



**GEOLOGY OF KAMPUNG BULUH,
PERMAISURI AND
SEISMIC INTERPRETATION OF
KAPAL FIELD, TERENGGANU OFFSHORE.**

by

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**A report presented in accomplishment of the essential for the
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APPROVAL

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I declare that this thesis entitled **“GEOLOGY OF KAMPUNG BULUH, PERMAISURI AND SEISMIC INTERPRETATION OF KAPAL FIELD TERNGGANU 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 BULUH, PERMAISURI AND SEISMIC INTERPRETATION OF KAPAL FIELD TERENGGANU OFFSHORE

ABSTRACT

This study mainly focuses on updating the geological map at Kampung Buluh, Permaisuri, Setiu Terengganu within area of 25,000 km² with coordinate 5 32' 35.54" N, 102 45' 23.87" E and involve seismic interpretation of Kapal Field, Terengganu offshore using 2-Dimensional data obtained from PETRONAS. The geological research includes mapping, petrography, lithology, stratigraphy, and geomorphology had been done at Kampung Buluh, Setiu, Terengganu. The geological mapping is significant for identifying the lithology of rock and analysis of geological structure or formation that occurred in the study area. Based on rock sample observation and further petrographic analysis, the lithology at the study area could be determine. Moreover, the geological mapping conducted at Kampung Buluh are believed to exist under Sungai Peris Formation, thus this study will help to identify the formation of Kampung Buluh. In addition, this research is helpful since no prior studies or geological research have been conducted to determine the kind of rock, geological formation, geomorphology, or lithology present in Kampung Buluh. Referring to the previous research, the Setiu area was dominated by the carboniferous age of rock formation which is around 359 to 299 million years ago. Based on detail analysis of the rock, the area of Kampung Buluh consists of slate, phyllite, schist, sandstone, and quartzite. Based on this finding and sample analysis, the region comprised the meta-sedimentary rock. As for the second objective, the seismic interpretation using secondary data had been conducted as it significant to interpret the hydrocarbon potential based on reflection data obtained.

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GEOLOGI KAMPUNG BULUH, PERMAISURI DAN TAFSIRAN SEISMIK KAPAL FIELD TERENGGANU LUAR PESISIR

ABSTRAK

Kajian ini memberi tumpuan kepada pengemaskinian peta geologi di Kampung Buluh, Permaisuri, Setiu Terengganu dalam kawasan seluas 25, 000 km² dengan koordinat 5 32' 35. 54" U, 102 45' 23.87" E dan melibatkan tafsiran seismik Kapal Field, Terengganu di luar pesisir menggunakan data 2 Dimensi yang diperolehi daripada PETRONAS. Penyelidikan geologi merangkumi pemetaan, petrografi, lithologi, stratigrafi dan geomorfologi telah dilakukan di Kampung Buluh, Setiu, Terengganu. Pemetaan geologi adalah penting untuk mengenal pasti lithologi batu dan analisis struktur geologi atau pembentukan yang berlaku di kawasan kajian. Berdasarkan pemerhatian sampel batuan dan analisis petrografi selanjutnya, lithologi di kawasan kajian boleh ditentukan. Selain itu, pemetaan geologi yang dijalankan di Kampung Buluh dipercayai wujud di bawah Formasi Sungai Peris, oleh itu kajian ini akan membantu mengenal pasti pembentukan Kampung Buluh. Di samping itu, penyelidikan ini membantu kerana tiada kajian terdahulu atau penyelidikan geologi dijalankan untuk menentukan jenis batuan, pembentukan geologi, geomorfologi, atau lithologi yang terdapat di Kampung Buluh. Merujuk kepada kajian sebelum ini, kawasan Setiu didominasi oleh zaman pembentukan batuan berkarbonat iaitu sekitar 359 hingga 299 juta tahun lalu. Berdasarkan analisis terperinci batuan tersebut, kawasan Kampung Buluh terdiri daripada batu tulis, phyllite, schist, batu pasir dan kuarzait. Berdasarkan penemuan dan analisis sampel ini, rantau ini terdiri daripada batu meta-sedimen. Bagi objektif kedua, tafsiran seismik menggunakan data sekunder telah dijalankan kerana ia penting untuk mentafsir potensi hidrokarbon berdasarkan data refleksi yang diperolehi.

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LIST OF ABBREVIATION

CL -Crossline

GIS -Geospatial Information System

GPS - Global Positioning System

HCL - Hydrochloric acid

HST - Highstand System Tract IL Inline

LST - Lowstand System Tract

mfs - Marine-flooding Surface

MFS - Maximum Flooding Surface

PETRONAS - Petroliam Nasional Berhad

PPL - Plane Polarized Light

TST - Transgressive System Tract T-Z Time-depth

UMK - Universiti Malaysia Kelantan.

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CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Geophysics is one of the methods that use physical fields at the surface to measure, obtain data, and interpret subsurface conditions. Geophysics also consider as the non-invasive method to analyze subsurface conditions on the Earth. The results of certain research are utilized to identify what is directly beneath the surface. Geophysics involve the study of the parts of the earth that are not visible to the human eye, such as the oceans and the atmosphere. Analyzing the earth's physical characteristics with the proper equipment is what this research is all about. Geophysical or hydrocarbon exploration can be work by using seismic reflection method. This technique of exploration geophysics uses the concepts of seismology to determine what element and characteristics of the Earth's subsurface exist by measuring the reflected seismic waves.

Geological mapping is one of the method that can be conduct in the field to get and obtain more information also data exist at the study area. This method very

significant as it can verify and expand the previous data regarding the study area. Geological mapping usually involve the site observation, analysis and searching the geological data like lithology, drainage, vegetation, land use, and landform. Moreover, the data from geological formation and geological structure also need to be recorded and further analysis can be done later.

Using the principles of physics, geophysics exploration is used to seek for hydrocarbons in the subsurface of Earth. There are several geophysical studies using measurements made at the Earth's surface that are affected by physical qualities that are distributed throughout its interior. It is the goal of any exploration project to locate new hydrocarbon quantities quickly and cheaply. Geological interpretation of geophysical data is critical to offshore petroleum exploration and production. Magnetic, gravity, and seismic geophysical technologies are utilized in the exploration of oil and gas deposits. In just the predrilling phase, the first two of these procedures are employed. Use seismic surveying for both exploration and development.

Gravity maps create various difficulties, the simplest of which is produced by distinct underlying substances exhibiting the same anomaly on the surface. At the same depth, it is hard to tell the difference between a tiny sphere with a high density and a big sphere with a low density. Because of their low density, salt domes and reefs may show up on gravity maps as drillable prospects. Seismic techniques are the most commonly employed in petroleum exploration of all geophysical approaches. It is possible to learn about the lithology and geometry of rock strata using seismic techniques, which measure the seismic velocity of the rock layers. A seismic wave is a shock wave (elastic wave) or a vibration that travels through the earth. The speed at which the wave travels, or its velocity, is directly proportional to

the rock's density. Elastic waves may be divided into two categories: P-waves, or "compressional" waves, and S-waves, or "shear" waves, are two types of waves.

In order to carry out this technique, you will need either a specialised air pistol or a seismic vibrator in addition to a controlled seismic source of energy, such as dynamite or a Tovex burst. The use of reflections to detect movement is central to reflection seismology, which has some similarities to sonar and echolocation. It is possible to locate and analyse prospective hydrocarbon sources via the use of seismic reflections. In reflection seismology, an elastic wave is used to find sources of hydrocarbon, water, or mineral, and it may also be used to gather information for geological engineering. Reflection seismology was developed in the 1960s. In order to offer information on the structure and distribution of rock types that lie under the surface of the earth, the results of seismic surveys and other geophysical data, such as the data from well logs and other geological data, will be integrated.

Seismograms often provide reflections from many layers deep inside the Earth's crust. The ability of seismic reflection data to map several ranges or layers in a single pass is a big part of the reason why this data is so valuable. After a certain point in the recording, there is an increase in background noise, which makes it difficult to extract reflections from the raw data. The seismic reflection data will help in producing the seismic cross section layer, thus, easily to be interpreted. Seismic interpretation is the process of analyzing a seismic record in order to derive information about the underlying geology at a particular depth. The process of interpretation may be divided into three interlinked categories: structural, stratigraphic, and lithologic. A cross section of seismic data significant as it could be used to determine and analyse the geological structures of the subsurface, such

as anticlines and synclines, as well as faults and other characteristics, (Dony, 2010). This cross-section provides photos displaying these structures. According to Mitchum et al. (1977), the finest quality exploratory seismic data may offer detailed information on structures as well as bedding information.

The information obtained from seismology may be used to ascertain changes in the porosity of the lithology and the degree to which the rock is fractured. The use of direct hydrocarbon markers is a component of the lithologic interpretation technique (DHI, HCIs, bright spots, or dim-outs). It is possible to partition the seismic cross-section into groups or series of reflections that are aligned and kept apart by a bounding surface. Analyzing the systematic endpoints of a reflection allows one to see the nonconformity and locate its source. Reflective packages between inconsistencies, also called stratum ends, may be broken down into truncation, toplap, onlap, and downlap, respectively. The majority of depositional sequences have a strong relationship, in most cases, with the local, regional, and global cycle of sea level. Reservoir is the element in a petroleum system that has an ability to store the fluid; water, oil, and gas. Reservoirs need to have characteristics of good permeability and porosity in order to accumulate and drain the oil. All types of rock could be reservoirs but usually sedimentary rock and also the rock that is highly fractured.

1.2 STUDY AREA

1.2.1 LOCATION

The study area will be divided into two which are Kampung Buluh, Terengganu and Kapal Field, Terengganu offshore. The first study area located at Kampung Buluh, Permaisuri Terengganu with center coordinate 5 32' 35.54" N 102 45' 23.87" E (A), 5°N30' 20.25" N and 102° 43' 49.99" E (B), 5° 30' 36.15" N and 102° 46' 30.40 E" (C), 5° 32' 52.78" and 102° 46' 20.49" E (D), 5° 32' 36.48" N, and 102° 43' 38.84" E (E). This study area will cover about 25km² and the dimension is about 5 X 5 km. Kapal field Terengganu offshore is in the Malay Basin and bordered by Terengganu coast. Malay basin categorised under east coast of Peninsular Malaysia which around 85,000 km² with about 500 km² long and 200km² wide (Petronas, 1999). Specifically, Kapal field located in the west of the Malay basin.

Kampung Buluh is a traditional Malay village located in Hulu Terengganu. The village is located 750 yards from Kuala Berang and 40 km from Kuala Terengganu. The village is connected by the T174 state route which connects Kuala Berang at the MDHT Interchange to Kampung Dusun. During the flood season, the area around the settlement is flooded and the bushes are also flooded, forming a ring-shaped land that is not flooded which is a residential area for the residents. The settlement conditions resemble the shape of the bamboo clump and the village is named after the shape.

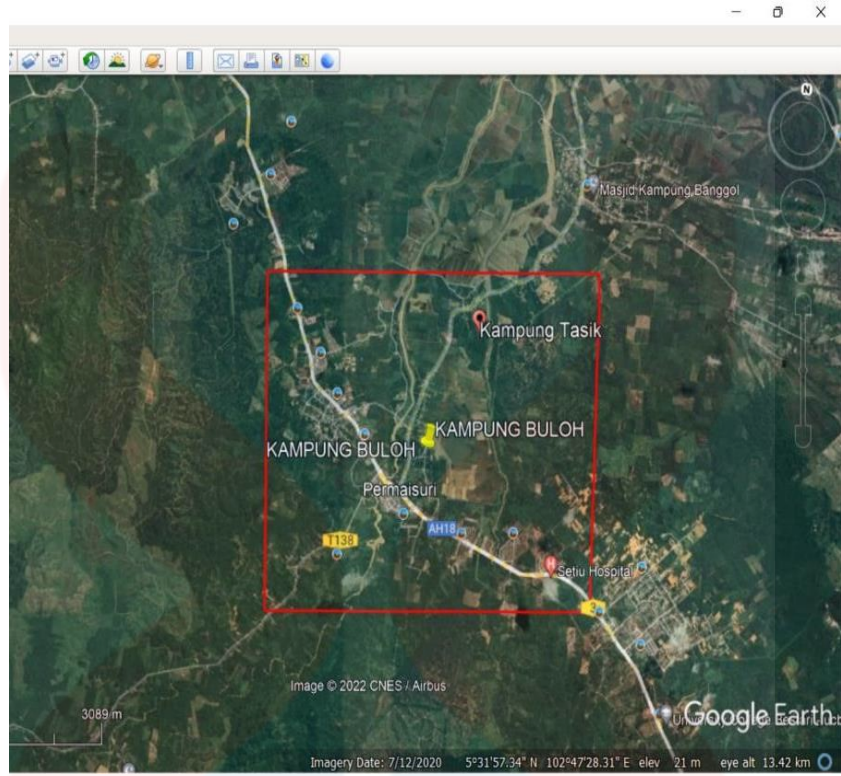


Figure 1.0: Location of study area (Kampung Buluh) via google earth

BASEMAP OF KAMPUNG BULUH, SETIU, TERENGGANU

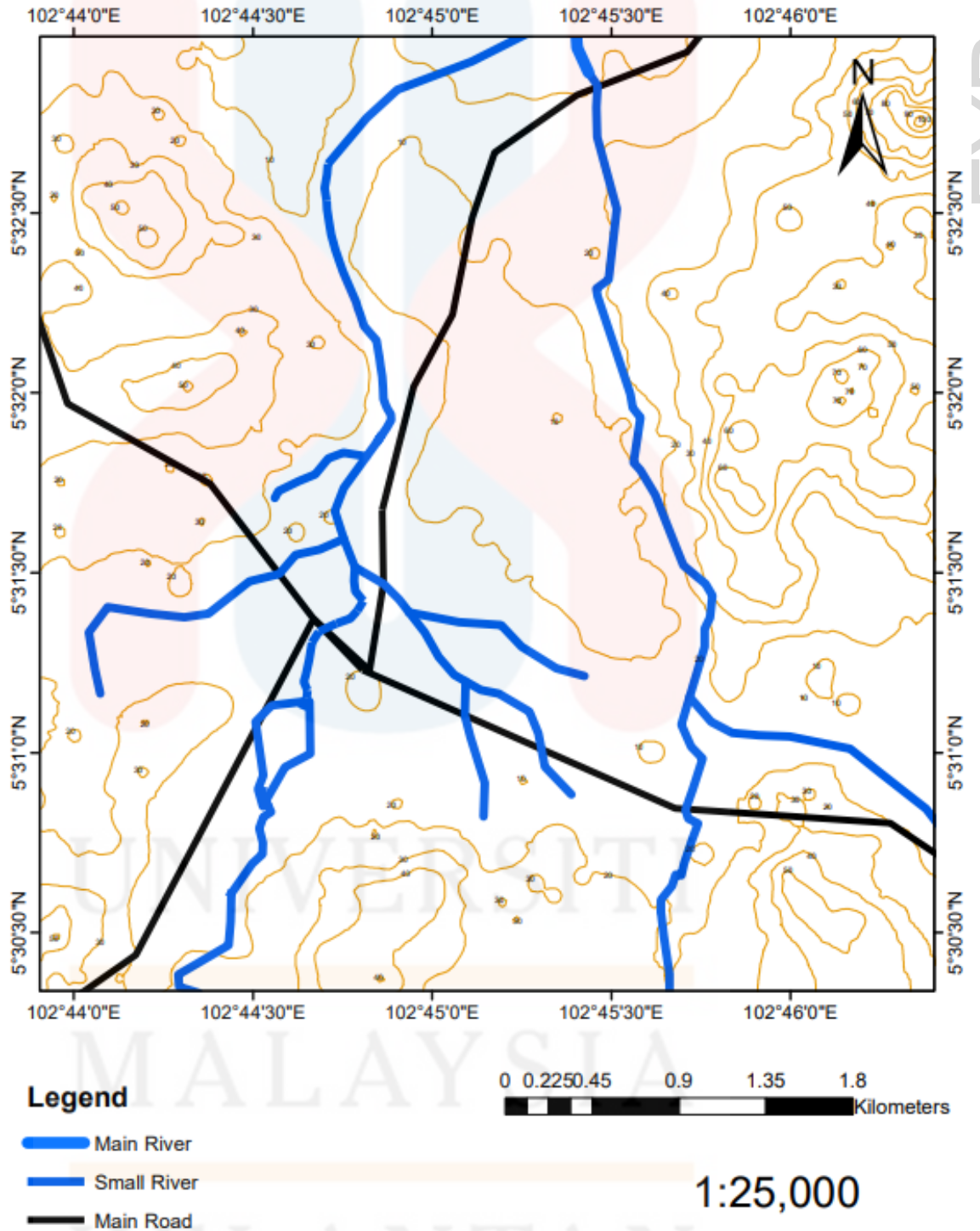


Figure 1.1: Basemap of the study area.

1.2.2 Accessibility

The location under investigation may be reached through a couple of different roadways. The region under consideration has both large highways and smaller roads that automobiles and motorcycles may use to get across it.. Figure 1.2, show the view of direction or routes at Kampung Buluh. In addition, the research area is accessible by a variety of roads, including village, housing area, and unpaved roads. Cars, motorcycles, and even pedestrians may travel the whole length of the road. In order to do research in the subject region, it is more convenient for the researcher.



Figure 1.2: The routes of Kampung Buluh via Google map.

1.2.3 Demography

The study of human population in a certain region is referred to as demography. This research takes into account births, deaths, and migrations of humans. Understanding the social and economic challenges through the lens of demography is extremely helpful. People are able to take action to solve some issues thanks to demography, which, at the same time, empowers people to take action.

The study of human populations via the use of statistics is called demography. The study of populations across time and geography, including their sizes, compositions, and migrations, is called demography. It draws on research techniques from a variety of disciplines, including history, economics, anthropology, and sociology, among others. When it comes to studying and forecasting social, cultural, and economic patterns connected to population, demography is a helpful tool for both public and private organizations, including governments and enterprises.

Stated by Population statistic- World Statistic Data, it estimated the total population at urban area Terengganu has been around 398, 079, while at city area in 2021 was 285,065 of people. Terengganu is still considered as sparsely populated.

1.2.4 Land Use

Bandar Permaisuri is a very small town that serves as the seat of the Setiu District in Terengganu, Malaysia. It was once the capital of Terengganu. In 1985 bandar Permaisuri was officially made the capital of the district as its geographical position is in the central area of Setiu district. This district is the youngest district of terengganu which was established on 1 January 1985 as a result of the certification of the Modernization and Administrative Development Unit (MAMPU). The city now houses government offices and institutions for the setiu district administration with Prince Jaya located in the south of the city being a satellite town for the placement of government employees in Setiu district.

1.2.5 Social Economic

The contribution of the manufacturing sector to the total gross domestic product of Terengganu was 33 percent, which was followed by the contribution of the services industry, which was up to 54 percent of the total GDP of the state. Terengganu's economy is highly dependent on the services industry, which contributed up to 54 percent of the state's total GDP. Terengganu's economy is mostly driven by agriculture, which accounts for 9 percent of the state's total gross domestic product and is one of the state's primary contributors to the state's GDP.

1.3 PROBLEM STATEMENT

The research is significant, as the Terengganu area is located in the Malay Basin and has become a potential area of hydrocarbon trap. Moreover, a lot of previous researchers did the study related to the hydrocarbon trap structure, generation and preservation of petroleum elements, and hydrocarbon generation. As clarification, this previous research is a proof that the possible hydrocarbon potential at Terengganu is exist. Thus, it is useful to identify a possibly hydrocarbon-containing reservoir area at the study area. In addition, a lot of study and research needs to be done to help with seismic interpretation. The seismic interpretation also must be done using software to obtain the data. The last is to interpret the data obtained from well log using Kingdom software 2021. Next, the Kuala Terengganu area's geological map must be updated with scale 1: 25 000 to reflect changes in the region's geological characteristics. The geological data obtain form geological mapping like lithology and geological structure were the important element in geological mapping. The detail of study area obtain can be summarise using the geological map.

1.4 OBJECTIVE

The main objectives of the study are:

1. To update geological map of 1: 25000 at Kampung Buluh, Terengganu.
2. To interpret the hydrocarbon potential using Kingdom 2021 software at Kapal Field Terengganu offshore.

1.5 SCOPE OF STUDY

The purpose of this study is to investigate the potential sources of hydrocarbons in Kapal Field, Terengganu offshore. Using the well log data obtained from Petroliam Nasional Berhad (PETRONAS) in the form of SEG-Y data and other types of data that will be provided, another study area at Kapal field will study about the geological features of the Terengganu offshore. This study will be conducted using the data that will be provided. After then, the data will be evaluated by utilizing the programme known as KINGDOM. In order to observe and investigate the geological characteristics of the Terengganu area, the research region, geological mapping with scale 1 : 25000 of study area need to be conducted and will be carried out in this study area in Kampung Buluh. Terengganu is located in eastern belt of Peninsular Malaysia, and Kampung Buluh was believed to have Sungai Perlis bed formation.

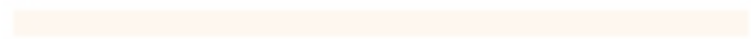
1.6 SIGNIFICANCE OF THE STUDY

The research was conducted to find the petroleum elements at Kampung Buluh, Terengganu in order to determine the potential of hydrocarbon sources. This study also will help to update the geological map at Kampung Buluh, Terengganu. For example, the streets and the drainage of the study area which are absent in recent maps will be updated. All the information will be gathered and will produce a geological map. The map is one of the needed pieces of information for geologists, government etc to explore, protect and extract the natural resources at the study area. Following that, the seismic analysis results will assist the government in exploring hydrocarbons, which may lead to increased national economic growth. Furthermore,

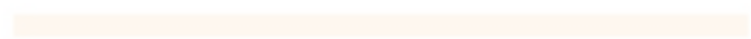
it will provide the researcher with an overview of the approaches that are being employed.



