GENERAL GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF THE SEMANGGOL FORMATION IN BUKIT KEPAH, KUALA NERANG

by

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DECLARATION

I declare that this thesis entitled "title of the thesis"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 : ______________________________

Name : ______________________________

Date : ______________________________

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ABSTRACT

The study area is located at Bukit Kepah, Kuala Nerang in Kedah district. Kuala Nerang located at northern part of Kedah and 34 kilometers away from Alor Setar town. Bukit Kepah is located near to Kuala Nerang town and connected by only one main road. The land of this area is mostly covered by paddy field and settlement. The purpose of this study is to update geological map of the area and to determine the depositional environment of the Semanggol Formation. Based on the literature reviews, Kuala Nerang composed of the Kubang Pasu Formation and Semanggol Formation but after doing ground geological mapping, it can be interpret that Bukit Kepah area is exposed to Semanggol Formation only. Depositional environment of the Semanggol Formation was determined by using lithostratigraphy analysis by observing and interpreting the lithology, sedimentary structures, and fossils. The depositional environment could be tidal flat environment based on fine grain of sediment rock and crinoidal stem fragments found. The fine grain sediments indicate the deposition occurred at low energy current and low relief area. The fragments of crinoidal stems found is proof that the flowing medium for deposition is water and the fossil is believed are transported to tidal flat area during high tidal level. Hence, it could be in subtidal to intertidal zones.

ABSTRAK

Kawasan kajian terletak di Bukit Kepah, Kuala Nerang di dalam negeri Kedah. Kuala Nerang terletak di bahagian utara negeri Kedah dan jarak dari Bandar Alor Setar adalah 34 kilometer. Kawasan ini dihubungi oleh satu jalan utama sahaja dan ia menghubungkan Bukit Kepah dengan pekan Kuala Nerang. Kawasan ini juga dilitupi oleh tanaman padi dan lading getah di tanah rata. Tujuan kajian ini adalah mengemaskini peta geologi and untuk mengenal pasti persekitaran pengenapan Formasi Semanggol. Berdasarkan kajian dulu, Kuala Nerang terdiri daripada Formasi Kubang Pasu dan Formasi Semanggol. Setelah kajian di lapangan telah dibuat, kawasan Bukit Kepah hanya terdiri daripada Formasi Semanggol. Persekitaran pengenapan telah ditentukan sebagai pengendapan kawasan pasang surut berdasarkan litostratigrafi analisis yang telah dibuat dengan mengkaji litologi, struktur-struktur sedimen dan fosil yang dijumpai. Berdasarkan sedimen yang bersaiz halus dan batang krinoid yang dijumpai, ia membuktikan kawasan pengenapan. Hal ini kerana, batuan sedimen butiran halus akan termendap di kawasan yang mempunyai arus tenaga yang rendah dan di kawasan yang rendah ketinggiannya. Batang krinoid yang dijumpai membuktikan lagi bahawa penyataan kerana adalah organisma laut yang hidup di kawasan air tenang. Ini juga membuktikan arus pengenapan adalah melalui air dan fosil ini dipercayai berpindah ke kawasan air yang tenang ketika air pasang surut tinggid di laut. Kesimpualannya, zon pasang surut bagi pengenapan ini ialah ‘subtidal’ dan ‘intertidal’.

TABLE OF CONTENTS

DECLARATION i

ACKNOWLEDGEMENT ii

ABSTRACT iii

ABSTRAK iv

LIST OF TABLES vi

LIST OF FIGURES vii

LIST OF ABBREVIATIONS x

LIST OF SYMBOLS xi

CHAPTER 1 INTRODUCTION 1

1.1 General Background 1

1.2 Problem Statement 2

1.3 Research Objectives 2

1.4 Study Area 3

- Demography 5
- Rainfall 5
- Landuse 7
- Social Economic 9
- Road Connection 9

1.5 Scope of Study 12

1.6 Research Importance 12

CHAPTER 2 LITERATURE REVIEWS 13

2.1 Introduction 13

2.2 Regional Geology and Tectonic Setting 13

2.2.1 Sedimentology and Stratigraphy 15

- Kubang Pasu Formation 16
- Semanggol Formation 17

2.2.2 Structural Geology 20

2.2.3 Historical Geology 21

2.3 Research Specification 23

CHAPTER 3 MATERIALS AND METHODS 24

3.1 Introduction 24

3.2 Materials 24

3.3 Methodology 26

- Preliminary Studies 26
- Field Studies 28

i) Geological Mapping 28

- Laboratory Investigations 32
- Data Analyses and Interpretations 33

CHAPTER 4 GENERAL GEOLOGY OF BUKIT KEPAH, KUALA NERANG 34

4.1 Geomorphology 36

4.1.2 Drainage System 40

4.1.3 Geomorphological Process 43

4.2 Stratigraphy 46

4.2.1 Lithostratigraphic unit 46

- Sandstone unit 49
- Siltstone unit 51
- Shale unit 52
- Volcanic Sandstone unit 53
- Alluvium 54

4.3 Stuctural Geology 57

4.3.1 Fault Analysis 57

4.3.2 Fold Analysis 58

4.3.3 Bedding Analysis 59

4.3.4 Joint Analysis 60

4.3.5 Lineament Analysis 62

4.4 Historical Geology 64

CHAPTER 5 DEPOSITIONAL ENVIRONMENT OF THE SEMANGGOL FORMATION IN BUKIT KEPAH, KUALA NERANG **66**

5.1 Lithology 68

5.2 Sedimentary Structure 70

5.3 Fossil 73

5.4 Depositional Environment of the Semanggol Formation at Bukit Kepah 77

CHAPTER 6 CONCLUSIONS AND RECOMEMENDATIONS **79**

6.1 Conclusions 79

6.2 Recommendations 80

REFERENCES **81**

APPENDICES **83**

LIST OF TABLES

No.	Tittle	Page
3.1	The Wentworth Scale	30
4.1	Topographic unit based on mean elevation	36
4.2	Lithostratigrahic unit of the Semanggol Formation in the study area	47

LIST OF FIGURES

No.	Title	Page
1.1	Location of study area in Kedah state	3
1.2	Basemap of the study area	4
1.3	Percentage distribution of race population in Kuala Nerang	5
1.4	Landuse map of Bukit Kepah, Kuala Nerang	6
1.5	Climate graph of Kedah state	7
1.6	Landuse map of Bukit Kepah, Kuala Nerang	8
1.7	Paddy plantation that working out by major Malay race	9
1.8	Photo of the main road of Bukit Kepah area	10
1.9	Road Connection map	11
2.1	Map of the three main belts in Peninsular Malaysia	15
2.2	Map of Chert Member in Semanggol Formation	19
3.1	Research flow chart of the whole study	27
4.1	Path of traversing and point of samples taken	35
4.2	Topographic Map of Bukit Kepah, Kuala Nerang	37
4.3	2D Topographic Map of Bukit Kepah, Kuala Nerang	38
4.4	The types of drainage pattern in Bukit Kepah	40
4.5	Drainage map shows drainage pattern exist in Buit Kepah	42
4.6	Photo shows physical weathering cause accelerated disintegration	44

4.7 Photo shows biological weathering by vegetation 45

4.8 The geological map shows distribution of lithostratigrahic unit in the Semanggol Formation 48

4.9 Hand specimen of sandstone 49

4.10 (a) Photomicrograph fined-grain sandstone under microscope with cross-polarized light and plane polarized light (x10 magnification) 50

4.10 (b) Photograph medium grain size sandstone under microscope with cross-polarized light and plane polarized light (x10 magnification) 50

4.11 Interbedded of sandstone with alternating thin layer of siltstone and shale 51

4.12 Bed of light grey shale in which crinoidal stem fragments found 52

4.13 Hand specimen the volcanic sandstone comprised with sand-sized grain 53

4.14 Photomicrograph volcanic sandstone under cross polarized light and plane polarized light (x10 magnification) 54

4.15 Swamp alluvium in Kuala Nerang 55

4.16 Volcanic ash deposit in Kampung Padang Nyior 56

4.17 Normal fault in Bukit Kepah 58

4.18 Folding at interbedded of sandstone – shale outcrop 59

4.19 Alternating of shale and siltstone in sandstone bed 60

4.20 Rose diagram of joint at study area 61

4.21 Outcrop where the set of joints are measured 62

4.22 Negative lineament at Bukit Kepah 63

4.23 Interpretation of lineament analysis using GeoRose software 63

5.1 First outcrop in Bukit Kepah for stratigraphic column 67

5.2 Second outcrop in Bukit Kepah for stratigraphic column 67

5.3 Planar cross bedded with inclined layers 71

5.4 Lamination in shale bed 72

5.5 Wavy bedding between sandstone and mudstone strata 73

5.6 Abundant of crinoidal stem fragments found in shale bed 74

5.7 Stratigraphic column for outcrop 1 at N 6° 16’ 48” E 100° 38’ 3” 76 75

5.8 Stratigraphc column for outcrop 2 at N 6° 16’ 41” E 100° 38’ 5” 76 76

5.9 3D model of tidal environment where the deposition of the Semanggol Formation occur 78

