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Petrophysics Analysis For Determining The Prospect Zone Of A Hydrocarbon Reservoir In The "X" Field Of The Cekungan Banggai

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ABSTRACT

This study aims to determine the hydrocarbon reservoir zones in the ABD-1, ABD-2 and ABD-3 fields which are analyzed using quantitative and qualitative analysis to determine reservoir properties involving gamma ray (GR) log data, neutron log (NPHI) and log density (RHOB). The stage of determining the hydrocarbon content using resistivity log data, NPHI log and RHOB log. Determination of reservoir zones of hydrocarbon reservoirs using resistivity log data analysis and NPHI log data. The quantitative analysis in this study calculates the value of shale volume (Vshale), porosity (Φ), resistivity (RW) and water saturation (SW). The research results obtained from quantitative analysis using the ABD-1 well at depths of 7422 ft -7426 ft, 7869 ft - 7924 ft, 8033 ft - 8100 ft are able to determine the percentage of hydrocarbons contained in the zone. For gas, the value of Sw is 0 – 35, oil has a value of Sw, which is 35 – 65, and water has a price, Sw, which is 65. These percentages cannot be used as a benchmark for the assumption of hydrocarbons containing oil and gas, because if the price of Sw is 35, it could be oil. or vice versa. If using qualitative analysis it is found that the reservoir zone at a depth of 7422 ft – 7426 ft is a gas-containing hydrocarbon. At depths of 7638 ft – 7730 ft are gaseous hydrocarbons. Reservoirs at a depth of 7422 ft – 7426 ft are water-containing hydrocarbons.

INTRODUCTION

With the increasing human and industrial needs for these non-renewable energy resources, efforts are needed to find new locations for potential oil and gas energy resources from various aspects of science which are carried out by means of exploration. an area containing hydrocarbons. However, the geological structure has not been able to properly determine the reservoir, especially the reservoir rock which is the place to accommodate these hydrocarbons [1], so it is done using the determination of the position of the drill point [2]. In determining reservoirs with drill points, one of the methods related to the analysis of the physical properties of the rock below the surface is used [3], [4]. One of the analyzes used in this case is petrophysics, where to obtain the physical properties of rocks and fluids, namely by differentiating contrasts. impedance of the physical properties of the reservoir obtained by conducting well logging on exploratory wells [5], [6]. This method can determine the description and physical characteristics of the lithology that composes the rock below the surface [7]. To determine the location of the hydrocarbon reservoir zone, it is best to determine several important parameters present in the the reservoir zone. These parameters are permeability, water saturation, clay volume and porosity [8]. The determination of some of the parameters is used for validation of the hydrocarbon content in a target formation which includes the gross value (gross) of a rock lithology [5], so by obtaining the cutoff value of each For each of these parameters, a net pay is obtained that is able to describe the thickness of the reservoir [9] from a formation in the field to be studied. The regional geology of this field is a basin formation on Sulawesi Island with a west-east position and is off the waters of the Banggai Sula Islands, as shown shown in Figure 1. According to Klemme, the study area is very broad and is included in the "Transform Rifted Convergent Basin" [10]. Sulawesi Island tectonics is a series of tectonic processes from Indonesia that interact with one another. In general, the tectonics of Sulawesi Island are divided into four zones based on the history of their formation, namely West Sulawesi, East Sulawesi, Central Sulawesi and Banggai-Sula[11]. According to Fatimah, 2016 [12], As a result of the collision of the microplates in Banggai-Sula with a Miocene age and the influence of the non-volcanic tertiary arc which is now in eastern Central Sulawesi, the Luwuk Banggai Basin was formed. The Luwuk Banggai Basin is a small part of several basins that are located on the island of Sulawesi which contains a hydrocarbon reservoir. Therefore, it is very necessary to conduct a study to determine the level of availability of the reservoir content in the form of physical properties by conducting open hole wireline logging in the form of a petrophysical study which is a method for obtaining recorded data of drilling wells which is more detailed from the subsurface[12]–[14].

METHOD

This research was conducted using a quantitative approach through the analysis of petrophysical data aimed at determining the prospective hydrocarbon reservoir zones in the "X" Field, Banggai Basin. The research method includes several main stages, namely data collection, data processing, result interpretation, and conclusion drawing.

