GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF LIMESTONE FACIES AT FELDA CHIKU 2, GUA MUSANG, KELANTAN.

by

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

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DECLARATION

I declare that this thesis entitled "Geology and Depositional Environment of Limestone Facies at Felda Chiku 2, Gua Musang, Kelantan." is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

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

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Geology and Depositional Environment of Limestone Facies at Felda Chiku 2, Gua Musang, Kelantan.

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Abstract:This research study touched on geology depositional environment of limestone facies at Felda Chiku 2. The important of the depositional environment for the community is to provide the sedimentation information to people that can used to avoid the natural hazard such as flood and the landslide. The depositional environment of limestone data collected for depositional environment of limestone from bottom to upper part of the limestone outcrop. Each part of the bedding of limestone take for thin section analysis. The method of taking sample from the bottom to the upper of the limestone outcrop is to detect the depositional environment of study area. Facies study for determine the depositional environment based on the structure, lithology, grain size and fossil content. There have four facies that identify in the study area: three are the limestone unit and one of the facies phyllite unit. The all four facies are show of shallow marine depositional environment. The shallow marine facies is considered as a part of the supratidal front to intertidal with the low energy and the low current of water.

Keywords: Depositional environment; limestone facies; sedimentation information; shallow marine; supratidal front.

Geologi dan Lingkungan Endapan Fasis Batu Kapur di Felda Chiku 2, Gua Musang, Kelantan.

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Abstrak: Kajian penyelidikan mengenai lingkungan endapan fasis batu Kapur di Felda Chiku 2. Kepenting dalam lingkungan endapan bagi masyarakat adalah untuk menyediakan maklumat pemendapan kepada orang-orang yang boleh digunakan untuk mengelakkan bahaya alam seperti banjir dan tanah longsor. Lingkungan endapan batu kapur diambil dari bahagian bawah ke bahagian atas singkapan batu kapur. Setiap bahagian dari batu kapur mengambil analisis bahagian nipis. Kaedah mengambil sampel dari bahagian bawah ke atas singkapan batu kapur adalah untuk mengesan lingkungan endapan kawasan kajian Pembelajaran fasis untuk menentukan persekitaran simpanan berdasarkan struktur, lithologi, saiz butiran dan kandungan fosil. Terdapat empat aspek yang dikenalpasti di kawasan kajian: tiga adalah unit batu kapur dan salah satu unit phyllite fasis. Keempat fasis terdiri daripada persekitaran endapan marin cetek. Fisika marin yang cetek dianggap sebahagian daripada bahagian supratidal untuk intertidal dengan tenaga rendah dan arus air yang rendah.

Kata kunci: Lingkungan endapan; fasis batu kapur, informasi pemendapan; marin cetek, depan Supratidal.

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LIST OF ABBREVIATIONS

N	North
E	East
Qtz	Quartz
PPL	Plane polarize light
XPL	Cross polarize light
GPS	Global positioning system
HCL	Hydrochloric asid solution
KM	Kilometre
MAIK	Majlis Agama Islam Kelantan
3D	Three dimension

LIST OF SYMBOL

%	Percentage
	Coarsening upward
×	Multiplication

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CHAPTER 1

INTRODUCTION

1.1 General Background

Gua Musang is located in the south of Kelantan, Gua Musang is the largest district in the Kelantan area and bordering with Merapoh, Pahang. The local karst, name Gua Musang cave has unique advantages due to their shape and process. In the Gua Musang have a main river that a Nenggiri river. The Nenggiri river are well connected system for rural area such as Broke Post, Mering Post and Pulat Post that are indigenous communities.

The study of the depositional environment are important for reconstructing of earth history, understanding earth process and helping humans survive and prosper on earth. Depositional environment are study of the sedimentology and the stratigraphy, where to know the depositional environment by the environmental analysis (Guillemot, 1996)

Depositional environment is a place where there is deposition process happen. It is characterised by specific physical, chemical and biological processes that act on the sediment deposited. To recognise the depositional environment of an area, geologist normally study the sedimentary facies, as they are the result of deposition of a given environment (Singh, 1986).

A depositional environment is a specific type of place in which deposited and where deposition process is happen. It is characterised by specific physical, chemical and biological process that act on sediment deposited. To recognise the depositional environment of an area, geologist normally study the sedimentary facies as they are the result of the deposition of a given environment (Singh, 1986).

Environmental analysis based on properties of rock that have environmental significant, which are sediment structure, texture, fossil and the sedimentary facies association. The information can construct the facies model that is a general summary of the characteristics of certain depositional system.

1.2 Study Area

1.2.1 Location

Felda Ciku 2 is located at east Gua Musang, Kelantan and Felda Chiku 2 are 34.7km from the Gua Musang town and its take half an hour from Felda chiku 2 to Gua Musang Town. Felda Chiku 2 beside Felda Chiku 1 and near to the Felda Chiku 3,4,5,6, and 7.

There covered around 25km² (5km × 5km). The study area is within Central belt of Peninsular Malaysia. The area cover 25km² is suitable area for the research because the wide area cover it easy to know the depositional environment. In the study area, the village are connect each other with the main road of the area. The village that are connect with the Felda Chiku 2 are Felda Perasu and Felda Chiku 1.

The coordinate between longitude is 102˚07’20”E to 102˚09’40”E and latitude from 04˚54’20”N to 04˚51’40”N. The highest elevation of the study area is 380m above sea level, whereas the lowest elevation 80m from sea level in Figure 1.1

1.2.2 Road Connection/Accessibility

The accessibility to get to this area are very easy and effective because have a main road of highway Kota Bharu- Gua Musang. This highway is the main road from the Gua Musang to the Kota Bharu and from Pahang, Kuala Lumpur also use this highways. The figure 1.2 show road access from the Kota Bharu to Gua Musang.

In the study area have accessibility like main road of the villager use for the daily activity. The road is for the used to collect the product of the palm oil. Mostly the the area are cover in the study area is the palm oil plantation. The accessibility of the study area are not so hard to access because have a road that the villager used for the activity daily life.

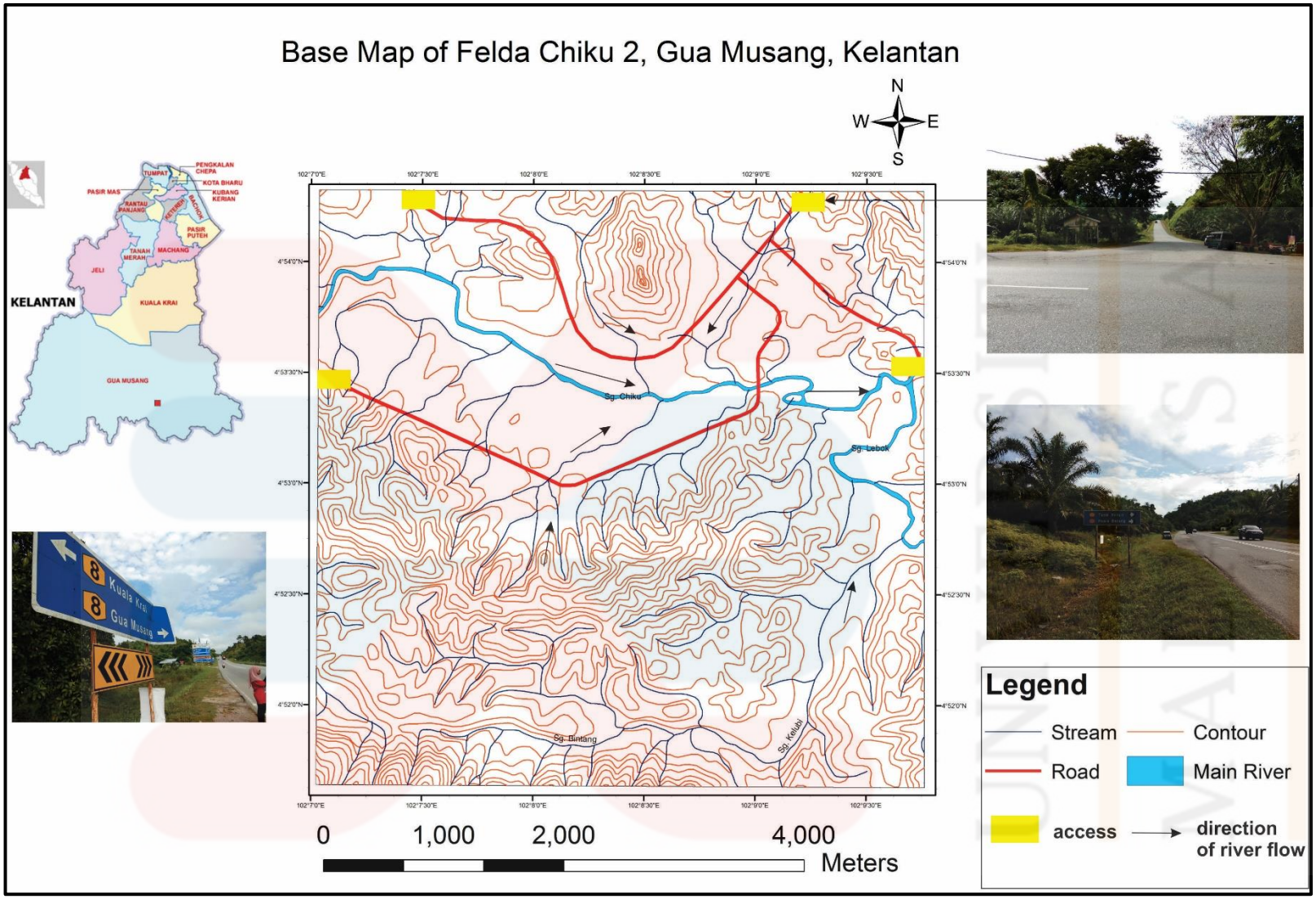


Figure 1.1 Base map of the study

Figure 1.2 Map of road connection (source: google map data, 2018)

1.2.3 Demography

The statistic from the Department of Statistic Malaysia, the population of Gua Musang District on 2010 is 90,057 population. The percentage of the Malay people is 76%, Chinese 5%, India 1% and the native people 13%. The distribution of the people is high in Gua Musang town as population are concentrating because to work over there. However, Felda Chiku area has smaller population based on the Department of Statistic Malaysia.

1.2.4 Land use

The Federal Land Development Authority (FELDA) is the agencies that develop land schemes in district of Gua Musang, Kelantan. The nine land schemes develop by the FELDA are Kemahang 3, Chiku 1, Chiku 2, Chiku 3, Chiku 5, Chiku 6, Chiku 7, Perasu, and Aring 1. A large part of the schemes under the FELDA was planted with oil palm (84.7%) while the rest was planted with the rubber tree (Hussin & Abdullah, 2012).

1.2.5 Social Economic

Gua Musang areas are mostly depending on the plantation of the palm, rubber and the forest product. The source of the social economic in the Gua Musang areas is palm and rubber product. In the Chiku area mostly are depending to palm product because in the Chiku area is the plantation of the palm tree that monitor by the government agency. Based on Hussin & Abdullah, (2012) the rural community

practiced subsistence agriculture and agriculture in the form ordinary farming as sources of their income.

1.3 Problem statement

For a general geology of Felda Chiku 2.Gua Musang, Kelantan, the earth is undergoes certain process throughout the year, which is the tectonic movement or weathering process, the lithology of earth surface might change. Weathering could alter the rocks chemically and physically. Thus, an update geological map a small scale (1:25000) needed because the geological data of the area might change throughout the time.

Base on the previous geological research, there are lack of the deposition environment information. However deposition environment are important as it will give the important sedimentology and stratigraphy data to the next researcher.

1.4 Objective

1. To produce geological map of Felda Chiku 2, Gua Musang, Kelantan.
2. To determine the depositional environment of Felda Chiku 2 area by facies analysis.

1.5 Scope of study

Study area that cover 25km² (5km × 5km) instead the area cover are river, land surface and the mountain. Based on the lithology in the area, deposition environment in the area mostly are sedimentary rock.

This study focused on the general geology and the sedimentology around the study area. Besides that, it focused on the depositional environment, sedimentary facies, sedimentary structure and the stratigraphy in the study area. The depositional environment analysis based on the sedimentary facies of the sedimentary rock. Furthermore, it also focused on the general geological aspect like geomorphology, geological structure and lithology at the study area.

In this research, petrography of rock also described based on plane polarized light (PPL) and cross polarized light (XPL). The thin sections of rock sample are prepared and it examined under the polarized microscope and will be interpret the depositional environment in the area.

1.6 Significance of study

The research are produce detail geological map in 1:25,000 in scale. This map are used for updating regional geological map and the geological map depositional environment provides the sedimentation information to people that can used to avoid the natural hazard such as flood and the landslide, and also need for mineral resource such as coal, oil and groundwater occurrence.

The research also can be used for the valuable for decision making for industry, mining and development in the study area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review is the previous studies are related to the next research. Literature review is the study that can identified idea for the title of the research, objective, problem statement, and the methodology of the research. Literature review is as the references for the researcher to the research study and to identify the methodology. These include the regional geology and the tectonic setting, sedimentology, stratigraphy, fossil, historical geology and the deposition environment.

2.2 Geology and Tectonic Setting

Peninsular Malaysia is one of the integral part of the SE Asia continental core of Sundaland (Metcalfe, 2011). It comprises two tectonic block (Sibumasu Terrane and Sukhothai Arc) and can be divided into three belt, which are Western, Central and Eastern belt. The Bentong – Raub suture zone is the boundary that separates

Sibumasu Terrane (Western Belt) and Sukhothai Arc (Central and Eastern Belts) (Metcalfe, 2013).

The sedimentation in the Central zone of the Peninsular Malaysia is associated with the plate tectonic. During Permo – Triassic period, there is convergence occurred between the western part of the peninsula and the eastern part by subduction of oceanic crust and a latest Triassic collision of the two tectonic blocks (Harbury *et al*, 1990).

Heng *et al*, (2006) stated that Kelantan consist of sedimentary and metasedimentary rock in the central zone that bordered by granite at west and east by Main Range (Titiwangsa Range) and Boundary Range respectively. There are granitic intrusive within the Central Zone, such as the Senting batholith, the Kemahang pluton and the Setong Igneous complex. The granite in Boundary Range (east of Kelantan) is overlain by the coastal alluvial flat of Sungai Kelantan, whereas the granite belts in central and west of the Kelantan, continue northward to south Thailand.

In Jurassic period, the crustal extension occurred in the Central Basin. Audley- Charles (1983) stated that it was the arc and back- arc extensional process which associated with the subduction at the active continental margin of eastern Gondwana. Anyway, Central Basin of the Peninsula is known as back-arc basin by Hutchison (1937).

Kelantan is in the central belt of Peninsular Malaysia and have varieties of rock that include igneous rock, metamorphic rock and sedimentary rock. Rock in Kelantan seems to align into one line from the north east, where this line actually part of the line Peninsular Malaysia (Rahman, 1998).

Kelantan is located at the west of Malaysia and recent studies have considerably extended the pre-tertiary stratigraphic range in west of Malaysia. In west of Malaysia, there are the major geological component namely the Carboniferous-Permian 'Calcareous series' the Triassic 'Arenaceous Series', and Mesozoic Granite (MacDonald, 1967).

2.3 Stratigraphy

In Central Basin of Peninsular Malaysia, there are 2 to 3km marine Triassic and Subsequently 1.5 to 2km of Jurassic to Early Creataceous continental sediment accumulated. Along the margin of the graben, the Early Triassic sediments includes shallow marine limestone, siliciclastic, olistostromes, and conglomeratic calcareous sediment. The olistostromes contains the clast of Palaeozoic limestone, tuffs, mudstones, tuffaceous sandstone, acidic volcanic and some conglomerate. Towards the central part of graben, it have a shale and deeper limestone. The Middle and Late Triassic is depicted by slope deposited volcanic clastic sediment for example coarse and fine tuffs with minor limestone and conglomerate (Metcalfe, 1989).

Permian sediment are widely distributed along river at Kelantan, such as Sungai Lebir, Sungai Aring, Sungai Relai, Sungai Paloh and Sungai Badong (Fontaine, 2002). The Youngest rock in Kelantan are the Jurassic to Cretaceous continental rocks. The overlain the Boundary Range Granite and Triassic sediments in gunung Gagau area (state boundary between Kelantan, Pahang and Terengganu) and to the west in the Gunung Perlis and Gunung Pemumpu area.

Based on Mazlan *et al*, (2010), the sequence consist of conglomerate which overlain by sandstone with sporadic volcanic intercalation.

Roslan *et al*, (1995) explain that these lateral facies changes could gathered within the same group as long as this sediment were deposited in shallow marine environment of the Gua Musang platform during the Permo-Triassic period.The proposed Gua Musang Groups includes the current (i) Gua Musang Formation (ii) Aring Formation (iii) Telong Formation and (iv) Nilam Marble (figure 2.1). The grouping of listed formation within the same group divides the new formation based on lithologic units.

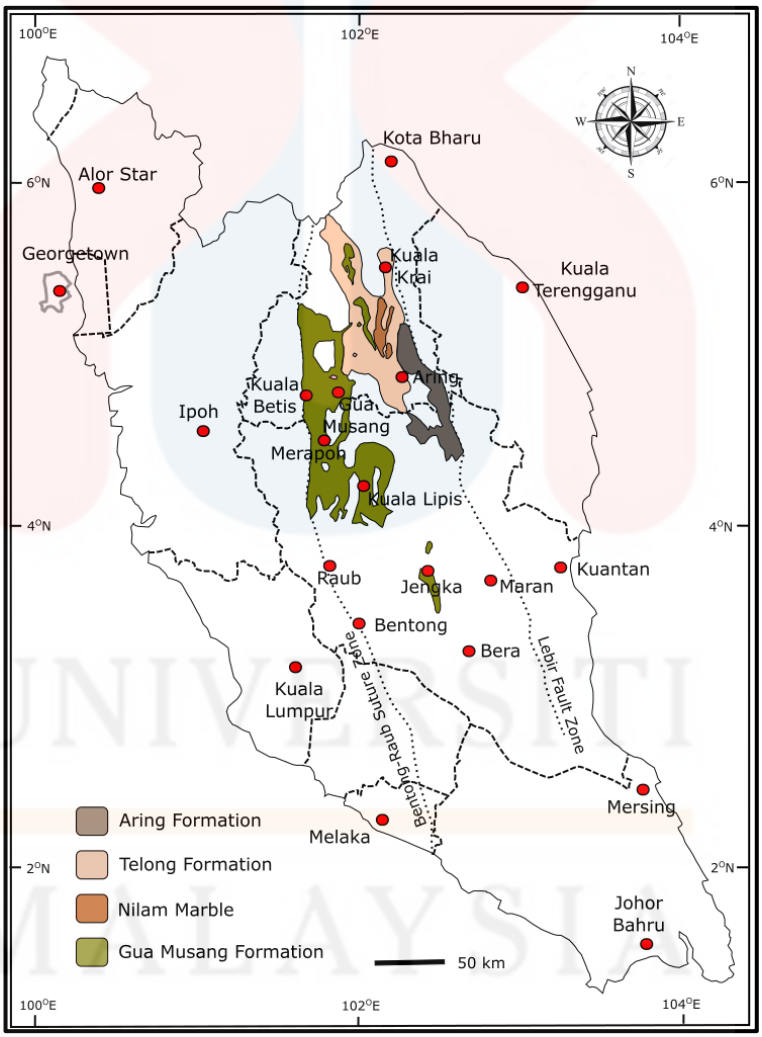


Figure 2.1 Distribution of Gua Musang Group (source: A newly proposed stratigraphic unit for the permo- Triassic Sequence of Northern Central Belt Peninsular Malaysia, Modified from Mohamed 1995.pg 132)

Foo (1983) dated the Aring Formation at Upper Carboniferous to Lower Triassic using foraminifera and bivalve .it is equivalent of the calcareous argillaceous Gua Musang Formation and similar rock to the south in the southwestern and western part of Pahang. So this, formation proved that turbidity in marine environment. Aring Formation consist of dominantly pyroclastic sequence (tuff) along with thin layers of argillite and marble interbeds. Numerous fossil were reported by Aw (1990) such as Lower carbon brachiopods and fusulinids, which are assumed as the oldest fossil in the Central Belt of Peninsular Malaysia.

