Unlocking Potential Resources at Shallow Zone for Future Development: Methodology and Application at Sisi-Nubi Field, Mahakam Delta*

Aditya Suardiputra[1], Rahmad Hidayat[2], Kelik Moersidin[2], Saras Nawangsari[2], Aldyth Sukapradja[2], Debrina Sugiharto[2], Hermawan[2], Soegianto Tjiptowiyono[2], and Cepi Adam[2]

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[1]Total E&P Indonesie (aditya.suardiputra@total.com)
[2]Total E&P Indonesie

Abstract

Sisi-Nubi (SNB) is a gas field located 25 km offshore from the modern Mahakam Delta. It consists of 3 stratigraphic units: Shallow zone, Fresh water sands, and Sisi Main zone. Current development planning focused on Fresh Water Sands (FWS) and Sisi Main Zone (SMZ) interval to tackle natural gas decline. Shallow zone is practically under-developed as the gas production is limited only from reservoirs crossed by existing wells. Shallow zone is a multi-layer reservoir and unconsolidated situated at depth 500-1800 mSS. The depositional environment is interpreted as shallow marine environment with periodic fluvial influx resulting from high frequency sea level fall. Integrated subsurface study was conducted to define methodology in order to unlock Shallow zone reservoir for future development. Seismic reprocessing was previously carried out in 2014 to improve seismic image at shallow part of the field. Taking advantage of being AVO class 3 sands, detailed iterative work between geologists and geophysicists were intensively conducted in order to: 1) understand geological framework of Shallow zone, and 2) define reservoir bodies from far amplitude sub-stack. Post-mortem analysis for each drilled reservoir and its AVO responds grouped the anomalies into three categories of confidence level: Low, Medium, and High with success ratio respectively 15/38/61%. This was considered too low to proceed for further development study. Seismic inversion was performed in order to obtain better reservoir characterization. Having distinctive characteristic, litho-seismic cube was generated using inverted P-Impedance (IP) and Poisson Ratio (PR) to predict gas sands probability. Further evaluation was performed using both sub-stack and litho seismic. This methodology improved significantly success ratio for each category of confidence level. The challenge for field development at Shallow zone is to identify the optimum platform location to reach maximum resources. A cone scanning method was developed to screen possible identified reservoir bodies that can be reached with a given set of drilling constraints from a single surface location. This method identifies and computes the associated reservoir bodies that can be accessed from a potential platform. This comprehensive G&G study proved the effectiveness method to evaluate shallow reservoir potential in Sisi-Nubi Field. Similar studies have been launched in other fields in Mahakam to unlock the potential future development in Mahakam.

Discussion

Sisi-Nubi (SNB) is a gas field located 25 km offshore from the modern Mahakam Delta. It consists of 3 main stratigraphic intervals: Shallow zone, Fresh water sands, and Sisi Main zone. Recent development plan has been focused on Fresh water sands (FWS) and Sisi Main zone (SMZ) while Shallow zone is practically under-developed since gas production is limited only from reservoirs found by existing wells. Shallow zone is an unconsolidated multi-layer reservoir situated at depth 500-1800 mSS. The depositional environment is interpreted as shallow marine environment with periodic fluvial influx resulting from high frequency sea level fall.

QPSDM seismic reprocessing was carried out in 2014 to recover amplitude loss that occurred in Shallow zone. It was the first subject that initiated the overall study since seismic amplitudes that shallow must be corrected due to possible gas chimney at very shallow zone. Subsurface study on Shallow zone was started early 2015 to define the reservoir characteristics. Using well data as an input for petro-elastic modeling in Shallow zone, provides necessary information on how seismic could distinguish between gas sand and non-gas sand.

Based on the petro-elastic model, it shows that gas sand has lower impedance that its cover layer (brightening) to the far-ultra far offset (AVO class III) while coal is dimming. Reservoir polygon is generated using far amplitude with cut-off respecting the well results. AVO information will be applied in seismic by subtracting far amplitude map with near amplitude map in order to characterize the gas sand. Post mortem analysis using Far-Near Amplitude (FNA) method was performed for each gas reservoir; the result was categorized based on the mean value inside the polygon that represents AVO responds (dimming, flattening, and brightening). The success ratio for far-near amplitude methods (Figure 1) is below 61% and it is considered low confidence to develop shallow resources using those figures.

