SAND DISTRIBUTION AND RESERVOIR CHARACTERISTICS NORTH JAMJUREE FIELD, PATTANI BASIN, GULF OF THAILAND

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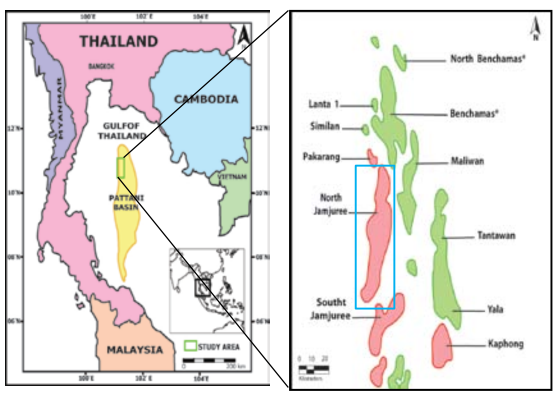
Abstract

North Jamjuree field suffers from a problem of high pay counts but with less than expected recoveries, compared to other platforms that are located along similar structures and focused on similar reservoirs**.** The key is that reservoirs are fluvial sands that, due to their stratigraphic complexity, result in varying degrees of interconnection both vertically and laterally and hence higher uncertainties in reserve estimation between platforms. This study attempts to better understand and predict geometries of sand distribution, in order to reduce the high uncertainty in reserve estimation and better predict production volumes. It uses an integration of regional stratigraphy, wireline logs and seismic data, combined with a set of newly constructed structure map and sand distribution maps. This gives an improved understanding of the geological model of the reservoir. Wireline correlation shows the main trend of sand is a near north-south set of variable thickness fluvial sand masses, which are seen in the structure overlay sand distribution maps and sands mapped using seismic attributes. Results of this new seismic-based analysis in MMIO-T4 section now show a broad meander belt with high gross sand, but less pay because of low net to gross effect, due to poor sealing capacity of the faults. In contrast, theT4-T3 and below-T3 sections are made up of very high gross sand intervals deposited in narrow channel belts, with net pay values that are better than in the MMIO-T4 section. This is because these intervals are thicker and net to gross is lower, a combination that means better sealing potential across faults. These new findings can be used for future well planning and improved forecasting production of profiles. It also indicates a new area of interest in what appear to be untapped reservoir sands in the southwest portion of the study area.

Keyword: Sand distribution, Reservoir Characteristics, Fluvial

1. Introduction

The Pattani Basin lies in the central Gulf of Thailand and contains hydrocarbon field where the main reservoirs are fluvial sands. These fluvial sands are stratigraphically complex. Currently, due to poor reservoir continuity correlations, the mapping of sand distribution and the characteristics of the reservoirs create high uncertainty in reserve estimates. For example, reserve calculations in the North Jamjuree field suffer from a problem of high pay counts and less than they expected recovery, compared to other platforms that are located along similar trends and structures. In the North Jamjuree area sands are discontinuous, and reserves are low, which suggests a current lack of understanding about geometries of sand distribution. This study attempts to better understand the reservoir geometries sand distributions in the North Jamjuree field and so to the current high uncertainty in predicting fluvial architecture. This will be done by using wireline log data, combined with 3D seismic data, combined with the mapped structure in order to construct a geological model of the reservoir. The aim is reduce the currently high level of uncertainty in reserve estimation and so better predict production volumes in this field. The study area is located within the North Jamjuree field, which is located on the north-western flank of the Pattani Basin in the Gulf of Thailand (Figure 1.1).



Figures 1.1 Study area is located in the Northern Pattani Basin Gulf of Thailand, along the western basin margin trend.

2. Methods

An integration well log data and seismic based analysis was used to investigate sand distributions and determine depositional environments. The gamma ray - acoustic impedance crossplots were done to determine the relationship between rock properties and acoustic impedances, the results can be then used to predict the actual seismic response in the study area. The depositional environment was interpreted based on gamma ray log analysis and the regional stratigraphic setting because of the absence of core data. Marker identification and well-to-well correlation were used to construct a series of sand distribution maps that were then used to give preliminary information about the reservoir geometries, and to determine an evolution of sand systems in the study area.

To compare well log data to the seismic, synthetic seismograms were generated. Three main markers, MMIO -T4, T4-T3 and below T3, were interpreted as key horizons, then contoured to create two-way-time structural maps, which were used to generate seismic attribute maps. Amplitude extraction maps were generated by using RMS (root mean square) amplitude attributes within various windows, in order to define the sand distributions and outline the main paleo-orientations of the reservoirs in the study area. The best results were windows ranging from 20 to 30 ms ,tied to the key horizons.

