GEOLOGY OF KAMPUNG BANGGUL, PERMAISURI, TERENGGANU AND IDENTIFICATION OF HYDROCARBON POTENTIAL AT BUNDI FIELD, TERENGGANU OFFSHORE.

by

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A report submitted in fulfillment of the requirements 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 KAMPUNG BANGGUL, PERMAISURI AND SEISMIC INTERPRETATION OF BUNDI 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 Kampung Banggul, Permaisuri, Terengganu and Seismic Interpretation of Bundi Field of Terengganu Offshore

ABSTRACT

Kampung Banggul is located at Permaisuri, Terengganu, where the area is famous for it is igneous, sedimentary and metamorphic rock. The objectives of the research at this area are to update geological map of Kampung Banggul, Permaisuri, Terengganu with a scale 1:25000 and to identify the hydrocarbon potential at Bundi Field, Terengganu Offshore. The mapping method in Kampung Banggul uses several methods of analysis like geomorphology, structural geology, petrography, stratigraphy and lithology. In Kampung Banggul, the types of rock that have are claystone and quartzite. Next, for the Bundi Field, a part of Malay Basin is located offshore Terengganu (Malaysia). The seismic sequence also has become focus of extensive and the main target of hydrocarbon exploration in this area. As a result of this research at Bundi Field, structural geology, sequence boundary, seismic facies and seismic pattern have been identified using Kingdom Software 2021. Lastly, the research area can be said have a potential hydrocarbon based on the structural that have been found within the study area like faults and anticline structure. Most of the hydrocarbon potential also is found in SB 3 and SB 4.

Geologi Kawasan Kampung Banggul, Permaisuri, Terengganu dan Tafsiran Seismos di Wilayah Bundi, Lepas Pantai Terengganu.

ABSTRAK

Kampung Banggul terletak di Permaisuri, Terengganu, di mana kawasan tersebut terkenal dengan kawasan batuan igneus, sedimen dan metamorf. Objektif kajian di kawasan ini adalah untuk mengemaskini peta geologi Kampung Banggul, Permaisuri, Terengganu dengan skala 1:25000 dan mengenal pasti potensi hidrokarbon di Lapangan Bundi, Luar Pesisir Terengganu. Kaedah pemetaan di Kampung Banggul ini menggunalan beberapa cara analisis seperti geomorfologi, geologi struktur, petrografi, stratigrafi dan litologi. Di Kampung Banggul, jenis batuan yang ada ialah batu lempung dan kuarzit. Jenis saliran yang terdapat di Kampung Banggul adalah corak jejari and dendritik. Seterusnya, untuk Lapangan Bundi, sebahagian daripada Lembangan Melayu terletak di luar pesisir Terengganu (Malaysia). Jujukan seismik juga telah menjadi tumpuan meluas dan sasaran utama penerokaan hidrokarbon di kawasan ini. Hasil daripada penyelidikan di Lapangan Bundi ini, geologi struktur, sempadan jujukan, fasies seismik dan corak seismik telah dikenalpasti dengan menggunakan Kingdom Software 2021. Akhir sekali, kawasan kajian boleh dikatakan mempunyai potensi hidrokarbon berdasarkan struktur yang telah ditemui dalam kawasan kajian seperti sesar dan struktur lipatan. Kebanyakan potensi hidrokarbon adalah terdapat di SB 3 dan SB 4.

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CL	Crossline
IL	Inline
GIS	Geospatial Information System
GPS	Global Positioning System
HCL	Hydrochloric acid
PETRONAS	Petroliam Nasional Berhad
PPL	Plane Polarized Light
SB	Sequence Boundary
T-Z	Time-depth
UMK	Universiti Malaysia Kelantan
XPL	Cross Polarized Light

CHAPTER 1

INTRODUCTION

1.1 Research Background

The study of geophysics focuses on the portion of the earth that cannot be seen with the unaided eye. Exploration of the Earth's interior utilizing physical properties observed at or above the surface of the Earth, as well as mathematical models to forecast such qualities is one focus. Sub-disciplines include seismology, geomagnetism and geodesy. Seismology is important for understanding large-scale Earth structure and earthquake behavior (Wheeler, 2014).

Other than that, mineralogy, density and other physical parameter at depth are derived via mineral physics experiments and mathematical modelling. Seismic survey data will be combined with other geophysical data, such as geological data and well log data provide the information on distribution of rock types and structure found below the surface of the earth.

1.2 Research Area

1.2.1 Location

The research areas have two locations which are Kampung Banggul, Permaisuri, Setiu Terengganu and Bundi Field Terengganu Offshore. Kampung Banggul, Permaisuri, Setiu, Terengganu with coordinate $5^{0}33'09.18''$ N, $102^{0}47'12.80''$E is the first location. The elevation is 18m and the imagery date is 7 October 2021. The study area will cover about $25km^2$. The study area dimension is about 5x5 km. Figure 1.1 shows the basemap of the research area.

The Malay Basin includes Terengganu Offshore. While Peninsular Malaysia's east coast in southern Thailand and the Terengganu coast encircle the Malay Basin. The Peninsular Malaysia and Vietnam, it is bordered Malay Basin is an estimated 100000 km^2 in size. The Malay Basin, Terengganu Offshore or more particularly Bundi Field, is where the research area is situated.

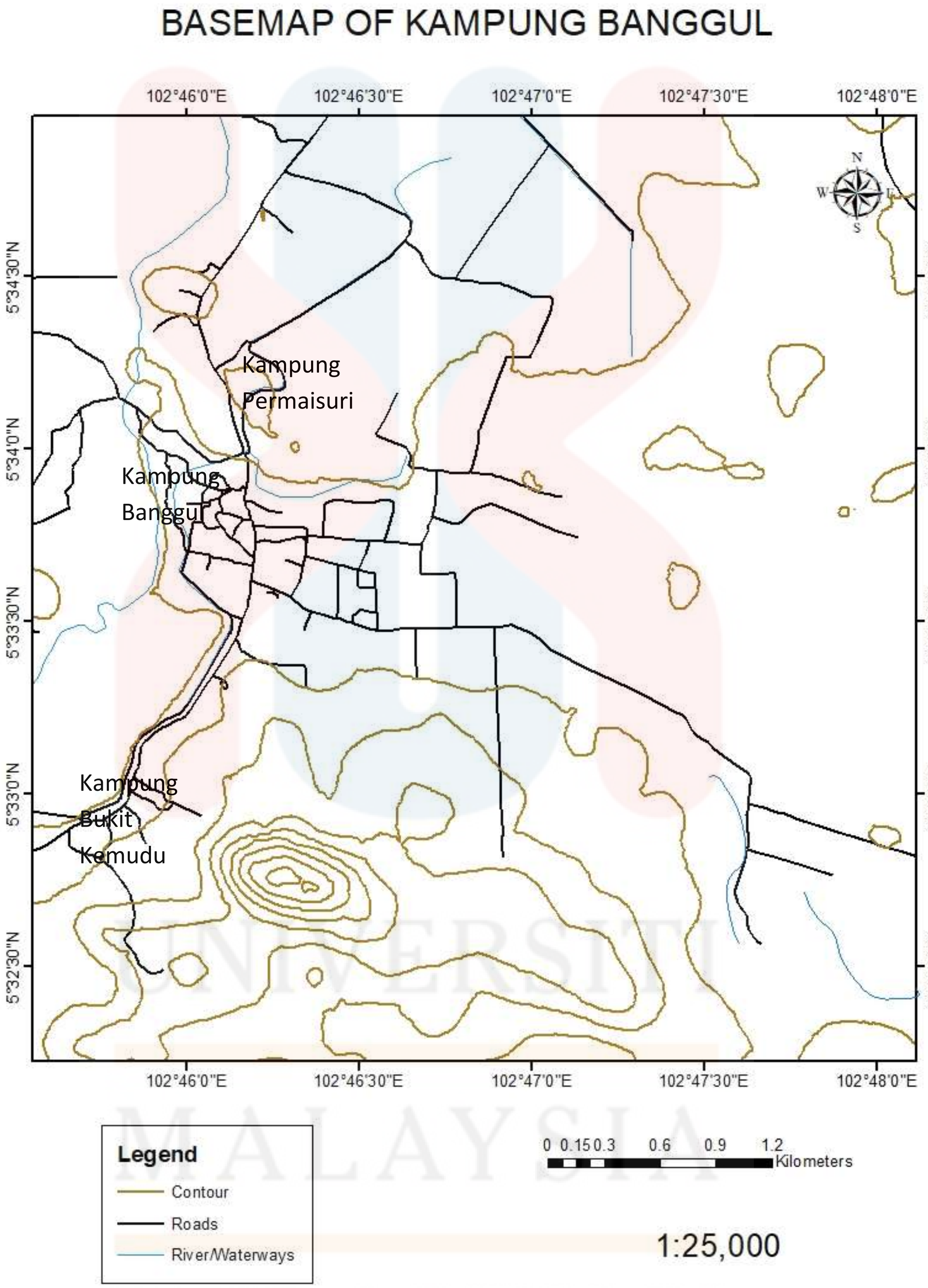

Figure 1.1: The base map of the research area

1.2.2 Accessibility

The research area is accessible through a few roads. The mains highways that connect Setiu and Kuala Terengganu are known as Bandar Permaisuri. Next, the study region is accessible by several village roads, housing area roads, and dirt roads. Every route can be reached by car, motorcycle or by walking. It is more convenient for the researcher to access to the research area.

1.2.3 Demography

Demography is learning of human population in a certain location. It is includes deaths, human births and migration. Demography is extremely helpful for understanding the social and economic issues. According to the Department of Statistics Malaysia (2021), Terengganu had a total population of 1500000 in 2010 and an average density of 81 persons per square kilometers. Terengganu remains a sparsely inhabited stated. Setiu district has a population of 54505 people and is covered by 1,304.36 km2 of land. The new district has an area of 135,905.80 hectares. Kuala Terengganu, Hulu Terengganu and Besut Districts border Terengganu Darul Iman which accounts for 10.49% of the total area of Terengganu Darul Iman.

1.2.4 Land Use

Setiu is one of the districts in Terengganu, Malaysia. Bandar Permaisuri is the serves as it is economic and commercial centre. Other than that, in this district also have school, village, kindergarten and mosque. After that, there also have a lot of beach, shop and resort for holiday or tourism. Last but not least, Setiu also covers up to 43% of the forest area, 21.6% for agriculture area and 75% is wetland area which covers beach and resort (Yet Yin Hee, 2018). So, form that, it is can see the land use at Setiu is suitable for tourism.

1.2.5 Social Economic

Setiu Wetlands are located in Terengganu's Setiu district. It is also the biggest coastal wetland complex on Peninsular Malaysia's east coast with a river that connects the Setiu River basin, Chalok River Basin and Merang River Basin which converges and forms a continuous lagoon. Setiu Wetland is presently a prominent focus for the development of research based on sustainable management of wetlands, biodiversity protection and ecological function maintenance. In this district, it is also include university and college, school and kindergarten. Last but not least, there are several factories and shops.

1.3 Problem Statement

So, that the aimed of the study to acquire a potentially reservoir area accommodate hydrocarbons. As we know, Malay Basin is the study areas that have potential of hydrocarbon trap and the study area for interpret the hydrocarbon potential is Bundi Field. Other than that, the findings can be linked to well log data within the research area's radius. So, further research must to be done to correlate this data to help facilitate regional understanding. After that, additional wells data will help further identification of potential rocks as hydrocarbon trap in the research region. The geological map in Kampung Banggul, Permaisuri, Setiu needs to be updated to reflect changes in geological features.

1.4 Objectives

In order to achieve the objectives, following tasks are performed:

1. To update geological map of Kampung Banggul, Permaisuri, Terengganu with a scale 1:25000.
2. To identify the hydrocarbon potential at Bundi Field, Terengganu Offshore.

1.5 Scope of Study

The research areas have two locations. The first area that chooses for the research of the geology is Kampung Banggul, Setiu, Terenggganu. The total areas for mapping that must cover for this research are $25km^2$. Kampung Banggul is a traditional village that existed before the second war. It is also have high or bumpy surface and surviving floods every year. So, the geological mapping must be conduct in this study area because to look the geological features and geological processes those have in this area.

Other than that, the second area that chooses for this research is Bundi Field. For the second research, it is focusing on seismic interpretation of Terengganu Offshore. For the study of seismic stratigraphy, the well log data will be correlated with the seismic data. Next, the study of concept consist a few different types of analysis techniques that being used and refer with all of the theories such as the characteristics of seismic refection analysis, seismic sequence analysis and facies seismic analysis.

Then, using interpretation from the facies analysis, geological structure, and depositional environment of the research region, seismic data is analyzed to find any probable hydrocarbon resource. PETRONAS provides the data in the form of SEGY data and other types of data as they become available. The KINGDOM Software will be used to examine the data.

1.6 Significance of Study

By conducting this research, it is able to identify the hydrocarbon potential of Bundi Field, Terengganu Offshore. From this study, it is also develop the recent geological database for the study region as well as an updated geological aspect of study. For example, the drainage and the streets of the study area which are absent in latest maps will be update. So, to get the all the information, mapping must do to produce the geological map.

Other than that, the map is one of the most important pieces of information for geologist, government officials, anyone who want to explore, conserve and exploit natural resources in the studied region. After that, the benefits from the results of the seismic analysis also will assist the government in exploring for hydrocarbons which might lead to a boost in the country's economy. The effectiveness method that used will be produced the best outcome.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will address prior tectonic evolution research that has taken area in Sunda Plate and Southeast Asia as well as the study region of Kampung Banggul, Permaisuri, Setiu, Terengganu and the Bundi Field Terengganu Offshore, Malay Basin. This analysis includes stratigraphic and general geology elements in addition to past studies to provide a better knowledge and visualization of the general geological areas of the study and to be references prior to interpret seismic data.

Other than that, the seismic data utilized in this study is secondary data from PETRONAS database which will be analyzed and interpret using computer software which are Kingdom 2021 software version. A basic summary of geological conditions and current hydrocarbon sources can be provided via the well log report. This topic is also very consequence as a starting point for make sure that the task is completed properly and efficiently.

2.2 Tectonic History and Evolution of Southeast Asia

2.2.1 Tectonic Element

Southeast Asia is a geologically complicated region that has evolved through various phases of continental accretion, mountain formation and rifling. Malaysia occupies a central positon in Southeast Asia such that it is geological history is intricately tied to that of the whole area. Other than that, the geology of Peninsular Malaysia and western Sarawak have substantially older geology that the rest of Sarawak and Sabah. It is also represented Cambrian rocks found on Langkawi, Malaysia's northwest peninsula (Madon, 2016).

Much of present-day Southeast Asia is covered by seas with numerous islands. Continental and transitional crusts generally underlie the shallow shelf seas with water depths of less than 200 metres. The deeper ocean basins are underlain by ocean crust. The mega-tectonic features of Southeast Asia can be explained generally by plate tectonics, the interaction of torsion ally rigid lithospheric units termed plates. There are three main lithospheric plates encircle Southeast Asia which are the Indian-Australian, Pacific and Philippine Sea plates (Madon, 2016).

Next, Southeast Asia also consists of a pre-tertiary continental core called Sundaland that runs from Myanmar to western Borneo and underpins much of Southeast Asia's western area. The Kontum Massif in eastern Vietnam has the oldest outcropping rocks in Sundaland. In contrast, Eastern Southeast Asia is geologically young that having developed during the last 50 to 60 million years (Late Cretaceous-Tertiary). Continental blocks formed during the rifting event also underpin the basin's boundaries, particularly the Luconia and Reed Bank blocks on the basin's southeast edge (Madon, 2016).

2.2.2 Early Tertiary Evolution

The slow disintegration of the supercontinent Pangea and the development of the eastern Tethys seaway are both directly tied to the tectonic evolution of Southeast Asia during the Paleozoic and Mesozoic. The Tethys Ocean filled a triangular gap between two prongs of the Pangean continent, Laurasia to the north and Gondwanaland to the south during the Paleozoic and Mesozoic periods. Continental Southeast Asia is made up of four main tectono stratigraphic terranes that originated during the break-up of Pangaea and the opening and closing of successive Tethys seas, according to stratigraphic, palaeobiological, and palaeomagnetic research (Madon, 2016).

Other than that, Sundaland is the eastern end of a major Late Triassic orogeny known as the Cimmerides or Indosinian Orogen which occurred form the closing of the Palaeo-Tethys Ocean. Southeast Asia's pre-tertiary development included the gradual suturing of allochthonous continental terranes that had splintered off from Gondwanaland since the Late Paleozoic. Last but not least, there are three main phases of rifting like Devonian, Carboniferous-Early Permian and Late Triassic –Early Jurassic. The closing of successive Tethys seas and the collision of terranes along significant suture zones were the result of these events (Madon, 2016).

2.3 Geological Setting of Permaisuri

The categorization of the Malaysia Peninsular into three segments known as the Western Belt, Central Belt, and Eastern Belt is widely acknowledged, however workers disagree on the exact limits. The Bentong-Raub Line which separates the Western and Central Belts was created by linking serpentinite bodies mostly discovered in Kuala Pilah, Negeri Sembilan and Bentong-Raub, Pahang (Abdullah, 2004).

After that, the extent of this barrier in the absence of serpentinite is very speculative. The Lebir Fault in Kelantan serves as the dividing line between the Central and Eastern Belts, and it extends southward to the centre of Johore (Abdullah, 2004).

Based on fossils discovered at Ulu Paka, Terengganu and other locations in north Pahang, Terengganu and Batu Rakit, the meta-sediments of the Eastern Belt—also known as the Sungai Perlis Bed—were mapped as Carboniferous. A variety of linear, thin bands of Triassic Jurassic sedimentary rocks are seen in this belt, according to an older geological map of Peninsular Malaysia. The interbedded tufficeous sandstone, siltstone, mudstone and small conglomerate on the other hand are thought to be of Late Permian age (Abdullah, 2004).

The East Coast Granite Belts are two elongated entities that contain the majority of the igneous rocks in this belt which include biotite granite and minor rocks of intermediate composition. Late Permian-Early Triassic and Late Triassic granites are found in this region. The Carboniferous period is represented by some of the intermediate igneous rocks. There are several basic to intermediate dykes in this area that penetrate granite and meta-sediments (Abdullah, 2004).

Lastly, Carboniferous meta-sediments, igneous rocks and Jurassic-Cretaceous continental deposits make up the northeast half of the Eastern Belt. Lastly, the most common with continental deposits occurring mainly in a few isolated locations are meta sediments (Abdullah, 2004).

2.3.1 General Structural Geology

Peninsular Malaysia has a north-northwest elongation that is parallel to its structural trend. In adding to those that strike north-northwest, the northwest of the Peninsula is marked by surface formations that trend in a northeasterly manner. The northwest part of Peninsular Malaysia has been discovered to have Mid-Permian folding. Following the Late Triassic orogenic event that impacted the whole Peninsula, post-mid-Permian carbonates and clastic deposited in the Northwest area were uplifted and folded (Spiller, 1998).

Other than that, tectonic transport routes in Peninsular Malaysia are generally westwards except for the Central Belt where east vergence is observed. According to one theory, the overall east-west compression brought on by the Late Triassic plate convergence is what caused the general west vergence and east vergence that the rocks of the Central belt experienced.

Finally, NW-SE structural grain of Peninsular Malaysia has noteworthy faults that are typically filled by enormous multiphase quartz dykes. For examples, the Klang Gates which may have experiences subsequent wrench motion (Spiller, 1998).

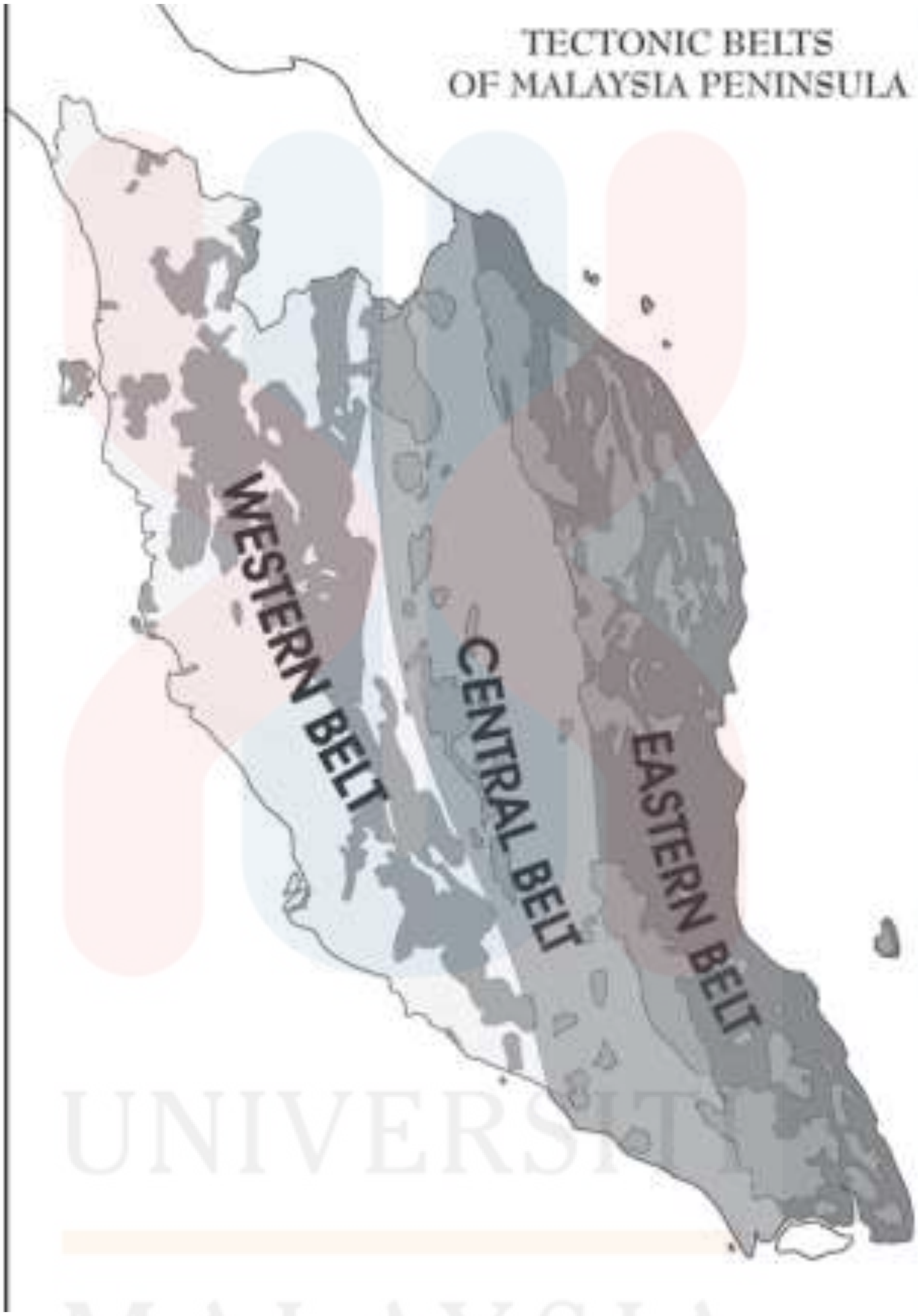

Figure 2.1: The division of the Peninsular Malaysia into the Western, Central and Eastern Belts (Spiller, 1998).

2.4 Stratigraphy

The Eastern Belt comprises all rocks to the east of Lebir Fault zone. There are two zones which are Kuantan Group and Gagau Group. The Lower Carboniferous interbedded sequence of sandstone, siltstone, and shale from the Kuantan Group of the Eastern Belt are the earliest rocks exposed east of the Bentong-Raub Line. The Visean to Namurian Charu Formation, which is part of the Kuantan Group, is topped by Namurian Panching Limestone, which is itself topped by the Late Carboniferous to Early Permian Sagor Formation.

Within the Kuantan Group, cross-bedding, shallow-water limestone and ripple marks are signs of a shallow marine near-shore depositional environment. Lastly, descriptions of coal seams from the Kuantan Group have also been made. Second, the Gagau Group is composed of incompletely consolidated conglomerate and sandstone that dips gradually. It is mainly flat-lying to gently dipping with local folding and it unconformably overlies Permian layers and in some areas granite (Spiller, 1998).

After that the Badong Conglomerate is then overlain by the Lotong Sandstone, completing the Group. Red conglomerate, sandstone, siltstone and shale make up the Badong Conglomerate. Small coal and Cross-bedded sandstone seams make up the Lotong Sandstone. Lastly, plant fossils imply a Lower Cretaceous to Upper Jurassic date (Spiller, 1998)

2.5 Malay Basin

Off the coast of Peninsular Malaysia is the Malay Basin and is regarded to be at the end of its exploration phase. Oil prospecting in the basin began in the late 1960s. Over 150 oil and gas discoveries had been made by 2003, with nearly a fifth of them now in production. Gas is extracted from fields in the basin's center and northwest regions. Along the basin axis, large anticlinal tendencies are present in these fields. (Bishop, 2002).

The Malay Basin Province is made up of Tertiary trans-tensional extensional basins with at least two total petroleum systems like the Oligocene-Miocene Lacustrine Total Petroleum System with lacustrine shale source and reservoir rocks unit, the South Malay Lacustrine assessment unit and the North Malay Lacustrine assessment unit. Coal and coaly shale sources as well as deltaic, offshore marine, fluvial and nearshore marine bar reservoirs make up the Miocene-Coaly Strata Total Petroleum System. Next, hydrocarbons are trapped in drape anticlines, transpressional folds and certain stratigraphic traps from the Middle to Late Miocene (Bishop, 2002).

The Khmer Trough and lesser areas of the Malay Basin, which are located largely in Malaysian seas but also in those of Thailand, Indonesia, and Vietnam make up the whole Malay Basin Province which is totally offshore in Cambodian waters. This province borders the South China Sea and the Gulf of Thailand, north of the Malaysian Peninsula, south of Cambodia and Vietnam, and west of Cambodia. It is less than 200 metres deep. The province has the ability to recover known reserves of more than 12 billion barrels of oil equivalent (BBOE), and it has produced more than 1.6 billion BBOE (Bishop, 2002).

Malay Basin is around 83,000 km^2. The basin is 200 km broad and 500 km long roughly. The Malaysian section of the basin has 338,000 km3 of Tertiary sediments, with more than 9,150 m of Tertiary strata in certain places. The Malay Basin has a northwest to southeast tendency, running practically perpendicular to the east/west going Penyu Basin and the northeast/southwest trending West Natuna basins to its south (Bishop, 2002).

2.5.1 Exploration History

Based on their individual reservoirs and physical locations, the Malay Basin may be split into six provinces namely, Southeast, Central, Northeast West, North and South. Southeast is the region with the highest exploration activity intensity followed by Central and Northeast. Exploration operations in the late 1980s were restricted to the Northeast region and following the formation of the Production Sharing Contract in 1985 (Bishop, 2002)..

Three major tectonic episodes, including upper Eocene to Oligocene extension with left-lateral shear and major subsidence, middle to upper Miocene north to south compression with reverse or right-lateral shear, folding, and inversion, and Pliocene to Holocene minor extension and gentle subsidence, resulted in the current petroleum province in the Malay Basin region (Bishop, 2002).

Other than that, pull-apart basins and half grabens were created by left-lateral shear throughout the late Eocene to Oligocene and thick sedimentary layers were produced there. The mid-Eocene collision between the India plate and the Eurasia plate led to the expulsion of some of continental Southeast Asia. This ejection caused left-lateral shear on the Three Pagoda fault zone in the Malay Basin, a significant fault system on Thailand's mainland (Bishop, 2002).

Southeast Asia suffered differential expulsion during the Miocene as a result of the combined effects of the Indian, Australian, and Pacific plates convergent northward and west. This ejection changed the fault zone's motion from left-lateral wrenching along the Axial Malay fault to right-lateral wrenching. The earlier half-graben basins were inverted as a result of the compression and wrenching that occurred throughout the middle to late Miocene. From somewhat inverted structures in the north to entirely inverted partial grabens in the southern section of the basin, the inversion rises. Anticlinal folds were created by the half grabens being inverted. Except for the southwest edge, where the anticlines trend northwest to southeast, and the northwest corner of the basin, where the anticlines nearly run north to south, these folds go east to west (Bishop, 2002).

The anticlines are situated in the deepest sedimentary layer of the half-grabens and are oriented parallel to the underlying half graben. Sediments that have been partially grabbed fold without obvious faulting. In the transpressive tectonic compressional phase, wrench faulting took place.

Prior to the deposition of the underlying Pliocene sediments, a period of erosion removed from the Malay Basin about 1,200 m of Miocene section (Bishop, 2002).

In the earliest Pliocene, compressional folding ceased to exist. Since the Early Pliocene, the majority of the region has been subject to gradual subsidence and regional deposition of marine clastic that lie flat on the ground. The most recent tectonic feature is a set of north-striking normal faults that run perpendicular to the crests of the anticlines (Bishop, 2002).

Pre-Cenozoic features had an impact on deformation during the Tertiary. A more than 500 km broad pre-Tertiary likely Late Cretaceous dome situated at the intersection of the Malay, Penyu, and West Natuna Basins. A mantle plume under this junction may be the cause of the junction's very high heat flow. The tectonic grain of Late Triassic to Early Jurassic structure from onshore data reflects the structural grain of the Cenozoic era. (Bishop, 2002).

