GEOLOGY AND LITHOSTRATIGRAPHY OF POS BLAU, LOJING, GUA MUSANG, KELANTAN.

by

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

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2019

DECLARATION

I declare that this thesis entitled “Geology and Lithostratigraphy of Pos Blau, Lojing, Gua Musang, Kelantan.” Is the result 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.

Signature : ________________________________

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APPROVAL

This is to certify that the thesis on “Geology and Lithostratigraphy of Pos Blau, Lojing, Gua Musang, Kelantan.” is prepared by Nurul Hidayatusakinah Binti Abdul Hadi, with matric number E15A0233, a student under my supervisor and guidance. I have gone through the thesis in every aspects of the research topic. It is to be noticed that the thesis fulfils the requirements of degree, and it has not been submitted to any university or institute for same degree.

The report is approved and accepted in quality form.

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GEOLOGY AND LITHOSTRATIGRAPHY OF POS BLAU, LOJING, GUA MUSANG, KELANTAN.

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Abstract: The background of study area is mainly located at the Pos Blau, Lojing, Gua Musang itself and several area around it which has the the significance of lithostratigraphic unit. Generally, the study area had given to be covered in 5km x 5km (25 km²). The coordinate for the study area are within (N 04º 47' 26.7", E 101º 43' 19.1"), (N 04º 47' 26.6", E 101º 42' 2.4"), (N 04º 44' 45.1", E 101º 46' 2.9"), (N 04º 44' 45.6", E 101º 43' 18.5") The main problem for this research there were several part of data at the study area of Pos Blau, Lojing, Gua Musang was did not fully completed and it is needed to remap the study area in order to get the full coverage of data for example, there was no information data of the road in each of the village road based on the geological information system. Thus, it needed to do the remap and corrected the scale of the study area. The objectives is to update the geological map of study area of Pos Blau, Lojing, Gua Musang in the scale of 1:25,000 and to identify the lithostratigraphy of Pos Blau, Lojing, Gua Musang.The method use generally field mapping, ArcGis software, Stereonet software, Georose software, thin section and petrography analysis. In conclusion, for the study area in Pos Blau, Lojing, Gua Musang, Kelantan there were several rocks identified from the youngest to the oldest such as conglomerate, limestone, mudstone, and interbedded of chert and tuff. The oldest rock in the study area are generally volcanic rock type such as tuff where it is estimated age at early Triassic. The carbonate rocks such as limestone where it is generally divided into two types of bedding which is well-bedded and thick-bedded limestone were found in the study area. Basically, in the well-bedded limestone it is generally to be found the presence of some fossils in it. But, unfortunately, from the observation in the field and observation under the microscope there was no presence of fossil detected from the rock sample that is taken from the study area. Furthermore, the age for the carbonate rock is estimated at Late Carboniferous to Middle Triassic. Moreover, there were also some siliclastic rocks such as mudstone which is aged about Carboniferous to Middle Triassic.

Keywords: Lithostratigraphy; fossils; volcanic rock; bedding

GEOLOGI DAN LITOSTRATIGRAFI DI POS BLAU, LOJING, GUA MUSANG, KELANTAN.

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Abstrak: Latar belakang bidang kajian terletak di Pos Blau, Lojing, Gua Musang sendiri dan beberapa kawasan di sekitarnya yang mempunyai kepentingan unit litostratigrafi. Pada amnya, kawasan kajian telah diberikan kepada 5km x 5km (25 km²). Koordinat untuk kawasan kajian berada dalam (N 04º 47 '26.7 ", E 101º 43' 19.1"), (N 04º 47 '26.6 ", E 101º 42' 2.4"), (N 04º 44 '45.1 " Masalah utama kajian ini terdapat beberapa bahagian di kawasan kajian Pos Blau, Lojing, Gua Musang tidak lengkap dan diperlukan untuk merangkum semula kawasan kajian untuk mendapatkan liputan penuh data, contohnya, tidak terdapat data maklumat jalan di setiap jalan desa berdasarkan sistem maklumat geologi. Oleh itu, ia perlu melakukan remap dan membetulkan skala kawasan kajian. Tujuannya adalah untuk mengemaskini peta geologi kawasan kajian Pos Blau, Lojing, Gua Musang dalam skala 1: 25,000 dan untuk mengenalpasti lithostratigrafi Pos Blau, Lojing, Gua Musang. Kaedah menggunakan pemetaan medan umumnya, perisian ArcGis, perisian Stereonet, perisian Georose, “thin section” dan analisis petrografi. Sebagai kesimpulan, bagi kawasan kajian di Pos Blau, Lojing, Gua Musang, Kelantan terdapat beberapa batu yang dikenalpasti dari yang termuda hingga yang paling tua seperti konglomerat, batu kapur, batu lumpur, dan interbed chert dan tuff. Batu tertua di kawasan kajian umumnya adalah jenis batu gunung berapi seperti tuff yang dianggarkan umur pada awal Triassik. Batu-batu karbonat seperti batu kapur di mana ia secara umum dibahagikan kepada dua jenis tempat lapisan yang mempunyai batu kapur yang berkaliber dan tebal terdapat di kawasan kajian. Pada dasarnya, di batu kapur yang telah dibina dengan baik, umumnya terdapat kehadiran beberapa fosil di dalamnya. Tetapi, malangnya, dari pemerhatian di lapangan dan pemerhatian di bawah mikroskop tidak ada kehadiran fosil yang dikesan dari sampel batu yang diambil dari kawasan kajian. Tambahan pula, usia batu karbonat dianggarkan pada Karboniferous Akhir hingga Triassik Tengah. Selain itu, terdapat juga beberapa batu siliklastik seperti batu lapis yang berumur kira-kira Karboniferous hingga Triassik Tengah.

Kata kunci: Litostratigrafi; fosil; batu gunung berapi; lapisan batuan

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Km	Kilometer
GIS	Geographic Information System
FA	Facies association
F	Facies

LIST OF SYMBOLS

°	Degree
σ	Compression force
N	North
E	East

CHAPTER 1

GENERAL INTRODUCTION

1.1 General Background of Study Area:

The background of study is mainly located at the Pos Blau, Lojing, Gua Musang itself and several area around it which has the the significance of lithostratigraphic unit. Mostly the rocks that covered in the area of Pos Blau, Lojing, Gua Musang is sedimentary rocks such as limestone. The study generally about the Earth as in Geology, the knowledges of learning about the structural, mineral compositions of rocks, formation of rocks, physical properties, and also the history of the Earth process. The study area also include a part of Lojing-Cameron Highland road which were numbered as Road 185. Furthermore, there were low in human population in this study area which were mostly lived by Orang Asli people and several Malay, Chinese and Indian. Moreover, in the study area also were mostly with socioeconomics came from the agricultural activities that were consist of oil palm plantation, rubber tree plantations and also small quantity of logging activities. As considered the study area were a part of Pos Blau which were the village for Orang Asli. Thus, it can ease the access across the study area with the help of their road connections and also the presence of Lojing-Cameron Highway. Apart from that, the track to be further covered in study area were mostly through the logging trails. Other than that, the highway also had been used to connect to the state's of Pahang which are Cameron Highland. On the other hand, the Cameron Highland were the continuation of Lojing highlands which were located in the South-Eastern part of Kelantan, at the foot of the Central Titiwangsa Range with an altitude from 610 - 1 500 m above sea level. In the study area also there were generally have been covered with some drainage system and one of their main river is Brooke's river (also spelled as Berok's river).

1.2 Study area:

a. Location

Pos Blau, Lojing of Gua Musang, Kelantan were the location of the study area which were also had some part of Lojing-Cameron Highland highway which is also under the Kelantan's state. Generally, the box had given to be covered in 5km x 5km (25 km^2) including the small portion of Gunung Ayam's foothill. Moreover, at the end of the Kelantan's state near in Lojing, Gua Musang, Kelantan also were located closed up with the border of Pahang's state. Mostly the rock composition and the rock distribution in Pos Blau, Lojing of Gua Musang were generally distributed of limestone, marble, tuff , shale, subordinate of sandstone and also consist of conglomerate rock from the Gunung Ayam. Furthermore, majority of the people were planting their crops mainly of oil palm plantations and rubber tree plantations. Other than that, there were minor of logging activities and half a minor of rain forest. Basically, the hilly and mountainous landform are the geomorphology at Lojing, Gua Musang and with highest elevations among all mountains in Lojing, Gua Musang is the Gunung Ayam with the height of 4,934 ft (1,504 m). On the other hand, the aged of Gunung Ayam were estimated at Permian-Triassic that were consist of conglomerate rocks and the Gua Musang Formation also were made up in this study area. In the study area also there were generally have been covered with some drainage system and one of their main river is Brooke's river. The coordinate for the study area are within (N 04º 47’ 26.7”, E 101º 43’ 19.1”), (N 04º 47’ 26.6”, E 101º 42’ 2.4”), (N 04º 44’ 45.1”, E 101º 46’ 2.9”), (N 04º 44’ 45.6”, E 101º 43’ 18.5”) as shown in Figure 1.2. The Figure 1.1 shows the study area located at Pos Blau, Lojing, Gua Musang, Kelantan.

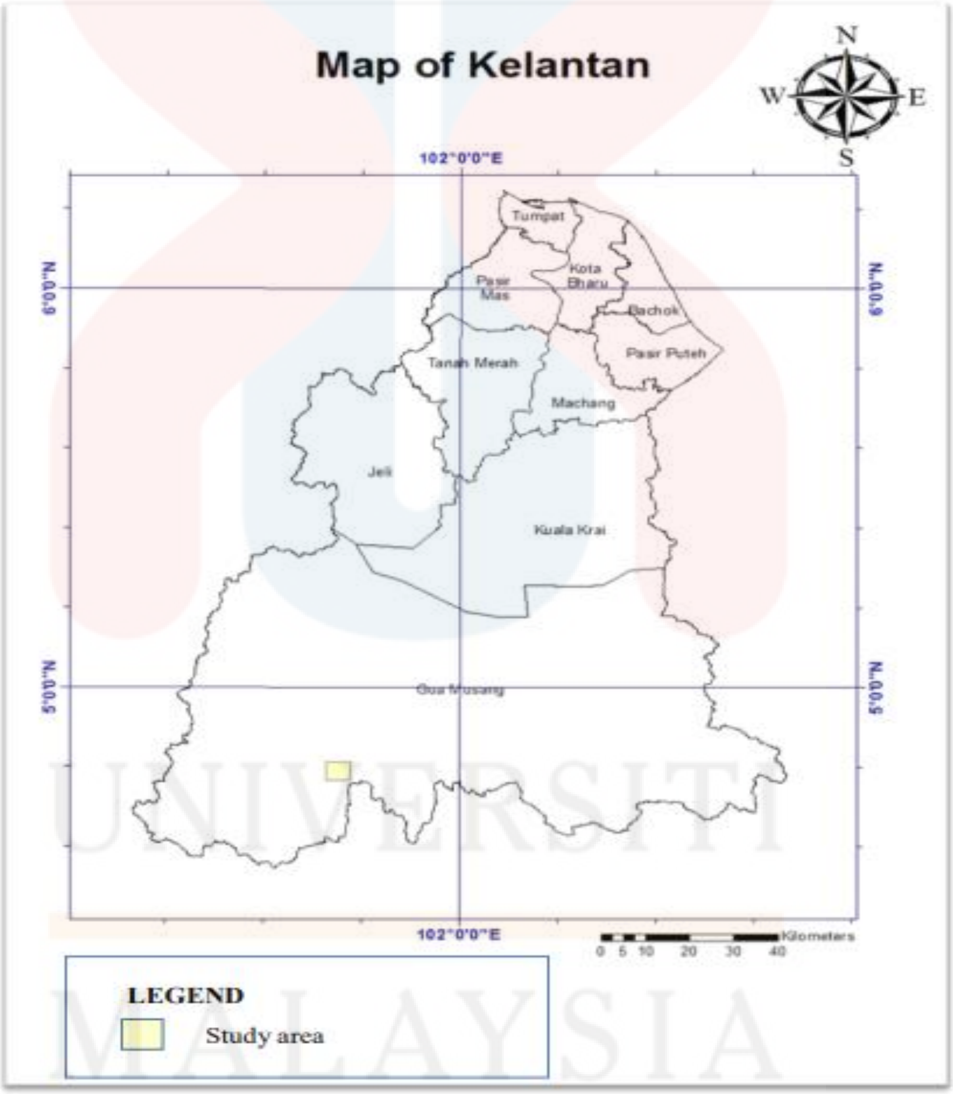


Figure 1.1: Box of study area in Lojing, Gua Musang, Kelantan.

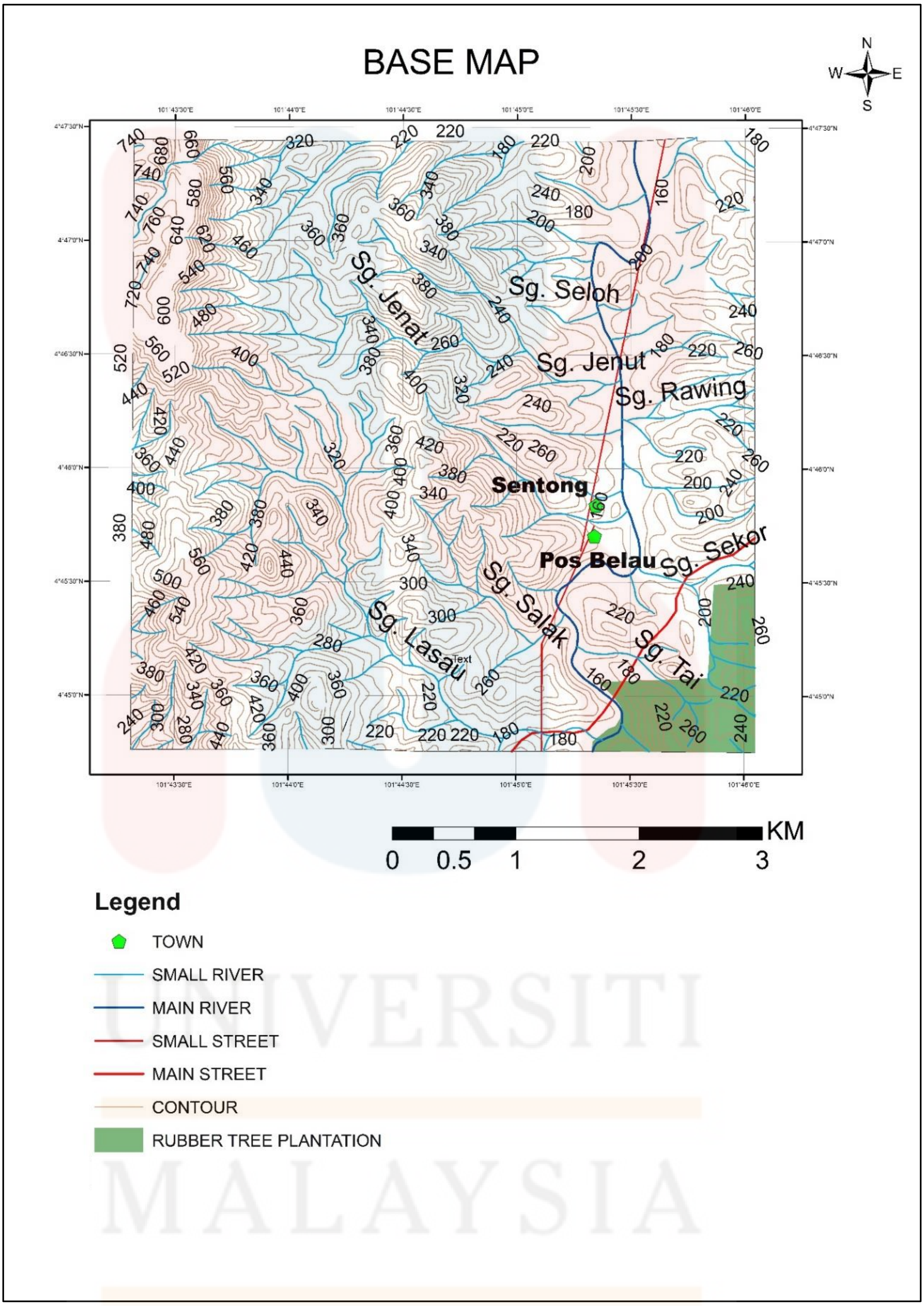


Figure 1.2: Base map of study area in Pos Blau, Lojing, Gua Musang, Kelantan.

b. Road Connection

All vehicles include motorcycles, cars and lorries can access the pavement road which is the Lojing-Cameron Highland and also the unpaved road shows in Figure 1.3 which were located in the oil palm plantation and rubber tree plantation. Other than that, there were also a highway connected to the study area (Figure 1.4) and there were some bridges that connected to the several villages in Pos Blau that across the Sg. Brooke (Figure 1.5).

Figure 1.3: The unpaved road further into study area.

Figure 1.4: The paved road (highway) to study area.

Figure 1.5: The bridge at Sg. Brooke connecting to Pos Blau.

c. Demography

Based on Department of Statistic Malaysia, during 2010, total people that lived at Gua Musang district is 90, 057 with dominant race is Malay, followed by Chinese, Indian and other races. On 2016, Gua Musang district has population of around 120,400 people. The percentage of Malay population is 76%, Chinese 5%, Indian 1%, Orang Asli 13%, and others (non-citizens) of 5%. Gua Musang are divided into three district which are Bertam, Chiku and Galas. According to Majlis Daerah Gua Musang , people distribution in Gua Musang are divided based on Table 1.1.

District	People Distribution	Male	Female
Bertam	16 923	8 670	8 253
Chiku	26 251	11 908	11 908
Galas	31 814	16 769	15045

Table 1.1: People distribution of Gua Musang (Source: Majlis Daerah Gua Musang, 2015)

d. Land Use

Mostly the land were covered by oil palm plantation (Figure 1.6 and Figure 1.7) and rubber estate. Other than that, the land were also covered by the residents that were Orang Asli residents. One of the sources for the residents were by the oil palm plantation business.

Table 1.2: Land use of Kelantan

No.	Category	Area (hectare)	Percentage (%)
1	Forest Reserve	894 271	59.5
2	Agriculture	335 660	22.3
3	Urban	4 967	0.3
4	Mining	3 737	0.3
5	Other : • River, dam • Reservoir areas • Cleared areas • Grazing Areas • Mangrove areas • Secondary Areas	263 565	17.6
6	Total	1 502 200	100

(Source: Department Of Mineral and Geoscience Kelantan, 2000)

According to the Table 1.2, more than half percent of forest covered the Kelantan area. The estate and reserved land were mostly covered at Jeli, Gua Musang and Kuala Krai which were in Southern district. Moreover, the remaining percents were being used for mining and agriculture that were located at alienated land.

Figure 1.6: Land use for oil palm estate.

Figure 1.7: The forest and oil palm plantation area.

e. Social Economic

Mostly there were rubber tapper, oil palm plantation workers, logging workers and also other industrial activities such as grocery shops, and stalls. There are a few grocery shop that were opened by the Orang Asli residents. Based on the Figure 1.8, there were few of rubber tree plantation and the Table 1.3 shows the industrial classification of Gua Musang residents based on their focusing area.

Table 1.3: Industrial activities of Gua Musang Resident

Focusing Area	Industrial classification
Gua Musang Town	Food product Craft product Wood product
Chiku Town	Biotechnology and Agriculture product
FELDA and selected PPD	Food product Agriculture product Tourism
Residental area	Food product Agriculture product

Figure 1.8: Rubber estate owned by residents in study area

1.3 Problem statement

The main problem for this research there were several part of data at the study area of Pos Blau, Lojing, Gua Musang was did not fully completed and it is needed to remap the study area in order to get the full coverage of data for example, there was no information data of the road in each of the village road based on the geological information system. Thus, it needed to do the remap and corrected the scale of the study area. Besides that, geological data for study area is not updated for a long of time besides, the resources for information and reading material for study area also limited. Furthermore, this study was an emphasis of previous or related in geology research study thus, it is needed to do the geological mapping at the study area to collect more data and to provide a new update information about the study area.

1.4 Objectives

I. To update the geological map of study area of Pos Blau, Lojing, Gua Musang in the scale of 1:25,000.

II. To identify the lithostratigraphy of Pos Blau, Lojing, Gua Musang.

1.5 Scope of study

The scope of study is more focusing on lithostratigraphy of the 5km x 5km at the study area of the Pos Blau, Lojing, Gua Musang. This research also include the geological mapping in order to achieve the objective to updating the geological map with scale of 1:25,000.

1.6 Significance of study

The significance of the study is that can manage to provide information about the lithostratigrapy of Pos Blau, Lojing, Gua Musang. Thus, people may learn new knowledges especially the reseachers and students about the lithostratigraphy of Pos Blau, Lojing, Gua Musang that yet had more to be discovered. Besides that, the initiative of topographical map, drainage map, contour map, geomorphological map and geological map were also very useful to the future researchers and also to the future generations to study more about the geological environment at Pos Blau, Lojing, Gua Musang and provided them an overview of the knowledges about geology in Pos Blau, Lojing, Gua Musang. In a nutshell, from this research the people out there not only the district of Pos Blau, Lojing, Gua Musang but also all over the world may learn new things and also may preserving and also conserving them in future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss about literature review of past studies that can be relate with this thesis. The purpose of literature review was to give a guidance in writing up the report and summarize past studies that had been done all around the study area.

2.2 Regional Geology and Tectonic Setting

Based on the report of Quarry Resource Planning for State of Kelantan by Osborne & Chappel Sdn. Bhd (2003) the occurance of rock deformation in Kelantan can be divided into several main unit which are sedimentary or metasedimentary rocks, extrusive rocks, granitic rocks and unconsolidated rocks. Other than that, based on the North-South central part of the Kelantan's state, there are several rock type that can be detected such as sedimentary or the metasedimentary rocks. Besides that, the most dominant rock dominated on that state of area is mostly sedimentary or the metasedimentary rocks. While on the other hand, in the West and East they were separated by a border of granite rocks at the Main Range and Boundary Range. The granitic rock types also continues along the other country rocks at the North-South way of direction. Moreover, the granitic rocks are also shortened to the North by the sediment of unconsolidated type of rocks of the Kelantan's alluvial plain.

