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GEOLOGY OF MUKIM RUSILA, MARANG, TERENGGANU AND SEISMIC INTERPRETATION OF KAPAL FIELD, TERENGGANU OFFSHORE

by

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A report submitted in fulfilment of the requirement for the degree of Bachelor of Applied Science (Geoscience) with Honours

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APPROVAL

"I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Applied Science (Geoscience) with Honours"

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DECLARATION

I declare that this thesis entitled "**GEOLOGY OF MUKIM RUSILA, MARANG AND SEISMIC INTERPRETATION OF KAPAL FIELD, TERENGGANU OFFSHORE**" is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree

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Geology of Mukim Rusila, Marang And Seismic Interpretation of Kapal Field of Terengganu Offshore

ABSTRACT

Mukim Rusila located at Marang, Terengganu where it has been long known as meta-sediment area. The objectives of the study at this area are to update a geological map with scale 5×5 km^2. This study involves several analyses which included petrography, stratigraphy, geomorphology and structural geology. Geological mapping had been done to collect the related data and the sample had been taken for petrography analysis. The analysis supported by the old research paper and journal. The study area consists of 3 lithology unit which is alluvium, mylonite and Charu/ Sungai Perlis Bed. In Charu/ Sungai Perlis Bed it consists lithology of phyllite and schist. The structural geology that been found are fault, vein and chevron fold. It is recommended that extensive study of the area that focus on structural geology and mylonite unit only since it is one of the new finding within this research. While for the Kapal Field, a part of Malay Basin, located offshore Terengganu (Malaysia). It has been known as a sediment area with a hydrocarbon reserve. So far, the seismic sequence has become focus of extensive and the main target of hydrocarbon exploration in this area. The detailed stratigraphy study and structural study have not been studied yet for Kapal field and it is recommended for the next research. The identification of six seismic section across the study area by using 3-D data has been conducted. Four primary reflectors have been recognised as sequence boundaries and each sequence contains some seismic facies unit which were determined based on seismic parameters. This study area can be said that have a potential hydrocarbon based on the structural that have been found within the study area such as faults and anticline structure.

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Geologi Kawasan Mukim Rusila, Marang, Terengganu Dan Tafsiran Seismos Di Wilayah Kapal, Lepas Pantai Terengganu

ABSTRAK

Mukim Rusila terletak di dalam daerah Marang, Terengganu, di mana Kawasan tersebut terkenal dengan kawasan batuan meta-sedimen. Objektif kajian ini adalah untuk mengemaskini peta geologi dengan skala 5 × 5 km^2. Kajian ini menggunakan beberapa cara analisis antaranya ialah petrografi, stratigrafi, geomorfologi dan struktur geologi. Pemetaan geologi telah dilakukan untuk mengambil data-data berkait dan sampel batuan telah diambil untuk analisis petrografi. Analisis yang dijalankan dirujuk melalui kajian-kajian lama dan juga jurnal. Setelah analisis dijalankan, kawasan kajian mengandungi tiga unit litologi batuan yang terdiri daripada aluvium, milonit dan lapisan Charu/ Sungai Perlis. Unit lapisan Charu/ Sungai Perlis terdiri daripada filit dan syis. Struktur geologi yang ditemui antaranya ialah sesar dan lipatan chevron. Setelah kajian selesai di buat, adalah disyorkan bahawa kajian lebih mendalam di dalam kawasan kajian berkenaan struktur geologi dan unit milonit kerana ia merupakan salah satu daripada penemuan baru dalam kajian ini. Beralih kepada wilayah Kapal, ianya sebahagian daripada lembangan Melayu yang terletak di lepas pantai Terengganu (Malaysia). Ianya dikenali dengan kawasan sedimen dengan rizab hidrokarbon. Sehingga kini, jujukan seismos telah menjadi fokus kajian dan juga potensi hidrokarbon di kawasan kajian. Kajian stratigrafi terperinci dan kajian struktur lebih mendalam untuk wilayah Kapal dan ianya disyorkan untuk kajian seterusnya. Pengenalpastian enam seksyen seismos di seluruh kawasan kajian daripada data 3-D telah dijalankan. Empat pemantul utama telah dikenal pasti sebagai sempadan jujukan dan setiap jujukan mengandungi beberapa unit fasies seismos yang ditentukan berdasarkan parameter-parameter seismos. Kawasan kajian ini boleh dikatakan mempunyai potensi hidrokarbon berdasarkan struktur geologi yang dijumpai antaranya ialah sesar dan lipatan.

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LIST OF ABBREVIATIONS

CL	Crossline
GIS	Geospatial Information System
GPS	Global Positioning System
HCL	Hydrochloric acid
HST	Highstand System Tract
IL	Inline
LST	Lowstand System Tract
mfs	Marine-flooding Surface
MFS	Maximum Flooding Surface
PETRONAS	Petroliam Nasional Berhad
PPL	Plane Polarized Light
TST	Transgressive System Tract
T-Z	Time-depth
UMK	Universiti Malaysia Kelantan
XPL	Cross Polarized Light

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CHAPTER 1

INTRODUCTION

1.1 Research Background

Geophysics is the study which involves the part of the earth that cannot be seen from naked eyes. It is the study that measures the earth physical properties by using the right equipment. In general, geophysics is the measurement of the physical properties under the earth's surface. Reflection seismology has a major role in the world of hydrocarbon exploration. Reflection seismology involves using the elastic wave that being generated for detecting the deposits of hydrocarbon, water, ore and also be applied to obtain information for geology engineering. Data that is produced from seismic survey will be used together with other geophysics data including the well log data and others geological data to produce information of the structure and distribution of rock types that located below the earth's surface. The development of recent technology will help to obtain data and also to process data. This is one of the factors that make the seismic method important in producing seismic cross-section.

Seismic cross-section obtained from each exploration is an image below the surface of the earth. It includes the interpretation of important geological information about structures and stratigraphy, sub-surface features. According to Dony (2010), the interpretation of the earth's sub-surface can be identified using cross-sectional of seismic

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that obtaining because this cross-section contains images that showing geological structures of subsurface such as anticline, syncline, faults, and others geological features. Seismic data also can be used to identify the stratigraphy of rocks. Mitchum et all. (1977) as the first group said that the best quality of exploration seismic data can provide details information about structures with the bedding information.

The study of sedimentation and stratigraphy using the interpretation of seismic data calls seismic (Mitchum et al. 1977). Pattern of strata that come that collected by form and termination of the reflection series will be used to identify and correlate the deposition sequences. It is also used to interpret the depositional environment and estimating the lithofacies units. The seismic cross-section can be divided into packages or series of reflections that are aligned and separated by bounding surface. The disconformity is identified by analysing systematic endpoints of a reflection. Reflective packages between inconsistencies or known as strata endings that are divided into truncation, toplap, onlap, and downlap. The major of depositional sequences usually closely related to the regional and global cycle of sea level.

Seismic sequences comprising information on sedimentation, sea level changes and age estimates are identified by facies seismic analysis. Each seismic unit is a seismic reflection group that has characteristics of different parameters in terms of shape, amplitude, continuity, frequency, and velocity. From all the parameters it's can interpret the history of strata, type of lithology and system tracts including Highstand systems tract (HST), Lowstand systems tract (LST), and Transgressive systems tract (TST). The reflection seismic method is a successful technique for detecting sequential sequences other than the use of well-drilling techniques, field outcrops and drill core sampling studies. Since the seismic reflection is a composite of the reflections produced by strata

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that have different elastic properties, the resulting reflection represents the surface of the strata that can also be associated with chronostratigraphic. It is not only be used to determine the rock structure but also be used to determine the position of the sea level at a relative rate, the hydrocarbon boundary, the different rock type boundaries, the lateral rock changes, the stratigraphic traps of hydrocarbon piles, the disconformity boundary and the sediment depositional environment.

The latest seismic data could be used in the interpretation of data that involves the analysis of reflection seismic waves known as seismic attributes. The seismic attribute data is defined as a piece of information obtained from seismic data either through direct measurement or through logic and experience based on reasoning (Adigun and Ayolabi, 2013). Among the examples of seismic attributes that include measuring of the mass, amplitude and frequency. The first attribute produced by corresponds to the complex 1-D trace seismic including envelope amplitude, instantaneous phase, instantaneous frequency and apparent polarity. Others commonly used attributes include coherence, minimum curvature, azimuth, and dip maximum of similarity. According to Adigun and Ayobi (2013), seismic features are part of the method to interpret seismic data qualitatively to facilitate structural and stratigraphic interpretations as well as giving the lithology and the estimates of the content of the substances. In other words, this method can benefit in characterizing the potential hydrocarbon reservoir more efficient.

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1.2 Study Area

1.2.1 Location

The study area divided into which is Mukim Rusila, Marang, Terengganu and Terengganu offshore. The first study area located at Mukim Rusila, Marang, Terengganu with coordinate 5° 15' 8.69" N and 103° 8' 11.92" E (A), 5°15' 8.69" N and 103° 10' 56.5" E (B), 5° 12' 25.6" N and 103° 10' 56.5" E (C), 5° 12' 25.6" N and 103° 8' 11.92" E (D). All four points will cover study area about 25 $km^{2.}$ The study area dimension is about 5×5 km. Figure 1.1 shows the location of the study area from Google Earth. Figure 1.2 shows the base map of the study area that contains coordinates, contour, and road connection. Before 1985, Marang district consist four Mukim only which is Rusila, Kerengga Island, Merchang and Jernung with population 54 996 person. On 1 January 1985, Marang district has been enlarged with add on 2 new Mukim which is Bukit Payong and Alur Limbat which before this under the management of Kuala Terengganu district. Total area in the Marang district until today is 666.54 km^2.

Terengganu offshore is located in the Malay basin. It is bordered by Terengganu coast. While the Malay basin is bordered by the east coast of Peninsular Malaysia in south-eastern Thailand and between Peninsular Malaysia and Vietnam. The basin extends to the north-west and merged with the Pattani Trench in Thailand and also stretches from the northwest - southeast in the Natuna West Basin, Indonesia. The dimension area of the Malay basin is estimate 100 000 km^2. The study area located in the Terengganu offshore, Malay Basin or more specifically in Kapal field. Kapal field located at the west of Malay Basin.

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Figure 1.1: The location of the study area via Google Earth

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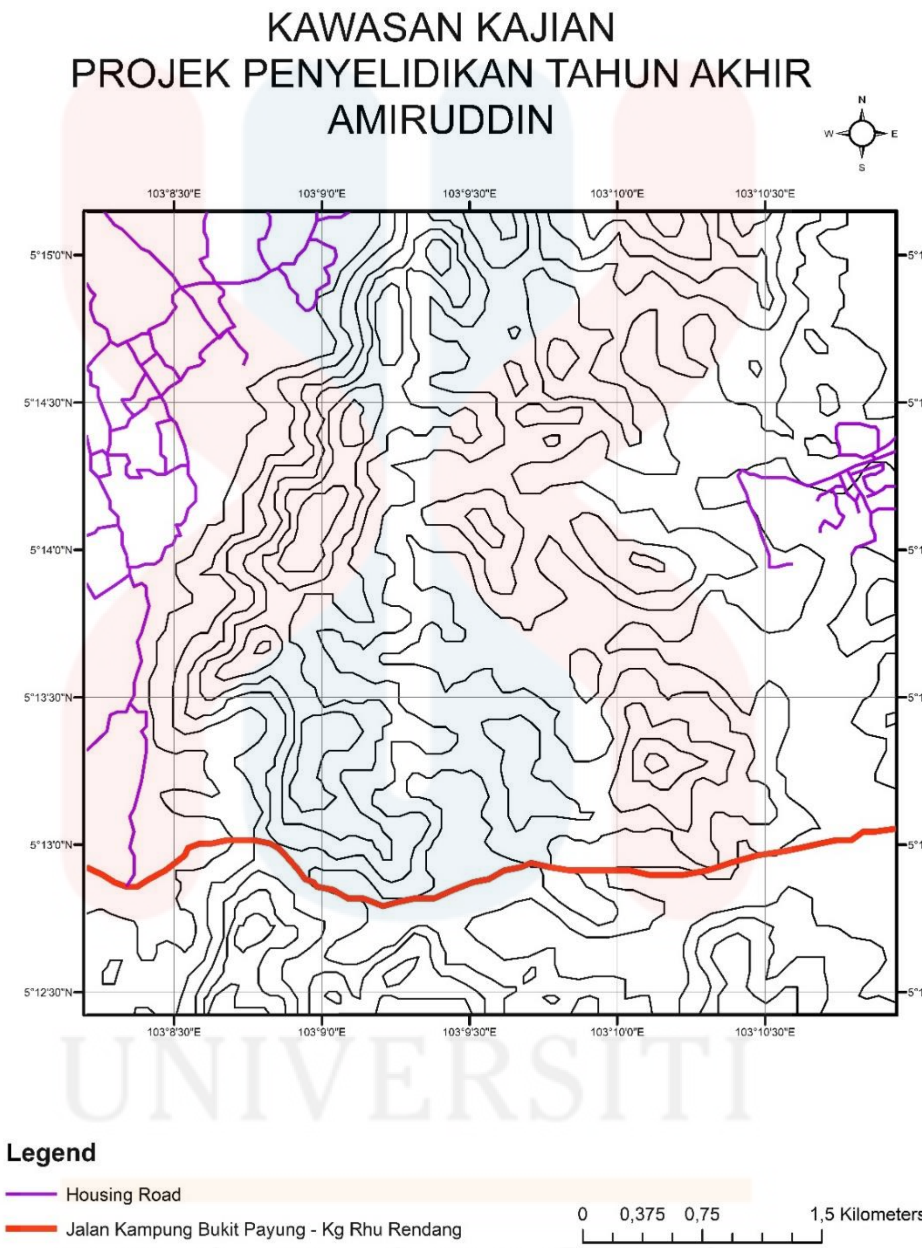

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Figure 1.2: The base map of the study area.

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1.2.2 Accessibility

There are a few roads that can connected to the study area. The main highway which are Laluan Persekutuan 3 that connected the city of Marang and Kuala Terengganu. Next, there are a lot of village road, housing area road and unpaved road that can be accessed to the study area. All the road can be accessed either by car, motorcycle or even by walking. It easier for the researcher to access the study area in order to conduct the research.

1.2.3 Demography

The study of human population in certain area is called demography it is included births, deaths and migration of human. Demography is very useful for understanding the social economic problems. At the same time the demography enables people to take solution regarding certain problems. Stated by Department of Statistics Malaysia it estimated the total population of Terengganu in 2010 was 1 050 000 with population density of 81 person per square kilometres. Terengganu is still considered as sparsely populated. The population of Marang district itself 99 000 people with 665 km^2 land that covered the district. Marang have 1.4% rate of growth.

1.2.4 Land Use

Marang can be categorised as development city. It can be saw by there is still have an ongoing development project around this area. In this district, consist university and college, school, and kindergarten. In addition, there a lot of factory and shop.

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Marang consist up to 40% of the Forest area. While for the agricultures area it up to 20% area in the Marang district. Closer in the study area, 50% of the study area located in the forest and agriculture area.

1.2.5 Social Economic

Terengganu gross domestic product is very dependent on the services sector, which it contributed up to 54% to the state gross domestic product then followed by manufacturing which is 33%. One of the important components to the Terengganu economy are agriculture which contributed 9% to the state gross domestic product. In Marang, the percentage distribution of workers by main industrial groups which leads by services (66.9%) followed by urban (21.1%), agriculture and fishery (17%) and the least one is manufacturing with 16.1%.

1.3 Problem Statement

The study area located in the Malay Basin is a potential area of hydrocarbon trap. In this study, the geological interpretation of the Terengganu offshore is known. This study is aimed to obtain a potentially reservoir area containing hydrocarbons. In addition, the correlation of the findings can be correlate with the well log data within the study area radius. Further studies have to be done to correlate this data to help facilitate regional interpretation. In addition, additional wells information will help further identification of potential rocks as a hydrocarbon trap in the study area. Next, the

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existing of the geological map at Kuala Terengganu area need an update to see the changes of the geological features.

1.4 Objectives

The main objectives of the study are:

i. To update a geological map of the Mukim Rusila, Marang.

ii. To identify hydrocarbon potential of Kapal Field, Terengganu offshore.

1.5 Methodologies and Scope of Study

The study area is divided into two for this research. The study of the geology of Mukim Rusila, Marang, Terengganu will be carried out in the area of Mukim Rusila within 25km^2 is the total area for this research. Geological mapping will be conduct in this study area to have an overlook the geological features of the study area.

Next, focusing on seismic interpretation of Terengganu offshore. It will study the geological features of the Terengganu offshore. Data of the well log will be tying with the seismic well log data for the study of seismic stratigraphy. The study concept consists a few types of analysis technique that being used and refer with all the theory by Sheriff (1980) which is seismic sequence analysis, facies seismic analysis and the characteristics of seismic reflection analysis. Next, analyse of seismic data to identify any potential of reservoir of hydrocarbon at the study area by look from the structure of the study area, facies analysis and depositional environment of the study area. The data provided by Petroliam Nasional Berhad (PETRONAS) in the form of SEG-Y data and

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others type of data that will be provided. Next, the data will be analysed by using KINGDOM software.

1.6 Significance of Study

This study will develop the latest geological database of the study area with an updated geological aspect of study. For example, the streets and the drainage of the study area which are absent in recent maps will be update. All the information will be gathered a will produced a geological map. The map is one of the needed information for geologist, government etc to explore, protect and extract the natural resources at the study area.

Next, the analyse result from seismic will help the government to explore the hydrocarbon that may lead to the increasing country economic. In addition, for the researcher it will give them an overview about the methods that being used.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter will discuss about previous research of tectonic evolution which takes place in Southeast Asia and the Sunda Plate and the area of study where it is located at Mukim Rusila, Marang, Terengganu and the offshore Terengganu, Malay basin. This discussion covers general geology and stratigraphic aspects as well as previous studies to provide understanding and visualization of the general geological areas of the study and to be references prior to interpret seismic data. The seismic data used for this study is secondary data taken from PETRONAS database and will be analysed and interpreted using computer software Kingdom 2018 version. The report of well logs obtained can help to give a general overview of geological conditions and existing hydrocarbon sources. This chapter is very important as a starting point in ensuring that the workings carried out can be done accurately and smoothly.

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2.2 Tectonic History and Evolution of Southeast Asia

2.2.1 Tectonic Element

Southeast Asia is one of the regions that have very complex geological regions comprising a combination of multiple micro continents that due to the collision of several major tectonic plates since 500 million years ago. It is composed by several highly active tectonic plates such as the Pacific Plate at the east, Northeast of Philippine Plate, north of Eurasian Plate and southern part of India-Australia Plate. The transitions of continental crusts generally underlie the shallow ocean with a depth of water ranging from less than 200m where the oceanic crust is deeper. The Southeast Asia mega tectonic can be described clearly by the tectonic plate, interaction between the lithosphere flash that being known as plate. Southeast Asia is surrounded by three main lithosphere plates, which is India-Australia plate, Pacific Plate and Philippine Sea. This concentrates toward Eurasia plate with relative velocity about 6-8 cm per year. The boundary between these plates is an active subduction zone that surrounds the region almost continuously from the Arctic Ryukyu in the northeast, through Philippines, Java and Sumatra, to Myanmar at the northwest. The movement of the India-Australia plate towards the north at the boundary of the continental plates is extremely oblong throughout Sumatra's arc. This can cause a strong shear component to change the shape of the subduction as a result of the deformation process (McCaffrey 1996; Malod and Kemal 1996).

South East Asia consists of the early continental terraces of Early Tertiary known as the Sunda plate which overlaps most of the western part of Myanmar to the south of Borneo. The oldest outcrops in Sunda plate are massive that located in the eastern part of

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Vietnam. Peninsular Malaysia and southwest of Borneo have formed a dignity where once formed the mass of earth during the Mesozoic and Early Cenozoic era. Southeast Asia is geologically composed of sedimentary sediment which is young and keep growing during 50 to 60 million years ago. Folding beds that run almost entirely to the north of Borneo in Sarawak and Sabah.

The offshore region between the South China Sea-Vietnam and Borneo seas is overlapping by the oceanic crust of the South China Sea basin during the Oligocene period (Taylor and Hayes 1998; Briais et al. 1993). The bottom of the basin is overlapped by continental blocks formed during the expansion process including Lucania and Reed Bank blocks. At the southern part of the basin, Fold-Thrust Belt beds are believed to represent the incremental prism is the prisms that result in collisions between microbial Lucia and Reed Bank fragments with the West Borneo Basement (Hazebroek and Tan 1993).

2.2.2 Early Tertiary Evolution

The tectonic evolution of Southeast Asia during the Palaeozoic and Mesozoic corresponded to the gradual separation of the Pangea super continent and the evolution of the oceans east of Tethys. During the Palaeozoic and Mesozoic, the Tethys Sea is composed of a triangle of the Pangea continent, Gondwana leads to the south and Laurasia leads to the north. Stratigraphic, paleobiologic and paleomagnetic studies have shown that the continent of Southeast Asia consists of several major terrain terrestrial territories that have been formed during the occurrence of Pangea and the opening and closing of the Tethys seas in succession (Metcalfe 1988, 1991, 1996). According to

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Metcalfe (1996), there are at least three nearby Tethys sequences during the collision process. Sunda plate itself is formed from two terrain composites separating the south-south ophiolitic suture zone from Thailand to the south of Peninsular Malaysia and possibly to Sumatra.

2.3 Geological Setting of Marang

The entire state of Terengganu lies within the East Line. The most dominant rocks are sedimentary rock (including metasedimentary rocks) most of it at the age Carboniferous and Permian and granite rocks. The meta-sediment rocks found on the east coast of the Peninsular Malaysia are known as a mitochondrial sedimentary by MacDonald (1967), most of which are said to be low grade metamorphic rocks derived from sandstone. Furthermore, the geological map of Peninsular Malaysia published by the Geological Survey of Malaysia by Chung (1973) marked the rocks in this Carboniferous aged area. Research done by Idris and Zaki (1986) at Batu Rakit area found fossil with age Carboniferous for sedimentary rock in that area.

At the Cendering area to Marang it consists of meta-sediment rocks which is slate, phyllite and quartzite. In some places the argillite rocks have weathered down to the metamorphic nature and look like mud stone rocks and siltstone. At the road cutting area that have been exposed and the outcrop at the beach area still shows metamorphism feature. Two generation of dolerite dyke founded at Bukit Temiang that cut granite at the area. Dyke that located almost to the north-south cut by dyke directed to east-northeast.

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North side of Bukit Panji have an outcrop of Igneous Dyke that have been weathered with width approximately 10 m.

Based on the presence of relatively high quartz minerals in the residual soil that represents the body of the igneous, it is believed that the dyke may be a porphyry quartz. In one locality, the porphyry quartz was cut by mid-composed dyke. Near the dyke there are many crystalline chiastolitic crystallites with a relatively broad distribution. Based on the presence of minerals that are more controlled by relatively high temperatures and relatively low pressure, this area is located not far from the igneous body at the bottom.

2.3.1 General Structural Geology

Based on lineament study, the regions the ridge almost parallel directions north-northwest. This area also is divided to three deformation that known as south deformation, central deformation and east deformation. In general, the main lineament directed to almost north-south to the northwest. Lineament at the northwest a bit curved while lineament at north-south a bit straight. The lineament of north-south and northwest being cut and moved by the short lineament that mainly directed to the north-northwest and east-southeast.

Most of the inverse fault and overthrust fault directed to the north and northwest tilt either to east-northeast or west-southwest. There is a somewhat steepest fault in north to north-west, indicating that the horizontal movement to the right may be due to the later phase of the deformation. A steep fault located at north-east corridor indicates a horizontal movement to the right while the timed-state shows a horizontal movement to the left.

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In addition, there is also an igneous dyke and quartz vein. There are two main direction of igneous dyke that are almost north-south or almost east-west. Observations in the north of Bukit Panji found that there was a dyke at north-south cut by the east-west dyke.

2.4 Stratigraphy

Geological sequence of Kuala Terengganu has divided into sediments, metamorphic and igneous rocks. Sediments and metamorphic rocks then divided into a few units which is Charu/ Sungai Perlis bed and alluvium which undergoes under Early Carboniferous and Quaternary period respectively. Charu/ Sungai Perlis bed consists of metasandstone with minor state and phyllite, slate, argillite, carbonaceous phyllite, metasiltstone and metasandstone schist and calc-silicate hornfels. Alluvial consist mainly of sand, silt and clay that widespread in the flat river valleys.

According to Bosch (1988), Quaternary alluviation are found between the capes along the seashore developed as beach ridges, along the major rivers which are Sungai Kemaman, Sungai Dungun, and Sungai Terengganu as fluvial deposition, and as paludal deposits along the glide and in structurally-controlled depressions inland.

Beach ridges (Matang Gelugor Member) are commonly found along this coast, the widest area which more than 4.5 km wide being located at north of Kuala Terengganu, through wide stretches are also seen at Kerteh and south of Kemaman. These beach ridges have also been seen as far as 10 km inland at Kemaman. Nossin (1965) said that the beach sands are generally well sorted with a median value ranging from 150 to 780µm.

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The oldest sedimentary basement is graben filled with clastic alluvium from Oligocene age and topography. The oldest graben may contain sediment from the late Eocene period to the Early Oligocene (Hutchison 1996). The sump rocks which from Oligocene and Lower Miocene age contain rough granular fluvial to moderate fluvial. Lacustrine shale depositional was spotted at the graben structure. The earliest sediment formed comes from the boundaries of the half graben basin. This lacustrine shale interpreted as the source rock for oil and gas in Oligocene aged and lower Miocene.

In general, the transgressive deposition in the Malay Basin continue in late Miocene to Pleistocene (Tjia and Liew 1996). Most of these regions are exposed to erosion during the Pleistocene period and river channels are cut along the basin (Tjia 1994).

Hutchison (1996) said that based on seismic data, it shows sediment thickness some kilometres below the Upper Oligocene strata and suggested the beginning of the Malay Basin before the Oligocene. Oligocene age reservoirs and early Miocene reserves include coarse-grained sandstone in between an estuary deposition to an average of alluvium deposition (Chu 1992; Hutchison 1996). Lacustrine shale since to accumulated at the remote graben (Hutchison 1996). The earliest sediment originates locally from the side of the graben part of the basin. This lacustrine shale is interpreted as the source rock for oil, gas and condensate in the Oligocene reservoir and Early Miocene (Creany et al. 1994; McCaffrey et al. 1998; Cole and Crittenden 1997; Todds et al. 1997).

