ONLINE PRESENTATION
24 - 25 OCTOBER 2020
PROFESSIONAL TECHNICAL PAPER

THE WINLAND r35 FOR PERMEABILITY ASSESSMENT IN LOWER GITA MEMBER RESERVOIR, TALANG AKAR FORMATION, FIELD "X", ASRI BASIN

Ade Hardian[1], Sugeng S Surjono[2], I Wayan Warmada[2]
[1] Master Student of Geological Engineering, Faculty of Engineering, Universitas Gadjah Mada
[2]Geological Engineering, Faculty of Engineering, Universitas Gadjah Mada
Corresponding author: sugengssurjono@ugm.ac.id

Abstract. Sedimentation process creates heterogeneity in the physical properties of reservoir rock. Rock typing is a method to determine the physical properties of rocks easier, especially for permeability. One of the methods in rock typing analyses is Winland r35. In this method, pore throat size parameter is calculated and can be grouped as rock types using hierarchical cluster analyses with the ward's algorithm. The quality of rock type results can be observed by the regression value (R^2) from trend line of porosity and permeability plots. The high regression value is considered as good rock type result and vice versa. Another way to verify rock type result is by using reservoir simulation of single well model. Permeability calculation by trendline equation will be input to single well model with other supporting data from petrophysics and pressure transient analyses (PTA). Reservoir model with good rock type will match the flow rate and bottom hole pressure aligned to drill stem test (DST) data. The results are four rock types formed by the Winland r35 method, showing low regression (R^2) value with quite different permeability calculation from the core permeability. Based on the matching to the oil rate and bottom hole pressure from the drill stem test (DST) data, this result is considered quite good and this method can still be applied to the lower Gita reservoir.
Keyword: Rock type, Winland r35, single well model.

1. Introduction

Young (1993) states that the sedimentary rock within the Lower Gita of the Talang Akar Formation in Asri Basin was deposited in the meandering river. The sedimentation process resulted in heterogeneous rock characteristics. The rock type methods is applied to make it easier in determination of rock characteristics, especially the permeability. Rock types can be grouped based on the similarity of the flow character. Winland r35 method is applied in this research to assess the permeability and verify whether the calculation is accurate or not. Comparison between flow rate and bottom hole pressure from drill stem test (DST) and single well model is done as the way to verify the rock type result.

2. Data and Methods

Rock type analyses utilize data from two wells, namely Well-A and Well-B with 64 and 61 core data respectively. Other data used in this study include logs from each well and the Drill Stem Test (DST) data from Well-C.

2.1. Rock Typing Analyses

Based on the research from H.D Winland in 1970, Ahmed (2019) states that Winland's study is a calculation of the pore throat size in 35% mercury saturation while testing mercury injection capillary pressure. This pore size calculation uses the equation below.

$$\text{Log (R35)} = 0.732 + 0.588 \log (k) - 0.864 \log (ø) \quad (1)$$

Where

k : Permeability (mD)

ϕ : Porosity (v/v)

The rock type can be defined by using the pore throat size parameters with a hierarchical cluster analyses method with Ward's algorithm (Abbaszadeh et al., 1996). This method will combine the parameters that are considered to have close similarity to a cluster. In the hierarchical cluster analyses, the input data is not only one parameter. The pore throat size can be accompanied by other parameters, such as porosity permeability, and others.

2.2. Petrophysics

Petrophysics in this study is useful for calculating V-shale, porosity, and water saturation, which will be used in making a single well model. Besides, the existing log data is used to spread the rock types that have been created vertically using tools from geology software, namely Multi Resolution Graph-Based Clustering (MRGC). This method adapts Aguilar (2014), whose research tested the log parameters that match the studied reservoir by trial and error. The spread rock type becomes a reference for calculating the permeability in areas with no permeability value.

2.3. Pressure Transient Analyses (PTA)

To find out the radius of the well to be made in a single well model, the radius investigation calculation can be used from the PTA analyses results. Pressure record from drill stem test DST is used in this analyses. The PTA using type curve matching will give more information on reservoir, such as lateral rock and fluid property changes.

2.4. Reservoir Simulation Single Well Model

This analysis is carried out as a way to determine whether the permeability calculated by the rock type analyses is accurate or not. In this analyses, the model created can calculate the flow rate and pressure from the reservoir. Due to the fact that permeability is the key for fluid to flow in the reservoir, if the calculated permeability is accurate, the flow rate and pressure from the model and DST test will be the same.