2.2.1 Distribution of Rocks

a. Unconsolidated Sediment:

Mostly the Northern site of Kelantan is distributed with of unconsolidated sediment type of rocks which are comes from the forming of Thailand until Terengganu boundary at the coastal site. This forms by the composition of alluvial plain from the Quaternary age with underlying with granitic types of rock at the bedrock. The part of the area is mostly covers up by aquatic life such as all the marine clay which are the area are belongs to a coast that are made up of peat, clay and silt sediment. Apart from that, while on inland these unconsolidated sediment where generally distributed as a discontinuous layer from the grain-sized of coarse to the silt kind of grain-sized or even come up with a combine mixture for the two both of grain-sized types. Moreover, it is mostly take away by the flows of rivers and stream into South China Sea.

b. Extrusive Rocks (Volcanic rocks):

While at the North-South in the central zone this kind of extrusive rock types can be found that form along and lengthen their body at that area at the central zone. While on the Eastern side of the Kelantan's state there are occupied of granitic type of rocks which border the range of boundary of Boundary Range Granite. Another type of rock is made up of acid to intermediate volcanic and intermediates to basics volcanic. The unconsolidated type of rocks cut between the belts of granitic type of rocks and the other country rocks at the North-South direction to the North by the unconsolidated sediments of the alluvial plain. Basic pyroclastics that consist mainly of andeseitic tuff are the main components which made the intermediate to basic volcanics and these type of rocks are with age from Permian (Geology and Mineral Distribution Map of Kelantan 2000).

c. Sedimentary and Metasedimentary Rocks:

At the land surface of Kelantan's state are covered by sedimentary or metasedimentary rock with half percent which is the rock of Ordovician to Cretaceous age based on the Geology and Mineral distribution Map of Kelantan (2000). It covered from the North-South central part of Kelantan and they can be grouping into their age which are:

1. Silurian-Ordovician sedimentary rocks
2. Carboniferous sedimentary rocks
3. Permian sedimentary rocks (Gua Musang Formation)
4. Triassic sedimentary rocks (Gunung Rabong Formation)
5. Cretaceous-Jurrasic (Gagau Formation)
6. Granitic rock

2.3 Stratigraphy

It was estimated that the Gua Musang formation's age were at Permian-Upper Triassic that were associated with the lithologies of limestones, conglomerate, shale, tuff, subordinate of sandstone and interbedded of chert with mudstone. At the Western part of Gua Musang there were located of Kuala Betis which were had some similarities to the Gua Musang formations in in lithologies aspects. Besides that, the distribution of rocks generally composed of conglomerate rocks are comes from the Gunung Ayam. Aw (1974) also stated that, the neggiri and Kuala Betis which were located at the Western part of Gua Musang had the same age of from the Gua Musang formation of rocks that were composely of limestone, argillite and also conglomerate rocks. While at the Ulu Kelantan there were suture zone of rocks within seven tectonic packages that can be found which were the phyllite, schist, melange, sandstone, mudstone, chert as well as serpentinite that had stacked imbricate structures (Tjia, H. D & Almashoor, S.S, 1993). Next, Figure 2.1 shows geological map of Kelantan that showing distribution of the rocks in Kelantan state. While on the North of Kelantan, it is dominated by the map shows that area is dominated by silt, clay, sand, peat and some minor gravel which are the Quaternary sediment. On the other hand, at the middle part of Kelantan, it is mostly composed of shale, siltstone, sandstone and limestone which is Tertiary sedimentary rocks followed by metamorphic rock such as sandstone, limestone, phyllite and slate and also Permian sedimentary rocks. Furthermore, with the aid of this figure, basically the study area are mostly located at the Permian region. Other than that, there were also some intermediate to basic volcanic rocks district and some acid to intermediate which is located at Gua Musang and Kuala Krai. Based on the Figure 2.2 shows the geological features of known and likely onshore Tertiary basins, Peninsular Malaysia.

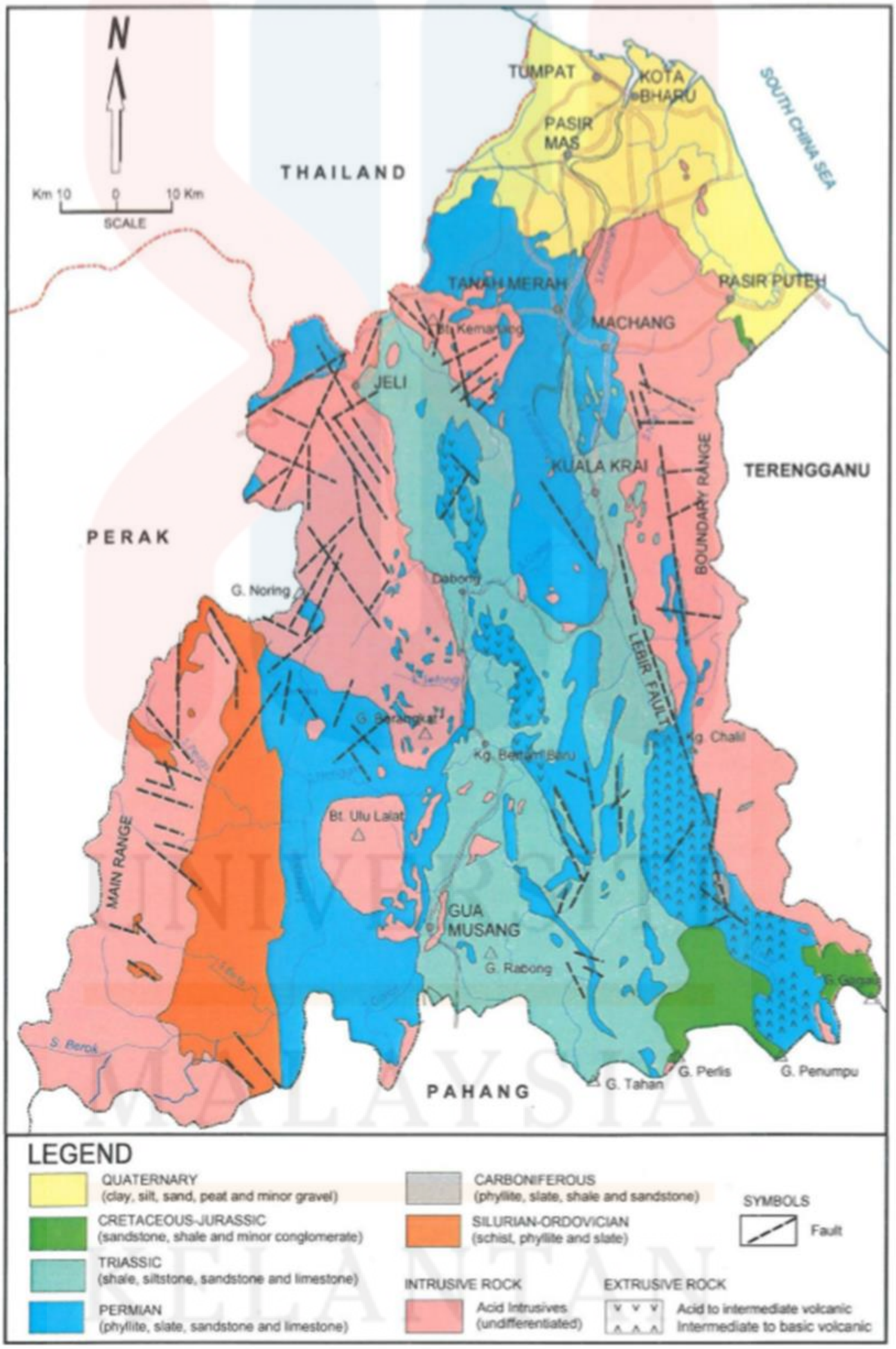


Figure 2.1: Geological Map of Kelantan (Source: Google image)

Locality	Bukit Arang, N Perlis & Kedah	Enggor, Central Perak	Batu Arang, Selangor	Kg. Durian Chondong, NW Johor	Kluang-Niyor, Central Johor	Layang-Layang, South Johor	Lawin, N Perak
Generalised Stratigraphy	Boulder Beds unconformable over Lower Sequence	Surface wash sediments over Coal-bearing Strata	Boulder Beds unconformable over Coal Measures	Alluvium unconformable over Lower Sequence	Alluvium unconformable over Lower Sequence	Pengeli Sand Member conformable over Badak Shale member	Boulder Beds
Lithology & Stratigraphy	**Boulder Beds** – Gravels & boulders in sandy matrix – Loose to weakly consolidated – Some 90 m thick – Fluvial sediments – Gentle dips – Age not known	**Surface Wash Layer** – Quartzite pebbles in sandy matrix – Unconsolidated – 1.2 m thick – Fluvial sediments – Horizontal layer – Age not known	**Boulder Beds** – Gravels & boulders in sandy matrix – Weakly to semi-consolidated – > 300 m thick – Alluvial fan deposits – Dip 20° to 45° – Age not known	**Alluvium** – Mainly sand with some clay – Unconsolidated – > 5 m thick – Fluvial sediments – Dip 20° to 25° – Pleistocene (?).	**Alluvium** – Mainly sand with some clay – Unconsolidated – > 5 m thick – Fluvial sediments – Horizontal beds – Pleistocene (?).	**Pengeli Sand** – Sands, clayey sands & clays – Unconsolidated – > 3.5 m thick – Fluvial to deltaic sediments – Horizontal beds – Pleistocene (?).	**Boulder Beds** – Grit, sand and pebble beds – Weakly, to semi, consolidated – > 300 m thick – Alluvial fan deposits – Dip 20° to 45° – Similar to Batu Arang
	Lower Sequence – Clay & sand layers with thin coal seams – Weakly to semi-consolidated – Minimum thickness 130 m – Dips of 10° to 35° – Lacustrine sediments – Late Neogene or Quaternary age	**Coal-bearing Strata** – Shales, sandstones & clays with lignite seams – Weakly to semi-consolidated – Maximum known thickness of 63 m – Reported dip of 10°	**Coal Measures** – Shales, sandstones, & clays with lignite seams – Weakly to consolidated – Maximum known thickness of 265 m – Dip 10° to 40° – Lacustrine sediments – Eocene to Oligocene	**Lower Sequence** – Shales, volcanic ash & clays with some lignite seams – Weakly to semi-consolidated – Maximum known thickness of 195 m – Dip 20° to 25° – Lacustrine sediments – Late Tertiary	**Lower Sequence** – Shales & clays with some lignite seams – Weakly to semi-consolidated – Maximum known thickness of 67 m – Dip 6° to 20° – Late Tertiary	**Badak Shale Member** – Mudstones & clay-shales – Weakly to semi-consolidated – Max. exposed thickness 95 m – Dips of < 15° – Lacustrine sediments – Miocene - Likely to be older	
Coal Seams	Thin lignite seams of limited lateral extent	**One thick lignite seam and another poor quality seam.**	Two thick coal seams - Upper and Lower Seams.	Some lignite seams of limited lateral extent.	Some lignite seams of limited lateral extent.	No lignite seams seen or reported.	Total absence of lignite seams

Figure 2.2: Geological features of known and likely onshore Tertiary basins, Peninsular Malaysia. (Raj,1998)

2.4 Structural Geology

According to Tjia and Syed Sheikh Almashoor (1996), there can be divided into seven tectonic unit along the East-West Highway which all had formed into imbricate structure associated with high angle of faults that were contact with each other. The Bentong-Raub Suture Zone are mainly the reason of the result that shows the undergone progressive-transpressive deformation (Ibrahim Abdullah and Jatmika 2003). Morever, based on the Shuib. M. K. (1994c), there were also thinly bedded chert that was deformed by the bedding and overlies massive shale along the Gua Musang-Cameron Highland road and East-West highway. Furthermore, it had been refolded on the chert bedded with showing isoclinals fold by the steep North-South reverse dextral fault. Tjia (1986, 1987, 1989a, 1989b), Tjia and Zaiton (1985) conclude that castward subduction was forming due to the tectonic transport that was primarily toward West during Late Palaezoic. Basir Jasin. Jatmika Setiawan & Ibrahim Abdullah (2010) states that in the West part is by olistrostrome while in the East part were by Lebir Fault Zone which were structurally divided in the state of Kelantan. On the other hand, there are a great formation at the middle part of Gua Musang which was a great fold toward North-South up to North-Northwest – South-Southeast.

There are three fundamental structures that can be divided, they are contact, primary structure and secondary structure. Primary structure is basically the structures that produced during the formation of the rock itself. For example, the primary structure are the unconformable contact, vesicles in basalt, cross bedding, depositional contact, and cross bedding. While in secondary structures, is when the rock body is formed then followed up the formation any kind of structures. Example of secondary structures area joints, folds, shear fractures, cleavage results from tectonic fabric, fault, foliation and lineation. Contact is the border or the boundaries that separate the different of rock body. There are three basic types of contact which are:

1. Depositional contact: Occurs when pre-existing rock is overlie or deposited by sediment layer.

2. Fault contact: Occurs when sliding is occurred then two block of rock are place side by side by a fracture.

3. Intrusive contact: Occur usually when igneous rock intrude a country rock which resulting a rock of body cuts another rock body.

2.5 Historical Geology

There are two formation that formed the Gua Musang district which were, Gua Musang formation and Gunung Rabong formation. Moreover, there are some rock such as argillite unit that were found in Gua Musang area and had been undergoes low graded metamorphism which subsequently turn it into slate and also phyllite. Furthermore, limestone rock which is basically the carbonated rock were also undergoes marblelized process that turned them into marble due to the contact metamorphism. Besides that, there were also some presence of conglomerate and sandstone at the Gunung Rabong.

Moreover, most of the argillite unit composed of sandstone that were interbedded with tuff resulted from the volcanic activities. Limestone unit followed by argillite unit dominated the Gua Musang district. However, the karst landform are formed due to the presence of carbonate rock which is limestone. These rocks units called as Gua Musang formation. Gua Musang can be divided into four divisions, they are Kuala Betis, Gua Musang, Aring and Gunung Gagau that was introduced by Yin (1965). Based on the Department of Minerals and Geosciences Malaysia (2003), sedimentary rocks aged Permian exposed on the Eastern part of Kelantan where they were overlied by Lower Paleozoic sequences in Southwest Kelantan and grouped as Gua Musang formation. These formation is made up of argillaceous with calcareous bedding, pyroclastic rocks and Taku schist. The age of the Gua Musang formation is determined by the occurrence of many fossils at many area around Gua Musang formation. Bivalvia fossils from genus Claraia age Early Triassic had been found in Gua Musang (Ichikawa, K. & Yin, E. H.,1996). At one of the part of Gua Musang district, in Pos Blau, some radiolarian fossils can be found in chert layers which are Pseudoalbaillella lomentaria Ishiga and Imoto, Pseudoalbaillella sakmerensis Konzur, Spongosphaeradiscus shaiwaensis Wang and many more. Based on these fossils, its conclude that the age for chert layer at that area is Permian (Dzulkafli ,M. A et.al, 2010).

2.6 Lithostratigraphy

Lithological characteristic and properties are considered in lithostratigraphy of rock unit in the rock strata and their relative stratigraphic positions. This can be considering by physical and geometric relationship to determine the relative stratigraphic position that can indicate which one are the younger and which one is the older beds. As there are units such as members, formations and groups that provide a basis for characterizing and describing rocks in lithostratigraphic unit into a hierarchical system. For example, a basaltic lithic tuff, interbedded coarse siltstone and claystone, an oolitic of grainstone, and others than that are form first part of the description related to the lithology of rocks and rock characteristics. The formation is basically contain of one lithology, combination of two or more or more than two lithologies are often to be grading a formation as interfingering units or interbedded units. Besides that, the structures such as ripple mark, scours, mudcracks, hummocky cross stratification, swaley cross stratification, cross lamination, normal grading, load cast, herring-bone cross bedding, water structures and so on are the example of sedimentary structures that may presence on the top and bottom of the strata. While in the aspect of petrography are used for determination for rocks composition, fossils content or trace fossil by conducting thin section analysis. Figure 2.3 and Figure 2.4 show the principle types of unconformities.

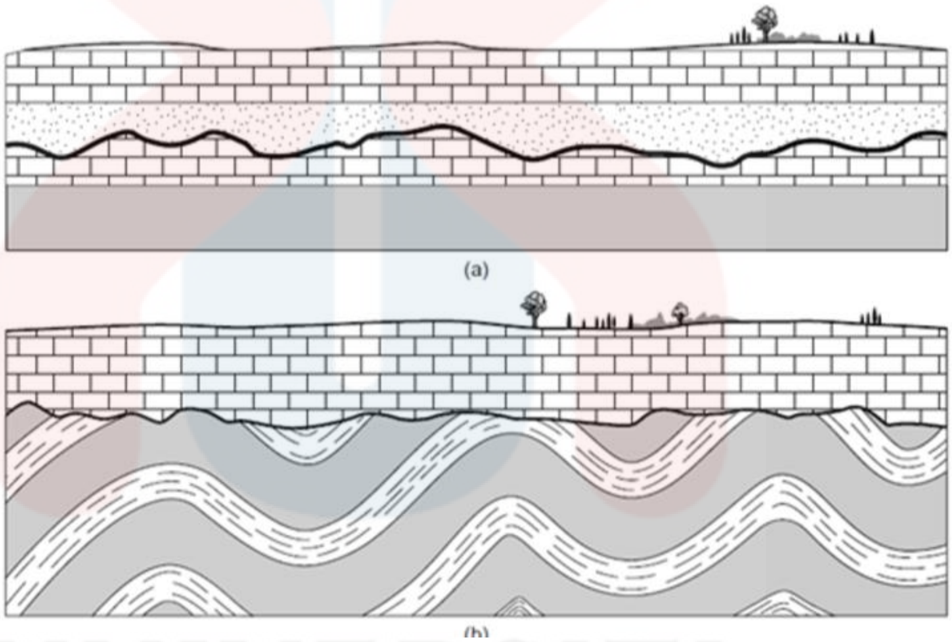


Figure 2.3: (a) Disconformity, (b) Angular unconformity.

(Source: Van Der Pluijm, Ben A., 2004)

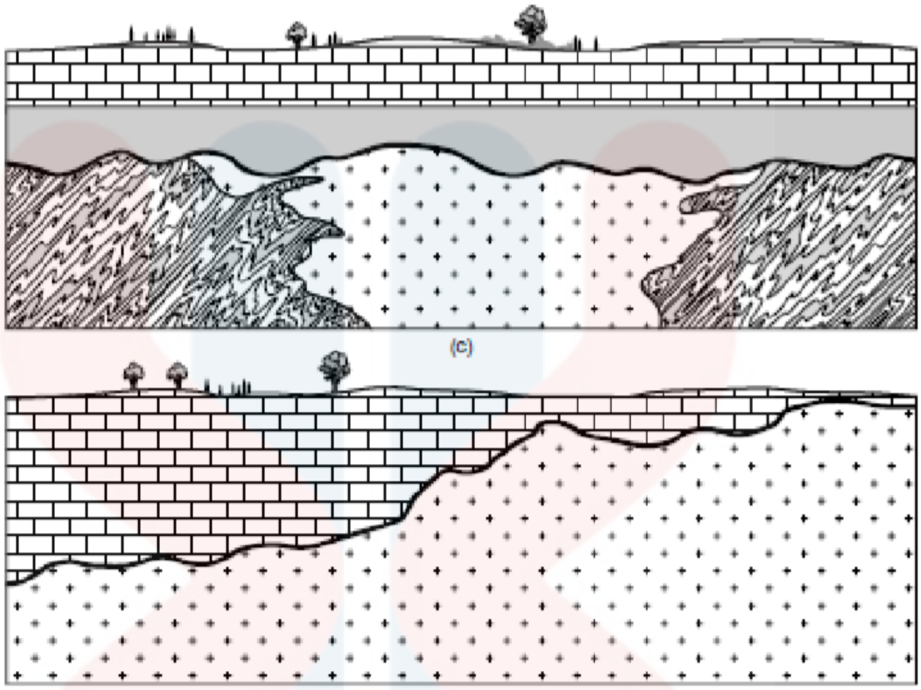


Figure 2.4: (c) Nonconformity, (d) Buttress unconformity.

(Source: Van Der Pluijm, Ben A., 2004)

Some of the features to identify unconformities by observed any occurrence of scour channels in sediments, basal conglomerate, age discordance from fossil evidence and soil horizon. From details, it shows in Figure 2.5. If strata in the sequence contain fossils, by determine the fossils species and their age, the gap in the fossil succession can be recognize. Unconformity also can be marked by a surface of erosion such scour features and paleosol.

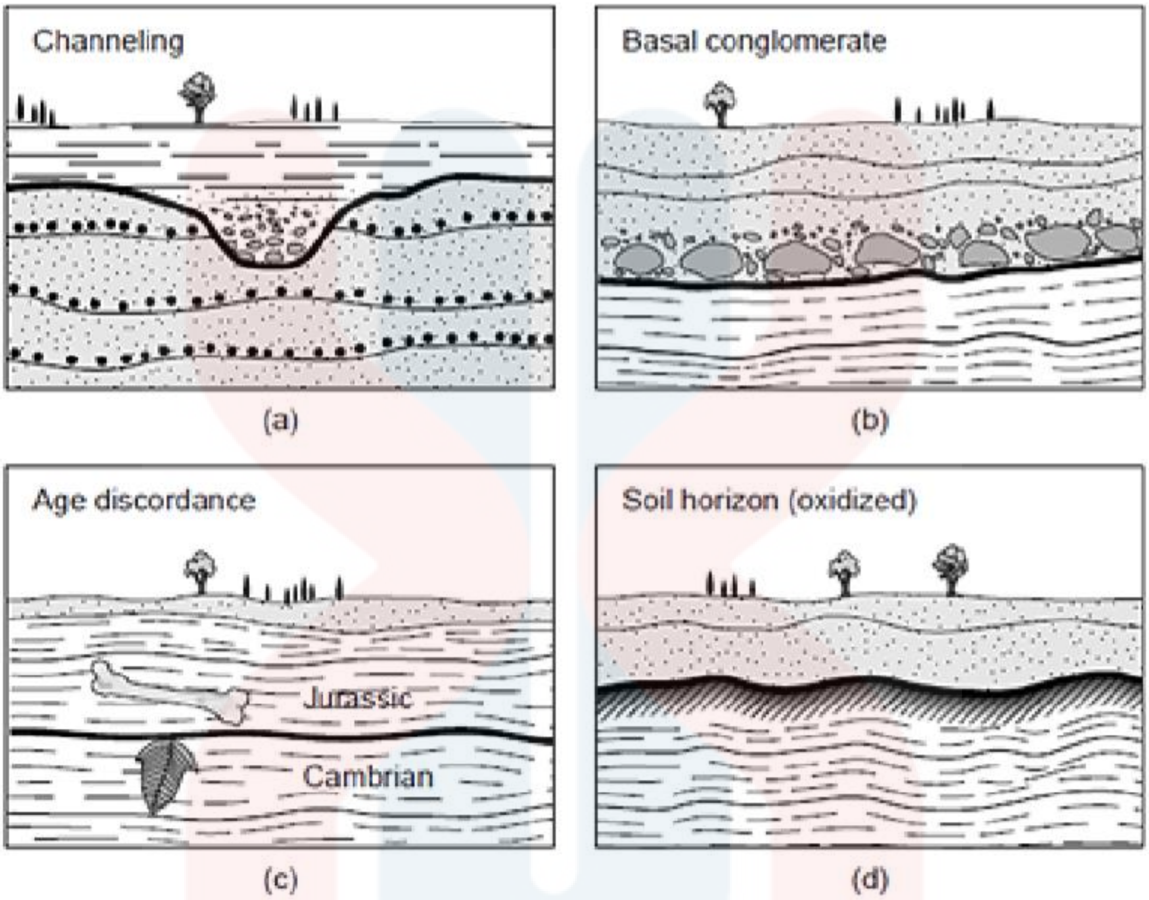


Figure 2.5: Features used to identify unconformities : (a) Scour channels in sediments, (b) Basal conglomerate, (c) Age discordance from fossil evidence and (d) Paleosol. (Source: Van Der Pluijm, Ben A., 2004)

Next, when countering a sedimentary rock outcrop, the most obvious characteristic is stratification also known as bedding. Recognition of bedding is critical in structural analysis as the bedding provides a reference for describing deformation of sedimentary rock. As the Law of Original Horizontality, sediments are initially deposited in form horizontal or nearly horizontal layers. If an outcrop showing tilting or folding, it can be conclude that, this outcrop undergone deformation. The study about depositional structures within beds and on bedding surface is very important in tectonic analysis because its contain information regarding the depositional environment, stratigraphic facing, current direction. Facing indicators will determine whether a bed is right-side-up or overturned. Table 2.1 shows the stratification terminology. Besides that, geologist also have developed special words for describing specific types of bedding as shown in Table 2.2.