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2.5 Malay Basin

Malay basin located at southern part of Thailand Gulf which is in between Vietnam and Peninsular Malaysia. This basin covers an area of about 80,000 km^2 and is filled with Tertiary sediments up to 14 km (Abd Rahim Md. Arshad et al. 1995). The Malay Basin was set up northwest and joined the Natuna West Basin, Indonesia.

The Malay Basin is a northwest basin with a basin dimensions of about 500 km long and 200 km wide. This basin contains a sediment of thickness around 12 km or more Oligocene aged. Generally, this Oligocene sediment is a land deposit with a small marine influence, while the Miocene sediment to the recent is a coastal deposit up to shallower sea. The Malay Basin is located at the centre of the Sunda plate which is the core of Southeast Asia. It is believed to have formed at the beginning of the Tertiary. The Malay Basin is shaped extensively with northwest-southeast orientation where it is based on pre-Tertiary of metamorphic, igneous and sediment rocks.

2.5.1 Exploration History

The Malay Basin can be divided into six provinces, namely Northeast, Southeast, North, South, West and Central based on their respective reservoirs and geographical location. In terms of intensity of exploration activities, Southeast is the highest followed by Northeast and Central regions. Exploration activities were only in the Northeast region in the late 1980 following the introduction of the Production Sharing Contract in 1985.

In 1968, Esso Production Malaysia Incorporation and Conoco companies were awarded the first concession for offshore areas in the east of Peninsular Malaysia. In

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July 1969, Esso drilled his first well which is Tapis-1, to the south of this basin. Tapis is a large anticline that extends from the east-west direction and cuts off the normal north-south fault. In 1975, oil and gas that from the Oligocene to early Miocene age founded at Seligi, Tapis, Pulai and Bekok field. While gas at Angsi, Besar and Belumut field (Ahmad Said 1982).

Tapis-1 well consist of gas that consist sandstone in Group J and K while Tapis-2 that being drilled on 1974 bring to the found of oil that comes from Group J sandstone. This is followed by the drilling of two wells explored in parts Jerneh which located at central of this basin. In 1970, Esso have drilled at Jerneh, Pilong, Sepat, Bintang and Belumut field. This ongoing exploration effort has lured oil discoveries in Seligi and Bekok in 1971. The first oil production is from Pulai and Tapis field in 1978. The effect of continuous drilling cause discovery Angsi, Besar, Palas, Gruntong, Irong, Irong Barat, Semangkok, Tinggi and Dulang.

At the end of 1997, a total of 342 wells were explored and drilled and 441,000 km of 2D and 3D seismic lines were obtained at the Malay Basin. The exploration effort has led to the discovery of oil and gas collections (Madon et al. 1999). The introduction of the Production Sharing Contract at the end of 1976 marked a very successful benchmark for exploration in the Malay Basin (Ahmad Said 1982). The exploration scenario has gone through the three-phase Production Sharing Contract beginning in 1976 following by 1985 and 1995.

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2.5.2 Source Rock

The abundance of oil and gas in the Malay Basin provides guidance on the existence of good and effective source rocks. The source rocks from the lacustrine sediments only penetrate to a shallow depth only at the edge of the hydrocarbon surface sink from the fluvial-delta precipitate dominate in the centre of the basin. The source rocks from fluvial-delta depositional environments are generally best found in Group 1 and E (Madon et al. 1999).

The source rocks of lacustrine deposition are good quality with Total Organic Carbon (TOC) 1-4% and hydrogen index as high as 750 (Creaney et al. 1994). Creaney et al. (1994) shows the dominant of parallel strata migration and there is also have a cutting strl0ata. Its main migration is towards northeast of the southwestern part of the Malay Basin.

Shale rock and coal- shale contain a high proportion of Pr / Ph which are comparable to mangrove swamps which are a source of rich with paralic, delta and estuarine origin in other basins in southeast Asia (Todds et al., 1997).

2.5.3 Reservoir Rock

Hydrocarbons in the Malay Basin are found in the sandstone of Group D to Group K. The depositional setting for these sandstones varies according to stratigraphy. In older groups (K, L and M), most fluvial channels come from lakes. In Group J and others younger group, sandstone on the beachfront and sub-tidal sand and complex channels are trapped in fluvial-delta to estuary.

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Characteristics of the reservoir for sandstones of the Late Oligocene to Miocene in the Malay Basin depends on the primary deposition of sediment facies, mineral contains and diagenesis of the deposit. Petrographic surveys and investigations have shown a significant difference in texture and mineral content of the groups that being interpret by seismic which is namely as E, I, J and K Groups. The oldest group K is braided stream deposits in a shallow marine environment containing good fined grains sized to moderate. Group E and I sandstone are deposited in estuarine environments with finely soft and rich matrix.

The original mineral content in sandstone has influenced the pattern changes of diagenetic post-deposition. High primers porosity is generally found in clean and mature sandstone. Porosity may be lost often due to quartz cementing and formation of authigenic clays.

2.6 Seismic Attribute

Seismic attribute is one of the quantitative measurement methods for seismic features. The analysis of attributes has played an important role in the interpretation of seismic since 1930. According to Barnes (2000), he advised when using various seismic attributes, it should be using an attribute that are closely related to one another. To prevent any wrong correlation, the uses of attributes that associated with physical features and features that fetched in the reservoir construction process (Kalkomey, 1998). Seismic attributes cover all quantities derived from seismic data and take into account the intermediate velocity, impedance acoustic inversion, pore pressure prediction, reflection termination, as well as complex sensor attributes into attributes.

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According to Chopra and Marfut (2005), there will be a shortage in estimation by giving attribute names to quantities based on sophisticated calculations such as impedance inversion and prediction of pore pressure and hence they agree with the determinants of recording data through geo-statistics or other techniques data integration.

Tanner et al. (1994) divides the attributes of seismic into two categories namely geometry and physical. The objective of this geometric attribute is to provide a clearer picture of geometric characteristics of seismic data including dip, azimuth and continuity. Physical attributes need to be linked to sub-surface physics parameters and are related to lithology. This includes amplitude, phase and frequency. This classification can be divided into post-stack and pre-stack attributes.

Brown (2004) has classified these attributes using a tree structure consisting of time, amplitude, frequency and attenuation as the primary branch in which the branch comes out into the post-stack and pre-stack categories. Time attributes provide information about stratigraphic and reservoirs.

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CHAPTER 3

MATERIALS AND METHODLOGIES

3.1 Introduction

In this chapter it will explained in details how the research was carried out. It will give researcher a guideline to follow the materials and method that be use in this research. In addition, it also will give an access to others to continue this research by using the guideline given. Materials and method first being choose to run the research. It will help the research to obtain data as well as analyse data.

There are several different phase of method processes in this chapter which is pre-field and field study, sampling, laboratory work, petrology analysis and interpretation, and seismic analysis and interpretation. The main role of the research is the method that will be use to conduct the research. It needs to be identified the materials in order to make it suitable with the method will used. Figure 3.1 shows the research methodology that use in order to run the research.

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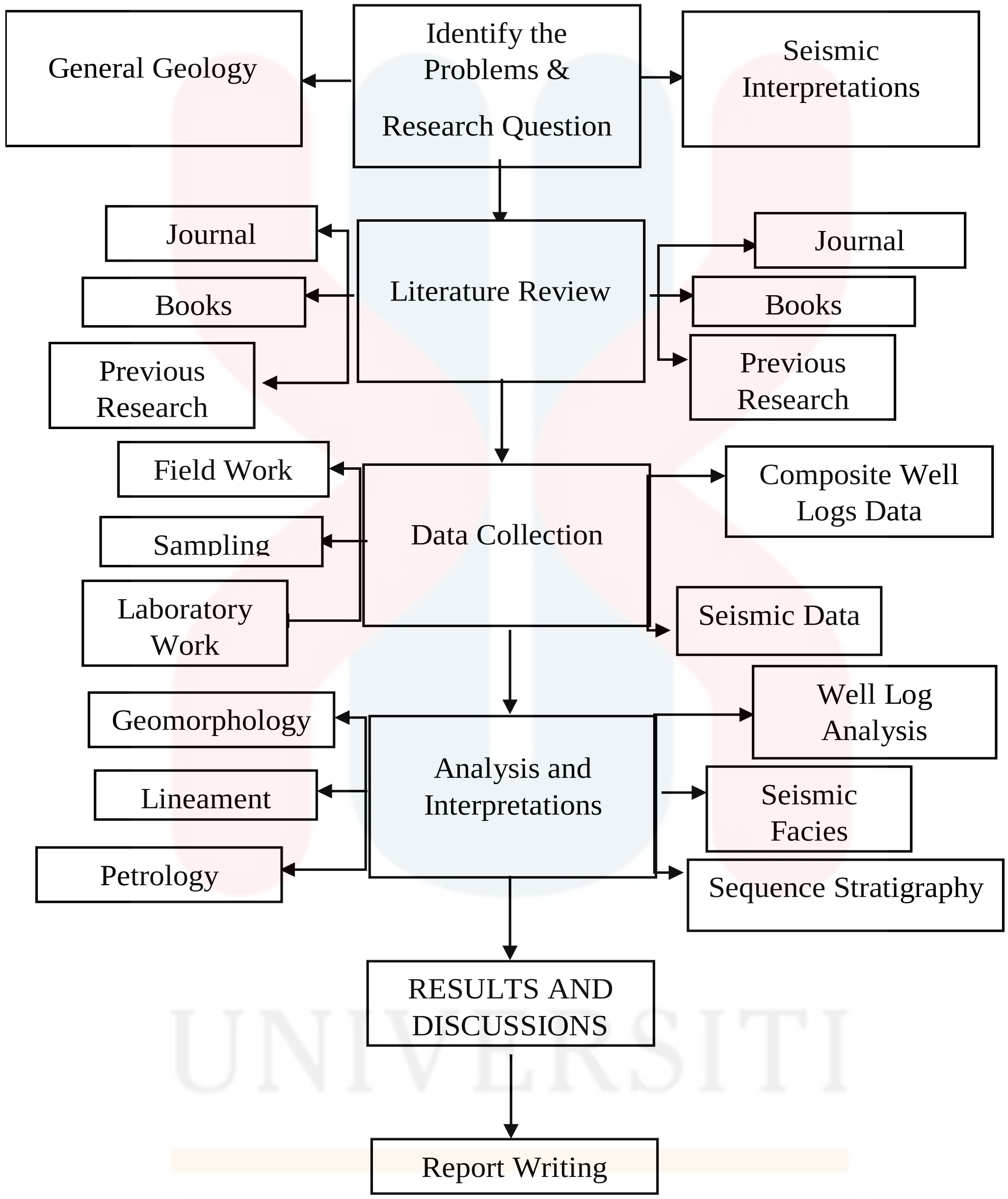

Figure 3.1: Flowchart of methodology that being used in this research

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3.2 Materials

3.2.1 Geological Mapping

There are certain materials that being use to conduct this research. For general geology, research need to do geological mapping of the study area which is Mukim Rusila, Marang, Terengganu. The materials include Global Positioning Systems (GPS), geological hammer (tip point and chisel), compass, geological sample bags, hydrochloric acid, measuring tape, field note book, hand lens. All this materials supply Faculty of Earth Science, Universiti Malaysia Kelantan (UMK) laboratory. In addition, during mapping some of the articles, journals and official reference from government department will help to conduct this mapping.

In order to proceed to the locations, the coordinates of the study area are needed and sample needs to marks with locations all this needs to use Global Positioning Satellite Systems (GPS). Location will mark and create a box in the GPS to help researcher to know the exact location of the study area. When sample is collected, the location will be mark and noted in the field note book for future reference. GPS is one of the devices that highly sensitive and received an information faster from satellites and will lets users know their location of traversing.

In order to obtain a fresh sample of rocks, geology hammer either chisel or tip point will use to splitting and breaking rock from the outcrop for sampling purpose. The sample are used to determine the composition, minerology and study the history of rock.

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Compass that usually use for geological mapping either Brunton compass or Suunto compass. If researcher would like to choose the one that more precision compass Brunton should be selected. It is the most frequent compass that is used to take strike and dip at the outcrop using its internal clinometer. It also can be used to know the directions of bedding at the sedimentary rocks.

One of the crucial items when conducting mapping is the geological sample bag. It uses to put the collection rocks, fossils, and mineral. To prevent rocks or fossils from break or contaminated geological sample bags is important. The sample will be preserved when using it. Mistake while organizing the sample from the field always happen, so to prevent it from happens the bag was label accordingly with the coordinate, expected type of rocks, place, date and time accordingly.

Cameras use an electronic image sensor to capture images that can be transferred and stored in a memory card or other storage inside the camera. This camera was used to take photo of outcrops and view of study area. The techniques when capturing the outcrop is important. It is compulsory to have scale when capturing the outcrop or sample that being collected.

Hydrochloric acid (HCL) is an acid that have many industrial uses. HCL is a corrosive and strong mineral acid. In geological field, geologist use the term "acid test" which means placing a drop of dilute 5% to 10% of hydrochloric acid onto the rock or mineral and watched for bubbles of carbon dioxide gas to be released. If the rock contains high carbon dioxide gas the bubbles will react vigorously. The acid test can be used to identify the rocks which is contains carbonate minerals. For example, to differentiate between limestone and

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dolostone, the rock is tested and see the reaction either it will produce a vigorous fizz or a very weak fizz when a drop of hydrochloric acid was places upon it.

The geologist’s measuring tape usually the reel-in variety and it is marked in meters and feet. This tape was used to measure the length and height of outcrops in the field. In some cases, measuring tape are not around research also use pacing technique to know the length and height of the outcrops or any geological featured seen in the study area.

Hand lens are magnifying glass which is a convex lens that is used to produce magnified image of an object. Hand lens was used at the field (usually) to identify mineral contained in the rocks and to see microfossil that was found in the rock before doing more investigation in the laboratory.

3.2.2 Seismic Interpretation

` In order to run seismic interpretations, the data granted by the management of a subsidiary of PETRONAS, namely Petroleum Management Unit. It consists the seismic reflection data, base map, seismic sections in form of SEG-Y data, T-Z Graph and other additional information such as geology report and completed final report of well log as a result of drilling in the study area. All this will help in this research. In addition, the time-depth curve used is to represent the recording wells obtained from the PETRONAS velocity survey. This depth of time depth is also used as the basis data in this study. Furthermore, the data provided will be processed using computer software Kingdom 2018 software.

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Time-depth graph (T-Z graph) has been generated from the well's velocity survey by PETRONAS at the field to measure the duration of the seismic wave from the surface to the hydrophone planned at a certain depth. This survey will help to identify and study about the facies of the area and others features.

Reflection seismic data is obtained through three components, which is from input sources, sensor arrays and recorders. The input source is used to generate a sound vibration that has the amount of energy, time, frequency, maximum amplitude and a certain phase. The source that flows beneath the surface of the earth will produce a wave of reflection and refraction recorded by the detector which is geophones. Then, this wave of reflection is recorded by a seismograph. Detected wave signals will vary and this is due to the characteristics of the sensors and recorders used.

Seismic cross section is a picture of cross section under the earth surface which located below of the seismic survey line. The seismic cuttings consist of lines that are in the form of waves arranged individually and printed on paper. Seismic cuttings to be interpreted are obtained from seismic surveys that have been processed. At the top of each seismic section there are numbers of shoot points used as a guide for making maps, so that every shoot point on the seismic section is shown on the map.

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3.3 Methodologies

3.3.1 Preliminary Studies

In order to obtain a first overview and idea for this research, preliminary studies being conducted for this research. It provided researcher an imagination about the research such as the geological setting of the study area, morphology, drainage system, way to obtain the seismic data and appropriated method that need to be run for this research.

Identifying the problem and create a research question is the first thing need to be done in this research. In this research it separated by two study which is general geology and seismic interpretation.

After knows the problem and research question have been created, proceed with the collection of literature review. It may come from journal, books or previous research thesis. Observation from topographic map and the satellite image also had been done.

3.3.2 Data Collection

After the preliminary studies, researcher start to gather all the information and present to the Petroleum Management Unit which is subsidiary company from PETRONAS to request a data from them. The data that being requested consist composite well log data, seismic data and others geological report about the study area that being collected by PETRONAS.

An observation at the study area must be done minimum a couple of weeks to complete this research by using a geological mapping method. All the area of the box

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with the area 25 km^2 must be covered. Field study is very crucial in the method of the research. By doing that, researcher can get a details information about the study area and to fulfil the objective of the research. A permission was taken from local government agencies in order to get an access to the study area, this is because some part of the study area is not allowed to enter due to safety reason. The communication with the local people was useful since they are familiar with the area and it will help researcher to finding an outcrop and not only depends on the base map. The field study includes looking for outcrops, geomorphology and also geological structure in the study area. All the picture of outcrops and geological features that will be found in study area was captured by the camera and a scale must be put beside the object (outcrops) or any geological featured to give rough estimation on dimension of the outcrops and geological features.

After detailed observation had been made, samples like fossil and rock sampling must be collected at the study area to study the geological information of the study area. Fresh rocks are needed to obtained from the study area so that the mineral contents present within the sample will not yet change.

3.3.3 Data Processing

The data that being collected from geological mapping process being sent to the lab for thin section. In this section it is important that researcher choose a fresh sample to do thin section. It helped researcher to do analysis of the sample.

The seismic data provided by the Petroleum Management Unit is secondary data covering basic maps, seismic templates, T-Z curves and well log data. This data needs to

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be reworked for processing and interpretation by using the computer version of Kingdom version 2018. This computer software comprises several levels of data processing and interpretation which include data management, data analysis, data interpretation and modelling. This SEG-Y data format needs to be imported into Kingdom computer software version 2018 first before data analysis is done. When the process of importing data is done, the sum of the crossline, and inline survey lines will be shown before the next process is to import the global coordinates. The exact coordinate value will result in an orthogonal form comprising the study area to be displayed on the computer screen.

3.3.4 Analysis and Interpretation

Petrological analysis and interpretation will be done after the laboratory works. Petrology is the study of rocks composition and its mineral in a view from physical and chemical features. It will explain the mineral content and textural relationship of the rocks at the study area. The analysis and interpretation being handle clearly to avoid the error and miss any important information.

After the data have been collected at the field which include the geological structure, land use, drainage pattern and the petrographic analysis have been done. All the results will record together and key in the data to Geospatial Information System. Researcher will analyse the coordinate then digitized it by using Geospatial Information System (GIS). GIS is one of the software to analyse, manage and display various form of geographically information. This will help to achieve the first objective of the research

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which is to update a geological map of the study area. It will create a better view and accurate of geological map.

The seismic reflection can be divided into three levels: data acquisition, data processing and data interpretation. Data interpretation is a complex process and requires a high degree of knowledge about what will be interpreted. According to Mc Quillin (1984), seismic data interpretation presents individuals from experienced and skilful geologists. Strong knowledge and extensive experience are indispensable by an interpreter to interpret seismic data. Interpreters should identify and eliminate all events associated with noise. Summary for interpretation, seismic features that show top onlaps, under onlaps and front onlaps should be sought because it is an indication of the erosion that occurs next to prove that there are two layers of different formations. Figure 3.2 shows a flowchart how research and data is interpreted to obtain a layer of formation of each subsequent layer in the study.

In order to recognize and correlate a sequence accurately, firstly, sequence boundaries must be determined and detected. Normally sequence boundary are determined on unconformity that based on the relationships with layers that not inline. The geological age at the above and below of unconformity being determined for provided the size of hiatus at the certain area. The time of sequence boundaries being detected by lateral the layer may become parallel but the hiatus being an evidence for continued to determine the unconformity. Finally, the sequence boundaries can be determined in between the parallel layers that does not have an evidence of hiatus and unconformity that being detected at conformity that related. Sequence boundaries are the important part in the seismic interpretation of stratigraphy sequences.

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The interpretation of transgressive surface is defined as surface that indicate the beginning of the relative sea level rise to their incidence. In the sequences stratigraphic, this surface indicates the increase in accommodation of sediments at nearshore area or coastal regions areas due to relative sea level rises. This surface also used as indicator of the reduction of sedimentation rate in the nearshore area. continental slope and basin base.

Marine-flooding surface (mfs) is defined as the surface which separates younger strata with older strata. This shows a sudden increase in the depth of water. This surface is usually located at the bottom of the marine shale marking a shifting diffusion of depositional environment between the shallower section at the bottom with a deeper section on the top.

Maximum Flooding Surface (MFS) also knowns as boundaries between transgressive unit with aggradation or regency above it. This surface is formed when the transgressive associated with the sea level rises relative till the maximum point. In the sequence stratigraphic concept, this surface indicates the rise of relative oceanic rates, which usually exceeds sedimentation rates in nearshore to shallow marine areas had been changed till decreasing from the depositional rate. This surface also indicates that when sea level rise rate is relative change, deposition system changes from land direction to direction of the basin.

Depositional sequence is the main genetic unit in a basin and because it is constrained by an unconformity plane then the sequence consists of a stratigraphic-time unit. Therefore, all strata within the sequence are deposited during a given time interval. The strata in the sequence generally parallel and have genetic relationships to the major

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deposition episodes. A sequence is composed of various facies but lateral strata of isochron strata that can pass through various lithofacies.

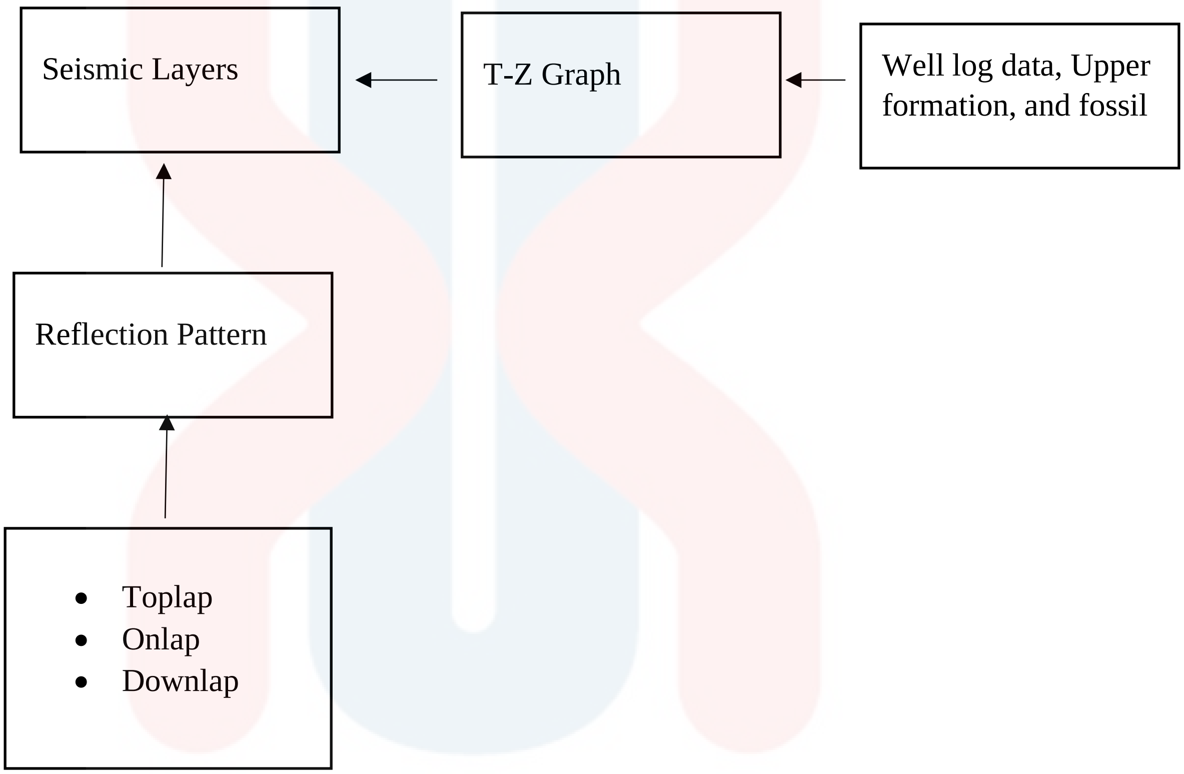

Figure 3.2: Flow chart on seismic interpretation that being used.

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System tract is the link of the depositional system that formed at the same time. System tract are one of the sections from the sequence of deposition and known by objective of their position in the sequence, the relationship with the surfaces of discontinuity and the build-up pole of para sequence. In every system tract analyse associated with certain sections from the cycle of the relative of the sea level that formed the sequence. In one cycle of the sea level, it always has three system that characterized the different sections of the sea level which is Lowstand system tract (LST), Transgressive system tract (TST) and Highstand system tract (HST).

LST is the oldest and the position located at the bottom in the ideal sequence. LST being deposits in one interval of the decrease of relative sea level till it achieved the positions of relative sea level minimum and stable. While for TST it located at the middle of ideal sequence that being border by transgressive surface at the below and maximum flooding surface at the top. This system track being deposited by the increase of relative sea level. It happened when the accommodation increases faster than depositional rate of the sediments. This can be verified by the depositions pole or a reversed pole to the surface. HST is the youngest in certain ideals sequence. It being represented by the order that deposits after the maximum transgressive. This system tracts being characterized by the relative slowdown of the sea level which results in a pattern of aggradation initially and then follow by a pattern of progradation. MFS is the lower border and then follow by next sequence boundaries.

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CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter it will explained in details the general geology results of the study area which is Mukim Rusila, Marang, Terengganu, Malaysia. It will contain an accessibility, settlement, forestry and vegetation, traverses and observation of the study area. Geomorphology of the area also will be explained which is the classification, drainage pattern, and weathering. In addition, lithostratigraphy, structural geology and petrographic study also covered in this chapter.

4.2 Accessibility

Mukim Rusila, Marang is located between Kuala Terengganu and Dungun, which is makes it easier access by the main highway which are Laluan Persekutuan 3. Mukim Rusila also have the road that connected it to Bukit Buloh. Next, there are a lot of village or housing road and unpaved road that being used by villagers and construction vehicles. Most of the road are easily to accessed to the study area via car and motorcycle to the study area.

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While conducted the research some of the area are mining site that made it not accessible because it covered by lake created from the mining activity. Since the mining site is private property, some of the company allowed researcher to enter the area but some not. It can be said, it will good the researcher uses a four-wheel drive to enter the area.

4.3 Settlement

Mukim Rusila is mostly dominated by the village area. Other than the resident area, Mukim Rusila also have mosque, school, factory, police station, fire and rescue station, private college, driving school and mining site. The resident area is consisting a village and modern house that nearby sea. The modern house is newly and currently developed at the study area. The mining site consists active and inactive site of mining activity. The study area can be said is one of the strategic locations of settlement because it has completed basic needed to resident nearby.

