GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF LIMESTONE FACIES AT FELDA CHIKU 1, GUA MUSANG, KELANTAN

by

NURUL AFIFAH LAILI BT SARIMIN

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

FACULTY OF EARTH SCIENCE

UNIVERSITI MALAYSIA KELANTAN

2019

FYP FSB

ABSTRAK

Pemetaan tanah dilakukan untuk menghasilkan 1: 25.000 peta skala kecil yang mana semua litologi di kawasan kajian dapat dikaji sepenuhnya dan dikenal pasti untuk lebih jelas. Selain itu, klasifikasi batu kapur di Gua Musang hanya berdasarkan pengedaran geografinya. Ini menyebabkan kekeliruan apabila asal batu kapur sepatutnya dikaji berdasarkan persekitaran endapan. Kajian lanjut mengenai spesifikasi batu kapur di kawasan Gua Musang mesti dilakukan. Secara rasional, batu kapur boleh diklasifikasikan di bawah formasi berkaitan yang mempunyai persamaan terhadap persekitaran endapnannya ketika proses pemendapan. Analisis microfacies dilakukan dengan memerhatikan 'thin section' di bawah mikroskop. Parameter seperti struktur sedimen, litholog dan juga kandungan biofasi diperhatikan semasa tafsiran. 'Folk's textural classification of carbonates sediment', 'Dunham's classification' and 'Standard Microfacies Type (SMT)' digunakan untuk mengenalpasti persekitaran pemendapan. Kesimpulan korelasi di antara parameter ini menghasilkan persekitaran deposisi fasis batu kapur di kawasan kajian yang merupakan laut cetek platform karbonat. Kehadiran fosil marin seperti *Fusulina sp. dan Operculina sp*. memperkuat pernyataan tentang asal batu kapur di kawasan kajian.

Kata kunci: Fasis batu kapur; persekitaran endapan; analisis mikrob

FYP FSB

UNIVERSITI

MALAYSIA

KELANTAN

FYP FSB

ABSTRACT

The ground mapping is done in order to produce 1:25,000 small scale of map which all the lithology in study area can be covered and identified for more details. Besides, the classification of limestone in Gua Musang is based on its geographical distribution only. This cause a confusion when the origin of the limestone is studied based on its depositional environment. Further studies in specification for limestone at Gua Musang area must done. The rational is, the limestone can be classified under related formations which has similarity on its environment during the deposit process. The microfacies analysis was done by observation of the thin section under the microscope. The parameters such as the sedimentary structure, litholog and also the bio-facies content was observed during the interpretation. The Folk's textural classification of carbonates sediment, Dunham's classification and Standard Microfacies Type (SMT) were used in identifying the deposition environment. The conclusion of the correlations between these parameters resulted the depositional environment of limestone facies in study area which is shallow marine of carbonate platform. The presence of marine fossil such as *Fusulina sp.* and *Operculina sp*. reinforced the statement about the origin of the limestone in study area.

Keyword: Limestone facies; depositional environment; microfacies analysis

UNIVERSITI
MALAYSIA
KELANTAN

FYP FSB

DECLARATION

I declare that this thesis entitled "Geology and Depositional Environment of Limestone Facies at Felda Chiku 1, 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 currently submitted in candidature of any other degree.

Signature :

Name : Nurul Afifah Laili bt Sarimin

Date :

UNIVERSITI MALAYSIA KELANTAN

FYP FSB

ACKNOWLEDGEMENT

I would like to express the deepest appreciation and pay gratitude to my supervisor Dr. Mohammad Muqtada Ali Khan and my first supervisor, Prof Surono Martosuwito for their guidance, persistence encouragement and associated aid through this study. Their experience, advice and useful details helped me a lot to complete this Final Year Project. Besides, thank to Ms Hafzan Eva bt Mansur for spent her time and joined the mapping. The knowledge taught by her during the field, helps me to better understand about my research.

I owe a deep sense of gratitude to my mapping partners, Nor Intan Shazlin bt Mohamad Rojali, Mohd Fikri Abdullah and Syahidatul Khazidah bt Azahan for being handful, enthusiasm, and dynamism I finished and complete my research. Their involvement during the ground mapping help a lot to cover every inch in my study area. not forget also to villagers from Perasu and Rantau Manis which provided the shelter, food and transportation during the mapping.

Next, my sincere thanks to my family for their understanding, financial and moral support during completing my final project. I would also thank to my classmates, SEG batch 2015 who had helped me giving encouragement and continuous support during completing my thesis.

UNIVERSITI
MALAYSIA
KELANTAN

TABLE OF CONTENT

FYP FSB

UNIVERSITI MALAYSIA KELANTAN

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

LIST OF TABLES

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

LIST OF FIGURES

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

FYP FSB

UNIVERSITI

MALAYSIA

KELANTAN

FYP FSB

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Geology is a branch of Geoscience which study about the Earth. It including the study of its composition, structure, process that occur which form those structure, and the evolution of the organisms over the time. It also can reveal the geology history and event of past. In addition, the geology also used to locate the resources within the Earth surface (Guillemot & Capenter, 1996)**.**

Depositional environment is study of the origin place where the deposition process of sedimentary rock occurred. Then it classifies based on it physical, chemical and biological to decide the deposition area. Besides, the geologist will study the sedimentary facies as the result can shows the exact deposition environment (Reineck & Singh, 1986).

Limestone is a type of sedimentary which generally made up from three component which are the carbonate grains, micrite and cement. Among of the carbonate grains, it made up from bioclast, ooids, peloids and intraclast. The bioclast and ooids is a limestone that contain skeletal fossil fragment that lied down in the marine environment. it also affected by the sedimentation environment factor in the time. These criteria are one of the parameters to emphasize the microfacies analysis where it will give a result in determining the limestone depositional environment. However, to identify the depositional environment of specific carbonate platform, the knowledge of sedimentology and palaeontology must know for accurate result. The occurrence of the fossil in the limestone is vital since it can indicate the paleoenvironment and the estimation age of the rock.

This study is focus on the depositional environment of limestone facies at Gua Musang district since there is a lot of limestone tower in this district than other places. In addition, this research is related closely with the pre-historic collision product between the Sibumasu Block and Indochina Block where the collision is catalyst in sedimentary rock distribution in the basin.

The deep water Semantan Basin to the south of Gua Musang platform was formed during Middle Triassic age. The Gua Musang-Semantan depocenter is distributed a bulk of carbonate platform with the various if sediment on the top. The growth and development of the basin was strongly affected by instability of its margins and volcanism that also contributed a tremendous supply of tuff sediment into the basin. By the end of Upper Triassic, the Gua Musang-Semantan depocenter was already uplift and eroded. The present of Gua Musang now is the product of the great collision between two blocks.

The study area is in Felda Chiku 1 which is located at the South of Kelantan. The land is dominantly cultivated with the oil palm. Besides, currently there is general limestone distribution map that provided by the Mineral & Geoscience Department Malaysia (JMG) for Gua Musang district. This map is lack in this research specification which is the facies of the limestone based on its depositional environment.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Thus, this research is about to produce a geological map for Felda Chiku 1 with scale of 1:25, 000 and identify the depositional environment of limestone facies. It including the geological mapping, studio work and construct the lithology of the limestone to correlates with its environment when the limestone is deposited. The result will be benefits to other researcher in future geological research and bring additional information to the Geology of Southern Kelantan.

1.2 Study area

1.2.1 Location

Generally, the study area is part of the Central Belt of Peninsular Malaysia. The study area is covered in 25 km^2 (5 km x 5 km) of Felda Chiku, east of Gua Musang district as shown in figure 1.1. It is also near to Gua Musang town. The coordinate of the longitude is from 102º6’58.3’’ E, to 102º9’41.6’’E and coordinate of latitude is from 4º56’22.8N to 4º56’23.1’’N. Besides, the study area is mainly covered with the palm plantation. In this Felda, there is a river named as Chiku River that located around the palm tree. Besides, there is a road which is the located at south of the study area. Furthermore, there is a small village of Chiku 1 and also school which named as SK Chiku 1 and SK Chiku2.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

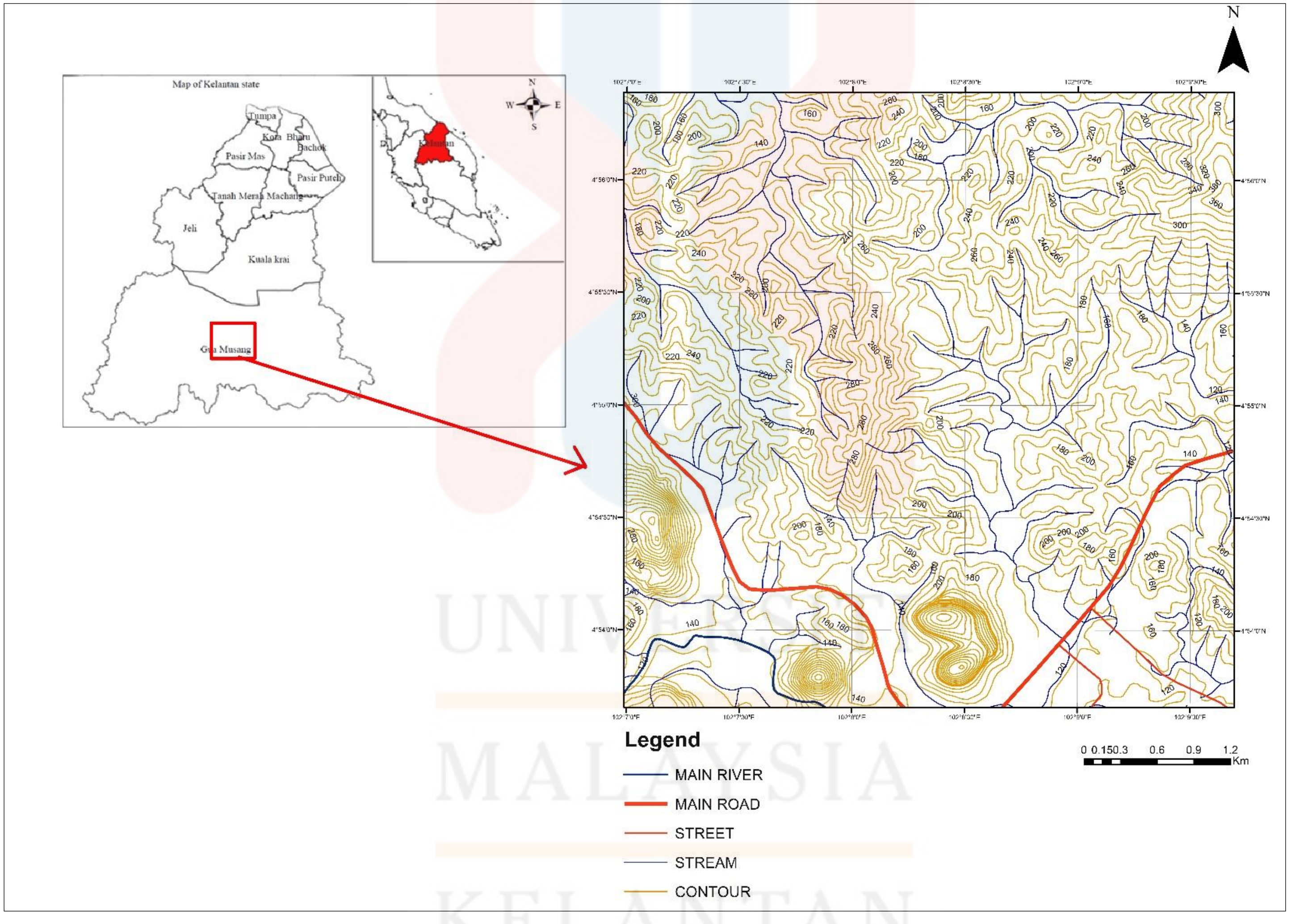


Figure 1.1: The map of study area in Gua Musang district.

UNIVERSITI MALAYSIA KELANTAN
FYP FSB

1.2.2 Road connection

There are two roads that can be accesses to reach the study area at Felda Chiku 1 from the main city, Gua Musang. The first road connection can be accesses is using Kota. Both roads are connected to Lebuhraya Kota Bharu- Gua Musang to enter the study area as shown in figure 1.2.

Figure1.2: The roads connection to Felda Chiku 1 Gua Musang from main city, Gua Musang.

1.2.3 Demography

From the official website of Department of Statistic Malaysia, the population of Gua Musang District on 6 JULY 2010 is 907050 people as shown in table 1.1. Besides, based on the data from Department of Statistic Malaysia (figure 1.3) show the dominant ethnics is Malay, follow by Chinese, Indian and others. The distribution of the people is high in Gua Musang town as people are concentrated to work there. Same like to Felda

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Chiku 1, the population in this area is high since there are a lot of job opportunity whether in government or non-government.

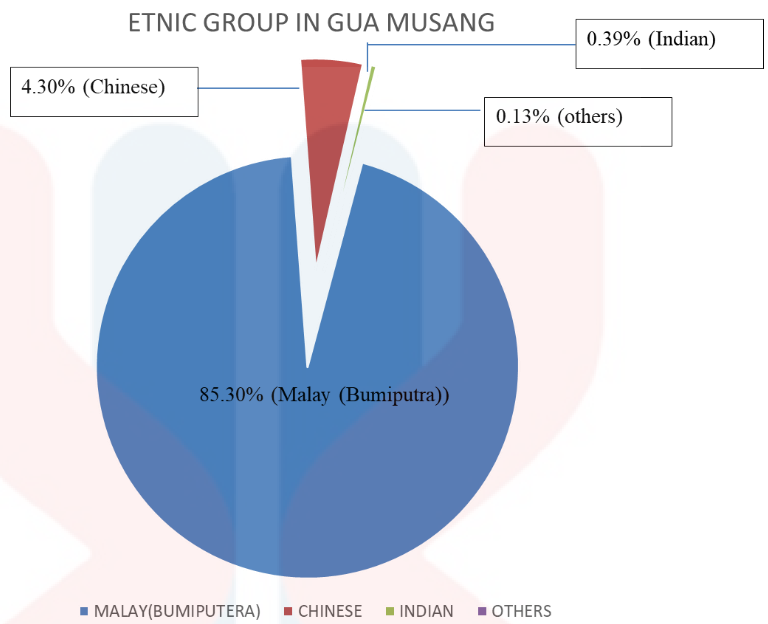
Table 1.1: The population development in Kelantan state

Name	Status	Population Cencus 2000-07-05	Population Cencus 2010-07-06
Kelantan	**State**	**1,313,014**	**1,539,601**
Bachok	District	111,040	133,152
Gua Musang	District	76,655	90,057
Jeli	District	36512	40,637
Kota Bahru	District	406,662	491,237
Kuala Krai	District	93,550	109,461
Machang	District	79,032	93,087
Pasir Mas	District	165,126	189,292
Pasir Puteh	District	106,138	117,383
Tanah Merah	District	103,487	121,319
Tumpat	District	134,812	153,976
Malaysia	**Federation**	**23,274,690**	**28,334,135**

Source: Department of Statistic Malaysia, Official Portal

UNIVERSITI MALAYSIA KELANTAN
FYP FSB

FYP FSB



Source: Department of Statistic Malaysia, Official Portal

Figure 1.3: The distribution of ethnics in Gua Musang District

1.2.4 Land use

Gua Musang is an area that has two large agencies opening the land scheme. These two giant agencies are KESEDAR and FELDA. Almost entire of the places is developing and scheme with the oil palm. In 2008, FELDA own 10,552.50 hectare of oil palm plantation (Fauzi Hussin, 2012).

1.2.5 Social Economic

Since in Gua Musang area is dominantly covered with the plantation, so this district is highly depended on the agriculture. In Felda Chiku 1, the social economic is related to the oil palm plantation. However, there small group of people live in Felda Chiku 1 works as government officer and also as a business man.

UNIVERSITI MALAYSIA KELANTAN

1.3 Problem Statement

Based on the previous geological research in Gua Musang district, there is only general geology map that has been produce by the Mineral & Geoscience Department Malaysia (JMG) in 2000 with scale 1:250 000. Since the scale is too big, the information provided is too general as it difficult to make it as references for this research. So, to give more details map, 1:25 000 small scale of map is produced to cover all the lithology in the study area.

Although there are a lot studied have been done by the researcher about the sedimentary rock distribution in Gua Musang, but for the limestone, there is limited research done especially in the study area. The classification of limestone formation in Gua Musang now is only divide based on the geographical distribution. Further study about the facies and the depositional environment of limestone for every hill is needed, perhaps the limestone can be identified and characterised based on its unique criteria and put under any formation that related with it.

1.4 Objective

i. To produce geological map 1:25 000 scale of study area.

ii. To determine the depositional environment of limestone facies at study area by using microfacies analysis.

1.5 Scope of Study

The study area is covered in $25km^2$ (5km x 5km) of Felda Chiku 1 which located at east of Gua Musang Kelantan. The geology features such as geomorphology,

FYP FSB

stratigraphy, lithology, geology structure and geological history are studied to produce the geological map. The observation on fresh outcrop also important in identifying the type of the rock.

The sedimentary logs based on lithologies and sedimentary structure are constructed to identified the depositional environment of limestone facies which has distributed within the study area. Petrography method will be used to make a thin section for the microfacies analysis.

1.6 Significant of Study

The important of the research is to produce geological map with a small scale which is equal to 1:25 000. This small scale of geological map has very details about the rock distribution and even the structure occurred in the study area. Hence, the map can be use as reference for other researchers.

Besides, the microfacies studied on limestone can help in classifying the limestone into the formation where it is belongs to. Based on (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016), limestone in Gua Musang district is need for further study in microfacies in order to refine the establishment of the Gua Musang Group. The studies of microfacies analysis for limestone can increase the knowledge about its depositional environment which gives information about their age and history of the deposit process.

These finding also important which can increase the value of the study area. The economic findings in the study area can create entrepreneur value. For example, some of the resource such as carbonaceous limestone is widely used in cement production.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will review the past research that related to this research. This is important as a comprehensive review of the literature is important because it provides an up-to- date understanding of the subject research.

2.2 Regional Geology and Tectonic Setting

The Peninsular Malaysia is part from the Sundaland core that has been through the evolution of Southeast Asia (Metcalfe, 2011). The Peninsular Malaysia can be divided into three longitudinal belts which are Western, Central and Eastern where each of them has their own characteristics and geological environment

The two tectonic block which are the Sibumasu Block (Western belt) and the Indochina Block (Eastern belt) is being split by N-S Paleo-Tethys Bentong-Raub suture. It defined the western margin of the Central Basin of Peninsular Malaysia, dominated by folded predominantly Carnian-Norian (Semantan Fm.) strata (Hutchison, 1989). This suture also become the boundary between the Western Belt and Central Belt as shown in

FYP FSB

figure 2.1. The general lithology of Kelantan is made up from sedimentary to meta sediment of rock in the centre area while be boarded with the igneous rock which is granite on the east and west. Within the central zone, there are fracture or windows that allow the intrusion of the granite such as Ulu Lalat (Seting) batholith, Stong Igneous Complex and the Kemahang Pluton (Goh, Teh, & Wan Fuad, 2006).

The Central Basin is formed when there were extensional of graben to the west by Raub-Bentong line and the extensional graben to the east by Lebir Fault (Metcalfe I. , 1989). The fault is believed happen during the Early of Permian that gave a huge distribution of sediment and meta sediment rock between Triassic to Early Cretaceous period. Gua Musang is part of the Central Basin which located on it centre of basin. The Centre Basin is filled with Triassic marine and Jurassic-Cretaceous continental sediment (Metcalfe I. , 1989).

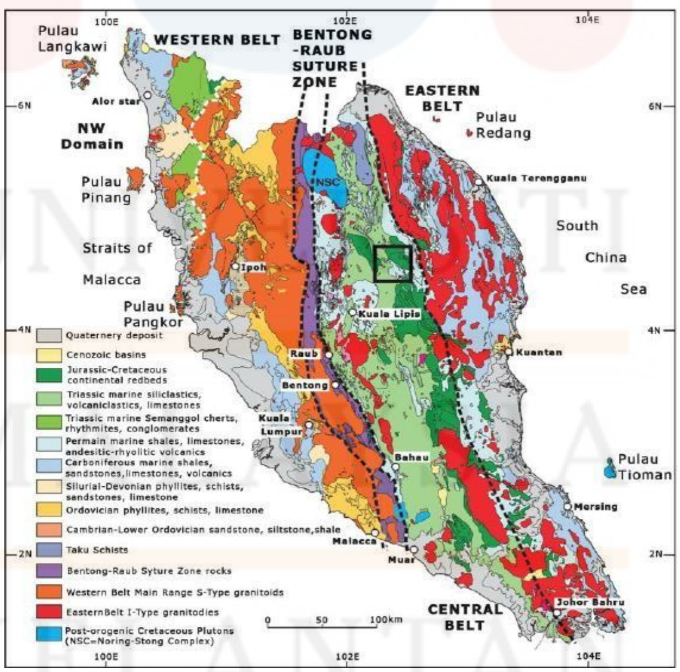


Figure 2.1: Geological map of Peninsular Malaysia

Based on sedimentological and paleontological evidence, the Gua Musang formations were deposited in a warm, shallow marine environment within the Paleo-Tethys Seaway of the Central Belt during Permo-Triassic time (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016).