Term	Description
Bedding	Primary layering in sedimentary rock that formed during deposition, display changes in texture, colour and composition.
Compaction	Unlithified sediments that have been squeezed due to pressure that applied by the weight of overlying beddings.
Overturned beds	Beds that have been rotated past vertical in the Earth surface frame of reference.
Parting	The tendency of sedimentary layers to fracture or split along parallel to bedding. This incident due to weak bonds between beds with different composition.
Strata	A sequence composed of layers sedimentary rock.

Stratigraphic facing	The direction to the depositional top (the direction to younger strata also known as younging strata).

Table 2.1: Some commonly used terms that are related to stratification.

Term	Description
Massive beds	The beds that are very thick with several metres and show no internal layering. Massive beddings formed in sedimentary environments where large quantities of sediment are deposited rapidly or in bioturbation environment.
Thick Beds	Beds that are range 30 to 100 cm thick.
Medium beds	Beds that are 10-30 cm thick.
Thin beds	Beds that are less than 3 cm thick.
Thinly laminated beds	Beds that are less than 0.3 cm thick.
Rhythmic beds	A sequence of beds in which the contract between adjacent beds is repeated periodically for a substantial thickness of strata.

Table 2.2: Terms used to describe types of bedding.

According to Khattak, O. (2018), it is presence of an unconformity when it provides a clear relationship in which the beds below the unconformity are clearly older than those above it when there is a break in sedimentation and where there is erosion of the underlying strata this. It must be younger rock than those below when all rocks which lie above the unconformity, or a surface that can be correlated with it. Apart from that, an angular unconformity is formed when where the strata have been deformed and partly eroded prior to deposition of the younger beds. A marks break in sedimentation of disconformity with also some erosion but without any deformation of the underlying strata.

Furthermore, the fossils content also provide a useful information for the history of formations or the past environments. Moreover, the specific description such as from the taxonomy about the fossil content can generate several ideas and definitions about the relative age in biostratigraphic terms which is not only the part of the definition of a lithostratigraphic unit. The diachronous unit, are often or the formation that was formed at different times in different places and deposited with the same lithological properties. Through the formation, in order to provide more specific distribution of the lithologies it can be divided into smaller units. The rock units that have limited lateral extent and are particularly related to a formation (or, rarely, more than one formation) can be classified in term of member. For example, a formation that were composedly mainly of sandstone but also associated with beds of conglomerate in some parts of the area of outcrop.

Moreover, there are also some parts might not have a member status, this is because a number of member’s formation does not have to be completely subdivided and may be defined within a formation (or none at all). Their lithology or fossil are helpful for naming the individual beds or sets of beds. Furthermore, these beds has its own initiative aspect for correlations because of their properties are easily recognizable. Other than that, when there is a share of some of their same characteristics of two or more formations found within each other they are considered as group. Besides, these groups can be traced in basin-wide commonly bound by unconformities. On the other hand, supergroup are known when unconformities that can be identified as major divisions in the stratigraphy are sometimes considered to be the bounding surfaces of associations of two or more groups over the area of a continent.

Last but not least, from the determination of fossil content such as radiometric dating or relationships with other rock units can assume the age for the formation, this can be included but does not form part of the definition for the formation. Besides, the facies's informations and environment's interpretations of deposition can be included but should not be defined in terms of depositional environment for aspects of formation, such as 'lagoonal deposits', because this is an interpretation from lithological properties and characteristics.

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

In this research there can be divided into six phases, which are preliminary research, field study, laboratory work, data processing, data analysis and interpretation and report writing. In order to obtain and analyzed data, materials and methods were examined and choose to fulfil data collection regarding study. Preliminary research contain two components, which are literature review and creating base map based on desk study and remote sensing with help of ArcGIS 10.2 Software. Literatures reviews was done from the sources of the data regarding the study area which can be found in libraries, journals, government books and research notes, books and e-publications. Next, fieldwork is conducted by using mapping activities. In this chapter were also included a flow chart to show the overall flow of method used to conduct the research (Figure 3.1)

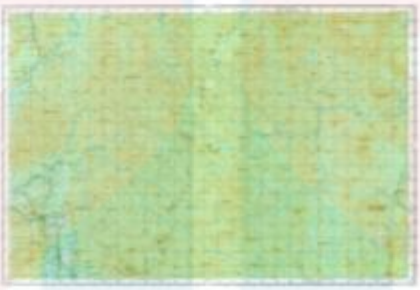
3.2 Materials

Based on the Table 3.2 below shows several materials that had been used in order to conduct the field work at the study area.

Table 3.2: Materials for fieldwork

No.	Figure of tools	Name
1	 Source : Google Image	Geological Hammer
2	 Source : Google Image	Portable Global Positioning System (GPS)
3	 Source : Google Image	Compass

4	 Source : Google Image	Hand Lenses
5	 Source : Google Image	Sample bag
6		Measuring Tape

7	 Source : Google Image	Hydrochloric Acid solution (HCL)
8	 Source : Google Image	Topographic map

3.3 Methodology

3.3.1 Preliminary studies:

This part will be more focused on the desk study before doing the research regarding the chosen topic. Firstly, this started with the study of the selected area, preparing the base map of the study area to be used for mapping and fully planning on ways to carry out research. All the resources such as from journals, articles, books, and previous thesis, internet that related to the topic are being taken. Besides, some of the geological features of the sites can be found based on the study of the selected area. Thus, this information acts as preliminary information before going to the site. Furthermore, the base map is generated by using ArcGIS 10.2 software and several of the data are taken from the Department of the Surveying and Mapping (DSSM). The base map are also attaches with layers such as contours, streets, town, river and etc.

3.3.2 Field Studies

To complete this research, all area of 5km x 5km within study area needed to be fully covered. During conducting field work activities, one of the important soft skill was how to deals with other communities. At first, permission from the owner of the local area should be taken in order to access study area. Communicating with the residents of study area is essential to get any useful information regarding study area, such which part of study area is access able, how to access an area. The permission from the authorities such as police department also should be taken for safety purpose. The field studies including doing basic geological mapping for study area by finding the outcrops and geologic structures . All those outcrops and geologic structures were examined carefully and the in-situ data were gathered. Each of the localities were noted in field book, a few pictures of the outcrops and any geological structures are taken by using camera, sketches of each outcrop is done and geologic features were noted in field book. During this process, the base map acts as a guide in study area. The traversing method is a surveying method used to cover study area. During conducted the field work, sampling of rocks were taken The sample of rocks should be fresh and not fully weathered in order to gain an accurate data. All of those samples placed in the sealed plastic bags. The information regarding the hand specimens such as the locations, physical appearance of the samples were wrote on the plastics bags. All the locations where samples were taken is marked in GPS as well.

3.3.3 Laboratory Work

I. Thin Section

The rock sample that have been collected are being cut into smaller pieces by using a machine. The fresh sample that are taken are from different places are fixed by using GPS (Suresh et.al.,2010). The collected sample are only taken with permission to enter those places whether it is from natural exposed outcrop or artificial exposure. Example from natural exposed is that such as river, coastal cliffs, high erosion area and example from artificial exposure is that created by human such quarries, road cutting and mines (I.M. Simpson,?) Thin section making equipment are the slab saw or Petro-cut machine, the grinder, the trim saw or PetroTrim the cut-off saw or Petro-thin machine, and the lap wheels. Firstly, there should be a glass slide that had been frosted to flatten and roughen at one of its surface to make sure the epoxy can bind well, it can be done using grinder. Next, hand specimen is then cut using the slab saw. The slab is then trimmed using trim saw in order to reduce the size of the slab to fix thin section glass. Next, the sample is grinded to a flat surface by using a diamond abrasion with distilled water. A 400-mesh diamond plate will be used for the final grinding while 600 mesh to 1200 mesh can be used to polish the surface of thin section. An epoxy resin such as Buehler resin and hardener is prepared for mounting with ratio 2:1. During the mixing process, air bubbles are ensures not entering the epoxy and the epoxy is place on the glass slide . After that, the rock's chip is then attached into rosted side of glass slide. The thin section is left for one day to ensure that rock's chip is fully attach to the slide. Next, sample that has been mounted on the glass slide will be grind again by using hand or by wheel using diamond impregnated metal plate or wheel. The type of 80 to 200 grit size will be used until the thickness of the sample is about the size of glass slide. Then, a 400 to 600 diamond grit is used to lap and get final thickness. The thickness of the thin section can be checked by using a petrographic microscope. The thin section is considered finish if the all minerals can be observed clearly under Thin Section and petrographic microscope. The common thickness for the sample of petrographic thin section is 30 microns or less.

II. Petrography analysis

The petrography is a process determines the type of rock from thin section by using the polarization microscope. The type of minerals, distribution of mineral, cleavage, fracture, texture and colour are determined under the microscope. The thickness is estimated about 0.03mm and it will be observe under microscope by cross polarized and plane polarized.

3.3.4 Data Processing

I. Stereonet software

The Stereonet software is used to create the Stereonet diagram with details of plane, line on the plane, arc and also small circle. There are several calculations to be done such as planes, poles and angle between poles and planes. This Stereonet software were used to know the paleostress direction from the data that had been collected from strike and dip angle from each of the bedding and fault that present at the surface of rocks in order to get the direction of force based on the diagram shows in the Stereonet software.

Moreover, this Stereonet software were also helpful in order to interpret the deformation that changed in each of the strata based on the bedding analysis in the Stereonet software.

II. GIS Analysis

The GIS analysis is an interpretation of the geological map by using ArcGis 10.2 software. By using this software, the topographic of the selected area can be analyzed and determined. Moreover, this software also used for updating geological feature found after the field mapping and thus produce new geological map for the study area.

III. Corel DRAW Software

The Corel DRAW it is a graphic software package produced to provide for drawing geological maps with that such powerful tools, geological profiles, cross sections, and also stratigraphic columns. However, although Corel DRAW can manage to help in terms of geology application soft skills, it also has several consequences such as the constructing of a stratigraphic column, the user must draw, reposition, resize, and fill shapes manually, which is both time consuming and inaccurate. On the other hand, Corel DRAW also does not supply the tools for plotting diagrams thus, users must plot the diagrams in Microsoft Excel before copying and pasting the diagrams to Corel DRAW for modification.

IV. Georose Software

The Georose software were used to produce the joint analysis diagram which were from the data that had been collected from the study area and then key in into the Georose software. Besides, this software has the configuration setting which enables users to get a full circle of joint analysis diagram or just a half from a circle of joint analysis diagram. Furthermore, the joint analysis diagram also provided an initiative figures which can help to interpret in which direction of the most strong force comes from, and also enabling users to identify the σ_1 and σ_3 based on the joint analysis diagram. Moreover, this joint analysis diagram also helped in lithostratigraphy which can be analyzed based on each of the strata that had been changed in their deformation based on this joint analysis.

3.3.5 Data Analysis and Interpretation

The data both from field work, laboratory work and processing data that have been collected, needed to be analyzed and interpreted. All data that can be gathered from the geological mapping activities such as structural geology, geomorphology, lithology, strike and dip, joints, fractures, landform , drainage pattern and water catchment were analyzed and interpreted in order to get the result and organized them in systematic ways. The lithology data can be used to produce lithology boundary map, cross-section, and the distribution of lithology within study area. Next, the data from strike and dip, joints and fractures reading can be used to interpret the direction of force that acting on study area as well as the deformation processes that occurs in study area by using GeoRose and Stereonet software. The petrography data from thin sections of hand specimens are interpreted and analyzed as well. The petrography data can be used to determine the minerals content of the rock, and eventually give the specific name for the rocks. All the data from field work and laboratory work were gathered and then presented in the report.

3.3.6 Report Writing

After correction and documentation, all of the data and results were gathered and compiled into a report. This way the data can be more arranged precisely and can be understood more easily about the flow of the research.

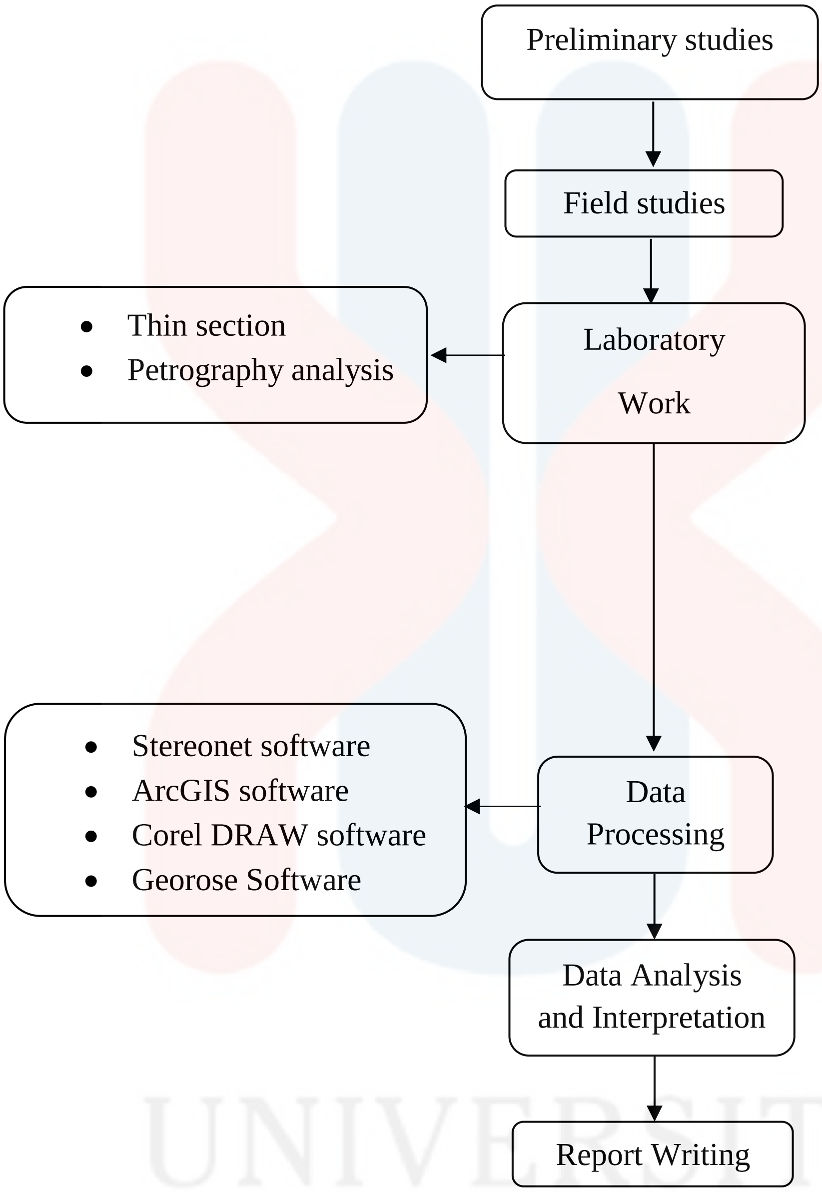


Figure 3.1: Research flowchart

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter is important because it more focus to complete the report. General geology is related to the part of geomorphology, stratigraphy, historical geology and structural geology of study area. This chapter is done by geological mapping and also literature review. Traversing is done due to the study area need to covers is 5km x 5 km (25 km^2). Some of the area cannot be access by ordinary cars because of the plantation area and high hill except for the residential area so, the traverse is continue by walking based on the previous studies and researches before going mapping.

Generally, geomorphology is defined as study of the characteristics, origin and development of the landforms. The geomorphology part included the study of the topography, weathering and drainage pattern of the study area.

Stratigraphy is involved studying about the strata and layering (stratification) of rock layer. This part divided to the several subfields such as lithostratigraphy, biostratigraphy, sequence of rock, and chronostratigraphy. The most concerned will focused about the lithostratigraphy. The thin section is being done to determine the mineral content. Then, petrography is continue to analyze the type of lithologies and to construct the geological map of the study area.

Structural geology is the processes or product of rock deformation. This part is carried out to identify the structure that occurs to the outcrop during mapping such as fault, fold fracture and joint. The structural analysis is done by plotting all the data into the software which are Rose diagram for joint analysis and Streonet software for streonet analysis. ArcGis also being used for analyse the topography and lineament as indicator of structure before going to mapping.

For historical geology, this will focused on chronology of the events in the study area. This also involved studies about sequence of lithology of the study area and deformation formed due the formation occurs.

a.Accessibility

The accessibility in the study area are basically interrelated to the socioeconomic activities of residental people of Pos Blau, Lojing, Gua Musang. The socioeconomic activities trails such as from oil palm plantation, rubber tree plantation and also logging activities trails (Figure 4) makes it easier to acces into further in the study area. The oil palm plantation is the major socioeconomic activities that are running at the Pos Blau, Lojing, Gua Musang which distribute many big and small pathway for motorcycles and cars enable to access into the woods. Next, the help from the logging trails also ease the journey to further access and traverse in the study area. It can be consider as relatively accessible in the study area, due to the daily economic activities of the local villagers and caused all the location were relatively accessible. The main road which is the Lojing-Cameron Highway act as the main road connecting to all the trails and pathways in the study area. There is also a small road (Figure 4.1) that is made for the villagers which is relatively poorly paved which connect the main road into their small village which is Pos Blau.

Figure 4.0: Oil palm plantation and logging trails.

Figure 4.1: Small road connect to Pos Blau village

b.Settlement

The settlement of the study area are generally small settlement which contributed from the villagers that set up their placement such as small houses (Figure 4.3), small farms, crops and several of their small shops (Figure 4.4). The population in study area can be classified as small to medium as the people distribution are majorly comes from the indigenous of Orang Asli population and minority comes from Malay, Indian and Chinese which are the outsider people of Lojing that comes from different country and build their settlement in the study area due to carrier engagement. The main village which locates the leader of the village is at Pos Blau village (Figure 4.2)

Figure 4.2: Houses that locates the leader of Pos Blau village

Figure 4.3: Small houses of Pos Blau residents

Figure 4.4: Small groceries shop located in Pos Blau village.

c.Vegetation

In the study area there are several vegetation which were mostly covered by oil palm plantation, rubber tree plantation and several villager's crops. The oil palm plantation are divided into a few different company such as Peransang Venture, Kapasiti Harapan, and SBSK Oil Palm SDN. BHD. Moreover, the vegetation that was planted were also based on the landscape of the area which is hilly area. There are also some of the villager's crops that were planted near to their settlement such as papaya trees, tapioca trees, durian trees, rambutan trees, and so many other thing which build their small orchard for their daily needs and also for their source of side incomes. Below shows some figures of the rubber trees plantation and oil palm tree plantation that were managed by the resident at the study area (Figure 4.5 & Figure 4.6)

Figure 4.5: Rubber tree plantation

Figure 4.6: Oil palm plantation

d.Traverse and Observation

The geological mapping in the study area was covered through tranversing and observation method, in order to collect geological data, rock sampling, and measuring. Traversing is one of the alternative mapping strategy to follow the formation contacts. The traverse route and target was planned and set before going to field.

Generally, the fresh outcrops can be traverse along the river rather than along the road cut. The observations are not made randomly, but followed the every change of the fixed patterns of lithologies. Moreover, the identification and observation were also made basically based on the geological structures such as fault, folds and joints that found in the study area. Furthermore, the changes of structures and lithologies were marked and recorded during the mapping process. Figure 4.7 below show the traverse map of study area.

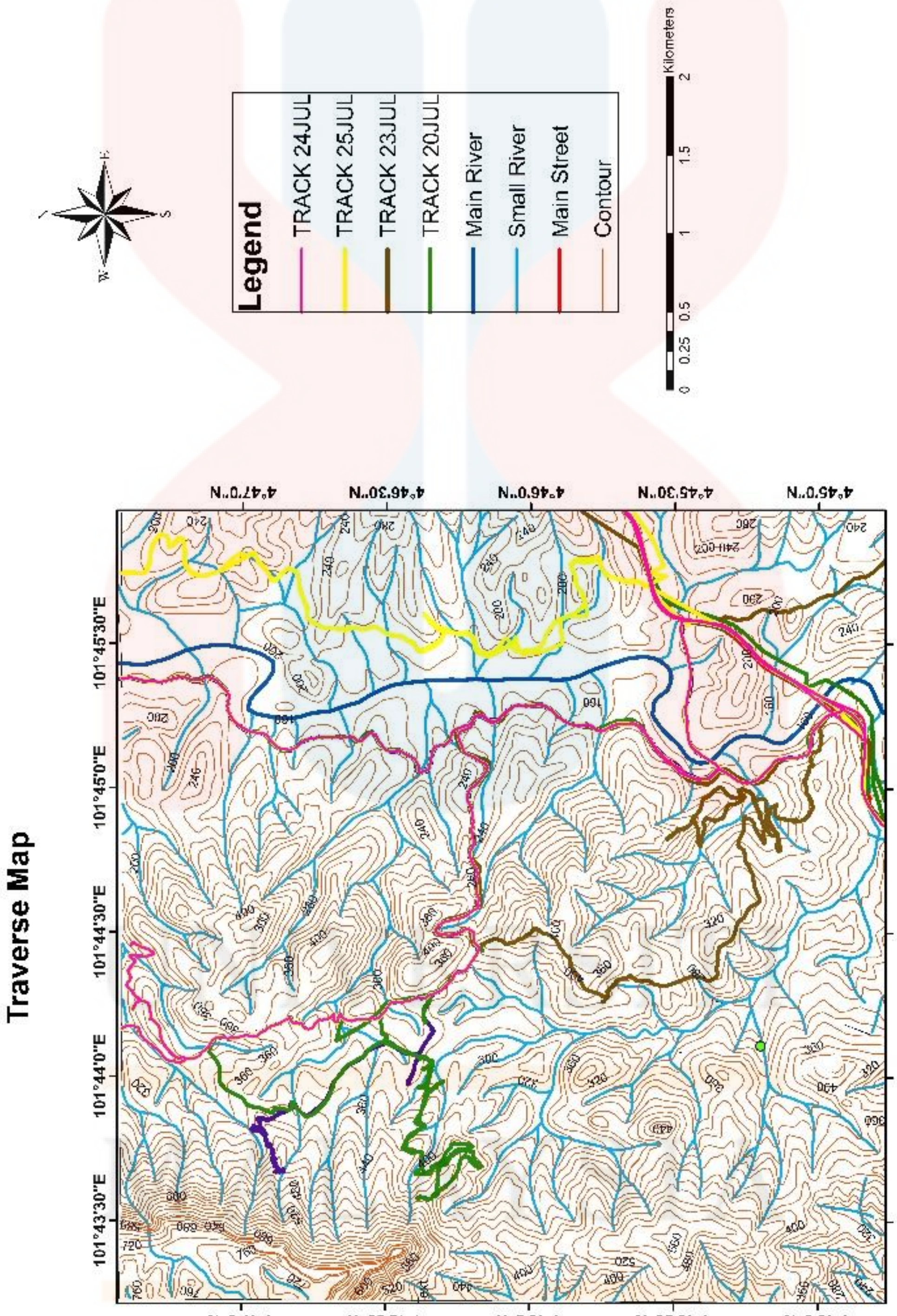


Figure 4.7: Traverse map of study area

4.2 Geomorphology

a. Geomorphologic classification

Geomorphology is referred to the landform and landscape of Earth. Landform such as mountain, valley and slope are those are characterizing as an individual features. Landscape is defined as combination of numerous landforms such as mountainous and terrain. Geomorphology can be divided into four major parts which are mountains, plains, plateaus and hills which those types occur also exist in the study area. The processes that shape the landforms are because of two broad categories either endogenic and exogenic process. Those processes take a long period of time to form. Endogenic is described as process that driven by internal convection that operate beneath the surface of Earth such as tectonic process, volcanism and isostacy animation.. Endogenic is a process that operates on the Earth surface such as weathering, erosion, aeolian activity and hydrologic cycle. There also process known as extragenic which from meteor impact but not be focused on this research. Mountain usually recognizes in form of peak, is a large landform that rise above the surrounding land. Valley is identifying drained by rivers and occur in flat plain or between hills while flat area landform that commonly occurs in low land known as plain area. Fluvial process is a morphology formed by the process deposition that associated by rivers and stream.

