3D-SEIMIC INTERPRETATION IN THE NORTHERN PART OF PATTANI BASIN, GULF OF THAILAND

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การแปลความหมายคลื่นไหวสะเทือนแบบสามมิติ บริเวณตอนเหนือของแอ่งปัตตานี อ่าวไทย

ปิยนุช นำปรัชญากุล

รายงานฉบับนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาตรี
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ABSTRACT

Oil and gas explorations in Thailand are concentrated in the Tertiary basins. One of the biggest offshore sedimentary basin in Thailand is the Pattani basin, which has many potential oil and gas fields. This project aims to identify the potential reservoirs for oil and gas in the northern part of Pattani basin. By using 3D-seismic data, two-way time structural maps can be generated and some significant features can be defined from attribute maps in order to locate the structural closures that are suitable for hydrocarbon accumulation.

From the results of study, the two-way-time structural maps of three Horizons illustrate a structural high in Eastern and Western parts of the area and gently down-dip slope to the graben center. Structures closures were in the up-thrown side of faults that located in the structural high area. In addition, result of attribute analysis for Horizon A shows a continuity of shale surface which was characterized as a regional seal, Horizon B illustrated a paleo-channel feature shown in seismic amplitude map, and Horizons C shown high amplitude anomalies that lie conformably to structure closures. These anomalies were believed to correspond to hydrocarbon accumulation in that closure. The conclusion from combined the structural map with an attribute map confirmed that there are four and three prospected areas in Horizon B and C respectively

หัวข้องานวิจัย: การแปลความหมายคลื่นไหวสะเทือนแบบสามมิติ บริเวณตอนเหนือของแอ่งปัตตานี อ่าวไทย
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บทคัดย่อ

การสำรวจหาแหล่งน้ำมัน และ แก๊สธรรมชาติในประเทศไทยนั้น ให้ความสำคัญกับแอ่งตะกอนใน ยุคเทอร์เชียรี เป็นหลัก โดยมีแอ่งปัตตานี เป็นหนึ่งในแอ่งสะสมตะกอนขนาดใหญ่ ที่สามารถพบแหล่งน้ำมันและแก๊สธรรมชาติที่มีศักยภาพ กระจายตัวอยู่มากมายในพื้นที่ การศึกษานี้จึงมุ่งเน้นเพื่อระบุบริเวณ ที่มีแหล่งกักเก็บ น้ำมันและแก๊สธรรมชาติ ในบริเวณตอนเหนือของแอ่งปัตตานี อ่าวไทย โดยอาศัยการแปลผลข้อมูลคลื่นไหวสะเทือนสามมิติ เพื่อสร้างแผนที่ธรณีวิทยาโครงสร้างของพื้นที่ศึกษา พร้อมทั้งศึกษาคุณลักษณะของคลื่นไหวสะเทือน ซึ่งมีความสัมพันธ์กับชนิดของหิน และของไหลในหินนั้นๆ เพื่อประมวลผลร่วมกัน และระบุพื้นที่ ที่มีโครงสร้างกักเก็บที่มีความเหมาะสมต่อการสะสมตัวของปิโตรเลียม

จากการศึกษาธรณีวิทยาโครงสร้างของพื้นที่ ซึ่งได้จากแปลผลข้อมูลคลื่นไหวสะเทือนสามมิติ พบว่า บริเวณที่มีพื้นที่สูง จะอยู่ทางทิศตะวันตกและทิศตะวันออกของพื้นที่ และมีความชันลดต่ำลงเรื่อยๆ เข้าหาจุดศูนย์กลางของแอ่งสะสมตะกอน ซึ่งมักจะพบโครงสร้างกักเก็บอยู่บริเวณที่สูงของพื้นที่ศึกษานี้ ยิ่งไปกว่านั้น จากผลการศึกษาคุณลักษณะของคลื่นไหวสะเทือน พบว่า ระนาบเอ แสดงลักษณะของหินดินดานที่เป็นตัวปิดกั้นที่แผ่กว้าง ระนาบบี แสดงให้เห็นลักษณะของทางน้ำโบราณ และ ระนาบซี แสดงลักษณะความผิดปกติของแอมพลิจูดค่าสูง ซึ่งอยู่ในบริเวณที่สอดคล้องต่อ โครงสร้างกักเก็บในพื้นที่ศึกษา โดยคาดว่าลักษณะความผิดปกตินี้ เกิดจากการตอบสนองของ ไฮโดรคาร์บอน ที่สะสมตัวอยู่ในแหล่งกักเก็บ ผลสรุปจากการวิเคราะห์ทั้งทางธรณีวิทยาโครงสร้าง และคุณลักษณะของคลื่นไหวสะเทือน จะได้พื้นที่ ที่มีความเหมาะสมต่อการสะสมตัวของน้ำมันและแก๊สธรรมชาติ 4 ตำแหน่ง บนระนาบเอ และ 3 ตำแหน่ง บนระนาบบี ตามลำดับ

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1.1 General statement

The growing population and rising living standards cause an increasing demand for energy. Despite the many efforts made to exploit new energy sources such as solar energy and bio-mass, oil and gas continue to be necessary sources of energy. The total amount of oil and gas produced each year is still increasing and is likely to continue to do so for at least the next 30 years (www.wikinvest.com/concept/Rising_Worldwide_Demand_for_Energy).

Since the first seismic surveys, in the 1920's (Bakker, 2002), the seismic reflection method has played an important role in the exploration of oil and gas. This method can provide subsurface images over depths from several meters to several kilometers. So it can assist in searching for the new petroleum reservoirs.

Oil and gas explorations in Thailand are concentrated in the Tertiary basins because Tertiary was a period of development of these basins. One of the biggest offshore sedimentary basin in Thailand is the Pattani basin, which has many potential oil and gas fields.

This project comprises of interpretation of seismic data in correlation with well log data. The results of this study are important to help locating potential reserves of oil and gas in the area studied. They also can be used as a supplementing data for supporting the petroleum production in the future which will help meet the demand and reduce the need to import oil and gas from other countries.

1.2 Study area

The study area is located in the northern part of the Pattani basin and lies on the northwestern flank of the Pattani basin, central Gulf of Thailand, which is about 200 km east of the shore as shown in figure 1.1. The major structures of this basin are graben and half graben. The major trend of structure is N-S direction. The study area covers approximately 900 sq. km and contains two exploration wells, namely Well A and Well B.

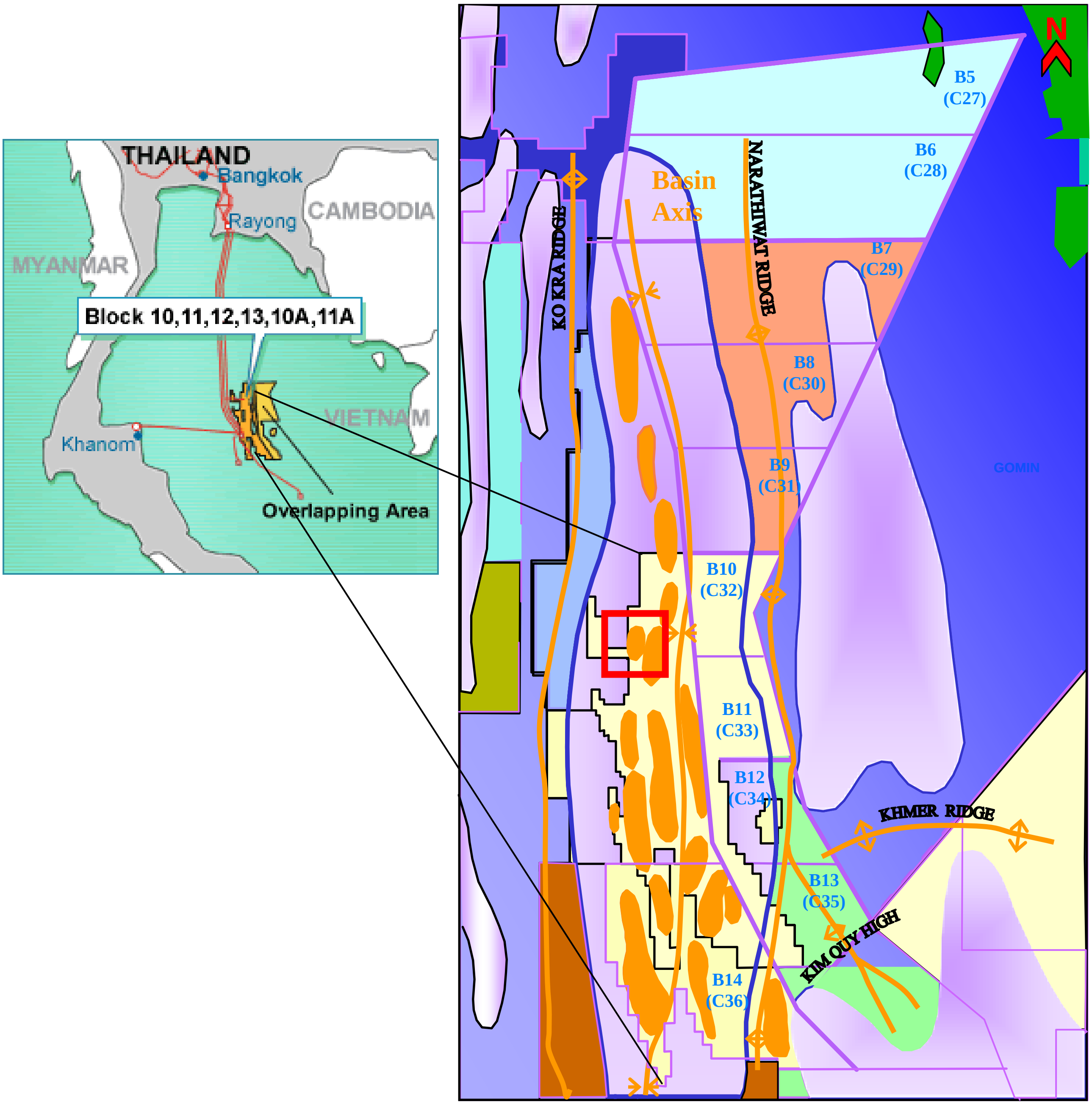


Figure 1.1 The location map of the study area (red square) in the northern part of Pattani basin, Gulf of Thailand (PTTEP, 2002).

1.3 Objective

This project aims to identify the potential reservoirs for oil and gas. By using 3D-seismic data, two-way time structural maps can be generated and some significant features can be defined from seismic amplitude and attribute maps in order to locate the structural closures that are suitable for hydrocarbon accumulation.

1.4 Methodology

1. Literature surveys

First, previous works that involved geological background and petroleum geology of the study area, geophysical theories, especially seismic interpretation method, and also well log interpretation will be fully reviewed.

2. Well study and data correlation

This step expects to identify the stratigraphy from wireline logs, which consist of gamma-ray log, resistivity log and sonic log of Well A and Well B, and then correlate them with a general stratigraphy of the Pattani basin. This result is used for selecting the marker horizons, namely: Horizon A, Horizon B and Horizon C. In addition, workstation orientation is performed at the same time.

3. Seismic interpretation

Charisma 4.2 software will be used in this project to interpret the seismic data and create the two way time structural map, and compute seismic attributes. In addition, synthetic seismograms from previous works are used to correlate with seismic section to obtain the position of marker horizons.

4. Data compilation

Compiling the structural map along with the computed attributes help to find the structural closures that are suitable for hydrocarbon accumulation.

5. Discussion and conclusion

6. Presentation and writing report

1.5 Database

All data in this study is kindly supported by PTTEP. The data are composed of;

1. Reports of well completion in the northern part of the Pattani basin and
2. Seismic data and well summary data.

1.6 Theoretical and literature review

Based on seismic reflections process, seismic energy will be impinging on an interface between two rock types with different velocities and densities. Part of the energy will be reflected at the interface and will return to the surface as a reflected wave, but most of the energy will be transmitted right through the interface. To use an optical analogy, seismic reflectors in the earth are more like a pane of window glass than a mirror; they reflect enough energy to give an image, but most of energy passes through them (Sheriff, 1989).

For a wave that strikes an interface at normal incident (angle of incidence = 0), the equation for amplitude ratio of the reflected wave compared to amplitude of an incident wave is simple. This ratio is called the reflection coefficient, or reflectivity, represented by symbol R.

