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Integrated Formation Evaluation to Peek and Unlock Hydrocarbon Potential in High Gamma Ray-High Resistivity of Argillaceous Thin-Bed Laminated Sandstone in The Ngrayong - Tawun Formation East Java Basin

Tino Diharja [1], Defri W. Widiyanto [2], Yugi Nusantara [2], Yudha H.M. [2]
[1] Research & Technology Innovation PT Pertamina (Persero), [2] PT Pertamina EP Cepu ADK

Abstract
Most of the old oil fields that producing from clastic reservoirs in the Cepu Block area have been exhausted and depleted with high water production (Water Cut > 90%) because these have been producing since the Dutch era. Most of the good quality oil reservoirs in clastic formations in the Cepu Block area have been found and produced. This makes a hard challenge to find new hydrocarbon potential in clastic reservoirs in this area.

Integrated formation evaluation from Mud Log, Advanced Wireline Log (Triple Combo Log, Borehole Image Log, Nuclear Magnetic Resonance Log, and Formation Tester) and Side Wall Core Analysis (Routine Core, Petrography, Scanning Electron Microscopy, and X-Ray Diffraction Analysis) data has been evaluated to find the upside potential of oil reservoir in the Ngrayong and Tawun Formation East Java Basin in the AK Field.

Based on the evaluation results, it was found the potential oil in the tight reservoir of Argillaceous Thin-Bed Laminated Sandstone with a distinctive characteristic of High Gamma Ray – High Resistivity. With this discovery, the Integrated Formation Evaluation in the AK Field has unlocked the hidden hydrocarbon potential in the clastic reservoirs of the Ngrayong and Tawun Formation in the Cepu Block area, East Java Basin. This has proven and opened new potential of tight oil sand (Unconventional Reservoir) in the Clastic reservoirs in the Cepu Block area, East Java Basin.

Doing further exploration on another area of East Java Basin and find out an effective production technology scheme for this tight Argillaceous Thin-Bed Laminated Sandstone reservoir become some challenges and could be the future interesting study topics, so that this potential could be found even greater and can be produced economically.

Keywords: *integrated formation evaluation, argillaceous sandstone, thin-bed laminated sandstone, tight oil sand, high gamma ray-high resistivity*

Introduction
AK Field is located in Cepu Block area in the western part of East Java Basin which is an area with a proven petroleum system and has produced a lot of oil and gas for Indonesia. Hydrocarbons from the cepu block are produced from old oil fields such as Kawengan, Ledok, Nglobo, Ngrayong, etc. as well as production from the Kujung carbonate reservoir on the cepu high platform such as Banyu Urip, Sukowati, Jambaran, Gundih, etc.

Most of the old oil fields that producing from clastic and shallow reservoirs such as Ledok, Wonocolo, and Ngrayong Formations in the Cepu Block area have been exhausted and depleted with high water production (Water Cut > 90%) because these have been producing since the Dutch era (Kristanto et. al, 2018). Most of the good quality oil reservoirs in clastic formations in the Cepu Block area have been found and produced. This makes a hard challenge to find new hydrocarbon potential in clastic reservoirs in this area.

From a subsurface perspective, the AK Field is located outside the cepu high platform area, so it is unlikely that a reef carbonate reservoir will form in this area. Therefore, exploration to find upside potential in the AK Field tends to be in some deeper clastic reservoirs such as the Ngrayong, Tawun, and Tuban Formations.

This paper focuses to discuss on utilization of integrated analysis formation evaluation from mud log, advanced wireline log, and Side Wall Core (SWC) analysis data to find out the upside potential of hydrocarbon reservoirs in the AK Field.

Data and Method
The data used for this evaluation are mud log data, advanced wireline logs data such as triple combo log, Borehole Image Log (BHI), Nuclear Magnetic Resonance Log (NMR), and Formation Tester that equipped by fluid analyzer and fluid sampling tools. In addition, Sidewall Core Analysis such as Routine Core Analysis (RCA), petrography, Scanning Electron Microscopy (SEM), and X-Ray Diffraction Analysis (XRD) are also used to provide a detailed description of the lithology, mineral content, and texture of rock samples. This comprehensive data mostly obtained from the N-1 exploration well which was drilled in 2017. In addition, this evaluation also uses data and information from 5 other existing wells in the AK Field.