4.4 Forestry and Vegetation

In Mukim Rusila, Marang, Terengganu, is one of the under-development districts in Marang, Terengganu. However, there are still consist of medium-heavy forest area around hills at the study area. The forest locality in the study area is uneven. Figure 4.1 shows the forest from the top of the hill at the study area.

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In addition, there are many plantation areas in the study area. The plantations are belonging to the private company that do palm plantations. However, the rubber plantations are privately owned by the villagers of Mukim Rusila.

Figure 4.1: The forest in the study area

4.5 Traverse and Observation

Traverse is one of the methods that being done in the field during geological mapping. The function of the traverse is to keep track of the researcher path during research. During traverse researcher do an observation and record the data for create a geological map. Figure 4.2 shows the traverse and observation map that represent the travelled path during mapping activities. The waypoints that represent observation map were arranged in the Table 4.1 it shows all the observation points during traverse.

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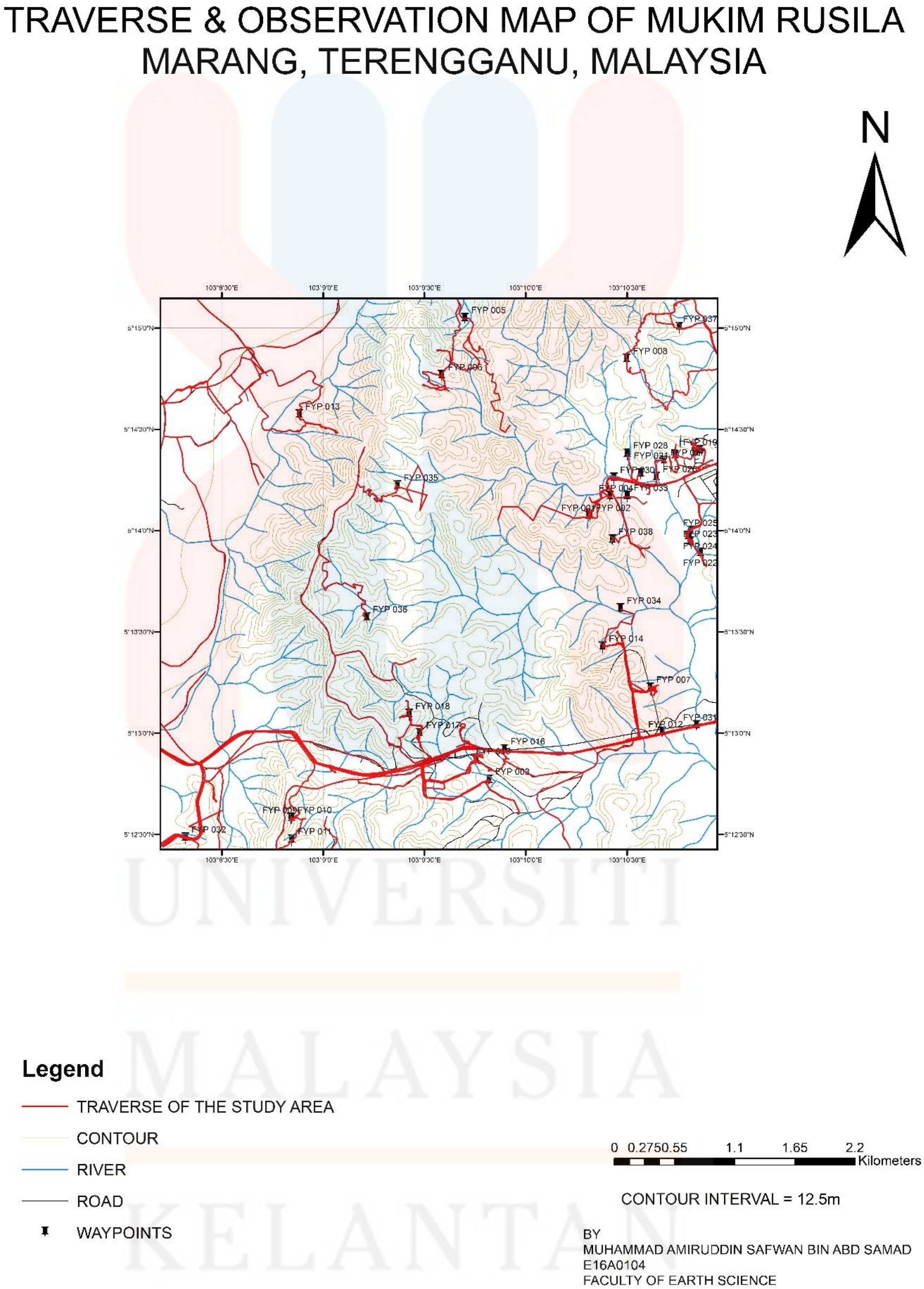

Figure 4.2: Traverse and observation map

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Table 4.1: Observation recorded for each point in traverse

WAYPOINTS	COORDINATES	OBSERVATION
FYP 001	5°14'4.227"N 103°10'18.538"E	Bedding reading
FYP 002	5°14'4.053"N 103°10'18.869"E	Identify structure and rock sample collection (phyllite)
FYP 003	5°12'45.882"N 103°9'49.133"E	Rock sample collection (schist)
FYP 004	5°14'9.91"N 103°10'24.92"E	Identify structure, bedding reading and rock sample collection (phyllite)
FYP 005	5°15'2.65"N 103°9'42.012"E	Rock sample collection (phyllite)
FYP 006	5°14'45.722"N 103°9'35.096"E	Rock sample collection (phyllite)
FYP 007	5°13'13.13"N 103°10'36.851"E	Rock sample collection (schist)
FYP 008	5°14'50.543"N 103°10'29.928"E	Geomorphological observation and bedding reading
FYP 009	5°12'34.495"N 103°8'50.737"E	Rock sample collection (schist)
FYP 010	5°12'34.549"N 103°8'50.507"E	Rock sample collection (phyllite)
FYP 011	5°12'34.549"N 103°8'50.507"E	Rock sample collection (schist)
FYP 012	5°12'59.987"N 103°10'40.386"E	Rock sample collection (schist)
FYP 013	5°14'2.339"N 103°8'58.611"E	Rock sample collection (phyllite)
FYP 014	5°13'25.309"N 103°10'22.796"E	Rock sample collection (schist)
FYP 015	5°12'51.923"N 103°9'45.342"E	Rock sample collection (schist)
FYP 016	5°12'54.871"N 103°9'53.698"E	Rock sample collection (phyllite)
FYP 017	5°12'59.656"N 103°9'28.638"E	Rock sample collection (phyllite)
FYP 018	5°13'5.311"N 103°9'25.488"E	Rock sample collection (phyllite)
FYP 019	5°14'23.489"N 103°10'51.47"E	Rock sample collection (schist)
FYP 020	5°14'22.823"N 103°10'50.236"E	Rock sample collection (schist)
FYP 021	5°14'22.092"N 103°10'44.216"E	Rock sample collection (schist)

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FYP 022	5°13'53.108"N 103°10'51.809"E	Rock sample collection (schist)
FYP 023	5°13'56.428"N 103°10'48.752"E	Rock sample collection (schist)
FYP 024	5°13'58.015"N 103°10'48.061"E	Rock sample collection (schist)
FYP 025	5°13'59.596"N 103°10'48.817"E	Rock sample collection (schist)
FYP 026	5°14'15.551"N 103°10'38.698"E	Rock sample collection (schist)
FYP 027	5°14'20.425"N 103°10'40.958"E	Rock sample collection (schist)
FYP 028	5°14'22.499"N 103°10'30.043"E	River observation
FYP 029	5°14'16.609"N 103°10'33.971"E	River observation
FYP 030	5°14'15.292"N 103°10'26.141"E	Rock sample collection (schist)
FYP 031	5°13'1.985"N 103°10'50.567"E	Rock sample collection (schist)
FYP 032	5°12'28.786"N 103°8'19.187"E	Rock sample collection (schist)
FYP 033	5°14'9.976"N 103°10'30.1"E	Rock sample collection (schist)
FYP 034	5°13'36.611"N 103°10'28.089"E	Rock sample collection (schist)
FYP 035	5°14'13.261"N 103°9'22.168"E	Rock sample collection (phyllite)
FYP 036	5°13'33.992"N 103°9'12.902"E	Rock sample collection (phyllite)
FYP 037	5°14'59.946"N 103°10'45.366"E	Rock sample collection (mylonite)
FYP 038	5°13'57.022"N 103°10'25.616"E	Identifying structure (chevron)

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4.6 Geomorphology

Earth’s surface physical features study is called geomorphology that includes the study of their origin, characteristics, processes, and development of the landforms. The study of geomorphological was done by observing the landforms, analysing the weathering rates, and classifying the drainage pattern of the study area which is Mukim Rusila, Marang, Malaysia. It is conducted based on topographic map, drainage map, and literature review and also by field observation.

4.6.1 Topographic Unit Classifications

The study area geomorphology is classified as hilly landform based on the study of topography map in the study area. Topographic unit classification is taken from Hutchison and Tan, 2009 which classified it to the five broad topographic units that can be distinguished based on the difference in mean elevation which is low lying, undulating, hilly and mountainous areas. Table 4.2 shows the topographic unit classification based on mean elevations from Hutchison and Tan (2009).

The elevations of the study area ranges from the lowest elevations which is 12.5 m to 174 m shows that it can classified as hilly landforms in topographic unit under 4 classification groups. Figure 4.3 shows the Datum Elevation Map that calculated based on the elevation at the study area.

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Table 4.2: Topographic unit classification

Classifications	Topographic Unit	Mean Elevation (m above sea level)
1	Low lying	<15
2	Rolling	16 – 30
3	Undulating	31 – 75
4	Hilly	76 – 300
5	Mountainous	>301

(Source: Hutchison and Tan, 2009)

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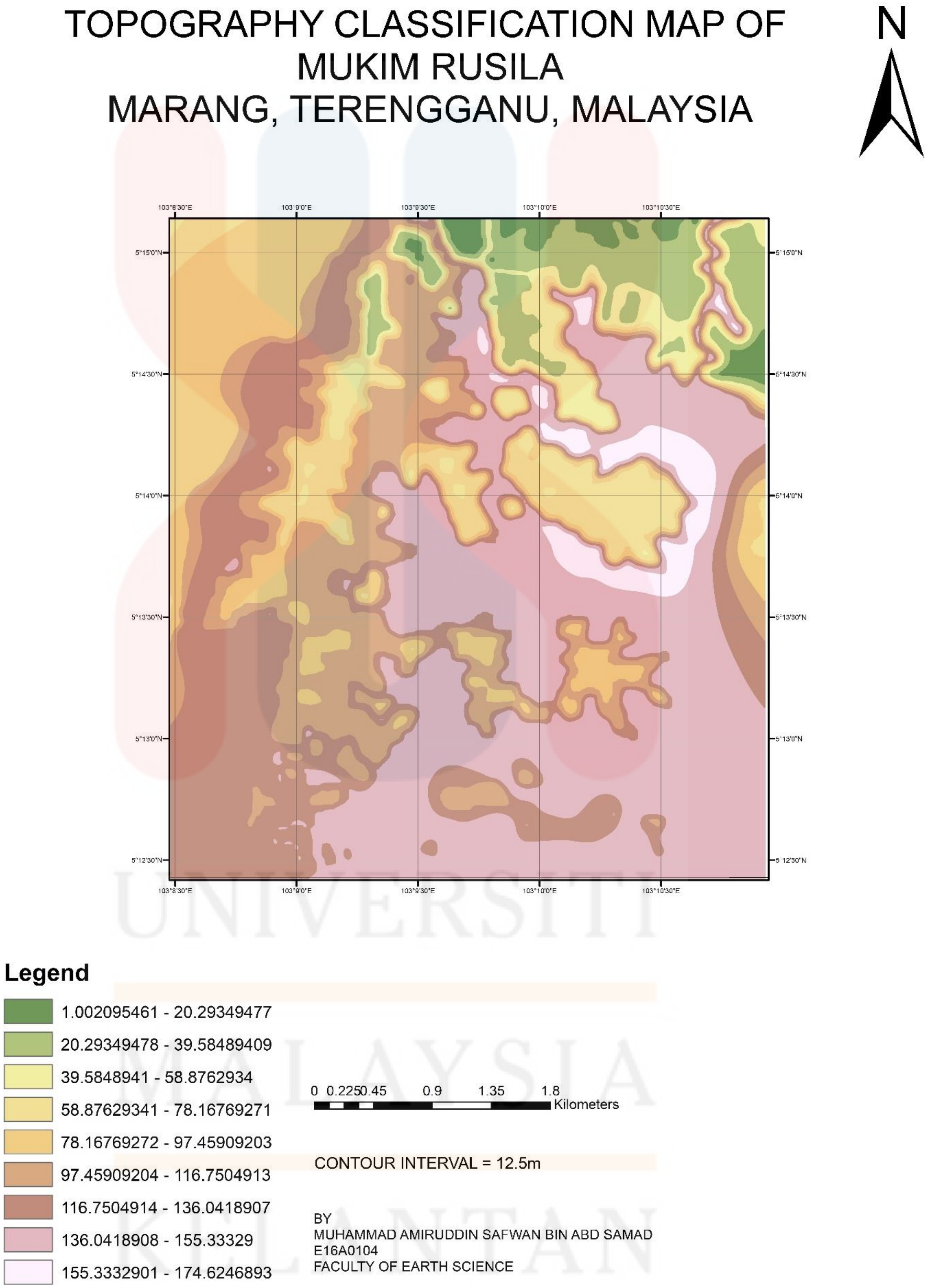

Figure 4.3: Datum Elevation Map

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4.6.2 Drainage Pattern

The river is a stream of water that flows through channels in the soil layer. A river starts from a plateau or on a hill or mountain and flows down from the plateau to the lowlands, because of gravity. A river starts as a small river, and it becomes bigger when further it flows. The network of streams and rivers in a particular drainage basin may form patterns that are governed by the topography of the land, whether the area is dominated by hard or soft rock, and also the presence of bedrock structure. There are few types of drainage pattern types which include trellis, dendritic, parallel, angular, contorted and radial. By using the topographic map and literature review can be classified.

Mukim Rusila, Marang, Terengganu consists dendritic type of drainage pattern. Tree branches—likes with a lot of twig is an indicator for dendritic pattern. It is resulted from a uniform surface control of the stream channels development. This type of pattern usually forms in flat areas and uniform bedrock where the bedrock structure such as fault and joints have no controls over the flow and position of stream channels. It is developing in area where the bedrock has equal resistance to erosion with no jointed rock. An example for this condition is at sedimentary rock like sandstone and shale. Figure 4.4 shows the drainage pattern map of the study area, Mukim Rusila, Marang, Terengganu.

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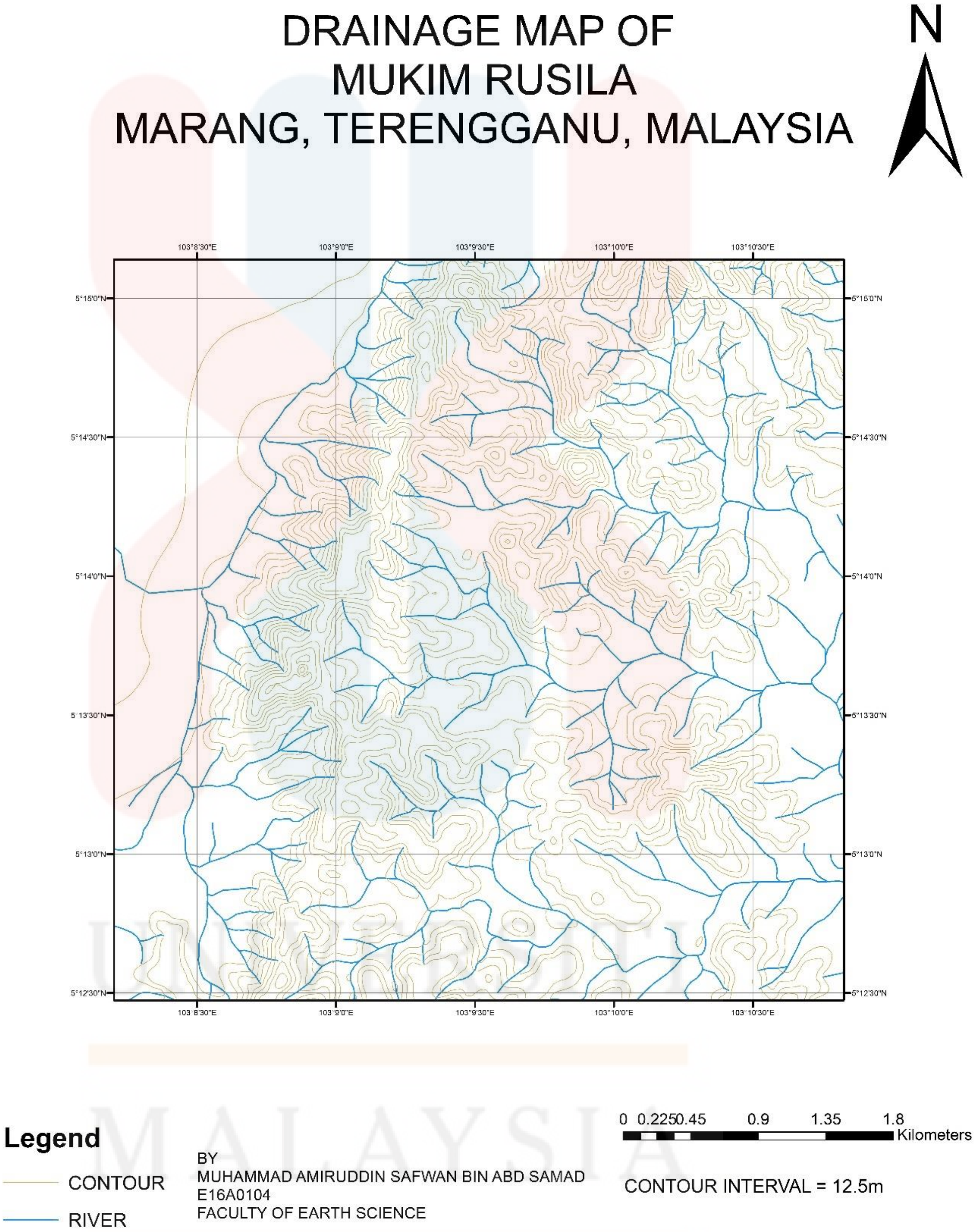

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Figure 4.4: Drainage Map

4.6.3 Weathering

Peninsular Malaysia is located within an area which is a humid region and it has climate of medium range temperature, high humidity and high rainfall. As a result, for this condition it is a favourable environmental condition for weathering of the bedrocks occur. Weathering consists a few types such as physical, chemical and biology weathering. All this type happened due to the climatic condition of the region.

i) Physical Weathering

Mechanical weathering or commonly known as physical weathering is part of geological process that putrefaction of rocks that not affect the chemical composition of the rock itself. The putrefaction of the rock is due to the force by a physical or mechanical force such as the pressure that acts on the rock or rain falling to the rock surface.

In the study area, there is presence of this type of weathering. The phyllite outcrop in Figure 4.5 shows the physical weathering that may formed by the forces or physical characteristics acts on the rock. Its break apart into smaller pieces without changed the rock origin chemical composition is the process of the physical weathering.

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Figure 4.5: Physical weathering at phyllite outcrop

ii) Chemical Weathering

The putrefaction of rocks materials into smaller pieces that change the chemical composition via chemical mechanism is called chemical weathering. The putrefaction of rocks is commonly through oxidation, carbonation, hydration and hydrolysis throughout the time.

The schist outcrop along the developing area nearby GANDA driving school can be found undergoes chemical weathering. It undergoes oxidation process that involves the reaction of oxygen with a metal element in the rocks and forms oxides. The reddish – brown iron oxides in Figure 4.6 formed on the surface of the rock as a result of oxidation on the schist outcrop.

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Figure 4.6: Chemical Weathering at schist outcrop

iii) Biological Weathering

The putrefaction of the rock by the action of living organism such as plants are called as biological weathering. Along with other types of weathering, it contributes to the further putrefaction of rock materials as it is more to be influenced by the environmental factors, such as biotic and abiotic factors.

Figure 4.7 shows the outcrop of mylonite undergoes biological weathering, in the figure can see the plant growth at the surface of the rock. The root of plants that exerts forces or pressure breaks the rock to fall to the surface.

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Figure 4.7: Biological weathering at the mylonite outcrop

4.7 Lithostratigraphy

Lithostratigraphy is a geological study that deals with study on rock strata and layering. The main focus of this research includes geochronology, comparative geology, and petrology. There are a few principles that being used for a explain about the presence of the strata. It can be said that when the hard rock cut by another rock formation, it can be said that the hard rock that cut the rock formation is younger than the existing rock. This study allows geologist to interpret the history of Earth by using the details of the rock composition, texture, structure and other features collected during geological mapping.

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4.7.1 Lithostratigraphy Position

The position for lithostratigraphy in the study area is arranged from oldest to youngest, which is under the unit of Charu/ Sungai Perlis bed, mylonite unit and alluvium unit respectively. The age of the lithology ranges from Palaeozoic to Cenozoic era. Charu/ Sungai Perlis bed unit is the oldest lithology composed in the study area, then followed by young metamorphic rock which is mylonite unit and alluvium unit. Figure 4.8 shows the stratigraphic column for the lithology found in the study area.

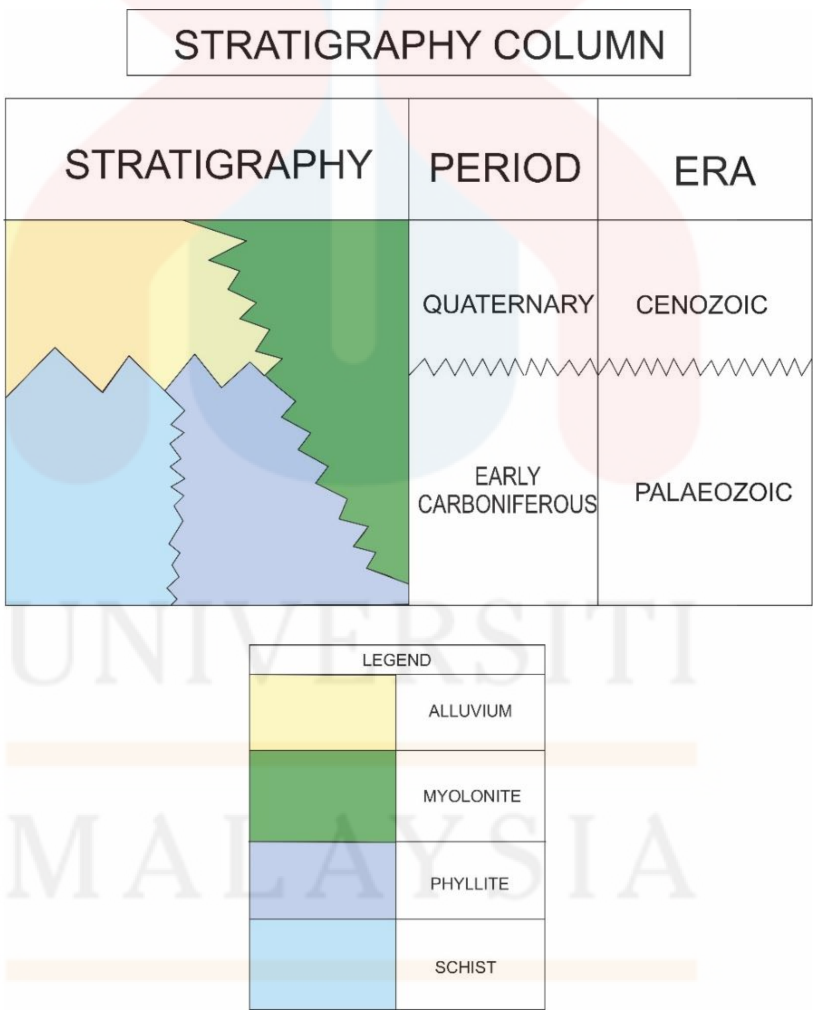

Figure 4.8: Stratigraphic column of lithology in the study area

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4.7.2 Unit Explanation

Inside the research area or study area it is composed of three main unit of lithological unit which is Charu/ Sungai Perlis bed unit, mylonite and followed by alluvium. The Charu/ Sungai Perlis bed unit consists of schist and phyllite as a main rock inside this unit in the study area. While the mylonite unit consists of mylonite as main rock and followed by others rock. Alluvium unit consist mainly of sand and clay. Table 4.3 shows the lithology of the study area with description.

LITHOLOGICAL UNIT

LITHOLOGY	DESCRIPTION	UNIT
	Alluvial that consist mainly of sand and clay. Widespread in the flat river	ALLUVIUM
	The colour of the rock tend to be predominantly pale white- brown. There is foliation structure (subslaty- subschistose) with palimpset texture. Dominantly mineral composition is Clay mineral - Silicate Clay.	MYLONITE
	The colour of the rock tend to predominantly greenish - gray. There is foliation structure (slaty-schistose) with palimpset texture. Dominantly mineral composition is Clay mineral - Chlorite and Silicate.	CHARU/ SUNGAI PERLIS BED
	Mainly schist with minor slate and meta-quartz wacke. Dominantly mineral composition is Quartz,Sericite and Clay mineral.	

Table 4.3: Lithological unit in the study area

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i) Charu/ Sungai Perlis Bed Unit

The Charu/ Sungai Perlis bed unit consist of mainly schist and phyllite. The phyllite outcrop is located nearby the gold mining site which is at the north - eastern to the west part of the study area. The weathering of the outcrop from partially weathered to highly weathered. The high of the outcrop is 2 m with the width 30 m. The landform surrounding the outcrop is mostly hilly landform and covered by some vegetation at the outcrop. Figure 4.9 shows the phyllite outcrop by using human scale, while for Figure 4.10 shows the close up for phyllite outcrop.

Figure 4.9: Phyllite Outcrop

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Figure 4.10: Close up of phyllite outcrop

Based on the hand specimen observation with using a combination of megascopic where the parameters of rock colour on the megascopic hand specimen tend to looks black ash – greenish colour. While under the microscope observation of phyllite thin section it being done by using ocular enlargement lens of 10x and objective enlargement of 5x there is foliation structure which is slaty – schistose. In addition, it also seen palimpsest texture which is blastoporphyritic – blastopellite that cover grain size <1/256 – 0.6 mm with good sorting. Figure 4.11 shows the Plane Polarized Light (PPL) of the phyllite thin section and Cross Polarized Light (XPL) on Figure 4.12.