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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter will discuss about previous research of tectonic evolution which takes place in Southeast Asia and the Sunda Plate and the area of study where it is located at Kampung Buluh, Permaisuri, Terengganu and the offshore of Terengganu. This discussion covers general geology and stratigraphic aspects as well as previous studies to provide understanding and visualization of the general geological areas of the study and to be references prior to interpret seismic data. The seismic data used for this study is secondary data taken from PETRONAS database and will be analysed and interpreted using computer software Kingdom 2021 version. The report of well logs obtained can help to give a general overview of geological conditions and existing hydrocarbon sources. This chapter is very important as a starting point in ensuring that the workings carried out can be done accurately and smoothly.

2.2 Tectonic History and Evolution of Southeast Asia

Terengganu is in eastern Peninsular Malaysia. The abundance of Triassic and Late Cretaceous-Palaeocene granites has resulted in remagnetisation of earlier rocks, rendering palaeomagnetic data interpretation problematic (Richter and Fuller, 1996). Clockwise declinations in Late Triassic granites, Permian to Triassic volcanics, and remagnetized Paleozoic carbonates have all been measured. The date of this magnetization is unknown; however it might be as ancient as the Late Triassic or as recent as the Middle or Late Cretaceous. Southeast Asia is made up of multiple extremely active tectonic plates, including the Pacific Plate to the east, the Philippine Plate to the northeast, the Eurasian Plate to the north, and the India-Australia Plate to the south.

Cambodia, Laos, Myanmar (Burma), Thailand, Vietnam, and the teeny-tiny city-state of Singapore at the Malay Peninsula's southern tip make up Mainland Southeast Asia. Cambodia, Laos, and Vietnam, which constitute the eastern section of the mainland, are frequently referred to as the Indochinese Peninsula. Myanmar (Burma) is also a part of mainland Southeast Asia. The Malay Peninsula is located in the western part of Malaysia, while Borneo is located in the eastern part of the country. Together, these two landmasses make up the nation of Malaysia. Indonesia and the Philippines make constitute the whole of Southeast Asia's other island territories, with the exception of the teeny-tiny sultanate of Brunei, which is also located on Borneo. Terengganu.

2.2.1 Stratigraphy

Kuala Terengganu's geological sequence is separated into sedimentary, metamorphic, and igneous rocks. After that, the sedimentary rocks and metamorphic rocks are categorised as Charu/Sungai Perlis bed and alluvium, both of which are associated with the Early Carboniferous era and the Quaternary period, respectively. The Charu/Sungai Perlis bed is made up of metasandstone with trace amounts of slate, argillite, carbonaceous phyllite, metasilstone, metasandstone schist, and calc-silicate hornfels. Other minor components include phyllite, slate, and argillite. Sand, silt, and clay are the primary components of alluvial deposits, which may be found in river basins that are relatively flat. The term "eastern zone" refers to the area of the Malay peninsula that is east of the Lebir Fault and encompasses the eastern part of Johore. This region may be found on the Malay peninsula.

The majority of the marine sediments that have been exposed in this region are Carboniferous in age, with considerable Permian inclusions. surface features in the states of Terengganu and east Johore. This zone contains sediments that are mostly of a shallow marine origin, and the composition of these sediments does not vary as much as the stratigraphic equivalents found in the central zone. In the eastern zone, the Kuantan group is the sole stratigraphic group that has been identified. The Sungai Perlis beds and the Dohol formation are the only two formations that have been recognised as of yet.

2.2.2 Geological settings

According to Noraisyah et al. (2015), Terengganu area mostly covered by deposits such as meta sediments, carboniferous Quaternary, perm, and granite. Terengganu's southeastern region was composed of Carboniferous or earlier meta-sedimentary rocks, including schist, phyllite, and slate, bordered by Early Triassic granite and Quaternary sediments. The granite exposure along the shore at Bukit Dal, Dungun, was marked by thick jointing induced by prior deformation.

Sedimentary rocks have been deposited in Terengganu from the Late Palaeozoic, followed by granitic intrusion in the Early Triassic. During the Post-Pleistocene, weathering processes occurred following rock exposure, followed by erosion and beach creation. These activities may have been responsible for the exposing of morphology or beach ridges along Peninsular Malaysia's east coast during this time period.

2.2.3 Malay Basin

The Malay Basin is a northwest trending elongate basin in peninsular Malaysia. It is completely offshore in the South China Sea. The Malay Basin is a complicated rift with several extensional grabens. Because of their enormous depths, most of these grabens have been interpreted using magnetic, gravity, and seismic data. According, to Arif (2011), the Malay basin is known as intracratonic basin because it is situated inside the continental interior in stable cratonic sections of the Sunda shelf, the basin is also classified as an interior extensional basin. The basin is filled with more than 14 kilometres of

Oligocene to recent silt and spans an area of up to 85,000 km², measuring 500 km² long and 200 km² broad (Petronas, 1999), retrieved from Arif (2011). Abd Rahim Md. Arshad et al. 1995, stated that the Malay Basin also comprised 14 km of tertiary sediment and the area of Malay Basin covers an area about 80, 000 km². This province's petroleum system contains active source rocks as well as all of the geologic materials and processes required for oil and gas accumulation. It contains a high-quality source rock with total organic carbon (TOC) levels ranging from 1% to 4% and a hydrogen index (HI) of up to 750. The depth of the sediments gives a good temperature environment for the generation of hydrocarbon. The collision between India and Asia during the Eocene period reactivated the normal fault in this region, creating a hydrocarbon migration channel. The existence of good grade sandstone reservoirs on top of the source rock layers has allowed the hydrocarbon to accumulate.

The passage of India into Eurasian caused the displacement of the Malaya continental blocks, which ultimately led to trans tensional shear and crustal extension close to the pre-tertiary era. This event marked the beginning of the tectonic history of the Malay basin. The expansion of the crust that occurred throughout the late Eocene, Oligocene, and Miocene periods resulted in the formation of a rift-sag structure in the basin (Madon, 1999). Rift sag basin has resulted in active faulting, and when sedimentation takes place, the weight of the sediment load generates gravity loading. This is in addition to the fact that crustal cooling leads the crust to grow thicker, which puts even more weight on the sediment. As a result, the basin has become much more sunken. Despite this, the basin inversion that resulted in the

creation of the axial shear zone didn't take place until the early to middle Miocene (Phey et al, 2017).

However, the Malay basin's basement is made up of metasediments, igneous rock, and carbonates that were deposited throughout the Mesozoic and Palaeozoic eras. In general, the Malay basin was created during the tertiary period. Following the tectonic uplift and deformation that occurred during the late middle Miocene, the pre-tertiary basement was raised to a shallow depth that trended southeast. The tectonic uplift has also resulted in the formation of compressional anticlines, which are surrounded by normal faults near the southern end of the basement. The faulting pattern in two-thirds of the southern Malay Basin shows faults moving in an east-west and northwest-southeast direction, respectively (Ngah, 1990).

2.2.4 Seismic Attributes

Seismic characteristics are a kind of geophysical data that may be obtained by computing, calculation, and other methods. They are used to facilitate geological and geophysical interpretation by highlighting certain structural elements, such as faults or folds. As a result of being beyond the seismic resolution, fractures do not appear as faint lineaments on seismic data; nonetheless, they are still difficult to distinguish. Measuring the fault azimuth on the printed surface map while looking at it from an aerial perspective is the technique that was used in this study for the purpose of determining the major stress. The orientation of the object and the length determine which locations on its surface are used to take measurements. In the last step, the data are compiled into the rose diagram so that the major stress direction may be

determined (Phey et al, 2016). In order for seismic interpreters to differentiate between cracks in a basement, seismic features, particularly curvature and coherence, help enhance the seismic picture (Chopra, 2009). The seismic data may offer a good picture of the reservoir structure, but there are some restrictions to fine features such as the size of the crack and its connectivity. Seismic data may provide a good perspective of the reservoir structure.

2.3 Petroleum system

Every chemical substance that may be discovered in nature can be placed into one of two categories: organic or inorganic. The term "organic compound" refers to any compound that contains carbon, and one requirement for inclusion in this category is that the carbon atoms inside the molecule must be covalently bound to at least some of the other atom present (Sidqi, 2004). Petroleum systems have elements such as migration pathway, mature source rock, reservoir rock, trap, and seal. All the elements relate and link with each other in order to produce hydrocarbon resources (GeologyScience, 2019).

2.4 Source Rock

The term "petroleum source rock" refers to the fine-grained silt that contains a significant quantity of organic matter and is able to develop and release sufficient quantities of hydrocarbons to form an accumulation of oil or gas that is suitable for commercial use. Shales and lime mudstones, both of which contain a considerable quantity of organic matter, are the types of rocks that are most usually used as sources. In the context of the petroleum industry, the term "petroleum source rock" refers to any rock that has the capacity to create and expel sufficient hydrocarbons to allow for the formation of an accumulation of oil or gas. In the context of the

petroleum industry, the term "petroleum source rock" refers to any rock that has the capacity to create and expel sufficient hydrocarbons to allow for the formation of an accumulation of oil or gas.

In accordance with the amount of oil they produce, source rocks are divided into the following three categories: Immature source rocks are those that have not yet produced any hydrocarbons, mature source rocks are those that are now in the generation phase, and post mature source rocks are those that have already produced all hydrocarbons of the crude oil type.

The quantity of organic matter (organic richness), the quality of the organic matter (kerogen type), the thermal maturation production capability, and the distribution of organic matter throughout the rock are the primary factors considered when determining the source of hydrocarbons [2–4]. Economic viability, fast availability of data, and continuity of sampling of vertically diverse shale sections are all benefits offered by indirect techniques that are based on wireline data. The amount of organic matter may be ascertained directly through laboratory tests of the rock samples that were used as sources (shale, limestone, or marl).

In order for source rocks to produce oil in quantities adequate for commercial use, one of the conditions that must contain a significant quantity or level of certain organic matter. This organic matter must be able to create and expel hydrocarbons. The organic matter content of the open marine argillaceous sediments has been reported to reach around 1.1 percent by Ronov (op.cit), whereas the organic matter content of the continental and lagoonal sediments has been reported to reach approximately 0.43 percent. Thomas categorized the potential of source rocks according to the weight percentage of organic carbon they contained, dividing them

into four distinct categories: poor source (less than 0.5 weight percent), fair source (0.5–1.0 weight percent), good source (1.0–2.0 weight percent), and very good source (>2.0 weight percent). According to Tissot and Welte's research, "clastic rocks, which are considered as source for petroleum contain a minimum of 0.5 wt percent of the total organic carbon (TOC wt %), while good source rocks contain an average of about 2.0 wt percent of TOC." Good source rocks are characterized by having higher levels of total organic carbon. The kind of organic matter has a significant bearing on the characteristics of the hydrocarbons that are produced.

According to the conclusions that Espitalie and her colleagues came up with, the presence of organic richness by itself may not be enough to assess source rocks. This is due to the fact that source rocks in which the organic matter is mostly inertinite, which means that it has been oxidised or biodegraded, are not capable of creating hydrocarbons, even if there are substantial quantities of the organic matter present. It is considered a poor source when the total organic carbon content is less than 0.5 weight percent, a fair source when it contains between 0.5 and 1.0 weight percent, a good source when it contains between 1.0 and 2.0 weight percent, and a very good source rock when it contains more than 2.0 weight percent TOC. This study makes use of the scale that was described by Peters and Cassa for evaluating source rocks, and it was employed in that work as well.

The kind of organic matter present is an essential component to consider when assessing the potential of the source rock, and it also has a significant bearing on the characteristics of the hydrocarbon products. According to the theory put forward by Peters and Cassa, the hydrogen index (HI) of gas-prone organic matter in mature source rock is less than 150, the HI of gas-oil-prone organic matter is between 150

and 300, and the HI of oil-prone organic matter is more than 300. In order to identify the various hydrocarbon compounds, it is essential to identify the kinds of kerogen that are present. The findings of the pyrolysis may be used for the classification of the various forms of organic matter. It is possible to do this by establishing a connection between the hydrogen index (HI) and the oxygen index (OI), (Nabil Mohammed, 2018).

2.5 Reservoir Rock

According to Donatien (2014), Reservoir rock is permeable subsurface rock and has a good porosity. It is one of the important elements that can produce hydrocarbons with the existence of good sealing properties of rock. Reservoirs rocks are dominantly sedimentary (sandstones and carbonates). however, highly fractured igneous and metamorphic rocks have been known to produce hydrocarbons, albeit on a much smaller scale. Donatien (2014) states that the reservoir rock has two types which are sandstone reservoir rock and carbonate reservoir rock. According to Alyafei (2019), the reservoir rock has pores (good porosity) thus it has the ability of storing the hydrocarbon. The lithology of petroleum reservoirs was subdivided into two; sandstone and carbonate. For example; sandstone reservoir rock may consist of silica grains, while carbonate rock has two major types (limestone and dolomite).

The Society of Petroleum Engineers Glossary defines a reservoir rock as a type of rock that possesses the characteristics of porosity, permeability, sufficient hydrocarbon accumulation, and a sealing mechanism to form a reservoir from which commercial flows of hydrocarbons can be produced. These characteristics are necessary for the formation of a reservoir. In other words, a reservoir rock is one that has all of the qualities essential for the formation of a reservoir. Both the

porosity and permeability of the reservoir rock are considered to be the most important of its physical qualities. Porosity is an essential characteristic of a rock that is used as a reservoir between them. However, from an explorationist's perspective, the most important quality of a good reservoir rock is its permeability. Permeability is a basic reservoir rock feature. Both of these are examples of geometric features that arise as a consequence of the lithological, structural, and compositional behavior of the material (composition). These geometrical aspects of a rock's physical composition and textural features include the sizes and forms of its individual rock grains, as well as its organization system and packing. In order for a lithological formation to be considered a reservoir, the rock that it is formed from must have pores and be permeable. It includes rocks that are composed of sediment. These sedimentary rocks might be composed of sandstones (such as quartz sand or arkosic sandstone), dolomite, or carbonates mud. As a rule, dolomites make excellent reservoirs due to the presence of Mg, which is 13 percent less abundant than Ca. This is significant because, during the process of dolomitization, there is a total decrease in volume of the material by 13 percent, which results in 13 percent porosity being created.

The reservoir's porosity is the attribute that indicates how porous a rock is. [Case in point:] It is also described as a measurement of the ability of reservoir rocks to hold or store fluids. This definition comes from another definition of the term. There is main and secondary porosity, and the porosity is genetically defined based on the usual sedimentologic definition of reservoir rock.

Primary porosities are divided into two which are intra particle and interparticle. Inter-particle (I) In this kind, rock content was rapidly lost in muds and carbonate sands due to the corresponding processes of compaction and cementation.

The majority of occurrences of this category come in the form of siliciclastic sands. Intra particle porosity (II), which refers to the porosity that is created inside the carbonate skeletal grains themselves.

Secondary porosity, often known as the porosity, that forms after deposition, may give rise to a handful of different kinds of reservoirs: The Dissolution Porosity Type (I) is Composed of Leaching and Carbonate Dissolution. Carbonate reservoirs is another name for this phenomenon. Fracture porosity (II), which is distinguished by its lack of voluminous characteristics.

The capacity of a fluid to move through its porous medium is what's meant to be measured by a substance's permeability. The reservoir's permeability is one of the major factors that define how successful it is. Both porosity and permeability are characteristics that may be used to describe the capacity of the reservoir rock in relation to the fluid content. In addition, a rock used as a reservoir might be porous without also being permeable. For instance, one might say that anything is permeable if and only if the pores are able to "communicate." As a result, knowing the permeability of the reservoir rock is an essential step for explorers because this property is essential for being used to determine if the reservoir actually has sufficient commercial accumulation of oil, despite the fact that measuring this property is extremely challenging. The concept of measuring permeability may be interpreted in two distinct ways, depending on the approach that is used. When the porous medium is totally saturated by a single fluid, the permeability will be defined as absolute; however, when its porous medium is occupied by more than one fluid, the permeability will be described as effective.

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

In this chapter, the methodology that was used to carry out the study will be broken down in great depth. It will provide researchers with a guideline to follow in order to properly follow the materials and methods that will be used in this study. In addition to this, it will also make it possible for others to pursue this line of study by using the guidelines that are provided. The materials and technique that will be used to carry out the study are being selected initially. The study will benefit from both the collection of data and the analysis of data.

This chapter covers a variety of various technique procedures, including pre-field and field research, sampling, laboratory work, petrology analysis and interpretation, and seismic analysis and interpretation, among others. The approach that will be used to carry out the study will serve as the primary focus of the investigation. In order to ensure that the materials are compatible for the technique that will be utilized, it is necessary to identify those materials. The research approach that we use in order to carry out the study is shown in Figure 3.1.

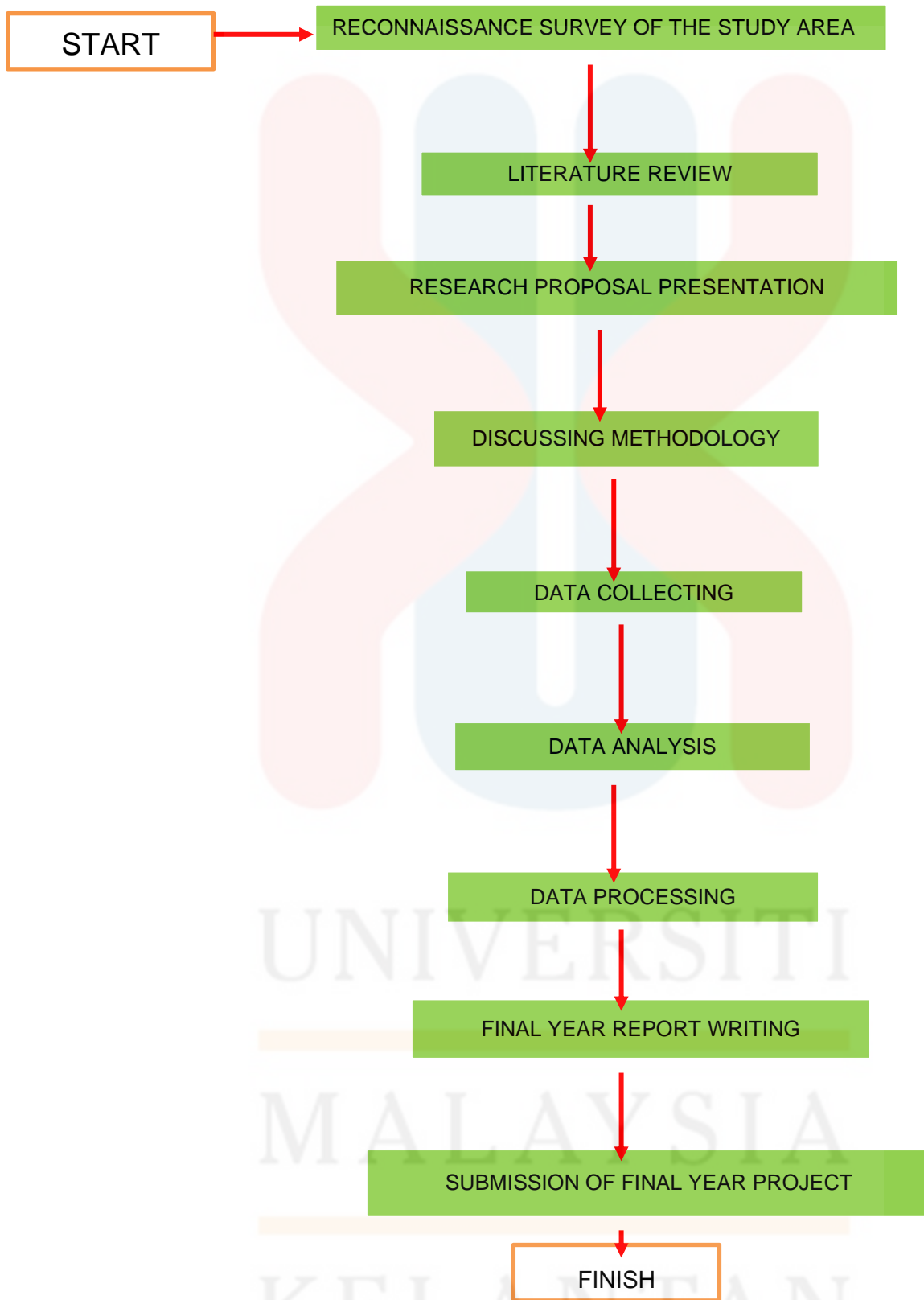


Figure 3.1: The research flow chart.

3.2 MATERIAL

3.2.1 Introduction

A geological map is a map consisting of geological data from the outer layer of the crust of the earth that is a blend of lithology, distribution of geological structure, stratigraphy, and geomorphology. Geological map specifics depend on the map's scale and the density and precision of field observations. For general geology, the mapping needs to be done in order to get the detailed information regarding the research at Kampung Buluh, Permaisuri Terengganu.

3.2.2 Geological Mapping

The materials that will be used for mapping are mostly a navigational system (GPS), compass, clock, notebook, hammer, hydrochloric acid (HCL), plastic sample, measuring tape, and hand lens. These materials can be obtained from the Faculty of Earth Science (FSB) with several steps in order to book it.

First of all, the Global Positioning System (GPS) is the most important material that will be needed in the mapping as it acts to find the coordinates and accurate location in the research area. Compass is used to take strike and dip at the outcrop using its internal clinometer. It also can be used to know the directions of bedding at the sedimentary rocks. A compass operates by sensing the natural magnetic fields of the Earth. Because of gravitational pressure, the Earth's iron core is half liquid and part solid crystal. Next, for hydrochloric acid (HCL), it can detect the changes in the rock when the acid dropped into the rock sample. If the rock oxidizes and produces bubbles, it shows the existence of calcium carbonate related to limestone rock. Hammer and plastic samples are important during mapping in order to break the massive outcrop of rock into smaller pieces so that the mineral is

easily observed. For the plastic sample, the rock will be stored and kept in the plastic sample with correct label and details (coordinate, location, mineral compositions, rock texture, color and grains).

