# GEOLOGY AND FORAMINIFERA OCCURRENCE AT CHIKU 3, GUA MUSANG KELANTAN

**by**

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

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## DECLARATION

I declare that this thesis entitled "Geology and Foraminifera Occurrence at Chiku 3, Gua Musang, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature: …………………………………..

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Date : …………………………………..

# 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 of the award of the degree of Bachelor of Applied Science (Geoscience) with Honors".

Signature: ………………………………….

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Date : ………………………………………….

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## GEOLOGY AND FORAMINIFERA OCCURRENCE AT CHIKU 3, GUA MUSANG, KELANTAN


## ABSTRACT

This research entitled Geology and Foraminifera Occurrence at Chiku 3, Gua Musang, Kelantan. The area of mapping study is located at Chiku 3 area. Three objectives was provided which is to update the geological map of study area with scale of 1:25000, to identify the occurrence of foraminifera in study area and to identify its paleo-environment based on foraminifera occurrence. To complete this research, field observation and and sampling method were done during geological mapping activity. While for the specification part, foraminifera been process through crushing, sieving and drying method and then was analyzed through picking and sorting method for the naming of it species. From the geological mapping activity, study area consists of four lithology unit which is pyllite unit, tuff unit, mudstone unit and limestone unit. From the analysis, the occurrence of foraminifera in Chiku 3 was dominantly by benthic foraminifera. Besides, in order to identify its paleo-environment, the paleobathymetry determination is used by using benthic foraminifera as indicators. Based on paleobathymetry determination, the paleo-environment of the area is from Middle Neritic zone – Outher Neritic zone with the depth around 30-200 m. Hence, this research was significant because the geological information can be used to construct a new geological map and the study of foraminifera occurrence are ideal because its paleo-environment can be identified.

# GEOLOGY DAN KEJADIAN FORAMINIFERA DI CHIKU 3, GUA MUSANG, KELANTAN


## ABSTRAK

Kajian ini bertajuk Geologi dan Kejadian Foraminifera di Chiku 3, Gua Musang, Kelantan. Kawasan kajian pemetaan terletak di kawasan Chiku 3. Tiga objektif disediakan iaitu untuk memperbaharui peta geologi kawasan kajian dengan skala 1: 25000, untuk mengenal pasti kejadian foraminifera di kawasan kajian dan untuk mengenal pasti alam sekitar paleo berdasarkan kejadian foraminifera. Bagi menyelesaikan kajian ini, pemerhatian lapangan dan kaedah pensampelan dilakukan semasa aktiviti pemetaan geologi. Manakala untuk bahagian spesifikasi, foraminifera telah diproses melalui kaedah penghancuran, pengencangan dan pengeringan dan kemudian dianalisis melalui kaedah pemilihan dan pengisihan untuk penamaan spesies itu. Dari aktiviti pemetaan geologi, kawasan kajian terdiri daripada empat unit lithologi iaitu unit pyllite, unit tuff, unit mudstone dan unit batu kapur. Dari analisis foraminifera, kawasan Chiku 3 dikuasai oleh foraminifera benthik. Selain itu, untuk mengenalpasti persekitaran paleo, penentuan paleobathymetry digunakan dengan menggunakan foraminifera benthik sebagai penunjuk. Berdasarkan penentuan paleobatik, persekitaran paleo dari kawasan itu adalah dari zon Neritik Tengah - zon Nistis Keluar dengan kedalaman sekitar 30-200 m. Oleh itu, kajian ini adalah penting kerana maklumat geologi boleh digunakan untuk membina peta geologi baru dan kajian kejadian foraminifera adalah ideal kerana alam paleo-nya boleh dikenalpasti

# TABLE OF CONTENTS

## LIST OF ABBREVIATIONS

| | |
|---|---|
| **GIS** | Geographic Information System |
| **GPS** | Global Positioning System |
| **SEM** | Scanning Electron Microscope |
| **PPL** | Plain Polarized Light |
| **XPL** | Cross Polarized Light |
| **$CaCO_3$** | Calcium Carbonate |
| **N** | North |
| **E** | East |
| **S** | South |
| **W** | West |
| **HCL** | Hydrochloric Acid |

# LIST OF SYMBOLS

| | |
|---|---|
| **%** | Percentage |
| **°** | Degree |
| **‘** | Minute |
| **“** | Second |
| **°C** | Degree Celsius (Temperature) |
| **km** | Kilometer |
| **µm** | Micron meter |
| **m** | Meter |
| **$O^2$** | Oxygen |
| **Fe** | Ferrum |
| **mm** | Milimeter |

## LIST OF TABLES

## LIST OF FIGURES

# CHAPTER 1

# INTRODUCTION

## 1.1 General Background

A detailed geological mapping study and specification of foraminifera occurrences has been conducted in Chiku 3 area, Gua Musang, Kelantan. The area of mapping study located at southern part of Kelantan covered oil palm plantation area. The data of geological mapping covered the 5 km x 5 km coverage of study area at which the distribution of foraminifera was preserved within the sedimentary rock mainly focused on Gua Musang Formation.

Foraminifera are single-celled organisms that evolve rapidly through time and are sensitive to depositional setting. The calcareous parts of its shell fragment fall down slowly toward the bottom of the sea. By the time, it slowly deposited by the mud and sediment on top of their layer becoming the part of the sedimentary layer. Study of foraminifera has been choose because of its abundance and rapidly evolved in wide environmental range and becoming one of the great factor for regional stratigraphy study.

## 1.2 Study Area

This subtopic will explain more information about the location of study area, the road connectivity, demography, land use and the social economic of people living focused in study area.

### 1.2.1 Location

The location of study area lies in Chiku 3 which is officially one part of the Gua Musang District and located at the southern part of Kelantan as shown in Figure 1.1. Basically the study area was covered box of 5km x 5km. The main road to access the study area was from Gua Musang (town) to Kuala Berang (town). The highest elevation was 280 m, while the lowest elevation was around 160 m above the sea level. Figure 1.2 show the base map of study area.

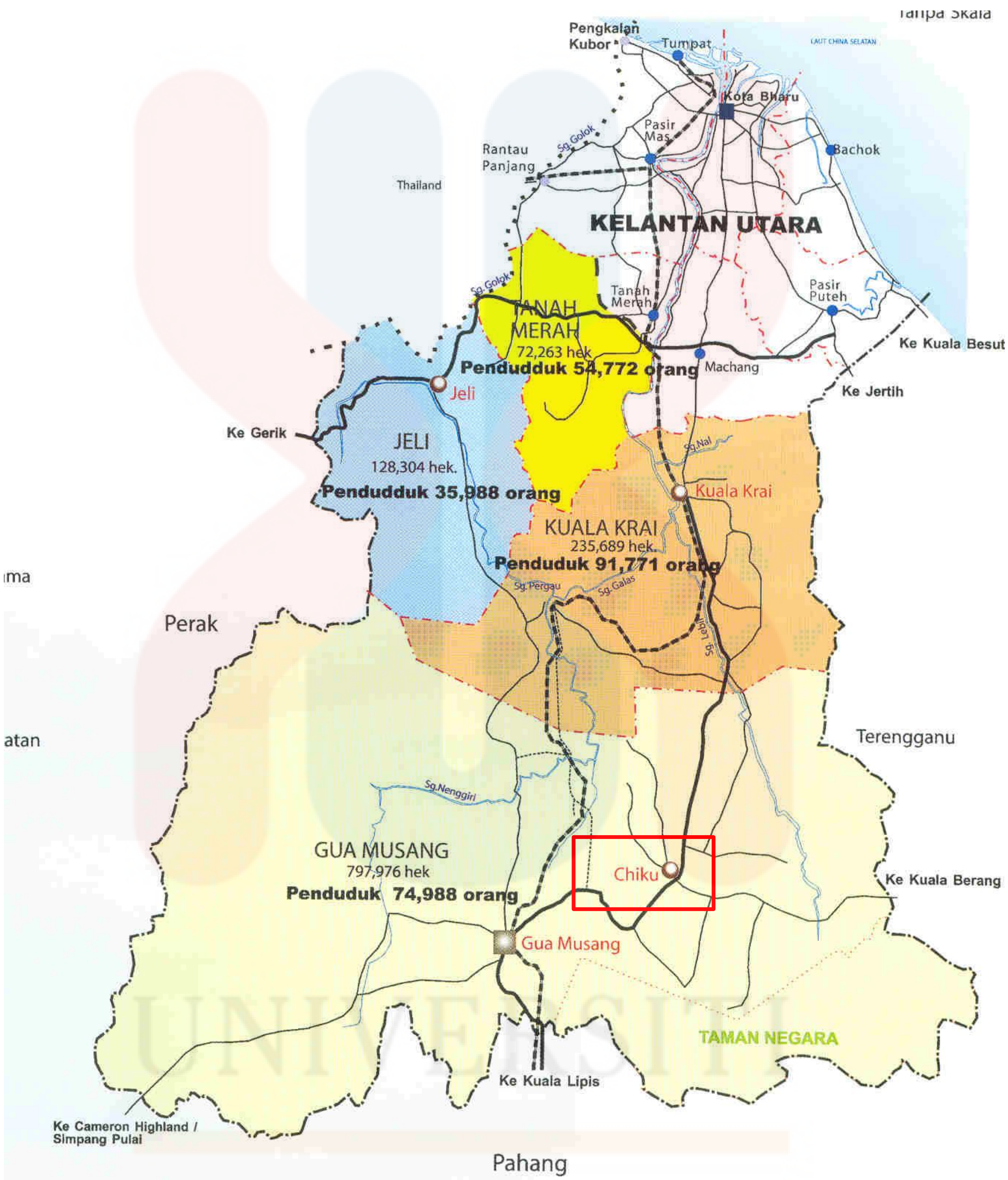



**Figure 1.1:** Location map of study area

(Sources: Google Image, 2014)

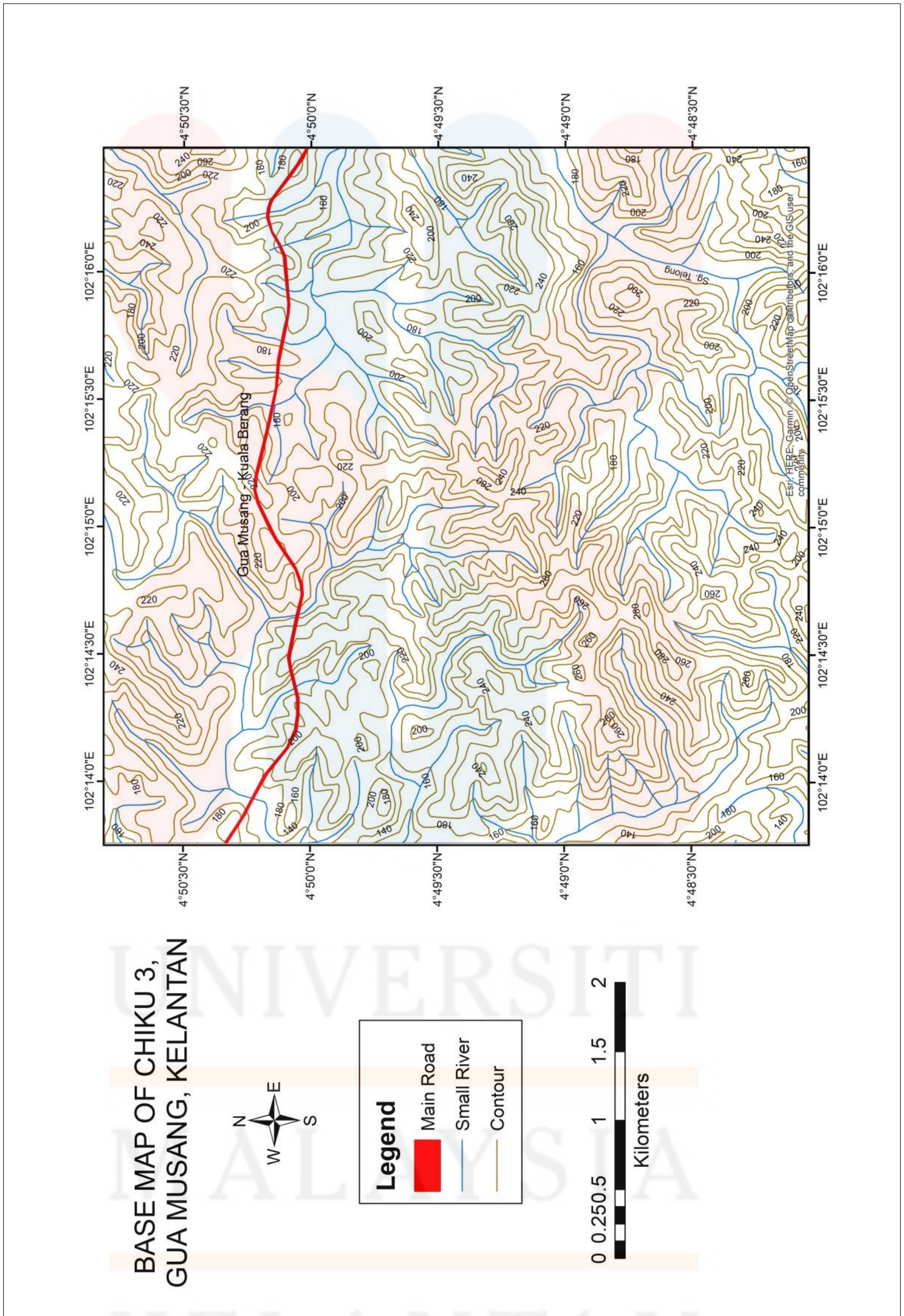



**Figure 1.2:** Base map of Chiku 3

### 1.2.2 Road Connectivity



The main road that found in the study area was a pave road connecting from Gua Musang to Kuala Berang as shown in Figure 1.3. Accessibility from these two towns to study area was easier because it can be access by vehicles by the main road.

**Figure 1.3:** Main road connecting Kuala Berang (town) to Gua Musang (town).

### 1.2.3 Demography

Fauzi and Hussin (2012) states that before 1976, Gua Musang District was placed under the administrative center of Ulu Kelantan District covering Kuala Krai and Gua Musang. At that time, Kuala Krai was the administrative center and in 1976, the status of sub-district was given to the Gua Musang. In September 1977, Gua Musang sub-district was changed to full-district and it was the ninth district in Kelantan. Table 1.1 below shows people distribution in each district of Kelantan

**Table 1.1:** People Distribution in Kelantan by each district in 2000-2015

| Bil | District | 2000 | 2010 | 2015 |
|---|---|---|---|---|
| **1.** | Bachok | 111,040 | 133,152 | 149,4000 |
| **2.** | Kota Bharu | 406,662 | 491,237 | 563,000 |
| **3.** | Machang | 79,032 | 93,087 | 100,000 |
| **4.** | Pasir Mas | 165,126 | 189,292 | 205,300 |
| **5.** | Pasir Puteh | 106,138 | 117,383 | 124,200 |
| **6.** | Tanah Merah | 103,487 | 121,319 | 136,700 |
| **7.** | Tumpat | 134,812 | 153,976 | 168,900 |
| **8.** | Gua Musang | 76,655 | 90,057 | 104,400 |
| **9.** | Kuala Krai | 93,550 | 109,461 | 120,900 |
| **10.** | Jeli | 36,512 | 40,637 | 120,900 |
| | **Total** | 1,313,014 | 1,539,601 | 1,718,200 |

(Source: Jabatan Perangkaan Malaysia Negeri Kelantan, 2016)

In this study area, most of the people distribution is a community from two large agencies which is KESEDAR and FELDA. From the year of 2000, the total number of the population in Gua Musang area was 76,655 people. While in 2010, the total of the population increasing to 90,057 and the recent one in 2015, Gua Musang has a population of 104,400 people. This shows that people distribution in Gua Musang District was increases by each year.

### 1.2.3 Land Use

The South Kelantan Development Authority (KESEDAR) and the Federal Land Development Authority (FELDA) are the two main agencies that develop land schemes in the district of Gua Musang, Kelantan. Most of the schemes under FELDA were planted with oil palm (84.7%) while the rest was rubber trees. While, under KESEDAR, most of the land schemes was planted with rubber (67%) and the remains were planted with oil palm. In the study area, oil palm plantation is the main soil used and some part of study area still covered by thick forest.

### 1.2.4 Social Economic

The social economy of the study area mainly depends on the agricultural activities. Mostly study area was occupied by the oil palm plantations. Most of the population in this area generated income through planting rubber and palm oil (Fauzi & Hussin, 2012). Table 1.2 and 1.3 below shows the production of the oil palm plantation and rubber for both agencies, FELDA and KESEDAR.