3. Result and Discussion

3.1. Rock Typing Analysis

The pore throat size calculation using the Winland r35 equation is performed on 125 core data. The next step is applying the hierarchical cluster analyses to group the calculation result to form rock type number. This analysis creates three cluster of rock types number (Figure 1). On the other hand, by plotting

porosity and permeability data, four (4) rock types can be identified from those quite random distribution (Figure 2). Consider to characteristics of distribution, the Rock type 1 is the best, while rock type 4 is moderate. The regression value (R^2) generated for each rock type indicates unfavorable results due to the scattered data, which resulted in varying permeability for the same porosity value. The existing trendline only represents the mean value of the permeability, which will be calculated. Reservoir simulation by single well model is required to evaluate the permeability calculation.

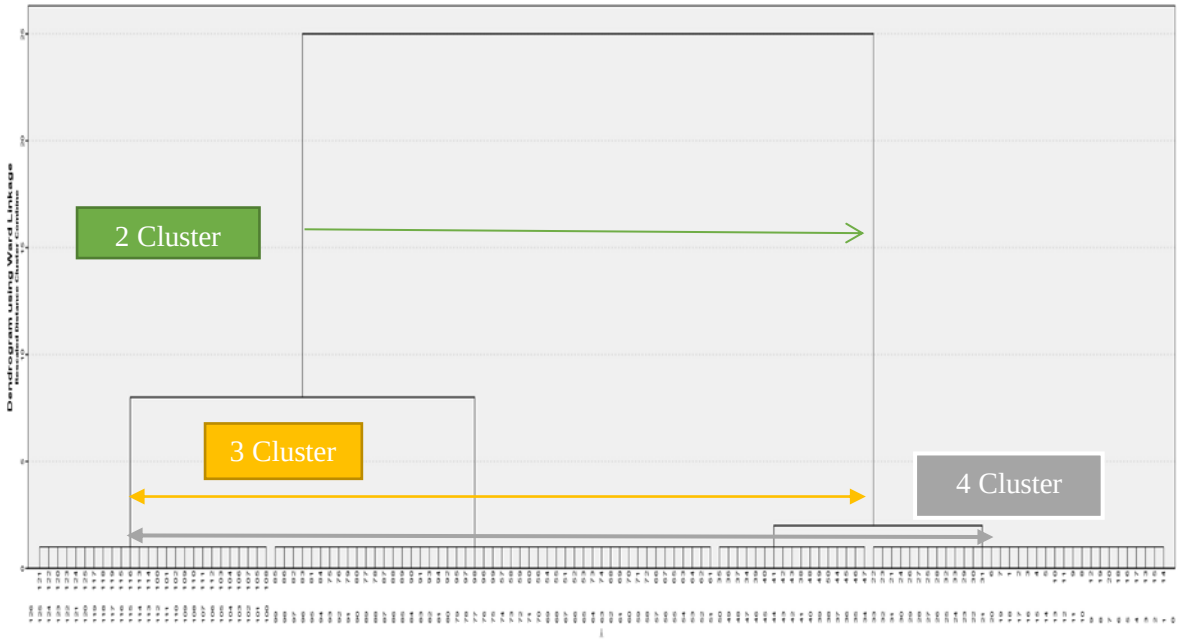

Figure 1. Hierarchical cluster analyses with Ward's algorithm in rock typing using Winland r35