3.2.3 Seismic Interpretation

The data from the PETRONAS subsidiary, particularly the Petroleum Management Unit will be used to conduct seismic interpretations. This data includes seismic reflection data, a base map, seismic sections in the form of SEG-Y data, a T-Z graph, and other information such as a geology report and a full final report of a well log from drilling in the study area. Furthermore, the time-depth curve is employed to illustrate the PETRONAS velocity surveys recording wells. In addition, the data processing will involve the use of computer software (Kingdom 2021 application).

PETRONAS at the field developed a time-depth graph (T-Z graph) from the well's velocity survey to estimate the length of the seismic wave from the surface to the hydrophone intended at a given depth. This survey will aid in the identification and study of the area's facies and other aspects. Reflection seismic data is collected by using three components: input sources, sensor arrays, and recorders. The input source will be used to create a sound vibration with the following properties: energy, duration, frequency, maximum amplitude, and phase. The source that runs under the earth's surface produces a wave of reflection and refraction that is recorded by the sensor, which is geophones. A seismograph then records this reflected wave. The features of the sensors and recorders utilized will cause variations in the detected wave signals.

A seismic cross section is an image of a cross section that is found below the seismic survey line and is positioned below the surface of the earth. The seismic cuts are made up of lines that are grouped in the pattern of waves, and each line is printed on its own separate sheet of paper. After seismic surveys have been analyzed, seismic cuttings that need to be interpreted may be retrieved from those surveys. There are numbers of shoot points used as a reference for producing maps that are located at the top of each seismic section. This ensures that each shoot point that is located on the seismic section is represented on the map.

3.3 METHODOLOGIES

3.3.1 Preliminary study

Preliminary study for this research is important because it could give the idea and more knowledge about the topic. This study will help in widening and strengthening the scope of research. preliminary research or study have several steps or ways which by research, surveys, research questions. In writing preliminary study, it has several stages which include the choice of the issue, refine the criteria of research, general questionnaire to help in problem statements, and explore what kind of sources could help in defending the objective of the research.

For preliminary study also, the study area or location were observed generally to get the simple glimpse of the area before proceed with geological mapping. This method is important to make sure the accessibility, location, demography and land use of the research area. Moreover, another method or processing can be done after the location was confirmed.

3.3.2 Data collection

For this research, data collection mostly can obtain from geological mapping such as lithology at the research area, fossils and geophysical. Geoscience data and collections exist in many shapes and forms like fossils, rocks, cylindrical core of rocks, sediments, or ice. In addition, the documentation also plays an important role in data collection as it includes the significant details which are age, location, depth, originator, and data acquired. Moreover, the data collection is necessary to discover, get an access of energy resources at study area. The only way to verify the quality, amount, and continuity of oil and gas reservoirs, coal seams, ore bodies, and water aquifers is to conduct a methodical investigation of cores, cuttings, well logs, and

seismic data. This will allow for the most accurate results. The process of resource assessment, which is crucial for the establishment of a sensible energy and natural resource strategy that efficiently balances usage, conservation, and requirements, requires these sorts of information as a key building block.

Hydrocarbon potential at Kapal field, Terengganu offshore can be obtain using Kingdom 2021 software by interpreting the seismic well log data at the study area. The interpretation of well log need to be done in order to get the specific result of hydrocarbon at the area. In order to finish this research utilizing a geological mapping approach, it is necessary to conduct observations at the study region for a minimum of a couple of weeks. It is necessary to cover the whole of the box, which has a total size of 25 km². The field study is an extremely important part of the research methodology. Researchers will be better able to achieve their goals and get detailed knowledge on the subject of their study if they follow this course of action.

The interaction with the local people was helpful since they are acquainted with the region, which will assist the researchers in locating an outcrop and ensure that they do not just rely on the base map. The geological structure of the research region, as well as its outcrops, geomorphology, and other features, will be investigated as part of the field study. The camera was used to take pictures of all of the outcrops and geological features that can be located in the research region. A scale should be placed next to the item (outcrops) or any geological feature to provide an approximate idea of the dimensions of the outcrops and geological features.

In order to analyze the geological information of the research region, it is necessary, after the completion of in-depth observations, to collect samples such as

fossils and rocks from the area under investigation. In order to ensure that the mineral composition of the sample does not shift, it is necessary to collect newly formed rocks from the region under investigation.

3.3.3 Data Processing

Data processing in this study will involve two parts, the first one is in the laboratory and the second one will involve the use of Kingdom software. For the laboratory part, the process to create a thin section from the samples will be done later. It is considered very important to choose a correct and fresh sample of rocks before it undergoes a thin section process. Secondly, the Kingdom software is the software that can help in processing the secondary data obtained from PETRONAS. This data needs to be reworked for processing and interpretation by using the computer version of Kingdom version 2021.

This piece of computer software consists of many layers of data processing and interpretation, some of which include data management, data analysis, data interpretation, and modelling. Before any kind of data analysis can be carried out, this data in the SEG-Y format must first be loaded into the Kingdom computer programme version 2021. After the procedure of importing data has been completed, the total number of crossline, inline, and inline survey lines will be shown before moving on to the subsequent procedure of importing global coordinates. When the precise coordinate value is used, it will produce an orthogonal shape that will comprise the study area and be shown on the screen of the computer.

3.3.4 Analysis and Interpretation

Petrology is the study of rock composition and mineralogy in terms of physical and chemical properties. The mineral composition and textural connection

of the rocks in the research region will be explained. To prevent errors and missing vital information, the analysis and interpretation are handled clearly. Petrological analysis is the investigation of reservoir rocks' mineralogical and chemical compositions, as well as their pore properties, is critical for determining reservoir quality, which governs reservoir rocks' ability to hold resources such as crude oil and geothermal heat.

Geospatial Information Spatial or known as GIS has a function to record and key in the data obtained from geological mapping such as location, land use, and drainage patterns. A geographic information system (GIS) is a computer system that captures, stores, verifies, and displays data about locations on the Earth's surface. GIS can display a wide range of data on a single map, including streets, buildings, and plants. This allows individuals to identify, evaluate, and comprehend patterns and correlations more quickly.

The data from this research is also very helpful to update the map at study area thus one of the research objectives will be to settle and achieve. Seismic data interpretation and processing can be broken down into these three distinct steps: collecting, processing, and interpreting the results. In order to properly analyze data, one must have a thorough understanding of the subject matter at hand.

Following the completion of the laboratory work, petrological analysis and interpretation will be carried out. The study of the minerals that make up rocks and the composition of rocks as seen through their physical and chemical properties is called petrology. It will explain the mineral composition as well as the textural relationship of the rocks that may be found in the research region. The analysis and

interpretation are being handled very carefully in order to prevent any errors and ensure that no vital information is overlooked.

In order to effectively identify and correlate a sequence, the sequence boundaries must first be defined and recognized. This is the first step in the process. In most cases, the sequence boundary is established based on an unconformity that is derived from the interactions between layers that are not lined. If the length of the pause at a particular location is known, then the geological age may be calculated for both the region above and below the unconformity. The period at when the sequence boundaries were first recognized by lateral the layer may eventually become parallel, but the pause served as evidence for additional investigation into the unconformity. Finally, the sequence boundaries may be identified in between the parallel layers if there is no indication of a hiatus or unconformity being found at the conformity that is associated to the conformity. When it comes to the seismic interpretation of stratigraphic sequences, sequence boundaries are a very significant component.

The interpretation of transgression surface is defined as a surface that indicates the commencement of the relative sea level rise to their occurrence. This interpretation is based on the fact that transgressive surfaces occur before relative sea level rises. This surface in the sequences of stratigraphic layers suggests that there has been an increase in the capacity to accommodate sediments at nearshore or coastal regions areas as a result of relative elevations in sea level. This surface is also employed as an indication of the decrease in the rate of sedimentation occurring in the region along the coast. slope of the continental rim and base of the basin.

The marine-flooding surface, also known as the mfs, is the surface that acts as a barrier between younger and older rock layers. This demonstrates that there was an abrupt rise in the depth of the water. This surface is often found at the bottom of the marine shale and marks a changing diffusion of depositional environment between the shallower region at the bottom and the deeper section at the top of the rock formation.

Maximum Flooding Surface, abbreviated as MFS, is another name for the borders that separate transgressive units from aggradation or regression above them. This surface is produced when the transgression component associated with the rising sea level reaches its highest point relative to the starting point. This surface, in the sequence stratigraphic concept, represents an increase in relative oceanic rates, which often surpass sedimentation rates in nearshore to shallow marine environments. However, these sedimentation rates had been changing until they were dropping from the depositional rate. This surface also reveals that when the relative shift in the rate of sea level rise occurs, the deposition system switches from the direction of the land to the direction of the basin.

Because it is confined by an unconformity plane, the depositional sequence in a basin consists of a stratigraphic-time unit. The depositional sequence is the primary genetic unit that makes up a basin. As a result, all of the strata that are included within the sequence were deposited within the specified time period. The strata that make up the sequence are often parallel to one another and have genetic connections to the main deposition events. A sequence is made up of several different facies, but it also contains lateral layers of isochron strata that may move through many different lithofacies.

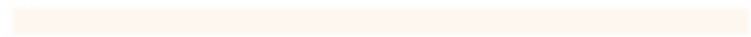
The connection between the depositional system that originated at the same time and the system tract is called a system tract. The system tracts are recognized by the goal of their location in the sequence, their interaction with the surfaces of discontinuity, and the build-up pole of the para sequence. They are also one of the sections that originate from the sequence of deposition. Analysis of particular parts from the cycle of the relative sea level that produced the sequence is performed on each and every system's tract. The Lowstand system tract (LST), the Transgressive system tract (TST), and the Highstand system tract are the three systems that always exist within a single cycle of the sea level. These systems are responsible for characterizing the various parts of the sea level (HST).

The LST is the one that has been around the longest and holds the position that is the farthest down in the ideal sequence. LST deposits were made during one phase of the decline in relative sea level, which continued until it reached levels of relative sea level that were both stable and lowest possible. While for the TST, this location is in the midst of the optimal sequence, which is bordered by the transgressive surface at the bottom and the maximum flooding surface at the top. This system is tracking the deposits that are occurring as a result of the rise in the relative sea level. It occurred when the accommodation increased at a pace that was greater than the rate at which sediments were being deposited. This may be shown using a depositions pole or a surface pole that has been turned upside down. In the chronological progression of various values, HST is the one that comes first. It is shown by the sequence of deposits made following the most extreme transgression. This system is defined by a relative slowness in the rise of the sea level, which first results in a pattern of aggradation and is later followed by a pattern of progradation. This system is characterized by the fact that it follows this pattern. The MFS serves

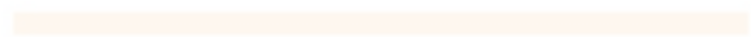
as the lowest boundary, which is subsequently followed by the subsequent sequence boundaries.



UNIVERSITI



MALAYSIA



KELANTAN

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter 4 which is general geology will explain regarding the full data obtained from site visit and mapping at the Kampung Buluh, Permaisuri, Terengganu. This chapter will cover several important topics; accessibility, settlement, forestry and vegetation, traverse, geomorphology, lithostratigraphy, structural geology, and historical geology. At the end of this chapter, all the geological details and data of study area can be understood.

4.2 Accessibility

Kampung Buluh, Permaisuri, Terengganu is a big village in Permaisuri and the town was named as Kampung Buluh before changed into Permaisuri. In terms of accessibility, the study area has no problems as it is consisting of all the accommodation needed by the people. It has main road that connecting Kota Bharu to Kuala Terengganu, also have main river of Setiu, Terengganu that flowing towards South China Sea. The small road in the study area also easily get access via

motorcycle except the paddy field area connected to close contour of hill that have no road to access. The study area is developed area that have been undergoing the construction process to create road, new house and certain area covered by vegetations. The hill of study area has been paved mostly to build accommodation for villagers.

4.3 Settlement

The study area at Bandar Permaisuri covering 20 % of village area. Kampung Buluh is an urban area that consisting of all the accommodation like hospital, school, university, stall, mall, groceries stores, and mosque. The area also facing construction to create more accommodation. The area also filled with traditional and even modern house that dispersed in the area.

4.4 Forestry and Vegetation

In Kampung Buluh, Permaisuri, Terengganu, is a town that has been under-development districts in Setiu, Terengganu. Kampung Buluh comprised the forest around 20 % of the study area with elevation ranges from 20 m to 180 m. The forest locality in the study area is uneven. The range of elevation consider low land to hill. In addition, there are many plantation areas in the study area which are rubber tree, paddy field, and palm tree. Refer to the figure 4.1, the google Earth Pro show the topography of Kampung Buloh.

As clarification, the study area at Kampung Buluh, Permaisuri are covered more with vegetation compared to the forest as the highest elevation ranges from 60-180m only. The figure 4.2 show the picture of palm tree, figure 4.3 show the rubber tree and picture 4.4 show the paddy field that cover around 40 % of study area.

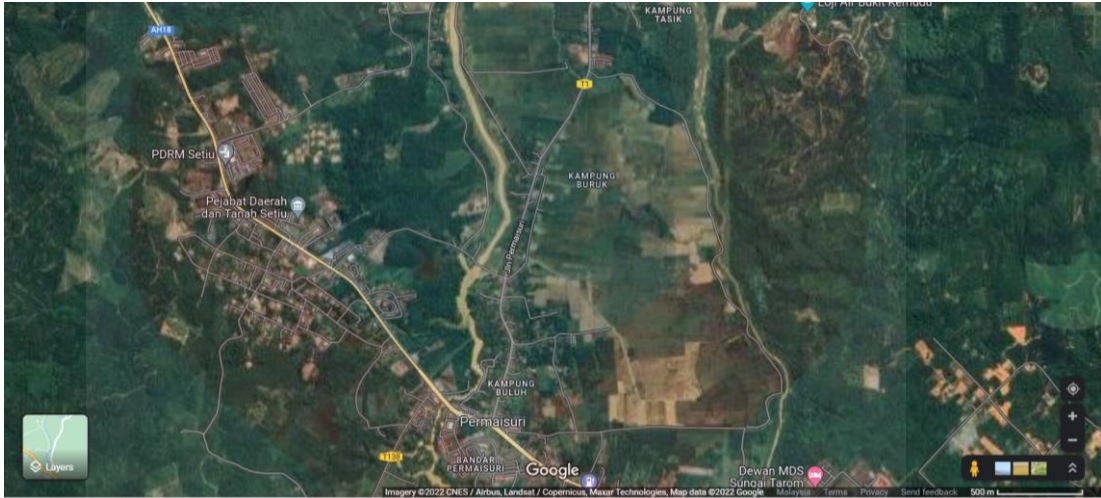


Figure 4.1: The topography of the study area through Google Earth Pro



Figure 4.2: Palm Tree at the study area

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Figure 4.3: Rubber tree at the study area



Figure 4.4: Paddy field at the study area

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4.5 Methodology

In the realm of surveying, a traverse is a kind of approach that is used to set up control networks also it has applications in geodesy. The establishment of traverse networks entails the placement of survey stations along a line or route of travel, followed using the points that were previously surveyed as a foundation for the purposes of observing the subsequent point. When carrying out geological mapping in the field, one of the ways that is carried out is called a traverse. During the research process, the traverse's role is to monitor and record the route taken by the researcher at the specific location of study area. During the traverse, researchers will make observations and make notes to compile data for a geological map. Thus, it will help in finding the data present in study area. During the mapping operations, the travelled route is represented by the traverse and observation maps, which can be found shown in Figure 4.5. The waypoints that form observation map have been placed in Table 4.1, and this table displays all the observation points that were made throughout trip.

In order to show the location of field data, geologic features, and their subsequent plotting in a base map, geological field mapping had been conducted in an area that was 25 km² in size. There are several different approaches that were used in order to make a traverse activity a success. First, the Global Positioning System (GPS) is used because of its quick adaptability for surveying and its ability to immediately supply a location including latitude, longitude, and height without the requirement to estimate angles and distances between intermediate sites. With the use of a GPS, the track and waypoint are recorded along each traverse way.

The GPS Exchange Format, commonly known as.gpx, is a file format that is widely used for storing GPS data and is supported by a wide range of GPS devices

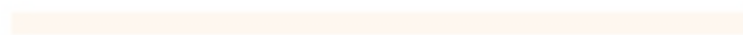
and software applications. The information on the tracks and waypoints was imported into Google Earth Pro so that the location of the traverse area could be shown. It was decided to update the waypoint placemarks and track routes in order to provide more information on the survey area.



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TRAVERSE MAP OF KAMPUNG BULUH, SETIU, TERENGGANU

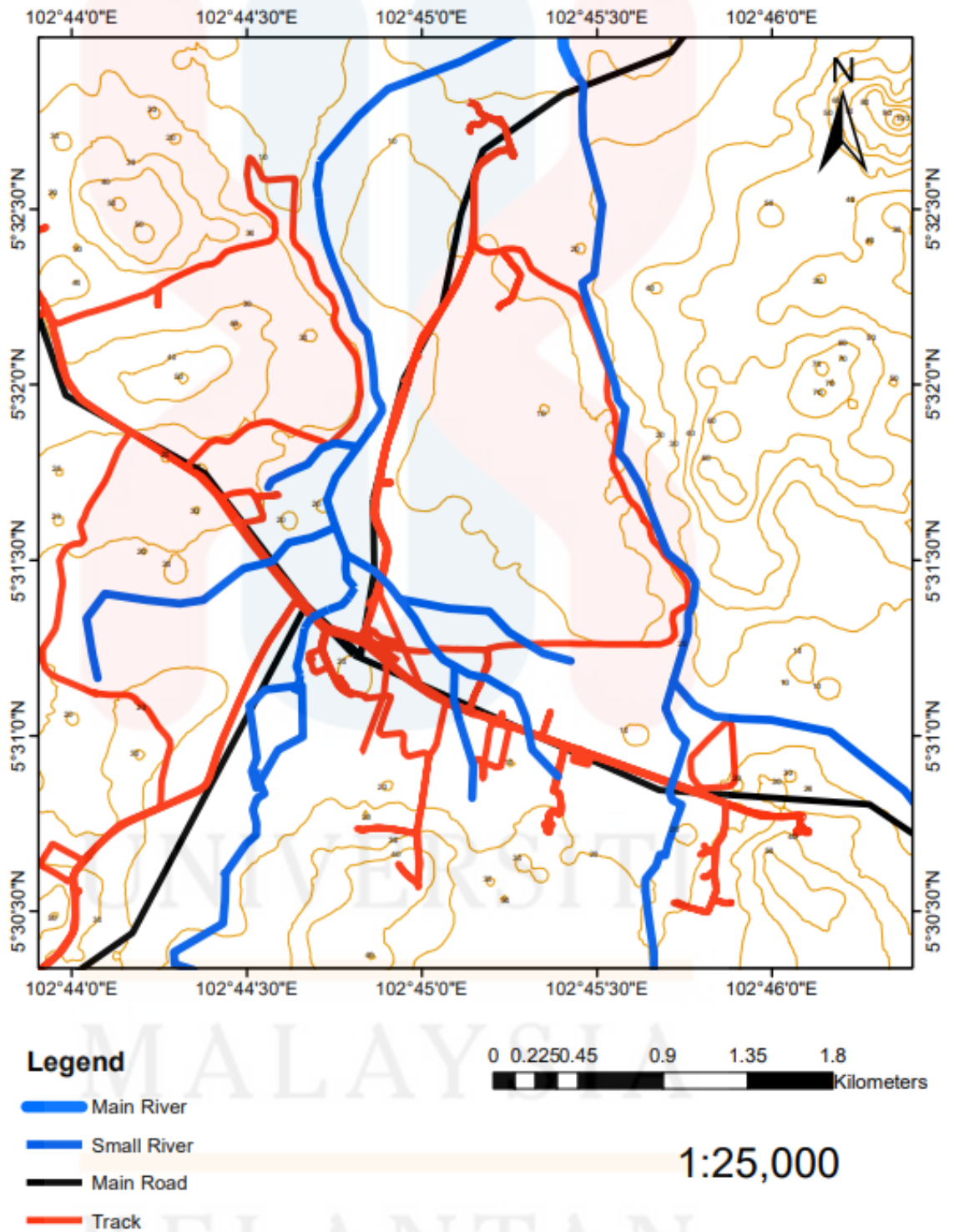


Figure 4.5: Traverse and Observation Map

Table 4.1: Waypoint of the study area

TYPE	LATITUDE	LONGITUDE	DESCRIPTION
Waypoint 1	5.53672900	102.73195300	Outcrop 1
Waypoint 2	5.53668100	102.73142300	Folding
Waypoint 3	5.53664500	102.73118400	Folding
Waypoint 4	5.53661900	102.73075100	Folding
Waypoint 5	5.53663000	102.73130200	Slate
Waypoint 6	5.53662200	102.73140800	Sandstone
Waypoint 7	5.54534800	102.75230000	River
Waypoint 8	5.53356400	102.74926900	Paddy field
Waypoint 9	5.53711500	102.75375200	Paddy field
Waypoint 10	5.53821700	102.75615700	Rubber tree
Waypoint 11	5.53410300	102.75883800	River
Waypoint 12	5.52105400	102.75570000	Rubber tree
Waypoint 13	5.51799400	102.75229700	Main road
Waypoint 14	5.51223900	102.76819600	Outcrop 2
Waypoint 15	5.50875300	102.76469100	Outcrop 3
Waypoint 16	5.51437600	102.76185300	River
Waypoint 17	5.51415200	102.75009600	Palm tree
Waypoint 18	5.51287900	102.74988700	Outcrop 5
Waypoint 19	5.51225900	102.74694000	Outcrop 6
Waypoint 20	5.51585300	102.74915900	River
Waypoint 21	5.50932700	102.73363200	Outcrop 7
Waypoint 22	5.50980800	102.73306300	Outcrop 8
Waypoint 23	5.51833100	102.73642200	Palm tree
Waypoint 24	5.51867300	102.73448800	River
Waypoint 25	5.54162200	102.72883500	Outcrop 9
Waypoint 26	5.53717000	102.73742100	Outcrop 10
Waypoint 27	5.54318000	102.74238600	River
Waypoint 28	5.53139400	102.74319700	Outcrop 11

4.6 Geomorphology

Geomorphology is the study of the physical features of the Earth's surface, including their origin, characteristics, processes, and evolution of landforms. This field of study is also known as geomorphology. In order to conduct the geomorphological research, the landforms of the study region, which is located in Kampung Buluh, Permaisuri, Terengganu, Malaysia, were observed, the rates of weathering were analysed, and a classification of the drainage pattern was made. It is conducted based on topographic map, drainage map, literature review and by field observation.

