The Stratigraphic Trap in the Benchamas Field
Pattani Basin, Gulf of Thailand

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Abstract

This research focuses on the possible key elements which define purely stratigraphic trap plays in unfaulted areas in the Pattani Basin, based on data from the Benchamas field. The analysis integrates the well logs, 3D seismic, mud log and production data to develop a model for the stratigraphic trap. Five wireline logs in unfaulted zones and nearby wells were used to define the lateral extent of the key reservoirs in the area and used to construct the initial model for possible trapping styles. Three-dimensional seismic data analysis corroborated the actual trapping styles which defined the post-analysis model. Detailed interpretation determined both structural and stratigraphic traps exist in the study areas. The thin sands, which pinch-out on the structural high, tend to be the stratigraphic traps with hydrocarbons filled full-to-base whereas the thick sands are more likely to be structural traps with hydrocarbons on water. The integration of amplitude maps and seismic character can image the channel sand distributions where the pinch-out sands are likely to be located on the channel margins, whereas the thick sands are found in the middle of the channel systems. Sequence 3 has a potential for stratigraphic trap from thin sands interbedded with thick shales. Production data reveals the reservoirs performance and shows that the pinch-out sands can be rewarding as seen by 195,000 bbl of cumulative oil production in the BEWG-17 well. Several constructed models were defined which add value to the understanding of the stratigraphic trap mechanisms in the basin and can help to choose future well locations in the Gulf of Thailand.
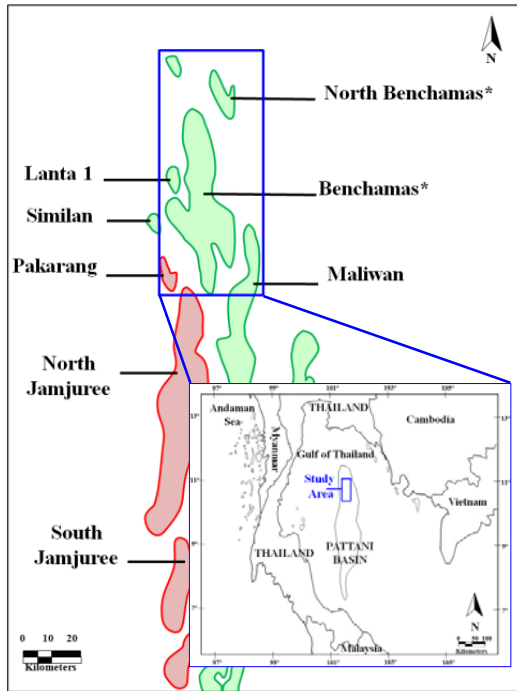
Keywords: Benchamas field, Unfaulted area, Stratigraphic trap and Pinch-out

1. Introduction

The understanding of stratigraphic trapping styles may add to opportunities of discovery of hydrocarbons in the Gulf of Thailand. The study area, the Benchamas oil field (Figure 1) is located in the northern part of the Pattani Basin with production from fluvial sands of Miocene and Oligocene ages. Five wells were drilled in unfaulted areas and were the focus of this study. To make a model for stratigraphic traps, well logs, 3D seismic, mud logs and production data are integrated through this research project.

This research project focuses on the possible key elements which can define purely stratigraphic trap plays in unfaulted areas. The main objectives of the study are :

1.) To study purely stratigraphic plays in unfaulted zones in the Benchamas field to understand why they worked or not.

2.) To define the possible key elements for stratigraphic trap.

3.) To develop the model for the stratigraphic plays and to apply the concepts of the stratigraphic traps for predicting future well locations.
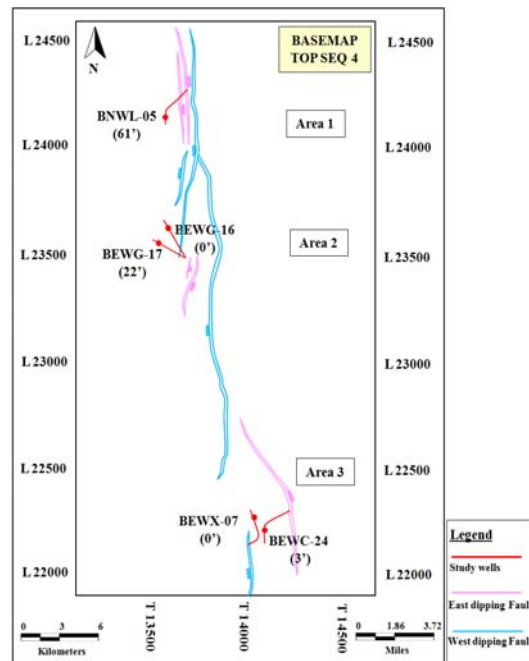
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Figure 1. Location map of the Benchamas Field, Pattani Basin, Gulf of Thailand.

