ธรณีวิทยาโครงสร้างบริเวณตอนเหนือของแอ่งสุพรรณบุรี พื้นที่บ้านไผ่ขวาง จังหวัดสุพรรณบุรี

นางสาวณัฏฐณิชา อนันต์สถิตย์พร
เลขประจำตัวนิสิต 5132747023

รายงานนี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาตรี
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จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2554

STRUCTURAL GEOLOGY OF THE NORTHERN PART OF SUPHAN BURI BASIN, BAN PHAI KHWANG AREA, CHANGWAT SUPHAN BURI

Miss Natthanicha Anansatitporn

ID : 5132747023

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(Dr. Pitsanupong Kanjanapayont)

Senior Project Advisor

ธรณีวิทยาโครงสร้างบริเวณตอนเหนือของแอ่งสุพรรณบุรี พื้นที่บ้านไผ่ขวาง จังหวัดสุพรรณบุรี

นางสาวณัฏฐณิชา อนันต์สถิตย์พร
ภาควิชาธรณีวิทยา คณะวิทยาศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
โทร : 085-8915076 อีเมล์ : Gifto_bg@hotmail.com

บทคัดย่อ

พื้นที่ศึกษาตั้งอยู่ทางตอนเหนือของแอ่งสุพรรณบุรี จังหวัดสุพรรณบุรีซึ่งพื้นที่ศึกษานั้นครอบคลุมพื้นที่ประมาณ 55 ตารางกิโลเมตร ลักษณะของแอ่งสุพรรณบุรีวางตัวอยู่ในแนวเหนือใต้ เป็นแอ่งแบบกึ่งกราเบน เป็นรอยเลื่อนปกติ โดยแอ่งสุพรรณบุรีนี้ถูกจัดให้เป็นแอ่งแบบพูล อพาร์ท (pull-apart) ซึ่งวางตัวอยู่ระหว่างรอยเลื่อยเฉือนขนาดใหญ่สองรอยเลื่อนนั่นก็คือ รอยเลื่อนแม่ปิง และรอยเลื่อนด่านเจดีย์สามองค์

จากการแปลข้อมูลคลื่นไหวสะเทือนแบบสองมิติเมื่อปี ค.ศ. 2004 แสดงให้เห็นว่าพื้นที่บริเวณนี้มีรอยเลื่อนที่สามารถเป็นโครงสร้างกักเก็บได้ (structural closures) ดังนั้นโครงงานนี้จึงได้ทำการแปลข้อมูลคลื่นไหวสะเทือนแบบสามมิติที่เก็บในปี ค.ศ. 2005 พื้นที่ศึกษาบ้านไผ่ขวาง และสร้างแผนที่โครงสร้าง โดยยังใช้ข้อมูลจากหลุมเจาะเพื่อทำการเลือกชั้นหิน X, Y และ Z เพื่อใช้ในการแปล นอกจากนี้แล้วยังได้ทำการวิเคราะห์ลักษณะรอยเลื่อนเชิงคุณภาพ หรือ Coherency attribute ร่วมกับการแปลเพื่อให้เกิดความแม่นยำเพิ่มขึ้นอีกด้วย จากการศึกษาพบว่า รอยเลื่อนในพื้นที่นี้ ทางตอนเหนือนั้นพบเป็นแบบกึ่งกราเบน แต่ต่อมาทางส่วนกลางค่อนมาทางใต้จะพบว่าเป็น กราเบนในที่สุด จากการทำแผนที่โครงสร้างและการทำการวิเคราะห์ระยะรอยเลื่อนในแนวตั้ง ผลได้แสดงให้เห็นว่ามีรอยเลื่อนที่มาบรรจบกัน (joined faults) อยู่ 4 บริเวณด้วยกันโดยส่วนใหญ่จะอยู่ทางตอนใต้จนถึงตอนกลางของชั้นหิน X และ Y และยังบ่งบอกว่า รอยเลื่อนเหล่านี้สามารถเป็นโครงสร้างกักเก็บปิโตรเลียมได้ นอกจากนั้นแล้วยังได้มีการสร้าง Reconstruction model ที่แสดงให้เห็นว่า ชั้นหิน X, Y และ Z ไม่ได้ตกสะสมในเวลาเดียวกัน เพราะมีการแสดงการเกิดการพัฒนาของรอยเลื่อนเข้าไปยังหินชั้นอื่น อันเนื่องมาจากการกดทับของชั้นหินตะกอนที่ตกสะสมตัวทับอยู่ด้านบนของแอ่ง ผลการศึกษาเหล่านี้แสดงให้เห็นถึงความสามารถในการช่วยลด ความไม่ต่อเนื่องของกลุ่มรอยเลื่อน และเพิ่มความสามารถในการระบุโครงสร้างกักเก็บได้

Key words: joined fault, coherency attribute, structural closure

STRUCTURAL GEOLOGY OF THE NORTHERN PART OF SUPHAN BURI BASIN, BAN PHAI KHWANG AREA, CHANGWAT SUPHAN BURI

Natthanicha Anansatitporn

Department of Geology, Faculty of Science, Chulalongkorn University.

Tel : 085-8915076, E-mail : Gifto_bg@hotmail.com

Abstract

The study area covers the northern part of Suphan Buri basin with the surface area of approximately 55 km^2. Suphan Buri basin is half graben with North-South trending normal faults. The basin appears to be pull-apart basin as it lies between two major Tertiary strike-slip faults zones, the Mae Ping fault and Three Pagoda fault zones.

. The previous 2D seismic interpretation in 2004 shows the faults in this area might form structural closures. This study aims to interpret and create structural maps for Ban Phaikwang area by using 3D seismic cube which had been acquired in 2005, well checkshot, and well top markers of X, Y and Z horizons. Coherency attributes, combining with seismic interpretation, were utilized to validate the faults existence. The detailed interpretation from this study found half graben in northern part and full-graben from central to southern part. From structural maps and fault throw analysis show that there are 4 joined faults mostly in southern and central part of area in horizon X and Y and some joined faults can be structural closures. Moreover from reconstruction model demonstrate sedimentary deposition of horizon X, Y and Z did not deposit at the same time and there are fault reactivations in this study area because of sedimentary loaded. The result shows that the selected technique able to reduce the uncertainty of fault segment continuity and the closure identification.

Key words: joined fault, coherency attribute, structural closure

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Chapter 1

Introduction

Suphan Buri Basin is one of the Tertiary sedimentary basins of Thailand. Suphan Buri Basin appears to be a half graben and lies on the west of the N-S suture zone of Shan-Thai plate and Indochina plate. The basin lies in the major Tertiary strike-slip of the Mae Ping and Three Pagoda faults zone (Fig. 1.1). Suphan Buri Basin is bounded by the N-S trending of the western boundary faults and eastern flexural margin. In this region a number of tectonic models for basin formation have been proposed such as the basin are pull-apart related to movement of major strike-slip faults (Chaodumrong et al., 1983; Rattanasthien, 1990; Ducroq et al., 1991; Jardine, 1997; Vilaihongs & Areesiri, 1997). Other tectonic models included uplift related to the metamorphic core complexes, and volcanic activity (Mcdonald et al. 1993; Dunning et al. 1995; Rhodes et al. 1997). There is a theory suggested that the Mae Ping faults zone and Three Pagoda faults zone underwent significant sinistral displacement during Eocene to Oligocene up to about 30 Ma (Lacassin et al., 1997; Morley, 2004). Since 30 Ma, sinistral movement ceased and became dextral movement. Nevertheless this dextral displacement did not appear to have strongly effected to rift basin development. The strike-slip faults zone does not seems to influence largely to rift basin activity (Smith et al, 2007).

The study area; Ban Phai Khwang area, is located in the Northern part of Suphan Buri Basin (Fig. 1.2). This area used to be studied by using 2D seismic survey data acquired over the basin by BP and PTTEP and well data to describe structural style (Seusutthiya, 2004). There for this study will use 3D seismic survey data to study due to checking joined faults and structural closures in 2D seismic survey data. This study focuses on structural geology: joined faults and structural closures by 3D seismic interpretation in Northern part of Suphan Buri Basin, Ban Phai khwang area and one well survey; L-1 (using to mark horizons in seismic sections). Furthermore using coherency attribute technique will reduce uncertainty of fault segment continuity as well.

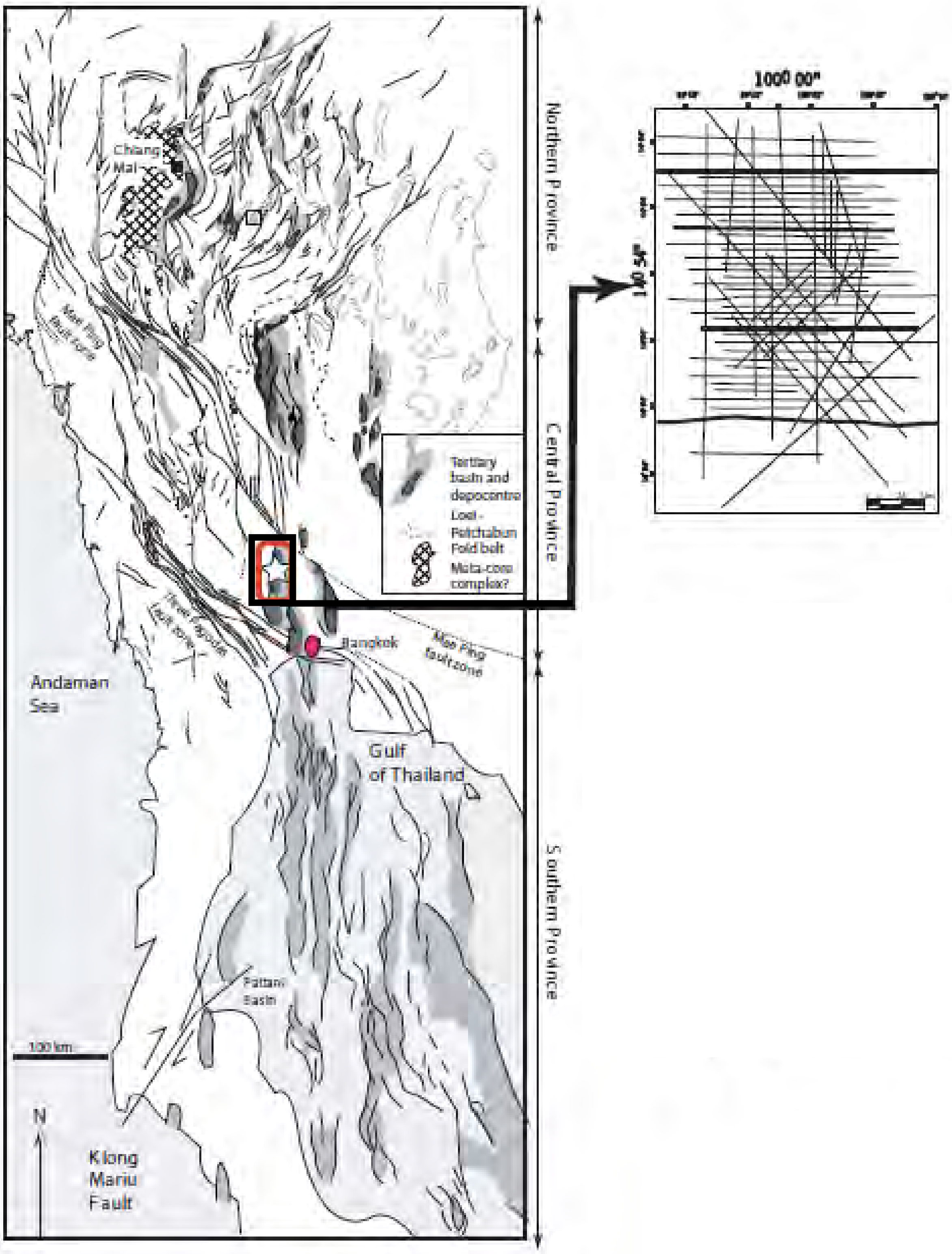


Figure 1.1 Location of Suphan Buri Basin and the basin components. (Modified after Morley, 2004)

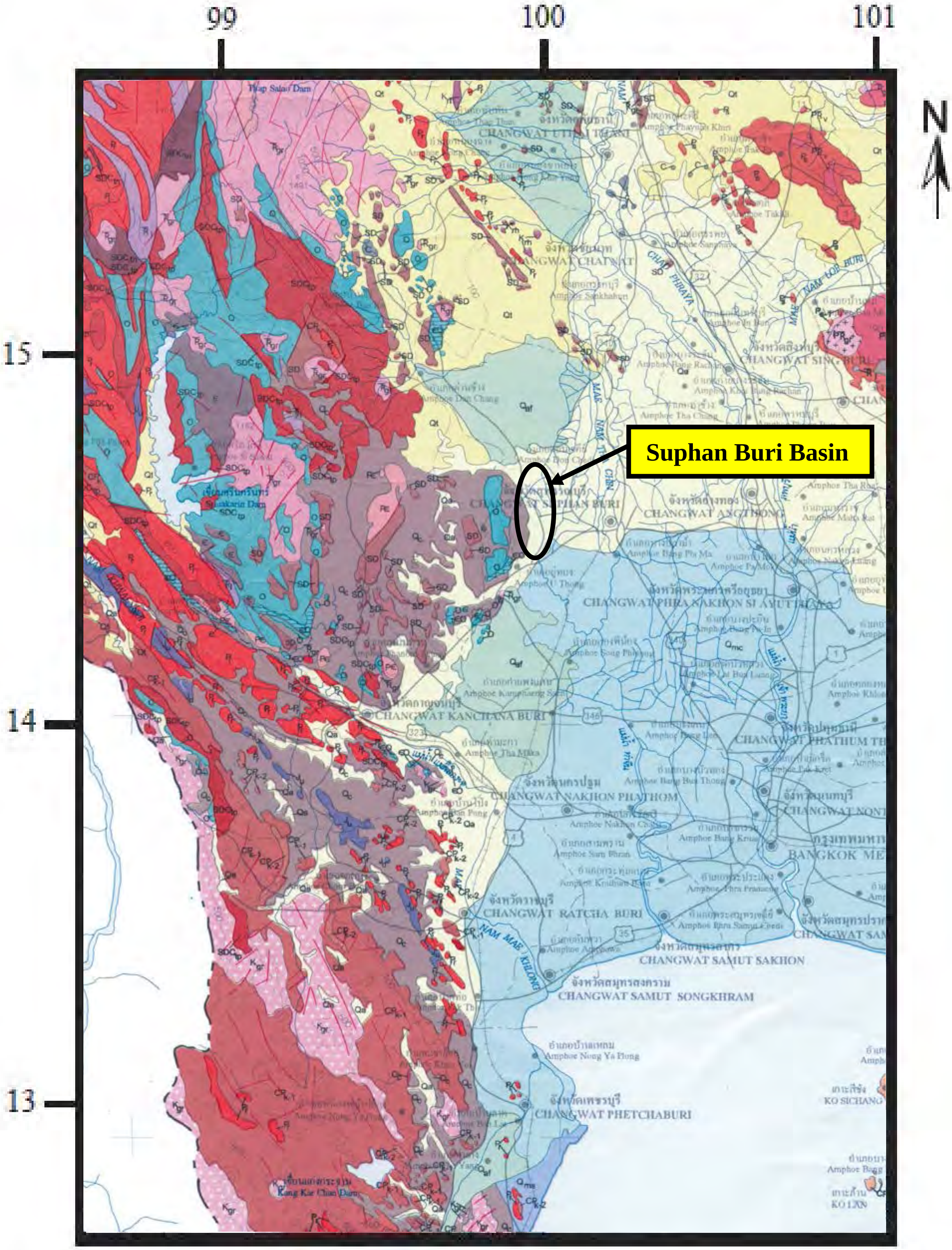


Figure 1.2 Location of Suphan Buri Basin located in the southern central plain of Thailand.

1.1 Location : Study area

Ban Phai Khwang Area is located in the Northern part of Suphan Buri Basin, Suphan Buri province; 85 km to the North West of Bangkok; the southern central plain of Thailand. Suphan Buri Basin locates between major Tertiary strike-slip faults zone, Mae Ping faults zone and Three Pagoda faults zone. The study area covers surface area of approximately 55 km^2 (Fig. 1.3).

1.2 Objective

To study and analyze structural geology ; joined faults and structural closures of the Northern part of Suphan Buri Basin, Ban Phai Khwang Area, Suphan Buri province by 3D seismic interpretation.

Hypothesis: This study area has joined faults and structural closures.

1.3 Scope of work

This study focuses on structural geology : joined faults and structural closures. Firstly interpret 3D seismic data in Ban Phai khwang Area that covers surface area of 55 km^2 in the Northern part of Suphan Buri Basin by using Kingdom software. Then analyze qualitative fault characteristic (fault detection) by using Coherency attribute technique or other technique. After that structural maps, fault throw analysis and flattened horizon w\are created for analysis and explanation of structural geology that it could has joined faults and structural closures.

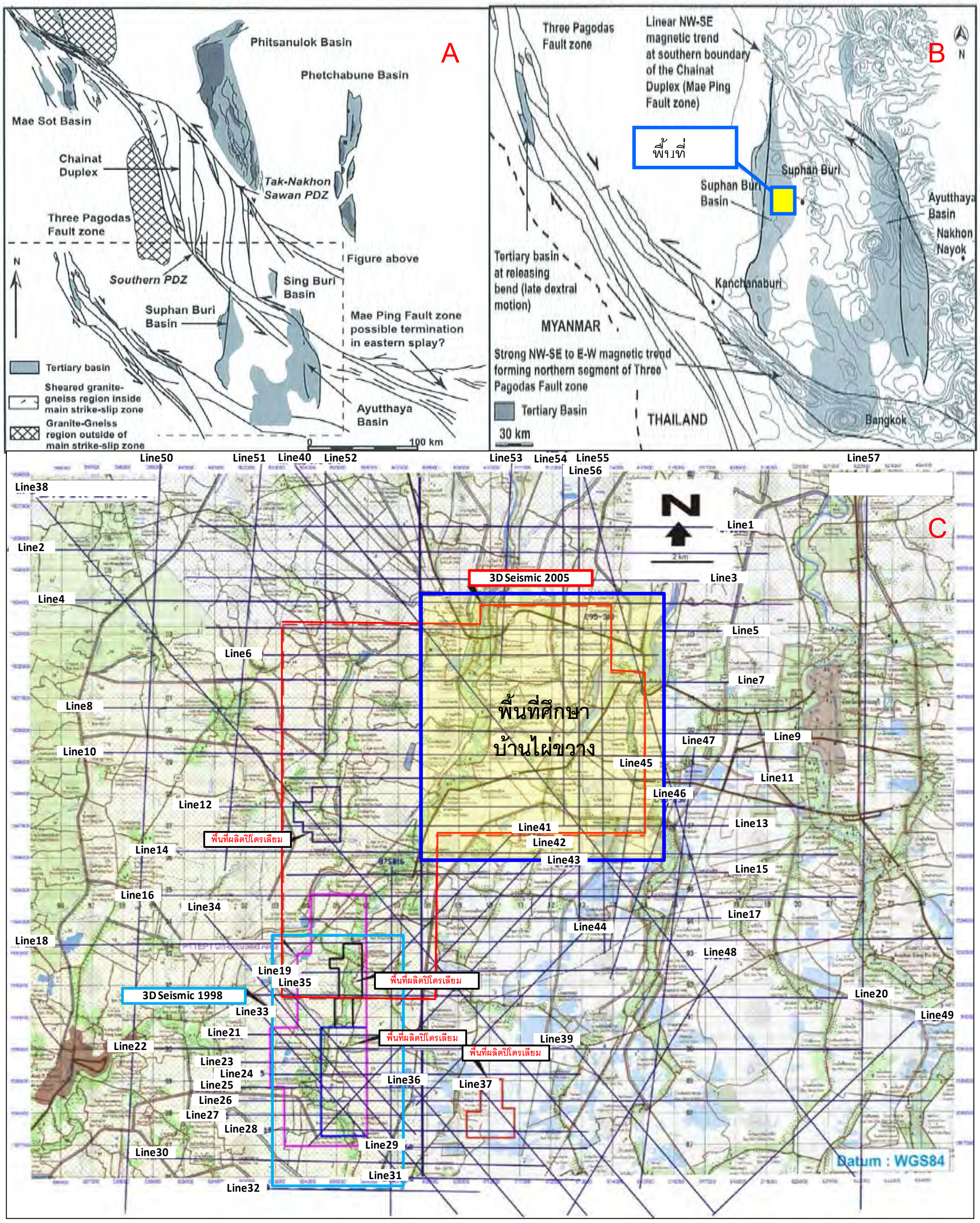


Figure 1.3 (A) Regional location map of Suphan Buri Basin, illustrating the neighboring major strike-slip faults and adjacent Cenozoic rift basin (Morley, 2006) (B) Suphan Buri Basin lies between major Tertiary strike-slip fault zones, Mae Ping faults zone and Three Pagoda faults zone (Morley, 2006) (C) Map shows location of Ban Phai Khwang Area in Suphan Buri province.

1.4 Expected output

Structural geology : joined faults and structural closures in Ban Phai Khwang Area, the Northern part of Suphan Buri Basin, Suphan Buri province.

