GEOLOGY AND LITHOSTRATIGRAPHY OF

SUNGAI ULU RAYA, KELANTAN

by

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

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APPROVAL

"I/ We hereby declare that I/ we 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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DECLARATION

I declare that this thesis entitled “Geology and Lithostratigrpahy of Sungai Ulu Raya, Lojing, 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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GEOLOGY AND LITHOSTRATIGRAPHY OF SUNGAI ULU RAYA, LOJING, KELANTAN

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Abstract: The study area is located at the Lojing, Gua Musang which part of the south-western corner of Kelantan state and it is lies between latitude 4˚47'27" N - 4˚49'57" N and longitude 101˚46'1.5" E - 101˚48'31.8" E. This research paper is concern with the objectives to produce the geological map in the scale of 1: 25,000 and to identify the lithostratigraphy of Sungai Ulu Raya, Lojing which lies under Gua Musang Formation. Besides, the study of the lithostratigraphy can determine the depositional environment by the facies analysis. The lithology that found in the study area is the limestone, tuff with subordinate mudstone and shale, and andesite rock. The methodology of this research was done through the satellite imagery interpretation, fieldworks activities and laboratory work. The geological map was produce by using ArcGIS software and the petrographic method was conducted to determine the mineral composition of rocks. The lithostratigraphy method was carried out along the outcrop at study area to establish the parameters used to the determine the lithostratigraphy, facies associated and sedimentary structural. The interpretation is supported by the presence of sedimentary structural and the facies analysis of the lithology unit in the research area.

Keywords: Lojing; Lithostratigraphy; Gua Musang Formation; Sedimentary Structural; Facies Analysis

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Abstrak: Kawasan kajian terletak di Lojing, Gua Musang yang merupakan bahagian barat daya negeri Kelantan dan terletak di antara latitud 4˚47'27 "N - 4˚49'57" N dan longitud 101˚46'1.5 "E - 101˚48'31.8" E. Objektif penyelidikan ini dilakukan untuk menghasilkan peta geologi dalam skala 1: 25,000 dan mengenal pasti lithostratigrafi di Sungai Ulu Raya, Lojing yang terletak di bawah Formasi Gua Musang. Selain itu, kajian lithostratigrafi dapat menentukan lingkungan pengendapan Formasi Gua Musang dengan mengkaji analisis fasies. Litologi yang dijumpai di kawasan kajian ialah batu kapur, tuf dengan lapisan batu lumpur dan syal, dan batuan andesit. Metodologi kajian ini dilakukan melalui penafsiran imej satelit, aktiviti kerja di lapangan dan kerja makmal. Peta geologi dihasilkan dengan menggunakan perisian ArcGIS dan kaedah petrografi dijalankan untuk menentukan komposisi mineral di dalam batuan. Kaedah lithostratigrafi dijalankan sepanjang singkapan di kawasan kajian untuk menentukan parameter yang digunakan bagi menentukan lithostratigrafi, analisis fasies dan struktur sedimen. Interpretasi ini dapat dikukuhkan dengan kehadiran struktur sedimen dan analisis fasies di setiap unit litologi di kawasan penyelidikan.

Keywords: Lojing; Lithostratigrafi; Formasi Gua Musang; Struktur Sedimen; Analisis Fasies

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cm	Centimeter
%	Percentage
ppl	Plane-polarised
xpl	Cross-polarised
°	Degree Celcius

CHAPTER 1

INTRODUCTION

1.1. General Background

Geology is the scientific study of the earth including the study of earth materials, structural and process occur on the earth surface. According to the Lyell, C. (1835), geology also occurred in the natural and inorganic materials and it is otherwise called the scientific investigation on the progressive changes.

Stratigraphy comes from combination of Latin *stratum* and the Greek *graphia.* It is the study of rock successions and the correlation of geological event and processes in time and space (Koutsoukos, 2005) whereas lithostratigraphy is the explanation of lithology unit and discipline of the rocks in the earth surface based on their rock types and their stratigraphic column relations. This is the main element of stratigraphy that deals with (Rocha et al., 2013).

The objective of this research research is focused on determining the general geology and lithostratigraphy of Lojing, Gua Musang. The lithostratigraphy is a sub-discipline of stratigraphy which is the topographical science related with the investigation of strata or rock layers (Protero, D. R., & Schwab, F., 2014). It is

imperative to know the history at the study area and lithological units for advancement and development purposes. A development such as for industrial area, cut slope for railways and any other construction purposes must be in good planning and to avoid any geological hazards such as landslide and flood. Hence, the development of land use must follow the lithological unit.

There are several tools available for monitoring the lithostratigraphy and geomorphology including Global Positioning System (GPS) and remote sensing techniques such as satellite image.

In this research, geological field mapping and satellite imagery was used in order to produce the detail of geological map for lithostratigraphy at the study area. The purposes of the geological map are to determine the rock distribution on the earth surface, the lithological unit and geological structural such as fault and fold. The other method used is to analysis the type of rock is by doing the laboratory investigation. According to the Buehler (2004), he said that cross sections are used valuable for the minerals and ores characterization, rock identification and determining of their properties such as cleavage, twinning, reflectance and others.

There are two sorts of specimen that need to be arranged for petrographic analysis, which are polished bulk specimens and thin sections. Polished bulk specimens are resembling to metallographic specimens in the surface where it is set up for analyzation with a reflected light micro-scope. Next, the thin sections are the process of determining the mineral composition by observation with a transmitted polarized light micro-scope.

The general plans of arrangements for making transparent thin specimen of rock is as the following: sectioning, grinding, cementing to a slide and polishing. The preparation of thin sections is a bit stunningly more troublesome than by getting arrangements for polished bulk specimens. For the most part, a thin segment must be set up to a thickness of generally 30μm, with near perfect parallelism under the microscopic view.

The last method to produced geological map of Lojing is by using software of ArcGis 10.3. This software is required to produce many types of map such as topography map, thematic map and others.

This chapter will be examined about general geography of the research area, problem statements of the study, objectives of the research, research significant, scope of study and expected outcomes resulting from the conducting research.

1.2. Study Area

Gua Musang is a remote zone that situated at Kelantan Southern Region and it is a biggest area in Kelantan. Gua Musang development is for the most part separate in Negeri Kelantan. Gua Musang Formation has the main fold which is lies in the middle part towards north-south up to north-northwest (Geological Society of Malaysia, 2010). Figure 1.1 shows the study area of Gua Musang. Gua Musang is likewise honored with characteristic attractions that can catch the attention of nature lovers, for example, caverns and limestone. There are many structural geologies that can be observe by researcher and students especially from geology field.

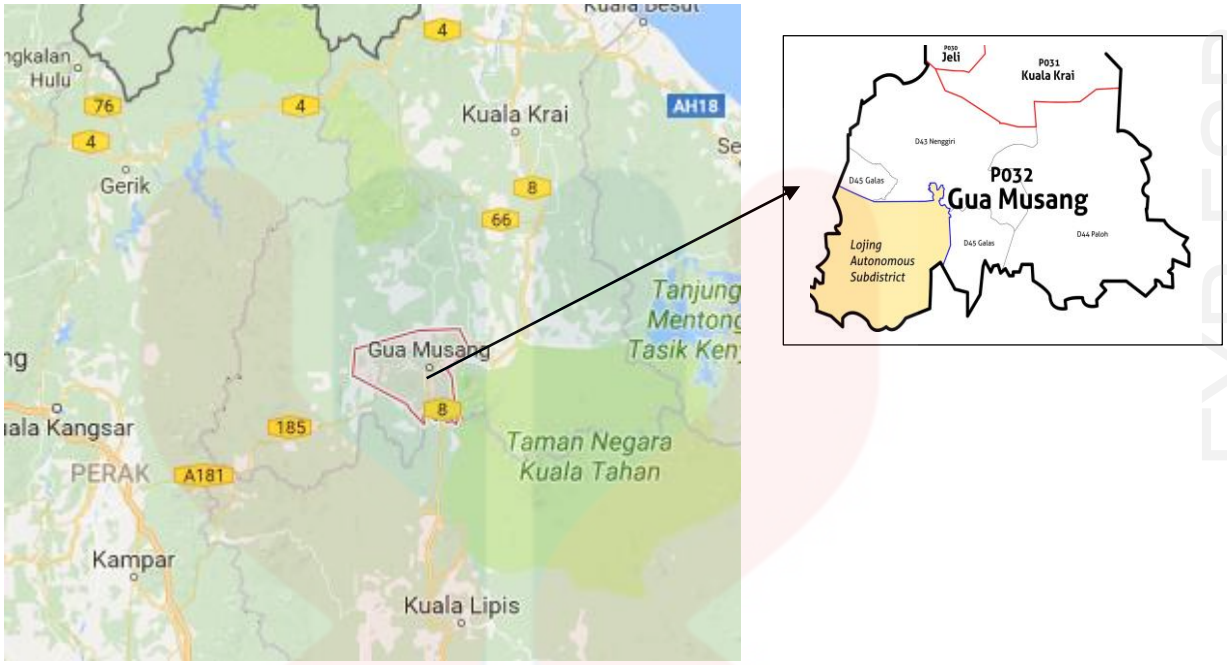


Figure 1.1 Map of Gua Musang (source: Google image)

According to Department of Survey and Mapping Malaysia, Kelantan (2016), Gua Musang area is 817,595 hectares which 48.54% more than the other districts in Kelantan. Kuala Krai shows the second largest which the area 227, 670 hectares in 13.52 %. It shows that Gua Musang is the largest district in Kelantan and many constructions can be done to develop Gua Musang. For the population, Kelantan shows the increasing rate of growth in 2016. The total population by gender, male shows the higher rate population which is 915.3 while the total female is 895.1. Kelantan has various races such as Malay, Chinese, India and other Bumiputera. Malay communities is the major races in Kelantan. (Department of Statistics, 2016).

From the observation and research, the age of the area of Gua Musang can be determine. The age of formation of Gua Musang between early Permian to late Triassic. (Hutchinson & Tan, 2009). Hence, this area should be developed as a Geopark due to its many natural attractions such as the Rafflesia flower and limestone cave that older than 300 million years.

As a geologist, Gua Musang is one of the appropriate areas to do the research in geological mapping based on age, formation of cave and geological structural. Hence, the origin history of Gua Musang can be obtains by doing this research.

1.2.1. Location

Lojing is the new district in Gua Musang and it is situated at the south-western corner area of the of Kelantan state with a region size of 1817 sq. km (Dony Adriansyah et. al., 2014). This closed to the boundary of Kelantan-Pahang. The coordinate for study area have longitude is 101˚46'1.5" E - 101˚48'31.8" E and latitude is 4˚47'27" N - 4˚49'57" N which covers of 25km2. The study areas are covered by palm plantation and rubber tree plantation that can be access by route of Gua Musang- Cameron Highlands. Figure 1.2 show the base map of study area which located at Sungai Ulu Raya, Lojing.

Lojing Highlands is strategically located in the southern part of Kelantan and bordered by Cameron Highland in the north at an attitude of 1400 meters above sea level with an area of approximately 23.435 hectares. (Nur Azuki Yusuff, 2008). Lojing Highlands is moderately cold with the temperatures between 18°C to 27°C. (Jabatan Meterologi Malaysia, 2010)

The Lojing area has being potential for development not only limited to forest and wildlife conservation but also an opposite location for education, recreation, and tourism. Furthermore, the moderately cold weather it offers is suitable for agricultural activities, businesses and tourism which best resembles its counterpart, Cameron Highland with regard to its potential prospect in the future. Besides, it is regarded a center for scientific research and data collection in ecology and forest diversity. Hence,

in light of that importance, opportunities that can lead to economic, social and political welfare services should be formulated and explored at its best. Prior to this, there has been no research on Lojing except for several studies on commercialized woods and wildlife.

1.2.2. Road Connectivity

Lojing was located along a highway of Gua Musang- Cameron Highlands. This is the main road that mostly being taken by worker's plantation and residences. From the main road to study area, it takes about 15 minutes to reach by using motorcar. The road is easily access to study area because it is the plantation area that being used by workers. There are aboriginal people villages at the study area and they also used the main road as accessibility. The majority people who live in Lojing Highland comprise the indigenous people of Sinai from Temiar tribe. It takes about two hours to reach the study of Lojing, Gua Musang from Universiti Malaysia Kelantan Kampus Jeli.

1.2.3. Demography

Demography is the examination of human peoples including their size, plan and appointment across over space, the method through which populations change. Births, death and movement are the central matters of demography, together creating populace dependability or change.

Demography is exceptionally valuable for understanding social and financial issue and distinguishing potential solutions. As a geologist, we should know the demographic before do the research and to do any development activities at certain area. There is no specific research that focused on human population and demography of Lojing. Hence, this subtopic will focus on Gua Musang.

For the general population appropriation, there are a few races at Gua Musang which are Malay, Chinese, Indian, Orang Asli and others races. For aggregate populace in 2014, the general population dissemination of Gua Musang is 114,500 individuals. (Jabatan Perangkaan Penduduk Negeri Kelantan, 2014).

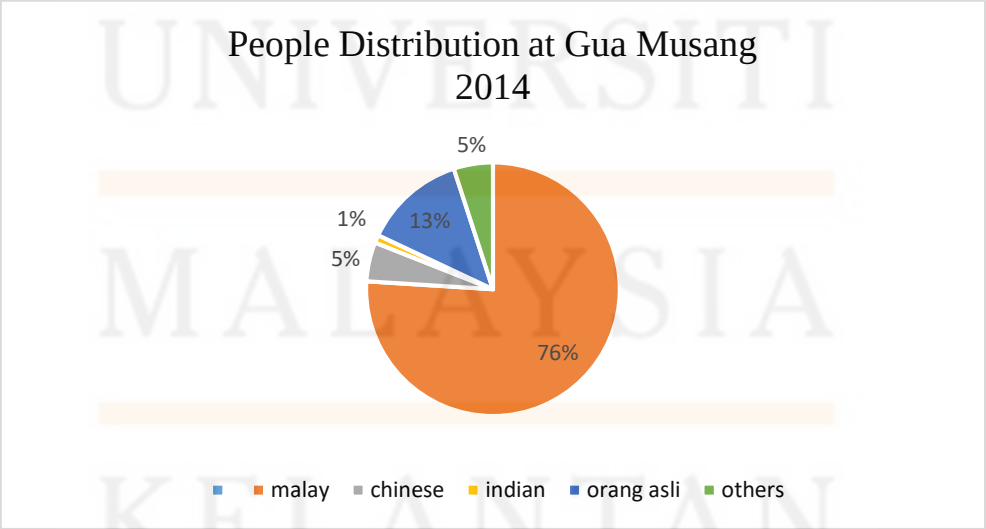


Figure 1.3 People distribution in Gua Musang, Kelantan (Majlis Daerah Gua Musang, 2014)