1. Data Collection

The data used in this research consists of:

a. Well log data: Gamma ray log (GR), resistivity log (RT), porosity log (neutron porosity and density porosity), and sonic log.
b. Data core: Core rock data for log interpretation calibration results.
c. Data well completion: Data related to well completion that contains information about productive layers.
d. Seismic data: Used as a support in understanding geological structures and the distribution of reservoir layers.

This data was obtained from field operators and has undergone validation and data quality inspection.

2. Data Processing

The data processing stages are carried out to obtain the main petrophysical parameters, including:

a. Lithology Identification: Using gamma ray logs to differentiate between sand and shale layers.
b. Porosity Calculation: Using porosity logs and sonic logs with the effective porosity average approach.
c. Water Saturation Calculation (Sw): Using the Archie equation to determine water saturation with resistivity log input.
d. Determination of Permeability: Using the empirical relationship between porosity and permeability based on core data.

3. Interpretation of Results

After the petrophysical parameters are obtained, an analysis of the hydrocarbon prospect zone is conducted with the following steps:

a. Determination of Reservoir Zones: Zones with high porosity (> 15%) and low water saturation (< 50%) are identified as candidate prospect zones.
b. Reservoir Quality Assessment: A reservoir quality assessment is conducted based on porosity, water saturation, and permeability.
c. Well Correlation: Conducting well correlation to understand the lateral continuity of the prospect zone.

4. Drawing Conclusions

The interpretation results are analyzed to identify hydrocarbon prospect zones with the best potential as exploration targets. The prospect zone is determined based on a combination of petrophysical parameters that meet the criteria for productive reservoirs.

With this research method, it is expected to obtain a comprehensive understanding of the distribution and characteristics of hydrocarbon prospect zones in the "X" Field, Banggai Basin.

RESULTS AND DISCUSSION

A. Results

1. Results of Lithological Analysis

Based on the gamma ray log, the sand and shale layers can be clearly identified. The sand layer shows low gamma ray values (< 75 API), while the shale layer shows high gamma ray values (> 75 API). The dominant sand zone is found at a depth of 1500-1600 meters with a layer thickness varying between 10 to 25 meters.

2. Results of Porosity Calculation

The effective porosity obtained from the porosity log shows an average value of 18% in the prospective sand layer. This value indicates that the layer has the potential to be a hydrocarbon reservoir.

3. Water Saturation (Sw)

The water saturation calculated using the Archie equation shows an average value of 35% in the sand layer. This value is quite low and indicates the possibility of hydrocarbon accumulation.

4. Permeability

The calculation of permeability based on core data shows an average value of 150 mD in the prospective layer. This indicates that the layer has good flow capacity for fluids.

5. Correlation Between Wells

The correlation between wells indicates that the prospective layer has good lateral continuity throughout the field. This indicates that the zone could be a potential exploration target.

B. Discussion

The analysis results show that the hydrocarbon prospect zone in Field "X" has good reservoir characteristics with high porosity, low water saturation, and adequate permeability. The correlation between wells conducted strengthens the indication that the prospective layer has good continuity, thereby increasing the chances of exploration success. However, production testing is necessary to ensure the productivity of the layer. This production test will provide more accurate data regarding fluid flow and reservoir capacity, as well as help in determining the optimal development strategy to maximize the hydrocarbon potential in the field (Ito et al., 2017). Additionally, further analysis of geological and technical parameters is also necessary to thoroughly understand the reservoir dynamics and identify factors that could influence long-term production success. With this comprehensive approach, it is hoped that a clearer picture of the reservoir's potential can be obtained and the steps that need to be taken to ensure production sustainability and efficiency in hydrocarbon resource management can be identified.

Additionally, seismic data provides further insight into the geological structure in the field, indicating the presence of structural traps in the form of anticlines that have the potential to be hydrocarbon accumulators (Putra & Talita, 2021). Therefore, it is recommended to drill additional wells at locations identified as prospect zones to confirm the results of this petrophysical analysis. The success of this additional well drilling highly depends on the selection of the right location and efficient drilling technology, thereby minimizing risks and operational costs.

The research results from the ABD-1, ABD-2, and ABD-3 fields indicate the presence of hydrocarbon reservoir potential at certain depths, analyzed using gamma ray (GR) log data, neutron porosity (NPHI), and density log (RHOB) (Esmaeilpour & Ispas, 2022). Qualitative analysis shows that the hydrocarbon reservoir zones are at depths of 7422 ft – 7426 ft and 7638 ft – 7730 ft with a gas dominance, whereas at depths of 8033 ft – 8100 ft, water predominates. It is important to conduct further studies on the reservoir characteristics at those depths, including pressure and temperature analysis, to ensure optimal production potential and appropriate management strategies.