2.3 Stratigraphy and Sedimentology

The central zone is boarded on the west by the Main Granite Range and Lower Palaeozoic sediment of Bentong Group. The northern part of the Eastern area is formed by the Lebir Fault while in the southern part is a random line joining the Lebir Fault. The oldest sediment that recorded in the central zone are scattered outcrop of Carbonaceous Limestone (Foo, 1983). The bulk of Upper Palaeozoic sediment that occur during the Permian, this sediment occurred as a linear belt boarded the Mesozoic sediment of the zone on both sides reaching until South Johore. There is a model which proposed by Hutchison (1988) showed that the Central Basin is regarded as a fore-arc or intra-arc basin, which separated from the Semanggol Basin (fore deep) by an outer arc formed by the uplifted accretionary complex (Bentong Suture).

Then during the Mesozoic era, the Peninsular Malaysia started to form landmass which resulted from the uplift followed by the subaerially exposure of land. Marine sediment was found in northwest Kodiang-Semanggol depocenter and the Gua Musang-Semantan depocenter in the central belt (Simon., 2013) . The Gua Musang depocenter has extensive in its development on the Upper Palaeozoic shelf of East Malaya. It characterizes by wide occurrences of tuff and associated lava, tuffaceous siliciclastic. The

FYP FSB

present of conglomerate show the basin was unstable since there is volcanic activity occurred that time.

Kelantan is dominated by shallow marine clastic and carbonates with interbedded of volcanic rock. In direction to the south of the Kelantan until North Pahang, the deeper marine turbiditic sediment is more dominant with tuffaceous in nature with the interbeds of volcanic (Lee, Mohd. Shafeea, Kamaludin, Bahari, & Rashidah, 2004) . But in Central Basin, the accumulation of sediment is almost 3 km of marine Triassic and subsequently 1.5 to 2km of Jurassic to Early Cretaceous. There is shallow marine of limestone, siliclastic, oliostromes and conglomeratic calcareous sediment along the margin of graben. During the Cenozoic era, there are sediment deposited which known as Quaternary sediment. This sediment that made up from gravel, sand, silt and clay are widely distributed on the north Kelantan.

2.3.1 Gua Musang Formation

Gua Musang Formation is located in the north part of Gua Musang-Semantan depocenter that lies between the Bentong-Raub suture in the Central belt. The forearc subsidence intensified in Gua Musang platform creating more accommodation space for carbonate-argillite-volcanic deposition. The deep marine Semantan Gemas basin is occurred after the oblique subduction Sibumasu block and eroded by shallow platform.

The current Gua Musang Formation started to develop from East. Volcanism peaks while forearc basin start to subside which represented in Aring Formation that made up from pyroclastic rock. The thick argillite and volcanic created shallow marine of Gua Musang platform environment in the Middle-Late Permian were favourable for

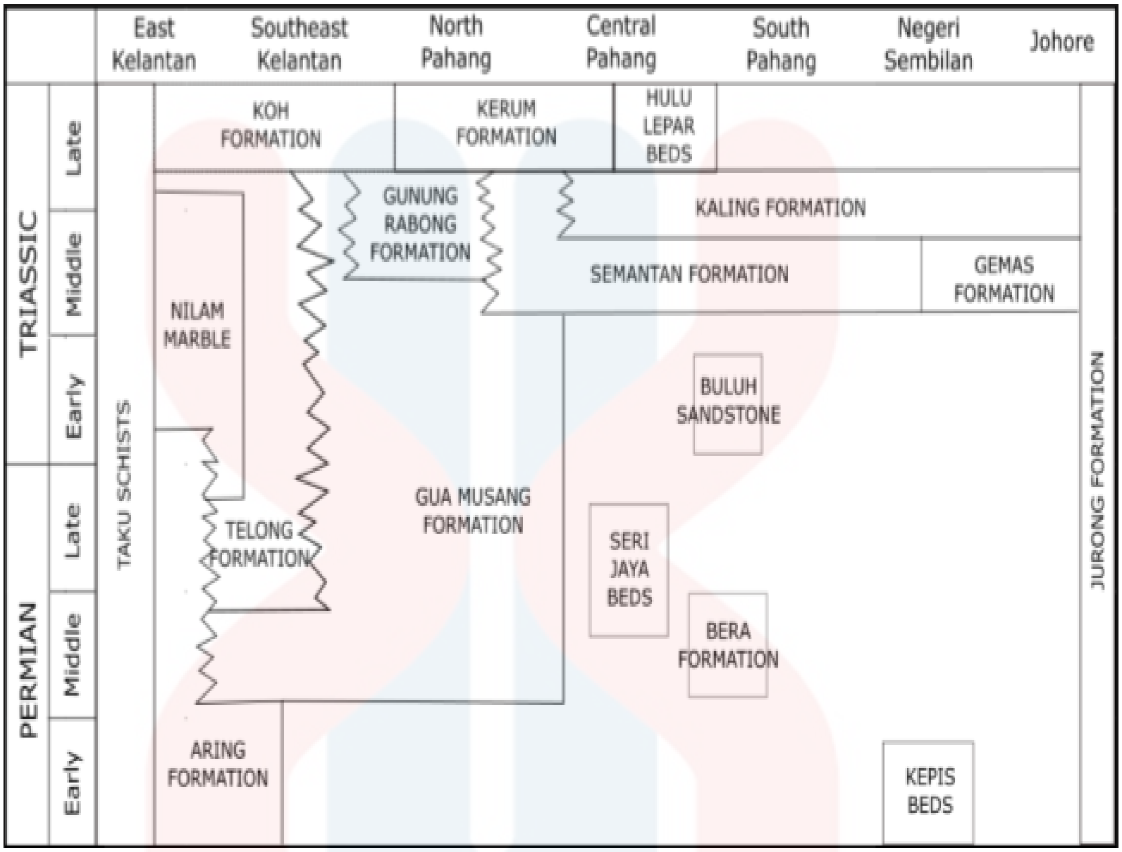
FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

carbonate development. This carbonate development consists of calcareous-argillaceous sequence of crystalline limestone with interbedded argillite and subordinate sandstones and volcanic (Foo, 1983).

The presence of Permo-Triassic sediments rock for formation in southeast Kelantan,which are Aring Formation that dominant to pyroclastic unit, Telong Formation for the argillite dominant, and Nilam marble for the metamorphosed limestone within the Sungai Aring. This distribution is correlated with Calcareous Formation (northwest Pahang) and deposited in same platform of Gua Musang platform (Aw, 1990).

But recently, the Gua Musang Formation has been proposed to become Gua Musang Group with few others formation which are Aring Formation,Telong Formation and Nilam Formation. This is because, wide spread distribution of argillite-carbonate-volcanic across the Northen Central Belt has same lithology with the Southern Central Belt area. Based on (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016), the carbonate facies are deposit on the Gua Musang platform during the Permian Triassic before subjected to erosion and karstification. Figure 2.2 show the chart of formations during the Permian and Triassic period.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN



(source: Metcalfe & Azhar Hussin,1995)

Figure 2.2: Stratigraphic correlation chart of Permian and Triassic of the Peninsular Malaysia.

2.4 Historical Geology

Figure 2.3 show the extensional process of the crustal in Malay Basin which caused by the strike-slip fault movement during the Permian period. This massive structure results in the formation of graben, the pull apart basin known as Central Basin. The Triassic sediment is start to deposit and accumulated. Early of the Triassic, only fine grain marine sediments are deposited, followed by coarser continent particle which is conglomerate and sandstone during the Late Jurassic-Cretaceous.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

2.5 Depositional Environment of Limestone in Gua Musang

In order to deposit the sediment, the specific process of sedimentary must occurred and it known as depositional environment. Based on Boggs (2014), there are three major of depositional environment which are continental (land), marginal-marine (transitional) and marine. A facies model will final up the characteristic of a given depositional settings. Sequence stratigraphy is based on the concept that the sedimentary rock record can be divided into unconformity-bounded sequences, which reflect the sedimentological response to sea level changes, subsidence, and sediment supply. The value of facies analysis and sequence stratigraphy is that they can provide some predictability to the facies distribution (Maliva, 2016).

The facies characteristics of the formation is represented by sedimentary log. Through this method it can improved the understanding and the communication between the researcher. In addition, a complete stratigraphic column is including the bed number, base depth, the type of the rock, primary lithology, the size of grain and also the colour of rock. Based on (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016) Gua Musang deposited in warm, shallow marine environment within the Paleo-Tethys Seaway of Central Belt during Permo Triassic time.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

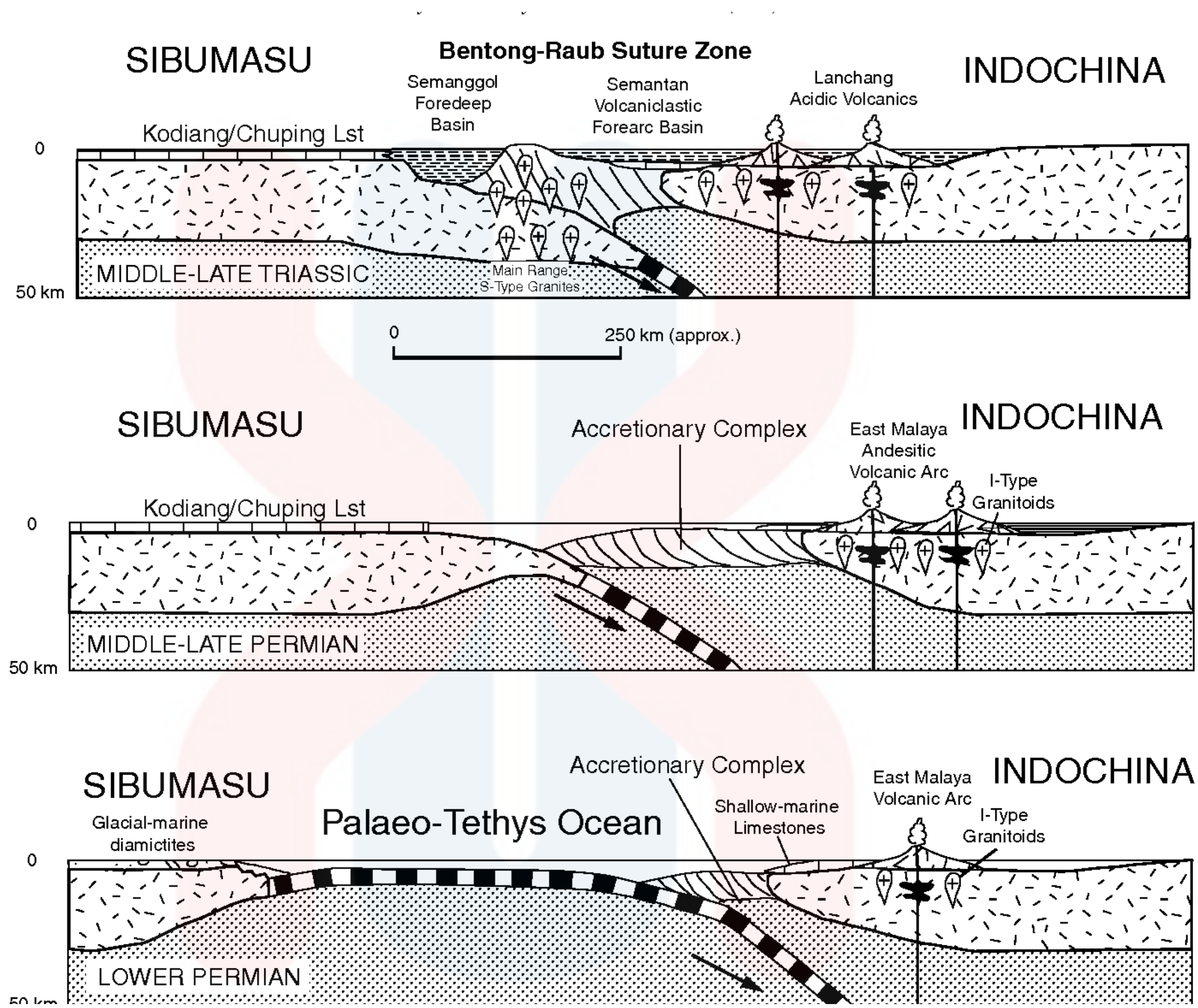


Figure 2.3: The conceptual cross-sections illustrating formation of the Bentong-Raub Suture by subduction of the Palae-Tethys Ocean and collision of Sibumasu with the East Malaya (Indochina) Terrane during the Indonesian Orogeny.

2.5.1 Carbonate Facies

Exposed carbonate facies create karst topography which dominantly in few places of East Peninsular including Gua Musang district. Variety of carbonate facies were distributed which is depend on the depositional environment and the tectonic forces.

The Nilam Marble is dominant facies with the carbonates as the colour of the limestone is dark. The Northern Kelantan limestone has been metamorphosed to marble while the south which is Gua Musang district is oppositely different. In south area, the content between micrites and allochems which consist of shallow benthic marine fauna such as brachiopods, bivalve, algae, and crinoid was expressed. The diagenetic process such as micritization, compaction, dolomization and metamorphism had been observed. (Idris & Hashim, 1988; Metcalfe I. , 1995). The depositional environment of the abundant limestones in south Kelantan (Gua Musang area) to north Pahang is indicate the continues of carbonate platform deposited before the erosion and karstification occur during the Permo-Triassic.

Besides, the variation of the limestone distributed also different depend on distance of the deposited area with the source. In Aring, the presence of thin and localized carbonate beds or lenses within thick volcanic and pyroclastic section suggest that Aring is located closer to the Permian volcanic source compared to Gua Musang (Dony, Hafzan Eva, & Siti Syaza, 2016). The dull water during that time caused by the debris of the volcanic is unsuitable for carbonate deposition. Once the volcanic debris deposited is done, the water become clear again and the carbonate deposition resumed. This show the interbed between the carbonate with the volcanic or pyroclastic during the active volcanic activities.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

2.6 Fossil

The widespread of argillite and presence of extensive carbonate indicate that the deposition within a warm, shallow and clear water platform (Fontain, 1986). This shallow marine within the paleo-Tethys Seaway of the Central Belt is proved by the large amount of benthic organism such as brachiopods and bivalve which inhabited the sea floor (Dony, Hafzan Eva, & Siti Syaza, 2016). The interbed with volcanic rock show that the depositional environment of this area is close to the volcanic source. Some of the past researcher suggested this type of environment is build up the marine topographic. These topographic created shallow environments which were favourable for limestone deposition and for diverse shallow water fauna to flourish (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016).

As discussed by Foo (1983), under the Gua Musang Formation that is predominantly by argillaceous and calcareous sequences, the fossil of ammonoids and pelecypods indicate a middle Permian to Middle Triassic age. It is uncomfortably overlain by the G. Rabong Formation and named after Gua Musang town in south Kelantan. Followed the discussion by Dony& Ahmad Rosli (2014) Nilam Marble Formation on the north of Central Belt is composed of dominantly massive limestones/marbles with thin tuff and argillite interbeds. There is shell fossil which mostly fusulinids within the limestone or marble. This lens-shaped calcareous rock is distributed separately within the Aring Formation and Telong Formation.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

CHAPTER 3

MATERIAL AND METHOD

3.1 Material

This chapter is explained what materials are used and how the research is conducted before, during and after the field. The materials needed for the field are topographic map, compass, Global Position System (GPS), hydrochloric acid solution (HCl), geological hammer, digital camera, field notebook, measuring tape, hand lens, stationary and sample bags. Besides, there five level of research, which are preliminary research, field studies, data processing, laboratory work, and data analysis and interpretation.

3.1.1 Topographic Map

It is the map that provide accurate graphic which represented the features that appear on the Earth's surface. The geomorphology and vegetation information are one of the examples that can provided by 2-dimensional topographic map. Besides, its act as a base map in geological mapping that guide the North direction, coordinates, the contour, scale bar and also the magnetic declination. It is very important thing for geologist during the fieldwork.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

3.1.2 Compass

Compass is a tool that used to measure bearing based on the landmark’s precise directional measurement. The compass also useful in measuring the orientation of the structure present on the outcrop and the attitude of the sedimentary beds to construct the sedimentary log.

3.1.3 Global Position System (GPS)

GPS is a network that connect to satellite orbit which send the detail of position in space back to earth. During the fieldwork, the GPS is used to locate the location on the map which is also help in traversing.

3.1.4 Hydrochloric Acid Solution (HCl)

A chemical that used to determine the carbonate rock type such as dolomite and limestone in very fast field test. The rock that contain carbonate mineral will react vigorously after a small amount of HCl in drop on it.

3.1.5 Geological Hammer

Hammer is the basic tool that used by geologist to collect data from the outcrop. Type of hammer that use is chisel hammer since the working area is underlain by sedimentary rock.

3.1.6 Digital Camera

Each geological data’s that occur at field must be captured in order to act as evidence. The data such as the outcrop, landform, geology structure and other geology features can be recorded and captured with high resolution image.

FYP FSB

3.1.7 Field Notebook

The field notebook is used to jot down everything that found during the mapping. It is important to protect it since all the field data is written in the book. Without it the report cannot be done.

3.1.8 Measuring Tape

Measuring tape usually used for measuring the outcrop. The outcrop can be measured from meter to kilometres. It is also can form 2D of outcrop which the width and height is taken.

3.1.9 Hand Lens

Hand lens used in the field to determine the minerals content or in the rock or other tiny things. The magnifier glass helps to determine the rock at field faster.

3.1.10 Stationary

The use pen, eraser, pencil and marker are necessary when collecting data. The marker pen is use when labelling the plastic sample as it can be permanently labelled. This easier the researcher to the identification of the sample taken for every station in the study area.

3.1.11 Sample Bags

Sample bag is use to keep the sample of the outcrop from different location. The sample bag is labelled with it details to avoid confusion.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

3.1.12 ArcGis Software

A software that used to create, edit, analysed and share information to construct a map. Base map is created by adding the topographic data from Jabatan Mineral and Geosains Malaysia into the software for field studies. The software is also used to produce geological map of Felda Chiku 1, Gua Musang.

3.1.13 Coral Draw Software

A software that is used for drawing stratigraphic column and 3-D block diagram. At first, the necessary data that collected from the field are computed into the software to draw the sedimentary log. Then, the output of the software is used for the depositional environment interpretation of Felda Chiku 1, Gua Musang.

3.1.14 GeoRose software

A software that is used to analysed the joint orientation and fault. The data of the orientation of the structure are added into the software. It may generate the rose diagram of strike, dip direction ad dip angle of the structure, as well as their stereonet.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

3.2 Method

In order to produce the 1:25 000 geological map and the depositional environment of limestone facies, few methods had been done.

3.2.1 Preliminary Study

Preliminary study is an early step to do before going to field. A little knowledge is needed as it is very useful references to know the study area better. Source of the literature review can be a journal article, books, internet and others sources

Through it, the regional geology of the area can be analysed. Besides, the topography map produced by the ArcGIS 10.2 software which it displayed the geology features such as contour, rivers and road accessible. The analysis of the map can be start by lineament identification because lineament is an indicator of the fault. Sometimes, the fault gives information about the past or recent of geology activities.

Besides, the highest elevation in the study area is 380m and the lowest is 140m. The elevation of the contour can provide information about the type of the rock which is affected by the weathering process. Usually the high resistance rock will have high value of elevation while the lowest elevation of contour shows the low resistance of rock toward the weathering process. So, the rock unit that distributed in the study area is mainly sedimentary rock and few places contain limestone.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

FYP FSB

3.2.2 Data Collection

All the data that obtained from the literature review will be use as the reference. The data collection will be dividing into two section which are data fieldwork and data of laboratory. Both data collection should be jot down in details.

3.2.3 Fieldwork

The field work can reach couple of weeks to be done. The preparation must well prepared including the transportation, accommodation and data collection. The mapping activity help in upgrading the knowledge of the study area. The evidence must be collected to support the research.

a) Geological mapping

The traverse method will be use to collect data in field. This is important as the study area is surely covered completely. The observing the road access and the landform in early stage can give the geology impression of the study area. So, the geological features and landmarks such as river, paved road, village are recognized and recorded.

b) Geomorphological mapping

By do the geological mapping, the geomorphology of the study area can be recognized. Hence make the lithologies analysis, structure geology and the stratigraphy of the study area can be obtained and produce geological map. Usually, the highland will be used to observed the geomorphology of the study area. The accessible highland with high elevation helps to recognize the landscape of the study area.

In structure geology, the bedding structure and the secondary structure such as joint and fracture is observed and measure their orientation. The direction of the strike and dip of the bedding can be determined by using left hand rule. The finger that has pointing own after the hand is placed on the bedding plane is showing the dip direction of the bedding plane. The compass is used to measure the bearing. For joint and fracture, their measurement is measured by compass and then analysis by using the Rose Diagram. In lithostratigraphy, the observation of the rock is characterized by their colour, texture and grain size. The boundaries of the rock will be determined by the rock unit that will recorded during mapping.

c) Rock Sampling

The sample of the rock must be fresh which has low rate of weathering process as the crystallization of the rock is still can be observed. Appropriates picture of rock sample is recommended as it can be an evidence.

