Petrophysical Analysis to Determine the Initial Oil Reserves in the AHP Field

Apolonius Harda Putranta Sudi\textsuperscript{1}, Ratnayu Sitaresmi\textsuperscript{2*}, Prayang Sunny Yulia\textsuperscript{1}

\textsuperscript{1}Teknik Perminyakan Universitas Trisakti, Indonesia
\textsuperscript{2}Magister Teknik Perminyakan Universitas Trisakti, Indonesia

\textsuperscript{*}rsitaresmi@trisakti.ac.id

Abstract. Petrophysical analysis is carried out for the evaluation of petrophysical parameters. The aim of this paper is to determine the initial oil in place (OOIP) by Volumetric method in the field that will be conducted research, such as reservoir thickness (h) or net pay, porosity (\(\phi\)), and also water saturation (Sw). This parameter is used to position the initial oil reserves (OOIP) at two wells that will be examined, namely A1-R wells and A5-R wells. After qualitative analysis of both wells, namely A1-R well and A5-R well, it was seen that A1-R and A5-R, the lithology well are dominated by limestone and After conducting qualitative analysis conducted quantitative analysis that is to find out the porosity (\(\phi\)), resistivity, water resistivity, water saturation (Sw) and net pay (h) of the two wells. From the calculation, the porosity value is obtained by 19\% in A1-R wells and the average porosity in A5-R wells is 26\%, water saturation (Sw) from A1-R wells and A5-R wells are 34\% and 28\% and net pay (h) values are 2.82 at A1-R wells and 2.83 in A5-R wells. After the volumetric calculation, the OOIP value of A1-R well and A5-R well is 8826315.716 STB and 85308364.22 STB.

1. Introduction

In this era of rapid technological development, many countries have explored the potential of renewable energy, but the need for oil in the world is undeniably still the most important source of fossil fuels. To increase productivity at the petroleum field, geophysical and geological studies continue. The geophysical studies that are often carried out are petrophysical analysis and seismic interpretation. Petrophysics analysis is important before the calculation of reserves. This analysis aims to determine the physical parameters of rocks such as shale content, porosity, permeability and saturation of water in a formation. Meanwhile, seismic interpretation method is carried out to get an overview of the sub-surface structure so that it can determine the shape of the lead layer below the Earth's surface. Based on petrophysics analysis and seismic interpretation, it can be estimated whether hydrocarbons located in the field can produce energy of great value and economic value or not. This research focused on petrophysical analysis of drilling well data and interpretation of seismic data. Petrophysics analysis aims to obtain the value of rock properties such as shale content (Vsh), rock porosity (\(\phi\)), water saturation (Sw), and net to gross value (N/G) of a reservoir. While seismic interpretation is done to obtain bulk reservoir volume (Vb) based on geometry.
2. Logging

Logging is a method of measuring the physical magnitude of rocks against the depth of a drill hole. In accordance with the purpose of logging is determining the physical magnitude of rocks, the basis of logging itself is the physical or petrophysical properties of the rocks (Harsono, 1997). Well Logging freely and simply means a recording recording of the depiction of properties, characters, traits, data, captions, and sub-surface sequences in a continuous and regular manner in harmony with the progress of the tool used. So that the resulting diagram will be an overview of the relationship between depth and the characters or traits in the formation (Rider, 1996).

3. Petrophysics Analysis

Petrophysics analysis is an analysis conducted in the field of measurement with well data as the main data. This analysis is carried out to determine the amount of certain physic rice in a formation in large units or litology in small units. Even smaller, this analysis can determine per-depth values at specific depth intervals. Some of these analyses are as follows: Volume Clay (Vcl) represents the volume of shale (Vsh) which shows how much shale/clay content is in a rock.

4. Qualitative Analysis

This analysis is a direct analysis using well data as the main reading. This analysis utilizes direct field data consisting of Gamma Ray (GR), Spontaneous Potential (SP) and Caliper log data in determining the permeable zone. As well as support of NPHI and RHOB log data in reservoir identification following Deep Resistivity log (LLD/ILD) in reservoir content identification.

5. Quantitative Analysis

Quantitative analysis is carried out after the completion of qualitative analysis in our qualitative analysis has determined the type of rock litilogy and the location of the oil and gas zone to be calculated. In this quantitative analysis we will calculate the values that will later be used as parameters in performing OOIP calculations. In this quantitative analysis, the values that will be calculated include sh value, porosity, water saturation (Sw), and water resistance value (Rw). Where these values will be used in calculating the amount of oil and gas content in the reservoir.

\[
V_{sh} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}
\]

\[
V_{sh} = 0.33 \left[2^{(2xGR)} - 1.0\right]
\]

\[
V_{sh} = 0.082 \left[2^{(3.7xGR)} - 1.0\right]
\]

Porositas absolute(\(\phi\)) = \(\frac{volume\ pori - pori\ total}{volume\ total\ batuan}\) x100%

Porositas efektif(\(\phi_e\)) = \(\frac{volume\ pori - pori\ berhubungan}{volume\ total\ batuan}\) x100%

\[
\phi_D = \frac{\rho_{ma} - \rho_b}{\rho_{ma} - \rho_f}
\]

\[
\phi_{tot} = \frac{\phi_D + \phi_N}{2}
\]
\[
\phi_{eff} = \frac{\phi Dc^2 + \phi Nc^2}{2}
\]

\[
\phi Dc = \phi D - (\phi Dsh \times Vsh)
\]

\[
\phi Nc = \phi N - (\phi Nsh - Vsh)
\]

\[
Vsh = \frac{GR \log - GR_{min}}{GR_{max} - GR_{min}}
\]

\[
R_{wa} = \frac{R_t}{F}
\]

\[
F = \frac{a}{\phi^m}
\]

