

Sand Body Architecture and Seismic Facies Analysis in Nong Yao Area, Pattani Basin, Gulf of Thailand

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Abstract

Analogues of fluvial channel systems were built for a better understanding of sand distribution and reservoir complexity, especially in isolated Early to Middle Miocene sand bodies, in the Nong Yao area on the south-east flank of the Pattani Basin in the Gulf of Thailand. Stratal slicing illustrated the complexity of the amalgamated and isolated fluvial systems where five channel styles were identified, including (1) large channel meander belts, (2) high-sinuosity large channels with large point bars, (3) low-sinuosity small channels with narrow point bars, (4) incised-channel fills and (5) tidal creeks. The best reservoir potential in the study area is in large channel meander belt systems which have high volumes and good connectivity, porosity and permeability. High-sinuosity large channels with large point bars are a secondary reservoir target while low-sinuosity small channels associated with narrow point bars have the smallest volumes and limited connectivity.

Keywords: Nong Yao Area, Reservoir Architecture, Reservoir Distribution

1. Introduction

Reserve estimation in the Nong Yao Field, has a high uncertainty because of the complex reservoir distribution and geometry, especially in the Miocene isolated sand body reservoirs. Shallow 3D seismic data was used to evaluate the internal architecture and distribution of early to middle Miocene fluvial sand bodies to build accurate analogues for the fluvial channel systems in the approximately 310 sq km study area on the southeast flank of the Pattani Basin in the Gulf of

Thailand (Figure 1).

2. Methods

Well log analysis and seismic interpretation were integrated to study sand body geometries and channel distribution in the early to middle Miocene, which was divided into three stratigraphic intervals based on 4 seismic markers and log characteristics (Figure 2). Acoustic impedance (AI) was calculated from an exploration well in the Nong Yao area and used to distinguish sand-prone and muddy

facies responding on seismic images. A synthetic seismogram was modeled for the well using a check-shot survey to correct the velocity and sonic data and there is a good correlation ($r_2 = 0.64$) between the synthetic and a seismic section at the well location, including good tie with the 4 key markers, which correspond to reverse polarity.

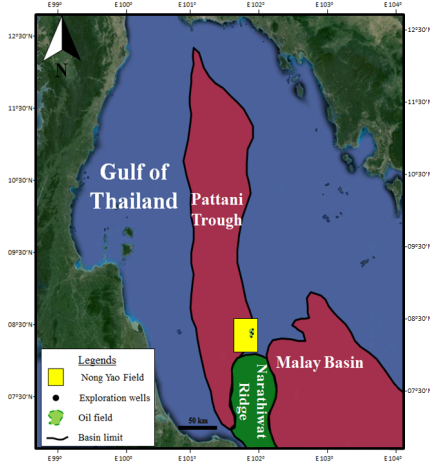


Figure 1. The study area is located in the Southern Pattani Basin, Gulf of Thailand.

Stratal slices were extracted for 10 ms and 15 ms rms-amplitude windows between the H2 and H7 horizons; 12 seismic attribute maps were extracted for the 15 ms windows for each interval while 20 seismic attribute maps were extracted from 10 ms windows (Figure 3).

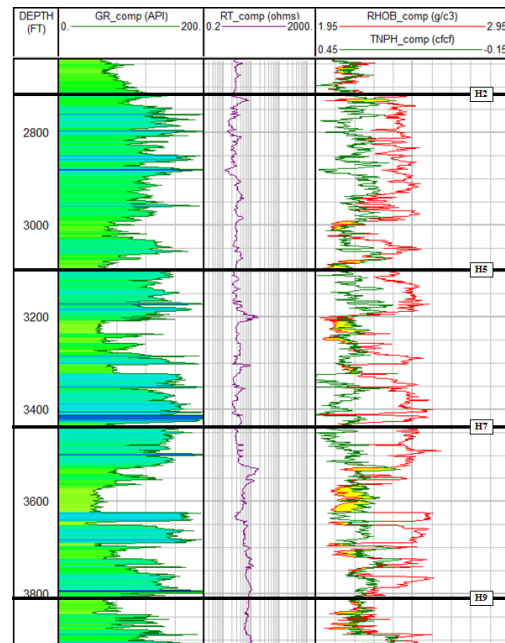


Figure 2. Well log plot (scale 1:2800) showing three different intervals divided by the H2, H5, H7 and H9 key horizons. The interval of interest is between the H2 and H7 horizons.