Mud log data are used to determine the description and lithological characteristics from the cutting samples, evaluate gas readings (total gas and gas chromatography) and oil shows in the target zone as an indication of potential hydrocarbon.

Advanced wireline log data are used to calculate petrophysical parameters and reservoir characterization in the target zone so that rock and fluid parameter values such as porosity, permeability, water saturation, and fluid type are obtained. These parameters are the main key to finding the upside potential of hydrocarbon reservoir in AK Field.

SWC analysis is carried out by performing RCA to measure the porosity and permeability directly from the core sample, performing XRD analysis to determine bulk and clay mineralogy of rock samples, and thin section analysis such as petrography and SEM analysis to determine the description, composition, mineralogy, pore spaces, and texture of the rock samples microscopically.

Integrated formation evaluation from these data has been evaluated to find the upside potential of hydrocarbon reservoir in the Ngrayong and Tawun Formation East Java Basin in the AK Field (Figure 1).

Result and Discussion

Kristanto et. al. in 2018 has carried out an integrated evaluation using comprehensive wireline log data obtained from the N-1 well to find out of potential hydrocarbons in the AK field. The evaluation has found several indications of potential oil reservoirs in the Tawun and Tuban formations, one of which is the K1 layer which has tight reservoir characteristic (Figure 2). The evaluation in this paper combines mud log, thin section, core analysis, and advanced log data to be able to understand more comprehensively down to the microscopic level of the reservoir.

Layer K1 Tawun Formation

Gamma Ray (GR) log data shows high to medium GR (40 – 80) GAPI in layer K1 (Kristanto et.al., 2018). Neutron – Density log also does not show any cross-over as a sign of reservoir zone. With the standard log layer K1 can be misinterpreted as a non-reservoir zone.

However, this layer has a relatively higher resistivity log value compared to the shale zone. Other characteristics of reservoir K1 can also be seen from the crossplot of log Sonic (DT) – Neutron (NPHI), which in this reservoir has relatively lower NPHI and DT values than the shale zone (Figure 3).

Cuttings description, gas reading, and oil show from mud log data of 6 wells in AK Field (including newest data from N-1 well) it was known that the K1 layer is argillaceous sandstone reservoir with very fine to fine grains with high gas readings, that showing total gas up to 461 Units (Background Gas 10 Unit) and high gas chromatography readings from C1 – nC5. In addition, the K1 layer observed an oil shows (trace) (Figure 4).

Integrated analysis data from advance wireline logging and side wall core analysis has proven that this reservoir is oil zone with porosity up to 21% and free fluid volume (FFV) from NMR log up to 8% (Figure 6). FFV is the amount of fluid volume in the reservoir pores that can flow or be produced (movable fluid). FFV is associated or can also be interpreted as effective porosity. BHI log interpretation shows that the K1 layer is a bioturbated sandstone and from petrography analysis, this reservoir has laminated and burrowed texture with 58% framework grain, 25% clay matrix and 7% cement (Figure 5). The fluid analyzer from the gas chromatography readings shows that this reservoir is oil zone. In addition, fluid sampling using a formation tester was confirmed to get oil from reservoir K1. RCA shows reservoir K1 has porosity of 14 – 21% with low permeability of 0.8 – 11 mD. SEM and XRD analysis of K1 reservoir shows that clay minerals in the form of kaolinite and illite fill the pore space which causes a decrease of porosity and permeability and resulted in increasing of irreducible water due to increasing of microporosity (Figure 6). With this permeability value, it is difficult for this reservoir to be produced naturally and flow continuously without hydraulic stimulation. Drill Stem Test (DST) on previous wells proves that K1 reservoir produces oil but none of them can flow naturally and continuously.

It is technically proven that the K1 layer is an oil reservoir with High GR High Resistivity characteristics in the lithology of argillaceous bioturbated sandstone. The future challenges are how to produce oil from this tight reservoir and explore other upside potentials with similar characteristics around the East Java Basin.