R = reflectivity or reflection coefficient

$$R = \frac{\text{Amplitude of reflected wave}}{\text{Amplitude of incident wave}}$$

$$= \frac{\rho_2 V_2 - \rho_1 V_1}{\rho_2 V_2 + \rho_1 V_1} \qquad \text{----- (1)}$$

$$= \frac{\text{Change in acoustic impedance}}{\text{Twice the average impedance}}$$

$$= \text{(1/2) change in (log of acoustic impedance)} \qquad \text{----- (2)}$$

The product of the velocity V and density ρ is call acoustic impedance, and it is depended on the median as shown in figure 1.2. The subscript 1 refers to the incident medium and 2, to the medium on the other side of the interface (Sheriff, 1989).

Seismic interpretation begins with the selection of seismic markers which correlated with geological events picked from well-log data. This structural interpretation mainly consists of creating horizons and fault planes.

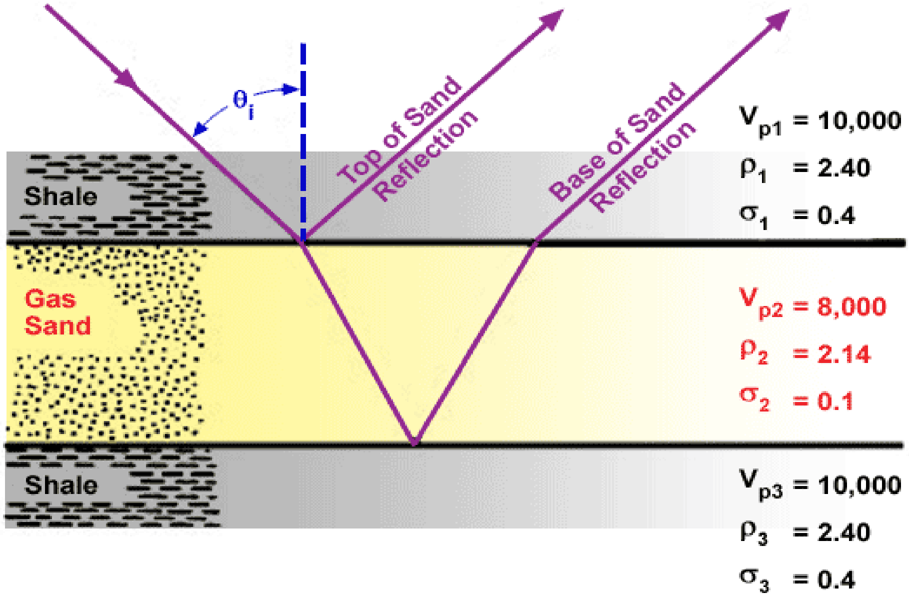


Figure 1.2 The reflection from the different medians that also have different acoustic impedances (Vp) (Ostrander, 1984).

Horizons are surfaces that created by the interpreter by selecting a reflector and picking it over the seismic data volume. As an example, three horizons are shown in figure 1.3. There are several reasons why a reflector is selected to interpret the horizon. The simplest reason is that the reflector is outstandingly clear and strong, making it easy to track. Sequence boundaries are important horizons used to distinguish between the different geological periods. Another example of an important horizon is the top of a reservoir, because it is helpful to identify the location of hydrocarbon accumulated (Bakker, 2002).

A fracture in the subsurface rock caused by tectonic forces is called a fault. Faults cause discontinuities in the layered structure that make the creation of horizons more difficult. To be able to continue a horizon over a fault, it is necessary to know the amount of vertical displacement between both sides of the fault. In addition, attribute studies are based on three significant components of seismic data; amplitude, phase and frequency. They can be helpful to define the sedimentary structures, depositional environment and indicate the hydrocarbon indicator (Bakker, 2002).

Chinbunchorn et al. (1989) assessed the petroleum potential of the Tertiary intermontane basins in Thailand. They suggested that these basins were developed in Tertiary time under non-marine depositional environment. They suggested the sequence of Lower to Middle Miocene lacustrine deposits as the most probable petroleum source rocks.

Praditan and Dook (1992) described the detailed geology of the northern part of the Gulf of Thailand, whereas Sattayarak (1992) briefly identified specified the opportunity of petroleum exploration in Thailand.

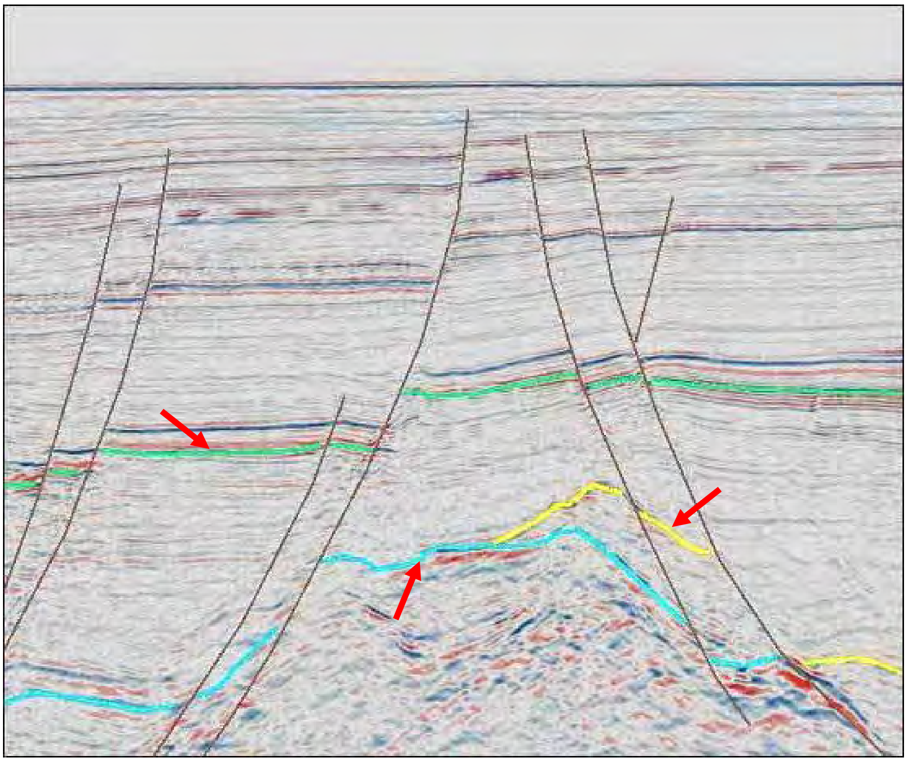


Figure1.3 A vertical 2D cross-section of a 3D seismic image. Three horizons have been tracked and they are pointed at by red arrows (Bakker, 2002).

Chapter 2 Geology of the Gulf of Thailand

2.1 Tectonic setting
2.2 Basin formation
2.3 Stratigraphy and sedimentology
2.4 Pattani basin

The Gulf of Thailand is a northwest-southeast trending, re-entrant, epicontinental sea, with a maximum water depth of approximately 90 m. Located fairly far from any active subduction or spreading centers, the Gulf of Thailand overlies a portion of Sundaland on the southern portion of the Eurasian Plate and exhibits only minor amounts of shallow focus seismicity (Achalabhuti, 1975).

2.1 Tectonic setting

In the Gulf of Thailand, the tectonic framework is controlled by N-S trending extensional faults. There are two major fault systems (1) NW-SE normal fault, Three Pagoda fault which runs from Myanmar border and appears to extend to northern part of the Gulf of Thailand and Mae Ping fault and (2) NE-SW strike-slip fault, Ranong fault runs across the peninsula of Thai-Malay to the northwestern part of the Gulf of Thailand. From these two major fault systems, the pull apart basins are developed in the Gulf of Thailand as shown in figure 2.1 (Achalabhuti, 1975).

A regional tectonic of the Gulf of Thailand are graben or half-graben (figure 2.2), formed by extension during late Cretaceous to early Tertiary times. The long extending Ko Kra ridge divided the Gulf of Thailand into two structural provinces. The eastern part of Ko Kra ridge, consists of two major sub-basins: Pattani trough in the northern and Malay basin in the southern part of the gulf. These two basins are separated by Narathiwat ridge. The western part of Ko Kra ridge, is composed of several small and shallow basins, e.g. Kra basin, Western basin and Chumphon basin. These basins are divided from other basins by elongate and narrow basement ridges (Polachan and Sattayarak, 1989).

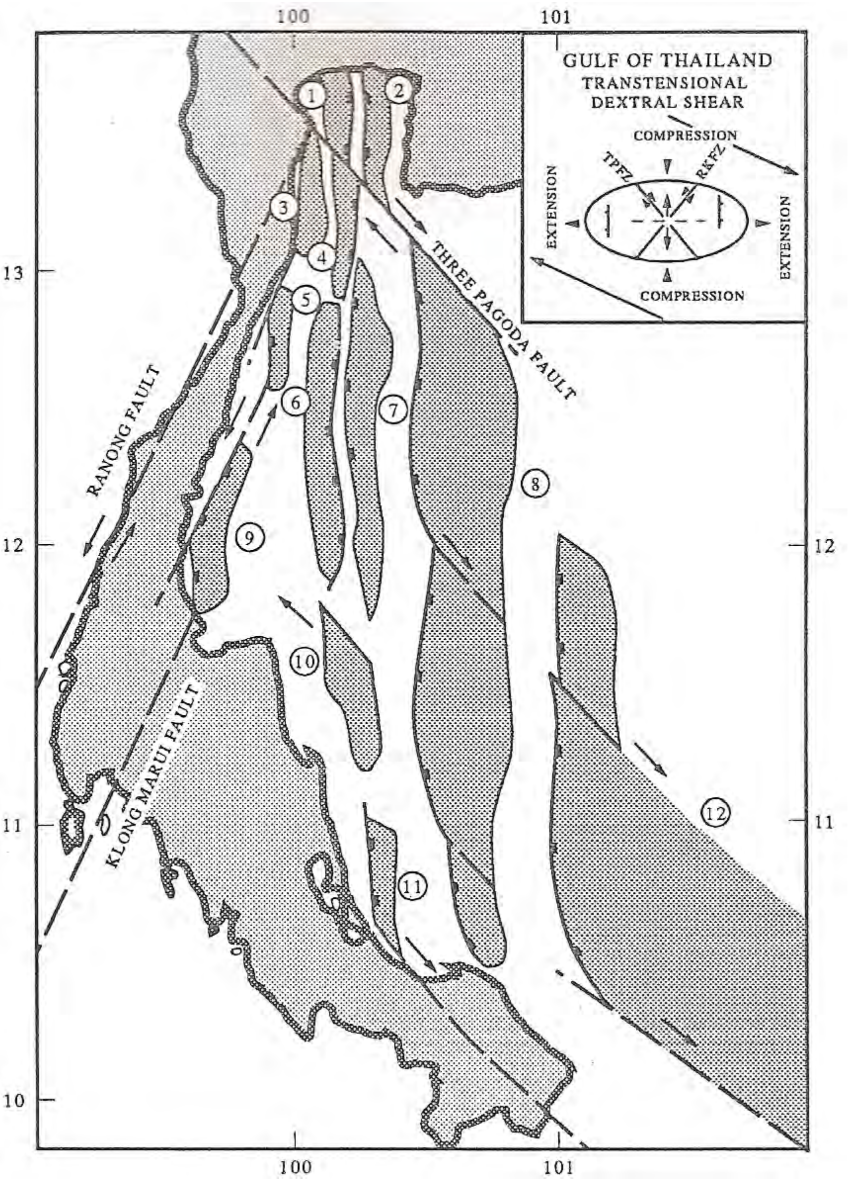


Figure 2.1 Diagrammatic representation of the development of pull apart basins in the Gulf of Thailand by the major strike-slip fault system.