**Table 1.2:** FELDA Gua Musang: Acreage of oil palm plantations in 2008.

| Scheme | Acreage of crops (hectare) | | Production (M/tonnes) |
|---|---|---|---|
| | Planted | Harvested | |
| Kemahang 1 | 1957.15 | 1957.15 | 23,877.15 |
| Chiku 1 | 1806.04 | 1806.04 | 28,611.92 |
| Chiku 2 | 1204.74 | 1204.74 | 20,665.12 |
| Chiku 3 | 788.40 | 788.40 | 12,261.56 |
| Chiku 5 | 1217.63 | 1217.63 | 17,104.71 |
| Chiku 6 | 832.56 | 832.56 | 13,886.43 |
| Chiku 7 | 1106.85 | 1106,85 | 19,226.22 |
| Perasu | 806.67 | 806.67 | 11,684.57 |
| Aring | 832.46 | 832.46 | 11,586.64 |
| Total | 10552.5 | 10552.5 | 158,904.32 |

(Source: FELDA Gua Musang office, June 2009)

**Table 1.3:** KESEDAR Gua Musang: Acreage planted with oil palm and rubber in 2008.

| Scheme | Number of settlers | Category of crops (hectares) | |
|---|---|---|---|
| | | Palm oil | Rubber |
| **Paloh 1** | 267 | 1203.88 | 429.70 |
| **Paloh 2** | 302 | 1113.80 | 480.86 |
| **Paloh 3** | 315 | 1420.14 | 942.86 |
| **Chalil** | 188 | 1136.80 | 462.59 |
| **Lebir** | 189 | - | 473.21 |
| **Meranto** | - | - | - |
| **Sungai Terah** | 357 | 12 | 910.67 |
| **Renok Baru** | - | - | - |
| **Jeram Tekoh** | 356 | 182.66 | 1655.60 |
| **Limau Kasturi** | 446 | - | 3895.00 |
| **Sungai Asap** | 250 | - | 1377.40 |

Source: FELDA Gua Musang office, June 2009

## 1.3 Problem Statement

Gua Musang formation consists of various numbers of foraminifera distribution which few study were being made. The location along the main road from town of Kuala Berang to town of Gua Musang has been known as the most abundant Triassic fossil within the Central Belt in Peninsular Malaysia. The discovery of this site started on 2008 when there was a constructional work done in study area where the hills has been cut in order to open a new road from Gua Musang town to Kuala Berang (Dony Adriansyah Nazaruddin & Ahmad Rosli Othman, 2014).

Geological information like geomorphology, lithology and structural geology about Chiku 3 area was difficult to find because there is no geology research done there yet. Besides, there a none of research about foraminifera study in Chiku 3 area. Another problem arise in study area is either there are abundant of foraminifera or not. From the past research, there are the present of foraminifera at Gua Musang Formation, but around the study area need to do the investigation first through mapping activity.

## 1.4 Objectives

I. To update the geological map of study area of scales 1:25000.
II. To determine the occurrence of foraminifera in the study area.
III. To interpret the paleo-environment of the study area based on foraminifera abundance.

## 1.5 Scope of study

This research study was focused on geology and foraminifera occurrences around study area of Chiku 3, Gua Musang, Kelantan. It covered 5km x 5km coverage of study area. Generally, this research was focus at the Chiku area which part of Gua Musang Formation. Other than that, general geology aspects such as geomorphology, geology structure and lithology were observed along the study area. Method and materials that used like geology hammer, measuring tape, hydrochloric acid, coin, brush, hand lanses, GPS and stationary. Petrography of rock will be determined through thin section process and prepared the sample to be examined under the polarized microscope. All the data and information were gathered and used in order to produce a geological map with scale of 1:25000. Besides the geological mapping, the study of foraminifera occurrence also being made in order to identify the variation species of foraminifera found within the study area.

## 1.6 Significant of study

This research about the geology and foraminifera occurrences was significant because the geological information about study area was used to construct a new geological map. Through that, it will give new information about geology and foraminifera study of research area. On the other hand, study about foraminifera abundance species are ideal because its paleo-environment can be identified. It also contributed to the industry to develop the study area as a paleontological site for future research on paleontological study.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

The purpose of conduction this literature review was to obtain the information and research data from the previous works which is related to the few aspect such as study area, research of general geology and the analysis of previous researcher. All of this information and data was collected from the journals, thesis, bulletin and books. Literature review will be very helpful in providing the general background of the research scope and as the guidance in this thesis report writing.

## 2.2 Regional Geology and Tectonic Setting

According to Tan (1983), Peninsular Malaysia was divided into three main belts which is western, central and eastern belt. All of these three belts were different from a few aspects like lithology, age, tectonic, structure and paleogeography.

Kelantan is located at the north east of Peninsular Malaysia and its coordinates lies between longitude 101º 20’ to 102º 41’E and latitude 4º 33’ to 6º 14’ N. State of Kelantan also share it boundaries with other state like Perak to west, Terengganu to east and Pahang to south. Kelantan can be divided into ten administrative district and district on north like Tumpat, Kota Bharu, Pasir Mas, Bachok, Tanah Merah, Machang and Pasir Puteh while three district on southern part which is Jeli, Kuala Krai and Gua Musang .

### 2.3 Bentong-Raub Suture Zone

Bentong-Raub Suture Zone as shown in figure 2.1, basically is a collision zone that happened between Sibumasu and East Malaya terranes. Bentong-Raub Suture Zone passed through the Raub and Bentong to the east Malacca and Peninsular Malaysia from Thailand. The Main Range granitoid's eastern limited in Peninsular Malaysia occupied by this Bentong-Raub Suture Zone. Bentong-Raub Suture Zone was a wide zone that located about 20 kilometers. There are few reasons why Bentong-Raub Suture Zone was formed. Firstly, it caused by the Palaeo-Tethys ocean lies on the bottom of East Malaya in Late Paleozoic through subduction process. Secondly, the collision of Sibumasu terrance and the underthrusting of East Malaya (Metcalfe, 2000).

In Late Paleozoic, subduction process was occurred when the Palaeo-Tethys oceans lies on the bottom of East Malaya. In order to destroy the Palaeo-Tethys's ocean, volcanic arc is needed. The oceanic island arc undergoes subduction process and marginal oceanic basin's closure to accrete into Sibumasu in the late Permian. Before Early Permian, Sibumasu will break down from Gondwana (Metcalfe, 2000).

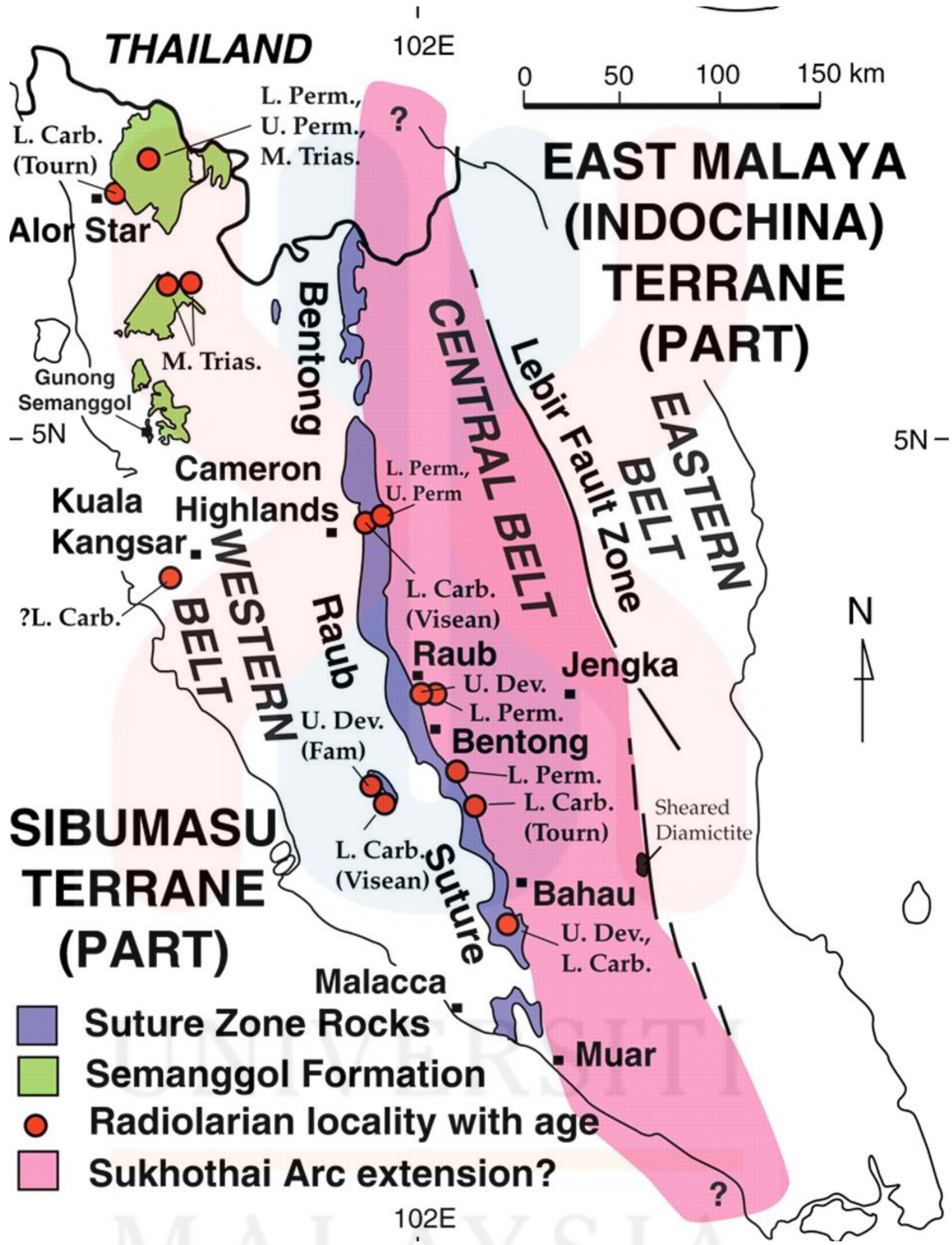



**Figure 2.1:** Bentong-Raub Suture (Metcalfe, 2011)

## 2.4 Stratigraphy and Sedimentology

Kamal Roslan (2006) divided stratigraphically the southern Kelantan into four areas which is Kuala Betis, Gua Musang, Aring and Gunung Gagau. Research area was located in Chiku area within the Central Belt of Peninsular Malaysia. Gua Musang tectonic setting was Gua Musang Formation. According to Mohd Shafeea Leman, (1993 and 2004) the Middle Permian to Upper Triassic Gua Musang Formation was mapped by Yin (1965) in south Kelantan. This formation was estimated to be 650 thick, made up of crystalline limestone, interbedded with thin beds of shale, tuff, chert nodules and subordinate sandstone and volcanic. The light grey calcitic limestone was hard, non-porous, brittle and splintery. Small amounts of carbonaceous, argillaceous and pyroclastic impurities are present in the grey to black varieties of the often recrystallized limestone. Few structures can be detected such as traces of bedding, cross lamination and oolites. The limestone occurs as lenses, forming cliff bound ridges and rows of isolated tower-like hills from the flanks of the granite mass around Bukit Raja Muda and extends northward to Gua Musang.

The stratigraphy of the Gua Musang exist in Central Belt as shown in figure 2.2 that stretches from Kelantan to Johor between the eastern foothills of the Main Range and forming its western boundary to eastern boundary identified by the Lebir Fault in the north own to the western boundary of Dohol Formation in the south according to Hutcinson (1973d).

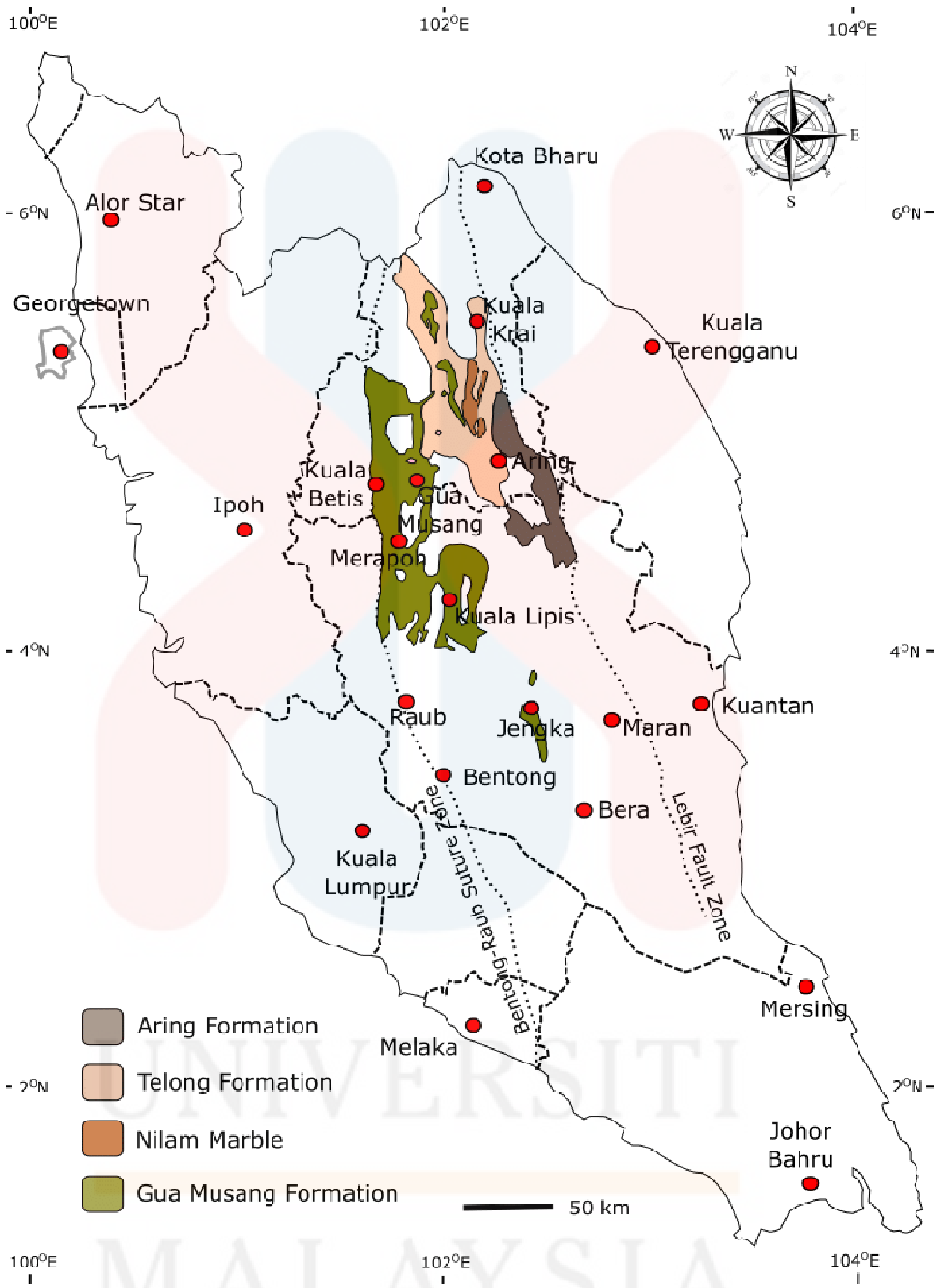



**Figure 2.2:** Location of Gua Musang formation

(Source: Geological Society of Malaysia, December 2016)

## 2.4 Structural Geology

Land mass of Peninsular Malaysia there were at least four tectonic activities occurred during the Palaeozoic and Mesozoic era and the most prominent occurring during the Triassic period.

The Peninsular have a NNW-SSE elongated shape of general structural trend that influenced by the distribution of the Main Range Granite, as backbone of Peninsula (Shuib, 2009). As reflected by strike ridges illustrated in the lineament map. The main structural trend of the Peninsula is NNW-SSE was defined by the strike of bedding and lithological boundaries, axial traces of folds and the strike of axial planes. This NNW-SSE general structural trend is superimposed by later N-S, NW-SE, NNE-SSW and E-W major faults.

Recent studies, based on satellite and Shuttle radar imagery, have identified more major fault. Tjia (1989) used a combination of both LANDSAT and SPOT imageries to illustrate the major faults and recognized four main and two minor lineament trends that well interpreted as major faults. Figure 2.3 shows the distribution of major faults based on published information and SRTM DEM interpretations. Major faults are taken to be those that exceed a total length of more than 50 km (Mustaffa Kamal Shuib 2009).