Aw (1990) declared that Telong Formation dated from Late Permian until Late Triassic based on the presence of fossil of pelecypod, ammonoid, gastropod and brachiopod. This formation correlates with the Gunung Rabong Formation or Telong Formation. Telong Formation is designated of Upper Permian – Upper Triassic based on the fossil record on pelecypods, ammonoids, gastropods and Brachiopods. The rock sequence of this formation mostly consists of argillite and marble with thin tuff and andesite (Dony & Rosli Othman, 2014). According to Zakaria Hussin et.al. (2008), the ammonoid assemblage is indicative of a Middle – Late Triassic age (240-220 million years ago) and belonged to the Tethyan Province.

Koh Formation is terrestrial sediment, which dated Jurassic limestone. The fossil is not found but this formation younger than Telong Formation. Koh Formation overlying between Telong Formations. Koh Formation consisting of the sandstones (arenite and rudite), argillite and mudstone interbedded. The age of the Koh Formation is Jurassic, Cretaceous terrestrial sedimentary rocks and Koh Formation are the youngest formation from this area (Dony & Rosli Othman, 2014).

The type of sediment in the east area of Nilam Marble and the Telong Formation have a same to rock of the Gua Musang Formation (Nuraiteng Tee Abdullah, 2009). The age of the depositional environment of the Nilam Marble are compacted of the carbonate of the Gua Musang Formation. The Nilam Marble Formation is thin tuff and argillite interbeds that composed of dominantly massive limestone/marble. In the Nilam Marble Formation there have shell fossils (mostly fusulinids), (Dony & Rosli Othman, 2014). Nilam Marble have two type based on the age range it is Permian Marble and Upper Triassic marble (Aw, 1990). The lens-shaped of limestone/marble are separately distributed in period between Aring Formation and Telong Formation Dony & Rosli Othman ((Metcalfe, 1989) (Peng, 1983) (Mcrobberts, 2000) (Placeholder1)2014).

Gua Musang Formation is located at the northern part of the Gua Muasang Semantan depocentre that lies east of the Bentong – Raub Suture within the Central Belt. Gua Musang Formation is composed of the crystalline limestone, interbedded with thin beds of shale, tuff, chert nodules and subordinate sandstone and volcanic.

Gua Musang Formation aged of the Middle Permian to Upper Triassic located in south of Kelantan Mohd Shafeea Leman (2004).the finding of fossil of ammonoid and pelecypods by Khoo (1983) prove the age formation is Middle Permian to Middle Triassic.

2.4 Structural Geology

Gua Musang Formation lies east of Bentong – Raub Suture within the Central Belt. Structure that has in the Gua Musang is mostly dextral reverse fault zone Hutchison (2009). Show that near to Pos Mering along Cameron Highland – Gua Musang road, the serpentinite is bounded within the schist by 1.5 m wide easterly-dipping NNW-SSE dextral reverse fault zone.

Based on Noda (2013), Malay Basin is considered as fault- termination basins. It is formed under transtentional stress at the end of strike- slip fault. The sediment supply into basin along the strike-dip fault is dominated by rivers. Both tectonic depression and high surface heat flow have contributed the subsidence of basin.

The Central Basin of Peninsular Malaysia is an extensional graben boarder by major fault along the Bentong – Raub Line at the west and by the Lebir Fault zone at the east. It happen during the Triassic when a major normal faulting which possibly began in the Permian occurred along the Bentong –Raub Line and Lebir Zone and eventually producing a graben (Metcalfe, 1989). According to Metcalfe (1989), the Triassic rock in Central Basin generally upright or gently plunging fold (both symmetrical and asymmetrical) that present in singe folding phase.

Based on the characteristics of other major faults of the Peninsular, it is the Lebir Fault Zone may have been initiated as a dextral strike-slip terrane-bounding fault (Hutchison, 2009).

2.5 Historical Geology

The Gua Musang Formation in south Kelantan- North Pahang was mapped by Yin (1965) to describe Middle Permian to late Triassic argillite, carbonate, and the term has been loosely used for nearly all Permo-Triassic carbonate –argillite-volcanic sequence in the northern part of Central Belt Peninsular Malaysia.

During the Permian period, sinistral strike- slip fault movement happened in Malay Basin which causes the extension of the crustal (Audley-Charles, 1983; Tjia, 1993). This result in the formation of graben, the pull apart basin, which is known as Central Basin. The basin was started to accumulate the sediment from Triassic period. In early stage of the deposition, only the fine grain marine sediment are deposited, then followed by coarser continental sediment at Jurassic to Cretaceous period (Metcalfe, 1989).

Aw (1990) similar lithology to the Gua Musang Formation in Felda Aring is named as Aring Formation, while that in Sungai Telong is calling Telong Formation. The relevance of grouping these formation lies behind the close association observe among these formation in term of sedimentology and paleontological aspect (Kamal Roslan Mohamed *et al*, 2016). Need to reassess the usage of the informal Gua Musang Formation for the future rank elevation, formalization and clearer understanding on the geology of the northern Central Belt, particularly with regard to deposition of various lithostratigraphic units within the Gua Musang platform (Kamal Roslan Mohamed *et al*, 2016)

The northern boundary of Gua Musang platform is inferred to be bounded by low to medium grade metamorphic rock of the Carbo-Permian Mangga Formation

The Malaysia-Thai Working Group, 2006 and Taku schists (MacDonald, 1967) in the north.

"Gua Musang Group " proposed function to distinguish central –northern distribution of the Calcareous Series deposited in the Permo- Triassic shallow marine from adjacent dominantly deep marine "Raub Group"(Kamal Roslan Mohamed *et al*,2016).

2.6 Depositinal Environment

The term facies is used either descriptively, for a certain volume of sediment, or interpretatively for the inferred depositional environment. Facies models are intellectual aids to understanding the deposition environment and the ancient of origin sedimentary rock (Anderton, 1985)

Depositional environment is a place which affected by the specific sedimentary processes condition to deposit the sediment. There are three major depositional environment, which are continental (land), marginal- marine (transitional) and marine. A facies model summaries the characteristics of a given depositional setting (Boggs, 2014).

According to Hasmie *et al.* (2016), the depositional environment can be interpreted based on the facies characteristics. These include the texture, grain size, grain composition, fossil content and energy index classification. Based on Abouessa *et al.* (2015) the fluvial floodplain as they found the evidence of cylindrical borrow trace fossil and interbed of sand and mud at Sirt Basin, Libya are indicate the depositional environment. Kepferle (1977) interpreted Kenwood

Siltstone Member in United State as deltaic environment from the evidence of stratigraphy, petrology and the bedding structure.

Facies description include lithology and thickness , colour , composition , grain characteristic, bedding characteristic , sedimentary structure , nature of overlying and underlying contact, trace and body fossil and post –depositional features (Tebogo, 2008). Sedimentary facies are the analysis of the rock sample that to know past historical depositional environment of the area for the important of the community. The structure present also can provide a clue about the depositional environment by analysis the transportation energy of the sediment to deposit (Reineck and Singh, 1980).

Petrography is important since it can tell about the mineral composition and grain shape of the rock. The composition and the rock structure of the rock determine via point count analysis is intended to show the composition in sedimentary facies. As the shape of the sediment grain depend upon the medium of transport (Reineck and Singh, 1980), depositional environment also can know. Petrography analysis is correlated to the stratigraphy and the fossil data for the better interpretation of depositional environment.

CHAPTER 3

MATERIAL AND METHODS

3.1 Introduction

This chapter explain what the material and equipment used in the research and how the research conduct before, during and after the field. Equipment and material are used in the field are topographic map, global positioning system (GPS), digital camera, hammer, field notebook, measuring tape and sample beg.

There have stage of the research that include in the field study before, during and after the field.

3.2 Material/Equipment

3.2.1 Hand lens

Hand lens are used to quick observe of the small and tiny particles in the rock that cannot be seen in naked eyes especially microfossil and the mineral. It has been using for the identified the mineral in the rock that can recognise the mineral.

3.2.2 Sample beg

The sample begs used for the rock sample that taken from the field. Sample begs needed because to protect the rock sample contact with the other rock sample and to make sure the data analysis from the rock sample is good.

3.2.3 Measuring tape

The precise measurement of lithology, outcrop and the structure is required to collect data in the field. The measuring tape can be used for the measure the thick of the bedding of rock.

3.2.4 Hydrochloric acid (HCL) solution

HCL solution used to test the present of carbonate minerals in the rock. HCL solutions bring to the field with the enough quantity for the test of carbonate mineral.

3.2.5 Digital camera

Digital camera used for the view of the outcrop and the panorama of the study is that are prove of the field measure and for the interpretation.

3.2.6 Global Position System (GPS)

GPS is a space-based satellite navigation system which can provides the location and time information on the Earth's surface.

3.2.7 Compass

Compass is a tool to measure the accurate bearing based on the landmark precise directional measurement. It is also needed for measuring the orientation of the structure present on the outcrop.

3.2.8 Geological Hammer

Hammer is a basic tool for the geologist as it is used to collect outcrop sample. The flat end of the hammer used to break the rock and light chisel work.

3.2.9 Topographic map

Topographic map represent a portion of the three – dimensional of Earth's surface in two-dimensional way. It acts as a base map of geological mapping as the position of contour, river and paved road with the north direction, coordinate, scale bar and magnetic declination data are known.

3.2.10 Field Notebook

Field notebook is used to jot down all the data and information that are obtained from the filed mapping. It should be fully protected especially during rainy day. Without recorded data, the analysis and interpretation data cannot be proceed.

3.3 METHODOLOGY

3.3.1 Preliminary study

Preliminary study is early step for conduct research. The preliminary research in include regional geology of study area that are study before going to the field. The regional geology is involved of the topography map and the literature review of the area. Review of topographic the study area give information for the geomorphology. To know the geomorphology in the area before mapping is important because from

the morphology in the map can assume type of rock. Topographic map produced in the ArcGIS 10.2 from the Google earth base map. From the topographic map are analysis the lineament as the interpretation and assume of the structural geology before go to the field. Indicator for structure geology is lineament from topographic map.

From the topographic map also can interpret the lithology boundary that assume from the different contour pattern. Contour pattern can interpret the type of rock, for example the igneous rock the contour pattern is small for the sedimentary rock the contour pattern is large contour where the sedimentary rock are soft. From the topographic map can be planning traverse compare to the google earth base map which part in the study area can be access from the elevation in the map. From the topographic map, also can planning which part are suitable and safe to access for mapping.

Literature review of the area is important to know the geological information from the previous study that will helpful in this research. The source of the literature review is book, articles, journal and internet as a reference.

3.3.2 Field study

Field study is the process of the mapping in the study area and how to manage collect of data in the field. However, the transport, accommodation and food should be prepared during the fieldwork.

Collect data from the field is parts of geological mapping should be proceed. In the geological mapping, traverse is important to cover the study area without loss any important data. Firstly, in the geological mapping is observe the landform and

geomorphology of the area. From the high elevation of the landform in the study area is the best view to survey (5km × 5km) study area. The important thing is the accessibility to achieve the study area for the potential data. The accessibility in the study area

In the field it is important of mapping is traverse that cover the area and to identify the lithology of the area. Identify lithology of the area to know the rock texture, colour, structure, and grain size. Each of the bedding of the rock taken for the thin section and for the analysis in the laboratory.

In structural geology, the bedding structure, sedimentary structure and secondary structure like joint, fracture are observed in their orientation are measured. The direction of strike and dip angle bed are determined by using right hand rule. When hand is placing the bedding surface, the dip direction is where the finger pointing down, whereas the strike is where the thumb pointing. After knowing the direction, the attitude of the bed measured using the compass. For joint and fracture, their orientation is measured to do the joint and fault analysis. The rock sample are take and the rock put in the sample beg with labelling. In labelling rock sample should have name, date, location and station number. Labelling the rock in the sample beg is some of the method to make sure the sample are not change with another sample.

Depositional environment of limestone data collect from the bottom to upper part of the limestone outcrop. Each part of the bedding of limestone take for thin section analysis. The method of taking sample from the bottom to the upper of the limestone outcrop is to detect the depositional environment of study area.

Depositional environment data collected from the lithology, sedimentary structure, and fossil content. The lithology and fossil collection data are need to combine for the age of the rock. The age between the lithology are important for the analysis depositional environment. The fresh sample are taken for petrography analysis because in the petrography need to calculate the percentage of the mineral of the rock sample. The data collect are observed from the texture, grain size, colour, and fossil. The fossil content observed to identify the relative age and the rock depositional environment.

For collecting depositional environment data, observation is important to do detailed section each of the observation. As trough observation, indicator of depositional environment can be identified. These include lithology, sedimentary structure and fossil content. In general, depositional environment is filled with the sediment that eventually form the sedimentary rock type is observe in term of grain size, grain shape, grain sorting, and grain orientation. The thickness of the bedding are measured using the measuring tape and ruler. Sedimentary structure that formed during the depositional environment is observed as a good evidence for the analysis for the research. The fossil content in the sedimentary rocks is observe as it is useful to identify the relative age of the rock and depositional environment. Stratigraphic column are sketched to show the relationship of the facies. Both the rock and fossil are sampled to the laboratory analysis.

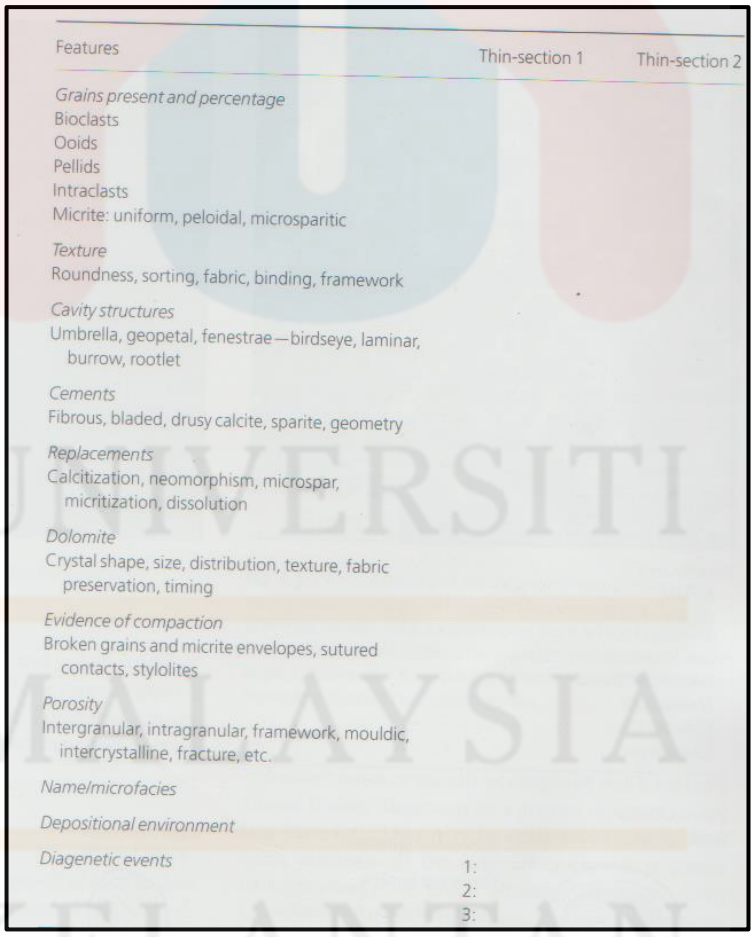
3.3.3 Laboratory work

Laboratory work are process, identify and analysis of the rock sample from the fieldwork. The data collect rock sample in the field are identifying in the

laboratory with the laboratory work. The laboratory work is including thin - section, petrography and analysis the rock sample.

The limestone or carbonate rock of thin section are identifying based on the schema of describing carbonate rock in thin section. In the table 3.1, carbonate rock thin section scheme are guide for the analysis of the rock sample. The analysis based on the cement, cavity structure porosity, texture and evidence of compaction. The analysis of the carbonate rock to know depositional environment of the research area.

Table 3.1 schema for describing carbonate in thin section (source: Sedimentary Petrology, Maurice E. Tucker, 2001. pg113)



Features	Thin-section 1	Thin-section 2
Grains present and percentage		
Bioclasts		
Ooids		
Pellids		
Intraclasts		
Micrite: uniform, peloidal, microsparitic		
Texture		
Roundness, sorting, fabric, binding, framework		
Cavity structures		
Umbrella, geopetal, fenestrae—birdseye, laminar, burrow, rootlet		
Cements		
Fibrous, bladed, drusy calcite, sparite, geometry		
Replacements		
Calcitization, neomorphism, microspar, micritization, dissolution		
Dolomite		
Crystal shape, size, distribution, texture, fabric preservation, timing		
Evidence of compaction		
Broken grains and micrite envelopes, sutured contacts, stylolites		
Porosity		
Intergranular, intragranular, framework, mouldic, intercrystalline, fracture, etc.		
Name/microfacies		
Depositional environment		
Diagenetic events	1: 2: 3:	

In the thin section of the rock sample do for identify type of the rock and depositional environment. For example, identify percentage of the mineral in the rock sample and the fossil in the rock sample with the sedimentary description guide.

Sedimentary facies used for the analysis the depositional environment of the sedimentary rock based on the study area. Sedimentary facies are to certain the volume of the sediment and deposition environment by analysis the composition, texture, grain characteristic and the bedding characteristic. The sedimentary facies analysis can know the past historical of the area based on the interpretation of the rock sample. Sedimentary facies analysis mostly used for the interpretation of the depositional environment based on the stratigraphy and the lithology.

Petrography analysis is used to analysis the rock based on the mineral, texture, colour, structure, grain shape and composition. Petrography analysis used for identify the rock name based on the percentage of the mineral in the thin section of the rock. From the petrography analysis it can be interpret the data.

3.3.4 Data processing

Data processing included the data of the preliminary study, fieldwork and lab work. This data process before interpret and analysis data. All the data from the preliminary study, fieldwork and lab work combine and integrate to produce geological map. The data from the fieldwork and laboratory work are related to the processing data, for example, lithology data are combine with laboratory work to get conformation of the age between bedding of the rock. For the identification of the depositional environment, the data lithology, sedimentary structure, and fossil are obtain in the fieldwork. In data processing for identify the depositional environment

is take over the composition, texture and depositional texture. This classification is one-step for the processing data before and after interpretation and analysis data. For the structural analysis is data process to know the how the structure form and to know the force come by using GeoRose. The fossil that found in the field are process to detect the species of the fossil for relation age between bedding of rock. The petrography of the facies are obtain and the filed work and the laboratory data are combining for interpretation.

3.3.5 Data analysis and interpretation

Data analysis and interpretation obtain after all the data processing complete. Data analysis obtain from detail thin section the rock sample. The sedimentary facies are analysis from the grain size, shape and fossil to interpret the depositional environment Felda Chiku 2 area.

There have three classification are used for data analysis and interpretation. The classification have different emphasis between each classification.

a) Folk's classification

The folk classification is a classification system for the carbonate rock devised by Robert L. folk (figure 3.1). The basic philosophy of Folk's classification is carbonate rock are siliciclastic rock in their mode of deposition, because their texture are both are control by the water energy in the depositional area.

The classification defines carbonate rock mainly based on composition that distinguish by three component. There is the grain (allocehems), matrix chiefly micrite and cement. The grain in the Folk's classification in limestone

are divided based on skeletal grain, ooids, peliods, intraclast and limestone formed in situ. The principal grains in limestone used as a prefix to micrite or sparite, whichever is dominant.

