65-1.42 μm.
6. Rock type 4 has a FZI value of 0.3-0.6 μm.
7. Rock type 5 has a FZI value of 0.16-033 μm.
8. Rock type 6 has a FZI value of 0.05-0.17 μm.
9. The results of calculations through equations for each rock type at all intervals get a percentage estimate of the permeability value of 81%.

By obtaining the coefficient correlation of the permeability prediction value on the log data on the core data, the study produces a value of the average permeability in each zone, from zone 28 to zone 32. Where the smallest average permeability prediction is in zone 28 and the mean prediction the highest average permeability is in zone 29.

IV. CONCLUSIONS

The conclusion obtained from the results of the study is that six rock types have been determined based on the petrographic description in the Pore Geometry Structure plot and have been verified by the rock type classification determined based on the J-function and MICP graph plots. FZI in wells that do not have core data can be determined by FZI propagation and produce a pretty good FZI correlation ($R^2 = 0.92$) between core data and log data. Furthermore, it is obtained good predictions of permeability ($R^2 = 0.81$).

It is recommended to verify rock type based on the J-function classification of rock types based on the classification of lithofacies, it requires more SCAL data, so that it can cover a considerable amount of data distribution.

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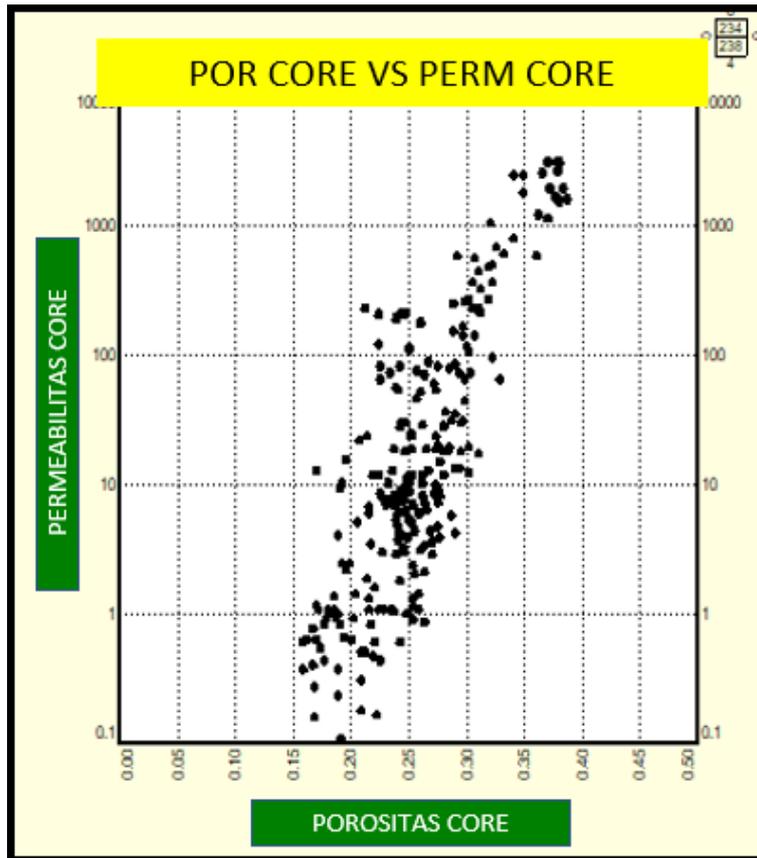
Figure 1. Porosity vs. Permeability
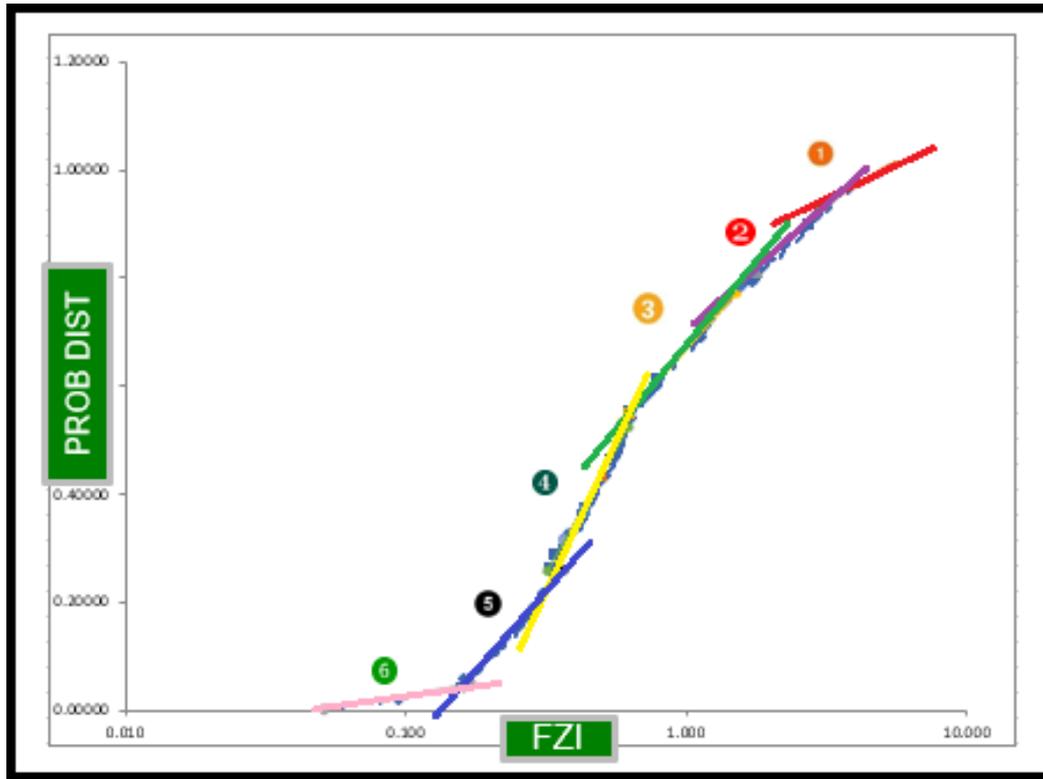
Figure 2. Results of Rock Type Distribution Based on FZI