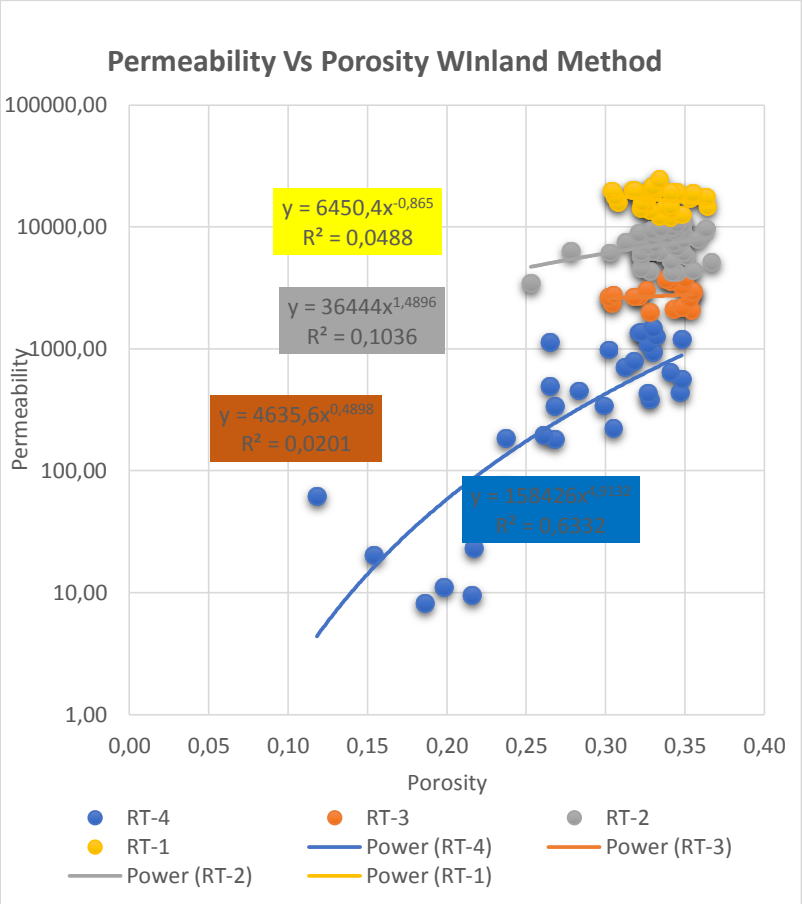

Figure 2. Porosity vs. permeability plot based on Winland r35 method

3.2. Petrophysics

Figure 3 is the calculation result of V-shale, porosity, water saturation, vertical distribution of rock types, and permeability by rock typing method at well-B. The calculation results of the V-shale and porosity are quite good because of the porosity calculation that almost matches with the direct lab calculation on core's porosity. Indonesian equation is used to calculate the water saturation, assuming that the reservoir is composed by clean sandstone. The distribution of rock types is carried out using MRGC (Multi Resolution Graph-Based Clustering) with the right trial and error parameters. In this study, the suit parameters are V-shale, porosity, and density log as shown in Figure 4. This rock type becomes the guidance for calculating permeability in areas where no core permeability is provided. The result of permeability calculation is quite match to the permeability measurement on core.

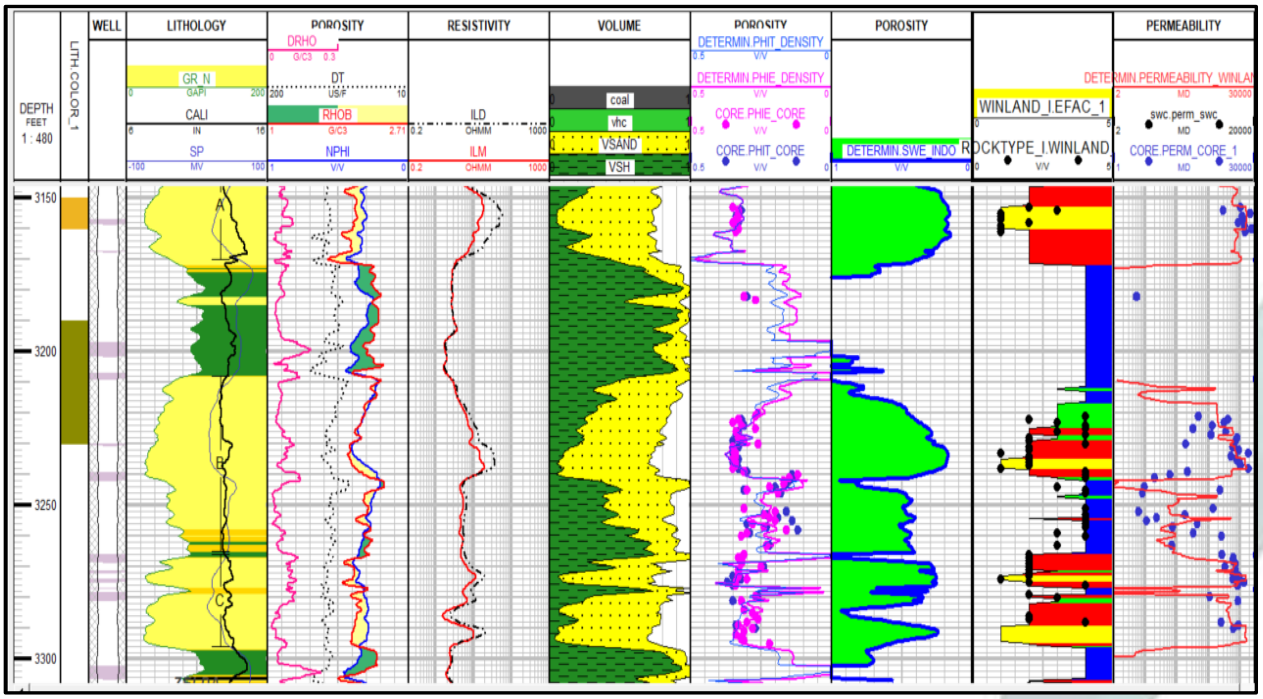

Figure 3. Petrophysical calculation at Well-B.