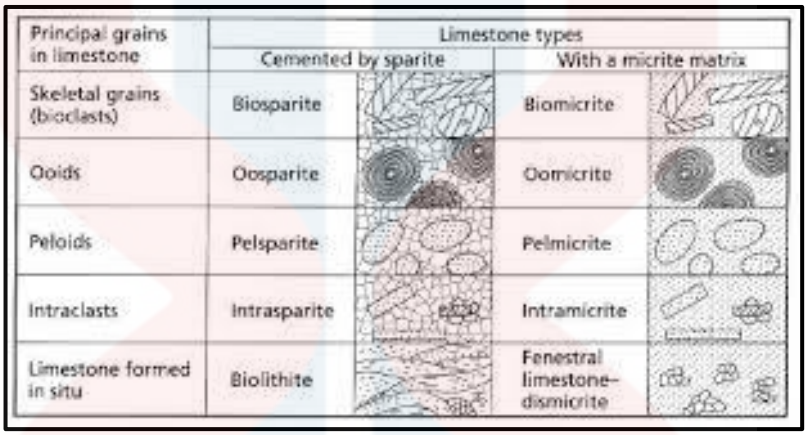


Figure 3.1 Classification of limestone based on composition (source: Sedimentary Petrology, Maurice E.Tucker, 2001. pg 129).

b) Dunham's classification

Dunham's classification in depositional texture used for interpretation and analysis of the depositional environment. Figure 3.2 show the classification of limestone based on the depositional environment that use in interpretation and data analysis. The classification on the depositional fabric are consider the dominating ground mass type, which is the same as Folk's classification. The Dunham's classification on depositional environment divides into five original component that in the original component have own description and the depositional texture. There have two major are distinguish, which is the group carbonate whose original component were originally bound together during depositional and carbonate whose original component were not originally bounded. In the original component not originally bound during deposition are need to consider the percentage of the grains and the grain

size. The original component not originally bound during deposition is (>10% grain >2mm). Original component originally bound during deposition are not consider the percentage of the grain size because the originally bound is perfect organism in stone.

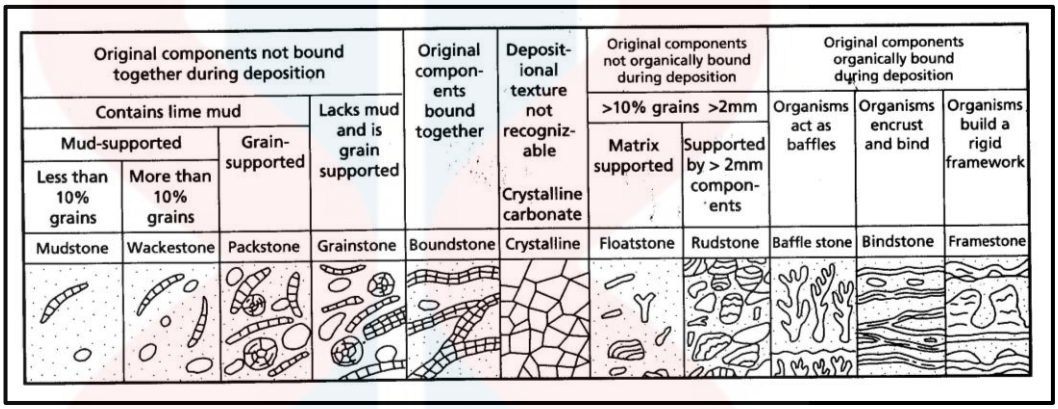


Figure 3.2 Classification of limestone based on depositional texture (source: Sedimentary Petrology, Maurice E. Tucker, 2001.pg 129)

c) Standard facies belt

Standard facies belt is the how to interpret and analysis the depositional environment based on the idealized sequence standard belt from Wilson (1975). The depositional environment based on the sequence in figure 3.3 is show the depositional environment in the deep marine (basin) to the shore (evaporate).

From the sequence it can interpret and analysis the depositional environment because from that can see the features of the depositional environment in one role of the sequence. The features like colour, sedimentary structure, facies, lithology and the grain type is can interpret in standard facies belt.

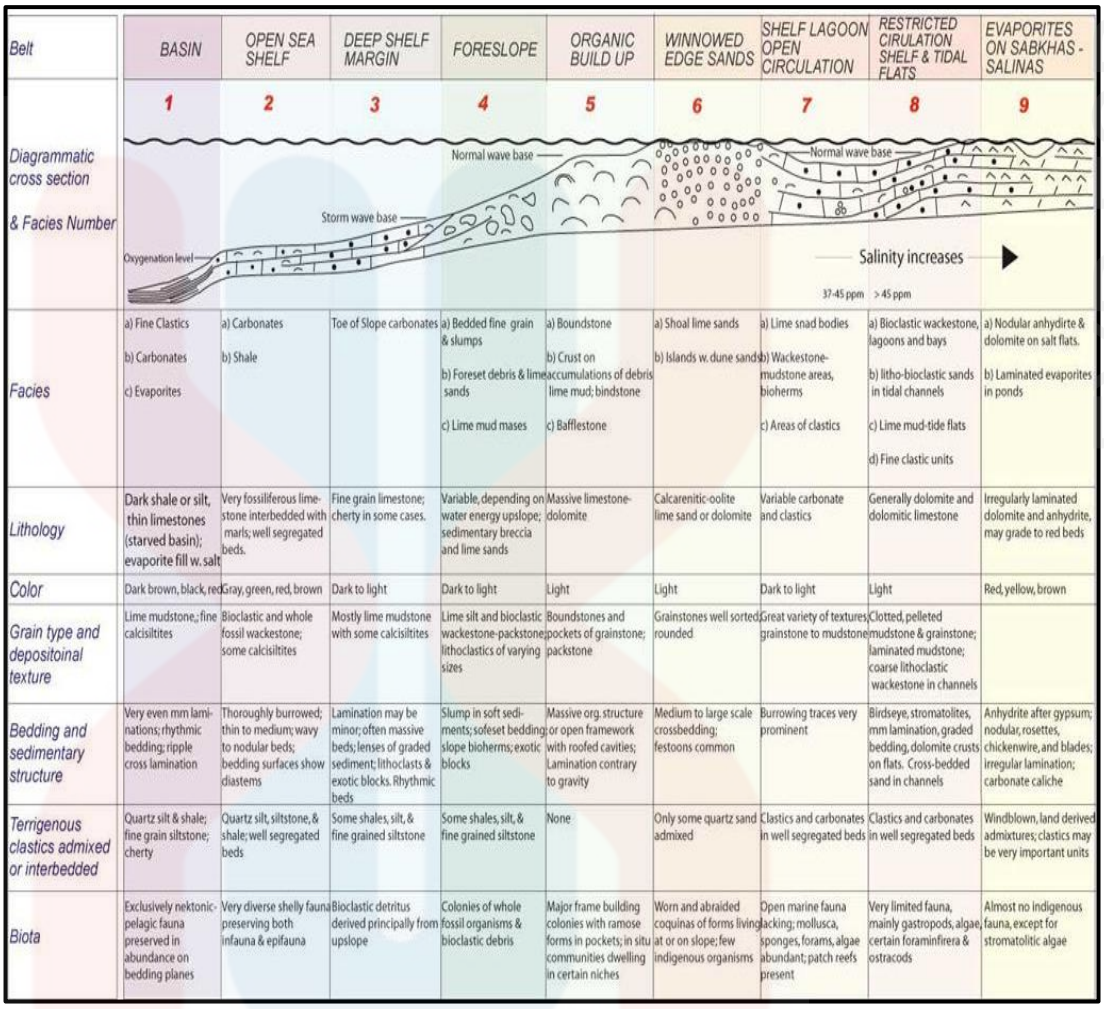


Figure 3.3 Standard facies belt (source:http://www.sepmstrata.org/page.aspx?pageid=281)

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is a survey on the whole of earth surface, from the formation of the universe, rock and minerals to geology processes and hazards. In this chapter, general geology including geomorphology of the study area, lithostratigraphy, structural geology and historical geology of the study area in Felda Chiku 2, Gua Musang, Kelantan.

4.1.1 Accessibility

Accessibility of the study area have three main road for access the study area. The main road to access of the study area are highway Gua Musang to Kota Bharu. This main road able to reach the study area at Chiku 2. Figure 4.1 below showed a signboard from the study area to Kuala Krai, Gua Musang and Kota Bharu.

Figure 4.1 Road accessibility from the study area to main town in Kelantan.

The second access in the study area are road from the Felda Perasu connect to the Felda Chiku 2. The road in the middle of the study area and it can be easier to mapping and collect data of the study area. Figure 4.2 and 4.3 below show the signboard Felda Perasu to Felda Chiku 2.

Figure 4.2 Signboard at the junction to the Felda Perasu and Felda Chiku 2.

Figure 4.3 Signboard to entering Felda Perasu.

The third acess for the study area are the road from Kuala Berang and Tasik Kenyir,Terengganu. This road commonly used for the oil palm farm woker because beside along the road are fully oil palm farm. Figure 4.4 below showed aceessibility from study area to the Terengganu. Along this Kuala Berang and Tasik Kenyir road have a small road that are can be acess from the NorthEast of the study area.

Figure 4.4 The road accessibility to the Tasik Kenyir and Kuala Berang, Terengganu.

4.1.2 Settlement

From the observation and survey of the study, area does not have any settlement inside the study area but not far from the study area have three village. There is Felda Chiku 1, Felda Chiku 2, and Felda Perasu. Felda Chiku 1 and Felda Chiku 2 3 kilometres from the study area. From the observation and survey at Felda Chiku 1 and Felda Chiku 2, have some facilities for example, for education have primary school and high school and have clinic for the health of villager. Facilities most important for all user not only for the villager because the facility can used for any emergency or for long the term. From the survey in Felda Chiku 1 and Felda Chiku 2 can be classify as cluster settlement because the two village in one place that have facility and relation between each village.

4.1.3 Forestry and Vegetation

Study area with 5km × 5km can be classify into two, which is forestry and vegetation. In the study area, the most dominant are vegetation and the rest are forestry. Vegetation in the study area can classify into two type, there are palm tree and rubber tree. Palm tree are the major of vegetation in the study area it 70% cover the study area. The palm tree in study area are more than 10 years planting and it almost 30 years replanting the palm tree. From the North of study area, palm tree already produced a product but in the South of study area, the palm tree replanting about three years ago. In the South of study area not produced any product because of the palm tree is small. Figure 4.5 below show the oldest palm tree that around the limestone karst. The view of morphology take at azimuth N14E where the elevation

around 280m from above sea level. From the azimuth can see half part of study area that cover the lower elevation.

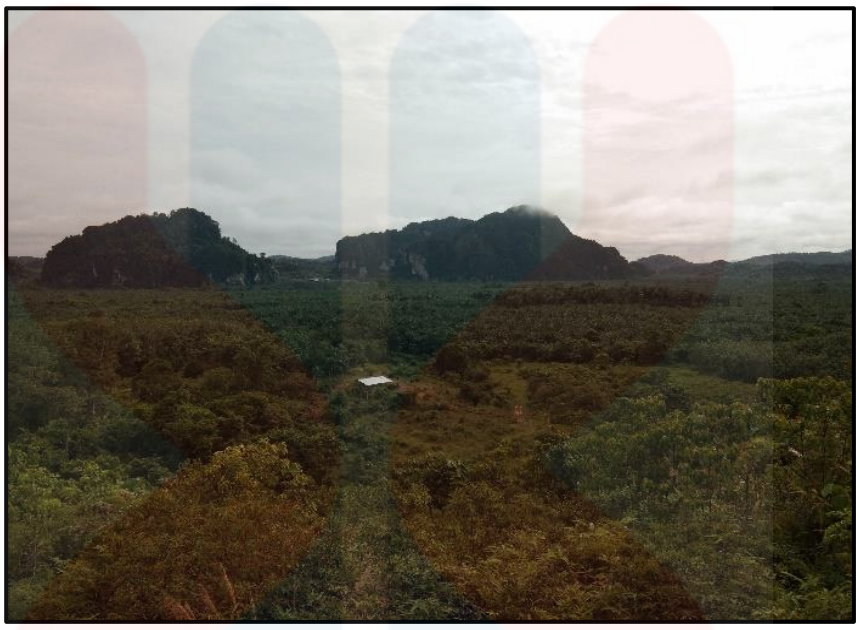


Figure 4.5 Vegetation of the oldest palm tree in study area.

The new planting of the palm tree at the centre of study area cover apart of high elevation and lower elevation. In the new planting of palm tree, have many of private owner for example Qim Sam Planting and MAIK planting. Figure 4.6 below show the new planting of the palm tree and show some access in the farm. For the rubber tree only 10% cover in study area.

Figure 4.6 New planting of palm tree.

Forestry in study area only 30% only it just mention in the statement above. The forest not explore for the new vegetation. Figure 4.7 below show some of the signboard "Hutan Simpan Kekal Dilarang Menceroboh" from Department of Forestry. To enter the forest for any work or any research must need a permission from the Department of Forestry. Forest in the study area are near to the "Gunung Rabong". Gunung Rabong as a one of the attraction for the tourism because in the peak of the mountain have a good view for the morphology of Gua Musang.

Figure 4.7 Signboard from the department of forestry

The forest in study area are cover 30% along the Southern of the area. There is boarder between the palm tree farm and the forest, until now the forest not explored for any vegetation and logging. Figure 4.8 below show the panorama view at azimuth N20E and the location is N 04˚ 51’ 50’’, E 102˚ 08’00’’. The forest beside the private Qim Sam palm tree farm and to access the forest need to enter the private palm tree farm.

Figure 4.8 South west part forestry in study area.

4.1.4 Traverse and Observation

Traverse is a track recording of data that are save in the Global Positioning System (GPS). Traverse are the prove of the data that collect in the field with the track recording, from the track recording with using Global Positioning System (GPS) or compass it can be recorded to make a prove that the area already visit and take a data.

Observation is needed in traversing because in traversing it can be save time while do a traverse it can be observe some of the data can collect in study area. For the example, observe the drainage pattern, weathering, lithology, forestry or vegetation and accessibility. Accessibility is the most important when do a traversing because can observe the access for the next track. Before make a traverse in study

area it need to interpret the base map for design of the traverse which is make a simple traverse, planning time and easier traverse.

Traverse map below show the seven track of traverse that means prove of the data collect in the field. Track 1 in the traverse map show the traverse in electron gold colour, traverse of track 1 is to check the interpretation of rock lithology. Track 1 start from the main road in the in the study area and the traverse is 15km long from the start. The traverse cross the mountain for recheck the interpretation and real life in field.

Track 2 show in the figure 4.9 is recheck the lithology of the limestone and tuff. The traverse is quite difficult because it need to cross some forest for reach the palm tree farm. For the track 3,4, 5, 6 and 7 as the same thing need to do and another thing to check in the study area are structure, fossil and something new.

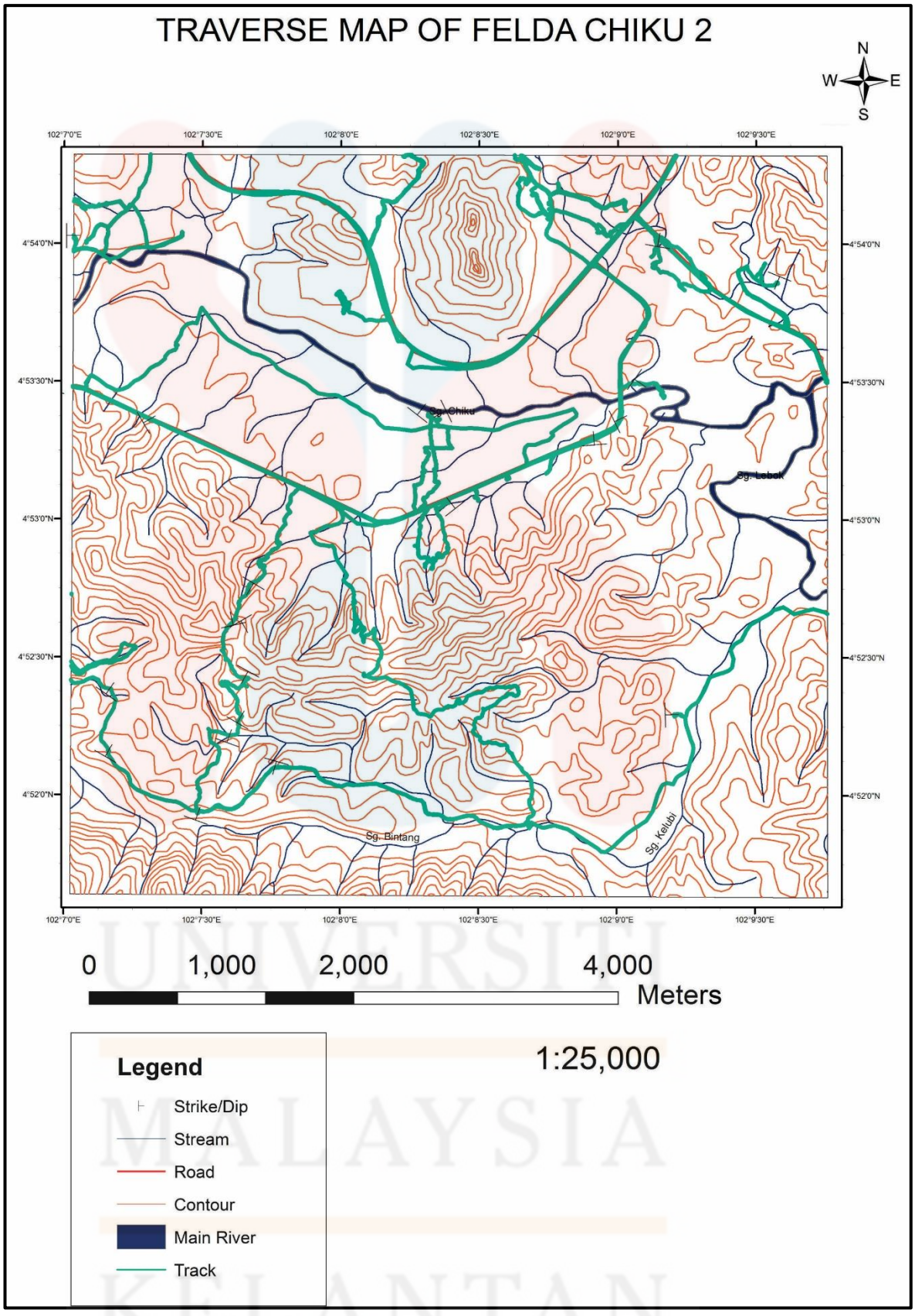


Figure 4.9 Traverse map of Felda Chiku 2

Observation in the field quite different with observation in the laboratory because in the field need to consider in all aspect. Observation in the study area is to make sure the thing that can be describe how it form and how it can be form in the field. The observation in the field also need to take some data to plot in the software or to calculate the data get in the field.

4.2 Geomorphology

4.2.1 Geomorphologic classification

Geomorphology is the study of the shape of the surface. The word "geomorphology" is derived from the Greek roots geo (earth), morphos (shape) and logos (study).

Geomorphology is define as the science of phenomena on or near the earth's surface and interaction between different type of material and processes, including solid, liquid and gases (Schumm,1991)

Geomorphologic classification it classify based on the slope map. From the slope map the morphology of the landform can be classify base on the colour and the elevation in the map. Morphology of the landform also can classify based on the drainage pattern. In the field to interpret the morphology, need to choose the best of the view in the high elevation. In the study area can be classify in into four morphology which is low lying, hilly, karst and mountainous. The four morphology are based on the elevation in the study area. For the low lying in the study area the elevation are from 0 -50 m, that means the colour in the map are green and the area are safe for the settlement and development. The hilly morphology and karst morphology, the elevation from 51 – 200m. The colour from the slope map show

yellow to orengish colour. The colour of contour are very important for reference of development. For the karst is not suitable for development and for the hilly morphology is not dangerous when the colour are yellow but is more hazardous when it turn to orengish to reddish colour because the slope become more steep. For the mountainous morphology in study area, the elevation are 201 – 300m above. That means the colour are turn to reddish in the slope map because it more steep slope.

Based on the slope map, morphology trace on the colour and elevation. In the slope map can classify in three colour it is green, yellow, and red. The colour classify based the elevation in the study area. Figure 4.10 show of the slope map in the Felda Chiku 2. The slope map in it can be describe the morphology of the surface but it only for landform but it also use for slope and the river morphology.

For the karst morphology are based on the shape of the karts. The karts in the study area have only one shape that can see from the landform of the karst, which is cone shape. Cone shape karts in the study area are isolated and rises above other surrounding foothills. The gradient of the circular base and smooth side are up to 30˚. In the cave morphology have another morphology which is stalagmite, stalactite, column and pillar. This secondary morphology that form after the first form of the karst. The secondary morphology of the karst cause of the dissolve of the karst limestone, so that it form the secondary morphology like cave.