1 = Sakhon basin 2 = Paknam basin 3 = Hua Hin basin
4 = North Western basin 5 = Prachuap basin 6 = Western basin
7 = Kra basin basin 8 = Pattani basin 9 = Chumphon basin
10 = Nakhon Sri Thammarat basin 11 = Songkhla basin 12 = Malay basin

(from Polachan and Sattayarak, 1989 based on Achalabhuti, 1975)

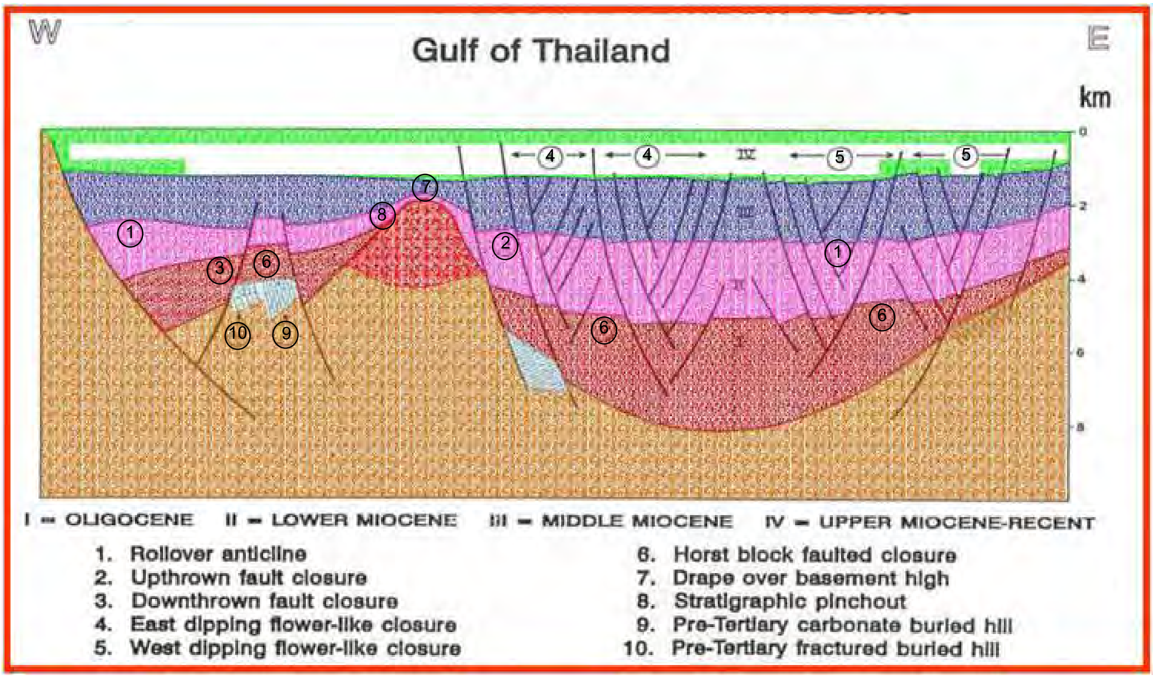


Figure 2.2 Regional cross-section in the Gulf of Thailand.

(www2.dmf.go.th/bid19/petro_province.asp)

2.2 Basin formation

The collision of Indian craton with Eurasia craton was the major cause of tectonics in the Southeast Asia, especially the creation of the Cenozoic basins. The beginning of the Cenozoic basin was related to strike-slip fault. The vector of the movement of the Indian craton to Southern Asia is at the rate of 15-23 cm/year towards the NE (Patriat and Achache, 1984).

Tertiary tectonics of Southeast Asia has been principally affected by the interaction of the Indian and Eurasian plates. The Indian plate was believed to be separated from Africa in the Late Cretaceous, eventually colliding with the Eurasian plate sometime in the Eocene. As the Indian subcontinent continued to be pushed north, Southeast Asia was slowly rotated clockwise, effectively changing the angle of subduction from a perpendicular orientation to increasing oblique. This increased oblique subduction angle resulted in the formation of large strike-slip faults, associated with the development of transtensional Cenozoic basin in this region (Patriat and Achache, 1984).

The time of the opening of the Gulf of Thailand is poorly understood. An apatite fission date of sediment-filled core sample in Tertiary basin from the Phitsanulok basin is younger than 44 Ma (Charusiri et al., 1992). Charusiri et al (1992) proposed that ^{39}Ar-^{40}Ar dating of gneissic rocks from Pranburi-Hau Hin fault zone supported that the gulf was opened during 33 Ma. On the basis of the published data, the earliest time of the opening of the gulf of Thailand should not exceed late Eocene.

2.3 Stratigraphy and sedimentology

The thickness of sedimentary rocks in the Tertiary basin in the Gulf of Thailand ranges from about 10 kilometers in the deepest part of the Pattani basin and the Malay basin to about 4 kilometers in the West graben areas (www.gregcroft.com/thailand.ivnu).

Pradidtan and Dook (1992) proposed the Tertiary stratigraphic sequence of the intermontane basins in Thailand, and revised the new stratigraphic sequence in the Gulf of Thailand. They divided the stratigraphy of the gulf into two major tectonostratigraphic units; syn-rift sequence that deposited during extension period and post-rift sequence that deposited after the extention.

The syn-rift sequence (Oligocene-Late Miocene) can be classified into 3 units; lower, middle and upper units. The lower unit (Late Oligocene-Early Miocene) consists of some interbeded red beds which are of fluvial system. The middle unit (Early Miocene-Middle Miocene) composes of high organic claystone and shale. The thick sequence of lacustrine deposits is shown in this unit, particularly in Kra basin and Chumphon basin. The overall lacustrine deposit has a thickness that exceeds 1000 meters, as evident by seismic and well log data. The upper unit (Middle Miocene-Late Miocene) is characterized by fluvial deposit associated with braided stream, meandering stream and some ephemeral lacustrine deposit.

The post-rift sequence (Late Miocene-Quaternary) unconformibly overlies the syn-rift sequence and consists of major high-energy fluvial, coarse sand and gravel interbeded with various colors clay. The trangressive section with thin coal and organic rich clay is quite distinctive. Which can be found in the Pattani basin and the Malay basin.

The name of this stratigraphic unit is Chao Phraya Group as proposed by Prididtan et al. (1990).

The lithology of Chao Phraya Group is homogeneous and a complete sequence has a thickness of about 1000 meters. Marine influence can be observed in the eastern part of basinal area. Floodplain and fluviatile sediments can be found in the upper part of the Chao Phraya Group.

2.4 Pattani basin

The Pattani basin is in the Gulf of Thailand, east of Ko Kra ridge. It is the largest basin in the gulf. The stratigraphy of the Pattani basin described by Tung-Yi and Chen-Hui (1990) is used as a guideline for the stratigraphic analysis. They identified five gross sequences from both seismic data and well logs. The environments range from lacustrine through fluvial-deltaic to the current shallow marine conditions. Only the fluvial and deltaic sequences produce significant quantities of hydrocarbons. The fluvial sequences are dominantly red beds comprising point bar sands and varied color red-brown shales. The deltaic sequence is gray in color with abundant coals and widespread low velocity, low resistivity shales. This sequence is usually overpressured.

There are five main deposition sequences recognized in Pattani basin as shown in figure 2.3. All of these appear to be time trangressive to some extent and can be summarized as follows (oldest to youngest);

Sequence 1, Pre-Late Oligocene to Late Eocene age, is about 8,000 feet thick in the deeper part of the basin. The seismic reflection data illustrate continue and strong reflection. This unit was believed to be consisted of argillaceous shale and limestone. Lacustrine and floodplain are the main depositional environments of this sequence.

Sequence 2, Late Oligocene as indicated by floras, is about 5,000 feet thick in the deeper part of the basin and consisted of varied color and reddish brown claystone and fine- to very coarse-grained sandstone. Gray claystones are in the deeper part of this unit but conglomerates are in the shallow part. Based on seismic reflection data the environment of deposition can be interpreted as fluviatile, dry floodplain and ephemeral lacustrine. This unit unconformably overlies the underlying unit.

Sequence 3, Early Miocene age as indicated by floras, is about 1,900 feet thick and consists mostly of gray claystone. Thin bedded sandstone and lignite are frequency found. The sandstones illustrate coarsening upward sequence. The environments of deposition are lacustrine, fluvio-lacustrine and coal swamps which are interpreted based on their lithology, fossils and wireline log patterns. This unit is the target of petroleum exploration. It overlies unconformable on the underlying sequence.

Sequence 4, upper to lower Middle Miocene age as indicated by floras, is about 2,500 feet thick and consisted of fine- to coarse-grained sandstones and various color claystone. Lignite and gray claystone are occasionally found. The sandstone in this sequence is identified as meandering channels. The environments of deposition are floodplain and fluviatile. The contact of this unit with underlying unit is gradational contact.

Sequence 5, Upper Miocene to Quaternary age, is above the Middle Miocene Unconformity (MMU) and about 5,500 feet thick in the central part of the basin. This unit shows the trangressive sequence and more marine influence upward.

Lian and Bradley (1986) divided the Sequence 5 in to three units as follows (older to younger);

The Florschuetzia meridionalis unit, Late Miocene-Upper Middle Miocene, is about 2,500 feet thick and consisted of gray and various color claystone and fine- to medium-grained sandstone. Lignite and limestone can be found in this unit. Microfossil and lithology indicate coastal and floodplain environments.

The Dacrydium unit, Pliocene age, is about 650 feet thick and consisted of gray clays and silts. Fine-grained sandstone, shell fragment and lignite are occasionally found. Coastal and inter-tidal depositions are indicated by microfossils.

The Podocarpus unit, Quaternary age, is about 650 feet thick and composed of gray clays, silt and occasional fragments of shell. Environment of deposition is intertidal to inner neritic as indicated by the microfossil.

Depositional sequences 2, 3, and 4 contain the main hydrocarbon bearing reservoirs. They are generally thin (average 5.5 m.), non-marine, and located at depth between 1200 to 3000 meters below sea level.

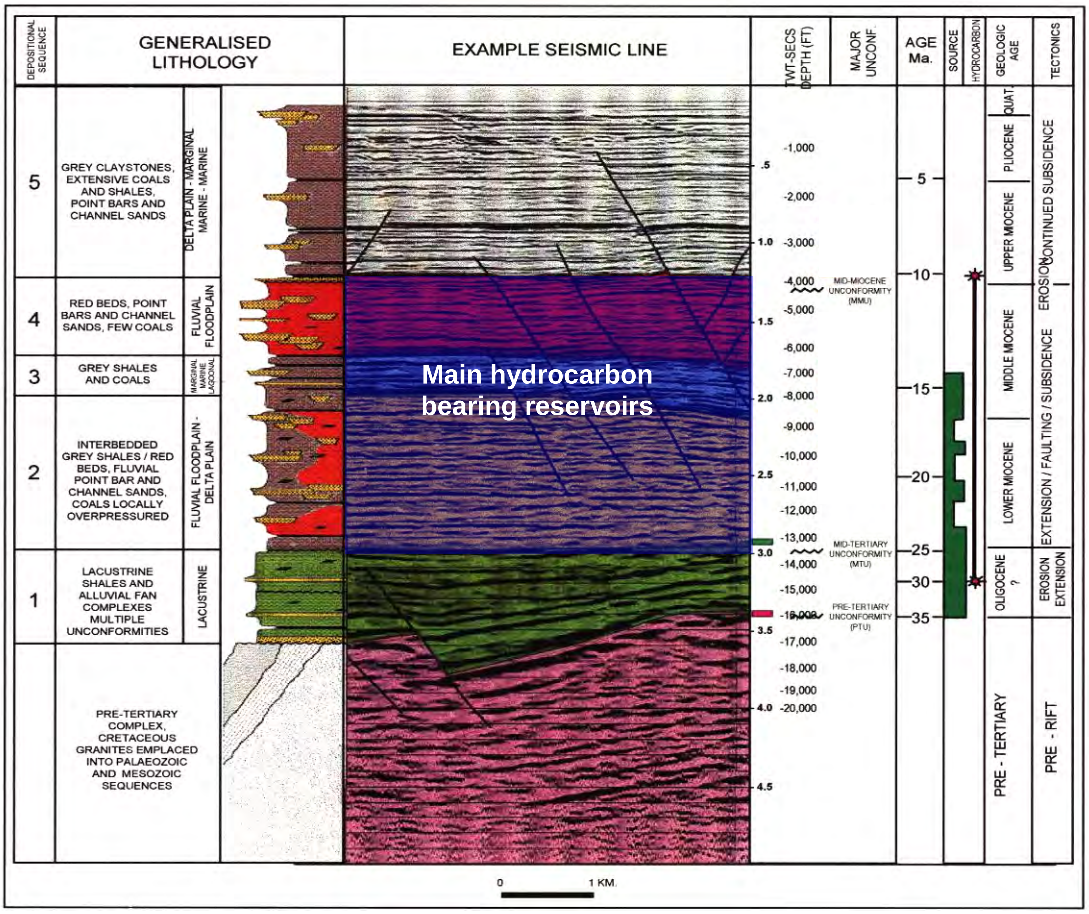


Figure 2.3 Sequence stratigraphy of the Pattani basin, Gulf of Thailand.