1.5 Regional geology

Ban Phai Khwang Area is located in the northern part of the Supha Buri Basin, Suphan Buri province, 85 km to North West from Bangkok in the southern central plain of Thailand which is flood plain region. Suphan Buri Basin is one of onshore Tertiary basins; a small basin approximately 970 km^2, which was formed as half graben in N-S direction. The basin is located nearby to the Nan-Uttardit suture developed during the early to middle Triassic on the Shan-Thai continental block (O'Leary and Hill, 1989). Suphan Buri Basin lies between Mae Ping faults zone and Three Pagoda faults zone in the North and the south respectively. This basin occurred during Oligocene to Miocene (O'Leary and Hill, 1989). The sediments that filled in this basin consist of conglomerate, sandstone, siltstone, shale and mudstone which deposited in lacustrine, alluvial and fluvial environment.

Stratigraphy of Suphan Buri Basin

Stratigraphy of Suphan Buri Basin was studied by Intaravijith (1993) and the PTTEP-1 technical team revised the stratigraphy into 5 units (Fig. 1.4). PTTEP-1 technical team established stratigraphy of Suphan Buri Basin and the characteristics of each unit are described from bottom to top as follow:

Unit A: Biostratigraphic data indicates an Oligocene age. The basin fill sediment is non-marine alluvial fan deposits which comprise mainly sandstones and conglomerates with interbedded siltstones, mudstones, and occasional limestones.

This unit shows a discontinuous pattern, lack of amplitude contrast and low frequency.

Unit B: This unit corresponds to an abrupt change from alluvial fan to stratified lake environment. The deposits mainly consist of lacustrine mudstone with minor siltstone and occasional fluvial sandstones. The age of Oligocene to early Miocene is suggested by a biostratigraphic study.

The upper part of this unit grades into fluvial-lacustrine sediments characterized on seismic by a pattern of low amplitude, poor to moderate continuity reflectors.

Unit C: This unit is interpreted as lacustrine a deltaic sediments. The sediment facies formed a lower lacustrine unit within an overall regressive stack pattern. The sediment are composed of intercalations of sandstones, siltstone and mudstones. The seismic facies is easily recognized by very high amplitude and good continuity seismic reflection character.

Unit D: This unit reflects a major fan delta progradation from west to east usually with minor interbeded mudstones. Major lacustrine mudstone deposition was renewed towards the top of the sequence, confining sandstone deposition to the proximal part of fans. This sequence was deposited in the early late Miocene; it is an upper lacustrine to deltaic unit. The sediments are composed of sandstone and siltstones with interbedded shallow lacustrine mudstones. This unit is interpreted by PTTEP as regressive low relief alluvial fans or fluvial braided plain sedimentation formed in areas where rivers flow into the basin.

The seismic character of this unit shows high amplitude and good continuity.

Unit E: This unit has been interpreted as post rift deposits. The fluvial sands in the lower part of this unit directly overlie the lacustrine and deltaic unit of unit C. distribution of this unit extends beyond underlying basin-bounding faults. This sequence was deposited in the Quaternary. The uppermost Cenozoic sediment comprises mostly unconsolidated sand, gravel, and vari-colored clay. This generally is fluvial dominated with occasional limestones.

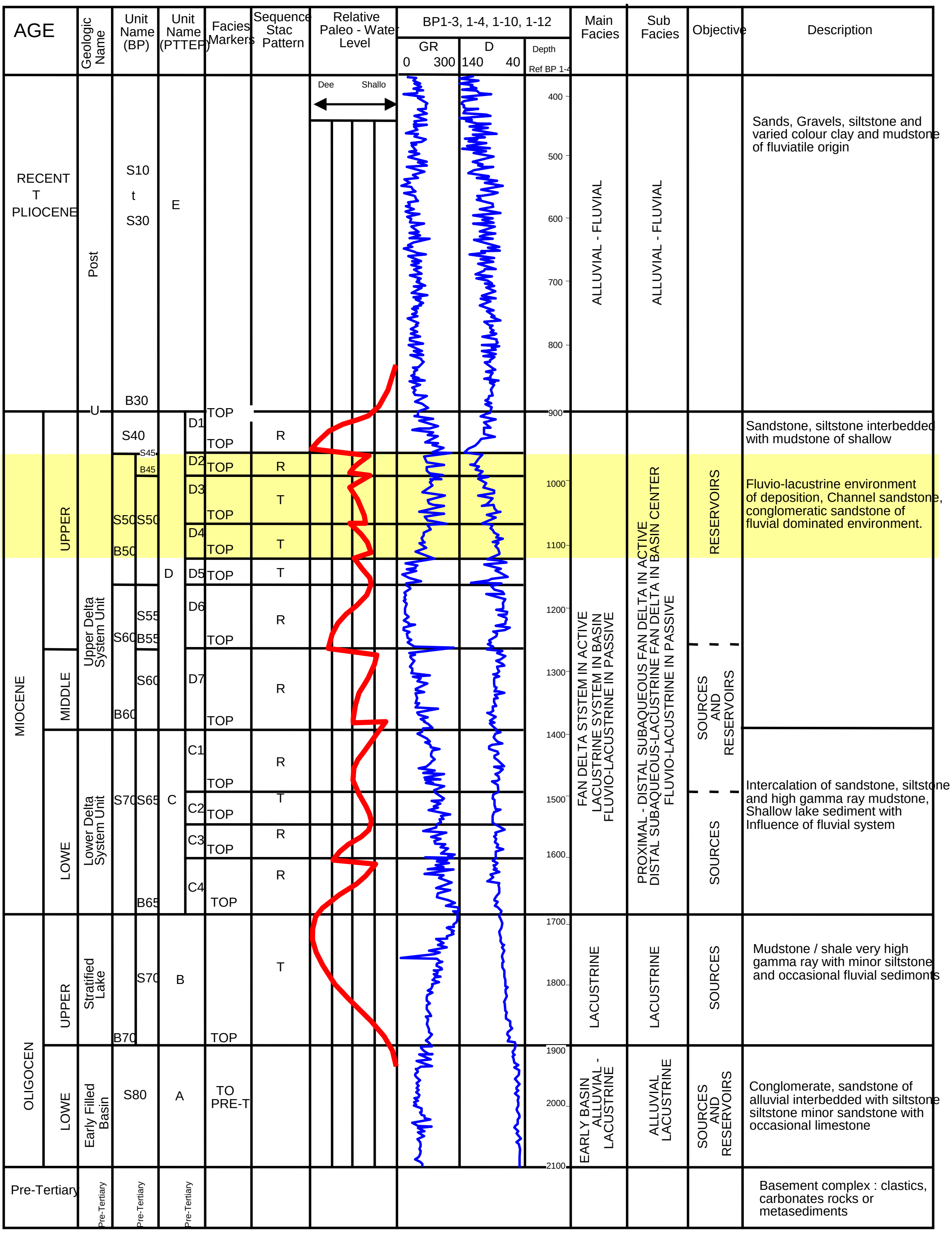


Figure 1.4 General stratigraphy of Suphan Buri Basin (after Intharavijitr, 1993).

1.6 Tectonic setting

In this region a number of tectonic models for basin formation have been proposed and mentioned before. Suphan Buri Basin has been explained as a pull-apart basin related with sinistral movement of major strike-slip faults during the Oligocene (Himalayan escape tectonic) (Fig. 1.3), but it also has had arguments about major strike-slip faults as follow:

Polachan et al. (1989, 1991) suggested that tectonics in South East Asia were dominated by strike-slip deformation and extension as a result of collision between India and Eurasia in the early Tertiary. Model of Polachan et al. (1991) shows that two major strike-slip faults zonesin central Thailand are major dextral strike-slip faults (Fig. 1.5). McCabe et al. (1988) suggested that recent earthquake analyzes show Mae Ping and Red River faults are currently dextral displacement too. However Taponnier et al. (1982) stated that Three Pagoda faults zone and Mae Ping faults zone indicate a sinistral sense of motion because of ductile structure in mylonites and ultramylonites. Several hundred kilometers of sinistral displacement on the Three Pagoda faults zone and Mae Ping faults zone are inferred on the basis of the offset of a Permo-Triassic granitic belt in western of Thailand. Lacassin (1993) stated that firstly, Three Pagoda faults, Mae Ping faults and Red River faults zones were sinistral strike-slip fault. Cooling ages from Micas, the Mae Ping faults and Three Pagoda faults indicated that this sinistral movement ceased at about 30 Ma and then dextral movement occurred later.

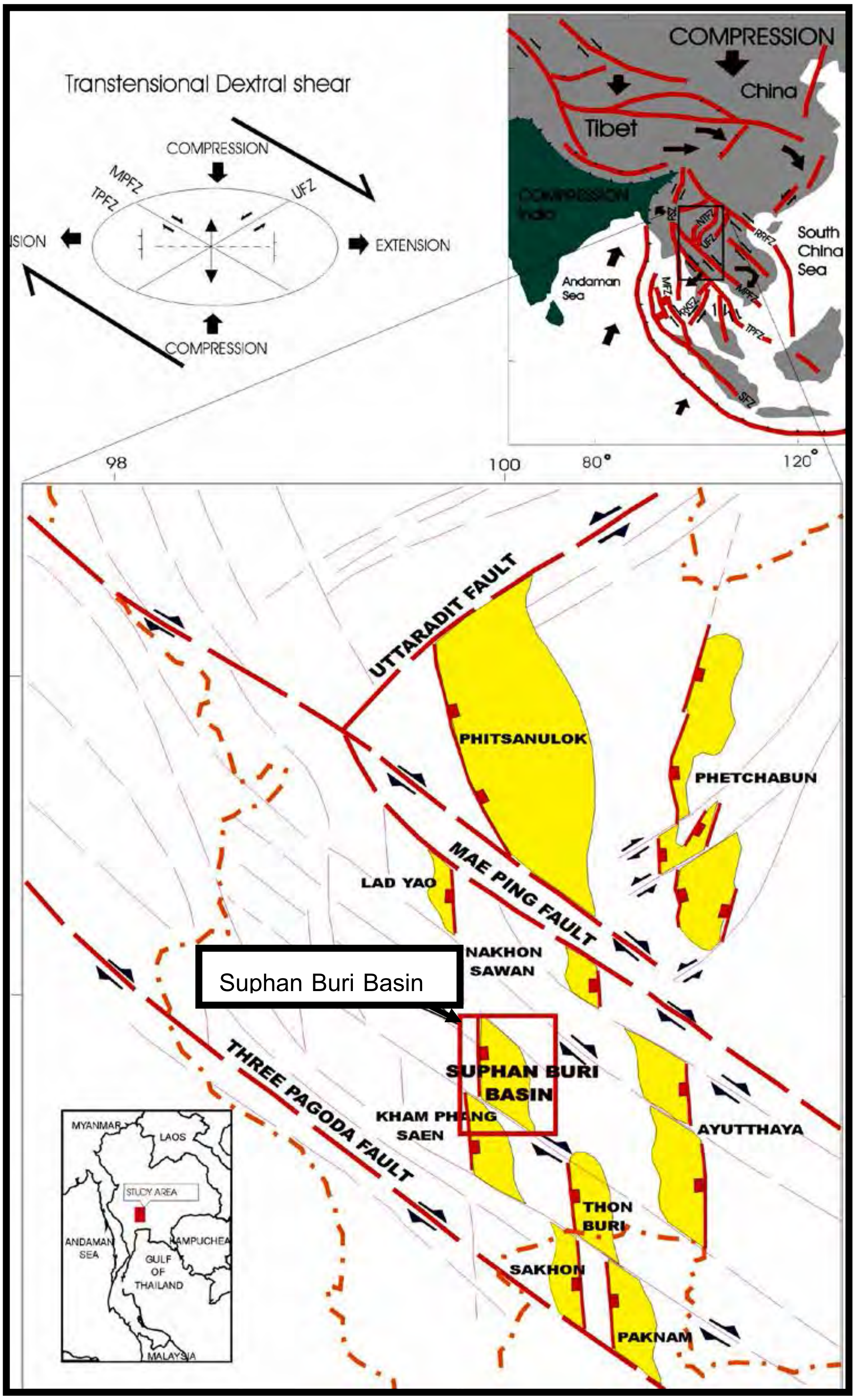


Figure 1.5 Structural map of central Thailand illustrating movement of Three Pagoda faults zone and Mae Ping faults zone (after Polachan and Sattayarak, 1989).

CHAPTER 2

2.1 Methodology

2.2 Previous works

Chapter 2

2.1 Methodology

There are main 7 steps to do in this project.

1. Data and previous works reviews about general geologic data and fundamental knowledge
2. Study methods and data that will be used.
3. 3D seismic interpretation and qualitative fault characteristic analysis
4. Study result data from 3D Fault and Horizon interpretation and qualitative fault characteristic analysis (Coherency attribute)
5. Discussion
6. Conclusion and report

The detailed of the study in this project are shown in a flow chart as follow (Fig. 2.1).

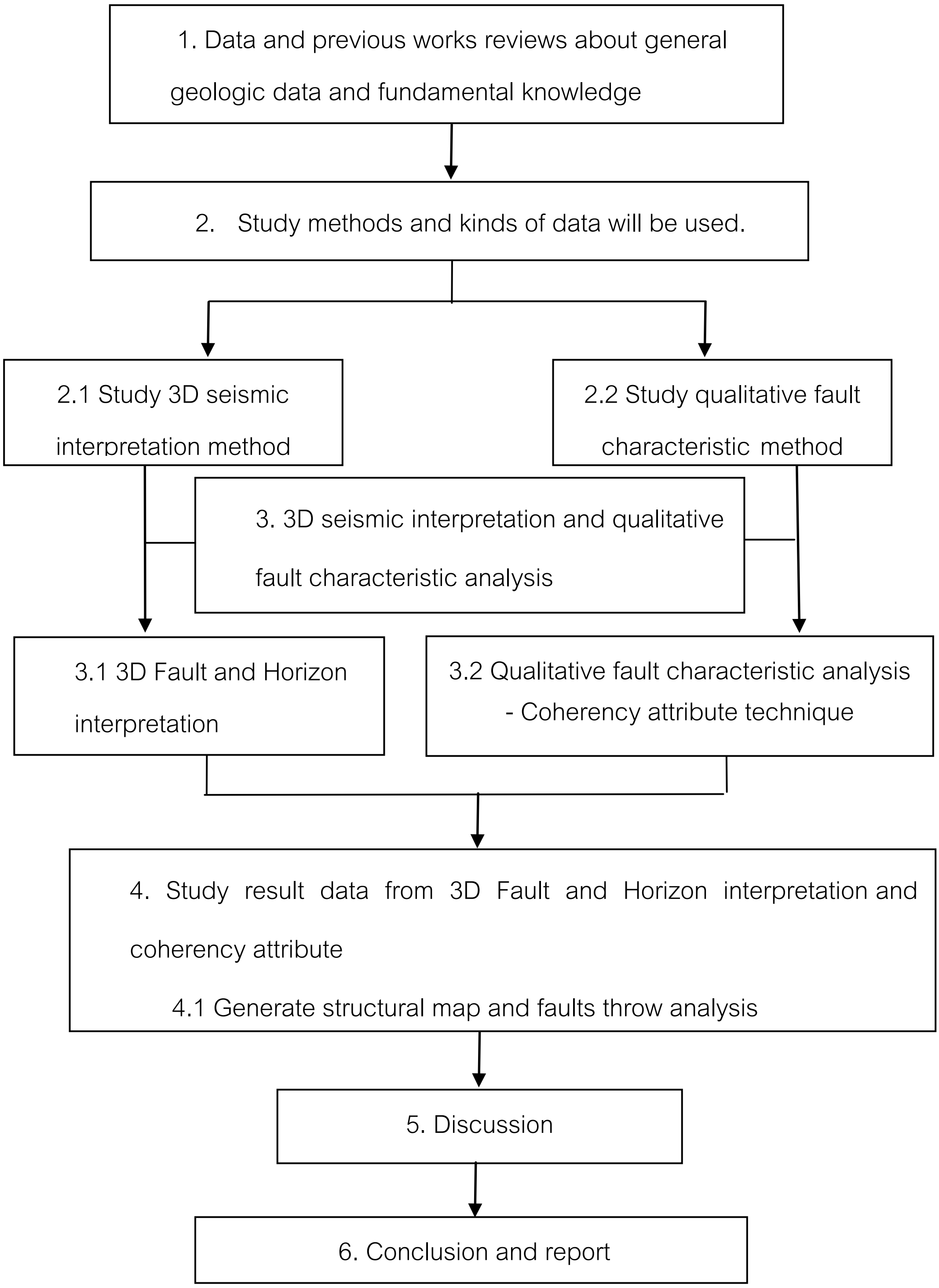


Figure 2.1 Flow chart shows methodology for a study in this project

2.1.1 Previous works

First procedure is studying previous works and fundamental data to understand about basis information in study area such as general geological background, regional structural geology, tectonic setting, stratigraphy of study area and seismic interpretation method.

2.1.2 Methods and kinds of data

This step is to study how to interpret and analyze qualitative fault characteristic. The data which is used in this study before interpretation and analysis is geophysical well log (from well L-1; contains sonic log, density log and gamma ray log) and synthetic seismogram

Synthetic seismogram is a direct one dimension model of acoustic energy traveling through the layers of the Earth. The synthetic seismogram is generated by convolving the reflectivity derived from digitized acoustic and density log with the wavelet derived from seismic data. To compare markers for matching between log and seismic section by correlation points picked on well logs with major reflection on seismic section. Quality of the match between well log and seismic section depends on well log data quality, time-depth chart, seismic data processing quality and quality of extraction a representative wavelet from seismic data.

2.1.3 3D seismic interpretation and qualitative fault characteristic analysis

Seismic interpretation is one of important processes to define and interpret seismic data. The methods of seismic interpretation are horizon selection, horizon picking, fault interpretation. In this study, Kingdom software is used to interpret seismic data. Fault interpretation was interpreted every each 8 inlines and select X, Y and Z horizons are used to represent top markers in seismic section.

Qualitative fault characteristic analysis used coherency attribute which is a technique that measures lateral change in seismic response, trace to trace coherence coefficients by calculating localized waveform similarity in both inline and cross line directions. The traces which are cut by faults have generally different seismic character than the neighboring traces. A continuous horizon shows high coherence values while a broken horizon (having fault or fracture) it will show low coherence values.

2.1.4 Studying structural geology derive from 3D Fault and Horizon interpretation and qualitative fault characteristic analysis

Structural map and fault throw analysis are generated for X, Y and Z horizons. Moreover the result of qualitative fault characteristic analysis derived from time slice (used coherency attribute) from seismic data. Moreover fault throw analysis is useful to help checking joined faults in this area.

2.1.5 Discussion

This procedure is to discuss all study results that receive and explain what study results give to solve a problem.

2.1.6 Conclusion

To summary the final results which get from the study how it is and conclude the results.

2.2 Previous works

O'Leary and Hill (1989) studied sedimentary basins in central of Thailand and found that the sedimentary basins are located nearby the Nan-Uttaradit suture (developed during the early to middle Triassic) on the Shan-Thai continental block. They proposed two major structural trends and elements that have controlled basin development in central Thailand

1) A N-S trending structural grain in pre-Tertiary section related to Indosinian orogeny (Permo-Triassic) and the final collision of western Shan-Thai

2) A series of NW-SE trending trans-current fault zones, with partial development of a conjugate NE-SW set of faults.

The timing of the right lateral movement that possibly created the pull-apart basin is still in discussion. The timing of strike-slip fault for regional and macro scale proposed in the literature is as follow.

Buayai (2000) studied structural geometry and evolution of major fault systems in the Suphan Buri Basin that lies on N-S trending and appears to be a half graben basin. There are fault splays oriented in NE-SW trending that characterized along western boundary fault systems. Fault geometry and basin development in this basin are likely influenced by N-S, NE-SW and NW-SE pre-existing fabric structures. The early stage of basin extension occurred in southern part of basin; near U-thong field in Oligocene with maximum displacements about 1300 meters. In late lower Miocene, a major transfer zone at the central boundary fault joining, initial northern and southern Suphan Buri subbasin had occurred. But there is no evidence supported that strike-slip tectonic caused the opening of Suphan Buri Basin. The opening of this basin is more likely response to Indian plate subduction rollback. High variation of fault displacement pattern of the western boundary fault system shows that the western boundary fault consisted of several fault segments which separated subbasin.