3. Results

3.1. Well log analysis

Gamma Ray - Acoustic Impedance Crossplots

The low impedance intervals matched very well with the low gamma ray intervals that were interpreted as sands. The overall results indicate the lower acoustic impedance represents the lower density sandstone. Moreover, MMIO-T4 has a good separation between sands and the surrounding shales, but in T4-T3 there is less separation between sand and shale.

Depositional Environment Analysis

The results from well NJWA-09, located in the southern area, is that the interval MMIO-T4 shows common characteristics with a blocky shape interpreted as fluvial dominant, while marine influence sands tend to be bell-shaped, but in T4-T3 and below T3 the intervals tend are fluvial dominated and show varying combinations of blocky shapes and bell shapes and low gamma portions of curves that were interpreted as channel fills, and serrated high gamma ray curves were identified as floodplain or overbank deposits in an overall fluvial environment.

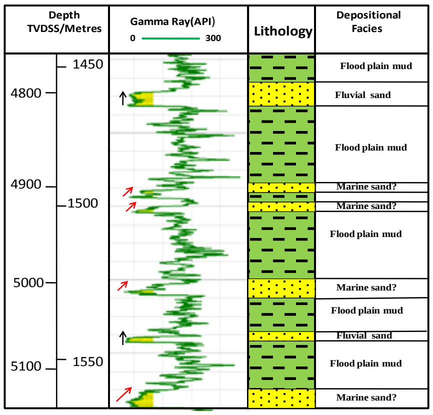


Figure 3.1. MMIO-T4 section in JA09 showing bell-shaped gamma-ray curves (red arrows) that likely fine-upward versus blocky shaped curves (black arrow) that likely indicate lesser vertical changes in grain size.

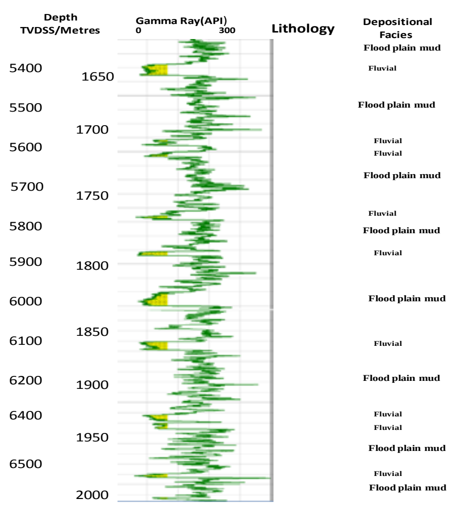


Figure3.2 The gamma ray curve in the deeper part of well JA09 showing bell-shaped gamma-ray curves (red arrows) that likely fine-upward versus blocky shaped curves (black arrow) that likely indicate lesser vertical changes in grain size.

Sand Distribution Sand distribution maps

The overall results of the sand distribution maps show a similarity to each other, with the typical distribution of sand-bodies characterized by a north-south orientation. Also the maximum thickness trend is aligned in the same direction. The sand-body thicknesses are quite consistent along the north-south trend, and significantly change laterally in the east- west direction (Figure 3). Consequently, the boundary of sand bodies can be easily mapped determined by the absence or presence of sands in penetrated wells.

The Gross sand map for MMIO-T4 section, shows that net sand thickness ranges up to 100 feet (30.47m). This maximum thickness distribution map shows a north-northwest to south-southeast (NNW-SSE) trend in both the northern and southern parts of the study area. The sand distribution in the northern part is thicker than in the southern area. This is matched in the map of the net to gross ratio, which ranges from 80-20 percent and correlation panels in this section are illustrated by two sections that cut across structure from a zone of high thickness to low thickness in gross sand and is illustrated in a continuous correlation

For Sequence 4-M5, Gross sand (ranging up to 100 feet (30.47m) shows a maximum thickness sand in the middle and thinner toward the margin in The trend of gross sand is NNW-SSE trending in both the Northern and Southern areas and this is the same in the net to gross map , which ranges from 40-30 percent. Correlation for this interval is presented in three panels showing sand distributions cut across structural grain with sand in a more discontinuous set of correlations, compared to the overlying interval M5-T3 Gross sand map, with thickness ranging up to 20feet (6.09m), shows a regionally trending NNW-SSE sand mass across the study area. The smaller of the two sand masses is in the north, and it shows an east-west trend, changing to a north –south trend in the southern area of sand. Net to gross in this section is 40-60 percent. Thickness of sand in this section changes from thicker to thinner from middle to margin. Correlations in this section are shown in two sections that cut across structure from high thickness to low thickness in gross sand, showing sand is discontinuous, much like the T4-M5 section

