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Simultaneous Exploration leads to a new oil pool discovery through down hole fluid analysis in a challenging bore hole environment – A case study from a field off the West Coast of India

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Abstract:

The primary objective of this paper is to highlight the discovery of a new oil pool by deployment of Logging technology and the judgmental skills of the authors during Fluid Identification through streaming real time down hole optical spectra. The reservoir was presumed to be gas bearing throughout the field. The idea of going in for fluid analysis was conceived from observations pertaining to this reservoir encountered at different structural levels during the drilling sequence of wells from an offshore platform. In one of the wells this reservoir showed a transition to oil towards its bottom part as deciphered through log motifs. At this stage, decision was taken to go for fluid identification with down hole fluid analysis tool in the next well in sequence where this reservoir was likely to be structurally deeper as per prognosis. The author successfully identified the formation fluid and captured a PVT as well as a normal sample with this novel technique and live oil authentication was done by draining the normal sample at the surface. This value adding innovative technique is detailed in this paper and would serve as a valuable concept to the oil industry & would also to be cost effective.

Introduction:

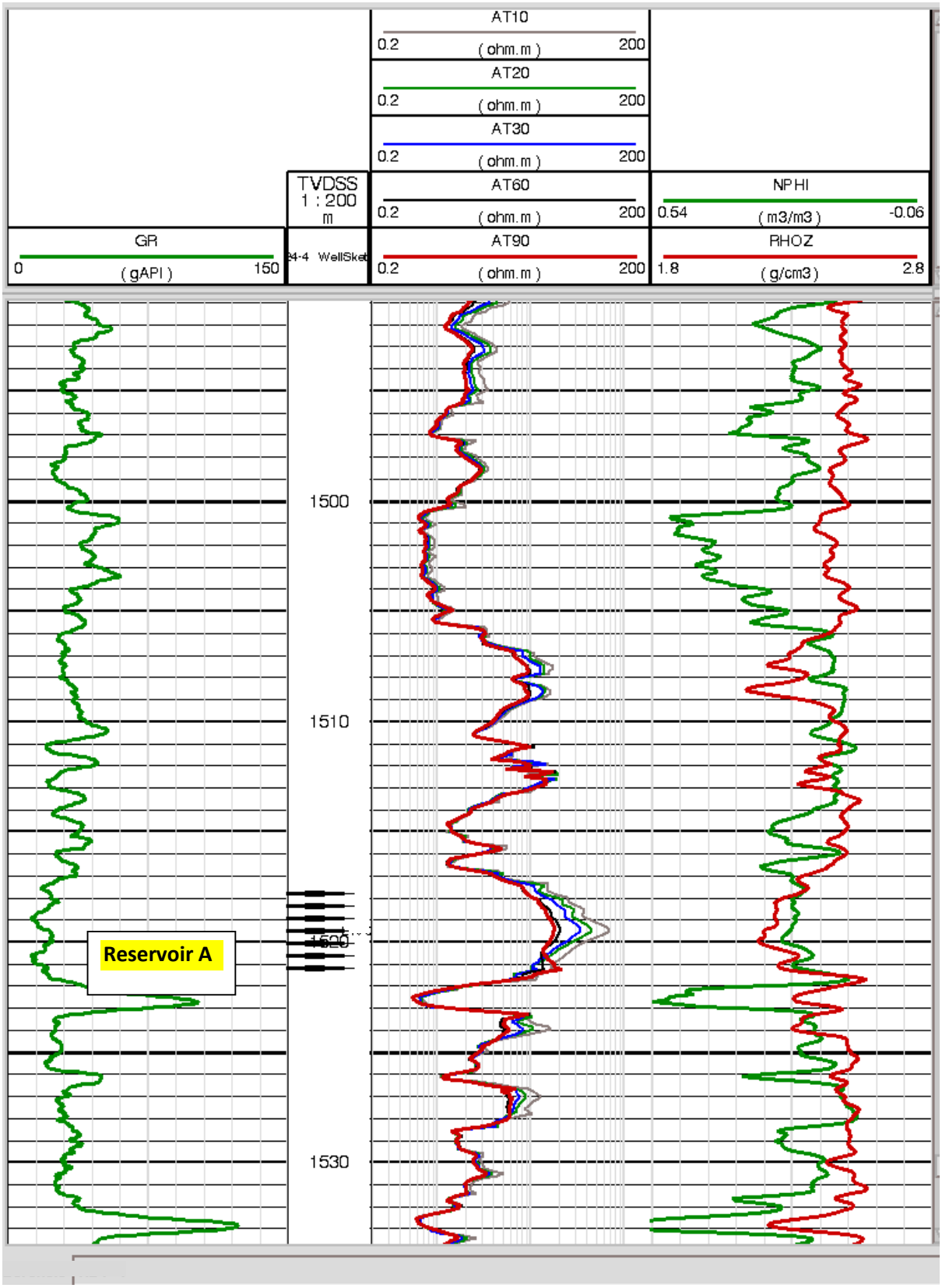
The reservoir for which the location was released is basaltic basement as this reservoir proved oil bearing in proximity wells including an exploratory well which produced 1000 BOPD from basement. A carbonate reservoir (Reservoir A) of late Oligocene age, above the basement was also under observation as three wells were to be drilled traversing this reservoir from a proximity platform. Two wells were intended for oil exploitation from basement while the third well was intended for exploitation from Reservoir A. Due to poor production from the first basement well, a proactive stand was taken to evaluate reservoir A in the next well targeted for basement as the structural trend in drilling succession was towards structurally deeper side & there could be a chance of oil presence, as a fall back option in case of discouraging results from Basement. The log motifs against Reservoir A were highly elusive & it was imperative to first assess the fluid nature through conventional logs & subsequently decide upon identifying the fluid nature through formation tester tool by streaming real time down hole optical spectra. A high precision petrophysical evaluation directed the decision to test the reservoir A, which was finally deciphered as oil bearing. In fact it served as a fall back option as the Basement gave discouraging results. Oil was established for the first time in this reservoir & future locations have been released. This paper highlights the innovative methodology used during fluid identification/sampling of reservoir A in an SOBM environment since it is more challenging to differentiate the synthetic oil mud with in-situ formation oil.