2. Methodologies

The study area is separated into 3 areas: Area 1, 2 and 3 (Figure 2), based on the well locations. Well logs were used to correlate sands to understand the lateral extent of the key reservoirs and to construct the initial models of the possible trap mechanism in each well. The gamma ray, density and sonic logs were used for acoustic impedance and gamma ray crossplots to help identify the relationship between rock properties and seismic character. To tie the well to 3D seismic, synthetic seismograms were created using time-depth relationships from nearby exploration wells in each area.

Three-dimensional seismic data was used to corroborate actual trapping style models. The seismic interpretation and depth structural map was generated to understand the structural styles and the possible key trapping factors in each area. The RMS amplitude map was made to image the regional depositional setting of the sands in

the interval of interest. Mud log data was used to inform the lithologic identification and used for the reservoir quality analysis. Moreover, the production data was useful for the reservoir performance. The cumulative oil production helped to support the actual reserves and the reservoir potential in subsurface.
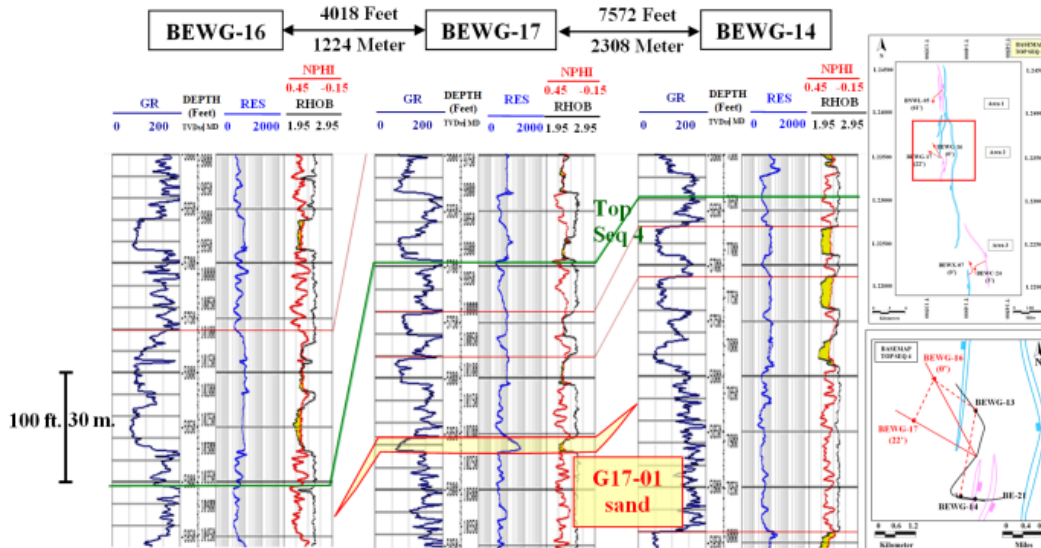

Figure 2. Map showing the 3 zones of study: Area 1, 2 and 3 within the Benchamas field. Pay is shown for each well.

3. Results

3.1. Well log analysis

Well Log Response

The well log response helped to evaluate the sand/shale distribution in the study wells. Due to the fact that they were drilled in unfaulted area, the sands are generally wet. Oil full-to-base was found in the thin sands. On the other hand, the thick sands generally had thin hydrocarbon on water.

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Figure 3. Well log correlation panel from the BEWG-17 to nearby wells. This shows the top sequence 4 and top of sands correlation. The BEWG-17 well shows the pinching out sand configuration of G17-01 sand which is oil filled full-to-base of 12 feet.

Well Log Correlations

The well log correlations were determined from the 'electrosequence analysis'. The top of sequence 3, 4 and 5 were correlated by extensive shale beds and coals and showed the structural correlation in a fault block. The majority of sand intervals were in sequence 3 and 4. Pay sands and some thick sands were correlated to identify the sand distributions. The results show that thick sands, particularly in the BNWL-05 well have continuity to nearby wells whereas the thin sands, particularly in the BEWG-17 well, did not correlate to other wells and shows pinch-out configuration. Figure 3 shows the example of well log correlation in BEWG-17 which is the potential stratigraphic trap by pinch-out.