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2.5.2 Source Rock

The two most efficient source rock intervals are group H and I., according on geochemical data and basin modelling results. Their efficacy is influenced by their current burial depth, maturity, and source rock quality. The distribution of oil and gas fields in respect to the current maturities of groups H and I is shown in Figure 2.3. The effective source rock kitchens that supply the charge to the oil and gas fields are defined by the maturity windows of groups H and I. Basin modelling was used to calculate the timing of hydrocarbon formation and ejection from these source rocks that will show in figure 2.4 (Mazlan madon, 2004)

According to the findings, oil ejection from Group H source rocks began around 5 Ma ago and is currently going strong. Around 11 Ma ago, oil began to be ejected from Group I source rocks but by 5 Ma ago only gas was being ejected. Since many of the structures in the basin centre are recent mostly from the last 4-5 Ma, it can only hold gas produced by Group I source rocks. Group I source rocks might potentially give to the gas. For instance, the Group K shale is a recognized oil source in the basin's southern region (Mazlan madon, 2004).

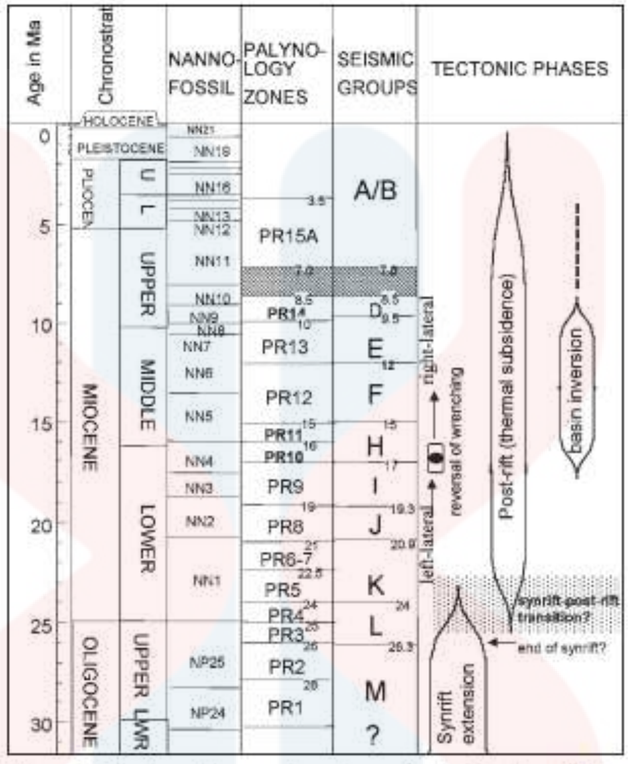

Figure 2.2 : The stratigraphic zonation that explain more about Group H and Group I

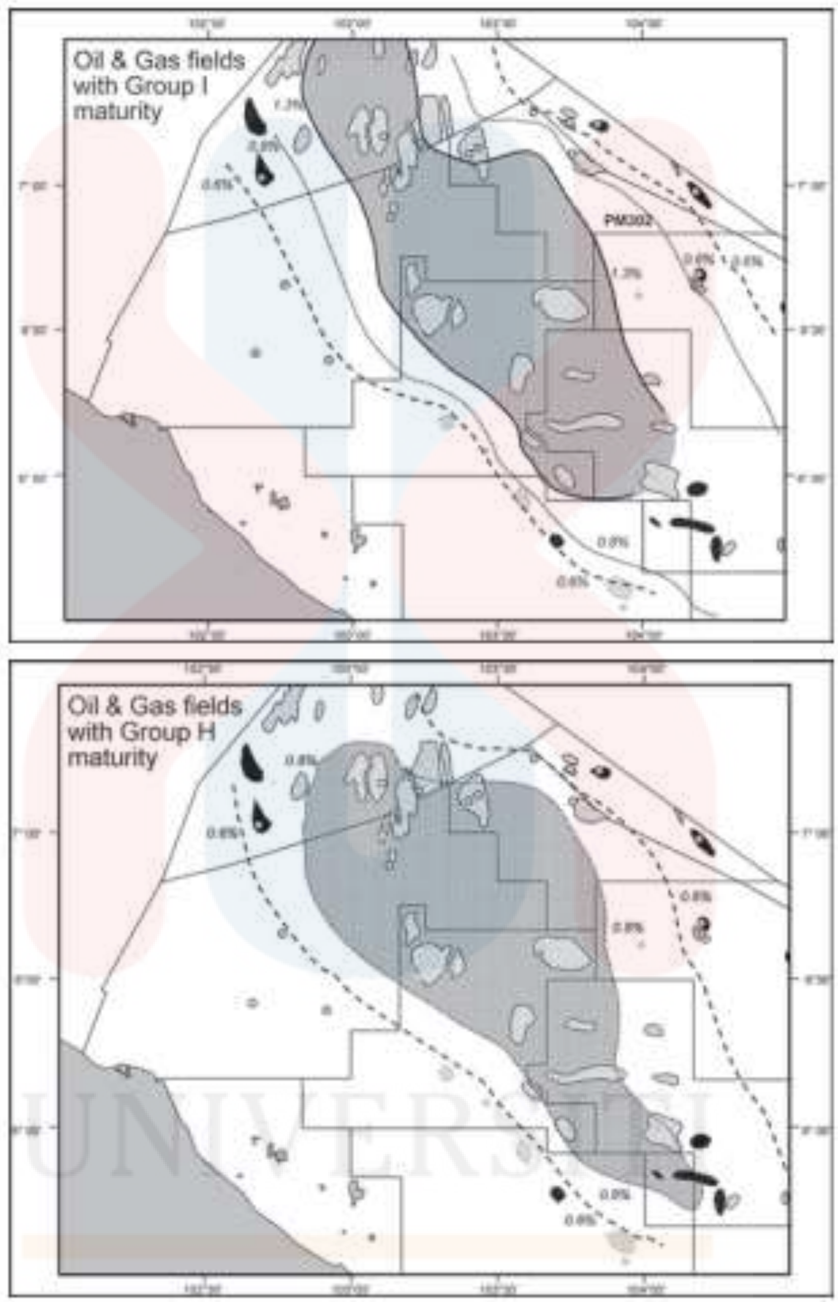

Figure 2.3 : Map of oil and gas field with overlay of (A) Group I maturity and (B) Group H maturity.

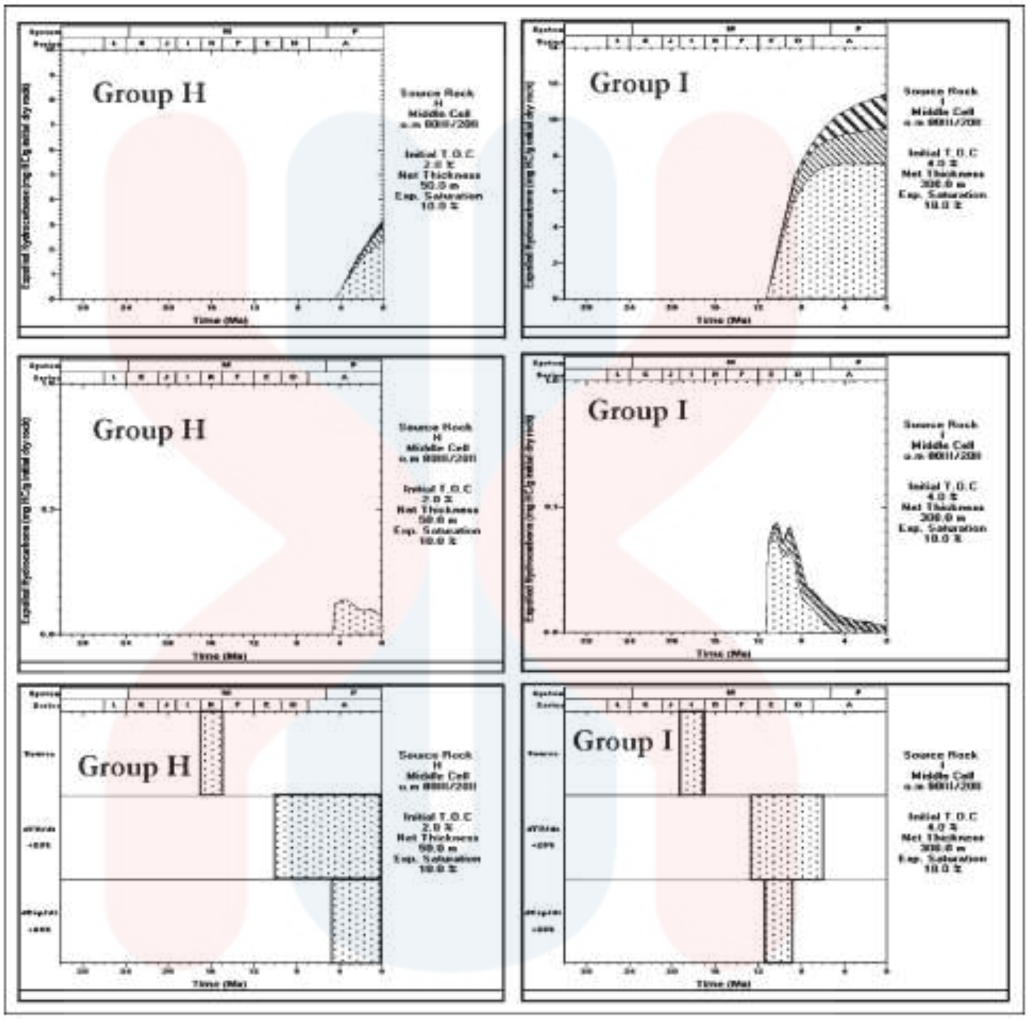

Figure 2.4: Basin modelling provides the source rock history. Group H is in the left column, while Group I is in the right. A overview of the deposition, generation, and ejection of source rock hydrocarbons is shown in the bottom figure. The top chart shows cumulative hydrocarbon generation

2.5.3 Reservoir Rock

The Malay Basin's reservoir quality is influenced by burial diagenesis and depositional facies. Middle Miocene shallow marine deposits are represented by fine- to medium-grained sandstones with porosity of 10 percent to 15 percent while Oligocene and Early Miocene deposits are primarily clean, medium-grained sandstones. Sandstones with fine to extremely fine grains and a lot of matrix make up the majority of late Miocene estuary deposits. The major causes of porosity loss include bioturbation, burial compaction, and authigenic clays. Locally significant is the development of secondary porosity caused by feldspar dissolving.

Other than that, hydrocarbons are found in Group D to K sandstone reservoirs in the Malay Basin. The K Group is thought to date from the late Oligocene to the early Miocene. The majority of the reservoir rocks in this category are fluvial sandstone with permeability of up to 3000 mD and porosities of 10–30%. Due to the elevation and exposure of the K Group during the deposition of the J Group, there is some secondary porosity development from feldspar solution towards the southern end of the basin. Quartz cements and authigenic clays are frequently used. This category is responsible for around 16 percent of the oil, gas and condensate reserves from lacustrine sources. Malay II/III fluvial channel sandstones are used in the Bongkot Field's production, which is located in Thai seas. These counterparts of the K Group were laid down by a large delta that was prograding northward. Sometimes, these layers immediately overlie lacustrine shales from the Oligocene (Bishop, 2002).

Sandstone also depositional conditions differ depending on stratigraphy. Reservoirs are generated mostly by fluvial channels in a non-marine-lacustrine environment in the older groupings (K,L,M). The sandstones of the J and younger groups are mostly shore face and subtidal shelf sands as well as the fluvial-deltaic to estuarine channel complex. Last but not least, the Upper Oligocene-Lower Miocene reservoir sandstones in Group J and K in the southeastern section of the basin as well as the E sandstones near the Jerneh gas field, are among them (Bishop, 2002).

2.6 Seismic Attribute

Since the 1970s, seismic attribute analysis has progressed. Instantaneous amplitude was employed as the direct instruction of oil and gas at the time. Nigel Anstey discovered aberrant variations in gas sandstone wave impedance in the early 1970s and exploited the reflection amplitude variation for gas-bearing sandstone reservoir prediction. Next, the introduction of complete 3-D interpretation tools has aided the growth of seismic properties. As a result, it's critical to create fast, accurate seismic data processing tools to replace the time-consuming human interpretation and emerging 3-D interpretation approaches (Ming Li, 2014).

Other than that, seismic characteristics can be divided into two groups which are geometrical and physical. This geometric attribute's goal is to make the geometric properties of seismic data such as azimuth, dip and continuity, more evident. Physical characteristics that are connected to lithology must be linked to subsurface physics parameters. This covers frequency, phase, and amplitude.

The primary branch of seismic characteristics in a tree structure is made up of time, amplitude, frequency, and attenuation. Stratigraphic and reservoir information is also provided by the time characteristics.

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CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

This chapter will describe in detail how the research was conducted. It will serve as a guide for the researcher in following the materials and methods used in this study. Furthermore, it will allow others to continue the research utilizing the guidelines provided. Materials and a technique are initially selected for the study. The research will benefit from data collection and analysis.

This chapter covers pre-field and field studies, laboratory work, sampling, petrology analysis, and seismic analysis among other methods. The approach that will be used to perform the research has the biggest importance in the study. To make the materials acceptable for the procedure being employed, it is must be recognized. The study methodologies that use in order to run the study will be shows in Figure 3.1.

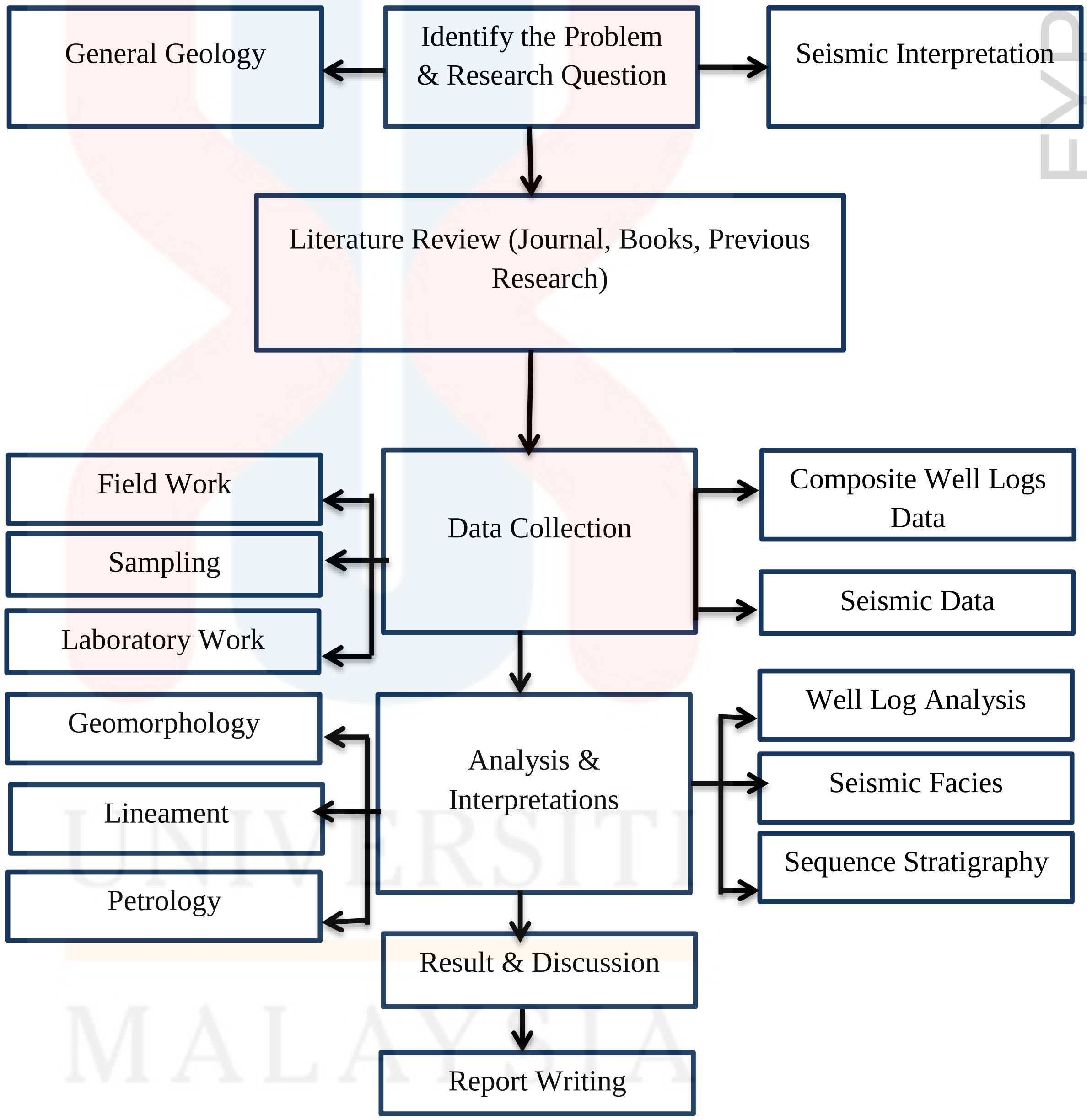


Figure 3.1: Flowchart of methodology that being used in this research

3.2 Materials

3.2.1 Geological Mapping

To perform this investigation, specific materials are being used. Geological mapping of the study region which includes Kampung Banggul, Permaisuri, Setiu, Terengganu is required for general geology. GPS, geological basemap (tip point and chisel), compass, geological sample bags, hydrochloric acid, measuring tape, field note book, and hand lens are among the items.

All this materials are supplies from Faculty of Earth Science, UMK laboratory. Besides that, during mapping some of the journals, articles, book and official references from government department also help to conduct this mapping. Other than that, the coordinates of the research region are required in order to go to the places and the sample must be marked with the locations. All of this requires the usage of Global Positioning Satellite Systems (GPS). In order to assist researchers in pinpointing the precise position of the study area, place will mark and construct a box in the GPS. The site shall be marked and written in the field note book for future use when the sample is collected. This gadget that is very sensitive and quickly receives information from satellites also informs user of their current location is GPS.

After that, geology hammer (tip point) used to split and break rock from the outcrop for specimen purposes in order to get a new sample. The composition, minerology, and geological history of rocks are studied using samples. Usually, either a Suunto or a Brunton compass is used for geological mapping. Brunton should be used if the researcher wants to make a more precise choice. Using its inbuilt clinometer, it is that is most frequently used to read a dip and strike at the outcrop. It may also be used to determine how the sedimentary rocks' bedding is oriented.

The geological sample bags are one of the most important tools while undertaking mapping. It is used to store the collection of minerals, rocks, and fossils. It's crucial to protect geological sample bags from contamination or breaking rocks or fossils. When used, the sample will remain intact. A mistake will always be made when arranging the field sample, thus to avoid this, the sample bag was labelled with the coordinates, expected the rock type, date, place, time, coordinate and elevation.

Images are captured by cameras using electrical image sensors, which may then be transmitted to and saved on a memory card or other internal storage. Photos of outcrops and the perspective of the research area were taken with this camera. The methods used to photograph the outcrop are crucial. When photographing the outcrop or sample that is being gathered, a scale is required.

Other than that, acids like hydrochloric acid (HCL) are used extensively in industry. A powerful and corrosive mineral acid is HCL. When doing "acid test" in the geological field, geologists apply a drop of diluted hydrochloric acid (5%–10%) to a mineral or rock and observe for the emission of carbon dioxide gas bubbles. When the amount of carbon dioxide gas in the rock is high, the bubbles will respond quickly. To determine which rocks contain carbonate minerals, utilize the acid test. When a drop of hydrochloric acid is placed on a rock, for instance, to distinguish between dolostone and limestone, the rock is tested to determine if it will respond by fizzing vigorously or weakly.

Next, the measuring tape used by geologists is typically reel-in style and has measurements in feet and meters. The field's outcrops' length and height were measured using this tape. When measuring tape is not available, researchers can employ pacing techniques to determine the height and length of any outcrops or other geological features present in the study region.

Convex hand lenses, like magnifying glasses are used to create enlarged images of objects. Before conducting further research in the lab, hand lenses were typically used in the field to classify minerals present in the rocks and to see microfossils that were discovered in the rock.

3.2.2 Seismic Interpretation

The data was provided by the management of a PETRONAS subsidiary, Petroleum Management Unit in order to perform seismic interpretations. It includes seismic reflection data, base map, seismic sections in the form of SEG-Y data, T-Z graph and other supporting documents such as geology reports and well log final reports as a consequence of drilling in the research region. Other than that, the time—depth curve used is to represent the recording wells obtained from the PETRONAS velocity survey. Lastly, the data will be process use computer software which is Kingdom 2021 software.

To calculate the time it takes for a seismic wave to travel from the surface to a hydrophone placed at a specific depth, PETRONAS at the field created a time-depth graph (T-Z graph) using data from the well's velocity survey. This survey will aid in locating and studying the local topography and other elements.

The three components that make up reflection seismic data are recorders, sensor arrays and input sources. A sound vibration with the required energy, duration, frequency, maximum amplitude, and specific phase is produced using the input source. The earth's subsurface source will cause a wave of refraction and reflection which the geophones' detector will record. Then, a seismograph captures this wave of reflection. Wave signals that are detected will vary depending on the sensors and recorders that are being used.

An image of a segment through the earth's crust that is below the seismic survey line is known as a seismic cross section. The seismic cuts are printed on paper as separate wave-shaped lines that have been individually organized. After being analyzed, seismic surveys provide cuts that need to be interpreted. Every shot the seismic portion at this place is represented on the map by using the numbers of shoot points at the top of each seismic section as a reference.

3.3 Methodologies

3.3.1 Preliminary Studies

It is conduct with collecting some references of previous study using qualitative methods with the supporting secondary data before collecting the primary data. To obtain the references can be finds through internet such as websites, scientific journal or articles and e-books. The qualitative methods which are the written documents that can be discover at the library in term of printed scientific journal or articles. From this research also get the secondary data from PETRONAS at Bundi Field.

3.3.1.1 Internet Resources

The resources that can be providing the information about research are mostly from internet with free access such as e-books, open journals, online articles or online journal. The image of the study area in types of serial photo can be retrieved from Google Earth and Google Maps are helpful to give a rough condition of study area.

3.3.1.2 Aerial Image

The software that is used to get the aerial image is Google earth can provide the general image of the study area such as road connection, structural features, topography and geomorphology. It is because from the Google Earth Pro, it can be used to mark which area that want to identify and do the mapping. So, the aerial image is important to know the area before go to mapping.

3.3.2 Data Collection

Following first investigation, the researcher began to gather all the data and offer it to the Petroleum Management Unit, a subsidiary firm of PETRONAS, in order to obtain data from them. The required data includes, seismic data, composite well log data and other geological reports obtained by PETRONAS in the research region.

3.3.2.1 Field Study (Geological Mapping Method)

Geological mapping is the most competent presentation of geological data and is used either for scientific or natural resource discovery for different purposes. A geological map is a map consisting of geological data from the outer layer of the crust of the earth that it is a blend of lithology, distribution of geological structure, stratigraphy and geomorphology. All the data is read by the symbols and colors. Geological map specifics depend on the map's scale, the density and precision of field observation. A geological map is the final product of all geological methods.

3.3.3 Data Processing

The hand specimen will be collects from the mapping; it is will analyze using petrographic analysis. Other than that, the information gathered during the geological mapping procedure is transferred to a lab for thin sectioning. It is critical that the researcher use a fresh sample for thin sectioning in this section. It aided the sample analysis for the researcher. So, from petrographic analysis, it is will know the type of rock that have in Kampung Banggul, Permaisuri, Terengganu.

The secondary seismic data given by the Petroleum Management Unit includes well log data, basic maps, seismic templates, and T-Z curves. This data must be reorganized before being processed and interpreted by the Kingdom version 2021 computer software. Data management, data analysis, data interpretation and modelling are only a few of the layers of data processing and interpretation that this computer programme includes.

3.3.4 Analysis and Interpretation

Following the laboratory work, a petrological analysis and interpretation will be conducted. Petrology is examines of the mineral composition and physical and chemical properties of rocks. The textural and mineral composition connection of the rocks in the research region will be explained. To prevent making mistakes and missing essential information, the analysis and interpretation are handled carefully.

After the data, including the geological structure, drainage pattern, land usage and petrographic analysis were gathered in the field. The data will be entered into the geospatial information system together with all of the findings. With the use of a GIS, the researcher will analyze the coordinate before digitizing it. GIS is one of the programme used to organize, analyze and display many types of geographic data. This will assist in achieving the project's initial goal, and to revise a map of the area's geology research region. It will provide a more accurate and clear geological map.

There are three layers of the seismic reflection which are data interpretation, data collection, and data processing. Data interpretation is a difficult procedure that calls for extensive understanding of the subject matter. Seismic data interpretation provides individuals from skilled and experienced geologists. An interpreter's significant expertise and solid understanding are essential for interpreting seismic data.

All noise-related incidents should be recognized and eliminated by interpreters. In order to illustrate that there are two layers of distinct formations, seismic characteristics that exhibit under onlaps, front onlaps and top onlaps, should be searched for interpretation. These features are a sign of the ensuing erosion. An outline of the process through which facts and research are analyzed to creates a formation layer between each layer of the research that comes after it is shown in Figure 3.2.

Sequence boundaries need to be found and identified in order to effectively correlate and recognize a sequence. SB are often established based on unconformity and interactions with non-inline layers. The extent of the hiatus at the specific place is used to establish the geological age at the unconformity's above and below. The layer may become parallel at the time when sequence boundaries are recognized using the lateral method but the pause serves as evidence that the unconformity is still being determined. Lastly, it is possible to identify the sequence borders between parallel layers when there is no sign of a pause or deviation from the relevant conformity. The crucial component in the seismic interpretation of stratigraphic sequences is the sequence boundaries

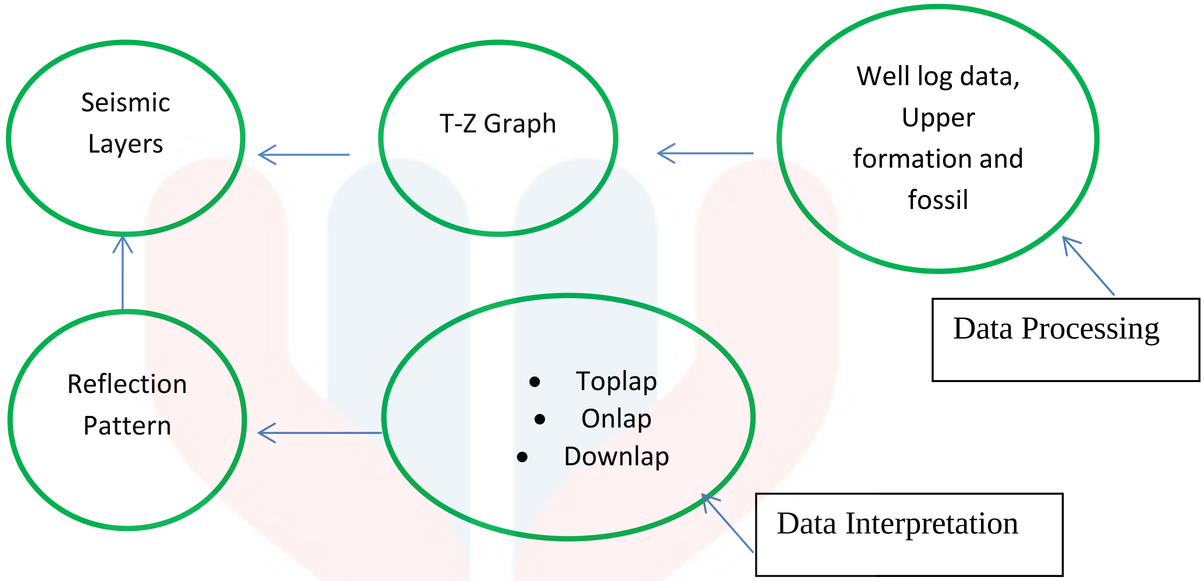


Figure 3.2: Flow chart on seismic interpretation that being used

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

More information regarding the general geology results of the research area Kampung Banggul, Permaisuri, Setiu, Terengganu, Malaysia will be provided in this chapter. It will cover the research area's traversal and observation, accessibility, habitation, forestry and vegetation. Additionally, the geomorphology of the area including its categorization, drainage system and weathering will be described. This chapter also covers litho-stratigraphy, structural geology, and petrographic analysis.

4.2 Accessibility

Kampung Banggul, Permaisuri, Setiu, Terenggganu is more easily accessible by use the major Kuala Terengganu Highway. Other than that, Kampung Banggul also was connected to Kampung Buloh via roadways. There are several unpaved and house roads that are utilized by construction trucks and locals. The majority of the roads leading to the research area are conveniently accessible by motorbike and four wheels.

Next, from the research area, it also found paddy field and it is covered almost 25 percent. Since the paddy field is private property, it can traverse between the main roads only. It is because when want to go paddy field area, it can traverse by tractor. Lastly, while doing the investigation, portions of the region are accessible due to sand mining sites. It is covered around 15 percent of study area for sand mining site. When do traverse and research in this area, four wheels is a good vehicle to enter the area.

4.3 Settlement

Kampung Banggul is mostly lead by the village area. Kampung Banggul also have a mosque, school, clinic, homestay, sand mining site and paddy field in addition to the residential neighborhoods. The residential area is made up of a village and modern house. The contemporary home is brand new and being built right now at the study area as well.