Layer I1 Ngrayong Formation

The interesting thing from layer I1 Ngrayong Formation is that there is a high gas reading in the sandy-shale zone of this layer from N-1 well mud log data. Total gas readings reached 262 – 409 Units (Background Gas 40 – 90 Unit) and gas chromatography also increased from C1 – nC5 (Figure 4). This contrast with the good reservoir zone of this reservoir which is above it which tends to have no abnormal gas readings.

RCA shows the lower part of layer I1 has porosity of 14 – 16% with very low permeability of 0.3 – 5 mD. From the BHI log, SWC and petrographic photos, layer I1 has relatively the similar features as reservoir K1, but this layer tends to contain more shale (Figure 8). FFV from NMR log in layer I1 is about 1% (Figure 7). Based on this analysis, it can be concluded that the lower part of layer I1 has a poorer and tighter reservoir quality than layer K1. This condition makes the potential of hydrocarbon in this reservoir more challenging to produce.

However, to ensure further analysis is needed to determine whether the hydrocarbon indications in this reservoir are only residual oil or whether it is live oil (movable oil) in tight reservoirs that can be produced to the surface with a scheme similar to the production of shale oil such as with multistage hydraulic fracturing. If indeed the indications of hydrocarbon in this layer can be produced, it is quite interesting to find a way to produce it, considering that this silty-sandy shale/claystone is quite thick, reaching more than 50 meters.

Based on the evaluation results, it was found the potential oil in the tight reservoir of Argillaceous Thin-Bed Laminated Sandstone with a distinctive characteristic of High Gamma Ray – High Resistivity. With this discovery, the Integrated Formation Evaluation in the AK Field has unlocked the hidden hydrocarbon potential in the clastic reservoirs of the Ngrayong and Tawun Formation in the Cepu Block area, East Java Basin. This has proven and opened new potential of tight oil sand (Unconventional Reservoir) in the Clastic reservoirs in the Cepu Block area, East Java Basin.

Conclusions

Integrated formation evaluation from mud log, advanced wireline log, and side wall core data analysis was succeeded in finding and unlocking hidden hydrocarbon potential reservoirs with characteristic High GR High Resistivity in tight argillaceous-bioturbated sandstone on layer K1 Tawun Formation and thin bed laminated Silty/Sandy-shale to argillaceous sandstone on layer I1 Ngrayong Formation in AK Field. This integrated formation evaluation also help to understanding the microscopic internal characteristics of these tight reservoirs.

Doing further exploration on another area of East Java Basin and find out an effective production technology scheme for this tight Argillaceous Thin-Bed Laminated Sandstone reservoir become some challenges and could be the future interesting study topics, up to this potential could be found even greater and can be produced economically.

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Kristanto et. al., 2018, Proceedings IPA 42nd Annual Convention & Exhibition, IPA18-100-G.

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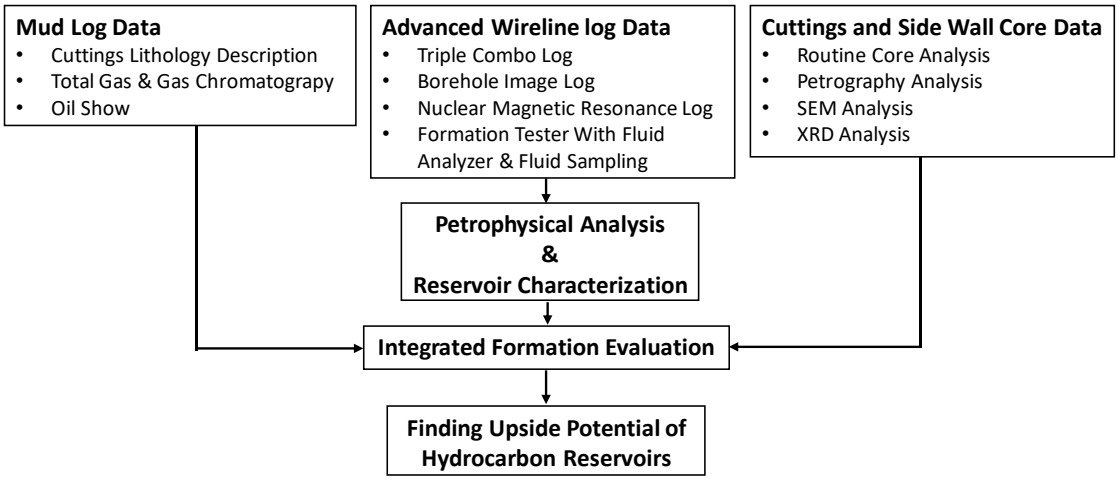