Acoustic Impedance - Gamma Ray Crossplots

The result of crossplots indicate that sands have low gamma ray, acoustic impedance and density; in contrast, shale has high gamma ray, acoustic impedance and density. This supports the top of the sand in well log corresponding to a trough (low impedance contrast) on seismic and base of the sand corresponding to a peak (high impedance contrast).

Well Tie to 3D Seismic

The synthetics were generated using the exploration wells to provide the time-depth relationship in each area. The tie between seismic character and petrophysical response from the well logs along the wellbore adds to confidence in sand interpretation. Synthetics in each area provided a good match between trough (low impedance) to negative reflector and peak (high impedance) to positive reflector on seismic. The correlation coefficient value is approximately 56% to 79% which is excellent. Time-depth table established the link between rock properties from well logs to seismic.
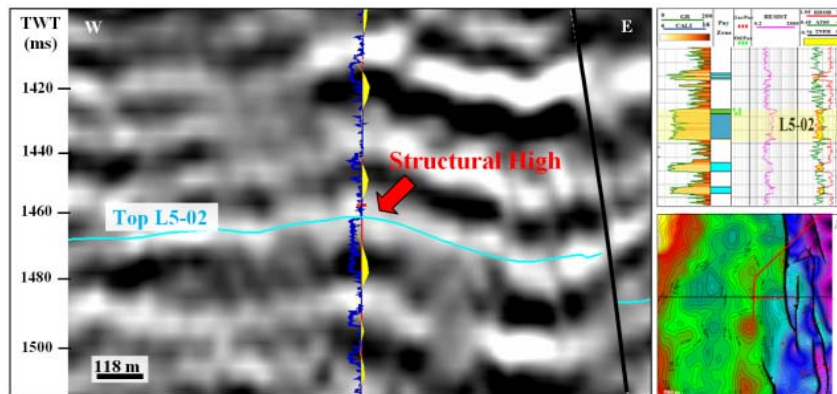
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3.2. Seismic Interpretation
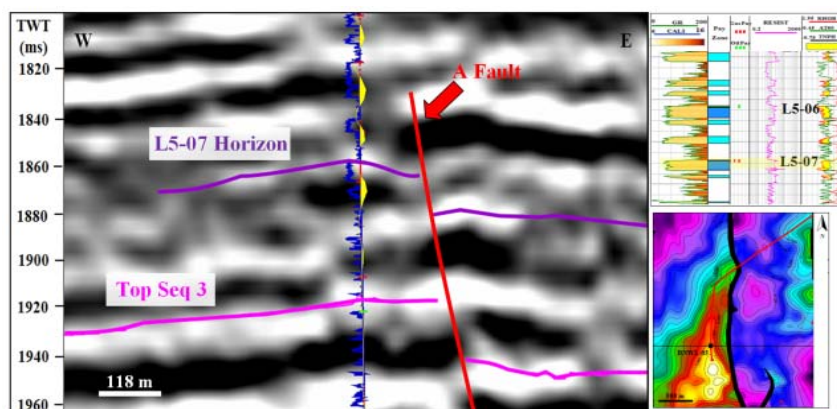
Horizon and Fault Interpretation

The seismic interpretation was a critical step to confirm the actual geological image for the post-analysis models for stratigraphic traps. Many horizons were interpreted to observe the structure and the potential stratigraphic trap in each area. The BNWL-05 well which has hydrocarbons on water sands seem to be structural traps: four-way dip closures and fault traps. Figure 4 is an E-W seismic cross section showing the L5-01 sand is within structural dip closure. Figure 5 is a seismic section through the L5-07 sand where the small fault is the main trap for this sand.

The depth structural maps were generated to observe the structure of the reservoirs in three-dimensions. These can help identify the understanding of trapping mechanism of thin hydrocarbons in each sand. The example of L5-02 sand (Figure 6) shows the penetration point of this sand is located in the closure area but the top sand down to spill point is only 15 feet of oil on water. This is consistent to well log data.

