[EA]Mitigating Reservoir Property Uncertainty and Identifying the Boundary between Conventional and Unconventional Reservoirs: An Integrated Case Study from Mature Fields in the South Sumatra Basin*

Abraham J. S. Simanjuntak[2], Ricky N. Syamri[1], Abdurahman F. Muslim[1], Feruz Kausar[1], Wawan Hermawan[1], and Grace S. Titaley[1]

Search and Discovery Article #20479 (2020)**
Posted May 25, 2020

*Adapted from extended abstract based on oral presentation given at 2019 AAPG Asia Pacific Technical Symposium, The Art of Hydrocarbon Prediction: Managing Uncertainties, August 7-8, 2019, Bogor, (Greater Jakarta), Indonesia
 DOI:10.1306/20479Simanjuntak2020

[1]Pertamina EP, Jakarta, Indonesia (abraham@noex.com.my)
[2]JX Nippon, Kuala Lumpur, Malaysia

Abstract

It is not uncommon to observe production (test) results that deviate from geological and geophysical reservoir study prognosis. More interestingly, this behavior is observed even when the log characters appear similar to offset or existing wells. Our experience in the South Sumatra Basin indicated in some wells, reservoirs that were thought to have relatively poor rock quality and low flow potential were reported to yield relatively moderate oil production, while vice versa: better-quality reservoir rocks reported oil rate that was below expectations, even lower than its perceived poorer (based on standard log signatures) rock quality counterpart.

Wells with minimum pay zone (as indicated by petrophysical evaluation results) were able to produce reasonable initial oil rate while wells with relatively thicker pay zones produce only similar or lower oil rate with some or significant water cut. Interestingly this phenomenon is observed not only on a single field but also on neighboring and other fields in the South Sumatra Basin. Over time this is also supported by years of sustained oil production and surveillance data during the development phase of such fields. This phenomenon has traditionally been regarded as complexity or uncertainty in reservoir property description and left without significant further research into investigating the cause and implication of such phenomenon within the context of overall understanding of hydrocarbon presence and distribution.

Given this background, we have performed a preliminary study revisiting the properties of reservoir and non-reservoir sections from three oil fields (Jirak, Tanjung Miring Timur, and Belimbing) in the South Sumatra Basin. The study makes use of actual rock samples and well datasets from different sources; the primary being core and logging datasets, supported by production (test) results as they provide direct measurements of rock (static and dynamic) properties. Geological and petrophysical information resulting from a range of routine and special core analyses measurements are incorporated in this study. Biostratigraphic, petrographic, XRD, and TOC data from special core analysis measurements are used to provide static descriptions of reservoir properties.

The core datasets are complemented by a range of logging datasets including nuclear magnetic resonance (NMR) and multi-source acoustic logs. Correspondingly, porosity, permeability, capillary pressure and relative permeability data from routine and special core analysis measurements as well as fluid PVT data are examined to provide dynamic descriptions of reservoir properties. Subsequently, the existing geological concept such as regional petroleum system as well as stratigraphic correlations are revisited and integrated in the study. A revisit of regional seismic data is also performed but mainly to validate the stratigraphic correlations made in this study.

The fields being studied are producing fields with production data spanning over 50 to 90 years. This is interesting data which also serves as an important calibration point to validate any new geological and petrophysical understanding resulting from this study.

Mature Fields

Jirak, Belimbing, and Tanjung Miring Timur fields are located within Pertamina EP Asset 2 operational area, onshore South Sumatra, Indonesia as shown in Figure 1. These fields are located as part of the Pendopo-Limau Anticlinorium, in the South Palembang Sub-basin, onshore South Sumatra. The Jirak (JRK) Field is located approximately 60 km west of Prabumulih City, with a structural closure of approximately 20 km^2 . The field was discovered in 1929 and has been producing since then, with peak production at c. 8800 bopd in 1940 and 245 wells drilled to date. Producing zones in Jirak consist of five main hydrocarbon bearing clastic sequences in the Talang Akar Formation namely the 1st, 2nd, 3rd, and 4th Sands and another one across the Lemat Formation, namely the 7th (Benakat) Sand. These reservoirs are deposited between 150 to 900 meters below ground level.

The Belimbing (BEL) Field is located about 130 km southwest of Palembang City. Its structural closure is approximately 48 km^2 . The field was discovered in 1955 and has been producing since 1965, with peak production at c. 7100 bopd in 1967 and 42 wells drilled to date. Producing reservoir sands in Belimbing consist of ten reservoir units at depths between 1300 to 1700 meters. These reservoirs also belong to the Talang Akar Formation. They are namely the R series (R3 and R4), S Sand, W series (W1, W2, and W3), and the X series (X0, X1, X2, and X3).