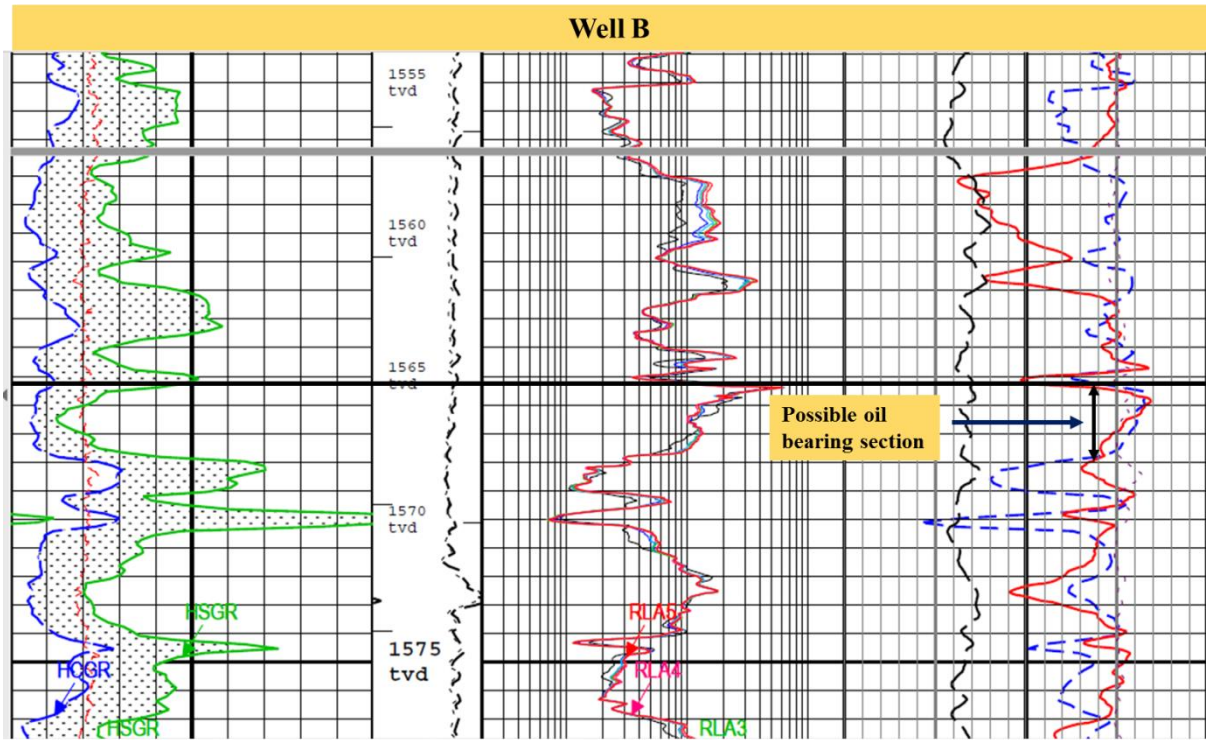
Reservoir Description:

