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Architecture of Middle Miocene to Pleistocene Sands using 3D Seismic in the Songkla Basin, Gulf of Thailand

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Abstract

The Songkhla basin lies offshore in the Gulf of Thailand and is one of the productive basins for hydrocarbon in fluvial reservoir sands of Cenozoic age. This study aimed to investigate the development of depositional settings in shallow section of the basin and documented both sand distribution and fluvial architecture using 3D seismic data. Moreover, wireline log data was also used to analyze the depositional environment at wells. Nine seismic time-slice images from shallow to deeper section were analyzed. Different parameters associated with channels were documented and these channels were classified based on key measured parameters. It has been observed that channels just above two unconformities are having low sinuosity while as we move upward from unconformities sinuosity increases. Moreover, the dominant flow direction in Middle Miocene was SW-NE, but above Middle Miocene unconformity dominant flow direction was W-E. The channels just above the two unconformities were interpreted as braided, formed due to the drop of base level. The base level drop might be related to combined effect of tectonic subsidence and sea level changes. Log interpretations along with seismic interpretation reveal fluvial environments in Middle Miocene. On the other hand no logs were available for the upper section (Middle Miocene to Recent) therefore only on the basis of results of seismic inversion it has been inferred that section above the Middle Miocene unconformity is more shaly followed by sandy section containing fluvial channels. The source of sediments changed above Middle Miocene unconformity from the southwest to the west.

Keywords: Fluvial architecture, Depositional environment

1. Introduction

The Songkhla basin is one of the productive basins, located in the south west Gulf of Thailand and most of the reservoirs are fluvial sands of Cenozoic age. This research documents channel architecture and predicted sand distribution in upper sequence of Songkhla basin.

This study investigates the development of depositional settings of different sands in the Middle Miocene to Recent section of the Songkhla basin by using 3D seismic data and wireline logs. The main objectives of the study are;

1. To interpret wire line logs to see the depositional environment.
2. Interpret 3D seismic data to map the fluvial channels distribution in the area.

3. Understand the evolution of the area through different depositional episodes.

The deposition model presented here can provide useful information regarding the understanding of the depositional environment of the area and enhance the understanding of the deposition processes in Gulf of Thailand

2. Methods

Well log interpretation was done to interpret the lithology. I prepared GR-AI cross plots to see the relationship between acoustic impedance and lithology. Seismic interpretation was used to investigate the sand distribution on nine time slices. Seismic inversion volumes were used to improve the resolution of seismic at greater depth. Moreover, the channels were digitized and key parameters documented.

3. Results

3.1 Basic Well log interpretation

Lihology analysis

Three lithologies have been interpreted from well logs and confirmed by rock cuttings, they are sandstone, shale and coal.

Well to Well Correlation

The correlation of four key markers based on log and well top data was done. The sedimentary sequence from Top Early Miocene to major break of gamma ray has different character based on GR log pattern in wells of eastern part as compared with wells of the western part. I observed that wells in the south have thicker sand sequence as compared the wells of northeastern part. Therefore the western part is mostly more sandy as compared to eastern part.

Gamma ray - Acoustic Impedance Cross plots

The result of an acoustic impedance versus gamma ray cross plot shows that generally sands are having relatively lower acoustic impedance as compared to the shale.

3.2 Well to seismic correlation

Synthetic seismograms were generated for five wells (R-1,RFF-1.RW-1 and RFF-1) by using sonic and density logs and check shot data was utilized for calibration where it is available.

3.3 Seismic interpretation

Nine time slices at different intervals (Figure 1) were analyzed to study the sand channel distribution and imported parameters were documented for each identified channel (Table. 1).

4. Discussion and conclusion

4.1 Discussion

Channels classifications

Base on the classification the low sinuosity channels (~1.0) are present just above the two unconformities. The average width of the channels below the MMU is greater than that of above it.

Miall (2002) characterized channels as;

1. Bed-load systems, such as braided rivers, and low-sinuosity rivers are most likely to occur during times of of base- level fall.
2. Meandering system characterized by free meander with well developed meander belts commonly characterized periods of modest accommodation generation.
3. The channels in the study area just above the unconformities are interpreted as bed load (braided channel) and gradually they changed to mixed load (meandering channel) channels as we move upward from the unconformities.

