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Integration of Petrophysical data for formation evaluation and permeability prediction in Siliciclastic sedimentary lithology

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Abstract
This study aims to conduct an integrated analysis of the M18-01 well with the approach of sedimentology, stratigraphic sequence, and petrophysical concepts. The data used include well logging data, RCAL (Routine Core Analysis), SCAL (Special Core Analysis), petrography, XRD, SEM, and biostratigraphy. The results of the analysis are used to determine the facies, depositional environment, sedimentation dynamics, cyclic stratigraphic conditions, and petrophysical properties of rocks in the target zone. In addition, permeability prediction was also carried out using the single regression method based on the regression between porosity and permeability of core rocks. The results showed that the average permeability value of this well is low for a reservoir zone. In addition, lithology analysis was also conducted using a combination of density, neutron log, and Gamma ray log. The results of this study are expected to contribute to a deeper understanding of the reservoir characteristics in the M18-01 well.

Keywords: Petrophysics, permeability, data integration, sedimentology

1. Introduction

The Meruap Block is located in the Sarolangun District, Sarolangun Regency, Jambi Province (Figure 1). The area is known to be a proven hydrocarbon-producing region. Physiographically, the Meruap Block is situated in the northern part of the South Sumatra Basin, or more precisely in the Central Palembang Sub Basin. The physiographic boundaries of the Central Palembang Sub Basin are demarcated by the Bangko Highlands to the west and the Twelve Mountains to the north (Pulunggono *et al*., 1992) [32]. This basin extends from the northwest to southeast between the Barisan Hills towards the south-west, and from the Strait of Malacca and the Karimata and Java Seas towards the northeast-east (De Coster, 1974) [74], the South Sumatra Basin was formed as a pull-apart basin due to the right-lateral rotation tendency of the NW-SE strike-slip fault. This has led to the South Sumatra Basin being dominated by the development of a continental rift basin. The South Sumatra Basin is also a prolific basin with hydrocarbon-producing layers ranging from the Air Benakat Formation, Gumai Formation, to the Talang Akar Formation. In the exploration activities that have been carried out, several problems were found that need to be resolved in the M18-01 well related to the reservoir target. Some of the problems encountered start from the character of the reservoir target, determination of the depositional environment, formation salinity, stratigraphy, and several other problems related to the target zone. To answer these problems, it is necessary to conduct integrated research with the conceptual approach of sedimentology, stratigraphic sequence and petrophysics. The method used is the integration of analysis of various data obtained from well logging data, RCAL (Routine Core Analysis) data, SCAL (Special Core Analysis), petrography, XRD, SEM and biostratigraphy in the M18-01 well. From the results of the analysis, it can be determined the facies, depositional environment and sedimentation dynamics in the research target zone, the condition of the stratigraphic sequence in the research area, especially in the zone close to the M18-01 well, and the petrophysical properties of rocks in the target zone related to SCAL and RCAL data.

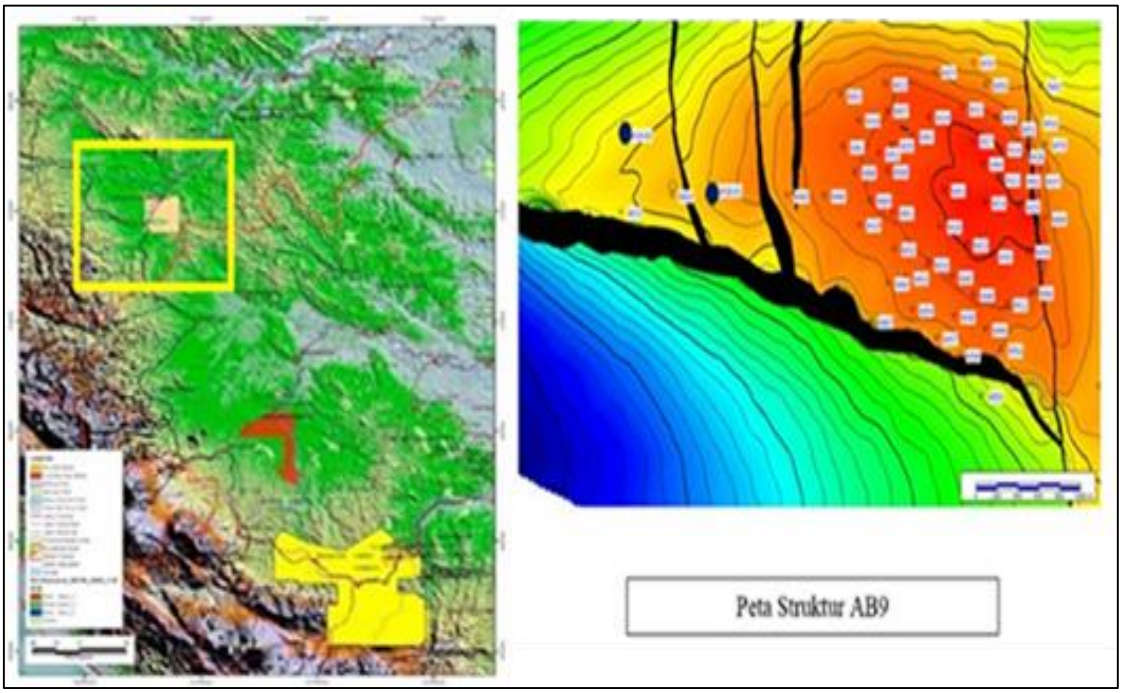

Fig 1: Location map of the study area

2. Materials and Methods

This study uses raw data, processed data and interpreted data. Raw data is LAS data from each well including caliper log data, gamma ray, spontaneous potential, density, sonic, resistivity, neutron, etc. (Table 1). Processed data is raw data that has been processed but has not been interpreted, processed data includes mud log data (Fig 2), core (Fig 3), SCAL and RCAL data from well M18-01.