There was a quest to discover new oil from reservoir A at deeper structural level after observing the transition from gas to oil in well B (Plate 1) against lower part of reservoir A. Well A being drilled with SOBM as the drilling fluid was critically monitored and reservoir A appeared to be oil bearing on log motifs (Plate 2). There was heavy mud loss against reservoir A and thus the log motifs could be elusive as the depths of investigation of Neutron Porosity & Bulk Electron Density tools is few inches which has certainly been invaded by SOBM filtrate and may show oil features.

Reservoir A has a thickness of 5 m. The various induction resistivity curves have a significant separation indicating transition from SOBM filtrate near the well bore to the uninvaded zone. This also signifies high permeability and the prime reason of heavy mud loss. The Spectral Gamma Ray suggests a good quantum of fractures. The drop in Bulk Electron Density associated with an increase in Neutron porosity indicates that the reservoir fluid may not be gas. To overcome this anomaly, Formation tester (with Fluid Analyzer) was deployed to ascertain reservoir fluid nature through real time down hole streaming optical spectra.

Plate A: Log Motifs against Reservoir A





Well B was drilled after well A. Observations on transition to oil in well A indicating the probability of this reservoir being oil bearing in well B lead to the decision on fluid identification in this reservoir

Plate 1: Transition from Gas to oil

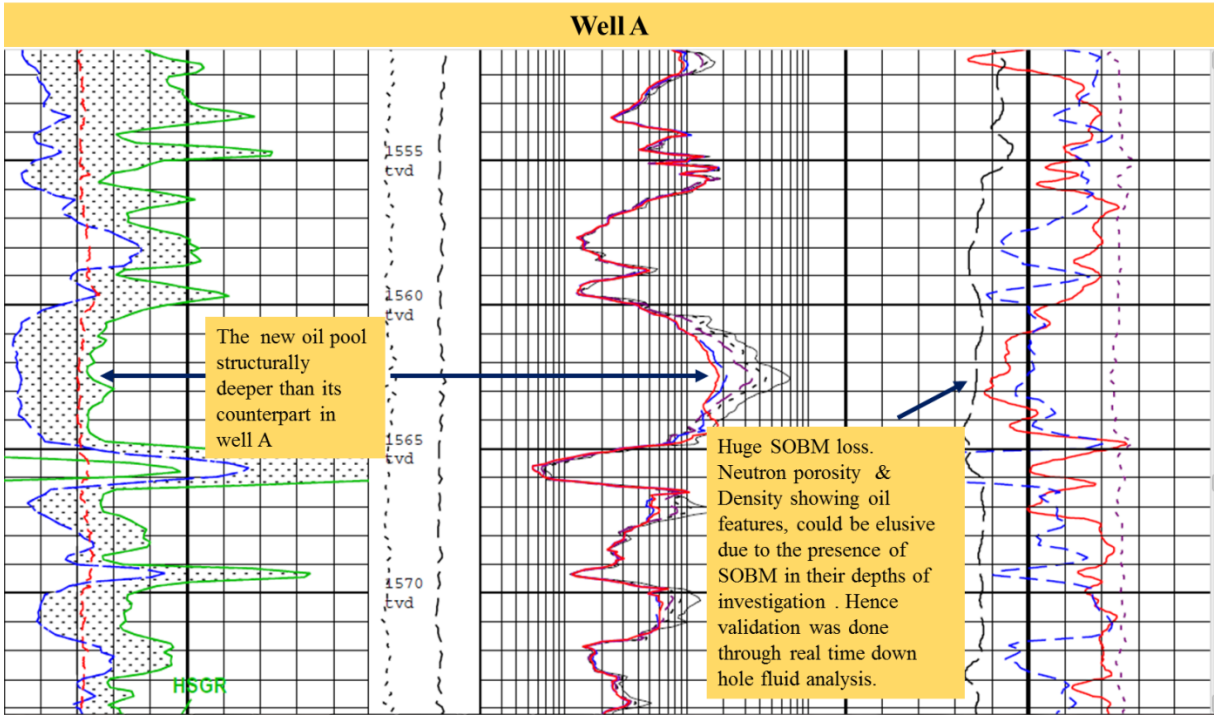


Plate-2: Anticipation successful. Reservoir found to be oil bearing- New oil pool discovery