Simultaneous seismic inversion was performed to achieve better reservoir characterization and prediction. The outputs from this study are inverted P-Impedance (IP) and inverted Poisson Ratio (PR) cubes. Feasibility study at wells showed that cross-plotting logs scale IP and PR could distinguish gas sand from other facies such as shale, coal, and wet sand. In general, this method uses a probability density function (PDF) obtained from cross-plot as an operator that will computes PDF cubes i.e. gas sand probability cube (Figure 2). Further evaluation was performed by combining both methods, Far-Near and Litho Seismic Classification (Figure 1). As a result, both methods have significantly increased our success ratio from 61% to 94% in predicting gas sand and have removed non-gas reservoir.

The results of the reservoir characterization study are reservoir distribution map at full field scale (Figure 2A). It is clearly seen that gas sand probability gave better view of reservoir distribution (Figure 2B), thus can be used as a basis to define potential area for development. Reservoir distribution in Shallow zone is scattered throughout the field and have limited range (Figure 2C1). The main challenge for field development is to locate optimum platform location in order to reach maximum resources. Cone scanning method is a tool contained in a Petrel workflow to screen possible identified seismic anomalies that can be reached with a given set of drilling constraints from a single surface location. This method identifies and computes the associated IGIP (reservoir bodies) that can be accessed from a potential platform. The drilling limitation range in this case uses a maximum inclination of 55 degrees. Using this inclination in all possible azimuths a cone is defined whose radius increases with depth (Figure 2C2). Any anomaly that is touching or within the cone is considered as reachable from the given surface location. A cone scanning method was implemented to scan surface location systematically. The maximum connected IGIP is retained as best potential platform (Figure 2C3). Cone scanning method could provide optimum platform location for future development in an efficient way.

Selected References

Cibaj, I., U. Ashari, J.A. Dal, V. Mazingue, and M. Bueno, 2015, Sedimentology and Stratigraphic Stacking Patterns of Sisi-Nubi Field Producing Interval, Lower Kutei Basin, East Kalimantan, Indonesia: Proceedings of Indonesian Petroleum Association, 39th Annual Convention, IPA15-G-245, p. 1384-1416.

Hutahayan, B., K.H. Teng, K. Moersidin, J. Bonnafe, N. Anggriani, and C.M. Adam, 2015, Resolving Seismic Attenuation Issue Through Q-Migration, A Case Study in Sisi-Nubi Field, Indonesia: Proceedings of Indonesian Petroleum Association, 39th Annual Convention. IPA15-G-134, p. 1586-1597.

Moersidin, K., A. Suardiputra, D. Sugiharto, and J. Clark, 2016, Sisi-Nubi Shallow Zone - Subsurface Study: Total EP Indonesie, Internal Report.

Sukapradja, A., and J. Clark, 2015, Multi Cone Platform Screening Methodology and Application, Sisi-Nubi Field – Indonesia: Total EP Indonesie, Internal Report.

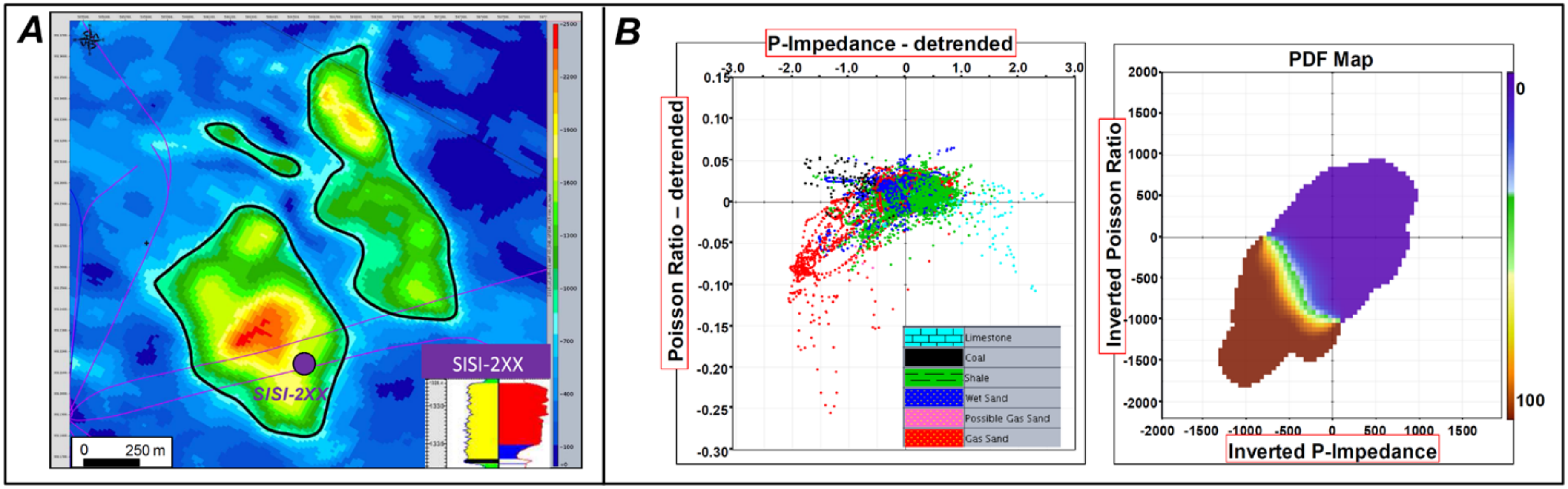

Figure 1. A) Far-Near Amplitude method. B) Litho Seismic Classification method.