A Examples of patterns and symbols used on litholog 83

B The lithostratigraphy log sheet represent series of bed of sedimentary rock 84

C Geological map of Bukit Kepah and cross section 85

LIST OF ABBREVIATIONS

etc. al. and others

cm centimeter

km kilometer

m meter

mm millimeter

LIST OF SYMBOLS

N	North
E	East
°	Degree
‘	Minutes
“	Seconds

CHAPTER 1

INTRODUCTION

1.1 General Background

The study area is located in northern part of Kedah which is Bukit Kepah, Kuala Nerang. It is located near to Kuala Nerang town and the area is only connected to only one main road. Kuala Nerang is exposed to Semanggol and Kubang Pasu Formation. Kubang Pasu Formation is composed of two lithologies which are argillaceous and arenaceous facies while Semanggol Formation is divided into three informal members which are Chert, Rhythmite and Conglomerate members (Basir Jasin and Zaiton Haron, 2007)

This research was done to gain data and information of the study area which based on field studies, sampling and laboratory investigation. Moreover, this research was needed to improve knowledge on the geology of Bukit Kepah and to determine the depositional environment of Bukit Kepah. The absence of updated data of the local area which is Bukit Kepah have been updated from the study. The geological map was updated by traversing along the study area. During geological mapping, geomorphological analysis and structural analysis were interpreted since the last study of Kuala Nerang by Mohammed Hatta and Zainol Hussin (1987) was long time ago. The geological details background of the study area needed to be improved. The depositional environment describe the process of deposition of a formation from a long time ago thus to determine the environment, lithostratigraphy analysis was done.

1.2 Problem Statement

To solve the research gap of this research, the main problem was the absence of updated data of the local area since the previous research which is "Geologi dan Sumber Mineral Kuala Nerang" has been done on 1987 which is likely twenty nine years ago. This study has lack information of geological background since it is specifically based on study of minerals at the study area. The data is important to be updated to know the changes of geology of study area due to tectonic activity throughout time. The geological map need to be update after all the information gained from the study area and has been analysed.

Besides that, based on study of (Basir Jasin and Zaitun Harun, 2007), the rocks of Semanggol Formation mostly is not clearly exposed because it is uplifted by the Late Triassic granite intrusion and caused by strong faulting and folding. Thus it gave difficulties to observe and analyse rocks from Semanggol Formation.

1.3 Research Objectives

The objectives for this research are:

i) To produce and update geological map of the study area with scale 1:25 000.

ii) To determine the depositional environment of Kubang Pasu and Semanggol Formation.

1.4 Study Area

The study area is located at Bukit Kepah, Kuala Nerang, Kedah. It is located at northern part of Kedah and 34 kilometers away from Alor Setar town. This mapping area of 25 km² includes Padang Sanai and Padang Terap area. This area is located near to Kuala Nerang town and connected to only one main road hence it can be traversed by car. The land of this area is mostly covered by forest and hills. There is also housing area along the main road. The research of this area will represented the geological properties of Kubang Pasu and Semanggol Formation.

Figure 1.1: Location Kuala Nerang in Kedah state (Kedah Legislative Assembly Constituencies, 2015)

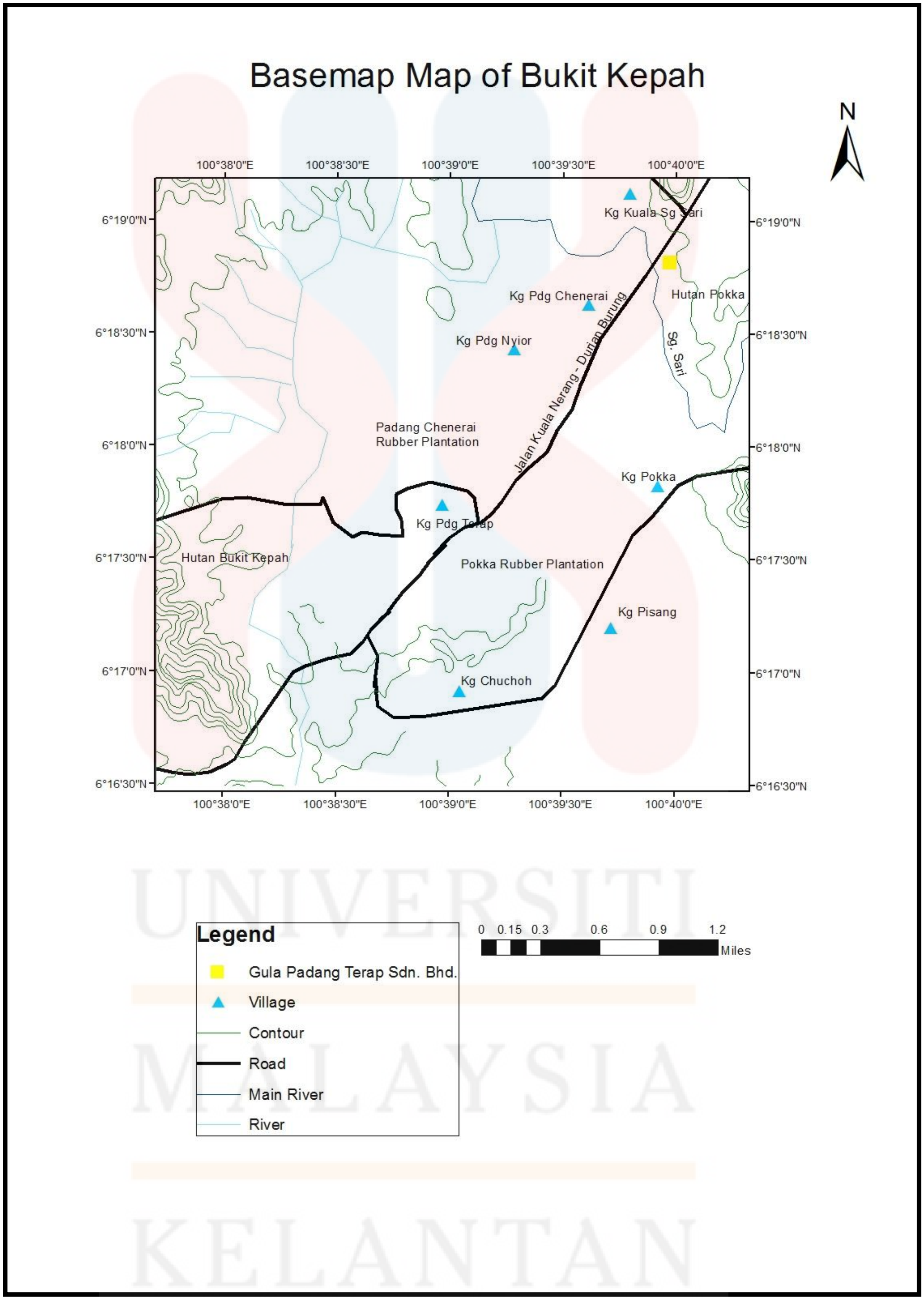


Figure 1.2: Basemap of the study area

- **Demography**

People distribution means the pattern where do people live in an area. The major race in Kuala Nerang is primarily Malay for about 61.17 % of whole population though there are significant Chinese and Indian minorities. Chinese and Indian consists of 24.8% and 14.03% respectively. Malay people in this area work in paddy cultivation and as rubber tapper in rubber plantation which is from FELDA, RISDA, and FELCRA. Almost of the Chinese people run a small business and live in town of Kuala Nerang. While Indian people become rubber tappers and work in rubber plantation.