Data acquisition strategy:

The data acquisition strategy was unique. Dynamic formation Tester run was carried out to confirm the presence of oil in Reservoir A. Fluid Analyzer was part of the tool string to carry out down hole Fluid Analysis in order to identify the fluid type during the course of pumping.

After setting the probe at the best porosity point formation pressure was found to be 2529.38 psi and mobility was reading 13.5 mD/cP. After repeating and stabilizing the build-up response, pumping commenced. Close to 140 liters of fluid was pumped from the formation in an extensive pumping session. Fluid Analyzer showed presence of oil in the flow line during the course of pumping. Differentiating Oil from SOBM filtrate was critical to ensure capture of representative formation fluid sampling. Plate B shows the Fluid Analyzer cross plot. Fluid fraction track showed presence of oil all along and there were no indications of any water traces. GOR track showed increasing trend initially and gradually stabilized at 150 m3/m3. The increasing trend in GOR indicated cleanup of the SOBM contamination. GOR value of 150 m3/m3 lies in the high confidence computing range of Fluid Analyzer. GOR is an important parameter that helps in differentiating between oil and SOBM filtrate. SOBM filtrate being dead oil is devoid of any gas presence. Absorption spectrums at various time stamps (Plate C) showed increase in the Optical densities of the Fluid Analyzer channels lying in the visible region as more and more fluid was pumped. This showed that the flow-line fluid was getting darker in color with prolonged pumping, signifying transition from colorless SOBM filtrate to dark colored oil.

GOR measurements and increasing trend in the color helped in differentiating Oil from SOBM. Once the GOR readings were fairly stable, fluid samples were captured and probe was retracted from the station.

Unique technique was adopted on modifying the operational pattern by reducing the pump rate and increasing the pressure in the tool flow line, the earlier observed gas streaks on real time streaming down hole optical spectra vanished, indicating that these gas streaks were coming out of formation oil which was below the Bubble Point in the tool flow line due to high pumping rate. After concluding that the formation fluid was live formation oil, a normal sample and a PVT sample were captured indicating the presence of formation oil. Reservoir A is presently producing 240 barrels per day of clean oil from the well where it was first explored.