In summary, the overall result of the sand distribution maps show similar overall trends in MMIO,T4,M5 and T3 sections of a NNW-SSE orientation and sand body thickness have similar North-South trend is with more local variations in west-east directions. The result from RMS mapping in the seismic (Figure 4.13) match with the gross sand maps from the wireline analysis that is a strongly north-south pattern to sand distribution. However the strong amplitude seen the west of the study area in the RMS attribute map do not match with the gross sand map

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3.2.Seismic interpretation

Well to Seismic Tie

Two synthetic seismograms were generated and show a good correlation between the rock property changes observed in well logs with changes in the seismic responses.

Horizon Interpretation and Structural Mapping

Only one synthetic seismograms was used to provide ties to the three key, MMIO, T4 and T3, surfaces for initial horizon interpretations. Typical seismic sections show the consistent characteristics consist of strong amplitude relatively continuous peaks of the MMIO and T4. The interval inbetween shows strong troughs, which have limited lateral extent, these are interpreted to represent sand bodies. Structural styles in this area comprise the full-graben faulted system, and gently dipping tilted strata high toward the upthrown side of faults, provided structural closures.

RMS Attribute Map Analysis

Sands in the study area are identified as low impedance sands from the result of crossplots. The synthetic ties also confirm that these sands are troughs on the seismic. Therefore, high amplitude troughs are an indicator of sands, while shale is represented by the background low amplitudes. The thicker sandstones are represented by higher amplitudes. The high amplitude corresponds to sands and the low amplitude corresponds to shale (Figure 5). This is an expected result based on the good correlation between sands observed in well logs and high amplitudes extracted from the seismic.

4.Discussion

The following discussion and maps shows a depositionally focused set of sands that helps explains why previous reserve calculations in the North Jamjuree field suffered from the problem of high pay counts and yet returns were less than expected compared to other platforms that are located along similar trends and structures. That is, many of the sands I mapped in this area are discontinuous, and so reserves are lower than calculations in previous models that assumed a higher degree of sand extent and connectivity. as we shall now discuss, only the upper sands which were deposited as broader channels have reasonable connectivity. Below, the fluvial sand geometries are associated with smaller less connect fluvial system sands, they are stratigraphically complex and this creates higher uncertainty in reserve estimations in this, the thicker interval in the studied section. Using the RMS attribute maps, it can be seen that sand distribution in the study area is mostly NNW-SSE trending. Structures do not control sand distribution as the high amplitude trends continue across the fault zones, as shown by the yellow arrow in the T4-T3 (Figure 4.1).

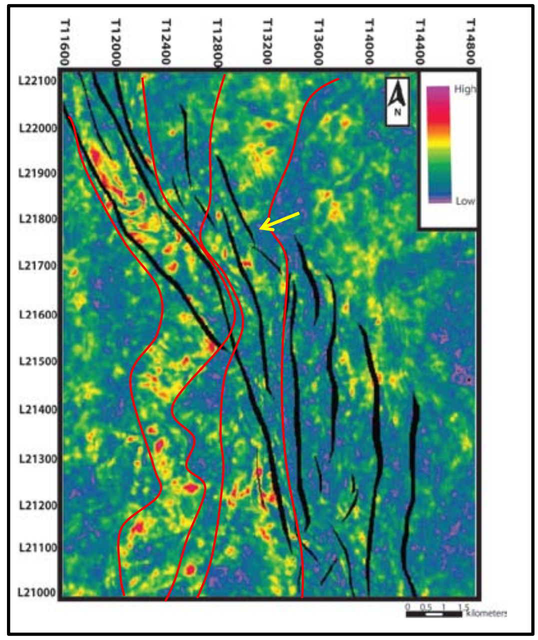
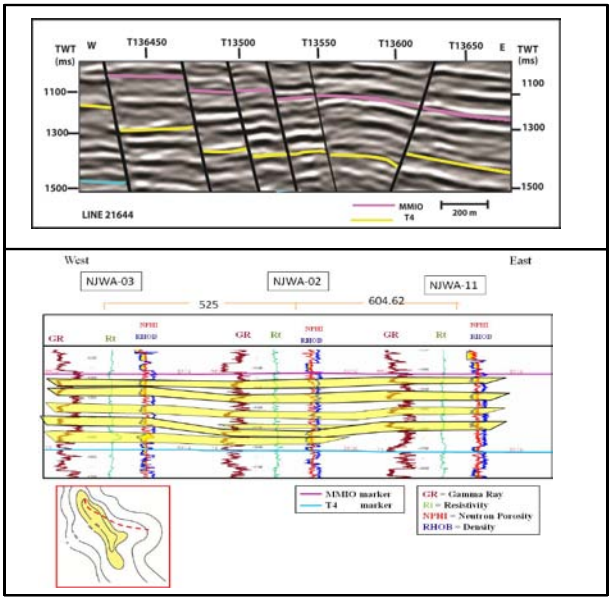
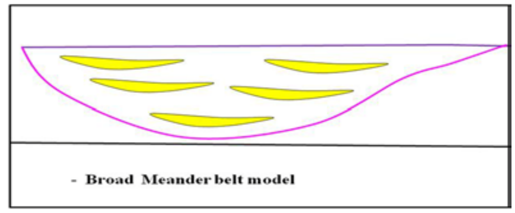