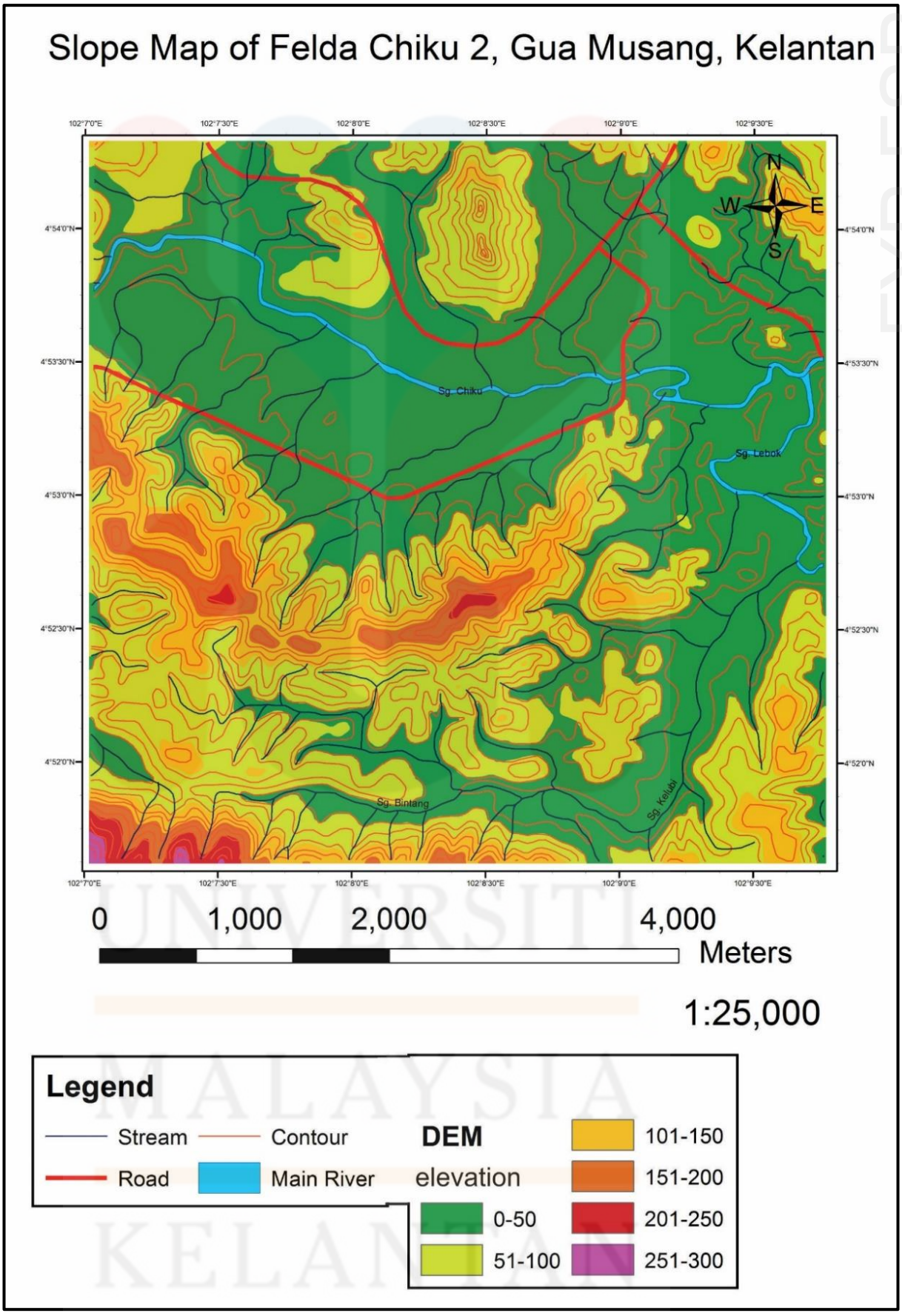


Figure 4.10 Slope map of the Felda Chiku 2

4.2.2 Weathering

Weathering is the external process of the earth and the process that break down the bedrock in the earth surface and turn into some particles. The process of the weathering are classify in three process it is, physical weathering, chemical weathering and biological weathering. This weathering process happen by the agent that can dissolve and break down the mineral and bedrock in the earth surface. The agent that usually involve in weathering process are water, ice, acids, salt, plant, animal and changes in temperature. All the agent of weathering make the process it become faster or slow and it take a long time to break the bedrock or dissolve the rock. Weathering may occur in the original source rea where bedrock is exposed or in rock material that have been eroded, transported and deposited thousands or kilometres away from their original source area.

The weathering condition the study area based on the unit of the rock. For the phyllite rock are more highly weather because the phyllite are metasediment rock which is the rock are not fully metamorphism.so the rock are very weak because it easily to break down then the other rock. Effect of weathering to the rock that can see in the field are rock become a loose sediment and deposit at the river. The soil in the study area also are very thick so that the rock highly weather. In study area the main weathering are physical weathering it can be related to the rosk and soil breakdown easily because of the physical weathering.

There are three type of weathering which is:

a) Physical weathering
b) Chemical weathering
c) Biological weathering

a) Physical weathering

Physical weathering also known as mechanical weathering is accomplished by physical forces that break the rock into smaller piece without changing the rock's mineral composition. Figure 4.11 below showed the outcrop that happen some of the rock break into the smaller pieces that means in the figure below show the outcrop occur the mechanical process.

Figure 4.11 Physical weathering at the siltstone and phylite.

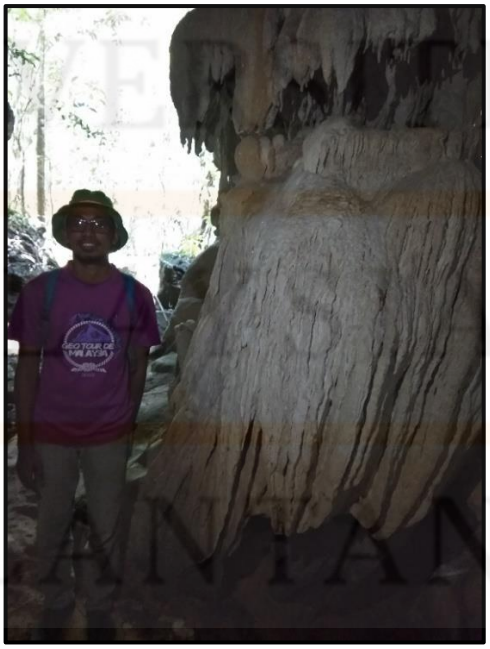


Figure 4.12 Chemical weathering of the limestone make some column in cave.

b) Chemical weathering

Chemical weathering are involve the complex process that alter the internal structure of minerals by removing or adding elements. During the transformation, original rock decomposed into substances that are stable in surface environment. In the figure 4.12 show of the column or pillar in the limestone cave. The process take a very long time to complete one of the column or pillar, this process call chemical weathering that change the structure of the mineral in the rock that dissolve the limestone.

c) Biological weathering

Biological weathering occurred due to the root of the plant wedging in the crack or joint of the rock. Figure 4.13 below show of the biological process that plant root wedging in the crack and the joint of the phylite.

Figure 4.13 Biological weathering of the phylite

4.2.3 Drainage pattern

Drainage pattern in the study area is important to assume type of the rock and the watershed of the area. Drainage pattern it form by the stream, river and lake. The geomorphology of the landform is one of the cause of the drainage pattern are different pattern with each other. Many type of drainage pattern that are commonly found in the field, but in the study area have two type drainage pattern which is dendritic and parallel drainage pattern.

Firstly, a dendritic drainage pattern are common form like a branches of tree root. Dendritic drainage are not straight and there are contributing streams which are then joint together in to the main river tributaries. Drainage pattern are develop when the river channel follow the slope of the terrain in study area. Dendritic stream pattern are commonly the rock type is impervious and non-porous. In the study area are mostly a dendritic drainage pattern and some part in the study area are parallel drainage pattern. The dendritic pattern tend to develop on surface that erode uniformly on gentle to moderate slope. The evolution of dendritic pattern is guide by lithological characteristics mainly permeability of underlying rock, the amount and regime of rainfall and resultant surface runoff and the time factor.

Rectangular drainage pattern have a little in the study area which in the centre of the study area. Rectangular drainage pattern is the main stream and their tributaries display many right- angle bends. In the study area have two part that can classify of the rectangular drainage pattern which is in the centre and in the Northeast study area.

Parallel pattern is like parallel with elongated catchment. It have long straight tributaries which joining at small acute angle. This pattern develop caused by steep slope with some relief. Due to the steep slope, the stream are swift and straight, with very few tributaries and all flow in the same direction.

Figure 4.14 show three drainage pattern that have and classify in the study area, which is dendritic, parallel and rectangular drainage pattern. The pattern of drainage in study area show river system in naturally without any human activities.

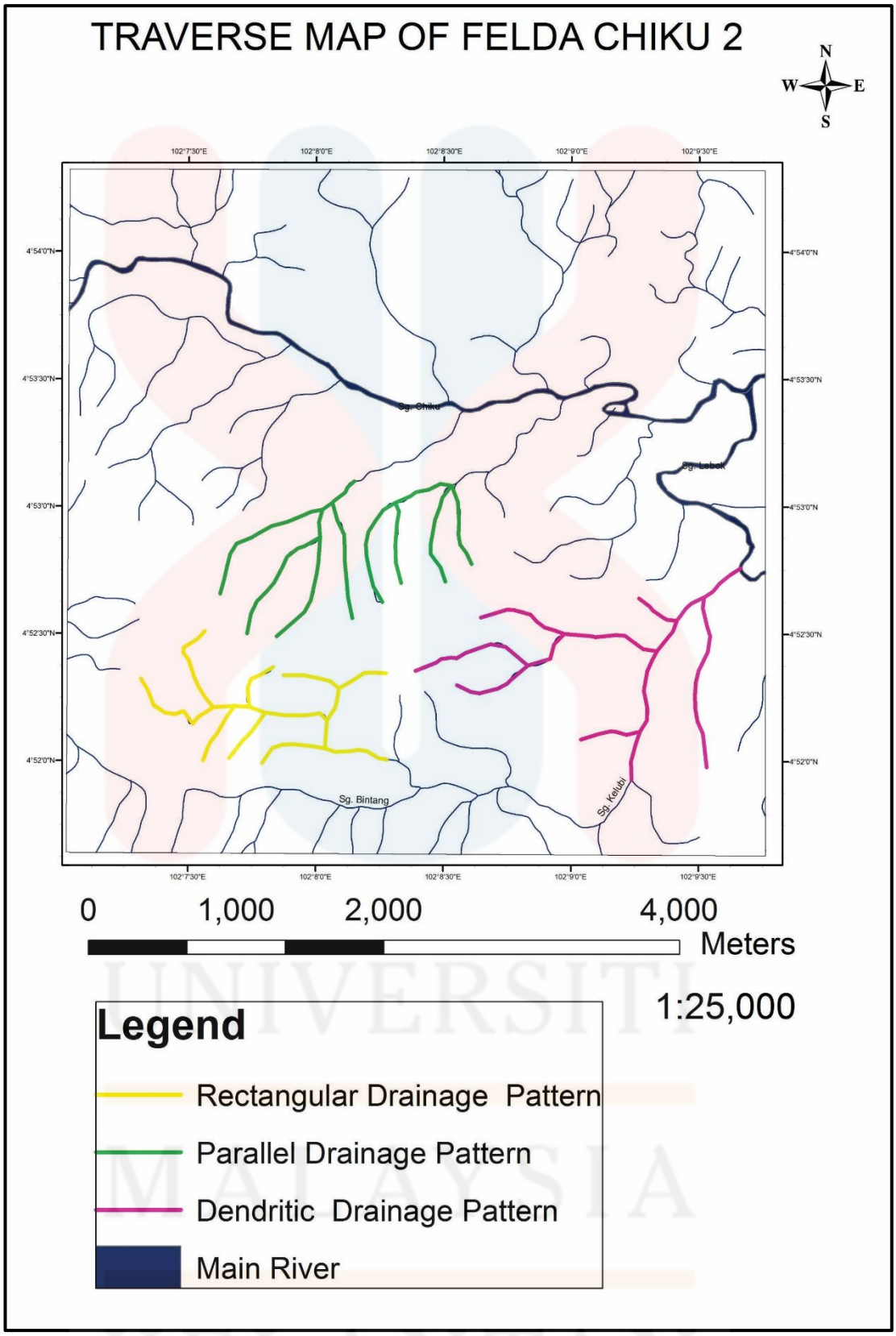


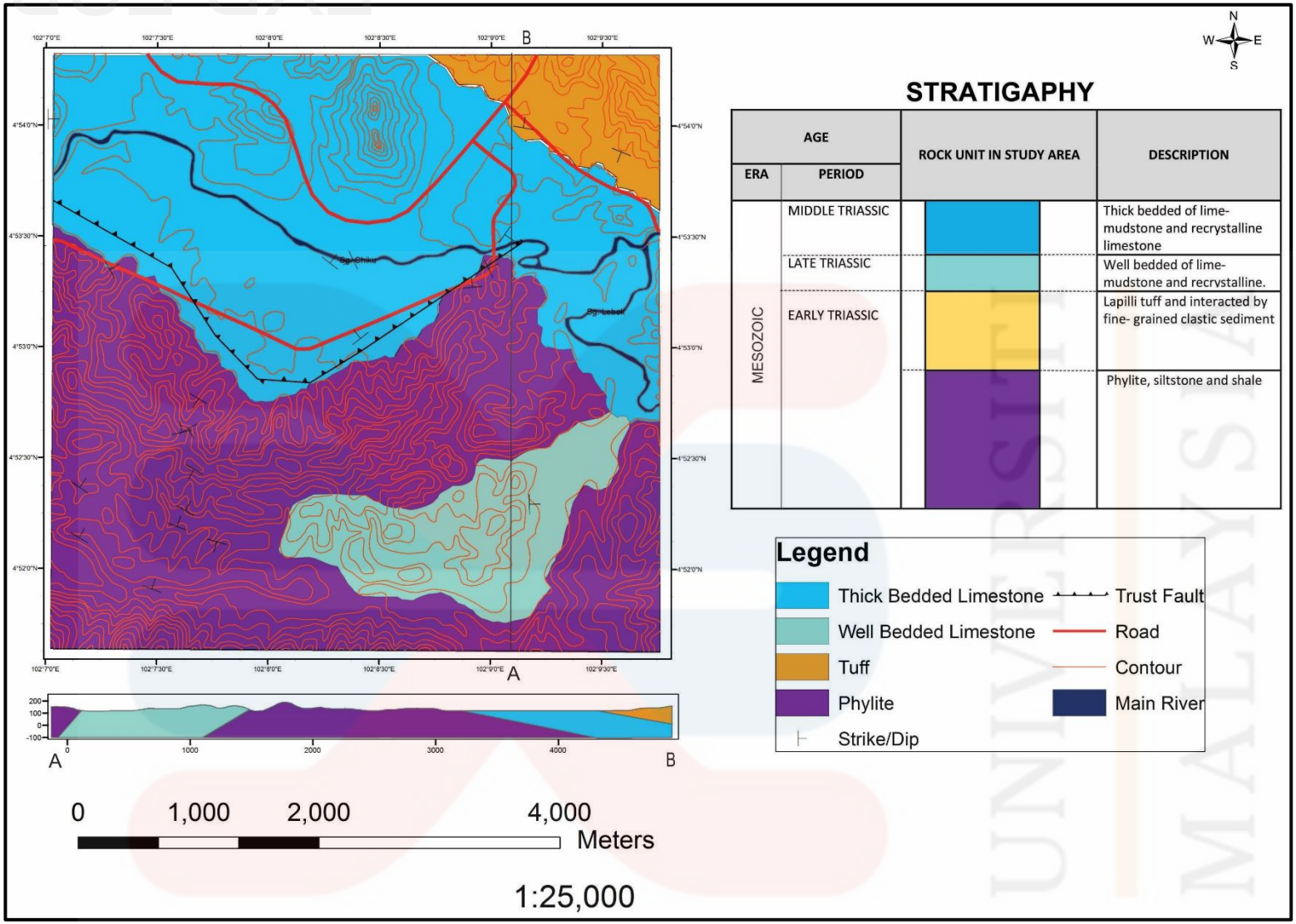
Figure 4.14 Drainage pattern and river system in study area.

4.3 Lithostratigraphy

The lithologies of the study area are mainly covered by the metasediment and limestone which is the metasediment rock become metamorphose. In the study area are divided into 4 lithologic unit; phyllite (metasediment), tuff, well bedded limestone and thick bedded limestone. All the lithologic unit are based on the dominantly of the rock unit in the area. The lithologic unit are recorded and divided in the geological map that have the cross section based on the data strike and dip in the field. The geological map show in the figure 4.15 that show the stratigraphy of study area. The lithology are measure on the along the hill in the palm tree farm and in the Bintang river. The lithology measurement are identify in different location and the lithology changes the grain size and the thickness.

4.3.1 Stratigraphic Position

The oldest of rock unit in the study area are phylite (metasediment) and its located at the central of the study area and also located more to the south west in the study area. The second oldest rock unit than the phylite are tuff that located at the north east of the study area. For the third of the oldest rock unit are well bedded of the limestone in the study area where the well bedded limestone located at the south east in the study area. The youngest rock unit in the study area are thick bedded limestone where in the study area, the limestone classify in different age.



4.15 Geological map of Felda Chiku 2

4.3.2 Unit Explanation

The lithologic unit are explained from the oldest of the lithology rock unit to the youngest lithology rock unit in the study area. The explanation of the lithologic unit with the horizontal distribution and the vertical distribution of lithologic. The unit explain with the estimation of the thickness of the rock unit, distributed area in study location, and the relationship between the units. The lithology of the earth lithologic unit are different composition in different location that can see in the petrographic analysis. In the petrographic analysis can identify the mineral composition, fossil and the structure. All the unit were explain in the feature that found in the field, for example fossil, structure and anything to relate with the depositional environment and historical geology of all unit.

4.3.2.1 Phylite Unit Interbedded with Siltstone

The oldest of the rock unit in the study area are phylite interbedded with siltstone where the phylite are dominantly than the siltstone. Phylite is the type of the metamorphic rock that are created from the slate. The composition of the phylite are quartz, mica and chlorite. The colour of the phylite outcrop more to the reddish brown to the oranges brown. The outcrop in figure 4.16 show the phylite interbedded with the siltstone and with the laminations in the outcrop.

Under the microscopic, the plane polarize light (PPL) show whitish brown colour, while under cross polarize light (XPL) show the dusty grey brown in figure 4.17. There have fine grain and have some course grain. There have some of the foliated, that means the pressure and force has happen to the rock. The shape of the

grain are mostly sub rounded to round. The mineral are found in the phyllite are grey and white quartz and mica in higher order of colour.