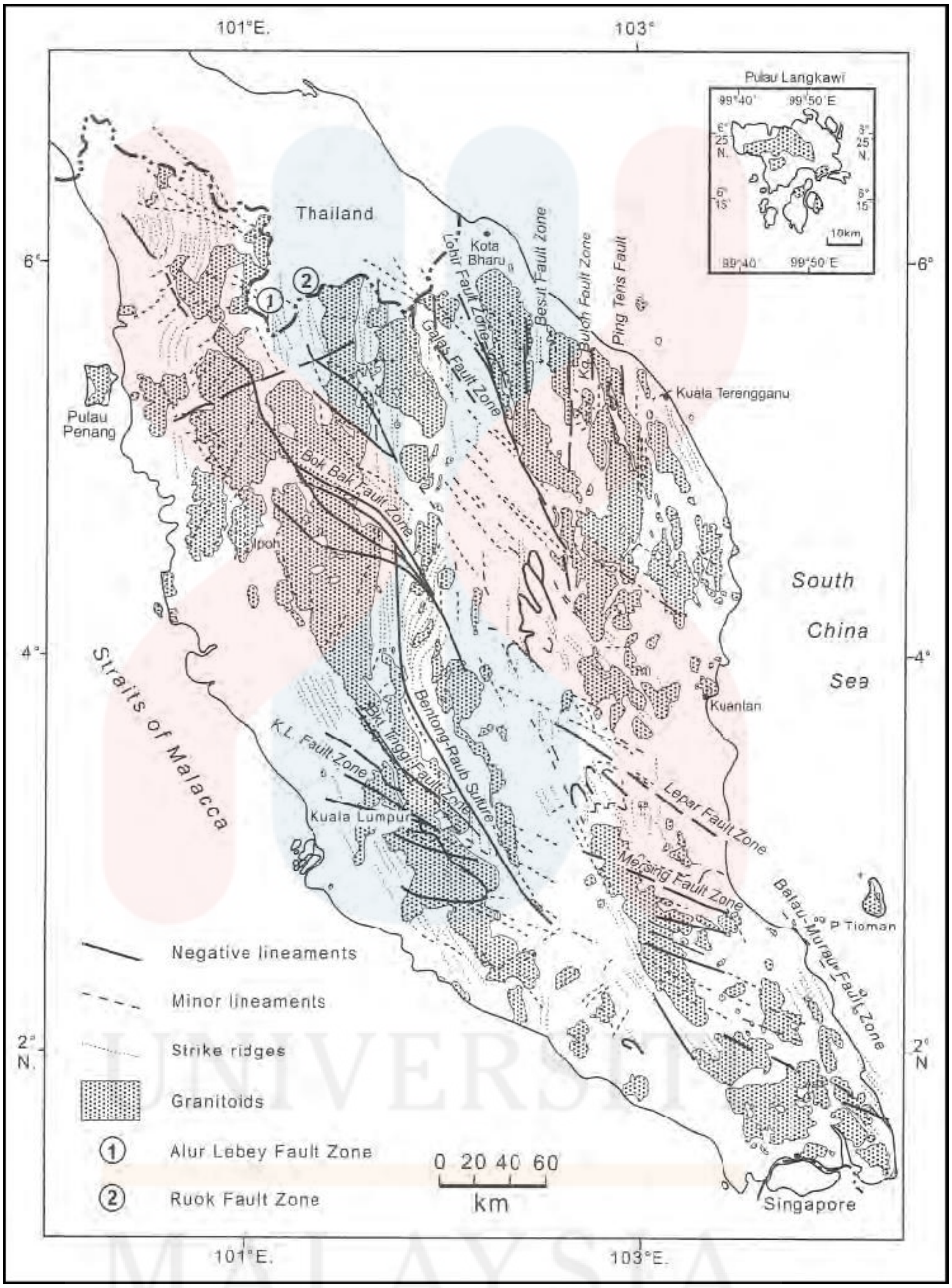



**Figure 2.3:** Interpretation of major lineaments as major faults of the Peninsula

(Source: Department of Minerals and Geoscience Malaysia, 2003)

The structures of the Peninsula reflect a long and complex tectonic evolution, possibly started early as Cambrian up to the Cenozoic. The boundary between the Central and Eastern Belts is marked by the Lebir Fault Zone (Mustaffa Kamal Shuib 2009).

Field evidence from Upper Palaeozoic and Mesozoic strata exposed in Peninsular Malaysia demonstrates that the structural style, degree and orientation of folding, axial-plane cleavage and faulting in Triassic, Jurassic and Cretaceous rocks of the central basin are remarkably similar. In contrast, the Upper Palaeozoic strata, especially the Carboniferous rocks exposed in the eastern part of peninsular, show multiple phase folding and regional metamorphism unlike anything seen in the Mesozoic rocks. The Raub- Bentong line was an important fault zone active during the Mesozoic but does not appear to have been a major tectonic suture since the Late Palaeozoic (Harbury *et. al,* 1990).

Gua Musang is also being part of the Bentong- Raub Suture Zone. According to previous study, it shows that the rocks within the suture along the East-West Highway can be divided into at least seven tectonic units that form an imbricate structure (Hutcinson 1973d). They are in high-angle fault contact with each other. Zones of sub-vertical to steep NE-dipping reverse to dextral reverse phyllonites or mylonites, striking NW-SE.

## 2.5 Historical Geology

According to (Bemmelen, 1949), Peninsular Malaysia with total land area of 130,268 $km^2$, forms part of Sundaland included Borneo, Java and Sumatra. The Peninsular is elongated in a general NNW-SSE direction with a maximum length of 750 km and breadth of 330 km. It separated from Singapore Island by the narrow Johor Strait whilst to the south and to the west, it separated from Sumatra Island by the Straits of Malacca (Raj, 2009). The peninsula can be subdivided into three belts characterized by different stratigraphy (Peng L. C., Palaeozoic Stratigraphy , 2009). The system range in Peninsular Malaysia started from the Cambrian to Quaternary which is from 570 million years to 10,000 years ago.

## 2.6 Foraminifera Occurrence

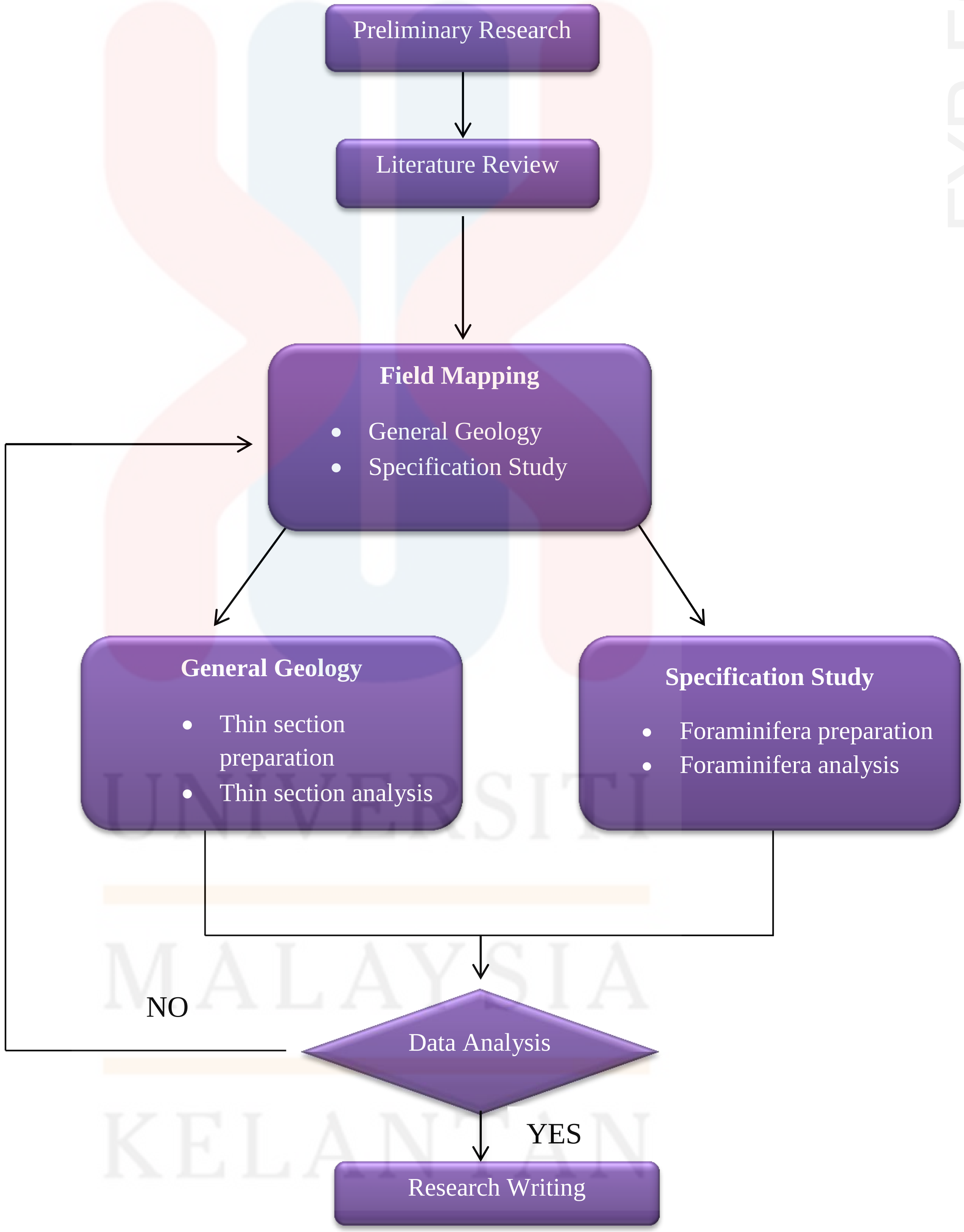
Microscopic, single-celled organisms called foraminifera hold the fossil record that extends from today to more than 500 million years ago. Although each of foraminifera consist of single cell, but they managed to build a complex shells around themselves from minerals in seawater. The shells are commonly divided into chamber that are added during growth, through the simplest forms are open. Depending on the species, the shell may be made of organic compounds, sand grains or other particles cemented together or crystalline $CaCO_3$. Foraminifera are among the most abundant shelled organisms in many marine environments. According to Wetmore, the study of foraminifera was useful in biostratigraphy, paleoecology and oil exploration fields. In terms of biostratigraphy, foraminifera provide evidence of the relative age of marine rock layers. This is because, they have been around since the Cambrian and they show fairly continuous evolutionary development. Thus, different species are found at different times and different environment. Fossil is an important key for us to learn about the past ancient environment. Foraminifera have been used to map past distributions of the tropics, locate ancient shorelines and to track global ocean temperature changes during the ice ages. If a sample of foraminifera contains many extant species, the present-day distribution of those species can be used to infer the environment at that location when fossils were alive. But, if the sample contains mostly extinct species, there are still numerous clues that can be used to infer past environments.

# CHAPTER 3

# MATERIALS AND METHODOLOGIES

## 3.1 Introduction

The materials and method that applied in this research was discuss briefly in order to make sure the progress of the research run smoothly.


Preliminary Research
Literature Review
Field Mapping
General Geology
Specification Study
General Geology
Thin section preparation
Thin section analysis
Specification Study
Foraminifera preparation
Foraminifera analysis
NO
Data Analysis
YES
Research Writing

## 3.2 Materials/Equipment

There are basic equipment that used in this geological mapping in order to obtain the data. The materials needed are:

i. Field Mapping

**a) Geological Hammer**

The two types of geological hammer had been used in this mapping study was tip pointed geological hammer and chisel typed geological hammer which has a slightly curved chisel-shaped blade. Hammer was used to break the outcrop in order to obtain a fresh sample for sampling purpose. Tip pointed geological hammer was used to break the hard rock such as igneous and metamorphic rock while chisel typed was used for fossil collections.

**b) Compass**

Compass was used to find the orientation of North, East, West and South direction. It also been used to find the strike and dip reading of the outcrop. There are two types of compass which is Suunto and Brunton compass.

**c) Global Positional System (GPS)**

GPS was used to mark and record the location (coordinate) of the outcrop, tracks, and waypoints that been observed in study area.

**d) Hand lenses**

Hand lenses being used for the observation of features that small in size such as to identify fossils, texture and mineral composition of the rock.

**e) Field notebook and complete stationary items**

Field notebook was compulsory equipment needed to write all the information and data that obtain from fields. These data were used as references during research writing.

**f) Sample bags**

Sample bags were used to store the samples before the samples being identify for laboratory analysis. Sample bags were labeled with coordinate, locality, name and date to avoid the confusion of the samples.

**g) Hydrochloric acid**

HCL solutions were used to observe the presence of calcium carbonate (calcite) mineral in rocks. If there were the presence of the calcium carbonate, it will react by give out the bubbles to the surface of the rocks.

**h) Measuring tape**

Measuring tape was used to measure the length of the outcrop to make sure the outcrop was map able in the map.

**i) Camera**

Camera was used to capture the image of the outcrop, sample and structure at fields. The image also been used as evidence during the presentation and report writing.

**j) Base Map of Study Area**

This base map was produced using ArcGIS software and used as reference about study area. The component that contains in this base map was street, main river, contour and town.

ii. Laboratory analysis for thin section

**a) Polarized light microscope**

In order to observe the composition of rock minerals and three-dimensional structure of microfossils specimens, polarized light microscope was needed.

**b) Thin section slide**

Thin section slide generally is a product of the thin section process. Mineral types and foraminifera species can be identified from this thin section slide. There are four steps involved in this thin section slide preparation.

iii. Laboratory analysis for foraminifera

**a) Crusher**

To crush all the rock samples to small pieces.

**b) Sieve**

To sieve each sample to a smaller amount of sediment grains with foraminifera sample. There are 3 difference mesh being used which is 63µm, 125µm and 250µm.

**c) Hydrogen peroxide**

The solution of hydrogen peroxide was used to separate the sediment from the large size of samples into a smaller size.

**d) Water**

Water was used to wash the sample during sieving process. While during picking and sorting process, water plays an important role to transfer the foraminifera samples from the black plate into foraminifera storage slide.

**e) Dry oven**

After the sieving process, the sedimentary sample will be left dry in the oven for 4 hours at the temperature of 38ºC.

**f) Stereoscopic microscope**

Stereoscopic microscope was used to analyse the foraminifera sample using picking and sorting technique.

**g) Foraminifera plate storage slide**

Black plate was used to collect all the foraminifera sample and places into its box. All the foraminifera picked have been sorted and grouped according to its species and family.

**h) Brush**

Used during the picking and sorting process, to pick and sort the foraminifera samples under stereoscopic microscope. The brush used was 000 size.

**i) Glue**

Used to glue the foraminifera sample collected to foraminifera plate storage slide.

## 3.3 Methodology

### 3.3.1 Preliminary studies

Preliminary studies are included early research done before going to field by starting to collect the information based on the previous research. It also included the studies from the map and literature review from the journals to get the general idea about the topics. The main objective of this preliminary study is to ensure that our research was not overlapped with other researchers.

### 3.3.2 Field Study

A field studies is about the investigation of the study area by visiting the study area, making an interpretation and do the observation. All the area in the box was covered and the outcrop and structure that found in study area were observed. All pictures of the outcrop were captured using a camera with a proper scale and noted all the data in field note book.

i) General Geology

**a) Traversing**

In field mapping, traverse method was used in order to find the location of the outcrop. Through traversing, all the geomorphology such as landforms and the direction of the river can be observed.

**b) Structural geology analysis**

Geology structure such as fault, fold and joint were identified in field. To determine the fault in field, Brunton or Sunnto compass was used. Through the attitude of fault surface, types of fault was identified. Joint and fault was determined through geological observation.

**c) Geomorphological analysis**

Geomorphology of the study area was determined through geological observation and through topography map. At field, the geomorphology of study area was sketched with a scale.

**d) Map preparations**

Base map was produced earlier before going to field. To produce a geological map, Arcgis software was used. All the data in Global Positioning System (GPS) was transfer using dnrgps software. Through the map, we able to show the distribution of various types of materials when do traversing.

**e) Sampling**

When do a field study, sampling is a part of it. Through sampling, many rock samples were collected. The rock sample was obtained by break the outcrop into small pieces using geological hammer. To make sure the data interpretation more accurate and precise, rock sample was taken in more than ten different localities. The fresh samples will be taken and its locality was marked in GPS.

All the geological structure present was noted including the sketch of the outcrop. All the sample was keep in sample bag with a correct labeling of station on it.

ii) Specification Study

**a) Foraminifera sampling**

Foraminifera sampling has been taken from a different places. The sample was taken to laboratory for further process and analysis to identify the occurrences of foraminifera species in study area.

### 3.3.3 Laboratory work

The rock sample that collected from site was carried to laboratory and doing the analysis. This analysis was important for the interpretation of the data. To identify the mineral in the rock, thin section process was done using petrographic microscope. For picking and sorting method, the mictofossil in 63 µm, 125 µm and 250 µm was sort according their taxonomy. This process only focused on 125 µm and 250 µm sieve only because of the time consuming.

i) General Geology

**a) Petrography thin section**

The fresh part of rock sample was carried to the lab for Petrography Thin Section process. It includes several steps to cut the rock sample. In conduction thin section, the glass slide need to prepared first, then the slab was cutting according to the size needed. Secondly, in order to reduce the size of slab, the chip was cut carefully which involved a trim saw. To cut off the chip, chip needed to glue at the slide first. Slide was grinded followed the correct thickness until the mineral can be identified in the section. Lastly, both minerals and rock sample were identified under petrographic study as in table 3.1.

| Procedures | Description |
|---|---|
| **Step 1: Cutting a Slab**<br>A suitable size of slab usually rectangular that fit on a slide was cut from the rock with diamond saw. |  |
| **Step 2: Initial Lapping of Slab**<br>The one side of slab was smooth on glass plate with 600 grit. |  |
| **Step 3: Glass Slide was Added**<br>After drying the slab, a glass slide was glued to the lapped face of the slab with epoxy. |  |

| | |
|---|---|
| **Step 4: Slab was Sectioned**<br>The slab was cut-off closed to the slide using thin section saw. The thickness was reduced on a thin section grinder. |  |
| **Step 5: Final Inspection of the thin section slide**<br>Final inspection needed to avoid a bubble that can block the minerals in the rock samples. |  |

**Table 3.1:** Preparation of thin section slide

ii) ArcGis Software

Arcgis software was used to produce a new geological map. All data and information got from geological mapping, will be convert using dnrgps software.

### 3.3.4 Data Processing

After all the data was collected through geological mapping, the data such as rock sample were processes through thin section and from the thin section process, the minerals contained in rocks and petrography analysis can be observed clearly. While for fossil sample collected, fossil was cleaned by using brush and roll in tissue to make sure it safe. The fossils that already clean, must be identify the species / genus according to the taxonomy. Data from Arcgis can produce a geological map.

### 3.3.5 Data analysis and interpretation

The data that obtained in field was interpreted to produces a new geological map. All the data about structure geology, lithology, sedimentary structure and fossil that found will be analyzed with details. Through that information and interpretation of study area, depositional environment and the age of the formation was interpreted.

## CHAPTER 4

## GENERAL GEOLOGY

### 4.1 Introduction

In this general geology chapter, the subchapter of geomorphology, lithostratigraphy, structural geology and historical geology will be discussed based on the data achieved during geological mapping activity. A details description and explanation about general geology was really important to understand the past earth history process. A further discussion has been done for a better understanding regarding to each main subtopic included in this general geology chapter. In this chapter, on each subtopic several maps regarding the topic will be attached such as geological map, drainage map, sampling location map and topographic map.