**Sw Archie:**

\[
Sw^n = \frac{a \cdot Rw}{\phi^m \cdot Rt}
\]

**Sw Simandoux:**

\[
Sw = \frac{0.4 \times Rw}{\phi^2} \left[ - \left( \frac{Vsh}{Rsh} \right) + \frac{5x \phi e^2 \left( \frac{Vsh}{Rsh} \right)^2}{RxRt \left( \frac{Vsh}{Rsh} \right)} \right]
\]

**Sw Indonesian:**

\[
Sw = \left\{ \frac{1}{\sqrt{Rtx \left( \frac{Vsh \left( \frac{Vsh}{2} \right) + \phi^m}{\sqrt{Rx}} \right)}} \right\}^{\frac{n}{2}}
\]

\[
OOIP = \frac{7758xVbx\phi x Sw(N/G)}{Boi}, STB
\]
6. Results and Discussions

In determining the estimation of initial oil reserves in research wells required parameters in the form of porosity (Ø), water saturation (Sw), and net thickness (netpay). The information data can be obtained from logging tools that are analyzed qualitatively and quantitatively. Qualitative log interpretation is done by quick look or by looking at log curve deflection either single or combination without accompanied by calculation. From qualitative analysis on triple combo logs of each A5-R and A1-R wells obtained the amount of permeable layer depth interval at A5-R wells is 2166.4-2171.8
meters and at A1-R wells the amount of permeable layer depth interval is 2328.5-2332.7 meters. This type of lithology in the productive layer is dominated by limestone at A1-R wells and sandstones at A5-R wells that can be determined by looking at core analysis, geological history of formation deposition in apr field, and by cross plot between neutron log and log density. The result obtained from A1-R wells is a minimum GR of 32,827 ºAPI and a maximum GR of 110.66 ºAPI, while in A5-R wells the result is a minimum GR of 34.82 ºAPI and a maximum GR of 126.14 ºAPI. Calculation of shale volume using GR log curve because GR log is considered capable of distinguishing radioactive elements (shale) and non-radioactive elements (formation rocks). With the GR log method in the monitoring of shale volume, the average shale volume at A1-R wells is 18% and at A5-R wells is 23%. Next determine the value of effective porosity. The porosity required to calculate the estimation of hydrocarbon reserves in this paper is effective porosity that is porosity that has been corrected to the volume of shale contained in the formations analyzed. In A1-R wells, the average effective porosity is 13% and in A5-R wells there is an average effective porosity of 13.3%. Before determining sw value, data such as turtuositas factor value (a), sementasi factor (m), and saturation exponent (n) are usually obtained from SCAL (Special Core Analysis) data in this well. However, due to the absence of SCAL data on one of the wells in the APR field, the values a, m and n are assumed by assuming the data from the existing reference is a value of 1, m value of 2, and n value of 2. In the calculation of the initial estimated oil reserves, the thickness value of the layer is required. The thickness of the layer in question is the netpay value which is the thickness calculated by using the cutoff price of Ø, Vsh, and Sw. Determination of the cutoff volume of shale is qualitative, i.e. determining the vsh cutoff which together with the porosity cutoff value will limit the cartesian graph to four zones. One such zone is desirable, namely zones with high porosity and low shale volume. From the plot result, vsh cutoff value of 50% and porosity cutoff value of 8%. That is, vsh values greater than 50% are considered unproductive and porosity values smaller than 8% are considered unproductive so should be cut. From the data obtained such as the area of the two wells of 5000 acres, the average porosity in A1-R wells and A5-R wells is 19% and 26%, average water saturation of 34% and 28%, and average netpay of 2.82 and 1.83 ft, and Boi of 1.57 bbl/stb, obtained by OOIP using volumetric method at A1-R wells of 8826315,716 STB and 85308364.22 STB.

7. Conclusion

From the analysis and discussion that has been done, it can be concluded as follows:

1. Lithology in both wells namely A1-R wells and A5-R wells determined from the results of log data readings where in A1-R and A5-R wells rock lithology are dominated by limestone

2. The average porosity of both wells is 19% in A1-R wells and the average porosity in A5-R wells is 26%.

3. The calculation result for water saturation value (Sw) using simadoux calculation method, Indonesian method and Archie method obtained Sw value from A1-R well and A5-R well value of 34% and 28%.

4. By using the values of petrophysical calculation parameters obtained, the value of Original Oil In Place (OOIP) or oil reserves contained in A1-R wells and A5-R wells amounted to 8826315,716 STB and 85308364.22 STB.

5. In these two wells there is no gas because in these two wells the gas content is very small and not economical.

References

1. Bishop, M. G. 2000. Petroleum Systems Of The Northwest Java Province Java and Offshore South East Sumatra Indonesia. Colorado: USGS.

2. Triwibowo, B. 2010. Cut-Off Porositas, Volume Shale, Dan Saturasi Air Untuk Perhitungan Netpay Sumur O Lapangan C Cekungan Sumatera Selatan. Jurnal Ilmiah MTG, 3 (2).

3. Asquith, G. dan Krygowski, D., Basic Well Log Analysis (Second Edition), (AAPG, Oklahoma, 2004).
4. Sembodo, H & Nugrahanti, Asri, 2012. Penilaian Formasi II, Universitas Trisakti, Jakarta.
5. Sitaresmi, Ratnayu, 2020, Petunjuk Praktikum Penilaian Formasi. Jakarta.