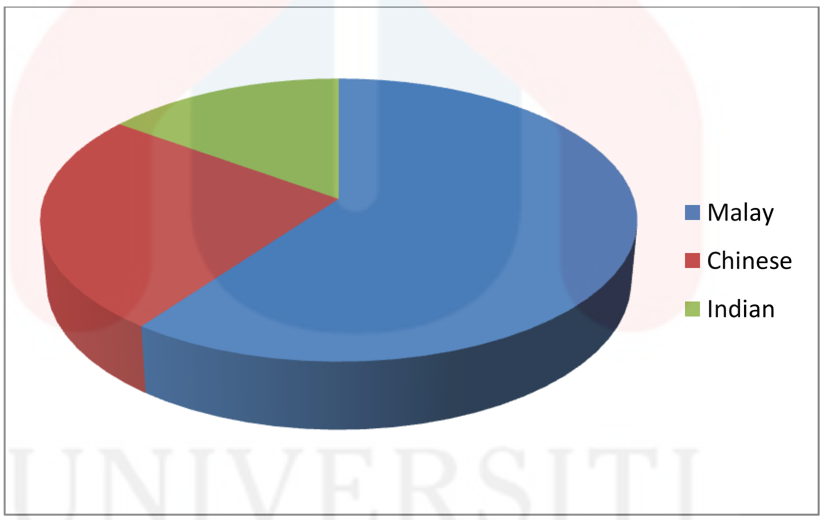


Figure 1.3 shows percentage distribution of race population in Kuala Nerang (Majlis Daerah Padang Terap)

The pie chart shows Malay is the major race in Kuala Nerang which is 61.17% follows by Chinese and Indian race with 24.8% and 14.03% respectively.

- **Rainfall**

Kedah is located near to the Malacca Strait. Therefore, the climate at this area is influenced by the seasonal wind flow patterns and the local topographic features. The changes of wind flow pattern in certain period result in four types of monsoon season, namely south-west monsoon season, north-east monsoon season and two shorter inter monsoon seasons. Kedah is a city with a significant rainfall. Even in the driest month there is a lot of rain. The average annual temperature is 19.5 °C in Kedah. Precipitation averages is 1935 mm.

The graph in Figure 1.4 shows the maximum temperature per month for Kedah state is 29°C while the minimum temperature is 26.5°C. During the inter monsoon season, in April to October, the wind blows slowly in the range of 10-15 knot and inconsistently.

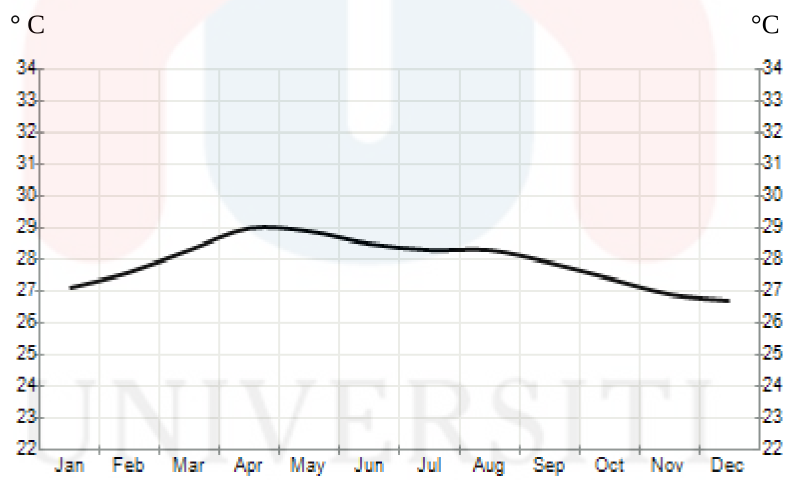


Figure 1.4 shows graph of average temperature in Kedah per month (source: World Meteorological Organization, 2015)

From the graph in Figure 1.5 it shows that the driest month is July with 67 mm of rainfall. Most of the precipitation here falls in November, averaging 245 mm.

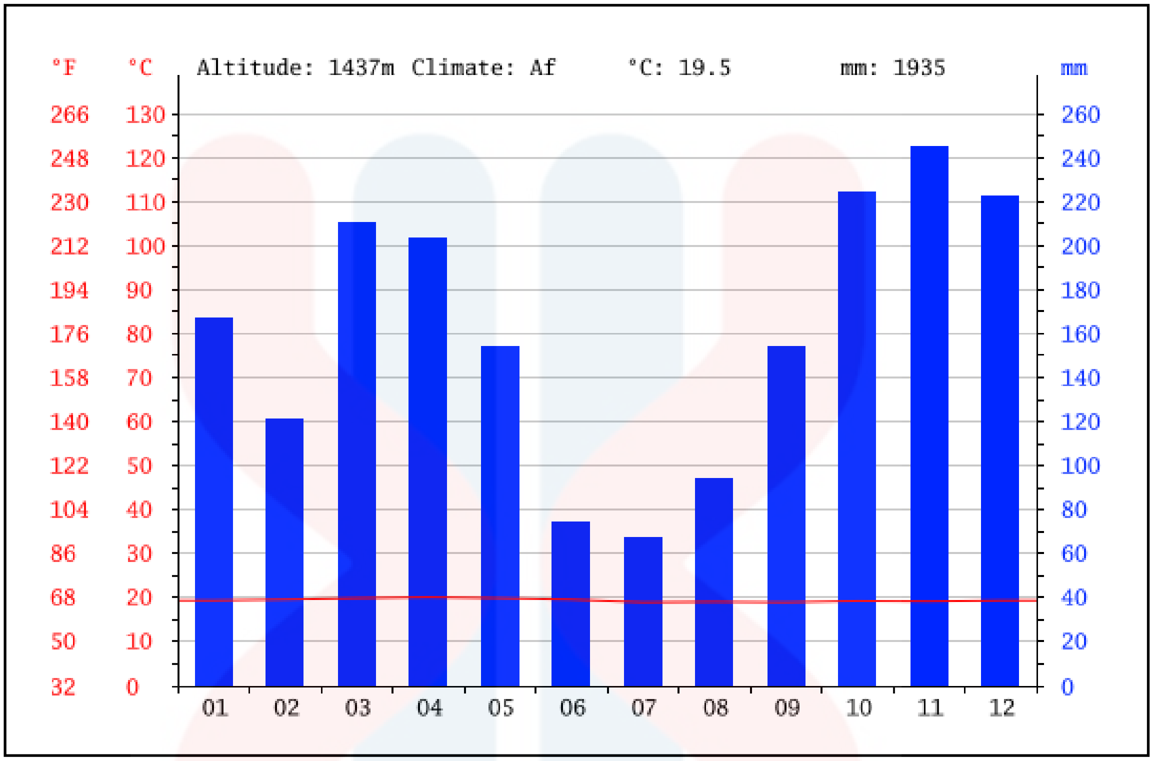


Figure 1.5 shows climate graph of Kedah state (Source: climate-data.org, 2015)

- **Landuse**

Almost 80% of Bukit Kepah are covered with tropical rain forest and almost preserved forest are used for logging activity. Other remaining land are for agricultural where paddy and rubber plants are the main crops for Kuala Nerang. Agricultural activity are run at lowlands area and hillside which primarily in the west area. Preserved forest are located in the north area of study area.