Seusutthiya (2004) studied structural style of the Suphan Buri Basin. In this study he used 2D seismic data and exploration wells have been used to interpret the basin history and compared the results with the regional tectonic setting and modeling. The structural style is controlled by the boundary faults which are the western low angle detachment boundary fault, western boundary fault and antithetic boundary fault (southern area). The pre-existing fabric in NE-SW and NW-SE directions influenced the fault pattern which overall strikes N-S. He suggested that from structural styles and regional setting shows that Suphan Buri Basin opened by E-W extension which developed by a combining of many tectonic driving mechanisms. Moreover the basin can be separated into two parts which is northern and southern part. From his interpretation by using 2D seismic sections, there are 5 types of structural closures in 4 regions in Suphan Buri Basin as follow:

1) Western flank : Ramp-Flat anticline, three-way dip closure against fault
2) Northern region : Minor detachment fault anticlines, the footwall conjugate fault blocks
3) Central region : Footwall conjugate fault blocks
4) Southern region : Footwall antithetic fault blocks

Morley (2006) studied structural geometry and evolution of Suphan Buri basin that lies between Mae Ping fault zone in the north and Three Pagoda fault zone in the south.These fault zones appeared to be sinistral displacement during Eocene to Oligocene up to 30 Ma. Since 30 Ma, sinistral movement ceased and became dextral movement. Nevertheless this dextral displacement did not appear to have strongly effected to rift basin development. Basin development is controlled by two main east dipping fault systems;

- Low angle fault system that controls western subbasin
- High angle fault system that controls the main Suphan Buri basin

CHAPTER 3

3.1 Database

3.2 3D seismic study

3.3 Results

Chapter 3

3.1 Database

In this study, database can be divided into two parts: well log data and 3D seismic data from PTT Exploration and Production Public Co., Ltd. Logging data of well L-1 which contains petrogeophysics (sonic log, density log and gamma ray log). 3D seismic data in this study area was collected by Compagnie Generale de Geophysique (CGG) in 2005. The 3D seismic data covers surface area about 117 km^2. The 3D seismic data acquisition parameters are shown in Table 3.1. Kingdom software was used to interpret 3D seismic data.

3D acquisition geometry	
Survey carried out by	CGG Crew THA 3536
Recording system	Sercel 408
Record length	6 seconds
Record format	SEG D
Traces interval	50 m.
Receiver line interval	300 m.
Source interval	100 m.
Source line interval	400 m.
Type of source	Explosive (Charge size 0.5 kg.)
Depth of source	21 m.
Bin size	25 m.x50 m.
Number of receiver line by swath	8
Geodesy	
Spheroid	WGS 84 (GRS 1980)
Geodatic datum	Indian 1975
Unit	International meters
Vertical datum	Mean sea level Ko Lak
Projection	Universal Transverse Mercator (UTM)
UTM zone	47 North
Central meridian	99 degree east
Scale factor a	.9996 at CM
False easting	500,000 m.

Table 3.1 3D seismic acquisition parameters which are conducted by Compagnie Generale de Geophysique (CGG) in 2005.

3.2 3D Seismic study

This study aims to generate structural maps and qualitative fault characteristic analysis (coherency attribute) in study area by using 3D seismic data and Kingdom software (Figure 3.1). to interpret seismic sections. Methodology will be mentioned as follow:

1. Tie/Calibrate well L-1 and seismic data by generating time-depth chart (Figure 3.2) and synthetic seismogram (Figure 3.3) combination with geological markers (markers X, Y and Z) which interpret from well log data.
2. Faults are interpreted for every 8 inlines and checked faults by looking between sections (Figure 3.5, Figure 3.6, Figure 3.7 and Figure 3.8) and interpret horizons for every 16 inlines, inline in E-W direction and cross line in N-S direction (Figure 3.9, Figure 3.10 and Figure 3.11).
3. Analyze qualitative fault characteristic by using coherency attribute in Kingdom software and check fault segments in time slices. (Figure 3.12 and Figure 3.13)
4. Draw fault polygons (Figure 3.14, Figure 3.16 and Figure 1.18).
5. Generate structural maps of horizons X, Y and Z (Figure 3.20, Figure 3.21 and Figure 3.22) and reconstruction model (flattened horizon) (Figure 3.23, Figure 3.24, Figure 3.25 and Figure 3.26)
6. Analyze fault throw by using Microsoft Excel to check joined faults (Figure 3.15, Figure 3.17 and Figure 3.19).
7. Define structural closures.
8. Discussion and conclusion.

3.2.1 Fault interpretation

3D seismic interpretation starts after studying all relevant previous works, well log data. From the north of study area, the first interpretation line no.1664 having E-W direction is intersected well L-1 (Figure 3.1). Fault interpretation is done by observing discontinuity of reflectors or distinction of seismic packages, displacement of seismic signal which caused by reflection coefficient and difference of horizon’s slope caused by fault slip. In this study will interpret 3D seismic section every 8 lines and cut 3 sections (line no. 1632, 1408 and 1200) to show overall structure in northern, central and southern part of area respectively.

From Figure 3.6 faults were interpreted with color lines (such as red, green, and purple) in vertical in this section is from line no.1632. It shows all faults have dipped in west which is half graben. It is normal faults and synthetic faults. From Figure 3.7 line no.1408, it is still normal synthetic faults but has antithetic west dipping faults too. Figure 3.8 line no.1200 shows full-graben of this area.

3.2.2 Horizon interpretation

Firstly using synthetic seismogram (Figure 3.3) that generate from well log data of well L-1 to adjust identically data between well log data and seismic data. Then pick match marker beds (markers X (red), Y (green) and Z (yellow)) on seismic section in inline no. 1664. While horizons are interpreted every 16 inlines it can check that horizons in inlines are correct by picking horizon in cross lines (N-S direction, Figure 3.9, Figure 3.10 and Figure 3.11) at the same time. If in inlines are correct in the cross lines will appear continuous same color points in the same loop (red color; peak or blue color; trough). If in inline horizon X is red color line in the cross line must be a red points see Figure 3.10 and Figure 3.11. Horizons are picked continuously and stop when reach a fault line.

Horizon X: The horizon X is an important seismic marker since in Utong field the horizon was one of the main producing layers. It also represents the end of the synrift sequences (Figure 3.4). This horizon was interpreted as a peak using Reverse Polarity seismic. Along northern part of the Suphan Buri basin this reflector is quite clear to follow.

Horizon Y: The top of the horizon Y is picked in a maximum trough (Reverse polarity). This horizon is a very strong seismic event and very easy to recognize and correlate across the various vintages of data throughout the basin and from one fault block to another.

Horizon Z: This horizon Z is picked in a trough. It is relatively easy to correlate 3D seismic data. This is an important horizon as it is associated with recently discovered pays, and it represents the base of the late synrift section.

After fault and horizon interpretation finish on base map will show all inlines that are interpreted and spaces between lines then create fault polygon by line fault boundaries and color them with black. Features of these fault polygons in base map are fault offsets.

3.3 Results

When 3D seismic fault interpretation and horizon interpretation finish there are 3 horizons X, Y and Z which were reservoir rocks from well log data. Both seismic interpretations and coherency attribute are used to generate structural maps, fault throw analysis and flattened horizon to solve a problem.

3.3.1 Coherency attribute

From definition of coherency attribute (A continuous horizon shows high coherence values while a broken horizon (having faults or fractures) it will show low coherence values) high coherence values are black color and low coherence values are white color. So from the results which display fault segments on it (Figure 3.12 and Figure 3.13) can check that faults were interpreted it correct or not. That means when display fault segments (cross sign with many color in Figure 3.12 and Figure 3.13) on time slice and coherency attribute if interpretation corrects fault segment and low coherence values (white color in Figure 3.13) will be same line. This technique will help to decrease uncertainty of fault segment continuity in interpretation.

3.3.2 Structural maps

Structural maps are generated into 3 depth maps from horizon X, Y and Z and show fault offsets and dip directions (Figure 3.20, Figure 3.21 and Figure 3.22). In this area faults are normal fault as synthetic and antithetic fault sets. Fault trending is N-S and NE-SW orientation. In the north of study area major faults dipping appear to be west and half graben (Figure 3.6), while in the central and the southern part major faults appear to be east dipping and full graben (Figure 3.7 and Figure 3.8) from horizons X, Y and Z respectively. Structural depth maps show that in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be structural closures. And it shows where can be joined faults and then will check with fault throw analysis in next topic to determine it that is joined fault or not again.

3.3.3 Fault throw analysis

Fault throw is measurement in vertical fault displacement (Figure 3.14 below) to make a graph for analysis fault throw to check anomaly of faults throw such as increasing of faults throw suddenly. If a fault which throw changes immediately (such as fault is dying; throw decreased and then throw increase suddenly at area that has another fault seem to come nearly to it so that is points which can be joined fault point). In this study fault throw analysis graphs show many point are joined faults (Figure 3.15, Figure 3.17 and Figure 3.19). Joined faults are the points that one fault or more ends up with another fault and increase force to a fault so this makes increasing of that fault throw immediately. Joined faults are the points between faults E1ends at E6, E4 ends E6, E5 ends E2 and W2 ends W1 (Figure 3.14, Figure 3.16 and Figure 3.18).

3.3.4 Reconstruction model (Flattened horizon)

After fault and horizon interpretation finish, it can make flattened horizon to check about sedimentary deposition time and reactivation of faults that occur in this area with from horizon X, Y and Z. It can indicate about the time when sediments deposited by reconstruction model (Figure 3.23, Figure 3.24, Figure 3.25 and Figure 3.26).

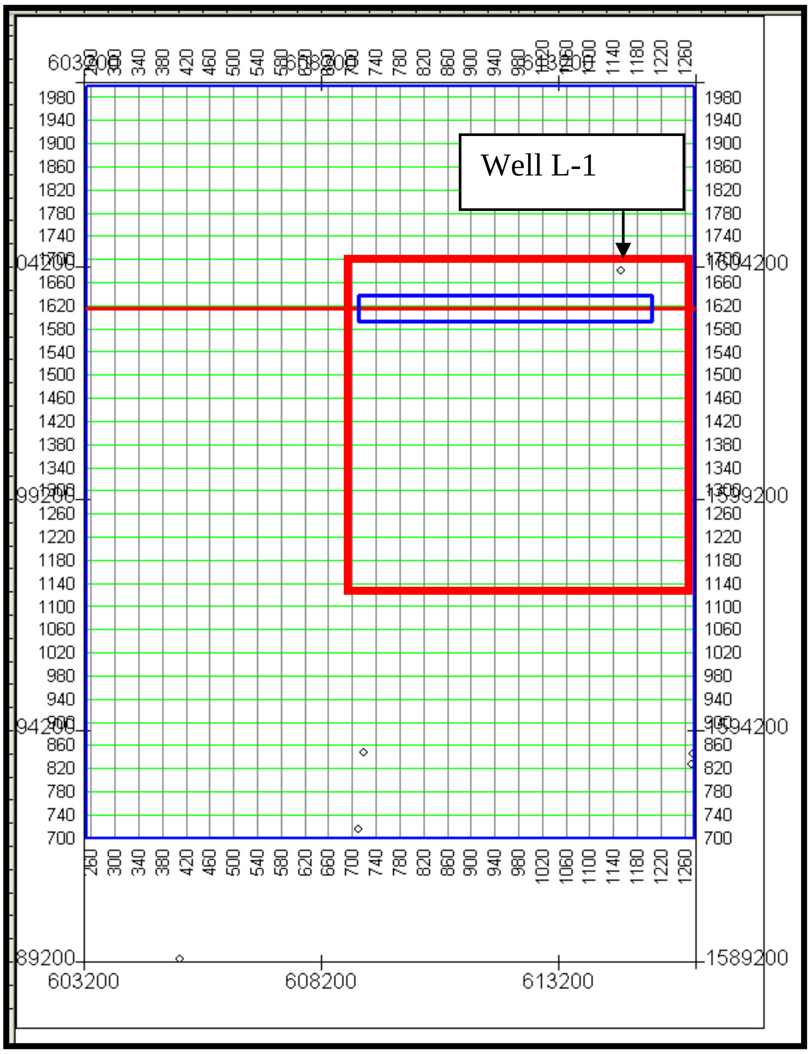


Figure 3.1 Study area in red square with well L-1 in the north of area.

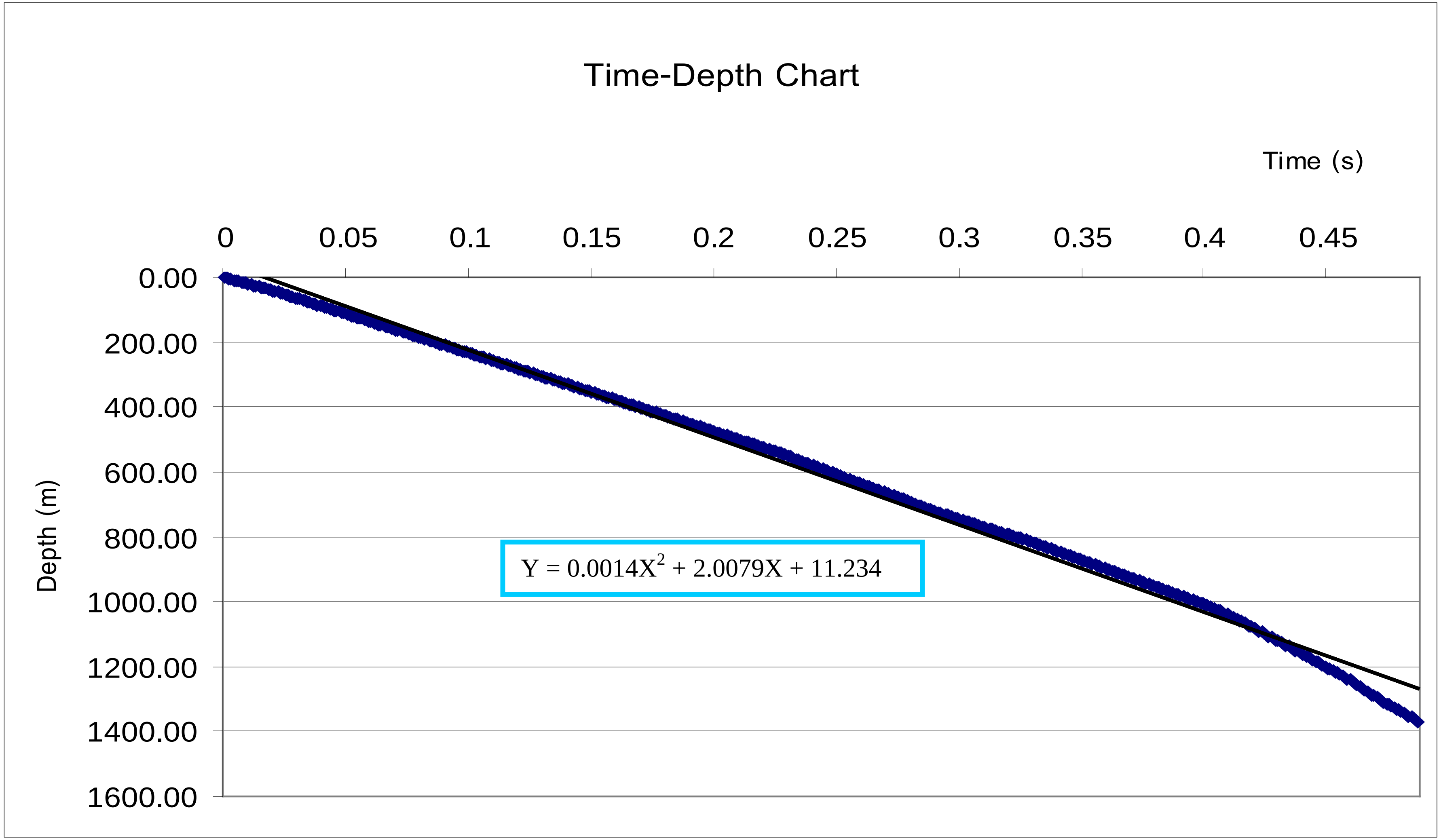


Figure 3.2 Time-Depth chart of study area with equation from well log data L-1.

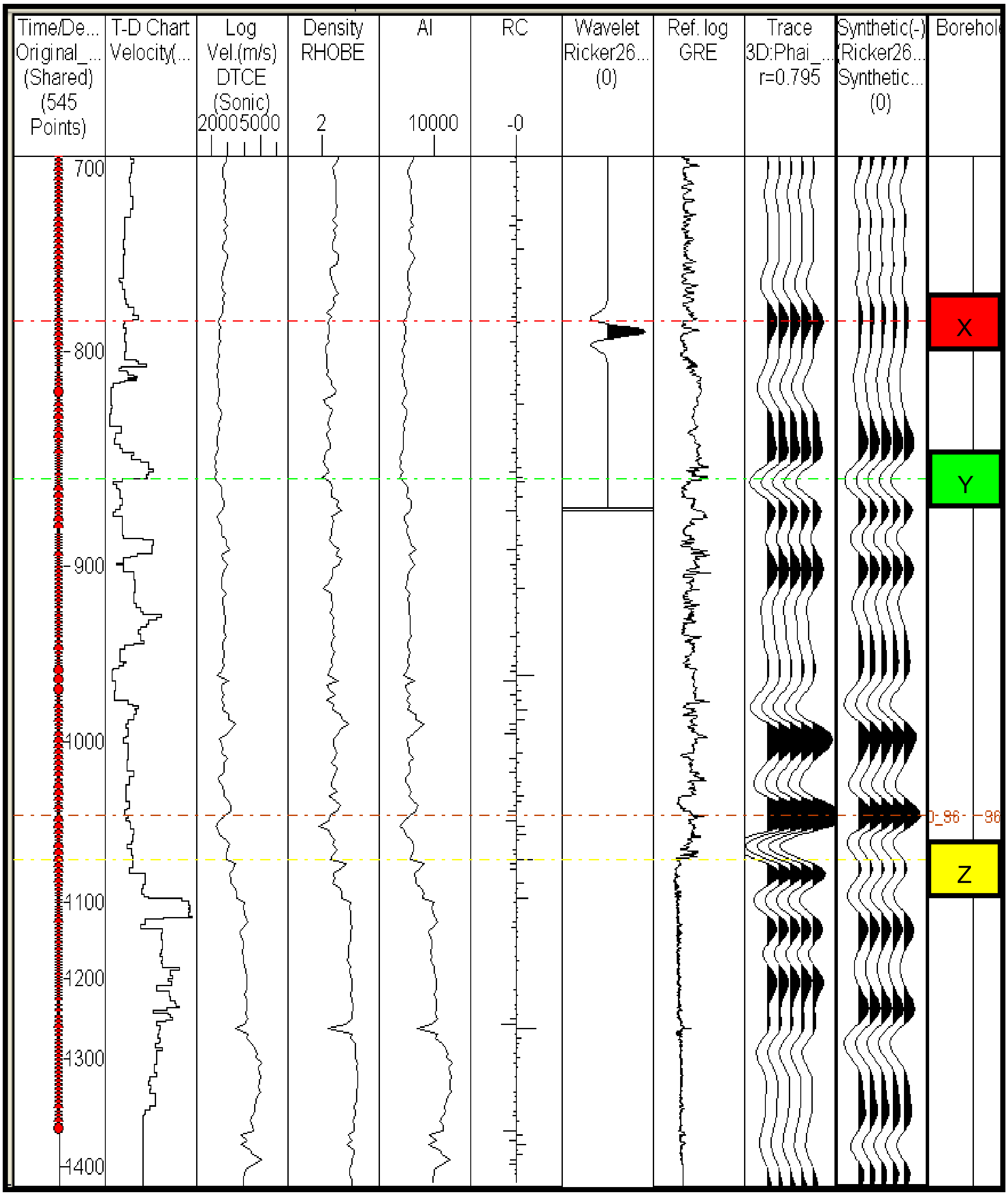


Figure 3.3 Synthetic seismogram (Depth) shows horizon X, horizon Y and horizon Z.