3. Results and Discussion

Petrophysical analysis is conducted to determine the physical properties of rocks and formation evaluation. In addition, petrophysical analysis also aims to assist in the integration of other data such as core rock sedimentology, stratigraphic sequence and so on.

Petrophysical data processing uses wireline data from well M 18-01 which has a depth of 4814.5-6510.25 ft. Identification of wireline log quality, gamma ray, density and neutron needs to be done before starting formation evaluation (pre-calc). The available density logs are in corrected condition according to the description in the wireline log report. The gamma ray and neutron logs did not have any information on the corrections made in the report, so both logs were assumed to be uncorrected. Further environmental correction procedures were not carried out in this study.

Table 1: Raw data from well M18-01

Well	M18-01
WIRELINE LOG	CAL
	CALA
	GR
	DT24S
	M2R1
	M2R2
	M2R3
	M2R6
	M2R9
	RMLL
	SPDH
	CNCF
	PE
	ZCOR
	SPDH
	TTEN
Core Sample	60 FEET
MUD LOG	v

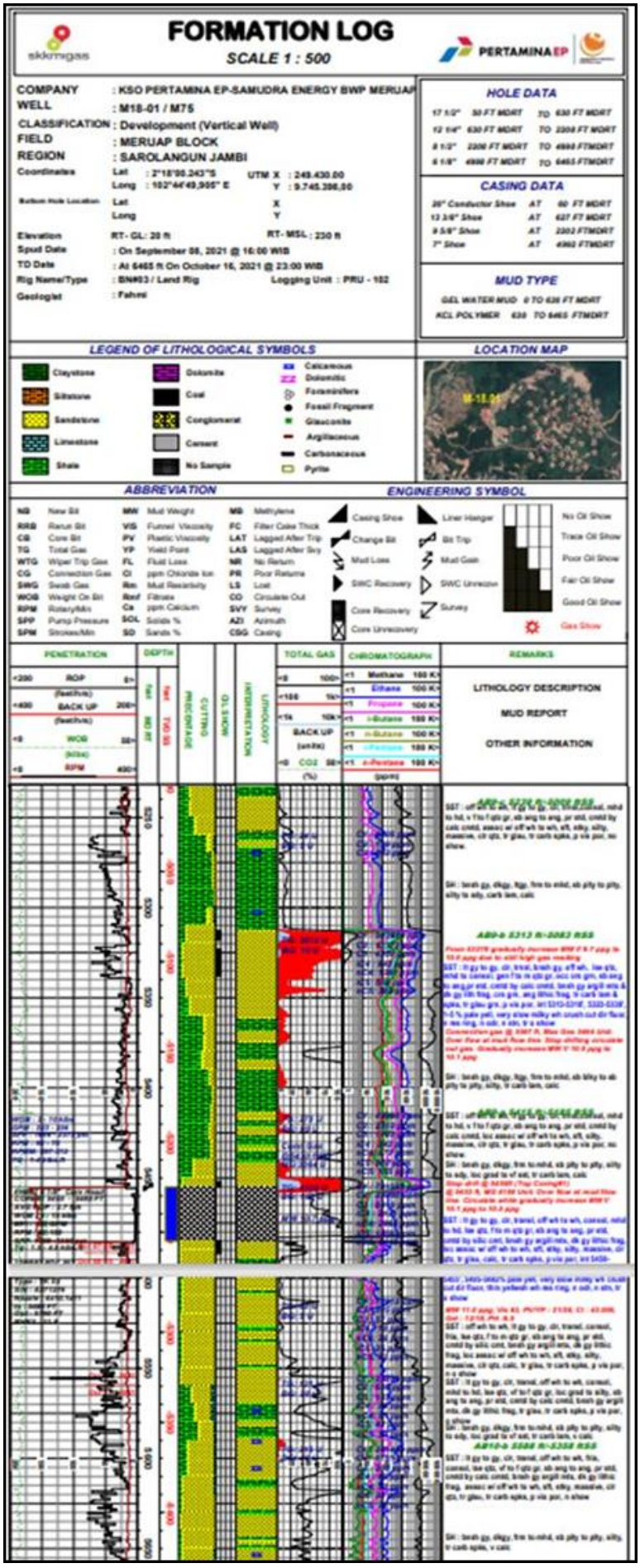

Fig 2: Mudlog data obtained at well M18-01

Fig 3: Example of core data taken at well M18-01

A. Environmental Correction & Quality Control Sumur M18-01

Well M18-01 has a badhole interval in the form of a breakout. The breakouts generally occurred in intervals with shale lithology resulting in poor density log recording. Badholes were identified by applying a cut off value on the caliper log of 1.5 in. The interval identified as a breakout is shown in Fig 4. In the figure the result of the hole breakout is shown. The intervals shown with red arrows, consistently show caliper log readings that exceed the cut off value.