Figure 1. Evaluation flowchart

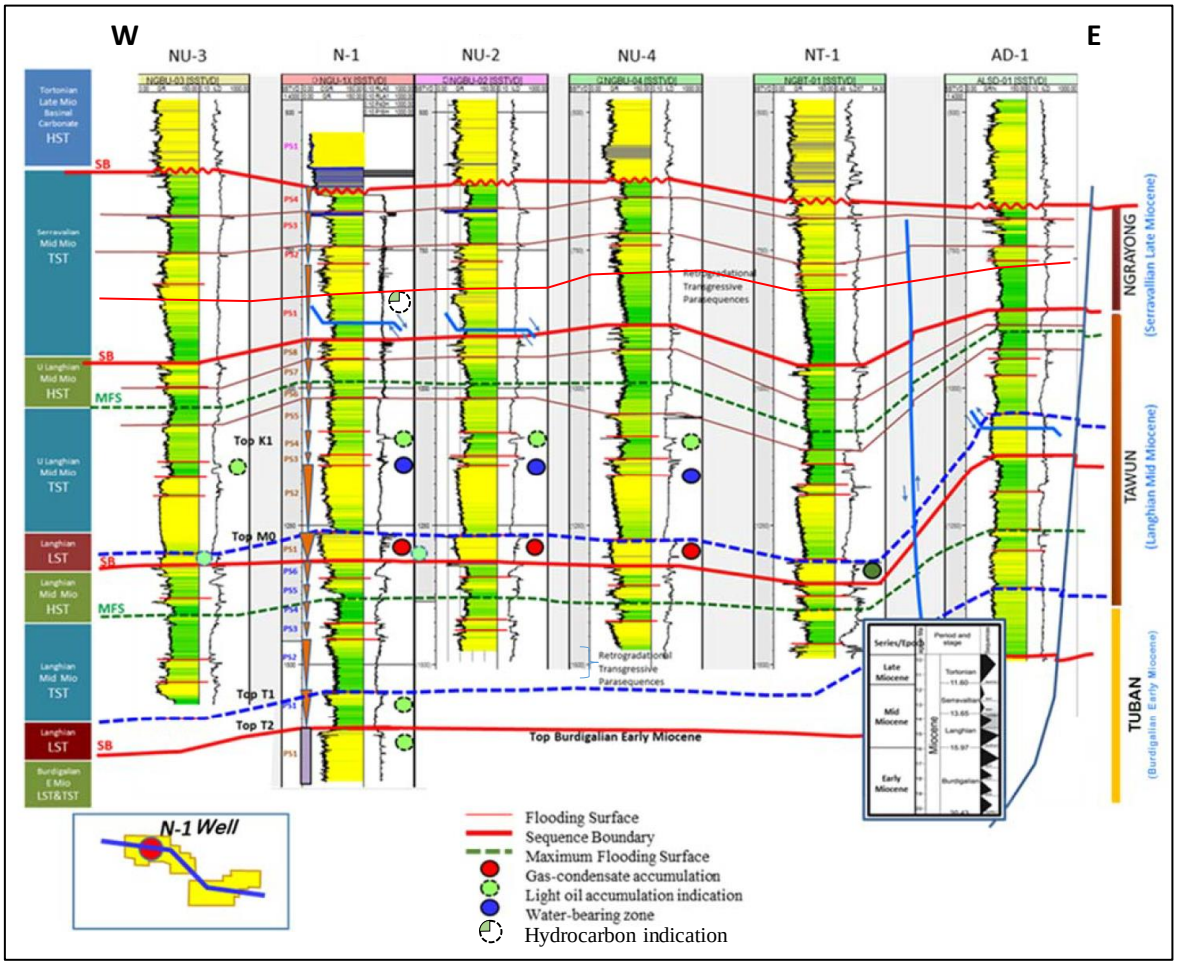

Figure 2. Wells log correlation of AK Field and information of hydrocarbon indication from each well (modified from Kristanto et al., 2018)