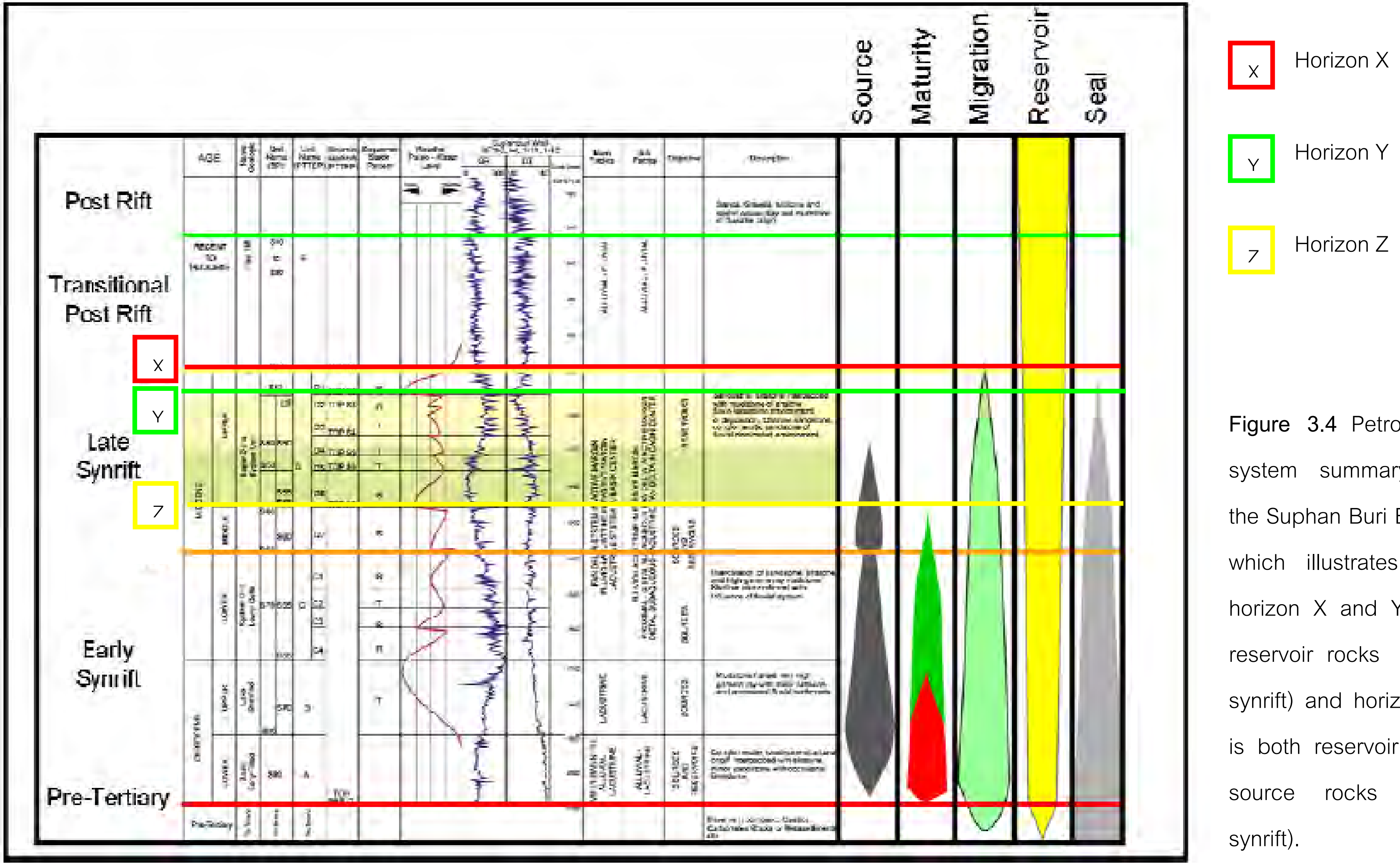


Figure 3.4 Petroleum system summary of the Suphan Buri Basin which illustrates the horizon X and Y are reservoir rocks (late synrift) and horizon Z is both reservoir and source rocks (late synrift).

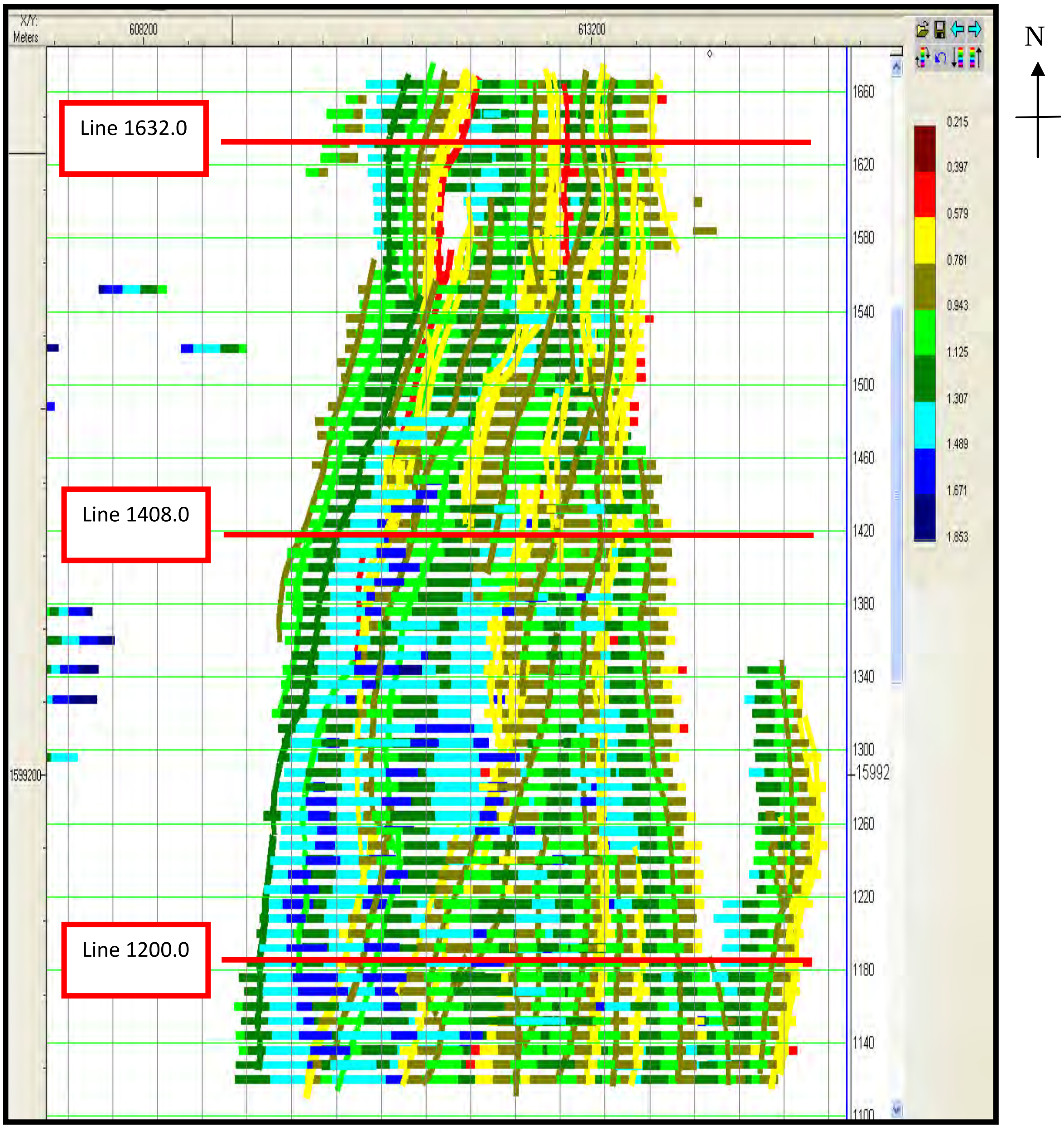


Figure 3.5 Fault interpretation in study area is interpreted every 8 inlines in this report will cut 3 seismic cross sections in the north (line 1632), central (line 1408) and south (line 1200).

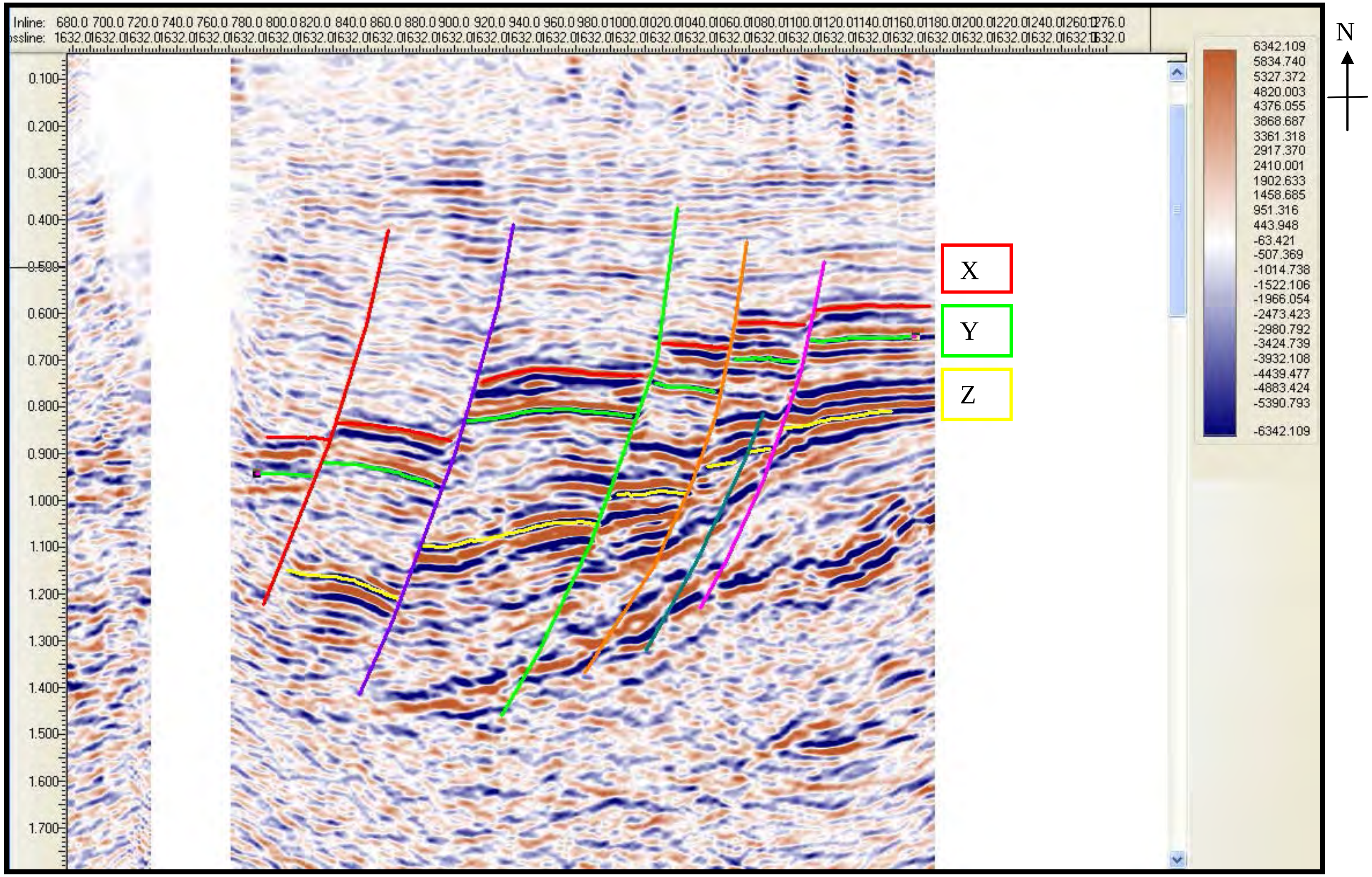


Figure 3.6 Seismic sections of line no.1632 with fault segments located in the northern part of the study area and horizon X, Y and Z are shown.

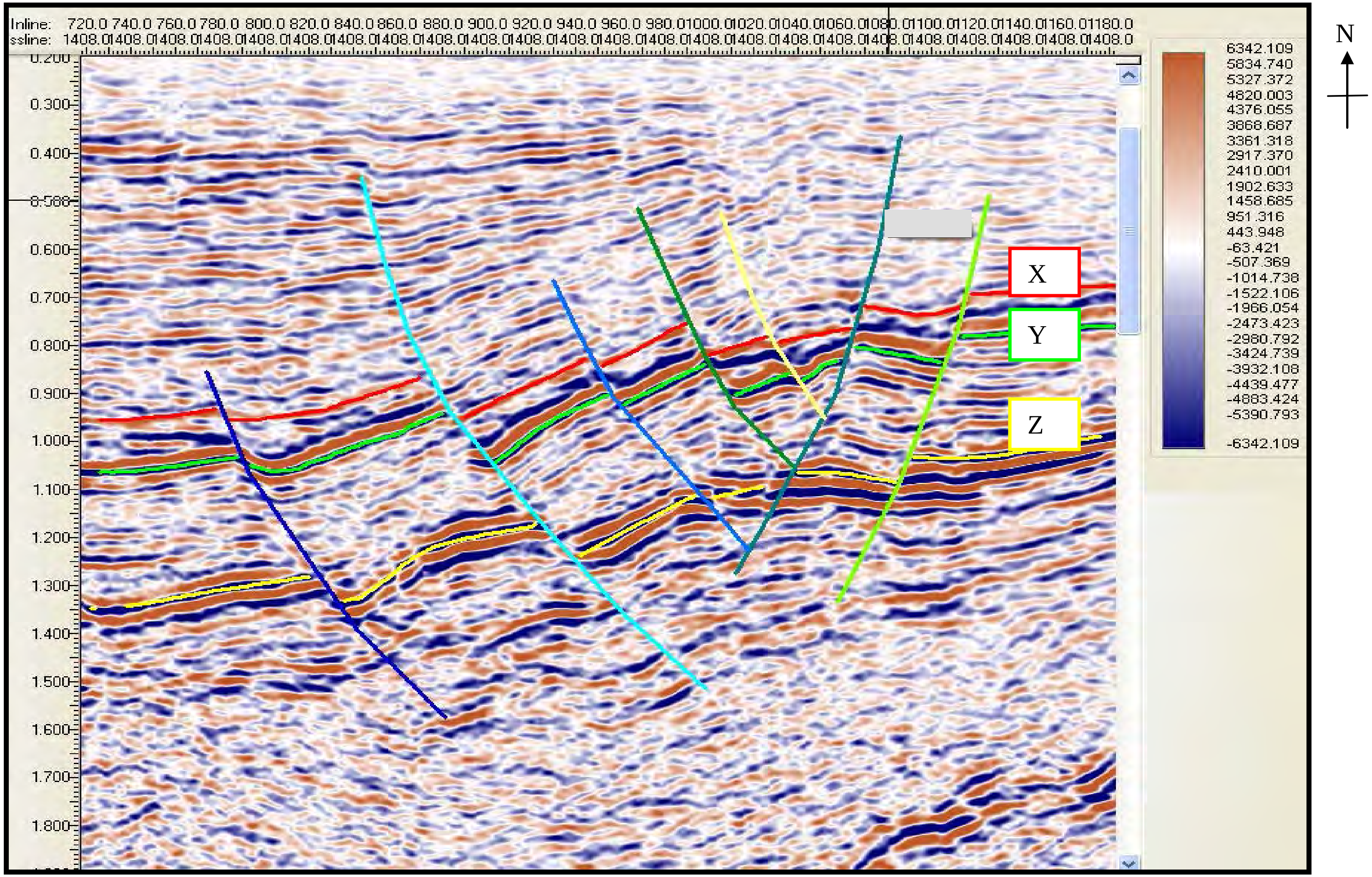


Figure 3.7 Seismic sections of line no.1408 with fault segments located in the central part of the study area and horizon X, Y and Z are shown.

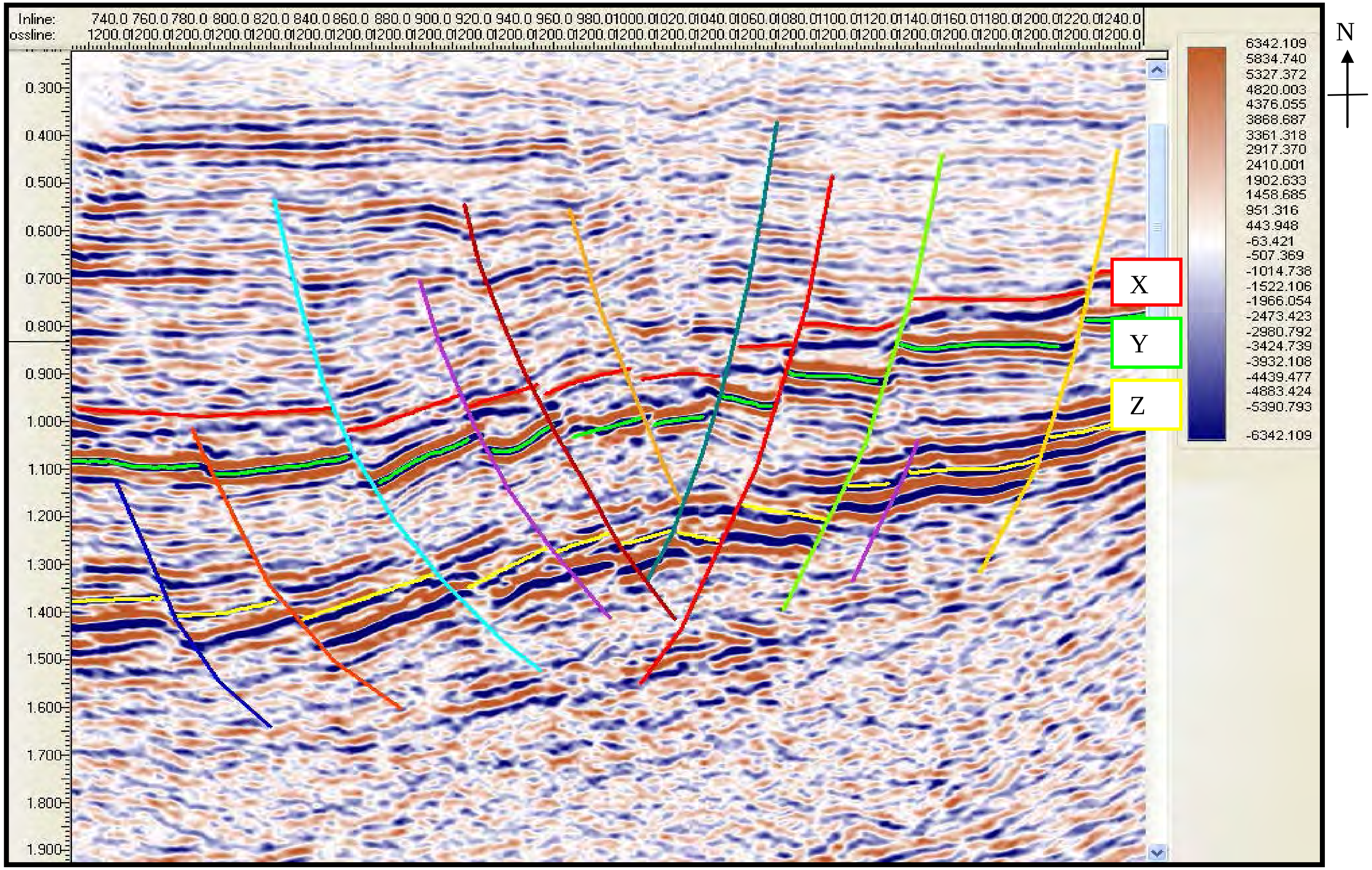


Figure 3.8 Seismic sections of line no.1200 with fault segments located in the southern part of the study area and horizon X, Y and Z are shown.

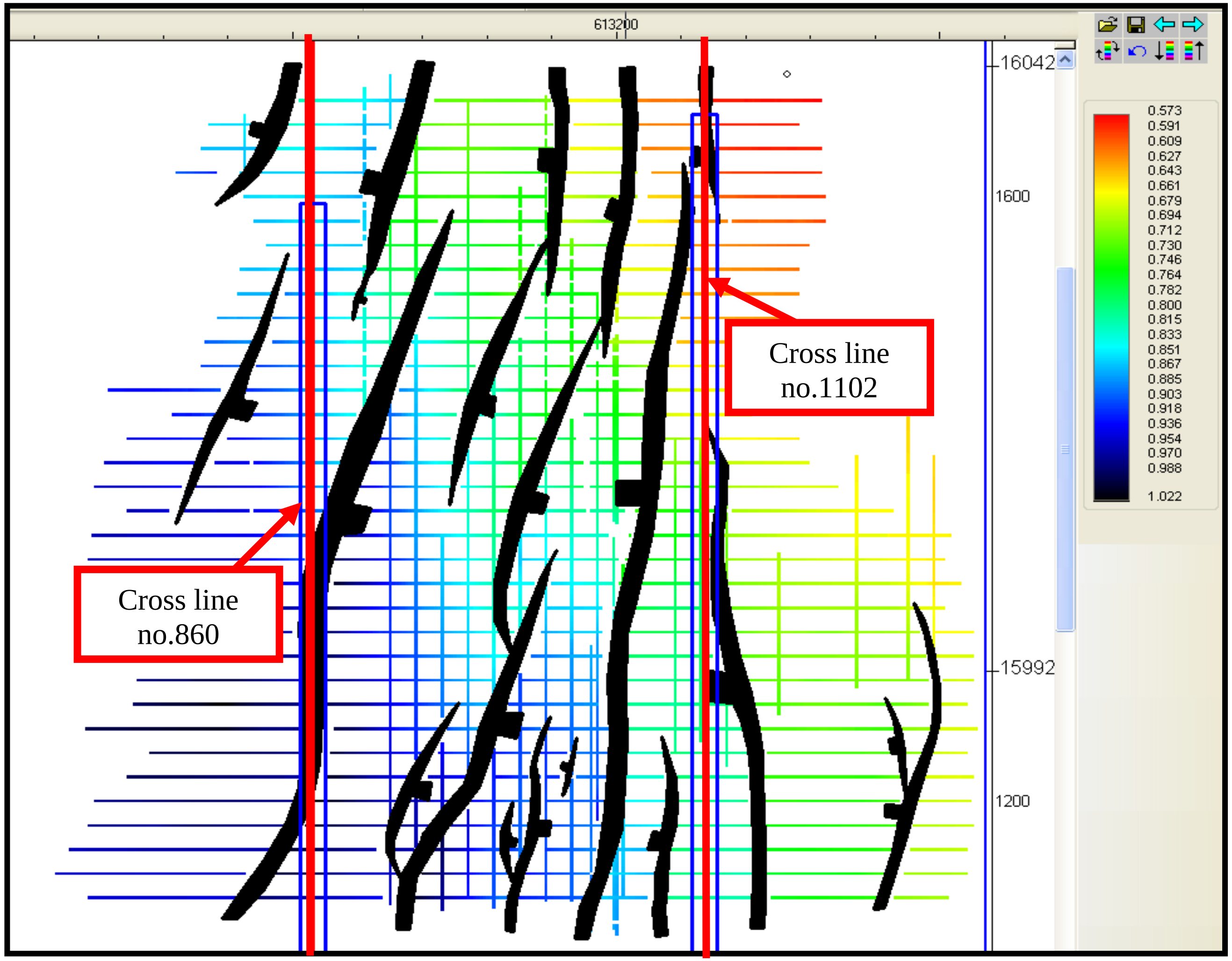


Figure 3.9 Cross lines no.860 and 1102.