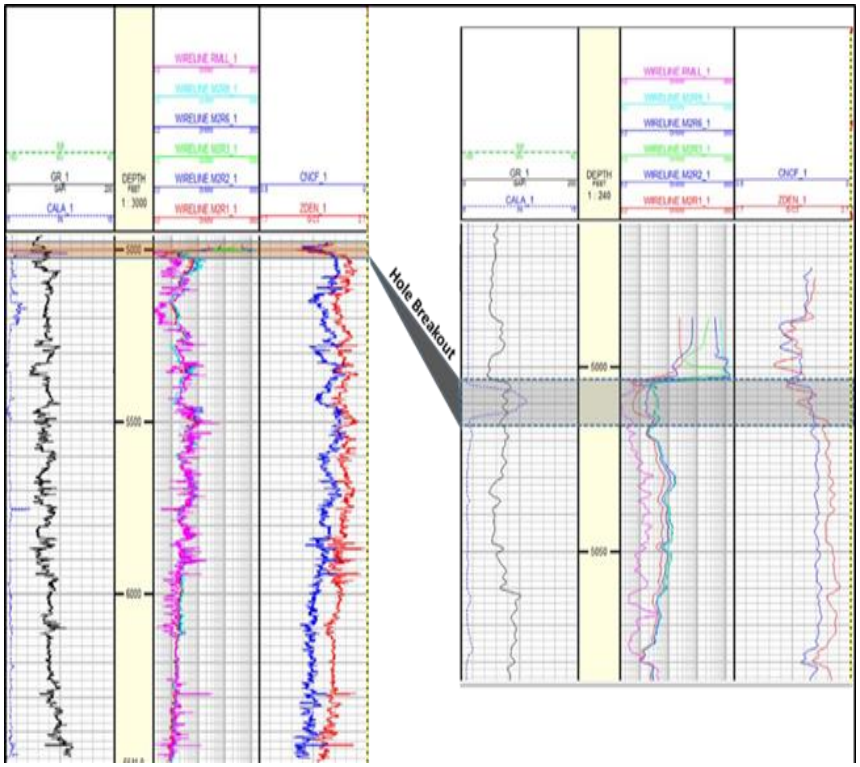

Fig 4: Identify the presence of badhole (hole breakout) well M18-01

The density log correction results have no significant changes, so the density log can be directly used for petrophysical analysis.

B. Lithology Analysis of Well M18-01

The lithology of Well M18-01 was determined using a combination of density and neutron logs (Fig 5) and by using Gamma ray logs (Fig 6). The lithology in this well can be divided into 2, namely shale and sand.

Shale is identified if the Delta DN log is positive, while sand is identified with a negative Delta DN log. The Delta DN log is the result of calculating the difference between neutron porosity and density porosity. A positive Log Delta DN means that the neutron porosity is higher than the porosity density, indicating shale lithology. While negative Log Delta DN means neutron porosity is lower than porosity density which indicates sand lithology.

Based on the corrected GR value, for clean GR is 42 API and for shale GR is 95 API. This value has been integrated using the cutting description.