Figure 4.1 Sand distribution in T4-T3 interval showing RMS attribute trends of high amplitude cutting across faults. Sands, are not controlled by faulting.

Based on well and seismic data correlations, two distinct types of sand systems are evident. The first, in the MMIO-T4 interval, shows relatively continuous sands across well-to-well correlations. The sands are interpreted as deposited as broad channels in a channel belt that is also broad. Gross sand and net to gross are both high in this relatively thin depositional interval and reserve estimates assuming reasonable sand continuity are correct as in figure 4.2





The second system is seen in the underlying T4-T3 and below-T3 intervals, both show much more discontinuity of sands in well-to-well correlations and discontinuity in the higher amplitude intervals in the seismic section. Both intervals are typified by narrower NNW-SSE channels, in channel belt seen in the RMS attribute maps. Gross sand is quite high as both these intervals are thick compared to the MMIO-T4 interval, but net to gross is relatively low. These sands are interpreted to be deposited in a series of disconnected narrow fluvial channel belts as shown in figure 4.3.

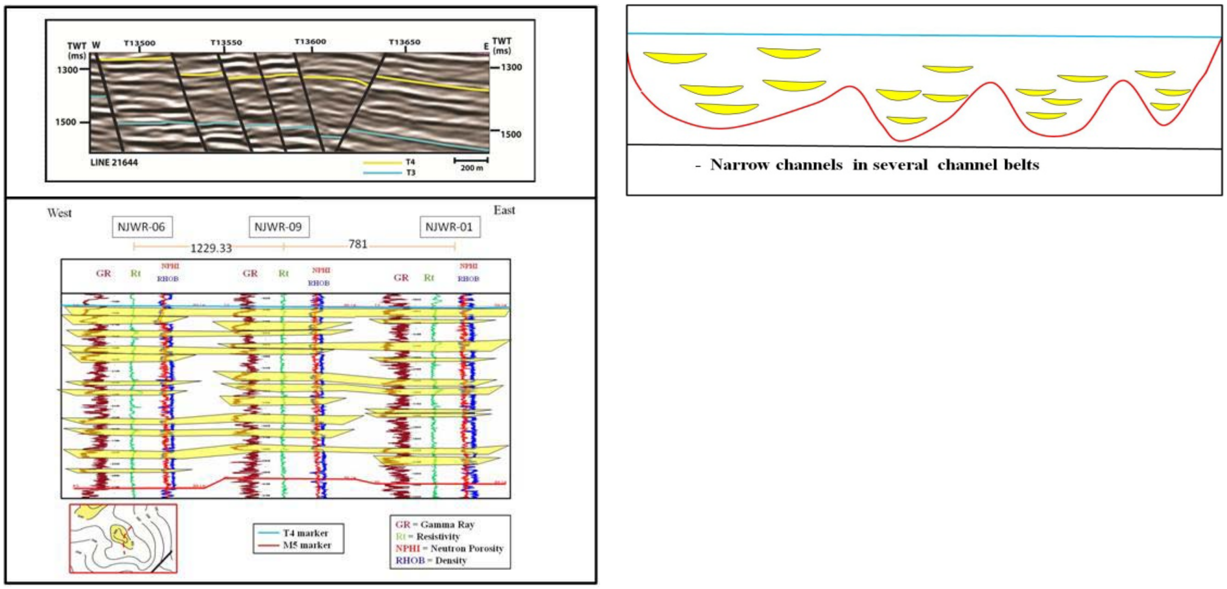


Figure 4.3 Discontinuity of seismic section, discontinuity of sand correlation in the well to well correlation, with narrow channels in channel belts in the interpretation of T4-T3 and below-T3 intervals.