(Unocal Thailand)

Chapter 3 Methodology

3.1 Method of study

3.2 Database

3.3 Well study and data correlation

3.4 Seismic interpretation

3.5 Combine anomaly map and structure closure

3.1 Method of study

This project aims to identify the potential reservoirs for oil and gas in the northern part of the Pattani basin. First, the previous works that were related to this study were fully reviewed and seismic data and well data were collected. Then, seismic markers were selected based on well-to-seismic correlation. Next, faults and horizons were interpreted by using Charisma program. This two-way time structural map of each interpreted horizons were generated and seismic attributes were also computed to help interpretation. Finally, compiling the structural map along with the computed attributes were performed and the structural closure that is suitable for hydrocarbon accumulation were finally identified. The flow chart of method of study is shown in figure 3.1.

3.2 Database

This study used data from PTT Exploration and Production Public Company Limited. The data are composed of:

1. Technical report (well summary report and final well report)
2. 3D seismic data in the northern part of the Pattani basin; inline from 5000 to 7000 and crossline from 2042 to 4480 (figure 3.2).
3. Wireline log data from wells A and B

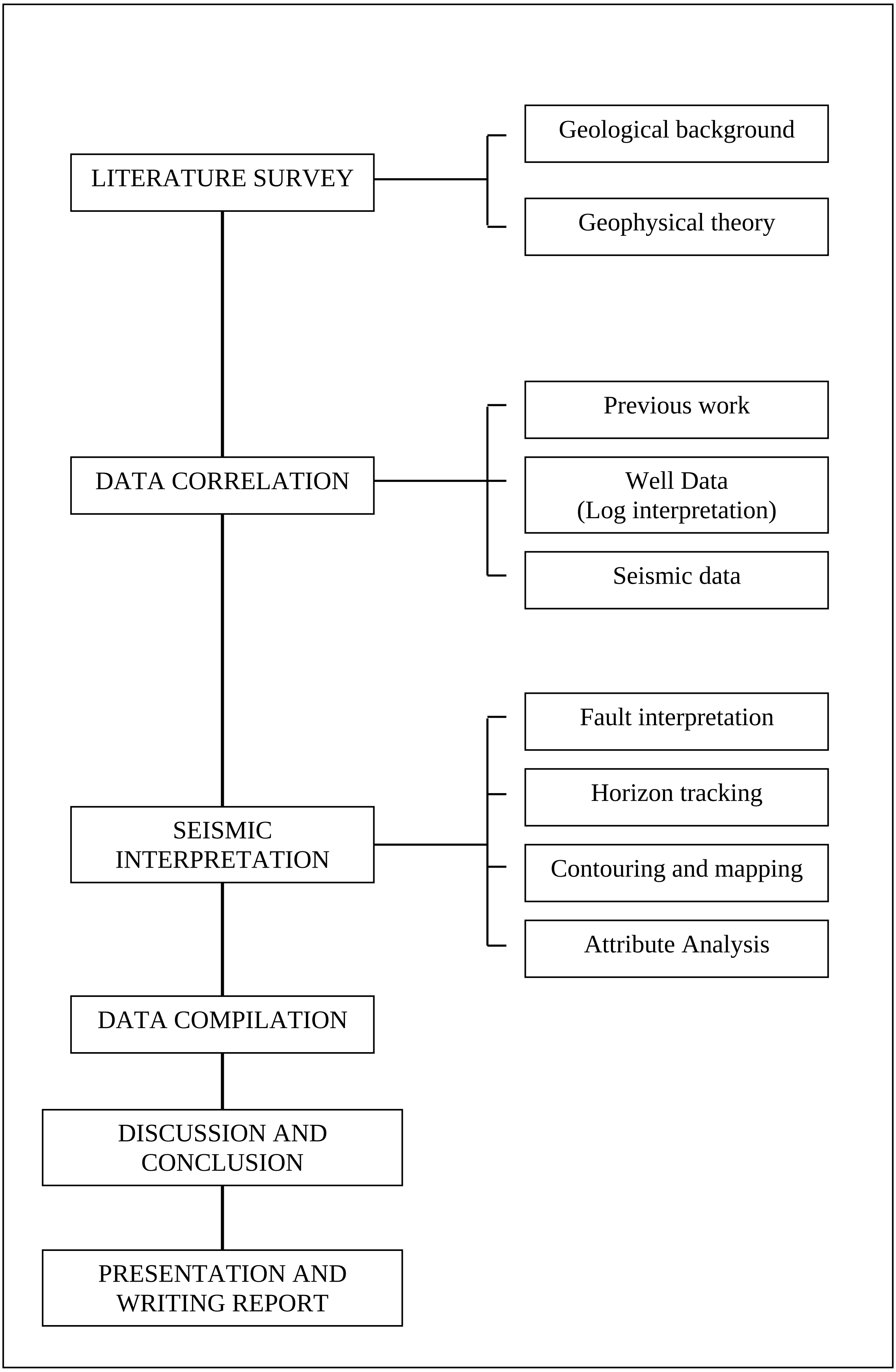
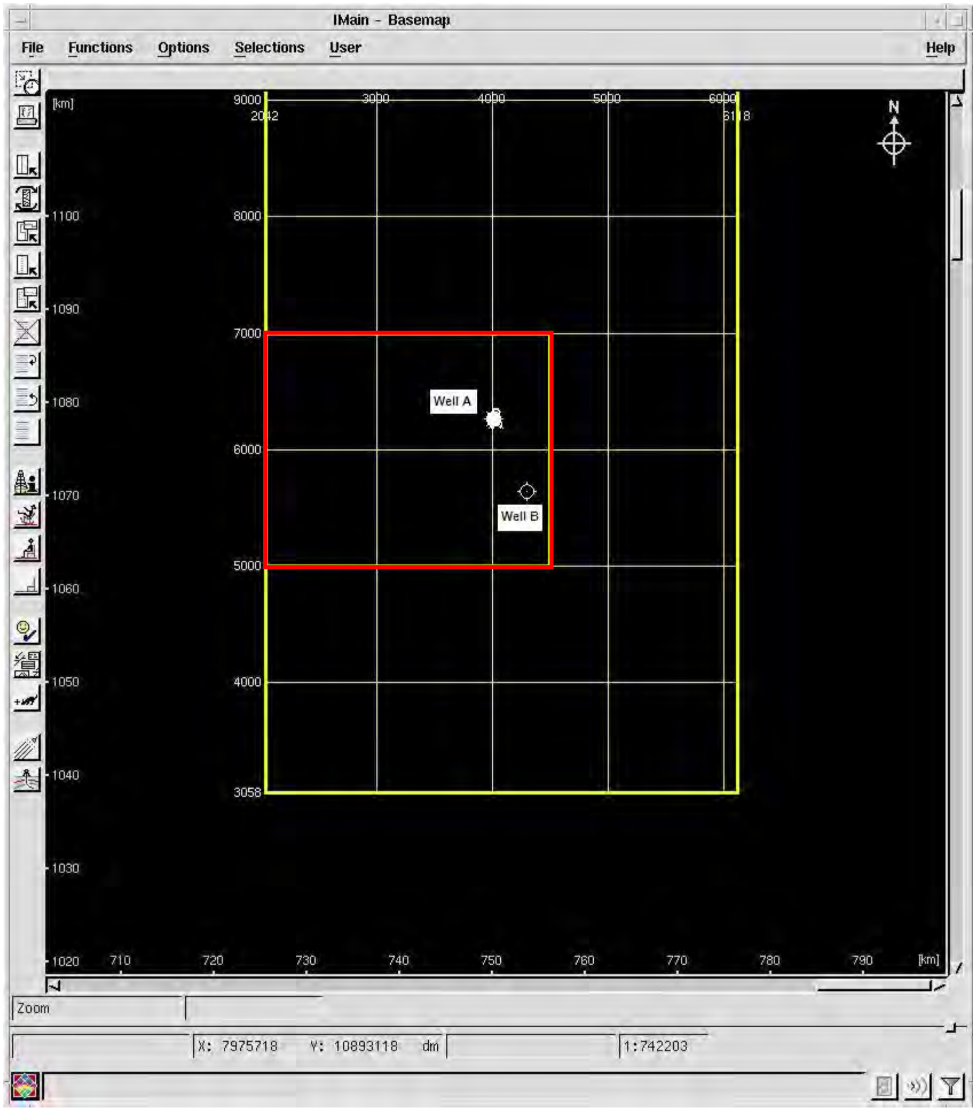


Figure 3.1 Flow chart showing the methods of this study.



X: 7975718 Y: 10893118 dm

1:742203

Figure 3.2 Seismic base map in study area: inline from 5000 to 7000 and crossline from 2042 to 4480 (red square).

3.3 Well-to-seismic data correlation

The aim of well to seismic correlation is to positioned events, which are seen in depth, into the time domain (geological markers and well trajectory).

1. Collecting previous studies including geological data, well log and seismic data.

2. Selecting key geological makers from wireline logs. Then define the seismic horizons that represent key geological markers, namely: Horizon A, Horizon B and Horizon C (figure 3.3).

Horizon A was defined as a middle of the sequence 5.

Horizon B was defined as a top of the sequence 4 which is above the MMU.

Horizon C was defined as top of the sequence 2 which is top of the reservoir.

These makers were defined based on well log data and the seismic reflectors which are outstandingly clear and strong.

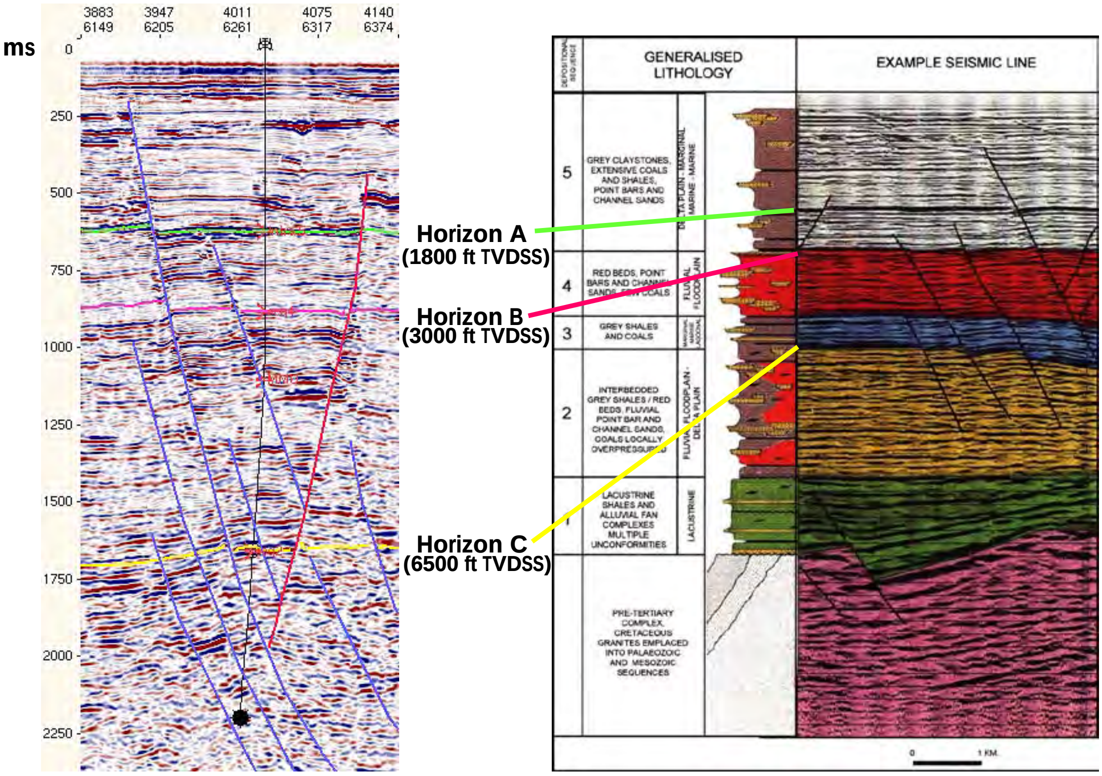


Figure 3.3 Define the seismic horizons that represent key geological markers.