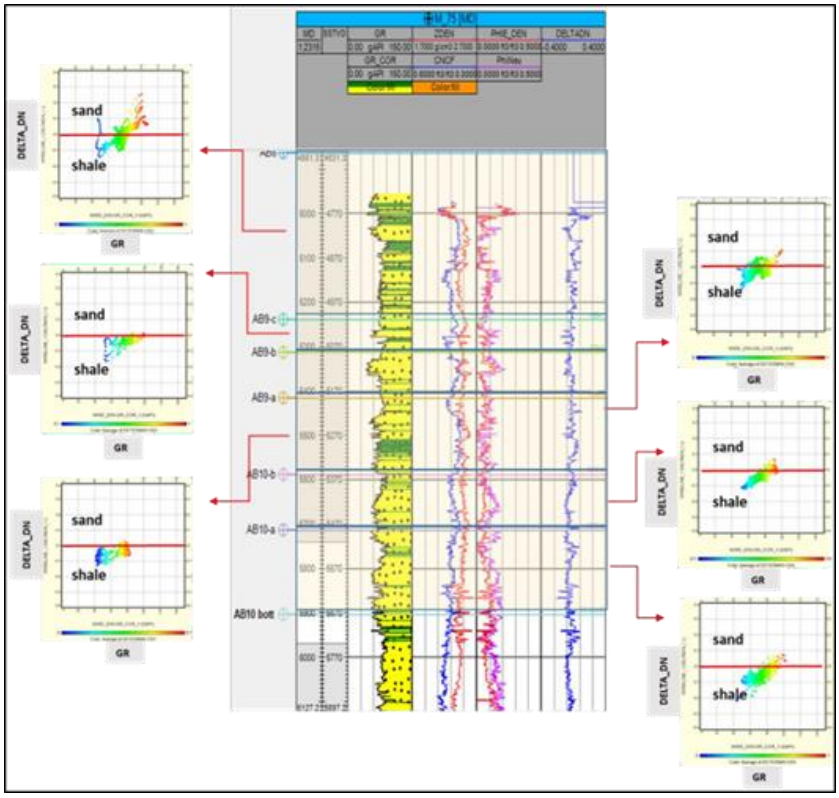

Fig 5: Lithology analysis results at Well M18-01

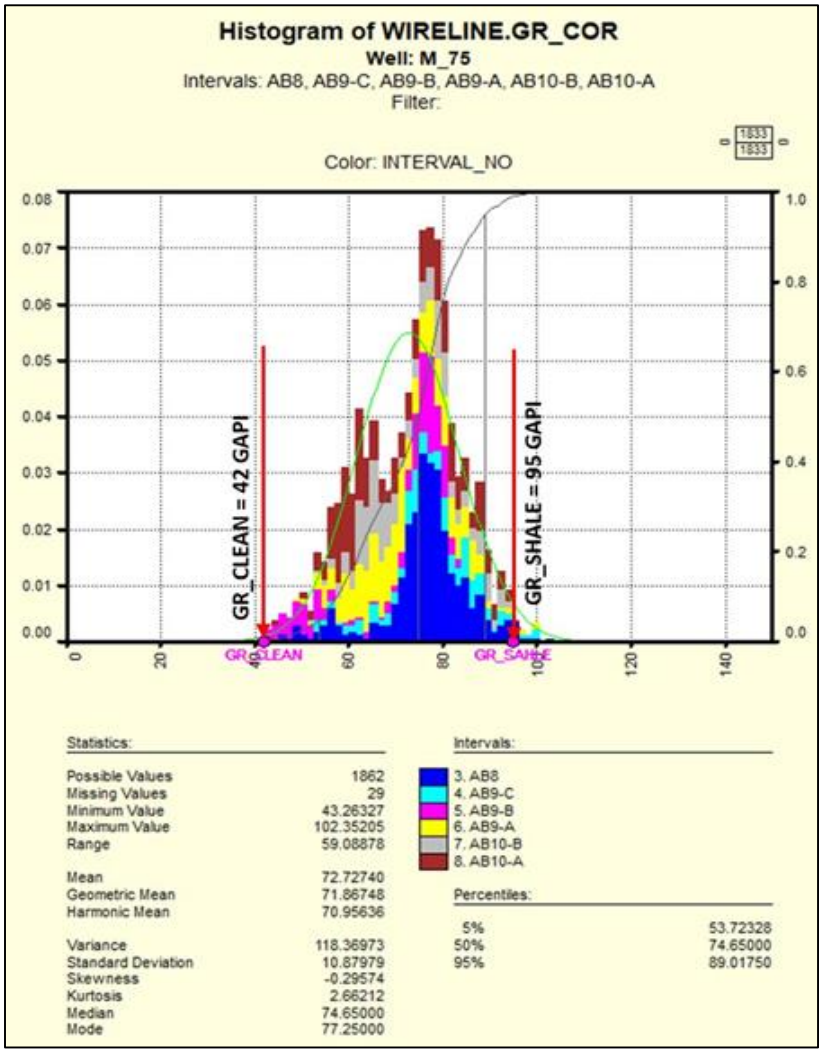

Fig 6: GR clean and GR shale well M18-01

C. Parameter Piking

The piking parameters are determined respectively based on the zoning that has been made. Fig 7 shows a cross plot between density vs neutron and vsh vs deep resistivity to determine the value of neutron, density, and resistivity readings against shale. The matrix density value is 2.65 because the rock in well M18-01 is a siliciclastic sedimentary rock. The dry shale density value is 2.71 and the neutron shale is 0.08 (Fig 7.).

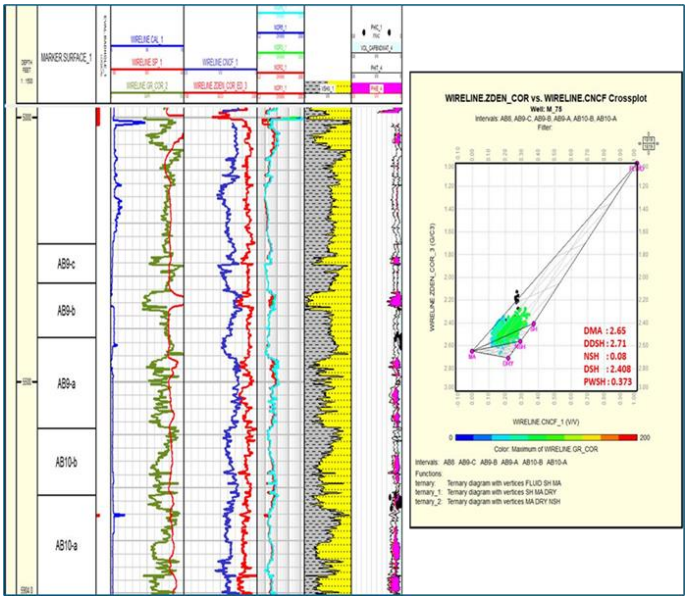

Fig 7. Density and neutron determination of shale in Well M18-01

The determination of the water zone can only be identified based on mudlog data at a depth of 5000-5050ft. The mudlog description explains that this interval is sandstone with no show and minimal gas readings (Fig 8). The picket plot between PHIT and resistivity in this interval shows an Rw value of 0.4 Ohmm at formation temperature. The clay resistivity value is inferred based on the resistivity value in the interval with more than 80% shale content, and the clay resistivity value is 1.37 Ohmm (Fig 9).

The results of the water saturation calculation show that intervals with low water saturation are only found in the AB9-a zone and AB10-a zone with a saturation value range of 60% - 90% (Fig 8).