In this area, homestay is important because Kampung Banggul also near with Penarik beach. Paddy field is one of the important parts in Kampung Banggul because it is the source to find financial. Therefore, based on the research, it can be claimed that the region is one of the crucial places for settlement since it meets the needs of the locals' fundamental necessities.

4.4 Forestry and Vegetation

In Kampung Banggul, Permaisuri, Terengganu, there are still hills surrounded by medium-heavy forest and the forest location is rough. The forest in the study area form the top of the hill shows in Figure 4.1

Other than that, palm plantation, rubber plantation and paddy field also found in the study area. Some of the palm plantations are belonging to the private company. For the paddy field and rubber plantation, most of the plantation, it is a privately owned by the villagers of Kampung Banggul. Figure 4.2, 4.3 and 4.4 shows the plantation that occured in Kampung Banggul, Permaisuri, Setiu, Terengganu.

Figure 4.1 The forest in the study area

Figure 4.2 The palm plantation in the study area

Figure 4.3 The rubber plantation in the study area

Figure 4.4 The paddy field in the study area

4.5 Traverse and Observation

One of the techniques used in the field for geological mapping is traverse. Traverse is a technique in the field of surveying to create a control network. By placing survey stations along a line or course of travel and using previously surveyed locations as a jumping-off point for the observation of future places, traverse networks are created. Traverse is the important things for do the geological mapping.

Other than that, the traverse's also purpose is to monitor the researcher's progress during the study process. Researcher makes observation while traverse and records the information to produce a geological map. The traverse and observation map that represent the route taken during mapping activities will shows in Figure 4.5. The waypoints for the observation map were organized in Table 4.1, which shows every observation point made throughout during the traverse.

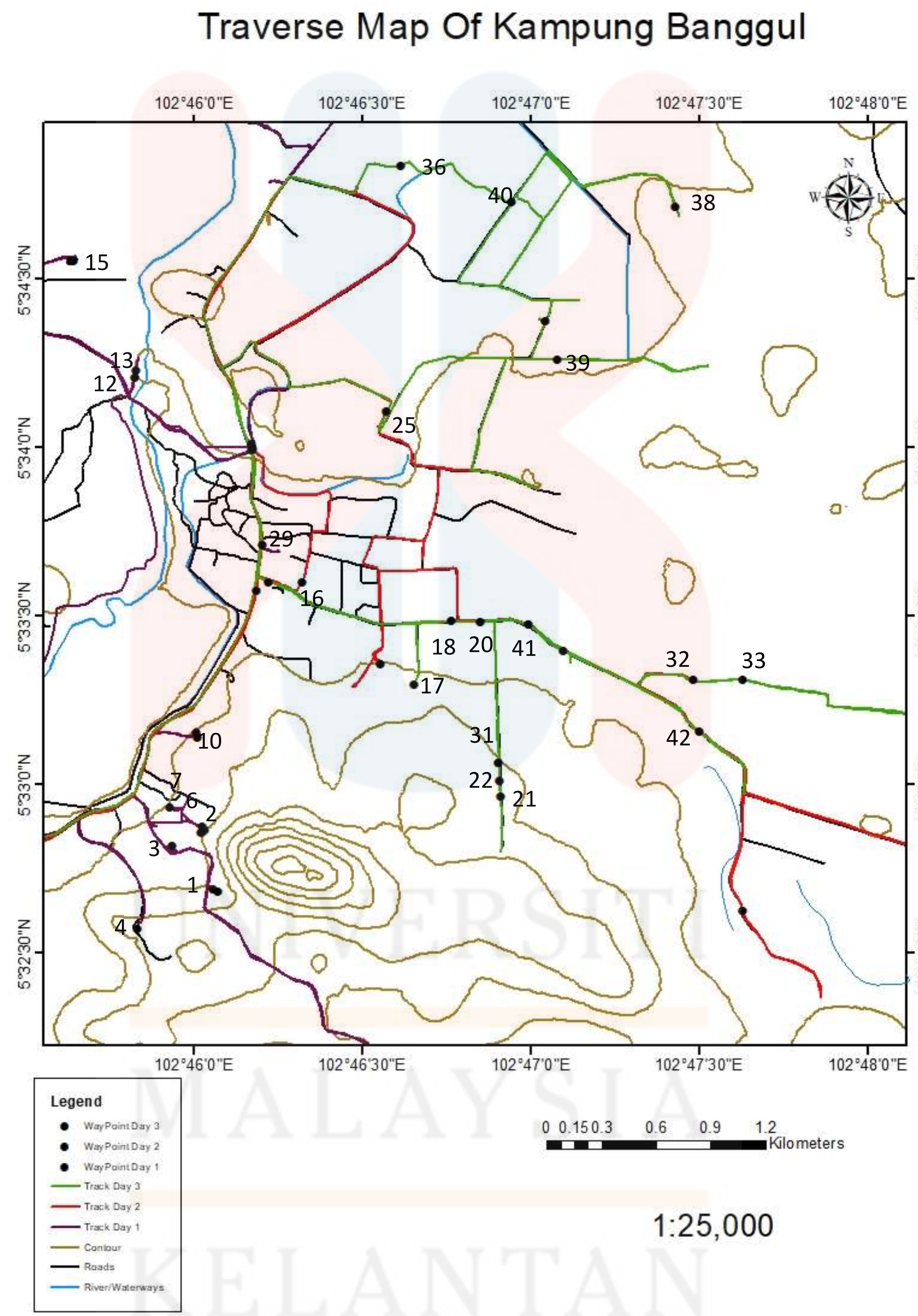


Figure 4.5: Traverse and observation map

Table 4.1: Observation recorded for each point in traverse.

WAYPOINTS	COORDINATES	OBSERVATION
FYP 001	5°32'52.37"N 102°46'01.42"E	Outcrop 1 Identify rock sample and structure collection (quartzite)
FYP 002	5°32'52.00"N 102°46'02.00"E	Rock sample collection (quartzite)
FYP 003	5°32'56.00"N 102°45'56.00"E	Identify bolder rock (granite)
FYP 004	5°32'49.00"N 102°45'56.00"E	Identify bolder rock (granite)
FYP 005	5°32'49.00"N 102°45'56.00"E	River Observation
FYP 006	5°32'41.00"N 102°46'03.00"E	Bolder rock sample collection (granite)
FYP 007	5°32'34.00"N 102°45'50.00"E	Geomorphology observation
FYP 008	5°32'36.00"N 102°45'51.00"E	Geomorphology observation
FYP 009	5°32'38.00"N 102°45'51.00"E	Geomorphology observation
FYP 010	5°33'09.00"N 102°46'00.00"E	Bolder rock sample collection (granite)
FYP 011	5°33'09.00"N 102°46'00.00"E	Outcrop 2 Identify rock sample and structure collection

		(quartzite)
FYP 012	5°35'01.00"N 102°46'07.00"E	River observation
FYP 013	5°34'13.00"N 102°45'50.00"E	River observation
FYP 014	5°34'14.00"N 102°45'50.00"E	Outcrop 3 Identify rock sample and structure collection (quartzite)
FYP 015	5°34'33.00"N 102°45'38.00"E	Outcrop 4 Identify rock sample and structure collection (claystone)
FYP 016	5°33'29.00"N 102°46'46.00"E	Plantation area
FYP 017	5°33'28.00"N 102°46'59.00"E	Plantation area
FYP 018	5°33'28.00"N 102°46'59.00"E	Unconsolidated area
FYP 019	5°32'37.00"N 102°47'38.00"E	River observation
FYP 020	5°33'29.00"N 102°46'51.00"E	Plantation observation
FYP 021	5°33'29.00"N 102°46'51.00"E	Outcrop 5 Identify rock sample and structure collection (quartzite)

FYP 022	5°33'22.00"N 102°46'33.00"E	Outcrop 6 Rock sample collection (quartzite)
FYP 023	5°34'06.00"N 102°46'34.00"E	Plantation area
FYP 024	5°33'36.00"N 102°46'19.00"E	Village area
FYP 025	5°34'00.00"N 102°46'10.00"E	River observation
FYP 026	5°34'00.00"N 102°46'10.00"E	Plantation area
FYP 027	5°33'42.00"N 102°46'12.00"E	Mosque area
FYP 028	5°33'34.00"N 102°46'11.00"E	Clinic area
FYP 029	5°33'18.00"N 102°46'39.00"E	Outcrop 7 Rock sample collection (quartzite)
FYP 030	5°33'06.00"N 102°46'54.00"E	Geomorphology observation
FYP 031	5°33'01.00"N 102°46'55.00"E	Geomorphology observation
FYP 032	5°33'04.00"N 102°46'54.00"E	Outcrop 8 Rock sample collection (quartzite)
FYP 033	5°33'09.00"N 102°47'30.00"E	Unconsolidated area
FYP 034	5°33'24.00"N	School area

	102°47'06.00"E	
FYP 035	5°33'35.00"N 102°46'17.00"E	School area
FYP 036	5°33'35.00"N 102°46'17.00"E	Plantation area
FYP 037	5°34'37.00"N 102°46'11.00"E	Plantation area
FYP 038	5°34'44.00"N 102°46'57.00"E	River observation
FYP 039	5°34'43.00"N 102°47'26.00"E	Plantation area
FYP 040	5°34'21.00"N 102°47'02.00"E	Plantation area
FYP 041	5°34'20.00"N 102°47'02.00"E	Plantation area
FYP 042	5°33'18.00"N 102°47'29.00"E	Plantation area

4.6 Geomorphology

Geomorphology is the study of earth's surface landforms, characteristic, processes and landscape development. Other than that, geomorphology is the study of the physical characteristics of the earth's land surface, including things like rivers, hills, plains, beaches, sand dunes, and many more landforms.

The landforms, weathering rates, and drainage patterns of the studied area Kampung Banggol, Permaisuri, Setiu, Terengganu, Malaysia were all observed while conducting the geomorphological study. It is carried out using a topographic map, a drainage map, a review of the literature as well as field observation. Figure 4.6, 4.7 and 4.8 shows the geomorphologies in Kampung Banggul. The altitude on Figure 4.6 shows 53.1 m. The geomorphic process is biological weathering. It is exogenic geomorphic process. In Figure 4.7, the altitude is 49.4 m. The geomorphic process is physical weathering and deposition.

Figure 4.6 The geomorphology biological weathering (altitude 53.1 m)

Figure 4.7 The geomorphology physical weathering and deposition (altitude 49.4 m)

Figure 4.8 The geomorphology biological weathering (altitude 32.2 m)

4.6.1 Topographic Map

Topographic map is an accurate and detailed representation of both man-made and natural ground features likes roads, railroads, power lines, contours, elevation, rivers, lakes and geographical names. There are seven type of topographic map which are relief, hydrography, vegetation, transportation, culture and boundaries.

So, geomorphology is classified as plantation vegetation based on the study of topography map. Table 4.2 shows topographic unit for a small plantation area on the left between the two images. The elevation of the study area ranges from the lowest elevations which is 10.0 m to 90.0 m shows and can be classified as plantation vegetation in topographic map. The Datum Elevation Map, which was calculated using the elevation in the research region, is shown in Figure 4.9.

Table 4.2: Topographic unit classification

Classification	Topographic unit	Mean elevation (m abov e sea level)
1	Low lying	<15
2	Rolling	16 – 30
3	Undulating	31 – 75
4	Hilly	76 – 300
5	Mountainous	>301

Source: (Tan, 2009)

Topography Map Of Kampung Banggul

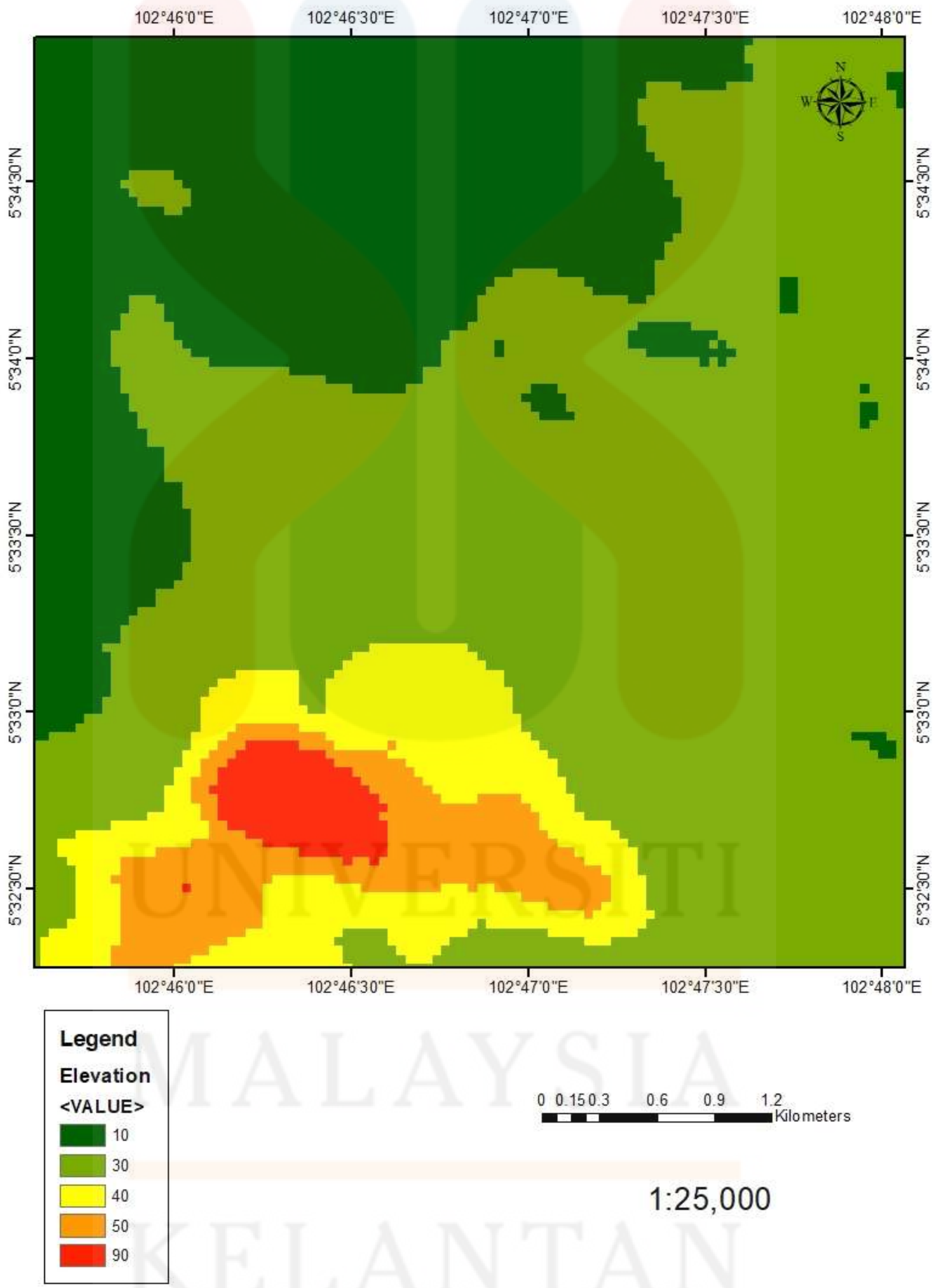


Figure 4.9 Datum Elevation Map

4.6.2 Drainage Pattern

A river is a naturally flowing body of water that flows toward an ocean, sea, lake, or another river. Freshwater rivers are most commonly seen. Rivers are strong geological forces with a lot of movement. There are three different types of geologic processes that are carried out by water passing through a stream like erosion, transportation, and deposition. A river is regarded as one of the earth's geological agents. Water flow possesses the force, velocity and power to produce energy. In addition, many landforms are created as a result of the geomorphic activities of rivers and it is referred to as fluvial landforms.

Fluvial landforms are divided by five which are stream and drainage, erosional work of stream, transportation by stream, erosional landforms and depositional landforms. Streams are bodies of moving water. The flow starts right after it has rained. Rainwater that falls on a land's slopes collects and begins to flow over the land as overland flow. The pattern that the stream, river and lakes create in a specific drainage basin is the next factor in the drainage system.

There are four main types of drainage pattern like dendritic pattern, rectangular pattern, radial pattern and trellis pattern. An area's drainage pattern, which is a pattern made over time by stream erosion, exposes characteristics of the types of rocks and geologic formations in the area. Streams drain this area's terrain. The pattern created by streams, rivers, and lakes within a certain drainage basin is sometimes referred to as the drainage pattern. It is determined by the topography of the terrain, the gradient of the land, and whether a specific location is characterized by soft or hard rock.

Kampung Banggul, Permaisuri,Setiu, Terengganu consists radial and dendritic type of drainage pattern. When the streams radiate outward from a central high point, a radial drainage pattern will forms around it. A summit's tributaries descend in all directions, following the slope downhill. Next, for dendritic drainage pattern also referred to as pinnate drainage, which is seen in areas with homogeneous material and resembles the branching of a tree. These grow in regions where sedimentary and granite rock that has not been bent by the stream has no distinctive structure or fabric and is equally susceptible to erosion from all directions. Lastly, it grows in lithological homogenous terrain with minimal faulting and jointing.

4.6.3 Weathering

Peninsular Malaysia has a climate of moderate temperatures, high humidity and high rainfall since it is situated in a humid location. Weathering is the degradation of rocks, soils, minerals, wood and manmade materials due to interaction with water, gases in the atmosphere and living things. Other than that, weathering happens naturally, unlike erosion, which includes the movement of rocks and minerals due to forces including water, ice, snow, wind, waves, and gravity. There are three type of weathering which are physical, chemical and biological weathering occurred in the study area.

i) Physical Weathering

Without undergoing any chemical change, physical weathering, also known as mechanical weathering, results in the degradation of rocks, minerals, and soils. Other than that, abrasion is the main mechanism of physical weathering. Next, pressure, temperature, root movement, frost, and burrowing animals all cause physical deterioration. The formation of gorges, ravines, and valleys all over the world is a result of abrasion caused by processes involving water, ice and wind that are laden with sediment.

So, in the study area, there is presence of this type of weathering. The quartzite outcrop in Figure 4.10 shows the physical weathering that may form by the forces of physical characteristics acts on the rock. The physical weathering process causes the rock to split up into smaller fragments without changing the rock's original chemical makeup.

Figure 4.10 Physical weathering for quartzite outcrop

ii) Chemical Weathering

Chemical weathering causes changes in the molecular structure of rocks and soil. For instance, occasionally the interaction between water and carbon dioxide from the air or soil is known as carbonation. Other than that, oxidation, hydration and hydrolysis are also component of the chemical weathering.

The claystone outcrop along the research area nearby Setiu River can be found undergoes chemical weathering. It passes through a process called hydrolysis in which new solutions are created as a result of chemical reactions between water and rock. Consequently, using this method, we will learn more about the minerals present in claystone outcrops.

Figure 4.11 Chemical weathering for claystone outcrop

iii) Biological Weathering

Biological weathering is the term for the weakening and subsequent deterioration of rock caused by organisms such as plants, animals, and microorganisms. Rock may experience stress or pressure from expanding plant roots. Biological processes apply pressure even if the process is physical. In addition, because it is more influenced by environmental elements like biotic and abiotic factors, it leads to the further putrefaction of rock materials together with other types of weathering.

The quartzite outcrop that is part of the research area experience biological weathering. Numerous plant species are growing around the quartzite rock. As a result, the quartzite outcrop may experience stress and pressure from growing plants roots.

Figure 4.12 Biological weathering for quartzite outcrop

4.7 Lithostratigraphy

A geological study called litho-stratigraphy examines the layers and layering of rocks. Geochronology, comparative geology, and petrology are the key areas of this study. The existence of the strata is explained using a few different principles. It is possible to say that the hard rock that formed the rock formation is more recent than the already present rock. By utilizing the specifics of the rock composition, texture, structure, and other aspects gathered during geological mapping, this study enables geologists to interpret the history of the earth.

4.7.1 Lithostratigraphy Position

In the study area, litho-stratigraphy is positioned under the sedimentary and metamorphic unit and is organized from oldest to youngest. The lithology ranges in age from the Carboniferous to the Late Permian. The stratigraphic column for the lithology present in the research area is depicted in Figure 4.13.

Stratigraphy	Period	Era
	Carboniferous	Paleozoic
	Late Permian	Paleozoic

Legend	
Colour	Type of rock
	Claystone
	Quartzite

Figure 4.13 Stratigraphic Column of lithology in the study area

4.7.2 Unit Explanation

Sedimentary and Metamorphic makes up the sole lithological unit found inside the study area. The principal rocks found inside the sedimentary and metamorphic unit in the study area are claystone and quartzite. The lithology of the study area is shown in Table 4.3 along with a description.

Table 4.3 Lithological unit in the study area

Lithological unit

Lithology	Description	Unit
	Sedimentary rock that consists mainly of claystone. It is behind Setiu River	Sedimentary
	Metamorphic rock that consists mainly of quartzite.	Metamorphic

i) Sedimentary rock

Sedimentary rocks are the kind of rocks that are created at the Earth's surface by the accumulation or deposition of mineral or organic particles followed by cementation. The general term for the actions that lead to these particles settling down is sedimentary. Sediment refers to the microscopic fragments that make up sedimentary rocks, which can be either biological or geological debris. The weathering and erosion of pre-existing rocks or the solidification of molten lava blobs released by volcanoes are the two main causes of the geological debris.

Water, wind, ice, or mass movements, together referred to as agents of denudation, convey the geological debris to the location of deposition. The remains and fragments of deceased aquatic organisms, as well as their faecal material floating in water and gradually piling up on the bottom of water bodies, formed biological detritus. Although the crust of the planet is covered with sedimentary rock to a great extent, just 8% of the crust is thought to be made up of sedimentary rock. Only a small layer of the crust, which is mostly made up of igneous and metamorphic rock, is covered by sedimentary rocks. Sedimentary rocks form strata when they are deposited in layers, creating a structure known as bedding. Large formations known as sedimentary basins are frequently where sedimentary rocks are deposited.

The sedimentary rock can be found in the river bed at the study area. It is consists mainly of claystone. The claystone outcrop is located near Setiu River. The high of the outcrop is 3 m with the width 50 m. The landform surrounding the outcrop is mostly low land and slightly sloping plain. Figure 4.14 shows the claystone outcrop by human scale.

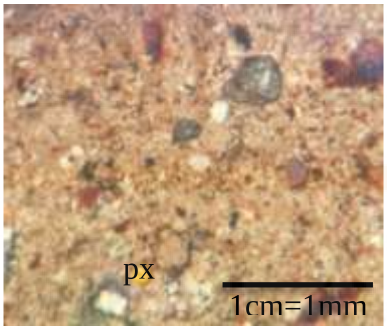
Figure 4.14 Claystone outcrop

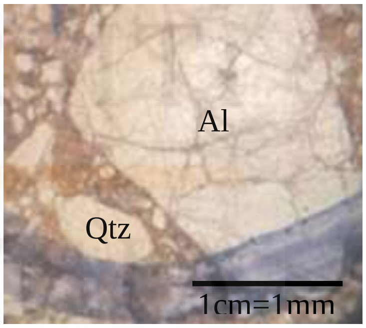
Based on the hand specimen observation with using a combination of megascopic, the colour of the rock is gray. Other than that, under the microscope observation of claystone thin section, it is being done by using ocular enlargement lens of 10x. Figure 4.15 shows the hand specimen of claystone outcrop.

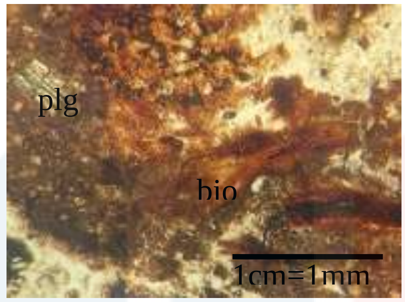
Figure 4.15 Hand specimen of claystone outcrop.

Figure 4.16 and 4.17 shows the Cross Polarized Light (XPL) and Plane Polarized Light (PPL) of the claystone thin section. Several minerals may be recognised when seen under a microscope using the PPL and XPL techniques. Quartz mineral can be seen under XPL and PPL. The colour under PPL and XPL is white colour. It has a low relief without cleavage and low pleochroism. Quartz presence spread in thin section with 10% abundance percentage.

Other than that, the types of minerals that found are alkali feldspar, pyroxene, biotite, plagioclase and opaque. The colour for alkali feldspar under XPL and PPL is gray to white. The shape of alkali feldspar is euhedral crystals. It is presence on thin section with 70%. For pyroxene, the colour under PPL and XPL is yellow. Can be seen it presence 2%. Biotite is presence on thin section 10% and the colour under XPL and PPL is brown. Lastly, the colour for plagioclase under XPL and PPL is gray to white. The presence for plagioclase under thin section is 5% and 3% of presence on opaque mineral.

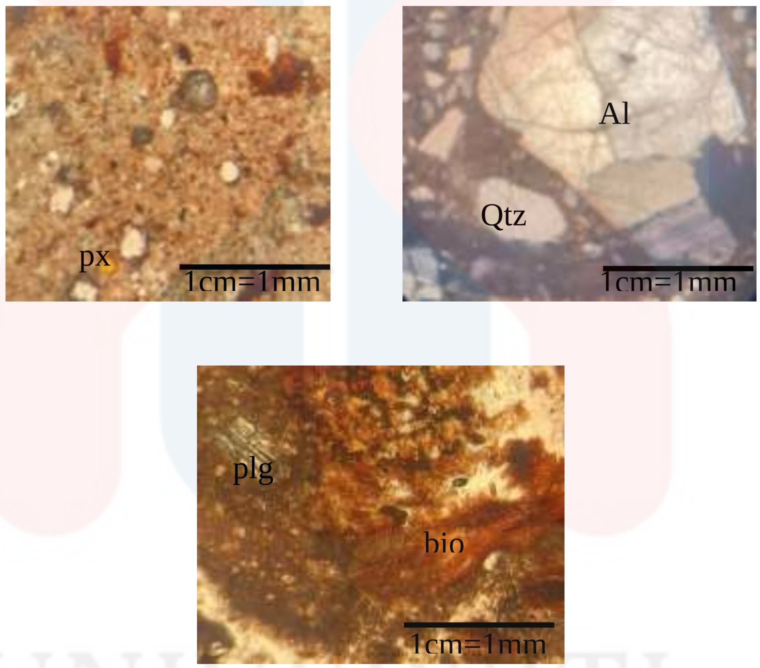






Magnificent: 10x/0.25 P magnificent

Figure 4.16 PPL view of claystone thin section under microscope



Magnificent: 10x/0.25 P magnificent

Figure 4.17 XPL view of claystone thin section under microscope

ii) Metamorphic rock

When rocks are exposed to high heat, high pressure, hot mineral-rich fluids, or more frequently any combinations of these conditions, metamorphic rocks are created. The rocks do not melt throughout the metamorphism process; rather, they become denser, more compact rocks. Either by the rearranging of mineral constituents or through chemical interactions with fluids that enter the rocks, new minerals are produced. Even rocks that have already undergone metamorphosis might undergo changes due to pressure or temperature. Thus, quartzite is the sort of rock that may be found in Kampung Banggul.

The outcrop weathering is highly weathered. The high of the outcrop is 4 m with the width 50 m. The landform surrounding the outcrop is low land and middle land. The geomorphological unit is slightly sloping plain. Figure 4.18 shows quartzite outcrop that found in Kampung Banggul.

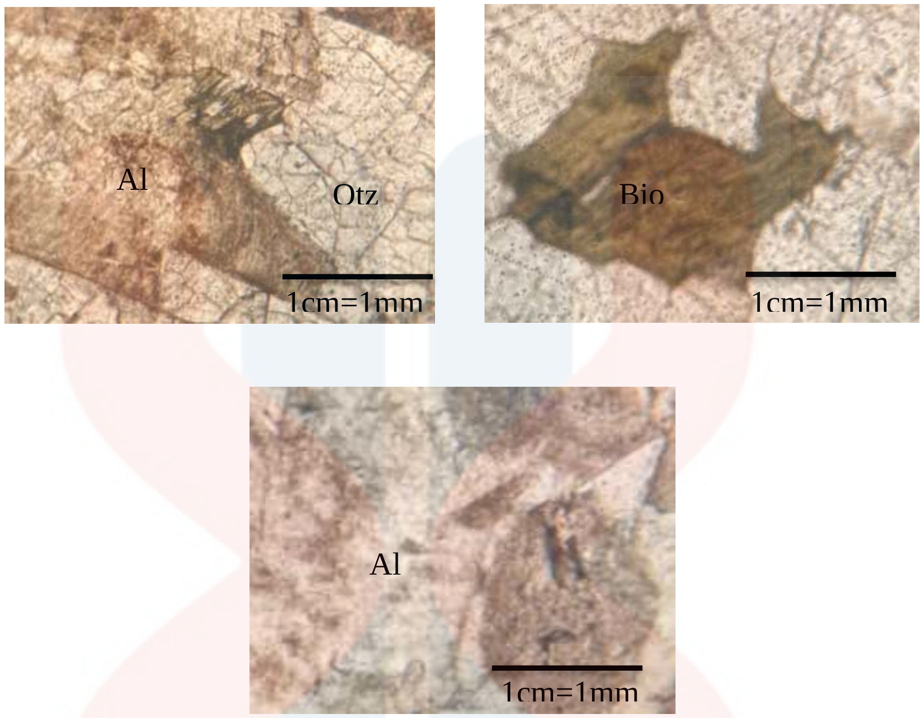
Figure 4.18 Qaurtzite outcrop

Based on the hand specimen observation with using a combination of megascopic, the colour is brown. Next, using a 10x ocular enlargement lens, sandstone thin sections are being seen under the microscope. Figure 4.19 shows the hand specimen of quartzite outcrop.