3.4 Seismic interpretation

Interpretation method for 3D seismic data in this study area is started by seismic line selection in Charisma software. W-E lines which are inline are considered because they are perpendicular to strike.

1. Fault interpretation

Fault interpretation was first performed on the section in dipline direction. In the seismic section, faults are observed by the discontinuity of reflectors and the displacement of seismic signals (peak or trough). Fault heaves were calculated at the same time to get the picture of fault trend. Different in dipping direction of faults were assigned in different colors (figure 3.3).

2. Horizon tracking

Marker horizons which consist of Horizons A, B and C were tracked on seismic sections as shown in figure 3.4. The reasons for choosing these horizons are because they have high amplitude which is outstanding clear and good continuity throughout seismic section. Horizon interpretation was done in every 20 line interval for both inline and crossline.

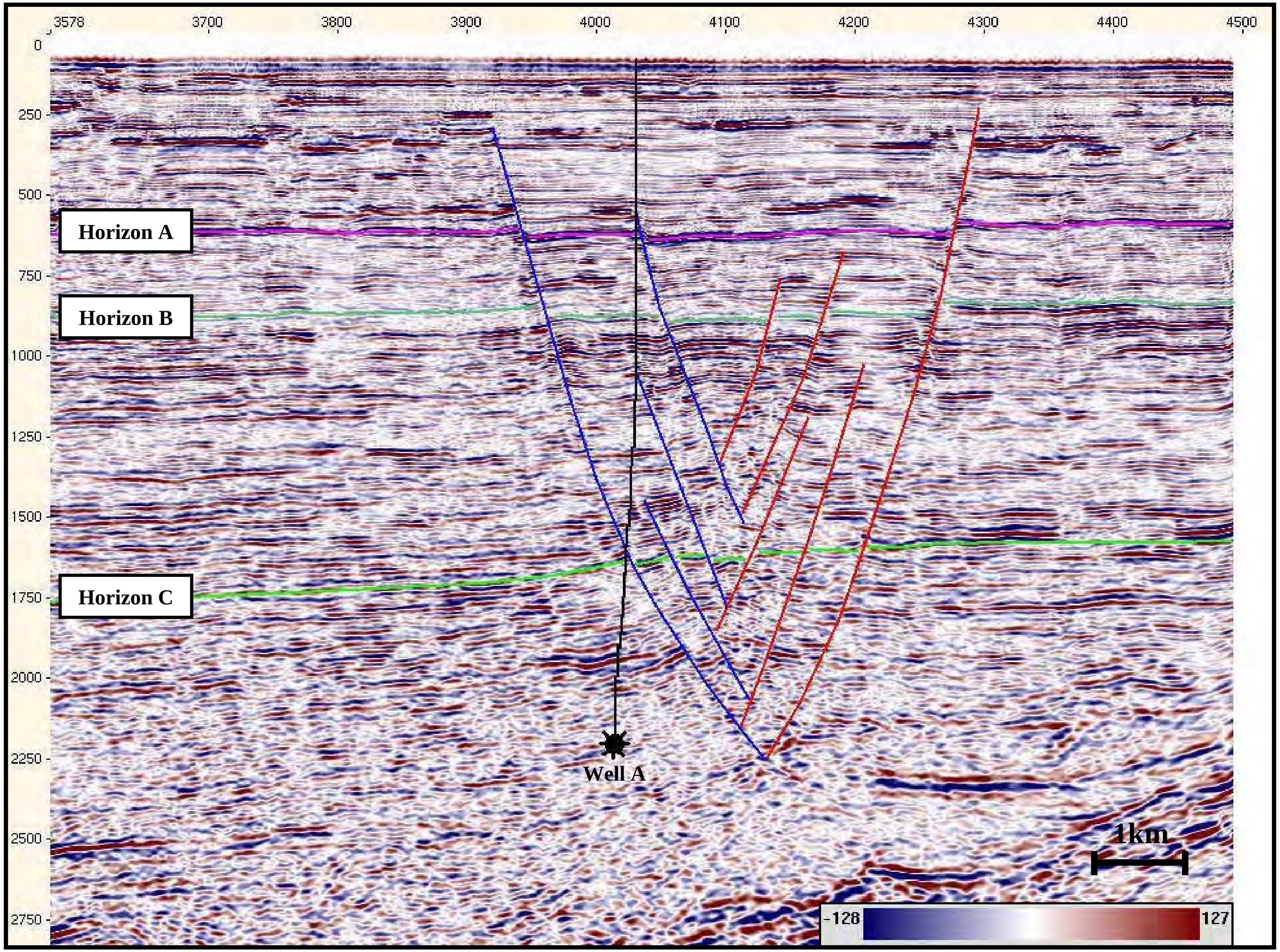


Figure 3.4 Seismic section, inline 6200, showing three interpreted horizons, faults and well A location. Different in faults dipping directions were shown in different colors (blue = dipping east and red = dipping west).

Faults and horizons interpretation are already finished. The creation of fault boundaries were done by connecting the same faults together. Features of faults appearing in base map are offset faults. Finally, seismic interpolation was generated to show time structural map (figure 3.5).

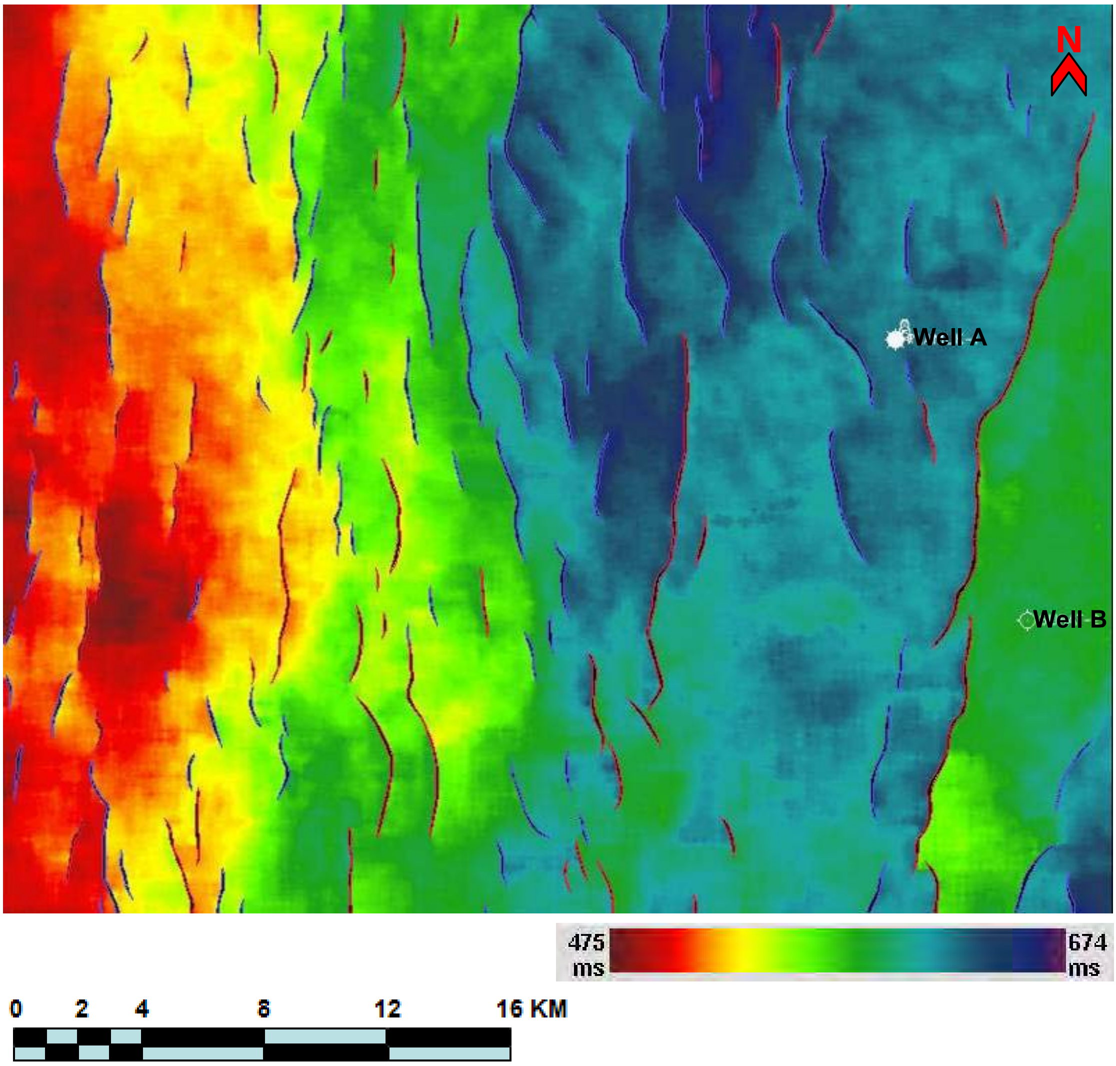


Figure 3.5 Two way time structural map of Horizon A.

From the Charisma 4.2 software, tracking algorithm that contains point and auto track were provided for interpretation. The horizon picking was usually performed as a loop to avoid the miss-tie error.

3. Attribute analysis

Amplitude information can help identifying gas and fluid accumulation, gross lithology, channel or deltaic sand, unconformities and changing in sequence stratigraphy.

The seismic attribute studied in this research is RMS (root mean square) amplitude that calculated within a specific window width (figure 3.6). It can detect amplitude anomalies due to gas and fluid accumulations. Bright Spot is a sudden increase in reflection amplitude generally associated with the replacement of fluid within a reservoir rock (Sheriff, 1989).

$$RMS\ amplitude = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(a_i)^2}$$

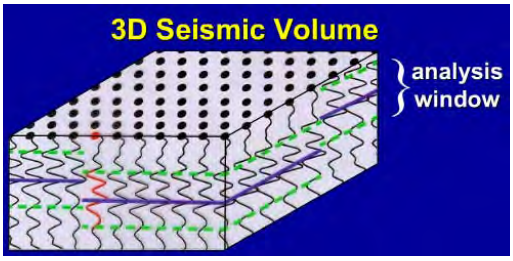


Figure 3.6 RMS amplitude equation (left) and analysis window of seismic data (Sheriff, 1989).

3.5 Combine anomaly map and structure closure

Compiling the time-structural map along with the computed attributes help to define the structural closure that is suitable for hydrocarbon accumulation.

Chapter 4 Result and Interpretation

4.1 Two way time structural maps

4.2 Amplitude maps

4.3 Prospected areas

4.1 Two way time structural maps

In the study area, seismic interpretation covers an area of 900 km^2 and contains three seismic horizons. These three interpreted marker horizon are used to create the two way time structural map that show in the figure 4.1, 4.2 and 4.3.

The first horizon (Horizons A) which is a top marker has a good continuity and high amplitude. The result of subsurface structural map of this horizon showed the structural high in the western part of the study area (red color) and gently down-dip slope in the west to east. And fault trended almost N-S direction.

Horizon B was the top of hydrocarbon bearing reservoir which illustrated the structural high in the same direction as Horizon A but the structural high of this horizon are greater than the first horizon.

Horizon C was high in western and eastern part of the area and down-dip slope to the graben center. From these three horizons, indicated that the main direction of sediment transportation was from west to east.