Even though some of the study sands are structural traps, the potential for stratigraphic traps exist as shown in the BEWG-17 well. The G17-01 and G17-02 sands are potential pinch-out sands updip on the flank of structural high to the west of the well (Figure 7). Well log data shows that
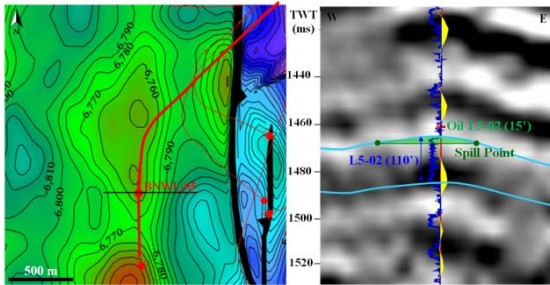

Figure 4. An E-W seismic section showing horizon interpretation of the L5-02 sand. It identifies the true trapping style as structural closure for this sand.
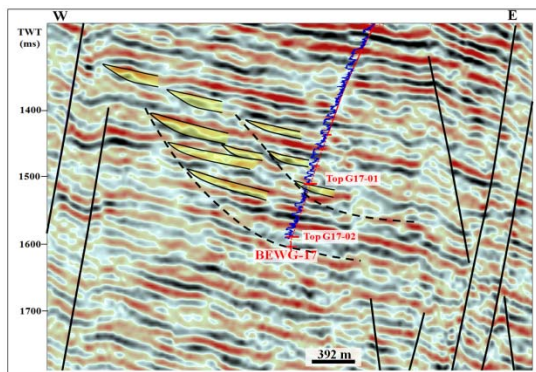

Figure 5. The detailed seismic section of L5-07 sand. This sand was trapped by small fault called 'A Fault' and has combination dip and fault trap closure.

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these sands are not correlateable to other areas. Another stratigraphic potential section is in sequence 3 where there are thin sands surrounded by thick shales.

Figure 6. The detailed depth structural map shows a hydrocarbon capacity of about 15 feet for this sand. The BNWL-05 well penetrated this sand at 6755' TVDss and spill point is at 6770' TVDss.
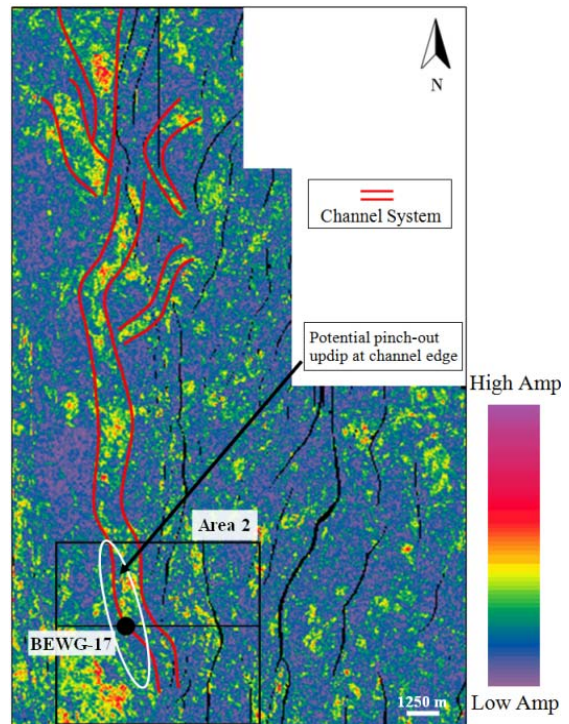

Figure 7. The seismic cross-section through the BEWG-17 well shows the pinch-out sand and possible channel system related to the seismic reflectors. This feature indicates the stratigraphic trap style.

RMS Attribute Map Analysis

RMS amplitude attribute maps were created by using a regional horizon and computed to cover the top sand interval on seismic data. The amplitude maps were used to see the overall picture of the possible depositional environments in the interval of interest. The high amplitudes represent the high contrast of formation layer which refers

to sands in this data set, whereas the low amplitudes represent the low contrast of rock formations in shale background in this area. Generally the results illustrate the possible sand geometry of a meandering channel deposit having many small channels associated inside. This is an important analysis to understand the trapping mechanism associated with hydrocarbon accumulation and to find the possible depositional environment related to stratigraphic traps. Based on the pinch-out feature in the BEWG-17 well, the RMS amplitude map can help to support the idea as shown that the well is located on the western channel edge where sand pinch-out updip is probable. Figure 7 is an example of the RMS amplitude map.

Figure 8. The RMS amplitude map of G17-01 sand interval. The red line is the possible channel sands system. This pattern can help to support the stratigraphic trap as shown in the BEWG-17 well which is located at the edge of the channel where sands pinch-out updip to west.