4.6.1 Topographic unit classification

After analysing the topographical map of the study region, the researchers determined that the landform in the study area corresponds to a hilly geomorphology. This topographic unit classification was taken from Hutchison and Tan's (2009) work, which classified it into the five broad topographic units that can be distinguished based on the difference in mean elevation obtained. These five broad topographic units are low lying, undulating, hilly, and mountainous areas. The topographic unit categorization may be seen in Table 4.2, which is derived from Hutchison and Tan's mean elevations (2009). Due to the fact that the altitudes of the research area span from the lowest elevations, which are 10 metres, to the highest elevations, which are 80 metres, it is possible to classify the topographic unit as having hilly landforms within the four categorization groups. The Datum Elevation Map that was generated based on the elevation at the research region is shown in Figure 4.7 below.

Table 4.2: Topographic Unit Classification based on Hutchinson and Tan (2009)

Classification	Topographic Unit	Mean Elevation
1	Low lying	<15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	>301

TOPOGRAPHY CLASSIFICATION MAP OF KAMPUNG BULUH, PERMAISURI, TERENGGANU

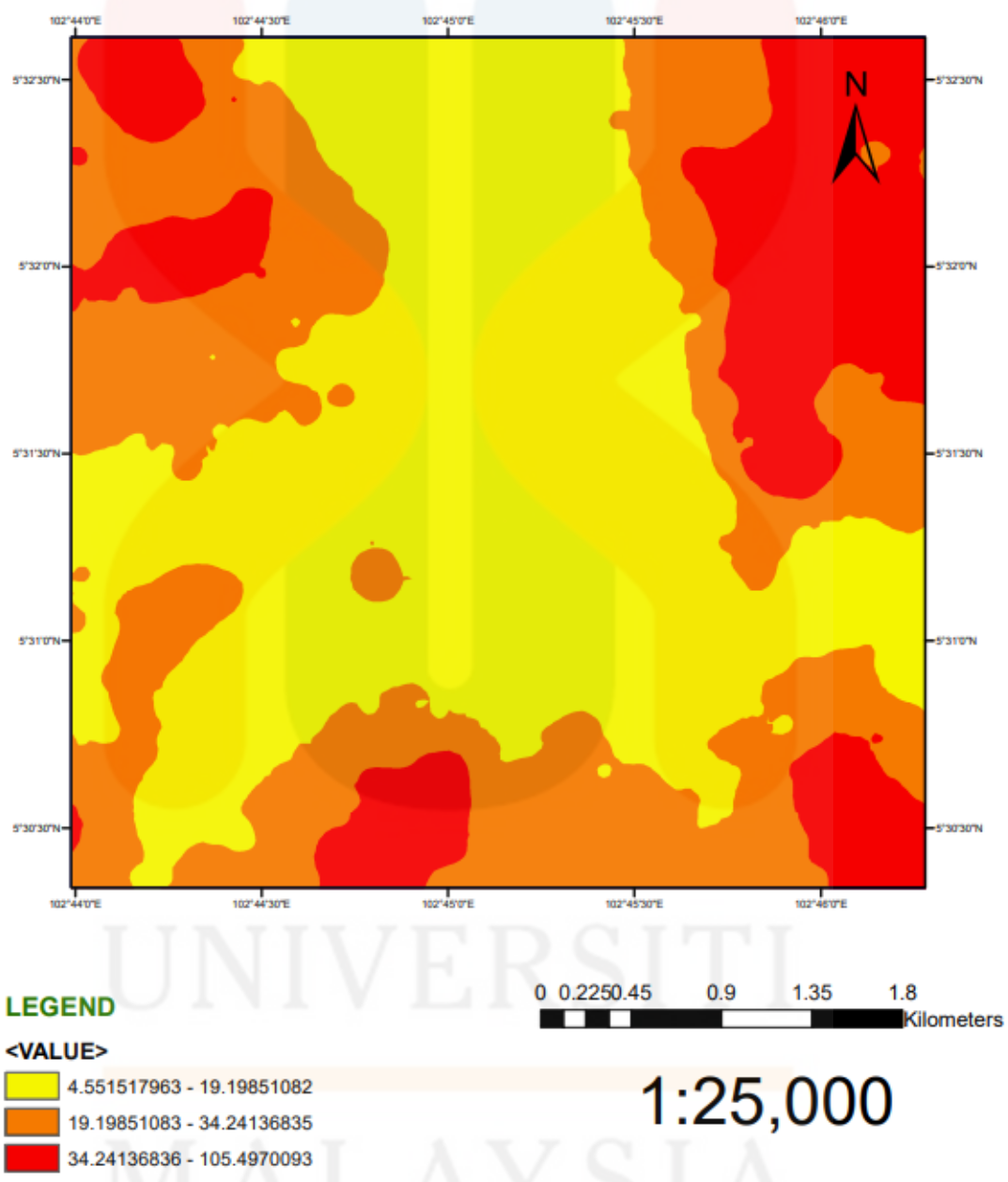


Figure 4.6: Datum Elevation Map

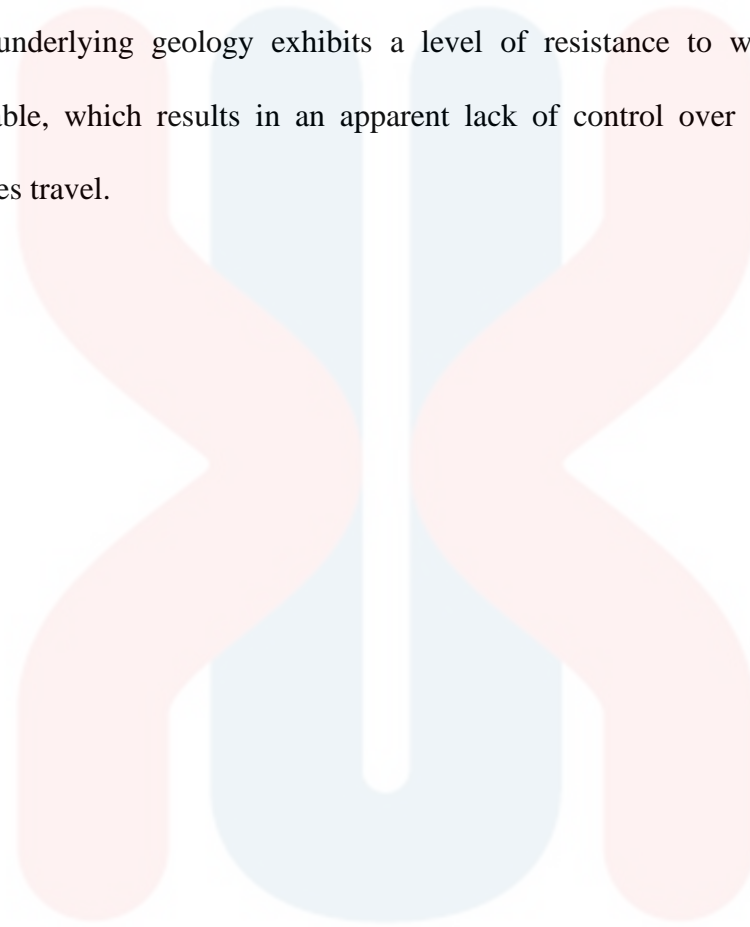
4.6.2 Drainage Pattern

The drainage pattern of a certain drainage basin is the pattern that is created by the streams, rivers, and lakes in that drainage basin. The pattern that is left behind after years of erosion by streams gives insight about the types of rocks and geologic formations that are present in an area of the terrain that is drained by streams. The topography of the land, the gradient of the land, and the kind of rocks that predominate in a given location are the factors that determine the drainage pattern.

The river is an underground waterway formed by the erosion of channels. Because of gravity, a river always begins its journey higher up on a hill, on a mountain, or on a plateau, and it always descends from the plateau to the lower ground. When it first begins its journey, a river is often rather little; nevertheless, as it travels downstream, it grows in size. The geography of the terrain, the existence or absence of bedrock structure, and the kind of rock that predominates the region all have a role in determining the patterns that may be formed by the network of streams and rivers that make up a given drainage basin. There are many different kinds of drainage patterns, some of which include trellis, dendritic, parallel, angular, distorted, and radial. These are the types. The topographic map and the literature study both need to be used in order to classify the information.

Kampung Buluh has a dendritic drainage pattern. Dendritic patterns emerge in areas where the rock under the stream, such as granite, gneiss, volcanic rock, and sedimentary rock that has not been folded (or unconsolidated material), lacks a specific fabric or structure and may be eroded readily in all directions. It forms in a landscape that is characterised by a consistent lithology and has a minimum of substantial faulting and jointing. The most frequent kind of drainage pattern is called

a dendritic drainage pattern, and it resembles the branching pattern of tree roots. It appears in places where there is a consistent layer of material below the surface. That is, the underlying geology exhibits a level of resistance to weathering that is comparable, which results in an apparent lack of control over the path that the tributaries travel.



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DRAINAGE PATTERN MAP OF KAMPUNG

BULUH, SETIU TERENGGANU

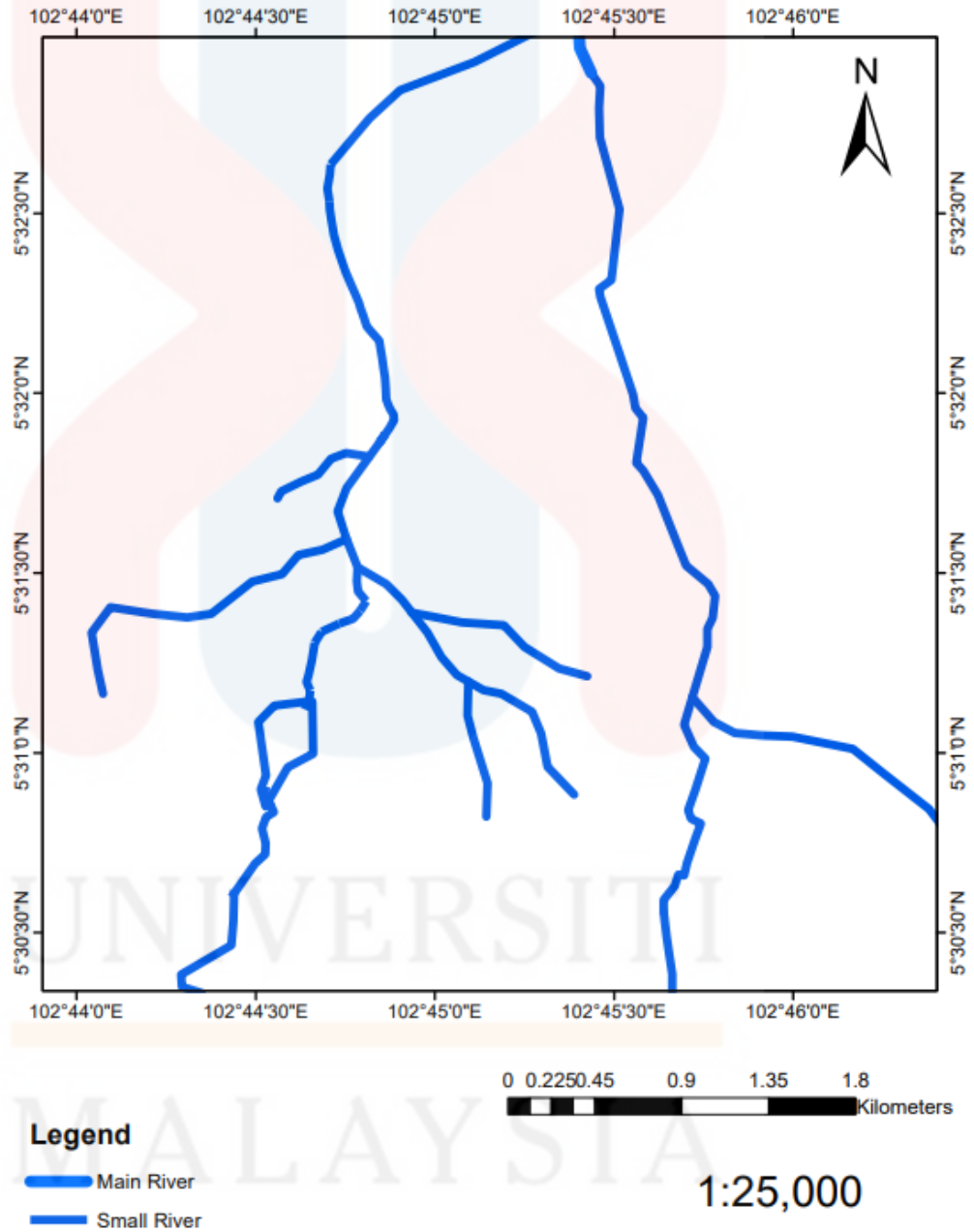


Figure 4.7: Drainage pattern map of Kampung Buluh

4.6.3 Weathering

Weathering is the process through which the influences of climate and weather, animals, and plants work on the surfaces of the land to break it down biologically, chemically, and economically. The disintegration and deterioration of rocks while they are still in place. It is possible for the process to be very drawn out and lengthy, taking hundreds of years to complete. However, deterioration may sometimes occur very quickly, such as the damage that can be caused to pavements or roads after a very cold and severe winter. Weathering and erosion have major difference as in the process of erosion, the rock and soil particles from the uppermost layer are worn away and relocated to new locations, but in the process of weathering, there is no moving agent of transport involved.

1) Physical Weathering

The term "mechanical weathering" may also be used to refer to "physical weathering." It is the gradual weakening of rocks, followed by their disintegration, that may be attributed to physical or mechanical forces. These forces include the activities on the rocks that are caused by abrasion, frost chattering, temperature changes, and the formation of salt crystals. The rock constructions are continually subjected to pressure from external environmental elements such as wind, sea waves, and rain, all of which contribute to the faster disintegration of the rock structures. Because the chemical makeup of the rocks is never disrupted throughout the process of physical weathering, there are no chemical transformations that take place. The steps that make up the process, also known as mechanical and physical weathering, are outlined below.

The process of mechanical or physical weathering is one that takes place all the time due to the impact that nature has on it. The process often takes place close to the surface of the earth, where it is impacted by the temperature, wind, and water. In this study area we found around 11 outcrop that showing similar lithology and conditions. At the first outcrop with coordinate (5.53672900 N, 102.73195300 E), the outcrop had a lot of minor fractures or joint that caused by physical weathering (water). Refer to the figure 4.7 and 4.8, the picture shows the outcrop surface covered by physical weathering at the second outcrop founded with coordinate (5.51223900N, 102.76819600 E) which may be caused by the rock being subjected to forces or physical features. The process of weathering causes rocks to break apart into smaller fragments, but it does not alter the chemical composition of the rock from which it originated.

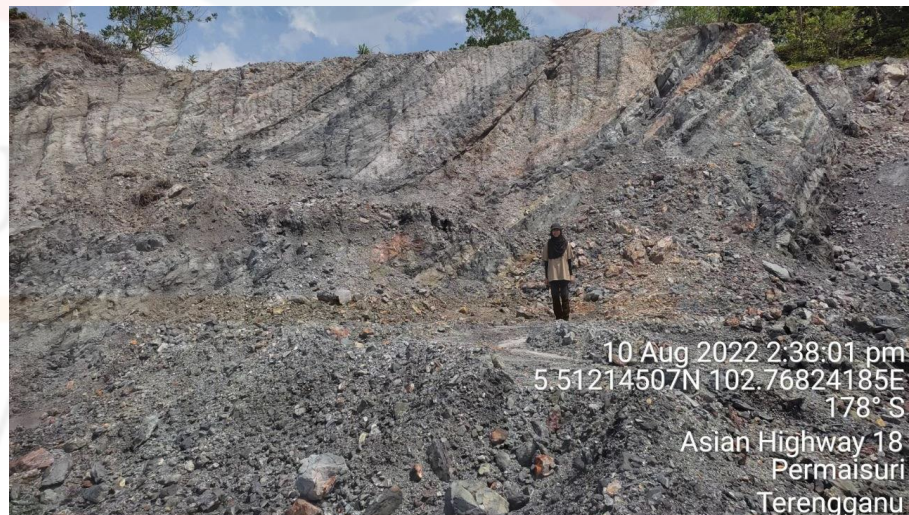


Figure 4.8: The physical weathering occurred on the surface of rock.



Figure 4.9: The physical weathering effecting the rock's surface

2) Chemical weathering

Rocks, soils, minerals, wood, and even artificial materials that are exposed to the elements of nature like air and water will undergo significant changes over a period of time both in their morphology and in their chemical composition and will ultimately break down into smaller pieces as a result of the processes of weathering. These changes can be observed in both the morphology and the chemical composition of the material.

Chemical weathering is the process that takes place as a result of chemical reactions that modify the chemical composition of materials like rocks, soils, and minerals. This process takes place over a period of time and ultimately leads to the development of secondary or brand-new minerals. Oxidation, hydrolysis, hydration, carbonation,

and reduction are the most typical kinds of chemical processes that may lead to chemical weathering.

Figure 4.9, illustrating the oxidation that occurred at the study area towards the outcrop as the certain minerals in the rock react with the oxygen that is present in the soil, water, or atmosphere. This may happen in a variety of environments. The process of oxidation moves forward at a more rapid pace when there is moisture present. Hydrated oxides are the final product that comes from this process.



Figure 4.10: The chemical weathering effecting the rock surface.

3) Biological Weathering

Weathering induced by species such as animals, plants, fungi, and microbes such as bacteria is referred to as biological weathering. While certain kinds of biological weathering, such as rock cracking by tree roots, are classified as either physical or chemical. However, biological weathering can be either

physical or chemical. Biological weathering can help physical weathering along by making rocks weaker or exposing them to physical or chemical weathering forces.

Figure 4.10 shows the outcrop of phyllite undergoes biological weathering that covering almost 80 % of the surface. The root of plants that exerts forces or pressure breaks the rock to fall to the surface. While the figure 4.11 also shows the weathering that occurred on the top of sandstone, causing the rock to break and split into small pieces.



Figure 4.11: The biological weathering covered the rock surface

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Figure 4.12: The biological weathering occurred on the top of sandstone

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4.7 Lithostratigraphy

Lithostratigraphy is a sub-discipline of stratigraphy, which is the branch of geological science that focuses on the study of different rock layers, also known as strata. Geochronology, comparative geology, and petrology are some of the major areas of study. Lithostratigraphical units are sedimentary or igneous formations that follow the Law of Superposition. The description, characterization, and naming of these units, as well as their connection, are all part of lithostratigraphy.

There are a few guiding concepts that are used in the process of providing an explanation about the existence of the stratum. When one rock formation cuts through another rock formation, it is possible to conclude that the hard rock that did the cutting is younger than the rock formation that it cut. the rock that is already there. Because of this discovery, geologists are able to explain events in Earth's past by employing the information gathered during the fieldwork about the rock's composition, texture, structure, and other aspects geological mapping.

4.7.1 Lithostratigraphy Position

Kampung Buluh is located at Southern part of Terengganu and discover to be under eastern belt of Peninsular Malaysia. The oldest stratigraphic units in the study area are the Paleozoic rocks such as schist, phyllite, and slate which underlie the Mesozoic rocks. According to Gries (1996), these Paleozoic rocks ranging in age from 542 to 251 million years ago and were eroded to a gentle undulating plain at the beginning of the Paleozoic Era. Based on lithology of rock at the study area, the age of rock is classified under carboniferous age (Paleozoic era). Carboniferous period exist around 359 to 299 million years ago.

Setiu Terengganu is located in the eastern belt which categorised under Charu formation or Sungai Perlis bed. The formation is at least 1500 m thick and is typically argillaceous consisting of an interbedded sequence of grey to dark grey carbonaceous slate, phyllite, schist, quartzite and metamorphosed sandstone with conglomerate. Based on finding during geological mapping, the lithology that can be confirmed exist is meta sediment rock like slate and quartzite, phyllite and schist that undergoing the metamorphism, and lastly the sedimentary rock which is sandstone.

Table 4.2: Stratigraphic Column

LITHOLOGY	ERA	PERIOD	FORMATION
Quartzite/ Sandstone	Palaeozoic	Permian	SUNGAI PERLIS BED
Slate/ Phyllite/Schist	Palaeozoic	Carboniferous	

4.7.1 Slate

Slate is a foliated metamorphic rock that form through low grade metamorphism. Uniquely it has slaty texture that differentiate slate from other metamorphic rock. Moreover, it has good fissility as when it broke up, it can form thin sheet of layer. Commonly it is fine grained thus make it invisible to diagnose the existence of minerals using naked eyes. The minerals that commonly can be found in slate rock are quartz, feldspar, muscovite, clay, and even graphite. Usually, the formation of slate associated with regional metamorphism.