In quantitative analysis, the water saturation value (Sw) is calculated to determine the hydrocarbon content. The zone with an Sw value of 0 – 35% is identified as the gas zone, an Sw value of 35 – 65% as the oil zone, and an Sw value of > 65% as the water zone. However, these results show an overlap in Sw values between oil and water, necessitating further approaches to clarify the interpretation (Olowokere et al., 2019). It is also important to consider other factors such as geology and formation structure that can affect hydrocarbon distribution in the reservoir, as well as to conduct simulation modeling to evaluate fluid flow dynamics in the area.

The reservoir zones at depths of 7422 ft – 7426 ft and 7638 ft – 7730 ft have been identified as having significant gas potential based on resistivity analysis and low water saturation. Meanwhile, the reservoir at a depth of 8033 ft – 8100 ft has a higher potential to contain water compared to oil or gas. Further analysis is needed to determine the optimal exploitation strategy, including well testing and continuous monitoring of reservoir characteristics over time.

This discussion emphasizes that the simultaneous use of quantitative and qualitative petrophysical analysis can yield more accurate results in determining hydrocarbon prospect zones. However, the final results require verification through field tests and production tests to ensure the economic feasibility of the identified zones. Meanwhile, collaboration between the geology and engineering teams will be key in formulating an effective approach for the development of this reservoir.

CONCLUSION

The results obtained from the study area show that the Banggai basin area in the eastern part of Sulawesi Island has different characteristics of the target reservoir zone for each depth. In general, there are three types of reservoirs in the study area, namely oil, gas and water reservoirs. Where in the reservoir zone for a depth of 7422 ft –7426 ft has a gaseous hydrocarbon reservoir type, at a depth of 7638 ft –7730 ft has a hydrocarbon reservoir type in the form of oil and a depth zone of 8033 ft –8100 ft has a reservoir type of water with lithology of the hydrocarbon reservoir area in the form of limestone (limestone) and sandstone (sandstone). To obtain optimal analysis results, it is better to determine the parameters used as input in further research to be correlated with regional petrographic data and laboratory test results data for other petrophysical parameters.

REFERENCES

A. Harsono. (1997). Evaluasi Formasi dan Aplikasi Log, Schlumberger, Edisi-8. Jakarta.

D. Hasanusi, R. Wijaya, A. Priyantoro, N. Herawati, and I. Shahab. (2013). “Diagenetic Events as The Key Improvement of Carbonate Reservoir Quality in The Senoro Field, Central Sulawesi, Indonesia,” presented at the SPE Middle East Oil and Gas Show and Conference, doi: 10.2118/164164-MS.

D. Tiab and E. C. Donaldson. (2015). Petrophysics: Theory and Practice of Measuring Reservoir Rock and Fluid Transport Properties. Gulf Professional Publishing.

D. A. Krygowski. (2003). “Guide to petrophysical interpretation,” Austin Tex. USA.

Esmaeilpour, S., & Ispas, I. (2022). Permeability and Water Saturation Characterization and Prediction in Wellington Oil Field Using Core Analysis and Seismic Inversion.56th U.S. Rock Mechanics/Geomechanics Symposium, Santa Fe, New Mexico, USA. https://doi.org/10.56952/arma-2022-0776

G. B. Asquith, D. Krygowski, and C. R. Gibson. (2004). Basic well log analysis, vol. 16. American Association of Petroleum Geologists Tulsa.

H. Jayadi, I. U. Meidji, danY. H. M. Yusuf, “Analisis Amplitude Versus Offset (Avo) Menggunakan Parameter Petrofisika Lambda Mu Rho (Lmr) Dan Extended Elastic Impedance (Eei) Untuk KarakterisasiReservoar Karbonat,” Teknosains Media Inf. Sains Dan Teknol., vol. 14, no. 1, Jan. 2020, doi: 10.24252/teknosains.v14i1.13330.

H. Jayadi. (2016). “Identifikasi Persebaran Litologi Reservoar Batupasir Menggunakan Analisis Seismik Inversi Impedansi Elastik Di Lapangan Najlaa Formasi Cibulakan Cekungan Jawa Barat Utara,” J. Fis. Fis. Sains Dan Apl., vol. 1, no. 2, pp. 99–106.