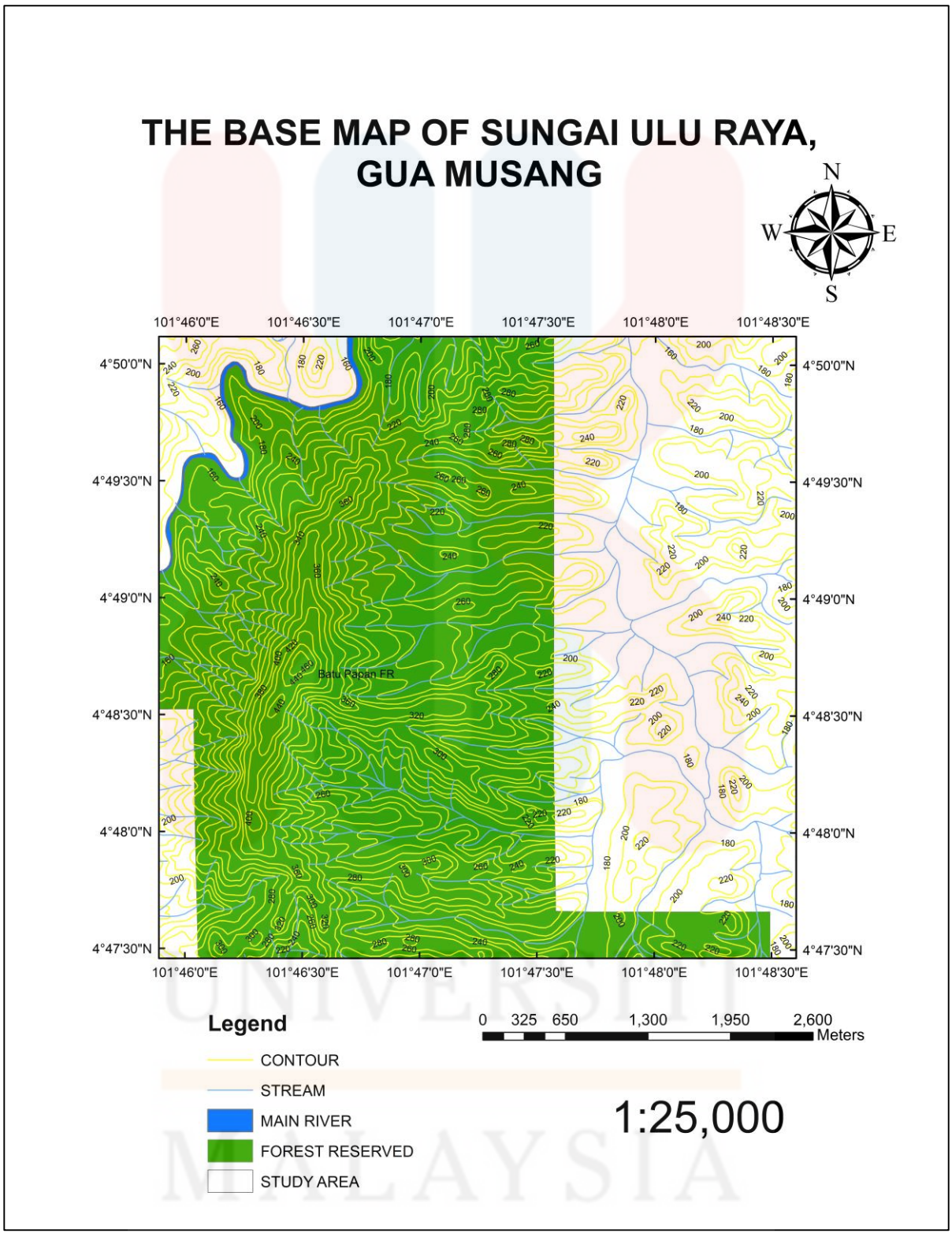


Figure 1.2 Study area of Sungai Ulu Raya, Lojing

1.2.4. Land use

For the land use of Lojing mostly covered by forest and plantation which are oil palm and rubber tree plantation. Some part of this study area has the logging activities. The forest at Lojing area is the land of the royal property that has been proclaimed. So, the area cannot be invaded by the public. Any activity involving the area shall obtain permission from the government. The Lojing is located at the highway which has been built from the cut slope. From the survey and observation, many landslides occur along the road. It is show that the sand was loose due to the rainfall distribution and construction systems. The topography of the study area is mostly covered with low lying plain which is flat with a few low hill surfaces which are not too high.

Figure 1.4 Plantation area of Lojing

Figure 1.5 The logging area

1.2.5. Social economic

The primary occupation and pay originating is from palm oil and rubber plantation. The salary inferred by each month covers the cost of living expenses and tutoring for the worker's children and their family. There are also have foreigner workers such as from Bangladesh and Pakistan. In addition, mining and logging activities also contribute in their economic.

From the observation, Lojing has no either shop or restaurant. The residences need to go at Gua Musang town to buy any groceries that take about 20 minutes. The Orang Asli at this area go to the fishing and hunting as their continuous of life. So, means that the aquaculture also be the main sources of economic at Lojing area.

As a conclusion, the main social economic at Lojing is from agriculture and aquaculture. Some of the residence has doing the small business such as selling the fruits from forest like stinky beans and cassava.

1.3. Problem Statement

Lojing has rapidly developed in terms of land use, infrastructure and accessibility. Therefore, local authorities need to provide the right development plan for the control of land use and development surrounding areas. The lithostratigraphy of that zone is one of the important needed in the planning of develop area. In addition, the previous research has been conducted long time ago at the study area but there is only a few research that focused on specification of lithostratigraphy.

1.4. Objectives

The main purpose of this study is to identify the general geology and lithoststratigraphy of Lojing, Gua Musang. These research is focused objectives of the study as follow:

1. To produce geological map of Sungai Ulu Raya in scale 1: 25,000.
2. To identify the lithostratigraphy of Lojing.

1.5. Scope of Study

The scope of this study is focus on distribution of rock. Hence, the lithostratigraphy unit of Lojing can be design. The other important aspects are to know the depositional environment of the area such as shallow marine. Some research need to be conducted to gain the information about the places by reading some research in geological technical reports in geomorphology, structural geology and petrology of the study area.

For the identification of lithology, the field mapping and laboratory work need to be conduct. Hence, the geological map can produce by using ArcGIS application software. A geographic information system (GIS) is a system create by the ESRI Company to manage, capture, manipulate, store, and analyze the data and present all types of geographic information (Chang, Kang-Tsung, 2012).

1.6. Significance of Study

Geoscience is study of Earth (Studying Geology, 2015). It is including on how living things incorporating people interface with earth. Geologist consider materials, forms, items, physical nature, and history of the Earth. Basic mapping is a part of geographical investigations that ought to be learned by all geologists.

The research study is train students go to the fieldwork and do the geological mapping. This mapping activities can train them to be more successful and qualified geologist in term of experience. They need to face many obstacles such as working at the hot open air environment, remote area which are difficult to access and spend their time by the outdoor activities. So, the significant of this study is to develop students become more discipline and competitive before venture in the real life career.

Next, this investigation could give data on topographical auxiliary and lithology to local authorities for any improvement territory, for example, Pejabat Tanah dan Daerah, Jabatan Kerja Raya and Jabatan Perancangan Bandar dan Wilayah. Further, this research investigation would be useful to the Jabatan Mineral dan Geosains (JMG) as this study can assist them with updating the topographical guide and give data about the investigation territory.

Furthermore, this study will provide the necessary information on the geological description such as area of land use, population and others. It would be beneficial to open public such as the researcher to get the information. There are many beneficial and advantages from this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed about the overview of Kelantan and the research area of Sungai Ulu Raya, Lojing. The general geology which is regional geology and tectonic setting was included.

2.2 Regional Geology and Tectonic Setting.

Peninsular Malaysia is a piece part of the Eurasia Plate, the South-East Asian Part which is known as Sundaland (Hutchison, 2014). The Bentong- Raub line (Bentong Suture line) was proposed as the major tectonic boundary between the western and central belt of Peninsular Malaysia (Tjia & Almashoor, 1996).

Bentong-Raub Suture is formed as an impact of collision zone between the two continental plate which are Sibumasu and IndoChina. It is recommended that the Bentong-Raub Suture zone addresses an area of the standard Devonian to Triassic Middle Palaeo-Tethys Ocean, and structures the limit between those two regions. Sibumasu was a bit of Cimmerian Plate which was added to Gondwana amid

Carboniferous while the East Malaya part was attached to IndoChina plate. Between those two plates there is a sea which isolated them called Paleo-Tethys Ocean. The major part of the history of the Paleo-Tethys Ocean was destroyed and drifted rapidly northwards during the Permia-Triassic (Metcalfe, 2000).

The Bentong Raub suture is a long suture zone that extending from Thailand to Peninsular Malaysia and it is also represent the geological structural which is shows the normal faults. It has been widely accepted in almost all paleo-tectonic reconstructions of Southeast Asia about the Bentong Raub Line (Hutchison, 2009). The Bentong-Raub Suture zone is all around uncovered and exposed well at road cuts along the Gua Musang-Cameron Highlands highway. According to Metcalfe, 2000 that he estimated the suture zone approximately 20km wide.

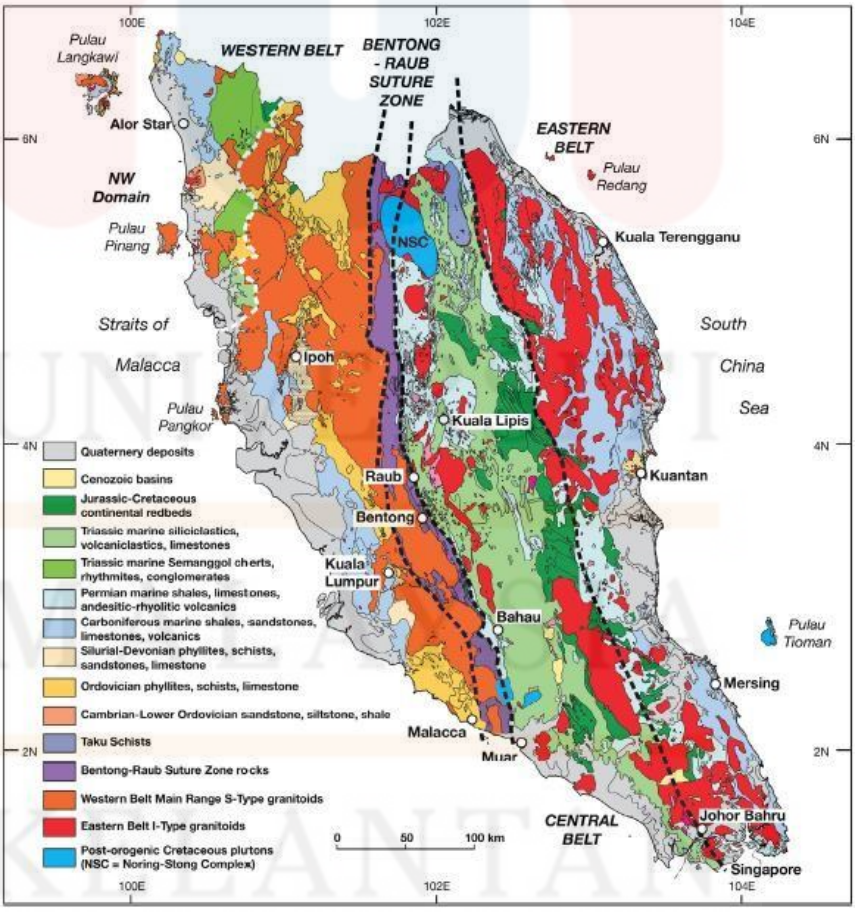


Figure 2.1: Geological Map of Peninsular Malaysia (Metcalfe, 2013)

2.3 Stratigraphy

The Gua Musang formation in South Kelantan – North Pahang was mapped by Yin (1965) to describe Middle Permian to Late Triassic argillite, carbonate, and pyroclastic/volcanic facies within Gua Musang area.

Che Abdul Rahman and Kamal Roslan (2001) were explained in their research paper that the state of Kelantan comprises of different rocks, including the three types of rocks which are igneous, sedimentary and metamorphic rocks. The rocks in Kelantan are distributed in a north – south area (Dony Adriansyah Nazaruddin *et. al*., 2014). For the distribution of igneous rocks in Kelantan, they are disseminated in two regions which is at the west and east borders of the state (the Main Range granite and the Boundary Range granite) and it also happens at the center of the state.

There are classified in four rock types of geology of Kelantan which are extrusive rocks, unconsolidated sediment, sedimentary or metasedimentary rocks and granitic rocks. For granitic rocks, they can be divided into two part of the bodies which is the rock bodies inside the Main Range and the Boundary Range. The geological age of Main Range granite is generally in between 200 and 250 million years ago at the Late Triassic age (Azman A Ghani, 2005).

The proposed Gua Musang Group includes the current Gua Musang formation, Aring Formation, Telong formation, and Niamh marble (Mohamed K. R *et al*., 2016). The grouping of listed formations within the same group divides the new formations on the basis of lithological units. Gunung Ayam Conglomerate which was named as the basal conglomerate of the Gua Musang formation is now regarded as the Bentong Raub Suture Zone (Tjia & Almashoor, 1996), and thus need to be excluded.

The proposed "Gua Musang Group" also functions to distinguish central-northern distribution of the Calcareous Series deposited in the Permo-Triassic shallow marine from adjacent dominantly deep marine "Raub Group". This is complete by inspecting the sedimentological and paleontological parts of the Permo-Triassic formations in Central Pahang to Central Kelantan. (Mohamed K. R *et al*., 2016). Table 2.1 shows the Gua Musang Formation.

Table 2.1 Gua Musang formation (Mohamed K. R *et al*., 2016)

Name	**Gua Musang formation**
Origin of Name	Gua Musang, South Kelantan
Age	Middle Permian to Late Triassic
Boundary	Unknown lower boundary; Upper boundary overlain by Koh Formation
Correlation	Upper part of Gua Musang formation interfingers with Semantan Formation, Telong formation, and Gunung Rabong formation
Lithology	Argillaceous and calcareous rocks interbedded with volcanic. Minor presecne of arenaceous rocks
Type area	Gua Musang area (extended to north Kelantan and Pahang)
Depositional Setting	Shallow marine shelf deposit, with active volcanic activity

2.4 Structural Geology

Lojing is situated in the southern part of Gua Musang. In the region of Gua Musang, the general arrangement of the significant tectonics pursues the minor influences which comprise of tight concentric folds, asymmetric, recumbent and over folds. The Gua Musang Formation lies east of the Bentong-Raub Suture within the Central Belt. Lojing was reported to be mainly dominated out of of calcareous and argillaceous rocks with subordinate arenite, pyroclastic and lava flows (Yin,1965).

The Peninsular of Malaysia were divided into three different belts which are Western, Central and Eastern Belts. Gua Musang Formation are situated inside the Central Belts and the Bentong-Raub Line is a specific of N-S lineament along the of the Main range through eastern lower regions that isolates the Western Belt from the Central Belt. Next, the Central Belt and Eastern Belt is separated by the Lebir Fault zones.

The numerous faults were drawn on published map, their nature, geometric and genetic relationships, age and conditions of deformation are inadequately known. Some major faults are divided into three types, namely terrane bounding, terrane-parallel, and terrane- crossing faults. (Mustafa Kamal Shuib, 2009a).

The faults are resulted due to the collision between Sibumasu and IndoChina. During Early Permian, the Sibumasu oceanic and East Malaya-Indochina continent from Gondwana Land collide. Sibumasu was subducted at the Paleo-Tethys Ocean. This subduction continued till Middle to Late Permian, until the whole oceanic crust was melted into the mantle. The collision was continuation of continent-continent collision during Middle to Late Triassic, resulting Main Range development in Peninsular and Bentong- Raub Suture zone.

Along the Gua Musang-Cameron Highlands road, the Bentong-Raub Suture is uncovering and being exposed as a 20km wide zone of deformed rocks. From the deformation of rocks, there are granitoid injection complex where the granitic intruded in dykes and sills. There other fault is occurring such as normal fault, strike-slip fault which is sinistral and dextral.

2.5 Historical Geology

Bentong-Raub Suture interpreted the zone of crumbled slates with vertical or upset isoclinal folds and minor ophiolitic bodies as addressing to maritime outside layer and dregs, molding an accretionary complex made by eastwards subduction. The Raub Bentong Suture Zone includes accretionary complex rocks, with oceanic ribbon-bedded cherts, argillites, turbiditic rhythmites, melange, serpentinites and continental margin or shelf deposits.

Sibumasu were part of Gondwana Land. It consists of Burma, Siam Sumatra and Western Malaysia in 280 million years ago. Based on Hutchison (2009), this terrain is characterized by pebbly mudstone which is interpreted as glaciogenic diamicities or tillities. Splitting between Sibumasu and Gondwana terraces gave insights to constrain the timing of rifting.

2.6 Geology and Lithostratigraphy of Sungai Ulu Raya, Lojing.

The lithostratigraphy is very important needed in the planning of develop area. Lojing has rapidly developed in terms of land use, infrastructure and accessibility. Accordingly, nearby experts need to give the correct advancement plan to the control of land use and improvement encompassing territories. In addition, the previous research has been conducted long time ago at the study area but there is only a few research that focused on specification of lithostratigraphy.

The main objective to this research is to produce the geological map of Sungai Raya Lojing, Gua Musang. This map is containing formation of lithostratigraphy. Hence, the characteristics of lithostratigraphy can be identify.

To obtain more about lithostratigraphy, the geological mapping need to be conduct. The study area has the various elevation and it consists of forests and plantation area. So the very details of research conducts are needed. It is to make sure that the information is given clearly.

This investigation is critical as it can give the detail topography and geology of the Sungai Raya, Lojing. It can have been done by examining the lithology, geomorphology and land geological structure present at the region. The lithology can be characterized explicitly and named by incorporating both field and petrographic investigation. This study will help in the proper development and construction at Lojing area by the identification of the types of lithology along with other important characteristics such as the geomorphology and structures. This research will help future researcher by providing more information lithology and the history of the area for a scientific studies and research of its tectonic settings and evolution.