The shale undergone the metamorphism (regional metamorphism) and changing the rock conditions. Regional metamorphism basically occurs in areas of above average pressures and temperatures, such as subduction zones. Shale is a sedimentary rock, which has a varied chemical composition, and it contains platy clay minerals that can align to pressure for regional metamorphism can occurred. The temperature and pressure increasing due to the metamorphism. So, the clay minerals in the parent rock are changed into mica minerals.

Based on geological mapping, the study area which in Kampung Buluh the slate rock is massive and distribute very well, thus make easier to obtain the fresh rock for petrography analysis. The colour of slate is gray to light black, have slaty texture, good fissility, brittle, and very fine to fine grain mineral composition. The type of metamorphism at the Kampung Buluh was regional due to the existence of folding.

Based on petrographic analysis, the mineral composition thar can be identified were mainly quartz, feldspar, chlorite muscovite, biotite, and illite. The kind of quartz that we saw was known as polycrystalline quartz since the individual crystals of the material are miniscule and are referred to as crystallites. In the rather thin piece of slate, quartz may be found mostly. Muscovite and biotite are the minerals that were found in the thin slice that was taken above. Mica was not present. Muscovite has an extremely transparent appearance and flawless cleavage, allowing it to be distinguished on the thin portion seen above with relative ease. Additionally, muscovite has a low relief, which means it is almost impossible to see under plane polarised light (PPL).

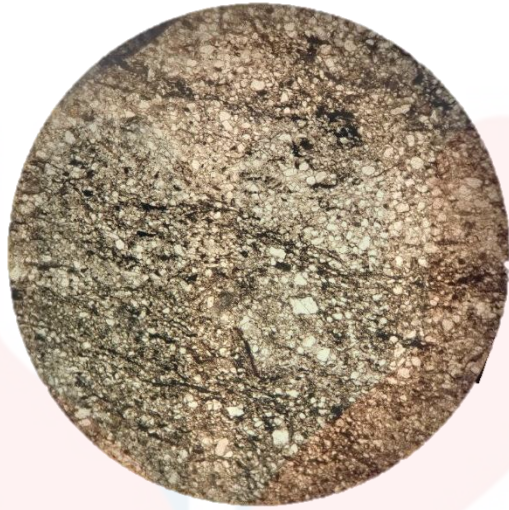


Figure 4.13: The polarised plane light (PPL) view of slate

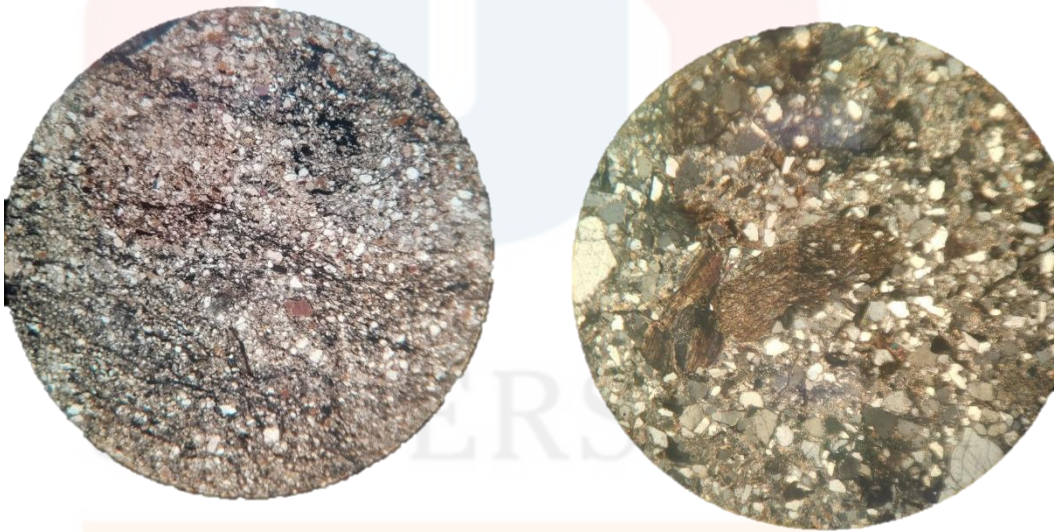


Figure 4.14: The Cross polar light (XPL) view of slate

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4.7.2 Phyllite

Phyllite is a foliated metamorphic rock. It can form from shale (sedimentary rock) or slate (low grade metamorphic rock). Compared to the slate, phyllite structure has more develop laminar. It also forms due to the regional metamorphism with existence of higher heat and pressure compared to the slate that change the mineral compositions. Common mineral in phyllite are quartz, muscovite, and biotite. The mineral in phyllite is visible to see using the eyes as the mineral size is larger. The process of metamorphism causing the breakdown of clay mineral to form mica which affecting the size of mineral exist in phyllite rock.

Based on geological mapping at the study area, the phyllite also exist in massive and easily can be found. The colour is darker than slate. The texture is also slaty and brittle, but have good fissility as it can split into thin layer or sheets very well. Minerals also can be seen using naked eyes even though very hard to determine what kind of mineral in there. The rock also has shiny appearance believed as the existence of mica minerals.

Based on petrographic analysis, the mineral that could be observed were quartz, muscovite, biotite, and graphite. The rock was filled with monocrystalline quartz derived from polycrystalline quartz which has coarser grain compared to the monocrystalline. The mineral of muscovite also can be identify based on petrography analysis. It is believed to form when rock undergone metamorphism that change the composition of mica.

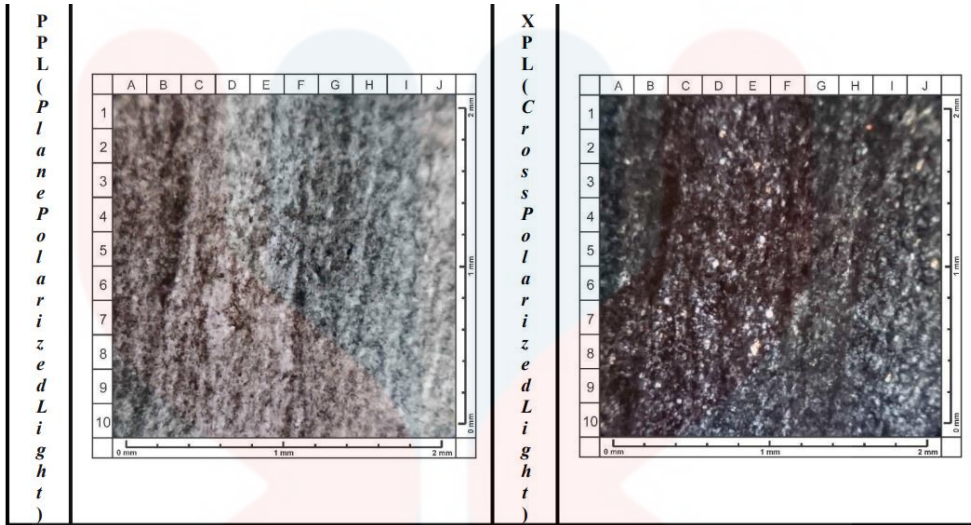


Figure 4.15: Cross polarised light and plane polarised light of phyllite

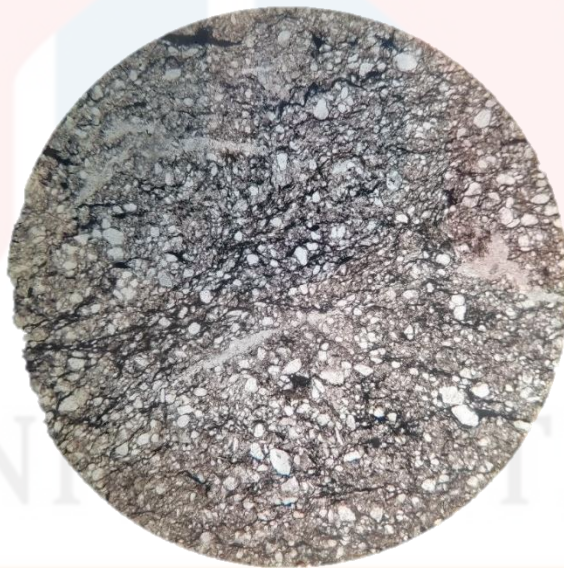


Figure 4.16: Cross Polarised light (XPL) for phyllite

4.7.3 Schist

Schist is a foliated metamorphic rock that faces higher heat and temperature during metamorphism. As it undergone high temperature and heat, the mineral inside the rock also changed and became more visible than low metamorphism rock. Schist rock is derived from phyllite, slate or directly from shale or mudstone. It is also related with regional metamorphism of existing rock

Based on geological mapping, the colour of schist is dark gray to black and have shiny appearance. It has foliation and the mineral composition can be seen with an unaided eye. The grain size is considered in a range of fine grain to medium grain. Schist is a foliated, coarse-grained metamorphic rock having a schistose texture, which means it looks scaly or flaky and may be split into thin sheets easily. Foliated metamorphic rocks, like other metamorphic rocks, arise as a result of severe pressures and temperatures acting on existing rocks. The degree of metamorphism rises with increasing pressures and temperatures. Because of this, the same initial rock (the protolith) might end up as numerous different forms of metamorphic rock depending on the circumstances it is exposed to.

Foliated rocks are often created when the rock is subjected to severe differential pressure. Simply said, the rock is being pressed far more tightly in one direction than in any others. Layers or bands develop perpendicular to the direction of maximal compression in foliated rocks.

Based on the thin section analysis, the mineral exist that could be identified were quartz, talc, feldspar and chlorite. the quartz exist in the thin section is polycrystalline. This kind of quartz is often obtained from metamorphic and sheared

rock. Grains are made up of interconnecting crystals (or sub-crystals) with straight or undulating (strained) extinction. Mica and feldspar crystals may be present. Talc, on the other hand, is a clay mineral that appears as an opaque in the thin section. It also had a flat construction.

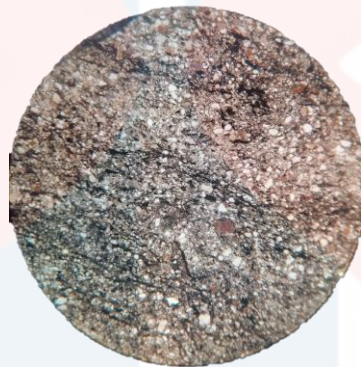


Figure 4.17: Thin section of schist

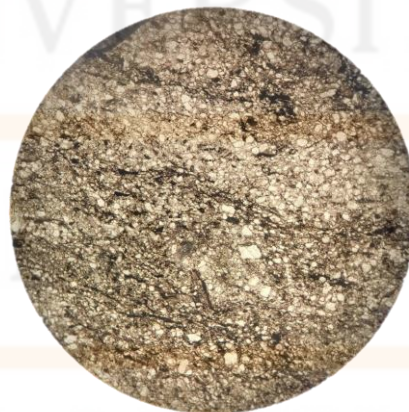


Figure 4.18: Thin section of schist

4.7.4 Quartzite

Quartzite is a metamorphic rock that is nearly completely made up of interlocking quartz crystals. Because to the inclusion of impurities such as hematite, it is commonly off-white or grey, although it may also be pink, red, green, blue, or yellow. Because quartzite is nearly completely composed of quartz crystals, when a new surface is revealed, it has a bright, glassy aspect. It has a rough and gritty texture to it. In a hardness test, it will scratch glass.

Quartzite is generated via medium to high-grade regional sandstone metamorphism. The quartz grains (and any other minerals) in the sandstone partly melt and recrystallize, forming interlocking crystals of about identical size. This method removes almost all porosity and sedimentary features from the original sandstone.

Quartzite is formed from quartz-rich sandstone that has been changed by strong pressure and heat deep under the earth. Metamorphism happens when the sandstone is exposed to these circumstances, recrystallizing the quartz grains and the silica that bonds them. This combines and alters them, resulting in an exceptionally powerful link.

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4.7.5 Sandstone

Sandstone is a kind of sedimentary rock that is composed of sand-sized granules of organic material, minerals, and other rocks. It is also possible for it to include a matrix of particles with a size similar to that of clay or silt, which fill the spaces in between the grains of sand, in addition to a cementing component, which binds the sand grains together.

Sandstone is a common kind of sedimentary rock that may be found in sedimentary basins all over the world. Sandstone was formed when sand was compressed and layered over time. Sand deposits that eventually turn into sandstone are carried to the basin by rivers, however it is also possible for them to be carried there by the action of waves or the wind.

It is possible for sandstone to have material ranging from fine to coarse grains and still be classified as sandstone; however, if the rock has more than thirty percent of grains that are gravel, cobble, or boulder size, then it is classified as conglomerate or breccia (together these are called rudites). Sandstone is composed of two other kinds of material in addition to the sediment particles: the matrix and the cement. Matrix refers to the fine-grained material (silt and clay size) that was present in the sediment at the same time as the sand, while cement refers to the mineral matter that was injected later to attach the sediment to rock. Sand is not included in the matrix.

According to the findings of a petrographic study, the minerals consisted of sand-sized minerals combined with fine-grain clay minerals. Quartz, feldspar, and pyroxene were the sand-sized minerals that could be distinguished. Because it contains a considerable quantity of matrix, it is possible to categorise it as sandstone

wacke (clay mineral). If you look at the rock in a thin piece, you can see that the mineral content is not very well sorted.

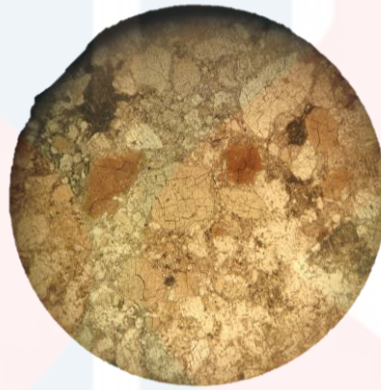


Figure 4.19: Plane polarised light (PPL) view of sandstone (wacke)

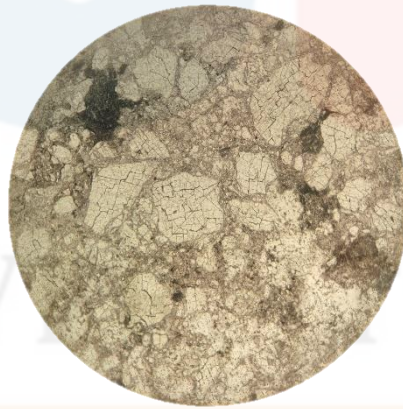


Figure 4.20: Cross polarised light (XPL) view of sandstone (wacke)

4.8 Structural Geology

Structural geology is one of the elements in geology that we must study and observe in order to understand the deformation and changes that occurred to the structure. It is the subfield of geology that investigates the three-dimensional geometry of rocks on scales ranging from micro to macro in order to provide an explanation for the deformation processes that rocks have through ever since their genesis. Additionally, the history of the planet is connected to structural geology in some way. Because of this, structural geology and plate tectonics are inextricably intertwined. The study of plate tectonics is a subfield of structural geology, which looks at how deformations in already-existing rocks might provide insight into the motions of the earth's crust.

There are several structural in geology which are veins, fold, fracture and fault. In this study area, at Kampung Buloh the folding, fracture, foliation and veins are common and easily to observe. Moreover, there have other structure like slickenside that can be found at the study area. These deformations are caused by stress, strain, high temperature, and high pressure.

4.8.1 Veins

Crystallization from hydrothermal fluids results in the formation of veins as a crystalline product. Depending on the fluid from which they are derived, their chemical make-up may be quite varied. The scale of these might be anything from one millimetre to one kilometre. They come into existence as a result of the host rock being fractured, which makes it possible for hydrothermal fluids to penetrate the rock and eventually precipitate inside it. In other instances, the rock cracks open once more,

allowing yet another wave of hydrothermal fluids to flow into the fissure. This procedure is referred to as "crack-sealing" since the vein is responsible for closing the break in the rock. Veins will crosscut and overlie one another more often when the forces on the rock alter the orientation of the veins over time. Figure 4. 4 shows the veins exist in the outcrop range from 0.2 cm to 5 cm.



Figure 4.21: Smallest vein (0.2 cm)



Figure 4.22: Quartz vein found in the study area.

Deposited through phyllite

4.8.2 Faults

A fracture or zone of fractures that runs between two different pieces of rock is called a fault. The blocks are able to move in relation to one another because to faults. This movement might take place suddenly, as in the case of an earthquake, or it can take place gradually, as in the case of creep. It's possible for faults to be as short as a few millimetres or as long as hundreds of kilometres. Most faults are responsible for producing recurring displacements over geologic time. When an earthquake occurs, the rock on one side of a fault suddenly slips with respect to the rock on the other side of the fault. The surface of the fault might be horizontal or vertical, or even at an arbitrary angle somewhere in between. There are several types of faults which are normal fault, strike slip, and reverse fault.

Sometimes complicated fracture systems are created when faults become dissociated, bifurcate, converge, or migrate apart from one another over great distances. The connection between a hanging wall and a foot wall may be used to illustrate the mobility of defects that are relative to one another (from one side to the other). A foot wall is a block that is positioned beneath a fault and has a fault plane that slopes downward. A hanging wall is a block (made up of rocks) that is located at the top of a fault plane that slopes downward.

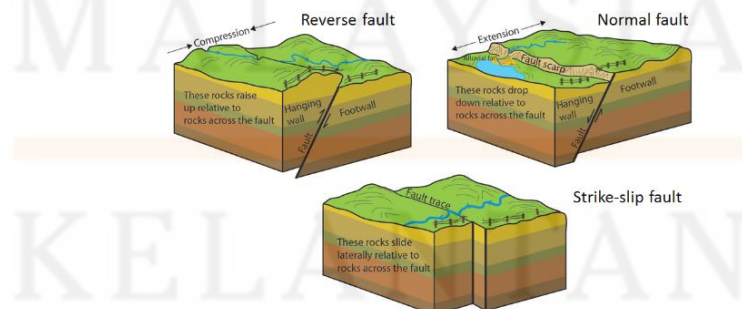


Figure 4.23: Type of faults

Based on geological mapping, the fault that could be found and identified can be classified under minor fault as the movement or displacement of rock doesn't obvious and ranges from 1-3 cm of displacement. At the study area, the major fault could not be found.

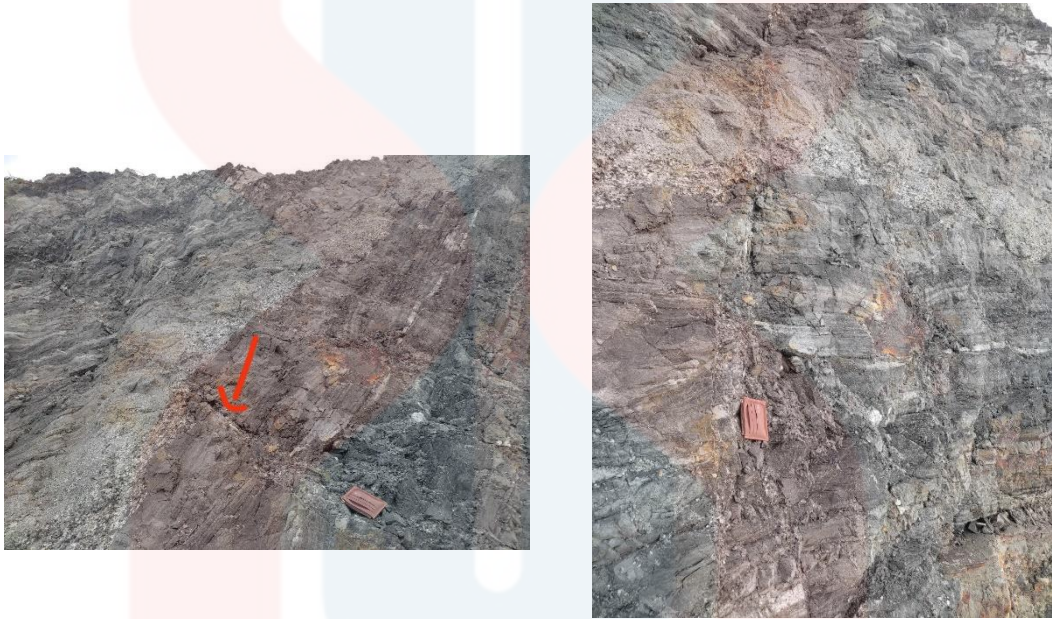


Figure 4.24: Displacement of rock found in study area

4.8.3 Folds

Folding of rock can occur when the rock is brittle and able to bend instead of break due to the long times of pressure. It is structured in the form of waves, successive. There are several types of folding which are anticline, syncline, monocline, symmetrical, asymmetrical, inclined, anti-form, chevron, slump, and

dome. In the study area, the fold that can be found were anticline, syncline, symmetrical, and asymmetrical.