4. Deposition system inferred to Middle Miocene to Pleistocene of Songkhla Basin.

5. The result for depositional environment interpretation was analyzed by integrated electrofacies analysis and channel morphology interpreted from time slices. The deposition environment sequence in the RFF-1 coming up from the bottom of unconformity is interpreted as fluvial followed by delta plain. The detail interpretation is shown in Figure 2 and mentioned below.

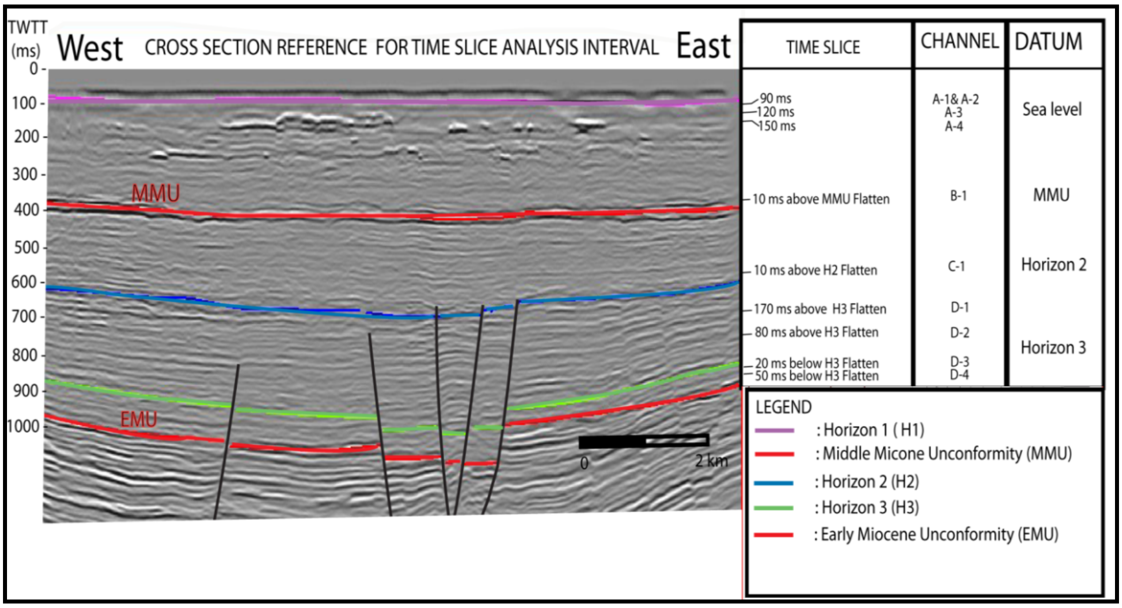

Figure 1. Time slices references.

Table 1. Key parameters of the observed channels

Channel No	From Datum	Channel Width(m)	Meander Wevelength (km)	Valley Length (km)	Meander-Belt Width (km)	Sinuosity	Datum	Flow Direction
A-1	90	358	29	23	4.8	1.3	Sea level	W-E
A-2		165	23	14	2.5	1.6	Sea level	S-N
A-3	120	370	16	11	2.5	1.45	Sea level	SW-NE, W-E
A-4	150	240	15	9.7	1.6	1.5	Sea level	SW-NE
B-1	-10	841	24	22	1.8	1	MMU Flatten	W-E
B-2		290	22	21	0.9	1	MMU Flatten	W-E
C-1	-10	497	22	14	1	1.5	Horizon 2 Flatten	SW-NE
D-1	-170	410	27	22	2.4	1.2	Horizon 3 Flatten	SW-NE
D-2	-80	216	10	8	0.4	1.25	Horizon 3 Flatten	SW-NE
D-3	20	631	27	15	2	1.8	Horizon 3 Flatten	SW-NE
D-4	50	659	17	15	1.1	1.1	Horizon 3 Flatten	SW-NE

Fluvial deposit: The sediment deposited above the unconformity is possible braided channel facies from the logs this facies generally shows low gamma ray at the bottom and at the top the gamma ray trend increases gradually and coal often appear in this interval. The blocky shape is indicated that amalgamated and bell shape pattern is comprised fining upward with strike of coal. Therefore, this interval interpreted as fluvial environment. The time slices show that this interval is comprised of low sinuosity channel overlain by high sinuosity channels.