CHAPTER 3

MATERIALS AND METHOD

3.1 Introduction

This chapter were discussed about the research flow and how to conduct the research from preliminary research to the step of analysis data and producing geological map. The flow of the research start from the preliminary studies, uses of equipment and materials, satellite imagery analysis, geological sampling, thin section preparation and data interpretation. The research is flow is based on the methodology that has been state.

3.2 Preliminary Research

The preliminary research is done before going to the field. It has done by referring the previous study that is related to the study area. Preliminary research also known as the desk study where all the data gathered from books, journals or any sources that relate. The material that have been referred are come from the different sources such as library, and any internet sources. For this research, the info from library

of Universiti Malaysia Kelantan are being the main sources. Next is the data from Jabatan Minerals and Geosains Malaysia where many research or paper can be referred.

There are many sources of information that can be gathered together such as bulletins, journals, maps, and images. The base map and topography map information was gathered by using ArcGIS Software.

3.3 Materials

A few materials are used according to the technique that apply in conducting the research. All the information about geology of study area and regional area can be found by the reading of previous journal and bulletins from the geological publisher such as Geological Society of Malaysia publications. The other source that can be refer is thesis, student paper, books and articles from Universiti Malaysia Kelantan (Jeli Campus) and the other data such as the number of populations can take by Mineral and Geoscience Department of Kelantan website. For the laboratory work, the hand specimen needed to do the further analysis. So the details mapping need to be conducted.

3.3.1 Basic Mapping Equipment

1) Global Positioning System (GPS)

GPS is used as positioning tools to conduct survey and geological mapping in study area to plot the certain locations or coordinates, tracking the traverse, elevations and also direction.

2) Compass

Compass used to determine direction and measuring strike and dip. The compass is important to know the direction in the study areas either at North, South, East and Western. Through the compass, the location and outcrop of study area can be identifying. The measurement of the strike and dip had taken at the bedding rock, fault plane and joint of the outcrop.

To get more accurate the measurements of the strike and dip the reading took a few times at different places at the same outcrop, the data had used to build the rose diagram, to know where the differential forces impacted on the rocks and came from which direction.

3) Base Map

The base map used as a guide during conducting geological mapping and investigations. It is needed before conducting the mapping which can provide the information of the study area in generally. The base map is important things that can avoid from misguide. Base map provide the contour lines, elevations, drainage pattern and lineament. It also used as a reference in the field and also as a preliminary planning at the study area.

4) Measuring Tape

The measuring tape used to determine the bedding thickness, joint space can be recorded accurately. It used when doing the lithology, and also measuring the joint orientation and frequency in the field.

5) Hammer

Hammer important equipment in taking the samples from the outcrops. Sometimes it can act as a scale when taking the image of the rock samples.

6) Field note book

All the observations or data at the field must be write down clearly. It is important to write all the information before turn into geological map. For example, the distribution of rocks is observing by the texture, colour and composition.

7) Hydrochloric Acid (hcl)

The hydrochloride acid (HCL) is used in determining the presence of calcite minerals. It will react with shows the fizzy sound when reacts with calcite in carbonates rocks.

8) Hand lenses

Hand lenses is the instrument needed in identify the type of rocks. It is used in identify the grain size. Grain size is the indicator in classified the type of rocks. It is the first analysis that conducted at the field once the outcrop exposed. This hand lenses are very useful when the grain size is so fine and cannot see by naked eyes.

9) Sample bags

A sample bag is the used when taking sample at the field. All the samples must be label and put into sample bag to remain their shape and composition.

3.4 Methodology

Methodology is referring to the steps in conducting the research. It is the effective methods that used to make sure that the research would manage properly and the objective of the research will achieve. The methodology will show all the procedure needed such as explanation of collection data, processing and interpretation of data analysis.

This chapter will explain the step that involved to complete the research project. Some flowchart is provided to summarize the processing and it will be more understandable. It includes data collection, data processing and data analysis.

3.5 Data collection

The data can be collect by primary or secondary data. Primary data which is the data obtain from main sources such as base map and geological mapping activities. Secondary data is a desk study used to get information such as from previous study, journals and reference books.

For this research of lithostratigraphy, the sedimentary log method is used. The data is collected by the geological mapping activities. All the details of the outcrop are recorded such as the texture, grain size and color. Then, all collected data will be analyzing in laboratory work and using the ArcGIS software to making the correlation. Next, the interpretation of data was done by the analyzing all the data collected.

3.5.1 Geological mapping

The geological mapping is the basic mapping to get the geological data at the field. The proper instruments and attire need to be concern before go to the site. For geologist, base map is the important thing before carried out the mapping. Base map shows the overall situation at study area. Hence, geologist can predict the condition of study area before they conduct the real mapping.

Geological mapping is the process of preparing a detailed geological report by choosing an area of interest and recognizing all the topographical parts of that zone which must include a map (Njue, 2010). The three basic reasons why geological field work is done include as a requirement of the government, exploitation of natural resources, and mostly for academic purposes. A good and effective geological mapping should have the three phases which are planning or reconnaissance, collection the data in details and reporting by their format. When conducting of geological mapping, some indicators and parameters need to be considered such as the geological structural. The parameters are important in taken in detail, accuracy and precise. When the output of geological map produces, this map should be interpreted with the expertise parties in order to analysis the data. This expertise is who in geology field that has the many experience and knowledge related to the field.

Some the other important things that need to be concern in field is the proper planning to conduct the mapping. Once at the field, be as detailed as possible in all descriptions. Observer play an important role in taking the precise data at the field. The other important things are in measurement. Measurements must be take more than once for confirmation purposes for example in taking reading of strike and dip. The wrong reading lead to the inaccurate results.

3.5.2 Rock sampling

During the field survey, rock samples are collected for further investigation in the laboratory. It is important to take the sample, which it is for identification of rocks and minerals content. The rock samples are must be collect in fresh condition, taken from the outcrop. The location of sample and details for geological data such as color, grain size and texture must be taken. The location of sample taken must be mark by GPS.

The size of sample taken must be not too small or too large. It is to make sure that the condition of rocks is remain same as at the field. For the sample, do not take the weathered one because the texture and composition cannot be identifying.

3.5.3 Thin Section Preparation

Thin section is used in investigation of petrographic microscope. Thin section is the analysis techniques to study of mineralogy and determine the mineral composition. It is important to determine the name of rocks. There are several steps need to do in laboratory investigations. For the first step of thin section, a hand specimen from the field is cut into the small size by using rock cutting machine. Then, the sample is ground with silicon carbide powder until the surface of rock is smooth. The sample must be dry before places it on glass slide. When the several hours, glued the sample on the glass slide and make sure there is no bubble on the sample surface. It is to make sure that there are no disturbed when doing the analysis of mineral composition. Next, move to the grinding part where the sample must be ground until it becomes the thinner and translucent. After get the result, the mineral identifying can be done under the microscopic view by plane polarized and cross polarized.

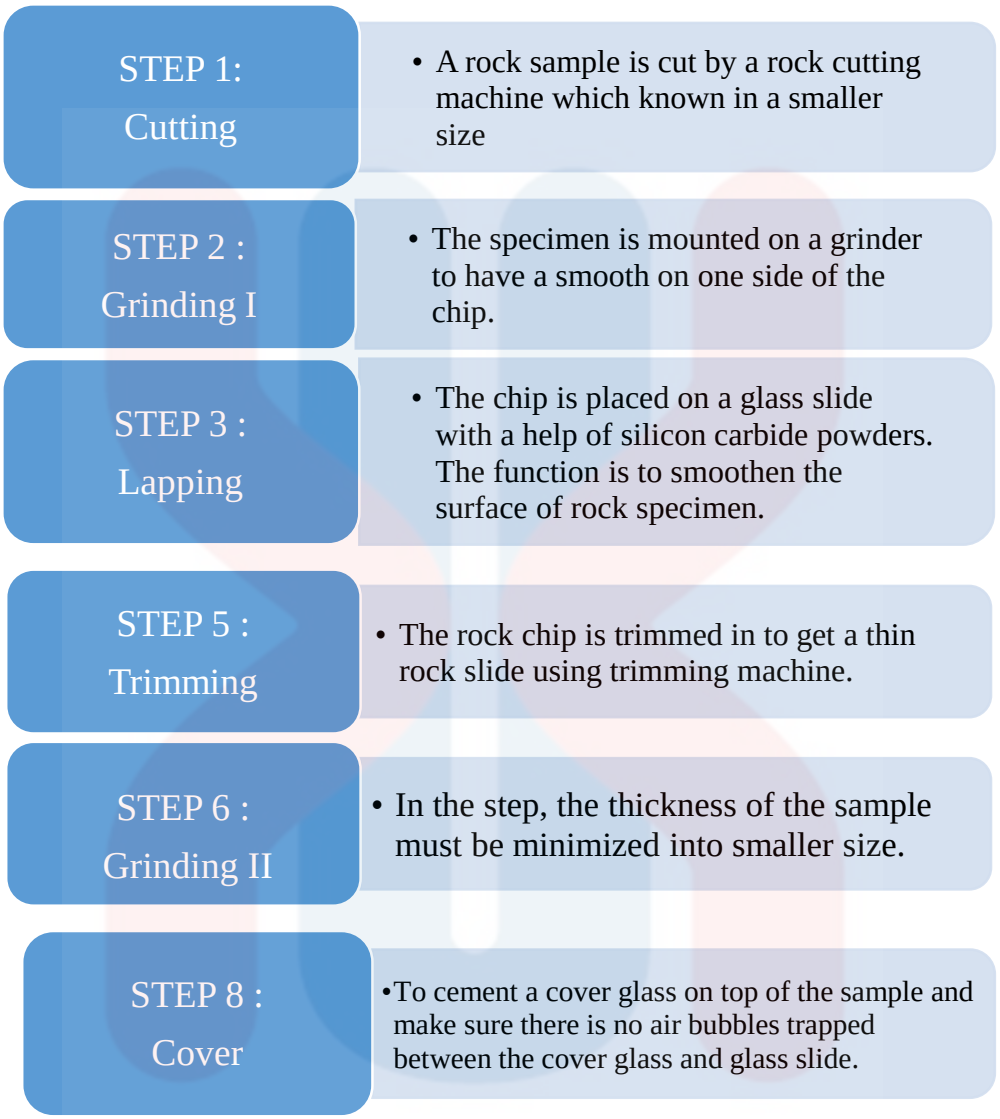


Figure 3.1 Flowchart of Thin section preparation

3.5.4 Petrography Method

Petrography is the study of rocks and minerals using a microscope (Wase Ahmed, & Voort, 2015). This petrographic analysis can be done by thin section to identification of rocks, minerals and ores. The other function of petrographic analysis is to the characterization of properties such as cleavage, twinning, reflectance and others. The slide of thin section is put under the microscope have the thickness about 0.03 mm or thinner. This specimen is observed with a transmitted polarized light microscope. It is to make sure that the grain size and percentage of each mineral can be classified. By using the provenance of the rock classification, the rock name can be identifying. Petrographic analysis also contributed in identifying depositional environment of study area. Each of specimens contain the different information that required to interpret depositional environment by identify the sedimentary structural and the presence of minerals.

The procedure for petrographic analysis are different due to the size of aggregates. For the last step, the percentage of each rock sorting will be determined to the closest 0.1 percent. The rates of good, reasonable, poor and harmful particles will be determined and the aggregate of the sub-total of mineral percentage should be 100%.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter included the part of general geology in geological aspects such as the geological mapping, geomorphology, lithostratigraphy and structural geology. General geology is very important to know the process, history and the formation at the study area. All the geological information can be gain by this activity and it very useful for the research purpose or government parties to develop this area.

The geological mapping aspects including traverse and observation, accessibility, settlement and vegetation at study area. Geomorphology is the landform of the earth surface. It can be the hilly area and surface area. Geomorphology also including the process of weathering, erosion and deposition. Lithostratigraphy is the rock layering of the earth surface or rock strata based on their lithology and stratigraphic relations. The study of rock strata is very important especially in construction purpose.

In general geology aspect, the structural geology is very important. It is study the rock units during their deformational process. Structural geology is used as the indicator of present rocks that describe the historical process.

4.1.1. Accessibility Location

The main route can be access by Lojing- Cameron Highland. For the study area, it mostly consists of palm oil plantation and the only way to cover the box is by using the unpaved route. This route has been used for the worker vehicles to pick up the palm oil. For the certain area, it cannot be access by any vehicles so the observation of this research has been conducted by pacing method.

Figure 4. 1 The accessibility to study area

4.1.2. Settlement

The settlement of the study area consists of native village area and worker's housing. The population of indigenous people there are only about 15 families consists of male, female and children. For the workers housing area, they mostly come from the different country such as Bangladesh and Indonesia. They usually came here as workers in logging activities and constructions.

Figure 4.2 A village near the study area

4.1.3. Vegetation

There are two types of vegetation at the study area which is palm oil plantation and rubber tree plantation. These two types of plantation become the main economic source for the villagers. The east part of the study area covers by palm oil plantation while the western part is covered by rubber tree plantation. Most of the rubber plantation farm are abandoned and not being economical due to the rubber tree conditions which is no produce the latex anymore. There are also has the forest reserved of Batu Papan which cannot be explore because of the high elevation and remote area.

4.1.4. Traverse observation

The traversing is one of the method in geological mapping where do the details observation along the point. It is to make sure that all the information can be collected. When traversing, the fresh outcrop is being chosen. All the information of rock description must be taken such as the texture, color, grain size and others. The details information must be collected before doing the analysis data and laboratory conducted. It is to make sure the data in high quality before processing. Figure 4.3 shows the traverse map along the study area of Sungai Ulu Raya.

4.2 Geomorphology

Geomorphology is defined as the science of landform that studies on their origin, evolution, form, processes and sediments at the surface of the earth. The landform such as hills, lake and valleys. Geomorphological processes can be divided into three which are exogenic, endogenic and extra-terrestrial. The geomorphological agents including the water, wind and gravity.

Weathering and erosion are both part in geomorphological process. The other aspect of geomorphological is drainage pattern. This landform is formed by the streams and lakes. It has the watershed at the high elevation where stored the rainwater, then the water flows to distributed to the streams.

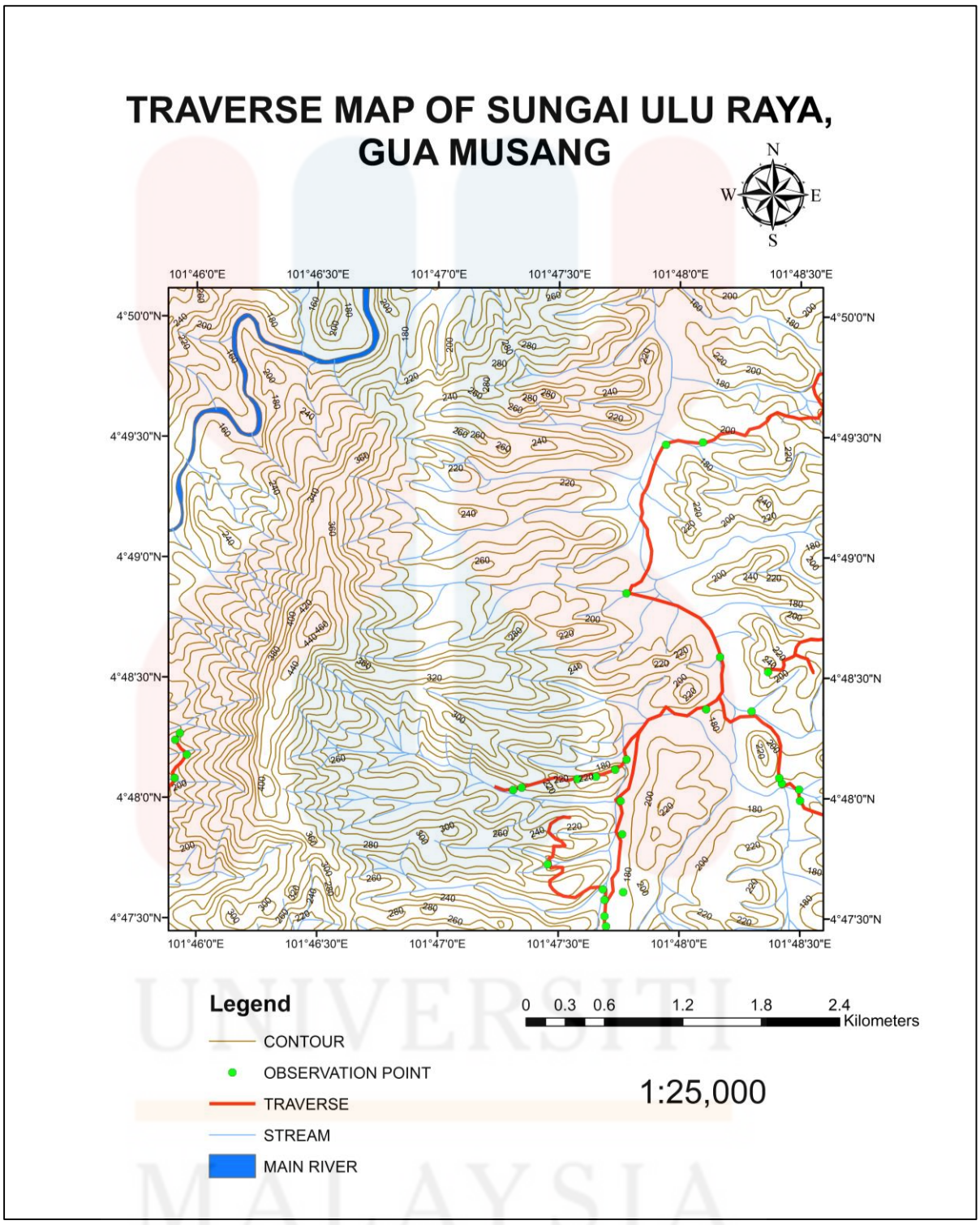


Figure 4.3 Traverse map of Sungai Ulu Raya

Figure 4.4 The geomorphology in study area.