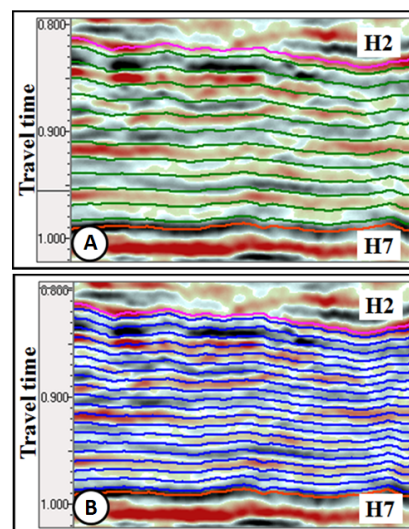


Figure 3. The stratal slices extracted from the A) 15 ms, and B) 10 ms rms-amplitude windows.

3. Petrophysical analysis

An acoustic impedance (AI) versus gamma ray (GR) cross plot was constructed to illustrate lithologic changes in each stratigraphic interval and each interval was characterized by its gamma ray, resistivity and sonic log signature. There is a good correlation between gamma ray value and acoustic impedance, especially in the shallow section. The cross plots suggest that sand with low impedance should stand out from background shale on seismic stratal slices down to the H5 horizon (Figure 4).

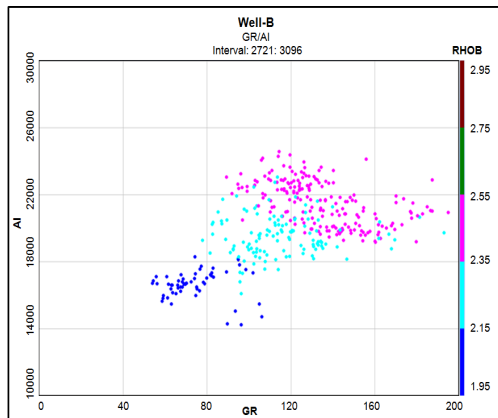


Figure 4. An acoustic impedance (AI) versus gamma ray (GR) cross plot of the H2 interval, with good separation between sand and shale.

4. Seismic interpretation

4.1 Structural Interpretation

Horizon H7 was used to create a two-way-time structure map of the study area that indicates a north to south graben with similarly oriented normal fault systems. There are flat structures in the middle of the mapped area and

multiple fault systems in the east but only one large fault set in the west. Horizons H2, H5 and H7 are strong seismic reflections that are continuous across the study area and represent regionally consistent geologic facies. The H9 key horizon was used only to compare channel systems underlying the interval of interest where seismic resolution is limited.

4.2 Well to seismic correlation

Three wells intersected channel systems that are well defined on stratal slice images and by gamma ray log signatures.

Well-A

The only fluvial style at Well A is the large channel meander belt displayed on slice H2H7_12/4 (Figure 5). This is the amalgamated channel sandstone which displays a stacked pattern of well-developed northwest to southeast oriented point bar deposits, as indicated by the clearly visible meander scrolls. Fining-upward profiles on the gamma ray log also are interpreted as large point bar deposits.

Well-B

An isolated small, low-sinuosity fluvial channel with narrow point bars extends from north to south in the center of the mapped area.

Well-D

This well intersected a large, high-sinuosity fluvial channel with well-developed, large point bars (Figure 6). The fluvial system is on the

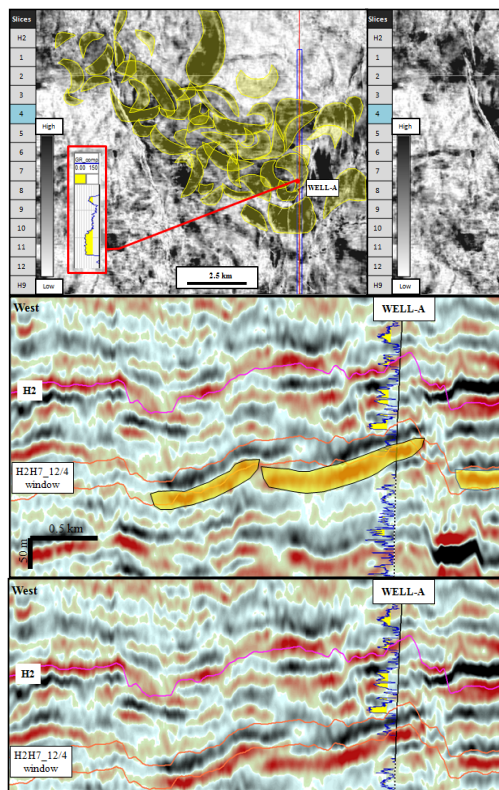


Figure 5. (A&B) Seismic slice H2H7_12/4 across a large channel meander belt, and C&D) a seismic cross-section through stacked pattern point bar deposits.

eastern side of the stratal slice in an area that is highly faulted.