The Tanjung Miring Timur (TMT) Field is located about 100 km northwest of Palembang City. The structural closure covers an area of approximately 60 km^2. It was discovered in 1951 and has been producing since 1970, with peak production at c. 4000 bopd in 1983 and 62 wells drilled to date. Reservoir sands in Tanjung Miring Timur consist of eight hydrocarbon bearing sands deposited between 1000 to 1200-meter depths. Similar to Jirak and Belimbing fields, these reservoir rocks (A, B, C, and D sand units) also belong to the Talang Akar Formation.

Reservoir Properties and Hydrocarbon Presence Uncertainties

Typical log signatures of the 3rd and 7th Sands in Jirak are shown in the following Figure 2. These two producing zones are chosen because they each represent different and relatively unique characteristics along with associated uncertainties in reservoir rock properties and hydrocarbon presence and distribution within the Talang Akar and Lemat formations.

Typical gross thickness of the 3rd Sand is c. 40 m with core-based average porosity of 22% and permeability of 1,500 mD. Its core samples indicate porosity range from 12 to 27% with corresponding permeabilities of 2 to 3,500 mD. Lithology is predominantly clean sandstone deposited in lower to middle shoreface environments. Mineralogy of the sandstone is predominantly made up of quartz up to 80-85 wt.% with 10-15 wt.% clays and a range of other carbonates and iron minerals with minor weight percentage. The clay minerals are relatively equal mixtures of illite and kaolinite. Given its relatively homogenous log characters, identification and evaluation of hydrocarbon presence/saturation, and characterization of rock properties (pay thickness, porosity, and permeability) have been relatively straight forward over this section. Cumulative oil production from the 3rd Sand stands at c. 16 MMSTB.

Typical gross thickness of the 7th Sand is c. 200 m. Core samples acquired across this section indicate a rather wide range of porosity from 2 to 27%. The corresponding permeabilities range from 0.1 to 160 mD. Accordingly, average core porosity is at 19% while permeability is at 40 mD. These characteristics contrast with the rock properties of the 3rd Sand. Mineralogy of this section includes mixtures of between 50-70 wt.% quartz, 30-50 wt.% clays, and relatively minor (< 10 wt.%) mixtures of other carbonates and iron minerals. The clay minerals are rather more variable as compared to that of the 3rd Sand as it consists of illite (dominant), kaolinite, chlorite, and smectites. Numerous sand-shale pairs and massive shale beds can be observed over this section as indicated by logs (GR & Density-Neutron) responses. Core descriptions indicate these shaly sandstone interbeds were deposited in fluvio-lacustrine environments. GR log contrast between sands and shales are relatively low as can be seen in Figure 3. In general, standard log characters over this section are highly variable causing identification and evaluation of producible hydrocarbon intervals and its saturation as well as rock properties characterization to be more complicated. Cumulative oil production from the 7th Sand stands at c. 1.6 MMSTB. However, it is anticipated that the 7th Sand still contains sizeable volumes of hydrocarbons given its relatively thick column. The Lemat Formation of which the 7th Sand is a member, is also recognized as a competent source rock within the South Sumatra Basin.

Practical Approach to Mitigation Uncertainties

NMR log was included in the logging program of JRK-243 well drilled in 2017 and shown in Figure 3. The NMR (track #7) measures magnetic relaxation time of rock components (matrix and fluid), and further used to infer porosity elements attributed to movable and non-movable fluids. These different elements of porosities can then be used to infer permeability (track #8) using an empirical correlation (e.g. TimurCoates in this case). Inherent uncertainties exist in the rock flow capacity as well as hydrocarbon presence due to relatively large fluids and pressure depletion that had taken place over the past nearly 90 years.

The application of NMR log in JRK-243 was practically helpful in selecting perforation intervals for swab tests across the various sands penetrated by this well. A successful swab test was obtained over a 1.5 m (681-682.5 m; Figure 3) perforation interval with reasonable volumes of oil. A couple of other potential intervals within the 7th Sand were also identified with the help of the NMR log. However, they were not tested (swabbed) due to operational time constraints while noting that the JRK-243 well was drilled to become a water injector well for the 3rd Sand. Evaluation of hydrocarbon presence within the 7th Sand sequence has been further expanded to include Total Organic Carbon (TOC) estimation using log responses as shown in the last track of the log plot in Figure 3. Passey's et.al.1 DlogR method has been chosen for computing TOC from logs in this study. A couple of notable shale layers (as confirmed by low NMR T2 response of < 3ms) with relatively high TOC (> 2 wt.%) have been identified between 657.9-658.5 m and 667-670.5 m. This then prompts us to thinking that perhaps both conventional and unconventional hydrocarbon reservoirs exist in the 7th Sand section of the Lemat Formation in Jirak Field.