4.2.1. Geomorphologic classification

For the morphology, the study area is mostly covered with low lying plain which is flat with a few low hill surface. According to the base map required at Figure 1.2, some part of this area also consists of hilly area. At study area, the lowest elevation is 160 m which flat surface and can be access by motorcar while the highest elevation is 440 m. This hilly area is most difficult part to explore because there was no road to access and quiet dangerous area. The difference level of elevation commonly shows the different type rock composition and structure. It is because they are formed by different process. A geomorphological map shown in Figure 4.1 based on Van Zuidam (1985) on the relations between the differences in elevation with morphology elements.

Table 4.1 The differences in elevation with morphology.

Absolute Elevation	Morphology Elements
< 50 meters	Low land
50-100 meters	Low lying plain
100-200 meters	Low hill
200-500 meters	Hill
500-1500 meters	High hill
1500-3000 meters	Mountain
>3000 meters	High mountain

4.2.2. Weathering

Weathering is the separating and breaking down of rocks, soils and minerals through contact with the Earth's atmosphere, biosphere and hydrosphere. Weathering mostly occurs in situ which means that there are no movement. Weathering and erosion are the different word with different meaning. Do not mistaken with the erosion term where the erosion refers to the movement of rock masses and sometimes also breaking it into smaller particles. Erosion involves by the agents such as water, ice, snow, wind and gravity. There are three types of weathering; mechanical, chemical and biological which is natural or by organism activities.

Mechanical or physical weathering is the process where it includes the atmospheric condition. There is the impact of breaking down of rocks and soils when

heat, water, ice and pressure are exposed to them. The example for mechanical weathering is hydraulic action. This process will be weakening the rocks when water such as waves rushes rapidly into the crack, then trapping the water and air at the bottom of the rock crack. By the higher force of pressure and temperature, the trapped air is suddenly released. The Figure 4.4 below shows the physical weathering on the igneous rocks.

Some of rock types form at depth and are stable under the tremendous pressure. Igneous rock is crystalline far below the surface, so when it is uplifted and the overlying material eroded, its contained energy is released by outward expansion, and the condition is called as the pressure release. The phenomenon occurs when there are present of humid and hot air.

Figure 4.5 Physical weathering on rock

Chemical weathering is process of the alteration of the rock into new minerals by chemically process. The process of chemical weathering commonly when there are present of the water and minerals in the soil or rock masses. Several agents of weathering are oxygen, air pollution, water and acid concentration. There are several process in this type of weathering; dissolution, hydrolysis and oxidation. The Figure 4.5 below show the osidation of iron occuring on the rock. The oxidation of iron in ferromagnesian silicates such as olivine, pyroxenes, amphibole and biotite forms the red iron oxide.

Figure 4.6 Chemical weathering on rock

Plants mechanically breakdown rocks with their roots, just as trees can break sidewalks or even the foundations of houses with their roots. Animals and other organisms is the main factors that cause rocks to break down. The movement of their activities causes pressure on rock that can lead to breakage and loosen of the soil. Some biological organisms also become the contributor in breaking down the rocks such as bacteria, plants, and animals. The Figure 4.6 below shows the biological weathering

weakening the soil materials and lead to the erosion and stream formation when there are water flowing.. The growing of roots will unsupported the earth materials when it grows larger and finally it will collapse.

Activities of organisms also contribute to the biological weathering. They break down organic compound within plants and release nutrients back into the soils.

Figure 4.7 Biological weathering on rock

4.2.3 Drainage pattern

At the study area, there are two types of drainage pattern which is trellies and dendritic. Drainage pattern of dendritic are more abundant than trellies pattern. Dendritic is most common drainage pattern and its look like tree roots. It develops in regions underlain by homogeneous material. Trellies pattern is develops where bands of rocks vary in resistance. It occurs where sedimentary rocks have been folded or tilted and then eroded. This is modified pattern of the dendritic pattern and many such water channels form a trellis.

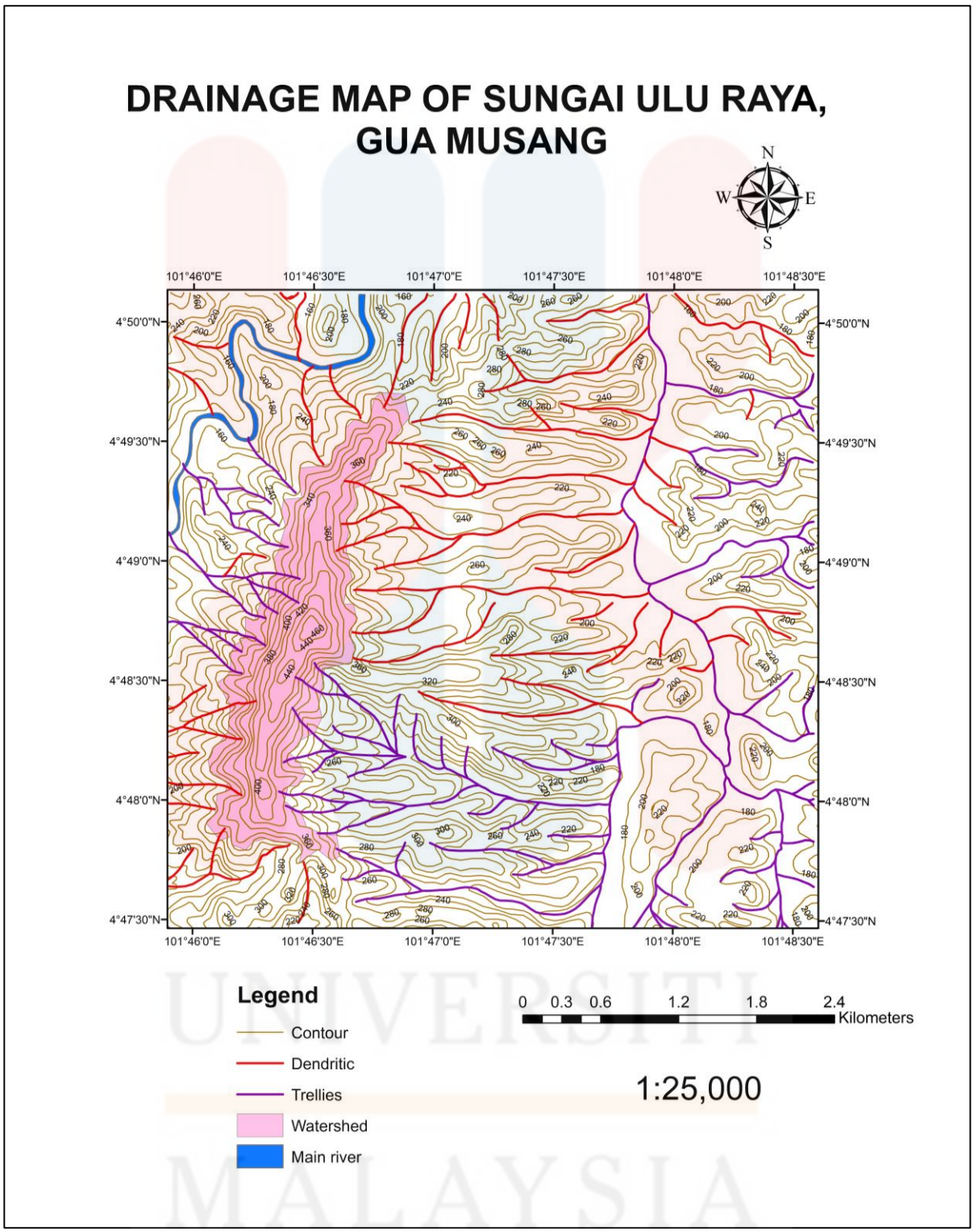


Figure 4.8 Drainage map of Sungai Ulu Raya

4.3 Lithostratigraphy

Lithologic stratigraphy or lithostratigraphy is a subdivision of stratigraphy which studies the relationship among rock units based on the rock type, physical characteristics and petrographic features. There are four lithostratigraphic units existed in the study area as shown in Figure 4.7 which are alluvium, andesite, limestone and tuff.

Alluvium is the youngest rock type which formed at Quartenary age and found along the river channel. The next lithology is the andesite intrusion which in Triassic age. The third lithology unit is the limestone where the age is in the Late Triassic.

The limestone unit is thick bedded with the grey color with the strike and dip reading is 302°/47°. The last unit lithology is the volcanic rock that found in the study area. The volcanic rock mostly abundant and presence in the Early Triassic. The strike and dip reading for the tuff unit is 200°/49°. According to the age, volcanic rock of tuff is the oldest, followed by limestone unit, andesite intrusion and alluvium.

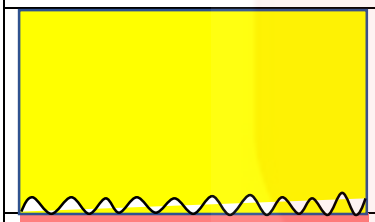
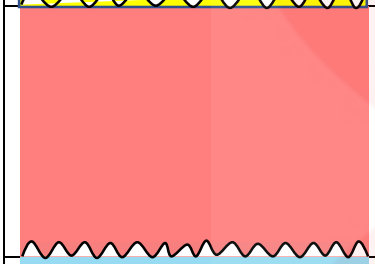
LITHOLOGY	LITHOLOGY UNIT	AGE	DESCRIPTION
	Alluvium	Quartenary	Made up of fine particles of sand and gravels.
	Andesite	Triassic	Intrusion
	Limestone	Late Triassic	With thick bedded limestone, grey colour.
	Tuff	? Early Triassic	Bedded tuff, lapilli tuff and subordinate with clastic sediments.

Figure 4.9 A stratigraphic column of study area

4.3.1 Tuff

Tuff is the volcanic ash that formed by the volcanic eruption. Tuff is abundantly in the study area interbedded with the mudstone and shale. The tuff has the light color and the texture is the pyroclastic. This rock type is found at 101°47’41.1” E, 04°47’37.3” N. This volcanic tuff usually soft and porous. It comes from the explosive volcanic followed by ash, magma and other materials. The outcrop of volcanic tuff at study area is very high rate of weathering.

4.3.2 Limestone

Limestone in the study area was found at particularly around the south-east part. The limestone was reacting with the hydrochloric acid (hcl) when there are present of calcium carbonate. The position of outcrop was found at the flat area, along the small river with thick bedded. There are many boulders of limestone and have the moderate rate of weathering. The commonly chemical weathering impact on limestone rocks by reaction between rainwater that makes the limestone dissolve. The rock has the fine-grained size and light grey color. Limestone is the most common rock type at the Gua Musang Formation and it is late Triassic age in the geologic time scale. At the study area, there are the formation of karst limestone. Limestone stores frequently happen in relationship with karst, a geology where limestone gradually breaks up away underground. The stores result in sinkholes, caverns and zones of shake breaks that frame underground seepage territories.

Table 4.2 Description of limestone rock sample

Location	101°47'45.83"E 4°47'51.025"N
Rate of weathering	moderate
Vegetation	Rubber plantation
Position of the outcrop	Flat area
Outcrop (Picture)	
Rock Description	1) Sedimentary rocks - Color: light grey - Compositions: mainly calcite carbonate - Grain: fined grain
Type of contact	structural
Age of the rock	Late Triassic

4.3.3 Andesite

The igneous rock was found at the study area where the location of the outcrop is at the west of the map. This andesite is fine-grained and extrusive igneous rock composed with abundantly plagioclase minerals and the other minerals such as biotite and pyroxene. The andesite formation is classified as the intrusion by the magma intrude in crystallization and solidified process and has proven by the invention of andesite extrusive over 2 meter at the study area. Based on the data collected from fieldwork, the rock sample taken shows it has light grey color with aphanitic texture. Most of the rocks found contain of plagioclase feldspar and has the moderate rate of weathering. Andesite is the fine grained rocks that formed when the magma erupted onto the surface and crystallize quickly.

Table 4.3 Description of andesite rock sample.

Location	N 04°48'10.9", E 101°45'57.6"
Rate of weathering	Moderate
Vegetation	Forest
Position of the outcrop	Hilly area
Rock Dimension	2 meter
Outcrop (Picture)	
Rock Description	2) Igneous - Color: light grey - Texture: aphanitic - Mineral Composition: biotite, feldspar, pyroxene - Degree of crystallinity (holocrystalline, hypocrystalline, holohyalline) - Grain size: fine grain
Type of contact	Intrusion
Age of the rock	Triassic
Location of the outcrop on the map	West

4.3.4 Alluvium

Alluvium is made up of the fine particles of sand and gravel. The alluvium is youngest of the stratigraphy age at study area which is at Quartenary age and it comes from the several processes which are transportation and deposition. Before deposited, the sediments of rocks undergo the weathering and erosion process which breaks the materials into small particles and transported by the water flows. They mostly deposited along the river channel.

The upper stream channel consists of coarse sand and gravels, fine sands, and at the lower stream channel consists of silt and clay. These sediments first deposited which largest particles with the high current and energy of water flow followed by the finest particles when the current is slow down. The last result when the water stops is the finer particles settle out on top of the large ones forming well-sorted deposits.

4.4 Petrography

In this study, there are two types of rock which have been analyzed which are igneous and sedimentary rock. Thus, a detailed observation is done on the samples. There are a total of four samples that have been analyzed through petrographic. Figure 4.11 shows the hand specimen of andesite taken at E 101°45’57.6”, N 04°48’10.9”. Figure 4.12 is the thin section observation result. Figure 4.13 is the hand specimen of breccia which was taken at 101°45’52.5” E, 04°48’02.2” N. Figure 4.14 is the thin section observation result. Figure 4.15 is the hand specimen of mudstone which was taken at 101°45'55.914"E, 04°48'16.031"N. Figure 4.16 is the thin section observation result. Figure 4.17 shows the hand specimen of the limestone sample which was taken at 101°47'45.83"E, 04°47'51.025"N. Figure 4.18 is the thin section observation result. Table 4.4 shows mineral composition for every sample with its percentage value.