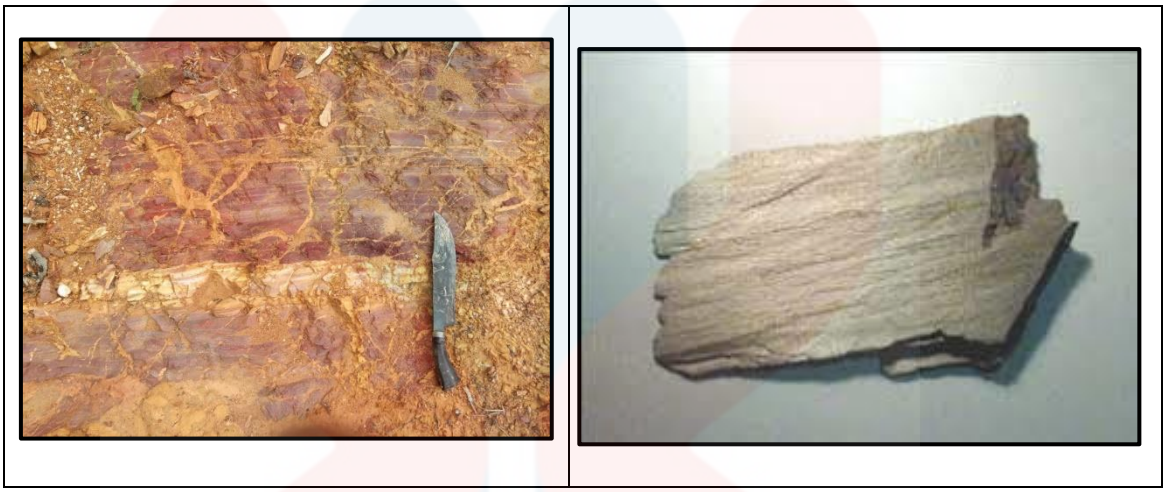


Figure 4.16 Outcrop and hand specimen of phyllite interbed with siltstone

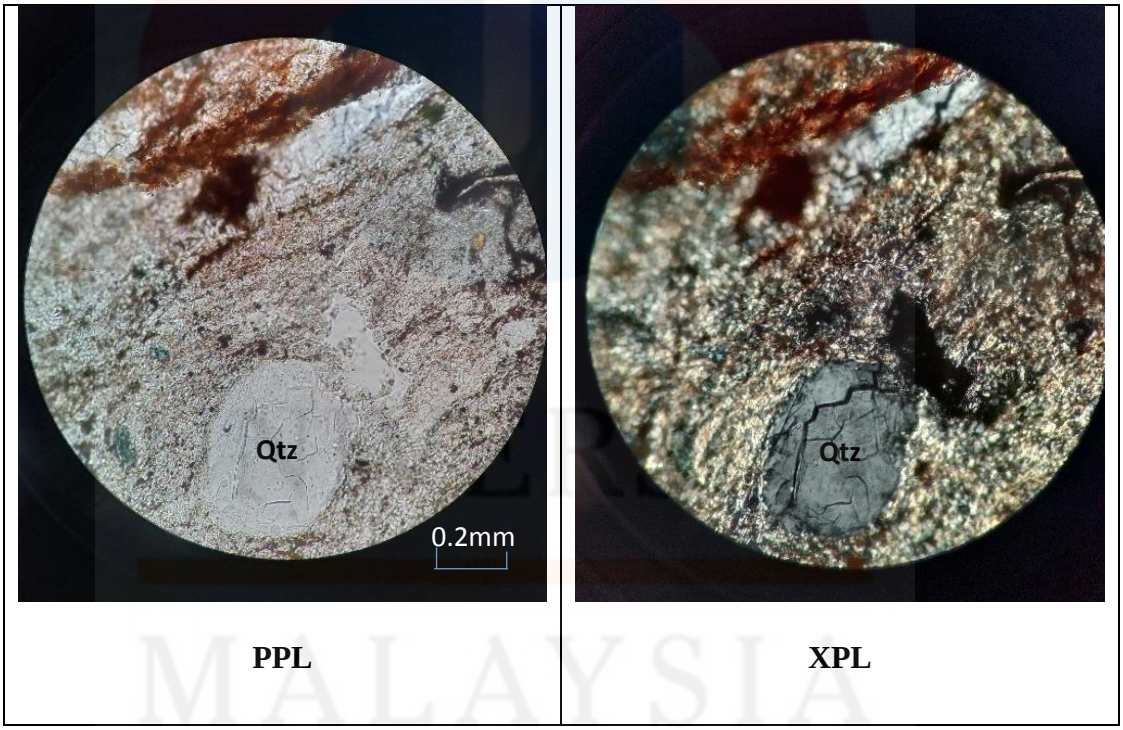


Figure 4.17 Sample of phyllite under microscopic of the plane polarize light (PPL) and cross polarize light (XPL)

Table 4.1 The description of the mineralogy in the rock sample of phyllite

Composition of mineral	**Description of optical mineralogy**
Quartz (Qtz)	It has low relief under PPL. It clear and colourless under PPL and XPL. It has sub - rounded shape has cleavage
Mica	It is colourless and clear under PPL, but masked with colour in XPL. Plenty mica was found in the sample.
Opaque mineral	Common mineral that black colour in both XPL and PPL.

4.3.2.2 Lapilli Tuff Unit

Lapilli tuff is the second oldest in the study area where the lapilli tuff unit located at the north east in study area. Lapilli tuff are is a minor of rock unit in the study area that lapilli tuff colour are light brown and the lapilli tuff are more than the 75% of the lapilli. Under microscopic the mineral in lapilli tuff are feldspar, quartz, and opaque mineral. In figure 4.18 show outcrop of the lapilli tuff with the hammer scale.

The groundmass of the lapilli tuff are from the ash and silica. The sample of thin section are use 10mm x0.65p under the microscopic. The figure 4.19 show of the thin section sample under PPL and XPL.

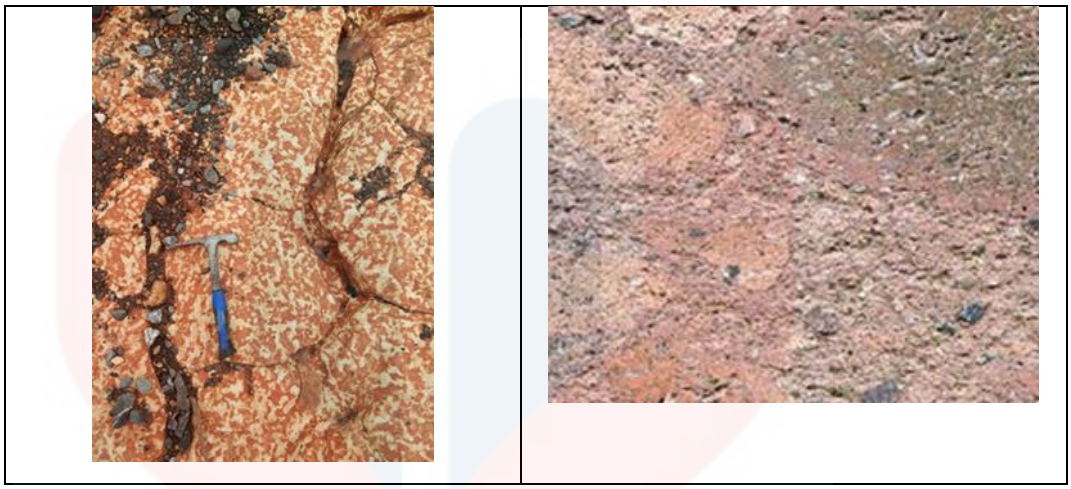


Figure 4.18 Outcrop and hand specimen of the lapilli tuff

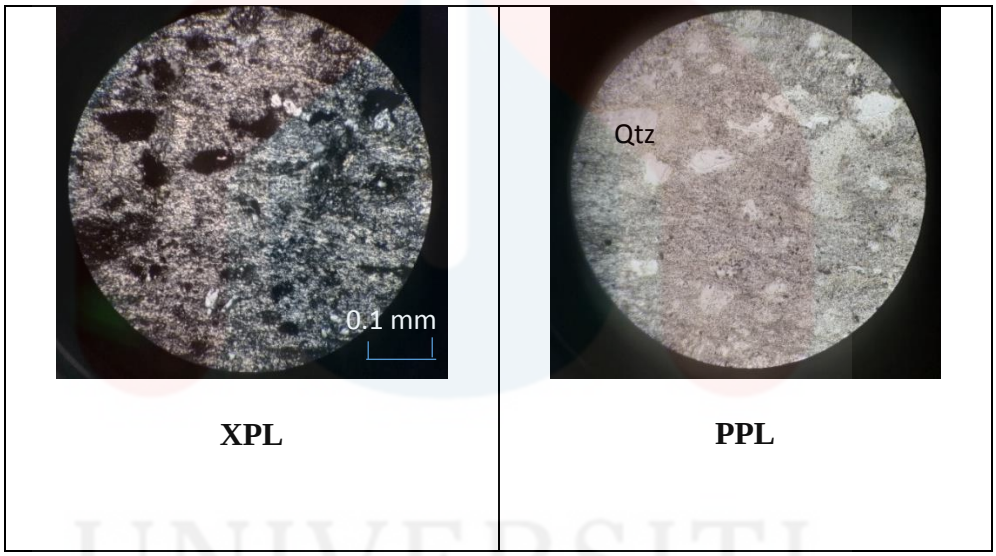


Figure 4.19 Sample of lapilli tuff under microscopic of the plane polarize light (PPL) and cross Polarized Light (XPL).

Table 4.2 Description of the mineral lapilli tuff in thin section.

Composition of mineral	**Description of optical mineralogy**
Quartz (Qtz)	It has low relief under PPL. It clear and colourless under PPL and XPL. It has sub - rounded shape has cleavage
Plagioclase Feldspar	It colourless and white under PPL but in the XPL it change in grey or other colour. The birefringence 0.007- 0.013.
Opaque mineral	Common mineral that black colour in both XPL and PPL.

4.3.2.3 Limestones Unit

a) Well Bedded Limestone

Well bedded limestone are located at the south east of the study area which is the outcrop well bedded limestone found in the river Sg. Rebok. The well bedded limestone unit are younger than the lapilli tuff but it older than the thick bedded limestone. The colour and the texture of the well bedded limestone are light grey and fine grain (smooth). The figure 4.20 show the outcrop of the well bedded limestone. In the well bedded limestone are lacking of the fossil but have some structure.

Under microscopic, well bedded limestone are have fine grain sediment it call as a groundmass and some of the opaque mineral it look so clearly under the microscope. Well bedded limestone have some of mineral like quarts, calcite, opaque mineral and feldspar because in the limestone have some sediment are deposit. Figure 4.21 show the well bedded limestone under microscopic.

Figure 4.20 Outcrop and hand specimen of the well bedded limestone beside the Rebok River in the study area.

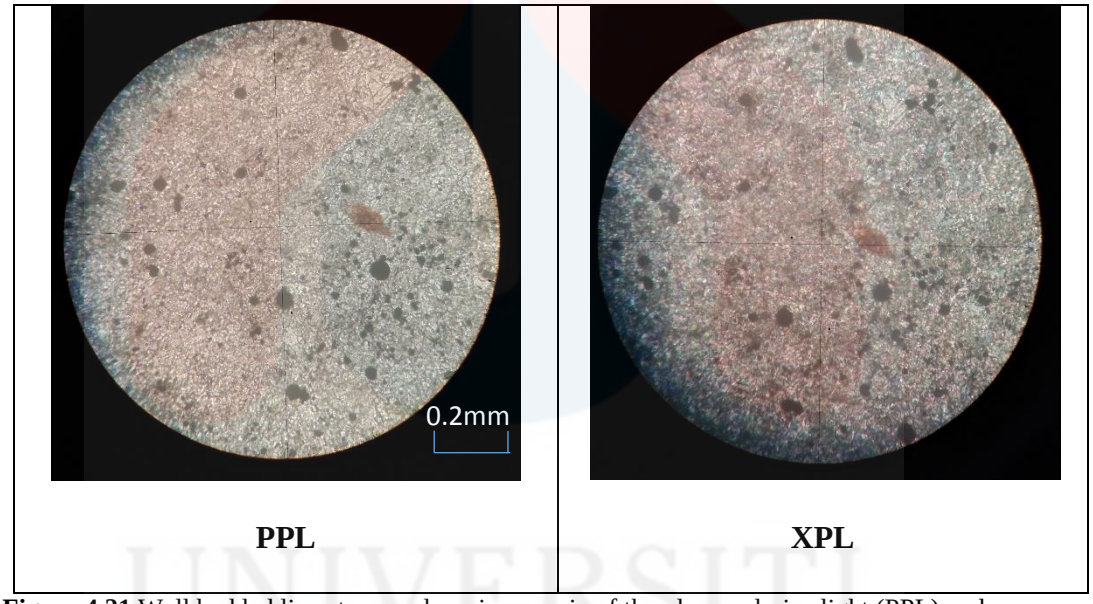


Figure 4.21 Well bedded limestone under microscopic of the plane polarize light (PPL) and cross Polarize light (XPL).

Table 4.3 The description of the mineral well bedded limestone sample.

Composition of mineral	Description of optical mineralogy
calcite	Calcite cemented the quartz and enclosing several grain
feldspar	It is glassy groundmass and have numerous small dark iron rich spot
quartz	Quartz grain with several and many sub-crystals, some of the latter with saturated contact.
Opaque mineral	Common mineral that black colour in both XPL and PPL.

b) Thick Bedded Limestone

Thick bedded limestone unit in the study area are the youngest rock that found in the south east in study area. The age of the thick bedded limestone are late Triassic .Thick bedded limestone also call as a massive limestone because it some part of the thick bedded limestone doesn't have a structure, fossil and anything else to refer. The figure 4.22 below show the outcrop of the thick bedded limestone.

Thick bedded limestone have some minerals like pyrite, quartz, calcite, feldspar and opaque mineral which can see in small particles under the optical microscopic. Figure 4.23 below show the cross polarize light (XPL) and the plane polarize light (PPL) of thick bedded limestone.

Table 4.4 The description of the mineral thick bedded limestone sample.

Composition of mineral	**Description of optical mineralogy**
calcite	Calcite cemented the quartz and enclosing several grain
feldspar	It is glassy groundmass and have numerous small dark iron rich spot
quartz	Quartz grain with several and many sub-crystals, some of the latter with saturated contact.
Opaque mineral	Common mineral that black colour in both XPL and PPL.

Figure 4.22 Outcrop and hand specimen of the thick bedded limestone is located at the palm farm

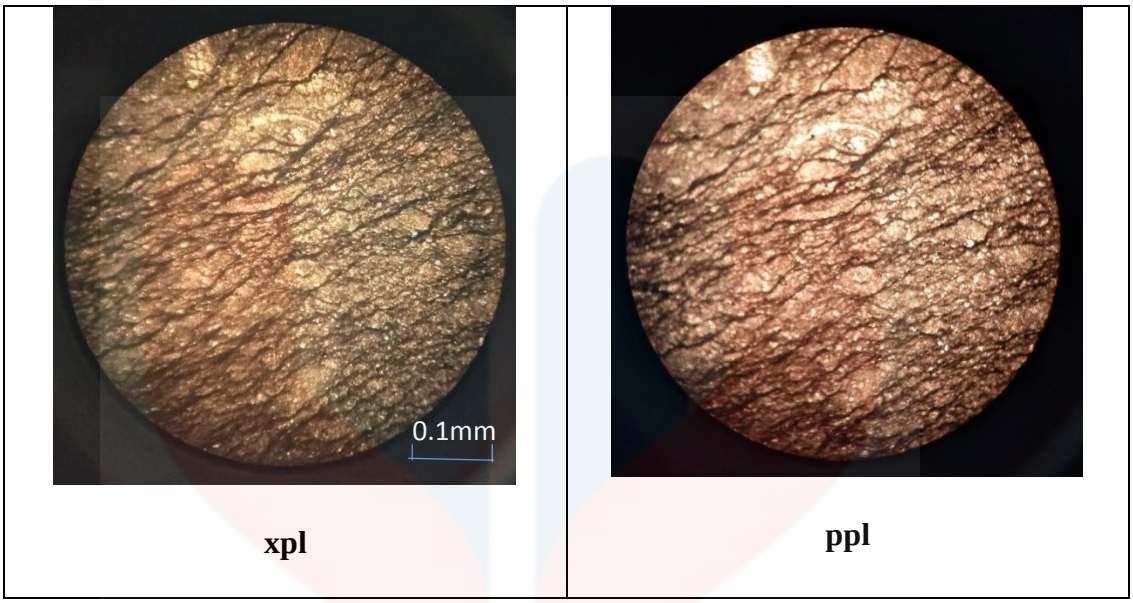


Figure 4.23 thick bedded limestone under microscopic of the plane polarize light (PPL) and cross Polarize light (XPL).

4.4 Structural Geology

Structure geology is a geometric configuration of rock, and deal with geometry, distribution and formation of structure. Analysing of the rock structure are mostly by observation, measurement and interpretation of the structure. The rock structure formed in faulting, folding, vein, joint and cleavage. For bedding is a structure that are formed by deposition of sediment. Earth's crust structure is a large lineament structure that can see in large view.

4.4.1 Lineament Analysis

Lineament analysis is the way how to check the structure in the field base on the lineament analysis. Lineament commonly used in a regional tectonic event. It is called regional structure of an area due to structural deformation, for example bedding strike, fold axis or fault zone. Lineament analysis is interpretation on the

map like a base map and the topographic map. In lineament analysis also are interpret the data base on the processing of the remote sensing data. In remote sensing data are accurate data to interpret because the data can see in 3D of the earth's crust.

Analysis of the lineament base on two features in the map which is stream and contour. There are two type of lineament which are positive lineament and negative lineament. Positive lineament represented by ridge, while negative lineament represented by valley or stream. In the map the analysis classify into two type lineament and curve lineament analysis. The analysis from the map which see the linear of stream line and contour line. The lineament of the stream and contour as indicator of the structure in the field. The linear line of stream and contour in the map as prove of the area have some structure. The line of lineament in the map is a good prove of the structure and conform the straight contour and stream in the map. The in dot line lineament in the map is not enough prove because the features are only one that cannot make prove in the area have a structure.

In the figure 4.24 lineament map below show of the curve lineament and lineament in the map. The analysis of the lineament also see the way of the lineament that can interpret what structure maybe in the field and how it happen. The lineament observe from the direction because the direction show the same, that means the major force come into one direction only.

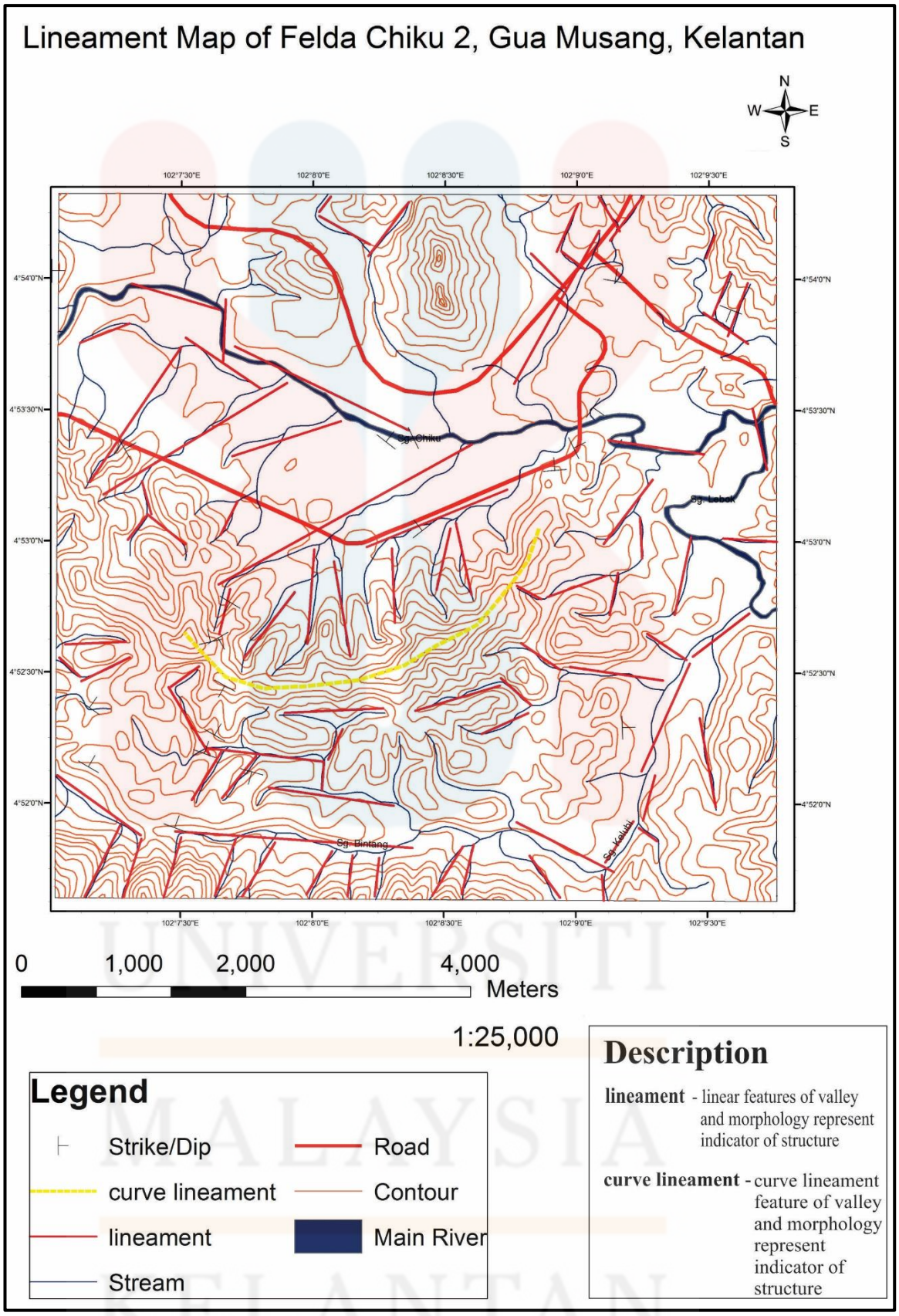


Figure 4.24 Lineament map of Felda Chiku 2

4.4.2 Vein

Vein is form when mineral and solution within the rock mass deposited through precipitation. Vein become from the hydrothermal and free with the cool temperature and form a vein. In a vein have many mineral deposit by the flow of the hydraulic from the earth mental. The mineral are commonly deposit in the vein are valuable of mineral like gold, silver, copper and iron.