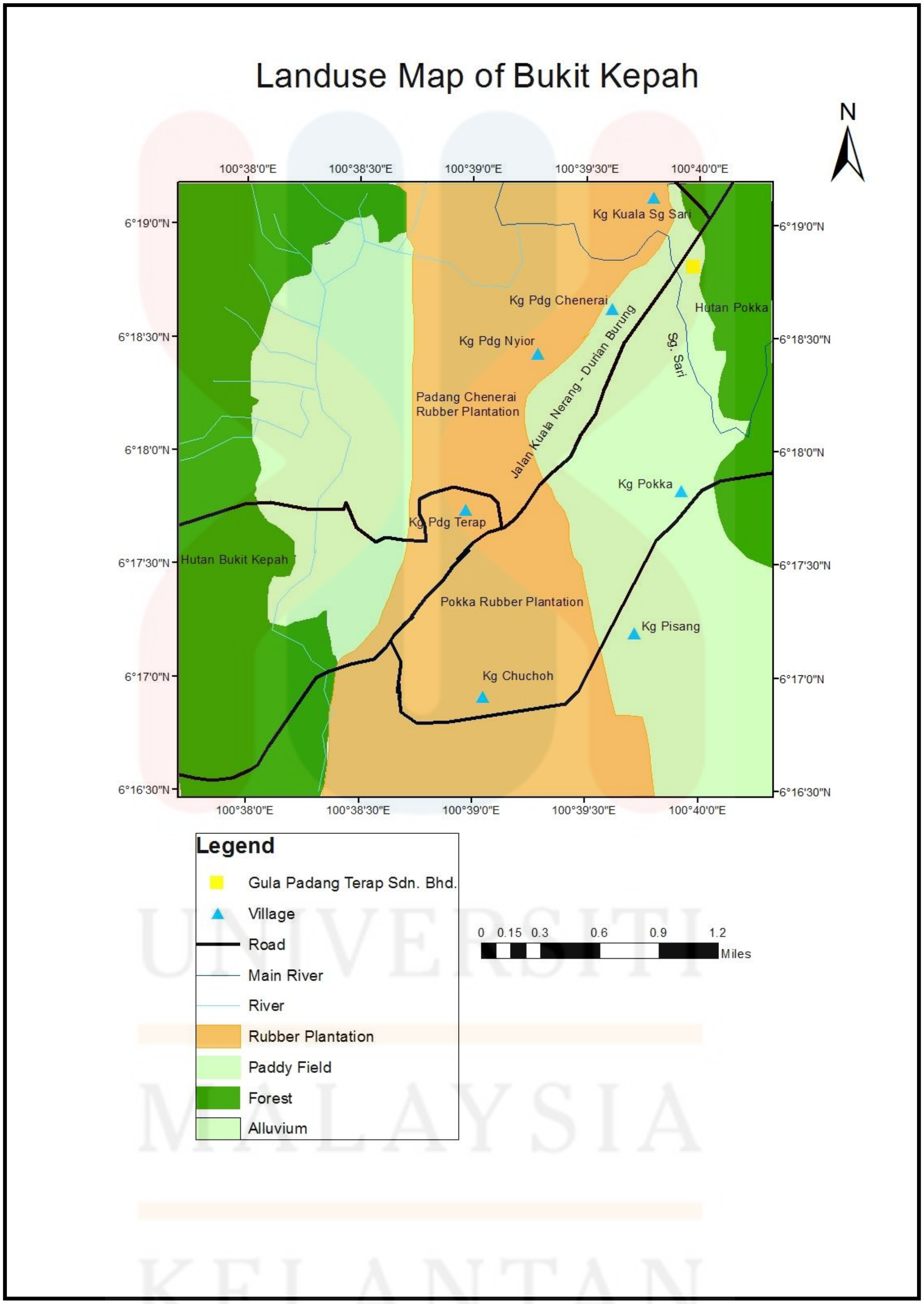


Figure 1.6 : Landuse map of Bukit Kepah, Kuala Nerang

- **Social Economic**

Kuala Nerang gives thousands of new jobs and hundreds of business opportunities available for foreigners and local people as its land suitable for paddy cultivation and rubber plantation. Most of the land surfaces are relatively flat, making it a suitable place for paddy cultivation. It has the largest double cultivation paddy field which is the main food source among Malaysians. There are many rubber tappers work at the rubber plantation and most of them are Indian.

Figure 1.7 shows paddy plantation that working out by major Malay race.

- **Road Connection**

The main connection of the Kuala Nerang is paved road. The main road of research area connecting Kuala Nerang and Jitra town. Besides that, many of the road in the south part has been paved. But in the north part there are new road connecting

Durian Burung and Pedu Dam. There are also a few road that are not paved for logging and agriculture activities. This road connected many rubber and sugar cane plantation to Sintok area which crossed north part of Kuala Nerang.

Figure 1.8 shows the main road of Bukit Kepah area which connects Kuala Nerang town to Durian Burung and Pedu Dam.

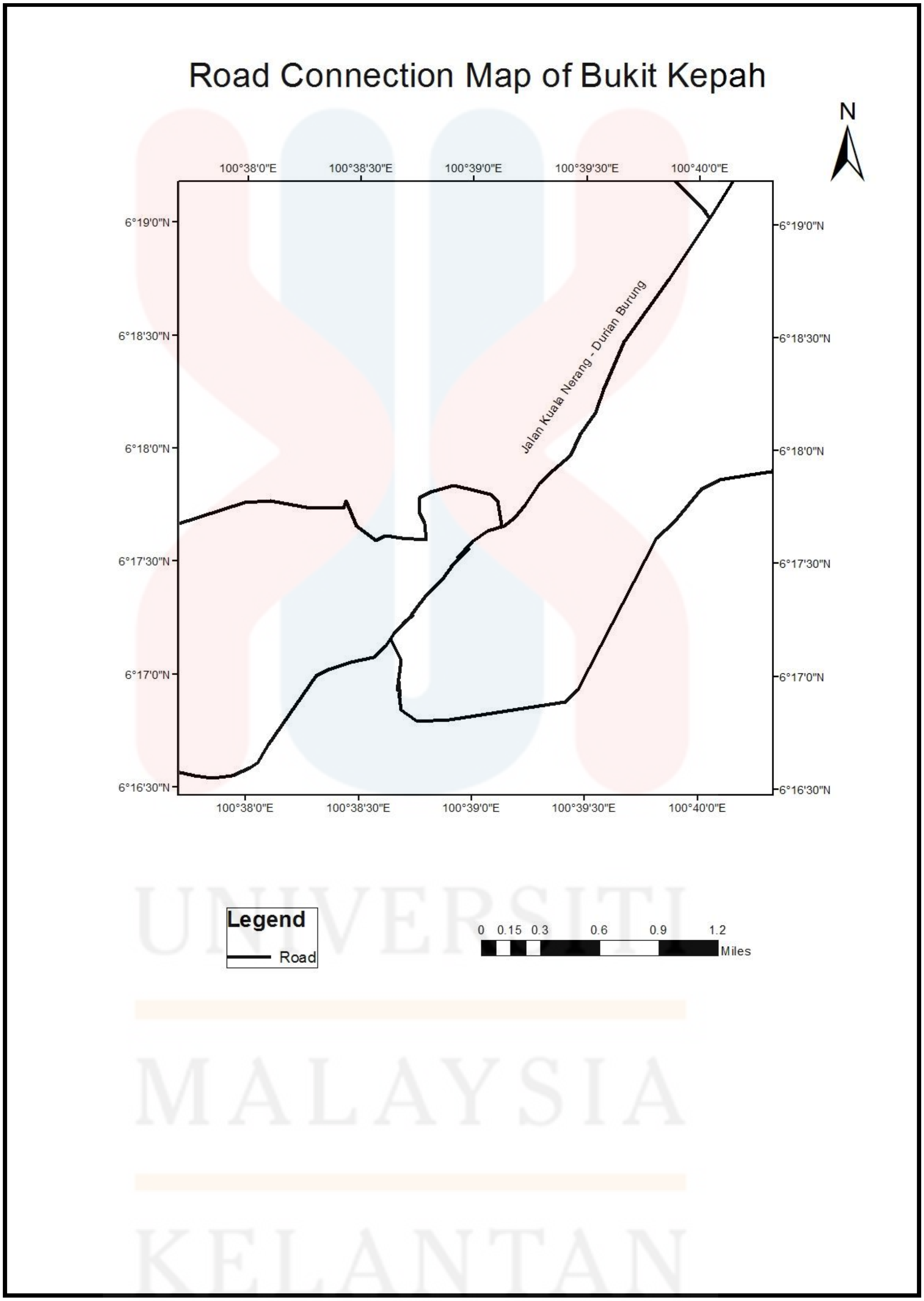


Figure 1.9. Road Connection map shows the main road used by the locals.

1.5 Scope of Study

The study of this research focus on depositional environment of the Kubang Pasu and Semanggol Formation. The lithostratigraphy analysis need to be study by using the parameters which are lithology, sedimentary structure, and presence of fossils. The comparable of the three parameters were studied in order to gain knowledge about the geological properties and depositional environment both formation in Kuala Nerang.

1.6 Research Importance

This study is important as it provides information of the historical geology of Bukit Kepah, Kuala Nerang, Kedah. By studying the depositional environment of the area, data and information of formation in study area can be improved since the previous study has been done a long time ago which is twenty nine years ago. The stratigraphic column of study area need to be updated. Besides that, this study is significant to update geological map of the area. The geological map is important as it gives evaluation of geological structures of the area and provides information of geological structures.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

By studying the literature reviews, an early interpretation of purpose on objectives can be achieved and give an early evaluation of the geological properties of the study area. The reviews of the study should be described, summarised, and clarified. Several research on the geology of the the Kubang Pasu and Semanggol Formation have been done before thus it is easy to make an early interpretation on the geological properties of the formation.

2.2 Regional Geology and Tectonic Setting

The regional geology and tectonic setting is a study of interpretation and to determine the paleoenvironment of certain part of area that was constructed after involve with great forces of tectonic forces. Peninsular Malaysia is an integral part of the Eurasian Plate, the South-East Asian part which is known as Sundaland (Hutchison, 2009). The edge of the Sunda Shelf extends N-S a short distance east of Vietnam and then curves eastwards as far as the West Baram Line (Hutchison, 2004).

Peninsular Malaysia lies on Sibumasu Plate. It was divided into two blocks which are Bentong-Raub suture, western part that belongs to Sibumasu block and the eastern part belongs to Indochina block. Sibumasu and Indochina terrain is origin from Gondwanaland (Meltcafe, 1981).