D. Permeability Prediction

Permeability prediction is done using the single regression method, which looks at the regression between porosity and permeability of the core rock. The core rock data used for permeability prediction is in zones AB9-b and AB10-a where AB9-a represents the claystone interval and AB10-a represents the sandstone interval. The equation obtained from the regression of core rock porosity and core rock permeability is used to predict permeability values in intervals that do not have core rock data. Figure 4.41 shows the regression and the equation used.

The permeability value in this well ranges from 0.01 - 1 mD. This is not much different from the permeability value of the core rock data which ranges from 0.01 - 0.09 mD (Fig 9). The result of the cross plot between the predicted permeability and the core rock permeability is 0.71 which means that the comparison between the two is representative. The average permeability value of this well is low for a reservoir zone.

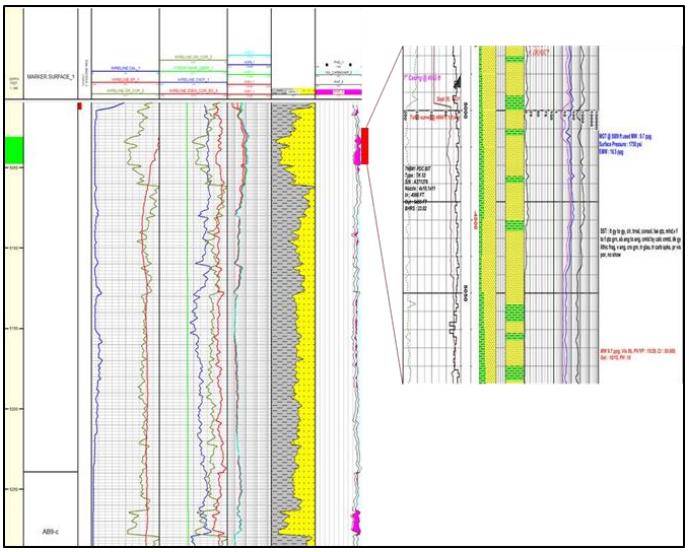

Fig 8. Water zone at well M18-01

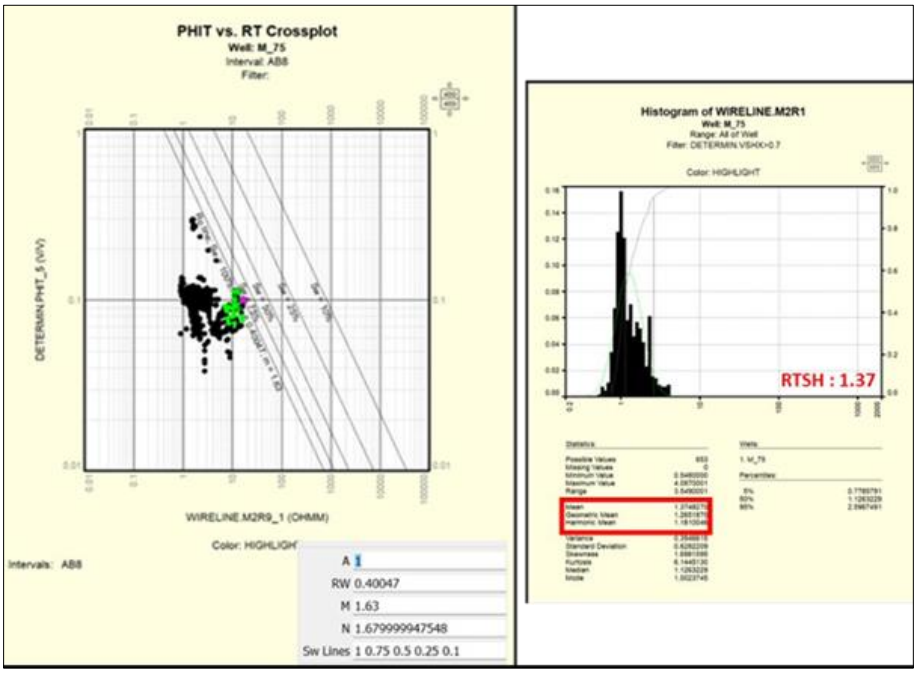

Fig 9: Water resistivity and clay resistivity parameters

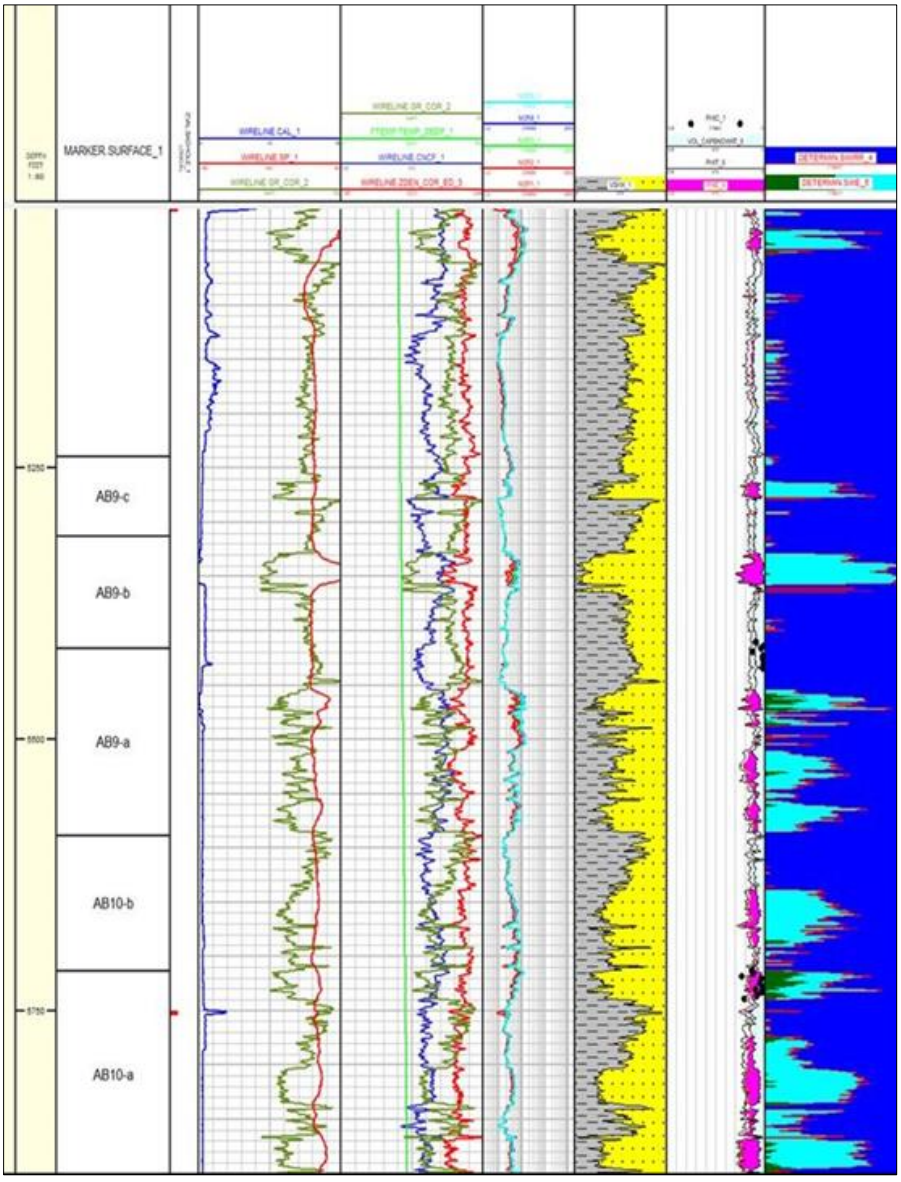

Fig 10: Water saturation in well M18-01

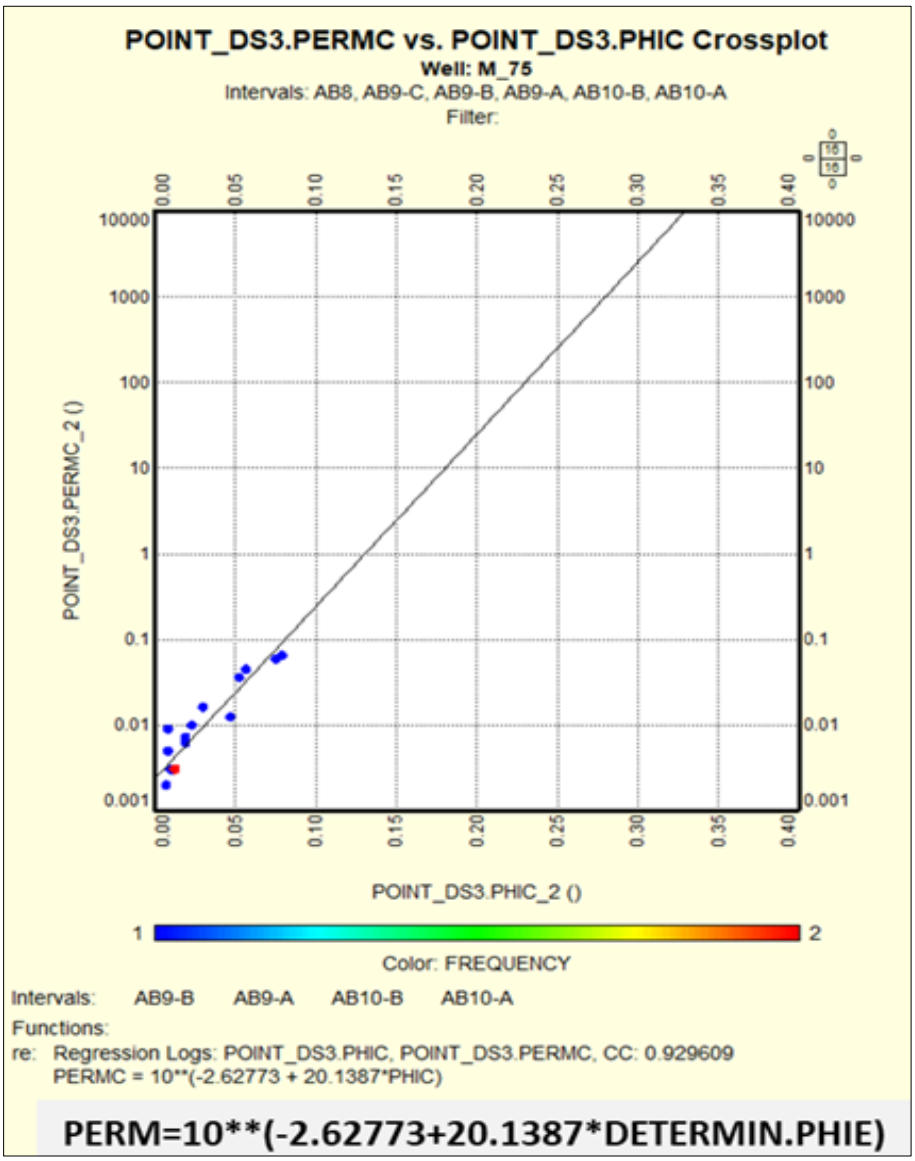

Fig 11: Regression of porosity and permeability of core

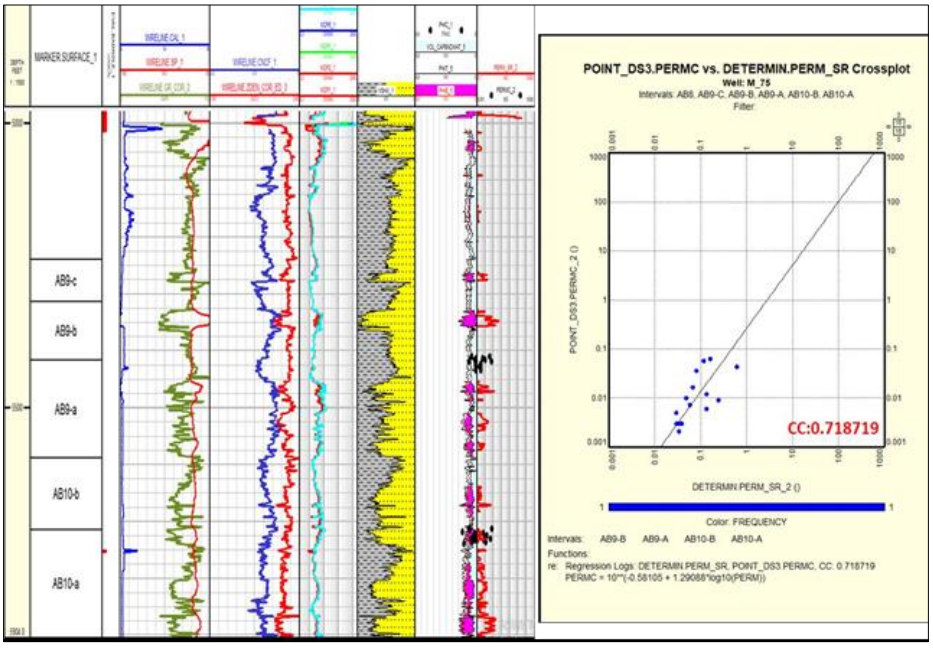

Fig 12: Permeability prediction results and cross-plots of core rock permeability and prediction

4. Conclusion

1. Petrophysical analysis of well M18-01 was conducted to determine the physical properties of rocks, formation evaluation, and water zone determination. The wireline data of well M18-01 is used to identify the quality of wireline log, gamma ray, density, and neutron before starting formation evaluation.
2. The results of the water saturation calculation show that the interval with low water saturation is only found in the AB9-a zone and AB10-a zone with a saturation value range of 60% - 90%.
3. The problems encountered in the M18-01 well related to the reservoir target require integrated research with the conceptual approach of sedimentology, stratigraphic sequence, and petrophysics. An integrated method of analysis of various data, such as well logging data, RCAL, SCAL, petrography, XRD, SEM, and biostratigraphy, is needed to answer these problems.
4. Permeability prediction was done by single regression method, with the result that the average permeability value of this well is relatively low for a reservoir zone.
5. Lithologic analysis results show that the density log correction results do not change significantly, so the density log can be directly used for petrophysical analysis.