Geomorphology are defined as the processes that take place of the Earth's evolutionary towards its shapes and landform. Furthermore, it also known as the study of the Earth itself in terms of the Earth shape and landform that have several process and evolution that creates the environment of the Earth interior. Moreover, the meaning of landform is that any naturally formed features or any recognizable of the solid surface on the Earth either in small, medium or large scale of features such as hills, karst, plains, valleys, river, streams, mountains, plateaus, bays, volcanoes, canyon, and mid-ocean ridges. On the other hand, landform are also divided into two categories which is gross physical features and physical attributes. In the aspect of gross physical features is that it take place such as for lakes, cliff, mountains, hills, ridges, as well as other kinds of oceanic water bodies and inland while in the aspect of physical attributes it take place such as for elevation, orientation, slope and soil type. Figure below shows some of geomorphology at the study area such panorama (Figure 4.8) of gunung ayam, quartz vein and hilly mountain and also some small scale of waterfall (Figure 4.9)

Figure 4.8: Panorama at the study area

Figure 4.9: Small scale of waterfall

Topograraphy is a study of shape, features of surface and also description of the formation. The features that related to the study area are included hilly, mountainous, plain, rolling and undulating. Based on (Raj, 2009), the topographic unit can be divided into differences elevation (Table 4) and below is also shown Figure 4.10 of geomorphological map (3D map) of study area.

Table 4: Topographic unit, (Raj, 2009)

Description	Low lying	Rolling	Undulating	Hilly	Mountainous
Mean elevation(m)	<15 meters above sea level	16-30 meters	31-75 meters	76-300 meters	>301 meters

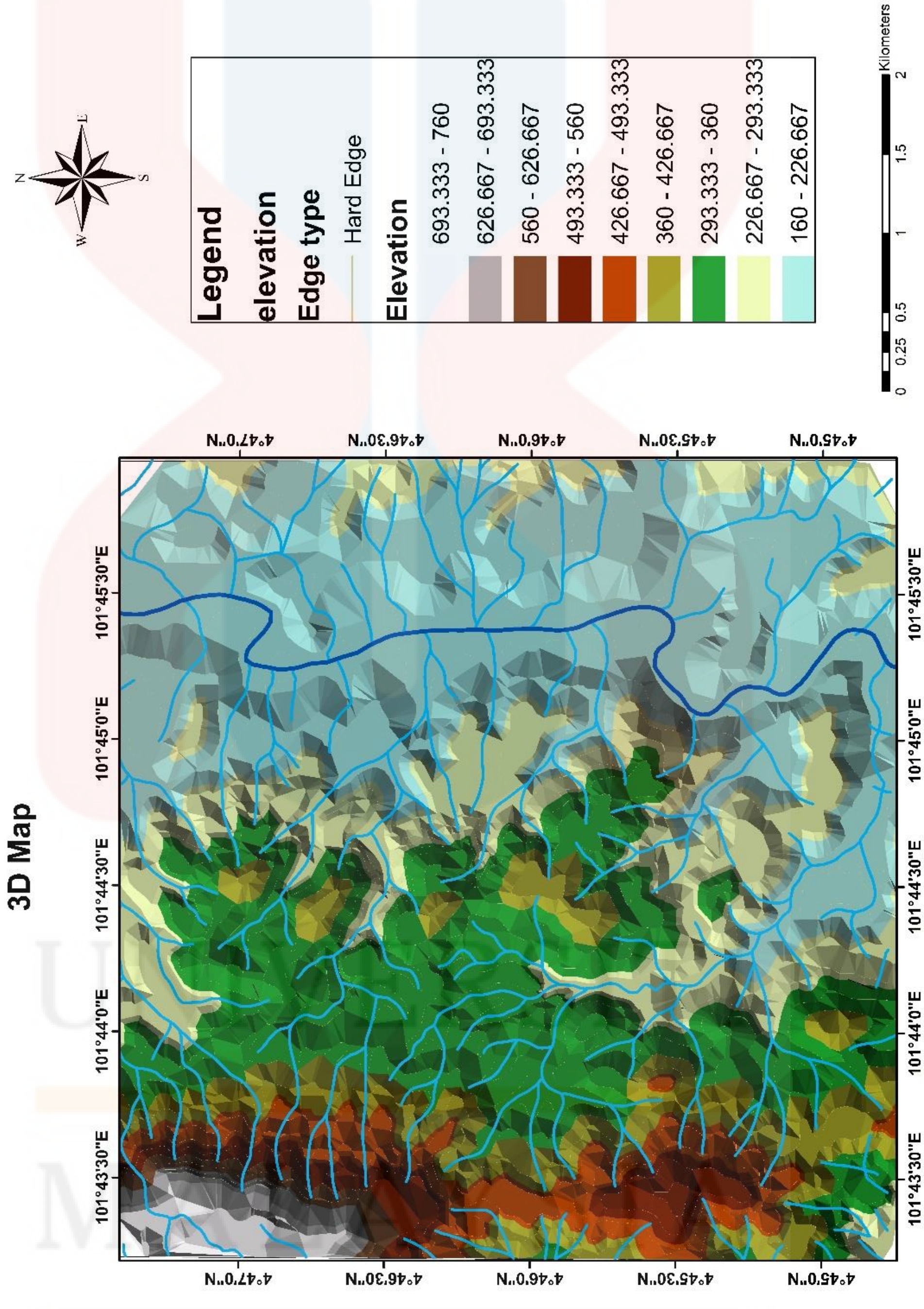


Figure 4.10: Geomorphologic map (3D map) of study area

b. Weathering

Weathering is the processes where the rock or minerals on the Earth surface are break down or loosen it strength because of many factors and reasons. Water, ice, acids, plants, animals, and changes in temperature are classifying as agents of weathering to occur. The loosen strength of rock cause the existence of erosion process to occur and thus the pieces of rock and mineral are being transported. Forces of weathering occur because there are no rock on the Earth can resist the weathering and erosion. Weathering is the process where it form in situ condition (same location) while erosion occurs in other places with help of agents.

The landscape or landform in an area will change because of the process of weathering. Weathering wears away exposed surfaces over time. Exposure of rock to surface is more vulnerable to weathering occur than a rock which being buried beneath the surface. This is because on the surface, there are agents that acts as catalyst of weathering such as wind and water. Soil is usually the first production of soil. Mixing of weathered materials from collection of rock and minerals make the soils more fertile than the soil is mix with only type of rocks. Weathering process can be divided into three, physical, biological and chemical weathering. All these three types of weathering have its own characteristics.

1) Physical/mechanical weathering

Physical weathering also known as mechanical weathering is a breakdown or loosens strength of rock and soil by the interaction to the atmospheric condition. This process related to disaggregation where disintegration of rock occurs without any chemical changes. The agents of physical weathering are water or ice, temperature and pressure. Water can seep into the rock via crack. When water freezing into ice, it widen the opening of cracks and splitting the rock. Once ice melts erosion process when water carries all the small fragments of rock and soils away. This process also known as freeze-thaw cycle. Figure 4.11 below shows the changes of temperature also can cause the rock changes. When the rock expand (hot condition) and contract (cold condition) and this process keep continue also cause the rock slowly cracking and splitting and also called exfoliation. Pressure also one effect of mechanical weathering. As an example of process known as unloading, a rock is being release by overlying rock, cause the rock to expand and form crack and fractures.

Figure 4.11: Physical weathering

2) Biological weathering

Biological weathering is define as a process that interacted only by organisms such as animals, plants, fungi and microorganisms. Figure below shows one of the processes by biological weathering is breaking rock by roots of tree. The cracks of rock also increase the response of the root to grow through the rock to achieve the water beneath the surface. This cause the opening of rock becomes bigger and splitting. Below shows biological weathering of oil palm trees (Figure 4.12)

Figure 4.12: Biological weathering of oil palm trees.

3) Chemical weathering

Chemical weathering is process that not related to the changes of rocks or splitting but is refer to the changes of the chemical composition. The chemical weathering is through carbonation, hydration, oxidation or hydrolysis. Carbonation is a process due to the rain which is slightly acidic because of the carbon dioxide (CO_2) combining with calcium carbonate such as limestone ($CaCO_3$) forming calcium bicarbonate, or $Ca(HCO_3)_2$. Figure below shows the alteration of chemical composition causes the dissolution process to occur. Hydration is a process reaction of water to a mineral such as anhydrous mineral. An example of the process is calcium sulphate ($CaSO_4$) where when react with water, turn into gypsum. Hydrolysis refers to the decomposition of chemical bond of minerals. Oxidation is defined as reaction of oxygen with metal element of rock forming oxides. Below shows chemical weathering of limestone (Figure 4.13)

Figure 4.13: Chemical weathering of limestone

Weathering composed of different grades based on its categorized. The grades are consists from Grade I to Grade IV based on table 4.1

Term	Description	Symbols
Fresh	No visible sign of decomposition (no discolouration)	I
Slightly weathered	Discolouration of rock indicates weathering of rock material and discontinuity surfaces.	II
Moderately weathered	Less than half of rock material is decomposed into soil.	III
Highly weathered	More than half of rock material is disintegrated into soil.	IV
Completely weathered	All the rock material is decomposed into soil with fragment and pieces of rock still preserved	V
Residual soil	Totally fragment and pieces of rock decomposed into soil.	VI

Table 4.1: Grade of weathering profile.

From the observation of the outcrop, the rock breaks down into small fragment and pieces because of the temperature and pressure that act on it. This outcrop (Figure 4.14) can be divided into two grades which are Grades V (Completely weathered) that shows the small fragment still preserved and Grade VI (Residual soil) that shows totally disintegrated into soil.

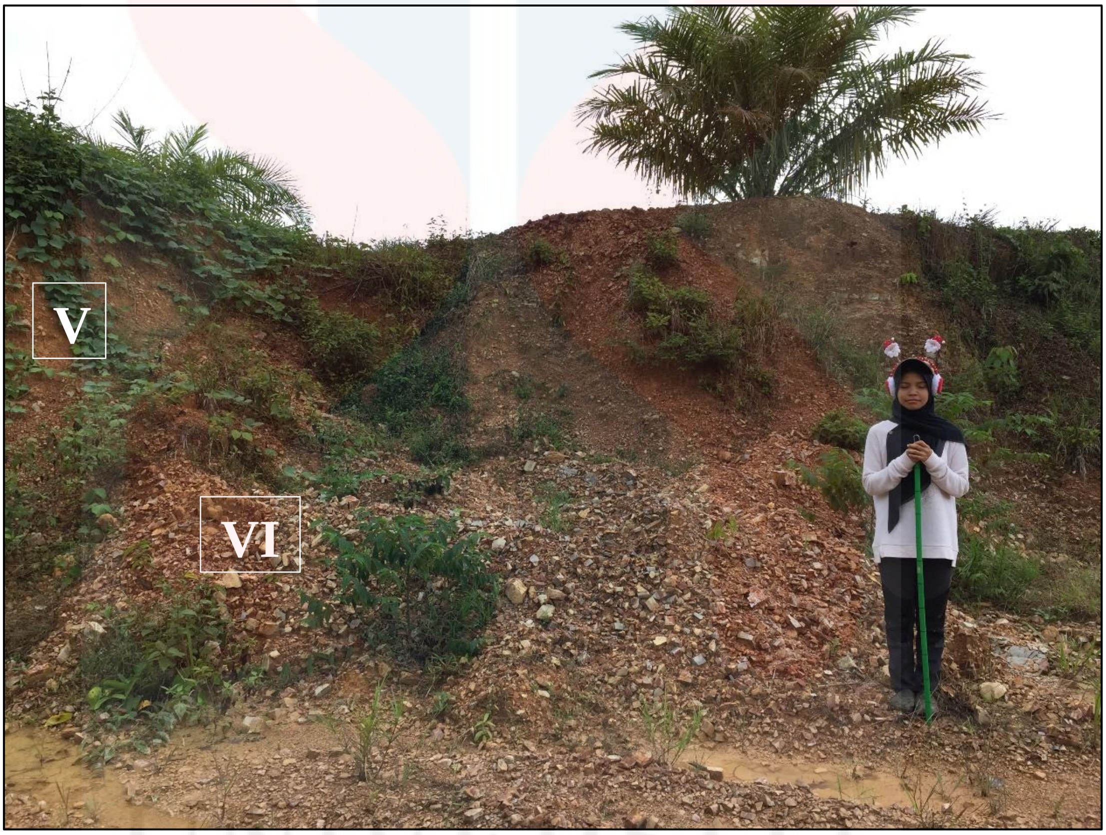


Figure 4.14: Weathered outcrop

c. Drainage Pattern

Drainage pattern in other word also called as river system is classifying as one of the types of geomorphology. The formation of river system is created by the streams, lakes and river in a particular drainage basin. The pattern is control by topography and gradient of land either the presence of bedrock and structures. Stream also classifying as a drainage basin where is topographic region from which receives groundwater flow, runoff and through flow. There are some types of drainage pattern such as dendritic, parallel, trellis, rectangular and radial. Figure 4.16 below shows the drainage pattern of the study area.

Dendritic is the most common drainage pattern that form like a branching of roots. It form because of the region is underlying by homogenous material and also the types of rock must in impervious and non-porous. The tributaries where flow from contributing stream joining together into the main stream and create the pattern. Generally, the pattern develops by the river channel follow the slope of the terrain. Mostly can be found in a V-shaped valley.

Parallel is one type of drainage pattern that can be found in the study area. The formation is caused by the steep slopes with some terrain. The steep slopes make the stream to flow straight in same direction with a very few tributaries. The pattern also develops in a region of parallel, elongate landform like outcropping resistant rock bands. Tributaries system encourages stretching out in a form of parallel following the surrounding of slopes. Parallel pattern usually act as an indicator existence of the structure such as faulting that across the steeply bedrock area.

Trellis drainage pattern is known as an area where the folding occurs. This occurs when the main river flow along the strike valley thus, small tributaries joining into the river from the steep slopes of mountain.

Rectangular drainage pattern commonly form in the area that faulting occurs. This pattern develops when stream flow to the rock which is uniform resistance to erosion. The faulting that happens to the surface produces the off sets to the stream. Finally, straight line of stream produced with small tributaries join into the main stream.

Radial drainage pattern is a stream that outward from a top of mountain. This pattern develop when stream flow in many direction from a central peak point. Mostly the pattern occurs in the area of volcanoes and Figure 4.15 below shows several example of types of drainage pattern.

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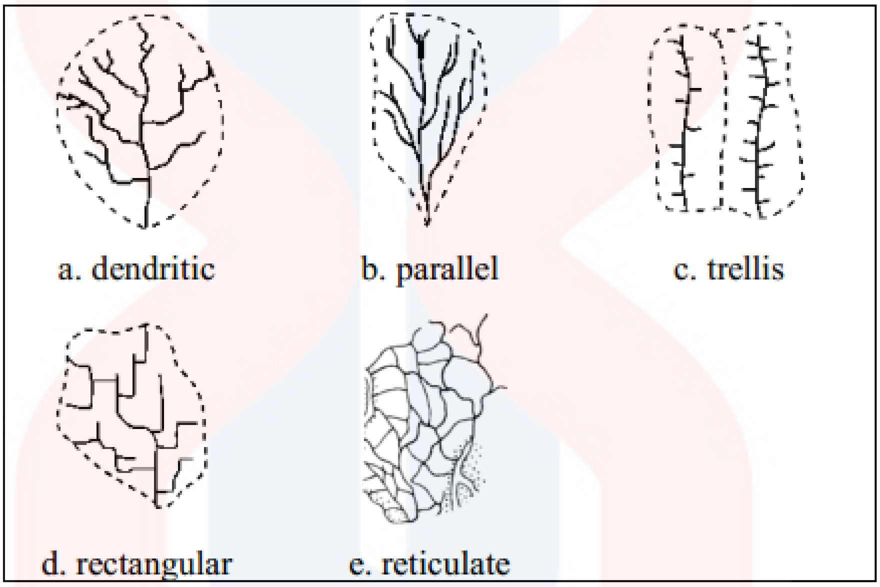


Figure 4.15: Example types of drainage pattern (Source: Google image)

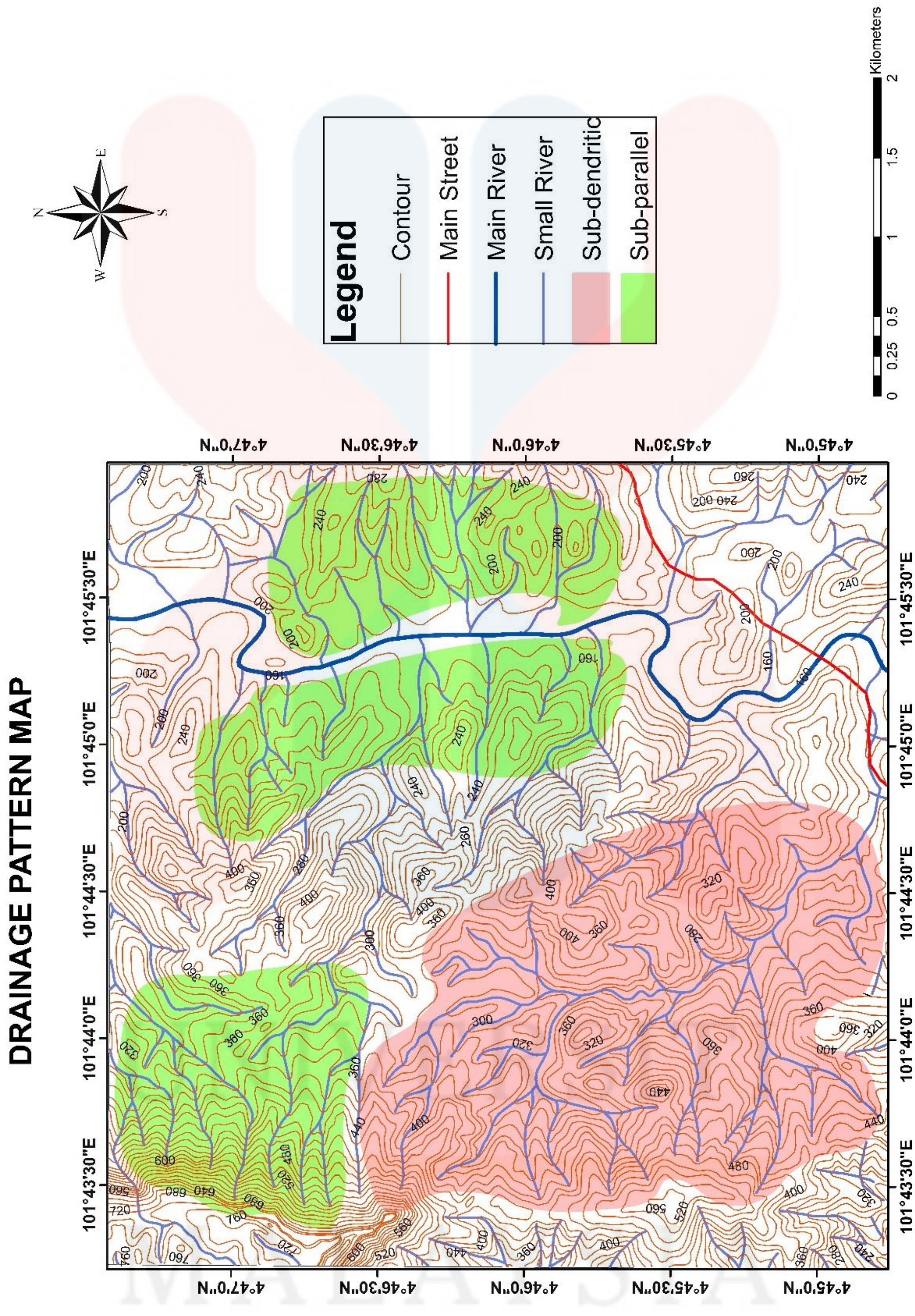


Figure 4.16: Drainage pattern map of study area

4.3 Lithostratigraphy

Lithological characteristic and properties are considered in lithostratigraphy of rock unit in the rock strata and their relative stratigraphic positions. This can be considering by physical and geometric relationship to determine the relative stratigraphic position that can indicate which one are the younger and which one is the older beds.

The geological mapping and field investigation was done by traversing the accessible to semi-accessible area. For each type of rocks, it can be classified by their colour, mineral composition, texture, grain size and weathering grade characteristics. Lithostratigraphic unit for each type of rock can be determined from their petrography, mineralogy, paleontology, lateral variation and relationship with adjacent units whether by horizontal or vertical. During the mapping process, several outcrops from different type of rocks have been identified which are sedimentary rock and igneous rock. There are four type of lithology of rocks in this study area which is conglomerate, limestone, mudstone, shale, chert and tuff.

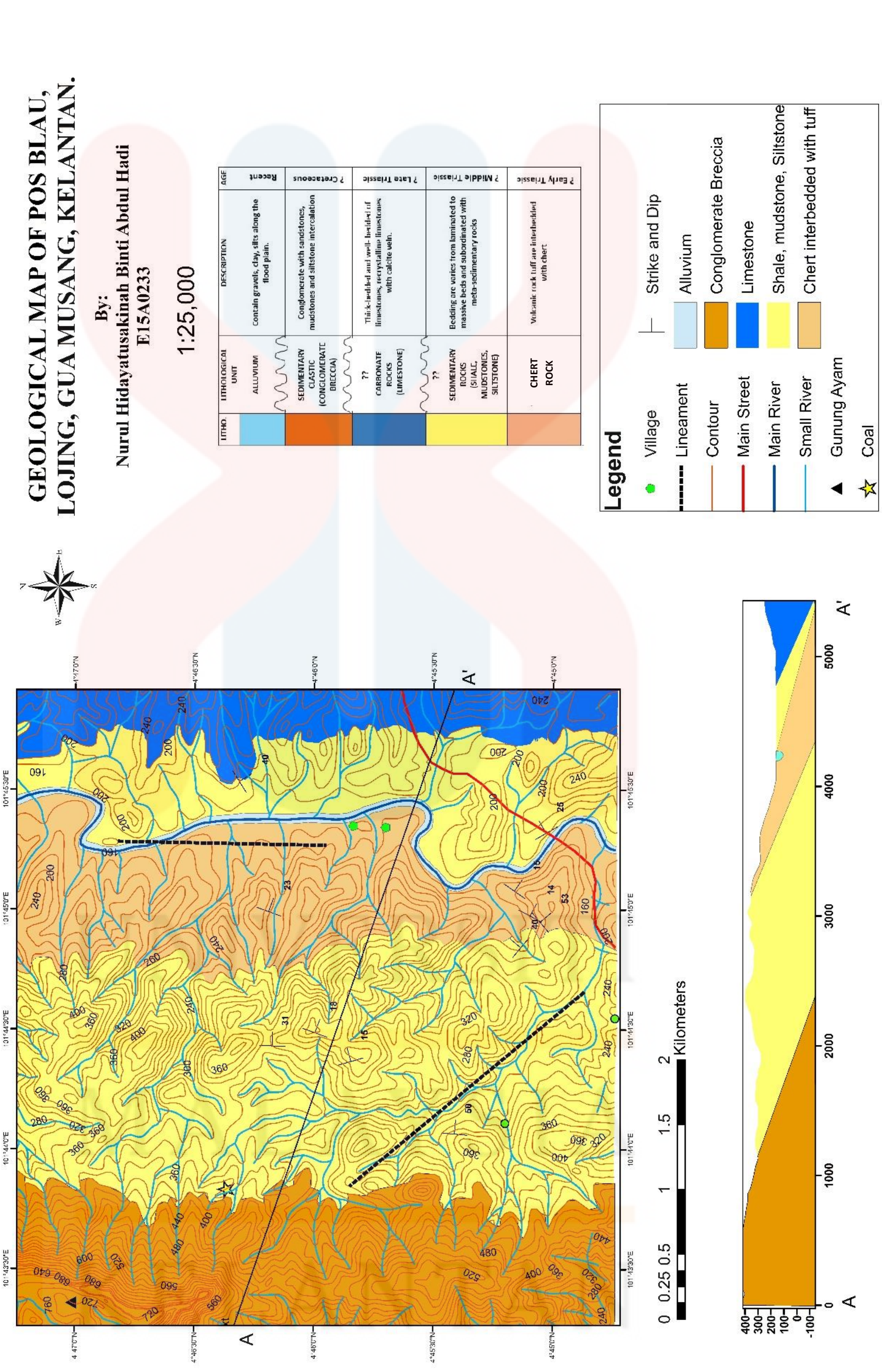


Figure 4.17: Geological map of study area.

a. Stratigraphic position

LITHO.	LITHOLOGICAL UNIT	DESCRIPTION	AGE
	ALLUVIUM	Contain gravels, clay, silts along the flood plain.	Quarternaary
	SEDIMENTARY CLASTIC (CONGLOMERATE BRECCIA)	Conglomerate with sandstones, mudstones and siltstone intercalation	? Cretaceous
	?? CARBONATE ROCKS (LIMESTONE)	Thick-bedded of limestones, recrystalline limestones with calcite vein.	? Late Triassic
	?? SEDIMENTARY ROCKS (SHALE, MUDSTONES, SILTSTONE)	Bedding are varies from laminated to massive beds and subordinated with meta-sedimentary rocks	? Middle Triassic
	CHERT ROCKS	Volcanic rock tuff are interbedded with chert	? Early Triassic

Table 4.2: Stratigraphic position of study area.