Veins are very classically thought of as being the result of growth of crystal in the wall of fracture within the rock. The crystal growth normally occurring to the wall of cavity and the crystal prominent in the wall space.

Figure 4.25 show the vein structure within the weather rock. The vein structure in the figure is not clear because the vein are weather. In the vein structure have some of the crystal growth with the iron in the crystal. It is the alteration in the vein and some of the mineral deposited with the vein.

In figure 4.26 show many of the vein structure in the same direction in the limestone outcrop. In the limestone outcrop also have a minor fault that cut the vein in the limestone outcrop. The average measurement veins length are mostly 0.5m to 1m and the width are 0.1cm to 0.5cm.

Figure 4.25 Weather of vein in weather phylite

Figure 4.26 Vein structure in limestone outcrop with minor fault

4.4.3 Joint

Joint is a break of natural origin in the continuity of either rock body and the layer of the rock. The joint is a fracture that are lack any visible or measurable movement parallel to the surface. Joint can identified through the mapping by identification of the orientation, spacing and physical properties. The data of the mapping were taken in a few location in order to get more reading.

The accuracy of the data is depend on how much of the reading strike and dip of joint in the study area. The accuracy data also depend on what type of the joint data take. Joint have two type which is shear joint and extensional joint. Shear joint and extensional joint totally different of data taking, for the shear joint just need to take the direction of the joint but the extensional joint need to take the trend and plunge data.

Joint can help to find the force that exist in the study area. Analysing the pattern of joint in study area and plotted in the rose diagram in manually or in software. It is important to correlate the rose diagram of the negative lineament with joint rose diagram, it is because negative lineament is an indicator of rose diagram of joint. If there any different pattern of force occurred in both rose diagram, it is mean one of the result is fault.

The first location of the shear joint data is in the thick bedded limestone. Figure 4.25 show the geo rose of the shear joint data that measure in the field. From the geo rose it can see the principle stress between the joint set in one location. The joint data need to be classify because joint have two different type which is extensional joint and shear joint. In this location the type of joint is shear joint.

The shear joint data, it take the direction of the joint in one way only. The principle stress are show in the figure 4.27 with the arrow. The principle stress is the big stress that occur to the rock or outcrop.

Location two of the shear joint data take in the limestone outcrop. The data of the shear joint in location 2 show in figure 4.28. The principle stress show in the figure, where the principle stress between the joint set and it the big stress of the rock come.

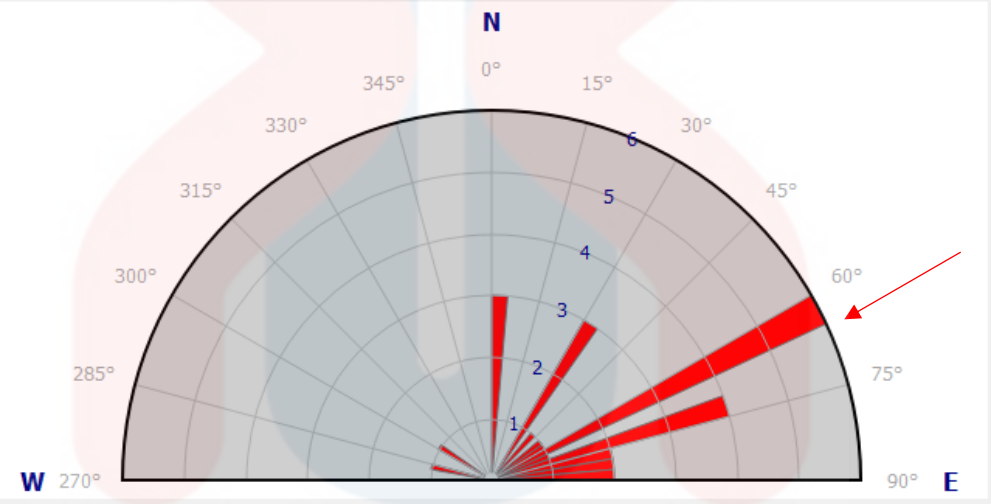


Figure 4.27 Georose of shear joint in first location

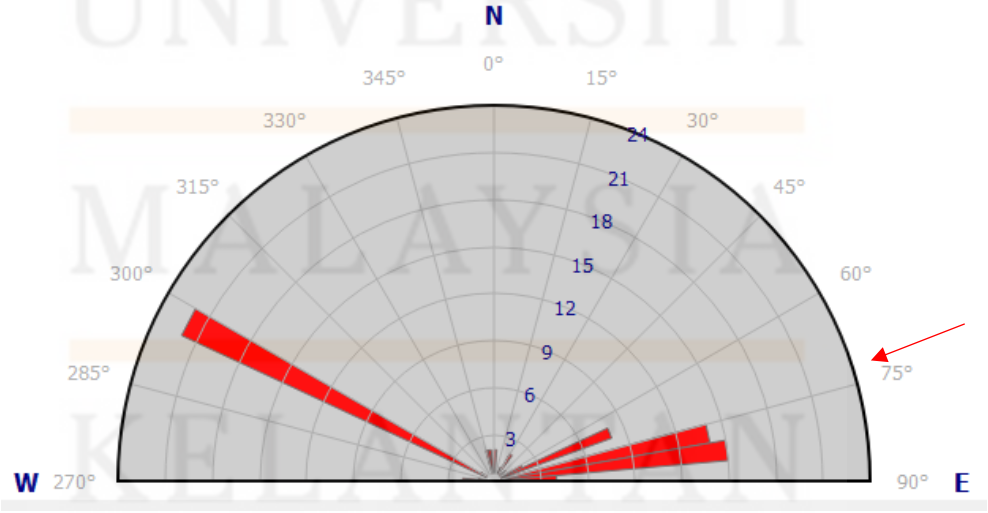


Figure 4.28 Georose of the shear joint in second location

4.4.4 Fault

Fault is a fracture along the displacement has occurred in rock and it happen due to the failure of the brittle and undeformed rock formation which involves fractional sliding on a pre-existing fault plane. There are three major categories of fault which are trust fault and reverse fault, normal fault and strike-slip. When maximum differential stress exceed the shear strength of an intact rock formation, or the frictional strength of a pre-existing fault then faulting occurred.

According the minor fault in the study area have two location that found in the field which are in the limestone outcrop and in the phylite outcrop. The fault in the limestone show in figure 4.29 and figure 4.30. In the outcrop have four place that can see the fault plane. The analysis of the fault base of the data of the strike and dipping angle of the fault plane. In the limestone outcrop the fault is strike-slip fault.

For the figure 4.31 show the fault in the different location and the measure of the strike is 10 and the deep angle of the fault plane is 40˚. The fault are found on the phylite outcrop and have two fault plane in one location but the measure of the fault plane are same with the first fault plane. The fault cutting the quartz vein within the phylite outcrop and it make a displacement of the quartz vein.

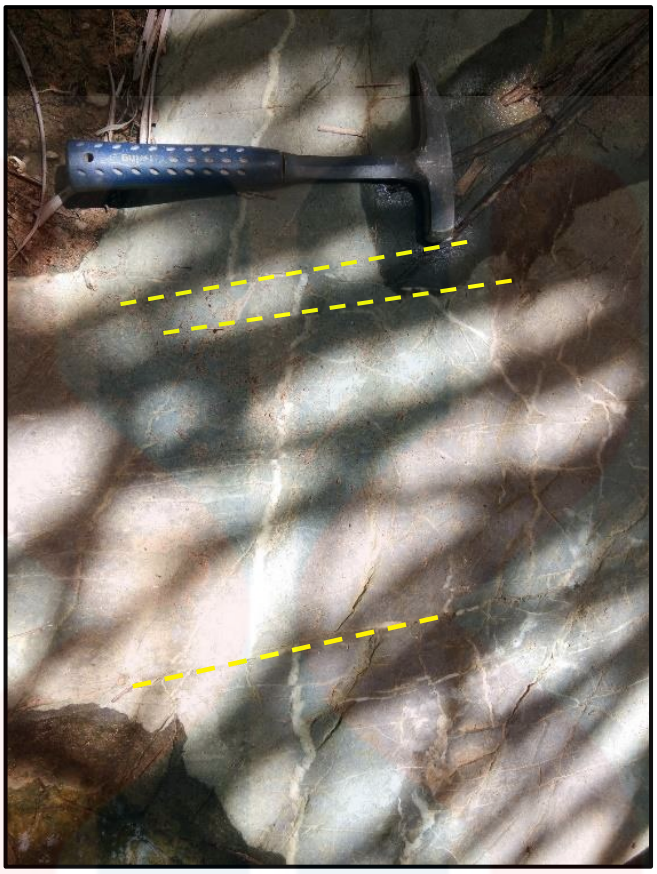


Figure 4.29 Three fault plane in limestone outcrop

Figure 4.30 Fault cut the vein in limestone outcrop

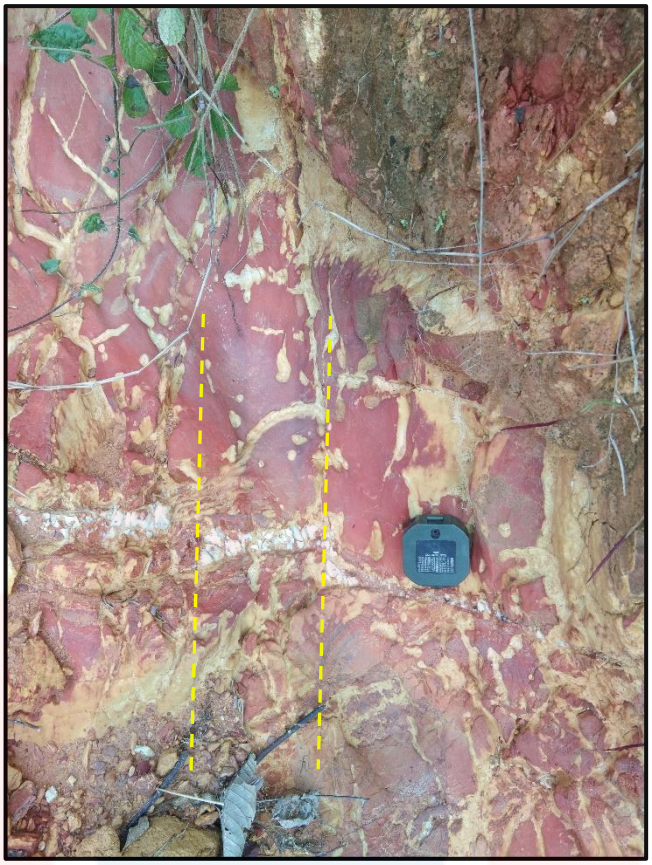


Figure 4.31 Fault cut the vein in the phylite outcrop.

4.4.5 Fold

There are some fold that found in the study area beside the road. The fold can see in the slope cutting beside the road. Fold is a one or stack of originally flat and planar surface and become bent or curved as a result of plastic and ductile deformation.

The analysing the fold from the strike and dip of the plunge of fold. From the plunge the data of strike and dip are change of the dipping and the strike. Figure 4.32 show the anticline of the fold in the slope cutting beside the road. The specific location of the folding is N04˚53’22”, E102˚09’0.6”.The strike and dip data take in three angle to the changes of the dipping, where the first angle take is 334˚/44˚ and the second angle are152˚/58˚ and the third angle are 35˚/71˚. From the data can see

and sketch the strike and dip of the fold and analysing that the fold are anticline fold. The red line in the figure 4.32 show the anticline fold.

The geometry of the fold can act as an important indicator of the nature deformation in the area. Anticline fold in the study area are interbedded of shale and phylite, where the anticline fold occur in this rock.

Figure 4.32 Anticline fold at the shale interbedded with phylite.

4.4.6 En echelon

In structural geology en echelon is a gash fracture that the structure within the rock caused by the non-coaxial shear. The en echelon structure appear as a set of short, parallel, planar and mineral filled lenses in the body of the rock. En echelon structure are normally filling with the quartz and calcite in the fracture within the rock. This structure as indicator to the faulting because this structure happen when originate as tension fracture that are parallel to the major stress orientation. The structure can be used to determine the incremental kinematic of the deformation history of rock.

This en echelon structure found in the limestone outcrop at the limestone quarry. En echelon structure growth of the fracture therefore causes the vein to take on a sigmoidal shape. Figure 4.33 show the en echelon structure in the limestone outcrop where the fracture are filling with the calcite.

Figure 4.33 En echelon structure in the limestone outcrop.

4.4.7 Shear Zone

Shear zone is a zone of strong deformation and the zone composed of rock that are more highly stained than rock adjacent to the zone. Shear zone are involve of rock deformed by shearing stress under brittle-ductile or ductile condition. In the zone of shear the rock are switch and tend the rock in new shape and make the zoning of the shearing. Shear zone is a zone can be a faulting but the ductile of the rock make some shearing and the fault cannot be happen in the rock. Shear zone can extend from centimetre to several kilometre in width and display deformation, folding and foliation in dynamics altered rock.

Figure 4.34 show the shear zone that found at the location N04˚52'17.6", E102˚09'12.6". The shear zone found in the well bedded limestone outcrop and the length of shear zone are 40cm.

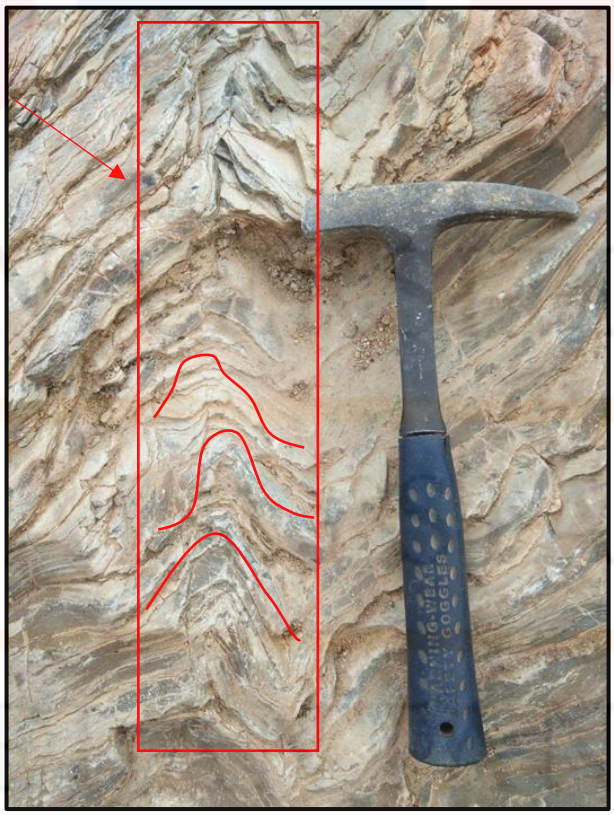


Figure 4.34 shear zone in the outcrop of well bedded limestone

4.5 Historical Geology

The historical geology in the study area was explain more detail in the depositional environment. The previous subtopic just explain the sequence of each unit in the study area. The depositional environment of the study area start from the oldest rock unit which mean from the Mesozoic age.

In the study area have two formation that include in the study area, which is Aring Formation and Rabong Formation. The Aring Formation it cover in the south east part in the study area. The Rabong Formation it cover south west part in the study area because in the study area in the south west have reserve forestry of Gunung Rabong.

The description of the phyite (metasediment) unit depositional environment are proven that phylite are in shallow marine. The phylite are from the siltstone, slate and become a metamorphic rock. Phylite found in the study area is upper than the limestone but the age of the phylite are (?pre Mesozoic), the oldest rock unit than the other rock unit in the study area. Phylite are uplift because of the structure in study area. The strike slip fault make the phylite are uplift that the other rock.

For depositional environment of the volcanic rock are start from the age (?Early Triassic), where the volcanic rock are lapilli tuff come after the phylite. The lapilli tuff happen when the volcanic activity and the course and fine crystal that produced from the volcano had undergone some transportation further from their source and eventually deposited and sedimentation in a very low energy environment. The volcanic rock are younger than the phylite because the phylite are come first than the volcanic rock.

Well bedded limestone under the limestone unit is the well bedded limestone age start from the middle Triassic. The well bedded limestone area is marine depositional environment because according Boggs (1995) thickly laminated and very thinly laminated as indicator of the deep marine depositional environment. The thickness of the bedding show the current of water and the grain size of sediment deposited. Depositional environment of the well bedded limestone is analysis all aspect which is texture, grain size, colour, structure and stratigraphy.

The thick bedded limestone in study area is the youngest rock unit than the other rock unit in study area. The age of the thick bedded limestone based on the past literature review are late Triassic. The thick bedded limestone in study area are massive limestone, where the thick bedded limestone does not have a structure and any fossil content.

Based on the Kamal Roslan Mohamed (2016), the carbonate deposition are was compress during volcanic eruption due to the murky water condition caused by the debris fallout and make unsuitable for carbonate deposition. After the debris volcanic deposit, the water become clear again and carbonate deposition resumed again.

CHAPTER 5

RESULT AND DISCUSSION

5.1 Introduction

Depositional environment is a place where the sediments are deposited when the energy of the sediment is no longer to carry it. It is the wide range of the depositional environment setting from the land to the deep marine. Every depositional environment of the rock unit has its own special characteristic by the combination of the sedimentary process. The interpretation of depositional environment is a part of the sedimentary process that look the facies of the rock based on the lithology, structure, texture, grain size, colour, geometry and paleocurrent.

In this chapter the depositional environment are describe in Felda Chiku 2 area. The interpretation of depositional environment limestone facies based on the four parameters which is grain size, lithology, structure and bedding thickness. Carbonate sediment originate on a land and in the sea.

5.2 Location of Litholog

The location of the lithologs take into two different place which is at limestone unit and phylite unit. The specific location of the well bedded limestone at N 04 52 17.6, E 102 09 12.6 beside the Sg. Kelubi. Figure 5.1 show the geological map of Felda Chiku 2 and show the cross section of the lithology, that means show the age of the lithology unit in the study area. The litholog measurement in the field are thickness of the bedding, strike/dip colour of the rock unit, grain size if can see with the naked eye and some of the structure that can see in the field. The analysis of the lithology column in the sub topic of facies analysis.

The specific location of the stratigraphy measurement show in red point in the map, where in the stratigraphy measurement are lacking of the fossil because of the strong weathering that show in the chapter 4. At the location also have some erosion because of the outcrop in point of the river. Therefore, the study of facies are just not only the fossil to know the depositional environment, it need to analysis in all aspect of the rock unit for example the stratigraphy, grain size, texture colour and the structure. In the next subtopic, lithology of the well bedded limestone are interpreted and analysis of the depositional environment based on the facies aspect in the study area.

The lithology of the well bedded are take in three facies and the phyllite lithology is one facies. All lithology are combine for data interpretation of the depositional environment. Well bedded limestone are take 5 meter interval between each other.