Figure 4.19 Hand specimen of quartzite outcrop.

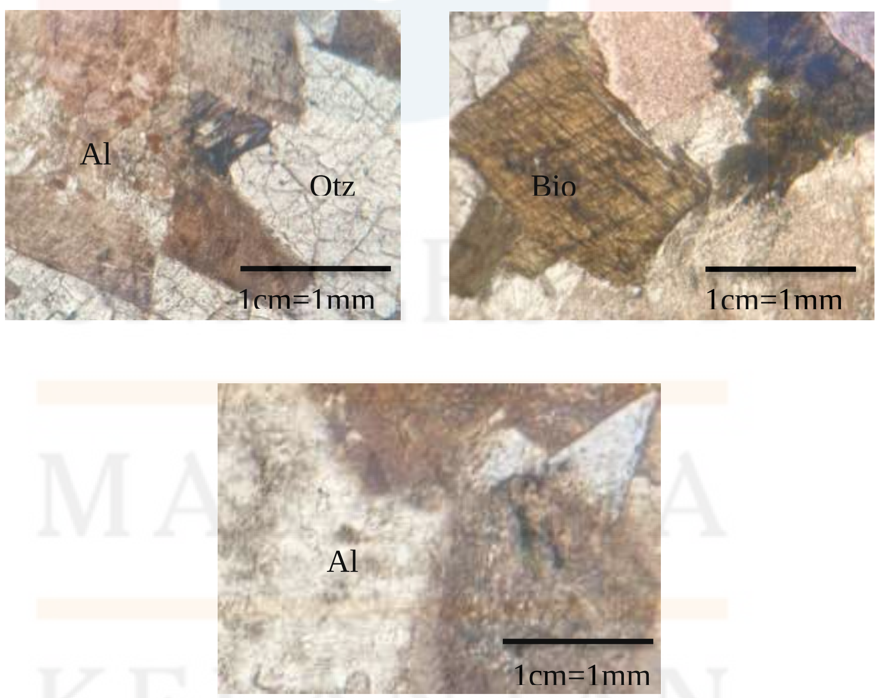
Figure 4.20 and 4.21 shows the PPL and XPL of the quartzite thin section. Several minerals may be recognized when seen under a microscope using the PPL and XPL techniques. Quartz mineral can be seen under XPL and PPL. The colour under PPL and XPL is white colour. It has a low relief without cleavage and low pleochroism. Quartz presence spread in thin section with 50% abundance percentage.

Other than that, the type of mineral that found are alkali feldspar, biotite and opaque. The colour for alkali feldspar under XPL and PPL is gray to white. The shape of alkali feldspar is euhedral crystals. It is presence on thin section with 40%. Biotite is presence on thin section 7% and the colour under XPL and PPL is brown. The shape of biotite is typically approximately hexagonal. Lastly, can be seen it presence 3% in the section for opaque mineral.



Magnificent: 10x/0.25 P magnificent

Figure 4.20 PPL view of sandstone thin section under microscope



Magnificent: 10x/0.25 P magnificent

Figure 4.21 XPL view of sandstone thin section under microscope

4.8 Structural Geology

The area of geology known as structural geology is concerned with the description, representation, and study of structure on a moderate to small scale as well as the form, arrangement, and internal structure of rocks. Therefore, structural geology is one of the geology subfields that should be examined during geological mapping. This study focuses on the 3-dimensional distribution of rock units and their deformations. Within the research region, geological structures such as lineament and strike and dip can be found.

a) Lineament

A fault or other underlying geological structure can be represented as a lineament, which is a linear landscape feature. The fault-aligned valley, series of fault or fold-aligned hills, straight coastline, or even the combinations of these characteristics are common manifestations of a lineament. Next, igneous intrusions such dykes, fracture zones, and shear zones can also be used to represent geomorphic lineaments. Lastly, lineaments can be easily seen on aerial or satellite photos as well as in geological or topographic maps.

From the research area, geomorphic lineaments also founds in the area of contour and river. Figure 4.22 shows the lineament map at the study area. The types of lineaments are human activities and tonal contrast.

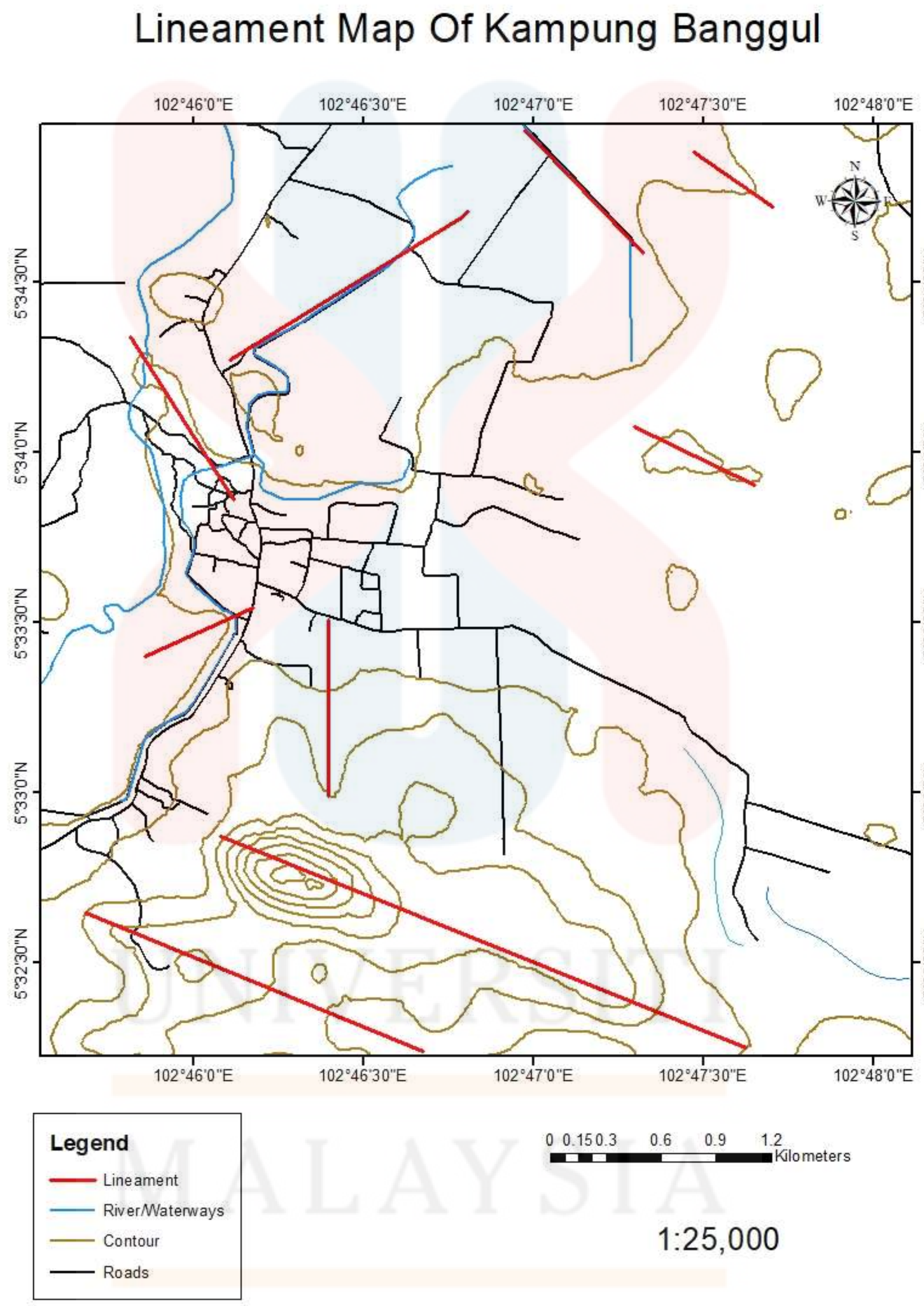


Figure 4.22 Lineament Map of human activities in Kampung Banggul

b) **Strike and dip**

One of the important things that need do when mapping is taking the reading of strike and dip. A measurement convention known as strike and dip is used to characterize the attitude or direction of a planar geologic structure. The azimuth of a hypothetical horizontal line crossing a feature's surface is its strike, and its dip is the angle of inclination as measured in relation to the horizontal. Other than that, it is employed in tandem to gauge and record a structure's attributes for research or application on a geologic map. So, from the research area at Kampung Banggul, it is take strike and dip to know the direction of a planar geologic structure and make rose diagram and stereonet.

Outcrop 1:

Dip	Strike
86^0	316^0
82^0	298^0
89^0	245^0
90^0	326^0
35^0	209^0
87^0	284^0
83^0	195^0
75^0	215^0
88^0	215^0
88^0	233^0

70^0	180^0
68^0	195^0
61^0	182^0
83^0	219^0
84^0	215^0
60^0	253^0
24^0	278^0
85^0	297^0
71^0	300^0
85^0	268^0
57^0	233^0
88^0	219^0
66^0	229^0
74^0	201^0
74^0	244^0
89^0	264^0
86^0	245^0
77^0	280^0
86^0	305^0
38^0	298^0
33^0	237^0
89^0	245^0
85^0	246^0

80^0	240^0
80^0	306^0
71^0	299^0
64^0	283^0
76^0	305^0
86^0	264^0
54^0	272^0

Outcrop 2:

Dip	Strike
89^0	153^0
89^0	170^0
89^0	161^0
46^0	164^0
46^0	209^0
65^0	208^0
90^0	145^0
88^0	84^0
89^0	145^0
86^0	174^0
90^0	147^0
82^0	185^0

82^0	215^0
82^0	248^0
75^0	257^0
81^0	215^0
81^0	269^0
88^0	216^0
79^0	213^0
78^0	214^0
14^0	189^0
86^0	233^0
85^0	215^0
65^0	258^0
75^0	264^0
84^0	255^0
84^0	230^0
87^0	227^0
67^0	297^0
89^0	117^0

Outcrop 5:

Dip	Strike
62^0	310^0

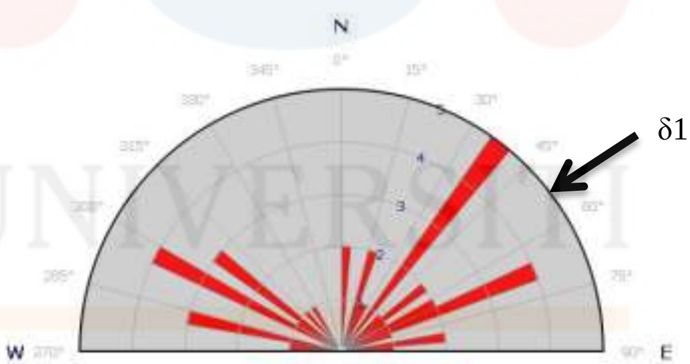
63^0	277^0
89^0	242^0
83^0	264^0
38^0	236^0
57^0	265^0
90^0	224^0
49^0	241^0
71^0	285^0
30^0	274^0

Outcrop 6:

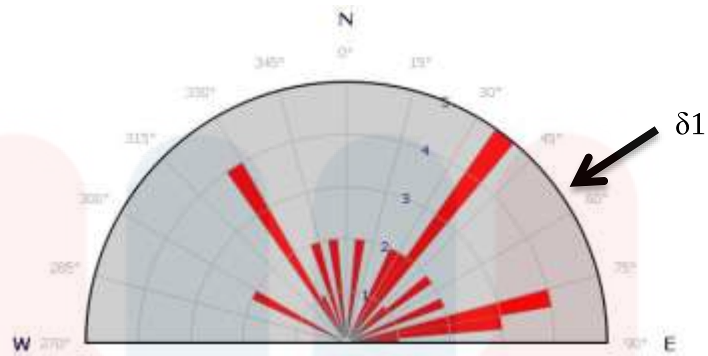
Dip	Strike
82^0	316^0
85^0	182^0
89^0	182^0
79^0	230^0
80^0	175^0
88^0	180^0
78^0	172^0
74^0	185^0
78^0	175^0
46^0	225^0

32^0	238^0
33^0	215^0
47^0	216^0
47^0	210^0
87^0	180^0
80^0	102^0
74^0	174^0
45^0	196^0
14^0	215^0
18^0	210^0

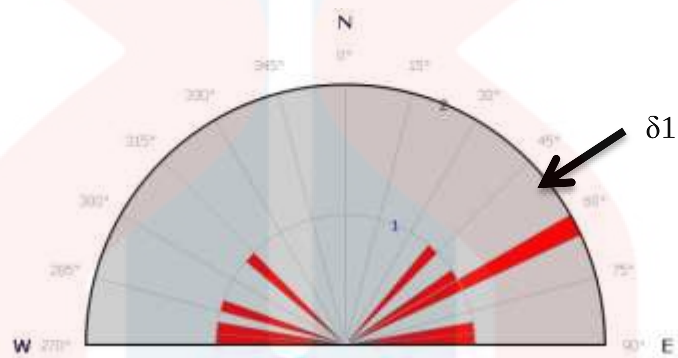
Rose diagram



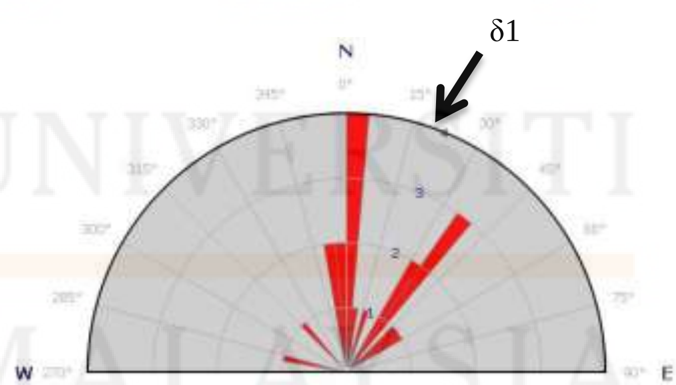
Outcrop 1



Outcrop 2



Outcrop 5



Outcrop 6

Figure 4.32 Rose diagram for the orientation of discontinuities collected from the research area

The orientation of discontinuities like joints are taken from the mapping and plotted in the Rose diagram as shown in Figure 4.32. From the Rose diagram, most the discontinuities were trending on outcrop 1and outcrop 2 from 035^0 to 075^0 while for outcrop 5 is from 045^0 to 090^0 and outcrop 6 is from 350^0 to 040^0. This indicated that the principal stress, $\delta 1$ for outcrop 1, outcrop 2, outcrop 5 and outcrop 6 is originating approximately from the direction of NE-SW. The rocks were pushed by the compressive forces coming from this direction, and as a result of their brittle deformation, they produced discontinuities.

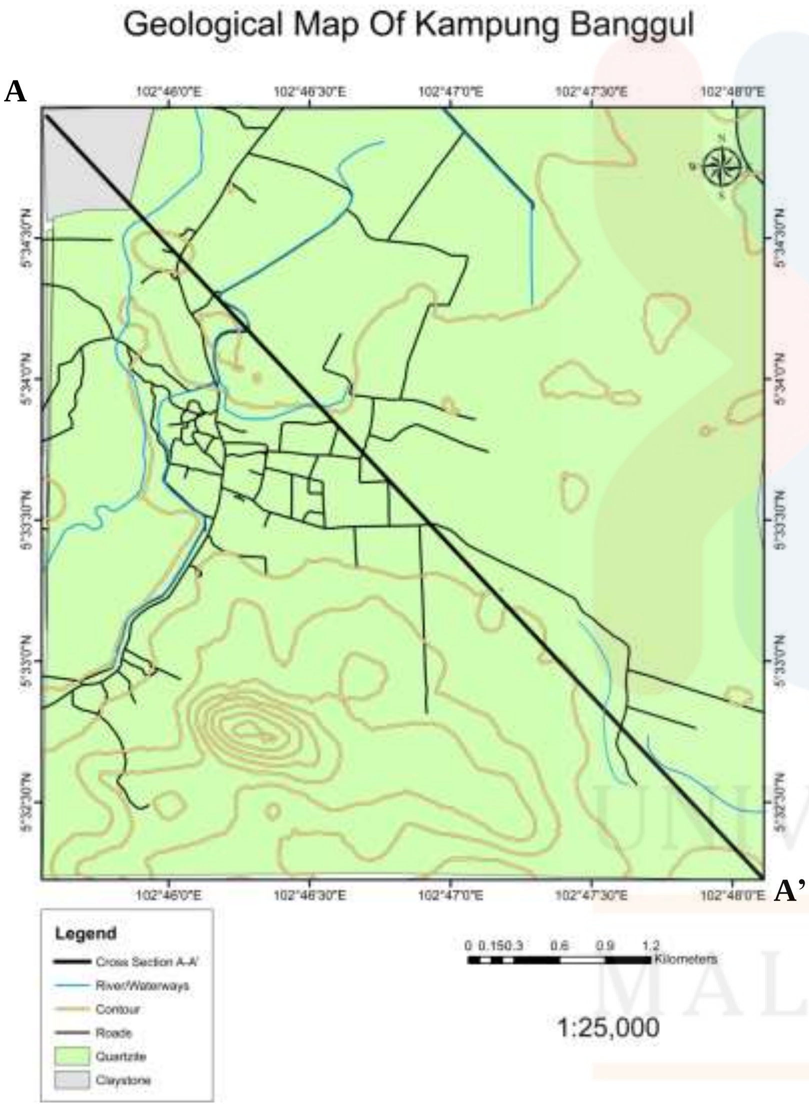
4.9 Historical Geology

Peninsular Malaysia's Eastern Belt includes the eastern portion of Johor and the eastern portion of the Lebir fault. East of Kelantan, Terengganu, and east of Johor are included in this belt, which is made up of rocks dating from the Paleozoic to the Cenozoic. Carboniferous meta-sediments, igneous rocks, and Jurassic cretaceous continental deposits make up the northern portion of the Eastern Belt.

The Sungai Perlis Bed is composed of carboniferous meta-sediments based on fossils discovered at Ulu Paka, Terengganu, as well as other localities in North Pahang, Terengganu, and Batu Rakit. In addition to that, sedimentary formations from the Carboniferous, Permian, and granite formation are the most prevalent rock types. The sedimentary rocks in the study area consists claystone and sandstone and for igneous rock consist of alkali feldspar granite.

Sediments and igneous rock make up the research area's geological succession. Sediments and igneous rocks then divided into a unit which is alluvium which undergoes under Late Permian, Carboniferous and Carnian. Ulu paka Formation consists of sedimentary and igneous rock. The geological map of the study region, scale 1:25000, as shown in Figure 4.24, revealed the composition of the study area to be sedimentary rock after the investigation was completed. The bolder of igneous rock also found in Kampung Banggul, Permaisuri, Terengganu.

GEOLOGICAL MAP OF KAMPUNG BANGGUL, PERMAISURI, TERENGGANU, MALAYSIA



BY

NURUL ASIKIN BINTI MOHD ARAHA

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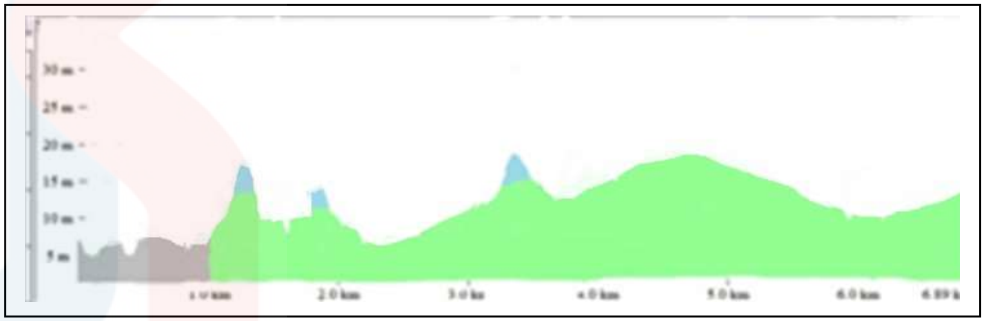
CROSS SECTION



Location: Kampung Banggul , Permaisuri, Terengganu

Figure 4.24: Geological Map of Kampung Banggul

CHAPTER 5

SEISMIC INTERPRETATION OF BUNDI FIELD, TERENGGANU OFFSHORE

5.1 Introduction

This chapter will cover the findings based on the seismic interpretation of the Bundi Field study area. It will go over how to interpret the hydrocarbon indicator and the sequence boundary in the study area. The base map for this investigation at Bundi Field, Terengganu Offshore, Malaysia is depicted in Figure 5.1. The data for the study area will give by PETRONAS. The five inline and five crossline segments from Bundi Field that have already been used for seismic interpretation were the subjects of this study. It will also be explained how to interpret sequence boundaries and probable hydrocarbons using geological structure.

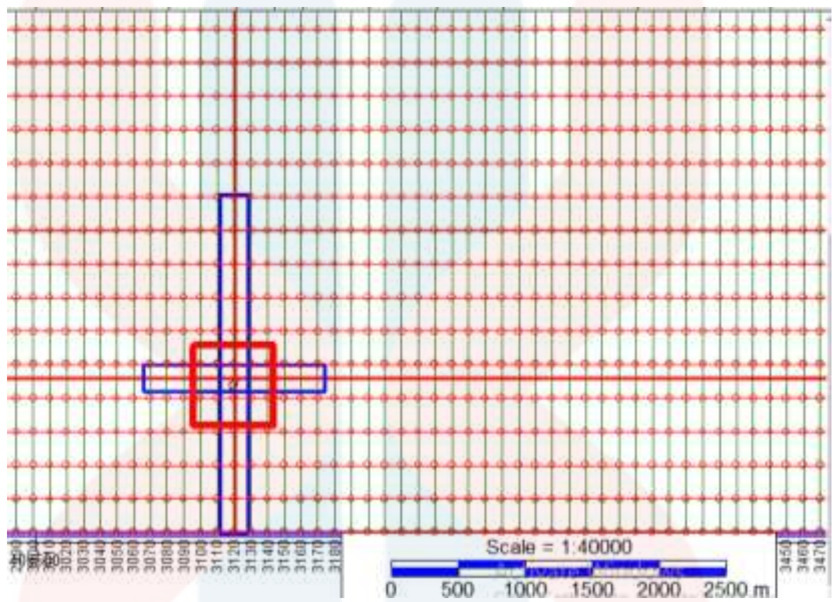


Figure 5.1 Base Map of the study area

5.2 Sequences Boundaries Identification

According to the theory that guides sequence stratigraphy, the depositional sequence can be divided into sequences. Unconformity that occurred during one significant cycle of relative sea level change binds the sequence borders.

When the relative sea level declines and is distinguished by a floor basin, subaerial erosion, and other variables, sequence boundaries are formed. The boundaries of the sequences being identified at this small scale can therefore be related to those at the global and regional levels. The seismic section's amplitude difference and the presence of different facies revealed the sequence boundaries for this project. Sand and shale make up the majority of the Bundi Field, according to the PETRONAS well log data. Coal and carbonate rock make up the Bundi Field's minor rock unit. Due to data limitations, well tying is not possible, and the only way to interpret the geological strata in the study region is through a report.

5.2.1 Seismic Line Inline 799

Five sequence boundaries were discovered on the seismic line inline (IL) 799, as shown in Figure 5.2. The termination patterns of seismic reflection vary for each sequence boundary. Reflection terminations represent stratal discontinuities that divide distinct depositional sequences and system tracts. Based on environmental variables like eustatic sea level rise, climate variation, tectonic subsidence, or changes in sediment supply, several types of reflection termination take place.

Figure 5.3 shows the sequence boundary SB 1 with presence of downlap and onlap which it terminates to the oldest strata below. Downlap is the reflector termination on surfaces which dip less than that of the overlying beds, lapping onto a structural low. Other than that, onlap is the reflector termination on surfaces with greater dips than that of the overlying beds, lapping onto a structural high.

Figure 5.4 shows the sequence boundary SB 2 with presence of toplap and downlap which it terminates to the youngest strata above and the oldest strata below. Toplap is the reflector termination at an overlying surface or upper boundary. Figure 5.5, 5.6 and 5.7 shows the sequence boundary SB 3, SB 4 and SB 5 with presence of toplap at the SB 3, SB 4 and SB 5 boundary which it moves toward the youngest strata above.