### 4.1.1 Accessibility

The road connection in the study area was identified during geological mapping activity. There are 4 connecting road can be used to reach study area as shown in Figure 4.3. First is from the main road, the highway that connecting from town of Gua Musang to Kuala Berang. This road can be used by any types of transportation. Secondly is from the road connection of Ladang Sungai Relai East that covered north part of study area as shown in Figure 4.1**.** The easiest way to access study area on the south part is from the road connection of Bee Garden Oil Palm Plantation following the unpaved road that commonly used by oil palm lorries as in Figure 4.2. Most of the study area is accessible using this road**.** Meanwhile, another road can be used to reach study area was from the road of Nationwide Oil Palm Plantation.

**Figure 4.1:** Road connection of Ladang Sungai Relai East

**Figure 4.2:** Road connection of Bee Garden Oil Palm Plantation

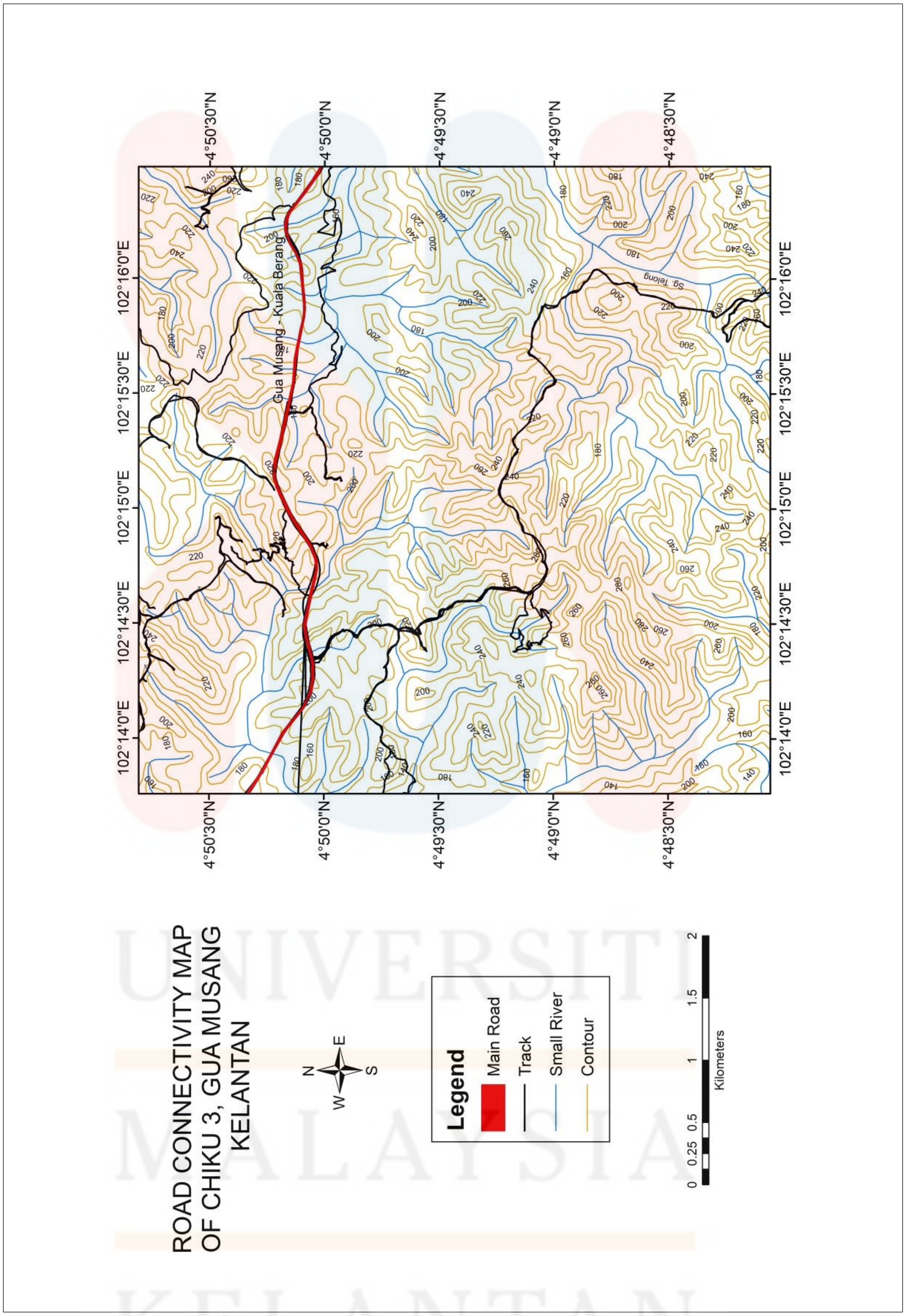



**Figure 4.3:** Road connection map in study area

### 4.1.2 Settlement

After mapping activity done, can be observed that in my study area there are no residential area can be located. Entire of the study area was dominated by oil palm plantation and small region by rubber plantation and forestry.

### 4.1.3 Forestry

The coverage of mapping area was majority dominated by the vegetation. Study area was comprise of two distinct region which 90 percent of study area dominated by the oil palm plantation area as shown in Figure 4.4, from three different company which is Ladang Sungai Relai East, Bee Garden oil palm plantation and Nationwide plantation. The another 5 percent was the area of rubber plantation and the remaining 5 percent conquered by forestry as shown in vegetation map in Figure 4.6.

**Figure 4.4:** Oil palm plantation in study area

**Figure 4.5:** Forestry in study area

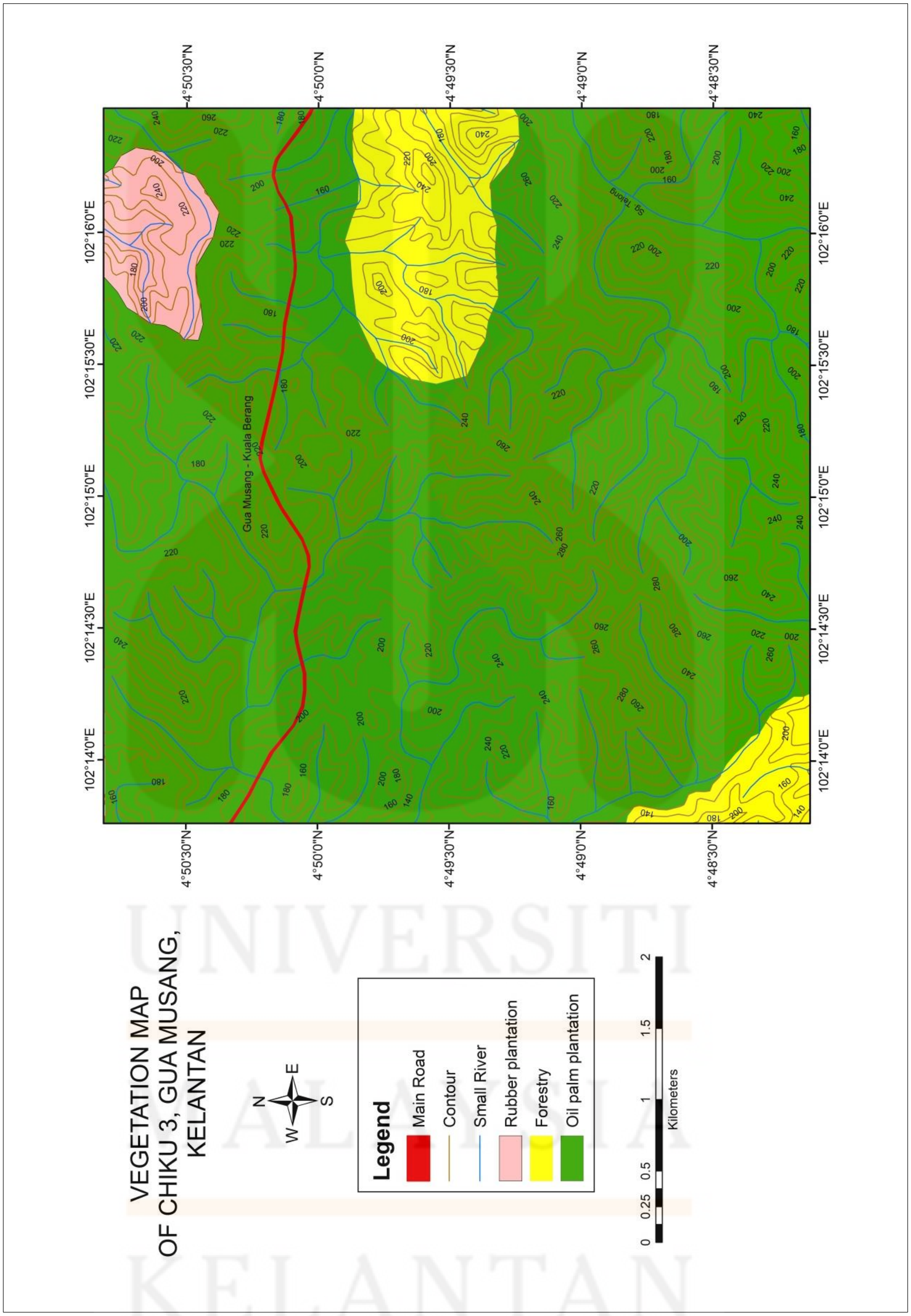



**Figure 4.6:** Vegetation map of study area

### 4.1.3 Traverses and Observation

Traverse is a method used in geological mapping activity in order to survey the study area. Along the traverse, targeted location with all geological information been marked using GPS. Besides that, observation and sampling activity on each location was important to obtain the geological information about study area. All the data and geological information will be interpret easily based on traverses been done. Figure 4.7 shows the traverse map of the covered area during mapping activity. Sampling station was marked with green circle while observation station with purple circle.

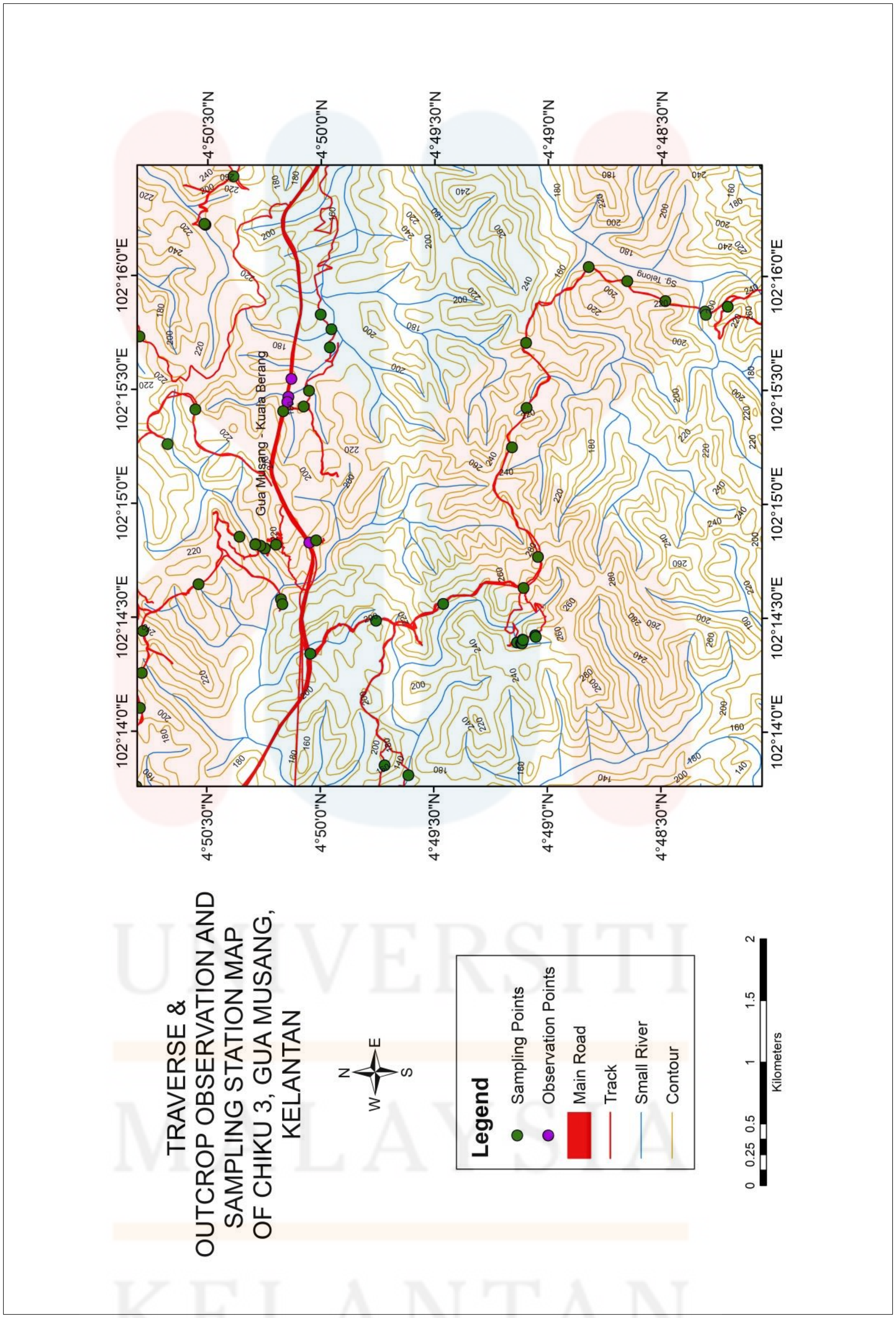





**Figure 4.7:** Traverse and outcrop observation and sampling station in study area

## 4.2 Geomorphology

Geomorphology is about study of the landform and process that involved related to its origin and evolution. Understanding in geomorphology is important to understand the process that occurred on the landform of the Earth. The mapping area of Chiku 3 has been influenced by the regional event that shapes its present-day landform. In this subtopic, further discussion about geomorphology will be discussed based data gained through geological mapping activity.

### 4.2.1 Geomorphological classification

Geomorphological can be identified based on several geological elements that found in mapping area. Based on data and information conducted during geological mapping activity, landform in study area can be classified as hilly area as shown in Figure 4.8 (a) (b).

Alluvial deposited can be found along the main stream bank. This is the commonly area where sediment deposition such as deposition of cobbles, pebbles and gravel act as the indication of river experience the higher energy during the time of deposition. Meanwhile the river shows it experience the low energy when there was the deposition of sand, silt and mud and only able to transport a small size of sediment.

Through the observation from mapping activity, hilly landform was identified based on the elevation of the contour on study area based on map in Figure 4.9. The lowest contour in study area was 140 meters, while the highest contour was 280 meters. This contour range represented the hilly landform of study area. Table 4.1 below shows the topography unit classification in study area. Different elevation represented different classification of topography unit. From the topographic map in Figure 4.10, clearly shows that the study area dominantly by hill area referring to 3D map elevation.

**Table 4.1:** Topographic unit classification

| **Classification** | **Topography Unit** | **Mean Elevation (m)** |
|---|---|---|
| **1** | Low lying | <15 |
| **2** | Rolling | 16-30 |
| **3** | Undulating | 31-75 |
| **4** | Hilly | 76-300 |
| **5** | Mountainous | >300 |

(Source: Hutchison and Tan, 2009)

a)


b)