Based on the table 4.17 above shows the stratigraphy position of the study area. The oldest rock is basically the tuff unit rock which were interbedded with chert unit rocks. It was found majorly chert unit rock and interbedded with generally small beds of tuff unit rocks. The age for the chert interbedded with tuff unit rock is estimated at Early Triassic. Moreover, the upper part that overlies the interbedded of chert and tuff unit rocks was that the sedimentary rocks which were the mudstone, shale, and also siltstone. Their bedding were varies and also found interbedded with each other such as mudstone interbedded with shale and also subordinated with some meta-sedimentary rocks such as slate and also phyllite. The age for those rock were at Middle Triassic. Next, were the carbonate rock which were generally limestone which have a thick bedding with its recrystalline limestone and some geological structures such as calcite vein. Furthermore, there were also some basal conglomerate that were subordinated in the limestone which were estimated occur by the structural contact. Last but not least, was the youngest rock which were the conglomerate rock in the study area which were generally found at Gunung Ayam. The age for the conglomerate rock were at Cretaceous aged. Based on the Figure 4.18 below shows the lithology map of the study area.

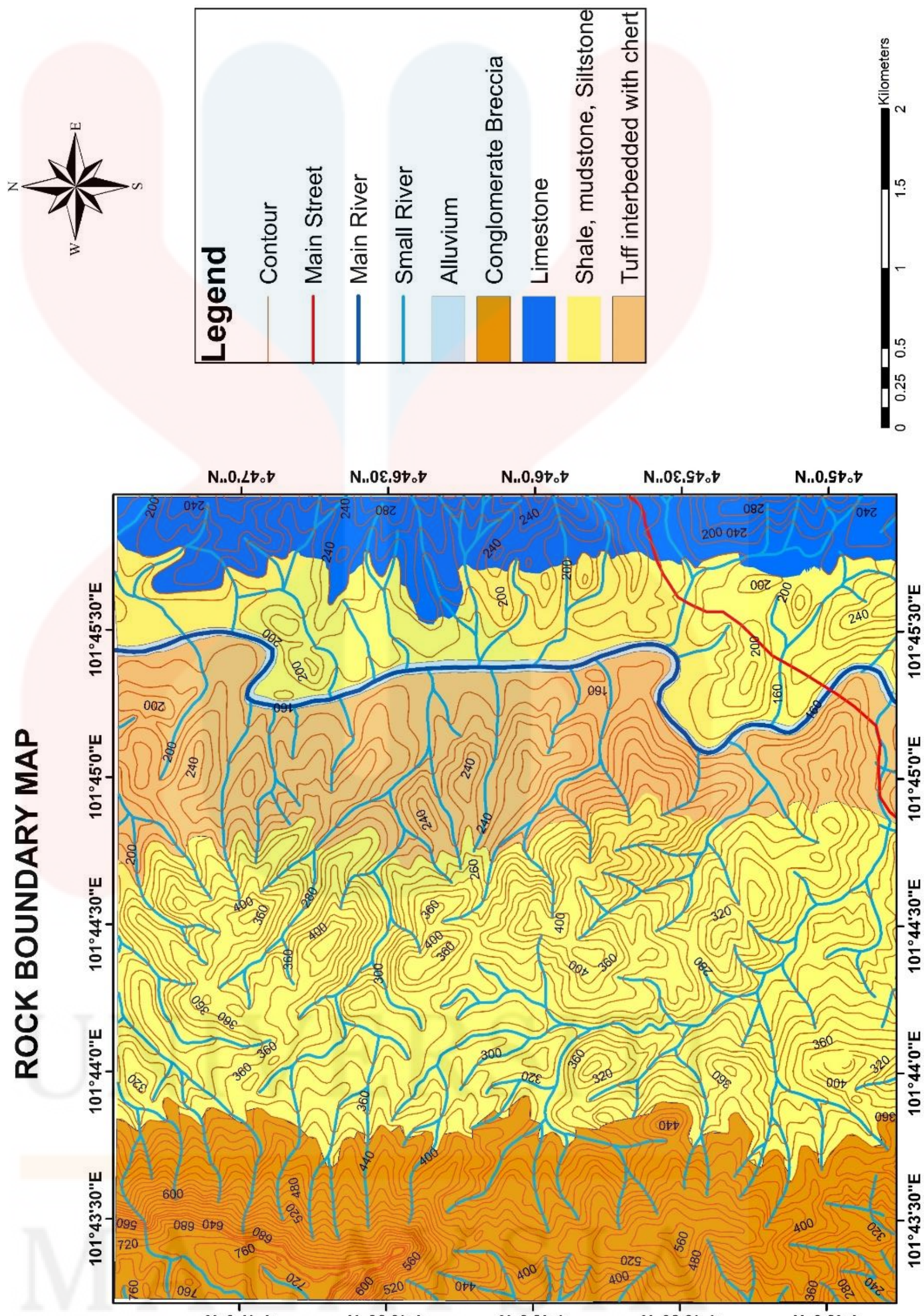


Figure 4.18: Lithology map of study area

b. Unit Explaination

Tuff unit:

Tuff have been dispersed and distributed majorly in the study area with the interbedded with chert rock. The coordinate tuff was found was at N 04 46’25.3’’, E 101 43’ 58.6’’. The tuff commonly found were generally weathered which were easily broken down and very difficult to find the fresh one. It is white in color and majorly found in fine volcanic ash which it is might be involved in volcanic eruption. Moreover, there is no obvious of geological structure found on the outcrop. Furthermore, the tuff sometimes can be considered as medium to small scale of bedding. Below show tuff outcrop and hand specimen of tuff rock sample (Figure 4.19 & Figure 4.20) found in Pos Blau, Lojing, Gua Musang, Kelantan which near to the Liziz oil palm plantation. Figure 4.21 below shows the tuff mineral thin section and on table 4.3 shows the mineral description of tuff rock thin section under microscope.

Figure 4.19: Volcanic ash of tuff outcrop

Figure 4.20: Hand specimen of tuff rock sample.

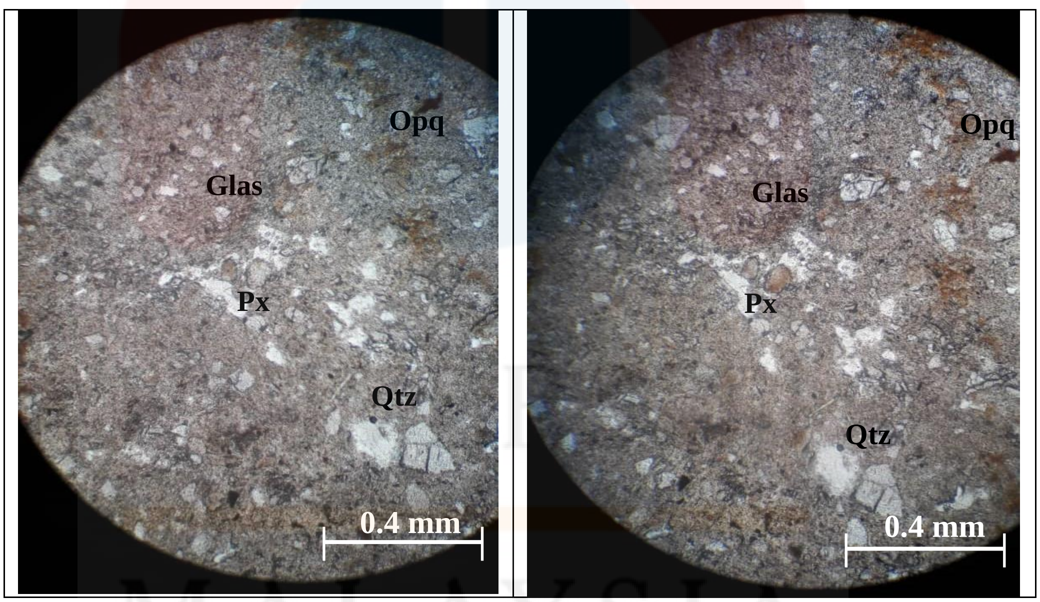


Figure 4.21: The photomicrograph of tuff under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Volcanic Glass (Glas)	Under PPL, shows clear and low relief, but it shows light black under XPL.
Opaque Mineral (Opq)	Opaque minerals are not common in this sample. It is black in colour in both PPL and XPL.
Quartz (Qtz)	It has low relief under PPL. The colour mostly colourless in PPL and XPL
Pyroxene (Px)	Show colourless colour in PPL and brown colour in XPL. Has low in birefringe and medium relief

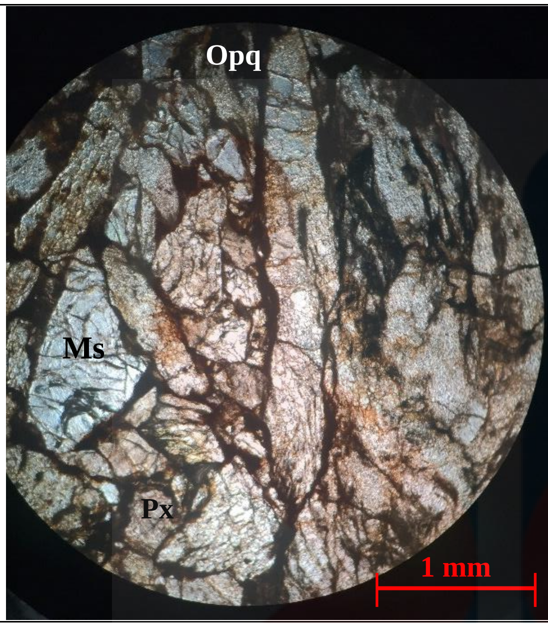
Table 4.3: The description of mineral under thin section of tuff sample.

Conglomerate breccia unit:

The conglomerate breccia rocks are majorly found at Gunung Ayam. The outcrop was found along the Gunung Ayam foothill. Moreover, mostly of the rock found around the foothill of Gunung Ayam The distribution for the conglomerate breccia rock were vertically in the map of the study area. This were because of the colliding of the Sibumasu tectonic plate and Indochina tectonic plate.

The rock composition for the conglomerate breccia rocks was basically sandstone, siltstone, andesite, quartz, mudstone and many more that were been cemented together and forms the conglomerate rock. The age for the conglomerate breccia rock were estimated at Cretaceous. Figure 4.22 below shows the hand specimen of conglomerate breccia rock at the foothill of Gunung Ayam. The conglomerate breccia rock may have variable of rock colour such as greenish-blue that may come from the andesite and also may be cemented together with sandstone, siltstone and many more. The grain-shaped are rounded-angular shaped with high sphericity (refer Appendix C). The sorting are very poorly sorted and it is fragment-dominated (refer Appendix B). Figure 4.23 shows the conglomerate breccia thin section and on table 4.4 shows the mineral description of conglomerate breccia rock thin section under the microscope.

Figure 4.22: Hand specimen of conglomerate breccia rock sample.



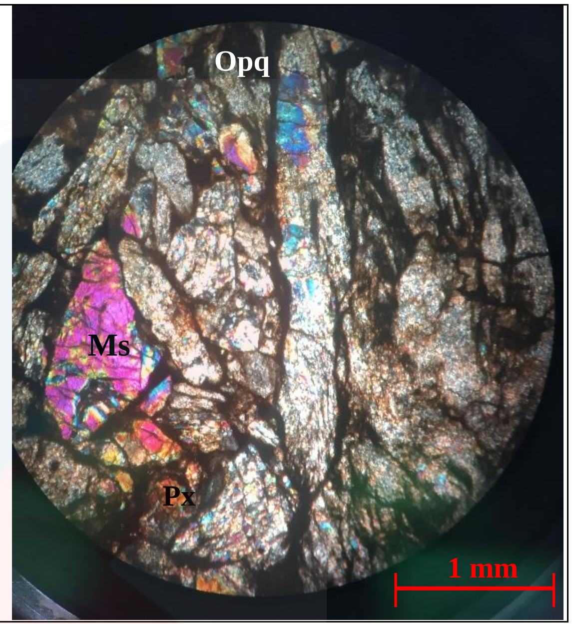


Figure 4.23: The photomicrograph of conglomerate breccia under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Muscovite (Ms)	Shows colourless in PPL and shows pink, blue in XPL. Has high birefringe. Has high relief.
Pyroxene (Px)	Show colourless colour in PPL and brown colour in XPL. Has low in birefringe and medium relief.
Opaque Mineral (Opq)	Opaque minerals are not common in this sample. It is black in colour in both PPL and XPL.

Table 4.4: The description of mineral under thin section of conglomerate breccia sample.

Shale unit:

The shale rock were mediumly weathered and the texture for the shale rock unit were very fine-grained. The distribution for the shale rock unit were also distributed vertically in the map of study area. The colour of the rock can be described in grey and black in colour. The grain-sized were very fined-grained. The age of rock were estimated at Middle Triassic. Below shows the outcrop of shale rock which were also interbedded with mudstone and the hand specimen of shale rock sample (Figure 4.24 & Figure 4.25).

The grain-shaped were subrounded with both high and low sphericity and moreover, the sorting of the minerals were moderately sorted and matrix-dominated under microscope observation (refer Appendix B & C). Figure 4.26 below shows the shale thin section and on the table 4.5 shows the mineral description of shale rock thin section under the microscope.

Figure 4.24: Outcrop of shale interbedded with mudstone rock unit.

Figure 4.25: Hand specimen of shale rock sample.

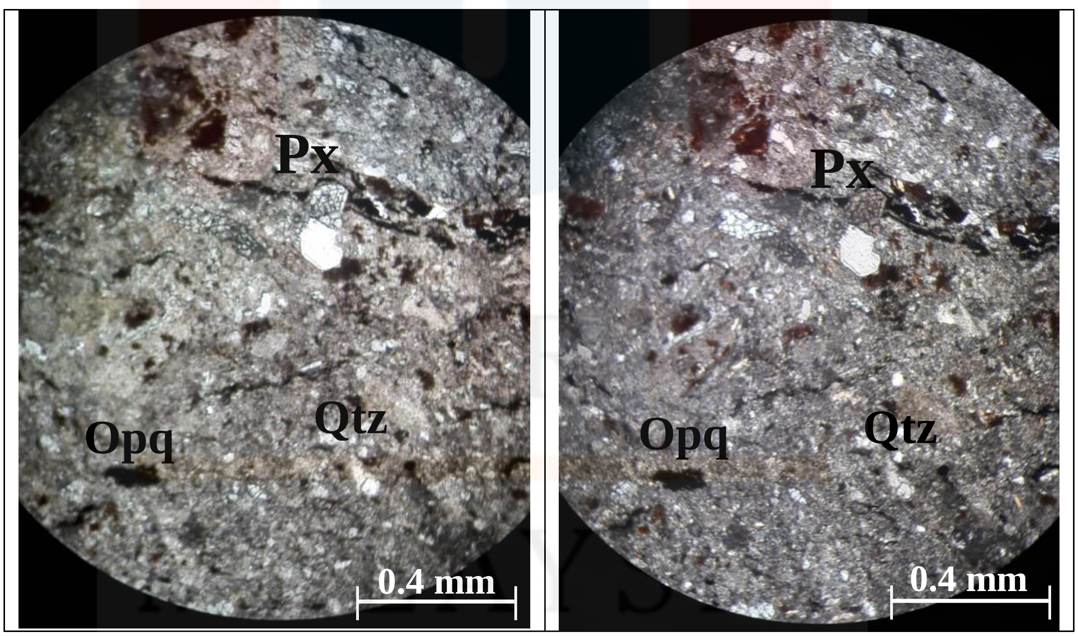


Figure 4.26: The photomicrograph of shale under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Quartz (Qtz)	It has low relief under PPL. The colour is grey-white in PPL and change to light black in XPL.
Opaque Mineral (Opq)	Opaque minerals are not common in this sample. It is black in colour in both PPL and XPL.
Pyroxene (Px)	Show colourless colour in PPL and brown colour in XPL. Has low in birefringe and medium relief.

Table 4.5: The description of mineral under thin section of shale sample.

Limestone unit:

The limestone rock unit were generally found at the Lojing-Cameron Highlands Highway. The colour of the limestone were basically black to dark grey in colour. The grain-sized were very fine-grained. There were several structures such as mineral-filled fracture such as calcite veins where the calcite veins reacted to the hydrochloric acid vigorously. The limestone unit rock seems to have very massive bedding which based on the field mapping observation there were no identification of well-bedded bedding. The age of the limestone unit rock can be described at Late Triassic age. Below shows outcrop of the limestone and the hand specimen of limestone rock sample (Figure 4.27 & Figure 4.28).

The limestone grain-shaped were sub rounded with both high and low sphericity. Furthermore, the sorting for the mineral in limestone were very poorly sorted and it is matrix-dominated under microscope observation (refer Appendix B & C). Figure 4.29 below shows the limestone thin section and on the table 4.6 shows the mineral description of limestone rock thin section under microscope.

Figure 4.27: Outcrop of limestone.

Figure 4.28: Hand specimen of limestone rock sample.

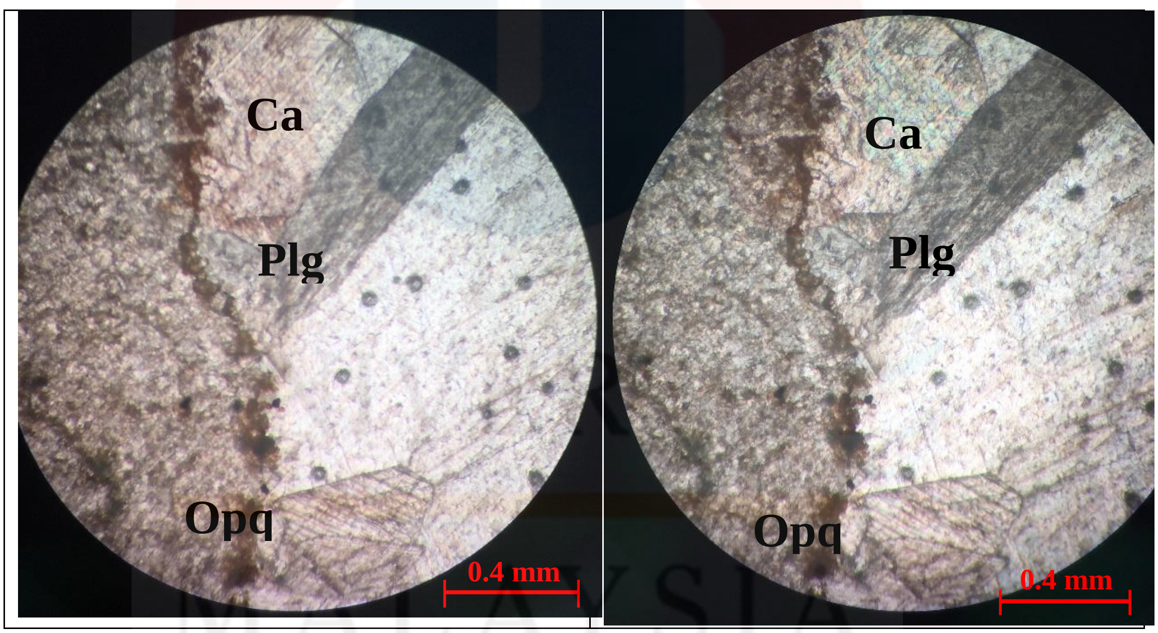


Figure 4.29: The photomicrograph of limestone under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Calcite (Cal)	It is colourless in PPL and change to masked in colour in XPL. Low in relief and birefringe.
Plagioclase (Plg)	Plagioclase shows low relief and colourless in PPL and low birefringe in XPL.
Opaque Mineral (Opq)	Opaque minerals are not common in this sample. It is black in colour in both PPL and XPL.

Table 4.6: The description of mineral under thin section of limestone sample.

Chert unit:

The chert rock outcrop were found at the Lojing-Cameron Highland Highway which were generally medium to highly weathered. The colour of the chert rock by the field mapping observation were generally grey and yellowish may be from weathering effects. The grain-sized for the chert rock were very fine-grained. Below shows the chert outcrop and the hand specimen for chert rock sample (Figure 4.30 & Figure 4.31). The grain-shaped for chert are angular shaped with both high and low sphericity. Furthermore, the sorting is well-sorted and matrix-dominated under microscope observation (refer Appendix B & C). Figure 4.32 below shows the chert thin section and on the table 4.7 shows the mineral description of chert rock thin section under the microscope.

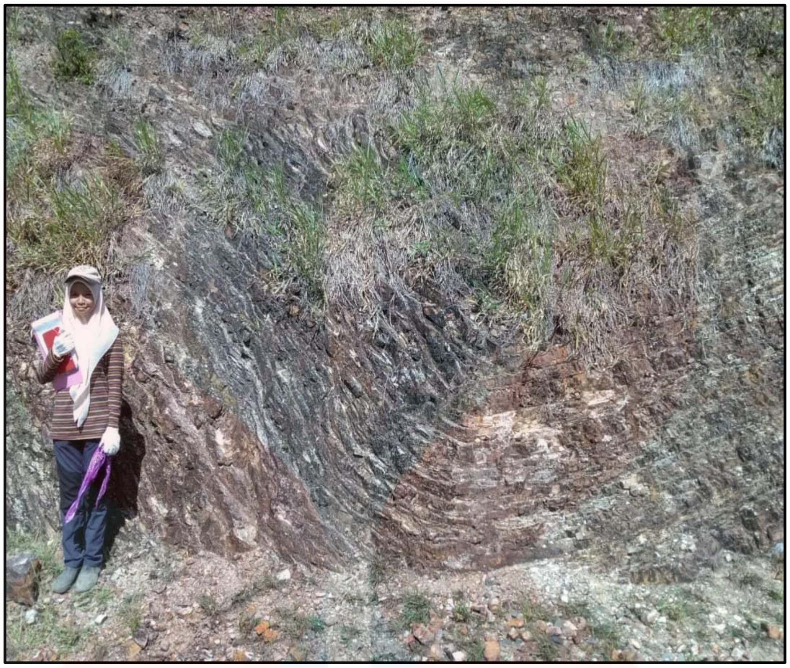


Figure 4.30: Outcrop of chert rock

Figure 4.31: Hand specimen of chert rock sample.