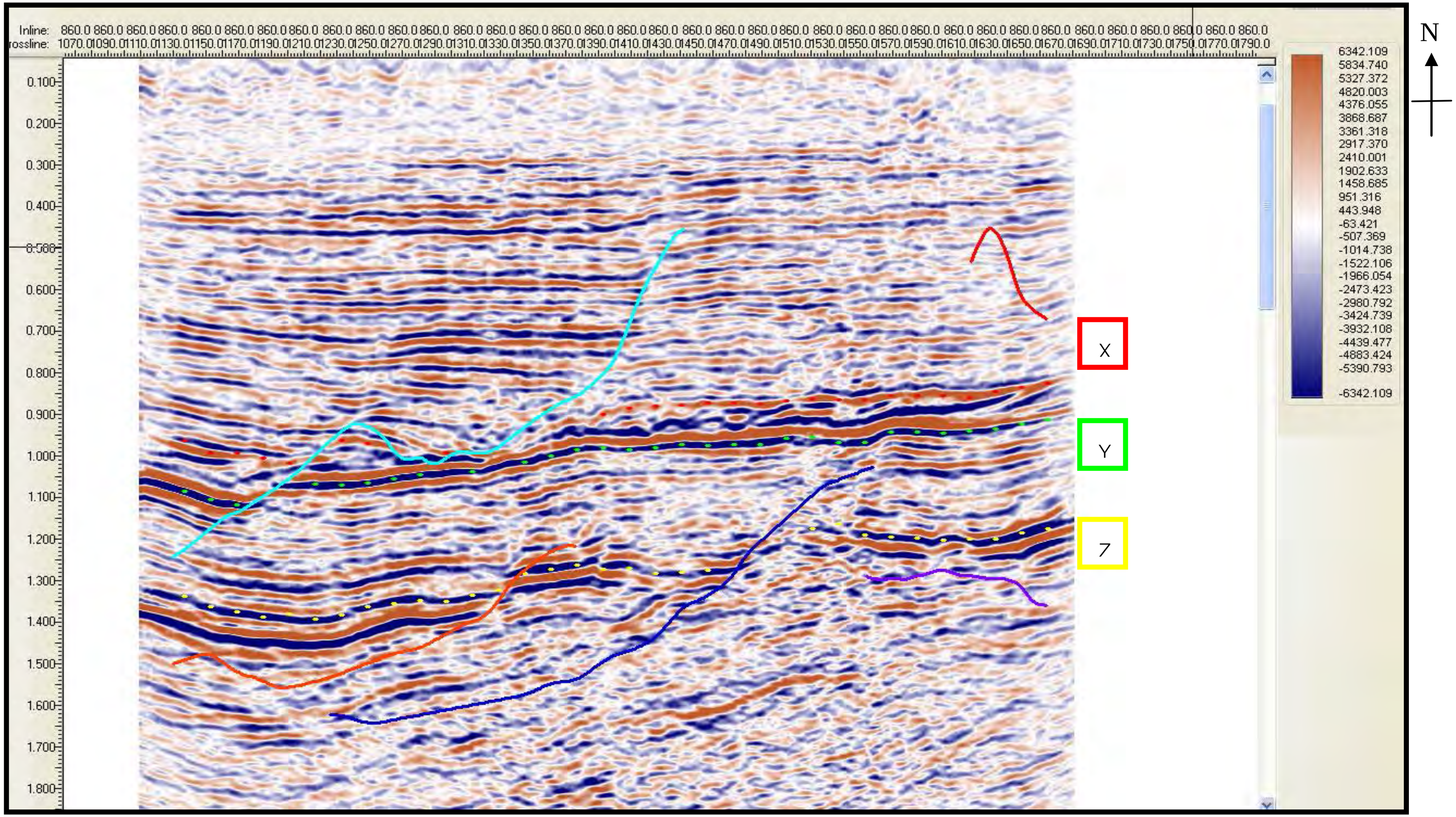


Figure 3.10 Seismic sections of cross line no.860 (N-S direction) with fault segments located in the western part of the study area and horizon X, Y and Z are shown by color points. It shows that same color points are in same lines.

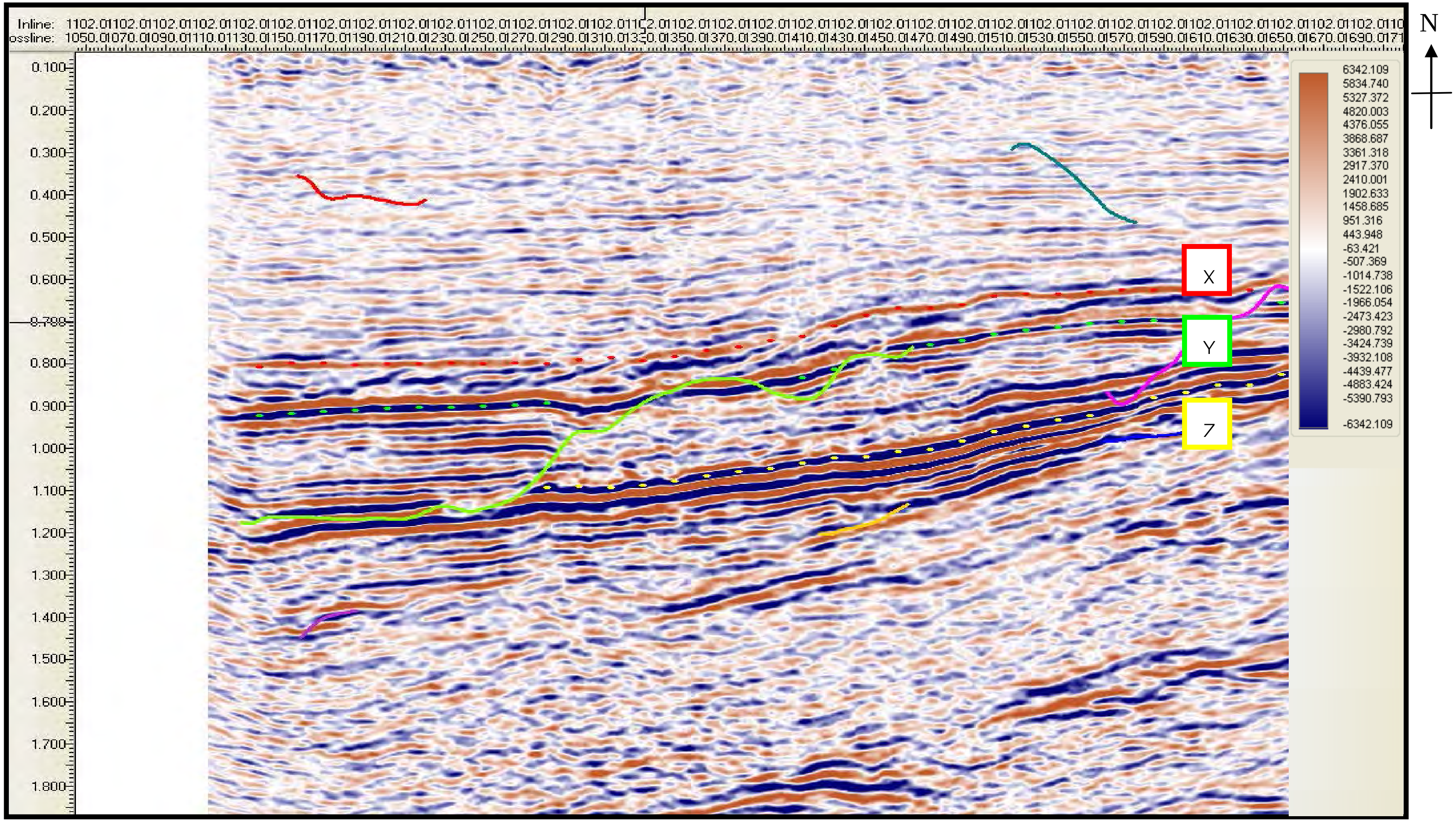


Figure 3.11 Seismic sections of cross line no.1102 (N-S direction) with fault segments located in the eastern part of the study area and horizon X, Y and Z are shown by color points. It shows that same color points are in same lines.

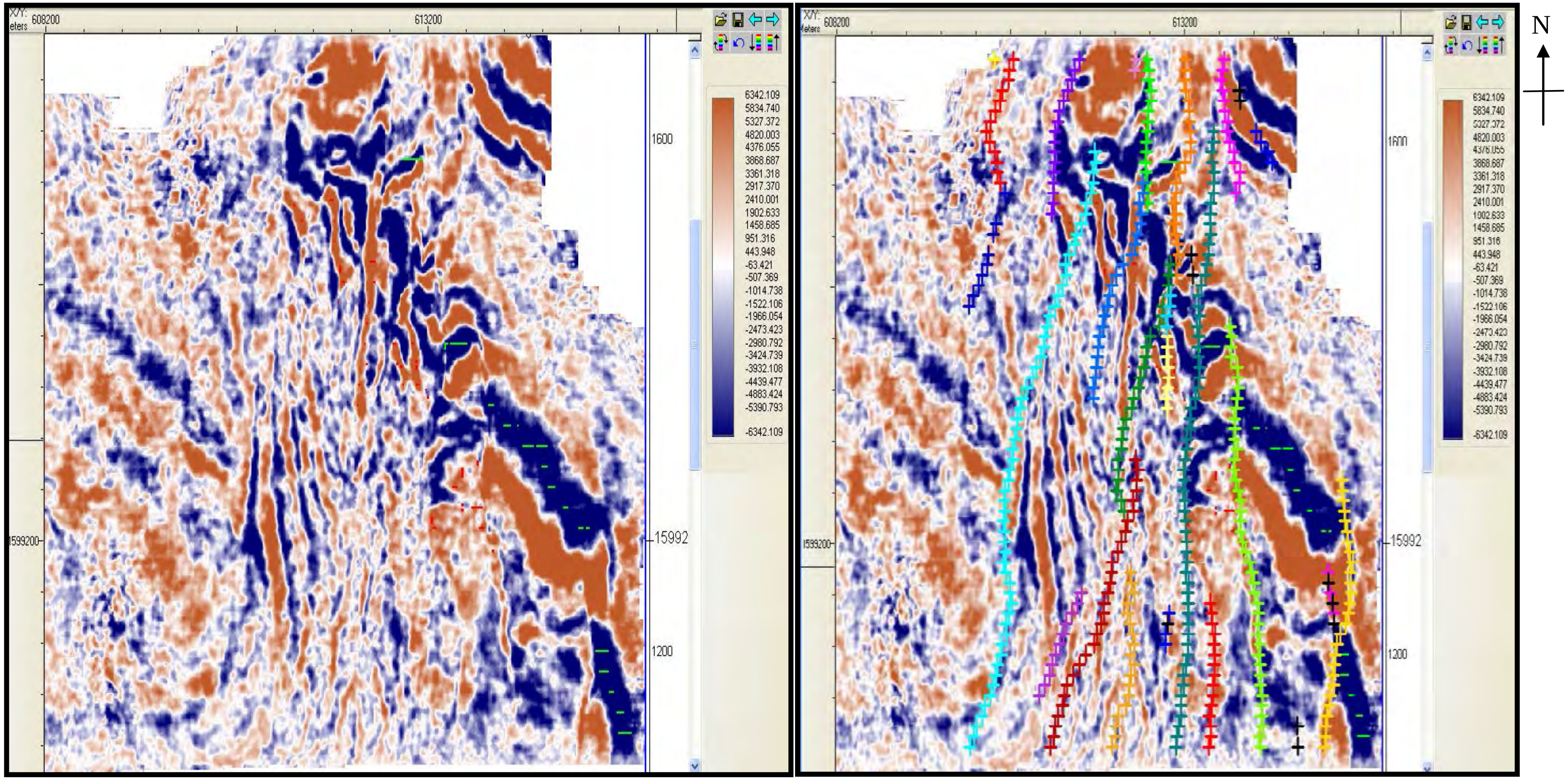
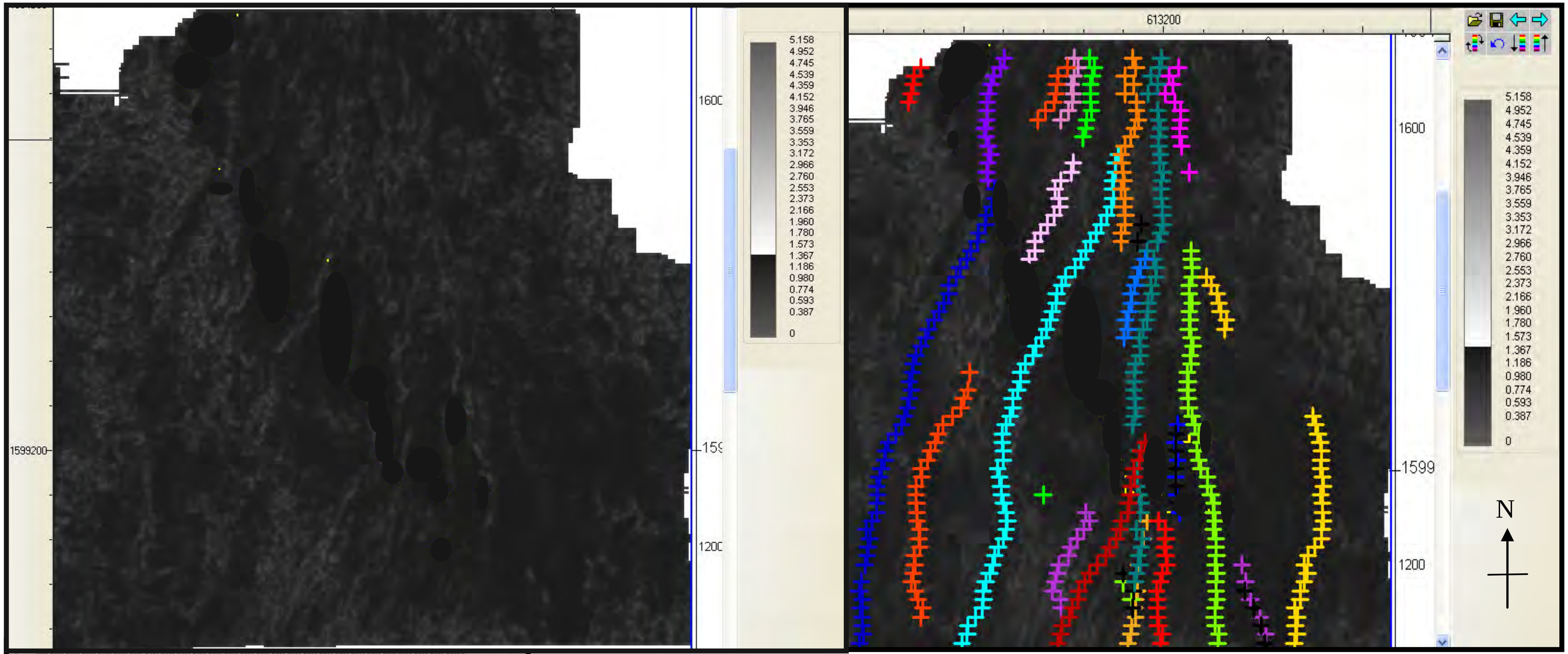


Figure 3.12 Time slice 0.788. Before display fault segments (Left) after display fault segments for checking fault segments (Right)



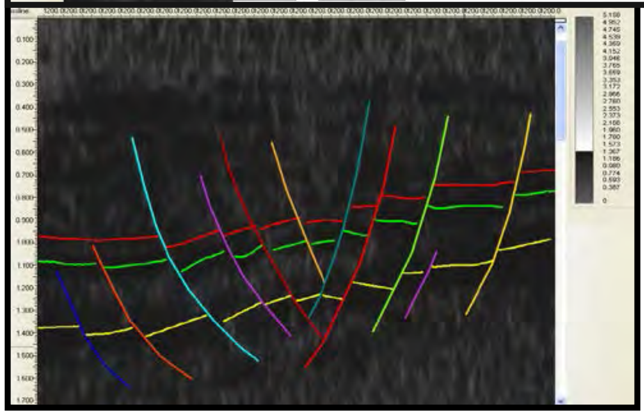
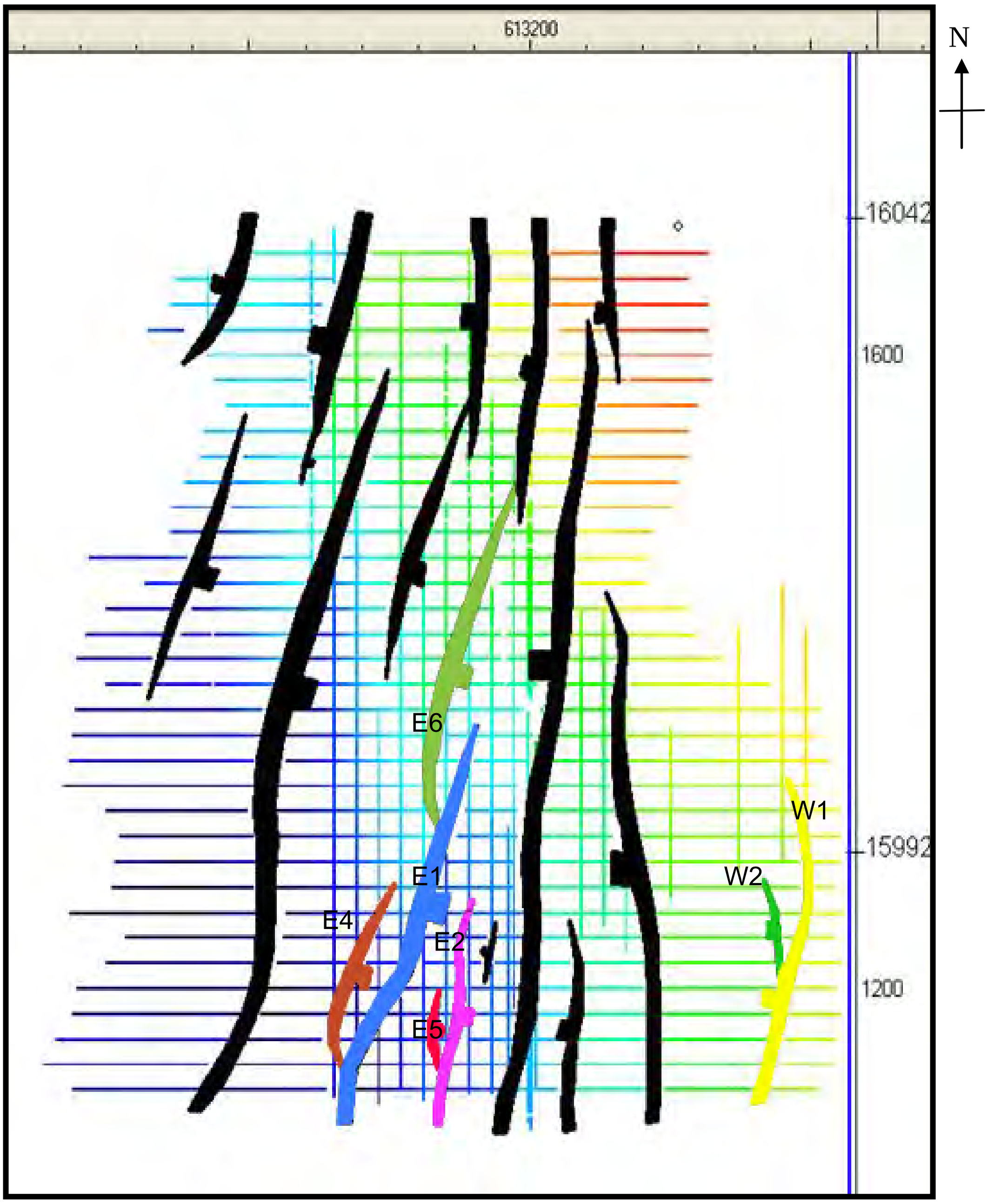


Figure 3.13 Coherency attribute (Time slice 1.176). Before display fault segments, Faults illustrate with white color (Left) after display fault segments for checking fault segments (Right) Coherency attribute seismic section line 1200 (below)



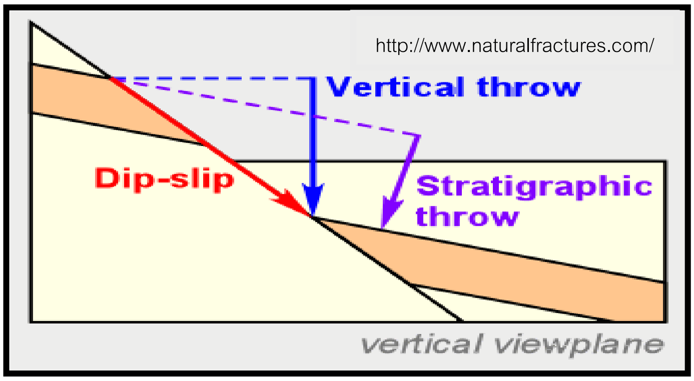


Figure 3.14 Horizon X interpretation which is interpreted every 16 inlines with displaying fault polygons (above). Fault throw is measured in vertical movement (below).