According to the PPL and XPL view under microscope there are a few minerals that can be identified. Quartz mineral can be seen on E1 based on Figure 4.11 and 4.12 for PPL and XPL view under microscope respectively, under PPL observation it shows white in colour while under XPL it shows ashy black. It has low relief without cleavage.

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low pleochroism and anhendral crystal shape. Quartz presence spread in thin section with 4% abundance percentage.

Lithic fragments are seen in brown in colour when PPL and dark in colour when in XPL. It is consisting from quartz mineral, opaque minerals and spotted in the thin section with 6% percentage of abundance in the thin section. Based on Figure 4.11 and Figure 4.12 it can be seen on J5.

Chlorite clay minerals in the PPL and XPL it can be seen the colour are greenish black, it has 1 direction cleavage. It shows medium relief and low to medium pleochroism. Its presence on thin section with 58% it also can be seen on D8 in Figure 4.11 and Figure 4.12.

Silicate clay minerals in the PPL and XPL can be seen on A10 in Figure 4.11 and Figure 4.12 respectively. The colour shows white ashy colour and ashy black colour on PPL and XPL respectively. It comes with crystal shape and no cleavage seen. Can be seen it presence 35% in the thin section. Other than that, the 3% of presence on opaque mineral in C4 based on figure attached can be seen with dark in colour in both XPL and PPL.

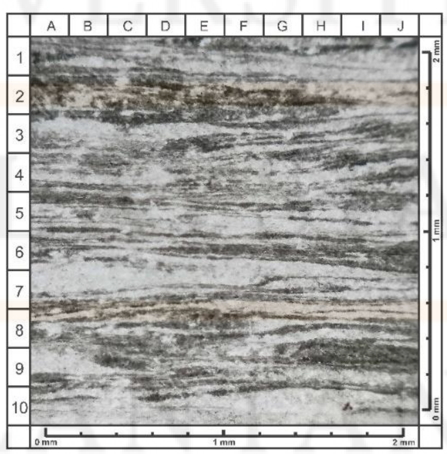

Figure 4.11: PPL view of phyllite thin section under microscope

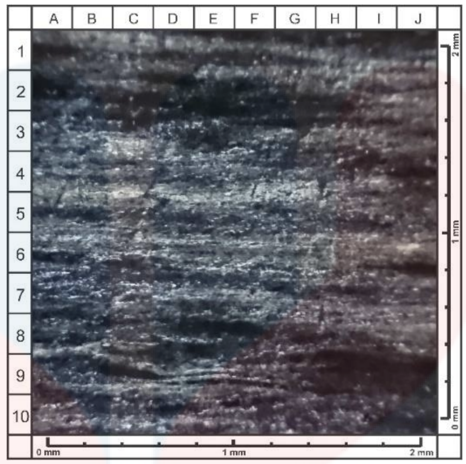

Figure 4.12: XPL view of phyllite thin section under microscope.

Schist outcrop also covered at the north – eastern to the west part of the study area. The outcrop weathering is partially weathered to highly weathered. The high of the outcrop is 4 m with the width 20 m. The landform surrounding the outcrop same like the carbonaceous phyllite which is mostly hilly landform and covered by the vegetation at the upper part of the outcrop. Figure 4.13 shows the schist outcrop by using panorama view. Based on the hand specimen observation with using a combination of megascopic where the parameters of rock colour on the megascopic hand specimen tend to looks black ash – greenish colour. While under the microscope observation of schist thin section it being done by using ocular enlargement lens of 10x and objective enlargement of 5x there is foliation structure which is schistose. In addition, it also seen palimpsest texture which is blastopsamit that cover grain size <1/256 – 1/2 mm with medium sorting. Figure 4.14 shows the PPL of the schist thin section and XPL on Figure 4.15.

According to the PPL and XPL view under microscope there are a few minerals that can be identified. Quartz mineral can be seen on A5 based on Figure 4.14 and 4.15

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for PPL and XPL view under microscope respectively, under PPL observation it shows white in colour while under XPL it shows ashy black. It has low relief without cleavage. Low pleochroism and anhendral crystal shape. Quartz presence spread in thin section with 35% abundance percentage.

Sericite can be seen at F7 in the Figure 4.14 and 4.15, the colour of the sericite is white ashy under PPL while under XPL brown-red ashy colour. It’s had low relieve and medium pleochroism. No cleavage and anhendral crystal shape. The presence in the thin section is 30%.

Silicate clay minerals in the PPL and XPL can be seen on A7 in Figure 4.14 and Figure 4.15 respectively. The colour shows white ashy colour and ashy black colour on PPL and XPL respectively. It comes with crystal shape and no cleavage seen. Can be seen it presence 35% in the thin section.

Figure 4.13: Schist outcrop

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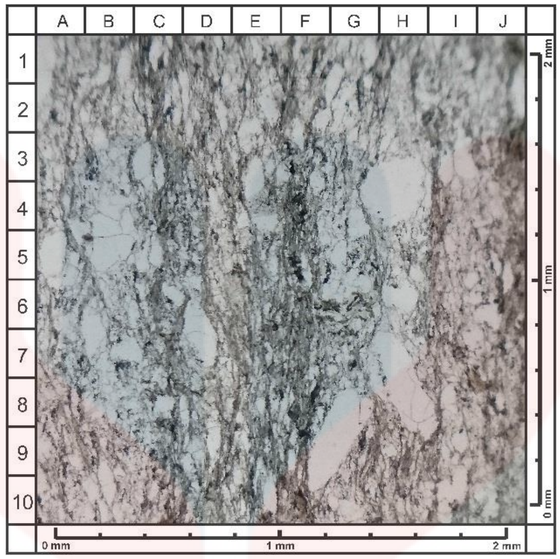

Figure 4.14: PPL view of schist thin section under microscope

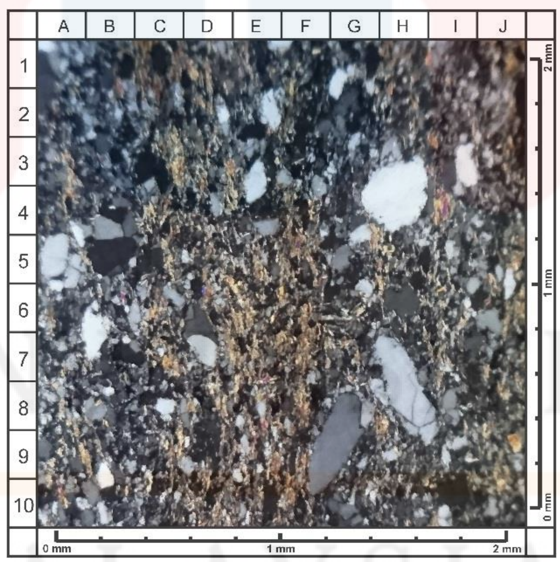

Figure 4.15: XPL view of schist thin section under microscope

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ii) Mylonite

The mylonite consist of mainly mylonite rock. The mylonite outcrop is located at part of the study area. The weathering of the outcrop from partially weathered to highly weathered. The high of the outcrop is 20 m with the width 30 m. The landform surrounding the outcrop is mostly hilly landform and covered by some vegetation at the outcrop. Figure 4.16 shows the mylonite outcrop, while for Figure 4.17 shows the close up for mylonite outcrop.

Based on the hand specimen observation with using a combination of megascopic where the parameters of rock colour on the megascopic hand specimen tend to looks dominantly pale white - brownish colour and it have medium grain size. While under the microscope observation of mylonite thin section it being done by using ocular enlargement lens of 10x and objective enlargement of 5x there is foliation structure which is subslaty-subschitose. In addition, it also seen palimpsest texture which is blastopsamit – blastopellite that cover grain size <1/256 – 1/6 mm with good sorting. Figure 4.18 shows the PPL of the mylonite thin section and XPL on Figure 4.19.

According to the PPL and XPL view under microscope there are a few minerals that can be identified. Quartz mineral can be seen on C1 based on Figure 4.18 and 4.19 for PPL and XPL view under microscope respectively, under PPL observation it shows white in colour while under XPL it shows ashy black. It has low relief without cleavage. Low pleochroism and anhendral crystal shape. Quartz presence spread in thin section with 20% abundance percentage.

Silicate clay minerals in the PPL and XPL can be seen on A1 in Figure 4.18 and Figure 4.19 respectively. The colour shows white ashy colour and ashy black colour on

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PPL and XPL respectively. It comes with crystal shape and no cleavage seen. Can be seen it presence 52% in the thin section.

Oxide clay mineral can be seen on petrographic studies, C7 Figure 4.18 and 4.19. It can be seen brown in colour in PPL while in XPL ashy – brownish black. It comes with crystal shape and no cleavage seen. Can be seen it presence 25% in the thin section. Other than that, the 3% of presence on opaque mineral in I7 based on figure attached can be seen with dark in colour in both XPL and PPL.

Figure 4.16: Mylonite outcrop

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Figure 4.17: Close up view of mylonite outcrop

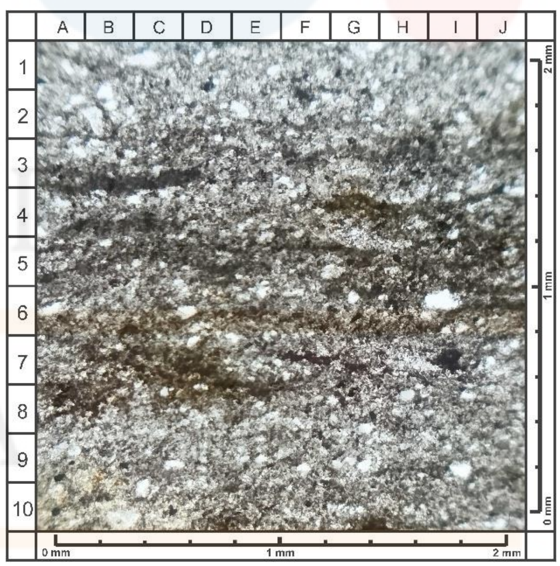

Figure 4.18: PPL view of mylonite thin section under microscope

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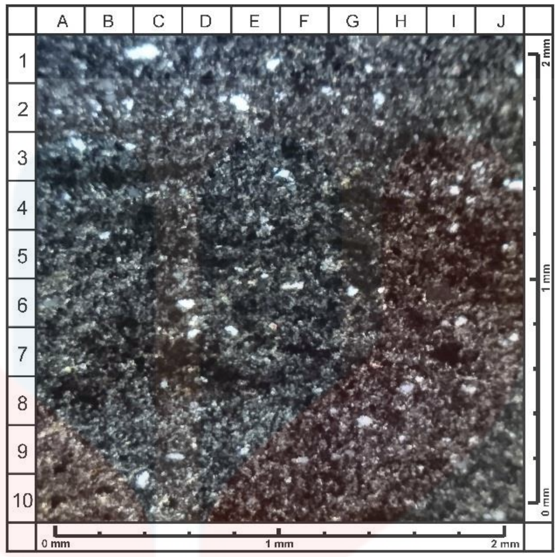

Figure 4.19: XPL view of mylonite thin section under microscope

iii) Alluvium Unit

In general, alluvium is a loose unconsolidated materials or sediments that not being cemented together to form a solid rock. It has been eroded, reshaped by water in some form. It is prescribed in a form of marine setting. Alluvium usually consists of a variety of materials that include fine particles of mud, clay, some larger sand and gravel particles. When this loose alluvial material is stored or cemented into a lithology unit it is called an alluvial deposit.

In the study area, the alluvium can be found the river bed and at the coast area. It consists mainly of sand, silt and clay, It widespread in the flat river valleys. It is under the unit of alluvium which composed in Quaternary era.

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4.8 Structural Geology

One of the sub-disciplines in geology that need to take a look during geological mapping is structural geology. It is the study of 3-dimensional distribution of rock unit with their deformations. Geological structural that are found within the study area includes vein, fault, and fold.

a) Vein

One of the structures that found in the study area is vein. Most of the outcrops in the study area consists vein. The distinct sheet – like body of crystallised mineral within the body of a rock called vein. It is formed where there is aqueous solution transport or carries mineral constituents within the fractures in rock mass and they being deposited through the process called precipitation. The hydraulic flow that involves in formation of vein is commonly due to hydrothermal circulation.

Quartz vein is the type of veins that found within the study area. The vein formed between the layers of rock body. Figure 4.20 shows the quartz vein found in mylonite outcrop.

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Figure 4.20: Quartz vein in mylonite

b) Fault

The definition of fault is a fracture field that associated with displacement of one rock block to others rock block. The distance of shifting only a few millimetres and up to dozens of kilometres. While field of the fault at first start from a few centimetres and up to dozens of kilometres.

In general, there are a few types of faults which is normal fault, translational fault, horizontal fault, oblique fault. Within the study area, there are seen normal fault at coordinates N05° 14’ 10” E 103° 10’ 18.6”. Normal fault can be planar fault or listric

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fault with the movement either rotational or non- rotational as in the Figure 4.21 that shows the model of normal fault. Fault that found in the study area is a planar rotational fault. Planar rotational fault will show an effect until the rock strata om hanging wall and foot wall will rotate or shift as in Figure 4.22 show the fault found in the study area. The foot wall shifts upwards while for the hanging wall shift downwards. This fault can't be mappable in the geological map due to small scale. In addition, this fault is not the major fault in the study area. It is the minor fault in the study area.

Based on the observation during geological mapping and literature review studies, researcher believed that there is major fault as shows in Figure 4.23. It can be said based on the shifting of the contour on the maps. Suggested to the upcoming researcher to study about the major fault in the study area. The fault may not be seen due to the development process within the study area.

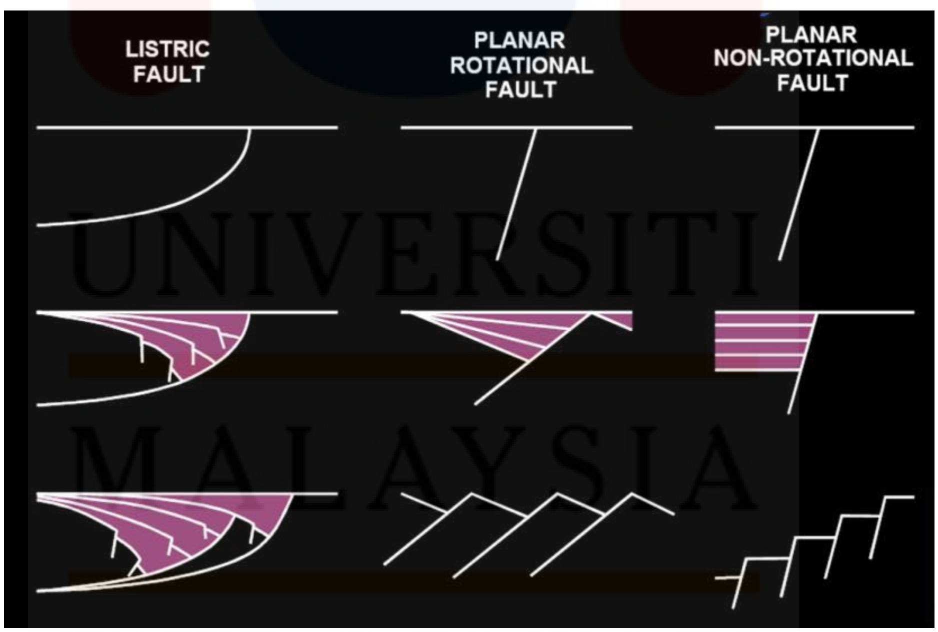

Figure 4.21: Model of the normal fault

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Figure 4.22: Normal fault that found in the study area

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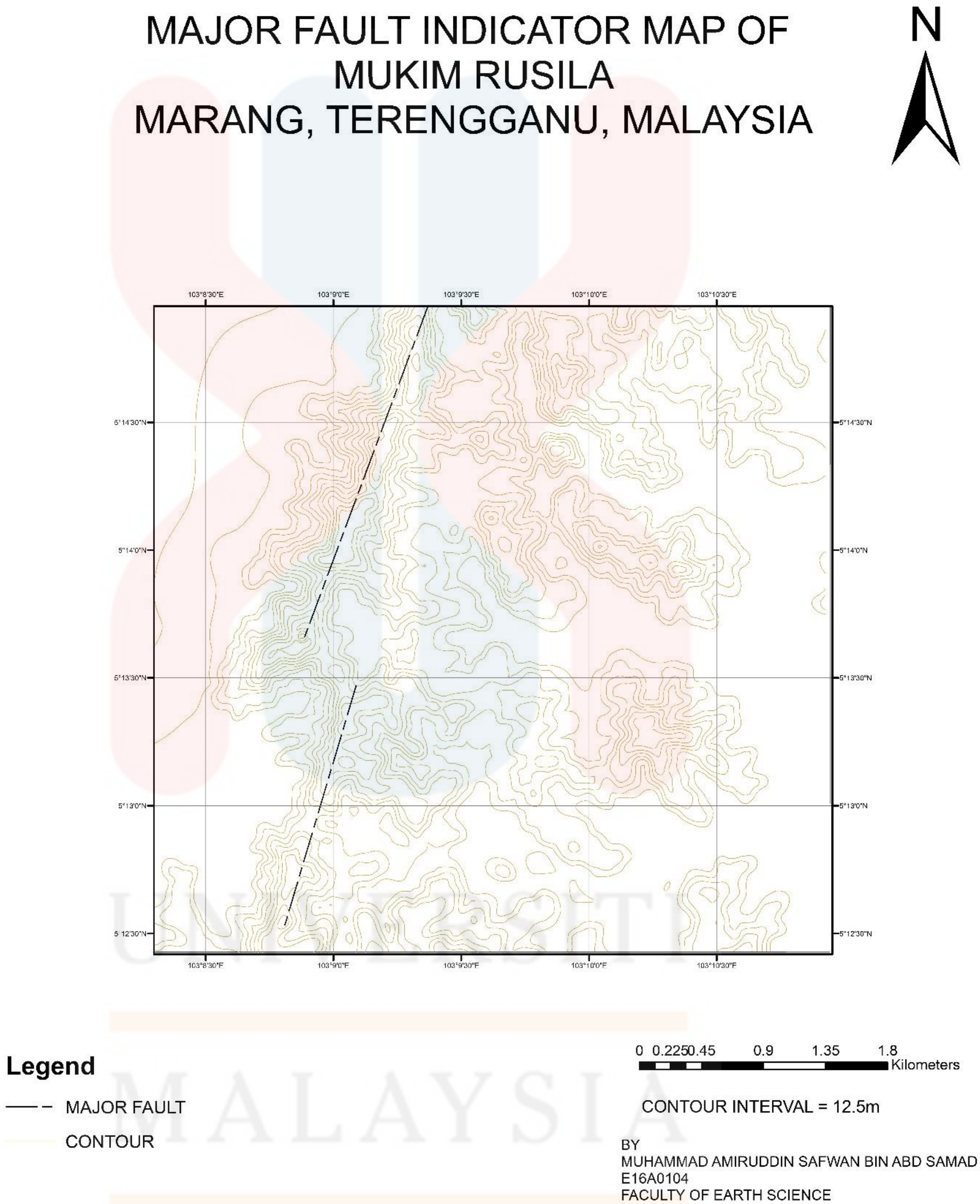

Figure 4.23: Major fault indicator map in the study area

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c) Fold

Fold is one the structural of geology on the rock body that looks like undulation waves on the earth surface. Early structure is the vertical or horizontal likes the sediments strata and developed during the deformation. It has the plastics and flexible characteristics. Fold is one of the structures that clearly and generally shows that location undergoes ductile deformation on earth.

In the study area at coordinates 5°13'57.022"N 103°10'25.616"E, chevron fold it seen at that location. Chevron folds has the feature that characterized by the repeated folded beds with straight limb that well behaved and it have sharp hinges. It can be seen with v – shaped beds at the rock strata. It is developed in the respond of either regional or local compressive stress. 60 degrees or less of inter-limb angles.

Based on observation, the chevron fold at the study area is quite big. It covers half of the hills. Figure 4.24 shows the chevron fold at the study area.

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Figure 4.24: Chevron fold in the study area

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4.9 Historical Geology

The entire state of Terengganu lies within the East Line. The most dominant rocks in the study area are metamorphic rock most of it at the age Early Carboniferous and Cenozoic era. The metamorphic rocks in the study area consists from low grade metamorphic such as phyllite, medium grade metamorphic rock such as schist and mylonite. The metamorphism process is one of the process changed of rocks because of there are changed in pressure, temperature and or there is chemical activity either by gas or fluid. While for mylonite, it happened when the big scale of shear strain accumulated in ductile fault zones.

Geological sequence of the study area has divided into sediments and metamorphic rocks. Sediments and metamorphic rocks then divided into a few units which is Charu/ Sungai Perlis bed and alluvium which undergoes under Early Carboniferous and Quaternary period respectively. Charu/ Sungai Perlis bed consists of metasandstone with minor state and phyllite, slate, argillite, carbonaceous phyllite, metasiltstone and schist and calc-silicate hornfels. In the study area, there is only phyllite and schist. Alluvial consist mainly of sand, silt and clay that widespread in the flat river valleys.

After the research had been done, the geological map of the study area with scale 1:25000 as shown in Figure 4.25 stated the study area consist sedimentary rock and metamorphic rock. Mylonite unit also presence at the study area and it considered as new findings at the Mukim Rusila, Marang, Terengganu.

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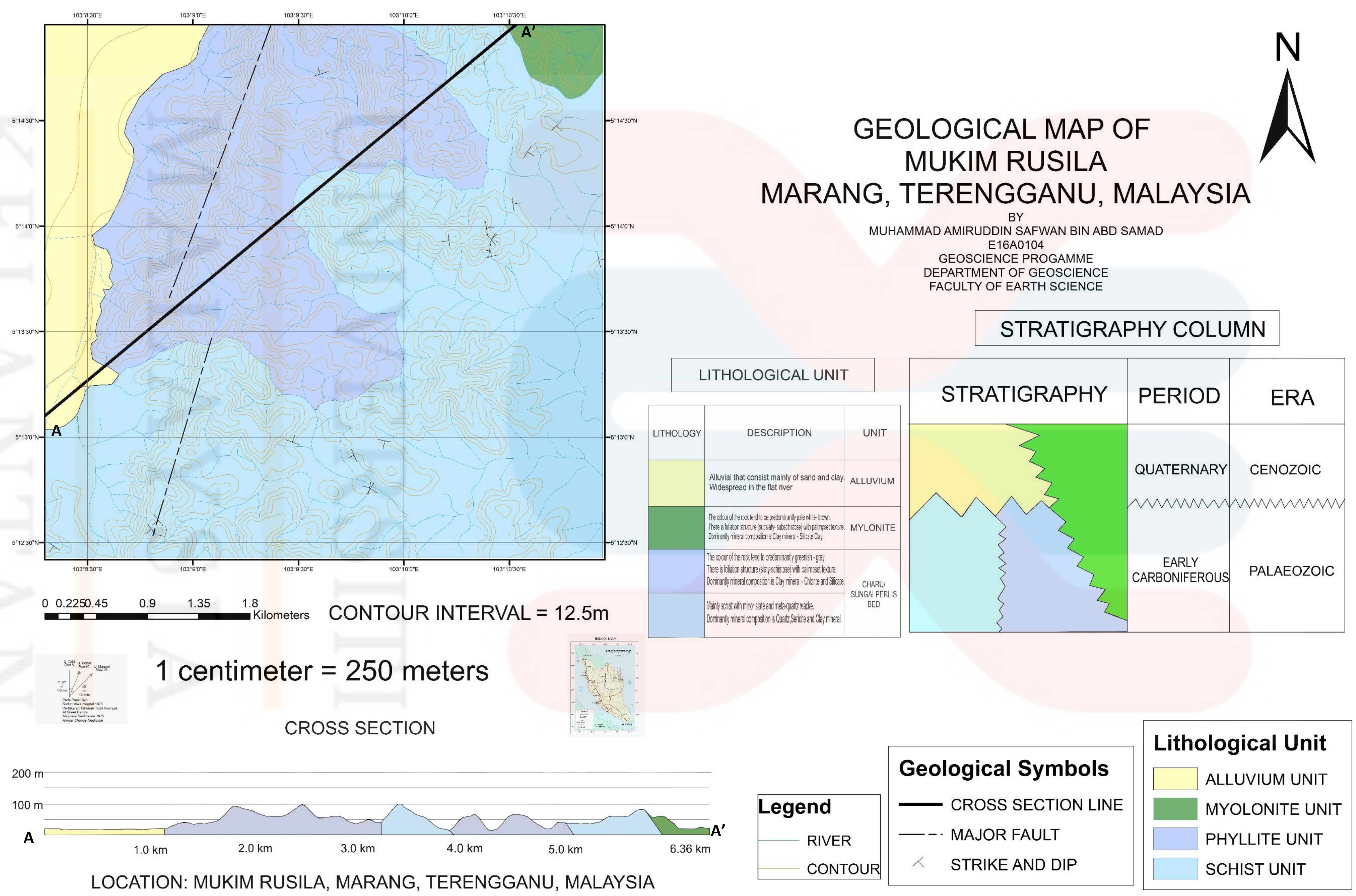

Figure 4.25: Geological map of the study area

CHAPTER 5

SEISMIC INTERPRETATION OF KAPAL FIELD, TERENGGANU OFFSHORE

5.1 Introduction

In this chapter will discuss the results obtained based on seismic interpretation of study area which is Kapal. It will cover the interpretation of sequence boundary and the hydrocarbon indicator at the study area. Figure 5.1 shows the base map for this research that cover 12.241 km^2 at Kapal field, Terengganu Offshore, Malaysia. The data given by PETRONAS for the study area consist from 1187 inline survey and 1013 crossline survey. This research focus on 3 inline and 3 crosslines from Kapal that already being used for the seismic interpretation which the interval of 12.5 m. The interpretation of sequence boundaries and the potential hydrocarbon based on geological structure also will be explained.