Complicating the net pay distribution is structure at the MMIO, T4 and T3 levels, it is a set of complex fault zones that compartmentalize reservoirs and reduce the size of traps. Net pay varies significantly in this area due to the different characteristics of the two kinds of sand systems. The MMIO-T4 section is interpreted as a broad meander belt, with high gross sand and high net to gross, but has reduced pay.

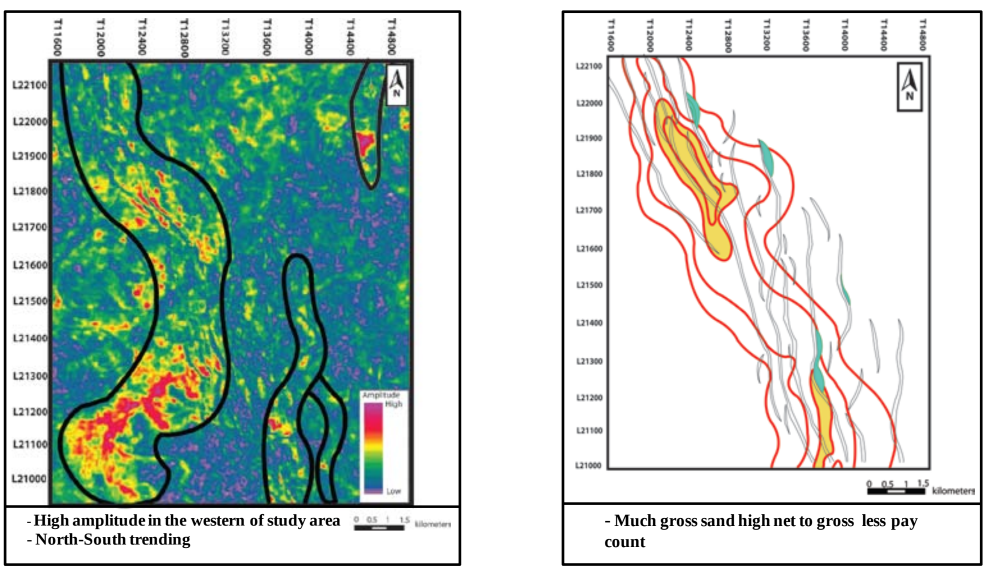


Figure 5.4 Broad channel belt in RMS attribute map with a high gross sand , but less pay count, because of poor sealing potentials.

In the T4-T3 section there is very high gross sand and the net pay is higher than the MMIO section, but the sands occur within narrower channel belt. This interval is thicker and its net to gross is low so, that there is better sealing potential across faults. This results in a high pay count in this section (Figure 5.5) although the individual traps are small and discontinuous.

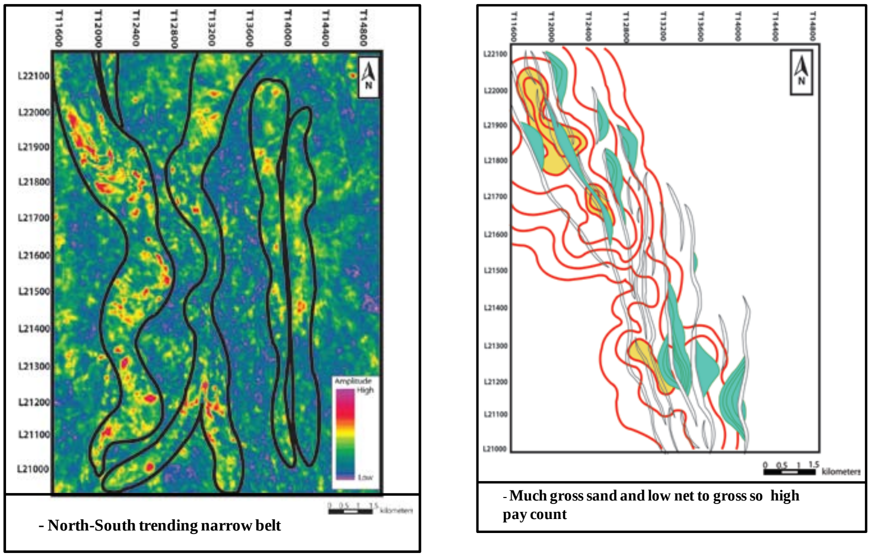


Figure 5.5. Sand distribution trend compared with gross sand map and net pay in T4-T3. High gross sand and the pay is low, but compartmentalized.