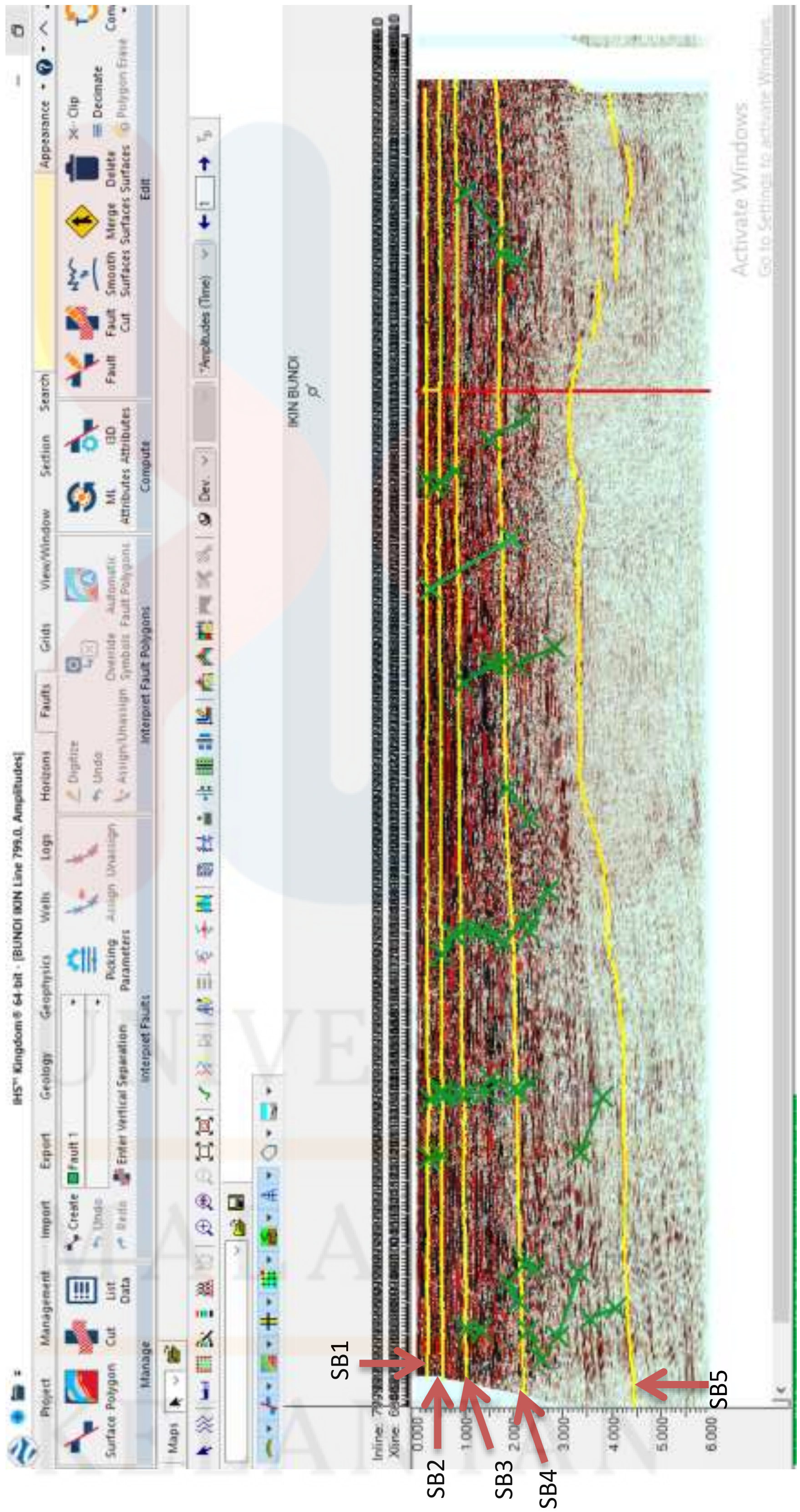


Figure 5.2: The Sequence Boundary in Inline 799

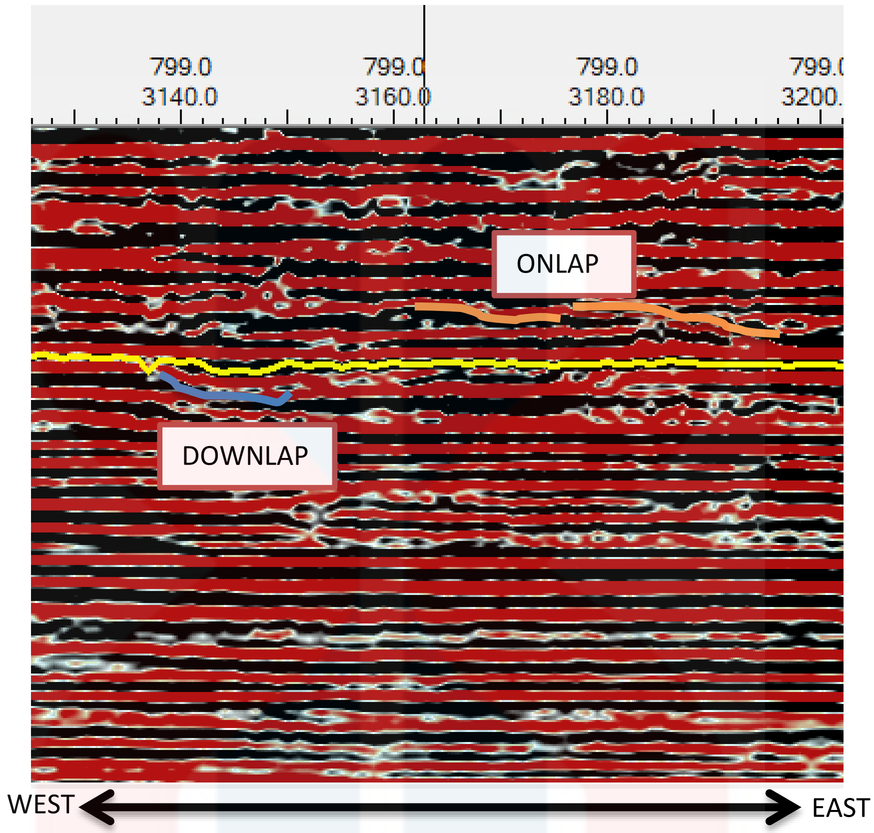


Figure 5.3: SB 1 Boundary at Inline 799

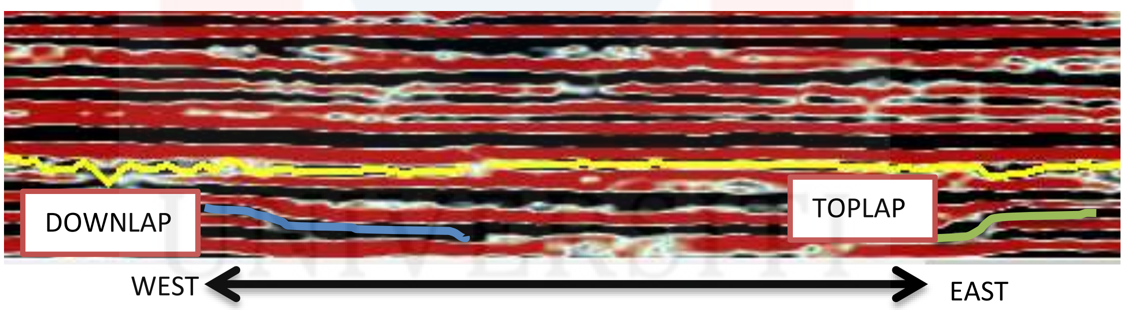


Figure 5.4: SB 2 Boundary at Inline 799

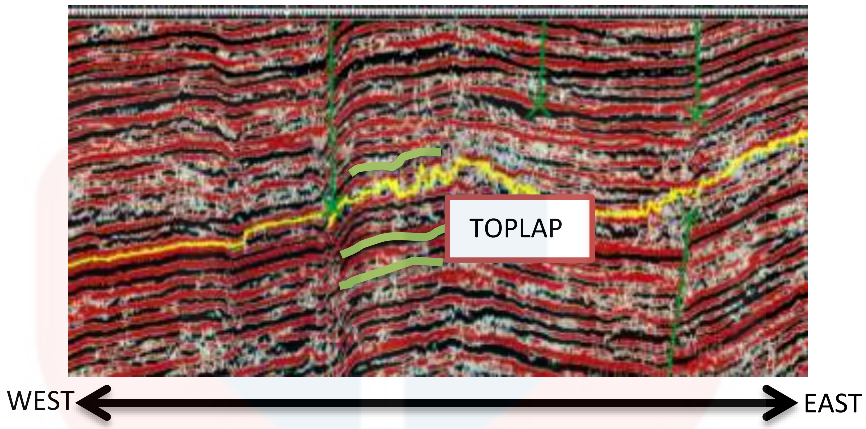


Figure 5.5: SB 3 Boundary at Inline 799

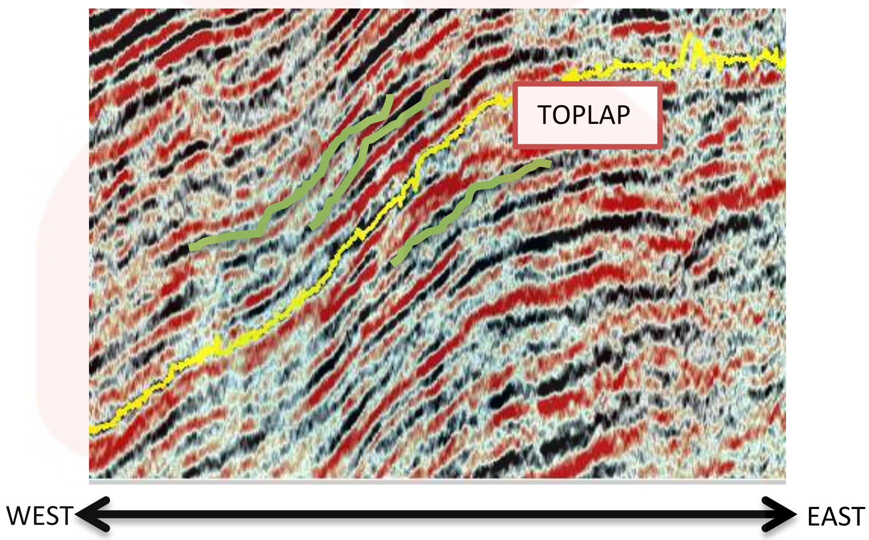


Figure 5.6: SB 4 Boundary at Inline 799

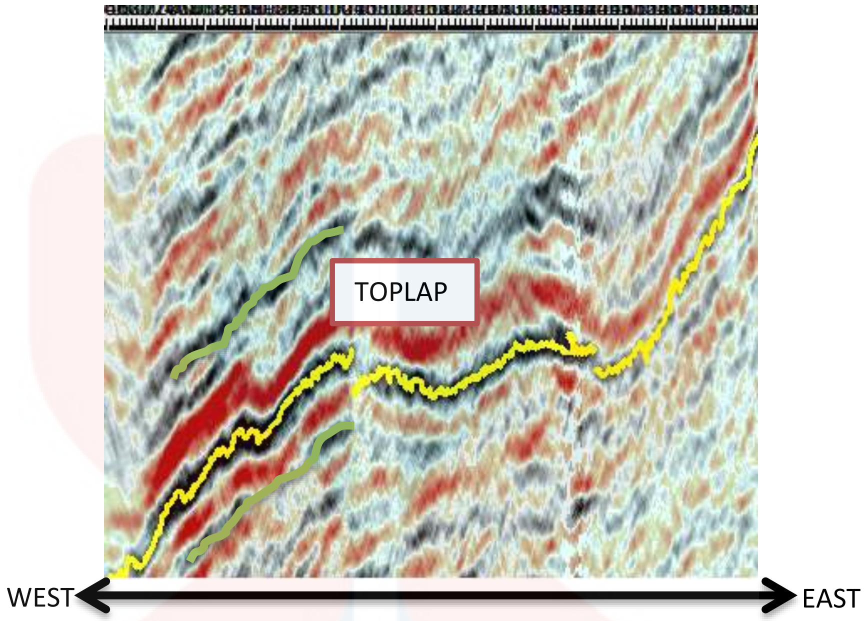


Figure 5.7: SB 5 Boundary at Inline 799

5.2.2 Seismic Line Inline 800

The total of 5 sequences boundaries were discovered on the seismic line inline (IL) 800, as shown in Figure 5.8. The sequence boundary SB 1 is depicted in Figure 5.9 with onlap present at the border where it connects to the earliest strata. Figure 5.10 and 5.11 shows the sequence boundary SB 2 and SB 3 with presence of downlap at the SB 2 and SB 3 boundary which it terminates to the oldest strata below. Lastly, Figure 5.12 and 5.13 shows the sequence boundary SB 4 and SB 5 with presence of toplap at the SB 4 and SB 5 boundary which it terminates to the youngest strata above.

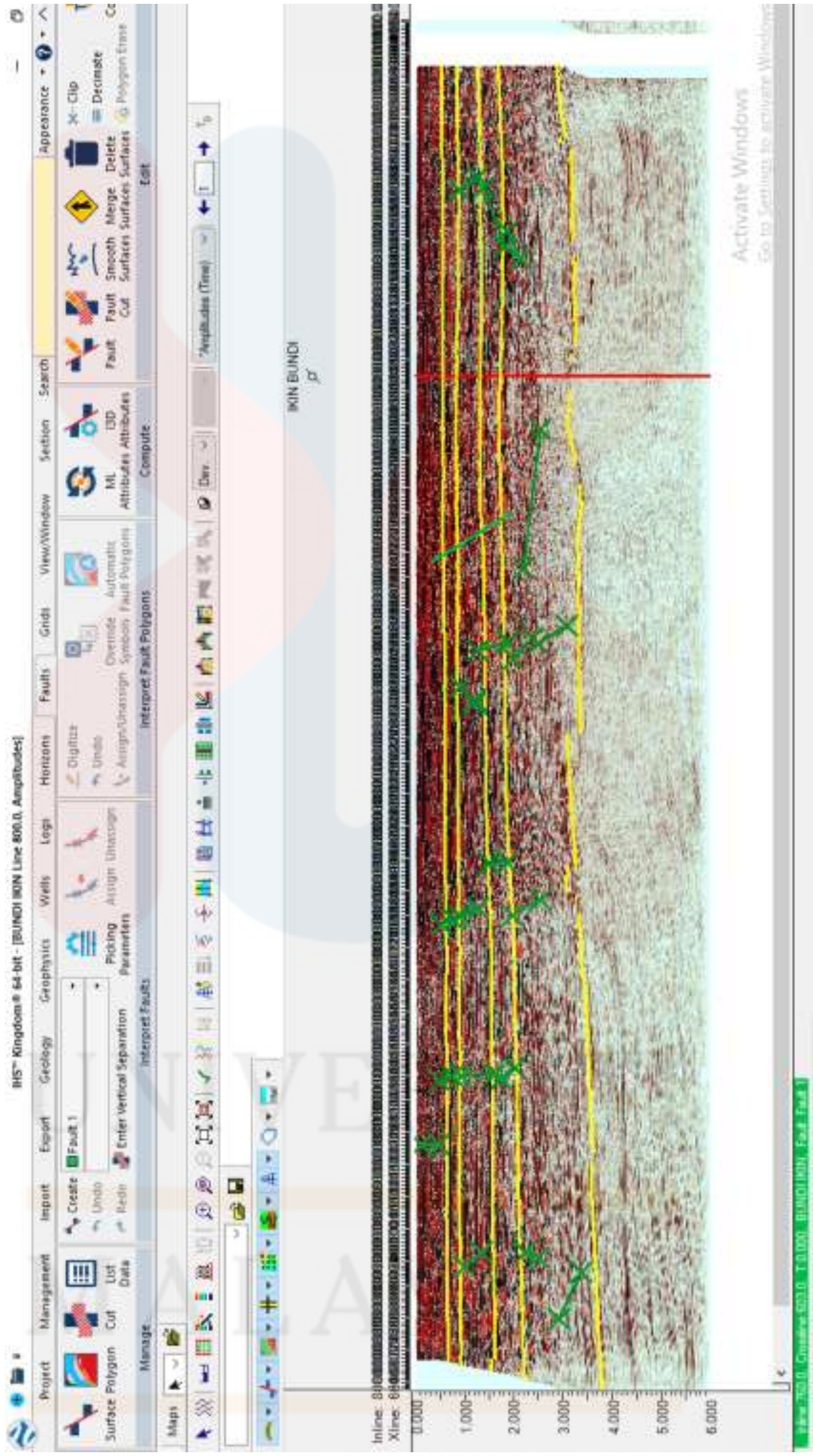


Figure 5.8: The Sequence Boundary in Inline 800

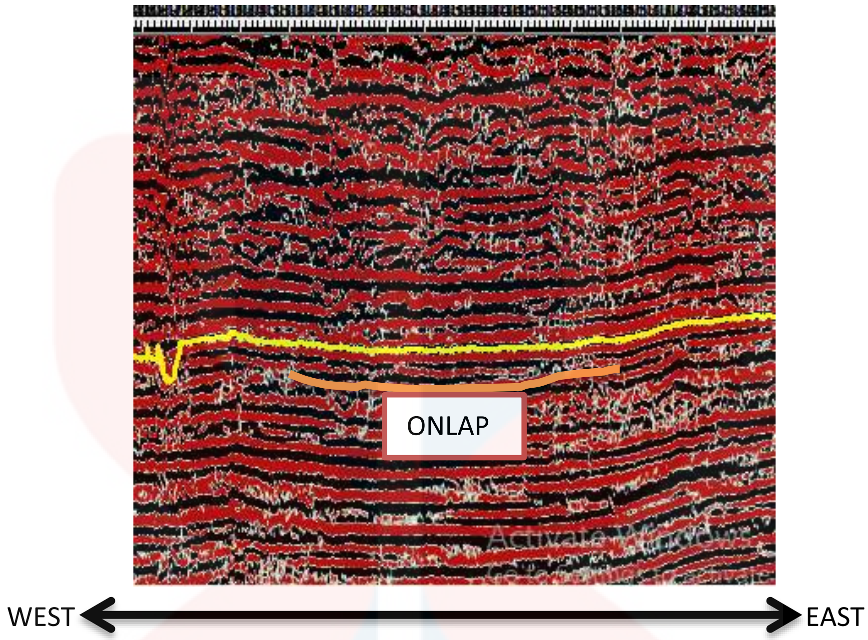


Figure 5.9: SB 1 Boundary at Inline 800

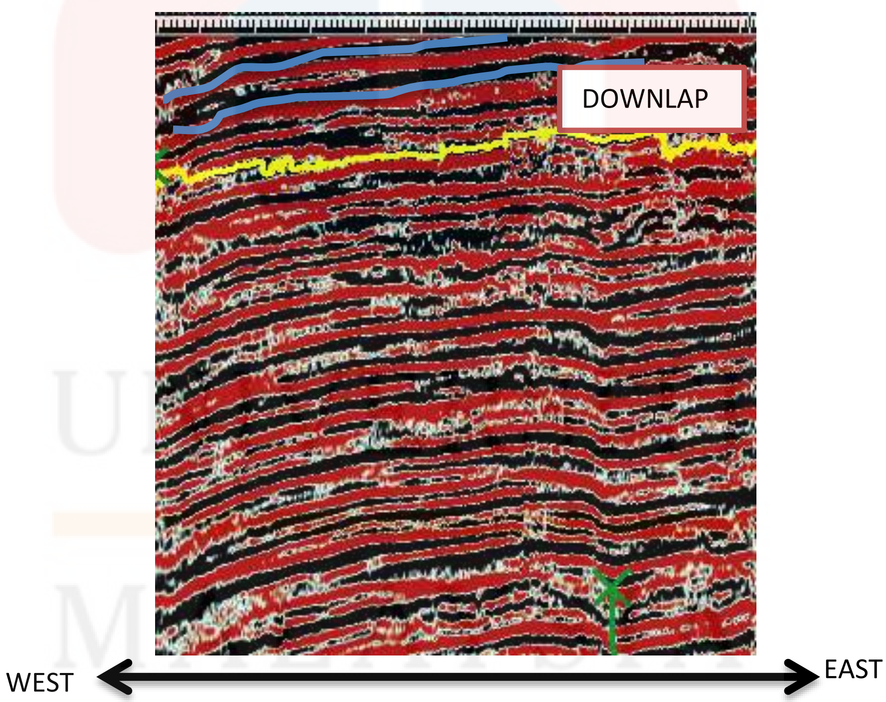
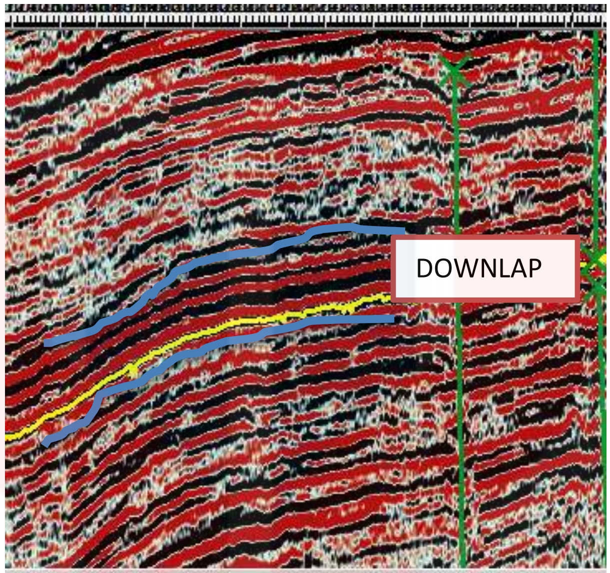
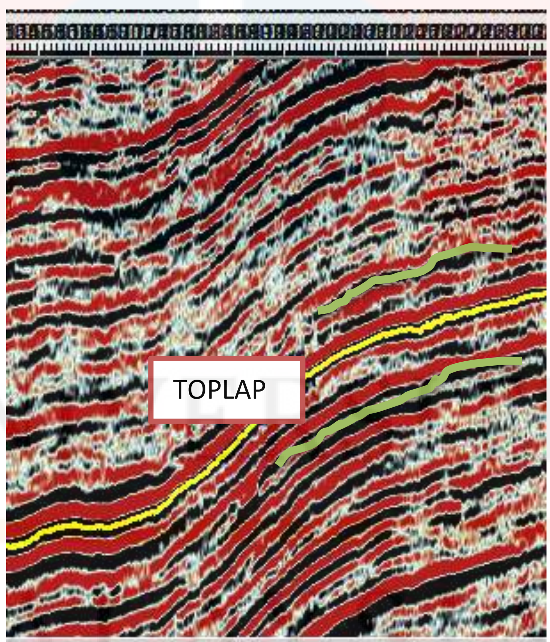


Figure 5.10: SB 2 Boundary at Inline 800



WEST EAST

Figure 5.11: SB 3 Boundary at Inline 800



WEST EAST

Figure 5.12: SB 4 Boundary at Inline 800

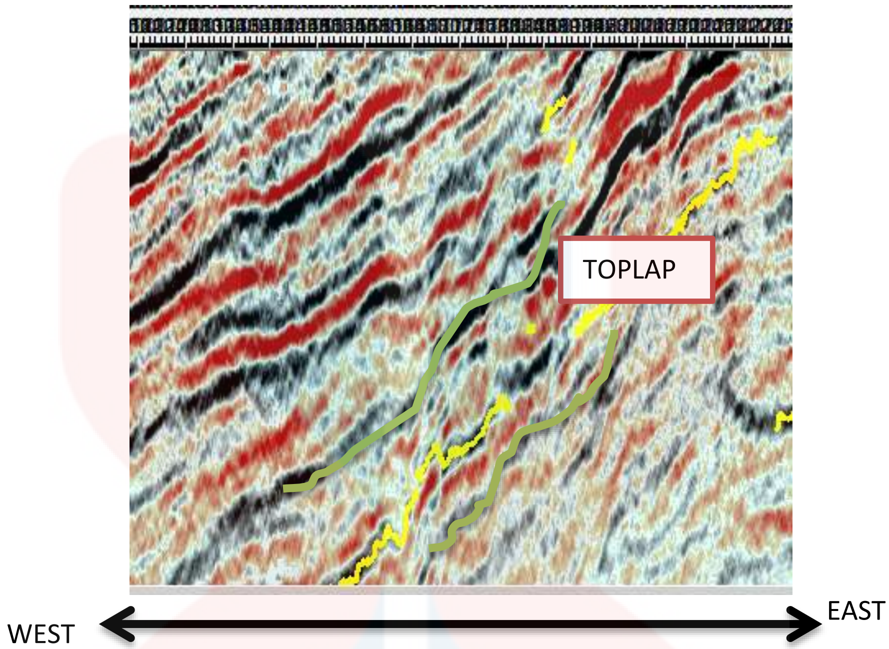


Figure 5.13: SB 5 Boundary at Inline 800

5.2.3 Seismic Line Inline 801

The total of 4 sequences boundaries were observed on the seismic line inline (IL) 801 as shown in Figure 5.14. The sequence boundary SB 2 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.15. The sequence boundary SB 3 is depicted in Figure 5.16 together with the downlap that finishes at the boundary to the oldest strata below. Last but not least, Figure 5.17 depicts the sequence boundary SB 4 with toplap present at the border between SB 4 and SB 5, terminating to the youngest stratum above.

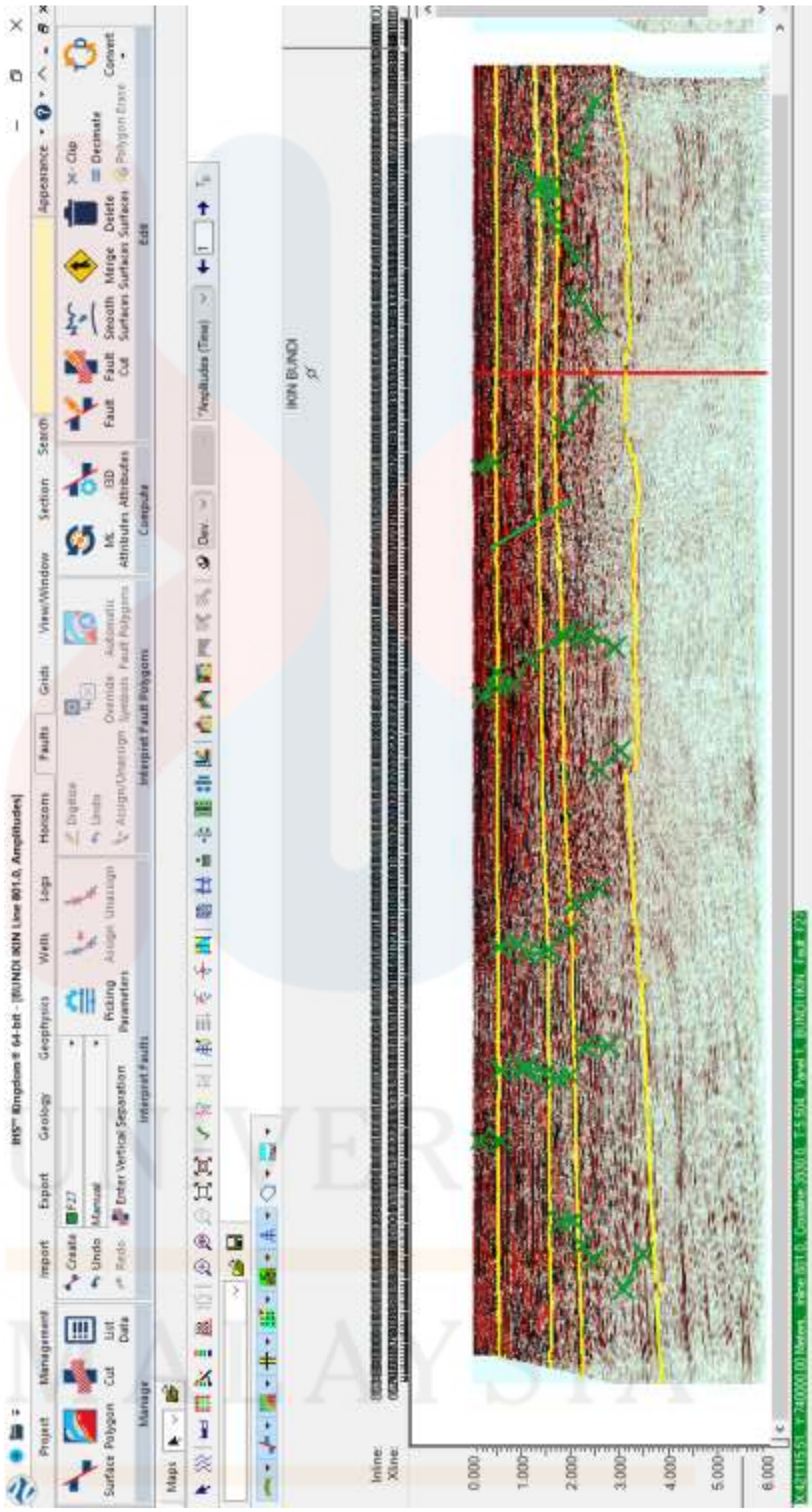


Figure 5.14: The Sequence Boundary in Inline 801

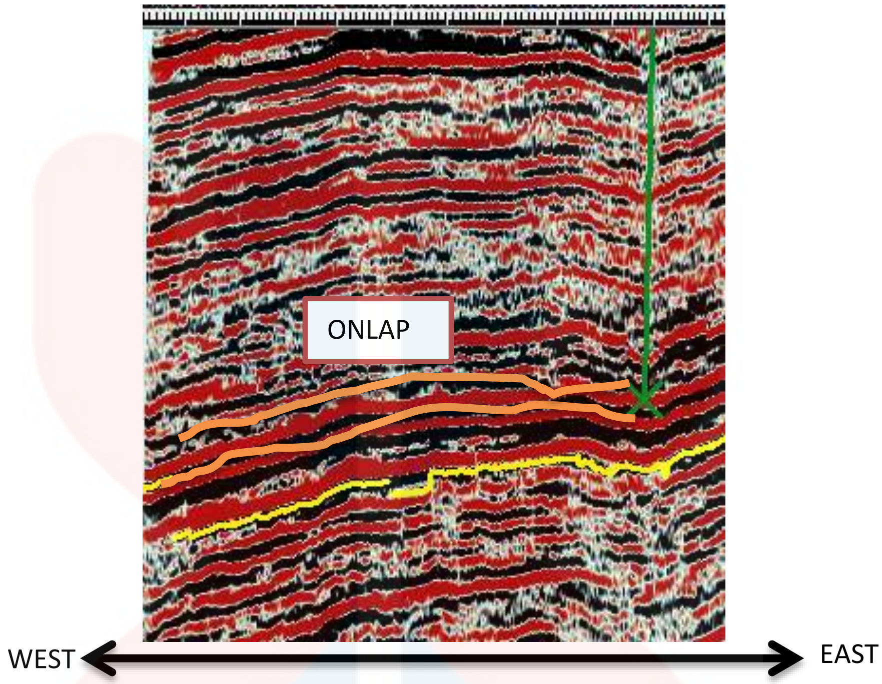


Figure 5.15: SB 2 Boundary at Inline 801

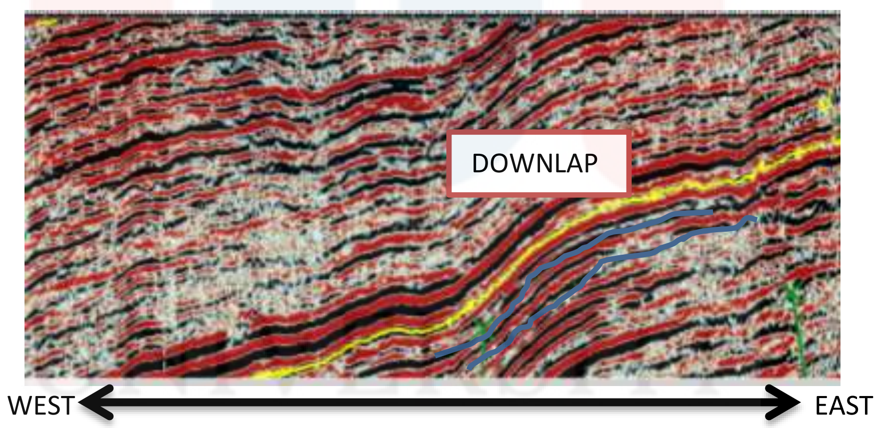


Figure 5.16: SB 3 Boundary at Inline 801

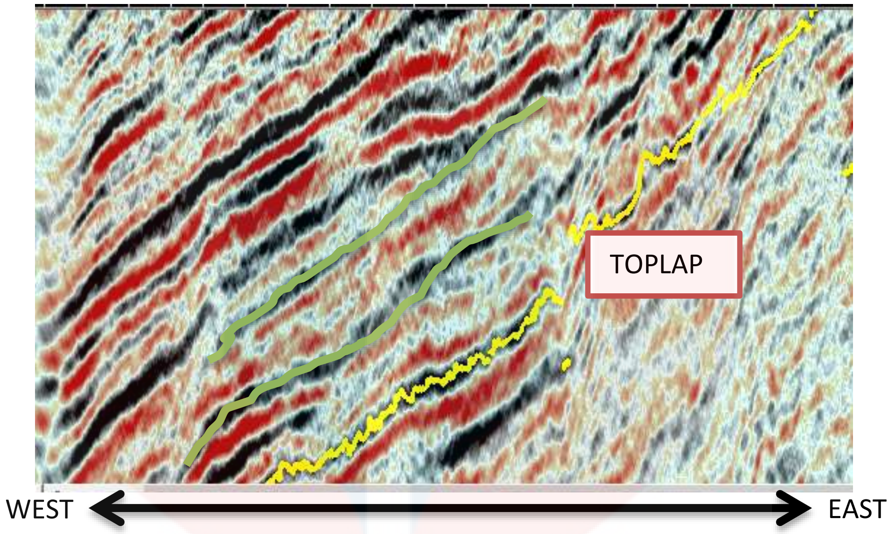


Figure 5.17: SB 4 Boundary at Inline 801

5.2.4 Seismic Line Inline 802

The total of 4 sequences boundaries were discovered on the seismic line inline (IL) 802 as shown in Figure 5.18. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.19. The sequence boundary between SB 2 and SB 4 is seen in Figures 5.20 and 5.22, where toplap is present and extends to the youngest strata above. Finally, Figure 5.21 depicts the sequence boundary SB 3 with the termination of the border at the oldest strata below.