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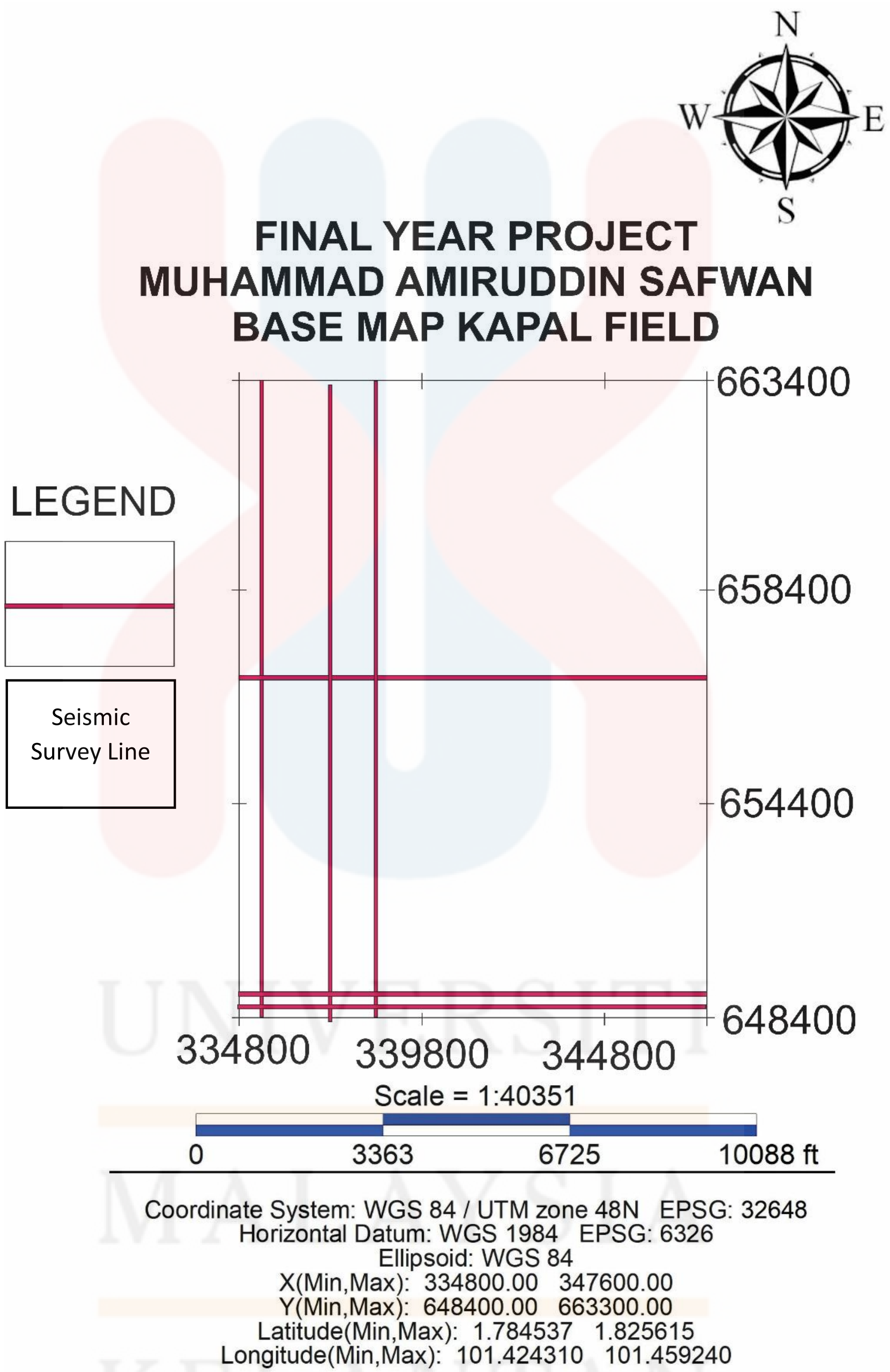

Figure 5.1: Base map of the study area

5.2 Sequence Boundaries Identification

Sequence stratigraphy is based on theory that said the depositional sequence can be divided into the unit which is called as sequence. Sequence boundaries bound by an unconformity that formed during one major cycle of relative sea level change (Boggs 2014).

Sequence boundaries form when the decreasing of relative sea level that being differentiated with a floor basin, subaerial erosion and other factors. Therefore, the sequence boundaries that being identify in this local scale can be relate to the boundaries of global and regional scale. The sequence boundaries for this project found from the seismic section through the amplitude difference and presence of difference facies. According to the well log report from PETRONAS, Kapal field consist major sand and shale. Minor rock unit in the Kapal field consist coal and carbonate rock. Due to the data constrain well tie cannot being done and interpretation of rock strata at the study area only can be done by report.

5.2.1 Seismic Line Inline 25894

On the seismic line inline (IL) 25894 as show at Figure 5.2, the total 4 sequence boundaries were found. This seismic line was found at two-way time between 0.1 ms to 7.6 ms. Figure 5.3 shows the sequence boundary T1 with presence of downlap at the T1 boundary which it terminates to the oldest strata below. A base-discordant relation in which initially inclined strata terminate downdip against an initially horizontal or inclined surface. The structural configurations of the beds of both sides of the unconformity and the internal reflection patterns displayed by overlain an underlain unit

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gives tectonic and environmental significance of the interface. It can give hints such as it was subaerial, submarine, fluvial or glacial in origin. It also can be Time gap is erosional or non-depositional. Non-depositional may indicates sediment bypass, topographic relief is planar, irregular, unconformity is local or regional or it may indicate relative sea level behaviour, sediment supply etc.

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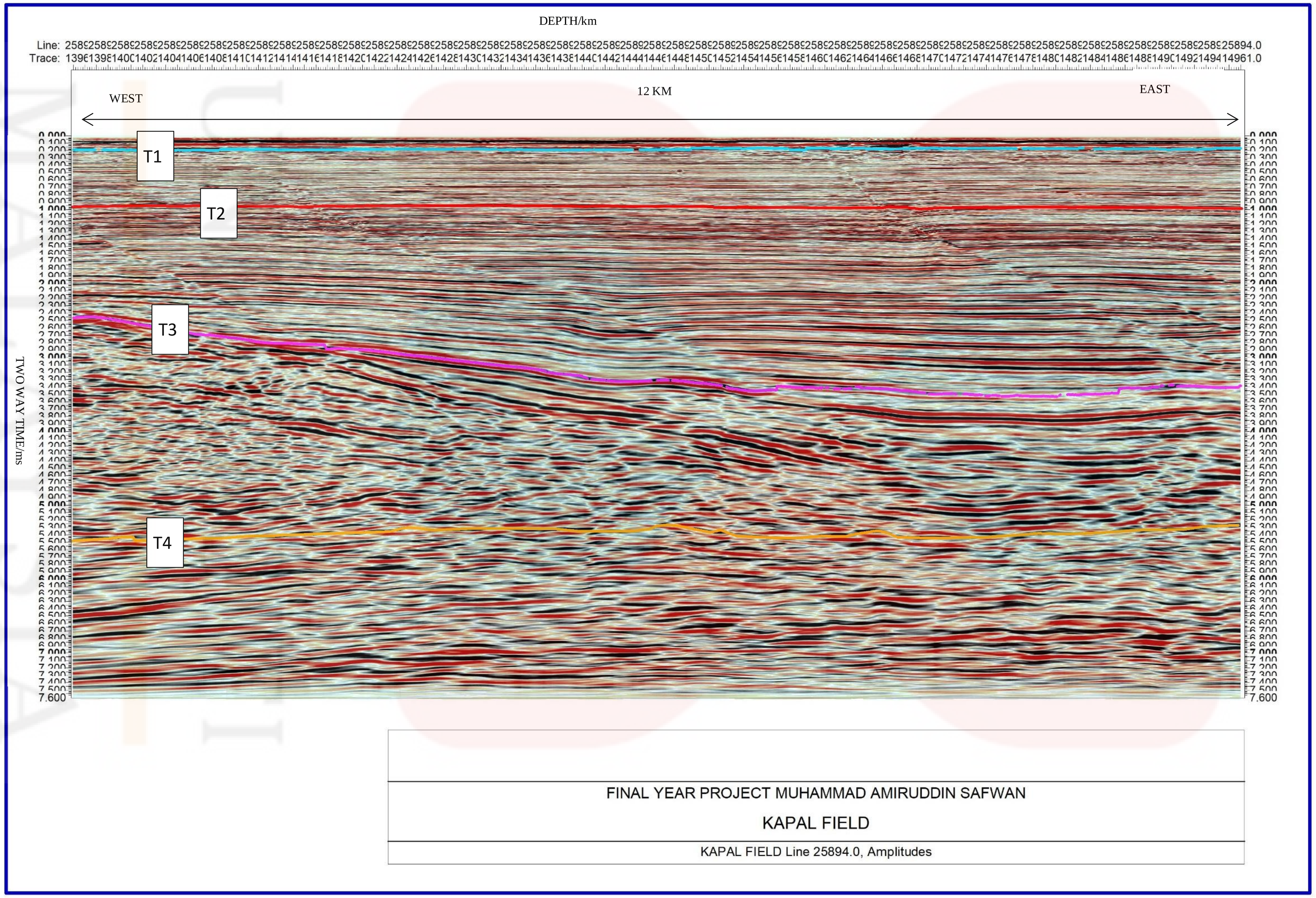

Figure 5.2: Seismic line IL 25894

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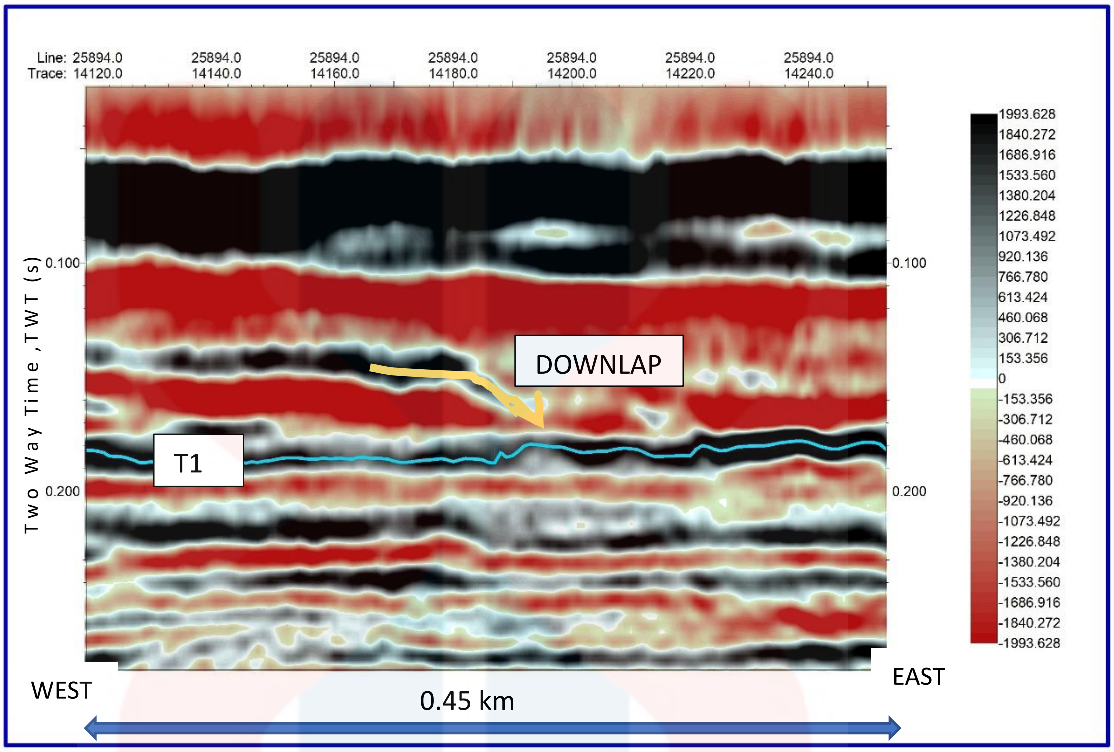

Figure: 5.3: T1 boundary at IL 258954

Figure 5.4 shows the sequence boundary T2 with presence of toplap at the T2 boundary which it terminates to the youngest strata above. It mainly as a result of sedimentary by passing with perhaps only minor erosion (Mitchum et all. 1977). This boundary was found at two-way time at TWT 0.95 ms. This is believed to represent the proximal depositional limit. These can be interpreted as sediment supply exceeding accommodation space, forcing progradation but with subsidence exceeding the relative change in sea level and consequent accumulation of topset beds. The change from no topset beds to aggradational topset beds indicates a turnaround from apparent still-stand to apparent rise in sea level at the site of deposition.

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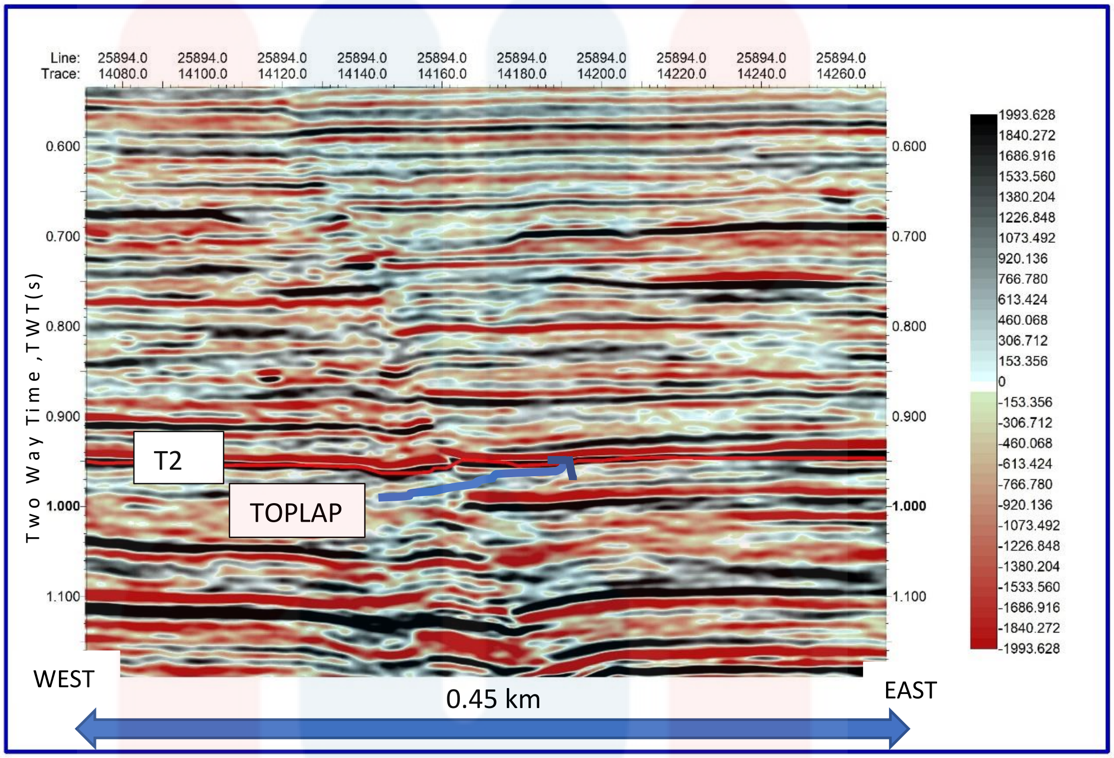

Figure 5.4: T2 boundary at IL 25894

Figure 5.5 shows the sequence boundary T3 with presence of downlap at the T3 boundary which it moves toward the oldest strata below. A base-discordant relation in which initially inclined strata terminate downdip against an initially horizontal or inclined surface. The surface of downlap represents a marine condensed unit.

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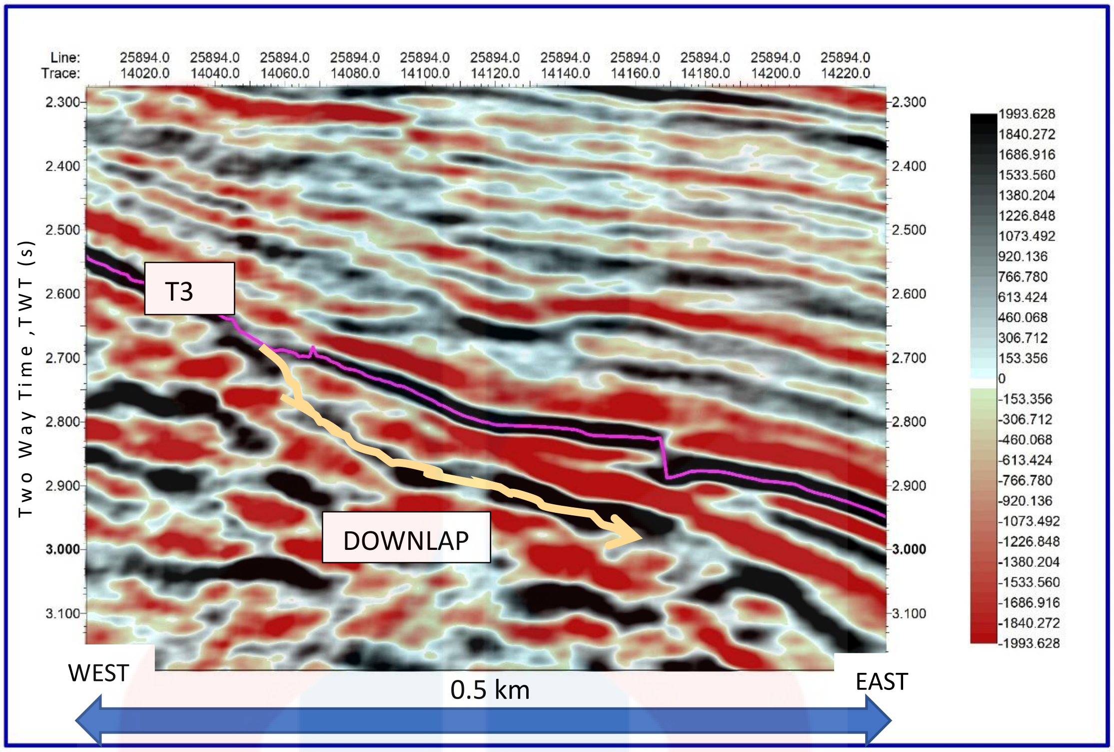

Figure 5.5: T3 boundary at IL 25894

Figure 5.6 shows the sequence boundary T4 with presence of toplap at the T4 boundary which it terminates to the youngest strata above. It mainly as a result of sedimentary by passing with perhaps only minor erosion (Mitchum et all. 1977). This boundary was found at two-way time at TWT 5.4 ms. This is believed to represent the proximal depositional limit.

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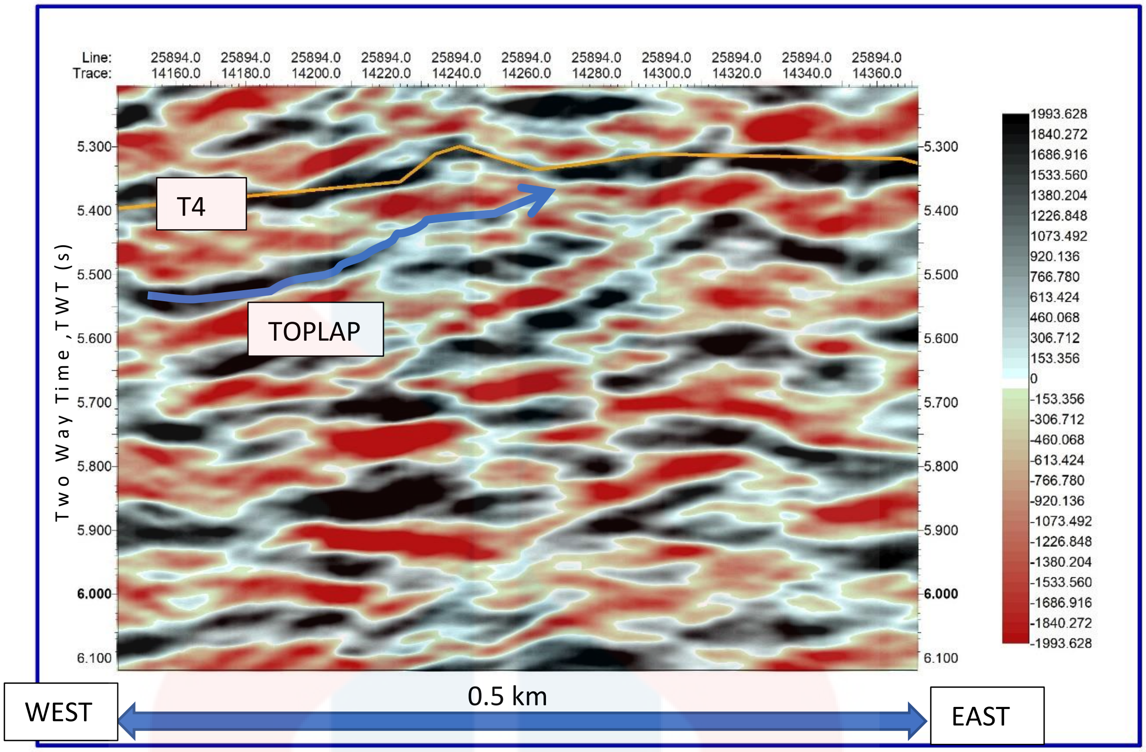

Figure 5.6: T4 boundary at IL 25894

5.2.2 Seismic Line Inline 25287

On the seismic line inline (IL) 25287 as show at Figure 5.7, the total 4 sequence boundaries were found. This seismic line was found at two-way time between 0.1 ms to 7.65 ms. Figure 5.8 shows the sequence boundary T1 with presence of toplap at the T1 boundary which it terminates to the youngest strata above. It mainly as a result of sedimentary by passing with perhaps only minor erosion (Mitchum et all. 1977). This boundary was found at two-way time from 0.02 ms until 0.19 ms.

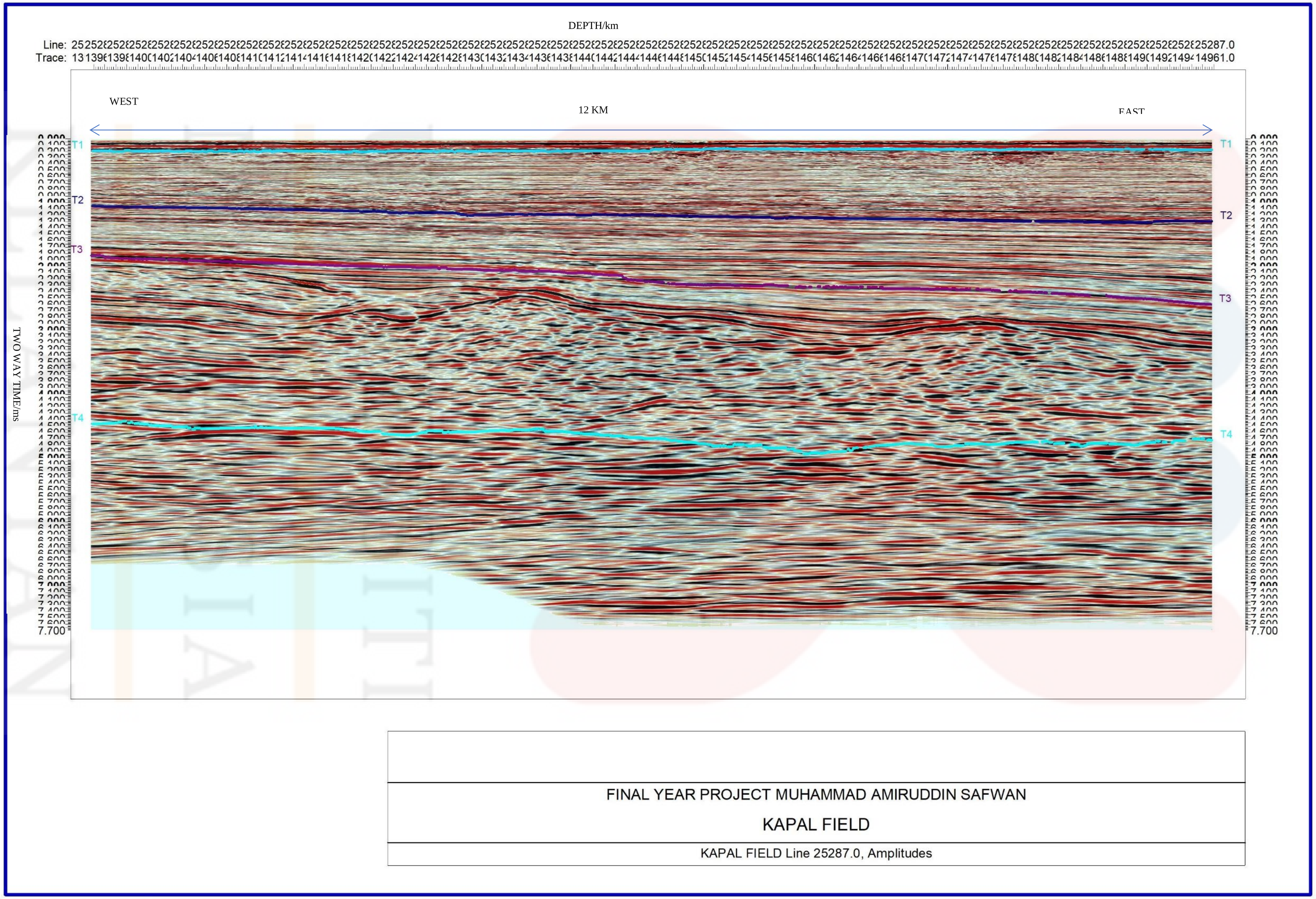

Figure 5.7: Seismic line IL 25287

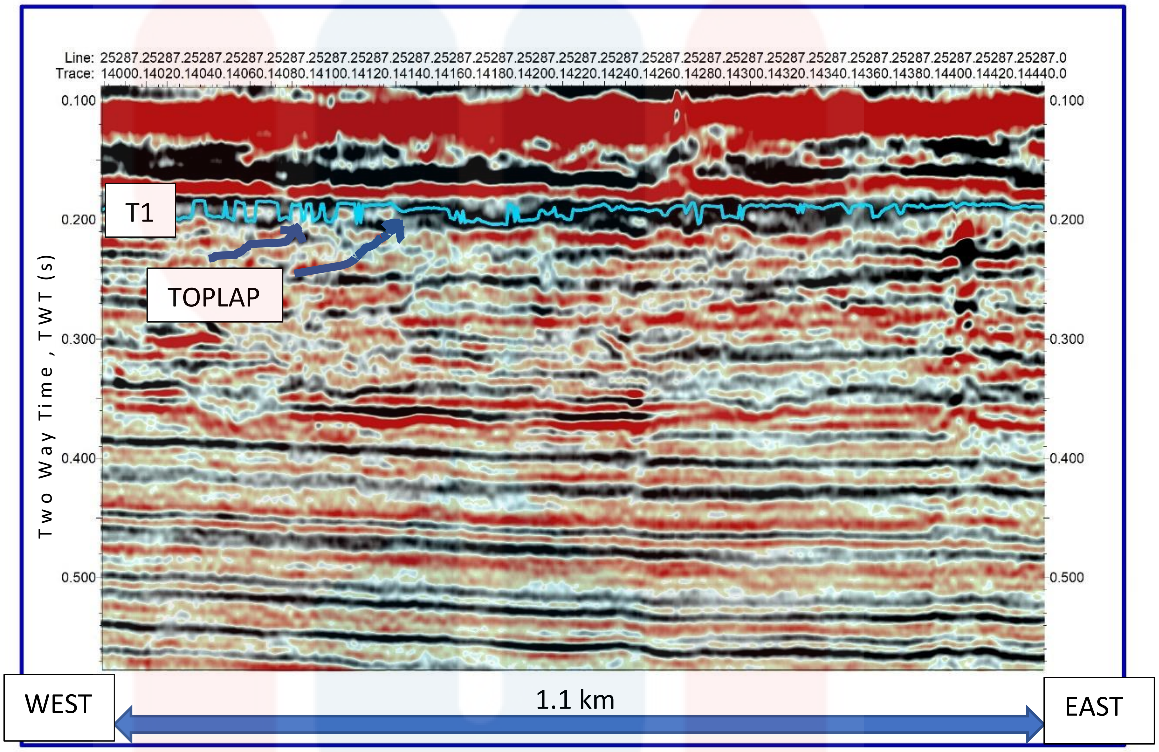

Figure 5.8: T1 boundary at IL 25287

Going down to 1.15 ms of two-way time (TWT) another boundary which is T2. Figure 5.9 shows the sequence boundary T2 with presence of onlap at the boundary which it terminates to the oldest strata. It terminates progressively against an initial incline surface. Besides that, toplap also seen at south east of the line.