Table 1. Classification of Rock Type Based on FZI Value

ROCKTYPE	FZI (µm)	
	RCAL	MICP
1	2.98-5.05	3.4-4.5
2	1.45-2.92	2.2-2.6
3	0.65-1.42	1.0-1.2
4	0.3-0.6	0.3-0.5
5	0.16-033	No data
6	0.05-0.17	No data
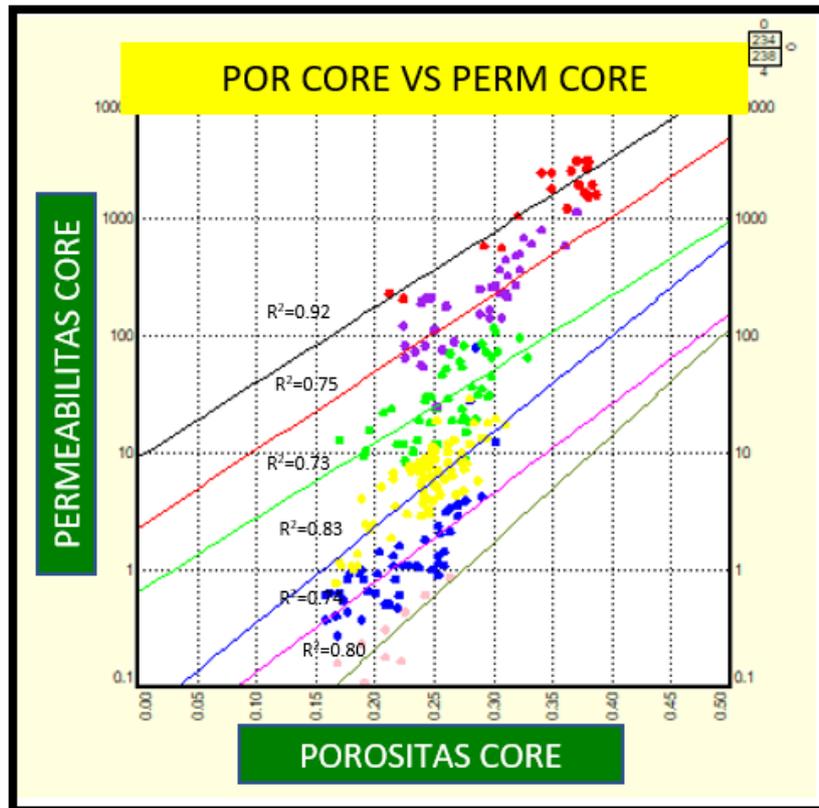
Figure 3. Rock Type Distribution Based on Relationship between Porosity and. Permeability
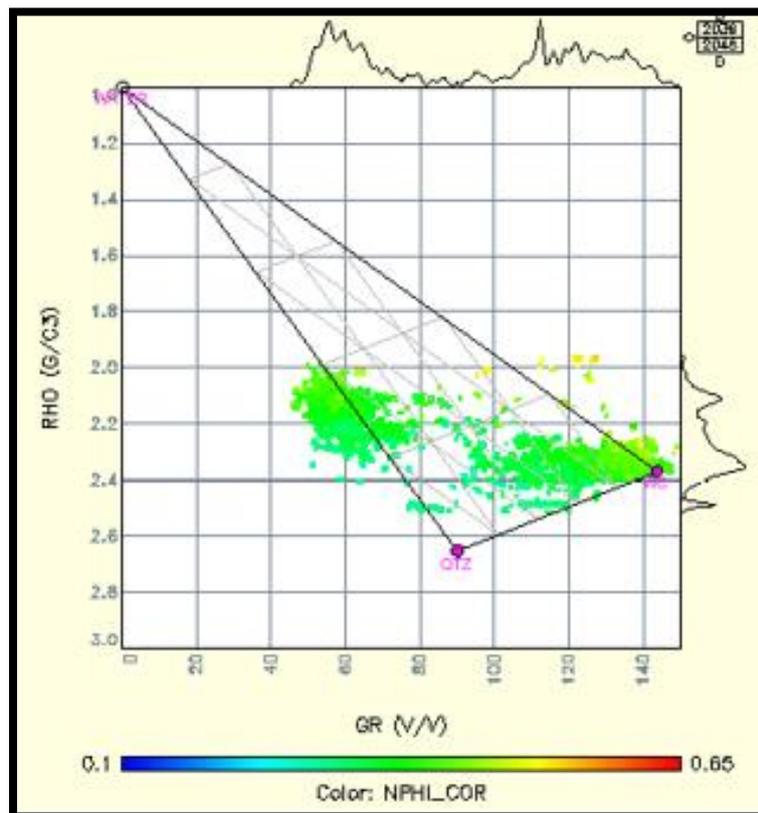