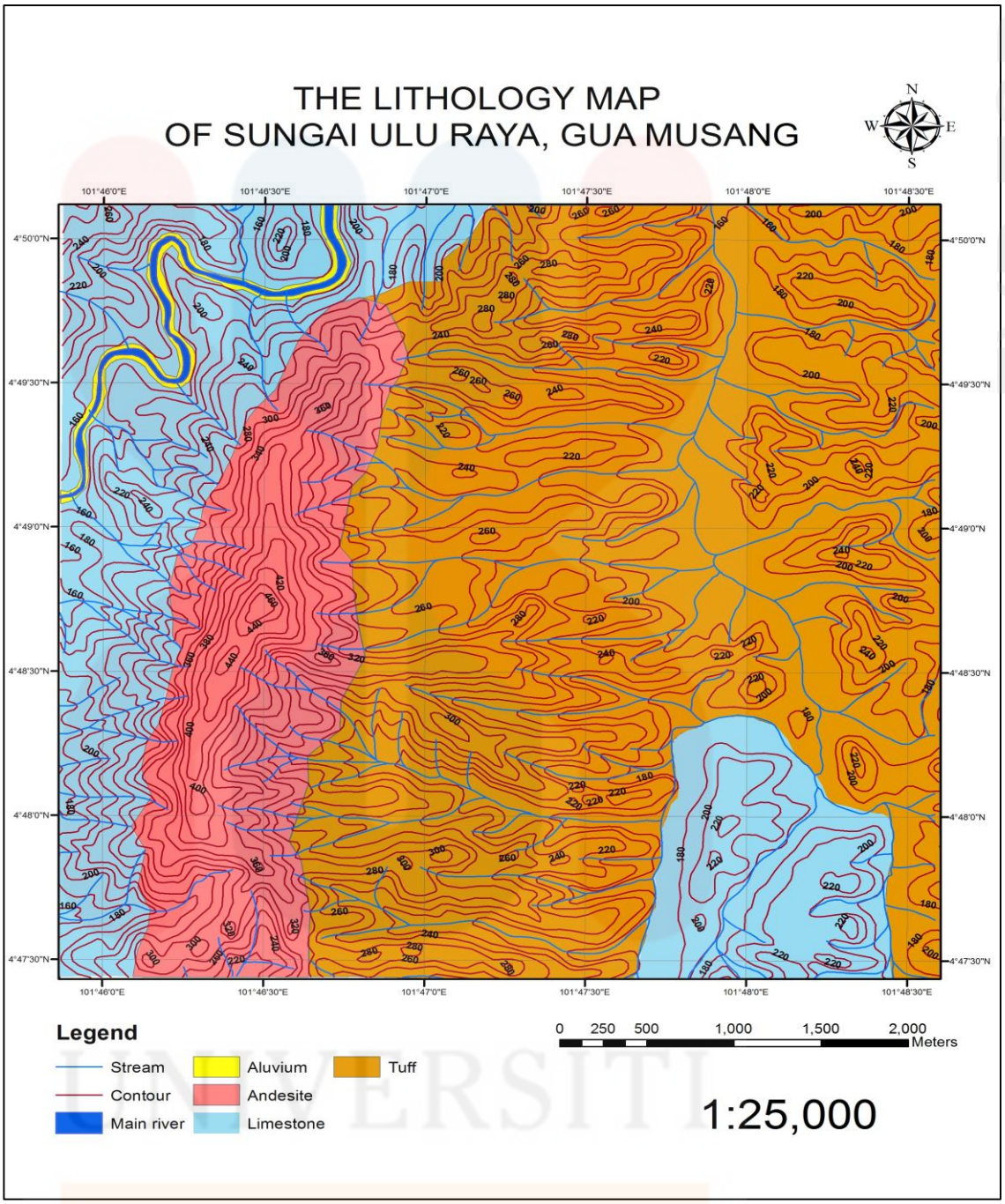
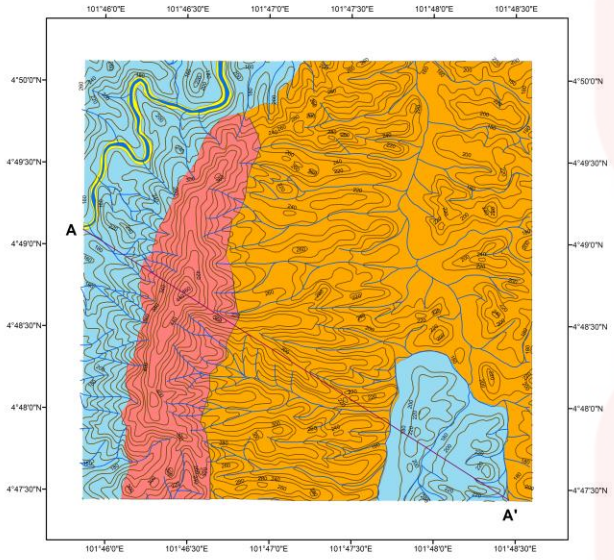
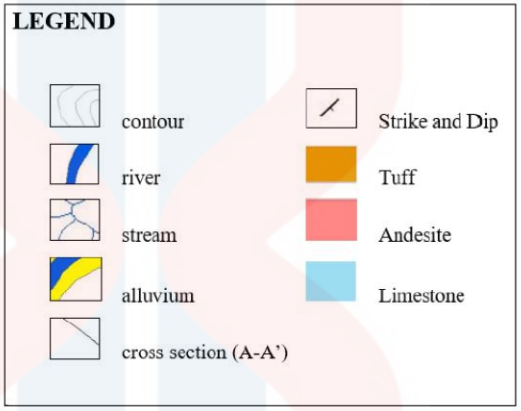


Figure 4.10 Lithology map of the study area





LITHOLOGY	LITHOLOGY UNIT	AGE	DESCRIPTION
	Alluvium	Quartenary	Made up of fine particles of sand and gravels.
	Andesite	Triassic	Intrusion
	Limestone	Late Triassic	With thick bedded limestone, grey colour.
	Tuff	? Early Triassic	Bedded tuff, lapilli tuff and subordinate with clastic sediments.

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GEOLOGY AND LITHOSTRATIGRAPHY OF SUNGAI ULU RAYA, KELANTAN

By:
WAN ZAINAH BINTI WAN ISA
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MAP SCALE 1: 25 000

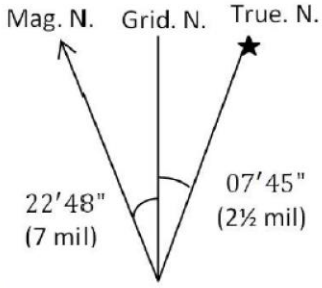


Figure 4.19 The geological map of study area

The figure 4.11 show the andesite sample and the result from microscopic view. Andesite has the most percentage of plagioclase feldspar with 60%. It has the low relief with colorless in thin section. The plagioclase feldspar shows the anhedral under the microscope. The quartz mineral also appears in colorless at plane polarized light (ppl) and change in grey color in crossed polar (xpl). Andesite also contain iron and magnesium minerals such as olivine, pyroxene and biotite.

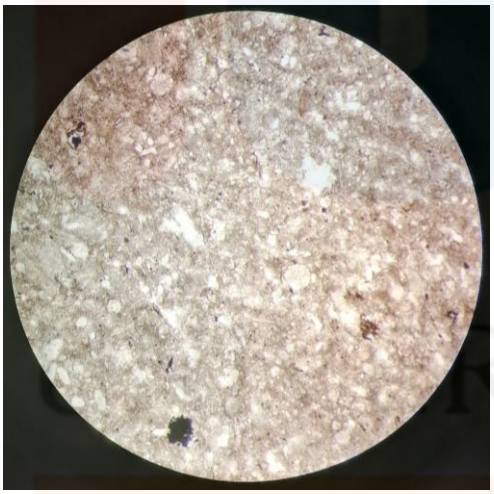
Breccia rock show in the figure 4.13 which has the plagioclase feldspar 50% and quartz minerals 45%. Breccia consist of the large angular fragments and filled with the matrix of smaller particles. The cemented matrix consists of clay and silt minerals while the fragments are mostly plagioclase feldspar. The other minerals are about 5% such as pyroxene and biotite.

Mudstone is the sedimentary rock that found at the hilly area with dark grey color. Under the thin section, the plagioclase minerals are present about 40%, quartz minerals in 25% and the other contain carbonaceous content that makes the color of rocks become darker. The groundmass is from the clay minerals. Some other minerals are present such as biotite and chlorite.

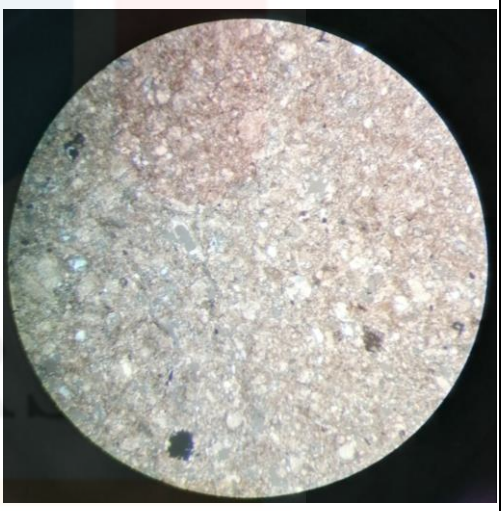
The last rock sample is the limestone where the most common minerals is the calcite. The calcite minerals are 50%, feldspar 25%, quartz minerals 20% and the other minerals are 5%. The limestone mostly has the fossil, and this rock sample shows the oolitic fossil that can be seen only under the microscope.

Sample 1

Figure 4.11 Shows the hand specimen of andesite sample



Plane-polarised



Cross-polarised

Figure 4.12 Microscopic view of Andesite sample

Sample 2

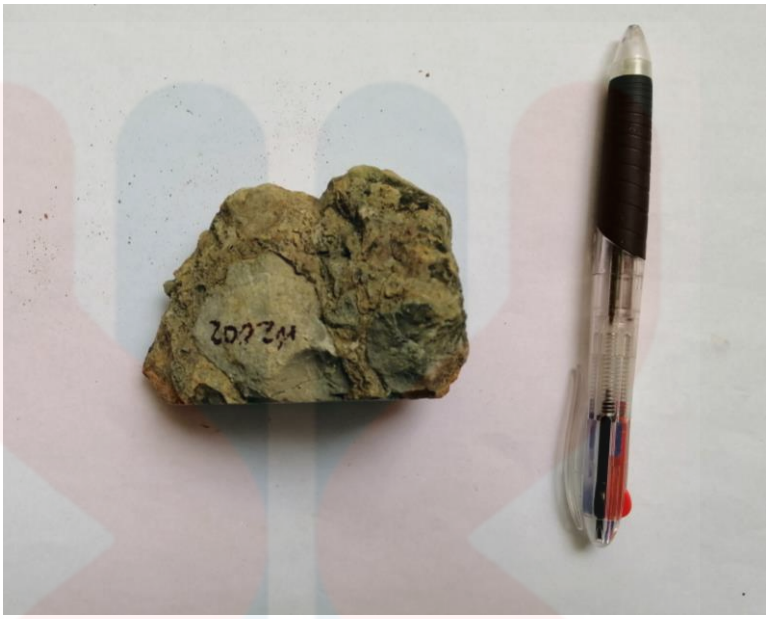
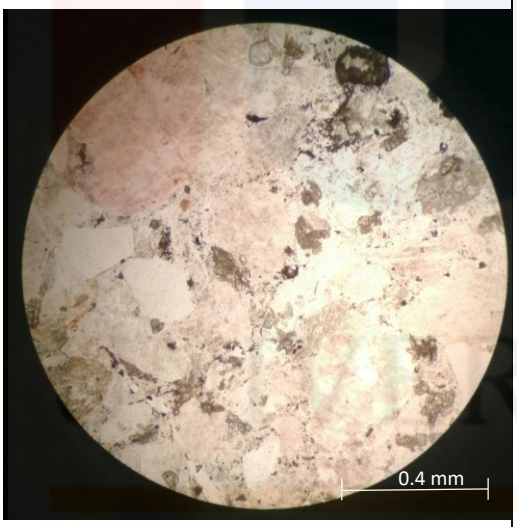


Figure 4.13 The hand specimen of breccia sample



Plane-polarised	Cross-polarised

Figure 4.14 Microscopic view of Breccia sample

Sample 3

Figure 4.15 The hand specimen of Mudstone sample

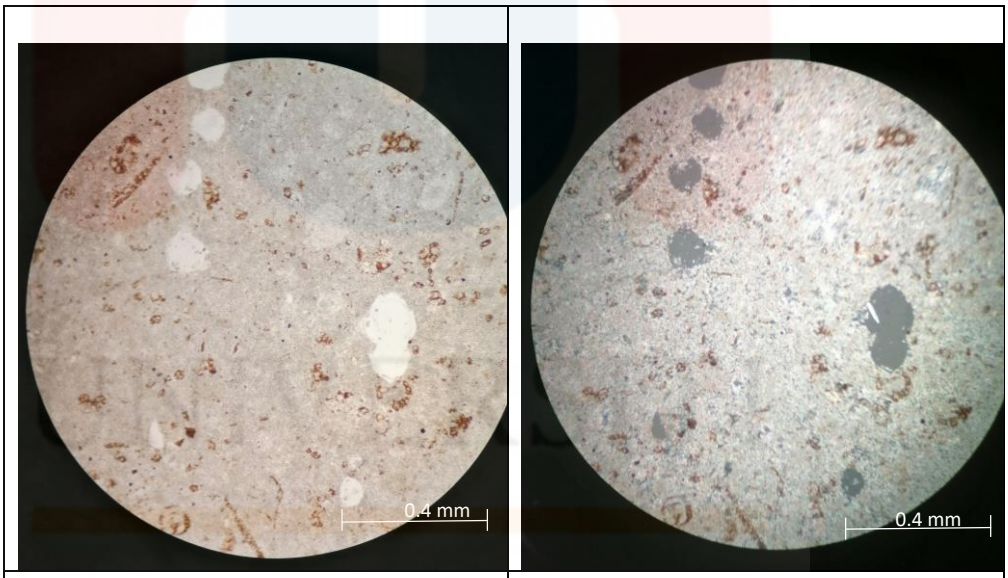
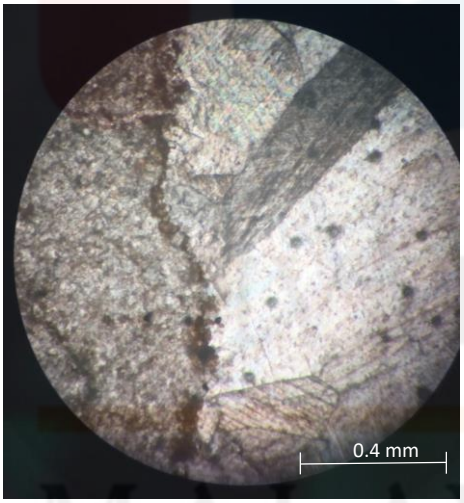


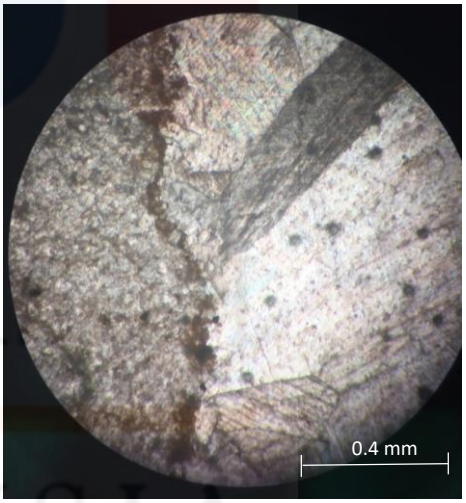
Figure 4.16 Microscopic view of mudstone sample

Sample 4

Figure 4.17 Shows the hand specimen of limestone sample



Plane-polarised



Cross-polarised

Figure 4.18 Microscopic view of Limestone sample

Table 4.4 Mineral Constituents in Samples

Samples	Mineral Composition	Other Minerals
Andesite Sample	Quartz: 25% Plagioclase Feldspar: 60% Pyroxene: 10% Other Minerals: 5%	Biotite, Amphibole
Breccia Sample	Quartz: 45% Plagioclase Feldspar: 50% Other Minerals: 5%	Pyroxene,
Mudstone Sample	Quartz: 25% Feldspar: 40% Biotite: 10% Chlorite: 10% Other Minerals: 15%	Groundmass: cemented clay and silt
Limestone Sample	Quartz: 20% Feldspar: 25% Calcite: 50% Other Minerals: 5%	Clay minerals

4.5 Structural geology

Structural geology is the one of the method in geology to know the historical of the past geological environments. It will describe the processes and products of rock deformation and the three dimensional distribution of rock. Structural geology such as fault and fold will describe the direction of force impacted on the rocks.it is important to study the structural geology to know the economic value of mineral and for specific investigations. In this study, a lineament analysis had been done in order to determine the historical deformation systems.

a) Lineament analysis

Lineament is a linear topographic features that be the first indicator of geological structural at the regional area. The lineament has straight lines or regularly sinuous features of geologically and significance can be seen in aerial petrography. They may show in drainage, river and contour lines. The lineament also be the one of fault indicator. In this research, the lineament analysis has done using the imagery satellite of study area and the its nearby region. This analysis gives the idea where the direction of force exerted on the rock. Figure 4.20 shows the satellite imagery map with black-line marked that shows the lineament.