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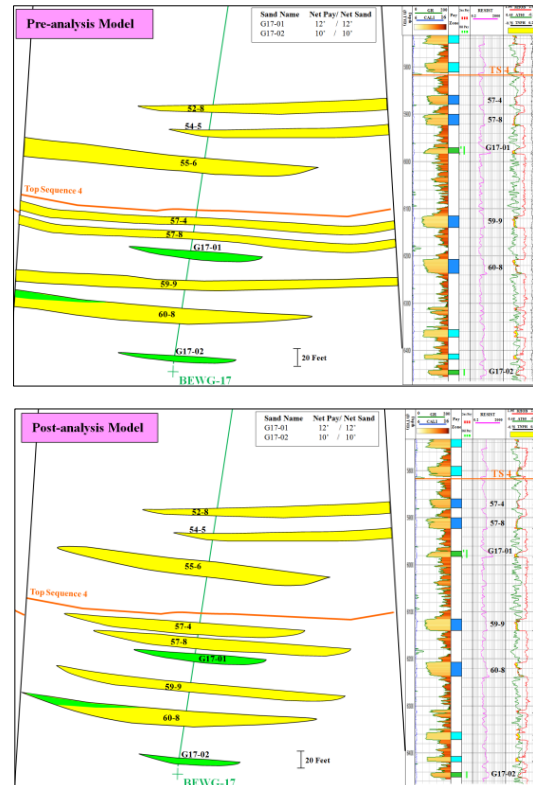### 3.3 Reservoir Properties Analysis

The mud log and production rate data helped to confirm the reservoir performance. For example, the BEWG-17 well has good reservoir properties and shows high cumulative oil production from only one thin sand. This indicates that the stratigraphic trap pinch-out sand is worth looking for.

4. Discussion

The integration of well log, 3D seismic, mud log and production data can help identify and understand the different stratigraphic traps identified in the Benchamas field. The initial and post-analysis models were compared for each area and actual trapping styles for each area was determined. The example for both initial and post-analysis for the BEWG-17 well is shown in Figure 9. The sand configurations in this study show thick sands have oil on water and tend to be subtle structural traps rather than purely stratigraphic traps. These sands are frequently found in the middle of channel systems. On the other hand, the stratigraphic traps tend to be in thin sands which pinch-out on the flanks of structural highs. Even though they are thin sands they can be rewarding as shown by high cumulative oil production in the BEWG-17 well. The well location suggests that the pinch-out sand was found at the edge of channel.

5. Conclusions

One of the wells drilled in unfaulted areas is actually a structural trap whereas another two wells have probably drilled stratigraphic traps. Thin sands which are filled full-to-base with hydrocarbons pinch-out combining with updip structure and are pure stratigraphic traps. In contrast, the thick sands that have thin hydrocarbons on water tend to be structurally trapped. The integration of amplitude extraction and

Figure 9. The pre- and post-analysis models show some corroboration for sand reservoirs. This well shows the pinch-out updip where the location for purely stratigraphic traps may exist.

seismic character can image the possible channel sand distributions which can indicate where there might be the pinch-out features such as the edge of channels, crevasse splays and interbedded sand in floodplains. Thick sands within the middle of sandy channel systems are unlikely traps off structure. Very thin sands in sequence 3 have the potential for purely stratigraphic traps. In summary, this study constructed several models for the understanding of stratigraphic traps in the Benchamas field area which can apply to other fields that have similar depositional settings of fluvial deposits. The stratigraphic trap model could be used to predict future well locations and provides an additional

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trapping mechanism to consider in the Gulf of Thailand.

7. References

Jardine, E., 1997. Dual petroleum systems governing the prolific Pattani Basin, offshore Thailand. Petroleum systems of S.E. Asia and Australasia Conference, Jakarta, May 21-23, 1997, p. 351-363.

Rigo, L., Baranowski, J., Mattingly, G., Chaikiturajai, C., Nelson, G., and Wechsler, D. 2002. Block B8/32, Gulf of Thailand: Petroleum system and implementation of technology in field development. Seapex Press 6, p. 46-55.

Watcharanantakul, R., & Morley, C. K., 2000. Syn-rift and post-rift modeling of the Pattani Basin, Thailand: evidence for a ramp-flat detachment. Marine and Petroleum Geology, v.17, p. 937-958.

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