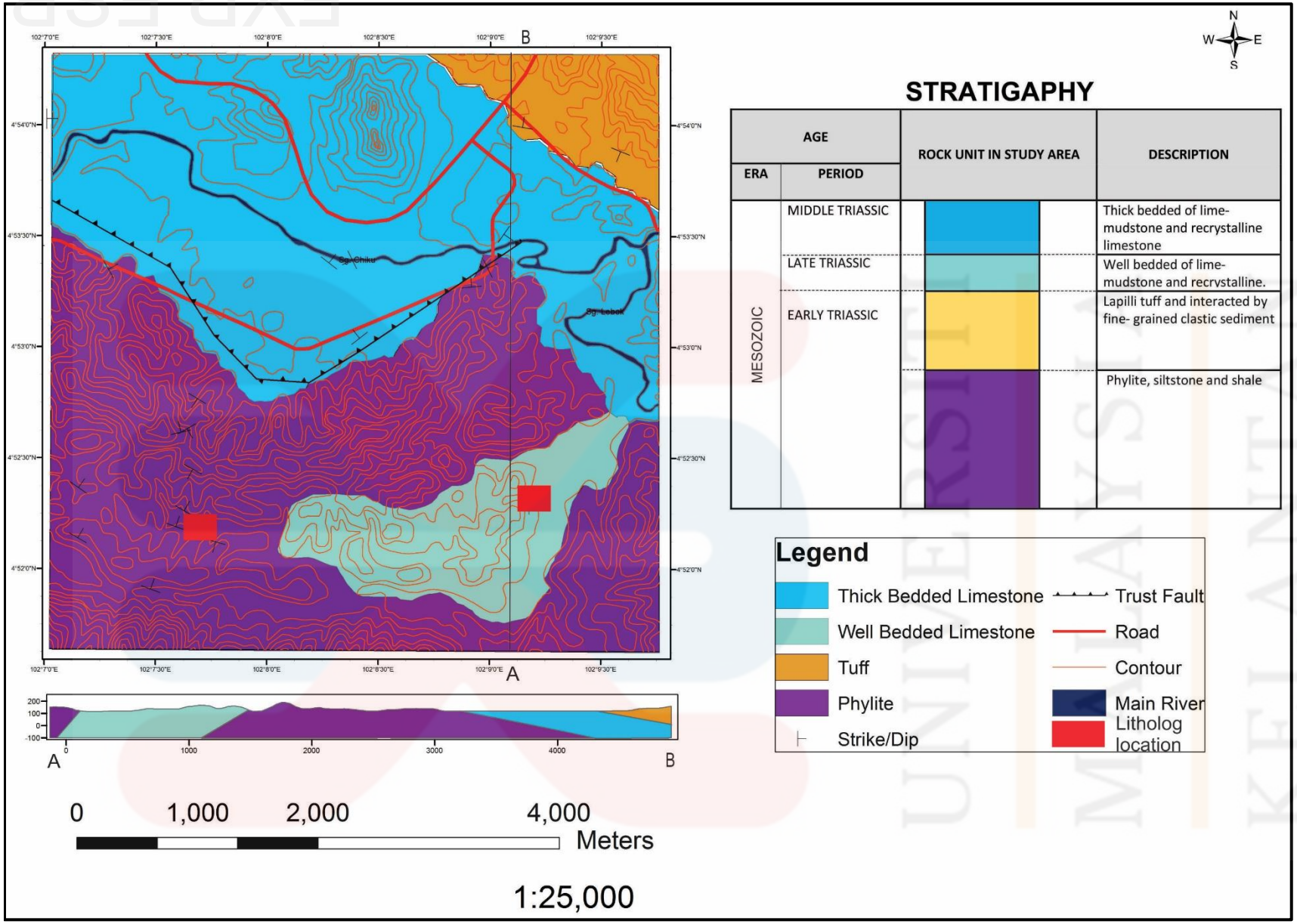


Figure 5.1 Geological map of Felda Chiku

5.3 Facies analysis

For the facies analysis it more specific to the limestone facies, so it focus to the limestone facies and lithology based on the Erik Flugel (1982) classification. Facies is the rock body which consist of a specific combination of lithology, physical and biological structure. These characteristic can be differentiate them from the rock bodies above, below and laterally adjacent (walker 1992). The indicator of depositional environment include bed thickness, lithology, structure and fossil content of a facies.

The facies analysis start with the lithology of the well bedded limestone which is the limestone analysis take the bottom, above and adjacent of the limestone bedding. In the limestone facies are lacking of the fossil content and the facies are interpret from the grain, which is coarsening upward or fining upward. Figure 5.2 show the lithology column of the well bedded limestone. From the lithology column of the limestone it analysis of all aspect in depositional environment.

The facies of the well bedded limestone take five meter interval each other because from the few meter the depositional environment are change. The facies are found in the study area are four facies which is three from the well bedded limestone and one from the phyllite unit. All the facies are combine together for interpretation of the depositional environment.

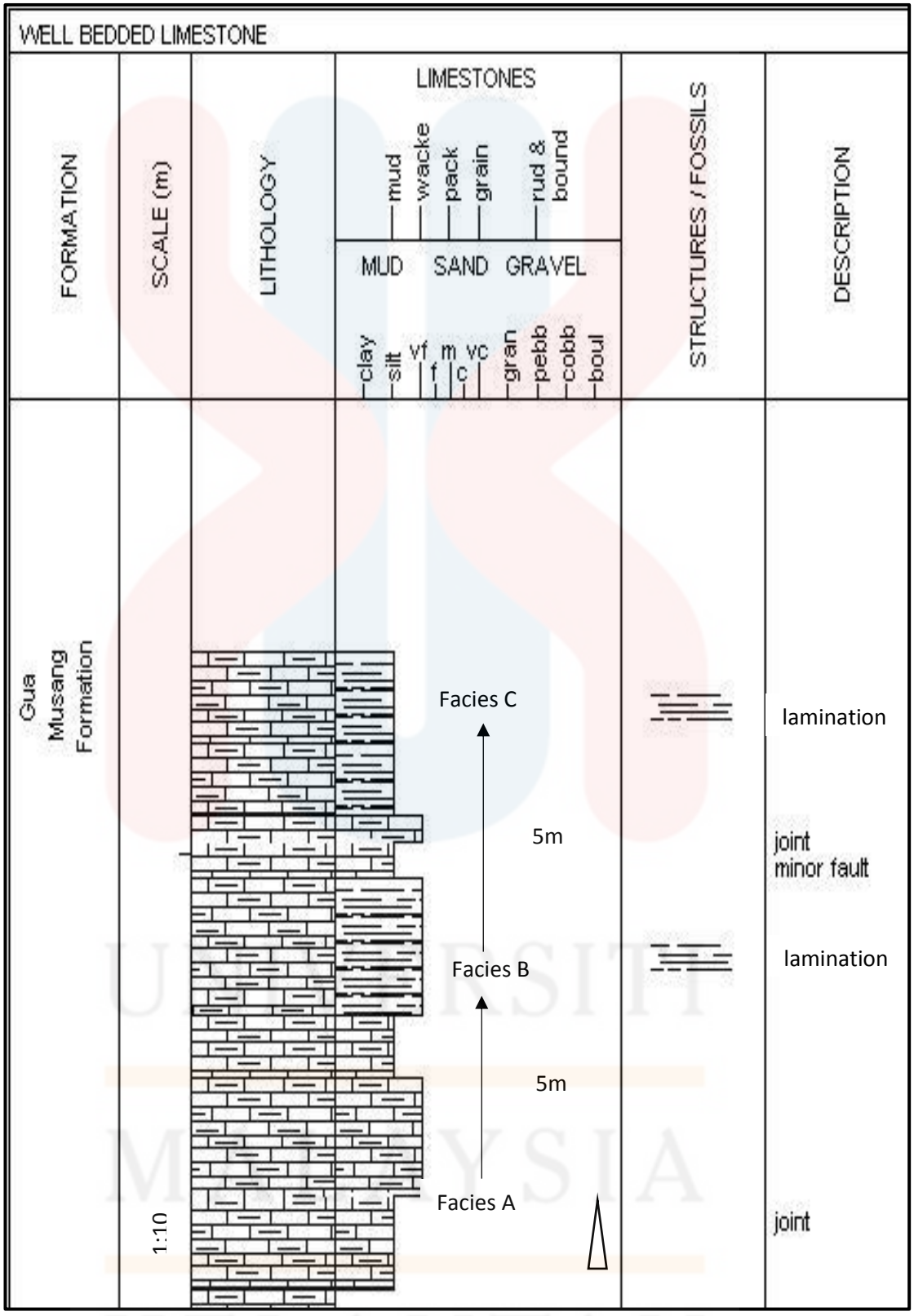


Figure 5.2 Lithology column of the well bedded limestone

5.3.1 Facies A

From the thin section of the facies A the particles of the limestone rock are more to the aggregate grain where the shape of the grain size irregular shape aggregate more strongly micritized particles bonded by cryptocrystalline matrix. The grain size of Facies A larger diameter about 0.5 to 1mm and the distribution based on the Erik Flugel (1982) restricted to the shallow water area with slow current flow and low wave energy. From the grain it show the indicator of the facies A are to the shallow water. The irregular of the grain shape is related to the transported of the sediment in slow current and low of energy.

The low current sediment transported are not so far and the shape are not rounded because of the energy of water is low. The analysis of the grain size and shape show the shallow water and slow current flow and low wave energy of the study area. In the facies A lacking of fossil content and the structure have a joint and shear zone. The structure show have some force that change the position of the lithology of well bedded limestone in the field. Figure 5.3 show the hand specimen with the scale.

Figure 5.4 show the thin section under microscopic and from the microscopic the grain it can see the grain shape and grain contact each other. The grain contact see in the microscope are the grain point contact each other. From the shape of the packing grain can interpret the grain are irregular shape.

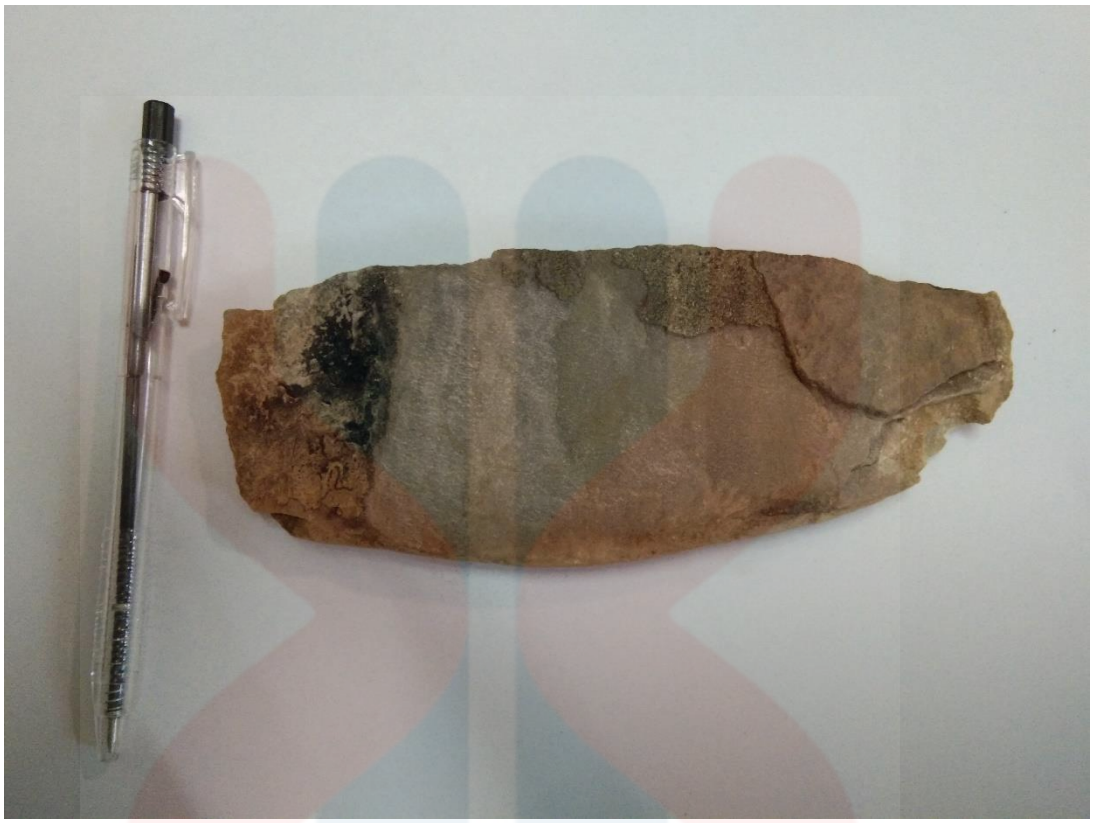
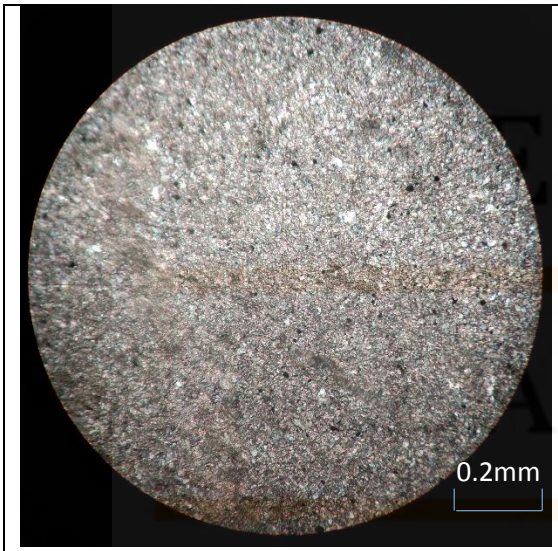
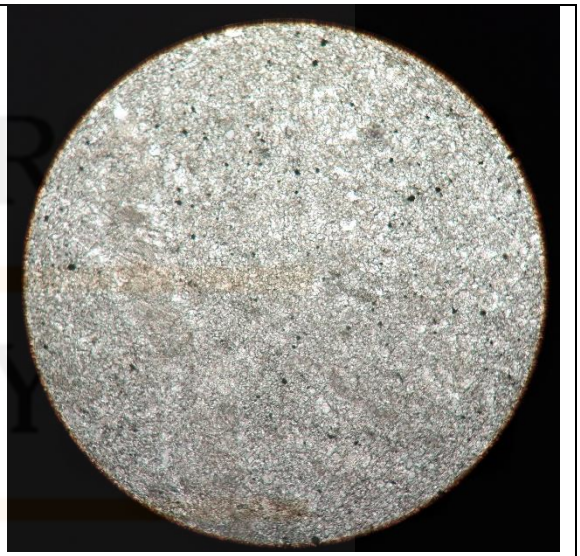


Figure 5.3 Hand specimen of the facies A



Cross polarize light
(XPL)



Plane polarize light
(PPL)

Figure 5.4 Show the sample under microscopic in cross polarize light (XPL) and plane polarize light (PPL).

5.3.2 Facies B

Facies B, thickness of the bedding is increasing upwards while remain the same laterally. According Boggs (1995) there have some range of the thickness of bedding, it is thinly laminated, medium bedded, and thickly bedded based on the scale of the bedding. The colour of the limestone are controlled by the depositional condition, diagenesis and recent weathering of the study area. The colour facies B controlled by the amount and composition of the organically derived carbon and content of clay and silt. The colour of the facies are more to the light grey. The analysis of the grain size and shape of the grain. In the lithology column in figure 5.2 show the grain size more upward more to the coarsening. Coarsening upward means the depositional environment of the sediment are shallow because of the transportation of the sediment. The transportation it include the roundness of the grain and shape. The roundness of the grain in the facies B is irregular shape aggregate more strongly micritized particles bonded by matrix. In the facies B have the lamination where the lamination known as sedimentary structure. The sedimentary structure know as horizontal planar lamination.

The horizontal planar lamination assume that the size or the kind of carbonate material deposited altered over a period of time. The alteration caused by variation in the kind and frequencies of sessile organism binding sediment and the fluctuating water energy. In the horizontal planar lamination carbonate sediment no bioturbation and no species diversities. According Erik Flugel (1982) the area have lamination are located in shallow seas, especially in the tidal and supratidal zones. The facies B also adjacent to the minor fault and also have some joint. This means the alteration of the lamination cause by the faulting at the facies B. Figure 5.5 show the lamination in the

well bedded limestone outcrop, where the horizontal planar lamination intercalated with the bedded limestone.

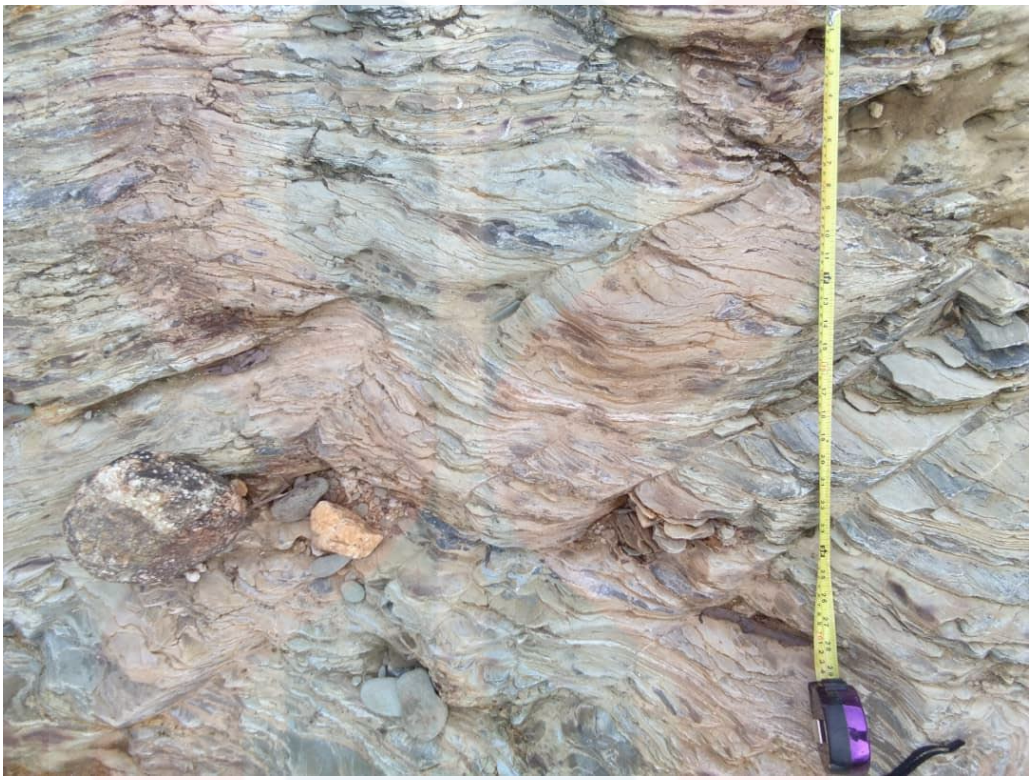


Figure 5.5 Horizontal planar lamination in the well bedded limestone.

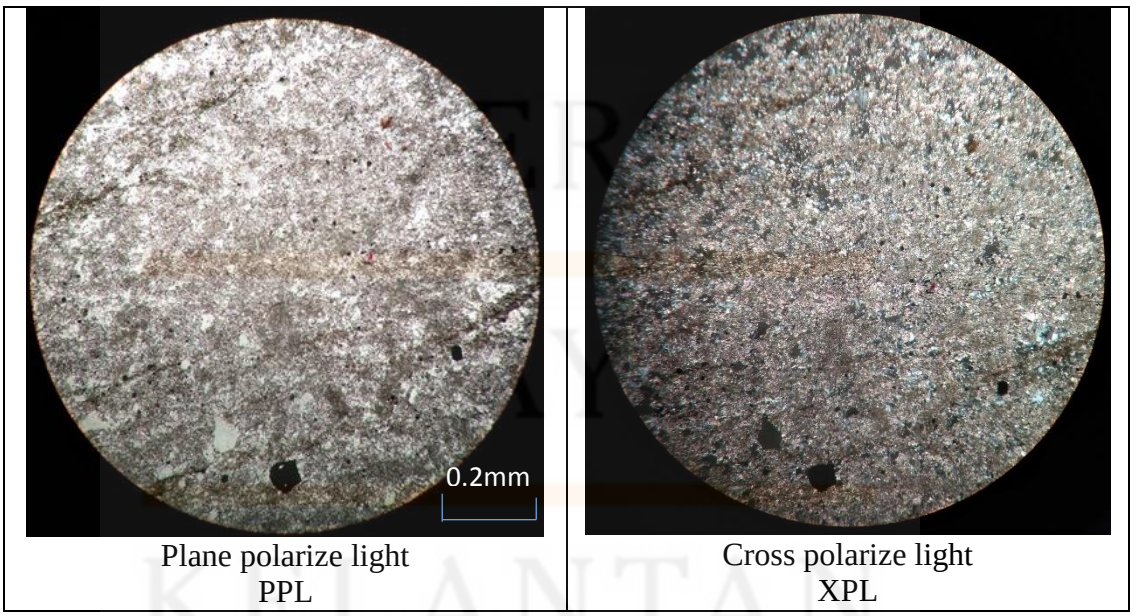


Figure 5.6 Thin section sample of facies B under microscopic in 10 x magnification.