The readings of lineament were taken by measuring the angle. Then, the reading values were interpreted by using GeoRose software. Figure 4.21 is the result of the analysis which shows that the maximum force exerted on the area towards North-East.

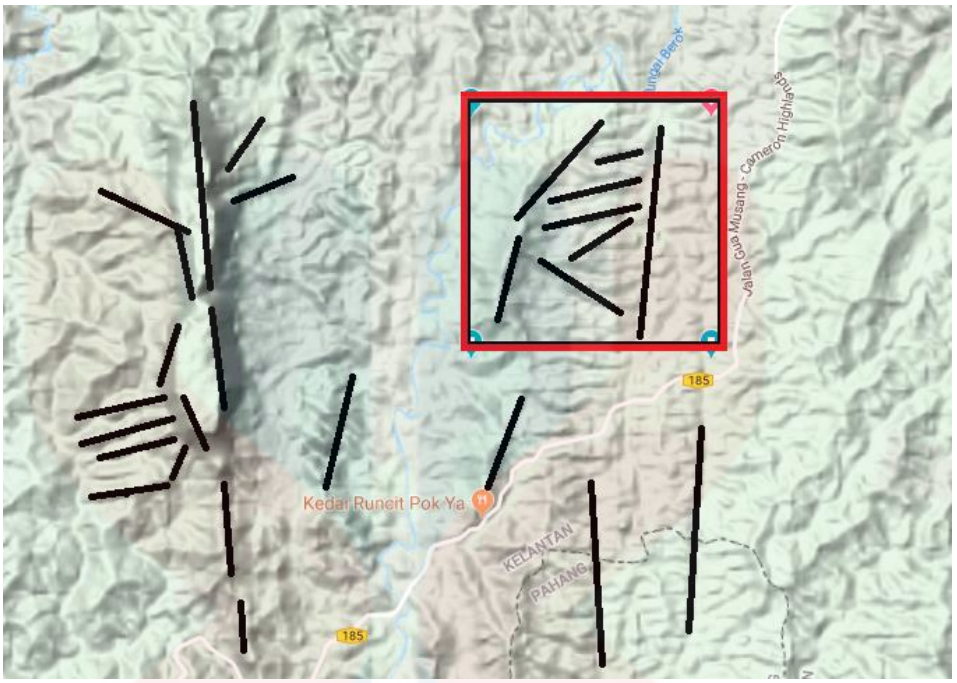


Figure 4.20 Satellite imagery of study area and its surrounding

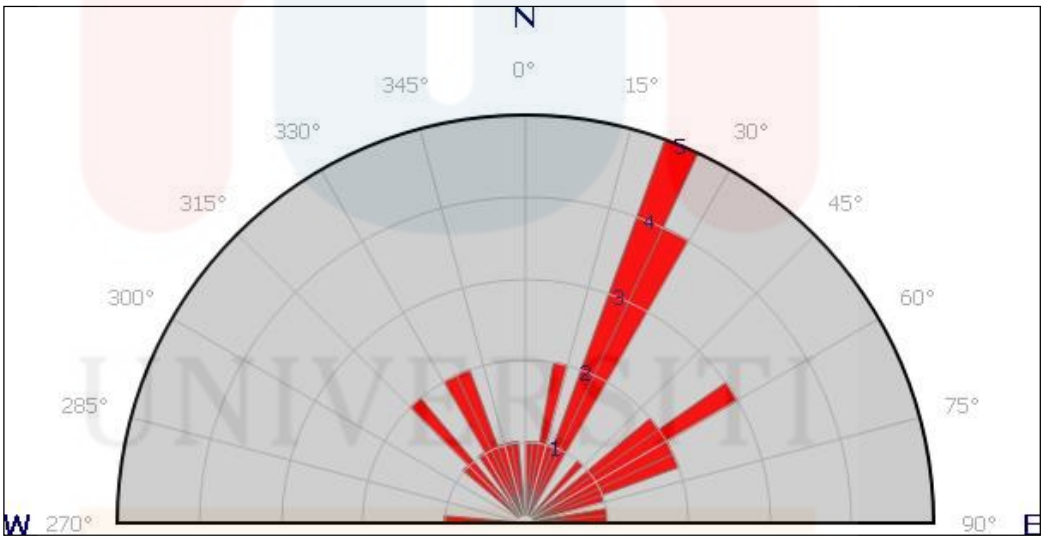


Figure 4.21 Rose Diagram of Lineament Analysis

b) Joint

At the study area, the joint was found on the sedimentary rocks which is shale. A joint is a fracture dividing rock into two sections that have not move away from each other. The joint in research area are not obviously because of the high rate or weathering makes the rocks becomes breaks easily to the small particles. The joint set above shows the similar orientation at the same area. It is formed due to force exerted on the rock.

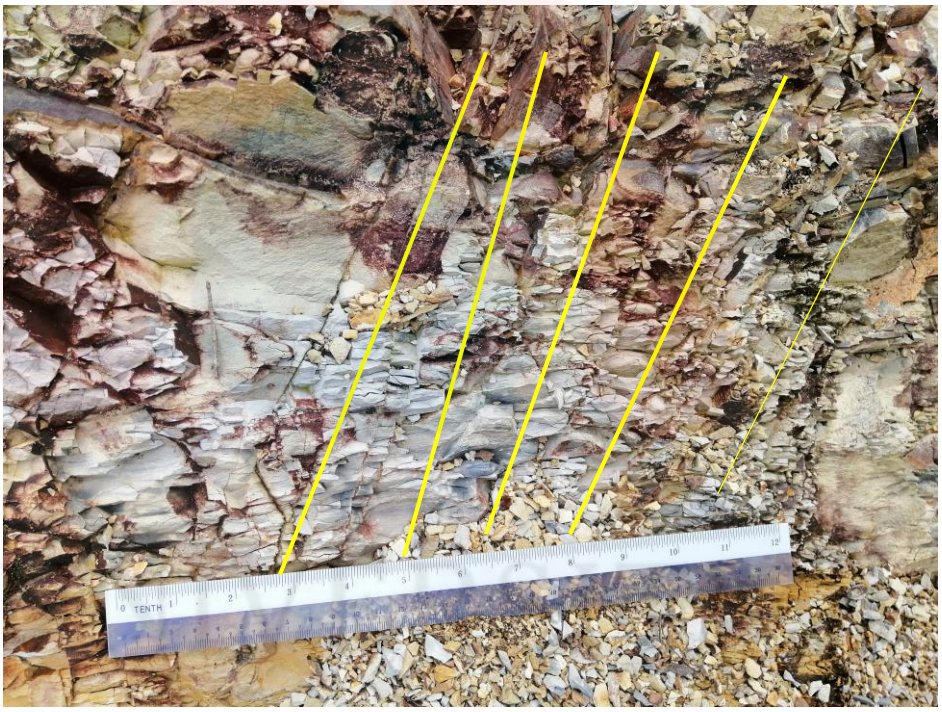


Figure 4.22 The joint sets

c) Fold

Folding is the process where the rock has been crumpled and bent. It is most commonly occurring due to the compression of the rock by force in differential direction. In the study area, the folding occurs at the sedimentary rocks which is shale. Most of folding occurs beneath deep of the crust where the rocks are more ductile. Figure 4.23 shows the folding area formed at bedding of volcanic rock and shale.

Figure 4.23 The folding structural

d) Lamination

Lamination is the small scale of sequence lines that occurs in the sedimentary rocks. They are bedding likely but in the strata is less than 1cm. lamination is the sedimentary structures that indicate their history of depositional environment such as from the marine of coastal environment. They are characterized by the fine grained sediments. The lamination formed by process deposition and lithification. The lamination where found at the hilly area of the mudstone layers. The lamination can be the indicator of depositional environment.

Figure 4.24 The lamination at study area

e) Bedding

The bedding layers is one of the most obvious features of sedimentary rocks. They show the different types of mineralogy, clast size, degree of sorting and different color of layers. In the study area, the rock strata have the different rate of weathering. The bedding layers can be seen easily by the naked eyes. In their original, undisturbed bedding sedimentary rocks are arrange almost horizontally. When they are disturbed or tilted, it shows there are plate tectonic movement along the years ago.

Figure 4.25 The bedding layers of sedimentary rocks.

4.6 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 pyroclastic or volcanic facies within Gua Musang area.

The Gua Musang Formation lies east on the Bentong-Raub Suture within the Central Belt. The Bentong Raub-Suture formed by the collision of Sibumasu and Gondwana.

Lojing is one of the part in the Bentong-Raub Suture which has a lot of structural due to the plate tectonic movement. According to the (Kamal, 1996), Gua Musang Formation consists of calcareous, argillaceous and tuffaceous rocks. This can be proven where there are present of these rocks in the study area.

Raub– Bentong Suture translated the zone of collapsed slates with vertical or upset isoclinal folds and minor ophiolitic bodies as speaking to maritime outside layer and dregs, shaping an accretionary complex created by eastwards subduction. The Raub Bentong Suture Zone includes accretionary complex rocks, with oceanic ribbon-bedded cherts, argillites, turbiditic rhythmites, melange, serpentinites and continental margin or shelf deposits.

The Figure 4.26 show the Sibumasu-Gondwana Collision model that explain briefly the process occurred at Early Permian- Late Triassic age. The Gua Musang Formation starts to develop at the east in Middle-Late Permian with thick argillites and volcanic creates shallow marine Gua Musang platform.

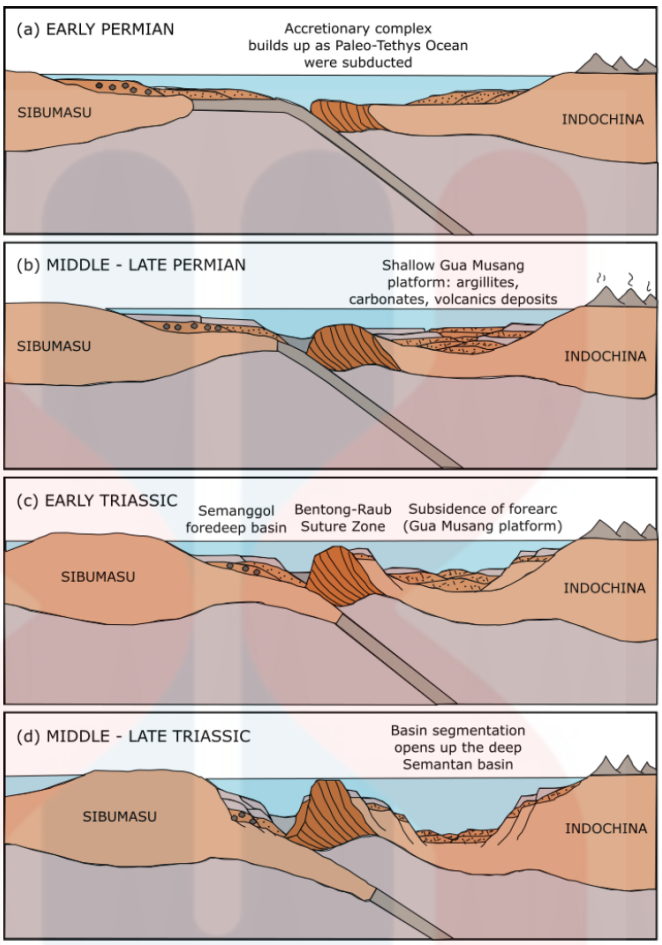


Figure 4.26 Sibumasu-Gondwana Collision Model (source: www.researchgate.net)

CHAPTER 5

GEOLOGY AND LITHOSTRATIGRAPHY OF SUNGAI ULU RAYA, LOJING

5.1 Introduction

Lithostratigraphy is the stratigraphic section to know the rock types and the depositional environment of the certain area. There are several parameters that need to be considered in this lithostratigraphy such as sedimentary structural, rock facies, grain size and color.

5.2 Depositional environment

A depositional environment is a specific type of a place where the sediments is deposited such as at the beaches, lakes, shallow marine or deep marine environment. The depositional environment is important for reconstructing the earth history and earth process. It is mostly consisting of sedimentary rocks such as sandstone, limestone and shale. The sedimentary rocks contain sedimentary structures such as the cross bedding, lamination and fossils. The sedimentary structures and fossil contain are the important to shows the earth process happened over the past years. Figure 5.1 shows the depositional environment of sedimentary rocks.

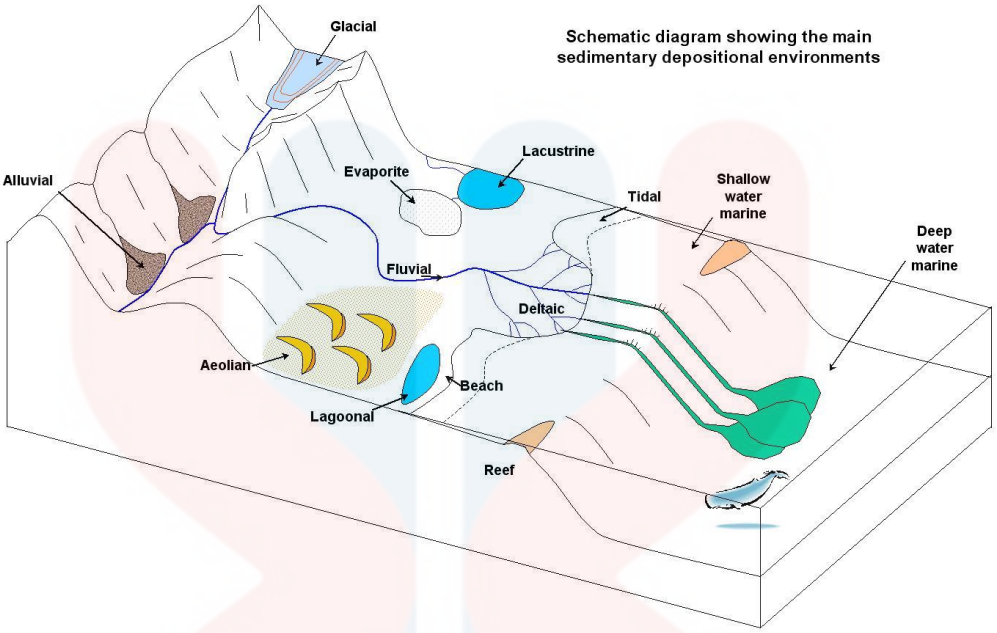


Figure 5.1 The depositional environment of sedimentary rocks (Source: Wenatchee Valley Colley, 2008)

The Figure 5.1 above shows the depositional environment process and the sediment types that were deposited. The depositional process can be divide by two conditions which is the terrestrial environments and marine environments.

5. 3 Sedimentary facies

The sedimentary facies of Gua Musang consists of argillaceous, arenaceous and volcanic facies. The argillaceous defines as the rock unit that has the clay minerals as the common minerals such as in shale, and mudstone. For the arenaceous, it mostly contains the coarse mineral and made up by sand such as the sandstone and siltstone. Next is the volcanic facies show in the study area which is the present of volcanic facies such as interbedded tuff and pyroclastic rocks. For the depositional environment, the Gua Musang Formation in Kelantan is dominated by shallow marines clastics and carbonate with volcanic interbeds.

5.4 Arenaceous facies

In the study area, there are present of the arenaceous facies which is sandstone and siltstone. The sandstone mostly composed of quartz, feldspar and lithic fragments. The outcrop of sandstone is mostly weathered due to the high pressure and temperature. For the siltstone, this rock mostly interbedded with pyroclastic rocks. In shows that there is the volcanic eruption process where interrupted the process of deposition. Siltstone is the clastic sedimentary rocks that has the composition between sandstone and claystone. The siltstone is more fine grained than sandstone. This rock types are quiet difficult to determine because the properties of the grain size. The siltstone commonly mistaken as the shale by their grain size.

5.5 Argillaceous facies

The argillaceous facies is present at study area which is shale and mudstone. The argillaceous rock is classified by the clay minerals as the common minerals. The shale has the clay size while the mudstone is very fine grained which the grain is grittier when touch by hand. Both of this rocks have the same greyish color but the mudstone has the darker than shale.