In order to collect the data for depositional environment at the study area, a clean preparation is a must. In terms of lithology as mentioned, the texture, colour and the grain size must be identified wisely. Besides, the sedimentary structures also important as it can be a hint for the past sedimentation and deposition environment. the fossil content can help in identifying the relative age of the rock and the depositional environment. Then, the stratigraphic column is sketch to show the relationship of the facies. During the field study, every outcrop and other important geology information are sketched and photographed with appropriate scale. The traversing and the location of the outcrop is mark on the base map. All samples are place in the labelled sample bags.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

3.2.4 Laboratory work

In laboratory work, all the sample collected at field will be examined. Few methods will be used to get the result.

a) Thin section

The rock sample will be cut into thin section. The rocks are first cut by non-deformational diamond saw into small pieces. The small sawn piece of rock is ground by hand or grinding machine until the rock is completely flat. Then, using epoxy or mounting medium, the flat surface is attached with the slide. After the glue is dried, the sample is cut down into the thickness approximately 2mm. The completed thin section is ready to do the petrography investigation under thin microscope.

b) Petrographic analysis

The mineral and the fragment are observed and their percentage in the rock is identified. Thus, the perfect name of the rock is given based on the rock identification chart. If there is any micro-fossil content in the thin section, the fossil should be named.(Chamhuri Siwar 2016)

3.2.5 Data Analysed and Interpretation

a) Field work and laboratory data

The data that attained from the field and from the laboratory work are considered as the resource material. The interpretation from the analysing of data is based on the literature review resources that relate with the research. During the fieldwork, the data from the GPS and data from traversing method is input into ArcGIS 10.2 to being

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

processed. This process is used to produce a geological mapping with scale of 1:25,000. The details data from the field is used in order to form sedimentary log. A software such as Corel Draw is used to construct the sedimentary log. The division that produce is shown the different facies with different characteristics. This can help in interpreting for the depositional environment of limestone at Felda Chiku 1, Gua Musang.

b) Microfacies Analysis

Microfacies analysis is the method in identifying the depositional environment which include the observation of carbonate's thin section under the microscope. Dunham's classification (1962) and Folk's classification (1962) chart were used during the analysis and data interpretation. Both classifications subdivide limestone primarily on the basic of matrix content. Dunham's classification as shown in figure 3.1suitable to refer during the field work and during the microscopic observation, while Folk's classification, figure 3.2, is restricted that it only suitable to use during the interpretation of limestone under the microscope.

Dunham divide the carbonates classification into five types based on the depositional fabrics which are mudstone, wackestone, packstone, grainstone and boundstone. Besides, Folk's separate the carbonate into three type, the discrete carbonate grains (the allochem), the microcrystalline calcite matrix (sub equal spar& micrite) and sparry calcite. Besides, Folk modified the classification based on the relative proportion of grain and carbonate mud, sorting and the shape of the grain. The textural of the grain also is divide to show the changing of the energy during the carbonate deposit. Micrite with 10% of grain, sparse biomicrite and packed biomicrite indicate lower energy sediment through the transitional zone. Entering the poorly textural of washed biosparite,

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

it showed the changes of the energy from shallow low energy to shallow high energy phase.

Then, the classification of the limestone facies is based on the Standard Microfacies Type (SMF Type). The SMF Types were defined for a model describing about the sedimentation on rimmed carbonate shelf and warm-water platform-reef environment in tropical latitudes. The occurrences and the distribution of the SMF Types are strongly dependent on the configuration and topography of the shelf (Flugel, 2013). Besides, the paleo-environmental interpretation derived from the microfacies should be control by lithological criteria and sedimentary structure evaluated by the high potential information provided by fossil and biogenic structure. In other way, microfacies sampling requires an understanding of the bedding and the depositional characters reflected by the sedimentary structure.

With the aid sedimentological figure 3.3 as well as paleo-ecological data the microfacies types of limestone of various ages can be combined into major types which reflect the depositional and ecological condition in a certain environment (Flügel, 1982). Limestone facies is represented by the thick succession of carbonate forming limestone and hill tower. This succession is distinguished on the basic of geographical distribution and the temporal difference (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016)

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

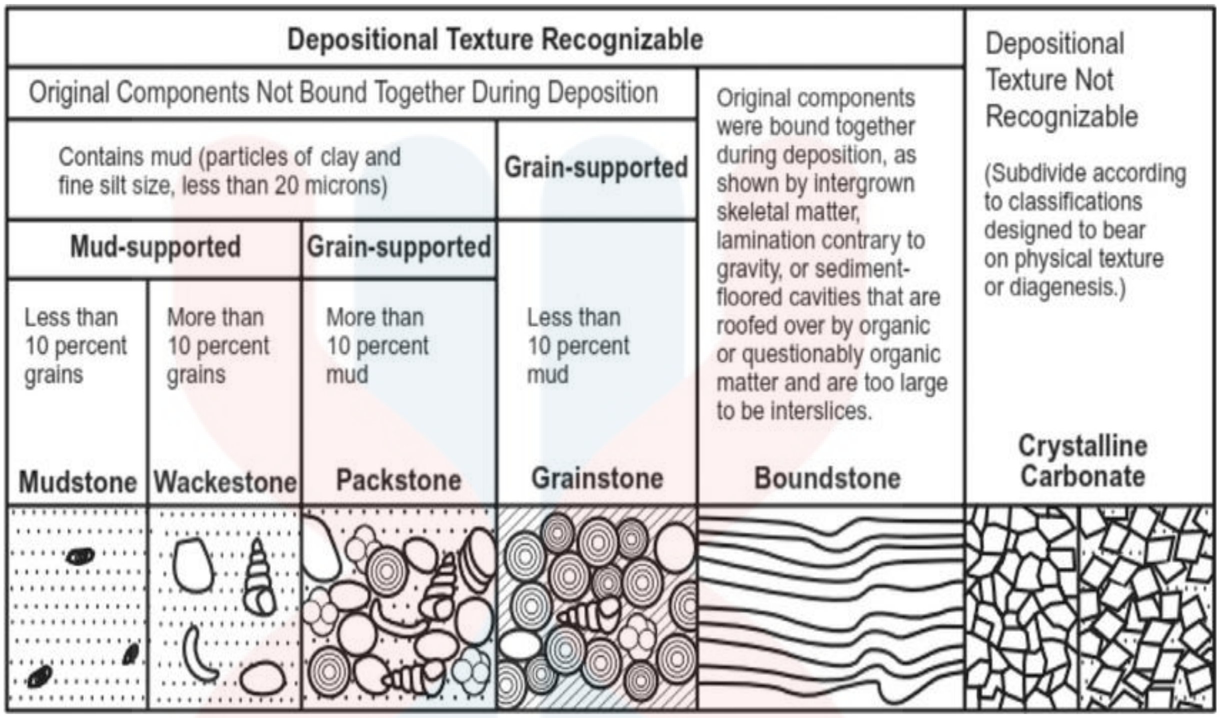


Figure 3.1: Dunham's classification of carbonate rock

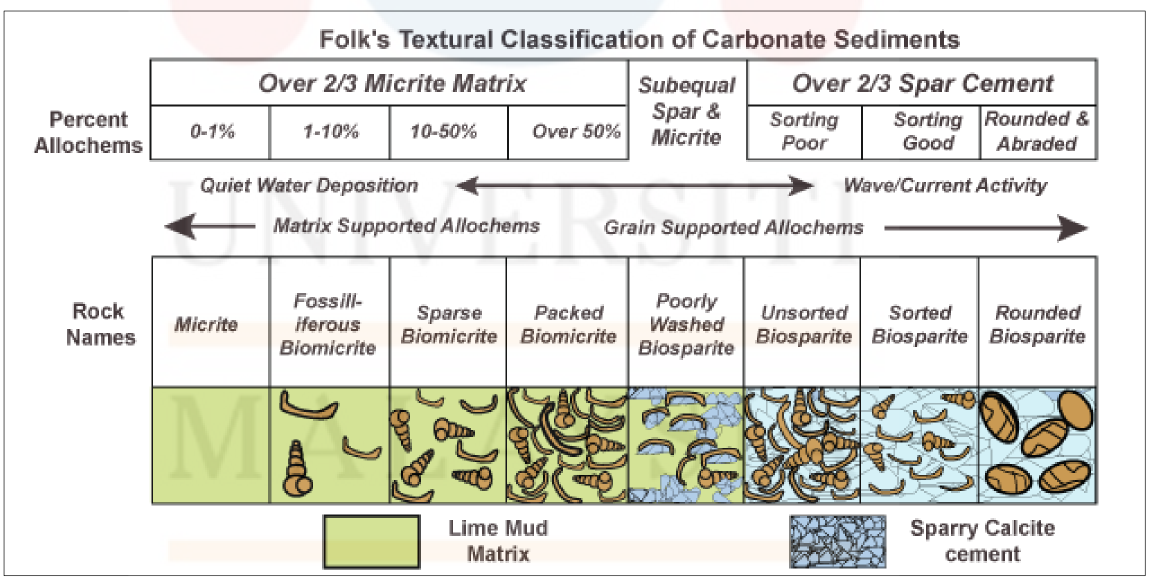
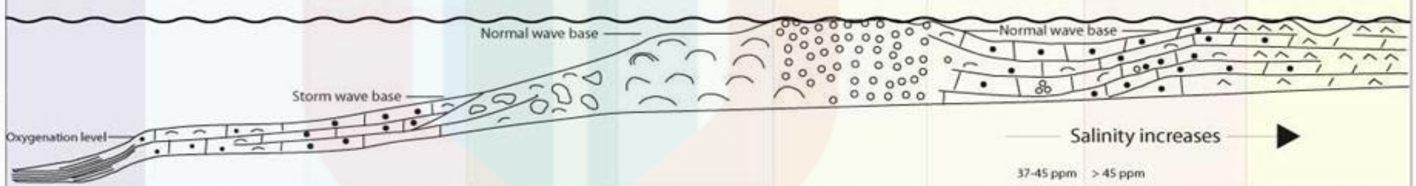


Figure 3.2: The Folk's carbonate classification

Belt	BASIN	OPEN SEA SHELF	DEEP SHELF MARGIN	FORESLOPE	ORGANIC BUILD UP	WINNOWED EDGE SANDS	SHELF LAGOON OPEN CIRCULATION	RESTRICTED CIRULATION SHELF & TIDAL FLATS	EVAPORITES ON SABKHAS - SALINAS
Diagrammatic cross section & Facies Number	1	2	3	4	5	6	7	8	9
Facies	a) Fine Clastics b) Carbonates c) Evaporites	a) Carbonates b) Shale	Toe of Slope carbonates	a) Bedded fine grain & slumps b) Foreset debris & lime sands c) Lime mud mases	a) Boundstone b) Crust on accumulations of debris lime mud; bindstone c) Bafflestone	a) Shoal lime sands b) Islands w. dune sands	a) Lime snad bodies b) Wackestone-mudstone areas, bioherms c) Areas of clastics	a) Bioclastic wackestone, lagoons and bays b) litho-bioclastic sands in tidal channels c) Lime mud-tide flats d) Fine clastic units	a) Nodular anhydirte & dolomite on salt flats. b) Laminated evaporites in ponds
Lithology	Dark shale or silt, thin limestones (starved basin); evaporite fill w. salt	Very fossiliferous limestone interbedded with marls; well segregated beds.	Fine grain limestone; cherty in some cases.	Variable, depending on water energy upslope; sedimentary breccia and lime sands	Massive limestone-dolomite	Calcarenitic-oolite lime sand or dolomite	Variable carbonate and clastics	Generally dolomite and dolomitic limestone	Irregularly laminated dolomite and anhydrite, may grade to red beds
Color	Dark brown, black, red	Gray, green, red, brown	Dark to light	Dark to light	Light	Light	Dark to light	Light	Red, yellow, brown
Grain type and depositoinal texture	Lime mudstone,; fine calcisiltites	Bioclastic and whole fossil wackestone; some calcisiltites	Mostly lime mudstone with some calcisiltites	Lime silt and bioclastic wackestone-packstone; lithoclastics of varying sizes	Boundstones and pockets of grainstone; packstone	Grainstones well sorted; rounded	Great variety of textures; grainstone to mudstone	Clotted, pelleted mudstone & grainstone; laminated mudstone; coarse lithoclastic wackestone in channels	
Bedding and sedimentary structure	Very even mm laminations; rhythmic bedding; ripple cross lamination	Thoroughly burrowed; thin to medium; wavy to nodular beds; bedding surfaces show diastems	Lamination may be minor; often massive beds; lenses of graded sediment; lithoclasts & exotic blocks. Rhythmic beds	Slump in soft sediments; sofeset bedding; slope bioherms; exotic blocks	Massive org. structure or open framework with roofed cavities; Lamination contrary to gravity	Medium to large scale crossbedding; festoons common	Burrowing traces very prominent	Birdseye, stromatolites, mm lamination, graded bedding, dolomite crusts on flats. Cross-bedded sand in channels	Anhydrite after gypsum; nodular, rosettes, chickenwire, and blades; irregular lamination; carbonate caliche
Terrigenous clastics admixed or interbedded	Quartz silt & shale; fine grain siltstone; cherty	Quartz silt, siltstone, & shale; well segregated beds	Some shales, silt, & fine grained siltstone	Some shales, silt, & fine grained siltstone	None	Only some quartz sand admixed	Clastics and carbonates in well segregated beds	Clastics and carbonates in well segregated beds	Windblown, land derived admixtures; clastics may be very important units
Biota	Exclusively nektonic-pelagic fauna preserved in abundance on bedding planes	Very diverse shelly fauna preserving both infauna & epifauna	Bioclastic detritus derived principally from upslope	Colonies of whole fossil organisms & bioclastic debris	Major frame building colonies with ramose forms in pockets; in situ communities dwelling in certain niches	Worn and abraided coquinas of forms living at or on slope; few indigenous organisms	Open marine fauna lacking; mollusca, sponges, forams, algae abundant; patch reefs present	Very limited fauna, mainly gastropods, algae, certain foraminfirera & ostracods	Almost no indigenous fauna, except for stromatolitic algae



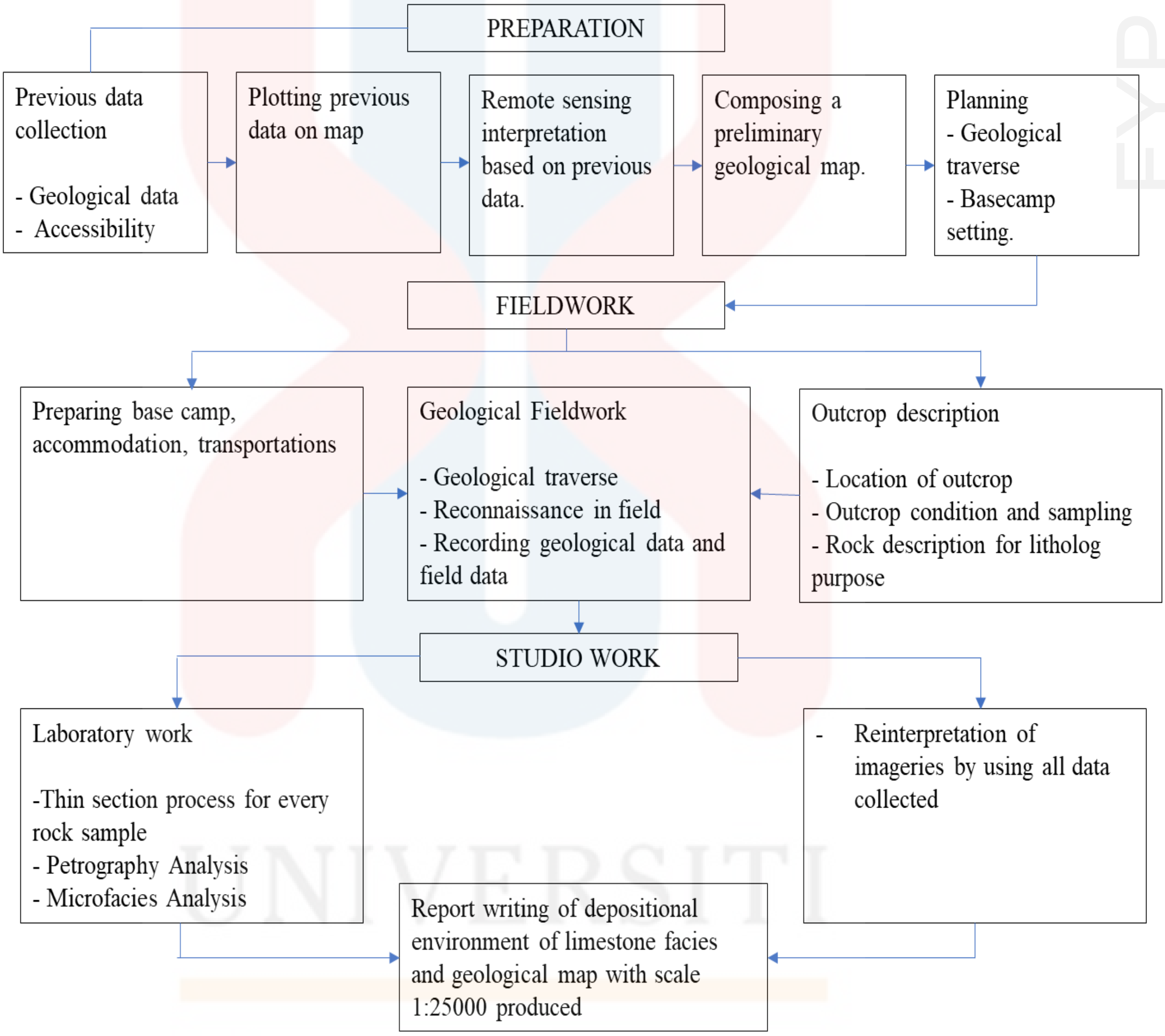
(Source: Reproduced by Nassir Alnaji (2002))

Figure 3.3: The idealized sequences of Standard Facies Belt (Wilson,1975)

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

3.3 Flowchart

The research flow chart is used to show how the research is handling. It is important to make the flow of the research work very well.



FYP FSB
UNIVERSITI MALAYSIA KELANTAN

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will discuss about the mapping activities in the study area which include all the geology characteristics such as the geomorphology, lithostratigraphy, structural geology and also the historical geology. All these characteristics show how the landforms are continuously formed and shaping the Earth. Besides, the area is dominant covered by the plantation of oil palm plantation with minor of rubber tree plantation. In the centre of the box, there is a thick forestry as shown in figure 4.2.

There is highway across the study area which is Kota Bharu- Gua Musang highway. Other road used to enter the study area is by Jalan Felda Perasu and from Felda Rantau Manis. All this road shown in figure 4.1. Mapping activity is conducted by using this road that connecting all the street of the small town and village in the study area as shown in figure 4.3. Besides, the main road also connecting the unpaved street of plantation area and mainly used by the workers to enter. Some of the area need used compatible vehicle because the road is bumpy and rocky.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

During the mapping, the motorcycle is used at high elevation to save the time and energy. The track that recorded in the GPS is transferred and processed in ArcGIS 10.2 to see the coverage percentage of the study area. This method is important in mapping to ensure the area has been covered enough to collect all the data. Figure 4.4, show the map of road that accessible during the mapping. There is no settlement in the study area unless the hut or small house that built by the workers to stay during their working time. But near to the study area, there is a community living in a village named Felda Chiku 1.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Figure 4.1: The accessible road in Felda Chiku 1, A is main road enter Felda Rantau Manis, B is The Kota Bahru-Gua Musang highway is the main road used by the user and C is Felda Perasu road.