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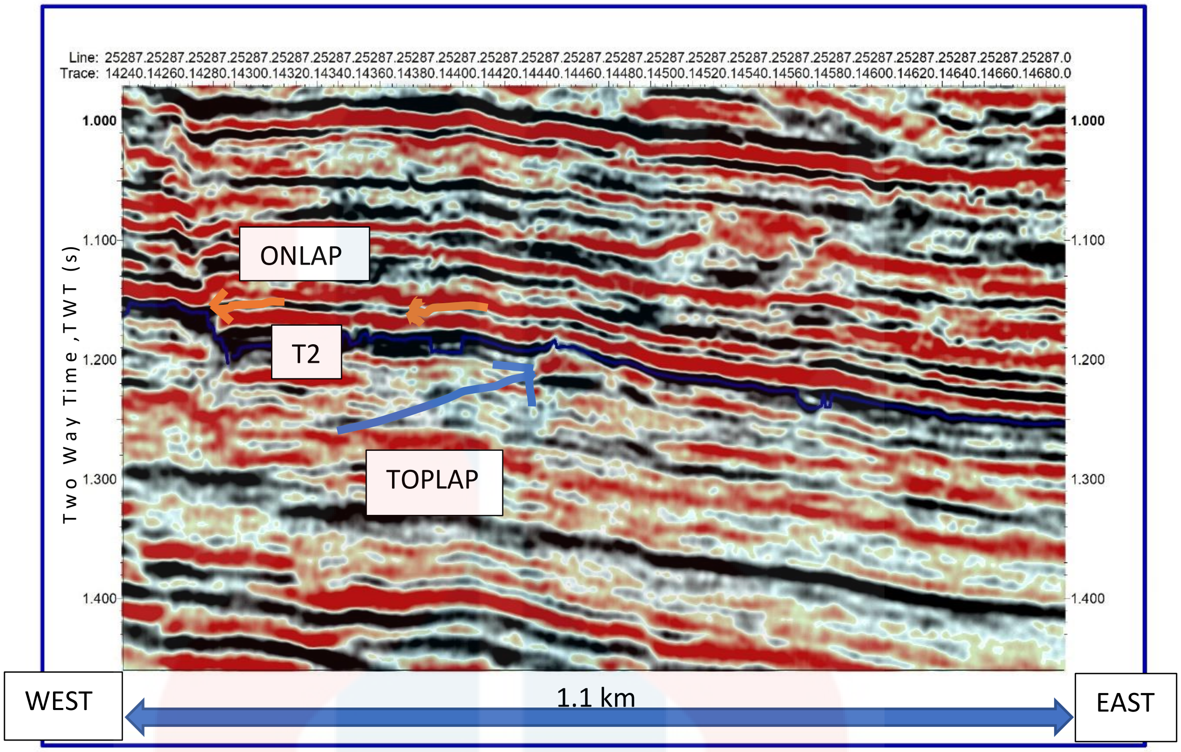

Figure 5.9: T2 boundary at IL 25287

T3 boundary can be seen at TWT 1.85ms. Figure 5.10 shows the sequence boundary T3 with presence of onlap at the boundary which it terminates to oldest strata which is T2. As mentioned above it terminates progressively against an initial incline surface.

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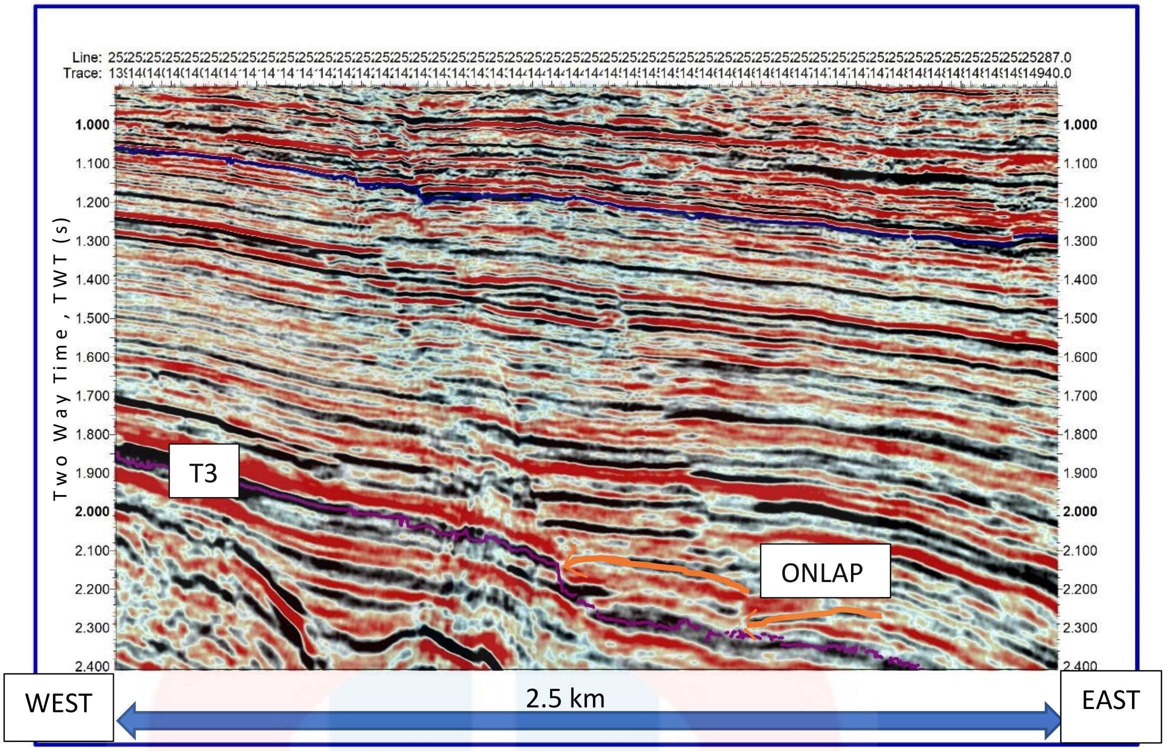

Figure 5.10: T3 boundary at IL 25287

Going down to 4.5 ms till the bottom which is 7.65 ms of two-way time (TWT) another boundary which is T4. Figure 5.11 shows the sequence boundary T4 with presence of downlap at the south west of the boundary. It terminates downdip against an initially horizontal surface. Looks at the south east of the line can saw toplap presence. It is believed that it undergoes transgressive system tract. As the rate of relative sea-level rise increases, it eventually outpaces the supply of sediment, leading to retrogradational stacking in the transgressive systems tract (TST). Retrogradational stacking is marked by well-developed flooding surfaces, that is, flooding surfaces with pronounced deepening. As a result, flooding surfaces within the transgressive systems tract are much

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more prominent than anywhere else in a depositional sequence. The first of these large flooding surfaces is called the transgressive surface, and it separates the underlying lowstand systems tract from the overlying transgressive systems tract. Also called the maximum regressive surface, it marks the most seaward reach of the shoreline within the sequence.

The rapid relative rise in sea level leads to the formation well-developed estuaries, and their trapping of sediment hinders the dispersal of sediment to the shelf. This starvation of sediment further promotes retrogradational stacking and commonly causes siliciclastic TST parasequences to be thin. This starvation of sediment also promotes the formation of features that indicate stratigraphic condensation, such as the formation of authigenic minerals, accumulations of marine fossils, unusually bioturbated horizons, and the formation of firmgrounds and hardgrounds.

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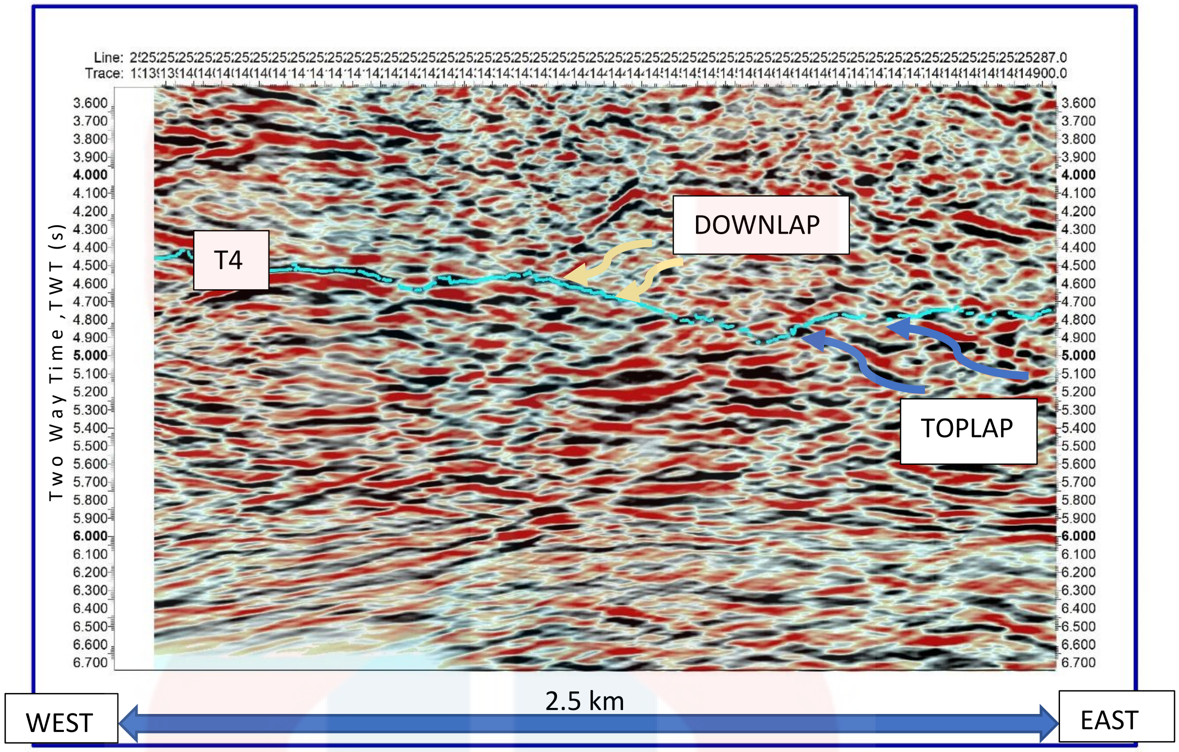

Figure 5.11: T4 boundary at IL 25287

5.2.3 Seismic Line Inline 25297

On the seismic line inline (IL) 25297 as show at Figure 5.12, the total 4 sequence boundaries were found same as IL 25287. In this point the obvious of downlap at T4 as show at Figure 5.13. It terminates at the oldest strata. It seen terminates towards to the south west of the line. While for toplap at the south east of the line it seen to terminates to the youngest strata at north west of the line. Others it same like IL 2527.

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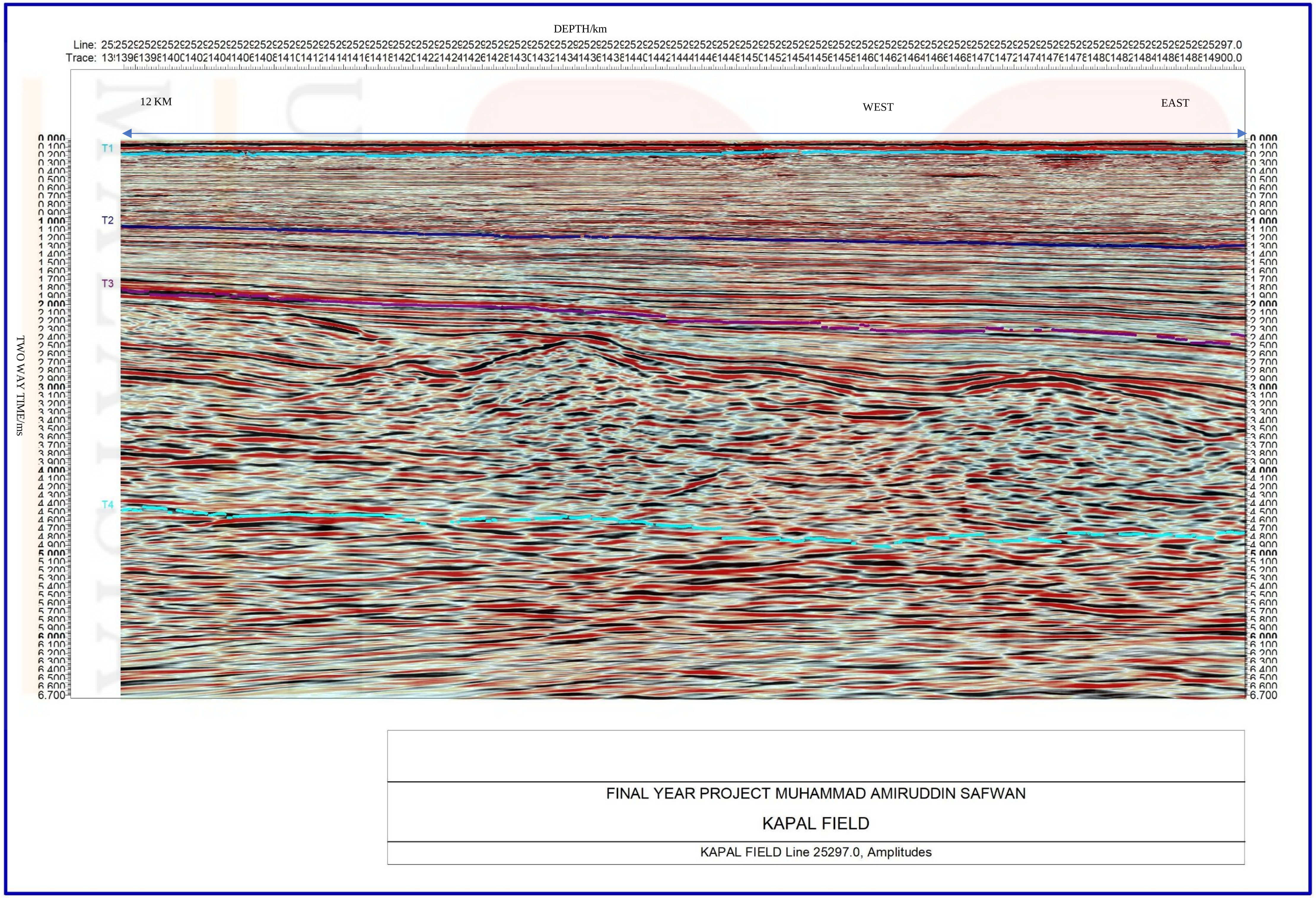

Figure 5.12: Seismic line inline (IL) 25297

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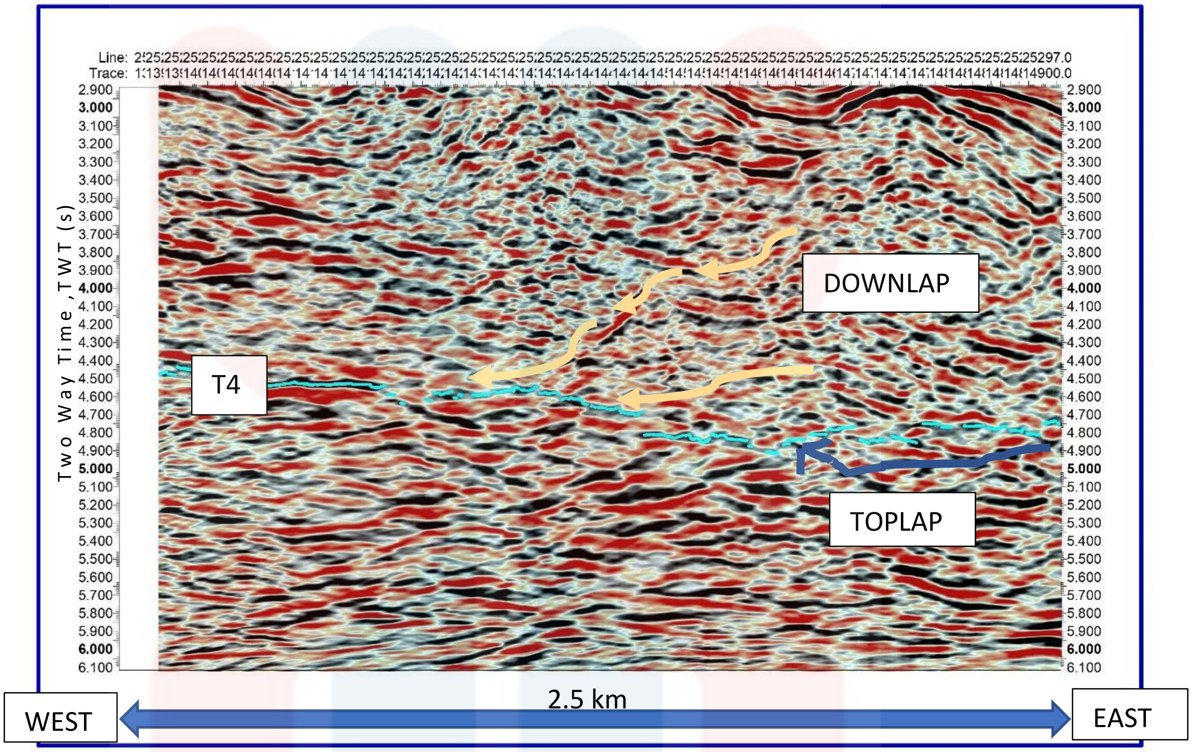

Figure 5.13: T4 boundary of IL 25297

5.2.4 Seismic Line Crossline 14144

The total of 4 sequence boundaries were seen. Figure 5.14 shows the boundary T1 which located at the above of line at TWT 0.18. Nearby the boundary seen onlap that towards the old strata below. Look through the seismic line for the crossline (CL) 14144 as show at Figure 5.15, the T2, T3 and T4 boundaries same like others and explained as below. Besides that, on south-west of the line toplap also seen at T1. Figure 5.16 shows the boundary for T2 at this line, it same like T1 where the onlap were seen.

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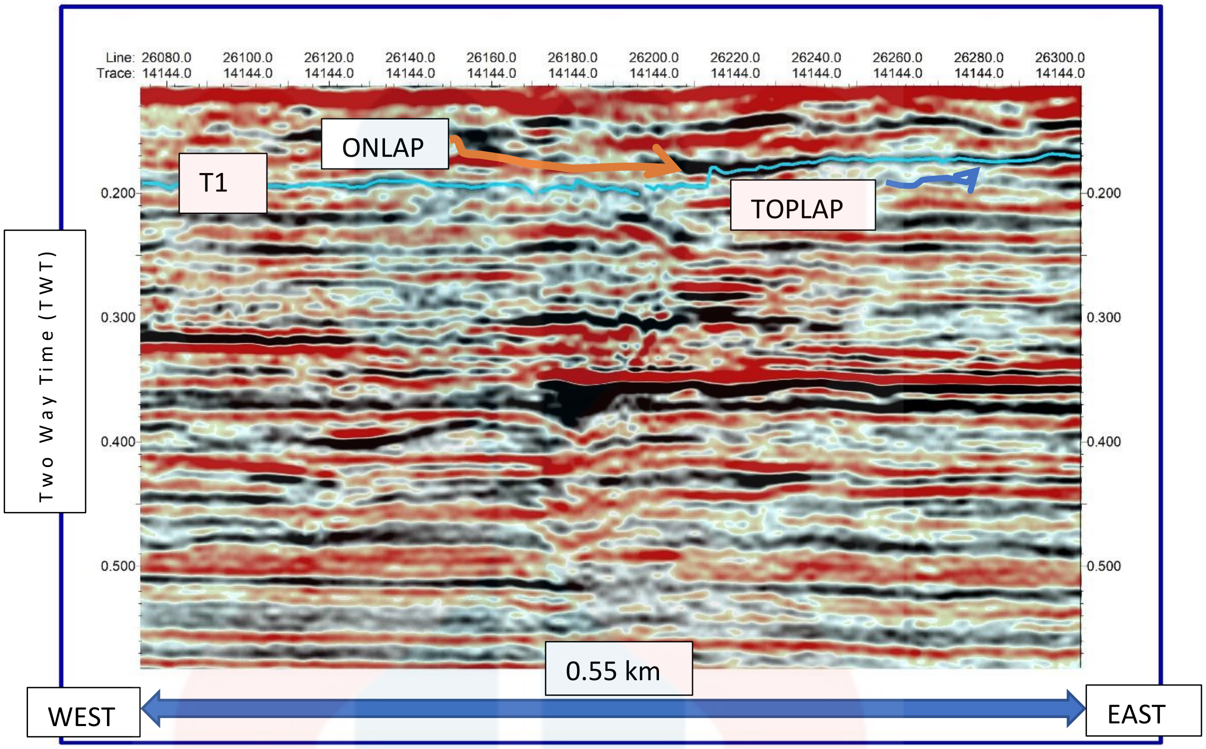

Figure 5.14: T1 boundary for CL 14144

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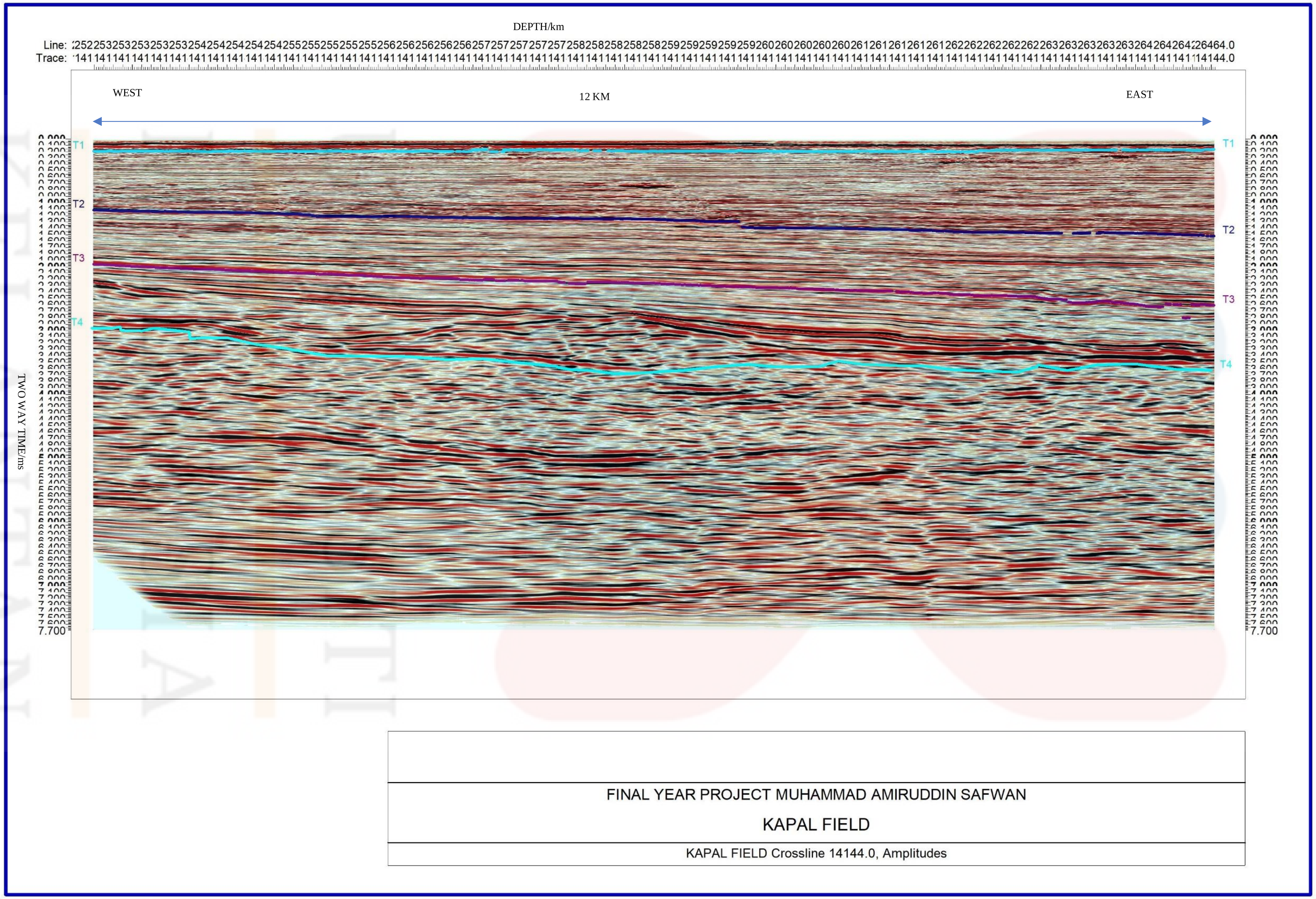

Figure 5.15: Seismic line for the crossline (CL) 14144

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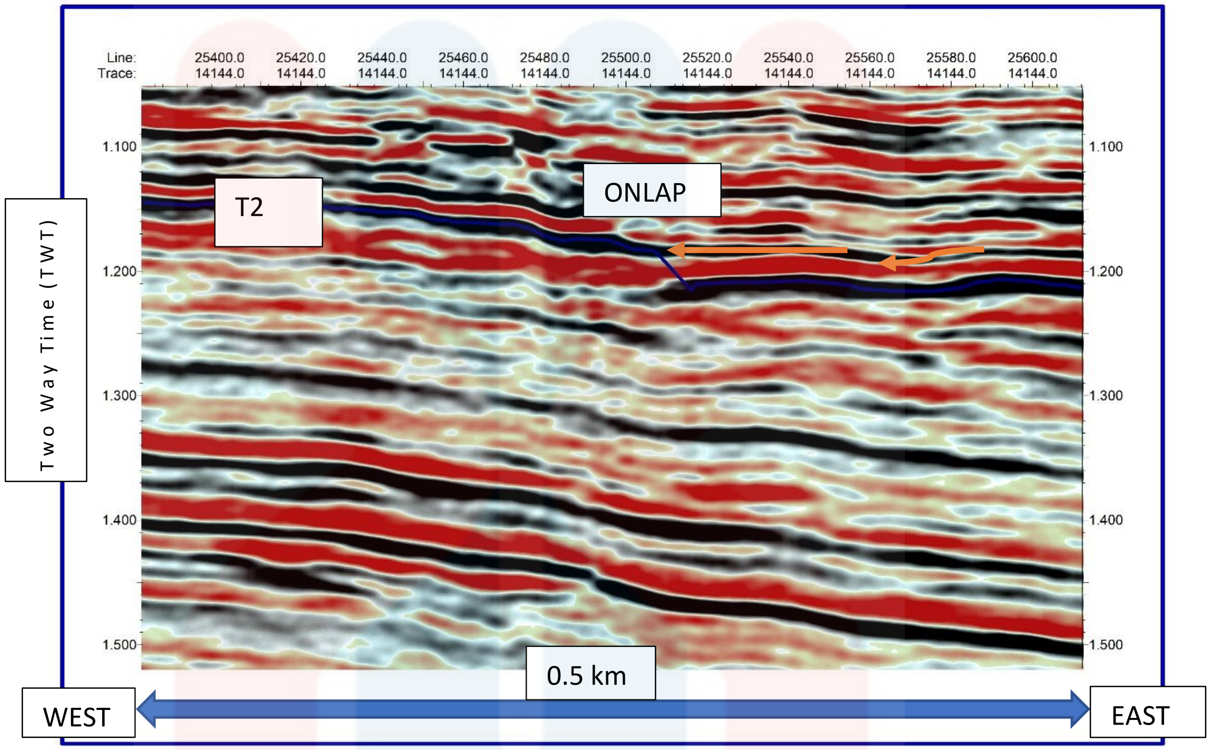

Figure 5.16: T2 boundary for CL 14144

Figure 5.17 shows the boundary for T3 at this line. Look through the boundary at TWT 2.0 ms seen downlap where the younger strata deposits lean towards the old strata. Figure 5.18 shows the T4 boundary and clearly seen the downlap at the boundary.