	NAME	COL	PAT	WEIGHT	PHIE_DENSITY	VSH	RHOB	WINLAND
1	RT-1			14				
2	RT-2			13				
3	RT-3			16				
4	RT-4			15				

Figure 4. Rock type spreading parameters.

3.3. Pressure Transient Analyses (PTA)

The results of the pressure transient analyses carried out at reservoir C in Well-B is shown in Figure 5. The test was carried out for elapsed time six hours with 3.5 hours of production with a flow rate of 3,553 BOPD and then shut-in for 2.5 hours. The reservoir model suitable for pressure derivative is homogeneous, meaning that the reservoir's pressure impulses detected similar physical properties laterally. The calculated radius of investigation from this analyses is 4,280 feet. This value is obtained because the average permeability from the calculation is 11 darcy, despite the fact that the well was shut-in in just 2.5 hours.

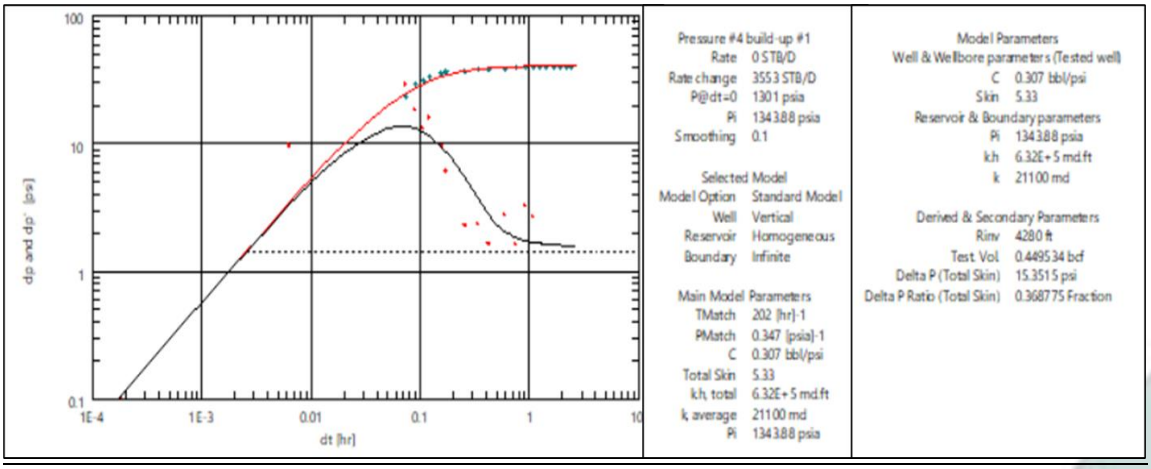

Figure 5. PTA analyses result at reservoir C at Well-B

3.4. Reservoir Simulation Single Well Model

This single well model is developed on the basis of physical properties, fluid, and PTA data. From the PTA reservoir model, it is assumed that laterally, the rock's physical properties are homogeneous, especially within the reservoir C at well-B, where this model is conducted. The single well model simulation results is shown in Figure 6, where Figure 6A is the history matching of the oil flow rate for 3.5 hours, while Figure 6B is the result of bottom hole pressure matching when the well was shut-in. Both of them indicate quite good results. This occurs because there are also modifications to the relative permeability parameters by changing the slope of the line from the flow rates of oil, gas, and water as shown in Figure 7.