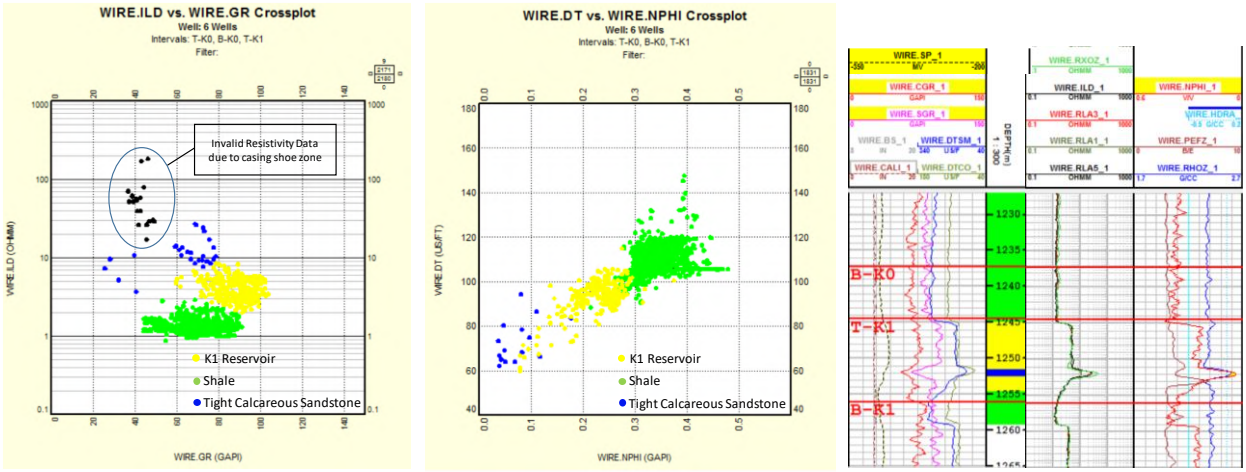

Figure 3. Resistivity (ILD) – Gamma Ray (GR) crossplot and Sonic (DT) – Neutron (NPHI) crossplot to identify and characterize K1 Reservoir.