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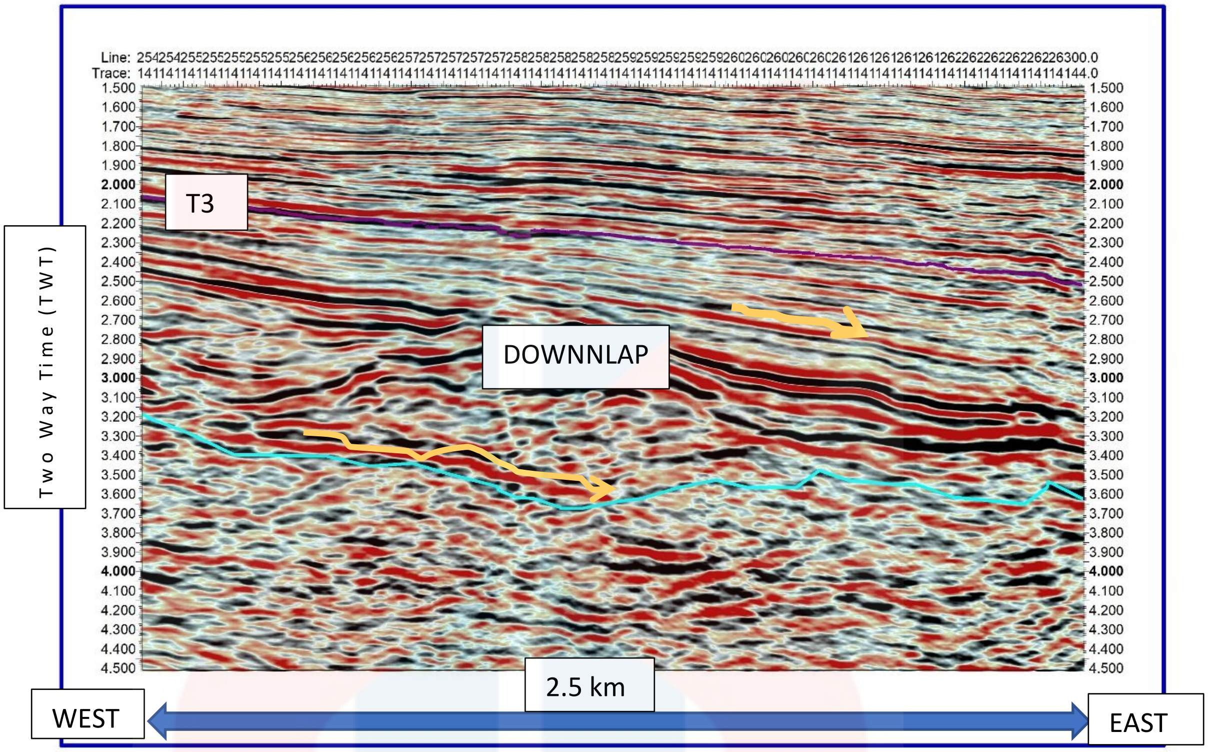

Figure 5.17: T3 boundary for CL 14144

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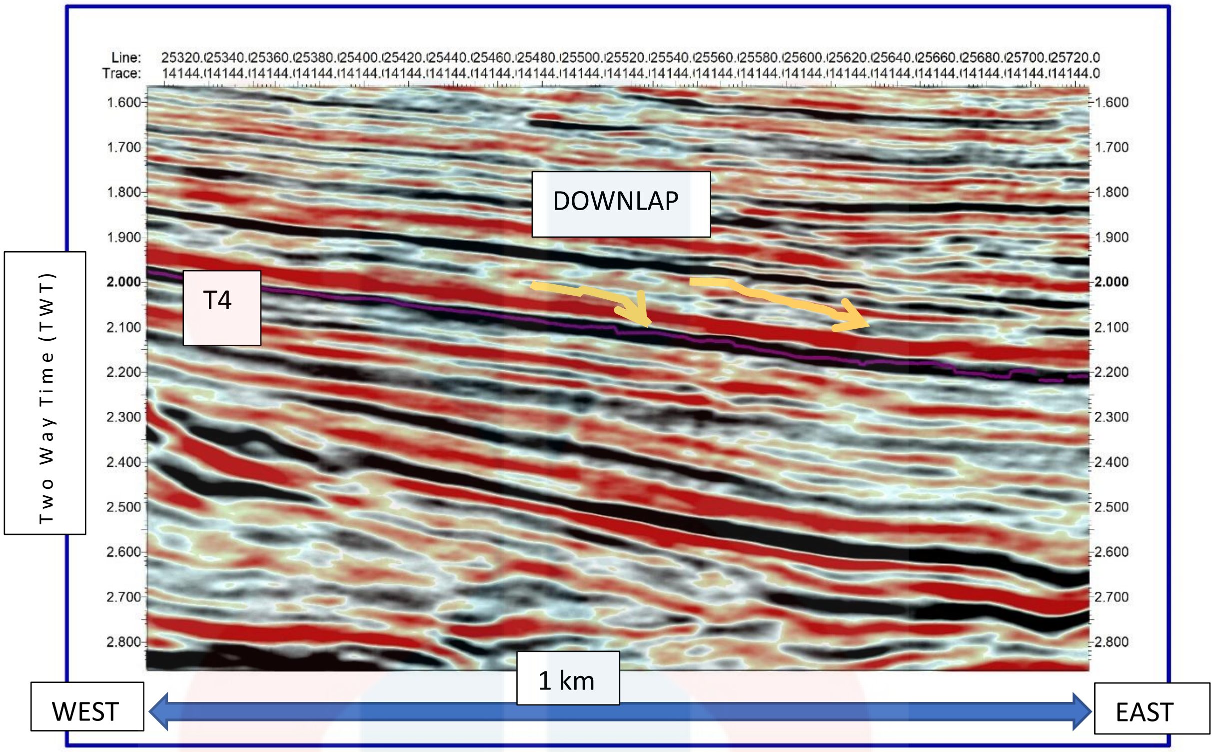

Figure 5.18: T4 boundary for CL 14144

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5.2.5 Seismic Line Crossline 14244

On the seismic line crossline (CL) 14244 as show at Figure 5.1, the total 4 sequence boundaries were seen. In this point the obvious of toplap at T1 as show at Figure 5.20. It terminates at the youngest strata. It seen terminates towards to the east of the line.

Figure 5.21 shows the boundary for T2 at CL 14144 which is at TWT 1.25 ms. Seen at this boundary is downlap where the younger strata deposits lean towards the old strata at TWT 1.35 ms. Figure 5.22 shows the boundary for T3 which at TWT 2.00 ms. Figure 5.23 shows the boundary for T4 which it lies at TWT 3.2 ms and seem to have downlap that lies on the boundary.

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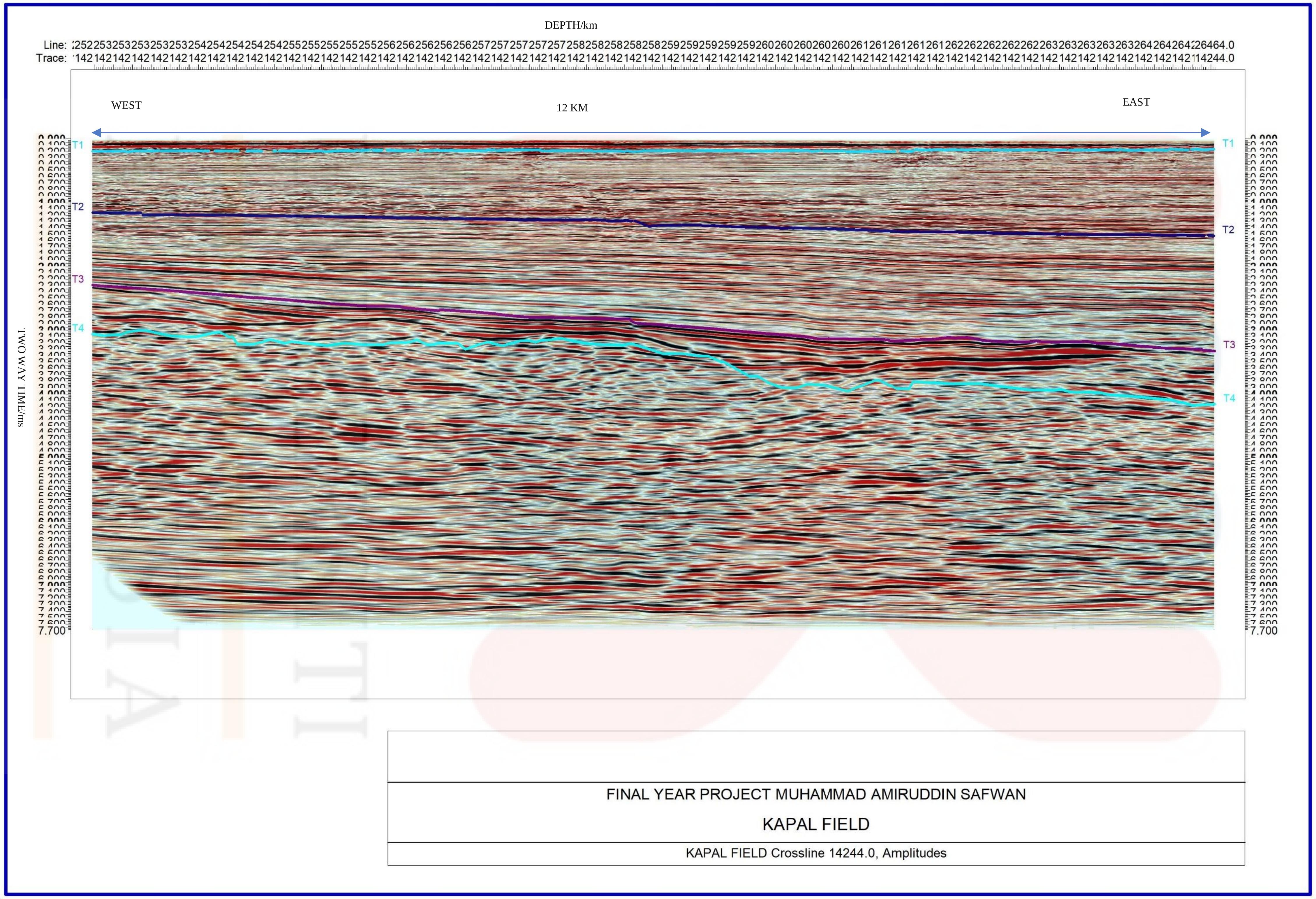

Figure 5.19: Seismic line crossline (CL) 14244

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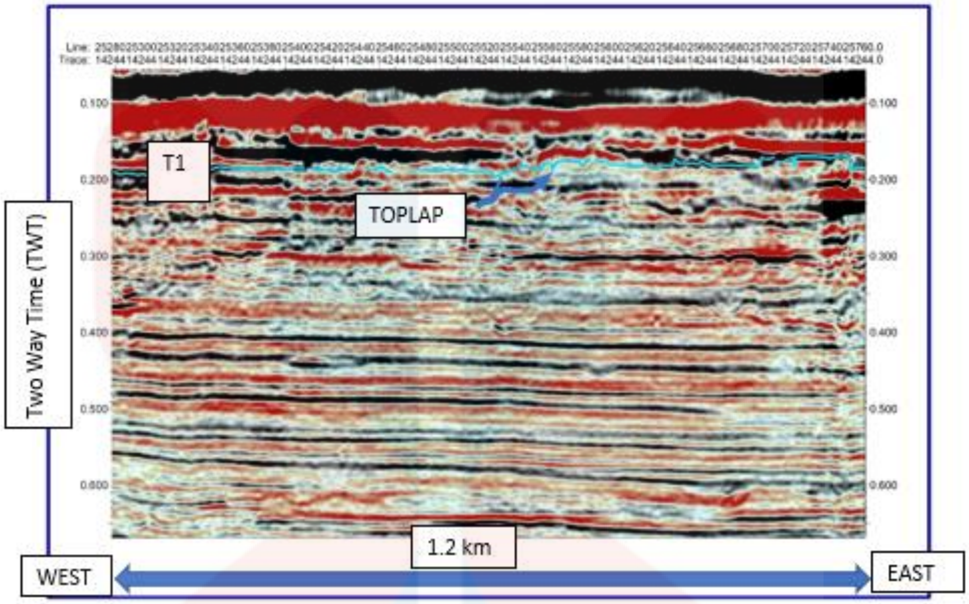

Figure 5.20: T1 boundary at CL 14244

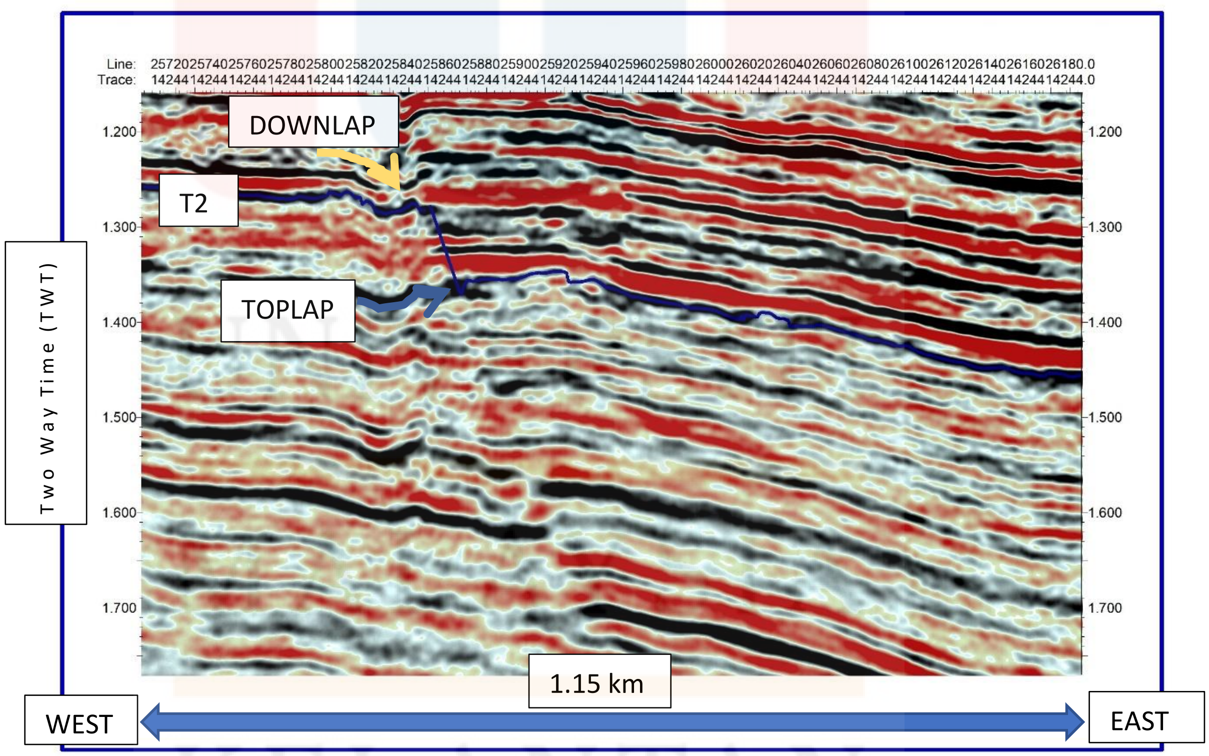

Figure 5.21: T2 boundary at CL 14244

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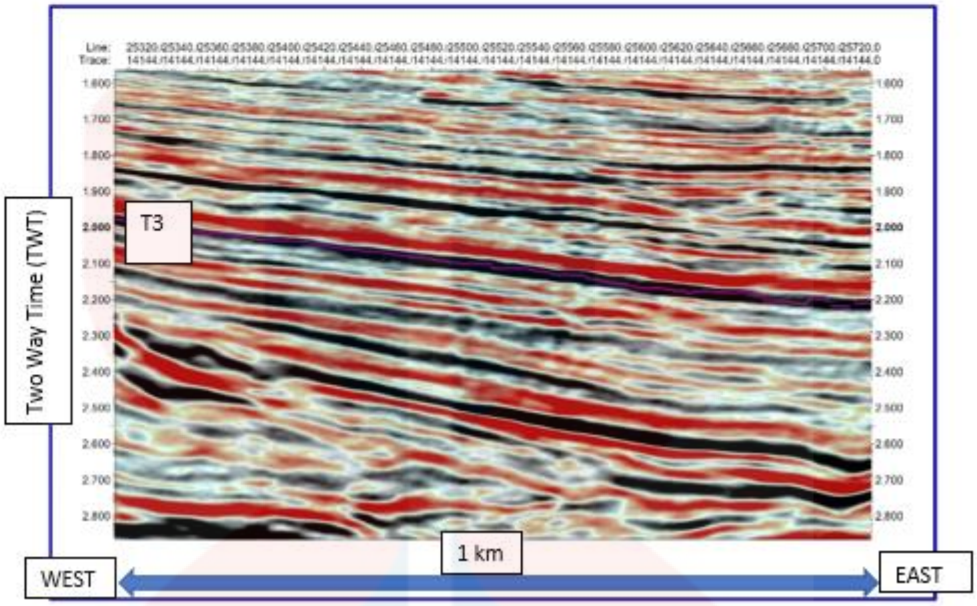

Figure 5.22: T3 boundary at CL 14144

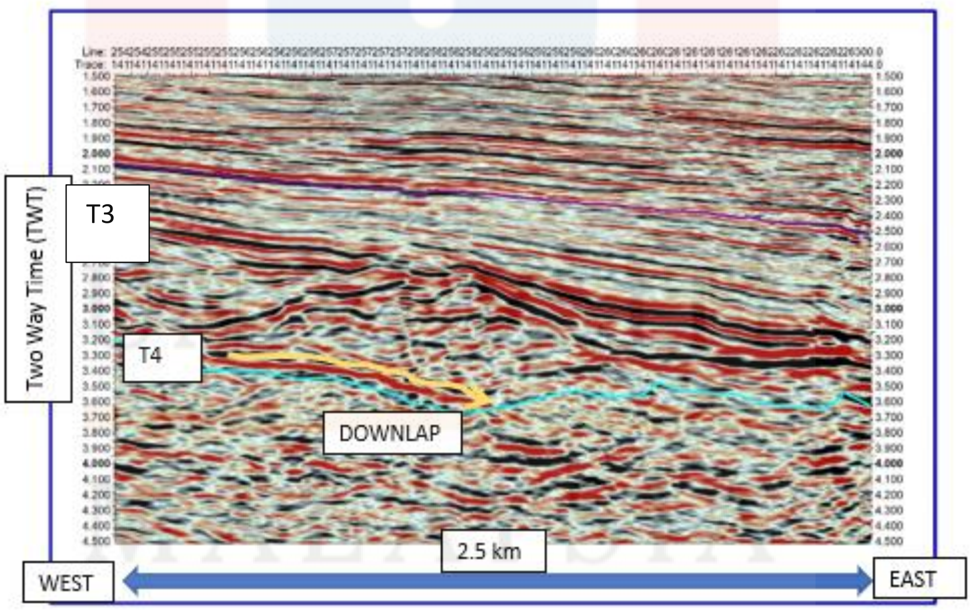

Figure 5.23: T4 boundary at CL 14244

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5.2.6 Seismic Line Crossline 13994

On the seismic line crossline (CL) 13994 as show at Figure 5.24, the total four sequence boundaries were seen. In this point the obvious of toplap at T1 as show at Figure 5.25. It terminates at the youngest strata. It seen terminates towards to the east of the line. Figure 5.26 shows the T2 boundary, at TWT 1.32 ms, nearby the boundary seen an onlap. According to the literature review these types of onlap represented as marine onlap.

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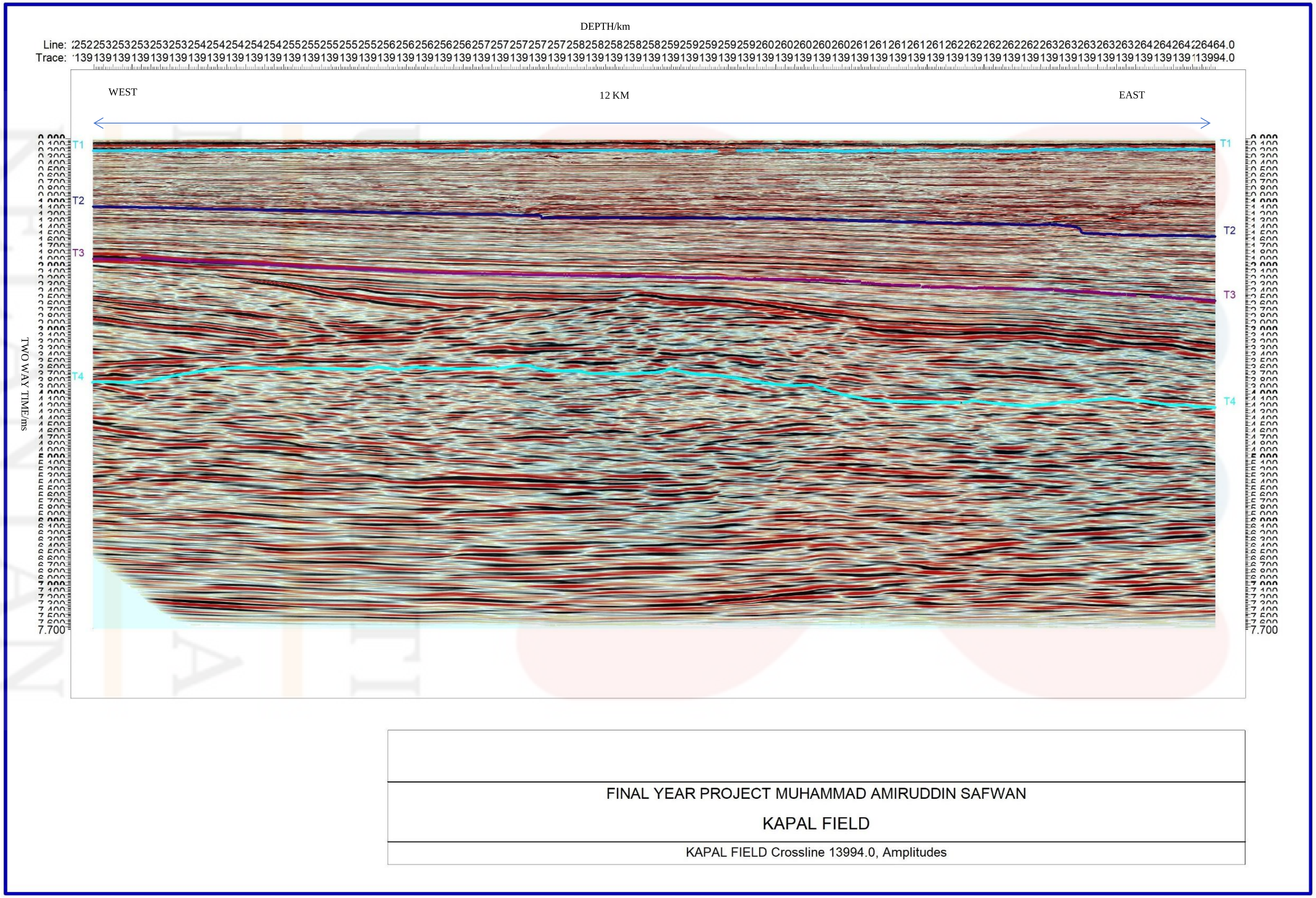