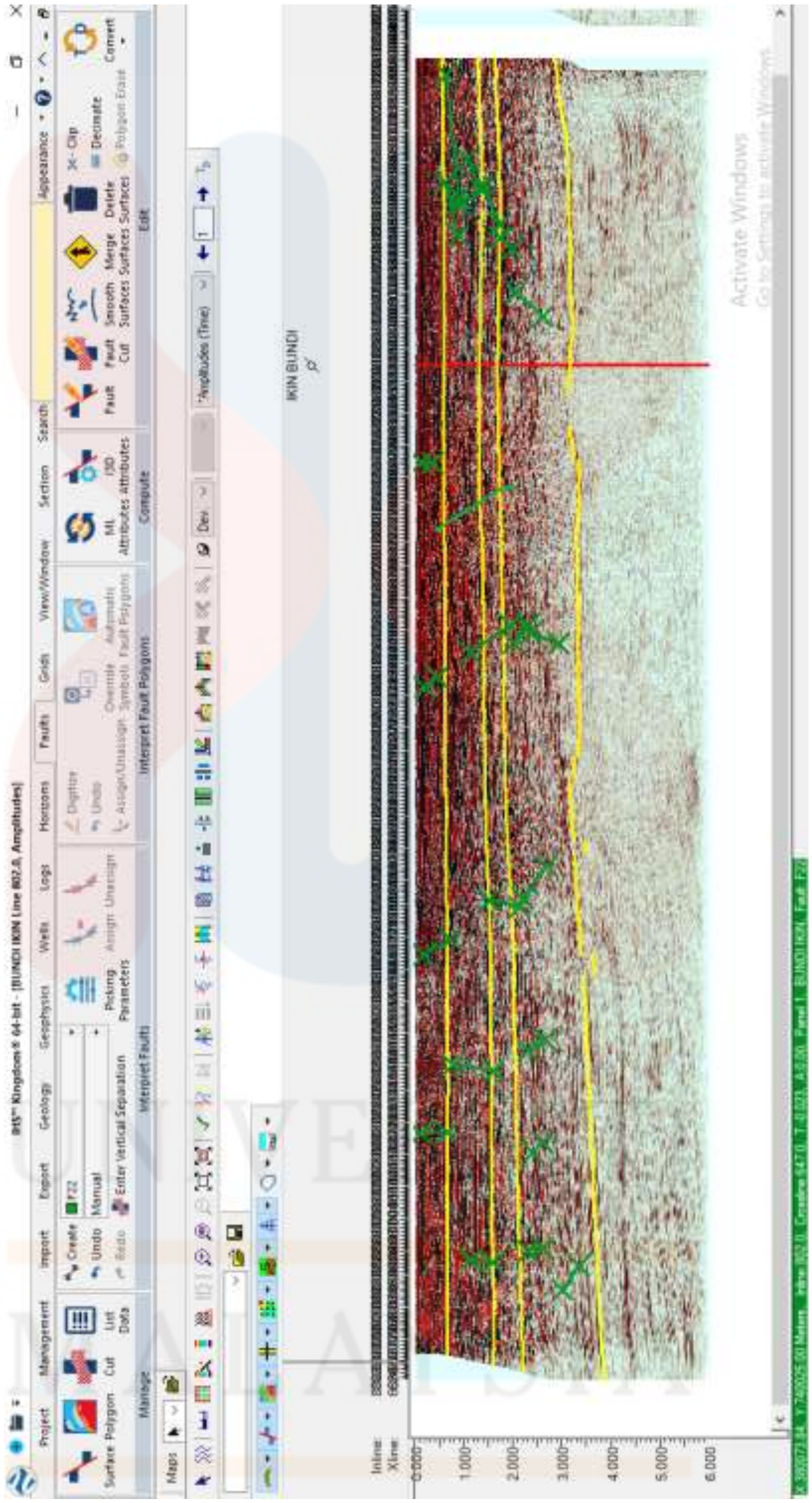


Figure 5.18: The Sequence Boundary in Inline 802

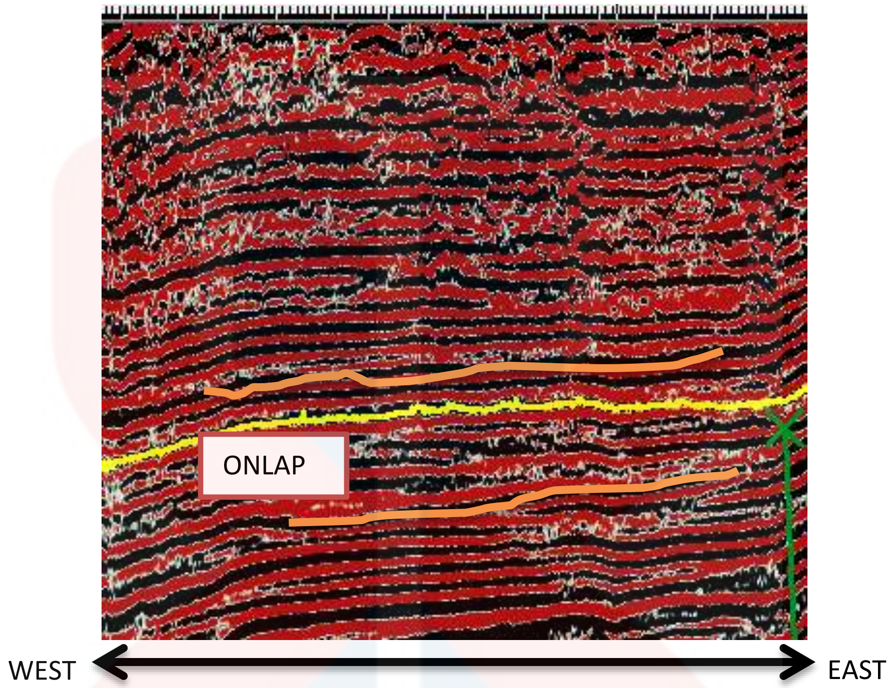


Figure 5.19: SB 1 Boundary at Inline 802

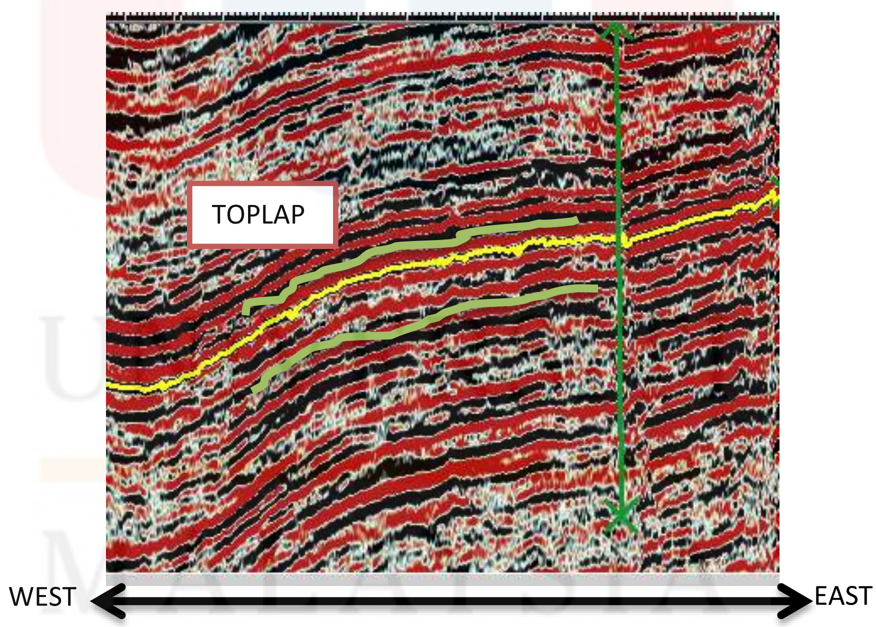


Figure 5.20: SB 2 Boundary at Inline 802

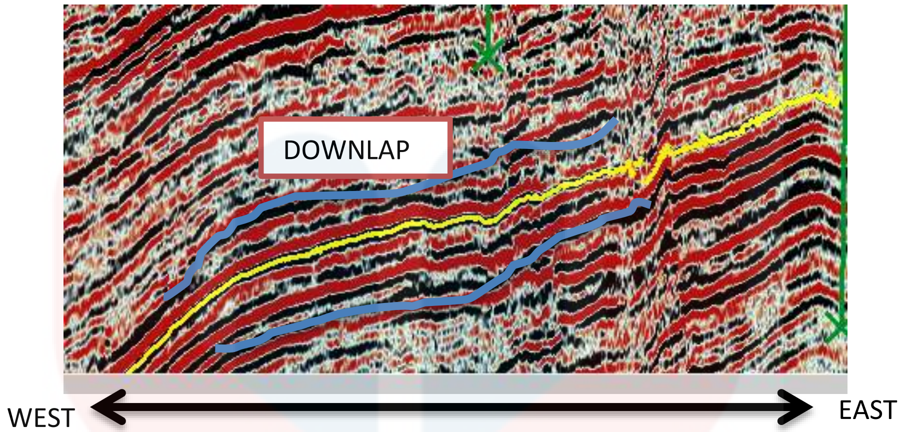


Figure 5.21: SB 3 Boundary at Inline 802

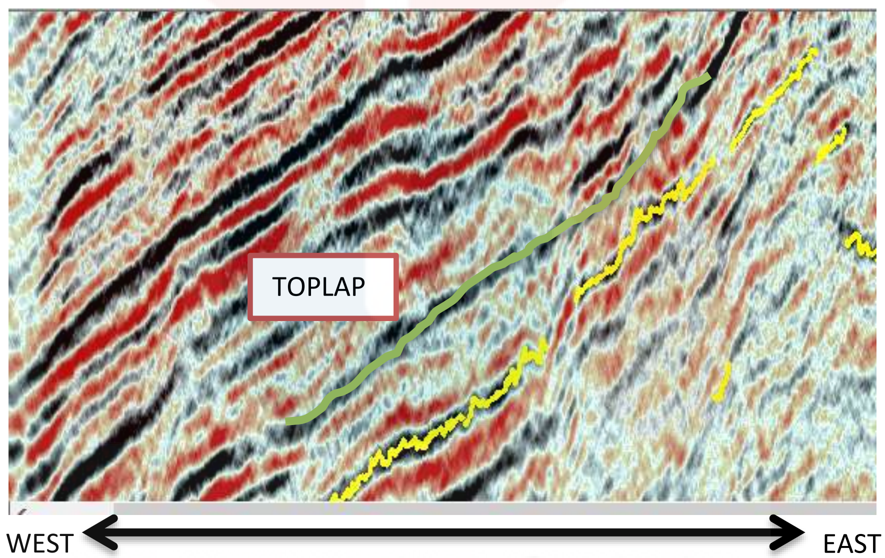


Figure 5.22: SB 4 Boundary at Inline 802

5.2.5 Seismic Line Inline 803

The total of 4 sequences boundaries were discovered on the seismic line inline (IL) 802 as shown in Figure 5.23. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.24. The sequence boundary SB 2, SB 3, and SB 4 are shown in Figures 5.25, 5.26, and 5.27. Downlap is present at the SB 2, SB 3, and SB 4 where it ends at the oldest strata below.

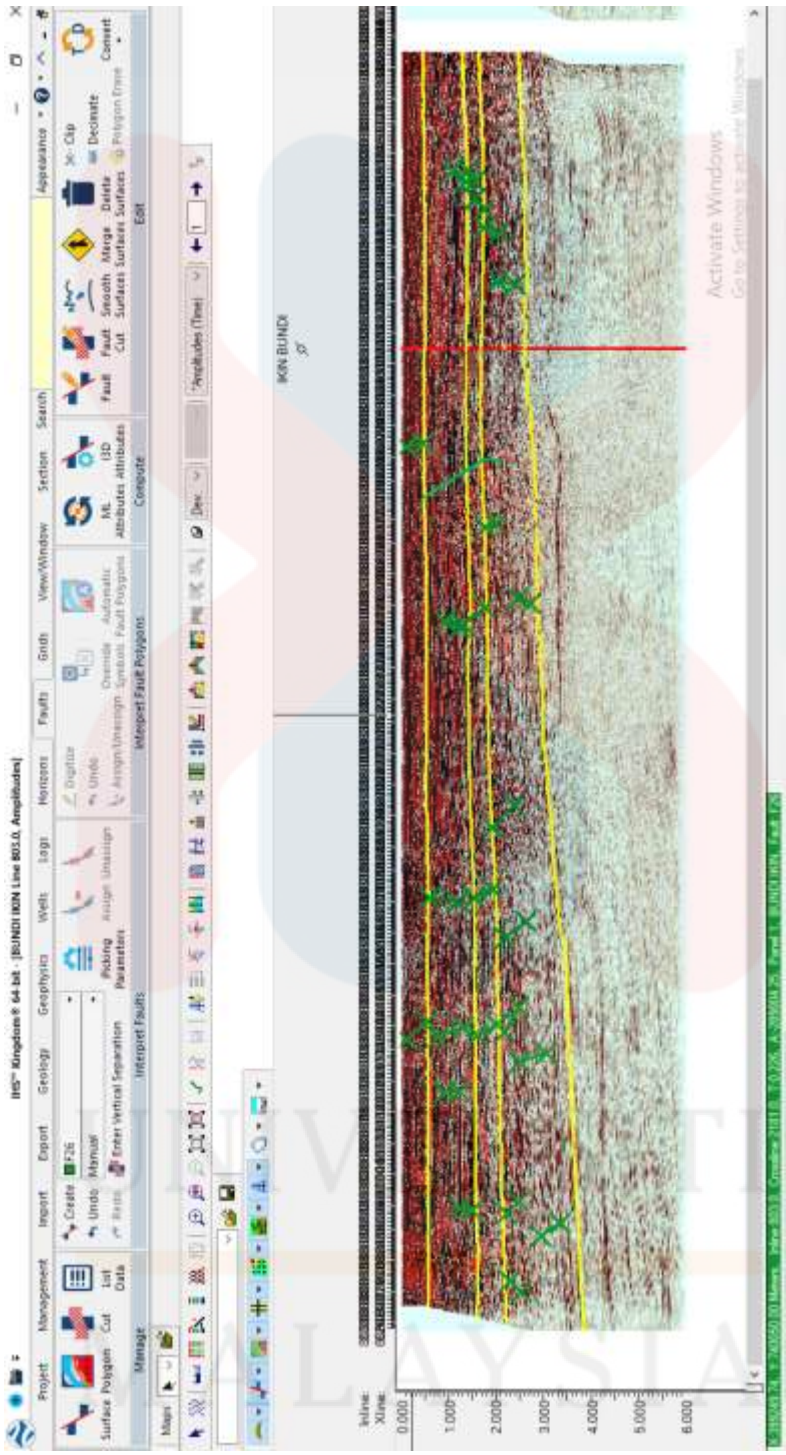


Figure 5.23: The Sequence Boundary in Inline 803

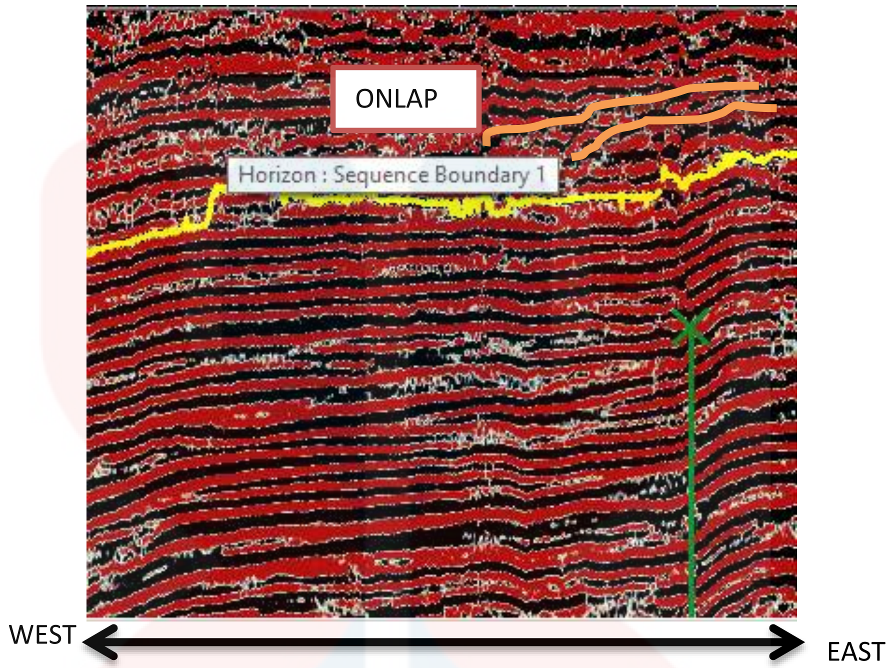


Figure 5.24: SB 1 Boundary at Inline 803

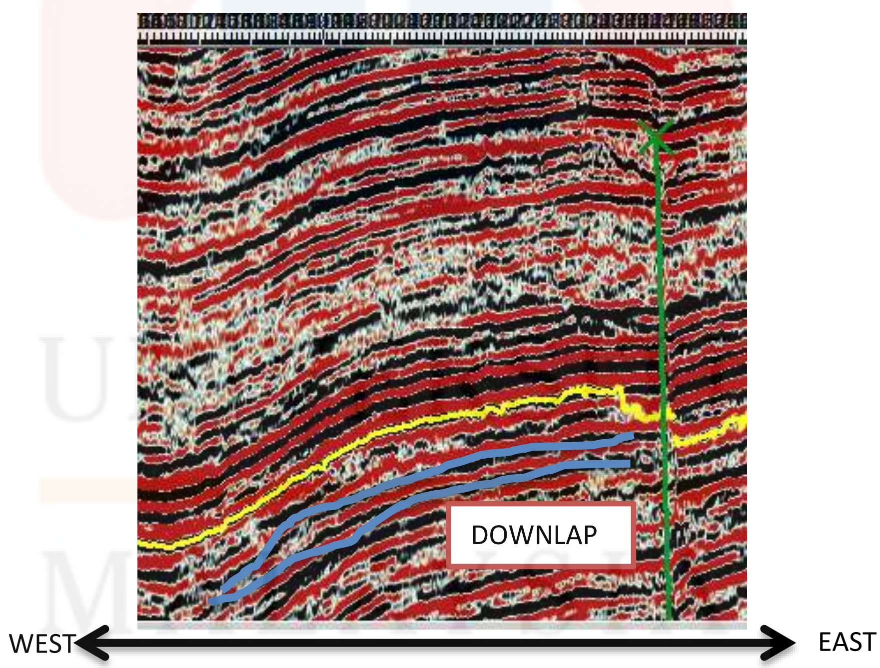


Figure 5.25: SB 2 Boundary at Inline 803

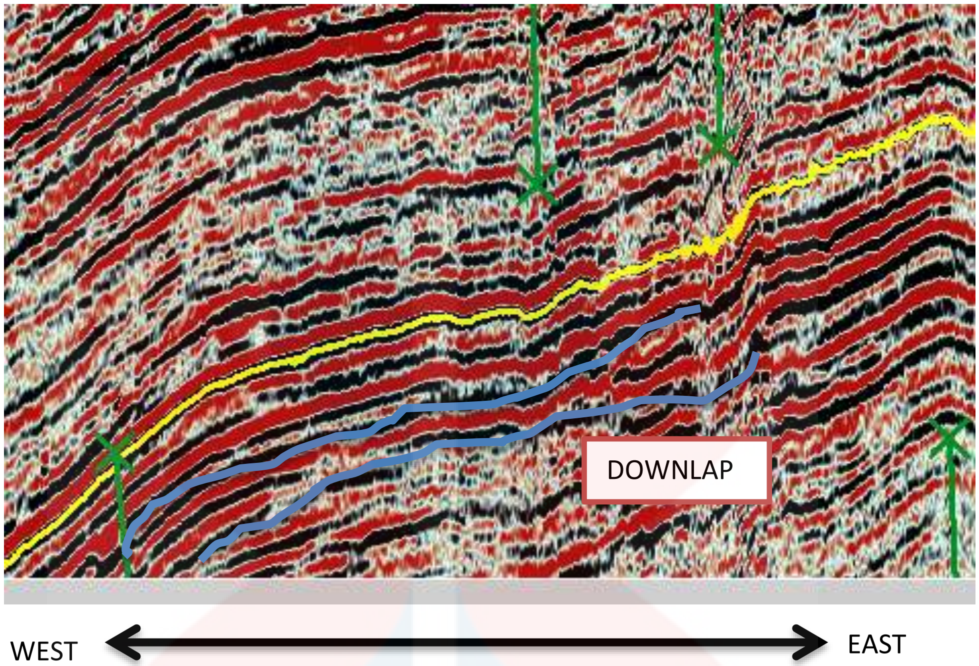


Figure 5.26: SB 3 Boundary at Inline 803

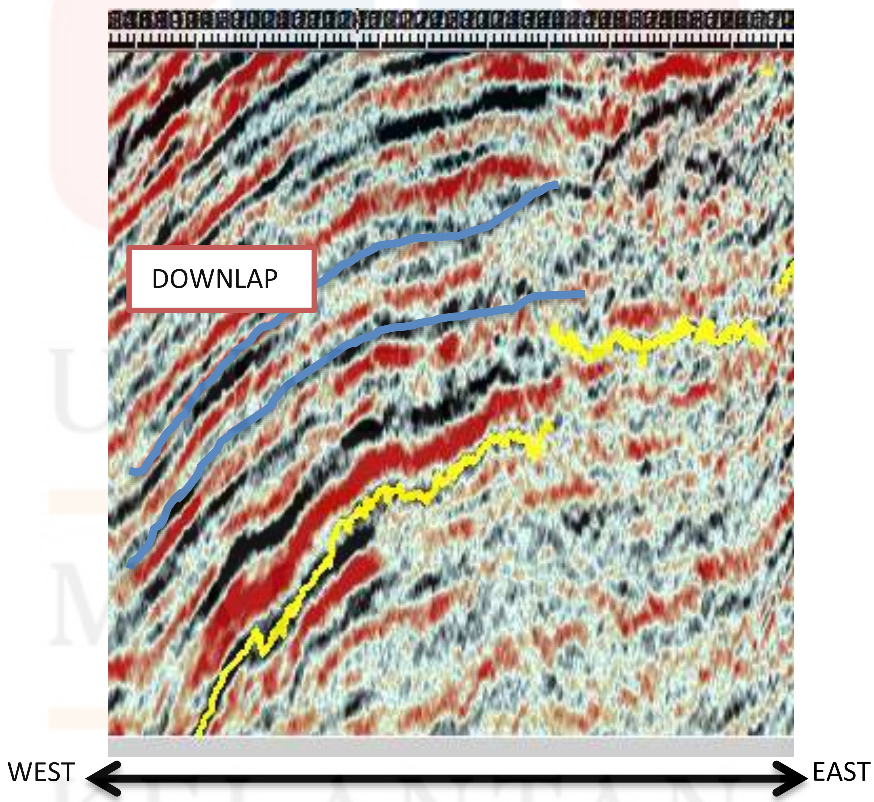


Figure 5.27: SB 4 Boundary at Inline 803

5.2.6 Seismic Line Crossline 3118

The total of 3 sequences boundaries were discovered on seismic line crossline (CL) 3118, as shown in Figure 5.28. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.29. The sequence boundary SB 2 is depicted in Figure 5.30 along with the downlap that finishes at the boundary to the oldest strata below. The sequence boundary SB 3 is also shown in Figure 5.31, where it terminates at the youngest strata above and shows the existence of toplap.