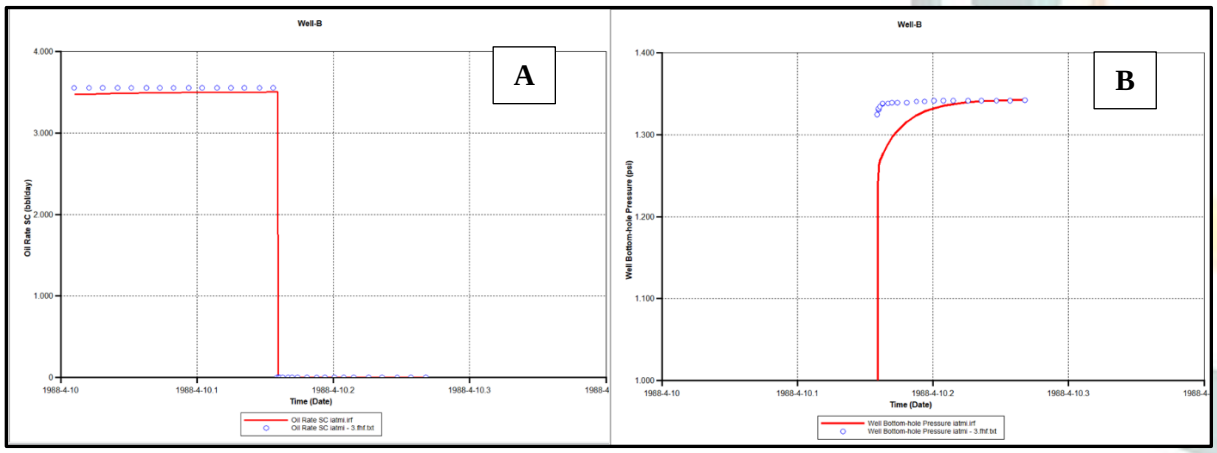

Figure 6 A. Oil rate matching, B. Bottom hole pressure matching.

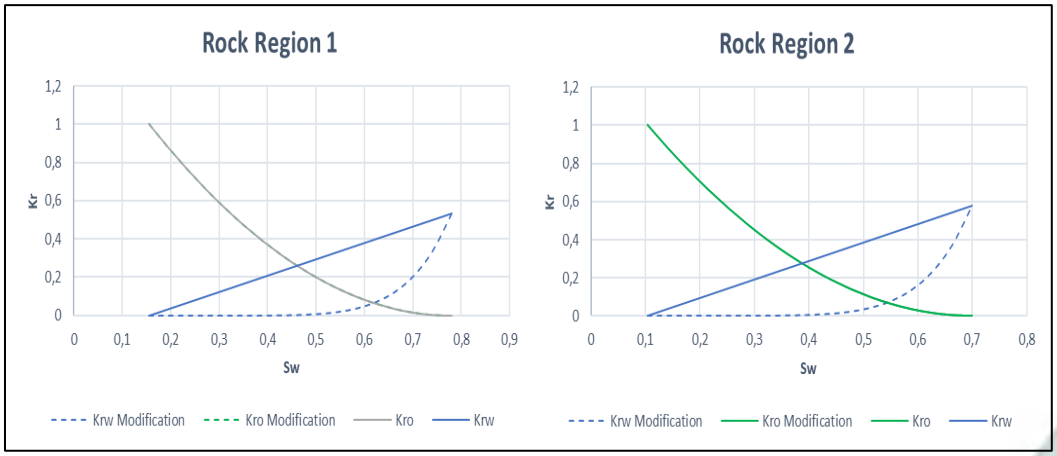

Figure 7. Relative permeability modification for matching.

Conclusion

The results of rock type analysis with Winland r35 method based on the pore throat size are not very good. The division of rock types by using hierarchical cluster analyses shown in the porosity and permeability plot indicates that the regression value (R^2) is low for rock type 2, 3, and 4. It later influence to permeability value that is calculated using the trend line equation, where several calculation results are not similar to the permeability value of the laboratory core analyses. Petrophysical analyses and Pressure Transient Analyses (PTA) show promising results in supporting the creation of a single well reservoir model. Porosity calculations in the petrophysical analyses are almost having the same number with the core data. Water saturation calculations that calculated using the Indonesian equation method is also supported the result. Type curve matching also indicates good results to determine the effective permeability and the radius of investigation for the single well model. The single well model using permeability from Winland r35 rock typing method exhibits a quite good match, with close value of oil flow rate and the bottom hole pressure from the models and DST data. From these results, it is concluded that Winland r35 rock typing method can be applied for Lower Gita reservoir.

References

1. Abbaszadeh, M., Fujii, H., Fujioto, F. 1996. Permeability Prediction by Hydraulic Flow Unit – Theory and Application. 30158-PA SPE Journal Paper. Doi:10.2118/30158-PA.
2. Aguilar, C ., and Govea, H, 2014. Hydraulic Unit Determination and Permeability Prediction Base on Flow Zone Indicator Using Cluster Analyses. SPE-169307-MS. Presented at SPE latin American and Caribbean petroleum Engineering Conference in Venezuela, 21-23 May 2014. doi:10.2118/169307-MS.
3. Ahmed, T., 2019, Reservoir Engineering Hand book. Fourth Edition, Gulf Professional Publishing, Houston, Texas, USA,.26-286.
4. Young, R., 2018, A review of Talang Akar Formation (Oligo-Miocene) reservoirs in the offshore areas of Southeast Sumatra and Northwest Java. https://doi.org/10.29118/ipa.2029.177.210.