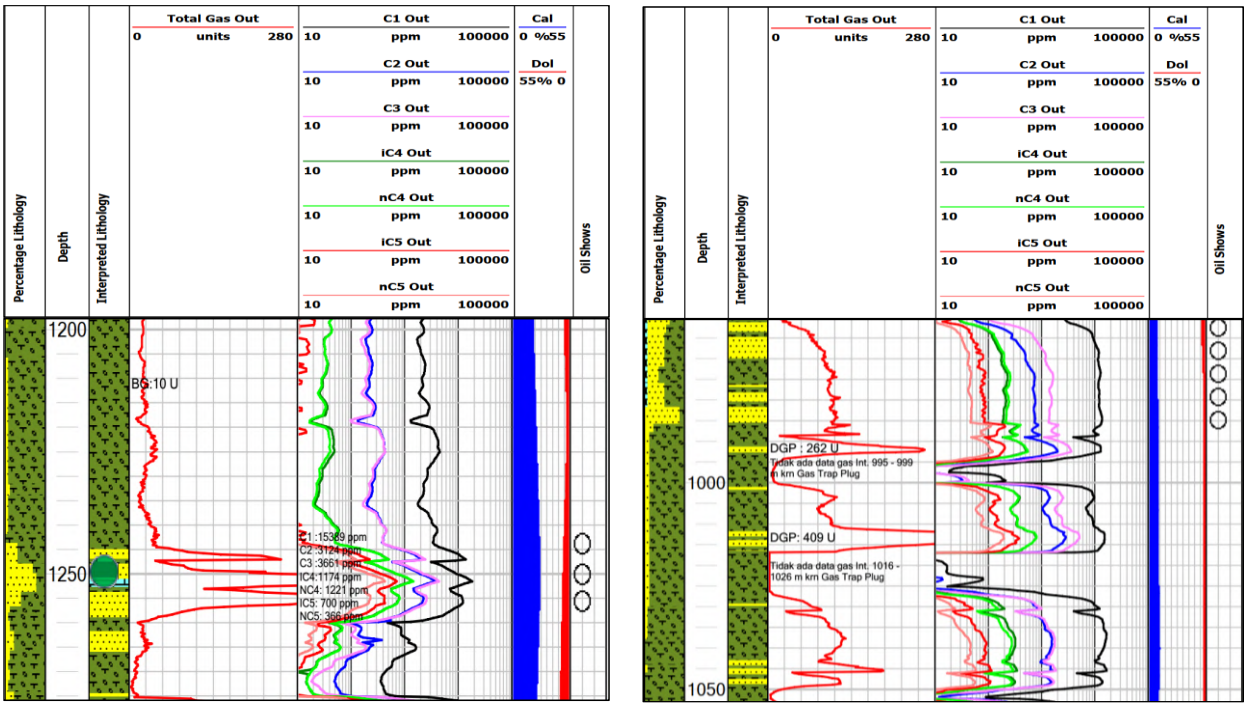

Figure 4. Mud log data layer K1 Tawun Formation (left) and Layer I1 Ngrayong Formation (right)

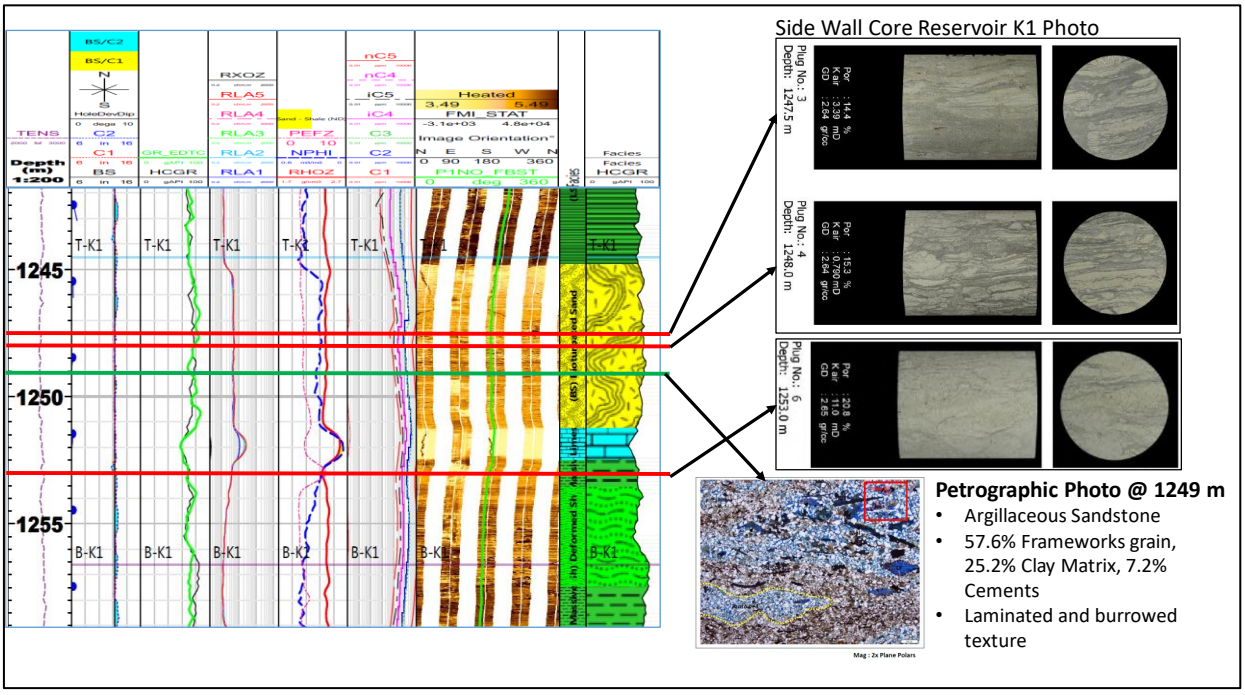

Figure 5. Integrated evaluation of Borehole Image Log data and Side Wall Core Analysis (Routine Core and Petrography Analysis) layer K1