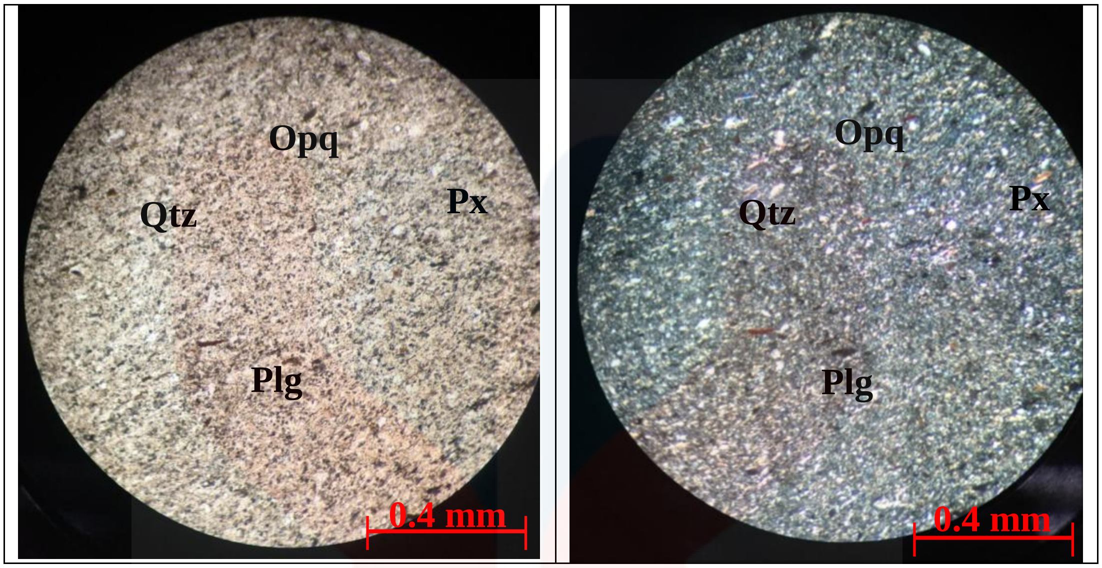


Figure 4.32: The photomicrograph of chert under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Plagioclase (Plg)	The plagioclase is anhedral shape and low relief. It is also low in birefringe. It is colourless under PPL and low birefringe in XPL.
Opaque Mineral (Opq)	Opaque minerals are not common in this sample. It is black in colour in both PPL and XPL.

Quartz (Qtz)	It has low relief under PPL. The colour is grey-white in PPL and change to light black in XPL.
Pyroxene (Px)	Show colourless colour in PPL and brown colour in XPL. Has low in birefringe and medium relief.

Table 4.7: The description of mineral under thin section of chert sample.

Mudstone unit:

The mudstone rock unit were generally found interbedded with shale rock at the Lojing-Cameron Highlands Highway. The colour of the mudstone were black and brown with a grain-sized of very fine-grained. The rate of weathering for mudstone were generally medium to highly weathered. The mudstone were generally interbedded with the sandstone rock unit. There were several structures found on the bedding such as folding that has dipping of 12º and dipping direction of 31. Figure 4.33 and Figure 4.34 below shows the outcrop of mudstone and mudstone thin section under microscope observation. The grain-shaped of mudstone under microscope observation were subrounded with both high and low sphericity (refer Appendix B & C). It is matrix-dominated and are aged at Middle-Triassic. Based on the table 4.8 shows the mineral description of mudstone rock under the microscope.

Figure 4.33: Outcrop of mudstone rock

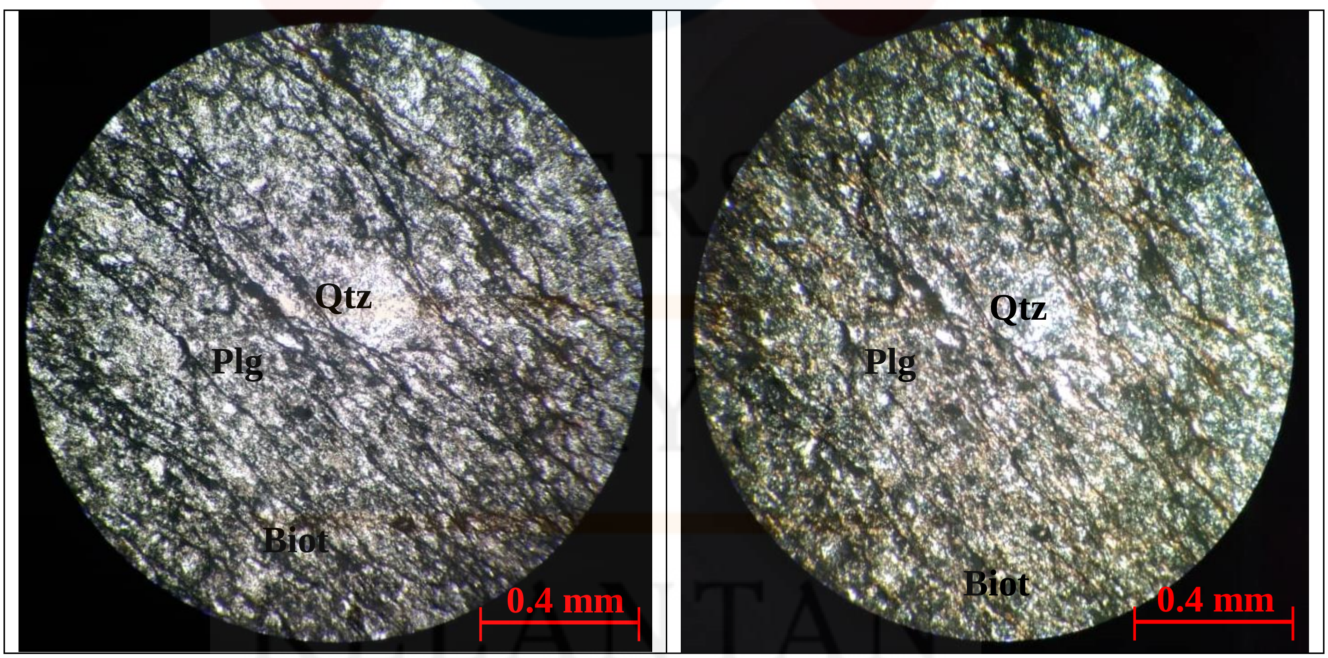


Figure 4.34: The photomicrograph mudstone under plain polarized (PPL) on the left and cross polarized (XPL) on the right.

Composition of Mineral	Description of Optical Mineral
Quartz (Qtz)	The quartz shows white in PPL and grey in XPL. It is anhedral shape and no cleavage.
Plagiclase (Plg)	It shows low birefringe in XPL and colourless under PPL.
Biotite (Biot)	It shows low relief and dark brown under XPL and light brown under PPL. Biotite shows no twinning under XPL.

Table 4.8: The description of mineral under thin section of mudstone sample.

4.4 Structural Geology

Based on the geological mapping fieldwork, the structural geological aspect also have been observed and analyzed. There are several geological structures that have been found in the study area which were also related as resulted from the collision of Sibumasu and Indochina plates which form Bentong-Raub Suture. The structures that causes due to the volcanic activity and tectonic setting will be explained here based on the field evidences that found for example, the structures such as thrust fault, folding of anticline and syncline, joints and also fractures.

The local structures basically associated within its regional structures, nevertheless it is important to observe and mapping out the local structures during geological mapping in the study area. Moreover, the lineament also are relatable with the local structures which has been mapped during the preliminary studies stage. Thus, from the lineament it can shows many indicators such as fault, joint, mineralization of rocks and so on hence the structural occurred can be identified at the location of lineament.

a. Fault

Thrust fault

Thrust fault trending at 8º and plunging at 75º at the foothill of Gunung Ayam that causes massive landslide and creates a large valley at the foothill of Gunung Ayam. The thrust fault is causes by the compression of the stresses and also result from the Earth crust being shortening. Thus, by the movement of rocks in which the hanging wall moving upward and foot wall moving downward and in which it also causes the older rocks to overlies the youngest rocks. (Figure 4.35)

Figure 4.35: Thrust fault at the foothill of Gunung Ayam

b. Joint

Joint is defined as break, brittle-fractured and natural process occurs on rock which exposed to the surface. Commonly, joint can be identifying nearly to the surface of rock and form in various directions either vertical or horizontal. Joint can be form in singly, but mostly in a joint set. Figure below shows the joint analysis of Georose (Figure 4.36) at the foothill of Gunung Ayam. It clearly shows that the major forces that come at the range of 90° from North-East which is also known as σ_1 force.

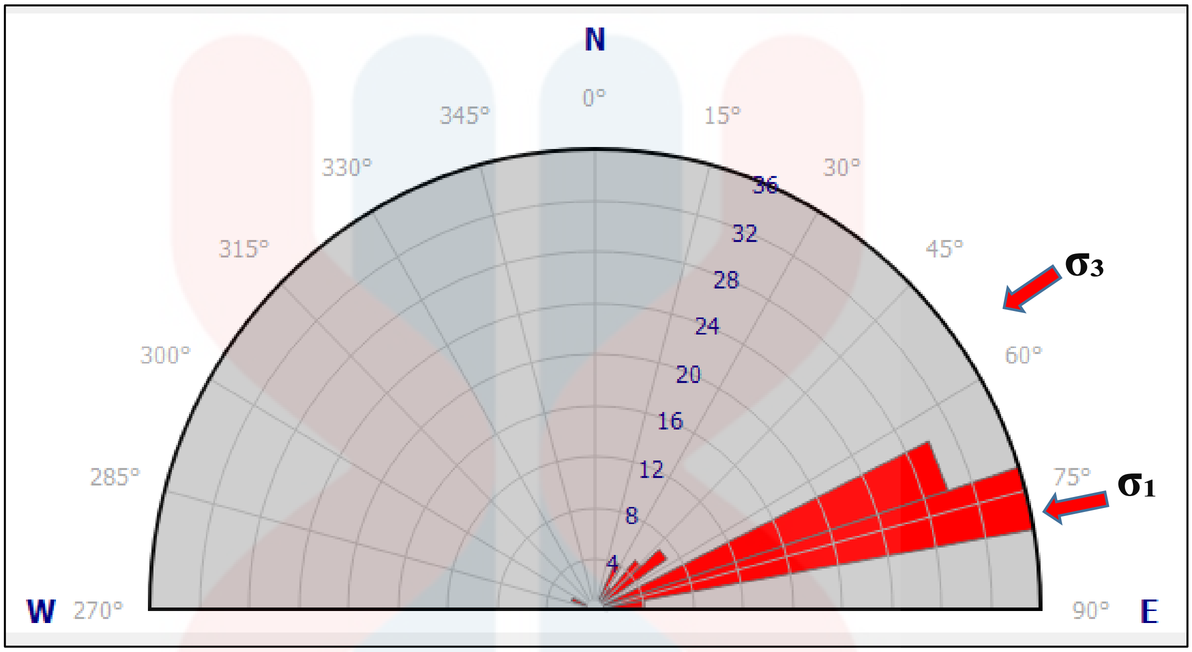


Figure 4.36: Joint analysis of Georose of joints at the foothill of Gunung Ayam

c. Fold

Folding is form when surface in on flat and planar condition are curved and bent due to high temperature and pressure. The folding process can occur in different size from microscopic to mountain sized. Figure below shows the folding that occurs to the host rock, schist which is because of the stress, high temperature and pressure due to the metamorphism process.

i) Syncline folding

These syncline folding (Figure 4.37) occurs at chert type of rocks that were also interbedded with some volcanics rock which is tuff. It direction of dip are about 330 and dipping at 25º. The location for the outcrop were at the Lojing-Cameron Highlands Highway.

Figure 4.37: Syncline fold of chert type rock interbedded with tuff.

ii) Recumbent Fold

The recumbent fold (Figure 4.38) are also from chert type of rock that were interbedded with thin layer of volcanic rock type which is tuff. The recumbent fold have that characteristic of fold that were mediumly sharp of hinge and mediumly tilting sideway. The location of the outcrop were at near the Pos Blau village.

Figure 4.38: Recumbent fold of chert type of rock interbedded with tuff.

Bedding Analysis:

Based on Table 4.8 below, the strike and dip that have been measure from one bedding to another bedding. The results are key in in the Stereonet software.

Number of bedding	Strike	Dip (°)
1	070	21
2	345	14
3	315	28
4	327	12
5	330	16
6	320	46
7	335	46
8	78	8
9	350	74
10	001	21
11	313	8

Table 4.9: Data collection for bedding analysis at chert outcrop at Pos Blau, Lojing, Gua Musang, Kelantan.

Figure 4.39 below shows the 2D stereonets of bedding analysis at chert outcrop of Pos Blau, Lojing, Gua Musang, Kelantan.and its paleostress direction.

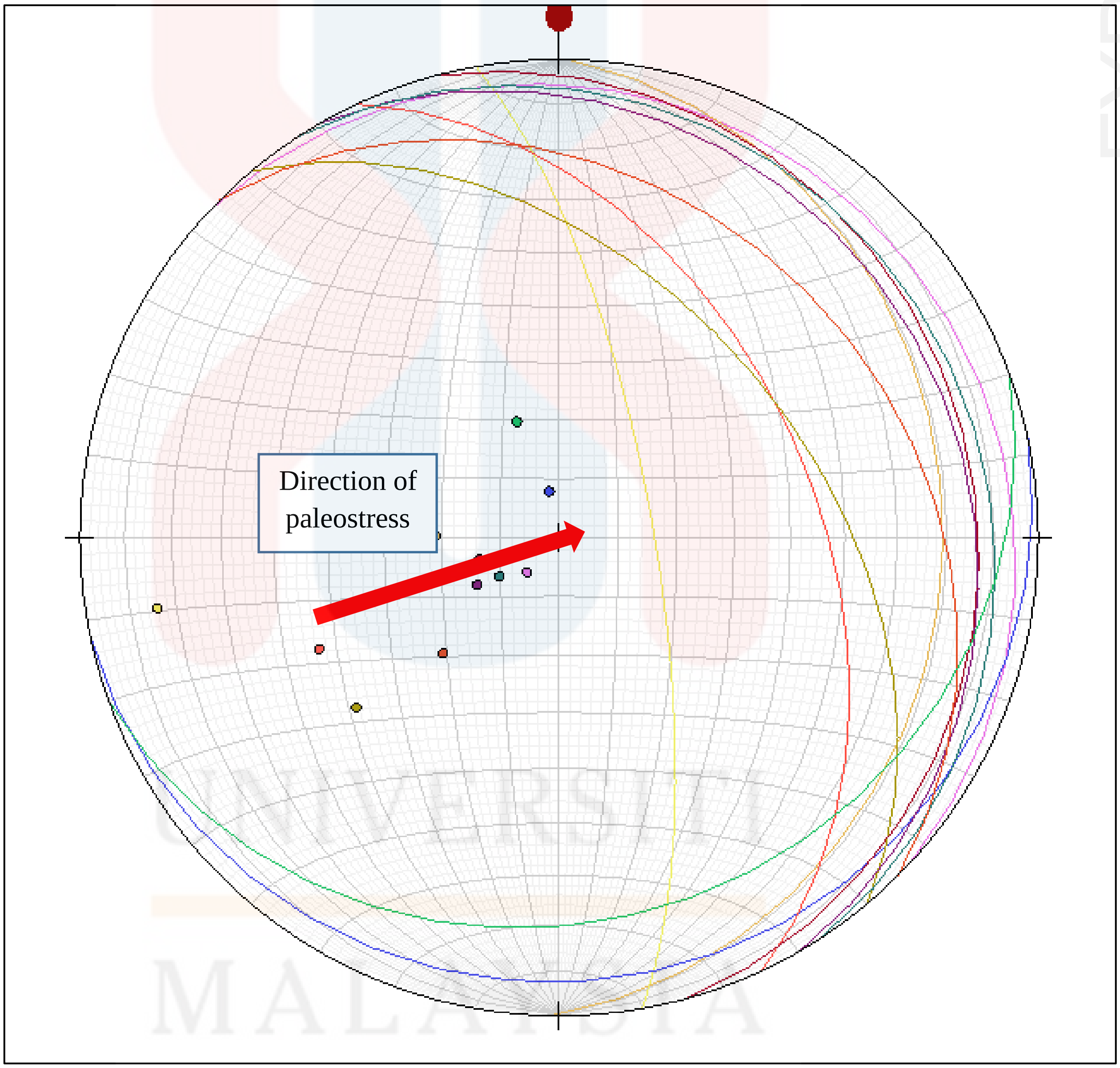


Figure 4.39: 2D view of bedding analysis at chert outcrop of Pos Blau, Lojing, Gua Musang, Kelantan.

Based on the Figure 4.39 above shows that, the first bedding until the last bedding did not have the same direction of dipping. There are 11 planes which represent 11 different beddings and the depositional are during different timeline. The paleostress of all bedding are estimated come from South-West direction.

d. Vein

Vein is a long distinct sheet-like body of crystallized minerals within a rock. Vein form when mineral constituents are flow by an aqueous solution usually by hydrothermal circulation and deposited as a precipitation. Figure 4.38 below shows the quartz is being deposited in the vein. This is the result crystal growth on the planar surface of rock and projecting into open space.

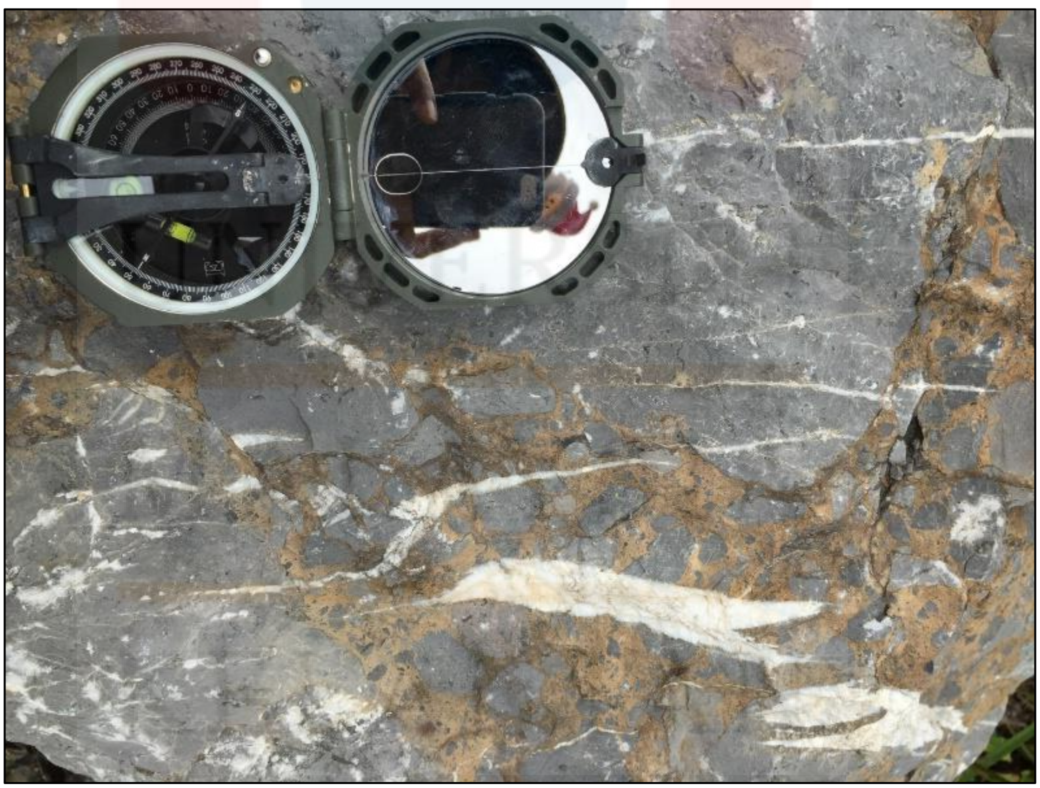


Figure 4.40: Calcite vein at a limestone rocks which reacts vigorously with hydrochloric acid (HCL)

e. Mechanism of structure

The mechanism of structure such the tectonic setting that makes the movement of plate tectonic on the Earth’s surface. Moreover, the movement of the plate tectonic will causes the occurrence of many structural geology indicator such as joint, mineralisation, faulting, folding and many more. There are also can be analyse by the lineament analysis which can be identified on the map that shows the strange lengthen area on mountain belt, disturbance on the straight river and many more. The mechanism of structure major sources are from the mantle convection zone underneath deepest in the Earth’s surface that circulate from hotter condition to the cooler condition and repeatedly circulates in order to achieve stable condition. Unfortunately, there may varies in some condition that the plate tectonic above the surface of Earth collide to each other in the geology aspect they may diverge, converge, sub ducted and may more.

4.5 Historical Geology

This study focuses on geological processes that form the lithology of the study area by reconstruct and understand the change to the landscape. In generally, the study area located at the Bentong-Raub suture zone within the collision zone between Sibumasu plate and Indochina plate during Upper Permian and was completed by Upper Triassic. In the past, Peninsular Malaysia and the regional South-East Asia countries such as Thailand and Vietnam were originally located deep down in the Paleo-Tethys Ocean. From the stratigraphic column, there are three formations that have been identified in the study area which are Semanggol Formation, Karak Formation and Gua Musang Formation. Semanggol Formation located at deep marine environment based on the chert lithology while Karak Formation and Gua Musang Formation located at shallow marine environment. Basir (2013) had stated that the oceanic plate of Sibumasu terrane that represents Semanggol Formation had been subducted under the Indochina plate that represent Karak Formation and Gua Musang Formation during the collision. From the collision, it produces compressional reverse faulting in imbricated structures, lateral fault movements and large-scale extensional fault (Tija, 1996). Breccia lithology identified is the product of faulting that happened during Lower Triassic that formed Gunung Ayam in Lojing area. Figure 4.41 illustrate the time lapse of tectonic evolution regionally at study area.