4.3 Facies analysis of stratal slices

Seismic facies below 200 ms TWT are clearest on stratal slice images with an rms-amplitude window parallel to the H2 and H7 horizons (0.8 to 1.1 ms TWT).

H2H7_20/1

Low-rms amplitude features cut across the northeast corner of the mapped area. They are interpreted as incised channel fill. They are most

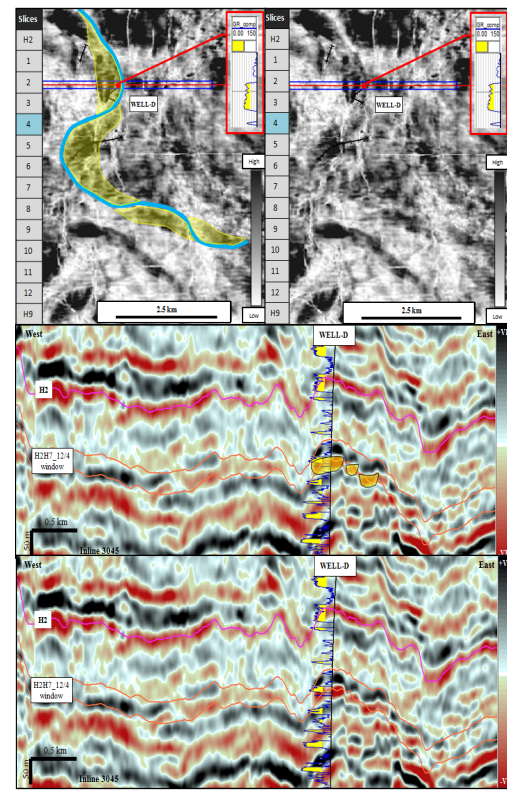


Figure 6. (A&B) the high-sinuosity large channel with large point bars on stratal slice H2H7_12/4, and C&D) a interpreted seismic cross-section through the well.

common close to the H2 horizon over the whole area, especially along the edge of the Nong Yao Field.

H2H7_20/3

There are two fluvial styles on this stratal slice. One is a large high-sinuosity channel with large point bars in the west and the other is a small low-sinuosity channel with narrow point bars that extends north to south and appears in the center and east of the mapped area.

H2H7_12/4

This image features a large amalgamated meandering fluvial channel belt that extends across the northern part of the mapped area. The multistory component of the meander belt is seen on the seismic image as high rms-amplitudes corresponding to large point bar deposits.

4.4 Channel styles

Five channel styles were identified in the study area based on channel size, channel sinuosity and meander belt size. Each channel type corresponds to a different depositional setting.

(1) Large channel meander belts

Large meandering systems with well-developed point bars. Abundant point bars reflects a low slope and high accommodation space and is associated with high energy fluvial systems.

(2) High-sinuosity large channels with well-developed point bars

High-sinuosity large channels with well-developed point bars commonly occur in gently sloped, high accommodation space, high energy fluvial systems where point bars are well deposited.

(3) Low-sinuosity small channels with narrow point bars

Low-sinuosity small channels with narrow point bars generally occur in fluvial systems with high depositional gradients and low accommodation space.

(4) Incised channel fill

Incised channels usually form during periods of negative accommodation or low accommodation space caused

by regional uplift or relative sea-level fall, although periods of increased discharge or reduced sediment supply also may trigger channel incised (Miall, 2002).

(5) Tidal creeks

Tidal creeks are unequivocal evidence of marine influence within a dominantly non-marine system and a of depositional setting close to the paleo-shoreline, possibly within approximately 10-15 km (Reijnen et al., 2011).

5. Reservoir implications

The different types of fluvial system have a variable stratigraphic and geographic distribution (Figure 7); consequently, reservoir quality is also variable. Large channel meander belts are the best reservoir target because they have the highest volume of sand-prone units as well as the highest porosity and permeability and good connectivity in the stacked point bar deposits. Isolated large, high-sinuosity channels with large point bars also are good reservoirs with high porosity and permeability in the point bar sands, although reservoir volume and connectivity is less than in large channel meander belts. Low-sinuosity small channels have the smallest reservoir volumes, low porosity and permeability and poor connectivity.

6. Conclusions

Integrating well log analysis and seismic interpretation to determine the reservoir architecture lead to the following conclusions:

1. Fluvial systems dominate the entire succession, although there is evidence of marine-influence on the youngest horizon.
2. Deeper intervals have complex fluvial systems with sand-prone units comprising both amalgamated and isolated channel systems.
3. Large channel meander belt systems have the greatest reservoir potential because of high volumes and good connectivity plus high porosity and permeability. Large high-sinuosity channels with large point bars also are good reservoir targets.

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