Figure 4.25: Major fold view at the study area

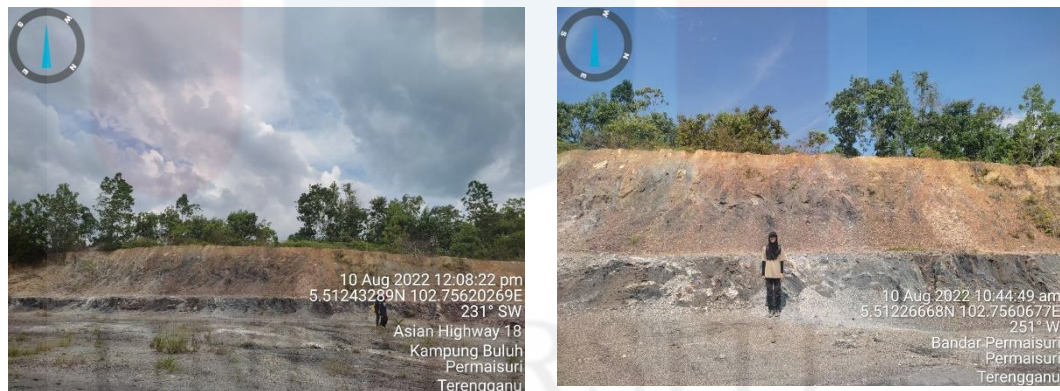


Figure 4.26: Overfold and recumbent fold at the study area

4.8.4 Foliation

In geology, the term "foliation" refers to the recurrent layering seen in metamorphic rocks. The thickness of each layer may range anywhere from less than the thickness of a sheet of paper to more than one metre. Shearing forces, which are pressures driving separate portions of the rock in opposite directions, or differential

pressure are the culprits behind this phenomenon (higher pressure from one direction than in others). The layers tend to develop either perpendicular to the direction of increased pressure or parallel to the direction in which the shear is acting. The formation of non-foliated metamorphic rocks often takes place in conditions when there is neither a considerable pressure gradient nor significant shear.

Foliation is very widespread in rocks that have been influenced by the regional metamorphic compression that is characteristic of the regions that are responsible for the creation of mountain belts. Foliation is often produced when minerals inside a rock align themselves in their most favourable orientation. In most cases, this occurs as a consequence of some kind of physical force and the influence that force has on the formation of minerals. Based on geological mapping, the foliation can be obvious saw on phyllite rock (figure 4.26) and slate rock (figure 4.27).



Figure 4.27: Foliation can be seen on phyllite rock above



Figure 4.28: Foliated slate rock

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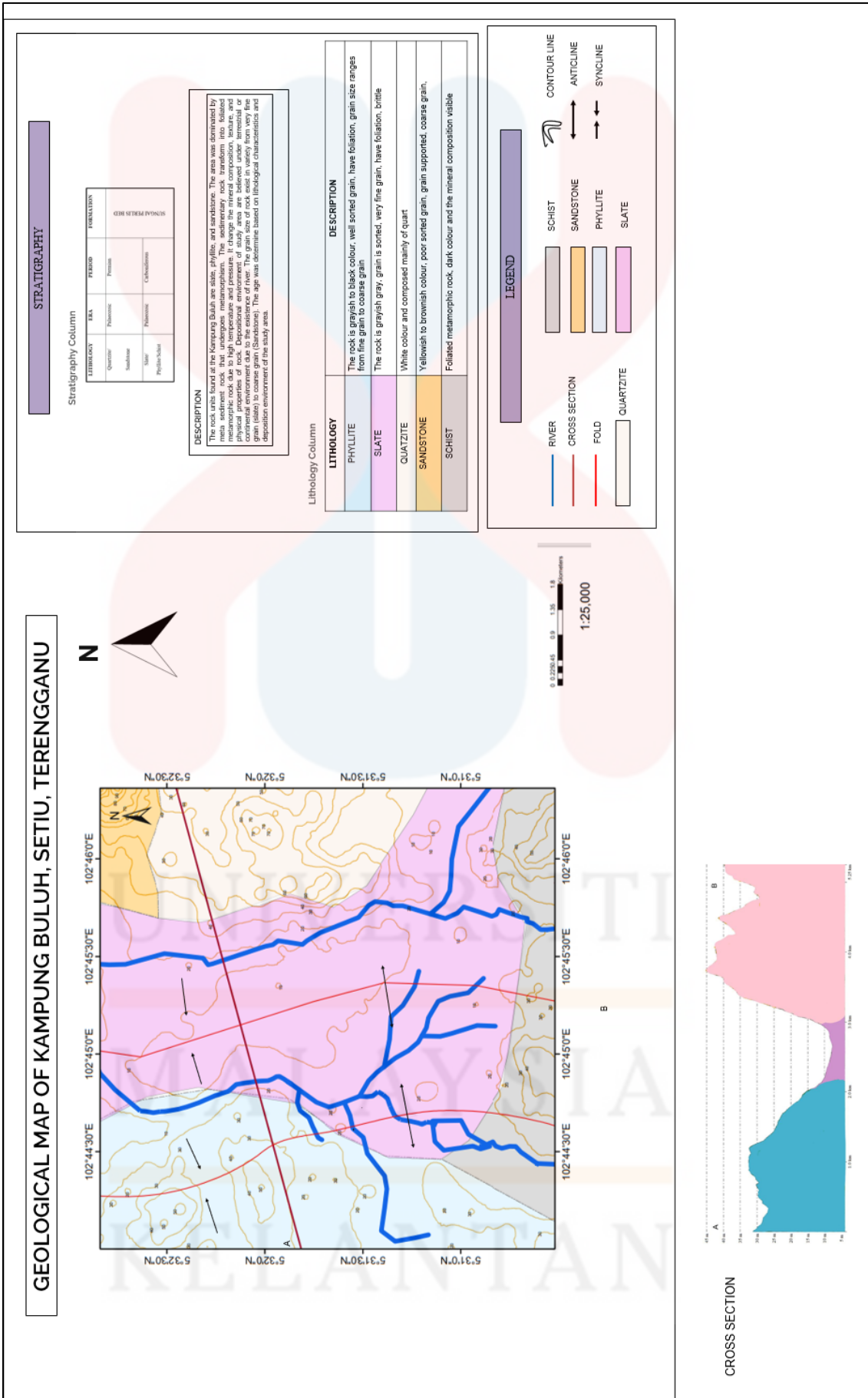


Figure 4.29: Geological map of study area

CHAPTER 5

SEISMIC INTERPRETATION OF KAPAL FIELD, TERENGGANU OFFSHORE

5.1 Introduction

This chapter will explain the findings based on seismic interpretation of the Kapal Field research region. It will go through how to evaluate sequence boundaries and the hydrocarbon indicator in the research region. The Kingdom 2021 software was used to interpret the 2D data of seismic. This research focuses on 5 lines from Kapal Field that already being used for the seismic interpretation. The interpretation of sequence boundaries and the potential hydrocarbon based on geological structure will be explained.

5.2 DEPOSITIONAL SEQUENCE

A stratigraphic unit composed of a relatively conformable succession of genetically related strata and bounded at its top and base by unconformities or their correlative conformities (Mitchum et al., 1977; Vail and others et al., 1977a). It is possible to determine the depositional sequence in seismic sections by locating seismic reflections that have a repeated pattern.

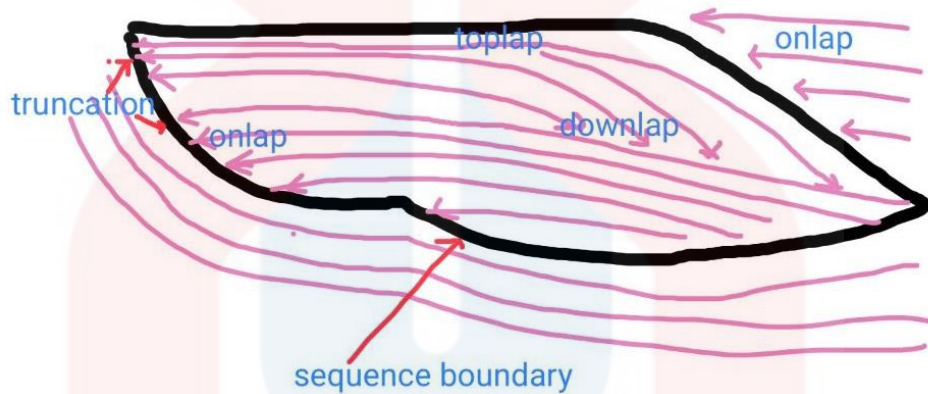


Figure 5.1: Illustration of depositional sequence in seismic.

5.2.1 Sequence boundary identification

More-or-less predictable patterns in marine sediments. Sequence boundaries are often observable on seismic lines that are sufficiently long, have appropriate resolution, and have acceptable data quality. In addition, these lines must have satisfactory data. Alterations in the sea level are likely to occur simultaneously throughout a vast region. Seismic sequence analysis aims to identify depositional sequences and system tracts on seismic sections by interpreting the location of their borders. This may be done by looking at seismic data. Discontinuities in seismic

sections are the indicator of a boundary, and their location is determined mostly by identifying terminations of reflections.

These discontinuities, which are based on seismic reflection terminations, are indications of depositional sequences and system tracts that were generated by one or more of the factors such as tectonic subsidence, which generates accommodation for sediment accumulation; eustatic sea level change, which may influences facies tract distribution; the sediments supply, which decides how much material is available to fill the basin; and climatic fluctuations, which can impact the kinds of sediment that are deposited. The above discontinuities have two types which are onlap and down lap, while below the discontinuities there are two patterns which are top lap, and truncation. These patterns have different terminations that differentiate each other.

LINE 21 DECONVOLUTION

Based on Figure 5.1 regarding Line 21 Deconvolution, the total of sequence boundaries that could be identified is 4.

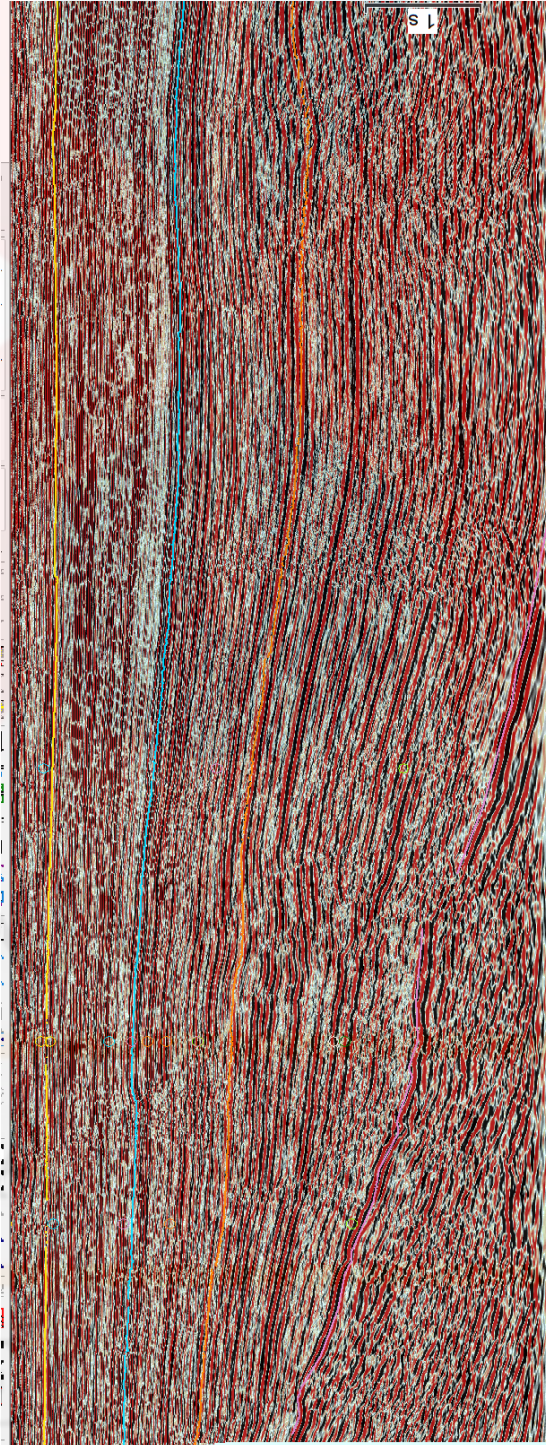


Figure 5.2: Sequence boundary for Line 21 Deconvolution

Deposition sequence can be interpreted based on four parameters which are amplitude, frequency, configuration, and continuity. All these parameters have their own characteristics that can differentiate and decide the sequence.

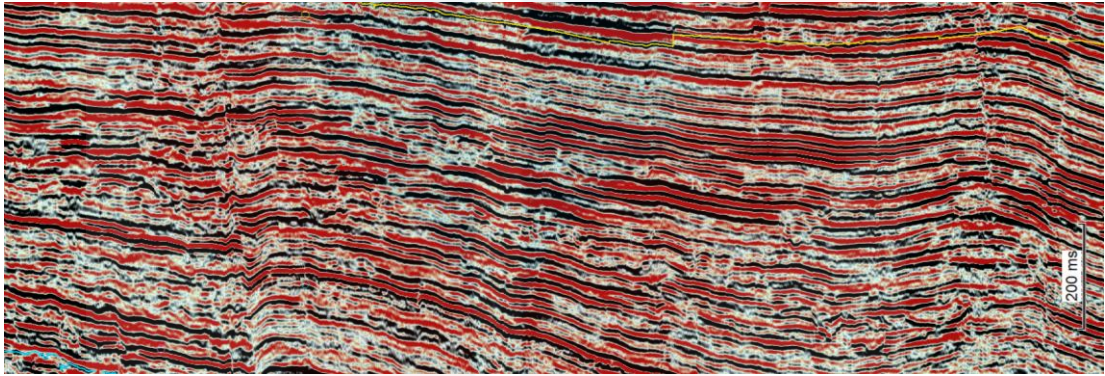


Figure 5.3: Facies unit in sequence boundary 1 to 2

5.2.2 Reflection Termination

Reflection terminations are the principal criteria for recognition of seismic sequence boundaries. The types of reflection terminations are based on the types of stratal terminations (Mitchum et al., 1977). stratal discontinuities recognized on seismic sections that separate apparently conformable sedimentary units from non-conformable units, forming the basis of seismic sequence stratigraphy. These discontinuities, based on seismic reflection terminations, are indicators of depositional sequences and system tracts formed by one or more of the variables such as; tectonic subsidence, eustatic sea level change, sediment supply, and climate variations.

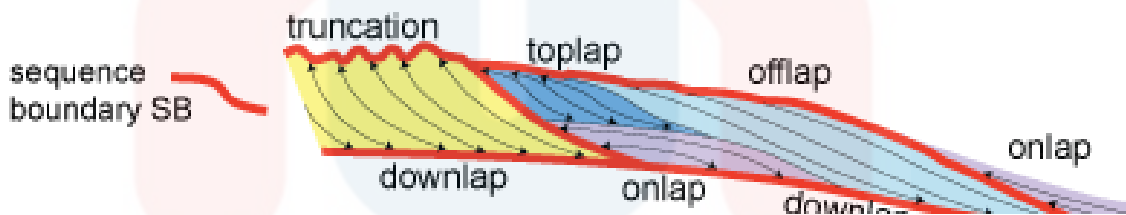


Figure 5.4: Diagram of seismic termination (source; Kendall,2012)

- a) Base lap
- On lap

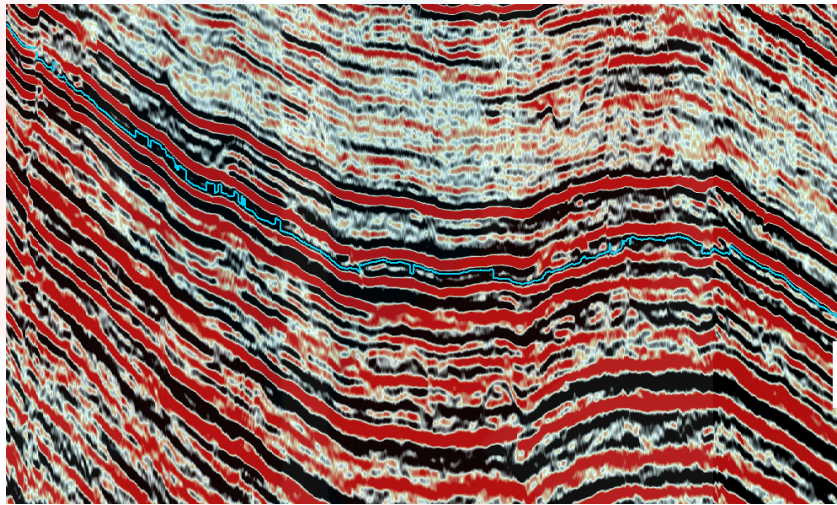


Figure 5.5: on lap found in Line 21 Deconvolution

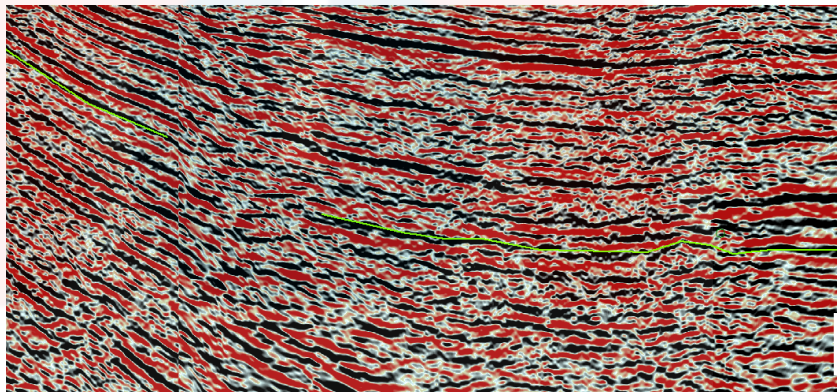


Figure 5.6: On lap found in Line 21 Algorithm

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- **Down lap**

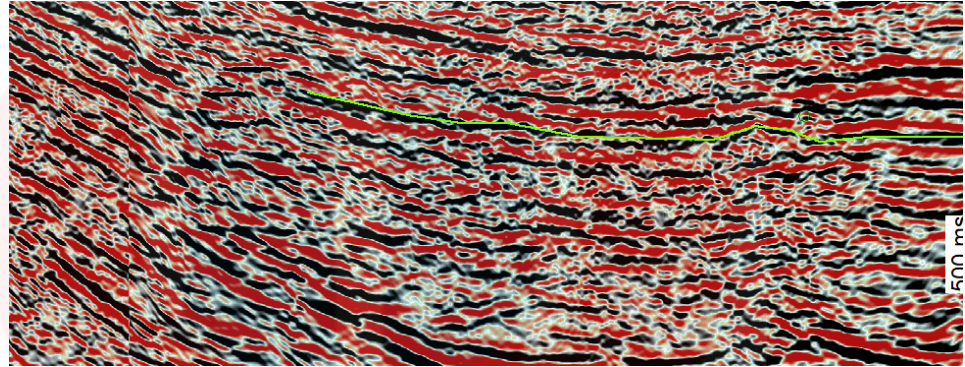


Figure 5.7: Down lap identified in Line 21 Algorithm

b) Truncation

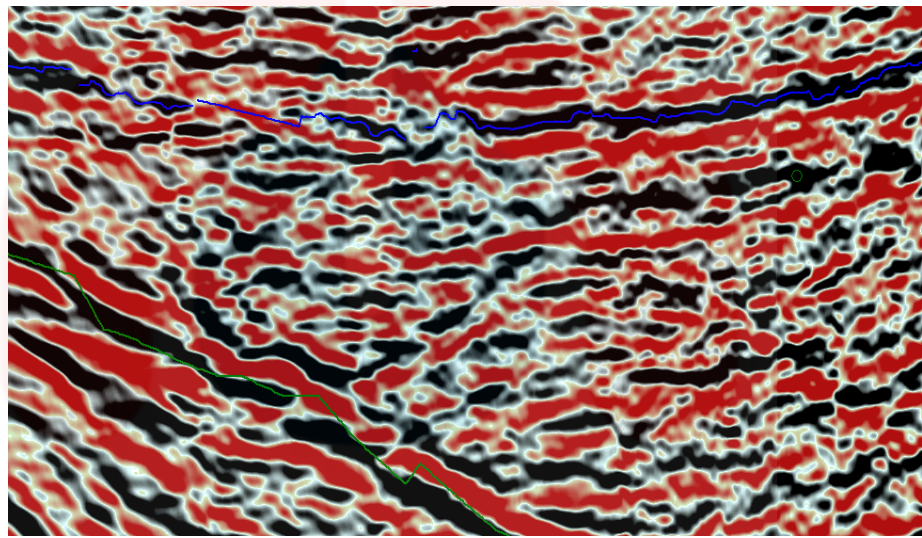


Figure 5.8: Truncation reflection identified in Line C14 Near off set

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c) Top lap

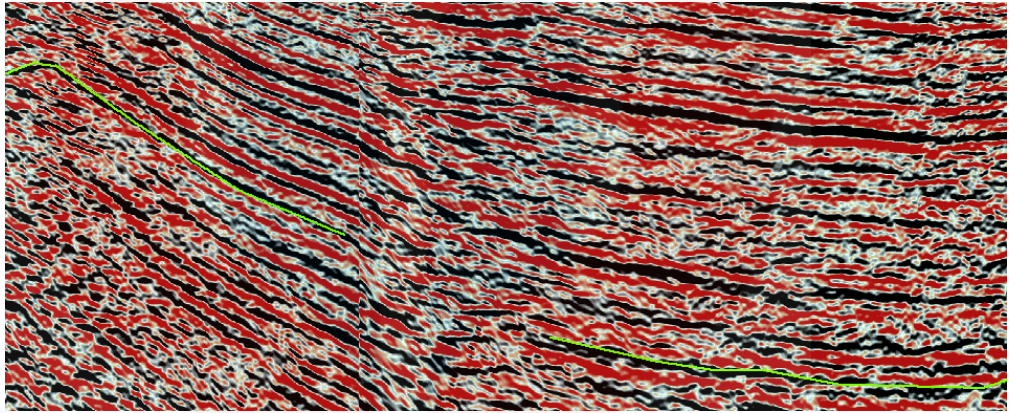


Figure 5.9: Top Lap found in Line C21 Algorithm

5.3 Seismic Facies Identification

After the border of the seismic series has been located, more interpretation must be done in order to get additional information that may be used to anticipate the lithologies that are present within each sequence using data that is acquired from seismic activity. Reflection terminations and geometries, seismic properties (amplitude, continuity), interpreting EODs (environment of deposition), and inferring lithologic content are the types of information that may be exploited.