Figure 4. Graph of GR vs. RHOB
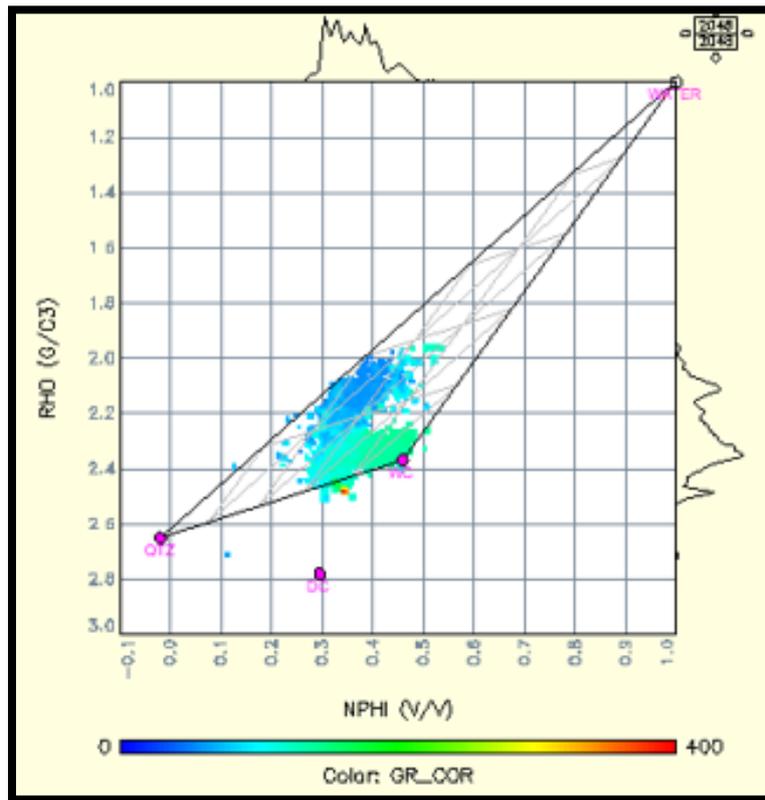
Figure 5. Graph of NPHI vs RHOB
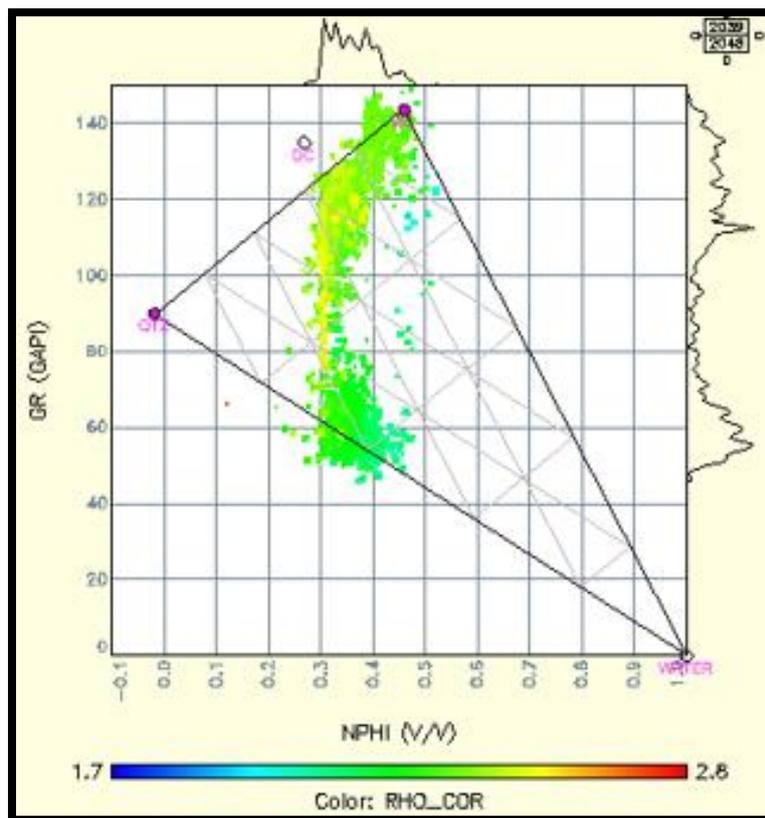
Figure 6. Graph of Graph of   NPHI vs GR

Table 2. Prediction of Average Permeability in Each Zone

ZONE	AVERAGE (mD)
28-A1	56.95
28-A2	19.221
28B	32.2
28C	66.28
28D	32.847
29-A1	75.759
29-A2	97.757
29B	126.374
32A	58.795
REG32	55.377