Peninsular Malaysia can be divided into three longitudinal belts which are Western, Central, and Eastern. The Western Belt can be subdivided into northwest sector and a Kinta-Malacca sector. The Western Belt consist of Langkawi Island, Kedah, Perlis and North Perak (Tan, 1983). The study area, Kuala Nerang is located at northern of Kedah. Figure 2.1 shows the three main belts in Peninsular Malaysia.

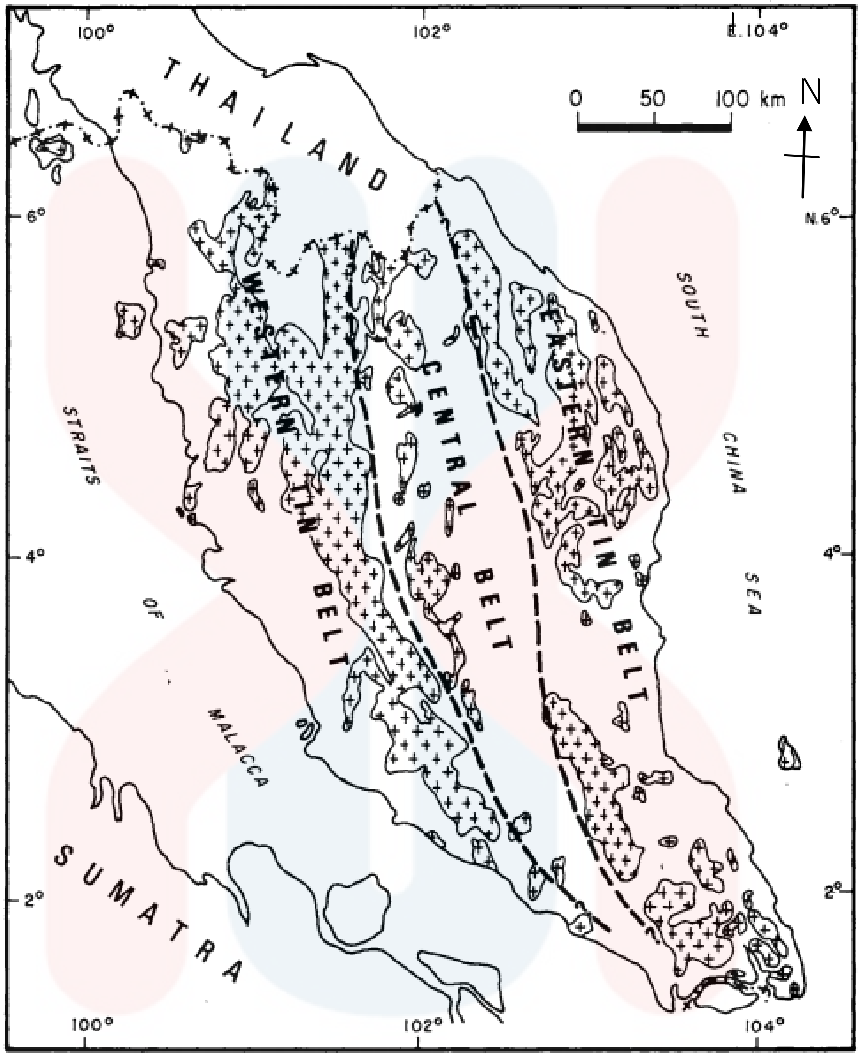


Figure 2.1: Map of the three main belts in Peninsular Malaysia (Hutchison, 2009)

2.2.1 Sedimentology and Stratigraphy

There are 42 geological formations aged Paleozoic as mentioned by Lee Chai Peng in 2004. Lower Paleozoic rocks are comprised to the western part of the peninsula while Upper Paleozoic rocks cover large tract of Central and Eastern belt. The area of Kedah, Perlis, and Langkawi Islands has the most complete Palaeozoic sequence in the peninsula ranging in age from the Upper Cambrian to Upper Permian. The Palaeozoic formations found in this zone are the Machinchang, Jerai, Setul, Mahang, Sungai Petani, Singa, Kubang Pasu and Chuping Limestone. In Mesozoic Era, Mesozoic formations are found in Northwest, Central Belt of Peninsula and also in West Sarawak. A very few Mesozoic rock formations are known in the Eastern Belt of Peninsular Malaysia and in Sabah. There are 38 of Mesozoic rock formations are found in Malaysia. Mesozoic formations encompassed of the Chuping limestone (refer Paleozoic section), Kodiang limestone and Semanggol formation (Lee Chai Peng, 2004).

The process of sediment deposition of Semanggol Formation occur during Middle Triassic until Late Triassic based on fossil *Posidonia, Halobia* and *Daonella sp*. found in shale. Based on facies analysis and fossils found, Semanggol Formation was analysed in submarine fan deposition in deep marine environment. The subduction process of Gondwana and Sibumasu blocks beneath Cathasia Eastmal-Indosinia block occurr during Late Triassic (Mohammed Hatta and Zainul Hussin, 2010). Sediments of Semanggol Formation experienced uplifting, folding, and faulting as well as granite intrusion during Late Triassic until Early Jurassic (Foo, 1990).

- **Kubang Pasu Formation**

The Kubang Pasu Formation covers a vast area in Perlis and northwestern Kedah. Kubang Pasu Formation is used by (Jones, 1978) for a sequence of Upper Palezoic rocks comprising shale, mudstone, siltstone, flagstone, subgreywacke, greywacke and quartzite. These rocks extend in the northern half of Perlis and extend into Thailand. They occupy a large portion of northwestern Kedah to the South, excluding the coastal plain which is covered by Quarternary alluvium. Kubang Pasu and Singa Formations are isochronous in part they appear but do not has time equivalent of each other.

In Perlis, Kubang Pasu strata lie conformably beneath the Chuping Limestone of Permian to Triassic age. Kubang Pasu Formation in Perlis is mostly Carboniferous or Permocarboniferous shown by the paleontological evidence. In north Kedah, the apparent lateral replacement found in Chuping. Limestone is similar from the lithology of strata to the Kubang Pasu of Perlis. It extends the time range of the unit well into Permian and possibly Triassic.

Kubang Pasu Formation is composed of two lithologies which are argillaceous facies and arenaceous facies. Argillaceous rocks of the formation consists of predominantly shale and some siltstone. The shale is varies in colour from grey to reddish purple and consist of fine-grained quartz and mica. Arenaceous rocks are found to be varies commonly grey to brown. They are well-indurated with beds generally between 10cm and 15cm thick. Quartz found in arenites are subangular to be subrounded and commonly range up to 0.5mm across. While the accessory minerals found include iron oxide, sericite, zircon and tourmaline. Compared to Semanggul Formation, arenites of the formation rarely contain chert fragments. (Hock, 1992)

- **Semanggol Formation**

Semanggol Formation was used by (Alexander, 1959) that adopted from the name Gunung (Putus) Semanggol range in north Perak which is underlain by Middle Triassic, argillo-arenaceous rocks and rudaceous-arenaceous. The name was adopted by (Burton, 1970) and (Courtier, 1974) to describe similar rocks in north Perak and South Kedah lithologically and chronologically. Semanggol Formation is exposed in three areas, north Perak, south Kedah and central to north Kedah.

The Conglomerate unit was deposited in a proximal submarine fan, the Rhythmite Member was deposited in distal submarine fan, and the Chert Member was deposited in a basin environment. The Chert Member is reported as the oldest member among the three members based on the study by the paleontologists but based on Discovery of Early Permian to Middle Triassic suggest that Chert Member is interfingering with other unit.

The Semanggol Formation is located at three different fault-displaced areas in Padang Terap (north Kedah), Kulim-Baling (south Kedah), and Gunung Semanggol (north Perak). In the Padang Terap area, Semanggol Formation consists of three members which are Conglomerate, Rhythmite and Chert members. It conformably overlies the Kubang Pasu Formation (Tan, 2009).

a) Chert Member

The chert is predominantly light coloured and the beds are a few mm to a cm thick. Generally, the chert occurs either as thin interbeds with silicified shale or mudstone. In petrographic, the chert is composed of cryptocrystalline quartz and chalcedon and radiolarian are abundant. The Chert Member is well exposed in Padang Terap and Kulim-Baling areas (Basir Jasin and Zaiton Haron, 2007).