UNIVERSITI MALAYSIA KELANTAN
FYP FSB

FYP FSB

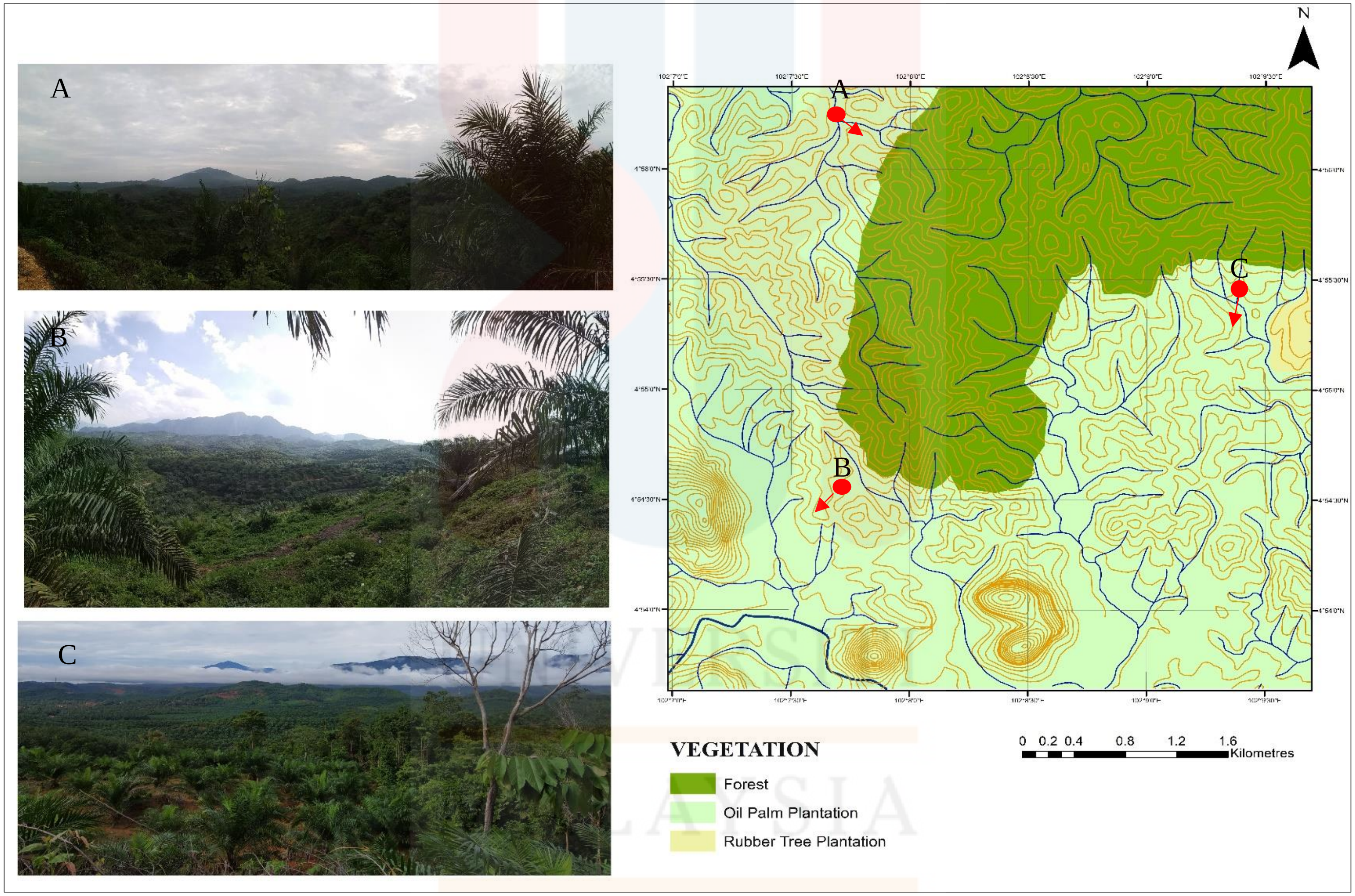
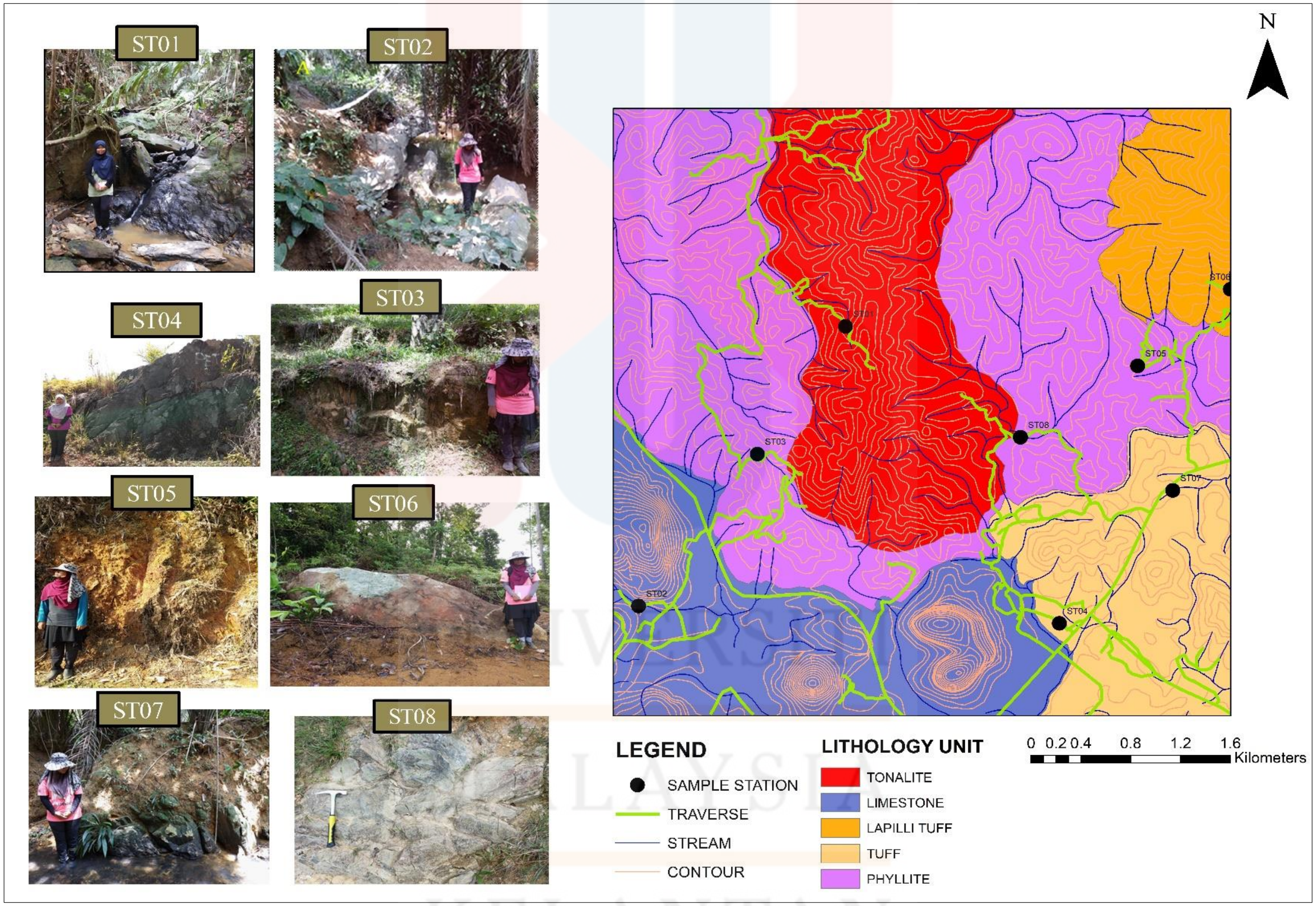


Figure 4.2: The type of vegetation spread on the study area. The red arrow shows the direction of the observation.

FYP FSB



KELANTAN

Figure 4.3: The traverse map and locality of sample taken.

4.2 Geomorphology

4.2.1 Geomorphologic Classification

Geomorphological study is the scientific study of land forms and processes involved in their formation process. The study of the geomorphology more focus on the pattern of drainage systems, topographic patterns and geomorphic processes that occur in the study area as a process of erosion, weathering and mass movement.

4.2.2 Topography

Elevation or altitude is a factor that is seen to determine the topography of a place. High topography area is often hilly or mountainous areas while low topography area, an area close to the river or sea. Topographic maps are generated by using satellite imageries and process in ArcGIS to produce a map. Other way, it can be observed in the field.

The type of the morphology element based on the absolute elevation in the study area is based on the table 4.1 prepared by (Van Zuidam, 1985) . Through the observation in lab and during the fieldwork, the elevation in the study area are almost in low hill range. This hilly area has been used entirely by certain people to plant oil palm as shown in figure 4.4 and figure 4.5. This show the main economy of the people who living near to this study area.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Table 4.1: Relationship between absolute elevation and morphology (Van Zuidam, 1985)

ABSOLUTE ELEVATION (mean sea level)	**MORPHOLOGY ELEMENT**
<50	Lowland
50-100	Low lying plain
100-200	Low hill
200-500	Hill
500-1.500	High hill
1.500-3.000	Mountain
>3.000	High Mountain

Figure 4.4: Panorama view from elevation of 180m above the sea level, point view to 235^{o}SW of study area

FYP FSB

Figure 4.5: Panorama view from elevation of 200m above the sea level, point view to 116ºSE of study area

The topography map in figure 4.6 show the range of the elevation which has divide into 10 classes. The highest hill which located on the Eastern part of study area reach elevation of 380m while the lowest elevation is dominated on the Southern part which reach only 120m above the sea level.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

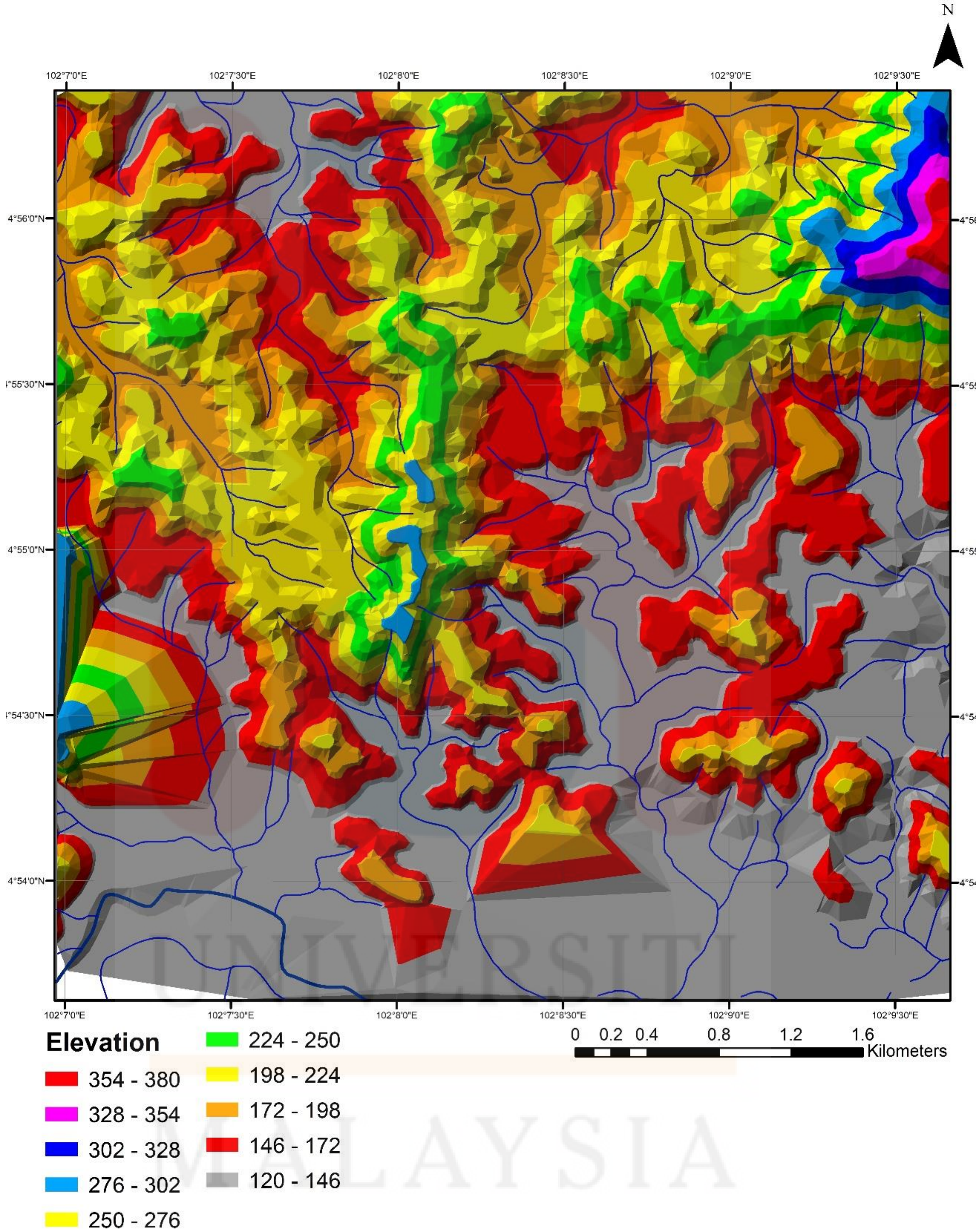


Figure 4.6: The 2D of topography map show the different division of elevation

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

4.2.3 Weathering

Weathering is part of geological process that forming the Earth landform. In definition, it an exogeneous geomorphologic process that breakdown of rocks by biological process, mechanical disintegration and chemical decomposition. Many rocks form under high temperatures and pressures deep in the Earth's crust and when it exposed to the low temperatures and pressures on Earth's surface the weathering process starts. By the assist of the biosphere agent which brought them into contact with air, water, and organisms, they start to decay. This process occurs in cyclic away where it is always end where it formed. There three types of weathering which are chemical, physical and mechanical weathering and all these weathering being observed in the study area.

Generally, the area has high rate of weathering process since the outcrop found almost weathered and already turn into soil. This is because the climate pattern in the study area triggering the process. Figure 4.7, show the average of temperature, precipitation, and sun penetration over the 30 years occurred within the study area. This condition created wet and dry pattern of climate in Gua Musang district which is favour for the weathering process to happen. Besides, not only the climate, the different mineral content in the rock also effects the rate process.

In the study area wet climate accelerated the rate of chemical weathering. When $C0_2$ mixed with the air and water to form weak acid. The weak acid breakdown rock more rapidly in wet climate compared with dry ones. As shown in figure 4.11, the formation of stalagmite in Gua Sejuk is caused by the limestone that been dissolved by the weak acid.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

But for the invulnerable to chemical attacks, it is commonly affected by the physical or biological weathering. In physical weathering, the fracturing caused by the freezing and expanded water found in crack will break down the rock as shown in figure 4.8. Biologically, the breakdown of the rock is caused by the growing root of plant (figure 4.9).

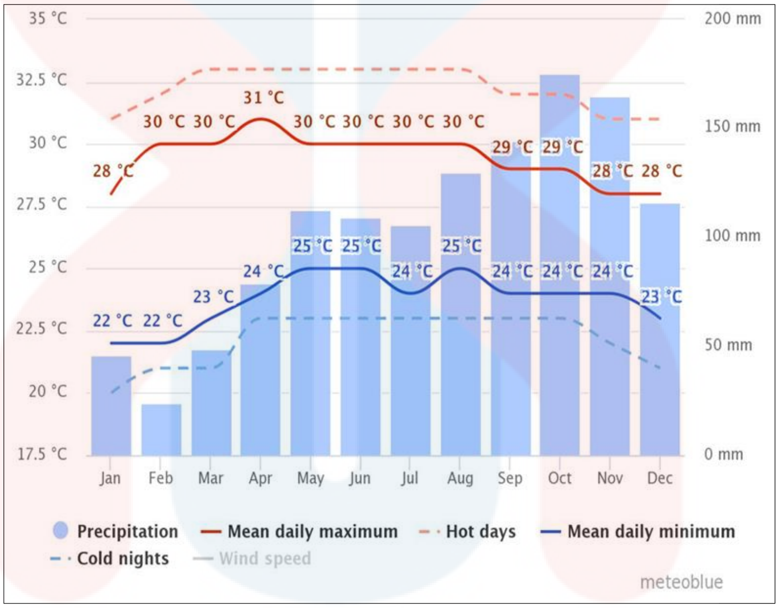


Figure 4.7: The average of precipitation and temperature of Gua Musang district for 30 years.

During the ground mapping, the types of weathering is determined by observed the physical characteristics rock such as the structure, colour, chemical changes (leaching zone) and grain size. Although the rate of weathering depends on the type of rock, but in tropical climates especially in study area, experience the high rates of weathering because of the combination of high heat and heavy rainfall.

FYP FSB

Figure 4.8: The rock is expanded and contract due to the changing of temperature cause it crack

Figure 4.9: The dominant weathering process in forestry area by biological weathering process

FYP FSB

Figure 4.10: The chemical weathering turned the soil to red colour due to the iron content react with the water

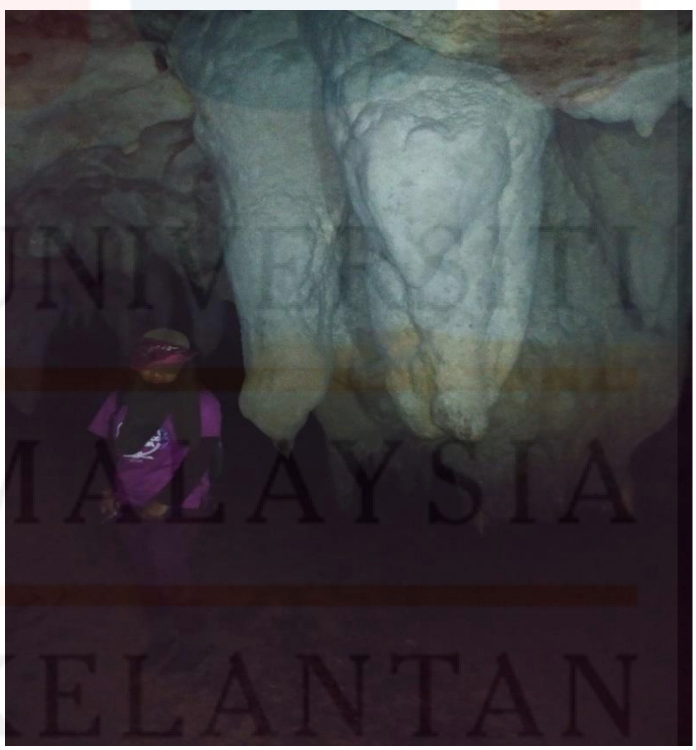


Figure 4.11: The huge stalactite formed from chemical process of calcite

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

4.2.4 Mass Wasting

Mass wasting is a part of geomorphology process of downslope of soil in response to gravitational stresses. The main factor for this process to occur is the heavy rainfall. The water will accumulate in the porous soil and increase the weight. The soil exposed directly to the surface without vegetation covered, lack of grip mechanism caused the soil not more supported and moved. Although the mass wasting cause by the increase of water in pores of soil, the rate of occurrence is various. There are few factors that need to concern which is the type of the earth material. The types can be in form of soil, debris or others earth move. Then the types of movement can be slides, falls, rolling and flow.

Based on the figure 4.12 show the soil is sliding down to the Earth surface. The continues process of thawing and freezing of water in the soil pores increasing the possibility of the soil to slide. Besides, the lack of vegetation planted on the soil also increasing the rate of mass wasting. The plant which naturally hold the soil to each other is absent, so this condition weakening the strength of the soil. The steepness of the slope also contributed in a mass wasting. The natural tendency of steep slopes is to move some of its materials downwards until the natural angle of repose is found.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

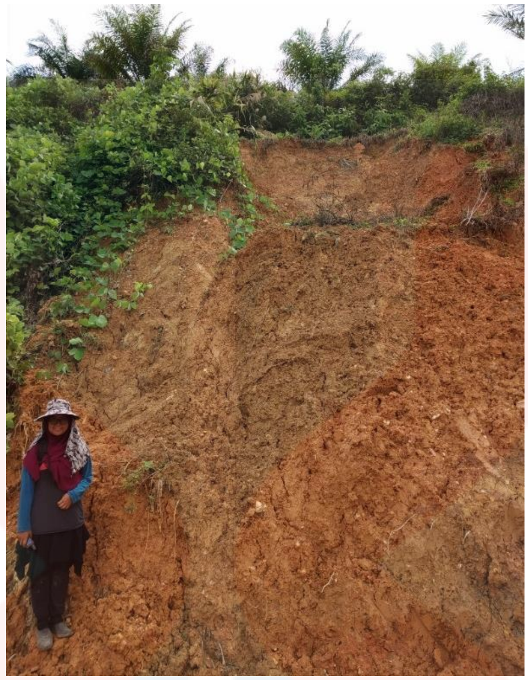


Figure 4.12: The landslide found in plantation area

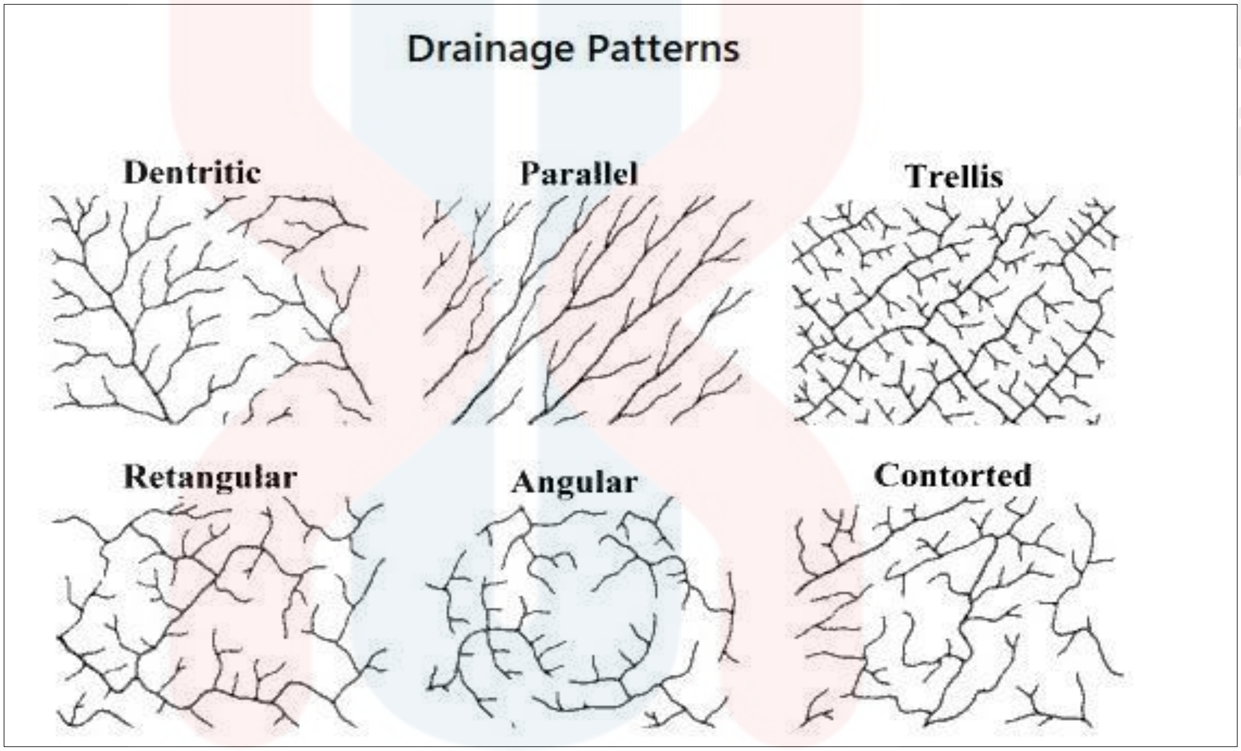
4.2.5 Drainage Pattern

Drainage system is the pattern formed by streams, rivers and lakes in a drainage basin. As an indivisible part of the land, drainage system is an important component in GIS and in terrain analysis. In a drainage system, streams or rivers always connect together to form networks. Inside a network, different patterns can be observed and related to other geographical factors. In a drainage basin, a number of factors such as topography, soil type, bedrock type, climate and vegetation cover influence input, output and transport of sediment and water (Charlton, 2008). As a consequence, drainage pattern can reflect the geographical characteristics of a river network to a certain level.