Delta plain deposit: Above the fluvial deposit the possible sedimentation is of distributaries channel facies represented by low gamma ray inter bedded with the high gamma ray.

The upper part of the log is represented by a series of coarsening successions with funnel shape pattern. This interval interpreted as delta plain environment. (Figure 2).

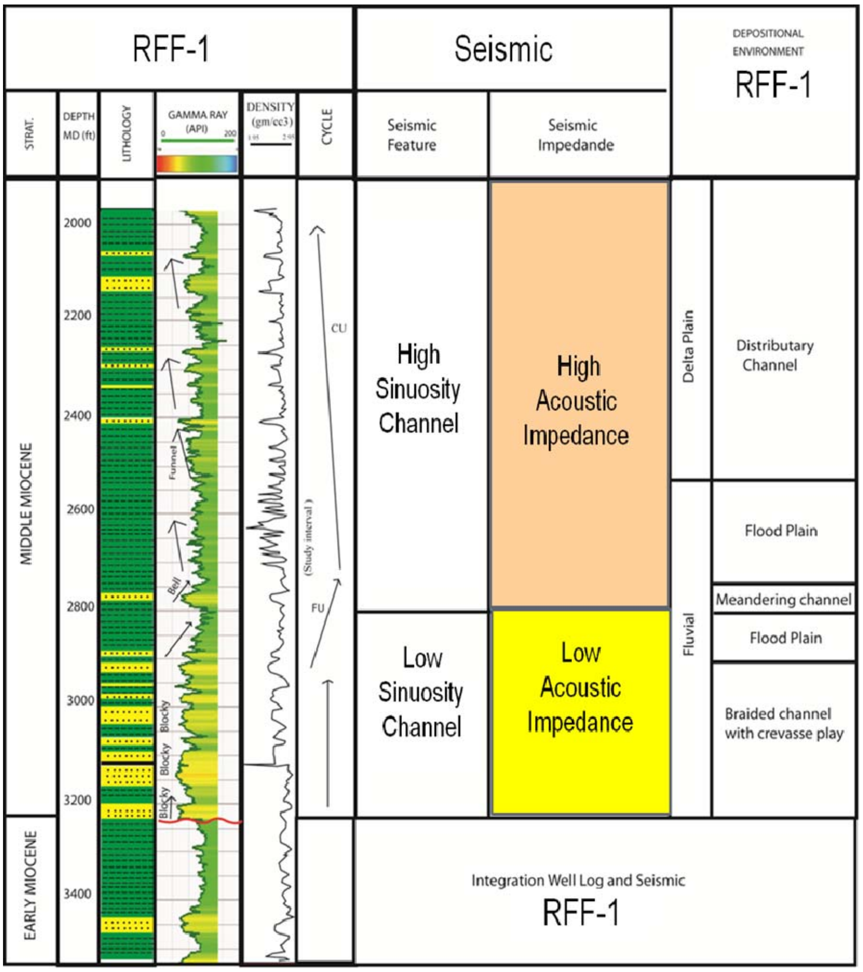

Figure 2. Well log and seismic integration to generate deposition environment for well RFF-1.

4.2 Conclusion

The important findings of the study are described below.

- Petrophysical properties show that low acoustic impedance character corresponds to the sands while the high acoustic impedance corresponds to the shale.
- The time slices show low sinuosity channels as well as high sinuosity channels. The low sinuosity channels were interpreted as bed load type (braided channel) and the high sinuosity channels were interpreted as mixed load type (meandering channel).
- Fluvial style in the Middle Miocene and Post Miocene was influenced by tectonic subsidence and sea level changes.
- The paleocurrent directions indicate that the sediment source has been changed after Middle Miocene unconformity from the southwest to the west of the area.

5. Acknowledgments

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6. Reference

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