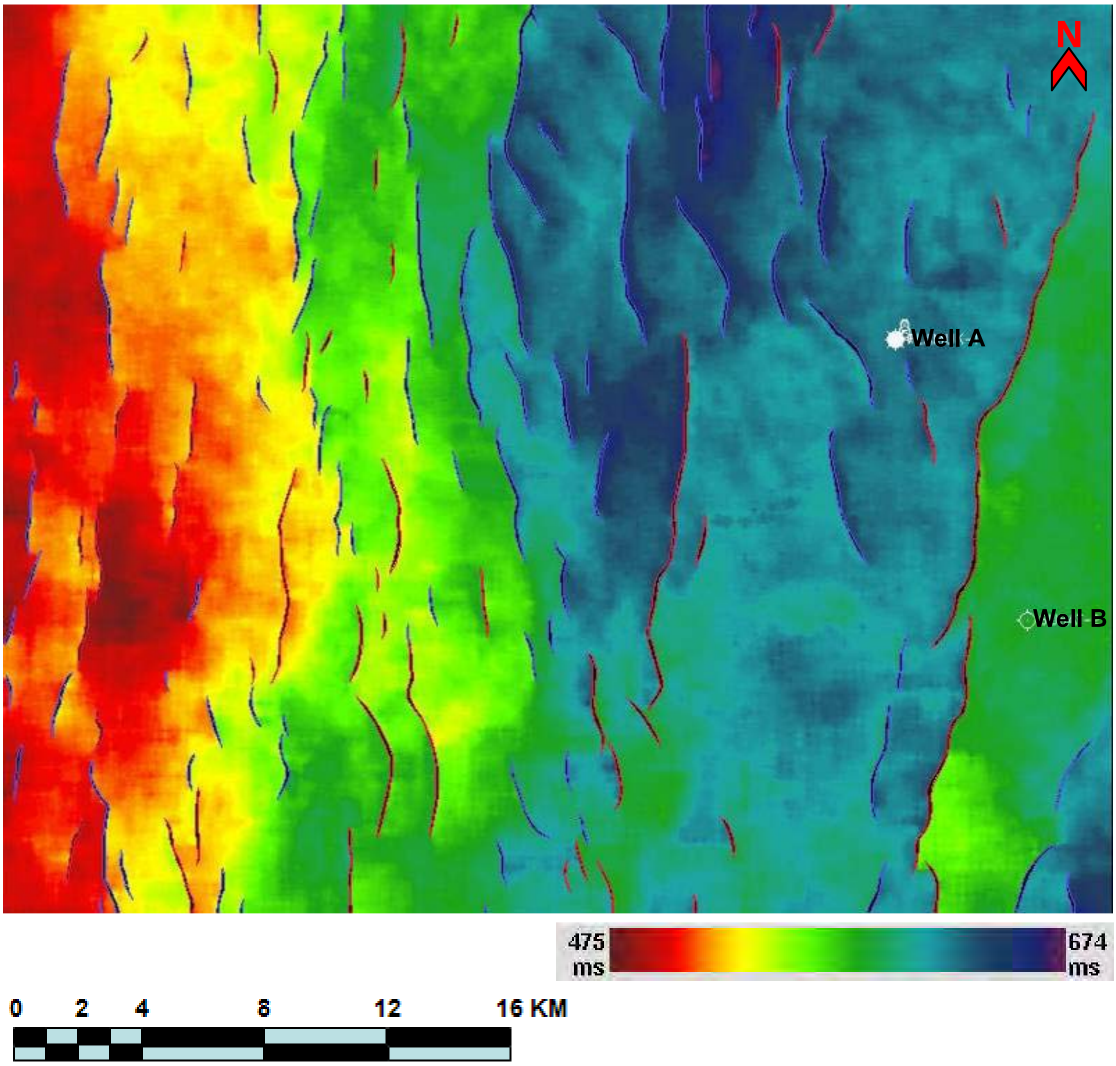


Figure 4.1 Two way time structural map of Horizon A

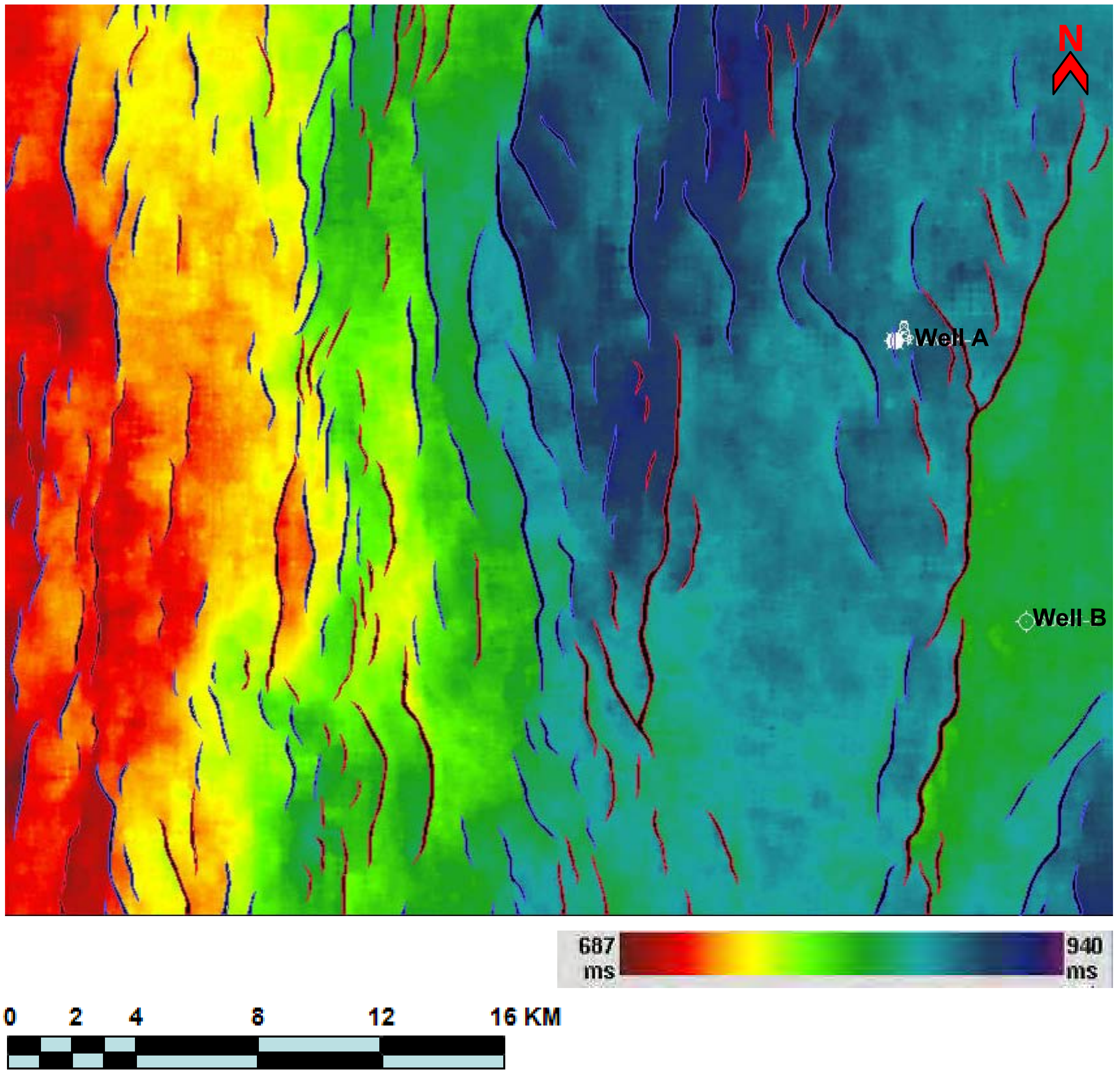


Figure 4.2 Two way time structural map of Horizon B

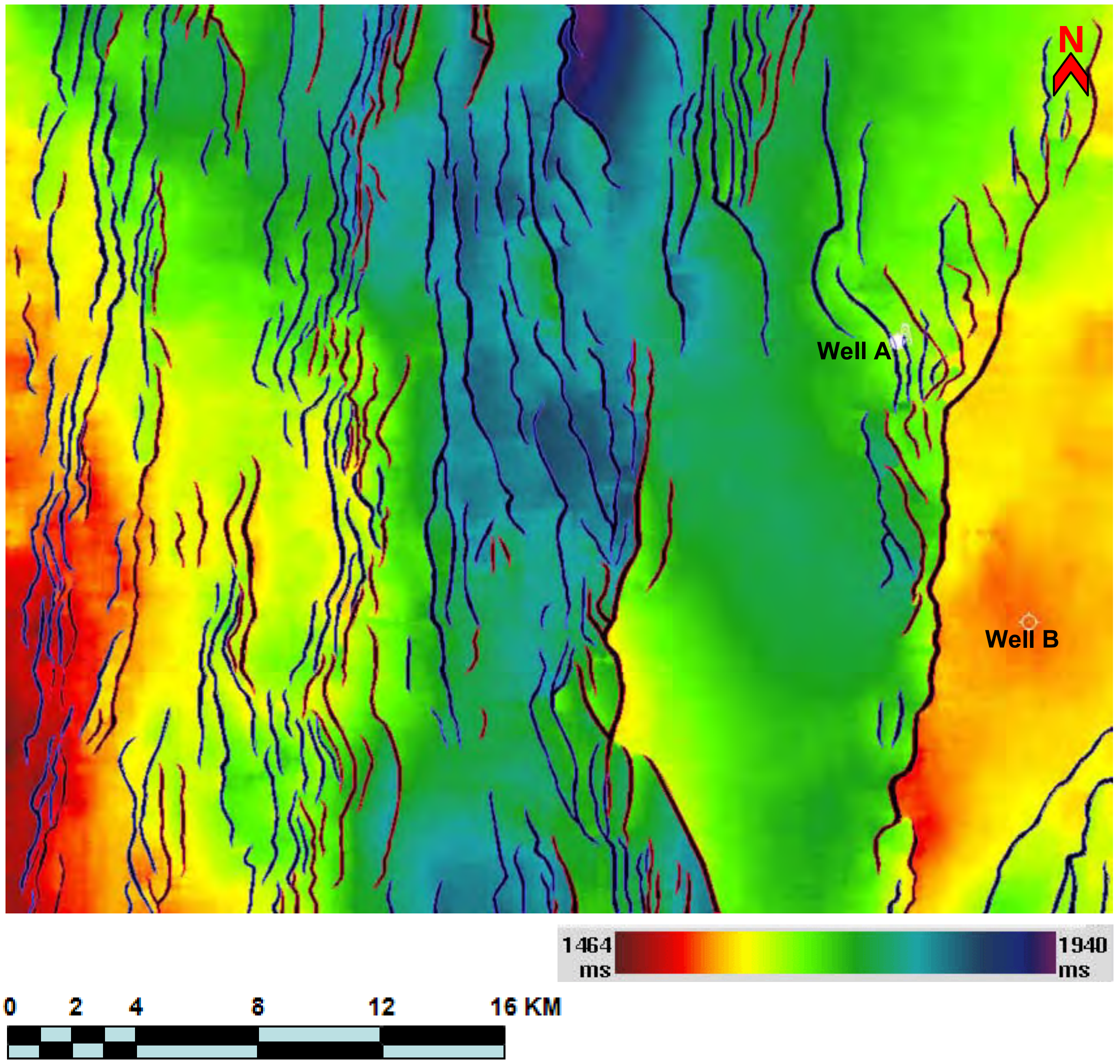


Figure 4.3 Two way time structural map of Horizon C

4.2 Amplitude maps

At first, three seismic attributes were generated and compared to select the best attributes that better clarify the subsurface features. So the result has shown that the RMS amplitude yielded the best details which can illustrate the significant feature and were suitable for the application in this area.

The amplitude map of Horizon A (figure 4.4) show a continuity of shale surface (green color) that related to the maximum flooding surface event and characterized as a regional seal. Furthermore, this map illustrated a channel belt trend in W-E direction which supported to the time structural map that main direction of sediment transportation was from west to east. Horizon A was not in a zone of hydrocarbon bearing reservoirs, so this horizon was unnecessary to indicate the prospected area.