Figure 5.24: Seismic line crossline (CL) 13994

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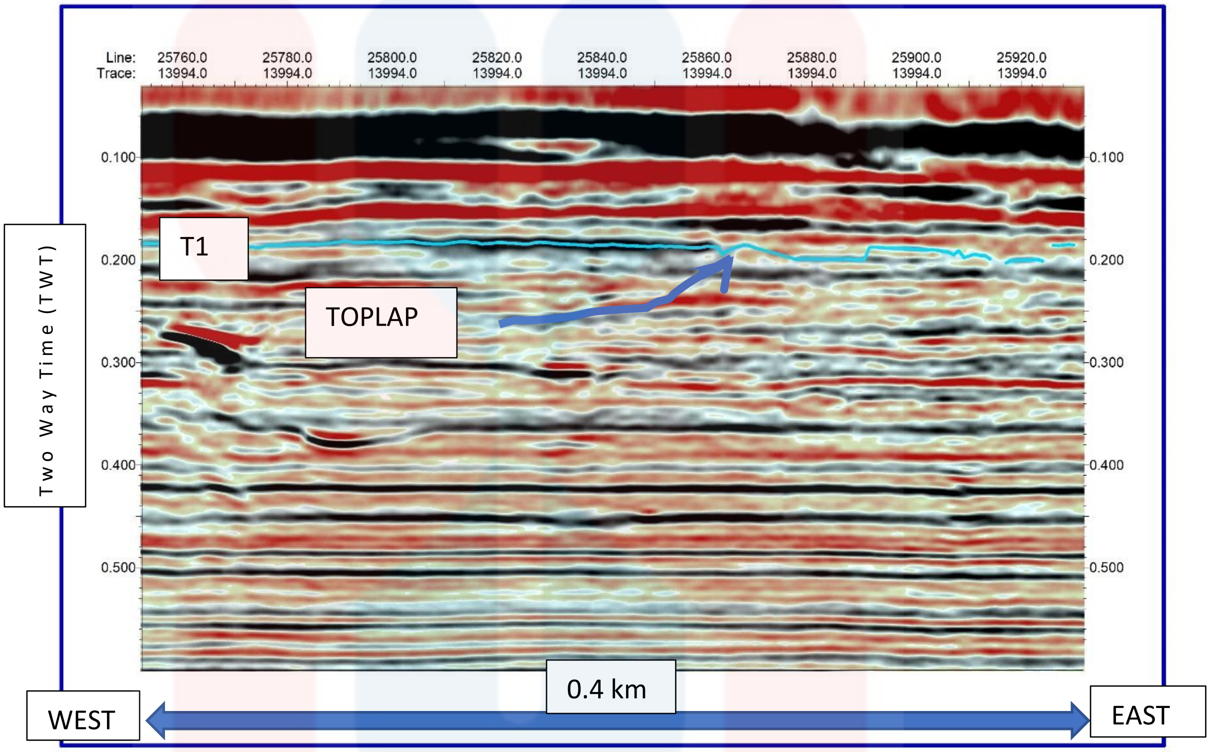

Figure 5.25: T1 boundary of CL 13994

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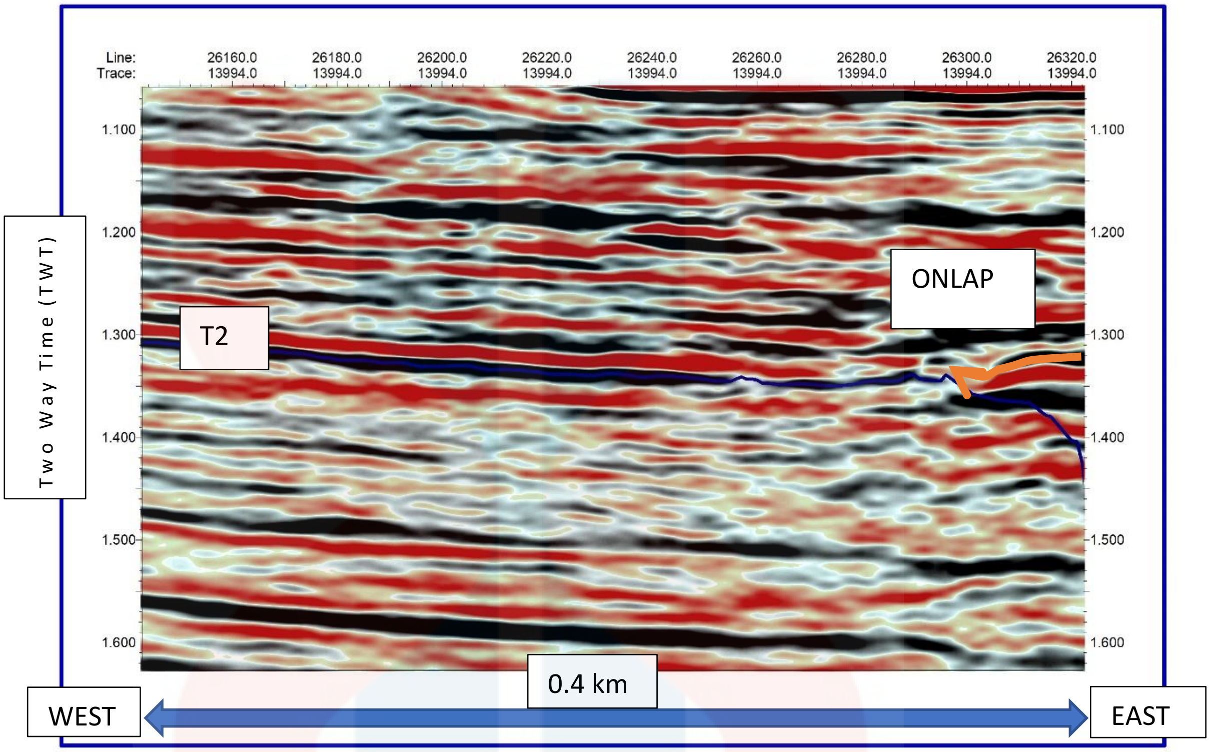

Figure 5.26: T2 boundary of CL 13994

Figure 5.27 shows the T3 boundary, at TWT 2.2 ms, present nearby the boundary is toplap, it is believed to represent a marine condensed unit. The toplap shows the clinoforms against an overlying lower angle surface. Figure 5.28 shows the T4 boundary, at TWT 3.6 ms. Present nearby the boundary are downlap from TWT 3.5 ms towards the T4 boundary.

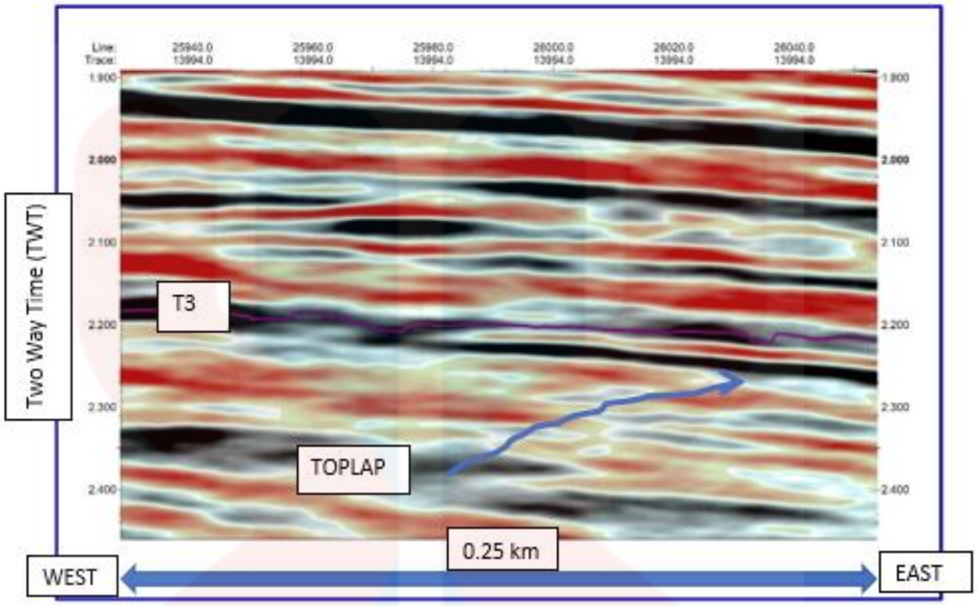

Figure 5.27: T3 boundary of CL 13994

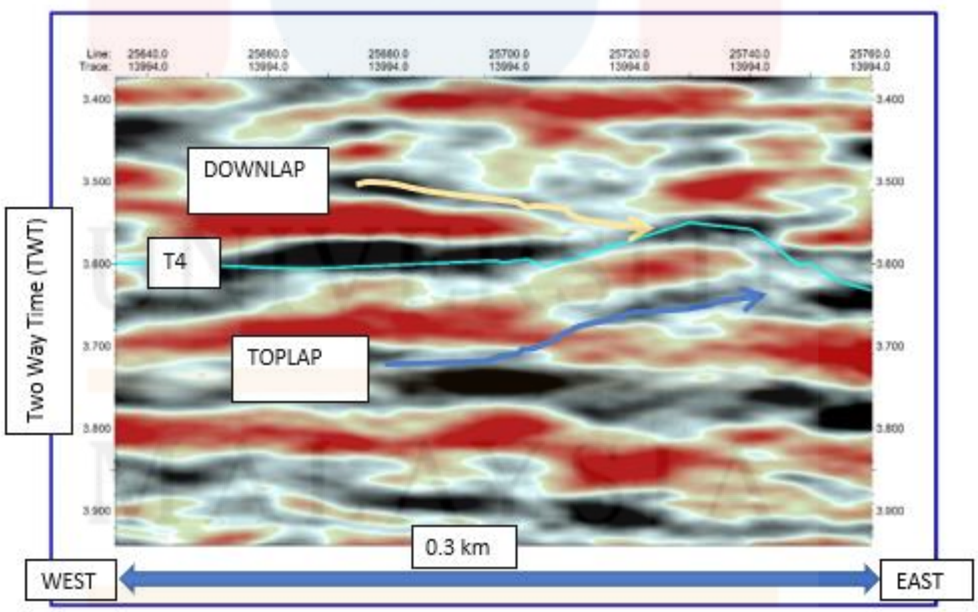

Figure 5.28: T4 boundary of CL 13994

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5.3 Structural Geology at The Kapal Field

Interpretation of seismic cross section for geological structures certainly requires detailed analysis, especially in fault interpretation and fold. However, the interpretation of this structure will only discuss the brief structure of the study area along the seismic survey line. Fault generally occurs when the cracks receive a fragile and elastic rock resulting in movement on the weak plane forming an unconformity to a sequence boundary. In the interpretation of seismic, fault can be determined by identifying the continuity of each reflection line formed. The non-homogeneity or non-linearity of a line give an information about the existence of such fault structures. However, the trend of the plane needs to be identified before the fault is chosen where the fault line on the seismic section must intersect at a non-homogeneous point on the other line. The fault will usually end in the event of another deposition that is visible on the seismic section and will also stop at the other fault line.

For fault interpretations, the selected seismic line is located at a distance of less than 2km between a seismic survey which usually gives the same fault plane along the parallel line. Based on previous studies, the structure of the study area is very complex as there are some structure of aggregation and fault that are difficult to interpret. The fault plane orientation around this study is complex but the normal fault usually dominates the fault trend in this Kapal Field from various directions. A normal fault is formed when a sliding block falls along the fault plane. The drop block is known as graben.

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The structure that involved at the Kapal Field area is very significant with the presence of anticlines, syncline and fault. Figure 5.29 shows the structure available at the Kapal Field. By the presence of the structure, it one of the indicators of the hydrocarbon presence at the area.

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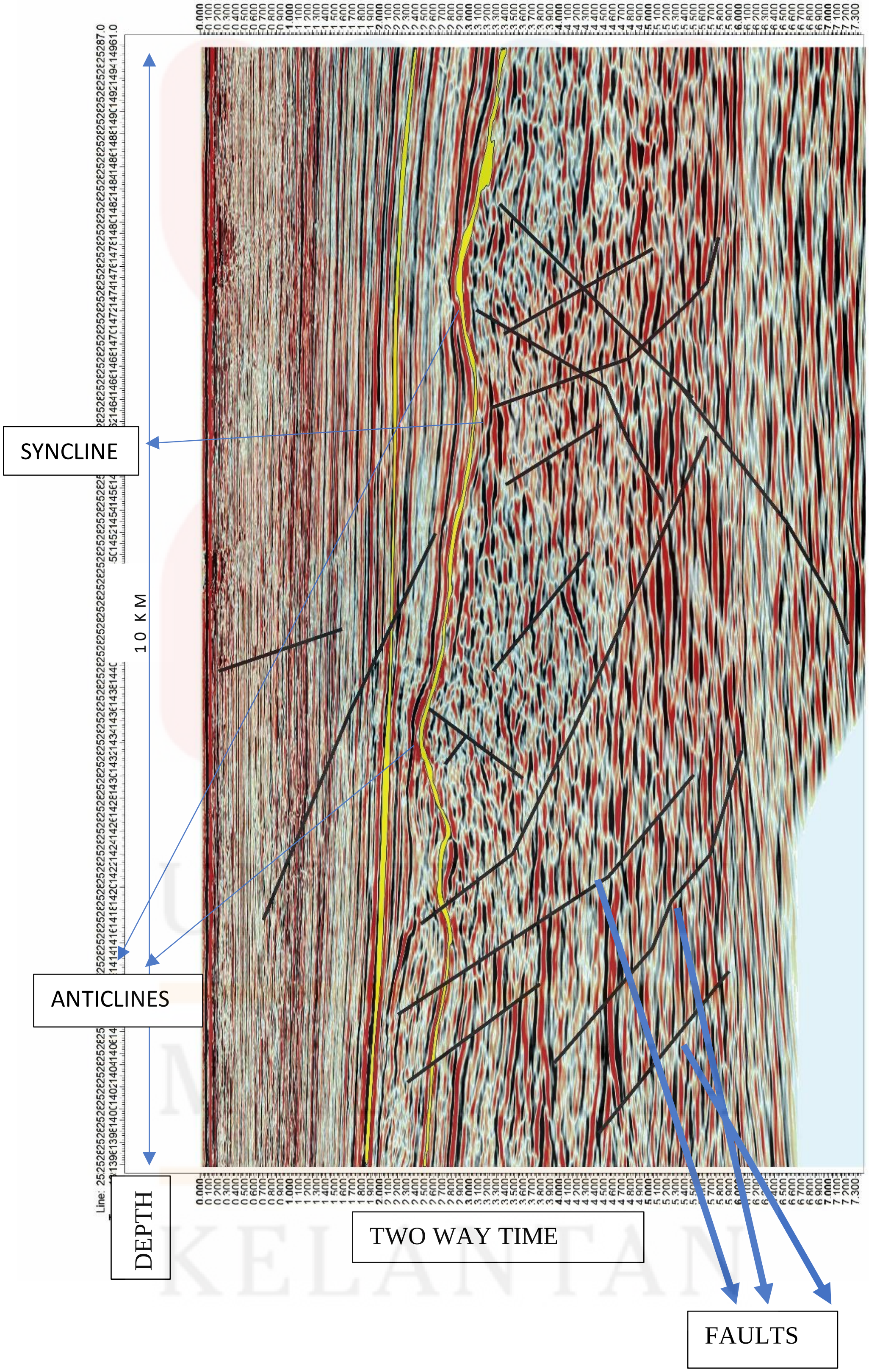

Figure 5.29: Structure available at Kapal Field

5.4 Seismic Facies Available at Kapal Field

Seismic facies analysis is an interpretation used to determine sediment sequence units generally through polar and patterns indicated in the seismic cross section. Next, the interpretations may reflect the geometry of the geological bodies, the type of stratification, the geological environment, the deposition process, the direction of sedimentation and so on. In general, the seismic facies that being described for the basin area can be classified into several series of facies such as parallel and sub-parallel, wavy, facies that reach out to south-east and chaotic.

Reflect facies can be seen prominently in every sequence. Parallel and semi-parallel facies consist from high amplitude to low amplitude. It also has moderate to high continuity. Moved to the bottom the frequency decreasing and amplitude decreased from high to moderate and finally low amplitude.

Wavy facies can be seen at the middle of the line in the survey, where it has high amplitude, high continuity and regularly spaced reflectors. In addition, it shows an asymmetrical in cross section. Furthermore, polar of the reflection that reach out to the south east with high amplitude also seen at the study area. After that, some of the reflector polar looks chaotic with a variable amplitude. Figure 5.30 shows the four major facies at the study area. Besides that, there are possibility the study area has a presence of gas because it has chaotic facies due to the gas gave an error to a wave. Amplitude analysis is particularly important in hydrocarbon exploration which can be indicative of the existence of hydrocarbon by looking at bright-spot or flat-spot amplitude anomalies.

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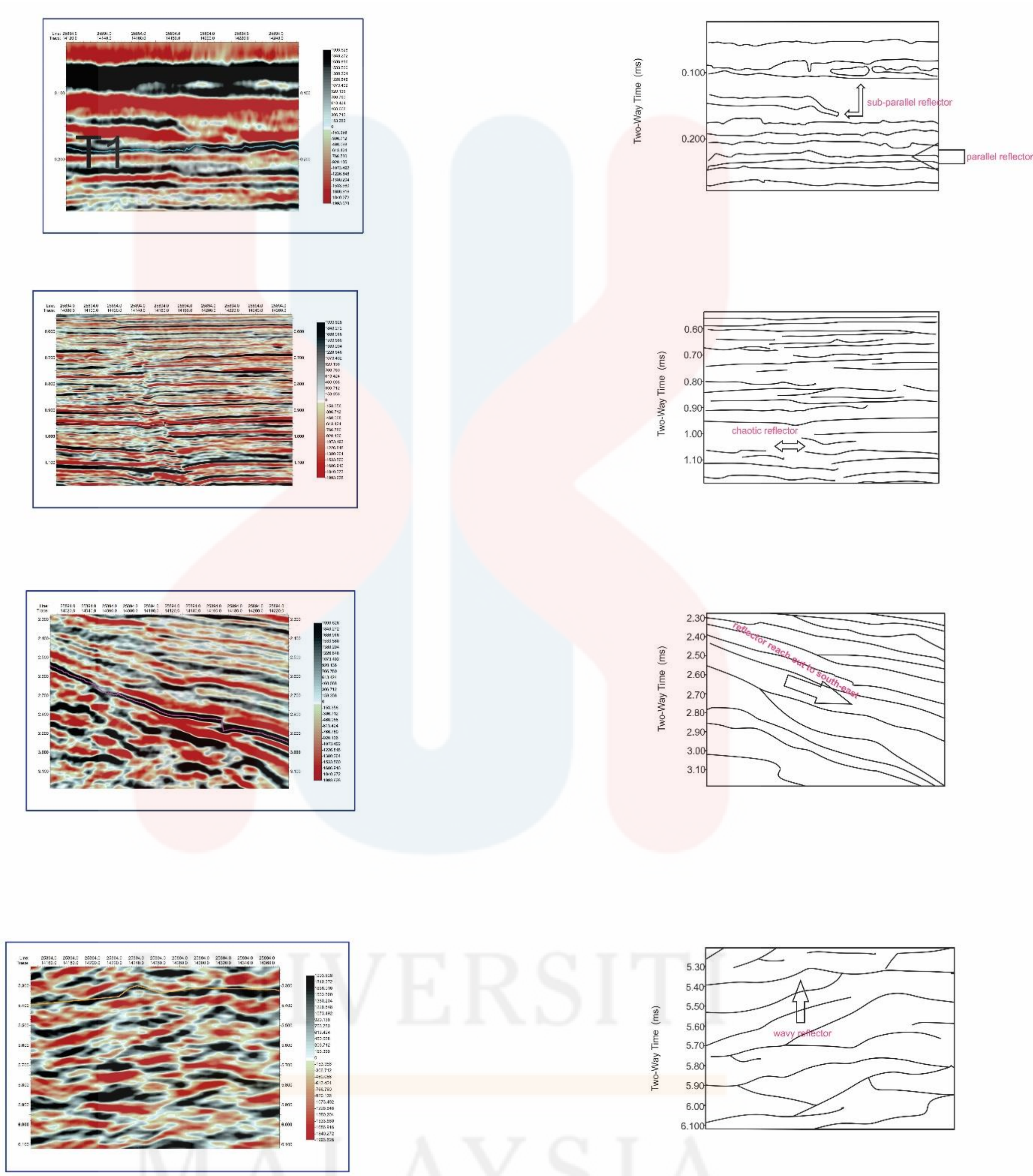

Figure 5.30: Major facies at the study area

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5.5 Analysis of Fluvial Channel

Malay Basin consists of up to 8 km thick of filling during or after the expansion at the age of Oligocene – Miocene until Pliocene. The youngest strata at the age Miocene to Pliocene that occur after the basin formation are dominated by thick sediments that up to 5 km with a depositional environment from coastal plain and coastal depositions that occur in tropical- moist climate. The fluvial of sandstone can be a good oil reservoir for hydrocarbon. In exploration, the study of the origin and distribution of sandstone fluvial channel is increasing.

In this section will explain in general the characteristics of seismic reflection that shows changed of morphology in river system and fluvial channel. The presence of the channel it shows at time slices (0.1 seconds until 0.6 seconds). Time slices are seismic sections viewed from a horizontal view. In this study, the attribute used is the amplitude attributes. Figure 5.31 shows the seismic section inline 25894 after the interpretation had been done. The total of two boundaries are marks to shows different seismic unit. This shows at least 2 episodes increasing and decreasing sea level on this sequence.

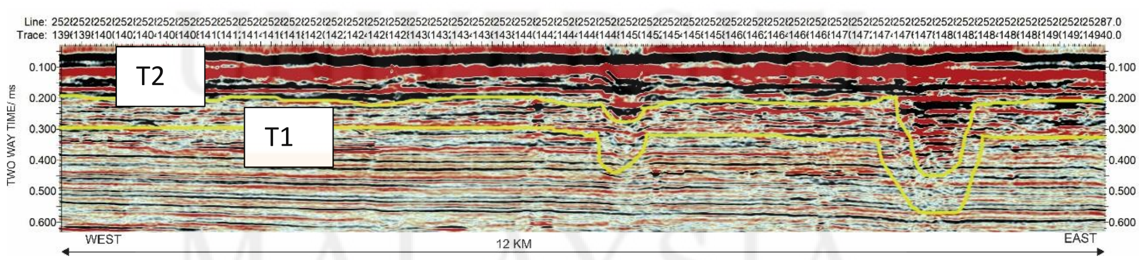

Figure 5.31: Seismic section inline 25894 after the interpretation

T1 boundaries located at the bottom and oldest while T2 at the top is youngest. In general, the channel shape oldest wider and lower sinuosity. It gradually become narrower and relatively high sinuosity on youngest channel. This is the results from the sea level change cycle. During sea level rise, the channel may change in size and geometry. It also become more highly sinuous with the formation of a deep shelf. As the sea level begins to decreasing, the channel flow becomes narrower. When the sea level is low the river flows and carrier's sediment until it is deposits at the downstream.

5.6 Potential Hydrocarbon at The Kapal Field

According to the facies analysis that had been done and structural that presence at the field, this field have a potential hydrocarbon. This can be look through the indicators of the hydrocarbon such as anticline ad syncline. The facies analysis show that the bright spot or flat spot at the seismic survey. In addition, according the presence of chaotic reflectors it maybe also associated with gas at the field.

A bright spot is a high amplitude (high reflectivity) seismic attribute anomaly that indicates the presence of gas (or 'soft' oil) in seismic data, which has a significantly lower velocity than in a brine-saturated rock. When water sand has lower acoustic impedance than its embedding shale, changing the water in the pores to hydrocarbon increases the sand–shale impedance contrast, and as a consequence increases the seismic reflection amplitude, which results in a bright spot. A seismic wave travels slower in oil than in pore water, but the difference is not always enough for a bright spot to be noticeable on the seismic section. Luckily, where there is oil, there is usually either saturated gas or gas on top, so bright spots are useful in oil exploration.

A flat spot is a seismic anomaly that appears as a horizontal reflector on a seismic section. Flat spots will occur when there is a contact between oil, gas and water in a limited area and the surrounding reflectors are not flat. The flat spot in itself is not

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an amplitude anomaly, but since the contact is often associated with gas, the area can contain a bright spot (Figure 5.32). Flat spots can occur when hydrocarbon-saturated sand with a lower acoustic impedance overlies water-saturated sand with a higher acoustic impedance. The flat spot is noticed at the hydrocarbon–water contact. This is always a hard reflector, with a positive reflection coefficient. The flat positive reflection is visible on a seismic section because it is flat in depth and will contrast with the surrounding dipping reflections.

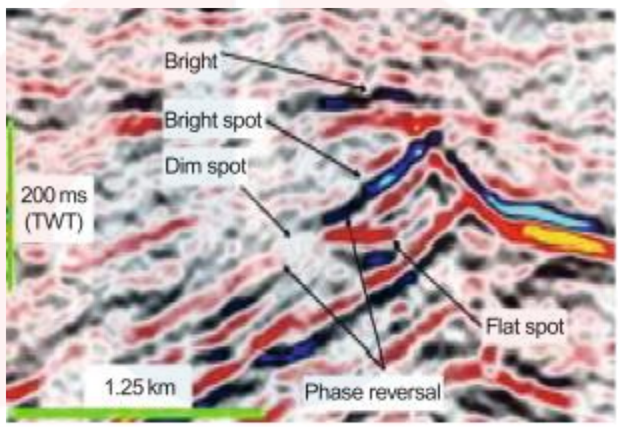

Figure 5.32: Flat spot at the Kapal Field

After that, the chaotic reflector as an indicator because by the presence of the gas it disturbs the wave and it became an error. In addition, the structural analysis also shows it have the characteristic as hydrocarbon trap. After done and correlate all analysis, it can be assumed that the hydrocarbon potential located at in between T2 and T4 boundaries since all indicator presence at that location.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

After the research had been done, the conclusion of the research that the objective is to update the geological map of Mukim Rusila, Marang, Terengganu with scale 1:25000 being successful fulfil. A geological mapping been done for around two weeks being conducted at the study area. According to the field data and petrography analysis that has been done, there are four lithologies that are found which is alluvium, mylonite, phyllite and schist. In addition, the geological structure are chevron fold, normal fault and vein.

Next, the objective for this research is to identify the hydrocarbon potential at the Kapal Field, Terengganu Offshore. According to the facies analysis that had been done and structural that presence at the field, this field have a potential hydrocarbon. This can be look through the indicators of the hydrocarbon such as anticline ad syncline. The facies analysis show that the bright spot or flat spot at the seismic survey. In addition, according the presence of chaotic reflectors it maybe also associated with gas at the field. Based on the assumption made by researcher, hydrocarbon potential is in between T2 and T3 boundaries at the study area.

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6.2 Recommendations

After the completion of this research, it is recommended for the next researcher to study about the mylonite in depth by conducting the structural geology study at the study area. In addition, based on regional geology of Terengganu area, it is suggesting for the research to study the potential of hydrocarbon onshore at Terengganu area. This study can help to boost the economic for the country while provide an information for academic purpose.

Next, Kapal Field is one of the big locations, this research not cover all of the area of Kapal Field. So that, the further study and upcoming research may continue to cover the Kapal Field. In addition, the study area also needs an extensive study on a detailed seismic stratigraphy and structural geology due to this research have a limitation of resources. In order to get a clear view of area hydrocarbon reservoir.

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