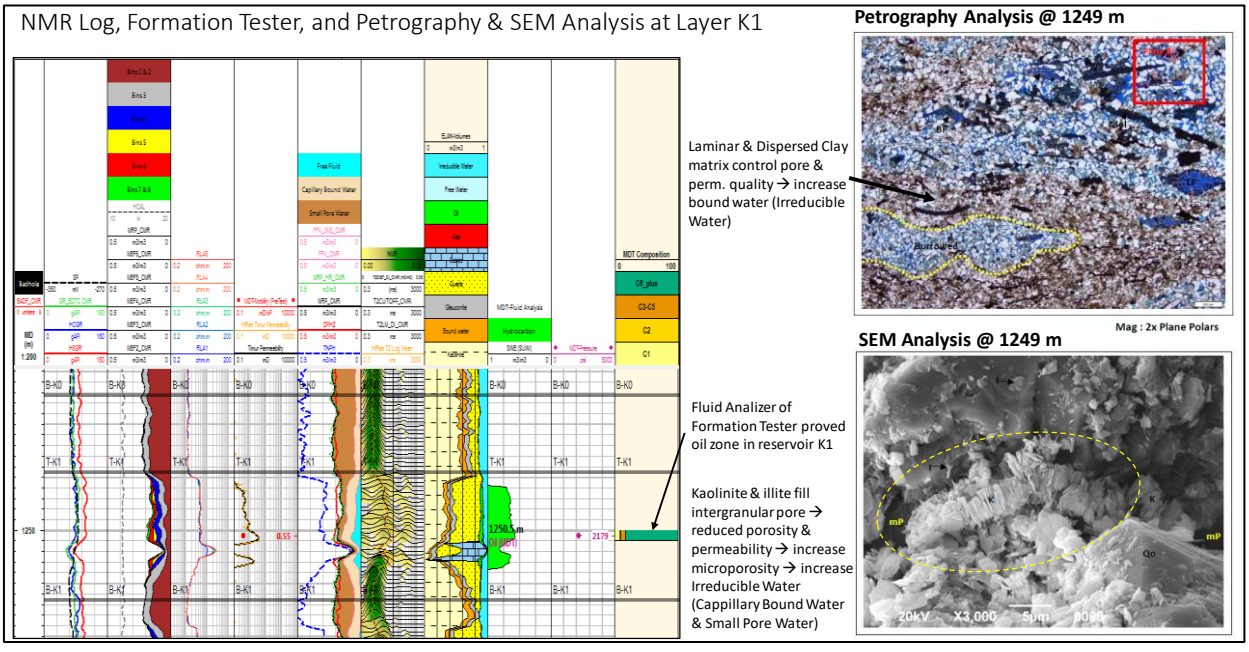

Figure 6. Integrated evaluation from NMR log, Formation Tester, Petrography and SEM Analysis data on layer K1