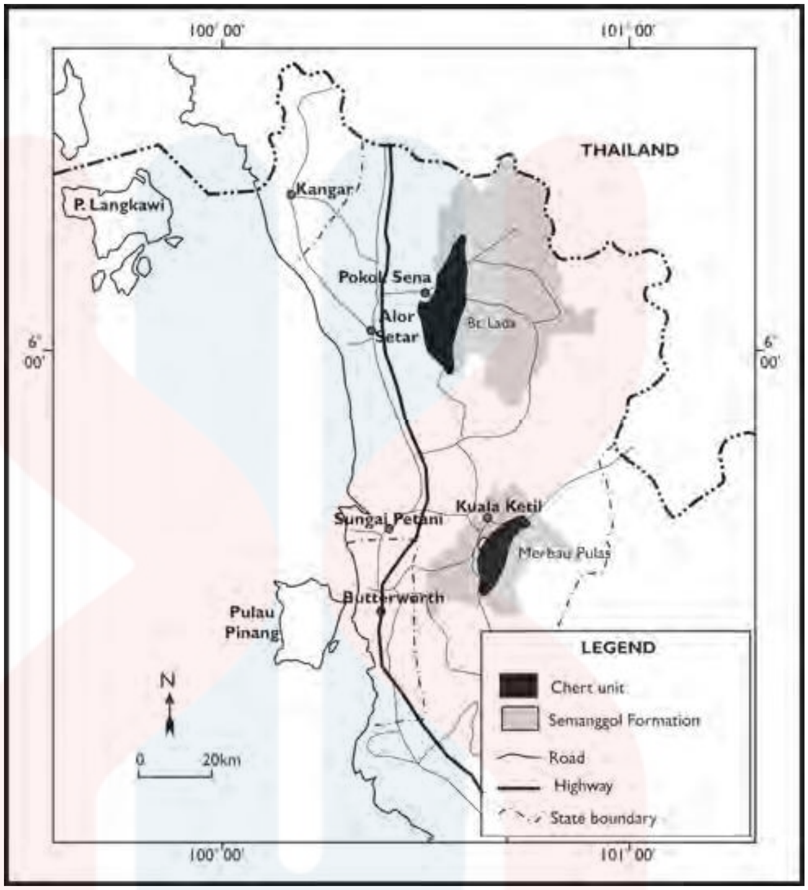


Figure 2.2 shows distribution of Chert Member in Semanggol Formation (Basir Jasin, 2007)

b) Rhythmite Member

Rhythmite Member is composed of alternating beds of sandstone, and mudstone, or shale, with occasional beds or lenses of conglomerate towards the eastern part of north Kedah. The sandstone and mudstone are thinly bedded, generally a few thick but thicker beds present. They also resemble the clastic rocks associated with the Chert Member. The sandstone has sharp lower bedding planes and may grade up into thin siltstone or shale. It also exhibit graded bedding, cross-lamination, convolute lamination and sole marks. It can be interpreted as turbidite. *Halobia* and *Posidonia* were the common fossils found in Rhythmite and Conglomerate unit (Basir Jasin and Zaiton Haron, 2007).

c) Conglomerate Member

Conglomerate Member exposed mainly in northeast Kedah and in Bukit Merah area of North Perak. This member is characterized by interbedded sandstone and mudstone with prominent conglomerate horizons. Clasts in the conglomerate range from granules to cobblers and are composed mainly of chert, quartzite, quartz, sandstone, shale, and mudstone. Based on previous study, the mudstone or shale intercalated with the conglomerate in the eastern part of north Kedah, yielded *Posidonia, Halobia,* and *Daonella indica* (Hutchison, 2009). All fossils listed are Middle to Late Triassic in age.

2.2.2 Structural Geology

Geological structures are important elements to show diversity geological treasures. The variety of geological structures is astonishing due to variety in type of origin, scale, size, age, outcrop quality and their heritage values. The varies formation are affected by tectonic activity that occurred at various time in the geological history of Peninsular Malaysia.

The most obvious regional structure in Peninsular Malaysia is the arrangement of the parallel and en echelon mountain ranges subparallel to the direction of elongation of peninsula. Some fold in the formation is believed are overtuned but not consistent in direction.

The activity of tectonic movement affected the lithology and morphology of surface of the earth. Among that is sedimentary rock formed folding. There were few anticline and syncline where the axis is parallel to tectonic pattern in North of Peninsular Malaysia. The main fault formed due to tectonic activity has changed rock structures and fasten deformation of joint and cleavage on rocks (Muhammed Hatta and Zainol Hussin, 2010).

Almost fault structure in Kuala Nerang is clearly seen in unit rock of metamorphic and granite together with Semanggol Formation. From the general pattern of structure, part of the fault stretched from Ulu Muda to the border area of Thailand. The two main lineament that have been observed from the past research were Koh Mai Lineament and Padang Terap lineament (Lai, 1986). Breccia that found in Durian Burung area proved the existence of fault in the area. The fault was named Durian Burung fault.

Set of joints in Kuala Nerang exist in many types of rocks but most clearly seen in igneous rock. Lai also stated that linear joints exist in Koh Mai Granite and Balek Angin Granite. While vein cleavage in slate was clearly seen.

2.2.3 Historical Geology

The historical geology of this area started when the tectonic movement of the Earth in during Middle Paleozoic cause the uplifting of to Early Paleozoic bedrocks (Jones, 1970). During Paleozoic to Mesozoic, a trangressive of deposition process has occurred results from the flood of land surface. While during Carbon, the process of sediment deposition forms the Kubang Pasu Formation. The correlation rock unit of the formation correlate with the same rock unit found in north of Kuala Nerang and continued to Thailand.

The deposition of sedimentary rock of Semanggol Formation that happened during Middle Triassic to Late Triassic was confirmed from the discovering of fossil *Posidonia*, *Halobia*, and *Daonella* sp. in bed of shale. Based on facies analysis and existence of fossil, the previous researcher interpret Semanggol Formation as submarine fan deposit in deep marine (Kamal Roslan, 1989). During Late Triassic, subduction tectonic block of Sibumasu Gondwanaland below the Cathasia Eastmal-Indonisia block caused sediment of Semanggol Formation to be uplifted, folded, and faulted together with intrusion of granite (Foo, 1990). The collision of both blocks formed granite intrusion near to Bentong-Raub Suture. The granite intrude into strata of Kubang Pasu Formation and Semanggol Formation rock unit.

Uplifting, folding and faulting during the granite intrusion in Late Triassic has exposed rocks in study area to weathering and erosion process. The rocks found in fault area along Durian Burung river showed that it was a strong faulting process and they were transport thus deposited again continental environment.

During Plestoicene, deposition of unconsolidated sediments consists of clay, siltstone, sandstone were unconformably overlain by volcanic ash. While during Quaternary, deposition of unconsolidated that consist of clay, siltstone, sandstone, andgravel until cobbler in subangular to rounded was deposited in river valley and flood plain.

2.3 Research Specification

The research is focused on depositional environment of the Kubang Pasu Formation and Semanggol Formation. Based on (Adeigbe, 2009), the depositional environment of formation can be determine through field relationship and grain size distribution of morphologic studies. While other depositional environment study on the Belait Formation by (Numair, 2013), the tide-wave and storm dominated environment of the Belait Formation was determined by acquring gamma-ray profile and construct a sedimentological log to describe the sedimentary properities of the formation. Thus, the methods that can be refer to determine the depositional environment is by interpreting the lithology and sediment properties of the formation. A research by (Basir Jasin and Zaiton Haron, 2007), the depositional environment of the Semanggol Formation is clarified as open deep marine environment based on the facies analysis interpretation and fossil radiolaria found.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter will discussed about the material and methodology were used in conducting this research. The subtopics will discuss about preliminary studies, materials and methods including field work and laboratory investigations.

3.2 Materials

Materials that were used in this research are mentioned below:

i. Base or topological map

It shows three dimensional shape of landscape by representing contour with lines on a two dimensional map. From the map, the shape or geomorphology of study area was interpreted first.

ii. Global Positioning System (GPS)

It is a satellite based navigation system includes three basic parts which are the satellite in space, monitoring station on the earth and the GPS receivers. It is used for GPS to locate the position, mapping lithology, tracking structures, measuring elevation, and saving the sampling point in the geological field mapping.

iii. Brunton or Sunton compass

This instrument is used if Global Positioning System (GPS) was not function during geological field mapping. Moreover, it is used to record the reading of strike and dip for the structure of outcrop.

iv. Hammer

It is use to take sample from outcrop. It is the basic things for geologist in geological field mapping when collecting sample. The best hammer to use for is a hammer with a piece of chisel head made of hardened steel and rubber coated shock reduction handle.

v. Digital camera

It is essential to use digital camera in geological field mapping. It is use the capture geomorphology, outcrops or any geological features that present in study area. A suitable scale must include when capturing the picture.

vi. Notebook

All the observation and important data must be written down in order to remember the data taken during the geological field mapping. To take note important data of outcrop or observable features. It should be hard covers and water-proof material to prevent damage of the data.

vii. Hydrochroloric acid

It is use as indicator present of carbonate minerals in rocks. It shows frizzy sound when carbonate minerals are present.

viii. Hand lenses

It functions to identify of rocks in larger magnify. This was done as first analysis before further analysis in laboratory investigation.

x. Sample bag

It is use to carry sample that has been taken from fieldwork. It prevents sample rock from damage.