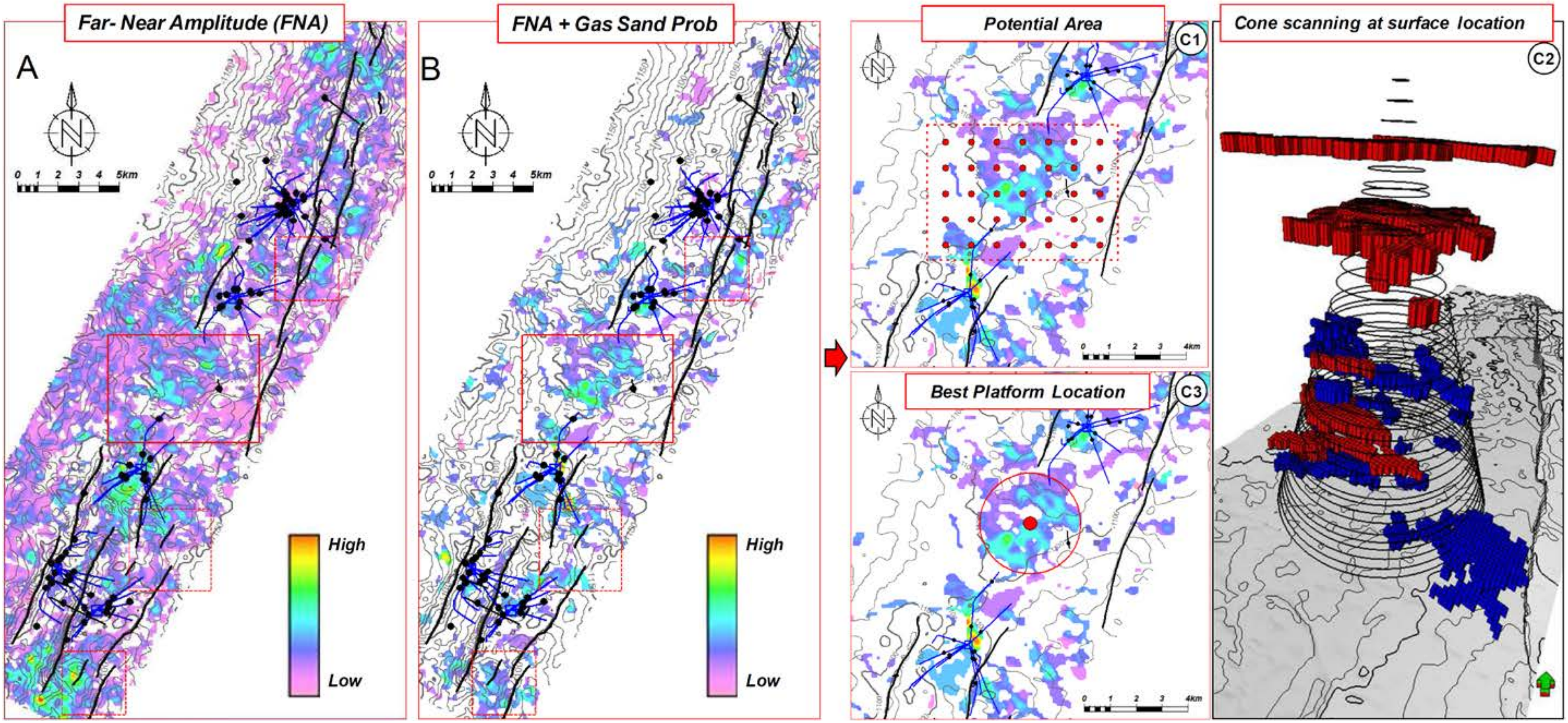

Figure 2. A) Stacked map of reservoir detected by FNA. B) Stacked map reservoir detected by FNA and Gas Sand Prob. C1) Potential area for scanning. C2) Cone scan reservoir bodies. C3) Proposed platform location.