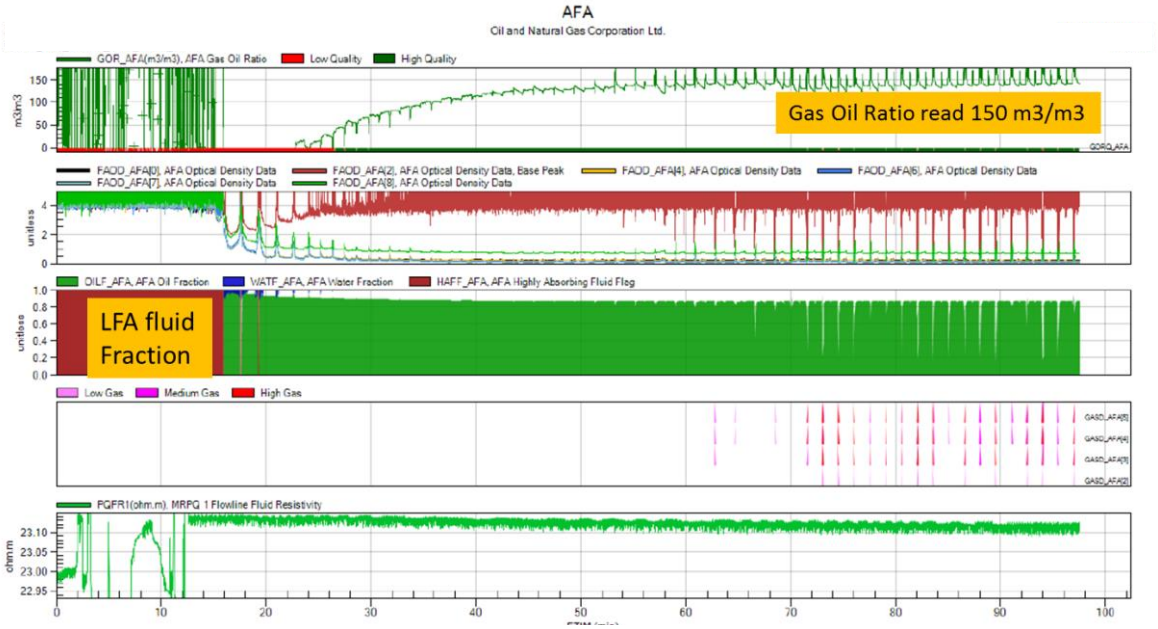


Plate B: Fluid Analyzer cross plot

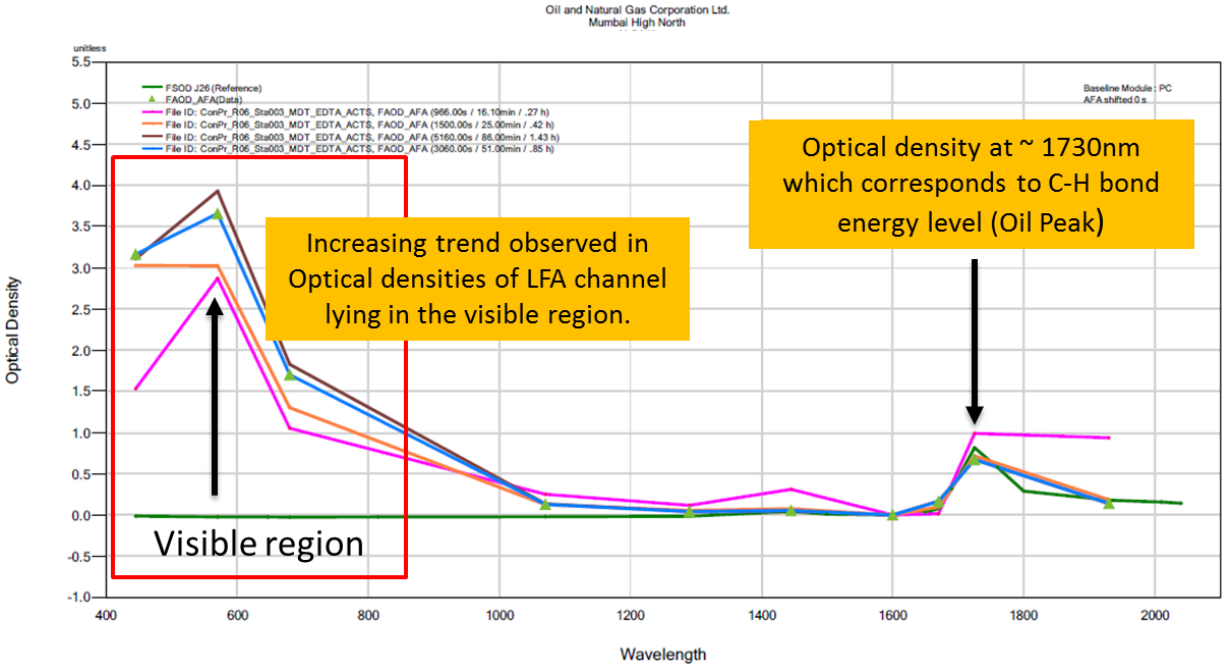


Plate C: Absorption spectrums at various time stamps

Conclusions:

- SOBM affects the tool response and log motifs may be elusive.
- This unique methodology also reflects on data acquisition management strategy without wasting rig time & with a quest to explore new horizons.
- Judicious use of high technology logging tools is vital in validating reservoir analysis.
- Down hole fluid analysis through formation tester has led to reserve accretion & release of new locations.
- New locations have been identified for exploitation of this newly discovered oil pool.

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The authors attribute their success of new oil pool discovery to the entire team of Logging Services for crucial deliberations during the course of operations resulting in successful capturing of formation oil for the first time from a carbonate reservoir (Reservoir A) of late Oligocene age.

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