3.3 Methodology

- **Preliminary Studies**

Preliminary studies refer to the initial interpretation of a issues related to proposed quality review or evaluation. This study need numerous materials study likely literature review such as journal, report, thesis, proceeding papers, books, and many more. This study was done to get early knowledge and full understanding of the related topic.

First visit to the study area also have been done to get early interpretation of the study area. The geological features observed were outcrops exposure, geomorphology of the area, drainage system, and road connection.

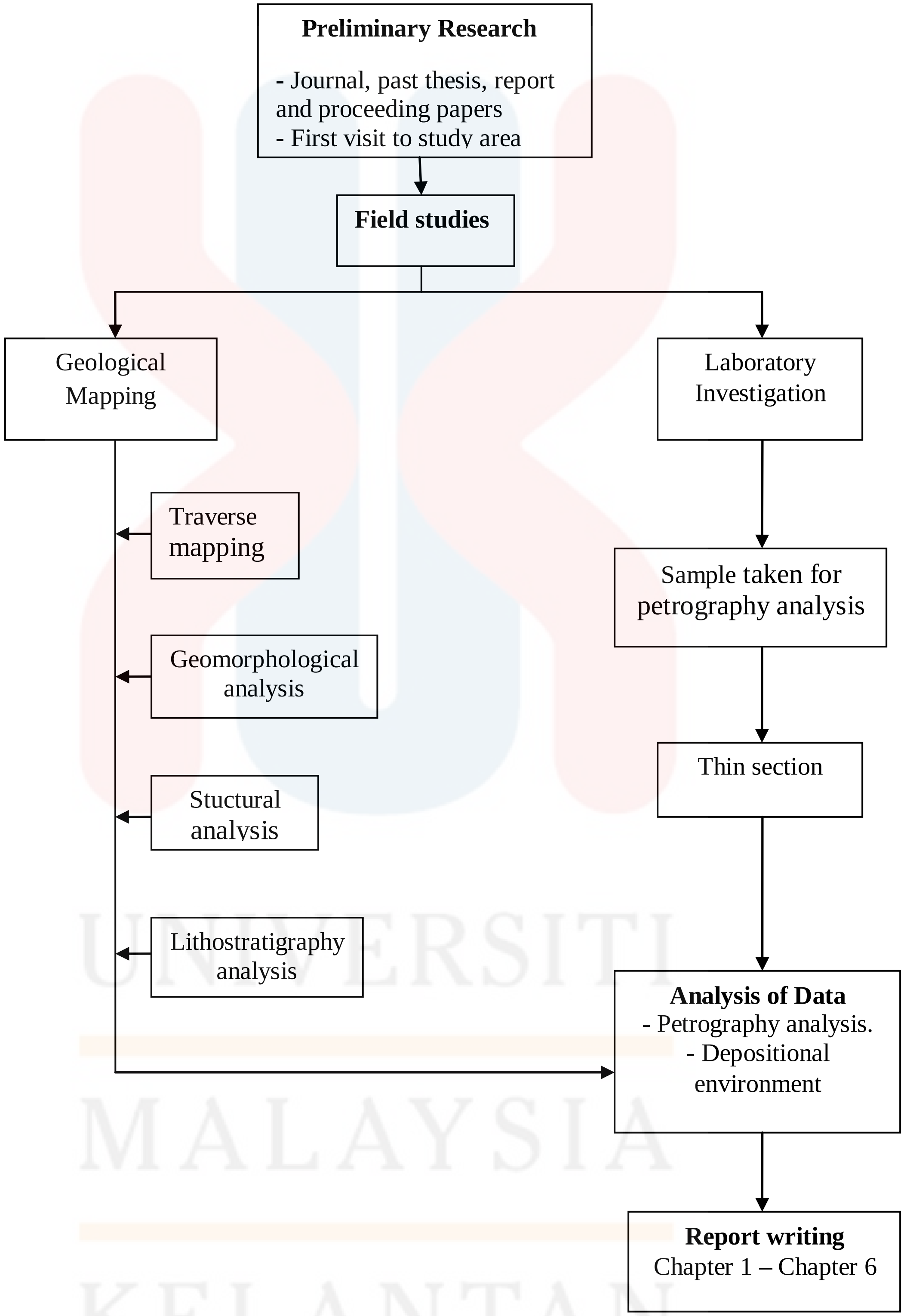


Figure 3.1: Research flow chart of the whole study.

- **Field Studies**

i) Geological Mapping

A geological mapping was done by traversing. The morphology of the area were determined based on contour on the base map. A geological mapping was conducted in 25km² study area. Mapping was done to recheck the information gained from the literature review as if there is no data updated from the area. During the fieldwork, the important data and information that need to be observed and collected were geomorphological analysis, structural analysis, facies analysis, lithostratigraphy analysis and also sampling. The purpose of this data and information was to fulfill the research objectives. The materials used in geological mapping was mentioned before.

a) Geomorphological analysis

This analysis discover the nature and origin of landforms for the study area. It concerned on the process that create the shape of the earth's crust. Thus the landform of the area need to be observed such as topography, drainage system, weathering process, mass wasting and hillslope.

b) Structural analysis

Structural analysis is important to study the distribution of three-dimensional rock units and their relationship to deformational history. Moreover it is also to gain knowledge of the stress that resulted from strain and geometries. For example, the structural evolution of an area can be interpreted by observing the widespread pattern of rock deformations such as mountain building and rifting. Structural geology is the tool used by geologists to understand the history of deformation, from understanding and interpreting displacements, strains and rates, through to stresses, pressures and temperatures.

By geological mapping, the deformation of rocks and their structures were observed. They represented the most direct and important source of information on how rocks deform. Measurement of dip and strike are important in structural analysis. Strike is the direction of a line produced by the intersection of an imaginary horizontal plane with an inclined bed while dip is the angle between the imaginary horizontal plane and the inclined bed measured in a plane oriented at 90° to the strike line. Brunton or Suunto compass was used to measure strike and dip. Faulting, folding, bedding, and joint are common geological stuctures present.

c) Lithostratigraphy analysis

Lithostratigraphy is the most fundamental kind of stratigraphic studies which composed of recognition, subdivision, and correlation of sedimentary rocks on the basis of their lithology. Thus to gain the information of this study, the lithology and stratigraphic relation need to observed.

There were three parameters used to consider in this analysis. They were lithology, sedimentary structure, and presence of fossils,. For lithology, the composition of mineral, colour, and texture were recorded. Sedimentary rock consists of clastic rock, chemical, and carbonaceous rock. For the stratigraphy studies, lithostratigraphy analysis need to be investigate.

A lithostratigraphy column was used to represent a series of bed of outcrops or rocks. The graphic lithostratigraphic column was useful to identify and interpret data using symbols and abbreviations. The important needed in this log is the scale measurement. The vertical scale is used to show the amount of data required. Thus a suitable scale measurement is important. Next, the sedimentary log can be drawn onto a log sheet form in the field. The symbols of every rocks and other geological features showed the representation of outcrop found in study area.

Sediment grain size could be distinguished by using The Wentworth scale. This scale can be used for clastic sedimentary rock to distinguish the grain size.

Millimeters	Wentworth Grade	Phi (Φ) Scale
>256	Boulder	–8
>64	Cobble	–6
>4	Pebble	–2
>2	Granule	–1
>1	Very coarse sand	0
>1/2	Coarse sand	1
>1/4	Medium sand	2
>1/8	Fine sand	3
>1/16	Very fine sand	4
>1/32	Coarse silt	5
>1/64	Medium silt	6
>1/128	Fine silt	7
>1/256	Very fine silt	8
<1/256	Clay	>8

Table 3.1: The Wentworth Scale (Source: Udden-Wentworth, 1922)

Carbonate or chemical sedimentary rocks are study by their chemistry and mineralogy. Limestone, dolostone, and travertine are carbonate sedimentary rock. The minerals that exist in this type of sedimentary rock are calcite, aragonite, dolomite and siderite.