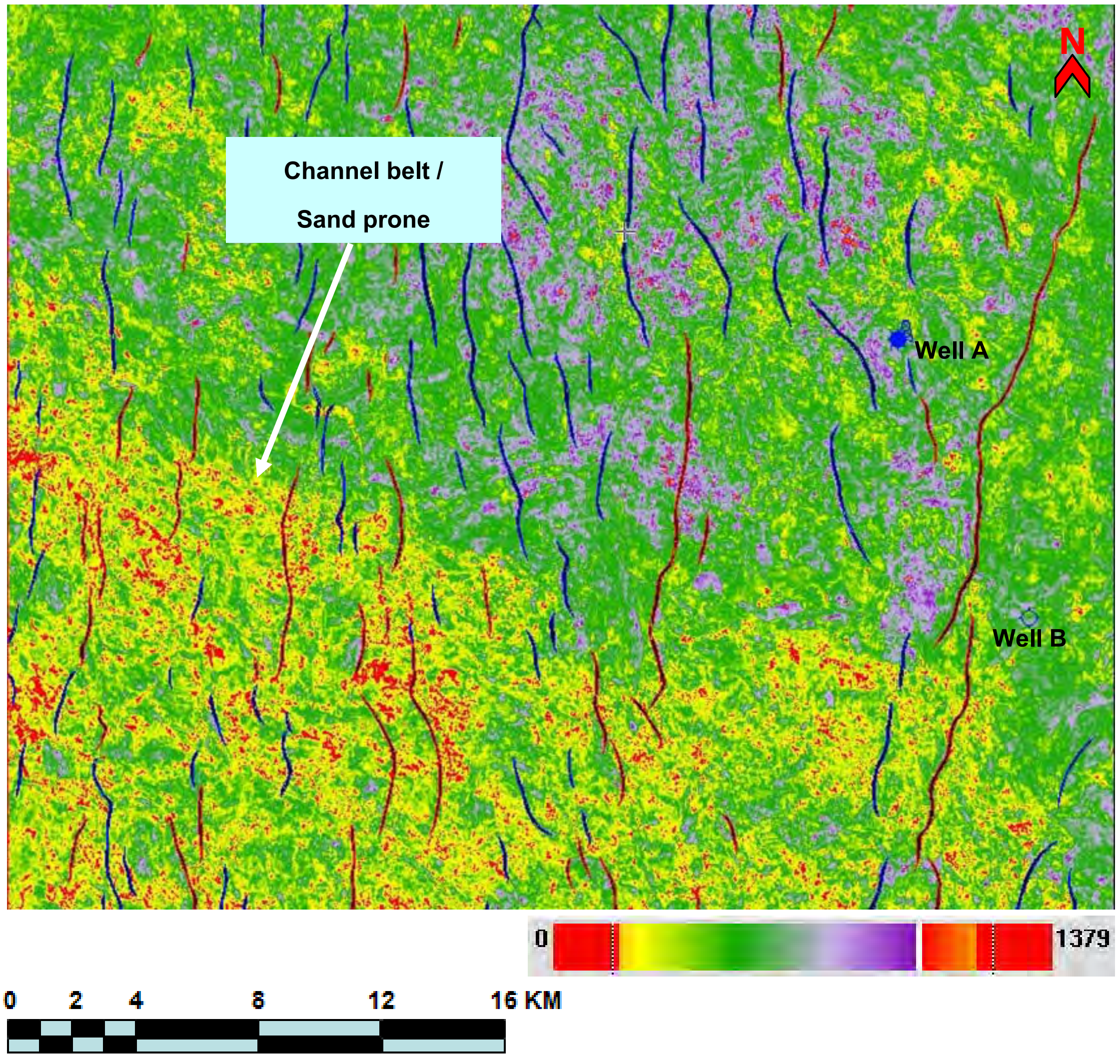


Figure 4.4 Amplitude map of Horizon A

Horizon B shown in figure 4.5 illustrated a paleo-channel feature which are meandering stream lied in NW-SE direction. The major feature can be observed, consist of point bar, crevasse splays, meandering belt et al. Then, this map showed the contrast of the lithology between inside the channel that often illustrated sand deposit and the outside the channel that showed the fine particle deposits (silt and clay).

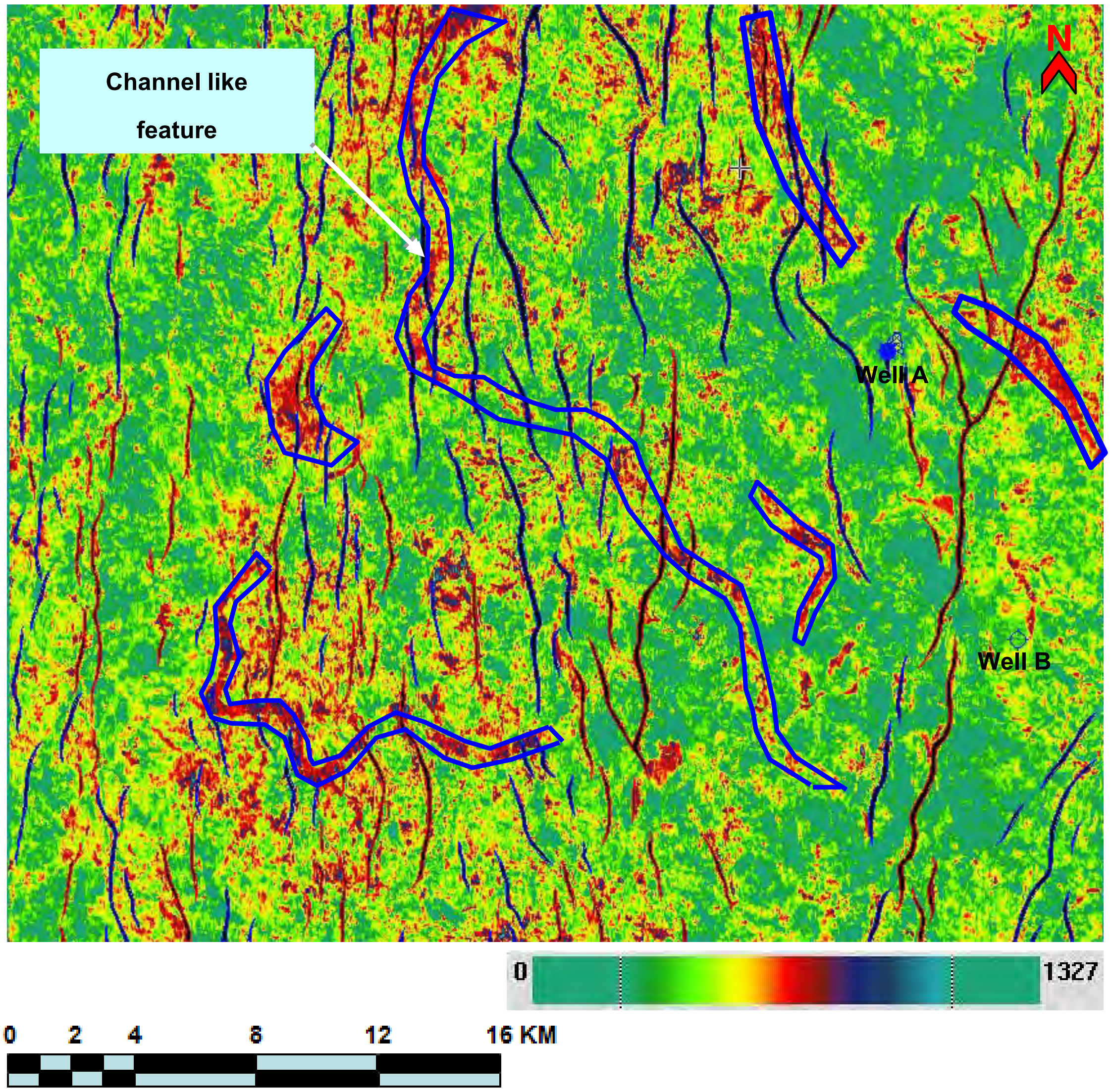


Figure 4.5 Amplitude map of Horizon B

Horizon C shown in figure 4.6 illustrated the sand prone that indicated by high amplitude anomalies in the SE part of the area. And these anomalies were laid conformably to structure closures.

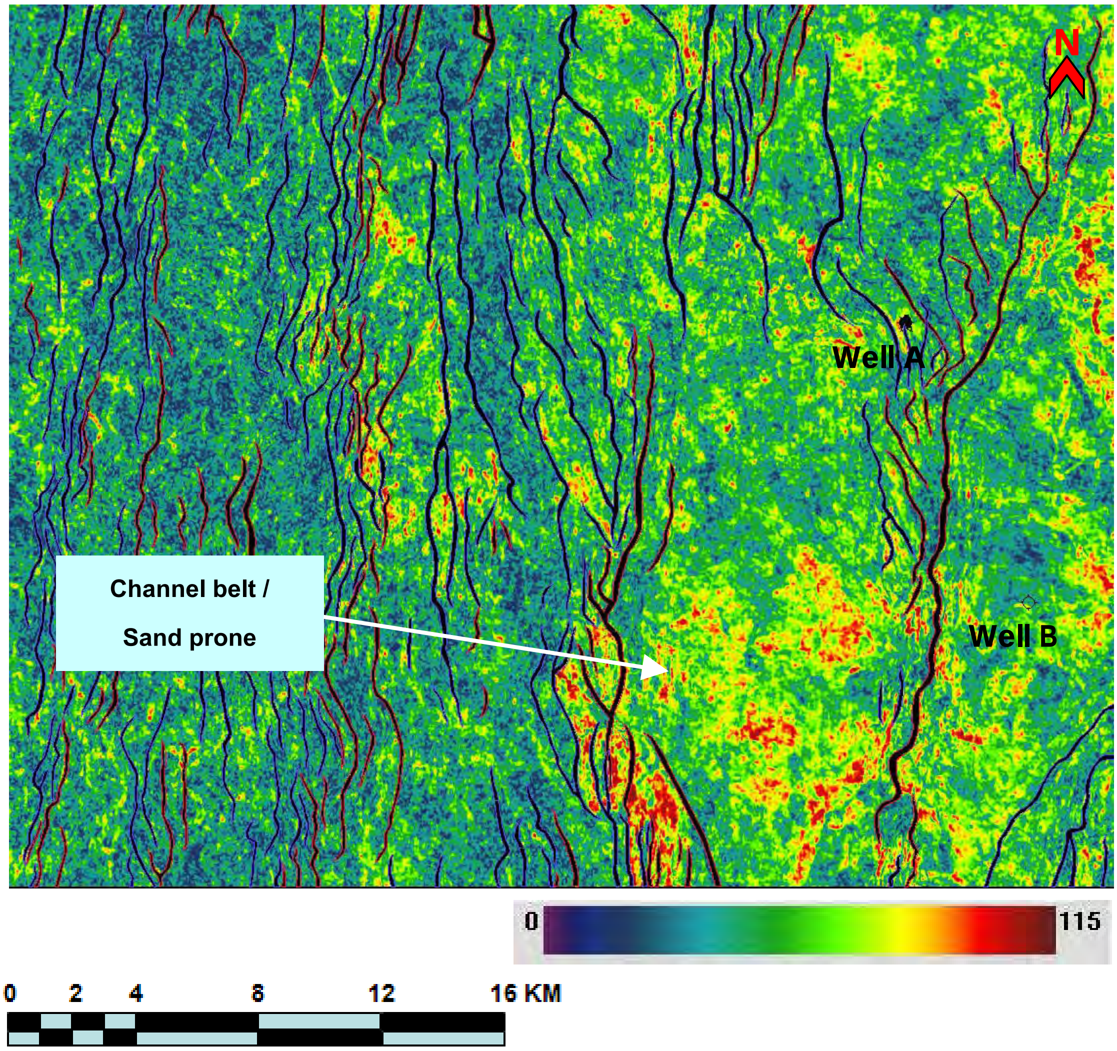


Figure 4.6 Amplitude map of Horizon C

4.3 Prospected areas

A combination of seismic structure and amplitude analysis allows us to better delineate reservoir compartment boundaries. Based on reservoir criteria which are lithology, structural high and structural closure, there are 4 and 3 prospected areas for Horizon B and C respectively (figure 4.7and 4.8).