**Figure 4.8 (a) (b):** Hilly landform in study area

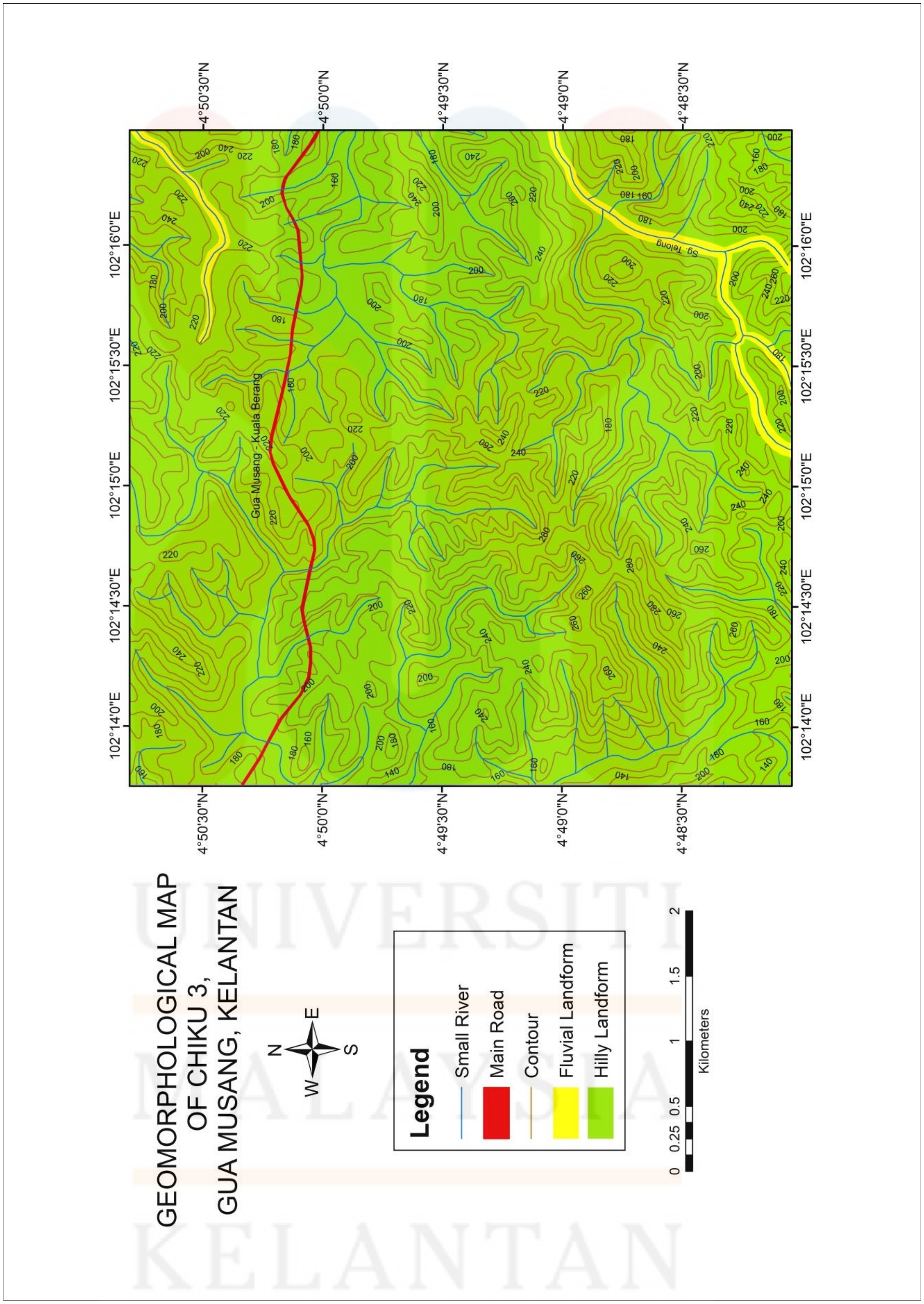



**Figure 4.9:** Geomorphological map of study area

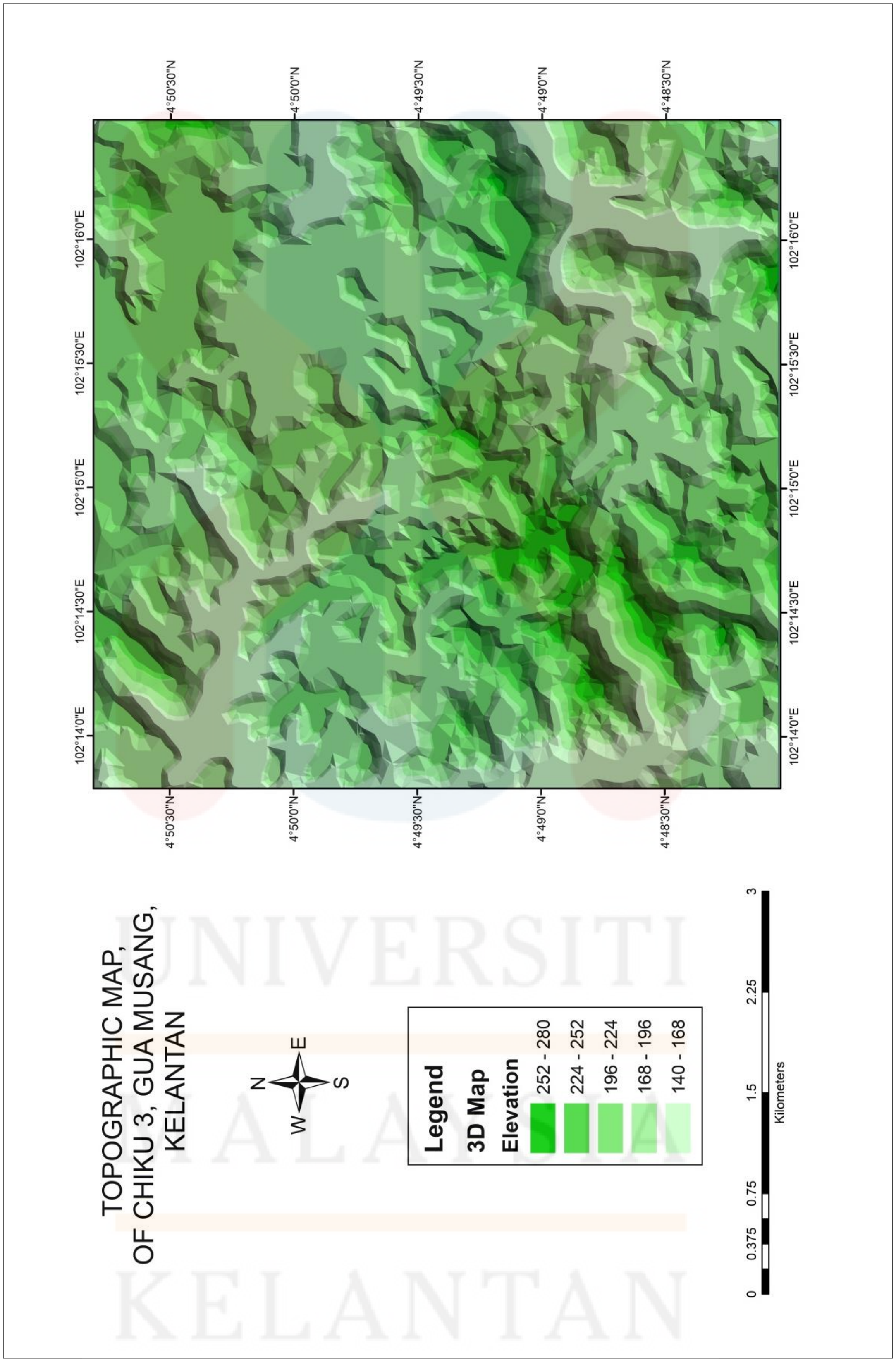



**Figure 4.10:** Topographic map of study area

### 4.2.2 Drainage Profile

Drainage systems or river systems are the patterns formed by the streams, rivers and lakes in particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. According to the configuration of the channels, drainage systems can fall into one of several categories known as drainage patterns. Drainage pattern depends on few factors such as topography and geology of the land. It also develop where the river channel follows the slope of the terrain.

From geological mapping activity, it is found that study area only consist of one drainage pattern type which is dendritic pattern. Dendritic pattern is the most and widespread pattern to be found on the earth's surface. This pattern is called dendritic because of the network of tributaries of various orders and magnitude of the trunk or master stream resembles the branches and roots and rootlets of a tree base on map in Figure 4.13. This pattern develops in a variety of structural and lithological environments such as in the mountainous and hilly areas.

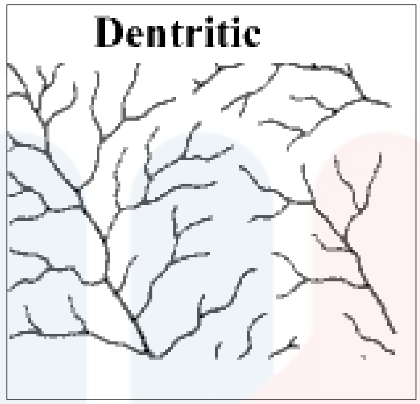



**Figure 4.11:** Dendritic pattern

**Figure 4.12:** Part of river in south part of study area

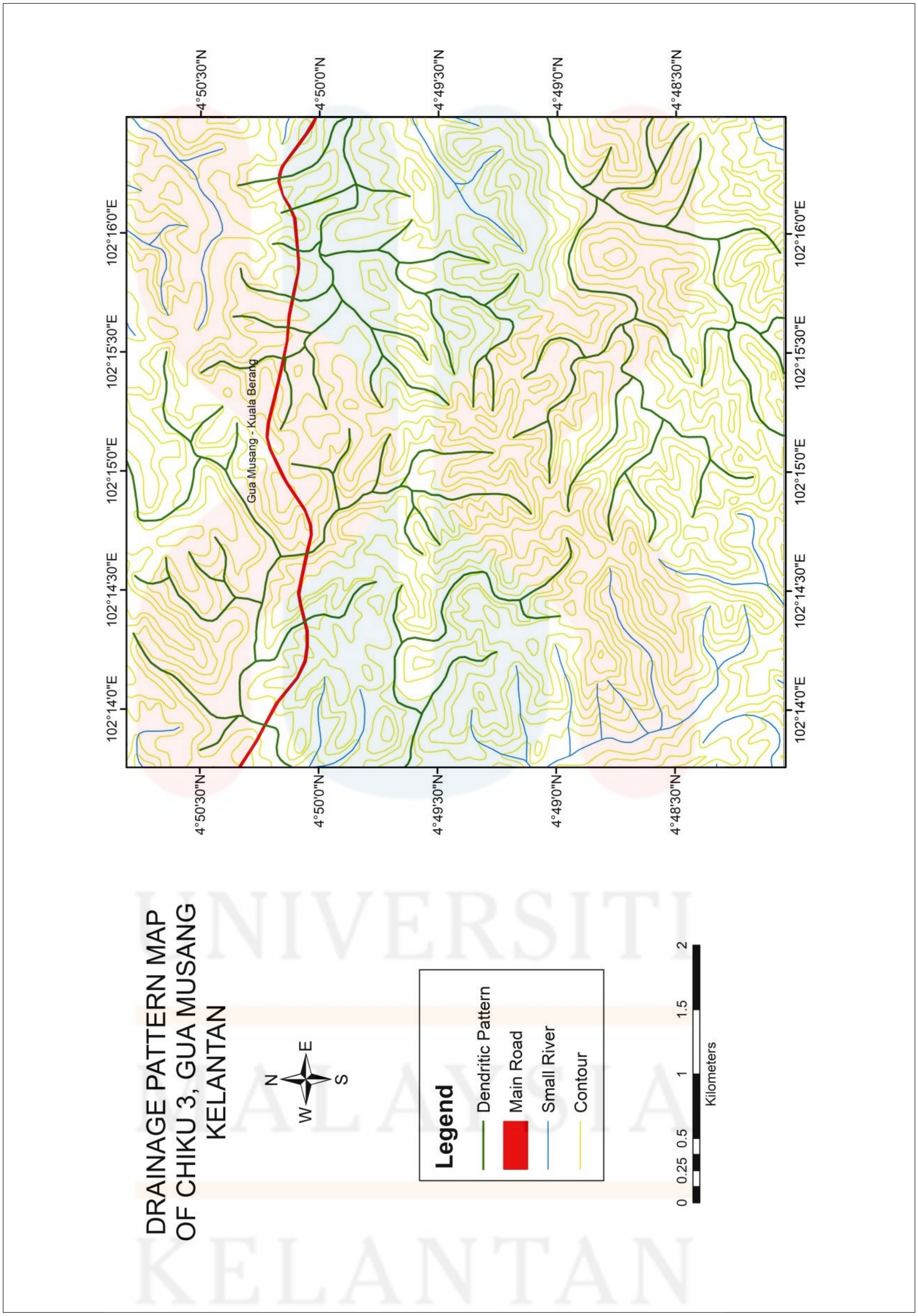



**Figure 4.13:** Drainage pattern map in study area

### 4.2.3 Weathering

Weathering is the process where rocks or soils are dissolved or worn away into smaller pieces due to particular environmental factors such as biological activity, extreme weather and agent of erosion such as water, wind and ice that influences the continuous breakdown, wearing away and loosening of rocks and soils (Sam Boggs, 2006). Weathering process occurs in situ and with no movement. Thus, weathering should not be confused with erosion, which involves the movement of rocks and minerals by agents and then being transported and deposited in other locations.

Rock in study area is dominated by the physical weathering, chemical weathering and biological weathering. Physical weathering is a weathering that caused by the effects of changing temperature on rocks and causing the rock to break apart without changing it chemical properties. Common action of physical weathering such as exfoliation, frost wedging, abrasion, thermal expansion and contraction. In Figure 4.14 (a) and (b), phyllite and shale has broken down into smaller fragment result from the continuous action of thermal expansion and contraction during hot weather.

a)

b)

**Figure 4.14: (a)** Physical weathering on phyllite outcrop **(b)** Thermal expansion on shale outcrop

On the other hand, chemical weathering occurs when rock are worn away by chemical changes. The natural chemical reactions within the rocks change the composition of rocks over time. Because the chemical processes are gradual and ongoing, the mineralogy of rocks changes over time thus making them wear away, dissolve and disintegrated. Higher temperatures will increase the rate of chemical weathering.

The chemical weathering found in study area involves oxidation process which the breakdown of rock by oxygen and water that often giving iron-rich rocks a rusty-colored weathered surface. Oxidation is the process whereby the rock minerals lose one or more ions or atom in the presence of oxygen. When minerals in the rock oxidize, they become less resistant to weathering. In Figure 4.15, certain part of mudstone outcrop turn into reddish color due to the oxidation of the metallic minerals in the rock. Minerals such as amphibole, pyroxene and olivine are abundant with iron and when it exposed to the atmospheric $O^2$, rusting process occur when iron and oxygen combined and formed iron oxide (rust).

The chemical equation of oxidation in metallic mineral shown as follows:

$$4Fe + 3O_2 = 2Fe_2O_3$$

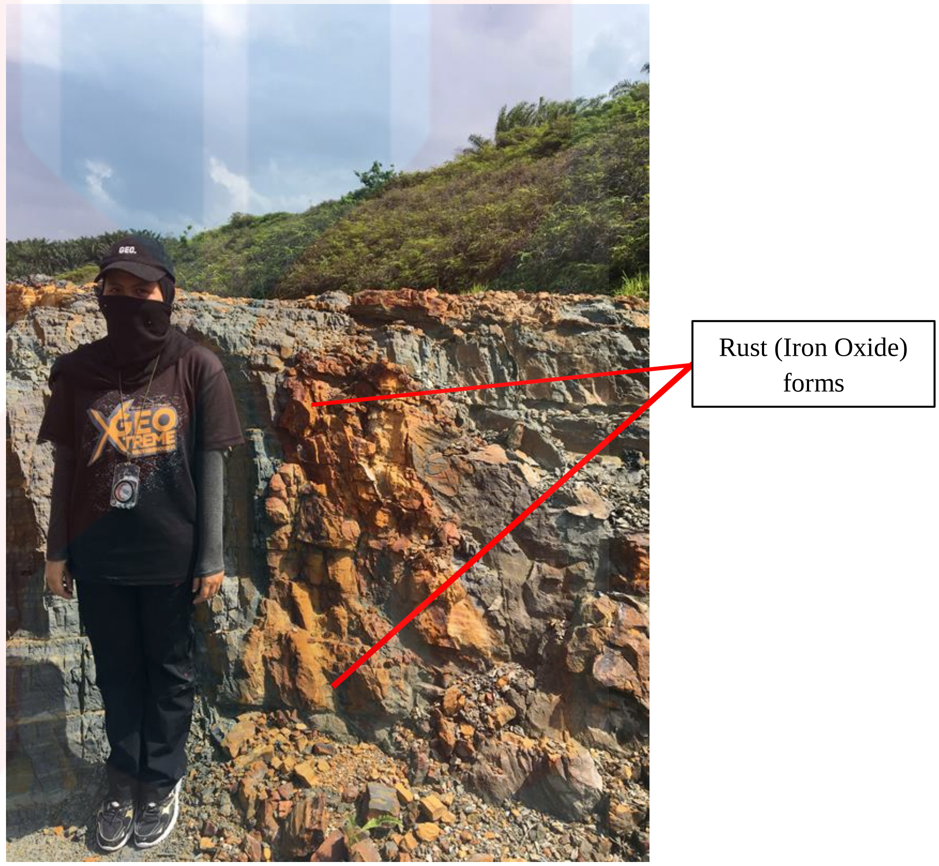



**Figure 4.15:** Chemical weathering on mudstone outcrop

Besides that, rocks in study area also experienced a biological weathering. Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. Trees and other plants can wear away rocks since as they penetrate into the soil and as their roots get bigger, they exert pressure on rocks and makes the cracks wider and deeper. Eventually the plants break the rock apart. Some plants also grow within the fissures in the rocks which lead to widening of the fissures and then eventual disintegration.

Burrowing animals such as moles, squirrels and rabbits can speed up the development of fissures. The same process also occurs in tuff outcrop as shown in Figure 4.16 (a) (b).

a)

b)

**Figure 4.16 (a) (b):** Biological weathering in tuff outcrop

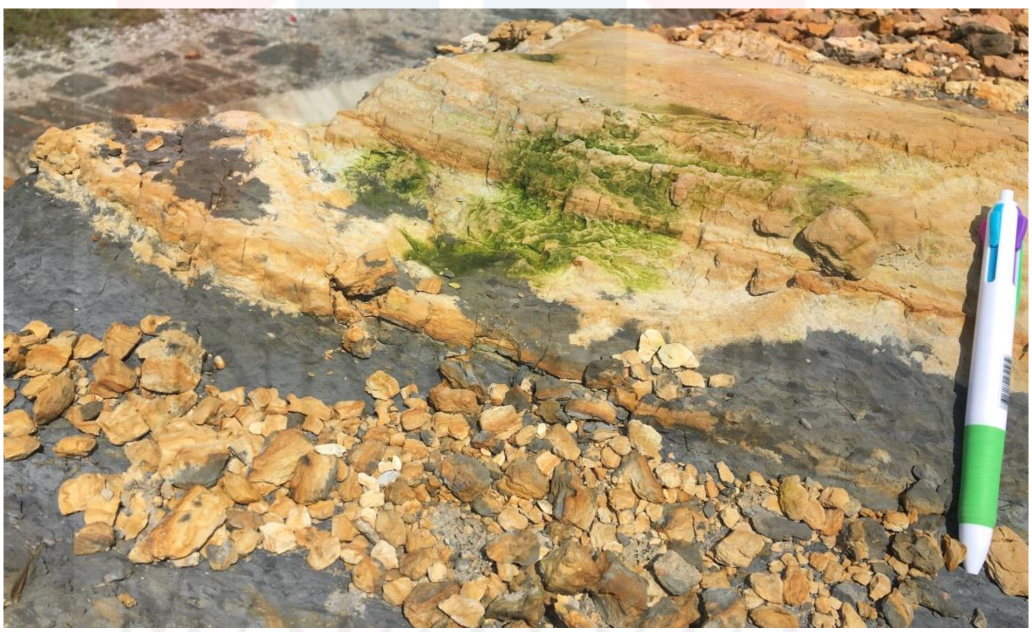


**Figure 4.17:** Fungus grow onto the mudstone outcrop

### 4.3 Lithostratigraphy

According to Sam Boggs (2006), lithostratigraphy is the field that mainly focused about the physical properties of strata and concerned about the organization of the rock units into its basic lithology characteristic. Lithostratigraphy is important for constructing geological map and making lithostratigraphic correlation of an area over time.