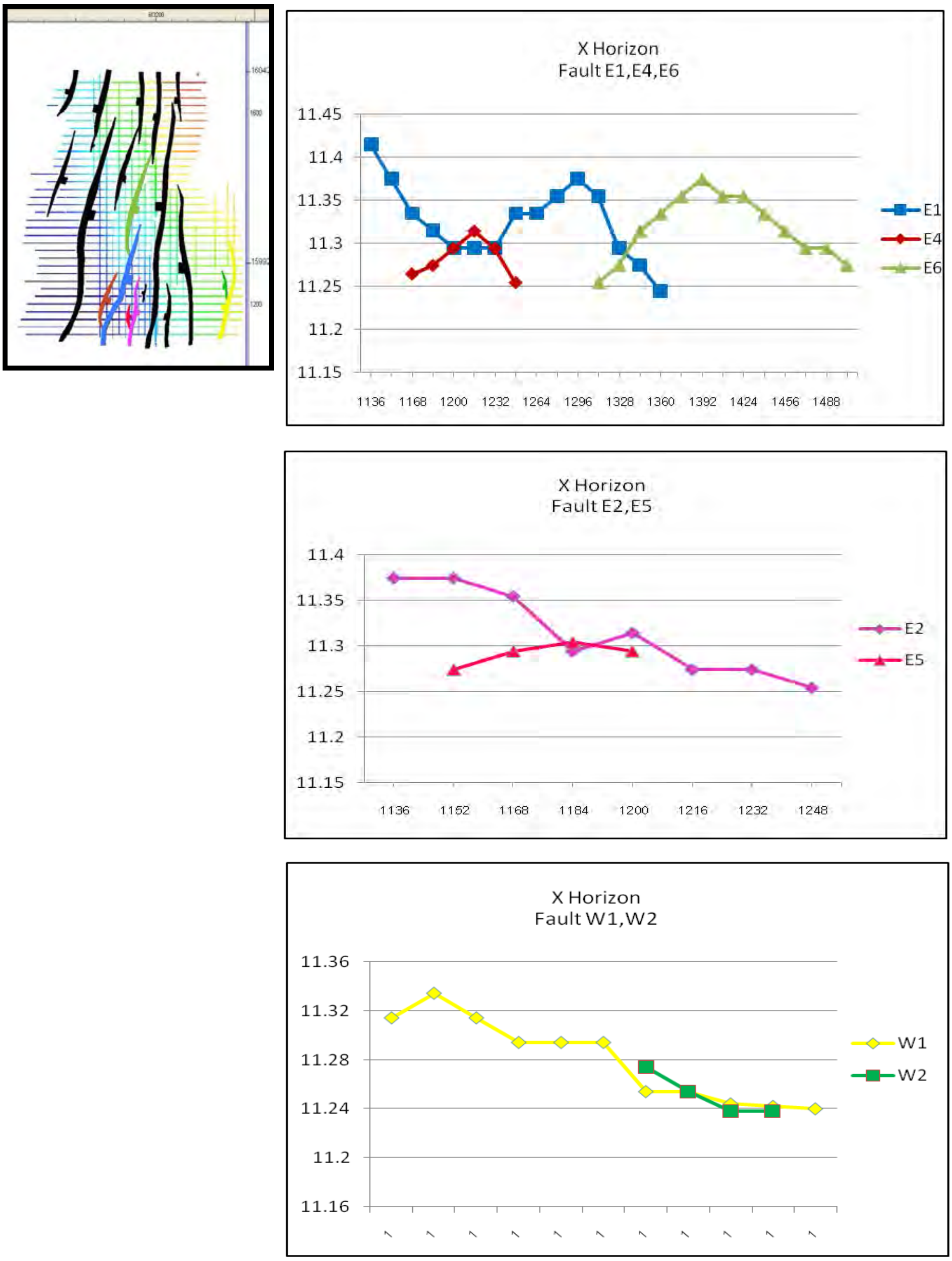


Figure 3.15 Fault throw analysis to check joined faults which are set of faults E1-E4-E6, faults E2-E5 and faults W1-W2. The results of analysis show that all fault sets appear to be joined faults because at one or two points changes throw immediately.

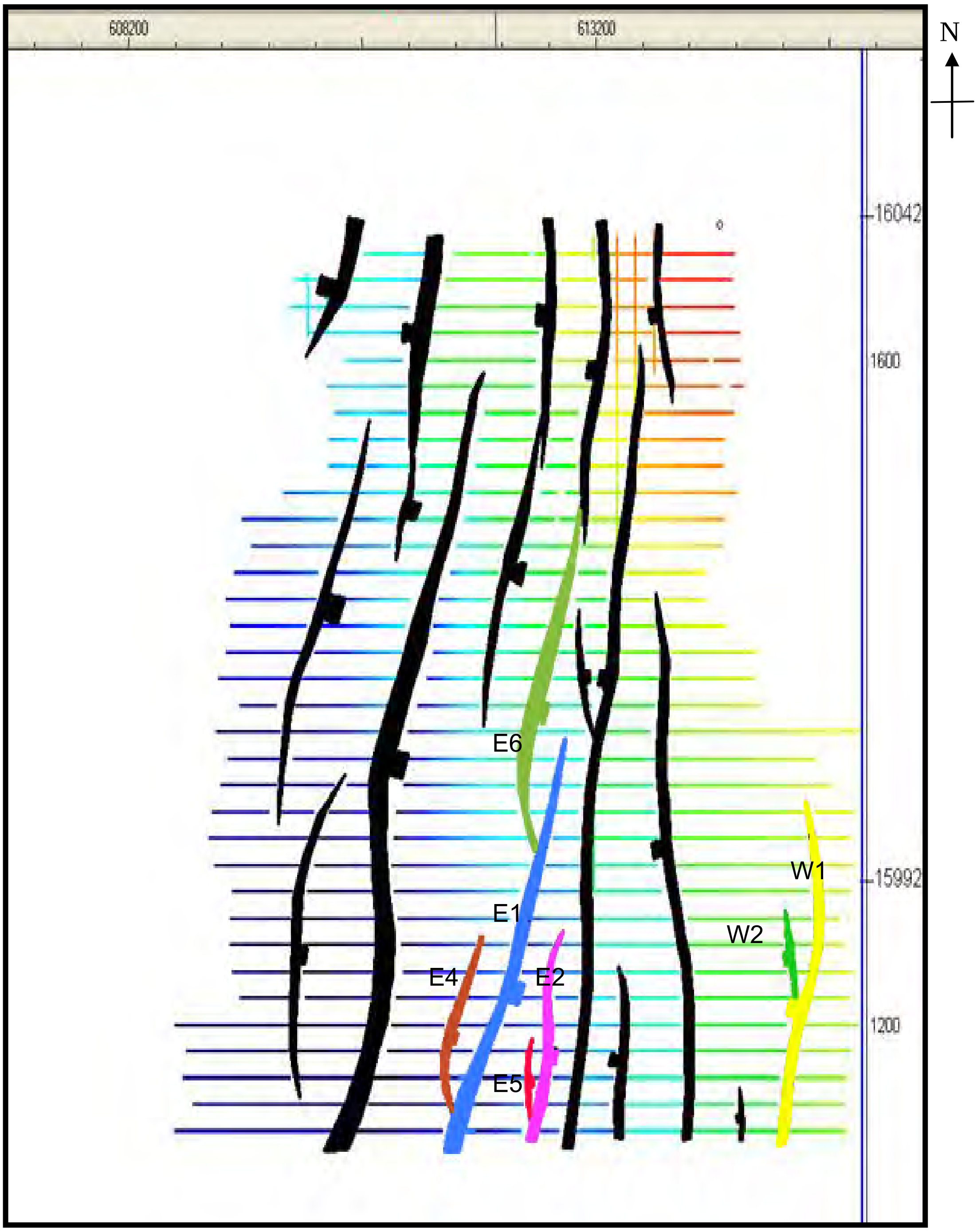


Figure 3.16 Horizon Y interpretation which is interpreted every 16 inlines with displaying fault polygons.

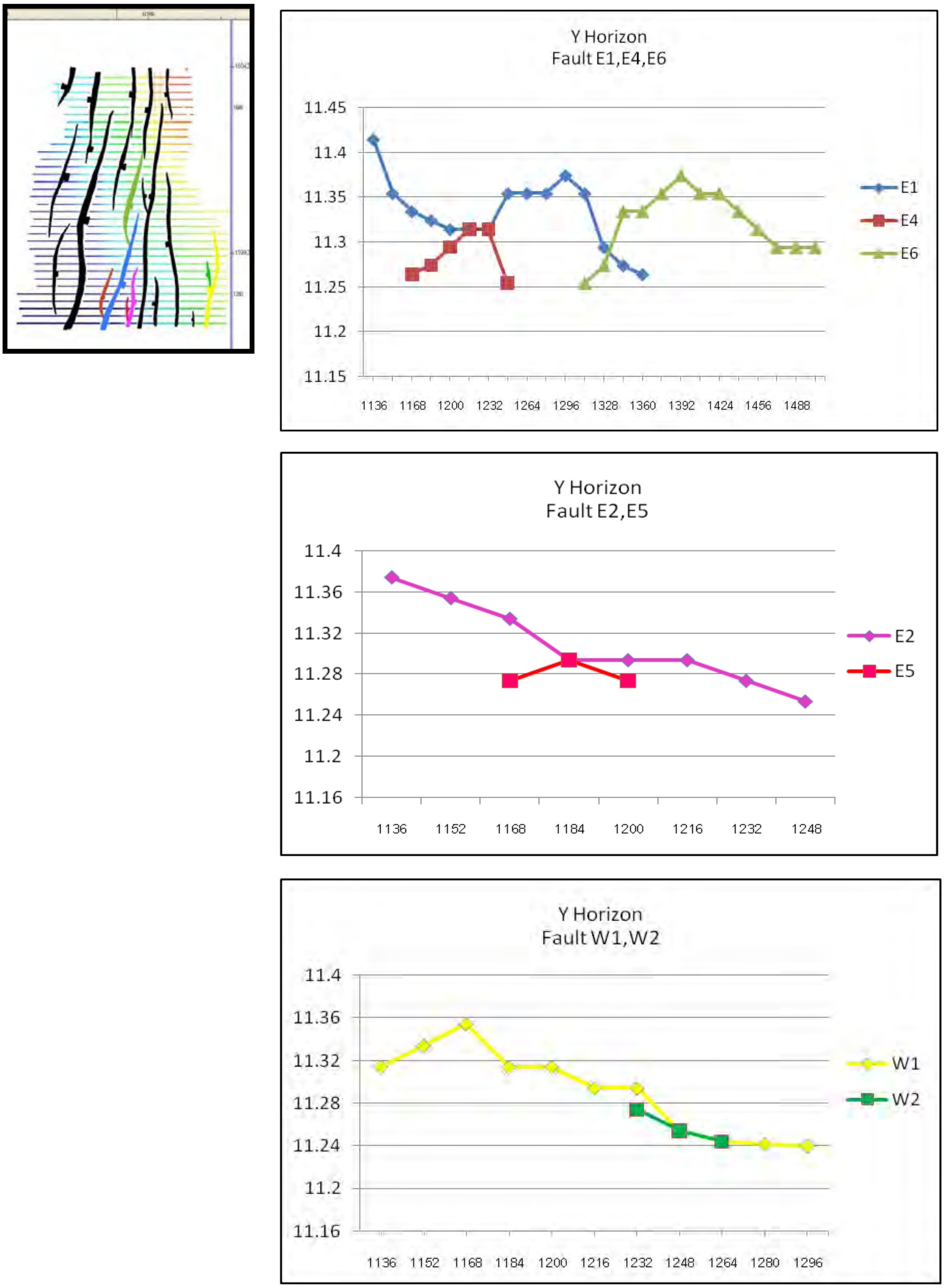


Figure 3.17 Fault throw analysis to check joined faults which are set of faults E1-E4-E6, faults E2-E5 and faults W1-W2. The results of analysis show that all fault sets appear to be joined faults because at one or two points changes throw immediately.

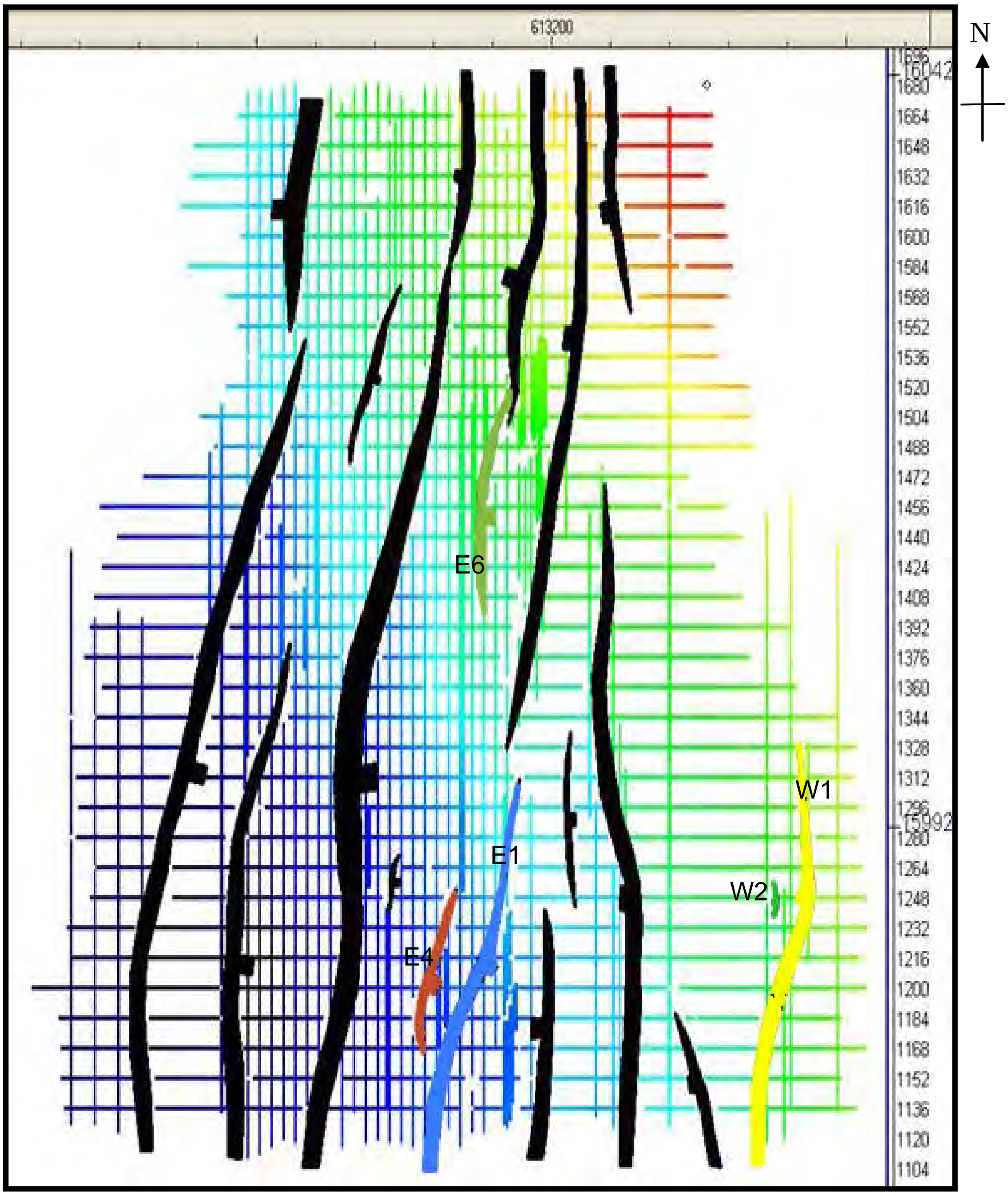


Figure 3.18 Horizon Z interpretation which is interpreted every 16 inlines with displaying fault polygons.

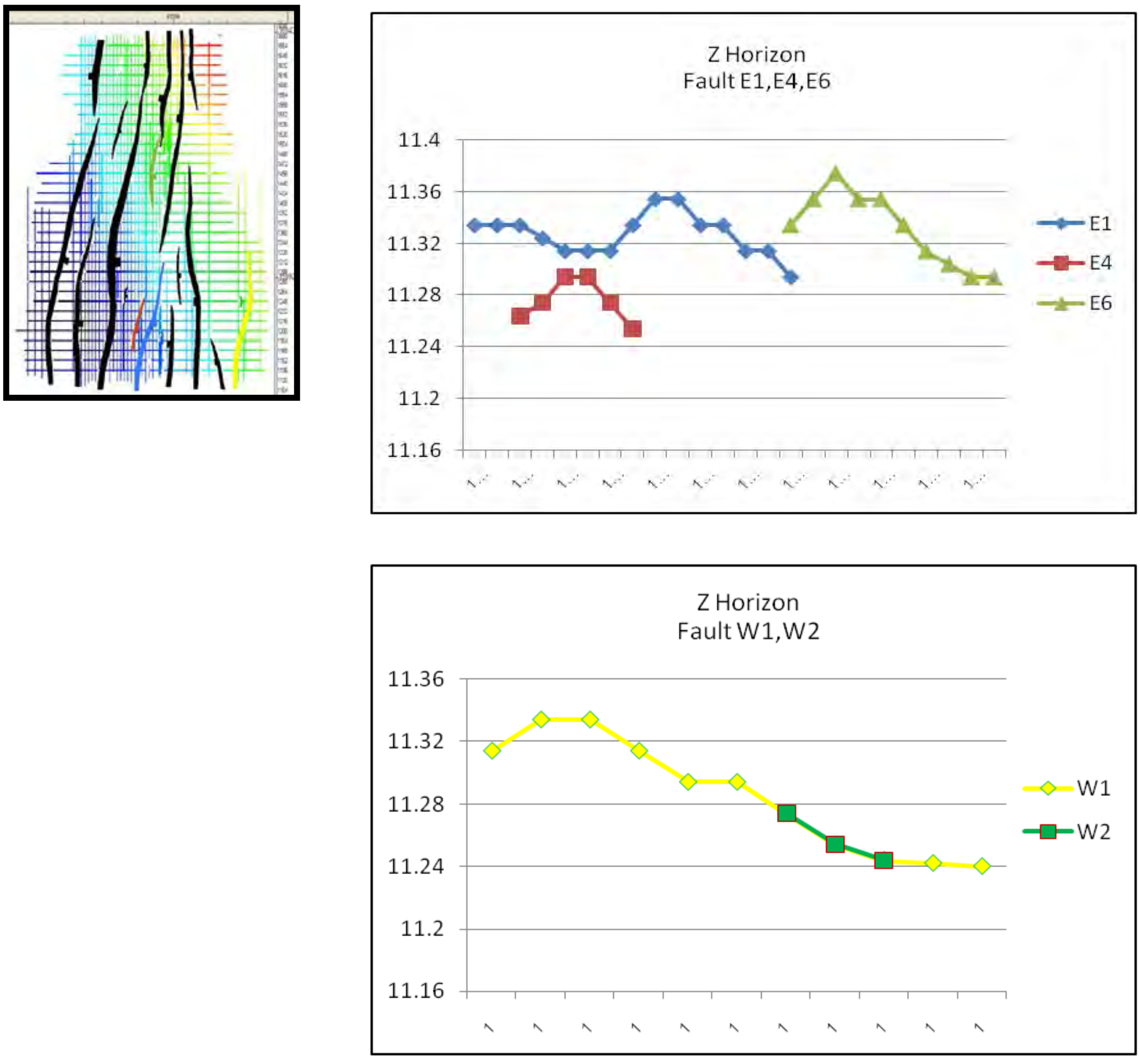


Figure 3.19 Fault throw analysis to check joined faults which are set of faults and faults W1-W2. The results of analysis show that all fault sets appear to be not joined faults because at it doesn’t change throw immediately at any points.