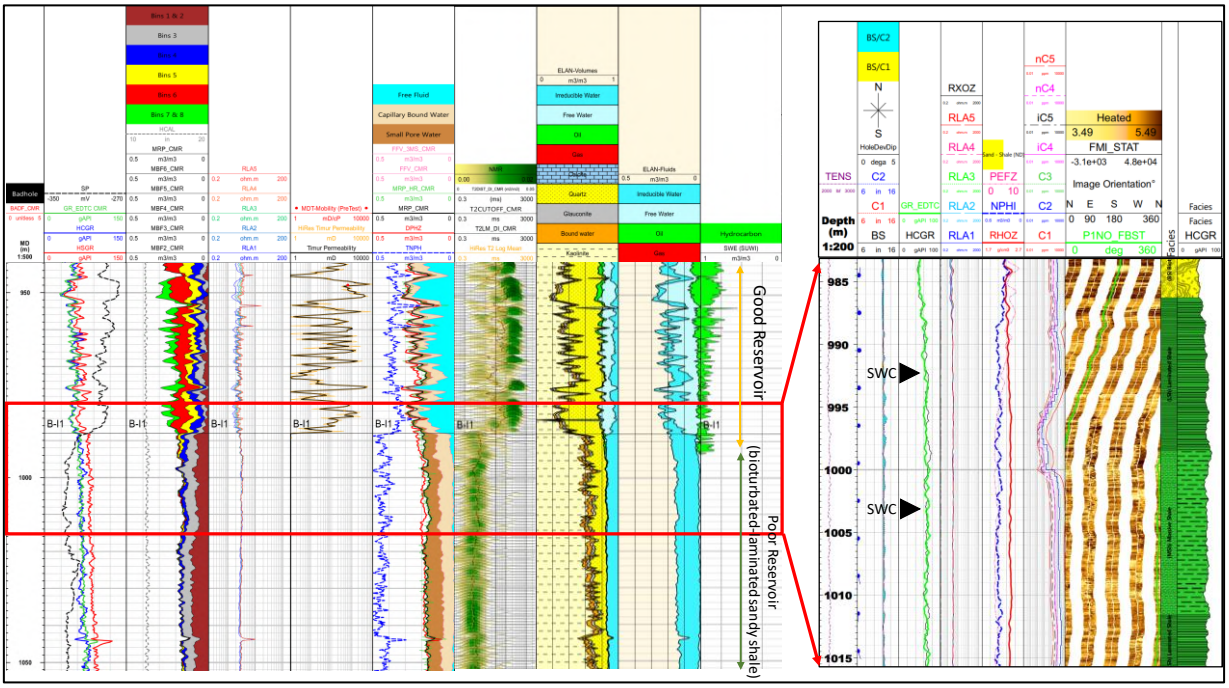

Figure 7. Advanced wireline log evaluation in layer I1

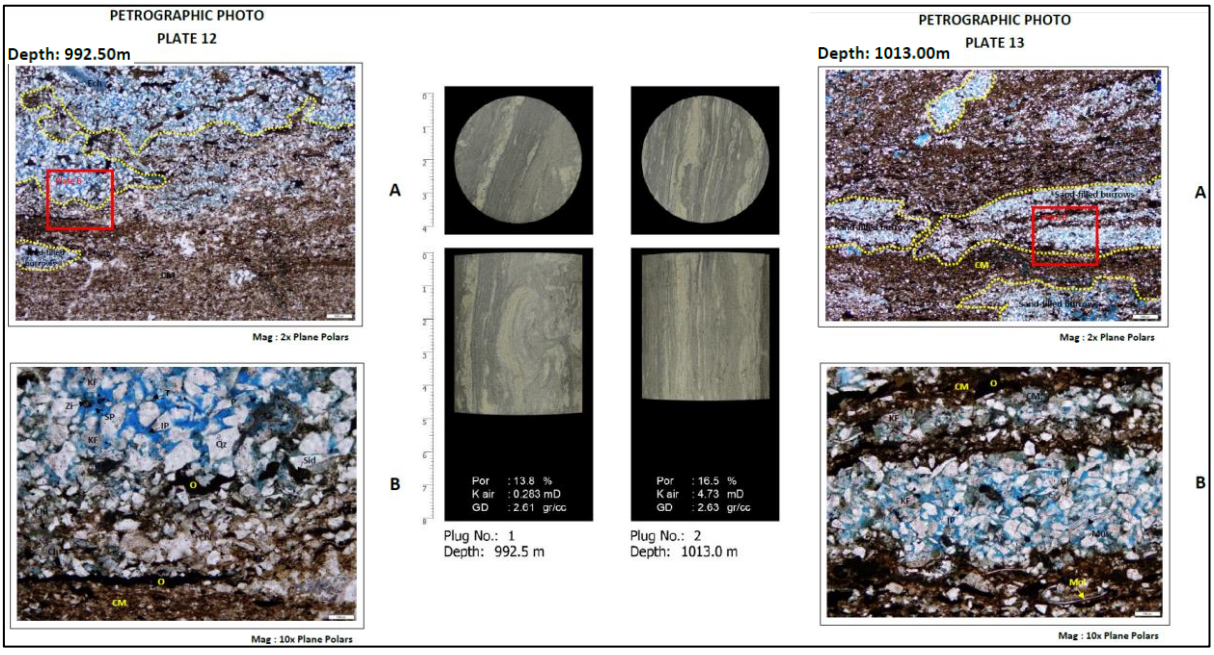

Figure 8. Petrography Analysis from SWC of layer I1