#### 4.3.1 Stratigraphic position

Generally, stratigraphy studies the subdivision of rock strata sequence. After geological mapping activity has been done in Chiku 3 area, it found that study area was lies under the Gua Musang Formation. Based on the rock sample, four different types of rock unit have been collected as shown in Figure 4.18. There are limestone, mudstone, tuff and phyllite unit. According to the Law of Superposition, the oldest sedimentary rock lies in the bottom and the youngest at the top (Ghosh, 2006).

| Era | Period | Lithology | Rock Unit | Description |
| --- | --- | --- | --- | --- |
| Mesozoic | Quartenary | | Alluvium | Fined grained sediment that deposited by flowing water and generally considered a young deposited in term of geologic time. |
| | Late Triassic | ls | Thick Bedded Limestone | Recrystalline limestone with calcite vein. |
| | Middle Triassic | mud | Mudstone | Consist of mudstone, shale, sandstone and tuff. |
| | Early Triassic | tf | Tuff | Mostly pyroclastic materials tuff with bedded tuff and lapilli tuff. |
| | Pre-Mesozoic | ph | Phyllite | Meta-sedimentary rock with fine grain sediment and brownish in color. |

**Figure 4.18:** Lithology of rock in study area

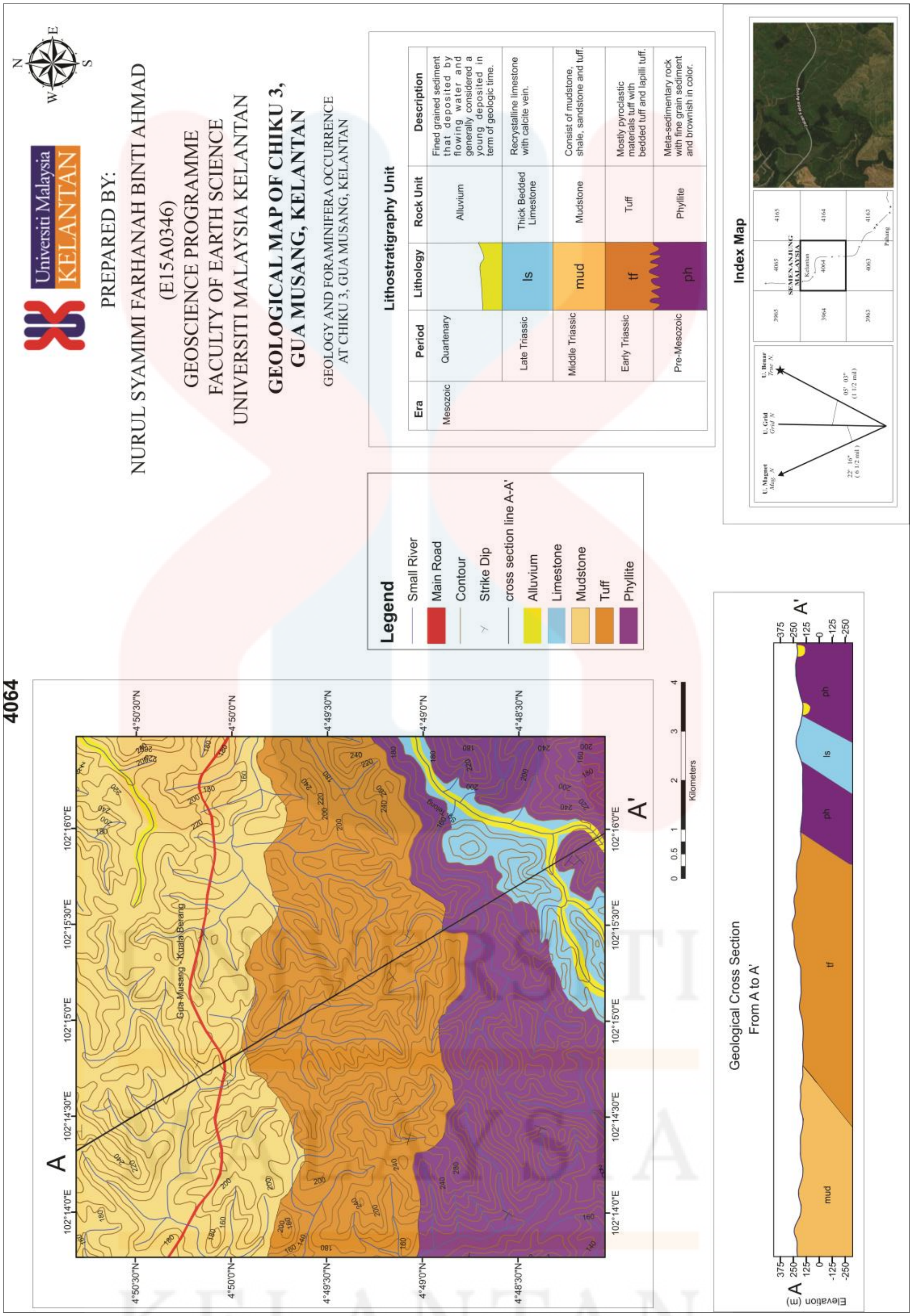



**Figure 4.19:** Geological map in study area

### 4.3.2 Unit Explanation

a) Phyllite Unit

Phyllite unit in study area was the third most dominant rock unit. Phyllite is a meta-sedimentary rock that dominated on the south part of the study area. The locality of the outcrop was located at foot hills area and exposed due to hill cutting as shown in Figure 4.20 (a). Phyllite outcrop can be found on the south and south east part of study area. The vegetation around the outcrop was surrounded by oil palm trees. The hand specimen of phyllite can be clearly seen has fine grained sediment and brownish in color as in Figure 4.20 (b).

a)

b)


**Figure 4.20:** (a) Outcrop of phyllite (b) Hand sample of phyllite

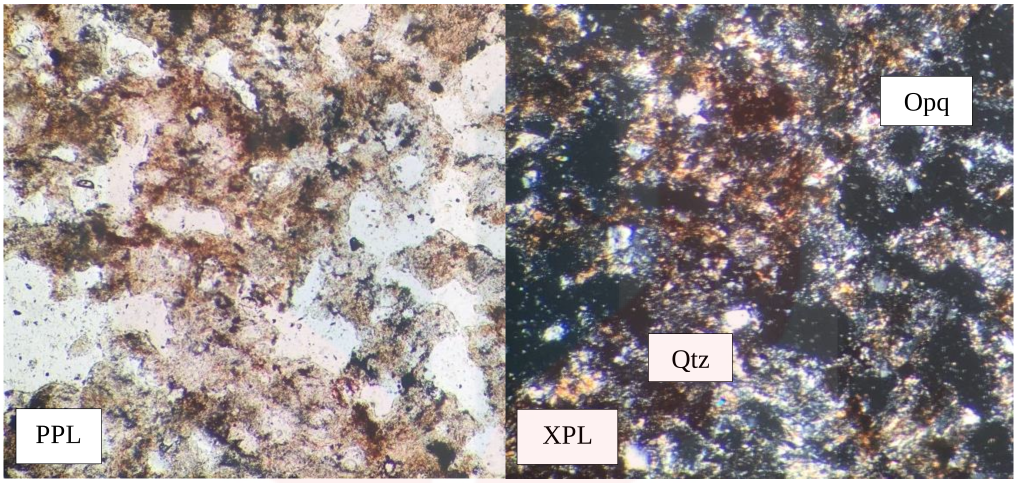



**Table 4.21:** Phyllite under plane polarized light (PPL) and cross polarized light (XPL)

Figure 4.21 above shows the petrography analysis of phyllite thin section observed under PPL and XPL with magnificence of 10x using microscope. The mineral can be observed from the phyllite thin section was quartz (Qtz) and opaque (Opq) mineral.

b) Tuff Unit

Tuff unit was the second most dominant rock unit in the study area. Tuff was a pyroclastic rock that mainly composed of volcanic ash and few other mineral formed in a volcanic explosion like dust or ash and will compacted and cemented together through time being. Tuff outcrop in study area located in oil palm plantation area and exposed in slope area due to hill cutting activity. Outcrop dimension estimated as 4 meters as shown in Figure 4.22 (a). The outcrop condition was slightly weathered. From hand specimen of tuff sample was soft and easily broken. The color observed was yellowish as shown in Figure 4.22 (b).

a) b)

**Figure 4.22:** (a) Tuff outcrop with human scale (b) Hand sample of tuff

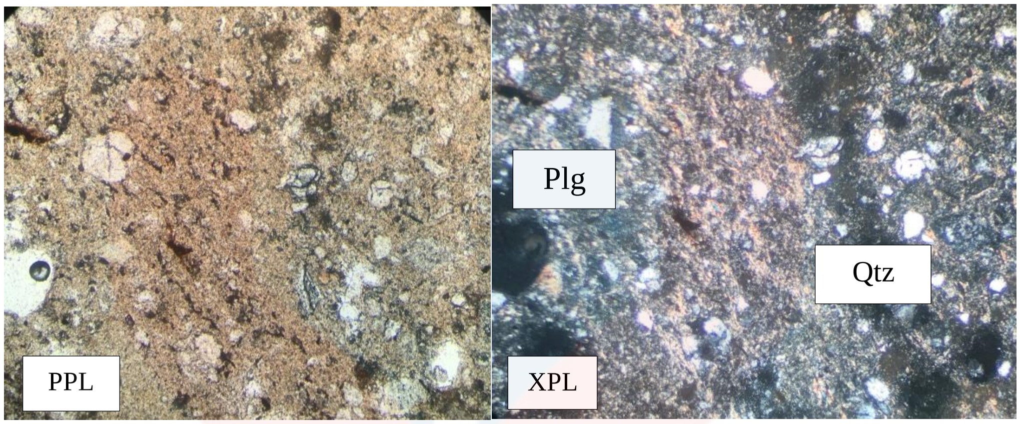



**Figure 4.23:** Tuff under plane polarized light (PPL) and cross polarized light (XPL)

Based on petrographic analysis of tuff sample in figure 4.23, tuff was observed under PPL and XPL with 10x magnificence using microscope. Plagioclase (Plg) and quartz (Qtz) mineral can be observed. The biofringe of plagioclase that observed was low.

c) Mudstone Unit

**i) Mudstone**

Mudstone is a fine-grained sedimentary rock with composition of 50% siliclastic grain with it grain size up to 0.063 mm. Mudstone commonly dominated with silt and clay size particle (Sam Boggs, 2006). Domination of mudstone in study area was only 15 percent and it only exposed along the main road as shown in Figure 4.24 (a). The outcrop condition was highly weathered and there was a present of rust may influence by the action of chemical weathering as mentioned previously in section 4.2.3. From the hand sample, mudstone in this locality was grey in color as shown in Figure 4.24 (b) and the sample was quite soft. It was observed as brittle and porous and easily broken with hand press.

b)

a)

**Figure 4.24:** (a) Mudstone outcrop with human scale (b) Hand sample of mudstone

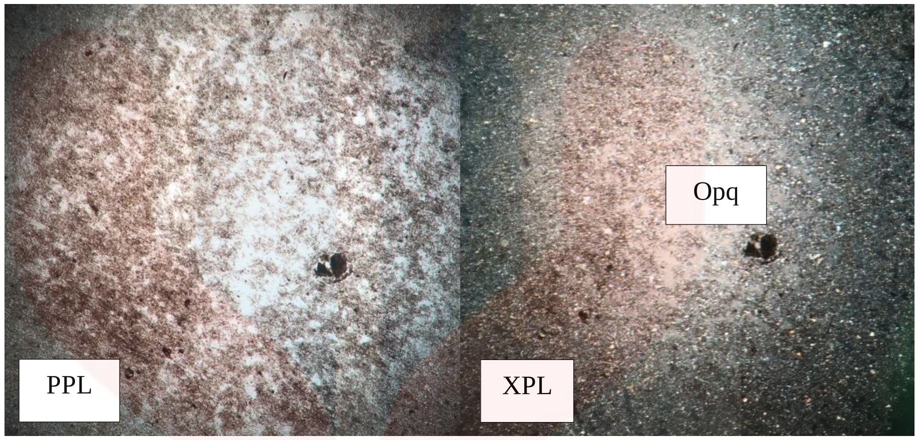



**Figure 4.25:** Mudstone under plane polarized light (PPL) and cross polarized light (XPL)

From the microscopic observation of mudstone in Figure 4.25, mudstone was observed under PPL and XPL with 10x magnificence using microscope. The sample of mudstone consisted 95% of mud and other 5% of opaque (Opq) minerals. Mineral in this sample was difficult to identify due to the high rate of weathering activity.

Besides, in this locality there are the present of fern and trace fossil. Fern fossil can be identified as *Cladophlebis gondwanica* Frenguelli, 1947 from Mesozoic Era (Chaloner, 1991) as in Figure 4.26. Meanwhile, the finding of trace fossil in Figure 4.27 can indicate the present of microfossil.

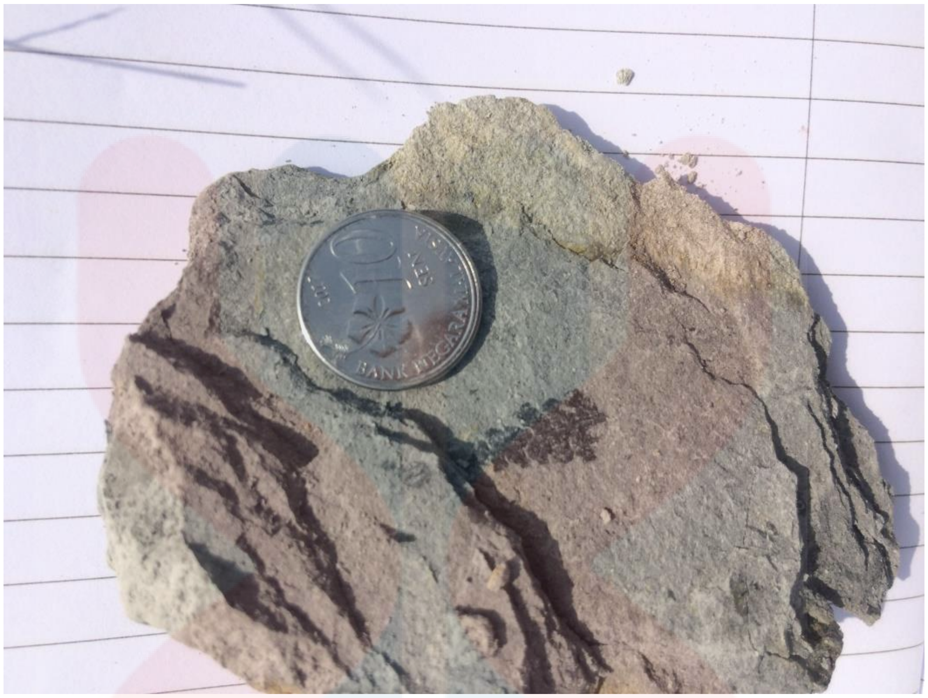


**Figure 4.26:** Fern fossil from Mesozoic Era

**Figure 4.27:** Trace fossil indicate present of microfossil

**ii) Shale**

Under mudstone unit, there are also the present of shale. Shale in study area was found with sandstone lenses. Outcrop of the shale was exposed due to hill cutting for construction purpose of Highway connecting Kuala Berang to Gua Musang. The outcrop was exposed to high rate of weathering and seems to experienced physical weathering where the rocks has broken into smaller pieces due to hot weather as shown in Figure 4.28 (a). The width of this outcrop was 3 meters and 2 meters high. Composition of the shale and mudstone is same but different in the present of fissility in shale. The fissility can be clearly seen through the hand sample of shale in Figure 4.28 (b).

a) b)

**Figure 4.28:** (a) Outcrop of shale with human scale (b) Hand sample of shale showing its fissility

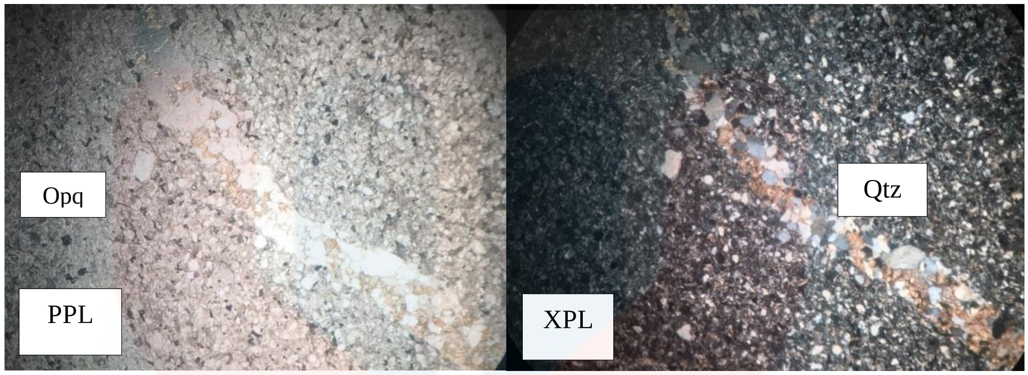



**Figure 4.29:** Shale under plain polarized light (PPL) and cross polarized light (XPL)

From the microscopic observation of shale in Figure 4.29, shale was observed under PPL and XPL with 10x magnificence using microscope. Shale can be classified as fine grained sedimentary rock. It does not react with hydrochloric acid and light grey in color. Quartz (Qtz) was colorless and low in relief. It also present in an anhedral-shape.