The section below T3 is thick, with a very high gross sand, it was deposited in narrow channel belts. Net pay is better than MMIO-T4 section and similar toT4-T3 as this interval is also thick and shows very high gross sand. However it has low net to gross, so this section also has better sealing potential across faults. This results in high pay in this section, but it highly compartmentalized.

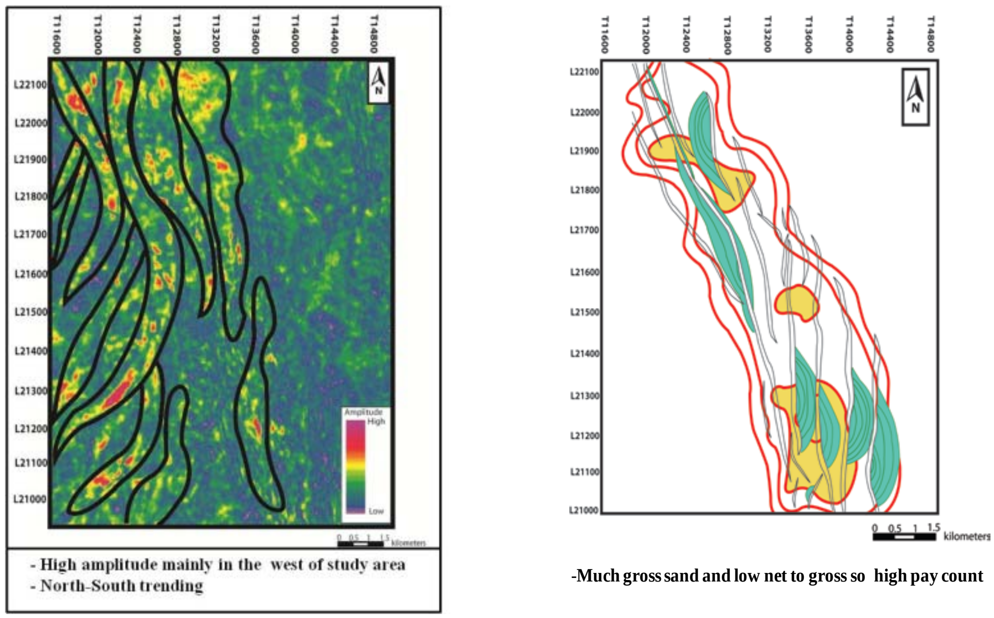


Figure 5.6 Sand distribution trend compared with gross sand map and net pay distribution below T3 section. High gross sand and the pay is high, but compartmentalize

In summary, pay is controlled by structure and sand distribution. High net to gross sections in structurally complex areas have low pay, due to poor fault seal potential. Low net to gross sections with sands deposited in narrow channel belts have more pay, but in very small disconnected compartments. The area of high amplitude: the southwest part of the study area need further evaluation as it in an area where possibly untapped reservoir is present.

4. Conclusions

1. MMIO-T4 section is dominated by a broad fluvial system with thicker sand and relatively good sand continuity, in contrast in the T4-T3and the below-T3 sections. Both these lower sections have discontinuous sands deposited in narrower fluvial channels, compared to MMIO-T4.
2.Sand distribution maps are generally NNW-SSE trending with some sands located across faults, where the faults have no influence on sand trends. That is, the faults in the study area are not syndepositional growth faults and the faults postdate sand depositional trends.

3.The overlay of structure and net to gross maps control pay in this area. In MMIO-T4 there is a high net to gross and a complex faulted structure. There is poor fault sealing because there is less shale in this section and therefore less pay (more sand-to-sand juxtaposition across faults). In contrast, in the deeper T4-T3 and below T3 intervals there is lower net to gross, meaning that there is a better cross-fault sealing potential. So the T4-T3 and below T3 intervals show a higher pay, compared to MMIO-T4, but the sands are less continuous.

5.The RMS amplitude attribute that are extracted from the seismic data can be used to predict sand rich trends in study area, with high amplitudes likely corresponding to sand and low amplitude to shale, a relationship that is confirmed by penetrated wells and sand distribution maps.

6. Acknowledgements

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