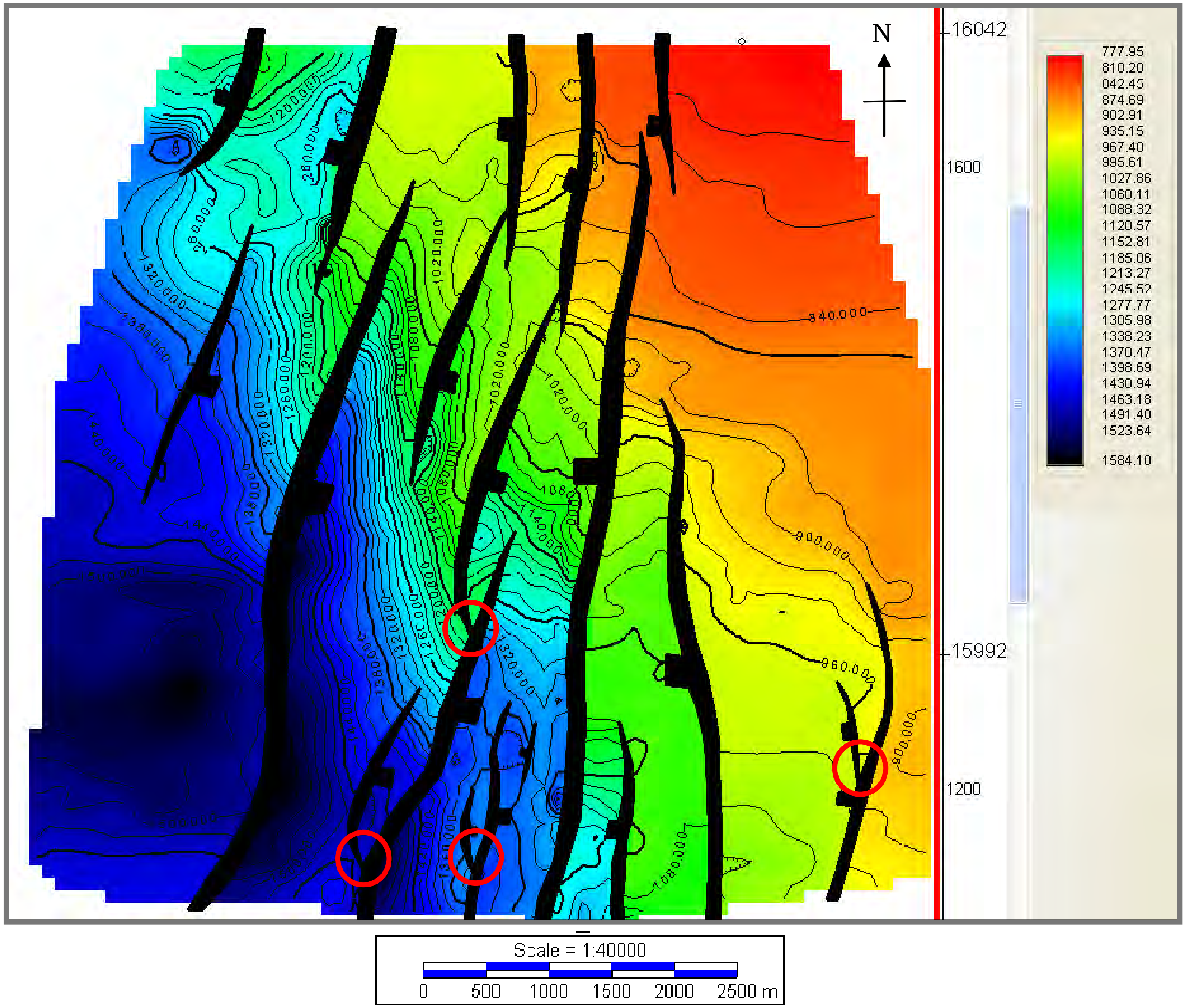


Figure 3.20 Structural map of horizon X displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be joined faults and structural closures.

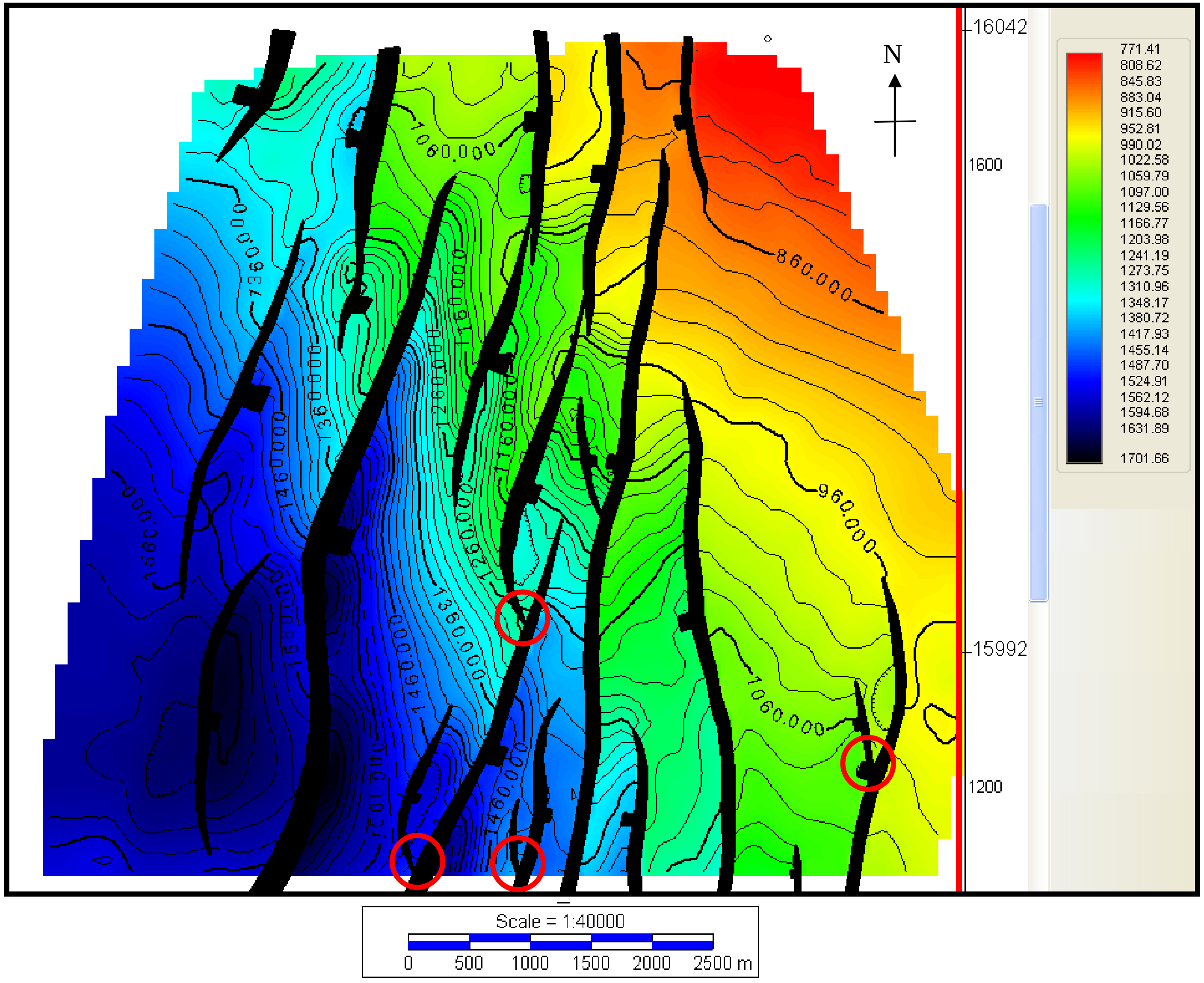


Figure 3.21 Structural map of horizon Y displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be joined faults and structural closures.

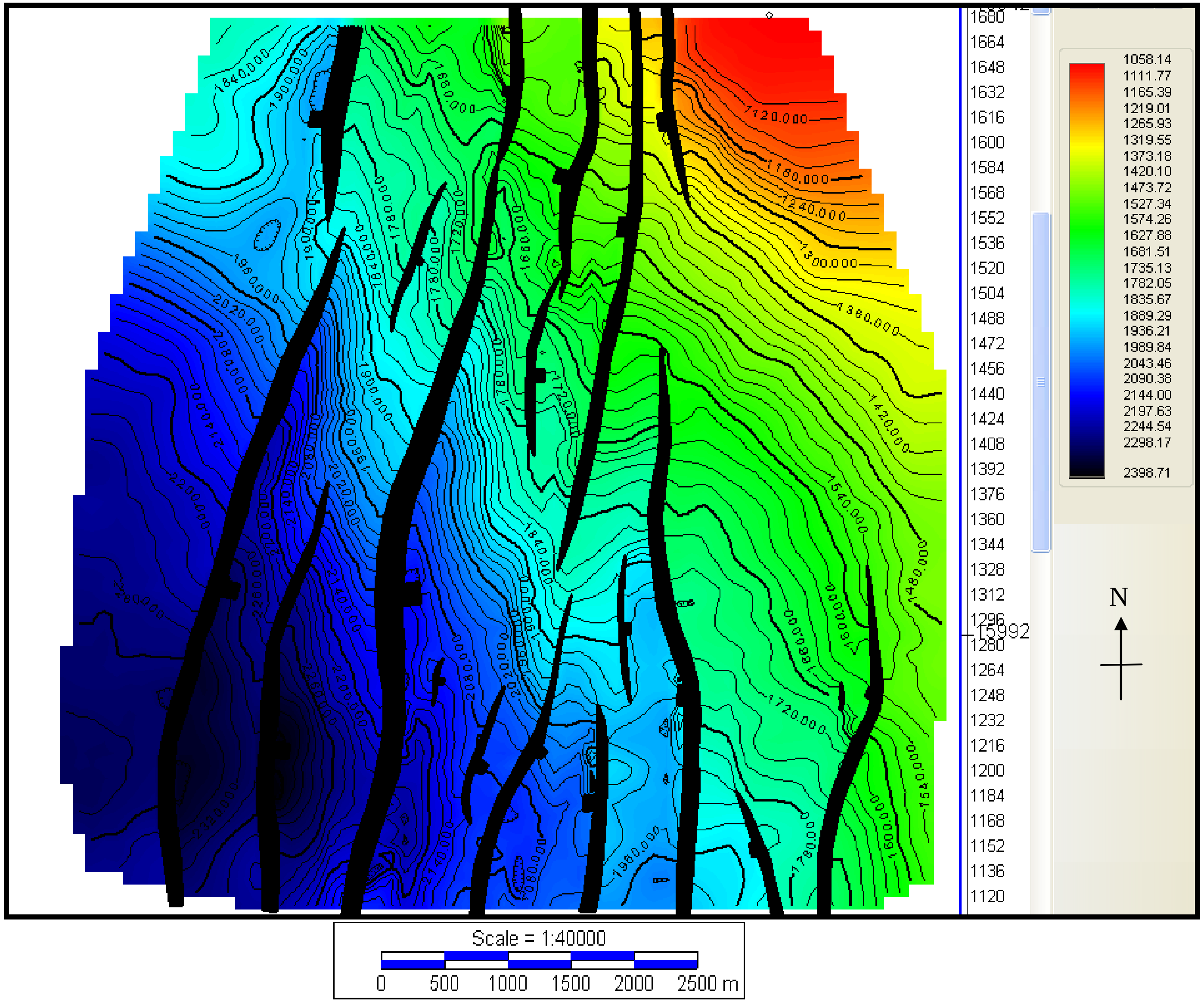


Figure 3.22 Structural map of horizon Z displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be joined faults and structural closures.

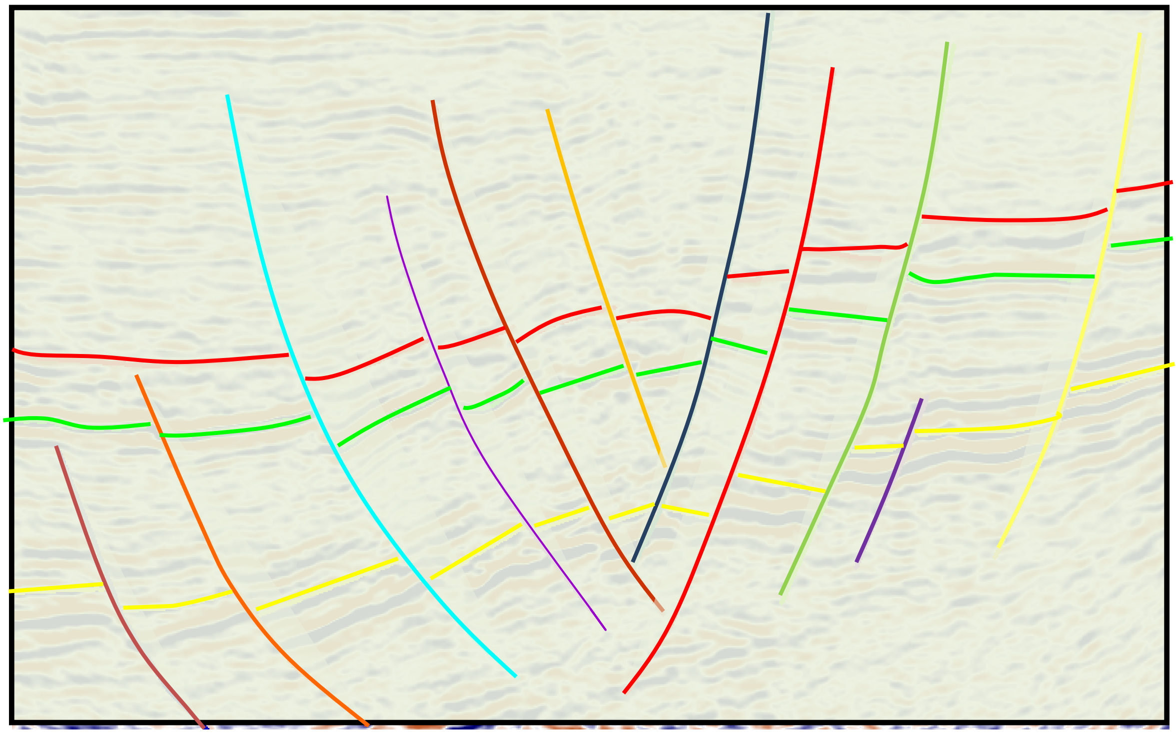


Figure 3.23 Faults schematic of seismic line no.1200 which is in the southern part.

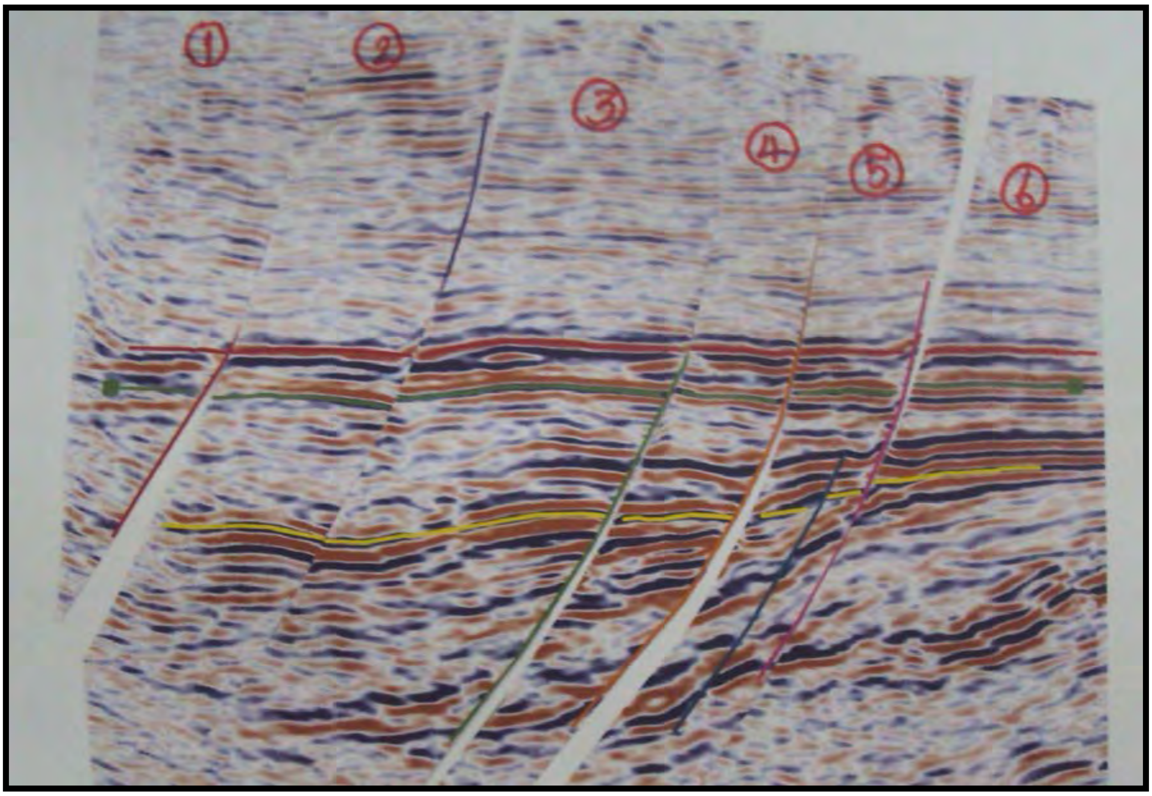


Figure 3.24 Flattened horizon for reconstruction model of seismic section line no.1632 which is in the northern part.

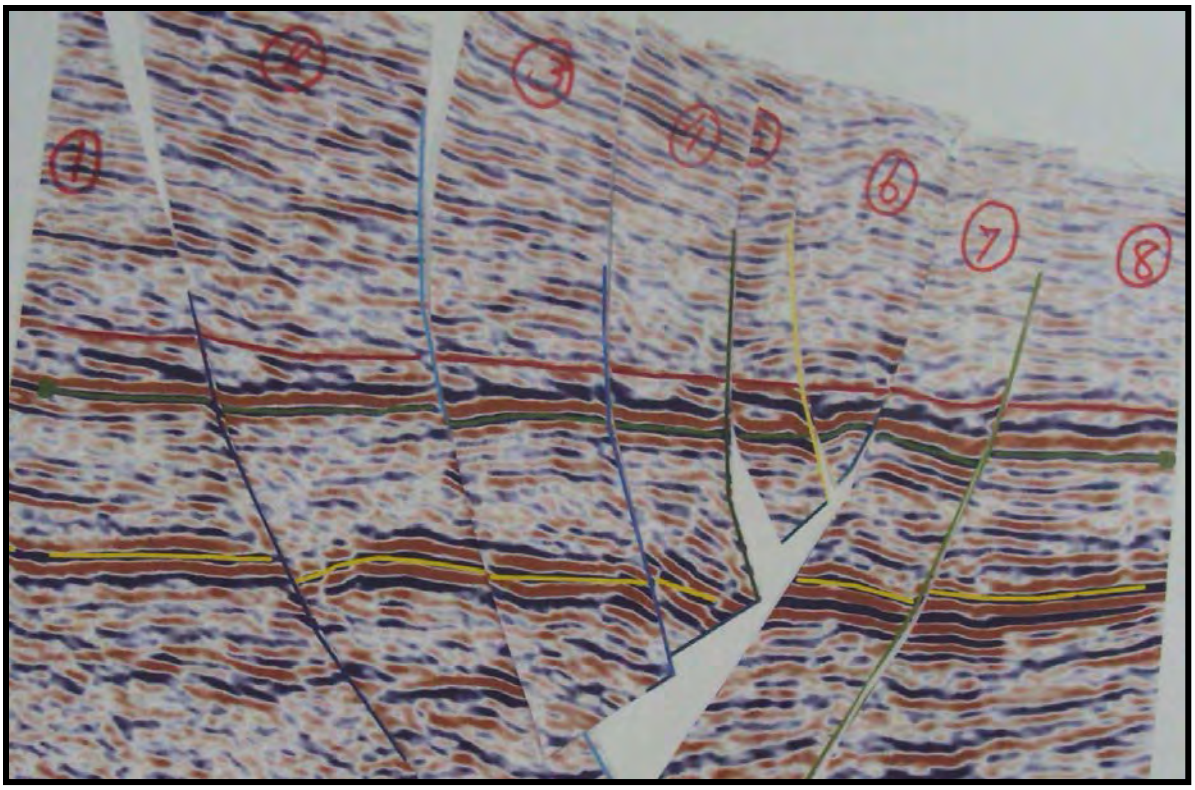


Figure 3.25 Flattened horizon for reconstruction model of seismic section line no.1408 which is in the central part.