The drainage pattern can be analysed by using GIS method. In current GIS systems, river networks are stored as line segments with their geographical coordinates

FYP FSB

and topological relationships. Then, input it in the ArcGIS to form a map as shown in figure 4.14, before classify it. The classification of the drainage pattern or shape of the is referred to figure 4.13.



Source: http://www.latestgkgs.com/drainage-pattern-3617-a

Figure 4.13: The general type of drainage network pattern

Based on the description of different drainage patterns, each pattern has its own characteristics, which can be reflected in some quantifiable variable related to some topological and geometrical aspects. Therefore, each pattern can be characterized by a combination of different variables. In this section, the method for drainage pattern recognition is introduced and one of it is through its criteria as shown in table 4.2.

FYP FSB

Table 4.2: Drainage pattern characteristic.

Drainage pattern	**Geometric and Topologic Characteristic**
Dendritic	-Tributaries joining at acute angle
Parallel	- Parallel-like - Elongated catchment - Long straight tributaries - Tributaries joining at small acute angle
Trellis	- Short straight tributaries - Tributaries joining at almost right angle
Rectangular	-Tributary bends - Tributaries joining at almost right angle
Reticulate	- Tributaries cross together forming a cycle

Source: (Zhang & Guilbert, 2012)

In the study area, there are two type pattern of drainage network which are, dendritic and parallel pattern. Dendritic is commonly found in the area with homogeneous lithologies, has horizontal or very gently dipping strata or the topographic surface has extremely low elevation. Besides, this pattern develops in a variety structural and lithological environment such as in hilly area. As refer to topographic map in figure 4.6, the study area has hilly elevation where this criterion is correspondingly in developing this pattern.

Next, the parallel drainage pattern also observed in the area that has uniform slope and dipping rock beds. It comprised numerous rivers which are parallel to each other and follow the regional slope.

FYP FSB

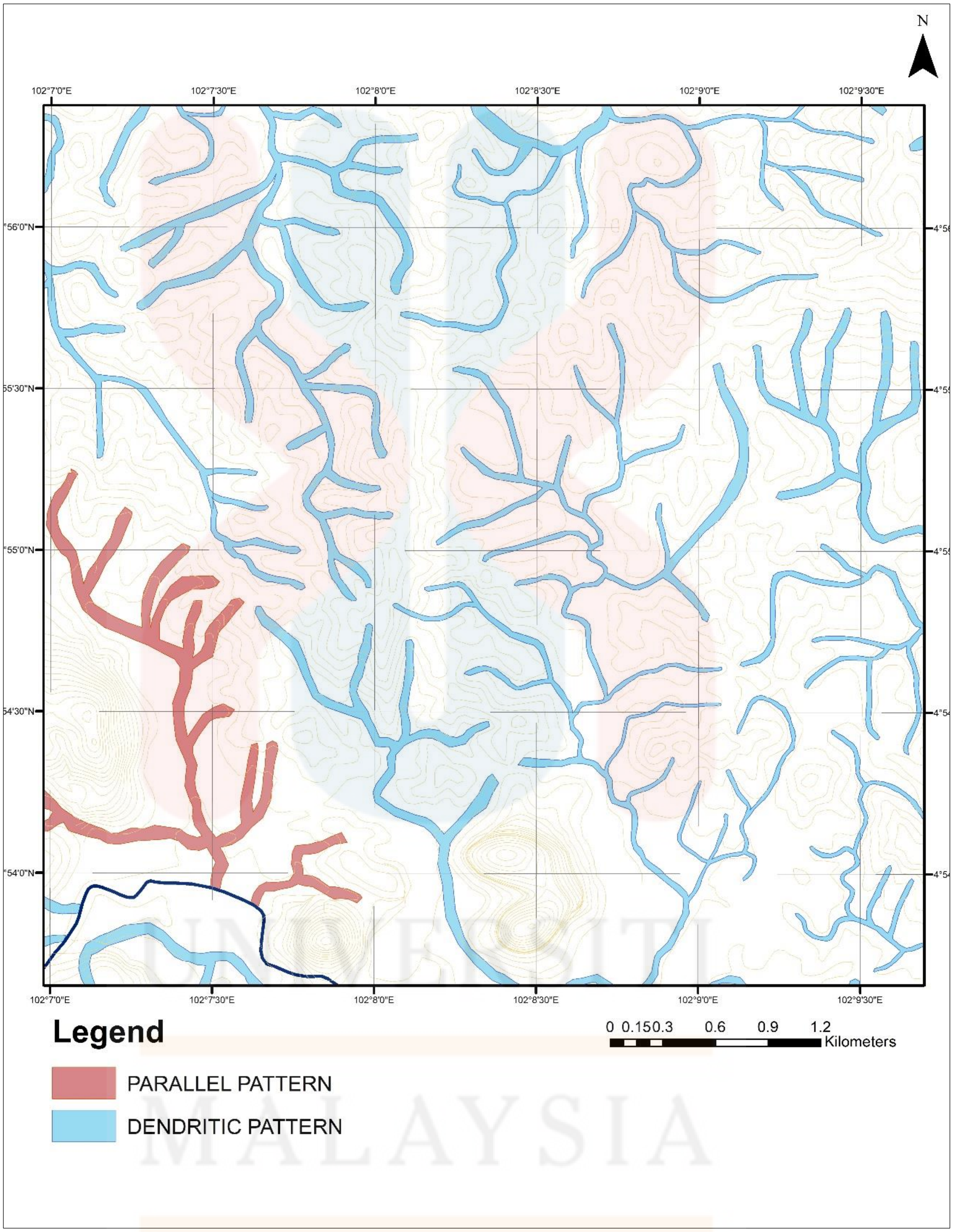


Figure 4.14: The map of drainage network pattern

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

4.2.6 Geological map

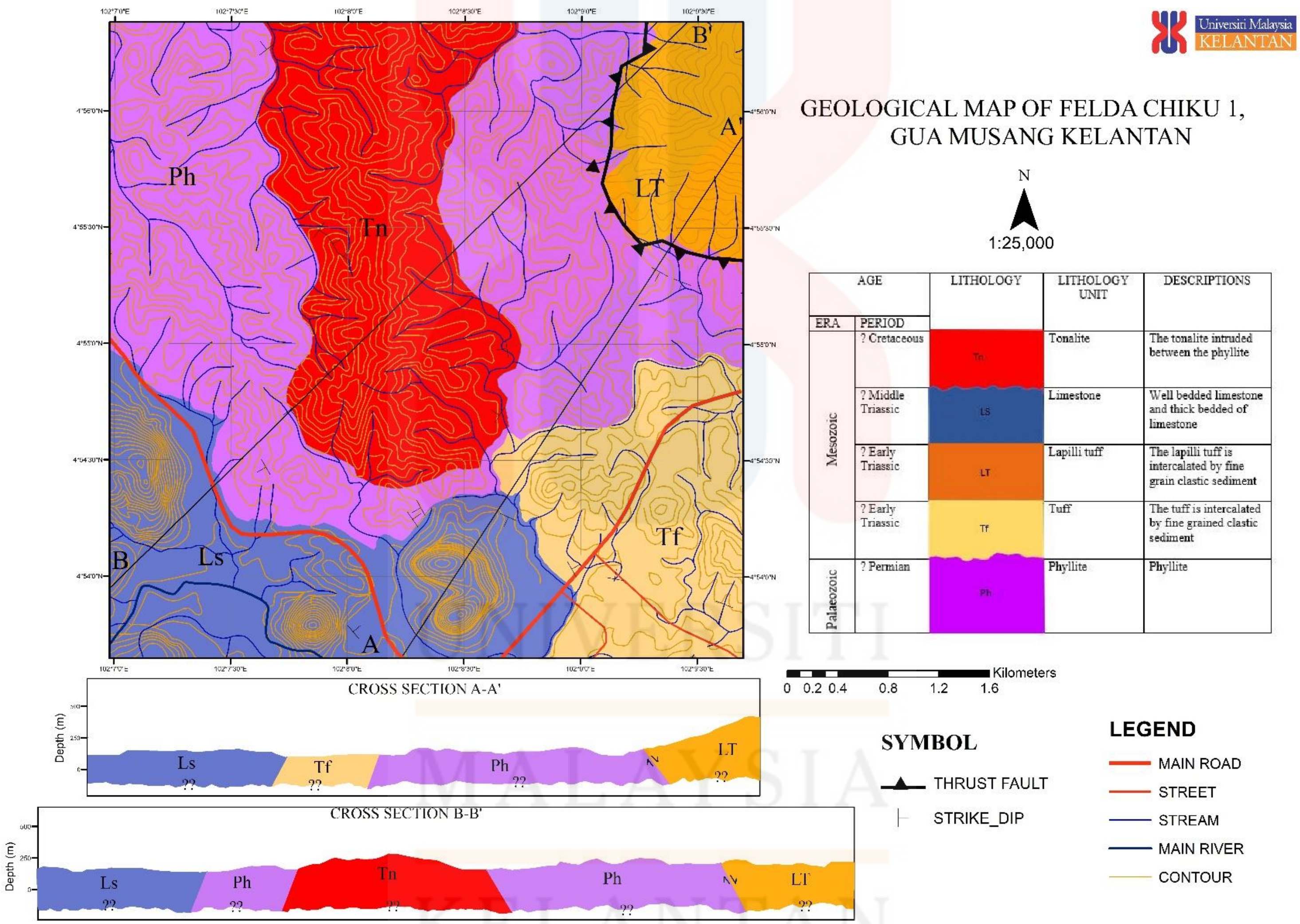


Figure 4.15: The geological map of the study area.

FYP FSB

4.3 Lithostratigraphy

The lithostratigraphy is the classification of rock based on observable lithological properties of the strata and their relative stratigraphic position. It includes the information of the geological distribution, geological process occurred in past and the age of the rock. It involves the attempt to determine the chronological sequence of geological event over the study area.

Besides, the petrographic analysis for thin section prepared from different type of rock sample. This sample then observed under polarizing petrographic microscope revealed the mineral content. The mineral identified based on optical characteristics under the plane polarized and cross polar media. This method allowed proper on naming the rock. The modal composition of the rock from the slide were prepared and shown with the following photomicrograph.

4.3.1 Stratigraphic position

There are five type lithologies of rock that distributed in the study area as shown in table 4.3 above. The distribution of rock observed are during Mesozoic era. It starts with the oldest rock, phyllite to the younger unit which is tonalite intrusion. Based on the lithology table below, all of unit of rock is present in the study area will be further describe in unit explanation.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Table 4.3: The lithology of rock distribution at study area

AGE		LITHOLOGY	LITHOLOGY UNIT	DESCRIPTIONS
ERA	PERIOD			
Mesozoic	? Cretaceous	Tn	Tonalite	The tonalite intruded between the phyllite
	? Middle Triassic	LS	Limestone	Well bedded limestone and thick bedded of limestone
	? Early Triassic	LT	Lapilli tuff	The lapilli tuff is intercalated by fine grain clastic sediment
	? Early Triassic	Tf	Tuff	The tuff is intercalated by fine grained clastic sediment
Palaeozoic	? Permian	Ph	Phyllite	Phyllite

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

FYP FSB

4.3.2 Unit Explanation

a) Phyllite unit

A metamorphic rock, phyllite unit is the oldest unit in the study area. It is deposited during Permian period.

i. Phyllite

The type of rock found is shale that the force that has been applied on it. So, it has foliation structure on the rock. This slow water deposition environment has fine grained and composed of mud and clay material that has been metamorphose by low level of temperature and pressure. The foliation is observed on the rock surface. The material content in this rock can refer to thin section figure 4.17. Besides, the distribution of phyllite almost covered quarter of the study area and it also can be found interbedded with limestone unit. The colour of the rock is diverse from red brown to orange colour as shown in figure 4.16. This colour depends on the iron content in the rock.

Figure 4.16: The condition of metasediment outcrop commonly found (left) and sample taken for thin section purpose(right).

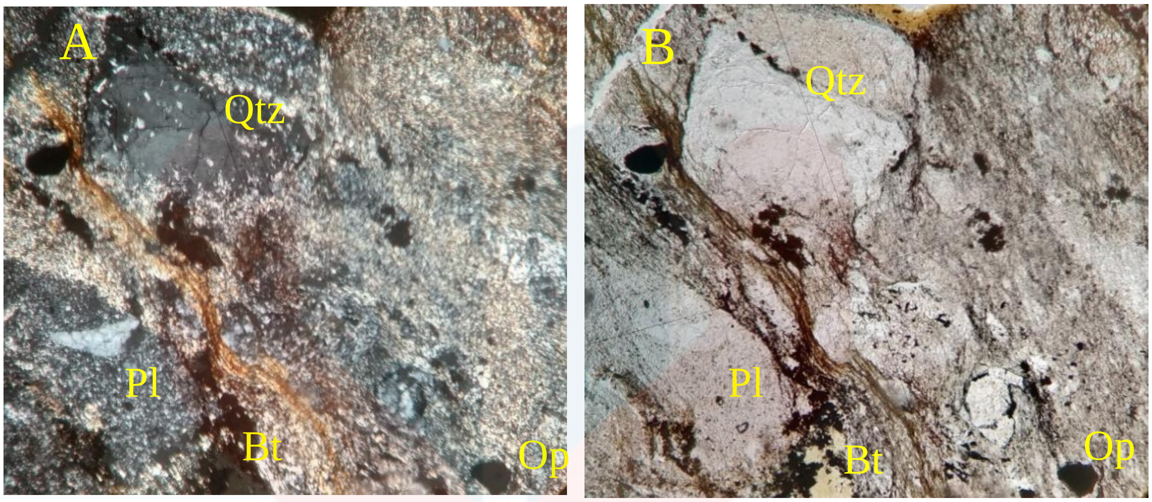


Figure 4.17: The petrography analysis of phyllite which is A is from cross polarized light and B is under plane polarized light. Qtz is quartz, Bt is biotite and Op is for mineral opaque.

Based on petrographic analysis on figure, it shows the fine groundmass of quartz with other mineral such as biotite and plagioclase. It is poorly sorted with a small fragment comprised in it. Further explanation about the mineral is explained in the table 4.4.

Table 4.4: The mineral composition of phyllite

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz	45	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

		have any cleavage. Under the cross polarize plain, the colour turned into black.
Plagioclase	15	In plane polarized, it is colourless and has sub-angular shape with size bigger than 2mm. It has low relief, no sign of pleochroism and found in the occurrence of quartz. The plagioclase has extinction angle not more than 12 ^{o}. Under the cross polarized plane, the colour change into light grey.
Biotite (Bt)	35	In plane polarized light, the one direction of cleavage is clearly observed by using 40x magnification. It has intense pleochroism where the extinction angle is 3^{o}. Under cross polarized light it has brown colour that turn to black when under cross polarized. The relief is medium and occur in round shape.
Opaque mineral (Op)	5	The subangular mineral that has black colour whether under plane polarized light or cross polarized light.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

b) Tuff unit

The active volcano activities during the Early Triassic give huge distribution of volcanic rock and there is injection of magma through the Earth layer formed pyroclastic igneous rock. It is found intercalated by fine grained clastic.

i. Tuff

The domination of tuff unit found at eastern part of the study area along the stream. The tuff was found interbedded with light colour of mudstone. The grain size is in range from fine to very fine which has mean diameter less than 2mm. Besides, the colour of tuff is light grey as shown in figure 4.18.

Figure 4.18: Tuff outcrop found in the stream(left) and sample taken for thin section purpose(right).

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

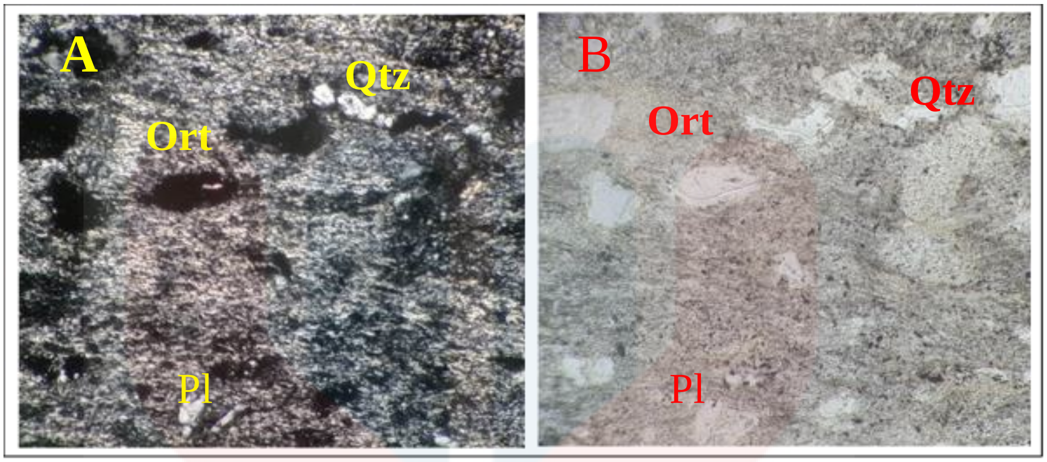


Figure 4.19: The petrography analysis of tuff which is A is from cross polarized light and B is under plan polarize light. Qtz is a quartz mineral, Ort is orthoclase while Pl is plagioclase feldspar.

Based on the figure 4.19, it shows the aphanitic texture where the groundmass is made up from small grain that hard to see by naked eyes. This extrusive formation of rock also knows by its poorly sorted since there is space formed between the grain. Further explanation about the mineral is explained in the table 4.5.

Table 4.5: The mineral composition of tuff

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz	55	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not have any cleavage.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

		Under the cross polarize plain, the colour turned into black.
Plagioclase	35	In plane polarized, it is colourless and has sub-angular needle like shape with size bigger than 2mm. It has low relief, no sign of pleochroism and found in the occurrence of quartz. The polysynthetic plagioclase that has extinction angle of 12 º. Under the cross polarized plane, the colour change into light grey.
Orthoclase	10	In plane polarized light, it colourless and has low birefringence. It also displays two cleavage that intersect at 90º. Besides, it exhibits low relief and has simple twin. Under the cross polarized plane, the colour change into light grey.

i. Agglomerate

Agglomerate is a large, coarse rock fragment that associated with lava flow that explode during the eruption. It grouped as pyroclastic igneous rock which consist of angular and rounded fragment from various size and shape is observed under the microscope (figure 4.21). The outcrop was found next to the highway with 2 meters high and 4 meters wide as shown in figure 4.20.

FYP FSB

Figure 4.20: The 3meter high outcrop of agglomerate found beside the Kota Bahru-Gua Musang highway(left) and sample taken for thin section purpose(right).

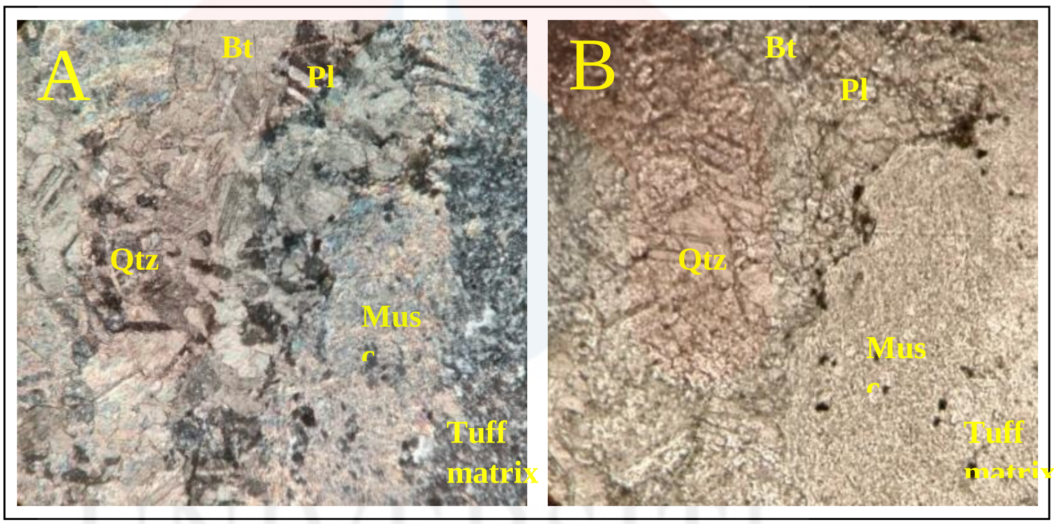


Figure 4.21: The petrography analysis of agglomerate which is A is from cross polarized light and B is under plane polarized light. Qtz is quartz, Bt is biotite, Pl is plagioclase, and Musc is muscovite.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Table 4.6: The mineral composition of agglomerate

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz	45	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not have any cleavage. Under the cross polarize plain, the colour turned into black.
Plagioclase	25	In plane polarized light, it is colourless and has sub-angular needle like shape with size bigger than 2mm. It has low relief, no sign of pleochroism and found in the occurrence of quartz. The polysynthetic plagioclase that has extinction angle of 12 ^{o}. Under the cross polarized plane, the colour change into light grey.
Biotite	20	In plane polarized light, the one direction of cleavage is clearly observed by using 40x magnification. it has intense pleochroism where the extinction angle is 3^{o}. The relief is medium and occur in round shape.