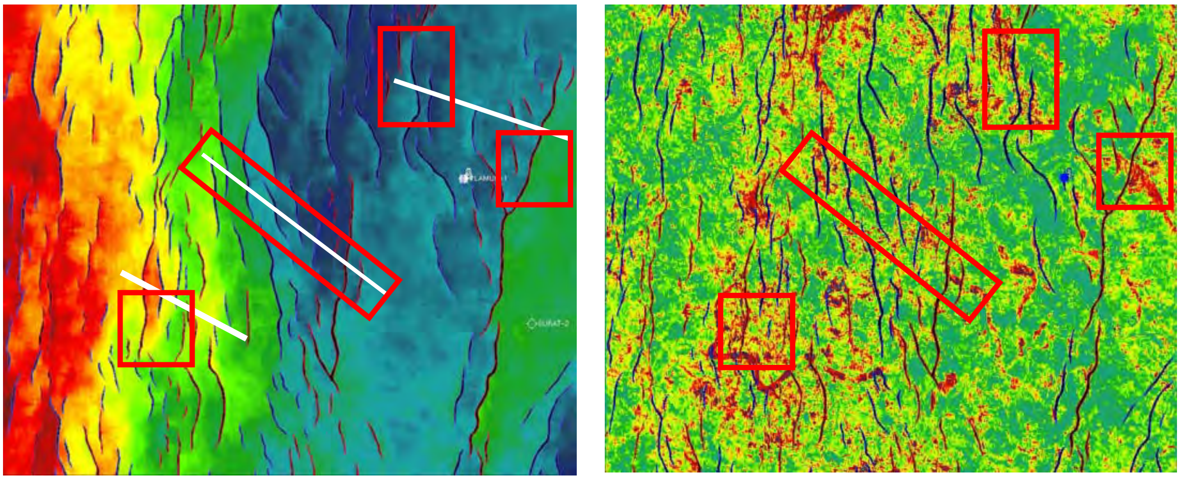


Figure 4.7 Horizon B, four prospected areas were indicated by red squares.

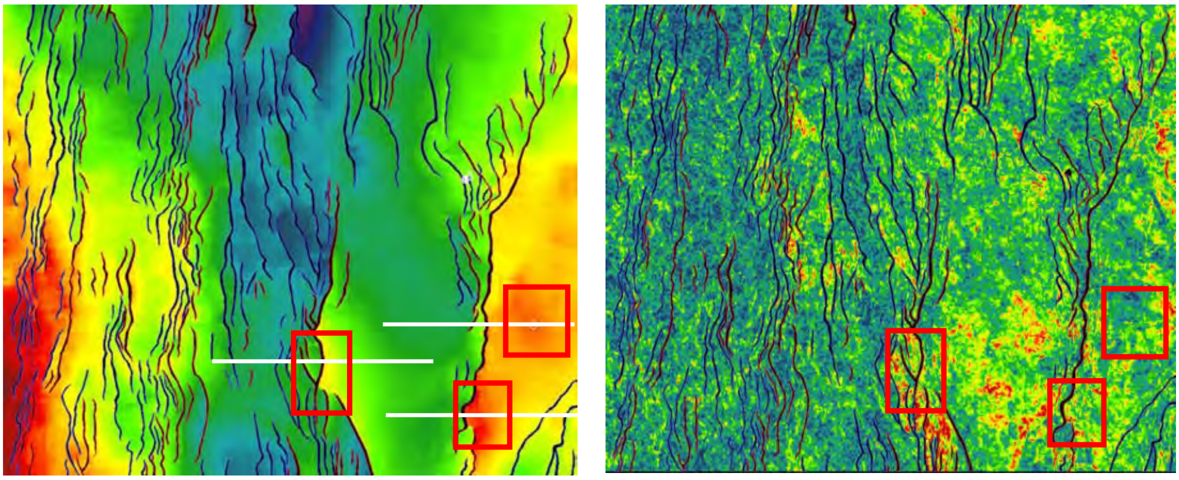


Figure 4.8 Horizon C, three prospected areas were indicated by red squares.

In addition, the following figures 4.6 and 4.7 are cross-section profile of the prospected areas which used for cross check the geological structure along the fault plane.

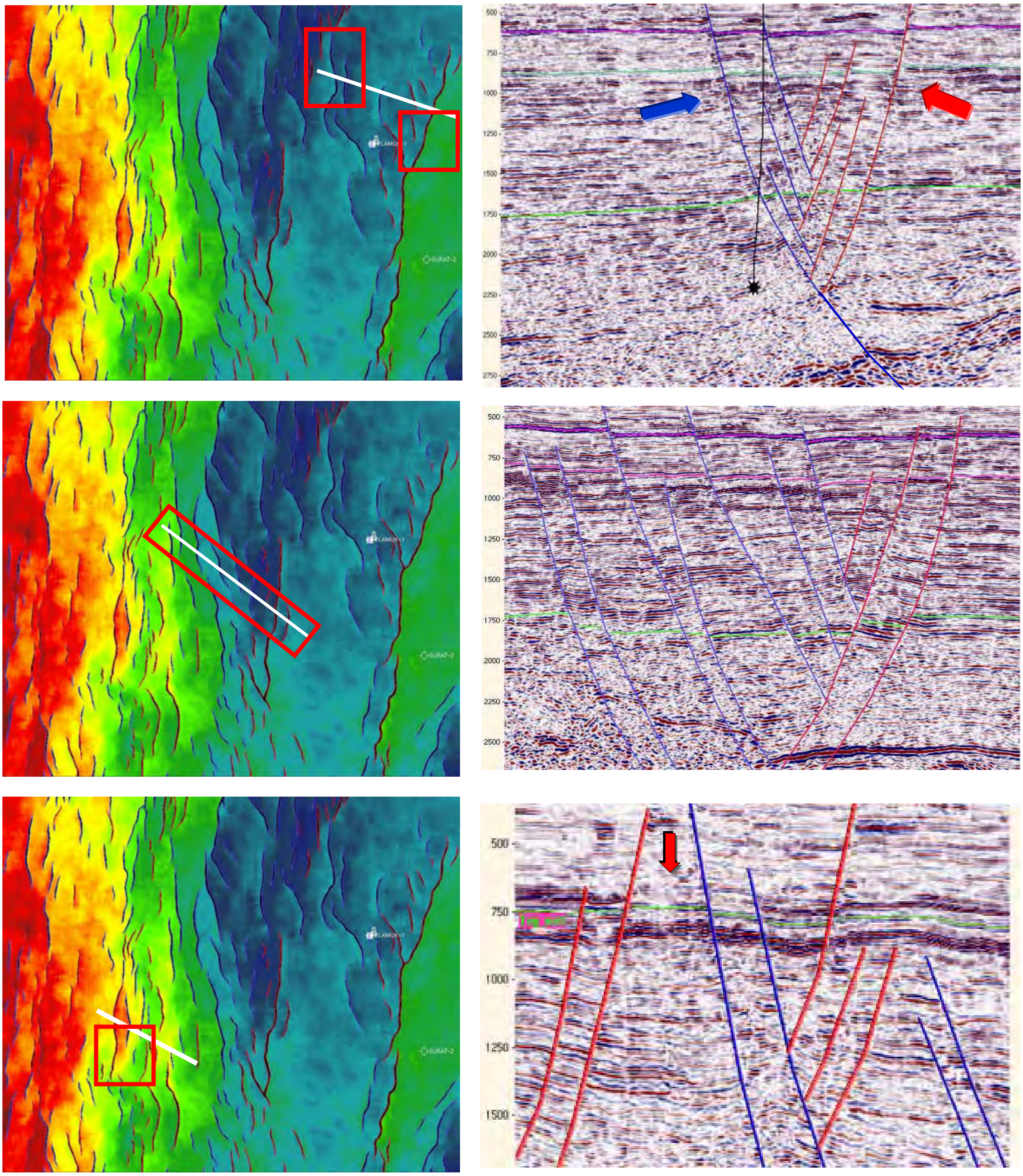


Figure 4.9 Cross-section profiles of prospected areas in Horizon B indicated in white lines in the time-structural map (left).

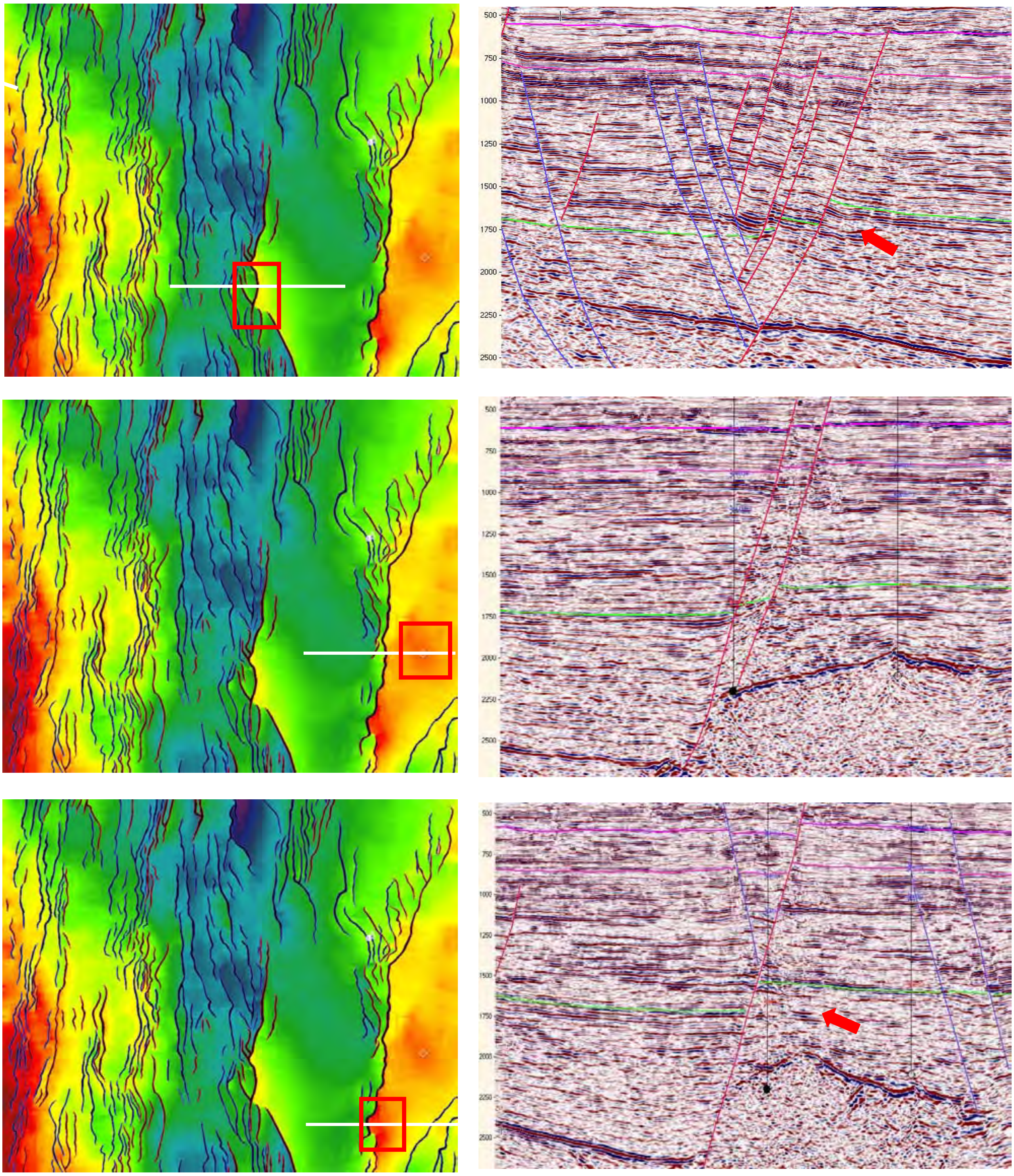


Figure 4.10 Cross-section profiles of prospected areas in Horizon C indicated in white lines in the time-structural map (left).

Chapter 5 Conclusion

Conclusion

The results from 3D-seismic interpretation and attribute analysis are as follow.

1. From structural maps of Horizon A and Horizon B, the structural high are in the western part of the study area and gently down-dip slope in the west to east. And fault trended almost N-S direction.

2. Horizon C show the structural high in the western and eastern part of the area and the attribute analysis illustrated anomalies lie conformably to structure closures which may correspond to oil and gas discovered at well locations.

3. There are totally 7 prospected areas for Horizon B and C which identified by used a reservoir criterion: lithology, structural high and structural closure.

4. Not only structural map can be obtained from seismic data, but with attribute study, depositional environment also can be known.

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