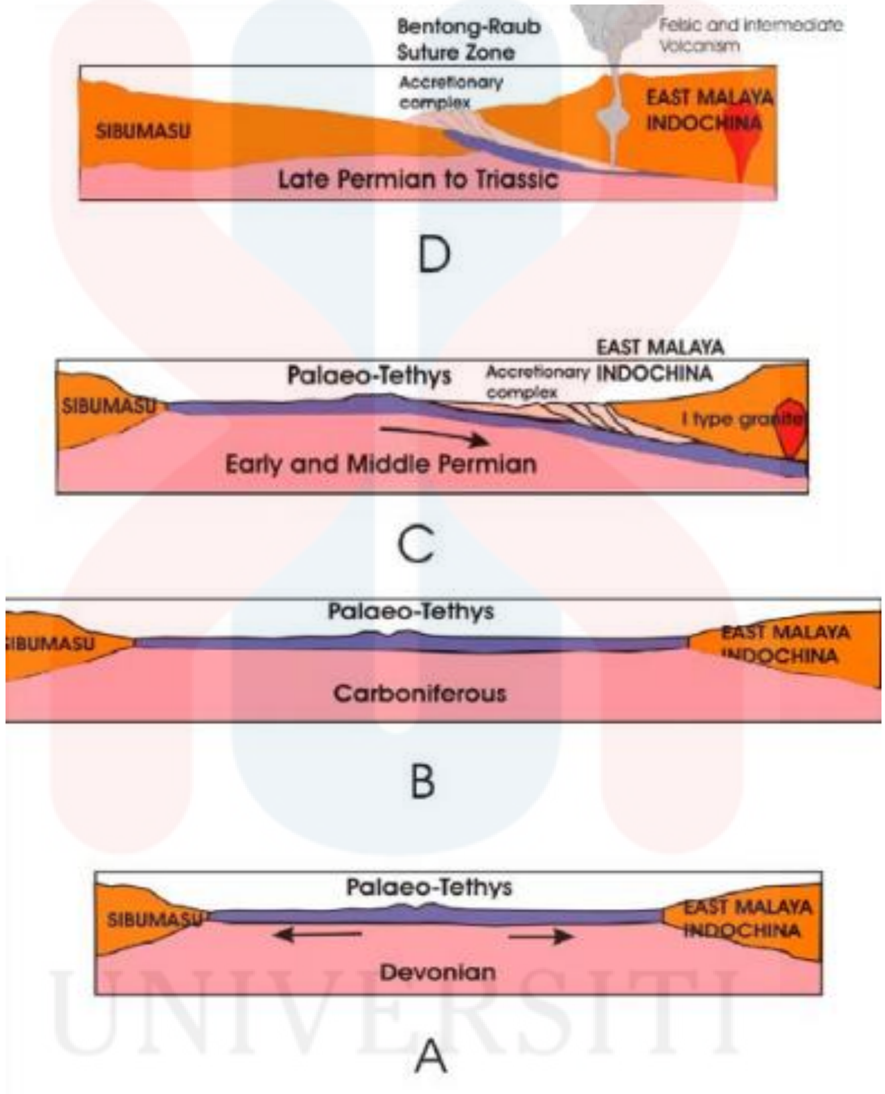


Figure 4.41: Bentong-Raub Suture formation (Basir Jasin, 2013)

CHAPTER 5

GEOLOGY AND LITHOSTRATIGRAPHY OF POS BLAU, LOJING, GUA MUSANG, KELANTAN.

5.1 Introduction

In this chapter it will be discussed about more specifically on lithostratigraphy of the study area in the Pos Blau, Lojing, Gua Musang, Kelantan. From the fieldwork in the study are where the data had been gathered and interpreted in order to appear the latest lithology unit in the study area from the aspect of its depositional environment which takes place from interpretation of the origin siliclastic sedimentary rocks such as mudstone and also based on their mineralogy and chemical composition of the detrital components in the rocks.

5.2 Facies and Facies Association

In the argillaceous facies there were shale and mudstone. The outcrop were mostly composed of shale and mudstone which were interbedded of argillaceous facies. Generally, mudstone rock composed by several of rock fragment while unlike the sandstone rock which were have several mixtures of grainy minerals and fragments of rocks which it can be said as dominated with grains in sandstone rock. By the percentage of heavy minerals and feldspar that increases with decreases of grain-sized, fragments of rocks, the amount of quartz, quartzite and chert also decreases. The domination of mud deposits accumulation may probably in most rapid in low wave and current agitation. The mudstone are mostly consist of silt grade quartz and clay minerals.

Based on the Figure 5.1 below shows the facies of mudstone (F1) and shale (F2). The mudstone (F1) generally have small beddng but then overlies with shale (F2) and continue to overlap each other with different thickness of each of the bedding. The repeated of the mudstone (F1) and shale (F2) produce a facies association (FA) of mudstone interbedded with shale (FA1) as shown in Figure 5.2.

On the other hand, on the same location there were also another facies which were chert and limestone. Figure 5.3 below shows the chert facies (F3) and limestone facies (F4). Generally, the chert facies are very fine-grained which were originated in a deep sea marine. As can be described in the mineral optical description under the microscope, the chert rock contain silicate minerals such as quartz, feldspar and others mineral which contain from the deep sea marine life which can be described as micro plankton or can be also such as spicule that contain silica in their bodies and then when they died the silica content embedded in the rocks that formed in the chert body of rocks.

The limestone unit of rock that contain several of calcite vein in the limestone bodies. The grain-sized for the limestone are very fine-grained which can be classified as grainwacke limestone as it is mud-supported and still contain more than 10% of grains (see Appendix D & E). There are also some composition of basal conglomerate on the limestone bedding which can be described as structural contact occurrence that causes the conglomerate rocks that supposed to be the youngest rock in the stratigraphic position but deposited in the limestone bodies because of structural movement such as thrust fault. The bedding of the limestone seems to be a massive bedding and there is no presence of any fossils from the observation of field mapping nor in microscope observation.

It is shows from both of the figure above shows that there are different facies but at the same location which is along the Lojing-Cameron Highlands Highway which are chert (F3) and limestone (F4). The chert (F3) seems a very long bedding until meets the limestone (F4). The chert (F3) does not seems to interbedding the limestone (F4) because there was no presence of their rock interbedded to each other repeatedly. Thus, (F3) and (F4) cannot be associated or assemblage together because of have different facies that did not have interbedded to each other. Hence, there are separated into two different facies association (FA) which is (FA2) for chert and (FA3) for limestone as shown in the Figure 5.4.

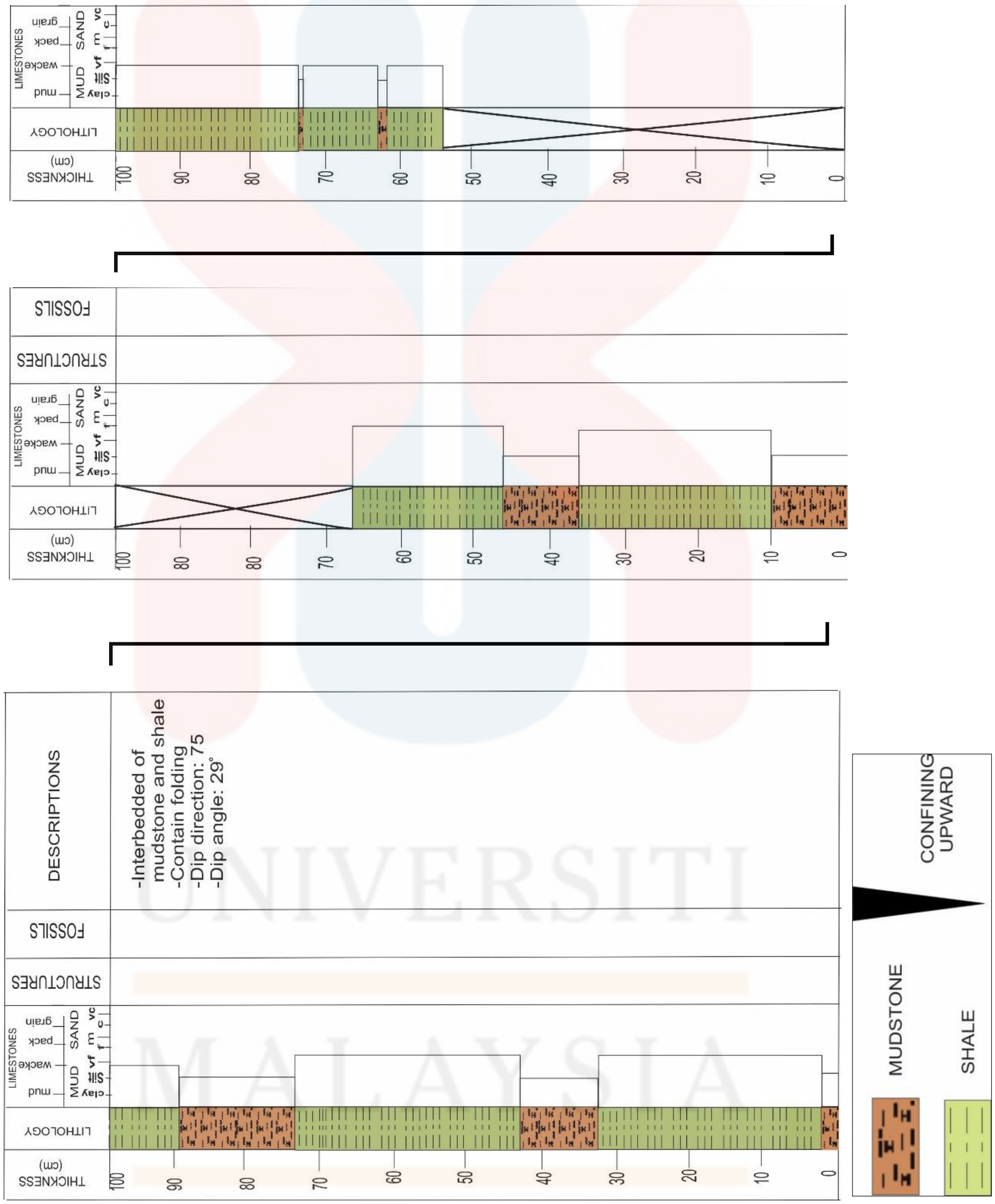


Figure 5.1: Facies of mudstone (F1) and shale (F2)

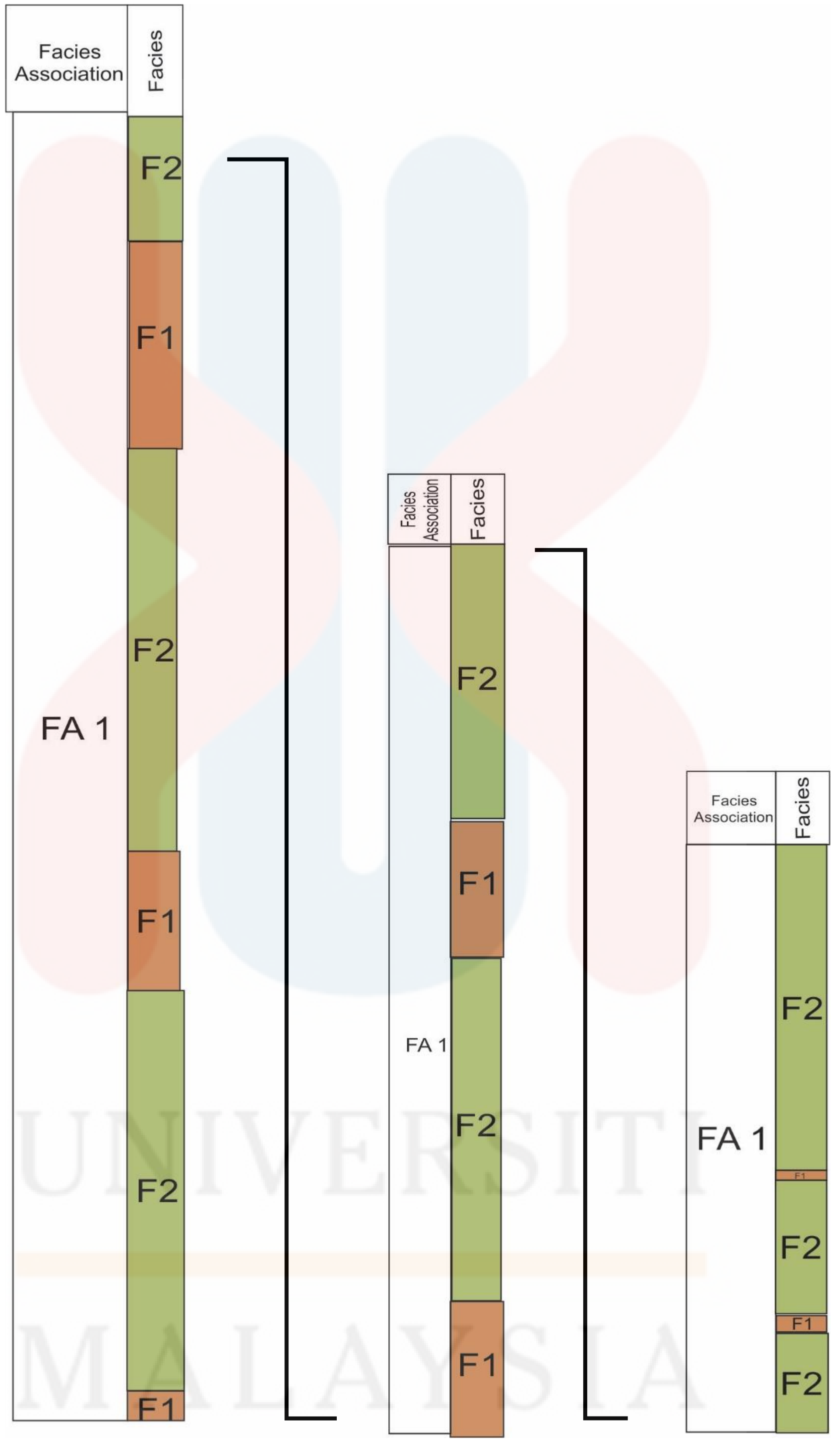


Figure 5.2: Facies association of interbedded mudstone and shale (FA1)

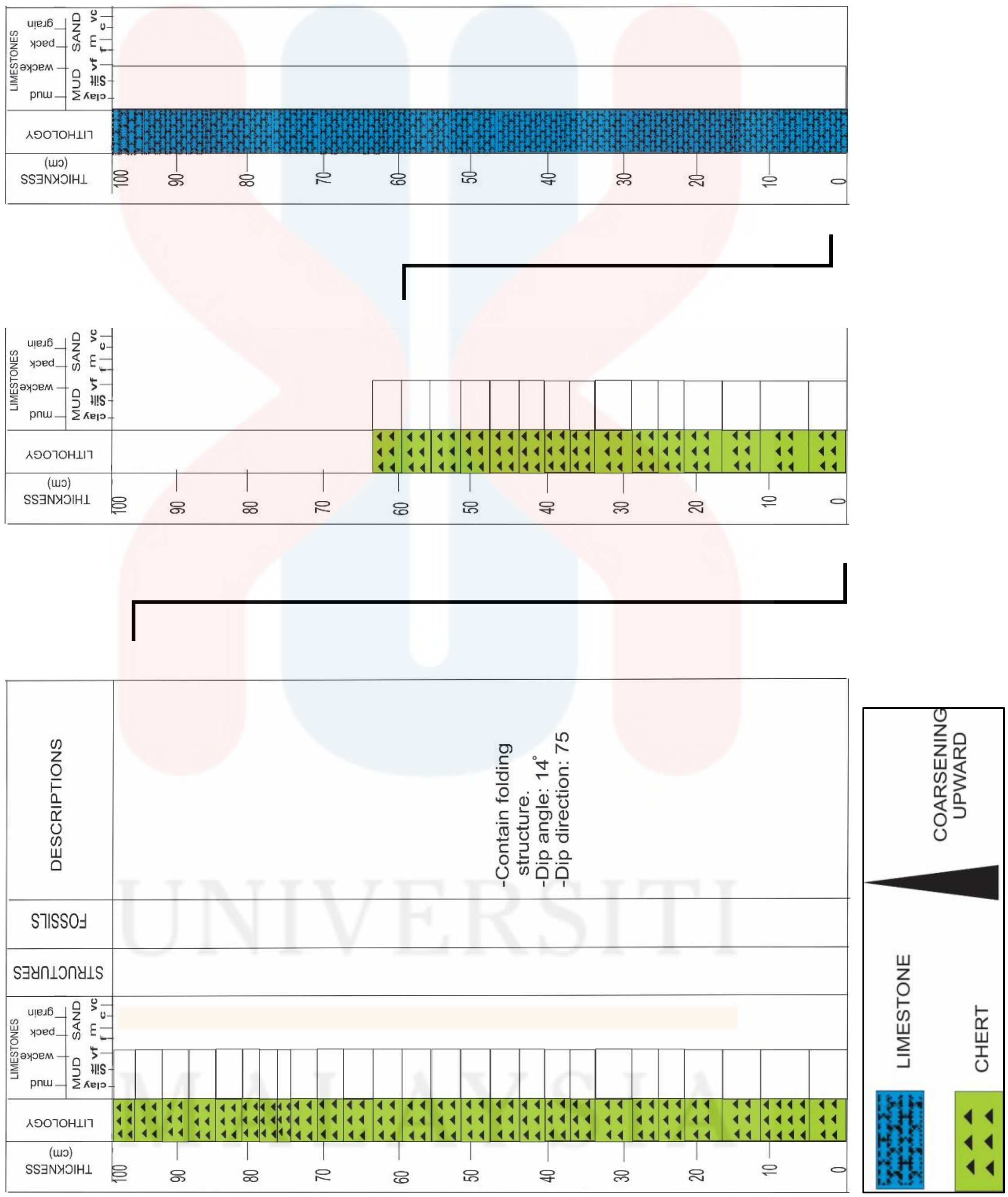


Figure 5.3: Facies of chert (F3) and limestone (F4)

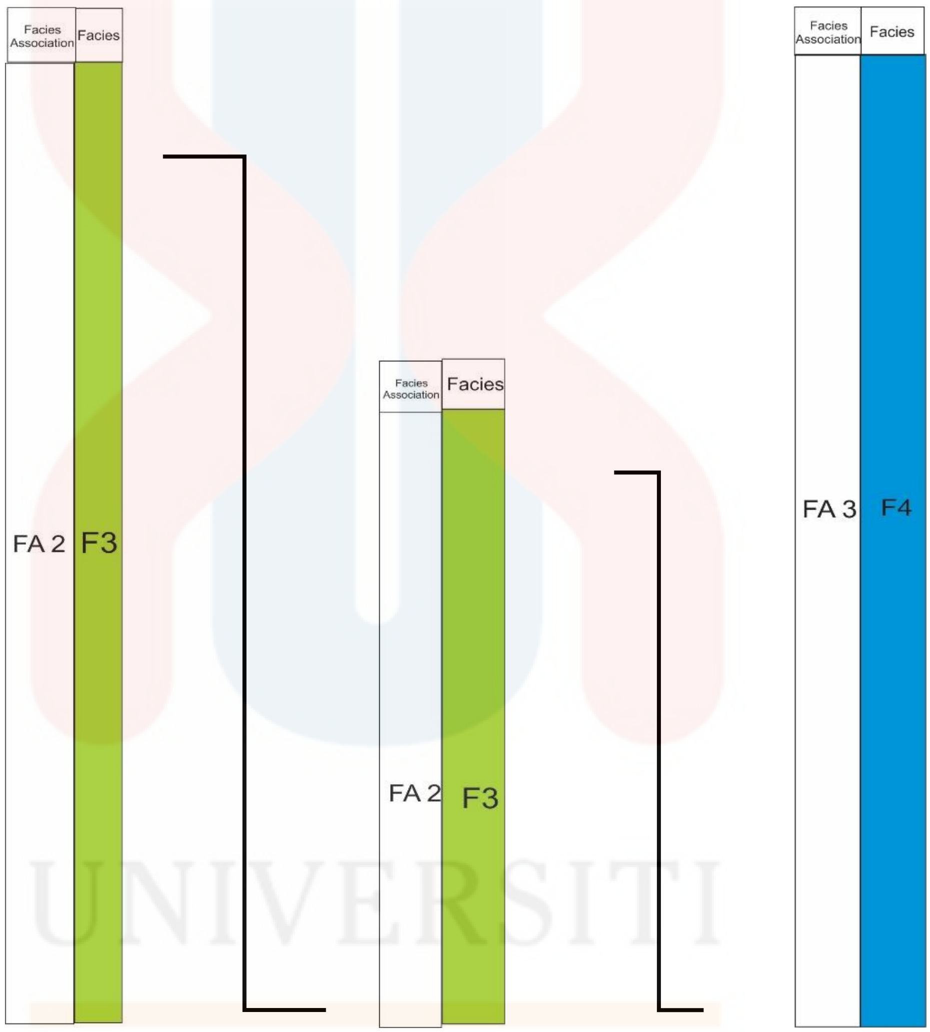


Figure 5.4: Separated facies association of chert (FA2) and limestone (FA3)

On the other location in the study area, based on the Figure 5.5 below shows the chert (F3) and tuff (F5). The location for the outcrop was located in village of Pos Blau which were exactly on the road cutting trail for the vehicles to go through the oil palm plantation. The bedding thickness measured and estimated at 113 cm thick. There were no fossils found by the observation based on the hand specimen nor in the petrography analysis in thin section. The chert and tuff unit rock were very fine-grained. Moreover, there were also some small scale of syncline folding structure on which dipping 12º and dip direction at 339. Thus, from the lithology it can be described as one facies association (FA4) because the interbedded of tuff and chert repeatedly by bedding.

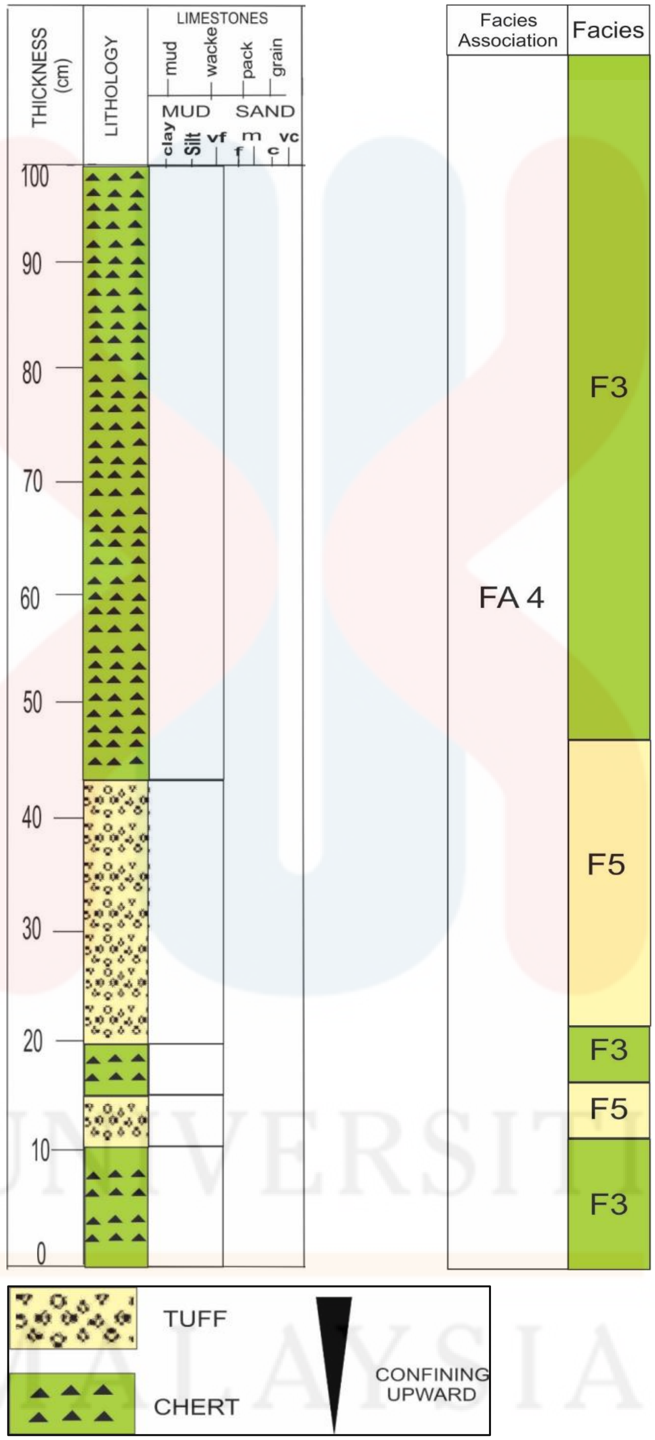


Figure 5.5: Facies of chert (F3) and tuff (F5) with facies association of interbedded tuff and chert (FA4)

Last but not least, to another different location in the study area there were mudstone (F1) and sandstone (F6). Shale and mudstone are example of argillaceous facies. There are few of rocks fragments that were commonly composed in mudstone but unlike composition in sandstone which composed mixtures of rock fragments and grainy minerals.