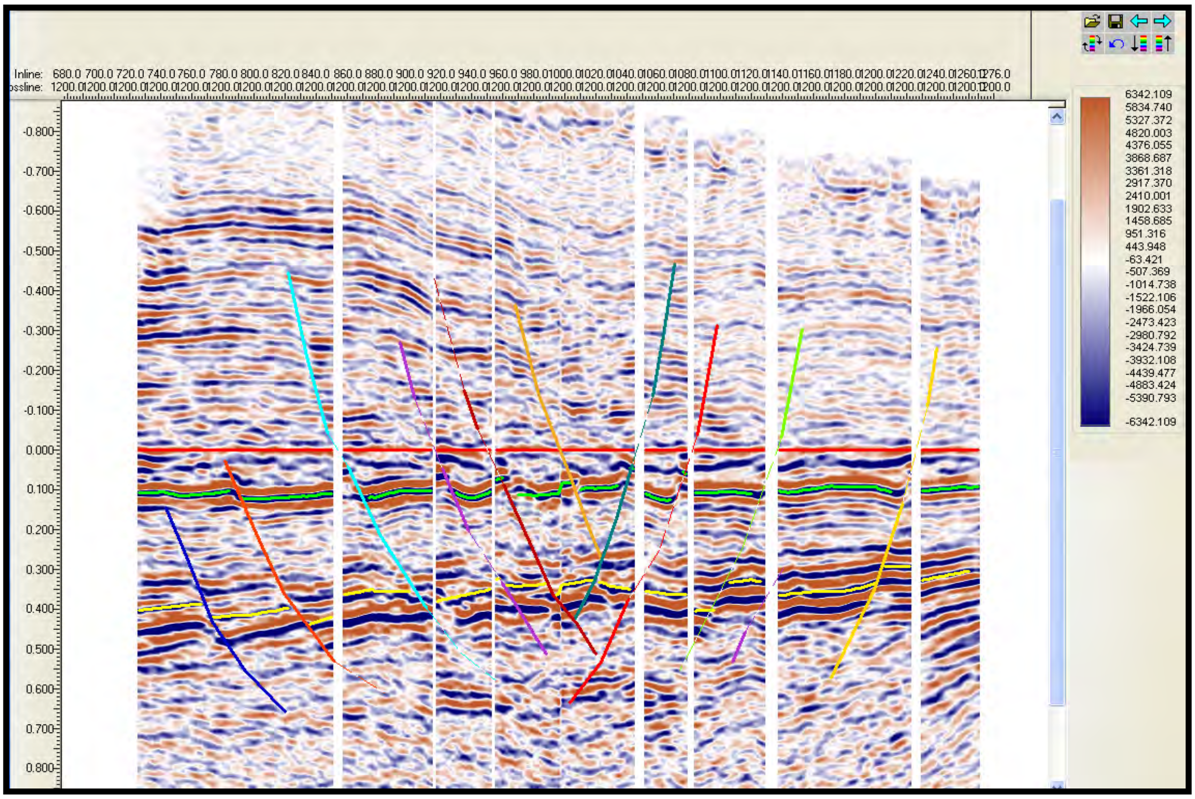


Figure 3.26 Flattened horizon for reconstruction model (by Kingdom software) of seismic section line no. 1200 which is in the southern part.

CHAPTER 4

4.1 Discussion

4.2 Conclusion

Chapter 4

4.1 Discussion

This project aims to study structural in Ban Phai Khwang area Suphan Buri province which covered by 3D seismic survey. From results, there are 3 structural maps and fault throw analysis of horizon X, Y and Z. The interpretation of 3D seismic data was done within Kingdom software suite in time domain.

There are 4 main topics to discuss for this study as follow:

4.1.1 Structural maps

In previous work (2D seismic interpretation) it shows joined faults more than in this study; this study illustrates 4 points that can be joined faults in structural maps of horizon X and Y. It is because of data which is used in the past it is 2D seismic but in this study uses 3D seismic data so results are more detailed than the past. Joined faults happen when two or more faults end with another. In this area joined faults mostly are in southern west which deeper than northern east because faults can not develop too much in margin area which shallower. From horizon X and Y, fault dipping is likely dominant in east direction more than west direction and major fault trends are in NNE-SSW and minor trends are N-S direction.

4.1.2 Fault throw analysis

The fault interpretation of horizon X and Y indicate that fault E6 and E4 join with E1, fault E5 joins with E2 and fault W2 joins with W1. This is because fault throw of these faults (fault E6, E2 and W1) increase immediately. This changing is from forces that receive from faults join so when forces increase fault throw increase too. The different of fault movement trend can be explained and separated fault evolution. The changing of fault throw can be used to define these joined faults.

4.1.3 Reconstruction model

Reconstruction model which are flattened horizon X and Z (Figure 4.1) show that sediments in horizon X and Z did not deposited at the same time and may has tectonic or faults activation more than one time because when horizon X is flattened horizon Z is not flattened too. If these horizons deposited at the same time and didn't have any tectonic event occurred before from stratigraphic principle these horizons would be parallel in horizontal plain. In contrast, horizon X and Z are not parallel. It shows that when horizon Z deposited already faults were happened in this area from tectonic event. After many years ago horizon X deposited on horizon Z having faults already and then these faults reactivated into X horizon. Faults reactivation might occur from sedimentary loaded because of increasing of weight rock. So fault reactivated more than one time if consider Y horizon as well.

4.1.4 Structural closures

Structural closure is a closed structure where probably can trap petroleum. In this study, from structural maps can indicates structural closures in horizon X, Y and Z by consideration faults, horizons which are reservoir and contour lines in structural maps. Criteria for consideration where can be structural closures is area where has a higher structure than around and contour lines are curved into faults like closed structure (Figure 4.2, Figure 4.3, Figure 4.4). So this study can indicate some structural closures the most in northern and central part because it is high area and easy way for migration of petroleum.

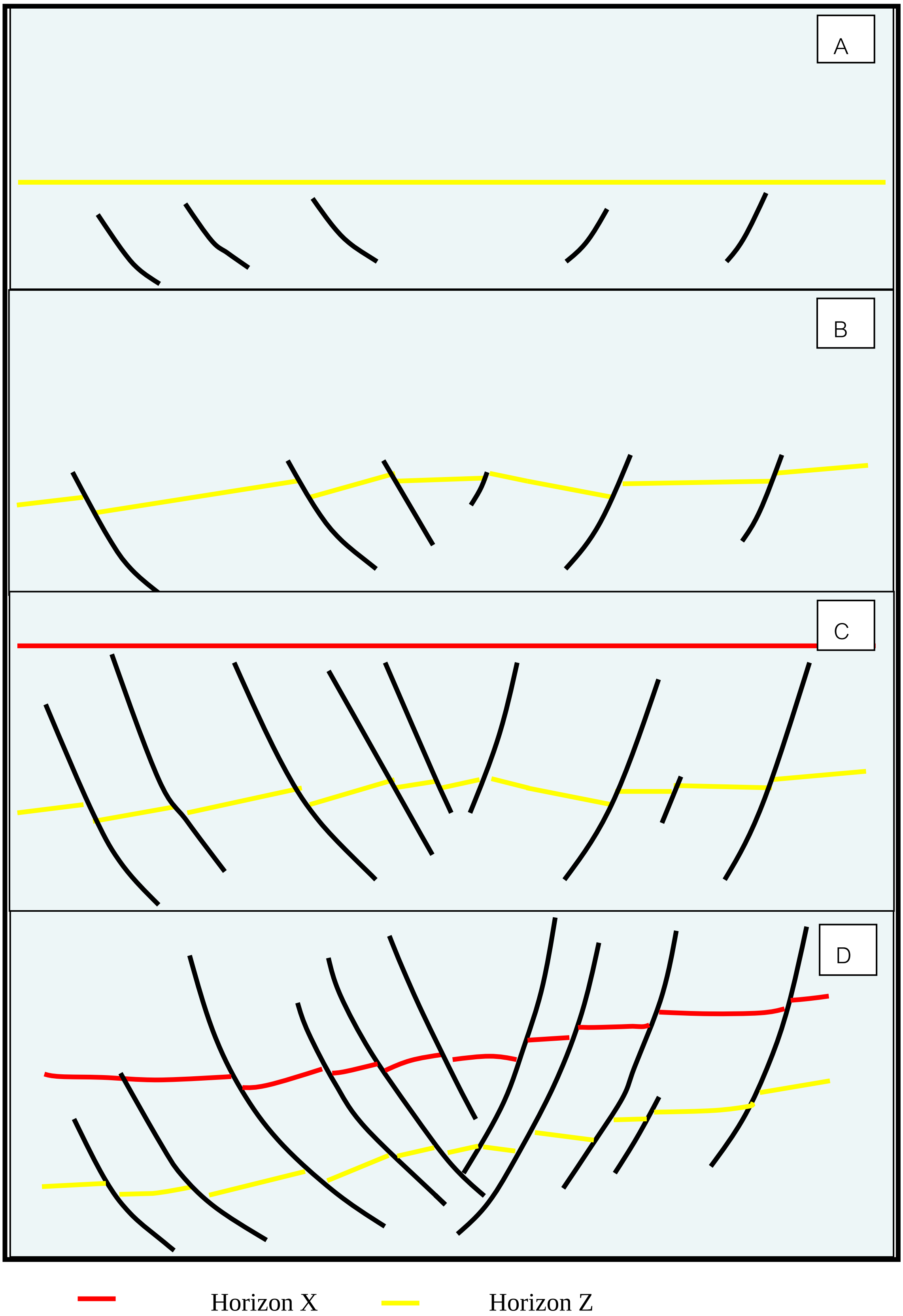


Figure 4.1 Restoration model of horizon X and horizon Z. (A) Flattened horizon Z (B) Occurring of faults in horizon Z (C) Faults continued to activate then horizon X deposited (D) Faults reactivated into horizon X.

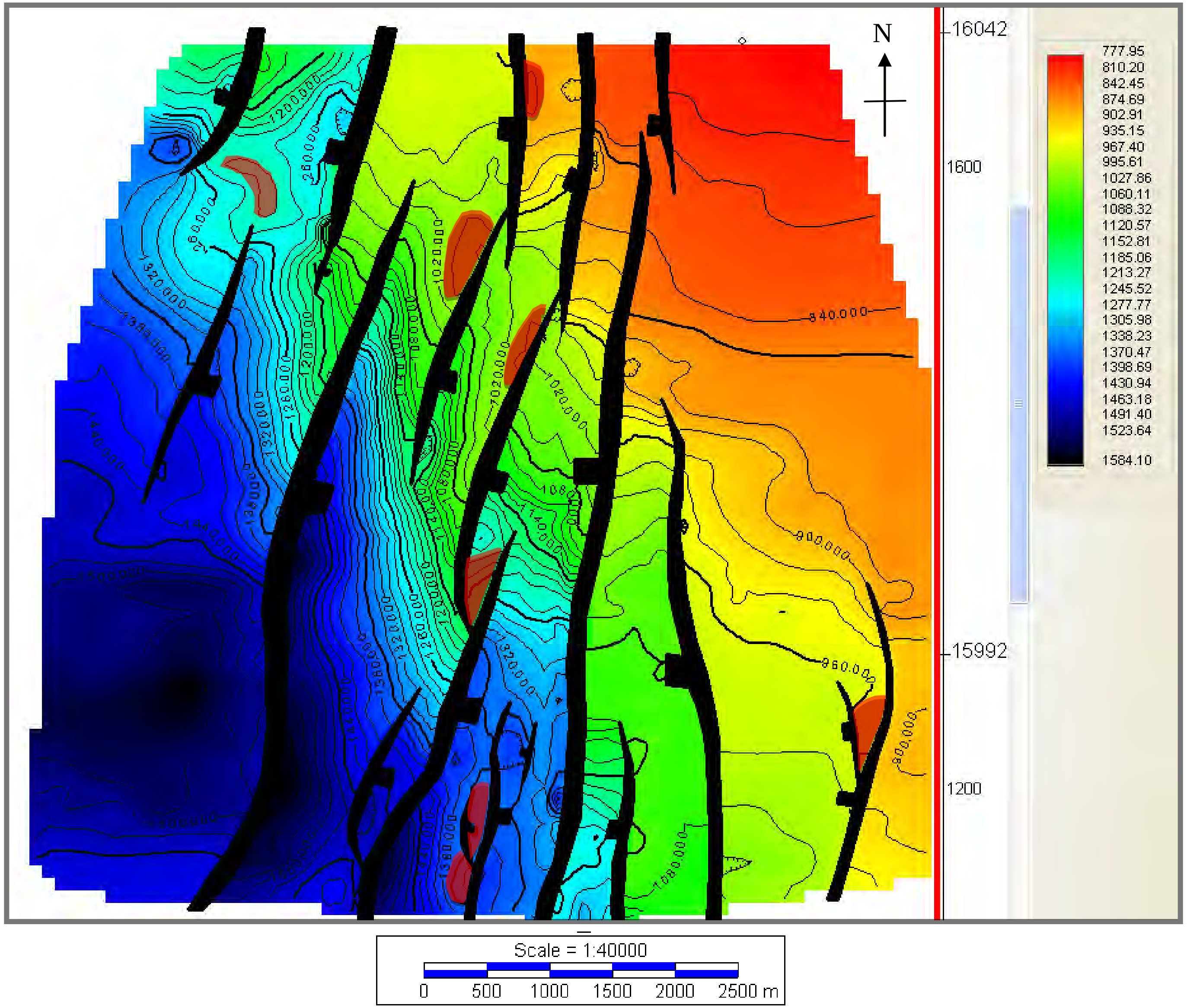


Figure 4.2 Structural map of horizon X displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be structural closures by red color sign.

Structural closures

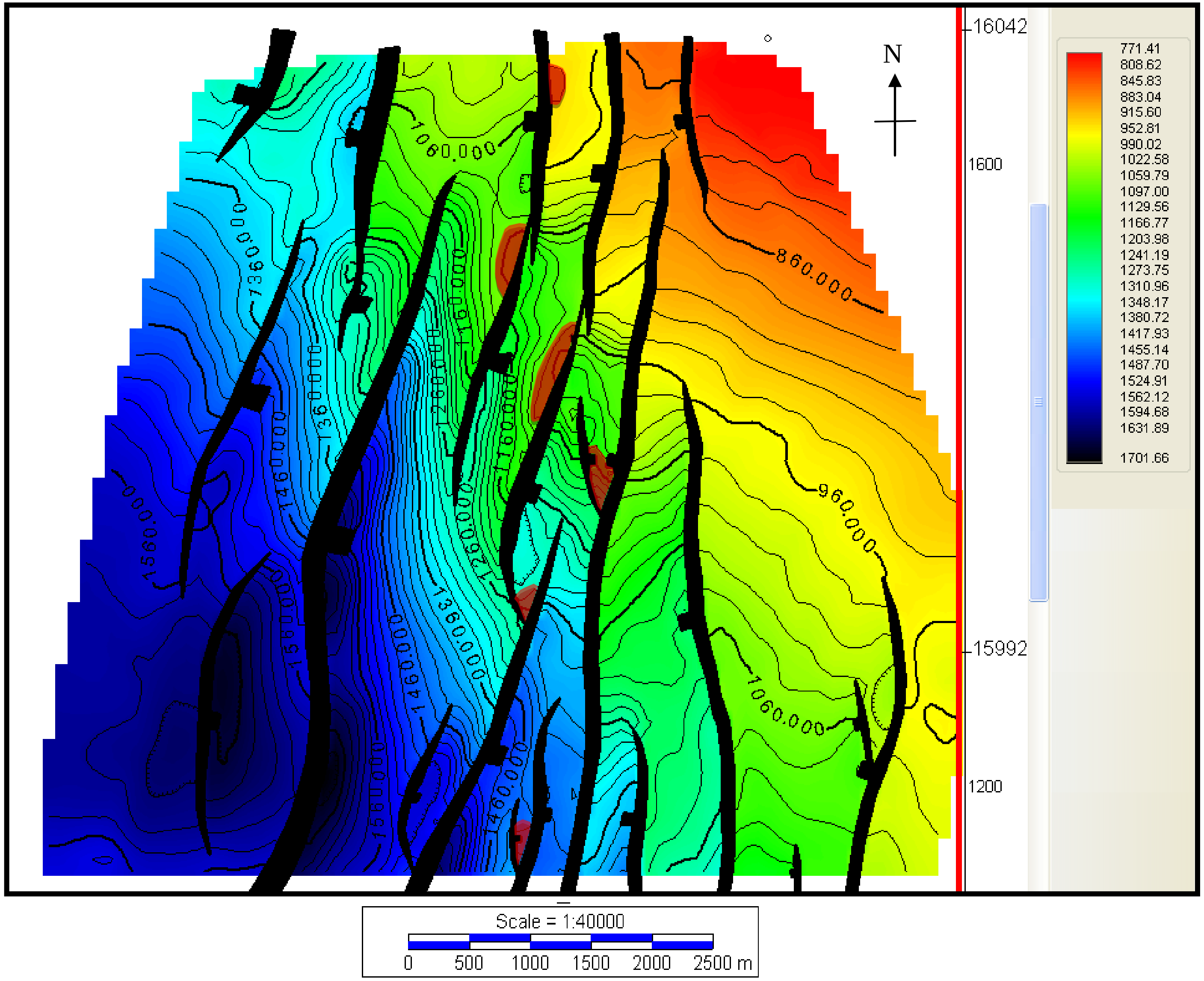


Figure 4.3 Structural map of horizon Y displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be structural closures by red color sign.

Structural closures

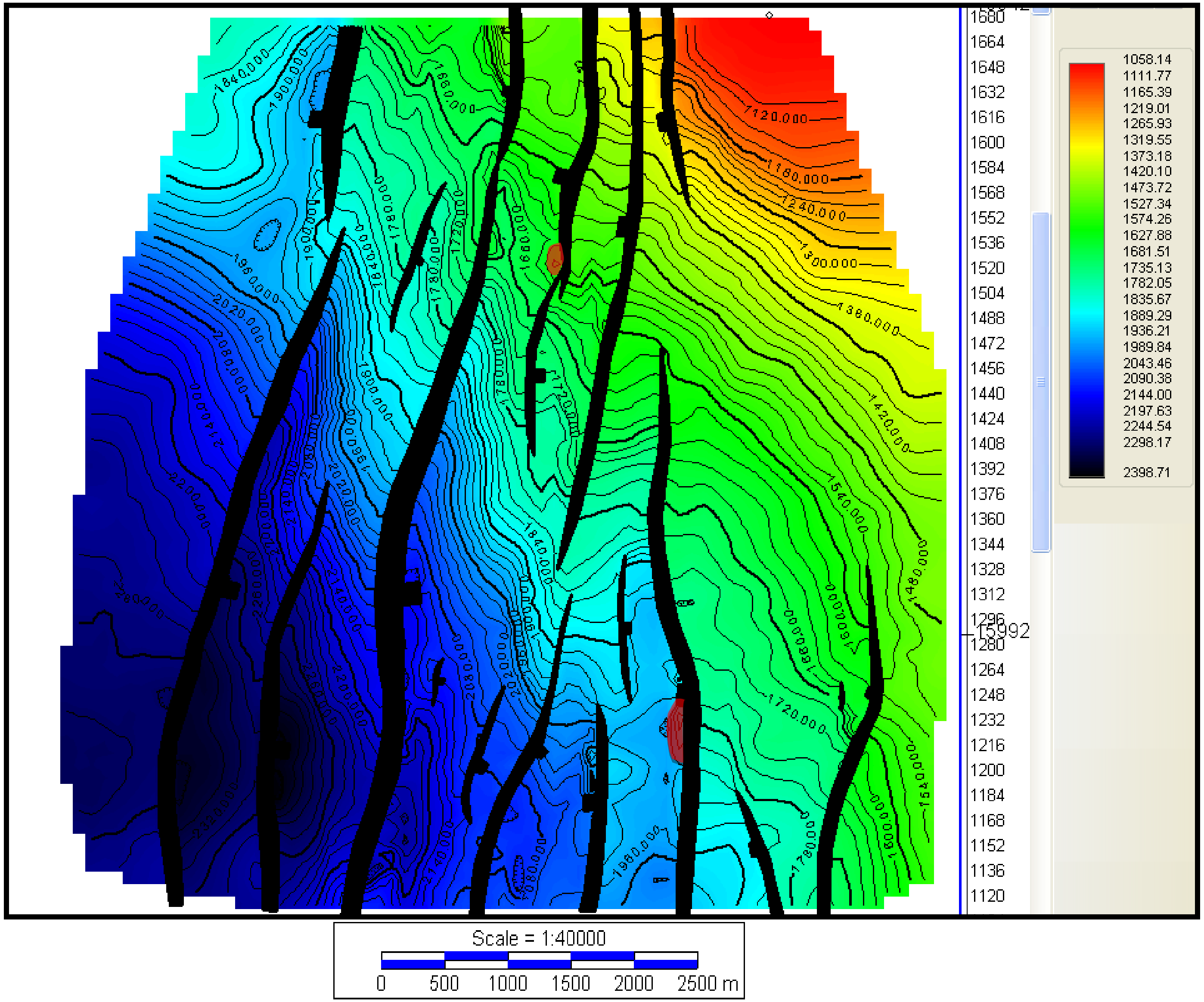


Figure 4.4 Structural map of horizon Z displaying fault polygons shows in the NE part is shallow area and SW part is deeper area. From structural map it can indicate where can be structural closures by red color sign.

Structural closures

4.2 Conclusion

From discussion which is mentioned above it can conclude for 2 main points of this study as follow:

4.2.1 Structural geology: joined faults

From seismic interpretation in this study area in northern part the most faults dipping are west direction while central and southern part are east direction. Regional structural geology shows this basin appears to be a half graben but in specific area such as study area: Ban Phai Khwang area found half graben in northern part and full-graben from central to southern part. This area is normal faults which are both synthetic and antithetic faults. Structural maps and fault throw analysis of horizon X, Y and Z demonstrate that there are 4 joined faults mostly in southern and central part of area in horizon X and Y and some joined fault can be structural closures. Moreover sedimentary deposition of horizon X, Y and Z did not deposit at the same time and there are fault reactivations in this study area because of sedimentary loaded.

4.2.2 Structural closures

This study can indicate structural closures in horizon X, Y and Z as follow:

- 8 closures in horizon X
- 6 closures in horizon Y
- 2 closures in horizon Z

In this area there are 2 types of structural closures which are 3-way dip closures and 4-way dip closure.

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