Application in Other Fields

The key learnings from Jirak Field have then been applied in the evaluation of Belimbing and Tanjung Miring Timur fields. Unfortunately, no NMR log has been acquired in these fields to date and no core-based TOC measurements are available. The DlogR method for computing TOC from logs has been applied on several wells in these fields but without calibration using core-based TOC. Our current results show relatively low TOC (< wt.%), which may suggest different characteristics of shales exist in the Talang Akar sections encountered in these fields as opposed to that in Jirak.

Conclusions and Way Forward

Our key takeaway is that combination of NMR logs and log-based TOC computation significantly reduces uncertainties in the identification and evaluation of hydrocarbon presence and reservoir (and nonreservoir) rock properties in mature fields, while at the same time useful to identify potentially producible hydrocarbon bearing shales. Further studies with additional datasets of NMR log and core-based TOC measurements as well as other supporting core geochemical analysis are still required to better understand the prospectivity of the potential hydrocarbon bearing shales in the Lemat Formation as well as its basin-wide distribution.

Reference Cited

Passey, Q.R., S. Creaney, J.B. Kulla, F.J. Moretti, and J.D. Stroud, 1990, A Practical Model for Organic Richness from Porosity and Resistivity Logs: AAPG, v. 74/12, p. 1777-1794.

Figure 1. Map showing locations of the Jirak, Belimbing, and Tanjung Miring Timur fields in South Sumatra.

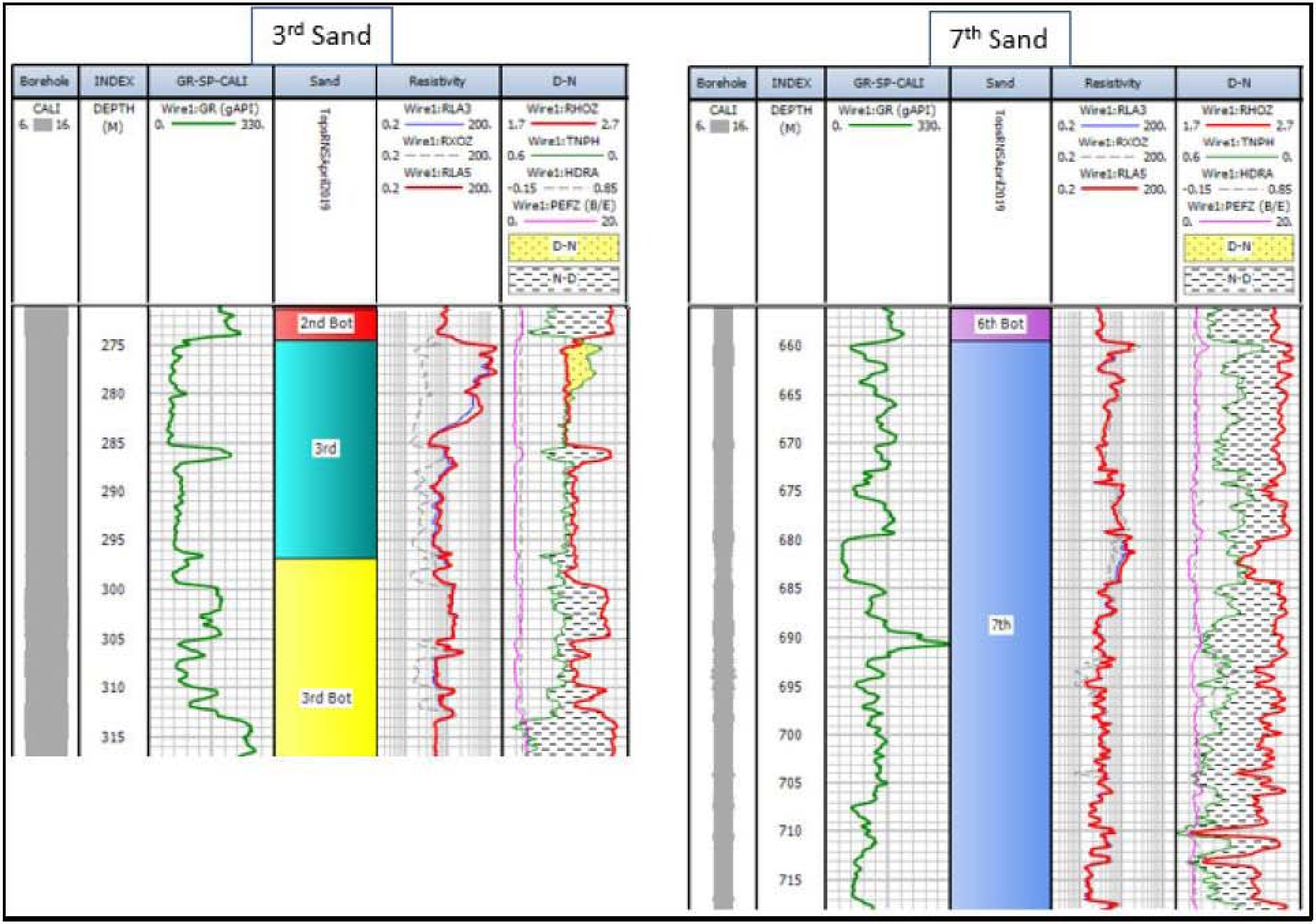

Figure 2. Typical log signatures of the 3rd and 7th Sands.