Shale and mudstone has the low percentage of quartz minerals that makes them easier to be eroded because there are no minerals with high hardness. These rocks cannot survive with the high pressure and temperature. At the study area, shale is mostly having high rate of weathering.

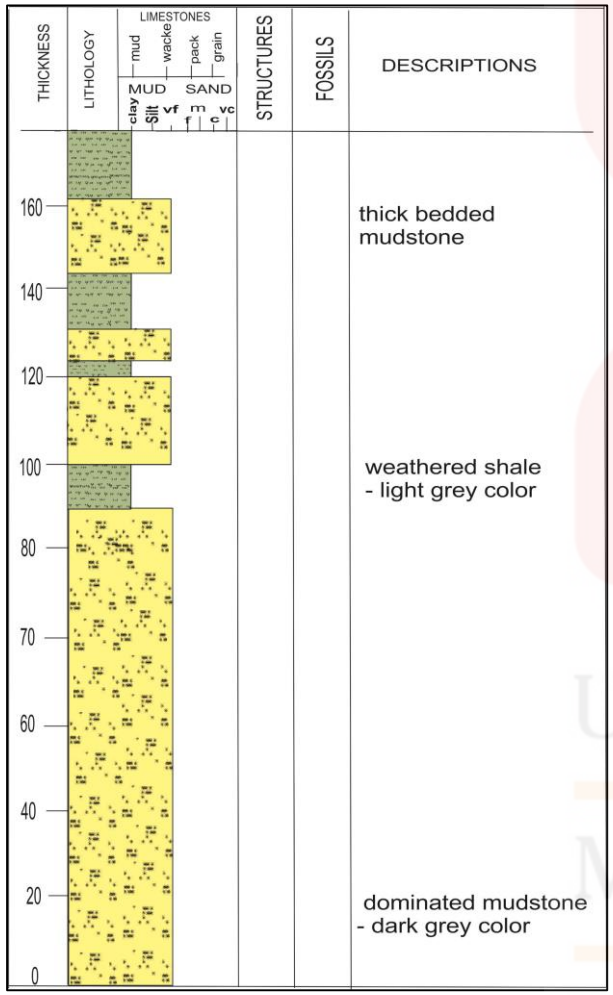
5.6 Volcanic facies

The volcanic facies is present at the study area show the past history of geological which is relate the volcano system. Bentong-Raub Suture was formed due to the collision between two plate which is Sibumasu and IndoChina. This study area is one of the area exposed by the structural of Bentong-Raub Suture. This collision was produced more volcanic eruption due to the plate tectonic movement. At the study area, there are present of pyroclastic rocks such as tuff.

5.7 Lithostratigraphy

5.7.1 Lithostratigraphy of the location A

The Figure 5.2 below show the sedimentary log of location A which located at the hilly area at coordinate 101°48’6.65” E, 04°48’22.21” N. This outcrop composed by shale and mudstone. Some of the rock unit has the interbedded between arenaceous and argillaceous facies. Shale is the clay minerals while the mudstone has the grains size of fine to very fine grained. From the field observation, the outcrop has the coarsening upward with the increasing in the bedded layers. The rate of weathering is medium where shale is mostly weathered that mudstone. There are present of iron oxide that makes the rocks becomes reddish color.



Facies	Facies associated
F2	FA1
F1	
F2	
F1	
F1	
F2	
F1	

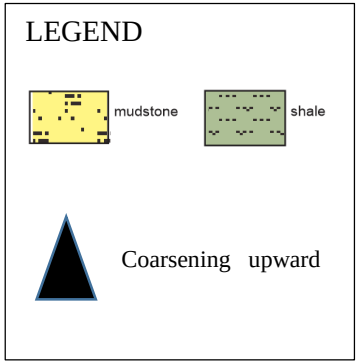
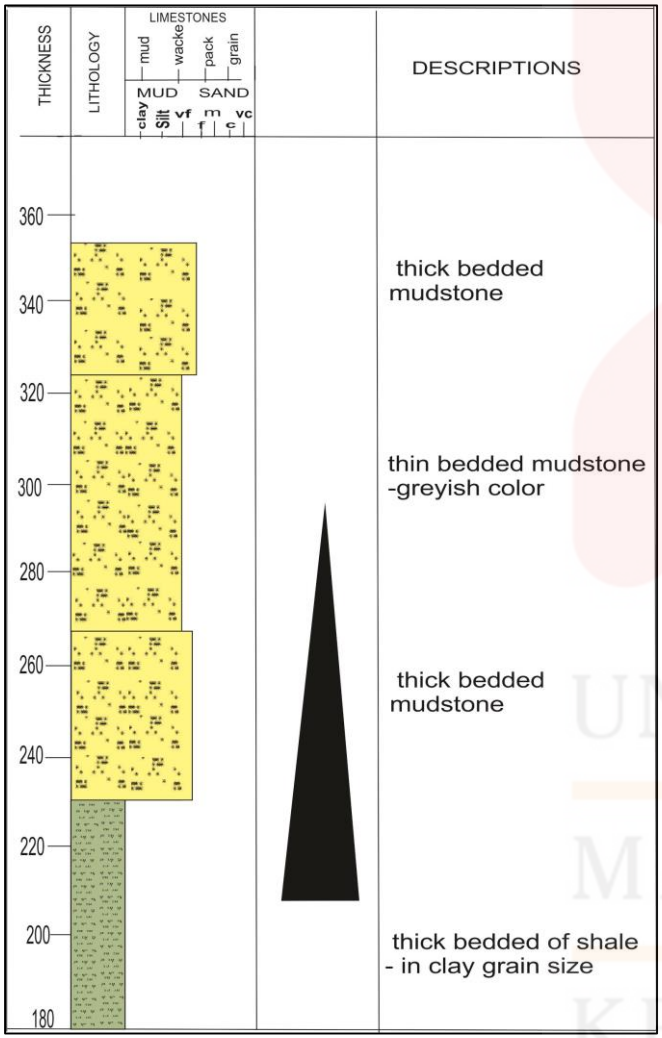
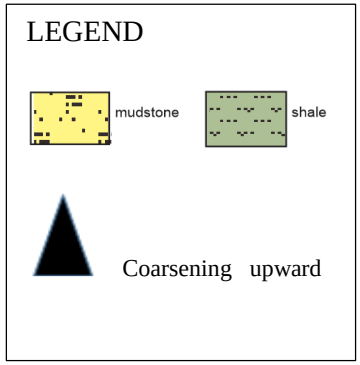


Figure 5.2 sedimentary log of location A

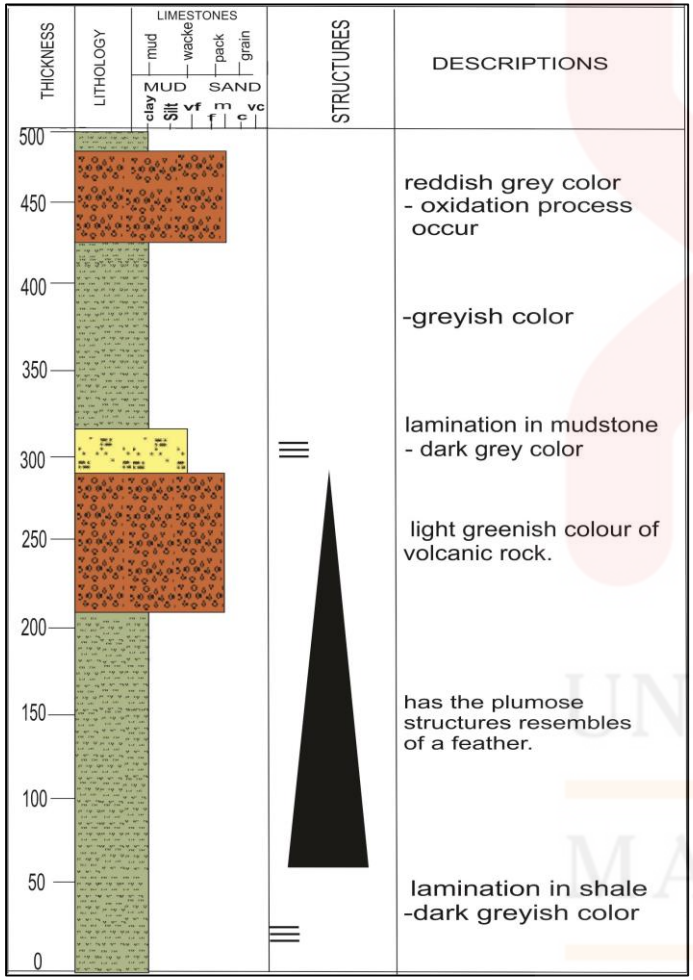


Facies	Facies associated
	FA1
F1	
F1	
F1	
F2	



5.7.2 Lithostratigraphy of the location B

The Figure 5.3 below show the sedimentary log of location B which located at the palm oil plantation at the coordinate 101°48’17.94” E, 04°48’21.77” N. This outcrop composed shale, mudstone, volcanic rock and interbedded shale with dominated volcanic rock. The volcanic rock is made up of tuff and pyroclastic materials. The outcrop has the fining upward with the decreasing in the bedded layers. There are the sedimentary structural of laminations that lies in the shale and mudstone. The sedimentary structural can be the indicator of the depositional environment.



Facies	Facies associated
F3	FA1
F2	
F1	
F3	
F2	

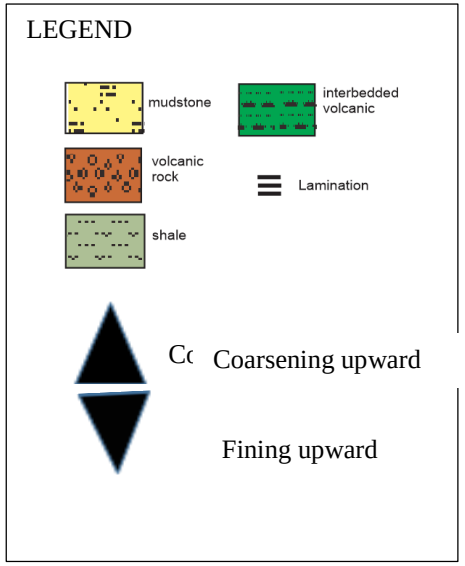
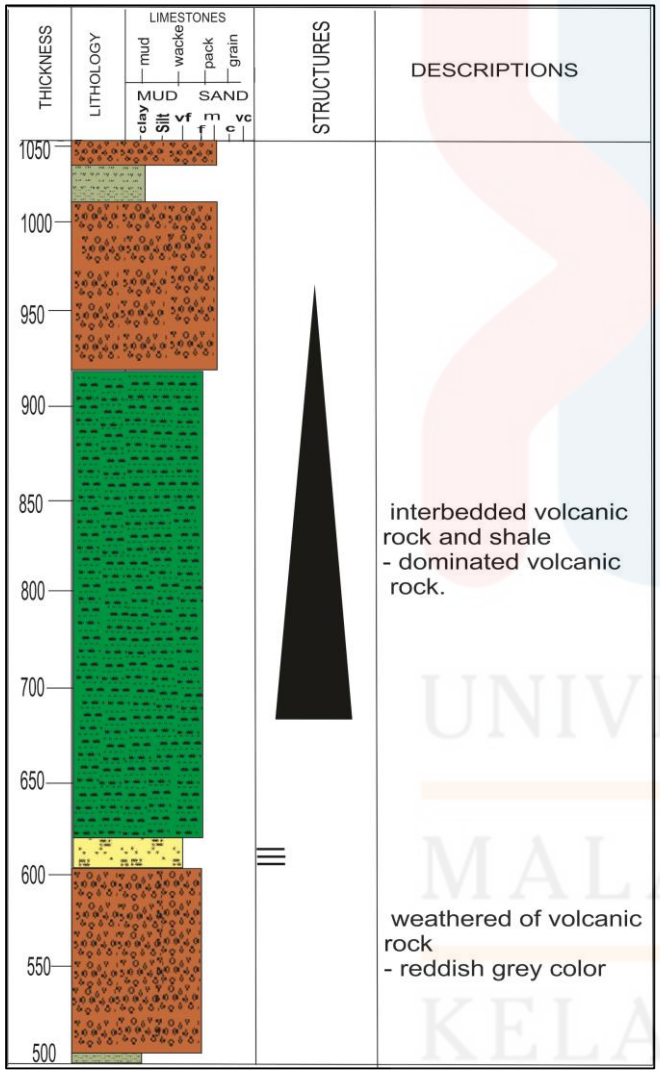
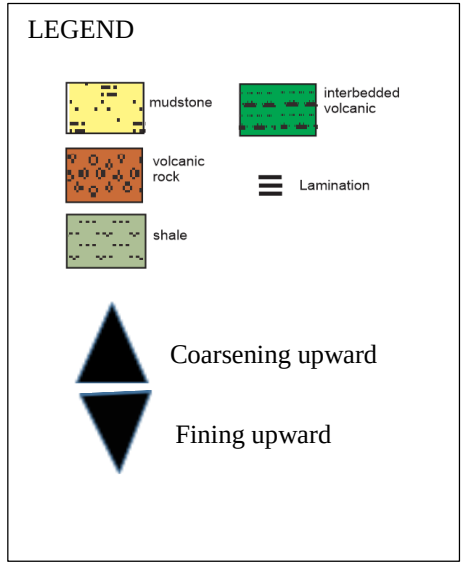
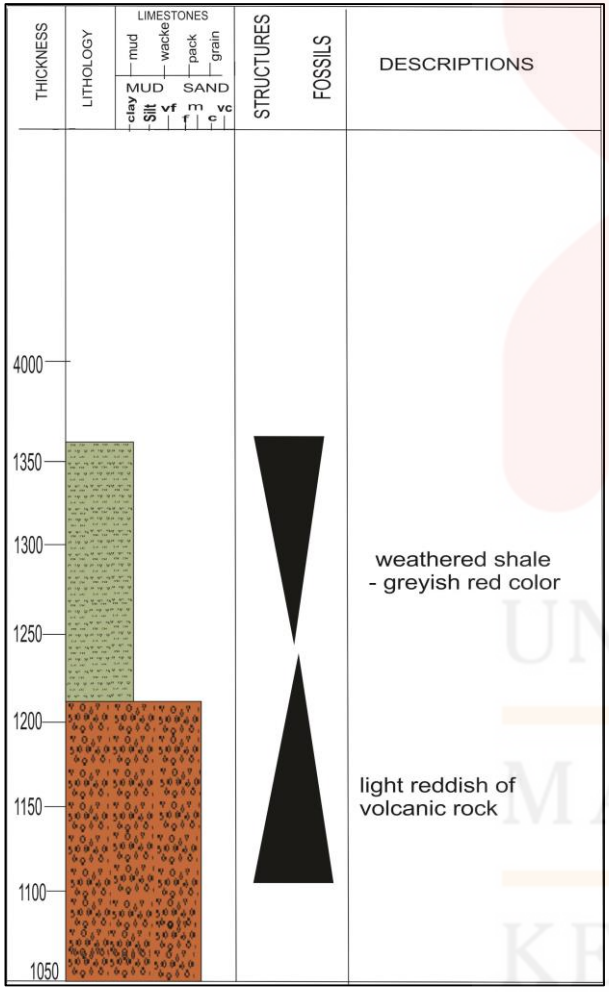


Figure 5.3 Sedimentary log of Location B

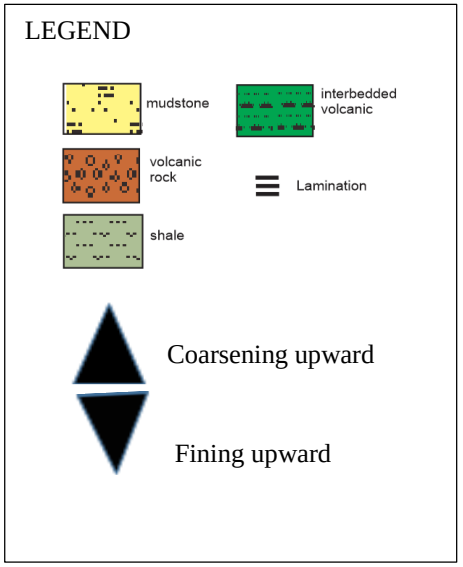


Facies	Facies associated
F2	FA1
F3	
F4	FA2
F1	FA1
F3	
F2	





Facies	Facies associated
F2	FA1
F3	



5.8 Facies and facies asscociation

There are four types of facies at the study area which are mudstone facies (F1), shale facies (F2), volcanic facies (F3) and interbedded volcanic with shale facies (F4). All these facies have associated together as known as facies association or assemblages. There are two types of facies association which are interbedded mudstone and shale (FA1) and interbedded volcanic rock with shale (FA2). There are several characteristic of the facies analysis that need to be consider such as the lithology unit, grain characteristics, the color, mineral composition and the present of sedimentary structures. At the study area, there are lack of the information in sedimentary structural. The lamination is the commonly found that can describe the depositional environment.