### iii) Sandstone

Beside shale, there are also the present of sandstone but the percentage of it distribution was not really dominant. Sandstone can be classified as siliclastic sedimentary rock with grain size of 1/16 mm to 2 mm. Sandstone in study area was found interbedded with mudstone as shown in Figure 4.30 (a). Sandstone was generally known to have higher composition of quartz mineral which make it more resistant towards weathering and erosion process. The outcrop of sandstone was located along the main road and has the dimension of 3 meter width and 2 meter high. Color that been observed was yellowish as shown in Figure 4.30 (b).

a) b)

**Figure 4.30:** (a) Outcrop of sandstone interbedded with mudstone (b) Hand sample of sandstone

b) Limestone Unit

Limestone is a sedimentary rock that composed mainly of calcium carbonate ($CaCO_3$). From the geological mapping activity, limestone outcrop were found permeable distributed in small area of Bee Garden Plantation area as shown in Figure 4.31 (a). The limestone outcrop was located in the river and the housing area. Limestone at field can be identified with two ways which is the limestone hardness of 3 which make it easier to scratch with a pen-knife. Second method was by using hydrochloric acid (HCl). When the limestone reacts with hydrochloric acid, it will release bubbles of carbon dioxide gas. Limestone in this locality was identified as thick bedded limestone with light grey color as shown in Figure 4.31 (b).

a)

b)


**Figure 4.31:** (a) Outcrop of limestone in housing area (b) Hand sample of limestone

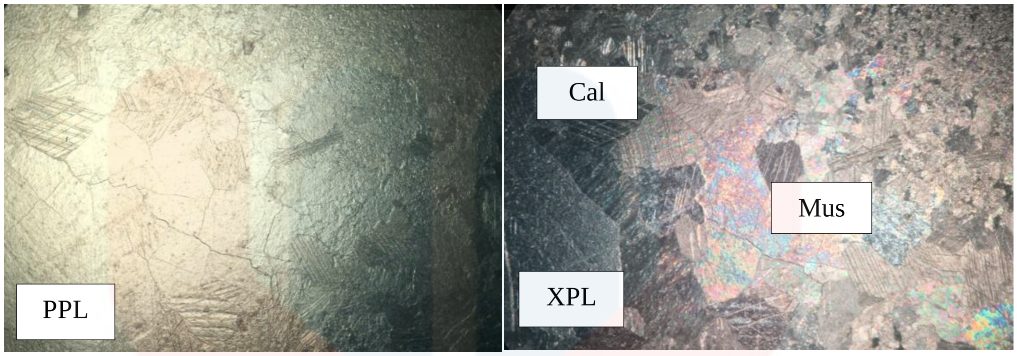



**Figure 4.32:** Limestone under plain polarized light (PPL) and cross polarized light (XPL)

Limestone was observed under PPL and XPL in figure 4.32 with 10x magnificence using microscope. Limestone was composed of cement which is finely light gray calcite (Cal). Muscovite (Mus) also can be identified with low relief.

c) Alluvium Unit

Alluvium is a material such as sand, mud or clay, silt and gravel that deposited by river flow and developed extensively in lower part of a river forming a geomorphological features such as floodplain and deltas.

The alluvium unit in this study area located along the main river at the north and south part. This alluvium unit is very young in term of their depositional materials and lies in Quartenary geological age. The depositional and erosion was ongoing process that always occurred and changed the structure of the river itself.

## 4.4 Structural Geology

In this subtopic, structural geology will be discussed about the process that lead to the formation of geologic structure and the effect of the structure to the rocks. Several analysis such as lineament analysis, joint analysis, fault and joint analysis needed in order to determine the pattern of the geological deformation in study area. Basically there was a lake of geological structure can be found in study area that due to the high rate of weathering process.

### 4.4.1 Vein

Vein is a distinct sheetlike body of crystallized minerals within a rock. It forms when mineral constituents carried by an aqueous solution within the rock mass are deposited through precipitation. Formation of vein usually associated with hydrothermal activity. There are two types of mineral that usually filled in the cracks which is quartz and calcite. Quartz vein in study area can be identified in locality of N 04º 50’ 08.6” E 102º 15’ 28.1” in shale outcrop as shown in Figure 4.33. Meanwhile, figure 4.34 shows the calcite vein found at the limestone outcrop lies between the coordinate of N 04º 48’ 39.1” E 102º 15’ 58.7” in the river at Bee Garden Plantation area.

**Figure 4.33:** Quartz vein in shale outcrop

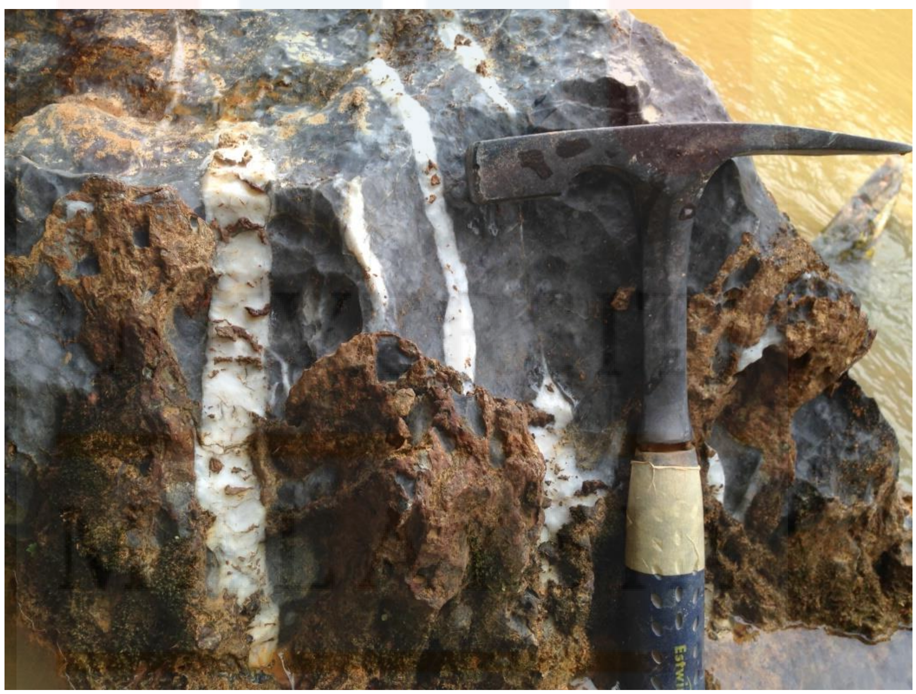


**Figure 4.34:** Calcite vein in limestone outcrop

### 4.4.2 Joint

Joint is a geological structure that results from the tectonic stresses on rock mass. A joint is a fracture dividing rock into two sections that moved away from each other. Under the action of large stresses, the rocks undergo such large strains that they eventually yield by deformation. Jointing also occur due to the rock experience physical weathering process such unloading and exfoliation. There are two classification of joints which is tensional joints and shear joints. Tensional joints or extensional joints are formed as a result of tension forces. These joint relatively open and have rough and irregular surfaces. Open spaces in extensional joint can be filled with minerals such as quartz minerals. Figure 4.35 show the extensional joint in weathered tuff outcrop that filled with quartz minerals.

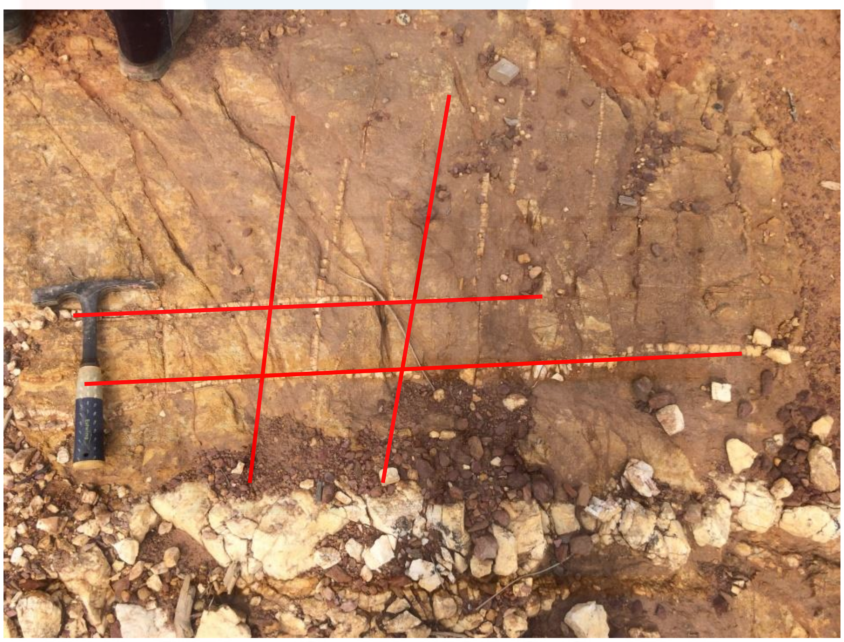


**Figure 4.35:** Extensional joint fill with quartz minerals

Besides extensional joint, there also the present of shear joint. Figure 4.36 show the joint reading at location 14. Joint reading was taken on the phyllite outcrop. From rose diagram below, it show the orientation of the major compressional force of $\sigma^1$ coming from N344°W while the minor compressional force of $\sigma^3$ coming from the direction of N281°W. Joint reading of location 14 was marked on map as shown in Figure 4.37.

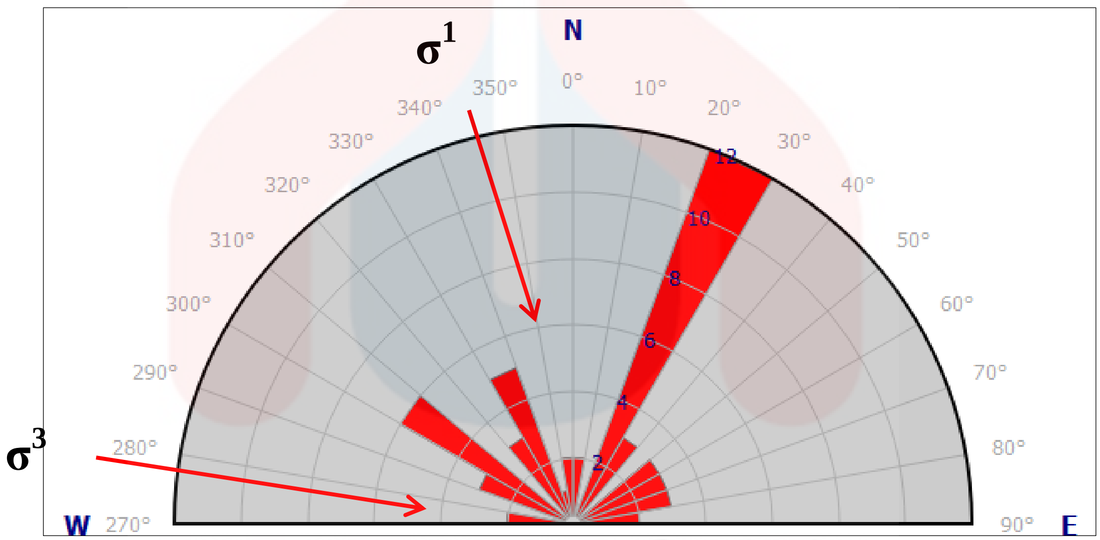



**Figure 4.36:** Rose diagram of joint reading in location 14

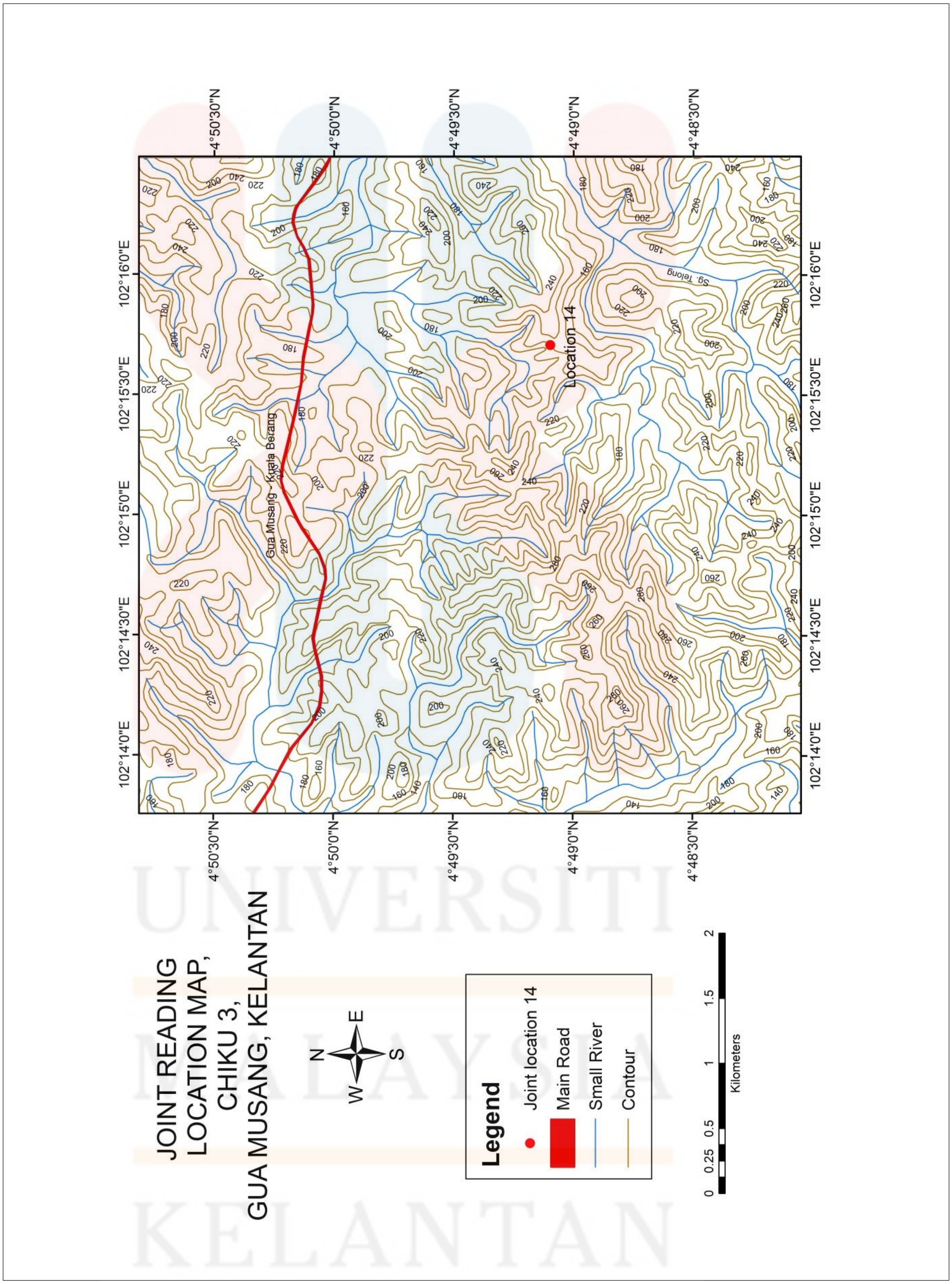



Figure 4.37: Joint location map in study area

### 4.4.3 Bedding

Bedding can be classified as the primary geological structure it can be used to recognized the sedimentary rocks. In study area, bedding was clearly exposed on the mudstone outcrop as shown in Figure 4.38. The bedding was observed with the range of 2-2.5cm.

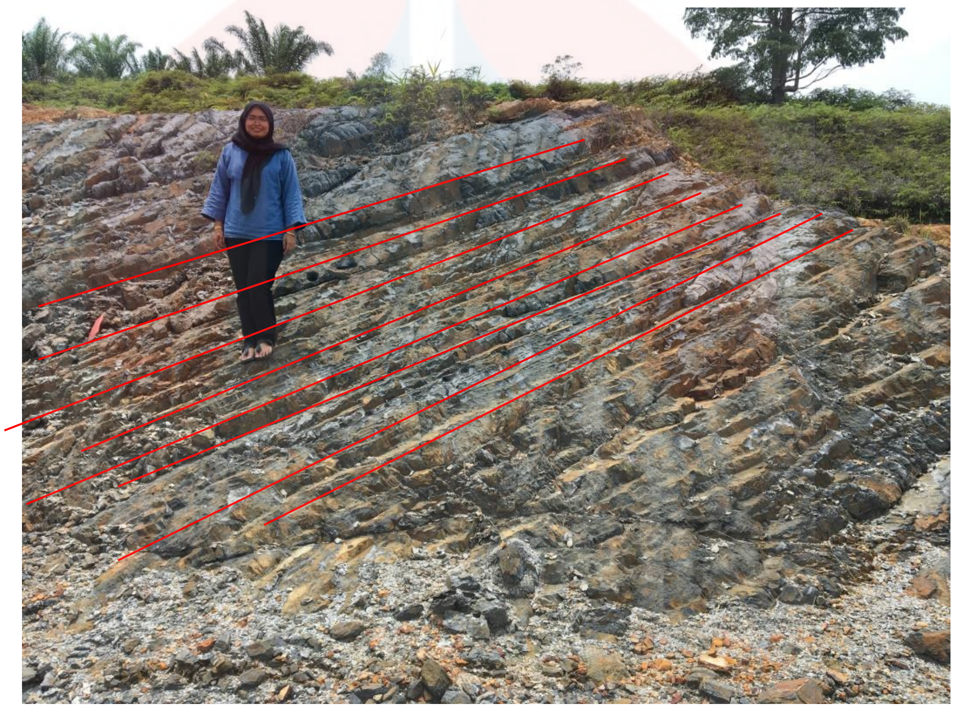


**Figure 4.38:** Bedding on mudstone outcrop

## 4.5 Historical Geology

Historical geology is the fundamental study about Earth and life through time and space. Through the historical geology, past of the Earth about physical, chemical and biological can be reveal. Geologist can use the information from the recent research and event to understand about how the record was formed represented by geological time scale.