Following the delineation of seismic sequences, the environment and lithofacies included within the sequences are interpreted using seismic and geologic data. The description and geological interpretation of seismic reflection characteristics is known as seismic facies analysis. These parameters include configuration, continuity, amplitude, frequency, and interval velocity. In seismic reflection configuration, the term "stratal configuration" refers to the geometric patterns and relations of strata within a stratigraphic unit. This interpretation is derived from the seismic reflection configuration. These are often suggestive of the context and processes of depositional activity as well as subsequent structural mobility.

Seismic facies units are three-dimensional seismic units that may be mapped. They are made of groups of reflections with characteristics that are distinct from those of neighbouring facies units. After the characteristics of the internal reflection, the external shape, and the three-dimensional associations of these seismic facies units have been identified, the units may then be interpreted in terms of the environmental context, depositional processes, and estimations of the lithology.

5.3.1 Principal stratal configuration

1) Parallel and Subparallel:

A section of the diagram or the example may be described using modifying adjectives such as "even" or "wavy." Parallel arrangements may take on a few different exterior shapes, but the sheet, sheet drape, and fill units are probably where you'll see them most often. Variations in other seismic characteristics including amplitude, continuity, and cycle breadth are used to categorise the several subtypes of this rather straightforward structure. This pattern is consistent with uniform rates of deposition occurring on a shelf that is sinking evenly or a basin plain that is stable.

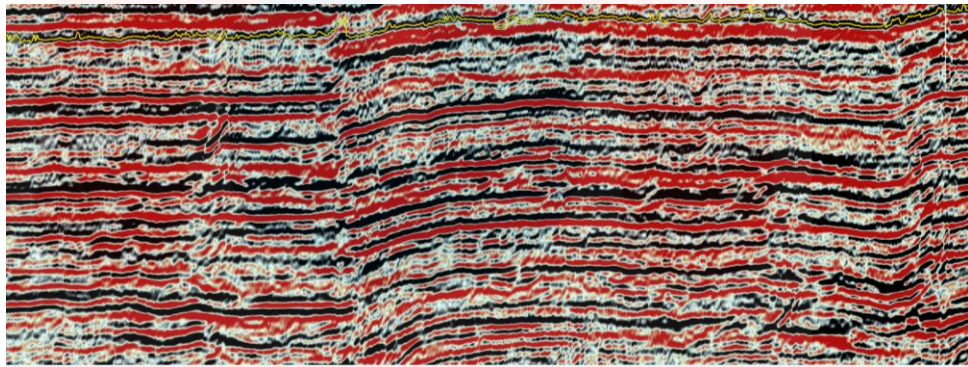


Figure 5.10: Parallel reflection in Line C14

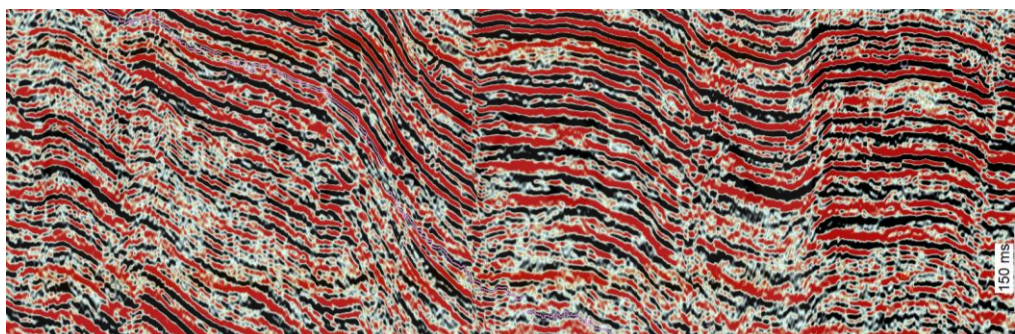


Figure 5.11: Parallel-wavy reflection on Line C21 algorithm

2) Divergent:

This reflection configuration is distinguished by a wedge-shaped unit, in which most of the lateral thickening is achieved not by onlap, toplap, or erosion at the base or top, but rather by thickening of individual reflection cycles within the unit. This contrasts with other configurations, in which the lateral thickening is accomplished by onlap, toplap, or erosion at the base or top. Within the wedge, non-systematic lateral terminations of seismic reflections often occur in the direction of convergence. These terminations are most likely caused by the gradual removal of strata until they are thinner than the resolution of the seismic instrument. Different configurations point to lateral differences in the rate of deposition or a gradual tilting of the depositional surface as possible explanations for the observed phenomena.



Figure 5.12: Divergent reflection on Line C21 Residual absorption

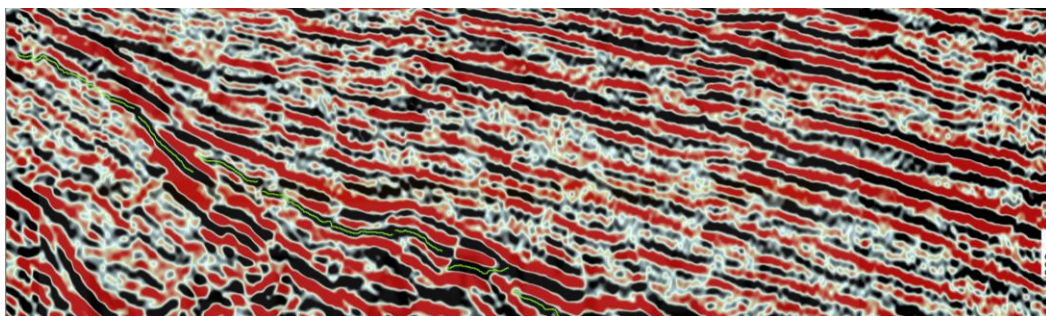


Figure 5.13: Divergent reflection on Line C21 Residual absorption

- Prograding Reflection Configurations:

The gradual lateral growth of gently sloping depositional surfaces, known as clinoforms, is what leads to the formation of progradation patterns such as sigmoid, oblique, complicated, shingled, and hummocky. The clinoform surface is one of the depositional characteristics that is seen the most often. Variations in the velocity of deposition and the depth of the water are two of the primary contributors to differences in the prograding clinoform patterns. It is possible to have a wide range of environmental environments. The configuration can be divided into upper, middle, and lower zones, which correspond to (Rich, J. L. et al., 1951) undaform, clinoform, and fondoform topographic environments, respectively, if the upper part of the pattern was deposited in shallow water and the lower part gently slopes into deeper water. For example, if the upper part of the pattern was deposited in shallow water.

A) hummocky clinoform reflection configuration:

consists of erratic lengths of subparallel reflection that are discontinuous and uneven, generating a nearly random hummocky pattern that is characterised by reflection terminations and splits that are not systematised. The hummocks have a low relief, which is getting close to reaching the limits of seismic resolution. This pattern often transitions laterally into clinoform patterns that are broader and more defined, and vertically into parallel reflections. The reflection pattern is often understood as strata that are producing tiny, interfingering clinoform lobes that are building into shallow water in a prodelta or interdeltic location.

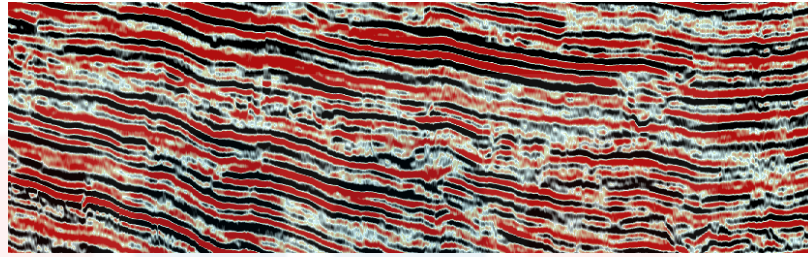


Figure 5.14: Hummocky clinoform reflection

b) Chaotic Reflection Configuration:

The discontinuous and discordant reflections that make up a chaotic pattern provide the impression of a disorganised arrangement of reflection surfaces. They are either regarded as strata that were deposited in a context that was changeable and relatively high in energy, or as originally continuous strata that have been distorted to the point that they no longer maintain continuity. It is possible that some of the reflection patterns seen in Figure 9a represent original stratal characteristics that are still identifiable after penecontemporaneous deformation. Other patterns (Figs. 9b) are so disordered that reflections across a large portion of a sequence could not be able to be understood in any recognised pattern of stratal structure. This is due to the fact that the patterns are so disorganised. It's possible for zones that are heavily faulted, folded, or deformed, as well as penecontemporaneous slump structures and cut-and-fill channel complexes, to have a chaotic seismic expression.

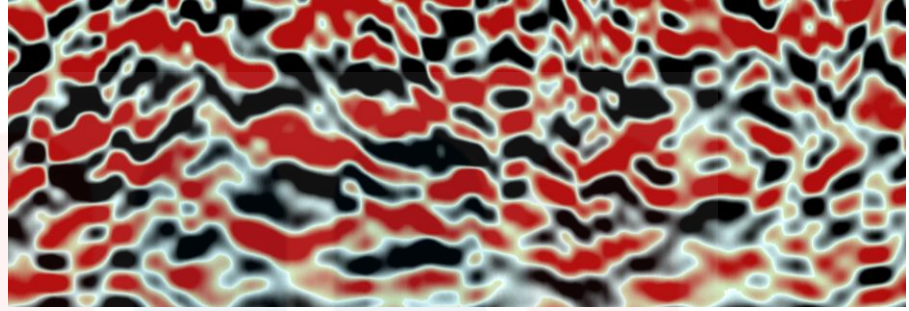


Figure 5.15: Chaotic reflection found in Line C14 near offset

5.4 Modifying terms

It is minor variation in reflection configurations. Have several types which are even, wavy, disrupted, hummocky, and contorted. Even and wavy is quite similar to parallel strata configuration. The disrupted and contorted modifying terms can refer figure below.

1) Disrupted

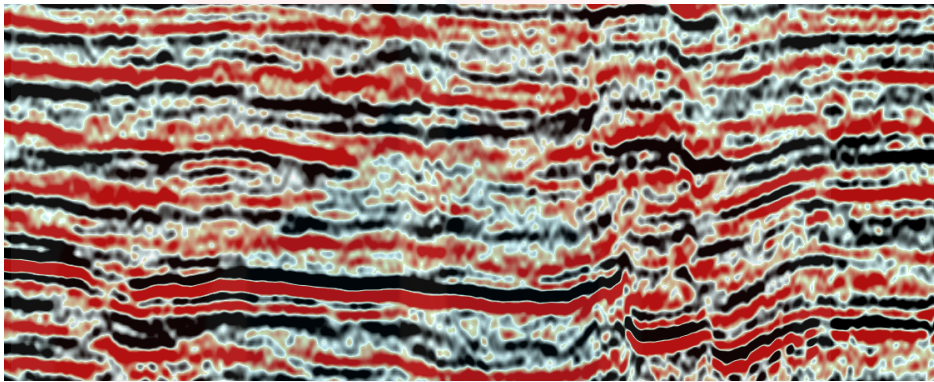


Figure 5.16: Disrupted modifying term found in line C21 Residual absorption

2) Contorted

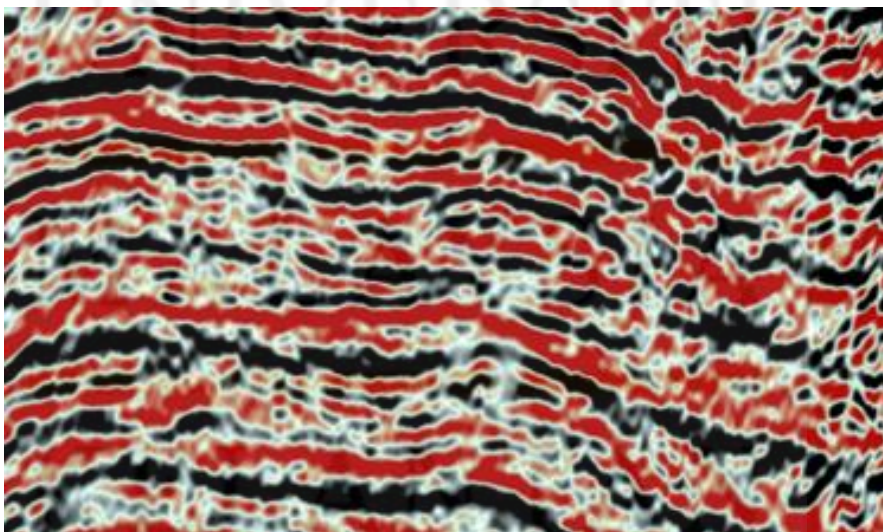


Figure 5.17: Contorted reflection found in Line C21 Residual Absorption

5.4.1 External form of seismic facies

Common modifying words may be used to explain differences in fundamental patterns of reflection configurations. There is no need to provide definitions for words like "wavy," "even," "hummocky," "lenticular," "disrupted," "contorted," "regular," "irregular," "uniform," or "variable." Sheets, wedges, and banks are the most prevalent types of shelf seismic facies units. They may be very massive as well. The configuration of the internal reflection seen inside these units is made up of a range of different patterns, including parallel, divergent, and prograding ones.

Sheet drapes often consist of parallel reflections that are regarded as strata that have been draped over underlying topography in a manner that suggests consistent, low energy, deep-sea deposition that is not affected by bottom relief. However, lenses are most often seen in the exterior form of prograding clinoform seismic facies units. Lenses may be found in a wide variety of seismic facies associations. The groupings of seismic structures known as mounds and fills are produced from strata that come from a variety of different sources, and they may either create prominences or fill depressions on depositional surfaces.

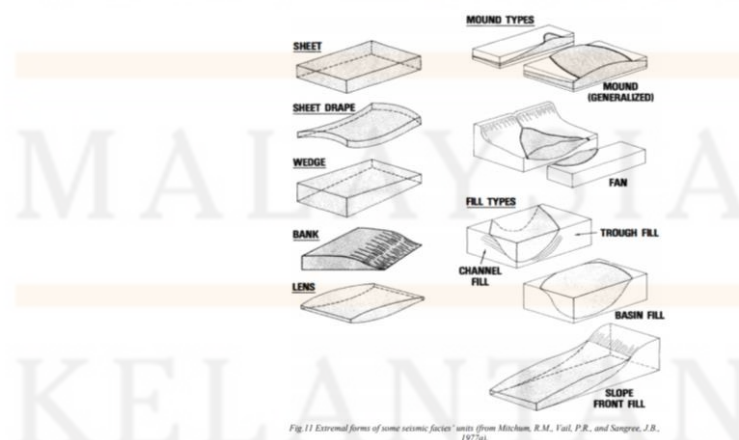


Figure 5.18: Diagram of seismic external form

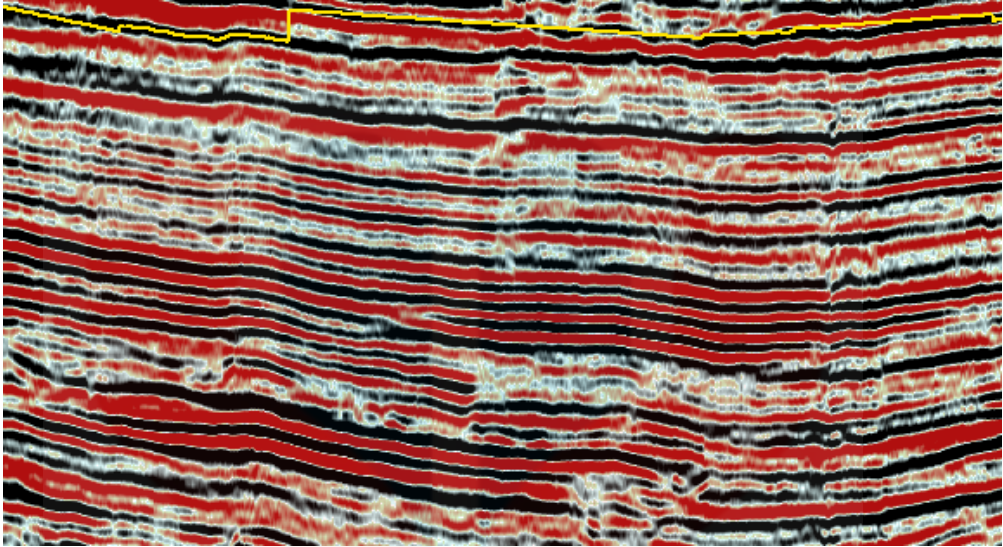


Figure 5.19: Sheet shape of seismic external form

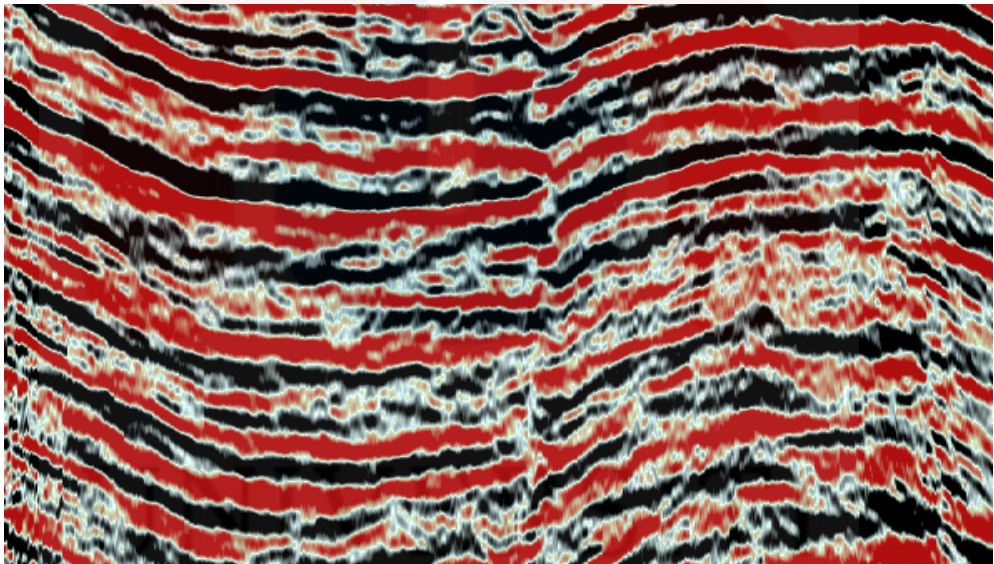


Figure 5.20: Sheet-wedge shape of seismic external form

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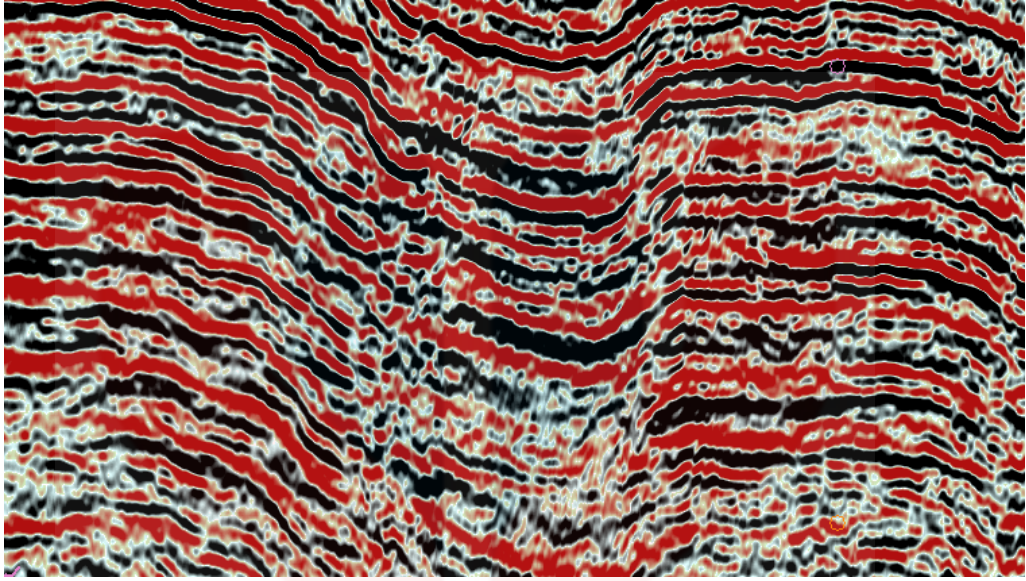


Figure 5.21: Lens-wedge shape of seismic external form

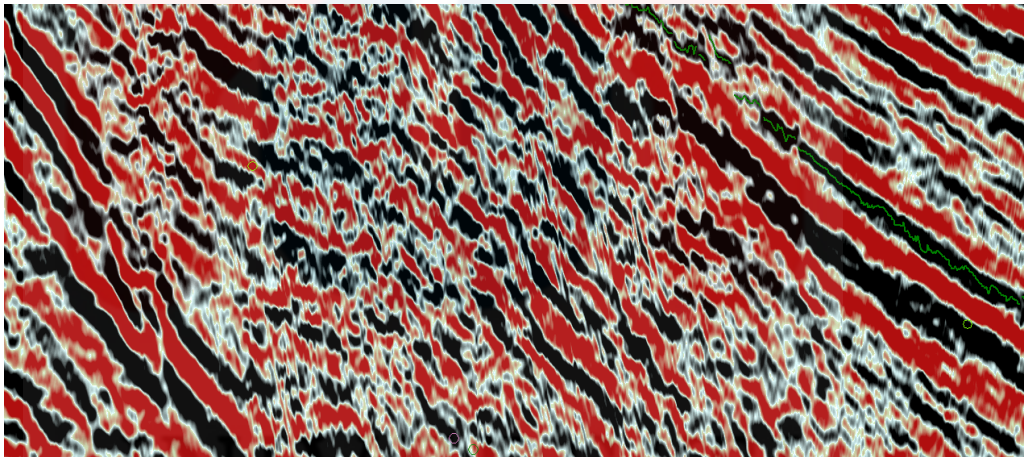


Figure 5.22: Lens-channel shape of seismic external form

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5.5 FAULT

A fracture or zone of fractures that runs between two different rock layers is called a fault. The blocks are able to move in relation to one another because to faults. This movement may happen suddenly, in the form of an earthquake, or it could happen gradually, in the form of creep. Both scenarios are possible. It's possible for faults to be as short as a few millimetres or as long as hundreds of kilometres. The majority of faults are responsible for producing recurring displacements over geologic time. In seismic imaging, waves that are reflected back from various geological levels are recorded, and then those recordings are stacked to form a two-dimensional or three-dimensional visual. Waves are reflected at the border between geological layers due to the variance in density that exists there. This is because various geological layers have distinct physical qualities. P-waves are the primary focus of our attention in imaging despite the fact that other types of waves exist (compressional waves).