5.8.1 Mudstone facies (F1)

Mudstone are commonly made up by the clay minerals and be classified as F1 in the sedimentary log. The thickness of the mudstone consists of thick and thin bedded where can easily observe by the naked eyes. The thickness of thick bedded is among the 70 cm when the thin bedded in 12 cm. the color of this facies are mostly dark grey color and have the sedimentary structures of lamination. The mudstone facies has medium rate of weathering. It is the moderate sorting due to the matrix of clay minerals.

5.8.2 Shale facies (F2)

The shale facies consist of light grey colour and has the grain sized between silt and clay. the sedimentary structural found which is the lamination. The shale facies has the thin bedded thickness and has the sharp and gradational of bedding layers. The shale mostly contains the fossils but they are absence. They shale is the predominantly matrix of clay minerals and it can be the indicator of shallow marine due to the rock colors and mineral.

5.8.3 Volcanic facies (F3)

The volcanic facies is present at the study area show the past history of geological which is relate the volcano system. Bentong-Raub Suture was formed due to the collision between two plate which is Sibumasu and IndoChina. This collision was produced more volcanic eruption due to the plate tectonic movement. At the study area, there are present of pyroclastic rocks such as tuff. For the depositional environment. The tuff shows the volcano system happened at the study area. The eruption of volcano may the result of interbedded tuff. The eruption comes and the pyroclastic were deposited. The process is repeated occurs in the plate tectonic movement.

5.8.4 interbedded volcanic rocks with shale facies (F4)

This facies has the thickness of 310 cm in the bedding layers but it was dominated by volcanic rocks, the color of this facies is the light to color due to the present of iron oxide. It has the bedded layers and the minerals of volcanic rocks is the fine grained where the grains feel gritty when touched it by the hand.

5.9 Depositional environment

The previous research of Gua Musang Formation explained that Lojing area and the surroundings are the shallow marine according to the several indicators such as lithology unit, sedimentary structural and the origin process of collision between Sibumasu and Indochina.

The depositional environment occurs by the process of transgression and regression. Both of this process occur at the marine area on the continental shelf and the result where different facies will be deposited. The both result of facies associated were divided by two types which interbedded mudstone and shale (FA1), and interbedded of volcanic rock with shale whereas the volcanic rock is dominated (FA2).

For the depositional environment of FA1, it can be concluding that the facies are happened at the continental shelf were the mudstone is the fine grain, black color and has the low energy. The other indicator is the matrix minerals are the rounded and it shows that mudstone and shale has the low energy that makes them are deposited not far from their parent rock. For the processes, it is the regression process where the result is the coarsening upward which is coarser from seaward to landward. After the regression of shale, there are

deposited of the mudstone and this process are repeated over the years which effect by the tidal flat process.

The figure 5.4 Show the transgression and regression process which occur at the marine environment. The shale is the indicator at the shallow marine environment. During this process, the differences rock types where deposited and that is the result of the interbedded rocks.

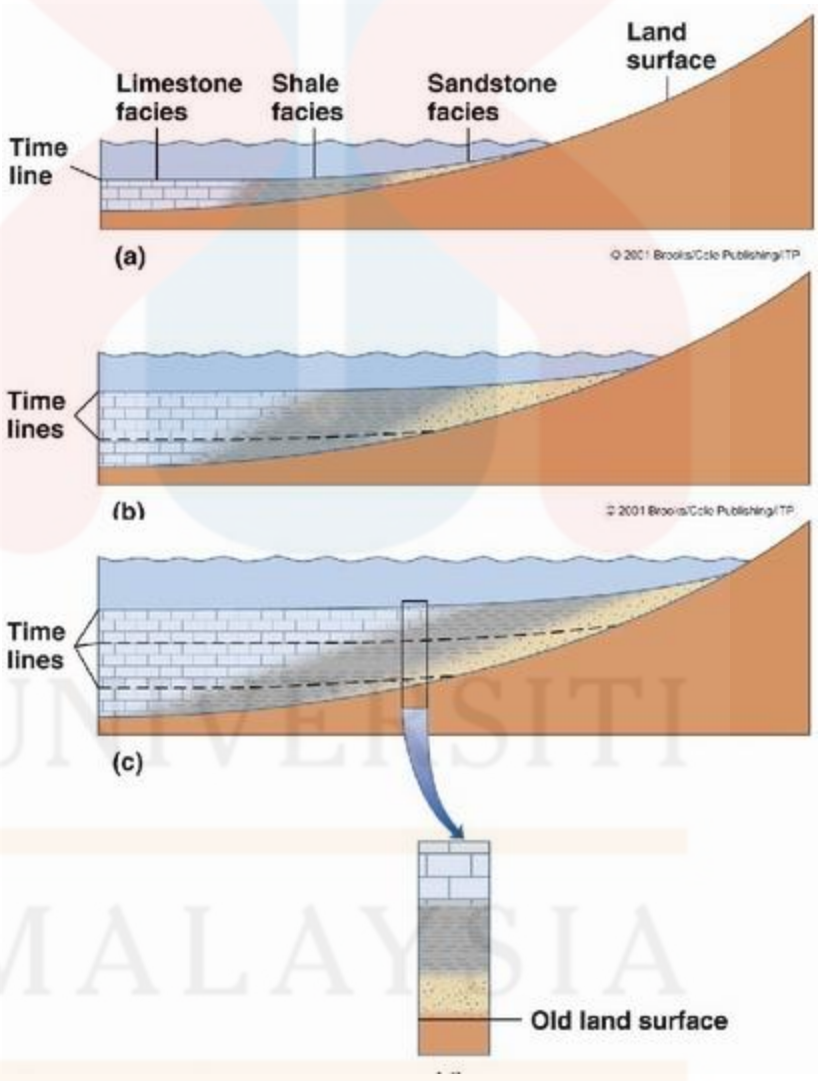


Figure 5.4 The transgression and regression process (Source: Geology ln)

At the study area, there are present of volcanic rocks. The process of volcanic eruption happened during the past years ago and deposited and the marine environment. During the plate tectonic movement and the continuous process, there are the deposition of the shale, mudstone and volcanic materials.

Next facies associated is the FA2 where the interbedded of volcanic rock and shale with dominated by volcanic rocks. The shale is the indicator of the shallow marine depositional environment. From the observation, the process in undergoes the transgression which is fining upward. During the transgression, all small materials are brought by the tidal and energy into from landward to seaward.

5.10 Depositional environment model

Figure 5.5 shows the depositional environment part in sedimentary rock. The facies associated of FA1 and FA2 that happened in depositional environment has been labelled.

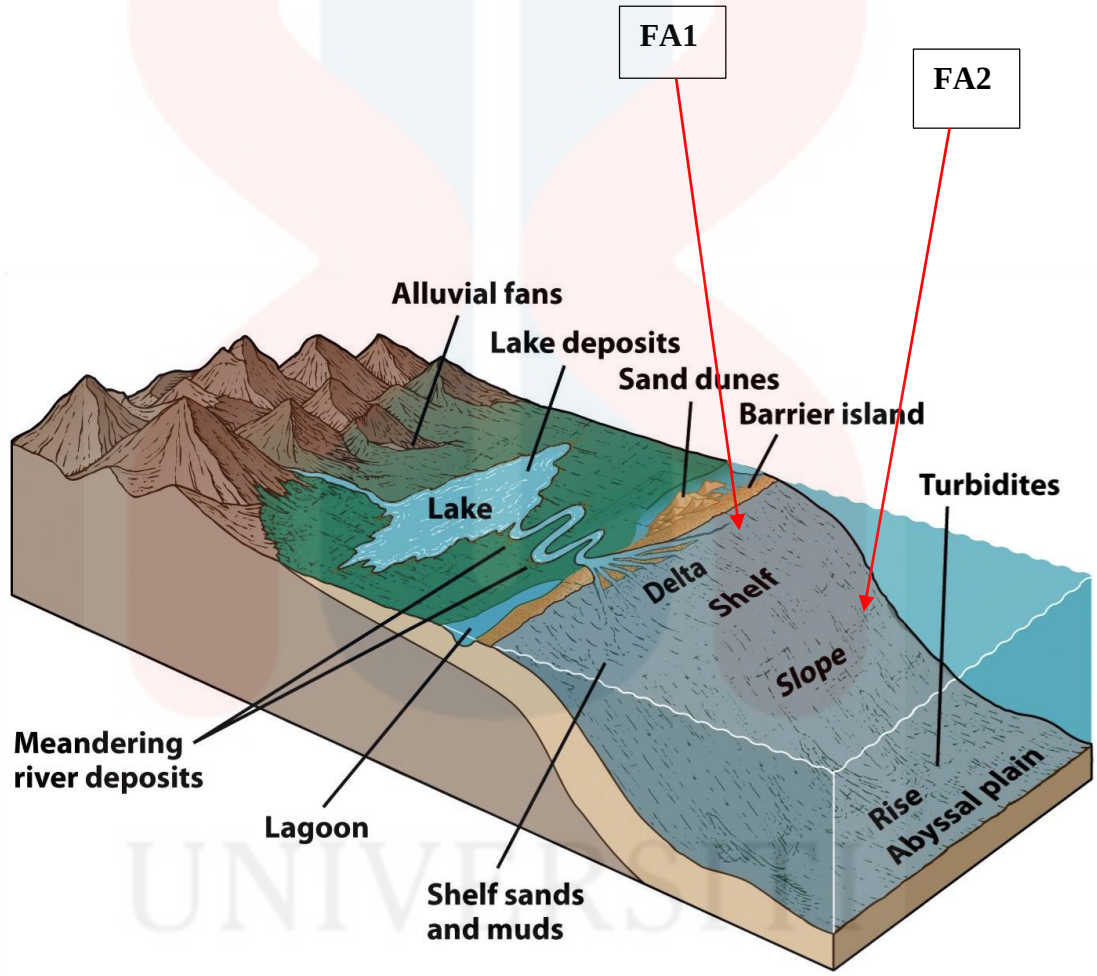


Figure 5.5 The depositional environment model.

(Source: http://www.drillingformulas.com)

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The aim of this research is to produce the geological map of the study area and to identify the lithostratigraphy of Sungai Ulu Raya, Lojing. The geological map consists of four lithologies; limestone, tuff, andesite and alluvium provided with the age starting from late Triassic to Quartenary. The geological map was produced by using ArcGIS software. The geological mapping was conducted done to collect all details of outcrops at the field before the geological map was produced.

The lithostratigraphy of Sungai Ulu Raya, Lojing have been analyzed by using two methods; petrographic analysis and stratigraphic section with correlate all the lithologies unit. From petrographic analysis, there are some minerals that have been identified such as the major minerals which are plagioclase feldspar, alkali feldspar, quartz and mafic minerals such as biotite and pyroxene. These mineral compositions can be identifying under the

microscopic view from the relief, color, cleavage and angle of extinction.

The stratigraphic method is correlate all the lithology unit of stratigraphic column according their geologic time scale, sequence of rock strata with the oldest rock at the bottom and the youngest rock on the top. The other parameters that need to be considered is the sedimentary structural with shows the depositional environment. The sedimentary structural will describe the past geologic at the study area. In this research, the arenaceous, argillaceous and volcanic facies is the indicator to determine the depositional environment. From the facies analysis, it shows that the research area is classified as the shallow marine environment.

As a conclusion, the main objective of this research are achieved when the geological map was produced and the lithostratigraphy of Sungai Ulu Raya, Lojing can be classified with the depositional environment.

6.2 Suggestion

The petrographic analysis of a rock or any lithology is very important to confirm the minerals composition and their distribution. Some of minerals cannot be identified easily under the microscope due to the weathering on the samples. The suggestion of this problem is to use the other analysis method such as soil petrographic analysis. It can detect weathered soil materials such as the clay minerals.

For the calculation of the minerals percentage, there are the software calculation that can be used to calculated the percentage of mineral using the formula. It is the one of the new method that can be used by students nowadays.

The research area has the limited accessibility. Many places at study area cannot be explore, so the data collected also limited. For the solving problem, the selection of study area for the research purpose must be suitable. Therefore, the collecting data will be more quality.

REFERENCES

Azman AGhani, (2005). Geochemical characteristics of S- and I-Type Granites: Example. *Geological Society of Malaysia Bulletin,* 123-134.

Buehler, (2004). Preparation of Petrographic thin section. E-Notes (The sum of our experiences). Vol. 1

Dony Adriansyah Nazaruddin *et. al*., (2014). Geological Studies to Support the Tourism Site: A Case Study in the Rafflesia Trail, Near Kampung Jedip, Lojing Highlands, Kelantan, Malaysia. International Journal of Geosciences, 5, 835-851. http://dx.doi.org/10.4236/ijg.2014.58074

Geoscience, S. o. (2015). Studying Geology. In T. U. o. Edinburgh (Ed.).

Hutchison, C. S. (2009). Bentong Raub Suture in C. S. Hutchison & D. N. K. Tan (Eds.), *Geology of the Peninsular Malaysia.*

Hutchison, C. S. (2014). Tectonic evolution of Southeast Asia. *Bulletin of the Geological Society of Malaysia,60,* 1-18.

Kang-Tsung Chang, (2012). Introduction to Geographic Information System, Sixth Edition, McGraw-Hill International Edition.

Koutsoukos, E. A. (2005). Stratigraphy: Evolution of a Concept. In E. A. KOUTSOUKOS, *Applied Stratigraphy* (pp. 3-19). Netherlands: Springer.

Lyell, C. (1854). *Principles of Geology* (9 ed.): University of Adelaide.

Koutsoukos, E. A. M. (Ed.). (2005). *Applied Stratigraphy* (Vol. 23): Springer.

Malaysia, G. S. o. (2010). Structural geology of Gua Musang Formation in Kelantan. Warta Geologi Geological Society of Malaysia (GSM). 36.

Metcalfe, I. (2000). The Bentong–Raub Suture Zone. *Journal of Asian Earth Sciences, 18*, 691-712.

Mohamed K.R, et al. (2016). "The Gua Musang Group: A newly proposed stratigraphic unit for the Permo-Triassic sequence of Northern Central Belt, Peninsular Malaysia." Bulletin of the Geological Society of Malaysia 62: 131-142.

Mustaffa Kamal Shuib, (2009a). Major Faults. In Hutchison, C. S., & Tan, D.N.K. (Eds). Geology of Peninsular Malaysia (pp. 249-269). Malaysia: University of Malaya and Geological Society of Malaysia.

Njue, L.M. (2010). Short Course V on Exploration for Geothermal Resources. GEOLOGICAL FIELD MAPPING

Nur Azuki Yusuff. (2008). A study on the acceptance of visitors by the Lojing community and the understanding of. 1-9.

Protero, D. R., & Schwab, F. (2014). Sedimentary Geology: An Introduction to Sedimentary Rocks and Stratigraphy (2nd ed.). Content Technologies.

Rogerio Rocha, et al. (2013). First International Congress on Stratigraphy At the Cutting Edge of Stratigraphy. Earth Sciences Department, Centre in Geological Science & Engineering International Comission on Stratigraphy (IUGS).

Tjia, H. D., & Almashoor, S. S. (1996). The Bentong Suture in Southwest Kelantan, Peninsular Malaysia. *Geology Society Malaysia,* 195-211.

W. A., & Voort, G. V. (2015). Tech Notes. Petrographic Examination Methods, 3(5). Retrieved December 3, 2018, from https://www.buehler.com/China/solutions/technotes/vol3_issue5.pdf.

In, G. (1970, January 01). How to Identify Transgression and Regression in a Sedimentary Outcrop? Retrieved from http://www.geologyin.com/2015/09/how-to-identify-transgression-and.html

Yin, E.H., (1965). Provisional Draft Report on the Geology and Mineral Resources of the Gua Musang Area, Sheet 45, South Kelantan. Geological Survey of Malaysia, 49 pp (unpublished).