Phyllite is formed by the arrangement of fine-grained mineral. It come from the parent rock of shale or mudstone which is argillaceous sediment. Parent rock of phyllite had faced the high temperature and pressure that come from the depositional and solidification process. The geological age of phyllite started to occur from Pre-Mesozoic era.

Next is tuff unit. Tuff is pyroclastic unit that formed from the volcanism activity that cause the ash erupts to the other place and causes the new landform to build. The age of this tuff unit was a Early-Triassic age.

Mudstone is a dark, fine grained sedimentary rock that formed from consolidated mud and clays. Mudstone in study area can be found at the north part. Its geological age was from Middle-Triassic age.

Thick bedded limestone in study area was formed by shallow marine environment with the low temperature. Limestone in study area believed that existed from the uplifting process and lies above the other lithology. The limestone was found with calcite vein at lower elevation and possibility as shallow depth marine in past environment. The geological age of the limestone in the research area was Late Triassic.

Alluvium as the youngest lithology in the study area was formed by the depositional of sand, silt, clay and gravel. Velocity of the stream can change the alluvium properties due to erosional process that occurs. Alluvium in study area had an age of Quarternary.

# CHAPTER 5

## OCCURRENCE OF FORAMINIFERA IN CHIKU 3

### 5.1 Introduction

Foraminifera are found in all marine environments and they may be planktonic or benthic in mode of life. Foraminifera have a geological range from the earliest Cambrian to the present. The earliest forms which appear in the fossil record have organic test walls. The earliest forms are all benthic, planktonic forms do not appear in the fossil record until the Mid Jurassic in the strata of the northern margin of Tethys and epicontinental basins of Europe. The fossilization potential of the tests render foraminifera a positive edge over other micro-organisms and make them as ideal bio-indicators for short-long terms changes of the marine environments.

This chapter was discusses about the occurrence of benthic foraminifera that found in study area. The specification research area lies in Chiku 3, Gua Musang, Kelantan. This area falls under Gua Musang Formation with predominantly argillaceous and calcareous sequences interbedded with volcanic and arenaceous rocks in the Gua Musang area of South Kelantan classified under Raub Group (Alexander, 1965).

## 5.2 Location

To collect the foraminifera samples, four different sampling station were identified located along the main road. The location of CP1, CP2 and CP3 were chosen as it was exposed within mudstone outcrop within the study area. This sampling station was selected due to the present of trace fossils. While CP4 was highly exposed at shale outcrop. On each sampling station, sample was collected along the main road as shown in the location map in Figure 5.1. The locality of sampling station in field shown in Figure 5.2 below.

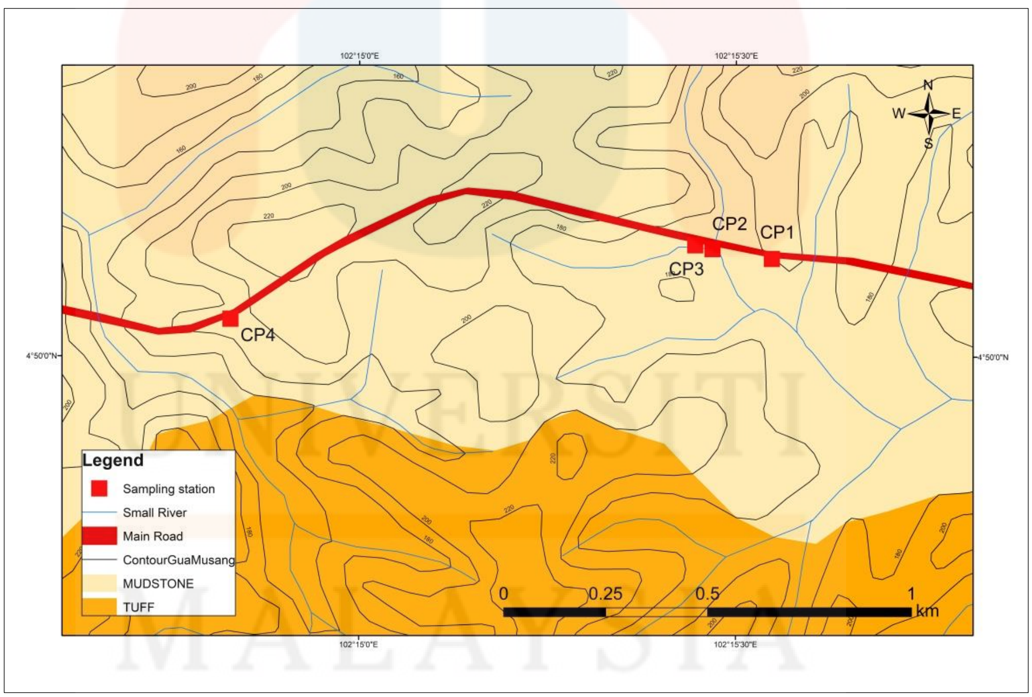



**Figure 5.1:** The map shows the location of sampling station for foraminifera occurrence purpose.

Checkpoint 1

Checkpoint 2

Checkpoint 3

Checkpoint 4

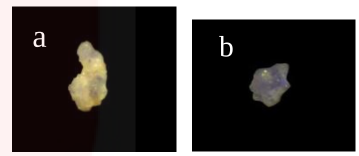
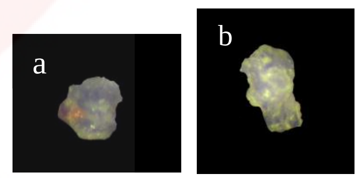
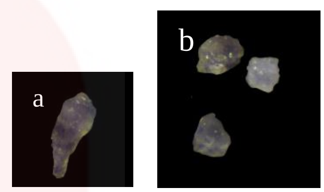
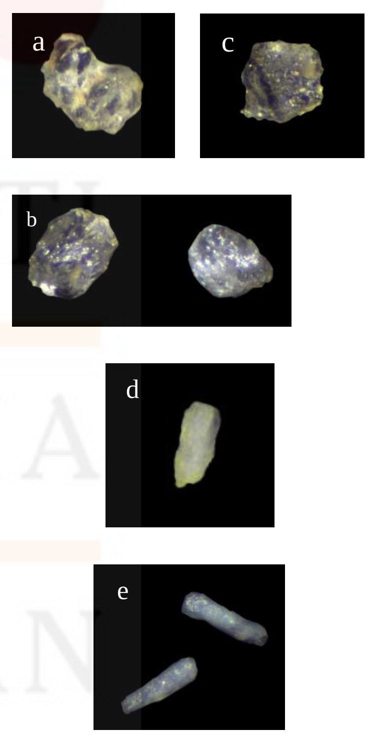
**Figure 5.2:** Shows the locality of four sampling station of sample were taken.

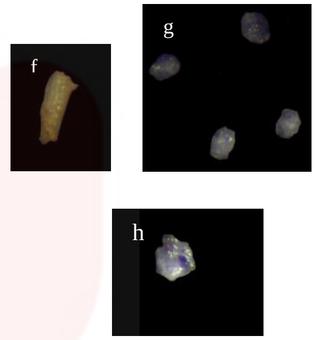
## 5.3 Result and Identification

After sampling process is done, all of these samples have been taken to the lab for the processing purpose. For processing part, the sample is prepared using crushing, grinding and drying method. While for analysis part, the sample is analyzed under stereoscopic microscope through sorting, picking and naming process. The, the identification of benthic foraminifera was conducted through the classification of their taxonomy. Taxonomy can be explained as the study of how to identify and name of the organisms. Fossil and living organisms used the same principles of taxonomic classification and it has a hierarchy of divisions. These principle were first proposed by Carolus Linnaeus, a Swedish biologist in the $18^{th}$ century. All life is divided into three domains which is Archaea, Bacteria and Eukarya. Genes will determine the differences of domains from one another based on their fundamental characteristics. For foraminifera, the order was belongs to the domain Eukarya in kingdom Protista and a single foram may have one or numerous nuclei within its cell (Wetmore 1995). Besides diatoms, forams is one of the major plankton types in the oceans.

The benthic foraminifera occurrence was shown in Table 5.1 on mudstone and shale lithology. The characteristic of mudstone was light grey in color and very fine grained sediment. Mudstone in this locality was highly exposed on high rate of weathering. While shale characteristic was dark grey in color and fine grain size. From the rock sample obtained from these four checkpoint, after preparation technique was done found several benthic foraminifera. Nevertheless, there are also the present of planktonic foraminifera but not abundance as benthic.

**Table 5.1:** The identification of benthic foraminifera that found from four sampling station based on micropaleontology analysis.

| Samples | Name of species | Pictures |
|---|---|---|
| 1 | (a) *Lenticulina* aff. *varians* (Bornemann) (b) *Gsollbergella spiroloculiniformis* (Oraveczne Scheffer) |  |
| 2 | (a). *Ophthalmidium* sp. (b). *Nodosaria* sp. cf. *springurensis* Crespin. |  |
| 3 | (a). *Duostomina* cf. *biconvexa* Kristan-Tollmann (b). *Krikoumbilica pileiformis* |  |
| 4 | (a). *Kutsevella?* sp. (b). *Haplophragmoides* sp. (c). *Krikoumbilica compressa* n. sp. (d). *Dentalina septacosta* n. sp. (e). *Nodosaria* sp. cf. *N. irwinensis Howchin* |  |

| | | |
|---|---|---|
| | (f). *Frondicularia parri* Crespin (g). *Oberhauserella lanidinica* (Oberhauser) (h). *Hemigordius volutus* Palmieri |  |

## 5.4 Paleobathymetry Determination

Since 1930's, benthic foraminifera have been used for palaeobathymetry determination. Paleobathymetry or paleo-depth is the determination of ancient water depth by using benthic foraminifera as an indicator. It is also the paleoenvironmental interpretation widely used in petroleum exploration in term of determining the depositional history of basin. Benthic foraminifera usually provided the information about the conditions at the sea floor. Different foraminifera present at different depth and show specific environment. Major depth zone were divided into three which is continental (nonmarine), transitional (marginal marine) and marine. All of these were based on their different depth like Neritic (continental shelf), Bathyal (continental slope) and Abyssal (sea floor).

Sampling area is made up of mudstone and shale lithology. Three samples were prepared as represent of 3 layer cross section in sampling area. Sample 1 (lower), sample 3 (middle) and sample 4 (upper). The paleobathymetry was determined from oldest to younger layer.

Table 5.2 below show the determination of paleobathymetry done based on benthic foraminifera occurrence at sampling area. Table below show the paleobathymetry analysis that obtained: *Lenticulina* aff. *varians* (Bornemann), *Gsollbergella spiroloculiniformis* (Oraveczne Scheffer).

**Table 5.2:** Paleobathymetry based on benthic foraminifera in sample 1 (lower layer).

| River | Transition | | | | Neritic | | | Bathyal | | | Abyssal (1800-4800 m) | Hadal (>4000 m) | Benthic fossil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Swamp | Lagoon | Fluvial -Marine | Open sea | Inner (0-30 m) | Middle (30-100 m) | Outer (100-200 m) | Upper (200-450 m) | Middle (450-900 m) | Outer (900-1800 m) | | | |
| | | | | | | | | | | | | | *Lenticulina* aff. *Varians*<br>*Gsollbergella spiroloculiniformis* |

Using the classification of paleoenvironment Bandy (1967), based on the identification of benthic foraminifera in Sample 1, can be conclude that the lower layer is deposited on Inner Neritic zone – Middle Neritic zone at depth of (0-30 m) – (30-100 m).

Next for middle layer, Table 5.3 below show the paleobathymetry analysis from the benthic foraminifera that obtained such as *Duostomina* cf. *biconvexa* Kristan-Tollmann, *Krikoumbilica pileiformis* and *Endothyra* cf. *Kupperi* Oberhauser.

**Table 5.3:** Paleobathymetry based on benthic foraminifera in sample 3 (middle layer).

| River | Transition | | | | Neritic | | | Bathyal | | | Abyssal (1800-4800 m) | Hadal (>4000 m) | Benthic fossil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Swamp | Lagoon | Fluvial -Marine | Open sea | Inner (0-30 m) | Middle (30-100 m) | Outer (100-200 m) | Upper (200-450 m) | Middle (450-900 m) | Outer (900-1800 m) | | | |
| | | | | | | | | | | | | | *Duostomina* cf. *biconvexa* Kristan-Tollmann<br>*Krikoumbilica pileiformis* |

Based on the identification of benthic foraminifera in table 5.3, according to Bandy (1967) using the classification of paleoenvironment, it can be said that middle layer was deposited on Middle Neritic zone – Outer Neritic zone of depth (30-100 m) – (100 – 200 m).

Lastly, for the lower layer the Table 5.4 below shows the paleobathymetry analysis from the benthic foraminifera that obtained like *Kutsevella?* sp., *Haplophragmoides* sp., *Krikoumbilica compressa* n. sp., *Dentalina septacosta* n. sp., *Nodosaria* sp. cf. *N. irwinensis Howchin*, *Frondicularia parri* Crespin, *Oberhauserella lanidinica* (Oberhauser) and *Hemigordius volutus* Palmieri.

**Table 5.4:** Paleobathymetry based on benthic foraminifera in sample 4 (upper layer).

| River | Transition | | | | Neritic | | | Bathyal | | | Abyssal (1800-4800 m) | Hadal (>4000 m) | Benthic fossil content |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Swamp | Lagoon | Fluvial -Marine | Open sea | Inner (0-30 m) | Middle (30-100 m) | Outer (100-200 m) | Upper (200-450 m) | Middle (450-900 m) | Outer (900-1800 m) | | | |
| | | | | | | | — | — | | | | | *Kutsevella?* sp. |
| | | | | | — | — | — | | | | | | *Haplophragmoides* sp. |
| | | | | | | — | — | | | | | | *Krikoumbilica compressa* n. sp. |
| | | | | | | — | | | | | | | *Dentalina septacosta* n. sp. |
| | | | | | | — | — | | | | | | *Nodosaria* sp. cf. *N. irwinensis Howchin* |
| | | | | | — | — | | | | | | | *Frondicularia parri* Crespin |
| | | | | | | — | — | | | | | | *Oberhauserella lanidinica* (Oberhauser) |
| | | | | | — | — | — | — | | | | | *Hemigordius volutus* Palmieri |

Based on the table above, the result in Sample 4 of benthic foraminifera on lower layer, according to classification of paleoenvironment Bandy (1967), can be conclude that the upper layer was deposited on Middle Neritic zone – Outer Neritic zone at the depth of (30-100 m) – (100-200 m).

In the nutshell, based on the research on sampling station along main road in Chiku 3 area, the observation shows that the depositional of paleoenvironment of layer in sampling area was from Middle Neritic zone – Outer Neritic zone at the depth of 30-200 m.

# CHAPTER 6

# CONCLUSION AND SUGGESTION

## 6.1 Conclusion

As the conclusion, all the data and information obtained from geological mapping activity and specification study about benthic foraminifera occurrences was concluded. The recommendations also provided for future researcher to improve this study either in geological mapping or specification.

Through this research, the geological map of study area was updated with scale of 1:25000. Based on the geological map, various geological aspects can be identified such as geomorphology, geological structure, lithology, drainage pattern and other geological information. To produce the geological map, geological mapping activity is required. Study area of Chiku 3 consisted of four differences lithology unit which is limestone unit, mudstone unit, tuff unit and phyllite unit. All of these units were lies in Gua Musang formation. In mudstone lithology unit was found fossil content, planktonic and benthic foraminifera also with fern fossil from Mesozoic era.

Therefore, for specification study about foraminifera occurrence and paleoenvironment analysis as mention in objective two and three, the occurrences of foraminifera in Chiku 3 area was dominantly with benthic foraminifera compared to the planktonic foraminifera. Although it was difficult to identify due to high weathering activity and the foraminifera was not in perfectly form, but the objective number two still can be achieved. Occurrences of benthic foraminifera were abundance with Nodosaria (40%), Krikoumbilica (25%) and Haplopharagmoides (15%). Meanwhile for paleobathymetry analysis using benthic foraminifera, it can be said that sampling area was deposited from Middle Neritic zone – Outer Neritic zone at the depth of 30-200 m.

## 6.2 Recommendation

The recommendation for future research in geological mapping activity is by using an appropriate tools and do more research about study area before going to field. Meanwhile for specification, the preparations of foraminifera need to be done more details and thoroughly in order to get a greater view of results. Next, to capture the image of foraminifera, highly recommended for using Scanning Electron Microscope (SEM) for a clearer picture. This can help to improve the quality of the research in the future.

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