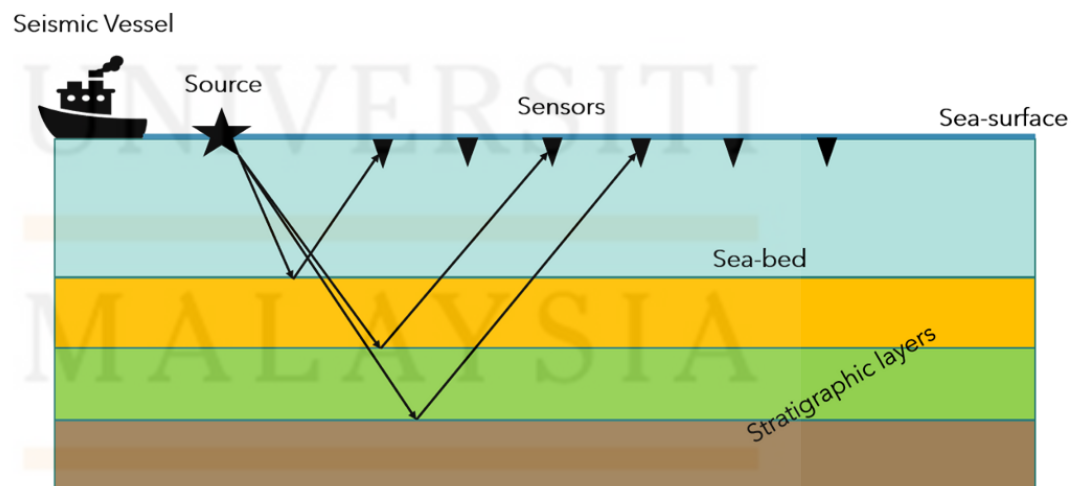


Figure 5.23: Illustration of seismic reflection

Geological structures known as faults are formed when a number of different physical processes, such as pressures, gravity, and plate tectonics, interact with one another to produce the desired result. These are the fissures or planes along which a slab of rock may slide from one location to another. There is a wide range of sizes for faults, ranging from a few metres to miles. The San Andreas Fault is a good example of strike-slip faulting that occurs on a very wide scale (also called Transform Fault). As can be seen in the following table, there are three primary categories of errors:

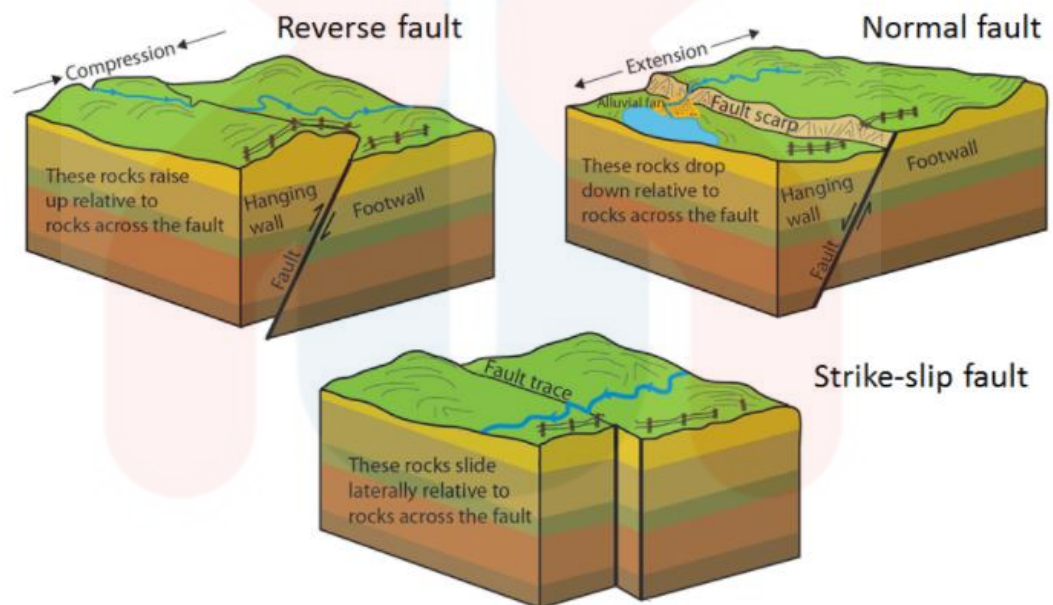


Figure 5.24: Illustration of three types of faults

In seismic exploration, one of the most significant parts is fault mapping. This is because a comprehensive examination of faults may assist determine whether or not there is a possibility of discovering an oil or gas deposit in the subsurface.

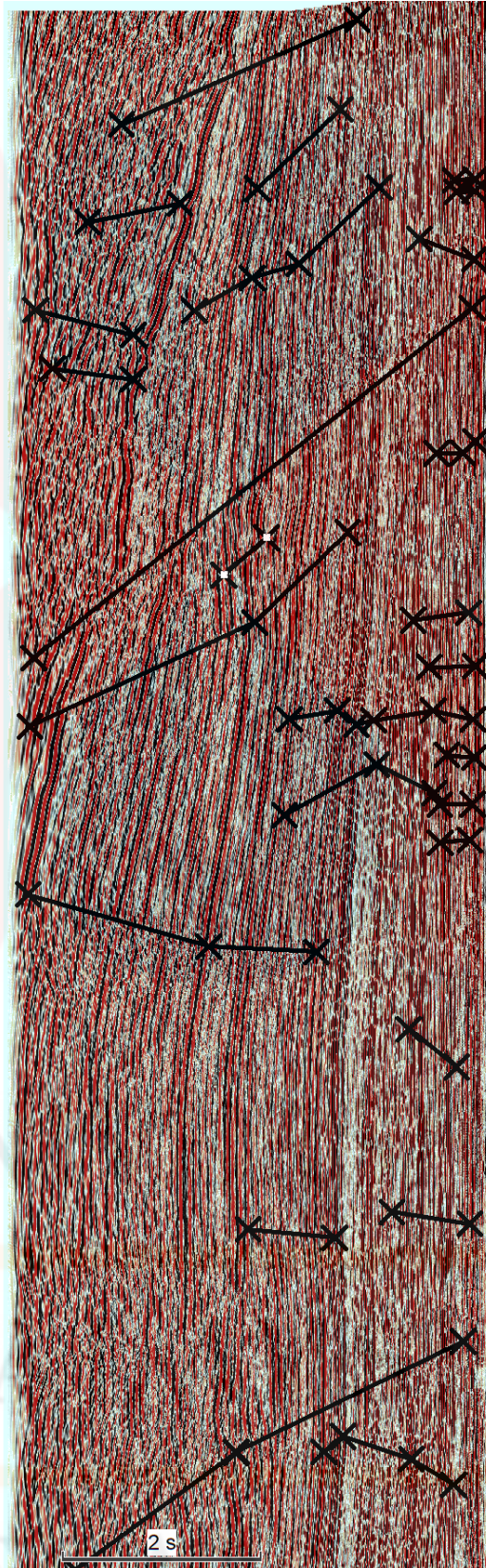


Figure 5.25: Faults identified in Line 21 Deconvolution

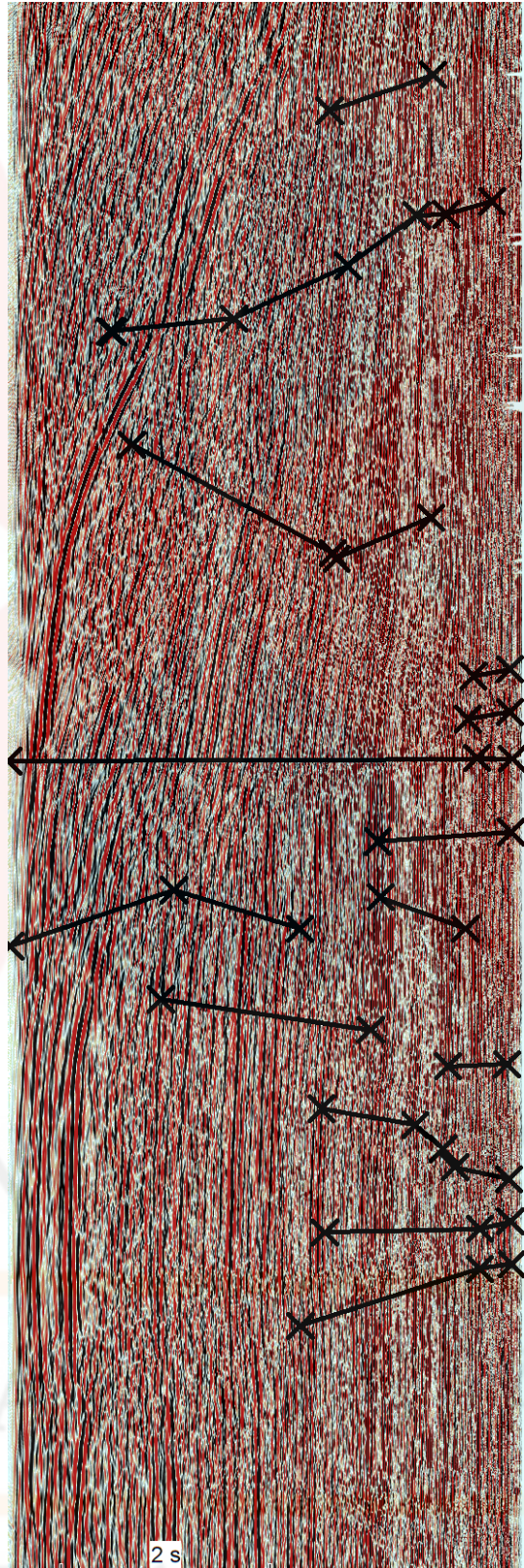


Figure 5.26: Faults identified in Line C21 Residual Absorption

5.6 FOLD

The movement along faults, diapirism, compaction, and regional subsidence or uplift may all lead to the formation of folds, which can be thought of as bends or flexures in layered rock. In seismic reflection profiles, folds are shown as one or more areas of dipping reflections (dip domains), which correspond to inclined stratigraphic connections. Folds may be found everywhere in the earth's crust. Folds are caused by pressure that is applied to rocks over extremely long periods of time (think millions of years). Therefore, rather than a swift action such as throwing the rock on the ground, the process is more analogous to waiting on it for millions of years, until the pressure is eventually sufficient that it changes shape.

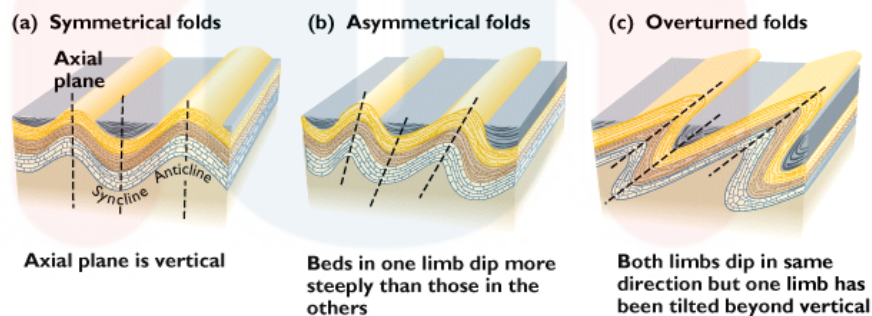


Figure 5.27: Illustration of fold types

When rocks are subjected to compressional stress, the result is the formation of folds. This happens when the rock is being driven inward from both sides at the same time. This is like to squeezing your hands together while simultaneously holding a spring in between them. You are compressing the spring as you push, just as rock may be squeezed in the same manner over extended periods of time using the same method. Depending on the direction in which the rock is bent when it is subjected to compressional stress, many kinds of folds may be formed. An anticline is a fold in

the rock that forms an arch as a result of the rock being folded in on itself from both sides.

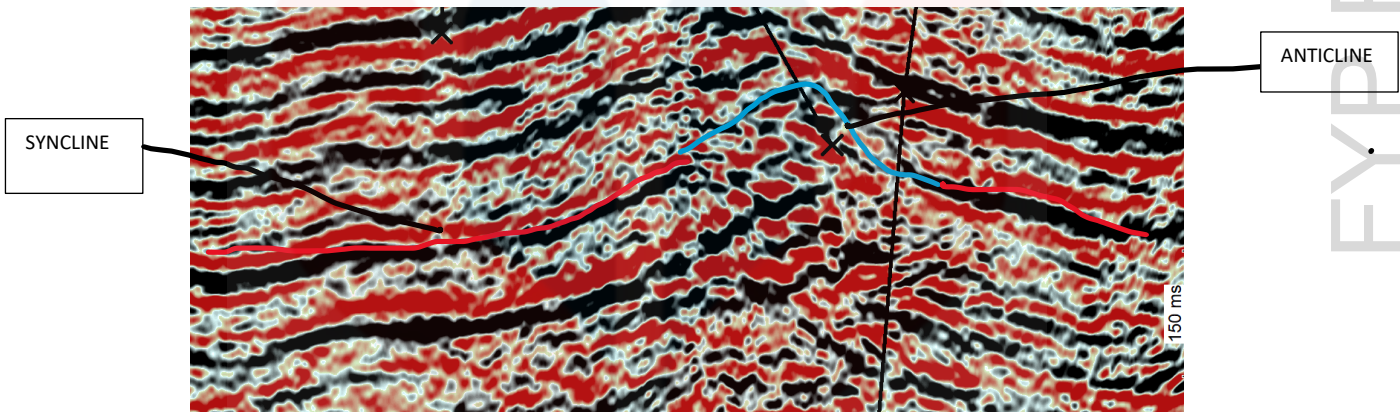


Figure 5.28: Fold found in Kapal Field

5.7 HYDROCARBON POTENTIAL

This field has the potential to contain hydrocarbons, as indicated by the facies study that had been completed as well as the structural presence at the field. This is something that can be determined by looking at the indications of the hydrocarbon, such as anticline and syncline. The results of the facies study indicate that the bright spot or flat spot may be found on the seismic survey. In addition, there is evidence that chaotic reflectors are present, which suggests that it may potentially be related with gas at the field. A seismic attribute anomaly with a high amplitude and high reflectivity is referred to as a bright spot. The existence of a bright spot in seismic data suggests the presence of gas (or "soft" oil), which travels at a substantially slower pace than brine-saturated rock does. In situations in which water sand has a lower acoustic impedance than the shale in which it is embedded, replacing the water in the pores with hydrocarbon can increase the sand–shale impedance contrast. This, in turn, can result in an increase in the seismic reflection amplitude, which produces a bright spot.

Even while a seismic wave moves more slowly through oil than it does through pore water, the difference is not usually significant enough to produce a bright spot on the seismic section. Fortunately, bright spots may be valuable in oil exploration since areas that contain oil often also include either saturated gas or gas on top of the oil. A seismic anomaly that manifests itself as a horizontal reflector on a seismic section is referred to as a flat spot. When oil, gas, and water come into contact in a confined space and the reflectors in the surrounding region are not flat, flat spots will develop in the surface of the water. In and of itself, the flat spot does not constitute an amplitude anomaly; nevertheless, given that the contact is often

connected with gas, the region may include a bright spot. When water-saturated sand is placed on top of hydrocarbon-saturated sand that has a higher acoustic impedance, flat spots have a greater chance of developing. Flat spots have a lower acoustic impedance. The interaction between the hydrocarbon and the water is where the flat spot is seen. Always a hard reflector, this one has a reflection coefficient in the positive range. On a seismic section, the flat positive reflection will stand out in comparison to the surrounding dipping reflections due to the fact that it has a depth profile that is uniform over its whole.

After then, the chaotic reflector as an indication failed to work properly due to the fact that the existence of the gas messes with the wave, which caused it to provide inaccurate results. In addition to that, the structural study demonstrates that it has the quality of being a hydrocarbon trap. After all of the analyses have been completed and correlated, it is safe to presume that the hydrocarbon potential is somewhere between the T2 and T4 boundary lines due to the presence of all indicators at that area (Line C21 Algorithms).

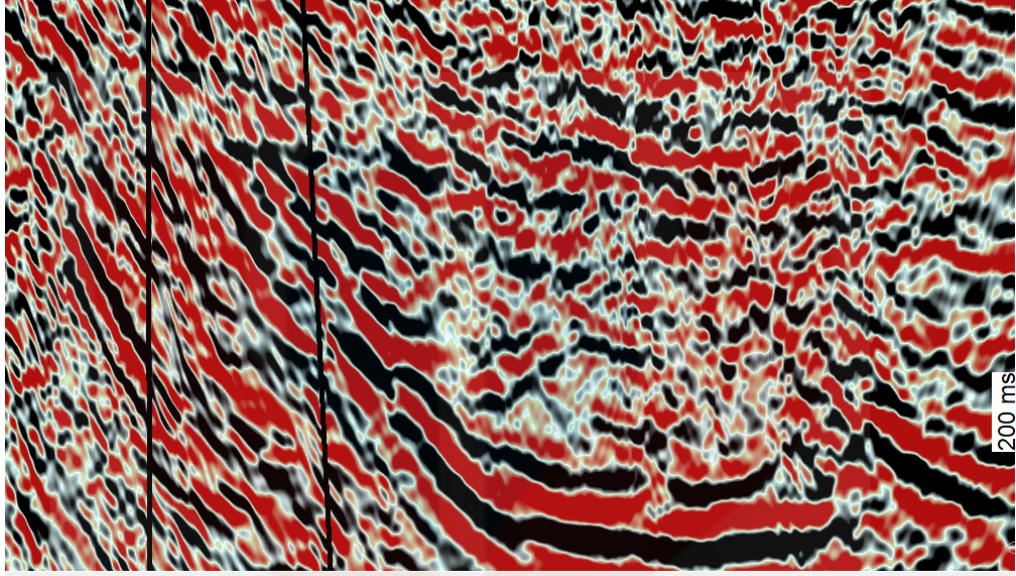
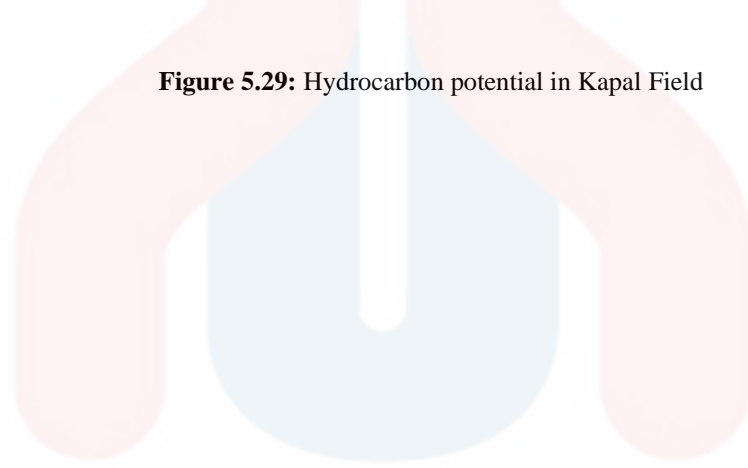


Figure 5.29: Hydrocarbon potential in Kapal Field



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CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, the main objective which to update geological map with scale of 1: 25000 of kampung Buluh, Permaisuri, Terengganu was successfully achieved. The geological mapping was conducted at Kampung Buluh for almost one week and around 75% percent of the study area had been mapped and the data was recorded. As for lithology at the study area, the meta sediment rock was found which are sandstone, quartzite, slate, schist, and phyllite. For accurate result, the samples collected was undergone petrographic analysis. Analysis of mineral composition was conducted in Faculty of Earth Science lab for almost one week. As for geological structure, the major fold which anticline, syncline, and overturned could be found while for fault, only minor fault with 1 to 3 cm displacement. Another geological structure found were joint, vein, and slickenside.

Next, the purpose of this study is to determine whether there is a possibility of finding hydrocarbons in the Kapal Field, which is located offshore in Terengganu.

This field has the potential to contain hydrocarbons, as indicated by the facies study that had been completed as well as the structural presence at the field. This is something that can be determined by looking at the indications of the hydrocarbon, such as anticline and syncline. The results of the facies study indicate that the flat spot or bright spot may be found on the seismic survey. In addition, if chaotic reflectors are present, there is a possibility that it is also related with gas at the field. Thus, both two objectives of this research had been successfully achieved.



6.2 Recommendation

Following the conclusion of this investigation, it is suggested that the subsequent researcher investigate the mylonite more thoroughly by carrying out a structural geology study at the location where the previous investigation was carried out. In addition, considering the regional geology of the Terengganu area, it is recommended that the research investigate the possibility of finding hydrocarbons on land in the Terengganu area. This research has the potential to both improve the economic situation in the nation and offer knowledge that can be used for academic purposes.

Next, Kapal Field is one of the significant areas; nevertheless, the scope of this study did not extend to cover the whole of Kapal Field. In order for the subsequent studies as well as the forthcoming research to be able to continue covering the Kapal Field. Due to the limited resources available for this research, the region that is being studied also requires considerable research on a thorough seismic stratigraphy and structural geology. Moreover, the area needs to be studied. in order to have a good look of the hydrocarbon resource in the surrounding region.