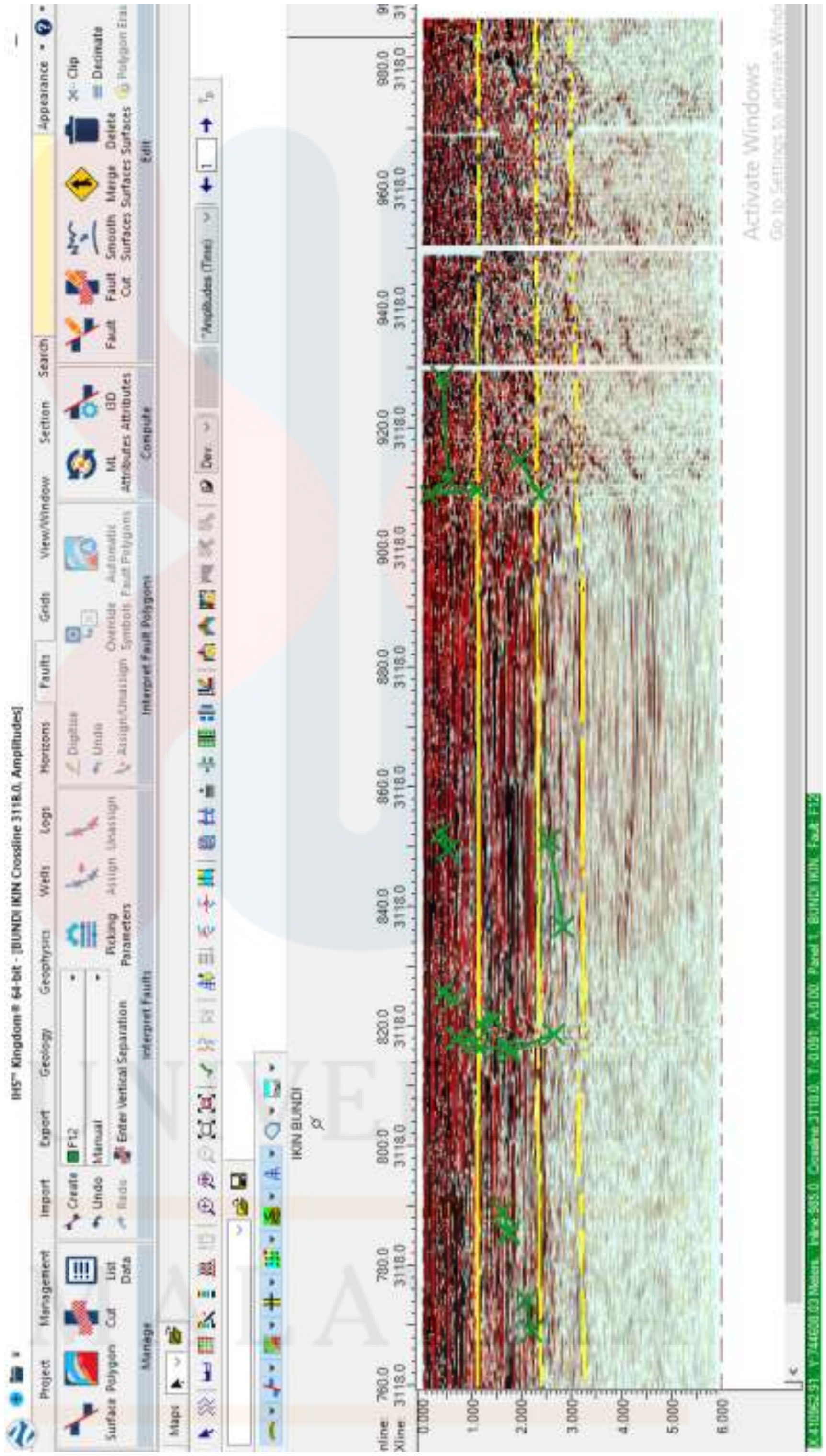


Figure 5.28: The Sequence Boundary in Crossline 3118

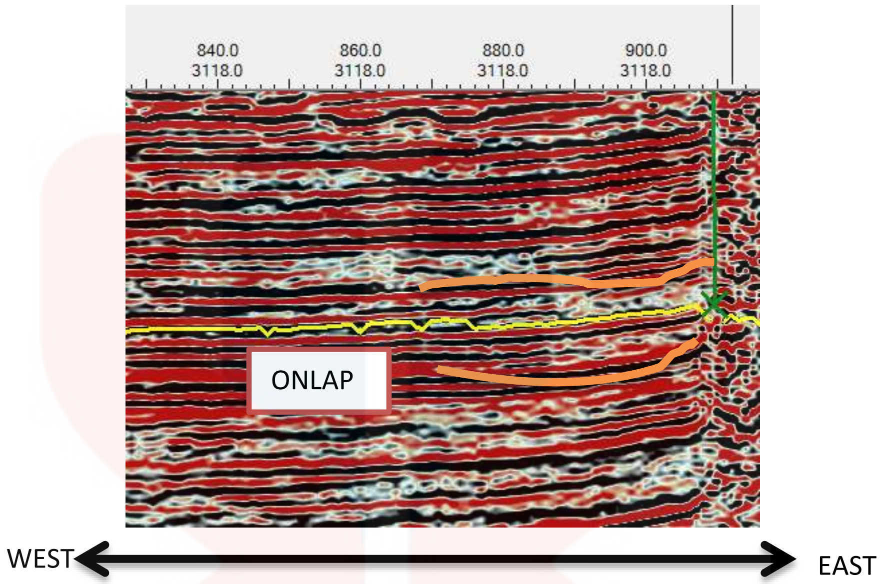


Figure 5.29: SB 1 Boundary at Crossline 3118

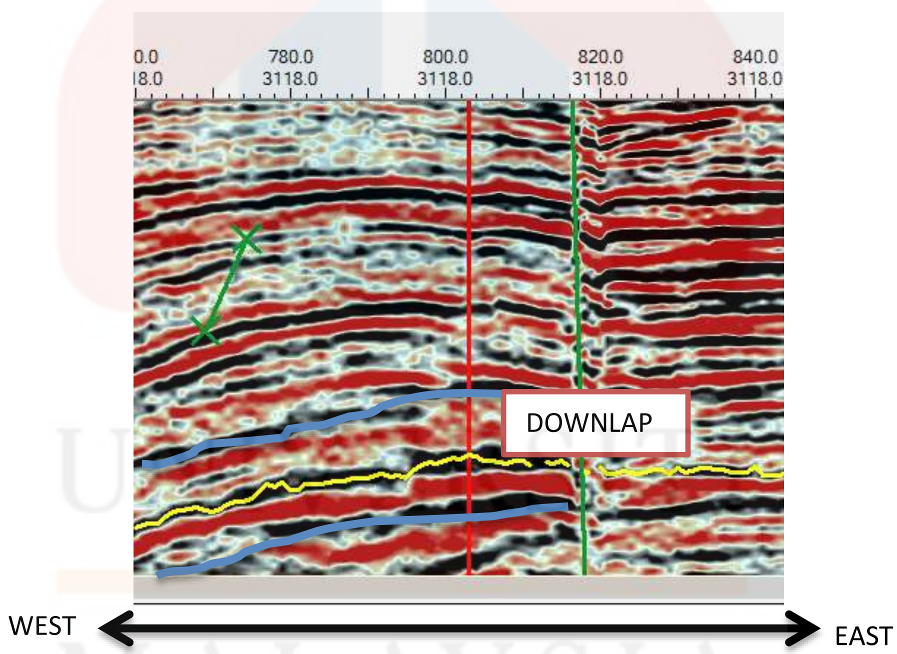


Figure 5.30: SB 2 Boundary at Crossline 3118

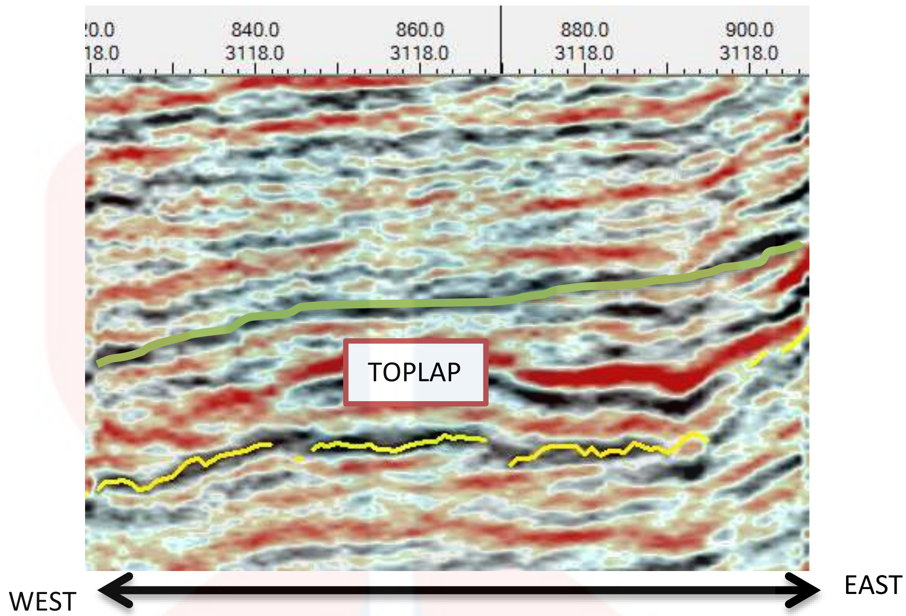


Figure 5.31: SB 3 Boundary at Crossline 3118

5.2.7 Seismic Line Crossline 3119

The total of 3 sequences boundaries were discovered on seismic line crossline (CL) 3119, as shown in Figure 5.32. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.33. The sequence boundary SB 2 is depicted in Figure 5.34 together with the downlap that exists at that boundary and finishes at the oldest strata below. The sequence boundary SB 3 is also shown in Figure 5.35, where toplap extends from the SB 3 to the youngest stratum above.

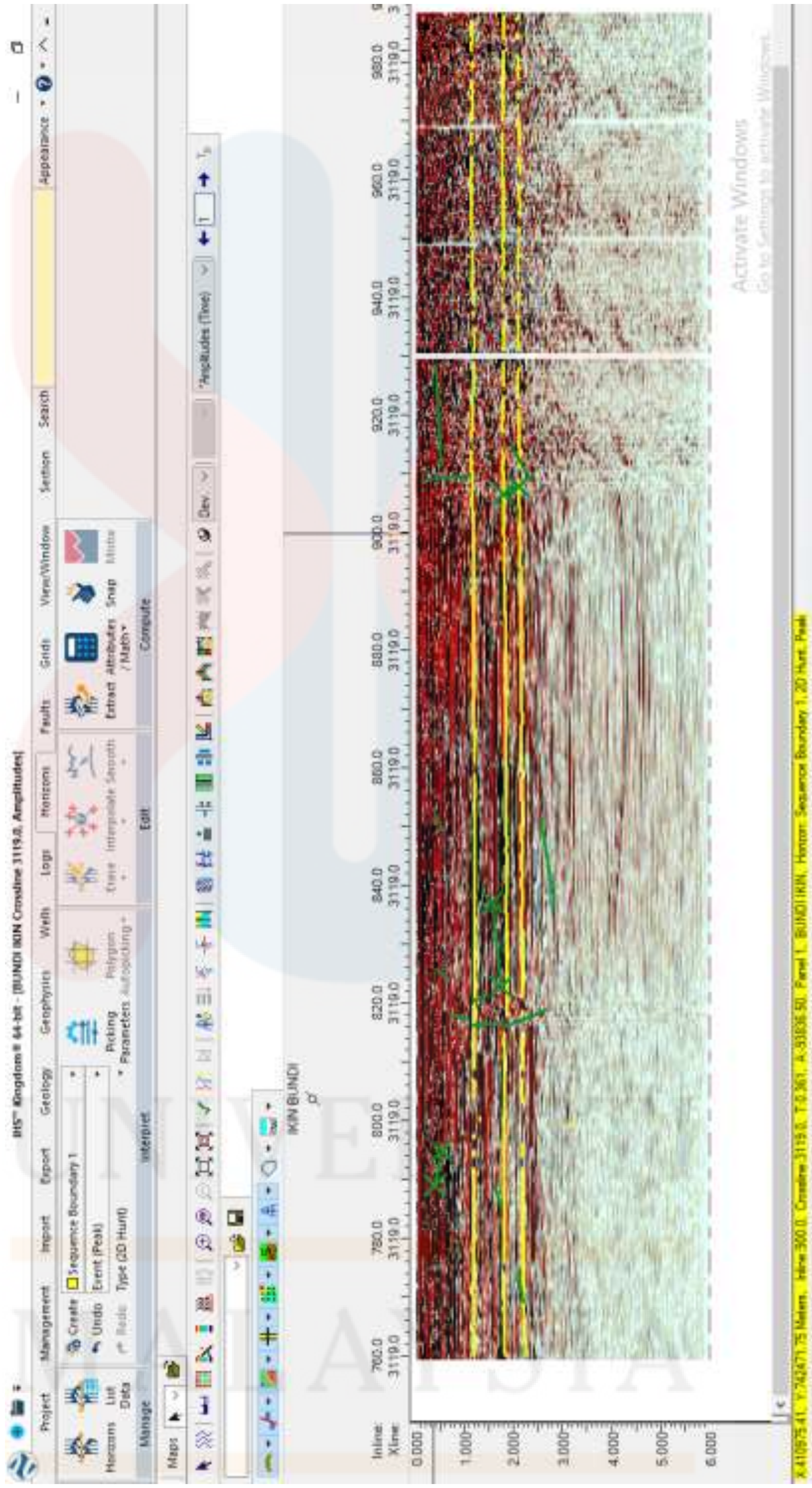


Figure 5.32: The Sequence Boundary in Crossline 3119

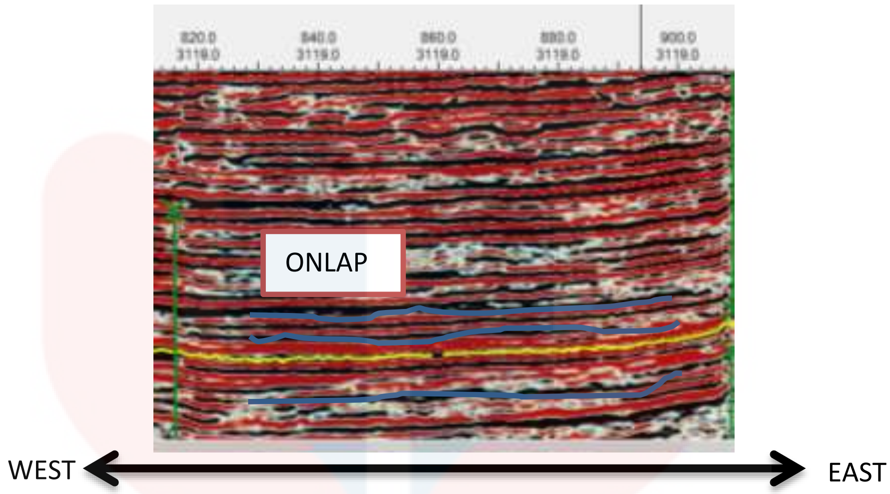


Figure 5.33 SB 1 Boundary at Crossline 3119

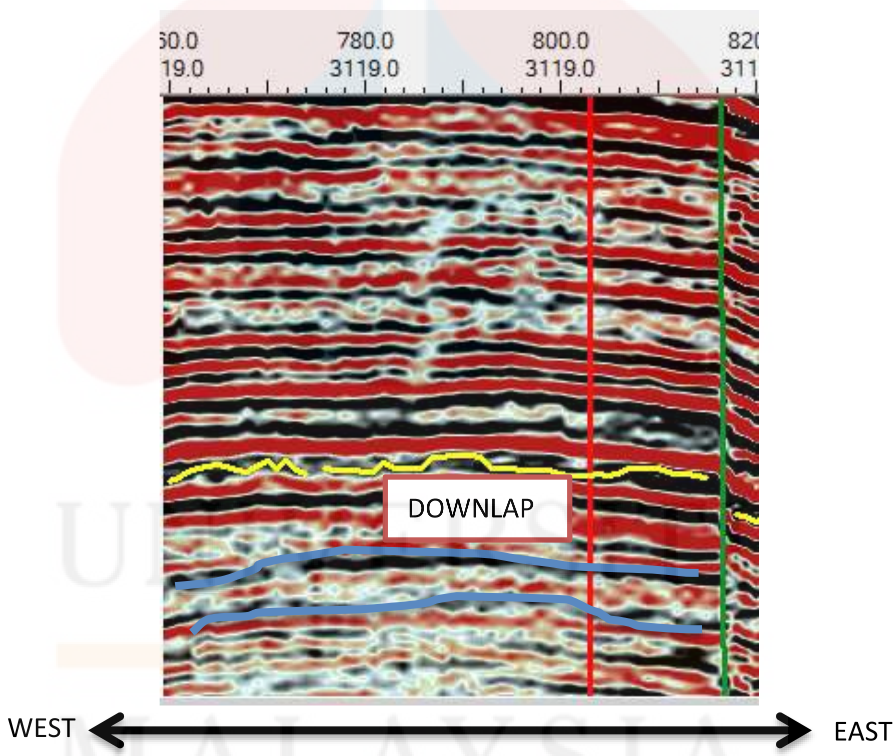


Figure 5.34 SB 2 Boundary at Crossline 3119

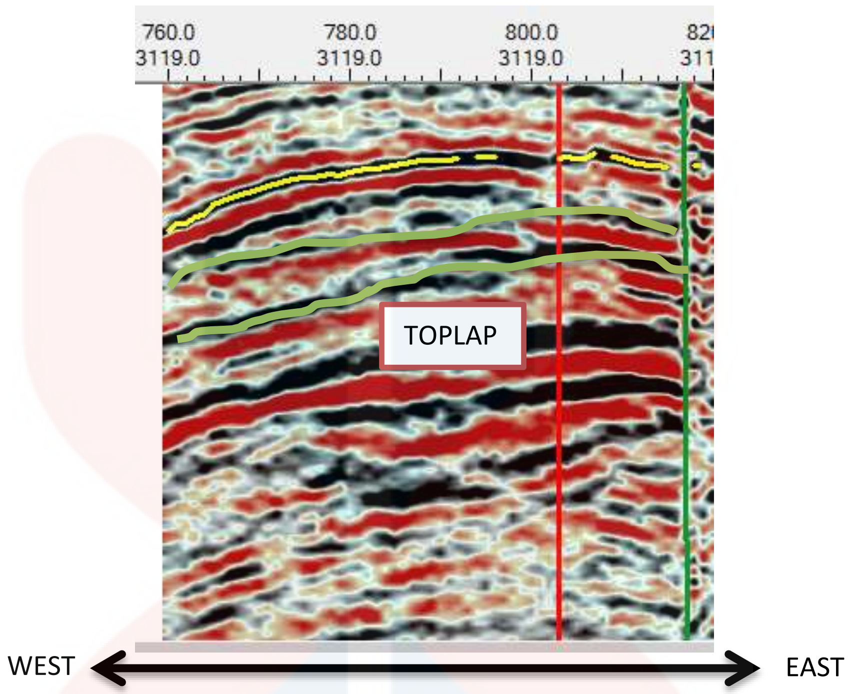


Figure 5.35 SB 3 Boundary at Crossline 3119

5.2.8 Seismic Line Crossline 3120

The total of 2 sequence boundaries were discovered on seismic line crossline (CL) 3120, as shown in Figure 5.36. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.37. The sequence boundary SB 2 is depicted in Figure 5.38 together with the downlap that finishes at the boundary to the oldest strata below.

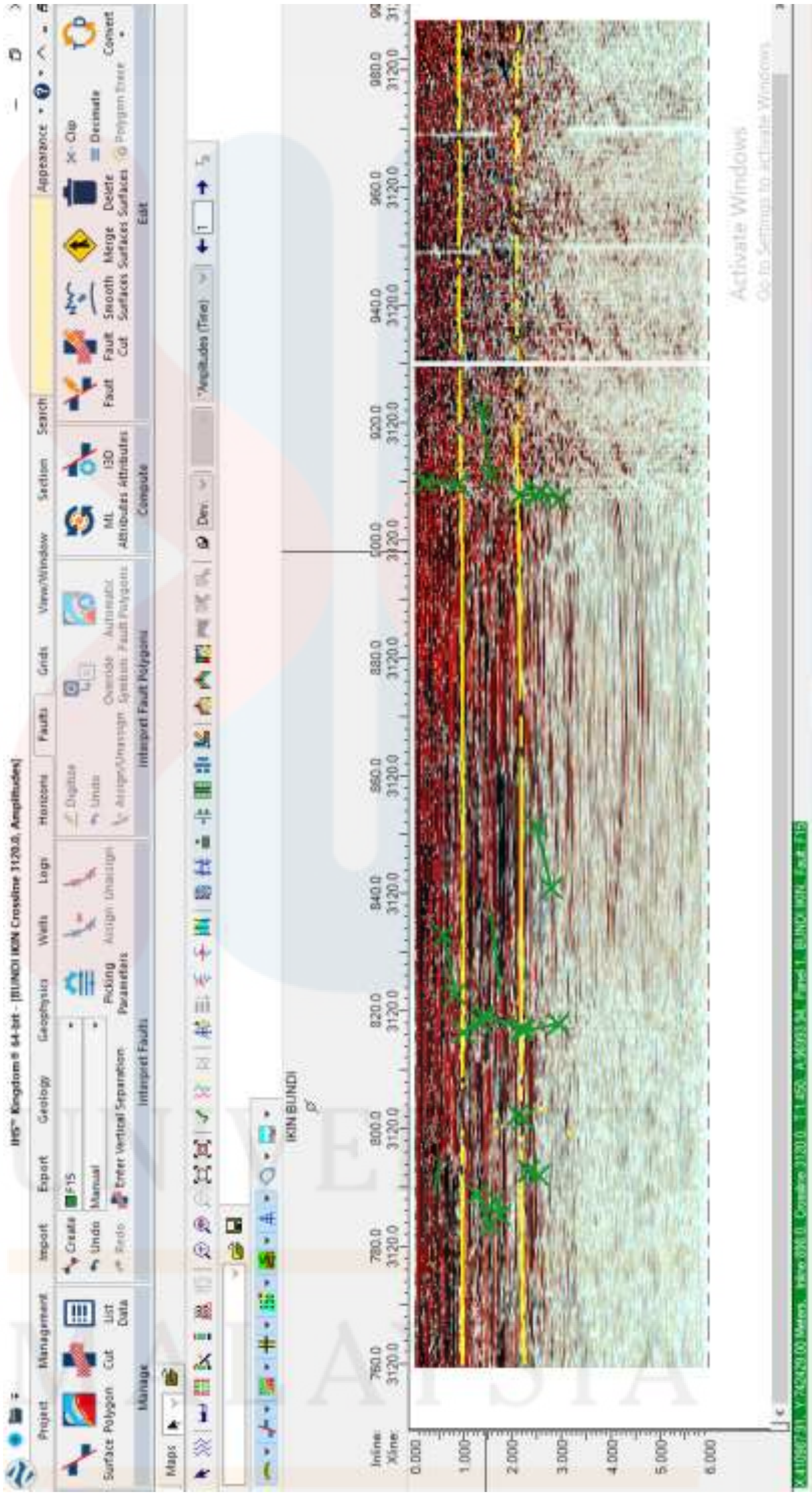


Figure 5.36: The Sequence Boundary in Crossline 3120

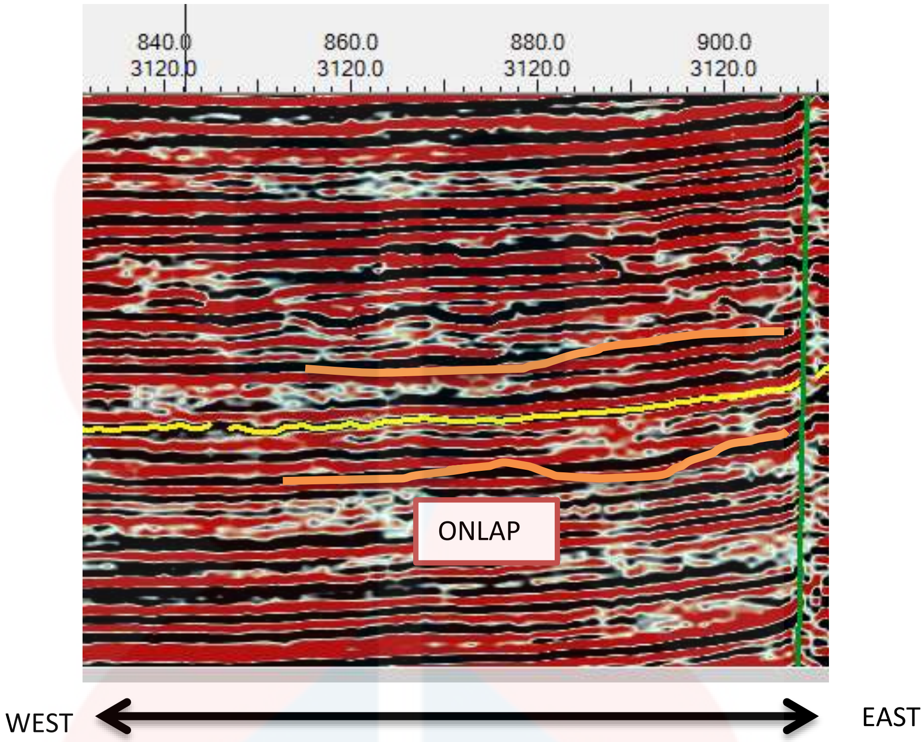


Figure 5.37 SB 1 Boundary at Crossline 3120

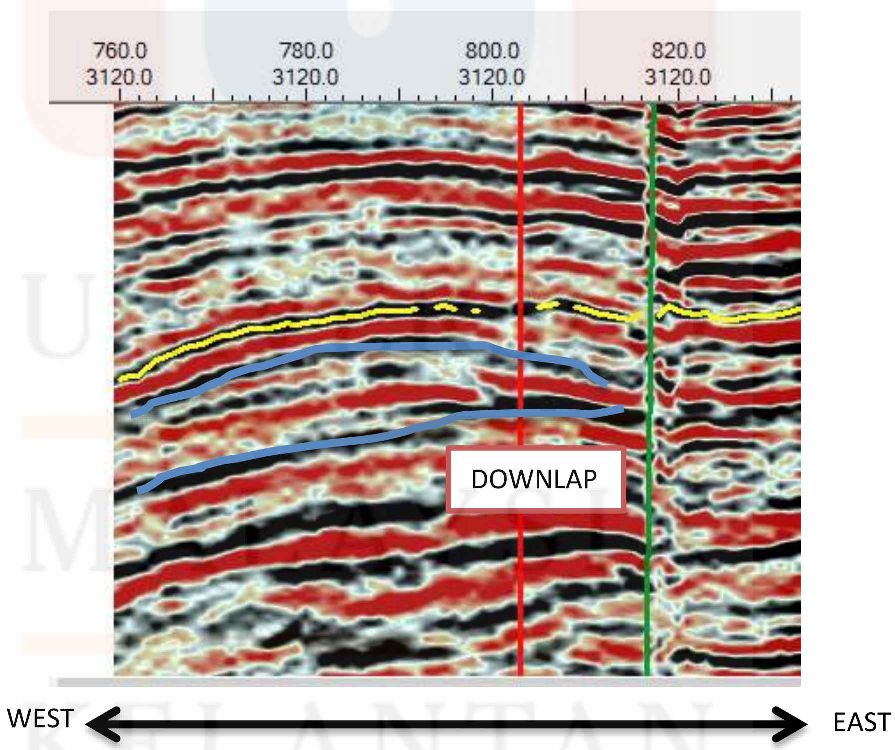


Figure 5.38 SB 2 Boundary at Crossline 3120

5.2.9 Seismic Line Crossline 3121

The total of 3 sequences boundaries were discovered on seismic line crossline (CL) 3121, as shown in Figure 5.39. The sequence boundaries SB 1 and SB 3 are depicted in Figures 5.40 and 5.42 together with the existence of downlap at the border, which terminates to the oldest strata below. The sequence boundary SB 2 is seen in Figure 5.41 with onlap present at the border where SB 2 ends and the earliest strata begin.

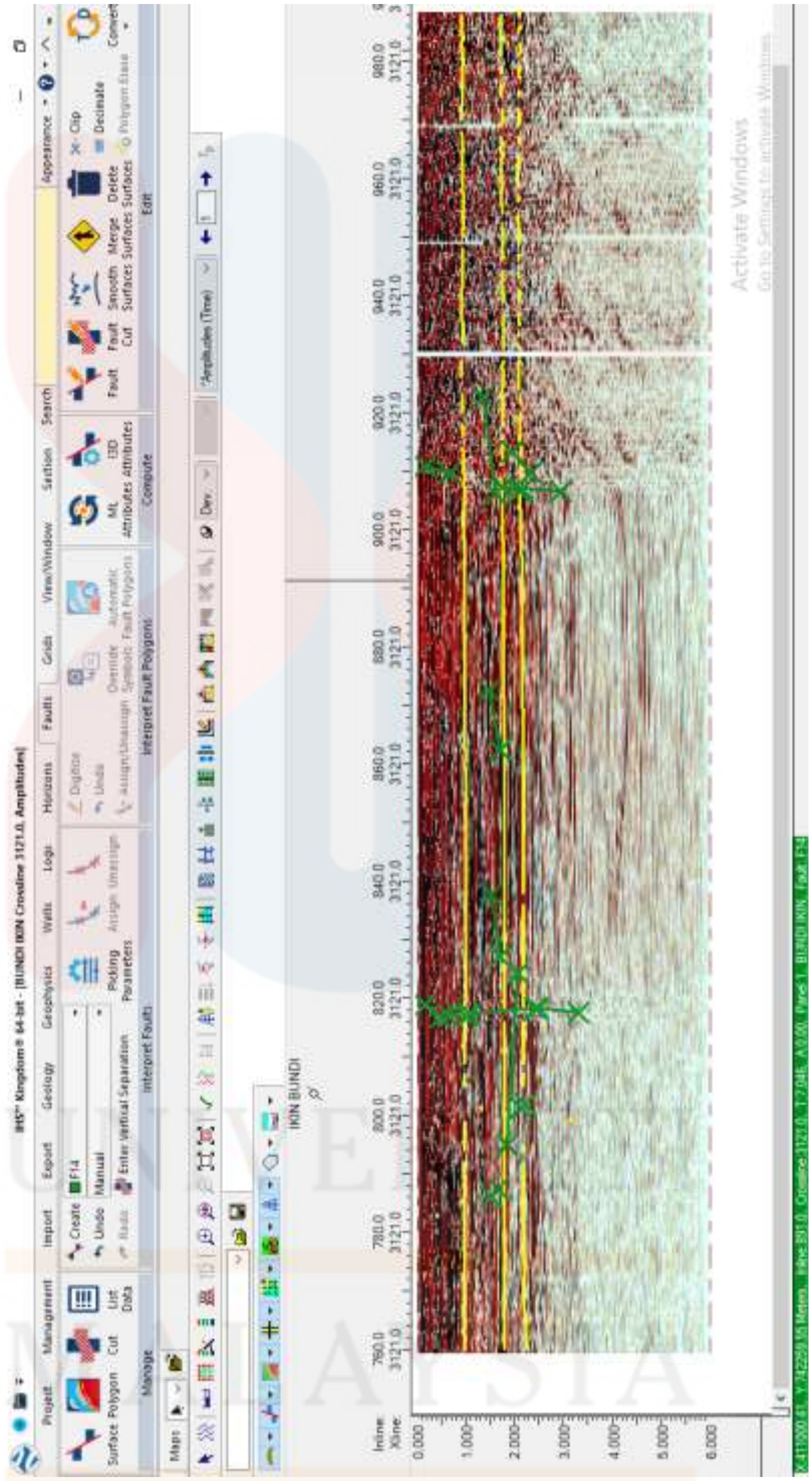


Figure 5.39: The Sequence Boundary in Crossline 3121

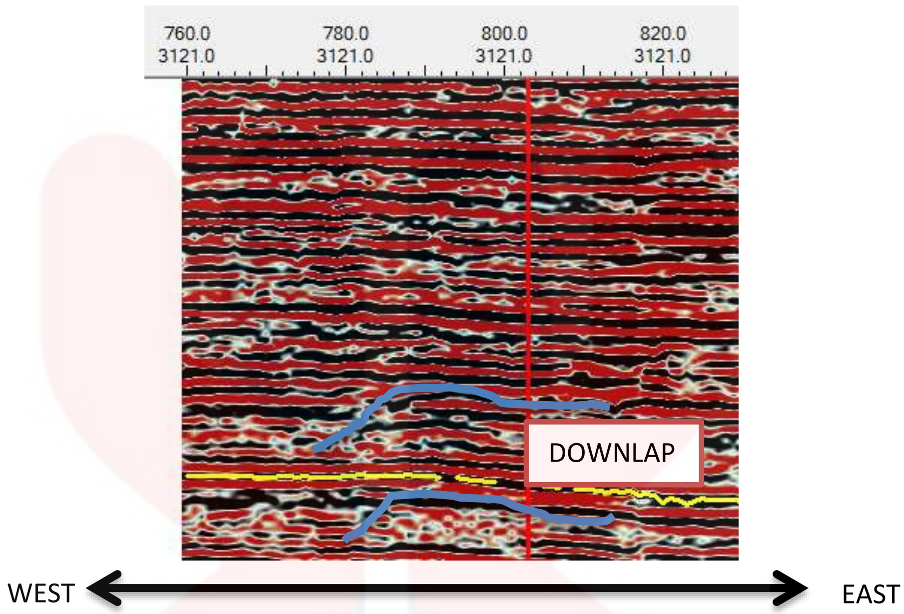


Figure 5.40 SB 1 Boundary at Crossline 3121

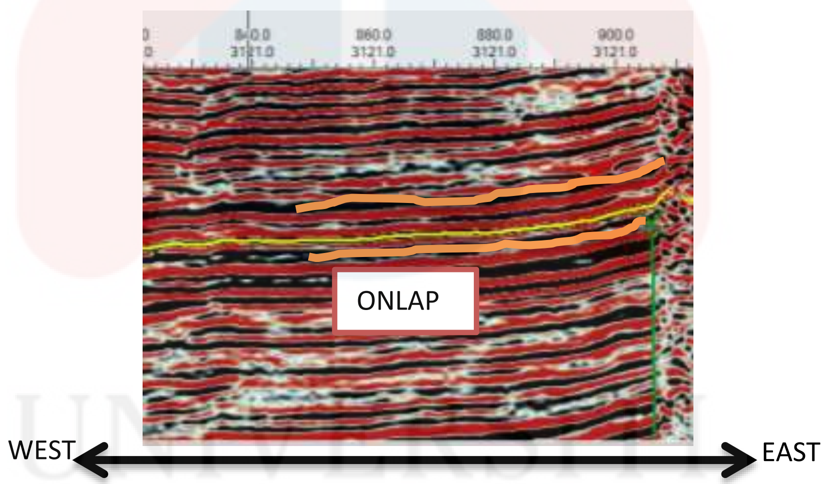


Figure 5.41 SB 2 Boundary at Crossline 3121

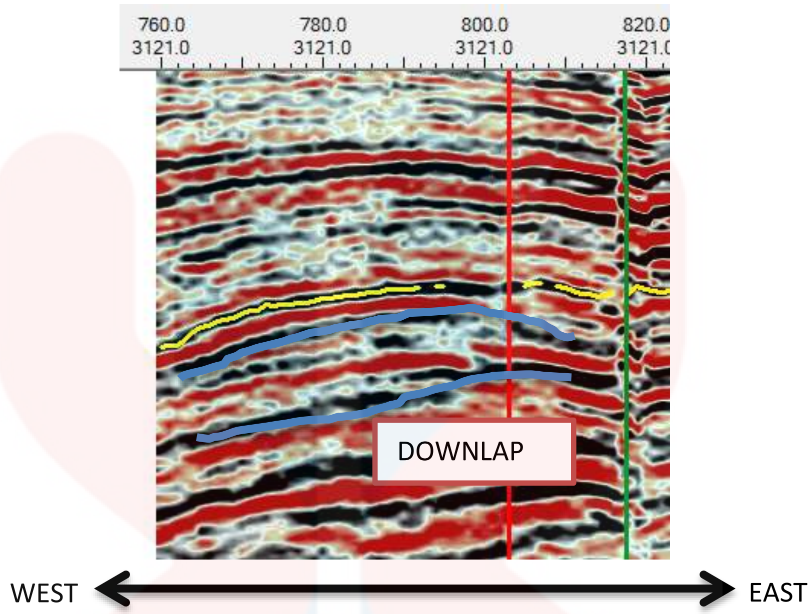


Figure 5.42 SB 3 Boundary at Crossline 3121

5.2.10 Seismic Line Crossline 3122

The total of 3 sequences boundaries were discovered on seismic line crossline (CL) 3122, as shown in Figure 5.43. The sequence boundary SB 1 with onlap at the border where it ends to the earliest strata is depicted in Figure 5.44. The sequence boundary SB 2 is depicted in Figure 5.45 together with the downlap that finishes at the boundary to the oldest strata below. The sequence boundary SB 3 is also seen in Figure 5.46, where toplap extends from the SB 3 to the youngest stratum above.