There was a marine fossil detected that was found near the bedding of sandstone (F6). The lamination for the sandstone unit were wavy-parallel lamination. The grain-sized for the sandstone (F6) rock unit were very fine-grained. The mudstone (F1) which is very fine-grained is deposited and overlies by the sandstone (F6). And then, the bedding of mudstone (F1) deposited back and then overlies by the sandstone (F6) once again. Hence, the mudstone (F1) and sandstone (F6) can be known as interbedding because of identical-repeated of the same rock unit thus, can be assemblage or associated them as on facies association referred as (FA5) as shown in the Figure 5.7 below.

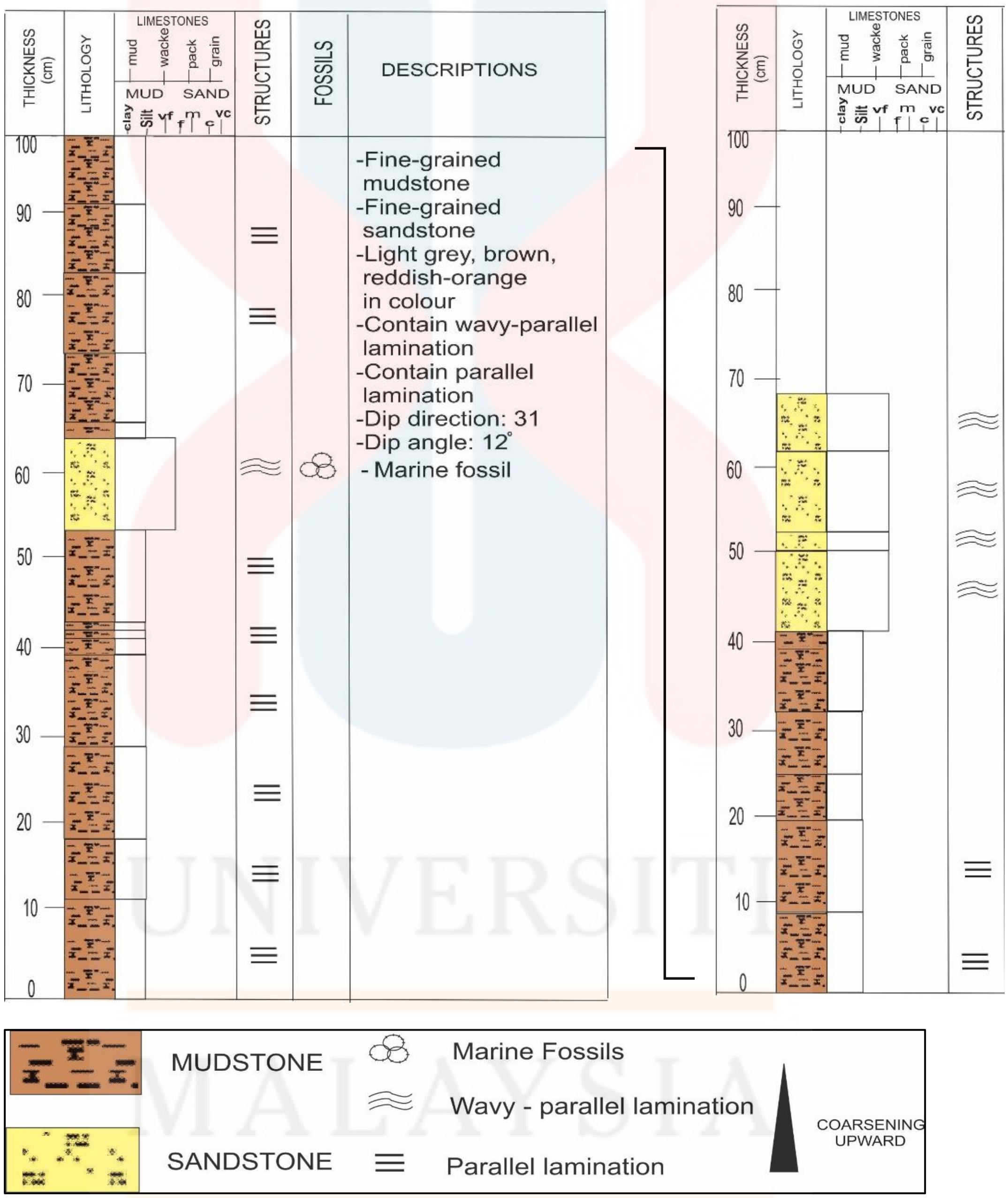


Figure 5.6: Facies of mudstone (F1) and sandstone (F6)

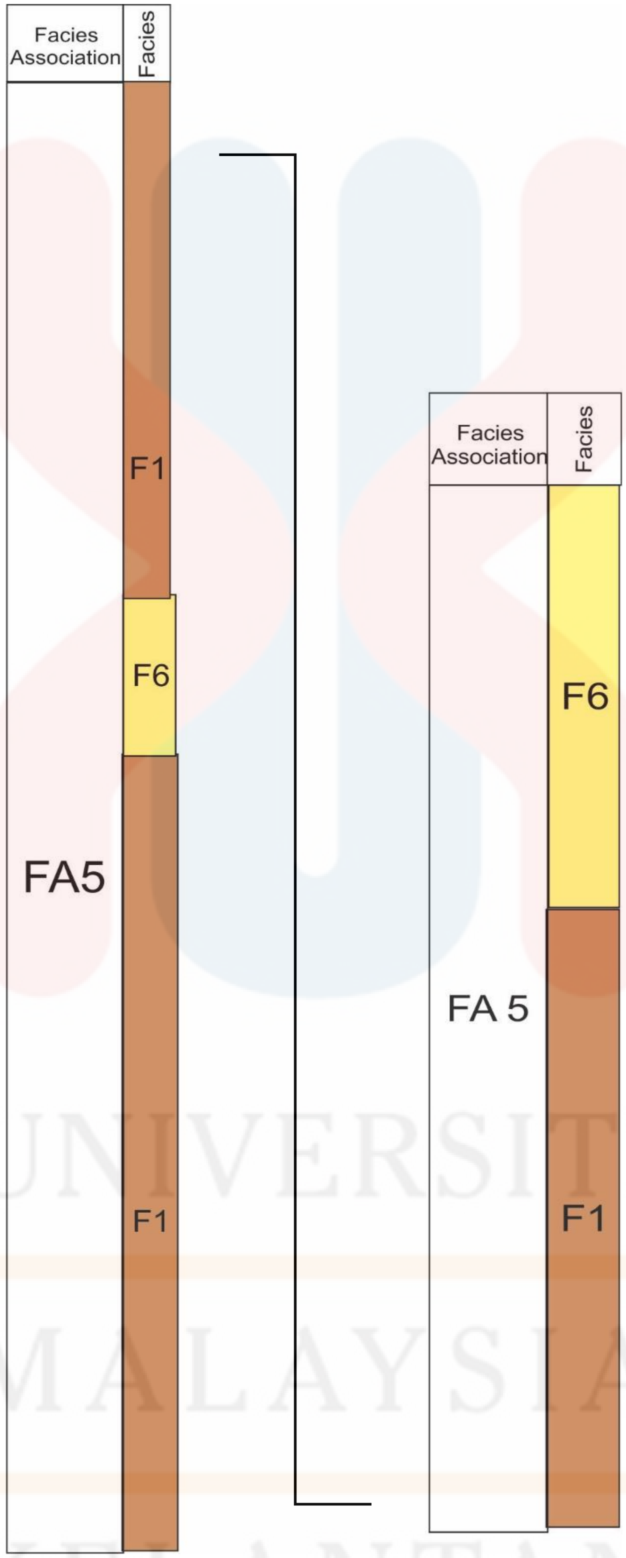


Figure 5.7: Facies association of mudstone and sandstone (FA5)

5.3 Depositional Environment

From the facies assemblage or also known as facies association thus, the depositional environment of all the facies can be interpreted and estimated. Based on the facies association of FA1, the depositional environment may be at the tidal area or the shoreface area because of the interbedded of mudstone and shale facies and also from the grain-sized (refer Appendix A) observation under the microscope shows that they are not very well-sorted and the grain-shaped also were sub-angular with both high and low sphericity which indicates that it is near to the land area where they are deposited. By means, the condition that are still under a high velocity which the grain-sized and shaped did not well-sorted and rounded enough to transported and deposited further to the sea environment.

Next, for the facies association of FA2 and FA4, the depositional environment can be described in deep marine environment because of the grain-sized of the chert itself was very fine-grained and the presence of silicate minerals in the chert which indicates the silicate element can be supplied by microscopic plankton in deep ocean. Other than that, the indicator also from the chert bedding that shows thin bedding and contain some folding structures which highly under stress and compression forces acting by the tectonic setting underneath the sea generated by the convection current mechanism.

On the other hand, the depositional environment of FA3 can be described at the deep-marine environment which may be at the reef because of its massive bedding alone without any interbedding with any other unit rocks. Moreover, there is no any sedimentary structure for example such as varves, ripple mark and mudcrack identified to shows that the FA3 is at the continental area (on land) such as in lakes environment.

Last but not least, the depositional environment for the FA5 can be estimated at the tidal flat area because of there was and interbedding and there were also some sedimentary structures such as wavy-parallel and horizontal bedding which indicates that it was near to marine environment. Moreover, the presence of the marine fossils that were estimated as Inarticulate from phylum Brachiopod which is shell-like marine life which lives in shallow marine environment.

All of the depositional environment of all the facies association of FA1, FA2, FA3, FA4 and FA5 can be seen more clearly as illustrated in the depositional model in Figure 5.8 below.

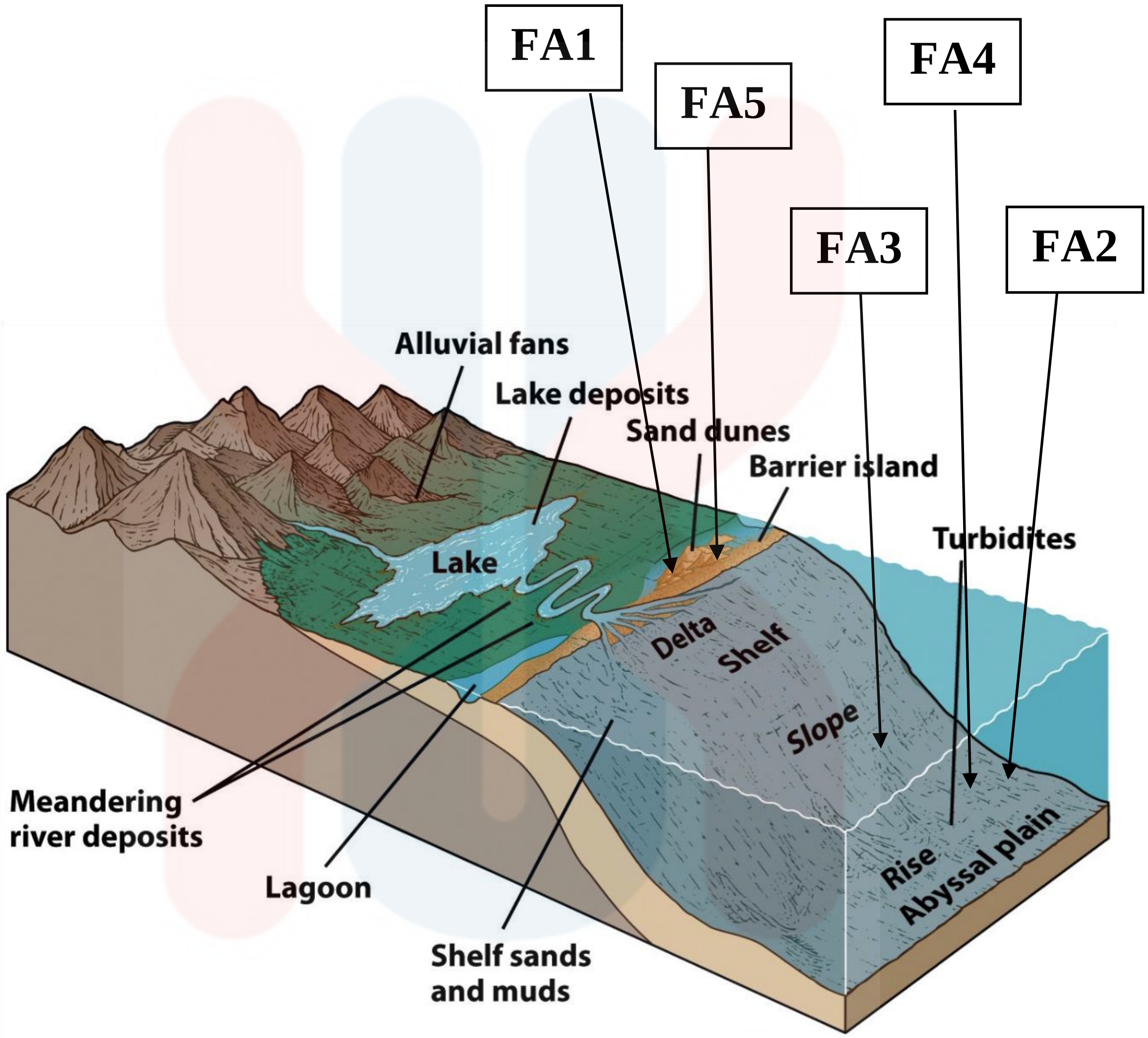


Figure 5.8: Depositional environment model of study area

(Source: Google image)

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

This chapter elaborate about the conclusion and recommendation for this research. The conclusion will focus on the general geology and the structural analysis of the study area. The recommendation explain about the future research topic and the overall finding regarding the study area.

Generally, for the study area in Pos Blau, Lojing, Gua Musang, Kelantan there were several rocks identified from the youngest to the oldest such as conglomerate, limestone, mudstone, and interbedded of chert and tuff. The oldest rock in the study area are generally volcanic rock type such as tuff where it is estimated age at early Triassic. The carbonate rocks such as limestone where it is generally divided into two types of bedding which is well-bedded and thick-bedded limestone were found in the study area. Basically, in the well-bedded limestone it is generally to be found the presence of some fossils in it.

But, unfortunately, from the observation in the field and observation under the microscope there was no presence of fossil detected from the rock sample that is taken from the study area. Furthermore, the age for the carbonate rock is estimated at Late Carboniferous to Middle Triassic. Moreover, there were also some siliclastic rocks such as mudstone which is aged about Carboniferous to Middle Triassic.

On the other hand, in the aspect of structural analysis such as from joint analysis and bedding analysis it can be conclude that the major forces that take place in the study area were comes from the North-East direction part of region. Other than that, the total area for the study area were covered at 5km x 5km which is ratio scale on map is 1: 25 000.

6.2 Suggestion

Basically there were some suggestion and recommendation which were the study area in the Pos Blau, Lojing, Gua Musang, Kelantan should be more further study for paleontology especially because of the presence of some fossils that were never identified by other researchers before.

The where also distribution of coal was found near to the Gunung Ayam foothill which are distributed between the border of conglomerate rock of Gunung Ayam and sedimentary rocks which are shale, mudstone and siltstone. The surface of coal that can be seen at about 1 meter and a half which are found in oil palm plantation. It is also distributed along N-S of the study area. This can bring opportunity for further research and studies about the coal formation and also to preserve them as is are rarely found and it takes several millions years to form. There were also some fossils found which can be described as Inarticulate from phylum Brachiopod.

Thus, this types of fossils can be described and estimated as lives in shallow marine environment and there were abundance of them can be found at the study area. According to Jones (1970) identified Inarticulata: *Orbiculoidea sinensis Mansuy* which are found by Jaafar (1979) in slate and shale in Tuan Estate, 17 km South of Karak which can be correlate with shale that are also found in Lojing that are also in the same suture zone which have the same kind of phylum.

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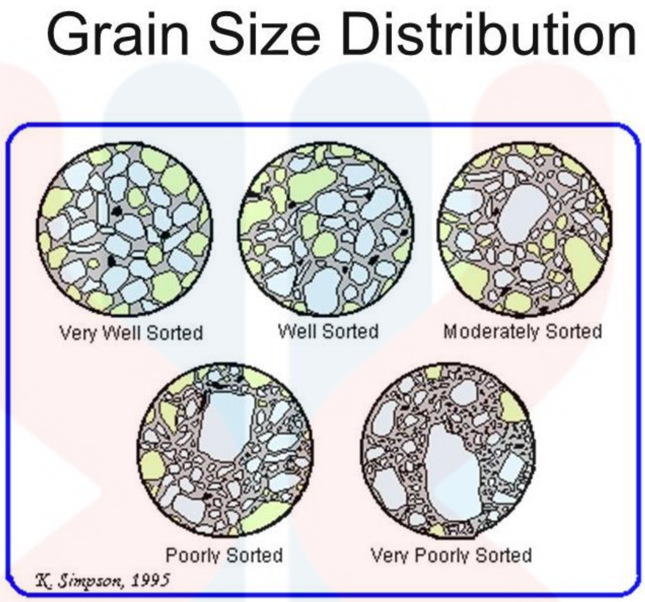
APPENDICES

Appendix A

Udden-Wentworth Grain Size Classification (Wenthworth, 1922)

Grain Diameter: millimeters	microns	phi	Wentworth Size Class		
				Boulder	Gravel
256		-8.0			
				Cobble	
64		-6.0			
				Pebble	
4.0	4000	-2.0			
				Granule	
2.0	2000	-1.0			
			vcU	Very coarse sand	Sand
1.41	1410	-0.5			
			vcL		
1.0	1000	0.0			
			cU	Coarse sand	
.71	710	0.5			
			cL		
0.5	500	1.0			
			mU	Medium sand	
0.35	350	1.5			
			mL		
0.25	250	2.0			
			fU	Fine sand	
0.177	177	2.5			
			fL		
0.125	125	3.0			
			vfU	Very fine sand	
0.088	88	3.5			
			vfL		
0.0625	62.5	4.0			
				Silt	Mud
0.002	2.0	9.0			
				Clay	

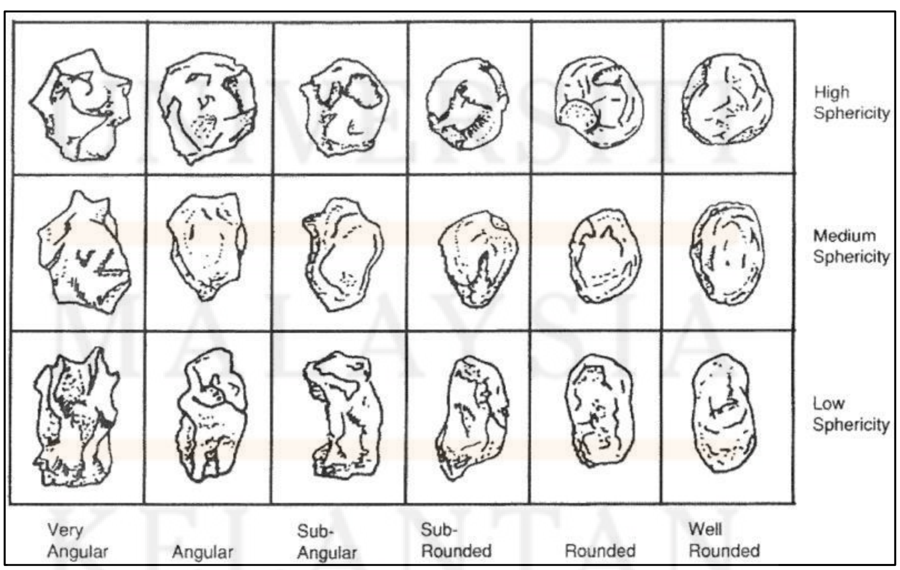
Appendix B



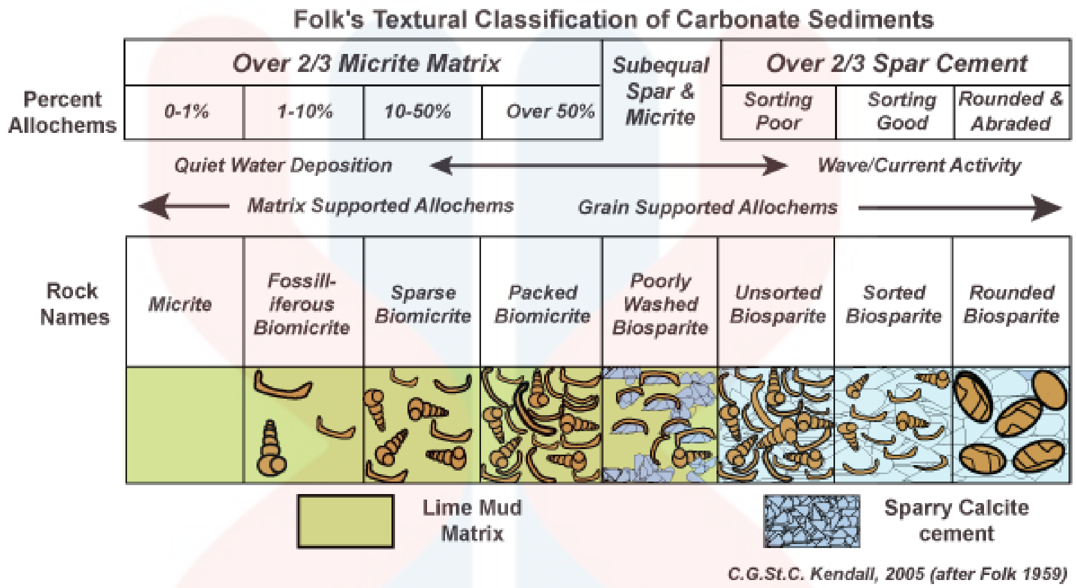
(Source: K.Simpson, 1995)

Appendix C

Particles Roundness (Tucker, 2003)



Appendix D



Appendix E

Carbonate Rock Classification (Dunham, 1962)

<table>
<tr><td colspan="6">Allochthonous limestone
original components not organically
bound during deposition</td><td colspan="3">Autochthonous limestone
original components organically
bound during deposition</td></tr>
<tr><td colspan="4">Less than 10% >2 mm components</td><td colspan="2">Greater than 10% >2 mm components</td><td colspan="3">Boundstone</td></tr>
<tr><td colspan="3">Contains lime mud (<0.02 mm)</td><td>No lime mud</td><td rowspan="3">Matrix supported</td><td rowspan="3">>2 mm component supported</td><td rowspan="3">By organisms which act as barriers</td><td rowspan="3">By organisms which encrust and bind</td><td rowspan="3">By organisms which build a rigid framework</td></tr>
<tr><td colspan="2">Mud supported</td><td colspan="2" rowspan="2">Grain supported</td></tr>
<tr><td>Less than 10% grains (>0.02 mm to <2 mm)</td><td>Greater than 10% grains</td></tr>
<tr><td>Mudstone</td><td>Wackestone</td><td>Packstone</td><td>Grainstone</td><td>Floatstone</td><td>Rudstone</td><td>Bafflestone</td><td>Bindstone</td><td>Framestone</td></tr>
</table>