FYP FSB

Muscovite	10	In plane polarized light, it colourless and has weak relief. Besides, it has perfect one direction cleavage and bright interference colour. Under the cross polarized plane, this monoclinic crystal system, show the colour of the mineral present in various.

c) Lapilli Tuff unit

Deposited during Triassic period and it is intercalated by fine grain clastic sediment.

i. Lapilli Tuff

Lapilli tuff is a pyroclastic igneous rock which formed when the material produced by the volcanic eruptions. The groundmass is dominant by tuff material with small green mineral being lapilli which thrown out during the explosive. The lapilli mineral has size between 2-64mm and appeared as elongated glassy dots in the rock sample. The mineral also can be seen by naked eyes as in figure 4.22. The lapilli tuff is found intercalated by fine-grained clastic sediment.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Figure 4.22: The lapilli tuff outcrop (left) and sample taken for thin section purpose(right).

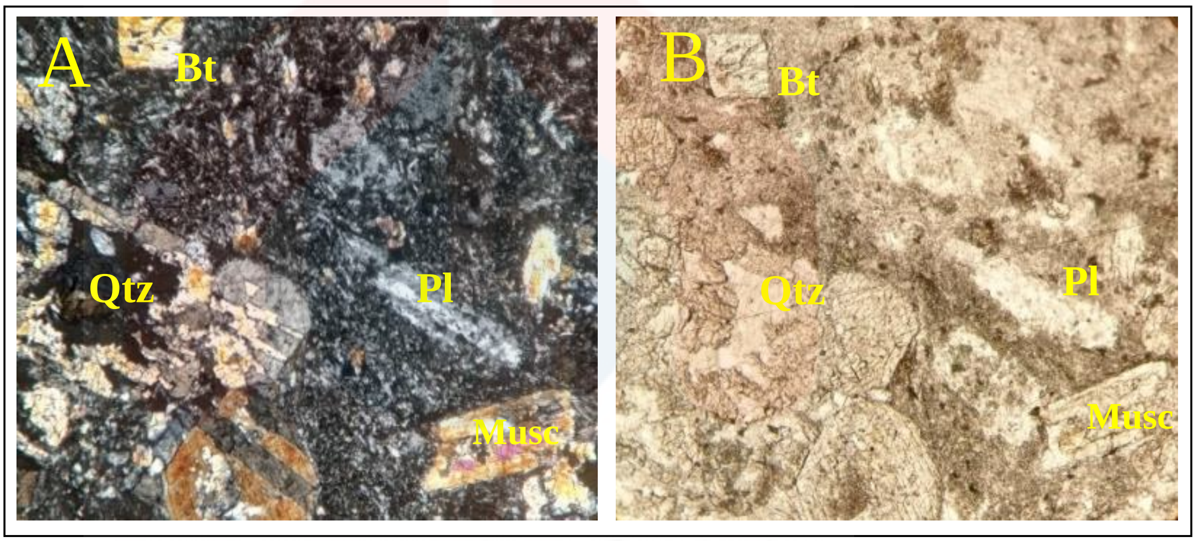


Figure 4.23: The petrography analysis of lapilli tuff which is A is from cross polarized light and B is under plane polarized light. Bt is biotite, Qtz is quartz, Pl is plagioclase, Musc is muscovite and Op is an opaque mineral

Based on the petrography analysis, the compact texture of volcanic ash can be seen with mineral fragment around it. During the explosion, the ash is still hot and the lapilli mineral is deposit into it. So, the groundmass of tuff is welded together with the fragment

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

and formed poorly sorted of lapilli tuff. The mineral composition present in the rock is described in table 4.7.

Table 4.7: The mineral composition of lapilli tuff.

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz	45	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not have any cleavage. Under the cross polarize plain, the colour turned into black.
Plagioclase	25	In plane polarized light, it is colourless and has sub-angular needle like shape with size bigger than 2mm. It has low relief, no sign of pleochroism and found in the occurrence of quartz. The polysynthetic plagioclase that has extinction angle of 12 º. Under the cross polarized plane, the colour change into light grey.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Biotite	20	In plane polarized light, the one direction of cleavage is clearly observed by using 40x magnification. it has intense pleochroism where the extinction angle is 3º. The relief is medium and occur in round shape.
Muscovite	10	In plane polarized light, it colourless and has weak relief. Besides, it has perfect one direction cleavage and bright interference colour. Under the cross polarized plane, this monoclinic crystal system, show the colour of the mineral present in various.

ii. Shale

Shale is sedimentary rock that has fine grained. Its formed from the compaction of clay-mineral size such as calcite and quartz. The colour of shale in the study area is orange to red show the content of iron is high. Besides, the shale has lamination which show very thin layers (figure 4.24).

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Figure 4.24: The shale outcrop found in plantation area has undergo chemical and biological weathering(left) and hand sample taken for thin section purpose(right).

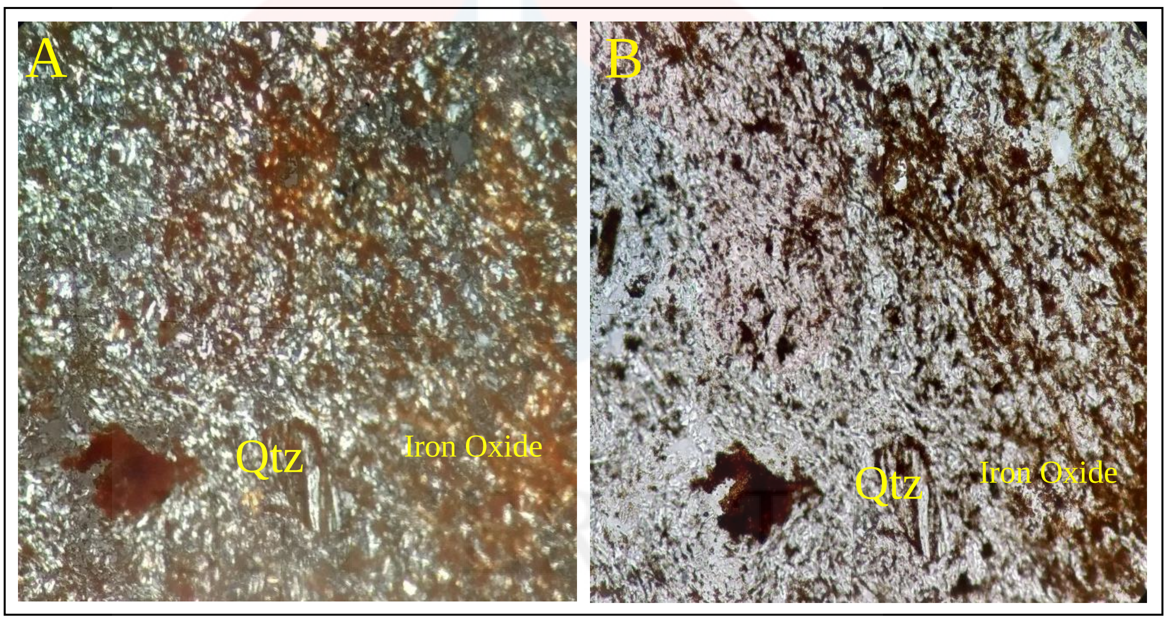


Figure 4.25: The petrography analysis of shale which is A is from cross polarized light and B is under plane polarized light. Qtz is quartz mineral and some content of iron oxide.

Based on the petrology analysis above, the groundmass of the rock is dominated by matrix. The present of iron oxide show that the rock is already weathered. Usually, shale contain clay mineral but the size of clay is too fine and it is difficult to see even

FYP FSB

under the microscope. The mineral composition present in the rock is described in table 4.8.

Table 4.8: The mineral composition of shale

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz	30	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not have any cleavage. Under the cross polarize plain, the colour turned into black.
Clay	55	
Iron Oxide	15	Only show brown colour when under plane polarized light and dark colour when under cross polar light.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

d) Limestone unit

Limestone is a sedimentary rock that made from calcium carbonate through chemical process of biological process. As shown in figure below 4.26, the limestone distributed almost 15% at southern part of study area. A carboniferous age of limestone has grey colour with fine grained.

Figure 4.26: A is the limestone outcrop exposed at the stream while B is the hand specimen for limestone.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

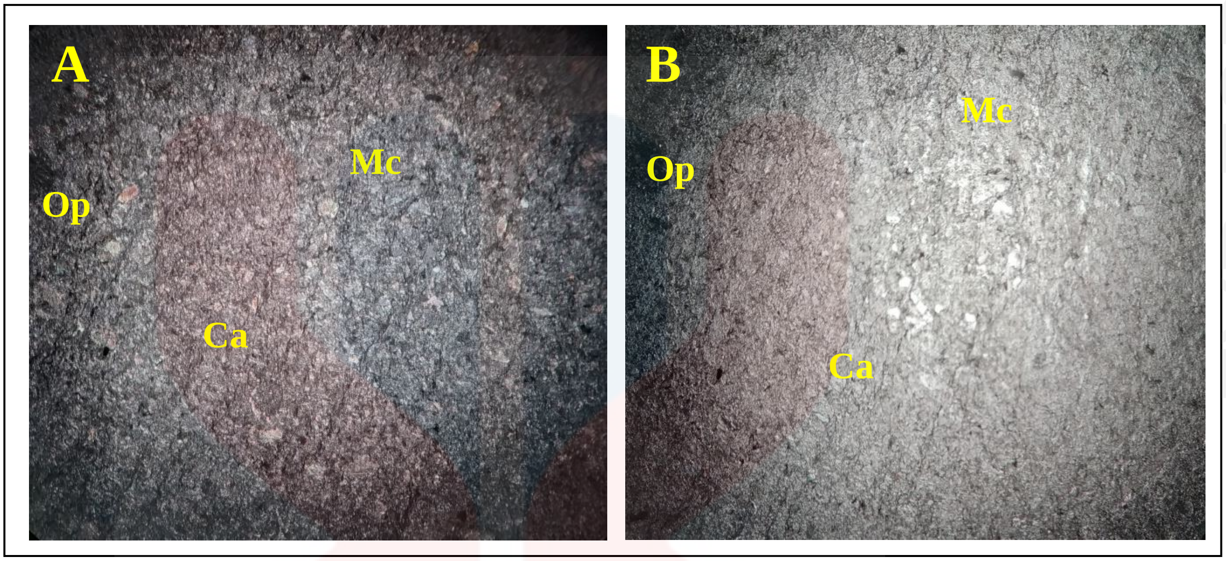


Figure4.27: The petrography analysis of limestone which is A is from cross polarized light and B is under plane polarized light. Ca is calcite mineral, Mc is mica mineral and Op is opaque mineral.

Based on the petrographic analysis in figure 4.27, the limestone is already marbleized as there are present of mica mineral. The groundmass is very fine grain and it is dominated by calcite mineral. Table 4.9 below is the further explanation for each mineral found in the limestone.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Table 4.9: The mineral composition of limestone

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Calcite (Ca)	55	In the plane polarized, it is colourless and low to moderate of relief. Besides, the cleavage is rhombohedral when there are three cleavage plane intersecting at angle that is not 90º. Next, under the cross polarized light the extinction angle is observed where the angle is symmetrical to cleavage traces.
Mica (Mc)	35	In plane polarized light, it colourless and has weak relief. Besides, it has perfect one direction cleavage and bright interference colour. Under the cross polarized plane, this monoclinic crystal system, show the colour of the mineral present in various.
Opaque mineral (Op)	10	The subangular mineral that has black colour whether under plane polarized light or cross polarized light.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

e) Tonalite unit

Tonalite unit is part of igneous rock, where the granite is transformed into tonalite with enough pressure and heat. This unit intruded during the Cretaceous and become the youngest member in the lithostratigraphic of the study area.

i) Tonalite

Tonalite is nan igneous rock that formed when the alkali feldspar is extracted from granite, its change it to granitoid and later it become a tonalite with quartz as major mineral. The porphyry tonalite rock is intruded through the meta sediment unit. It is an intrusive rock with phaneritic texture as shown in figure 4.29. It also contains mafic mineral such as biotite. There are fragments of mineral on the groundmass which result in moderately sorted.

FYP FSB

UNIVERSITI MALAYSIA KELANTAN

Figure 4.28: The tonalite outcrop reached 5 meter high.

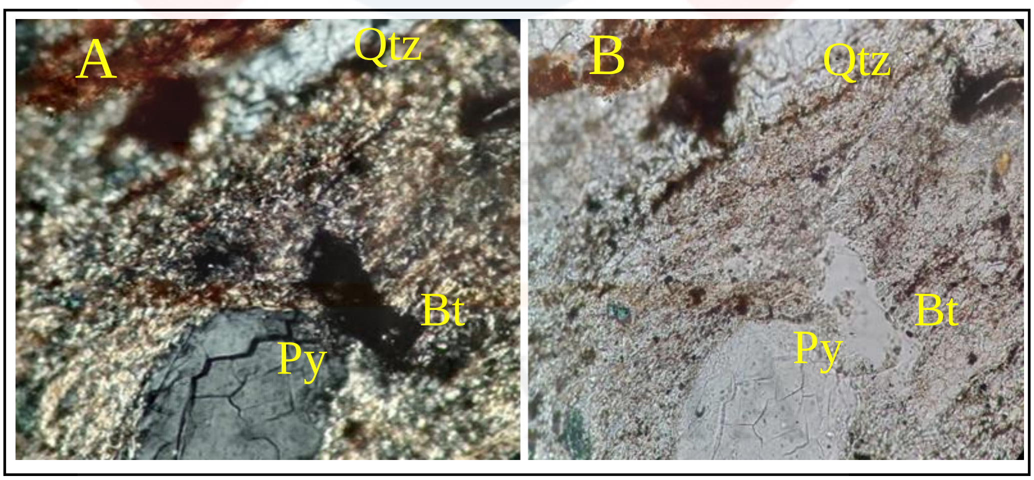


Figure 4.29: The petrography analysis of tonalite which is A is under cross polarized light and B is under plane polarized light. Bt is biotite, Qtz is quartz, and Py is pyroxene.

FYP FSB

KELANTAN

Based on the petrography analysis, some of the mineral has undergo metamorphism as the mineral change it original shape. For example, the quartz mineral has elongated. As shown in figure 4.33 above, the structure present on the outcrop show huge force of physical activity from Earth. Table 4.10 below show the explanation of mineral content in the rock.

Table 4.10: Mineral composition for tonalite rock

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz (Qtz)	60	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit none pleochroism. Besides, it also does not have any cleavage. Under the cross polarize plain, the colour turned into black.
Pyroxene (Py)	15	In plane polarized light, it is colourless. The well-formed crystal seen here to have two directions of cleavage with intersection at 90º. Under the cross polarized light, when it rotated, the light grey colour turns to black at every 90º show it is anisotropic mineral.

FYP FSB

Biotite (Bt)	25	In plane polarized light, the one direction of cleavage is clearly observed by using 40x magnification. it has intense pleochroism where the extinction angle is 3^{o}. The relief is medium and occur in sub angular shape.

ii) Mica Schist

Foliated metamorphic rock that has been subjected to compressive forces, heat and chemical activity. Besides, the intense environment that change the clay mineral into metamorphic mineral as shown in thin section figure 4.30. The colour of the rock is from silver to grey and has smooth surface to touch.

Figure 4.30: The mica schist outcrop (left) and sample taken for thin section purpose(right).

The be called as schist, there is no specific mineral content to name it, it only need the platy metamorphic minerals stay in alignment to exhibit the distinct foliation. Next,

FYP FSB

the platy mineral is believed from the clay mineral of shale. The heat and pressure provided from the tonalite intrusion, compressed the shale rock and change it into schist.

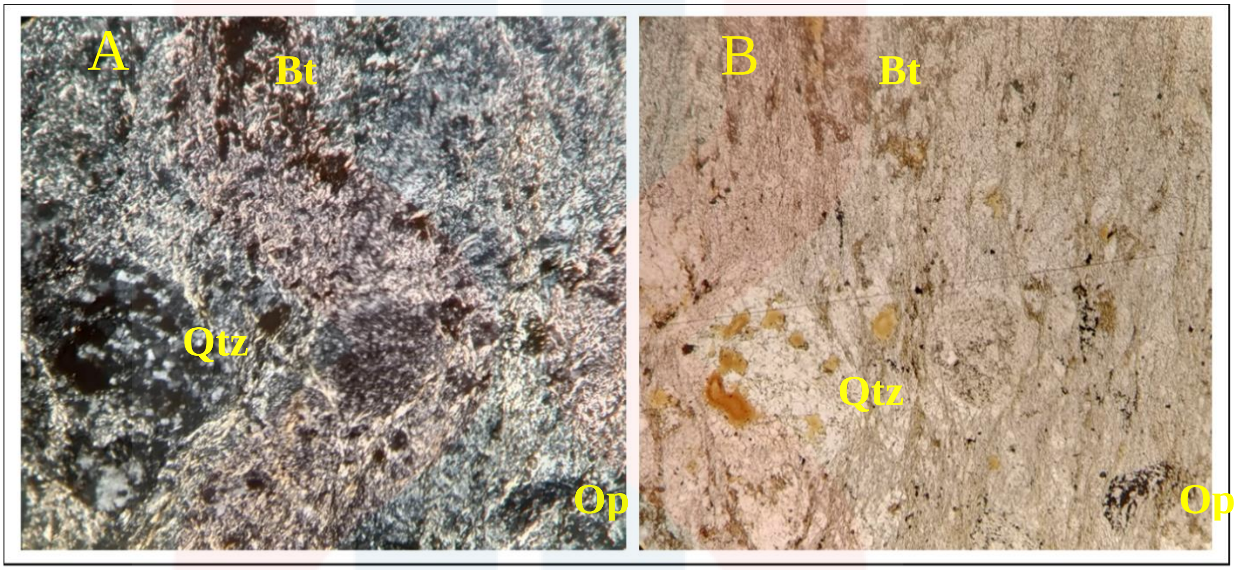


Figure 4.31: The petrography analysis of mica schist which is A is from cross polarized light and B is under plane polarized light. Qtz is quartz mineral, Bt is biotite mineral and Op is opaque mineral.

FYP FSB

UNIVERSITI
MALAYSIA
KELANTAN

Table 4.11: The mineral composition of mica schist.

Mineralogy Description		
Composition of Mineral	Amount (%)	Description of Optical Mineralogy
Quartz (Qtz)	55	In the plane polarized, it colourless and has sub-angular shape with variance size fro1mm-3mm. It has low relief and exhibit no pleochroism. Besides, it also does not have any cleavage. Under the cross polarize plain, the colour turned into black.
Biotite (Bt)	35	In plane polarized light, the colour of the mineral is brown. Besides, it has one direction cleavage and has medium relief.
Opaque (Op)	10	The subangular mineral that has black colour whether under plane polarized light or cross polarized light.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

4.4 Structural Geology

Structural are the principal sources of information on the nature of the deformational timeline as it affected the Earth. The structure present were related to some chronology that happen in the past which revealed the process. The structure also can indicate the temperature-pressure condition that operate during the deformation and it also can revealed the stress distribution at the time formation. Besides, the movement that affect solid rock on and beneath the Earth surface resulted from the forces that can cause structure such as folds, joints, fault and the lineation.

During the field study, these structures are hard to find due to the high rate of weathering activity of the rock. So, the structure observation has done during the lab work through the satellite imaginary and other indicator that showing the present of it. The following structure were observed and these provide an information about the geological history of the area.