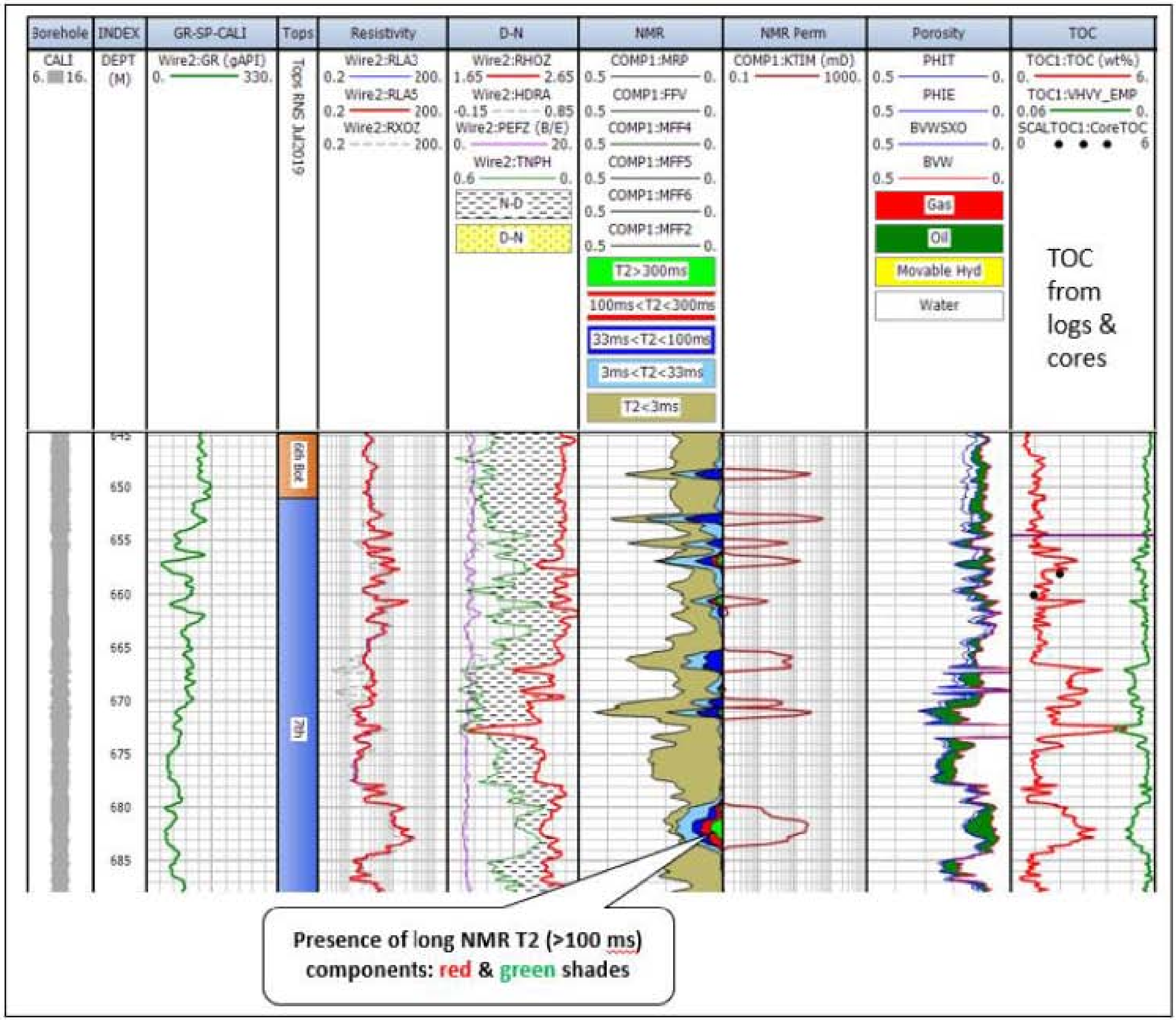

Figure 3. Standard & NMR logs + Inferred NMR Permeability + Interpreted Porosity and Fluid Saturations + TOC.