From the plane polarize light in figure 5.6 can see the lamination of the facies B and the alteration of the lamination in the facies B. In the microscopic, the grain size of the sediment is fine grain and it call groundmass. From the analysis lithology structure and the grain, facies B is same as the facies B but it has alteration because of the faulting in the place.

5.3.3 Facies C

Facies C are composed of the well bedded limestone where it is same to the facies A and B. The thickness of bedding in facies B are coarsening upward, where the thickness of bedding become upper become thick bedding than the facies B and Facies A. From the lithology of the facies B, the grain size are measure from the facies A to Facies C.

In the lithology can analysis the grain particles are more upward more coarsening, it means the depositional environment of all facies are shallow marine environment. The structure in the facies C are horizontal planar lamination. The horizontal planar lamination in the facies C is not same as the Facies B cause the horizontal planar lamination in the facies C there no have alteration of the lamination. Figure 5.7 and figure 5.8 show the thin section of the facies C under microscopic which is to interpret and analysis of the of the grain size of the sample and show the hand specimen of the facies C.

The grain size of the sample facies C show the grain size 1mm to 1.5 mm with the irregular shape and the packing of the particles in the sample are point contact of each other grain.

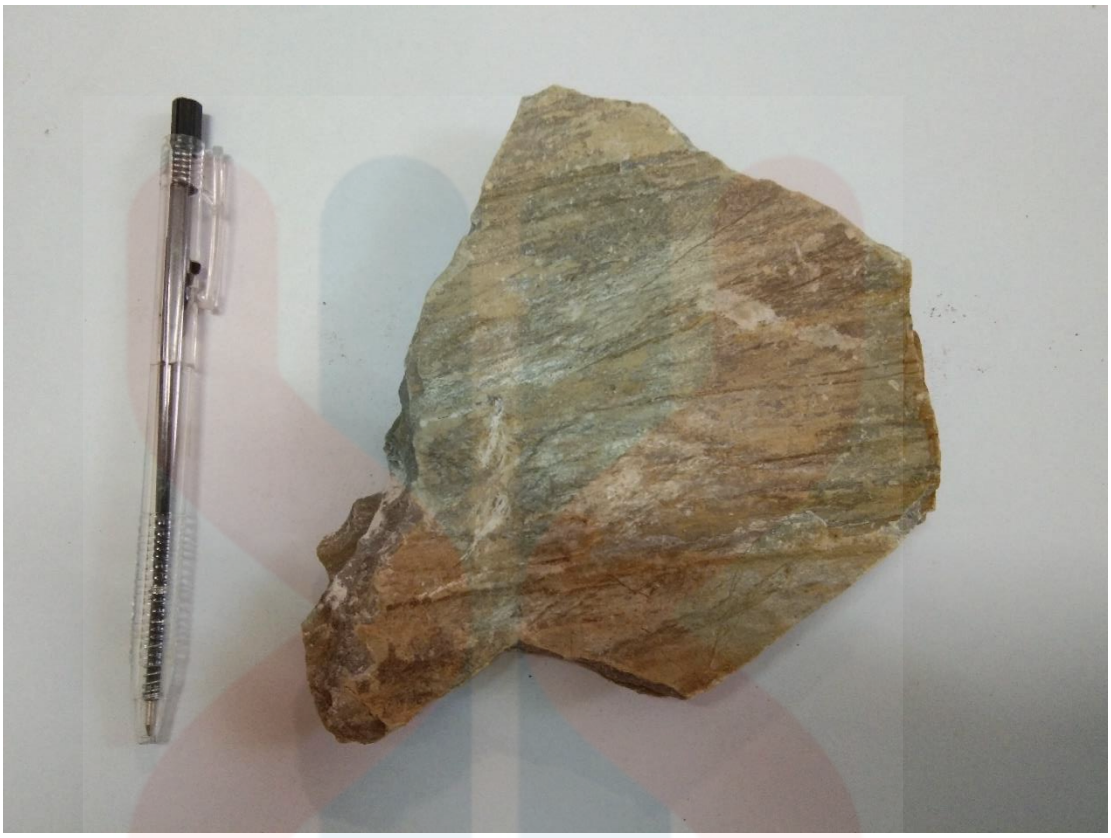
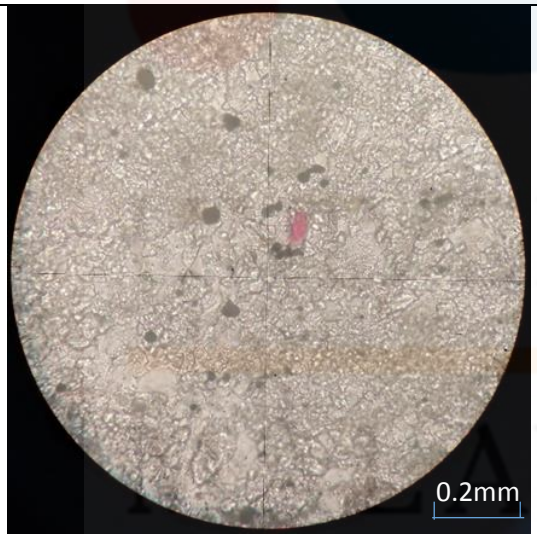
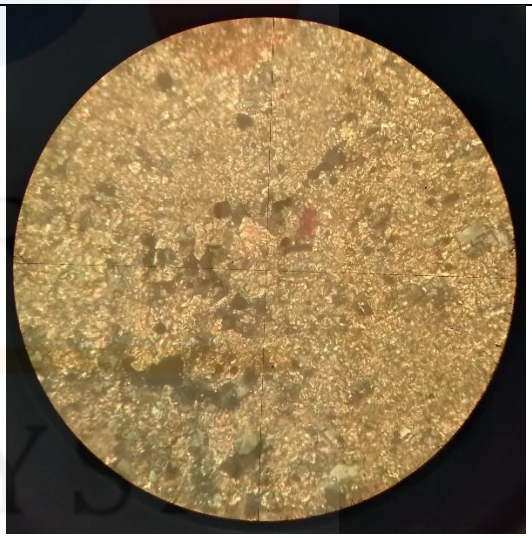


Figure 5.7 Hand specimen of the facies C



Plane polarize light
PPL



Cross polarize light
XPL

Figure 5.8 The thin section of the sample facies C under microscopic (PPL)

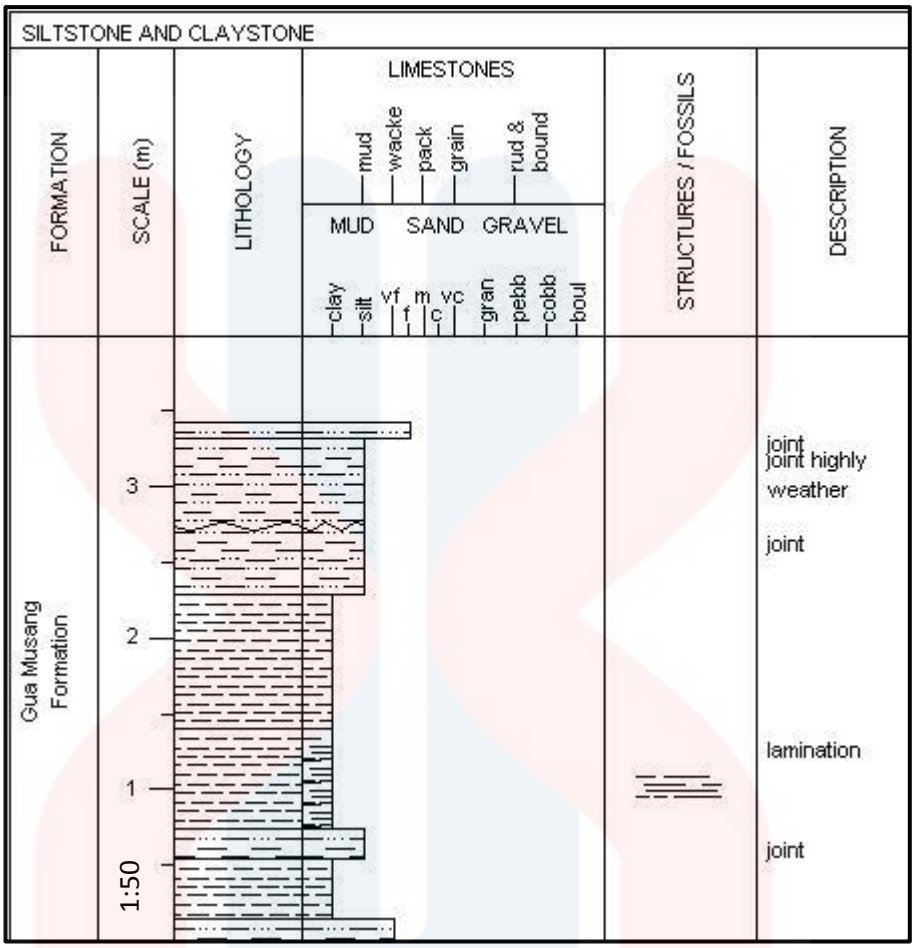


Figure 5.9 Lithology column of interbed silt and clay in facies D

5.3.4 Facies D

Facies D is from the phylite unit (metasediment). The lithology of the facies D measure in the second location. This facies is advance for the specification because the specification of the study is limestone facies. This facies it looked from the lithology, bedding thickness, grain size and structure.

From the bedding thickness of the facies D, it thickening upward of the bedding. The thickening of the bedding is show the deposition of sediment on landward. The structure in the facies D have is joint. Joint is the secondary structure that form in the facies D, which means after the movement of the strike- slip fault the shear joint form. The figure 5.10 show of the interbedded silt and clay.

The grain size of are predominantly of silt and clay, where the clay sedimenet very fine sediment that can make it to plasticity and the silt mixture of the clay and sand. In the upper of the sequence of the lithology the grain size from the silt and clay become to the fine grain. The grain show of the deposition of the sediment from the marine to landward depositional environment.

Figure 5.10 Location of facies D and interbed of silt and clay outcrop.

5.4 Summary

The depositional environment of the limestone unit in the Felda Chiku 2, Gua Musang is interpreted based on the four facies characteristic, which is lithology, bed thickness, sedimentary structure and grain size. There are three facies (facies A to facies C) identified in one lithology sequence of well bedded limestone and one facies (facies D) identified in lithology column in phylite unit. The four facies are consist of shallow marine. The all facies show the indicator of the shallow depositional environment. The shallow marine facies is considered as a part of the supratidal front to intertidal with the low energy and the low current of water. The figure 5.7 show the model that study area in supratidal depositional environment

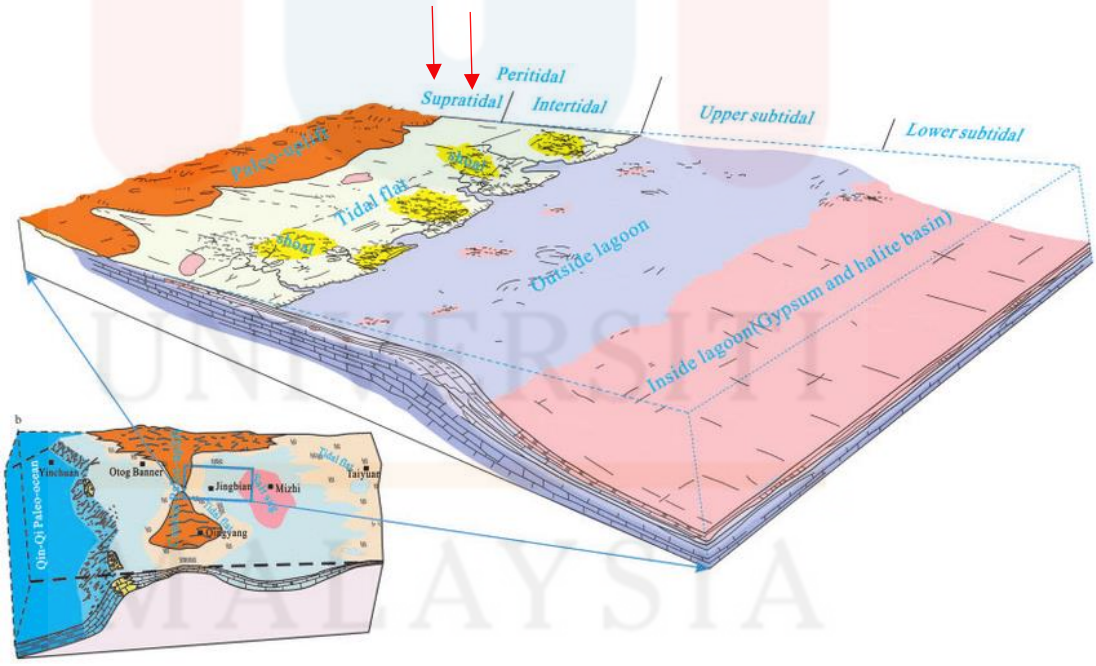


Figure 5.11 Model of depositional environment

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, the geological map of the Felda Chiku 2 area, Gua Musang with scale 1:25,000 scale is produced. It is consist of four lithological unit with the age ranged from the Mesozoic to the Late Triassic. The specification of the depositional environment in limestone facies in Felda Chiku 2 area is determined as a supratidal to tidal flat which in shallow marine environment. It has characteristic of the shallow marine in the three facies.

The study area in Felda Chiku 2, Gua Musang consist of four lithology unit which are phylite unit (metasediment), tuff unit, well bedded limestone and thick bedded limestone. There is part of Gua musang Formation which is the range of the age from the Mesozoic toe the Late Triassic. The oldest metasediment unit is made up of phylite,siltstone and shale.tthe heavy sedimentation increased the lithostatic pressure and temperature of basement which cause them metamorphose. The metamorphism degree is increase by the movement of the strike slip fault.

The metasediment unit overlain by the Early Triassic tuff unit and follow by the sedimentation of the Middle Triassic well bedded limestone. Because of the movement of the strike slip fault the well bedded limestone become alters and in the well bedded limestone have some alteration.

The metamorphism degree increased by the strike- slip fault movement, the action of the fault allows the formation of Late Triassic thick bedded limestone unit. The force produced by the strike slip fault released tension by forming the other secondary structure such as joint, shear joint, cleavage, vein, folding and en echelon on the Middle Triassic and Late Triassic.

The depositional environment of the limestone unit in the Felda Chiku 2, Gua Musang probably is a shallow marine. The shallow marine depositional environment in study area which is supratidal. There are three facies analysis based on the characteristic in therm of lithology, bed thickness, grain size and structure. The three facies A to C show the shallow marine evidence that it in the supratidal, which are the low energy and low current of the water.

6.2 Recommendation

Some part of the Rabong Mountain area, Gua musang is inaccessible due to heavy vegetation. It is recommended to mapping by using some modern technology such as digital mapping and drones or unmanned aerial vehicles (UAV). The digital mapping software has upgraded its function and able to geological assessment of facies and examine the geological features of the rock. Furthermore, in the Felda chiku 2 have more outcrop of the limestone unit in study area, it is recommended to do more investigation on the microfacies study on limestone because the depositional environment is wide range and need further the facies study and paleocurrent study for the create some model of the depositional environment in the area.

For the further study need to study the fossil content in the limestone for the specific age and to refine the establishment of the Gua Musang Group.

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APPENDIX A

Data of joint

Data joint location 1

Strike	frequency
180	3
210	3
252	2
75	2
80	1
100	1
66	1
81	1
64	1
40	1
51	1
63	1
88	2
71	2
60	4
58	1
120	1

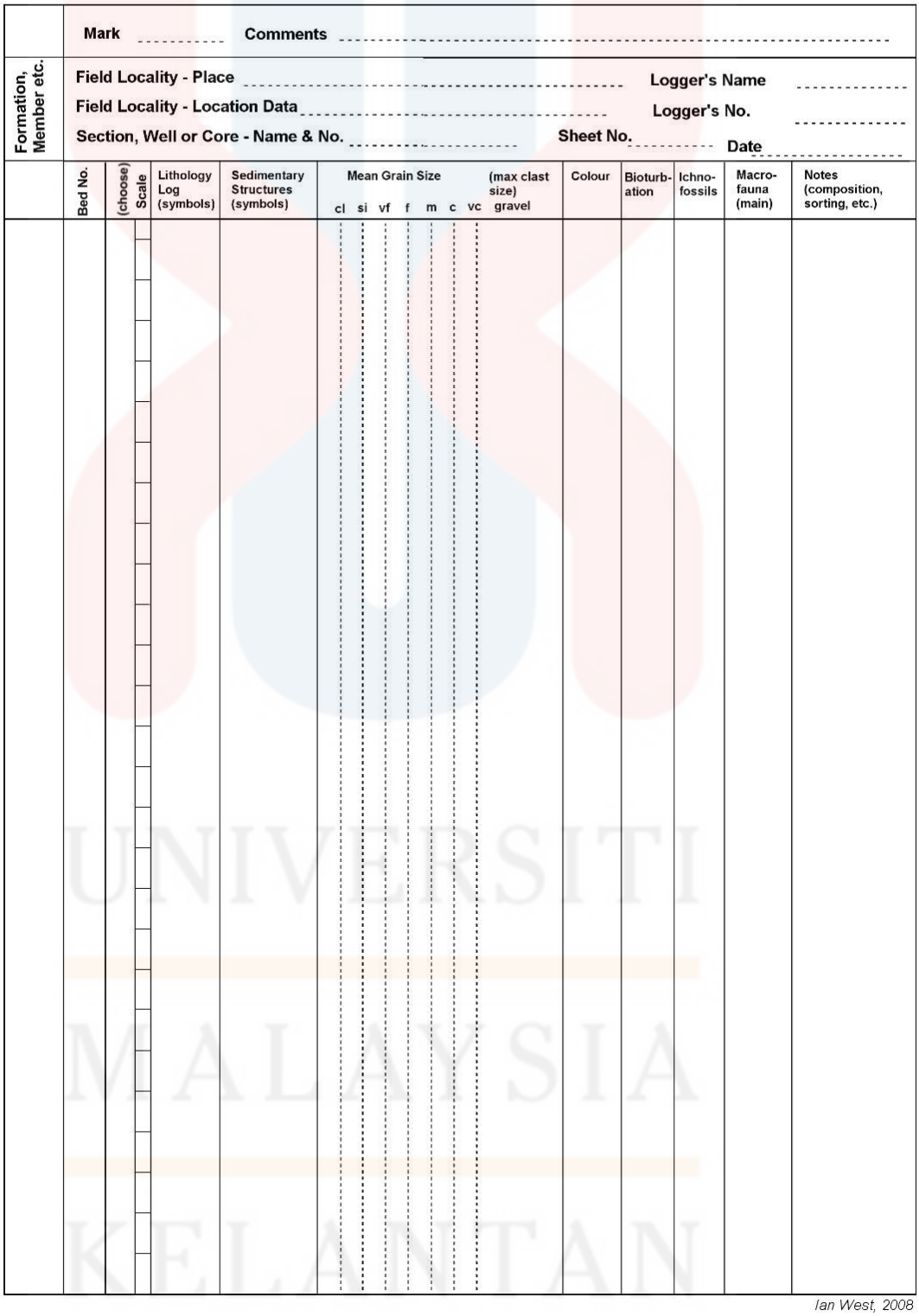
Data joint location 2

Strike	frequency
116	9
76	6
90	2
116	9
76	6
87	4
95	1
120	1
75	2
32	2
82	6
68	7
82	7
60	1
45	1
62	1
28	1
352	2
348	2
2	2
298	3
260	3

APPENDIX B

Example of lithology column

Field Excursion to Osmington Mills
Exercise: Prepare a detailed log of a section of about 3 m . through part of the Bencliff Grit or Osmington Oolite Members.
(Use for guidance: Stow, D. 2005. Sedimentary Rocks in the Field: a Colour Guide, or similar handbook)



Ian West, 2008

APPENDIX C

Alignment diagram