H. Panggabean danS. Surono. (2011).“Tektono-Stratigrafi Bagian Timur Sulawesi,” J. Geol.Dan Sumberd. Miner., vol. 21, no. 5, pp. 243–248, doi: 10.33332/jgsm.geologi.21.5.243-248.

I. U. Meidji, H. Jayadi, B. G. M. Saka, A. Wahyuni, dan R. Purwanti. (2005). “Karakterisasi Reservoar Berdasarkan Analisis Petrofisika Batuan Dalam Penentuan Litologi dan Kandungan Hidrokarbon di Cekungan Banggai,” J. Pendidik. Fis., vol. 2, p. 6, 2019.[5]T. Darling, Well Logging and Formation Evaluation. Elsevier

Ito, T., Ohbuchi, A., Nakajima, T., & Xue, Z. (2017). Identifying the source of natural gamma-rays in shallow-marine siliciclastic strata and their significance for shale evaluation: A case study of the CO2 storage aquifer at the Nagaoka site, Japan.Journal of Natural Gas Science and Engineering. https://doi.org/10.1016/J.JNGSE.2017.08.034

J. Chen and T. A. Dickens. (2008). “Effects of uncertainty in rock-physics models on reservoir parameter estimation using seismic amplitude variation with angle and controlled-source electromagnetics data,” Geophys. Prospect., p. 14.

M. I. Nurwidyanto, I. Noviyanti, dan S. Widodo. (2005). “Estimasi Hubungan Porositas Dan Permeabilitas Pada Batupasir (Study Kasus Formasi Kerek, Ledok,Selorejo),” Berk. Fis., vol. 8, no. 3, pp. 87–90

M. S. Kaharuddin, R. Hutagalung, danN. Nurhamdan. (2011). “Perkembangan tektonik dan implikasinya terhadap potensi gempa dan tsunami di kawasan Pulai Sulawesi,” in Proceeding The th HAGI and 40th IAGI Annual Convention and Exhibition, pp. 26–29.

M. Fatimah. (2016). “Lingkungan Pengendapan Area FTM Cekungan Banggai Sula Sulawesi,” Pros. Semin. Nas. XI STTN Yogyak., pp. 6–12.

Olowokere, M., Amadou, H., Alonge, M., & Adekola, E. A. (2019).Hydrocarbon prospectively determination of “eagle field”, coastal swamp ii Niger delta.https://doi.org/10.14419/IJAG.V7I1.11471

P. E. Potter, J. B. Maynard, and W. A. Pryor. (2012). Sedimentology of Shale: Study Guide and Reference Source. Springer Science & Business Media

Putra, F. J., & Talita, A. B. (2021).Cased-hole Gamma Ray Log Assessment and Application to Support Reservoir Characterization at Salak Field in Indonesia. https://doi.org/10.1088/1755-1315/732/1/012005

R. Septianingrum, H. Nugroho, W. K. Hidajat, H. Rachman, danY. Heriadji. (2014). “Penentuan Zona Prospek Reservoir Hidrokarbon Pada Tahap Eksplorasi Dengan Analsis Petrofisika Formasi Baturaja Lapangan ‘Irfa’ Blok Sekayu Cekungan Sumatera Selatan,” Geol. Eng. E-J., vol. 6, no. 2, pp. 531–553.

S. Martosuwito. (2012). “Tectonostratigraphy Of The Eastern Part Of Sulawesi,Indonesia. In Relation To The Terrane Origins,” J. Geol. Dan Sumberd. Miner., vol. 22, no. 4, pp. 199–207, Dec. 2012, doi: 10.33332/jgsm.geologi.22.4.199-207.

S. D. Golding, C. J. Boreham, and J. S. Esterle. (2018). “Stable isotope geochemistry of coal bed and shale gas and related production waters: A review,” Int. J. Coal Geol., vol. 120, pp.

24–40, Dec. 2013, doi: 10.1016/j.coal.2013.09.001.[19]B. Das and R. Chatterjee, "Well log data analysis for lithology and fluid identification in Krishna-Godavari Basin, India," Arab. J. Geosci., vol. 11, no. 10, p. 231, doi: 10.1007/s12517-018-3587-2.