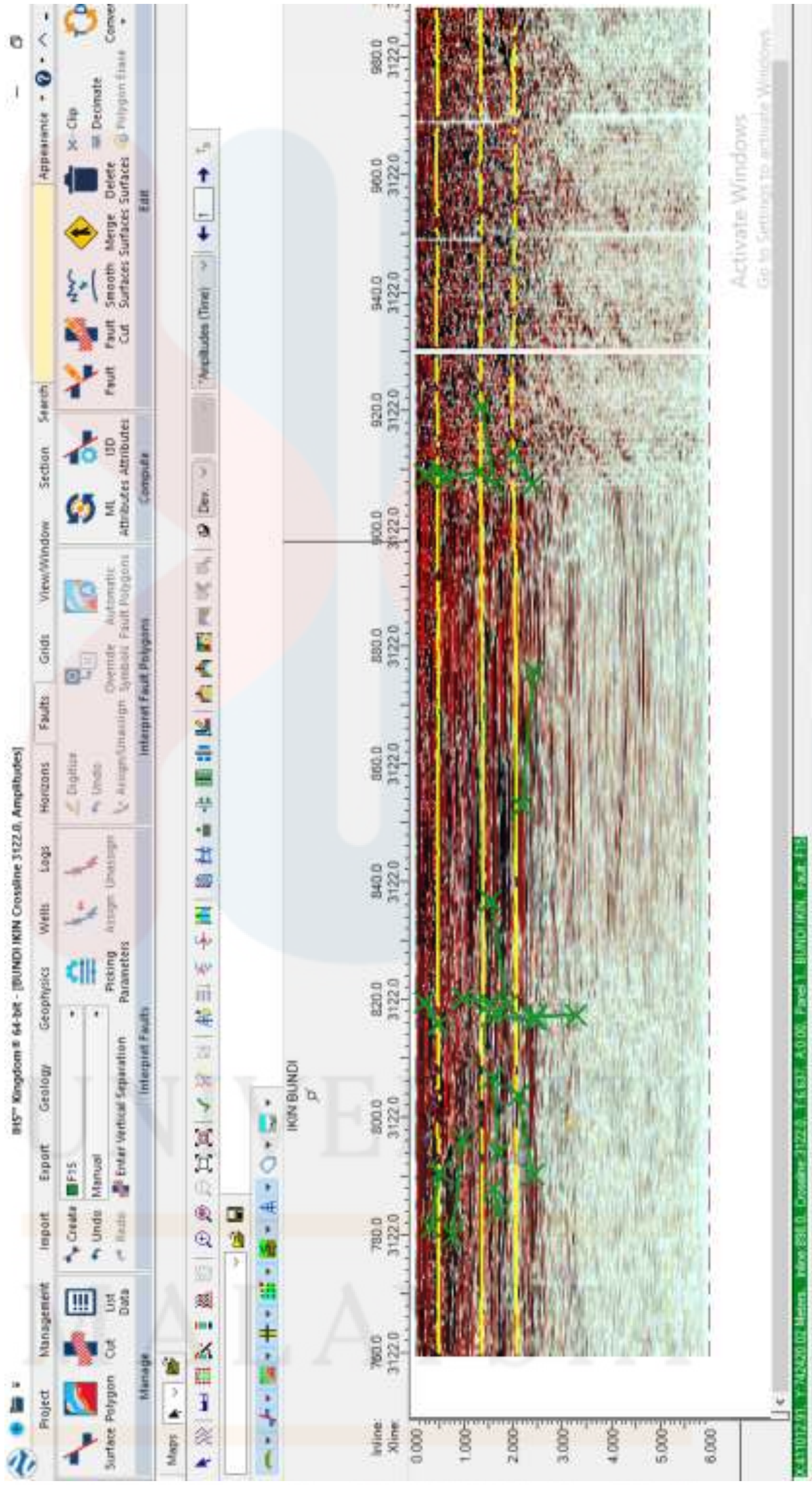


Figure 5.43: The Sequence Boundary in Crossline 3122

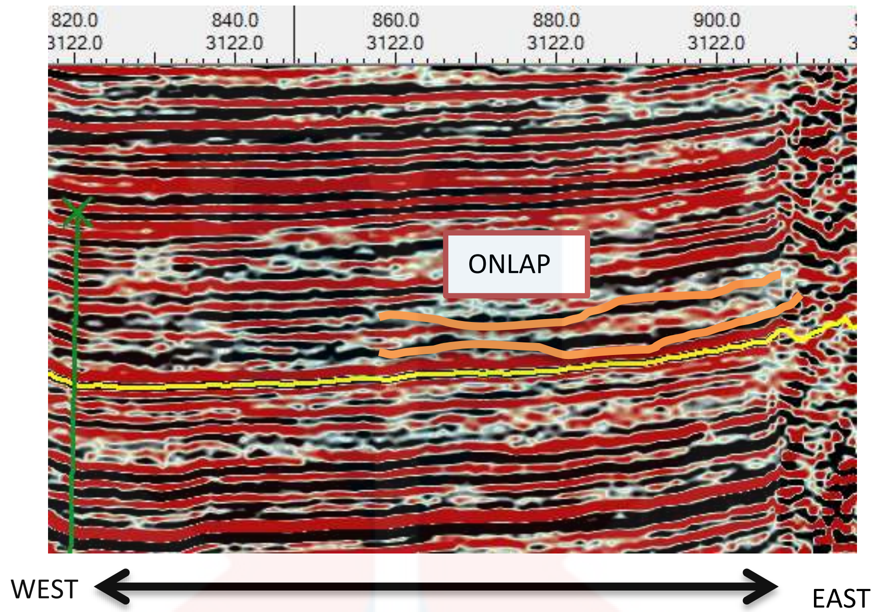


Figure 5.44 SB 1 Boundary at Crossline 3122

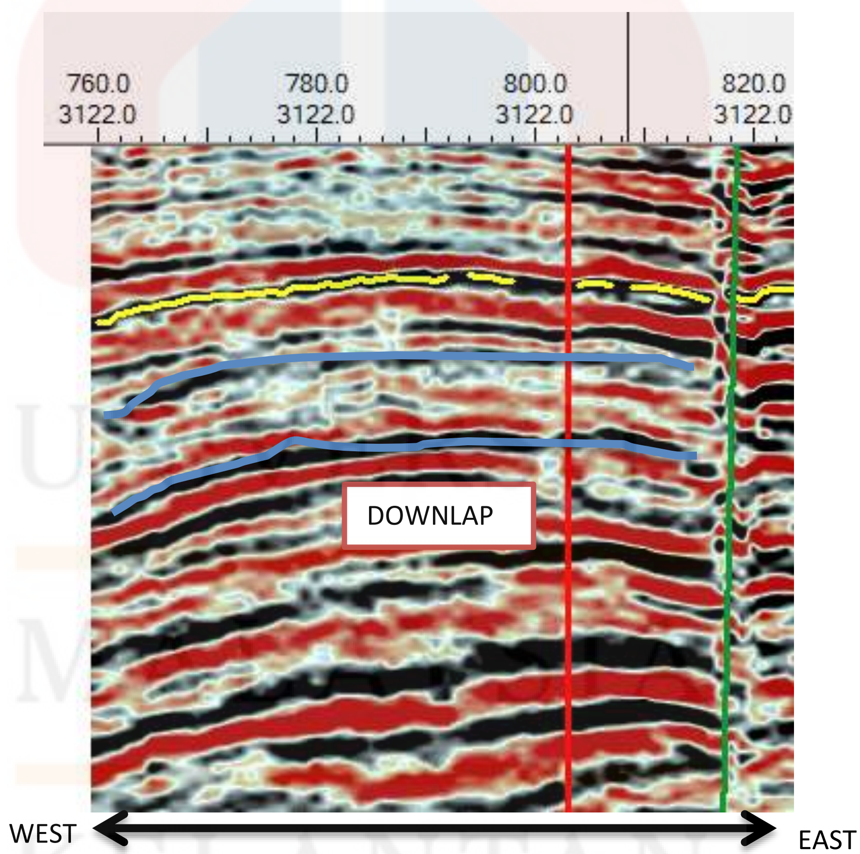


Figure 5.45 SB 2 Boundary at Crossline 3122

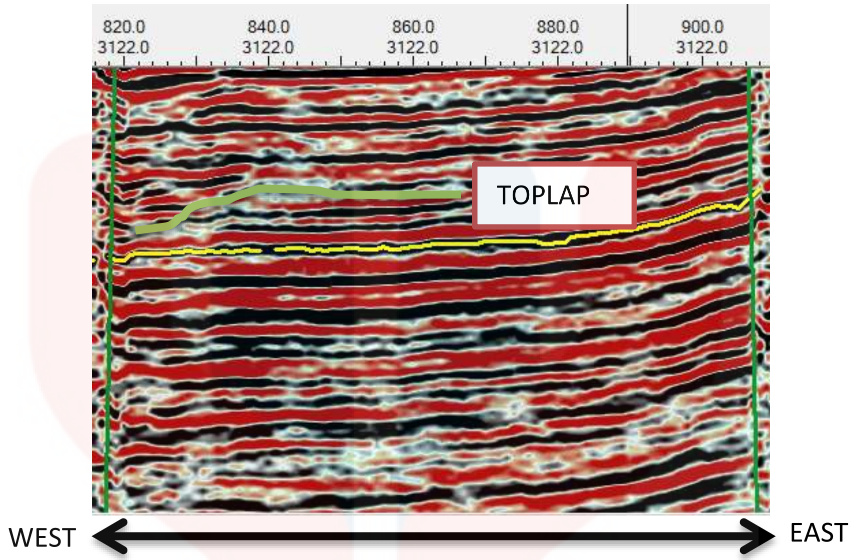


Figure 5.46 SB 3 Boundary at Crossline 3122

5.3 Structural Geology at Bundi Field

Fault

Fault and fold requires detailed analysis for interpretation of seismic cross section for geological structures. The interpretation of this structure, however, will simply go over a brief overview of the study area's structure along the seismic survey line. When conducting seismic investigation, faults are processed, recognized and depicted in a variety of ways using a technique called fault imaging. There are many reasons to image faults seismically.

Other than that, faults are very important in the petroleum exploration industry for many reasons. It can function as a seal or a conduit to carry hydrocarbons to a trap. A fault trap can be economically viable to drill and produce if it has enough volume to hold oil and gas. The easiest approach's to identify a fault when interpreting seismic data is to observe a substantial movement in a group of seismic reflectors. Most of the fault that found in Bundi Field is normal fault. When a sliding block falls along the fault plane, a typical fault is created. The term graben refers to the drop block. Figure 5.47 and 5.48 shows the major fault that have in line Inline while Figure 5.49 and 5.50 shows the major fault in crossline.

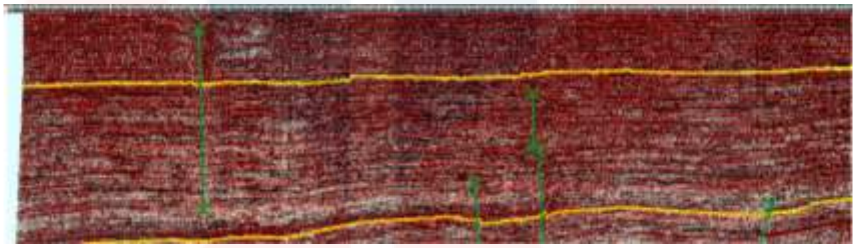


Figure 5.47 Major Fault at Inline

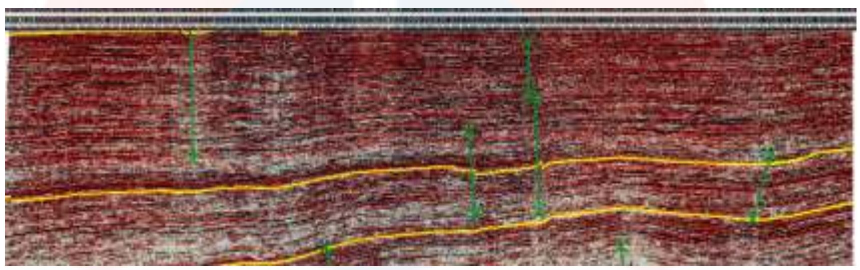


Figure 5.48 Major Fault at Inline

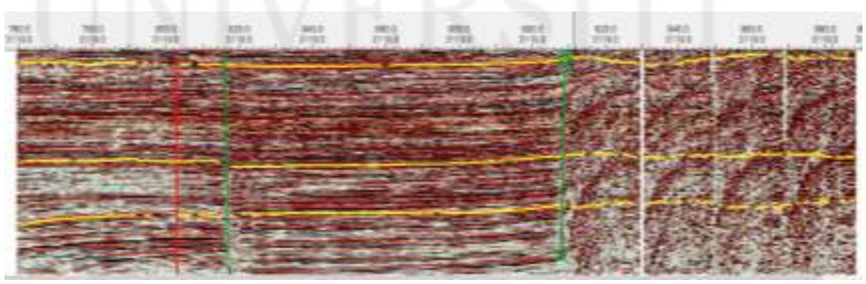


Figure 5.49 Major Fault at Crossline

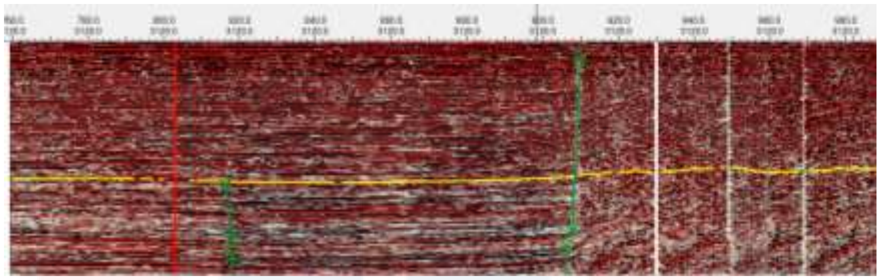


Figure 5.50 Major Fault at Crossline

<u>Fold</u>

The type of fold that found in Bundi Field are syncline, anticline, chevron, symmetrical and overturned. Folds are flexures or bends in stratified rock that result from movement along faults, diapirism, compaction, and localized subsidence or uplift. Seismic reflection profiles express folds as one or more dipping reflection zones that correspond to inclination stratigraphic contact.

Syncline is a fold that is concave upward while anticline is a fold that is convex upward. Next, repeated well-behaved folded beds with straight limbs and acute hinges, known as chevron folds, are a structural element. Symmetrical fold when it is axial plane is vertical and thus both the limbs have same amount of dip. Lastly, overturned fold is if in any fold both the limbs dip towards the same direction. Figure 5.51, 5.52, 5.53, 5.54 and 5.55 shows the type of folding which are syncline, anticline, chevron, symmetrical and overturned.

So, the structure that involved at the Bundi Field area are very significant with the presence of syncline, anticline, symmetrical, overturned, chevron and fault. One of the signs of the existence of hydrocarbons in the region is the structure's presence.

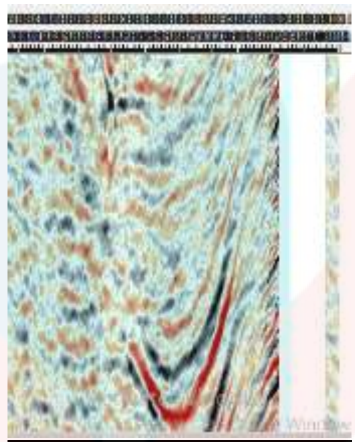


Figure 5.51 Syncline

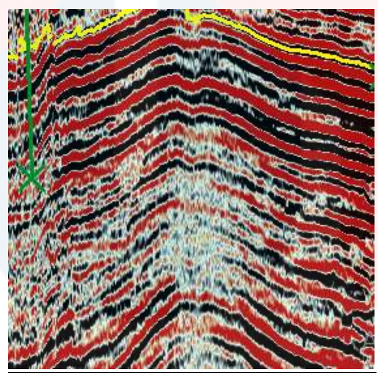


Figure 5.52 Anticline

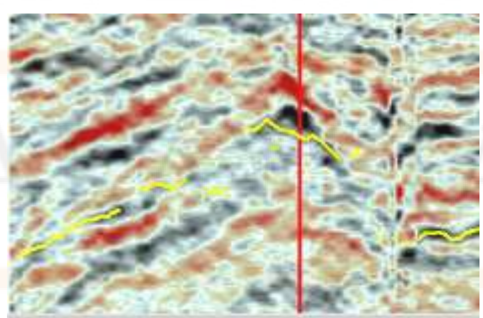


Figure 5.53 Chevron

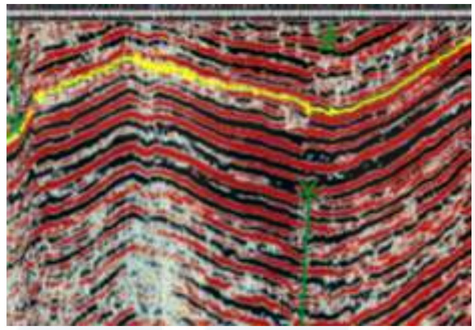


Figure 5.54 Symmetrical

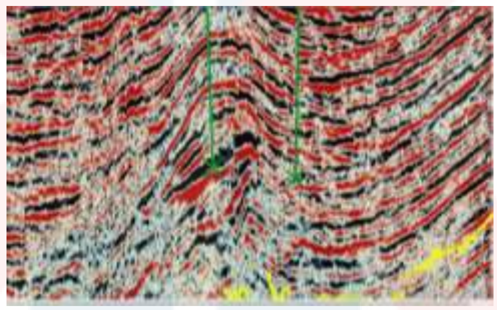


Figure 5.55 Overturned

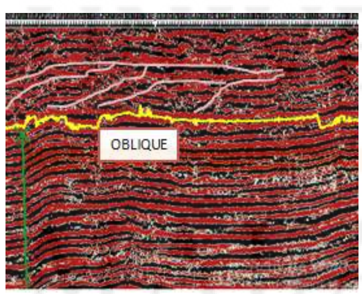
5.4 Seismic Facies Available at Bundi Field

The description and interpretation of seismic reflection characteristics including configuration, continuity, amplitude, and frequency in the context of a depositional sequence's stratigraphy is known as seismic facies analysis. In order to recognise lateral lithofacies and fluid type changes, the aim is to identify all seismic parameter variations occurring in third-order sequences and related system tracts. Of all the variables, reflection pattern geometries may be the most useful for calibrating with litho-facies inferred from well logs, cores, and cutting.

Seismic facies described for the basin region may generally be divided into many series, such as parallel and sub-parallel, wavy facies that extend to south-cast, and chaotic facies. Every sequence features significant reflection facies. Parallel and chaotic facies consists from high amplitude to low amplitude. It also has medium amplitude which is contorted to chaotic. As the frequency dropped, so did the amplitude, which went from being high to moderate to eventually low.

Other than that, the survey's middle of the line, where it has high amplitude, high continuity, and regularly spaced reflectors, exhibits wavy facies. In addition, it shows a symmetrical in cross section. There are several reflector polars that appear chaotic and have changing amplitudes. Oblique facies consist high amplitude and mounded consists high to medium amplitude. The reflection continuity of oblique is semi-continuous.

Figure 5.56 shows the 5 major facies that found in the study area. Besides that, the chaotic surface of the studied area, which results from the gas converting to a wave, raises the chance that gas is present there. Amplitude analysis is crucial for hydrocarbon exploration because bright-spot or flat-spot amplitude anomalies might reveal the presence of hydrocarbons.



Oblique

Parallel

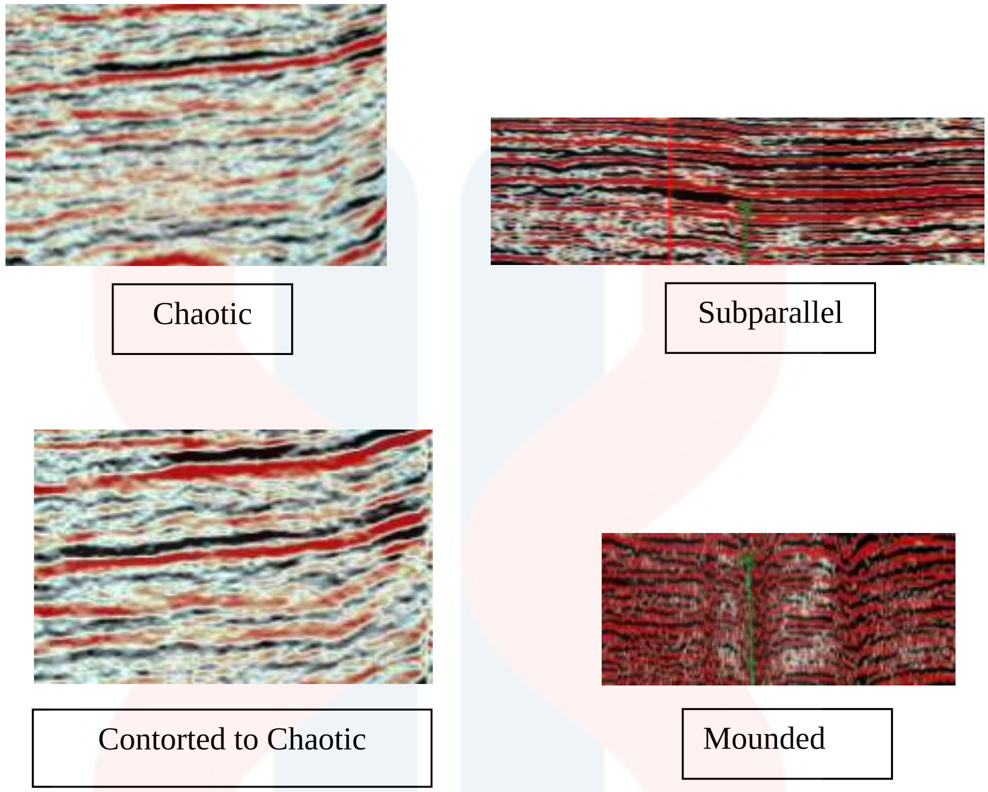


Figure 5.56 Major facies at the study area

5.5 Potential Hydrocarbon at Bundi Field

This field has a potential hydrocarbon, according to the facies analysis that had been done and the structural presence at the field. This can be examined using hydrocarbon markers like synclines and anticlines. The flat spot or bright spot at the seismic survey is revealed by the facies analysis. In addition, it might be connected to gas at the field based on the existence of chaotic reflectors.

A localized high amplitude seismic attribute anomaly known as a bright spot can reveal the existence of hydrocarbon. When a hydrocarbon replaces the brine-saturated zone that underlies shale, increasing the reflection coefficient, a bright spot is principally caused by an increase in acoustic impedance contrast. So, the sands and shales compact at different rates and the acoustic impedance equation described above breaks down beyond a certain depth, the effect diminishes with depth. Below this depth, the shale and sand acoustic impedances will intersect, making a dim region more advantageous for oil exploration.

A flat spot is a seismic attribute anomaly that appears on the seismic image as a horizontal reflector cutting across the strata. The way it looks can reveal the presence of hydrocarbons. When a gas-filled porous rock with lower acoustic impedance is placed on top of a liquid-filled porous rock with higher acoustic impedance, the rise in acoustic impedance can cause a flat spot. Due to its flatness and the contrast with the dipping reflections all around it, it can stand out on a seismic image.

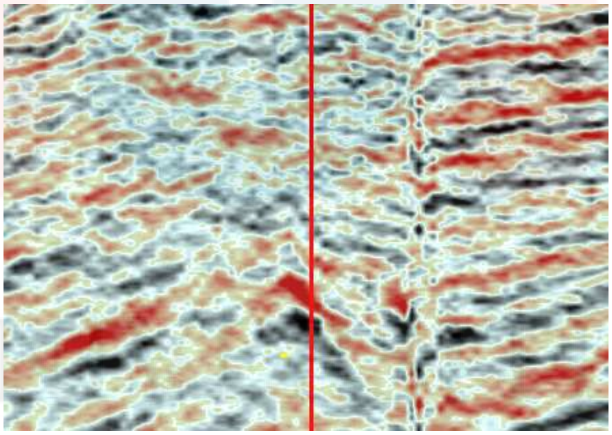


Figure 5.57 Potential Hydrocarbons at the Bundi Field

The chaotic reflectors were then used as an indicator because the gas' presence caused the waves to be disturbed and turn into errors. Additionally, the structural study demonstrates that it has the property of being a hydrocarbon trap. After completion and correlation of all analyses, it is reasonable to believe that the hydrocarbon potential is situated between SB 3 and SB 4 limits due to the existence of all indicators there.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The study's findings showed that the goal of successfully updating the geological map of Kampung Banggul, Pemaisuri, Terengganu at a scale of 1:25000 had been achieved. Approximately 4 days were spent doing a geological mapping of the research region. There are two lithologies that found which are claystone and quartzite as determine by field data and petrography analysis. From the petrography analysis, the type of mineral that found are quartz, biotite, alkali feldspar, plagioclase, pyroxene, opaque and it is show the type of rock is claystone. For quartzite, the types of minerals are quartz, alkali feldspar, biotite and opaque. It is also know the geological time scale for the rock. Other than that, the geological structures are lineament and strike and dip also found in the study area. So, from all the finding that found, it is shown the formation in Kampung Banggul is Sungai Perlis Bed.

Next, the objective for this research is to identify the hydrocarbon potential at the Bundi Field, Terengganu Offshore. This field has a potential hydrocarbon, according to the facies analysis that had been done and the structural presence at the field. This can be examined using hydrocarbon markers like synclines and anticlines. The flat spot or bright spot at the seismic survey is revealed by the facies analysis. Additionally, in accordance with the existence of chaotic reflectors, it might potentially be connected to gas at the field. According to the researcher's premise, the study area's hydrocarbon potential lies between the SB 3 and SB 4 limits.

6.2 Recommendation

After complete of this research, it is recommended for the next researcher to study about the alluvium in depth by conducting the structural geology study at the study area. In addition, it is recommended that the research look at Terengganu's onshore hydrocarbon potential based on the local geology of the region. This research can support the nation's economy while offering data for scholarly purposes.

The research does not completely cover Bundi Field, which is one of the larger places. Therefore, the Bundi Field may continue to be covered by future research and studies. Due to the limited resources available for this research, the study areas also require a thorough investigation of a detailed seismic stratigraphy and structural geology. It is also can know more hydrocarbon potential that have in Bundi Field.

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