4.4.1 Lineament analysis

Lineament is defined as a mappable linear surface features, which differ distinctly from the pattern adjacent feature and reflect subsurface phenomena. The purpose of this method is to extract lineament from satellite image in order to contribute understanding source and direction of the strongest force(σ^1). The Landsat image is use for the analysis which processed in the ArcGis 10.2 application and produce lineament map as shown in figure 4.32.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

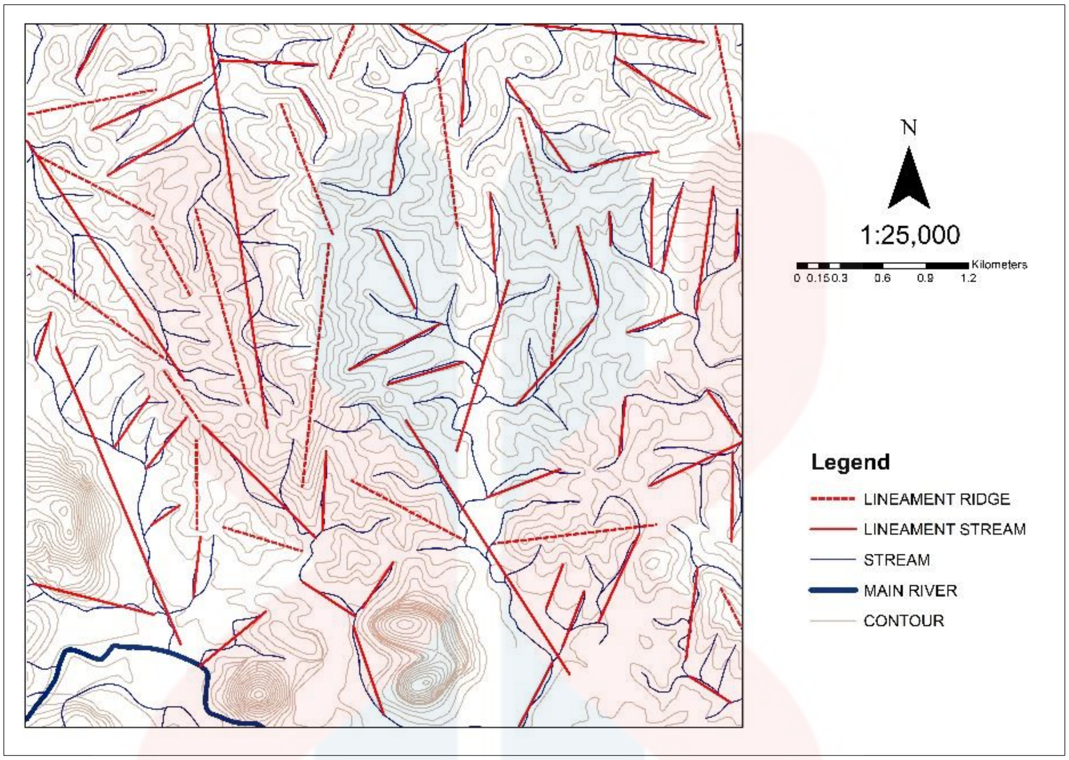


Figure 4.32: Lineament map

Based on the figure above, the force is commonly come from direction of N-W. This interpretation is made to observed the trend of the direction of lineament. Besides, the lineament analysis is done before going to field. This is because the straight features of lineament can indicate the present of geological structure in the field such as fault that will discuss more in mechanism structure.

4.4.2 Joint Analysis

Joint analysis is used to interpret force on the exposed outcrop. The direction of the joint is collected and process in Geo Rose to create rose diagram. The joint reading is taken in locality of 102º 7’53.3’’E, 4º 55’28.6’’N. The exfoliation joint type is very common with igneous rock where the rock is facing unloading of vertical stress. The

FYP FSB

uplifting of the rock into the ground surface by the past compressional forces. Normally, the fracture of the rock is parallel toward the surface exposed. Based on the rose diagram below, the forces that formed joint on tonalite outcrop give direction force of NNW-SSE.

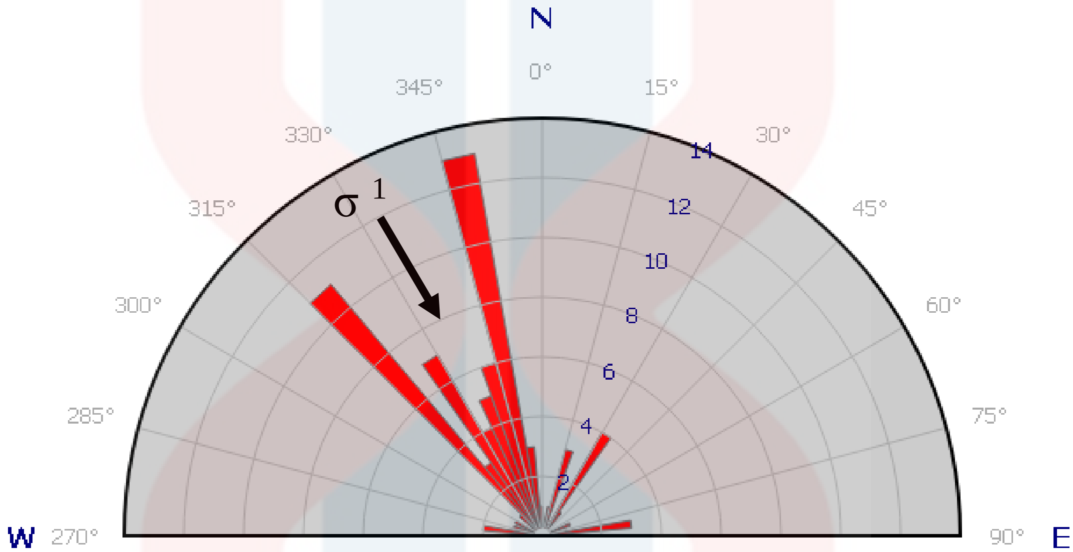


Figure 4.33: The rose diagram shows the direction of force of exfoliation joint.

4.4.3 Thrust fault

Fault is a brittle deformation that helps in shaping the Earth surface. The forces from various sources is applied on the rock and causes it to change physically. Fault can be divided into three type which is normal fault, reverse fault/thrust fault and strike-slip fault. This structure can observe during the fieldwork or even in the lab. During the field, structure such as drag fold or sudden changes of rock layer are indicator to the fault activities. If during the lab works, it can be observed through the geological map and cross section.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

The thrust fault is found on the geological map after the data from mapping activities is processed in the ArcGis 10.2 application. The data show that the oldest metasediment unit is placed over the younger unit which is lapilli tuff unit. Based on the Law of Superposition invented by Nicolas Steno, state that the undisturbed layer of rock sequence, the younger rock will stay on top of the oldest rock. Instead to follow the rule, the metasediment rock placed over the lapilli tuff rock unit as shown in figure 4.34. Stratigraphically, the metasediment unit is distributed during Permian and lapilli tuff is distributed during the Early Triassic. The force applied cause the metasediment push forward over the lapilli tuff unit. This is how the present of thrust fault can be prove through stratigraphy.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

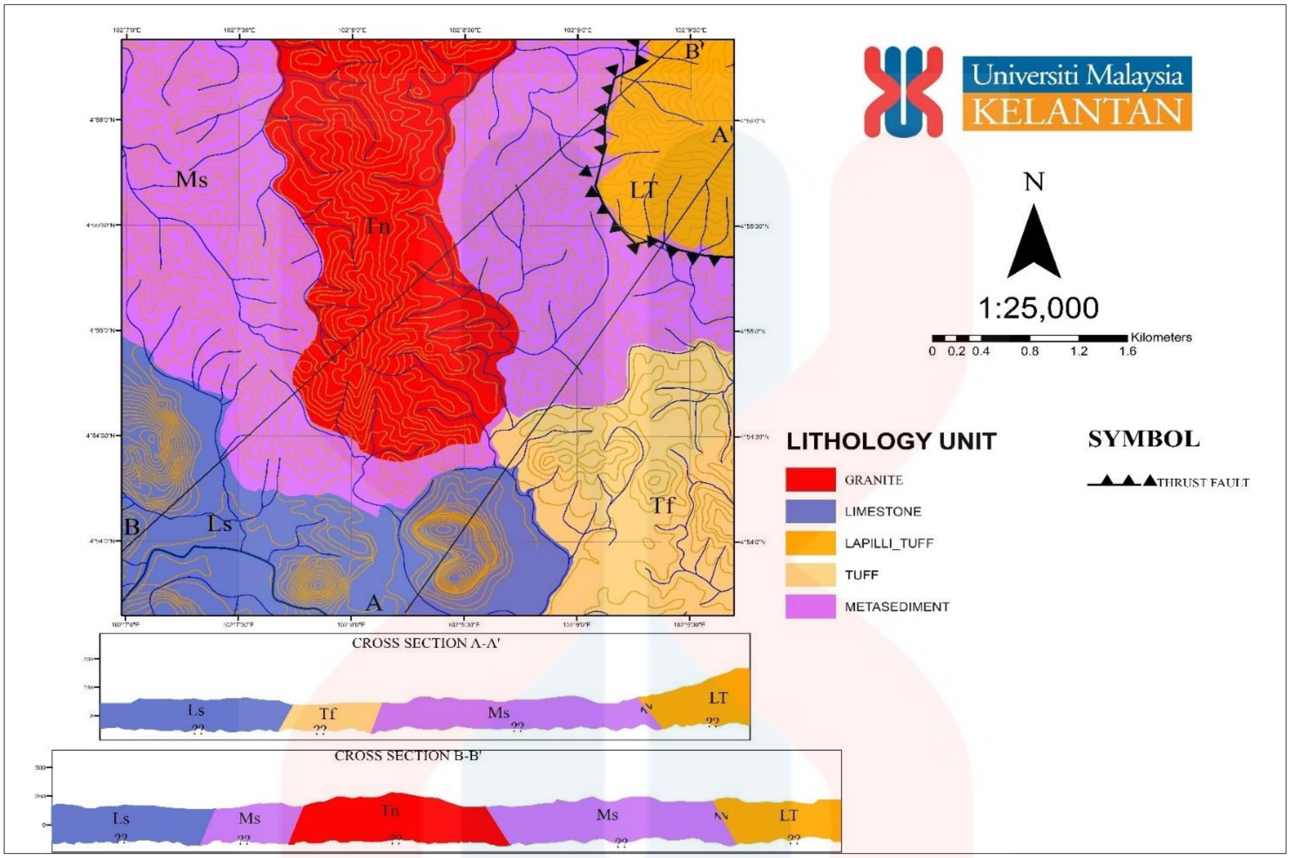


Figure 4.34: The cross section shows the position of the rock based on their age of distribution.

4.4.4 Mechanism Structure

The NNW-SSE direction of the force is mostly taken from the straight stream. As shown in figure, the stream in NNW-SSE are mostly straight toward the direction instead of other direction, NNE-SSE. This show that the river in NNW-SSE is younger and form earlier than NNW-SSW. So, the readings of strike and dip of lineament are being input in the Geo Rose application to produce rose diagram. the purpose of the rose diagram is to find out the direction of main force (σ^1). By taking the reading between two peaks of the forced direction, the σ^1 is identified. Base on the rose diagram in figure 4.35, it shows the direction of σ^1 is from N15^{o}W (345^{o}W).

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

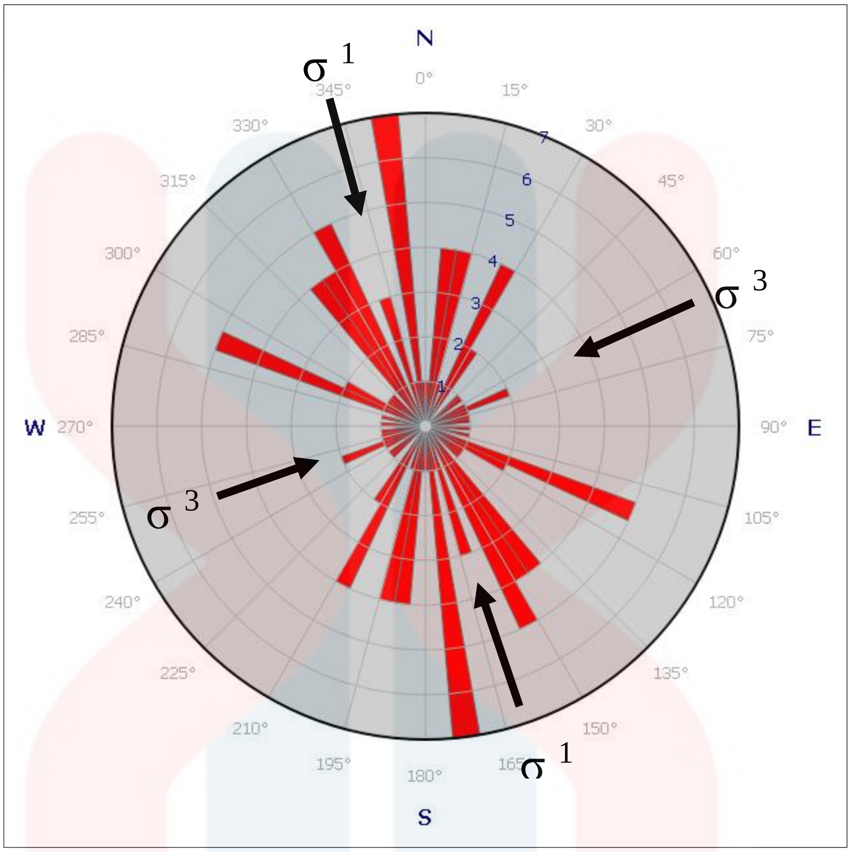


Figure 4.35: The rose diagram of lineament analysis from the Landsat image has been processed in GeoRose application.

4.5 Historical Geology

Gua Musang Formation is located on the South Kelantan where the 5x5 km^2 study area has been done. It is a part of Central Basin where the extensional of the basin during Permian cause the tremendous deposition of argillite, calcareous and pyroclastic rock. during the Permian the settlement of fine grain sediment in the basin become the dominant facies in the study area. The fossil content in the argillaceous facies as more fossiliferous on the northern part of Gua Musang, but decreasing in fossil content when going to the southern part.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Early Triassic period, the eruption of the volcano is active and deposited the pyroclastic rock. The source of the volcanic eruption is believed near to the Aring area since the place is dominant by pyroclastic rock. It shows that the source a bit far from study area which result the small crystal fragment of lapilli embedded in tuff matrix. The lapilli were expelled right after the tuff sediment being deposited and cemented together. The continues of sedimentation process cause the shallowing the ocean floor and increase the burden on top of the earliest sediment deposited. Besides, it creates the warm and shallow marine environment that triggered the succession of carbonate deposit during the middle Triassic.

As mention above, the sedimentation process occurred continuously in Triassic period had add the burden and increase the vertical stress which causes the oldest Middle Permian sediment and limestone into great depth. So, basically the increasing of temperature and pressure cause the rock to undergo low grade of metamorphism. Then, during Cretaceous period the intrusion of dark colour of tonalite into the meta sediment unit in the study area.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

CHAPTER 5

DEPOSITIONAL ENVIRONMENT AND LIMESTONE FACIES AT FELDA CHIKU 1, GUA MUSANG.

5.1 Introduction

Deposition environment is the accumulation of sediment in a place where there is no energy enough to transport them. The 10% of marine carbonate production take place in shallow seas and 90% of the modern carbonate production is related to the deposition of calcitic plankton on the deep sea (Flugel, 2004). Each deposit process has its own characteristics neither in physical or biological that could help the scientist to identify its provenance. Physically, the texture, colour, grain size and structure are the common characteristic used in interpreting the environment, while in biological the term of fossil assemblage flora and fauna that populate in the setting. This is known as diagenesis that can further studied under the thin section.

Microfacies analysis of carbonate rock require a knowledge of a modern carbonate and an understanding of biological and geological changes during earth history. Those characteristic distinction of sediment any rock that are visible and identifiable under

FYP FSB

microscope. But, during the field observation, the bedding characteristic and the diagenetic features are expressed in the lithology to summarize the setting and environment.

In this chapter, the depositional environment of limestone facies of Felda Chiku 1 is described. Few criteria that has been interpreted during the field and lab works which is the thickness of the bed, lithology, sedimentary structure and fossil content. There are three lithologs been studied where two lithologs were located in the box and another one litholog was outside of the study area. The outcrop in the box is hard to access to get some sample, so the decision to take outcrop from outside has been made. This addition of litholog for limestone, can increase the accuracy in interpreting the depositional environment.

5.2 Microfacies Analysis

The observation of limestone under the microscope which closely related to sedimentology and paleontology disciplines. Both disciplines are important for application during the field and lab work.

5.2.1 Limestone facies

The first location is located at Damai Quarry of Gua Musang with coordinate of N04º53''46.9', E102º 08'' 0.05'. The 208 metres wide of outcrop limestone in the study area been chosen as location for the specification. The first inspection of sample during the field is based on the grain-size, primary sedimentary structure and geometry of litho-

FYP FSB

units as well as vertical facies changes in one location. There are 6 samples were collected in constant interval which is 100metres for every section for microfacies analysis.

Figure 5.1: The location for first lithology for microfacies analysis for facies A, B, C, D, E and F.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

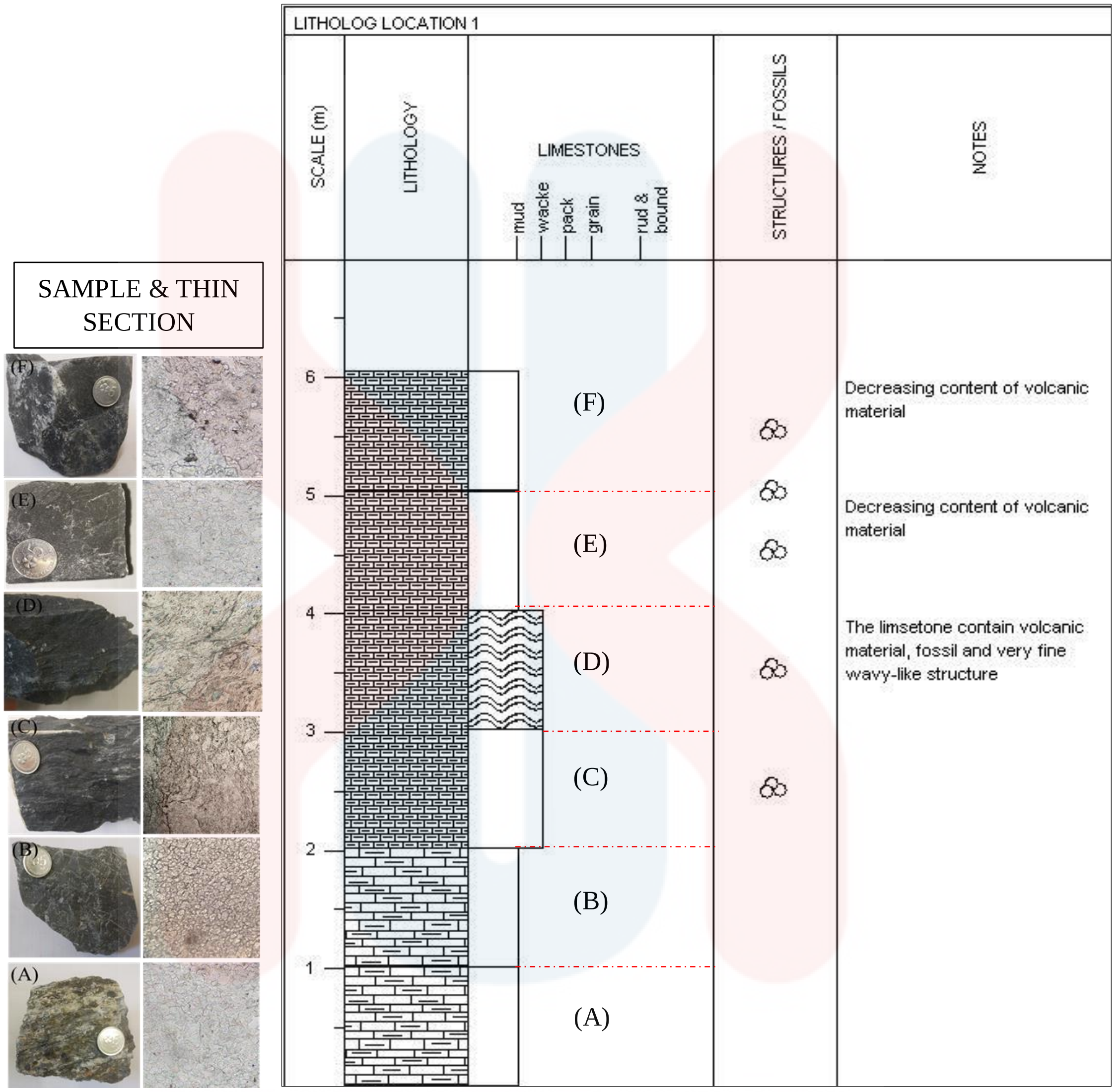


Figure 5.2: The details for limestone facies litholog in location 1

a) Facies A

On the field, the limestone is in white colour unlike the others. It has medium grain and the crystal of the grain can see by naked eyes as shown in figure 5.3 (right). The calcite vein observed filling up the crack of the limestone.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

Under the microscope of 40x magnification, the limestone is made up of calcite and dominant with grain matrix supported. Type of grain for facies A is micrite. The micrite mineral is undergone diagenesis when they got enough pressure and temperature from the tectonic pressure allow them to recrystalized. Besides, the allochemical characteristic is shown as there is volcanic material embedded together with the microcrystalline calcite matrix. The volcanic material gives opac criteria when under the plane polarization. No fossil observed.

Figure 5.3: The hand specimen (left) and the thin section (right) of facies A.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

b) Facies B

On the field, the light colour of the limestone is in light colour as shown in hand specimen in figure. The colour indicate that this section of limestone is lacks with carbon content. Compared to facies A, physically the rock is harder and lot of the calcite crystal can be observed, attach on the limestone surface.

Under the 40x magnificent of microscope, the groundmass is made up from micrite matrix as shown in figure 5.4 below (right). The primary calcite mineral in the is already undergone neomorphism and forming a crystal shape. The compaction process causes the mineral close to each other creating the contact between them. This condition can name them as unsorted biosparite with poor sorted cement. No fossil observed.