5. Acknowledgements

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6. Reference

1. Argakoesoemah RMI, Kamal A. Ancient Talang Akar Deepwater Sediments in South Sumatra Basin: A New Exploration Play. Proceedings, Deepwater and Frontier Exploration in Asia & Australasia Symposium. IPA. DFE04-OR-009; c2004.
2. Armstrong H, Brasier M. Microfossils. United Kingdom: Blackwell Publishing; c2005.
3. Ariyanto Y. Pemodelan Impedansi Akustik Untuk Karakterisasi Reservoar Pada Daerah "X", Sumatera Selatan. Skripsi, FMIPA Universitas Indonesia, Jakarta; c2011.
4. Berggren WA, Berggren WA. A Revised Cenozoic Geochronology and Chronostratigraphy. In: eds. Geochronology Time Scales and Global Correlation, SEPM Special Publication. 1995;54:129-212.
5. Blow WH, Bronnimann P, Renz HH. Late Middle Eocene to Recent Planktonik Foraminiferal Biostratigraphy. In: eds. 1st Conf. on planktonik microfossils, Proc. (Geneva, 1967). Leiden: E.J. Brill; c1969. p. 199-412.
6. Blair TC, McPherson JG. Alluvial Fans and Their Natural Distinction from Rivers Based on Morphology, Hydraulic Processes, Sedimentary Processes, and Facies Assemblages. J Sediment Res. 1994; 64(3):450-489.
7. Bishop MG. Petroleum Systems of the Northwest Java Province Java and Of shore South East Sumatra Indonesia. USA: USGS; c2000.
8. Bolli HM, et al., eds. Plankton Stratigraphy. Cambridge: Cambridge Univ. Press; c1985.
9. Edgar NT, Saunders JB, Bukry D. Low latitude Coccolith biostratigraphic zonation. In: eds. Init. Repts. D.S.D.P. 1973;16:685-703.
10. Bukry D, Larson RL, Moberly R. Coccolith and Silicoflagellate stratigraphy, Northwestern Pacific Ocean. In. eds. Init. Reports. D.S.D.P., 1975;32:677-701.
11. Clure J, Fiptiani N. Hydrocarbon Exploration in The Merang Triangle, South Sumatra Basin. Proceedings, Indonesian Petroleum Association Twenty-Eight Annual Convention & Exhibition, IPA01-G-010; c2001.
12. De Coster GL. The Geology of the Central and South Sumatra Basins. In: Proceedings Indonesian Petroleum Association (IPA) 3rd Annual Convention; c1974. p. 77-110.
13. Dickinson WR, Beard LS, Brakenridge GR. Provenance of North American Phanerozoic sandstones in relation to tectonic setting. Geological Society of America Bulletin. 1983;94:222-235.
14. Darlymple RW, Choi K. Morphologic and Facies Trends Through the Fluvial-Marine Transition in Tide-Dominated Depositional Systems: A Schematic Framework for Environmental and Sequence-Stratigraphic Interpretation. Earth-Science Reviews. 2007;81(3-4):135-174.
15. Desjardins PR, Buatois LA, Mangano MG. Tidal Flats and Subtidal Sand Bodies. In: Developments in Sedimentology Amsterdam: Elsevier B.V. 2012;64:529-561.
16. Ferdiyanto G, Sunardi E, Ismawan. Analysis of sequence Stratigrap Hy, Lemat Formation to Gumai Formation, Gn Field, South Sumatra Basin. Proceedings, Indonesian Petroleum Association Twenty-Ninth Annual Convention & Exhibition, IPA03-SG-006; c2003.
17. Galloway GE, Hobday DK. Terrigenous Clastic Depositional Systems: Applications to Fossil Fuel and Groundwater Resources. 2nd ed. Germany: Springer-Verlag; c1996. p. 489.
18. George P, James A, MacEachern S, et al. Developments in Sedimentology. Netherlands: Elsevier B.V.; 1995;64:216.
19. Germeraad JH, Hopping CA, Muller J. Palynology of Tertiary sediments from tropical areas. Review of Palaeobotany and Palynology. 1968;6:189-348.
20. Ginger D, Fielding K. The Petroleum Systems and Future Potential of the South Sumatra Basin. In: Proceedings of the Indonesian Petroleum Association 30th Annual Convention and Exhibition, Indonesia; c2005.
21. Heidrick TL, Aulia K. A structural and Tectonic Model of the Coastal Plain Block, Central Sumatera Basin, Indonesia. Proceedings, Indonesian Petroleum Association 22nd Annual Convention. Jakarta; c1993. p. 285-316.
22. Hori K, Saito Y, Zhao Q, Cheng X, Wang P, Sato Y, Li C. Sedimentary Facies of the Tide-Dominated Paleo-Changjiang (Yangtze) Estuary During the Last Transgression. Mar Geol. 2001;177:331-351.
23. Ingle JC, Keller G, Kolpack RL. Benthic foraminiferal facies, sediments and water masses of the southern Peru-Chile Trench Area, Southeastern Pacific Ocean. Micropaleontology. 1980;26(2):113-150.
24. Jones SJ. Introducing Sedimentology. Edinburgh: Dunedin Academic Press Ltd; 2015.
25. Jones RW. Challenger Foraminifera. Oxford: Oxford University Press; c1994. p. 149.
26. Koesoemadinata RP. Outline of Geologic Occurrence of Oil in Tertinary Basins of West Indonesia. AAPG Bull.

1969;53(11):2368-2376.
27. Koesoemadinata RP. Tertiary Coal Basins of Indonesia. In: Prepared for the 10th Ann. Of CCOP, Geology Survey of Indonesia. Oxford: Wiley-Blackwell; c1976. p. 419.
28. Perch-Nielsen K, Bolli HM. Cenozoic Calcareous Nannofossils. In: eds. Plankton Stratigraphy. Cambridge: Cambridge Univ. Press; c1985. p. 427-554.
29. PETRONAS. Chronostratigraphic Chart of the Cenozoic and Mesozoic Basins of Malaysia; c2007.
30. Pettijohn FJ. Sedimentary Rocks. 2nd ed. New York: Harper and Row Publishers; c1975. p. 628.
31. Pulunggono A, Cameron NR. Sumatran Microplates, Their Characteristics and Their Role in Evolution of the Central and South Sumatra Basin. In: Proceedings PIT XII IAGI, IAGI, Jakarta; c1984.
32. Pulunggono A, Haryo A, Kosuma CG. Pre-Tertiary and Tertiary Fault System as A Framework of the South Sumatra Basin: A Study of SAR-MAPS. Proceedings Indonesian Petroleum Association 21st Annual Convention. Jakarta: IPA; c1992. p. 339-360.
33. Perillo GME. Geomorphology and Sedimentology of Estuaries. In: Developments in Sedimentology. Amsterdam: Elsevier B.V. 1995;53:471.