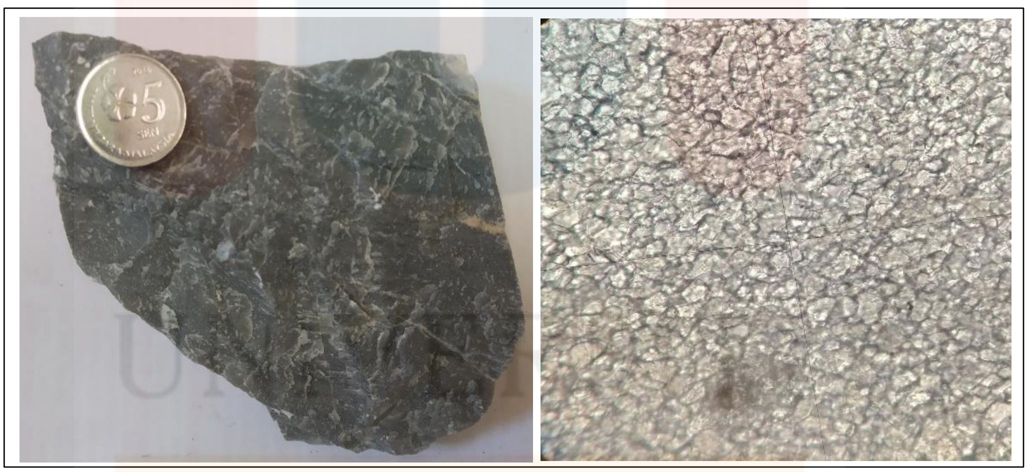


Figure 5.4: The hand specimen (left) and the thin section (right) of facies B.

FYP FSB

c) Facies C

On the field, the limestone has dark colour show that the bedding contained high amount of carbonate. The grain also very fine and few foraminifera fossil observed on the hand specimen. Under the 40x magnification observation for petrographic analysis, the limestone is made up of calcite and dominant with micrite matrix supported. The percentage of the micrite is almost over 10%. Based on Folk's textural classification, the specimen can be named as sparse biomicrite.

Same with the previous facies, the contain of volcanic material also observe in this specimen. The volcanic material gives opac criteria when under the plane polarization.

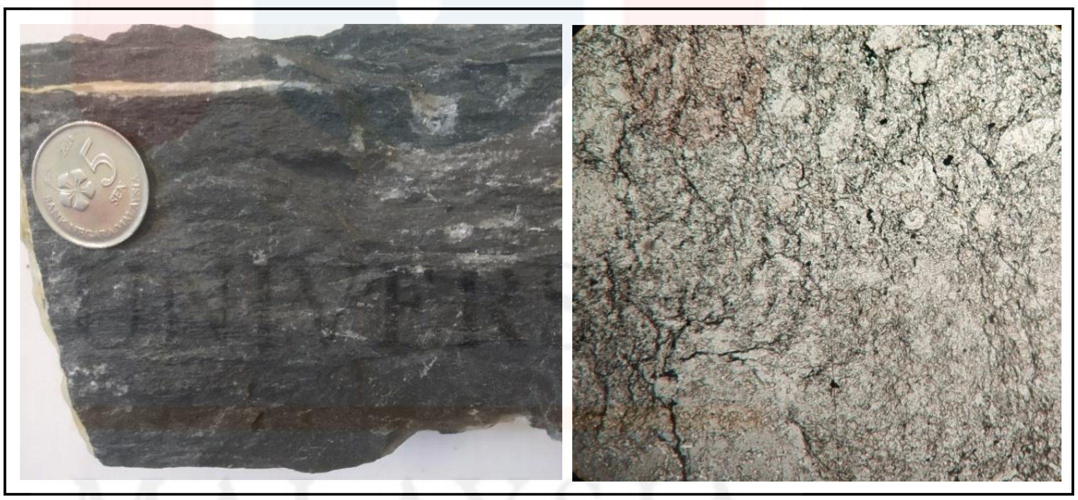


Figure 5.5: The hand specimen (left) and the thin section (right) of facies C.

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

d) Facies D

The hand specimen of limestone as shown in figure below. The colour of the rock is dark show the high content of carbon. Very fine scale of lamination also observed. Physically, the rock at this bedding has soft texture with very fine grained.

Under the 40x magnification, the specimen has mud supported groundmass with contain more than 10% of grain. This specimen can be named as sparse biomicrite as stated in Folk's textural classification. The benthic fossil found under 60x mgnificant that will discuss in limestone sub unit analysis (5.5.2). The round shape lies on the ground mass in a volcanic materials deposit into the lime-mud groundmass.

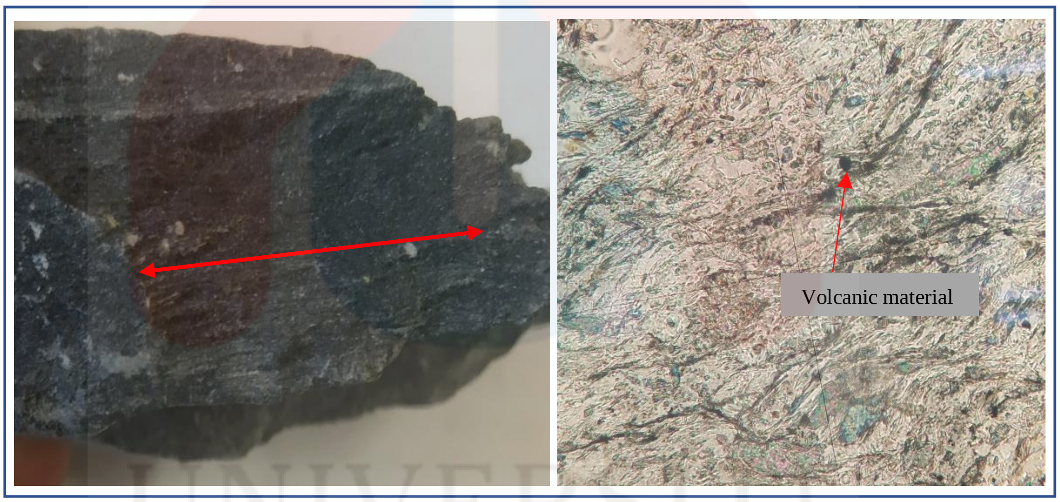


Figure 5.6: The hand specimen (left) and the thin section (right) of facies D. The arrow on the right show the direction of lamination.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

e) Facies E

The facies E which found at massive outcrop of limestone which has dark colour of limestone. The limestone has very fine grain and calcite crystal attached on the surface.

Under 40x magnification of microscope, the groundmass is a mud supported and has 10% of grain which can classify it as wackestone. Although the groundmass is made up from mud, some of the mineral already crystallize but not well form. So, the type of sorting is well sorted. No any fossil observed under it. The rounded volcanic material also found on the groundmass.

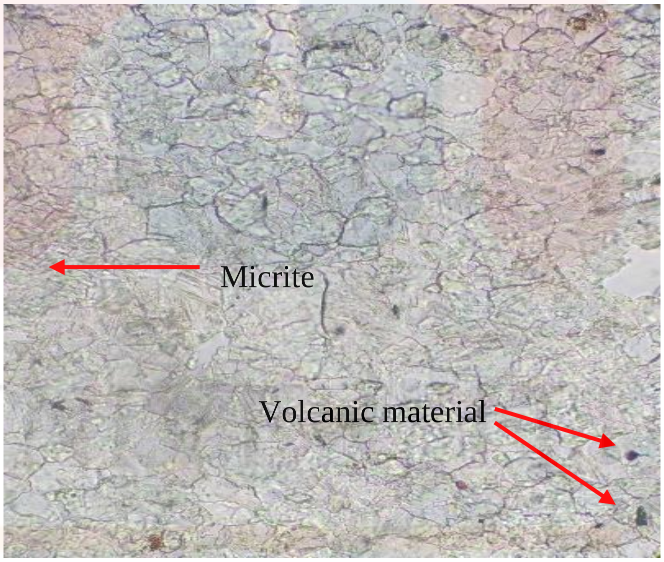


Figure 5.7: The thin section of facies E.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

f) Facies F

On the field, the bedding has dark colour of limestone. The calcite vein can be found widely distributed in the same bedding. Besides, the grain of the limestone is very fine.

Under the 40x magnificent of microscope, the groundmass of the facies F is micrite but some of the mineral already metamorphosed. The orthorhombic aragonite mineral is one of the minerals observed. Then, the sorting of the rock is very poor.

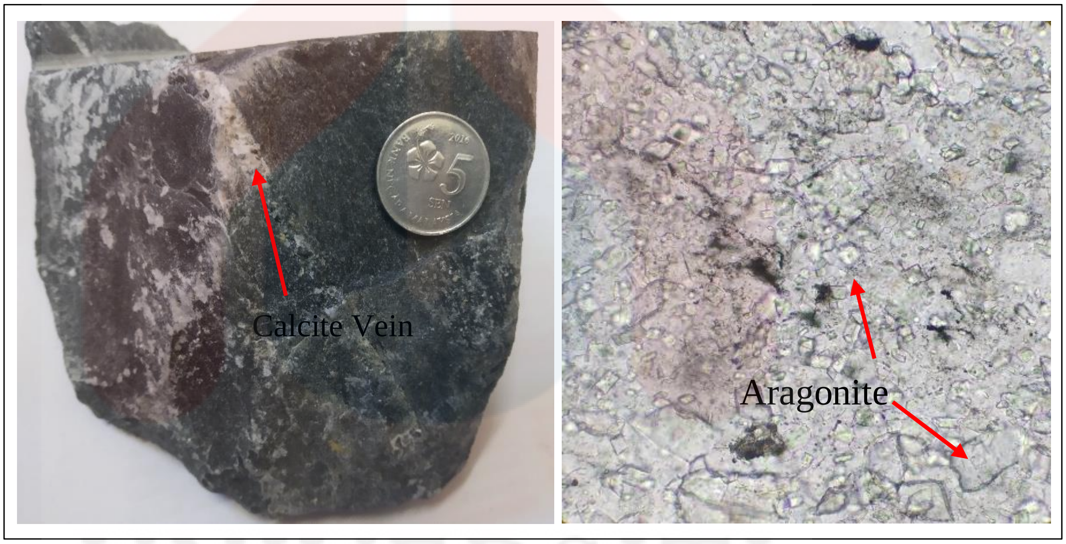


Figure 5.8: The hand specimen (left) and the thin section (right) of facies C.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

5.3 Limestone Microfacies Analysis

The analysis has been studied base on the structure, texture and also the fossil content for each facies.

5.3.1 Texture

The variety of ancient water current present in the basin where the carbonate rock is accumulated give different grain deposit on a bed. Hence, the types of the grain were one of the parameters in deciding the types of the depositional environment. Besides, other parameter that widely used in studying the depositional environment is the distribution of the fossil.

The textural of the carbonate deposit is based on Folk's (1959). The classification is based on the groundmass type. After observing the facies under the microscope, found that the facies A, B, C, D, and F made up from micrite cement. The micrite is a mud-lime which is deposit in slow and quiet water current. The quiet and slow water energy occurred in the platform, indicate the formation of well bedded limestone as shown in figure 5.1 above. The very fine scale of lamination exposed on the bed of facies D, interpreted that the bed effected with the fluctuation of water in shallow marine.

In addition, all the facies contain volcanic material, explain that the deposit of the carbonate on the basin is together with the sedimentation process. The volcanic material is rounded show that the material was transported before it accumulated into the carbonate bed. Usually, the rounded material show that it already transported in far distance, so the source of the volcanic can be far from the carbonate platform. The crystallized mineral is cause by the tectonic that came during or after the carbonate deposit.

FYP FSB
UNIVERSITI
MALAYSIA
KELANTAN

5.3.2 Fossil Abundance

There are fossils found in some facies of location 1. Under the microanalysis, the fossil is observed using 10x magnification. Facies D has the most of fossil content as shown in figure 5.9. As mentioned by Metcalfe (1989) , in Triassic Sedimentation in the Central Basin of Peninsular Malaysia, sediment in Gua Musang tend to appeared with Paleofusulina continuously until early Triassic. However, some of the fossil found could not identified because the shape of the fossil is unclear under the microscope. The shape of the wall and chamber of benthic foraminifera is very important as it is one of the parameters to differ the species. One species has been identified which is *Operculina sp* and *Fusulina sp*. Both fossils are under benthic foraminifera order.

Figure 5.9: The fossil of benthic foraminifera fossil found under the 10x magnification of limestone (facies D).

FYP FSB
UNIVERSITI MALAYSIA KELANTAN

Figure 5.10: The *Operculina sp* inhabit the shallow carbonate platform.

Figure 5.11: The *Fusulina sp.* deposited at the same platform.

FYP FSB
MALAYSIA
KELANTAN

Here some of the chronological of sediment deposit for all the facies. Early, the carbonate is already deposit on the shallow Gua Musang platform. A sudden process of volcanic eruption causes the carbonate deposition became unstable. The sedimentation of volcanic debris occurs and the water is cloudy. As the sun could not penetrate, the carbonates deposit is lower. As the sedimentation rate is lower, the water became clear again and the sun penetration triggered the carbonate to deposit again (Mohamed Kamal, Nelisa Ameera, Mohd Shafea, & Che Aziz, 2016). The fluctuation of water probably occurs during the sedimentation and carbonate deposits.

In conclusion, the limestone is deposit in shallow carbonate platform where the environment is more to warm water, shallow depth and quiet. This area is very suitable for very fine and fossiliferous carbonate deposition as it has very low water current. Besides, the present of benthic foraminifera fossil in the facies also show the organisms inhabit in a shallow environment.

FYP FSB

UNIVERSITI
MALAYSIA
KELANTAN

FYP FSB

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, the geological map of the Felda Chiku 1 Gua Musang with 1:25,000 scale is produced. The geological map shows the lithology unit types occurred in the study area. there are 5 types of litholog unit with age ranged between Permian to Cretaceous. Besides, the deposition environment of limestone based on the microfacies analysis show that the limestone in study area is deposit in quiet and shallow marine.

The study area made up from 5 lithologies as mentioned above which are phyllite, tuff, lapilli tuff, limestone and tonalite. The phyllite is the oldest unit which overlain by the tuff, lapilli tuff and limestone unit during the Triassic period. The youngest unit is a tonalite which intrude the phyllite unit during the Cretaceous period. The NNW-SSE direction is the main force (σ^1) effected the study area. besides, there is thrust fault came from NNE direction of the study area.

The depositional environment of the limestone is determined after did the microfacies analysis. The texture, structure and fossil content become the main parameter in analysed the deposit environment. Folk's textural classification of carbonate sediment and Dunham's classification become the main reference during the microfacies analysis.

The characteristic for each facies is studied to get details before conclude the deposit environment. After through all the inspection, the deposit environment is determined. The limestone is deposits in shallow marine of carbonate platform which is warmed, quiet and shallow marine environment. The Central Basin which the Gua Musang shallow platform is located become the place where the limestone in the study area is deposited. The volcanoes eruption, sedimentation process and the fluctuation of water effect the shallow marine carbonate deposit.

6.2 Recommendation

In order to enhance the studied of the limestone facies in microfacies analysis, few other methods can be used such as Scanning Electron Microscopy (SEM). The scanning electron microscope can also be used in mineral identification and semi-quantitative chemical analysis when it is equipped with energy dispersive analyser. The analysis of sample through SEM is fast and it only requires little amount of sample. SEM is useful in the identification of the fine grain sample. This will overcome the grain size limitation of the polarizing microscope study and provides more accurate data.

Although the depositional environment of the limestone in Felda Chiku 1 been identified through this research, there is lack of other evidence from sedimentology such as the paleocurrent direction. It is very recommended to other researcher to continue this studied or related to this topic, so the provenance of the limestone in the area can be more understandable.

FYP FSB

REFERRENCE

Aw, P. (1990). *Geology and Mineral Resources of the Sungai AringArea,Kelatan Darul Naim.* Ipoh: Geological Survey Malaysia.

Charlton, R. (2008). *Fundamentals of fluvial geomorphology.* London: Routledge.

Dony, A. N., & Ahmad Rosli, O. (2014). Geoheritage Conservation of Paleontological Site in Aring Area,Gua Musang District,Kelantan, Malaysia. *International Journal on Advanced Science Engineering Infromation Technology*, 14-19.

Dony, A. N., Hafzan Eva, M., & Siti Syaza, A. S. (2016). Geoheritage of Labuan Island. *Bulletin of the Geological Society of Malaysia*, volume 62, 117-129.

Fauzi Hussin, H. A. (2012). The Role of FELDA and KESEDAR in the Development of Land in the District of Gua Musang: A Comparison the Socio-Economic Level of the Settlers . *Sustainable Agriculture Research* , 284-291.

Flugel, E. (1978). *Microfacies Characteristic.* New York: Springer Verlag Berlin Heindelberg.

Flügel, E. (1982). *Microfacies Analysis of Limestones.* Heidelberg: Springer-Verlag Berlin.

Flugel, E. (2004). *Microfacies of Carbonate Rock: Analysis, Interpretation and Application.* Springer Berlin Heidelberg.

Flugel, E. (2013). *Microfacies of Carbonate Rock: Analysis,Interpretation and Application.* Springer Science & Business Media.

Fontain, H. (1986). The Permian of Southeast Asia. *CCOP Technical Bulletin,18*, 1-109.

Foo, K. Y. (1983). The Palaeozoic Sedimentary Rocks of Peninsular Malaysia- Stratigraphy and Correlation. *Workshop on Stratigraphy Correlation Rock of Thailand and Correlation*.

Foo, K. Y. (1983, September). The Palaezoic Sedimentary Rocks of Peninsular Malaysia- Stratigraphy and Correlation. *Workshop on Stratigraphic Correlation of Thailand and Malaysia*, (p. 11). Haad Yai Thailand.

Francisco Gutiérrez, M. G. (2016). *Structural Landforms.* Springer, Cham.

Frank S. Reed, J. L. (1953). Preparation of Rock Thin Section. *Amer. Mineral.*, 1184-1203.

Friedman, G. M. (1965). Occurrence and Stability Relationships of Aragonite, High-Magnesian Calcite, and Low-Magnesian Calcite Under Deep-Sea Conditions. *Geological Society of America Bulletin*.

Goh, S. H., Teh, G. H., & Wan Fuad, W. H. (2006). Gold Minerlization and Zonation In The State of Kelantan. *Geology Society of Malaysia Bulletin 52*, 129-135.

Guillemot, M., & Capenter, J. (1996). *Element of Geology: Oil and Gas Exploration Technique.* Paris: Edition Technip.

Hutchison, C. (1988). *Geological Evolution of South-East Asia.* Oxford: Clarendon Press.

Hutchison, C. (1989). Geological Evolution of South-East Asia. In *Oxford Monographs onGeology and Geophysic,13* (p. 368pp). Oxford: Clerendon Press.

Hutcshison, C., & Tan, D. N. (2009). *Geology of Peninsular Malaysia.* Kuala Lumpur: The University of Malaya.

FYP FSB

FYP FSB

Idris, M., & Hashim, C. (1988). An Upper Permian Fossil Assemblage from Gunung Sinyum and Gunung Jebak Puyoh Limestone,Pahang. *Warta Geologi,14(5)*, 199-203.

Lee, C. P., Mohd. Shafeea, L., Kamaludin, H., Bahari, M. N., & Rashidah, K. (2004). *Stratigraphic Lexicon of Malaysia.* Kuala Lumpur: Geological Society of Malaysia.

Maliva, R. G. (2016). Facies Analysis and Sequence Stratigraphy. *Springer International Publishing*, 22-48.

Metcalfe, I. (1989). Triaassic Sedimentation in the Central Basin of Peninsular Malaysia. *International Symposium on Intermontane Basin: Geology&Resources Chiang Mai Thailand,* (pp. 173-183). Chiang Mai Thailand.

Metcalfe, I. (1995). Mixed Permo-Triassic Boundary Conodont Assemblages from Gua Sei and Kampung Gua,Pahang,Peninsular Malaysia. *CFS Courier Forschunginstitute Senkernberg* , 487-95.

Metcalfe, I. (2011). Palaeozoic-Mesozoic history of SE Asia. . In R. Hall, & M. Cottam, *The S Asian Gateway: History and Tectonics of Australia-Asia Collision.* (pp. 7-35). Geological Society of London Special Publications,.

Mohamed Kamal, R., Nelisa Ameera, M. J., Mohd Shafea, L., & Che Aziz, A. (2016). The Gua Musang Group: A newly proposed stratigraphic unit for the Permo-Triassic sequence of Northern Central Belt, Peninsular Malaysia. *Bulletin of the Geological Society of Malaysia*, 131-142.

Reineck, H., & Singh, I. (1986). *Depositional Sedimentary Environment with Refrences to Terrigenous Clastic.* Berlin: Springer.

Simon., K. (2013). Mesozoic Tectonostratigraphy&Sedimentology of the Central Belt, Pahang, Malaysia. *(unpublished)*.

Surono, M., Arham, M. A., Udi, H., & 'Ainaa' Mardhiyah, H. (2018). Lithostratigraphy of Gua Musang (inprep).

Van Zuidam, R. (1985). *Aerial photo-interpretation in terrain analysis and geomorphologic mapping.* The Hague: Smits Publishers.

Zhang, L., & Guilbert, E. (2012). A Study of Variables Characterizing Drainage Patterns In River Networks. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* (pp. Volume XXXIX-B2). Melbourne, Australia: XXII ISPRS Congress.

UNIVERSITI MALAYSIA KELANTAN