Sedimentary structure are structures that formed during deposition of environment. Study of sedimentary structures is important because they are the most valuable features to interpret depositional of environment. The present of sedimentary structures in a rock can tell us a lot about the condition of deposition. There are two useful ways to classify them. Firstly, by the basis of kind of mechanism that produces them which are the physical sedimentary structures, chemical sedimentary structures, and biogenic sedimentary structures. Secondly, by time of development relative to time of deposition which are primary sedimentary structures and secondary sedimentary structures.

Finally is the nature, distribution, and preservation of fossils contained in sedimentary rock. Sedimentary rocks contain the fossil record of ancient life organisms that enables the evolutionary advancement from simple to complex organisms in the plant and animal kingdoms.

d) Sampling

During the geological mapping, sampling method was used to take samples from outcrops for further observation and investigation. For geological field mapping, the sampling was useful for thin section study which is for the identification of rocks and minerals content. To locate each site form where the sample has been take, a GPS was used. A geology hammer was used to break the outcrop into rock fragments.

Fresh sample is important to take because weathered sample is not suitable for laboratory investigations. Then the samples were keep in sample bag with labeling to make sure there was no mixing of sample from other locality. For facies analysis, each types of rock found in the geological mapping has been taken from a fresh outcrop. Thus, the physical characteristics of the rock sample can be identified.

- **Laboratory Investigations**

i) Petrography analysis

The method used in laboratory investigation was petrography analysis. This analysis was conducted more precisely on the texture, mineralogy, and fossil content of the sedimentary rocks. The purpose of this analysis was to characterize minerals, rock fragments and other components identified in standard size petrography thin section.

It is important to assess mineral composition and classify rock type. The minerals which were cannot be seen by naked eyes were identified under polarized microscope. In this analysis, samples must be taken for a size like hand specimen or more than that. If the sample was hard enough and not easily to break, thus the sample were straight cut by the cutter into small pieces. Next, the samples were grinded to get the minimum thin section which is less than 0.003 mm thick.

For easily break sample such as sedimentary rock, the suitable way to use is different from other hard rock such as igneous rock and metamorphic rock. The sample was cut using Diamond blade cutter. Sample like sedimentary rocks should care with gentle. Samples that have lamination and bedding cut with cross sectional direction to get the laminated and bedding surface as the surface of interest. Surface of interest was grinded to get the smooth surface , the sample cemented first by Canada balsam. Next, the sample must dry on the hot plate to do cementing process.

Next, the samples were grinded until the minimum 0.003 mm thick of the thin section was observed. This process was handle with care to prevent loss or damage to the sample due to over pressure. The samples were cemented with the glass slide after dried and the cementing process use the lake gum. Lastly, the slice of the thin sections were observed through the microscope and determination of minerals were recorded.

- **Data Analyses and Interpretations**

The purpose to analyze data is to obtain usable and useful information. The data that were obtained and analysed by the help of ArcGis and GPS. For the geological mapping and sampling, the data recorded were transferred and interpreted after the laboratory investigation had been done. For lithostratigraphy analysis, a stratigraphic column was drawn and the depositional environment was interpret.

CHAPTER 4

GENERAL GEOLOGY OF BUKIT KEPAH, KUALA NERANG

General geology is the study of geological science of an area. The study area located at Bukit Kepah, Kula Nerang is in Kedah state. Generally, this chapter will be discussed on the geomorphology, stratigraphy, and structural geology of Bukit Kepah, Kuala Nerang. Historical geology also will be discussed to tell the geological processes that change the earth surface and subsurface which includes geomorphology, stratigraphy, and structural geology to tell the sequence of earth events. The geomorphology on Bukit Kepah today are the results of many gemorphological process that happened many long time ago. Topography give effects to the formation of drainage system and weathering process can changes the geomorphology of Bukit Kepah.

Based on the geological mapping, flat area covers almost 70% of Bukit Kepah which composed of alluvium deposits. The flat area is suitable for paddy cultivation and hilly area is suitable for rubber plantation due to the soil fertility. The block of the study does not comprised of many contours thus the discussion structural geology was not discuss in details. The subtopic historical geology will give a summary of all the event happened in Bukit Kepah throughout time.

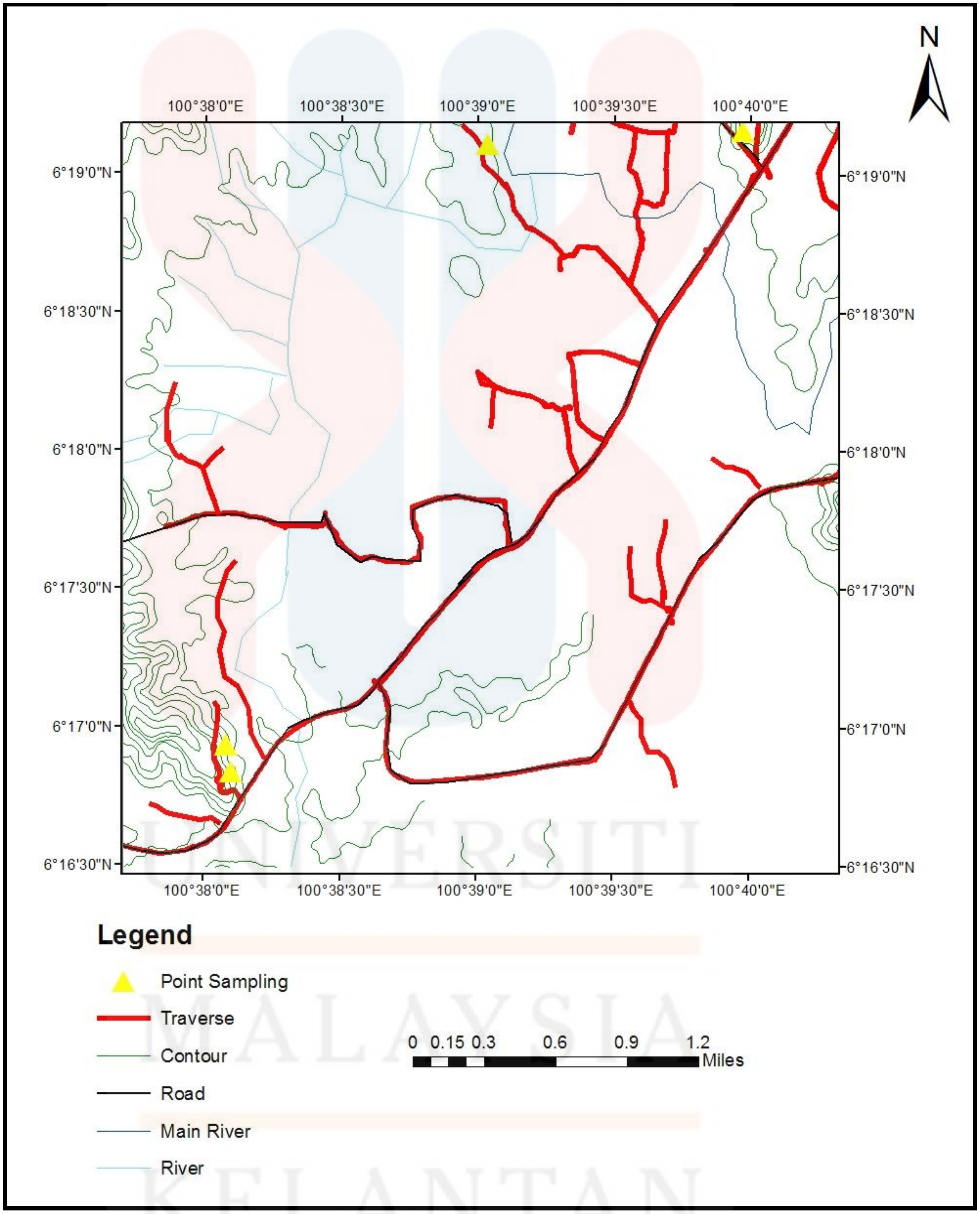


Figure 4.1: Path of traversing and point of samples taken.

4.1 Geomorphology

Geomorphological features can help in interpretation of geological structures and type of lithology. Geomorphological analysis of the study area is analysed and interpreted based on outcrop found topography map and satellite image. This subtopic will discussed three main aspects of geomorphology which are topography, drainage system and geomorphological process of Bukit Kepah, Kuala Nerang.

4.1.1 Topography

Topographical features of Peninsular Malaysia specifically inland are rolling to undulating, hilly to mountainous. Topographical features are distinguished by the mean of elevation to represent the area whether low lying, rolling, undulating, hilly and mountainous.

	Topographical Unit	Mean Elevation (m above sea level)
1	Low lying	<15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	>301

Table 4.1: Topographic unit based on mean elevation (adopted from Geology of Peninsular Malaysia)

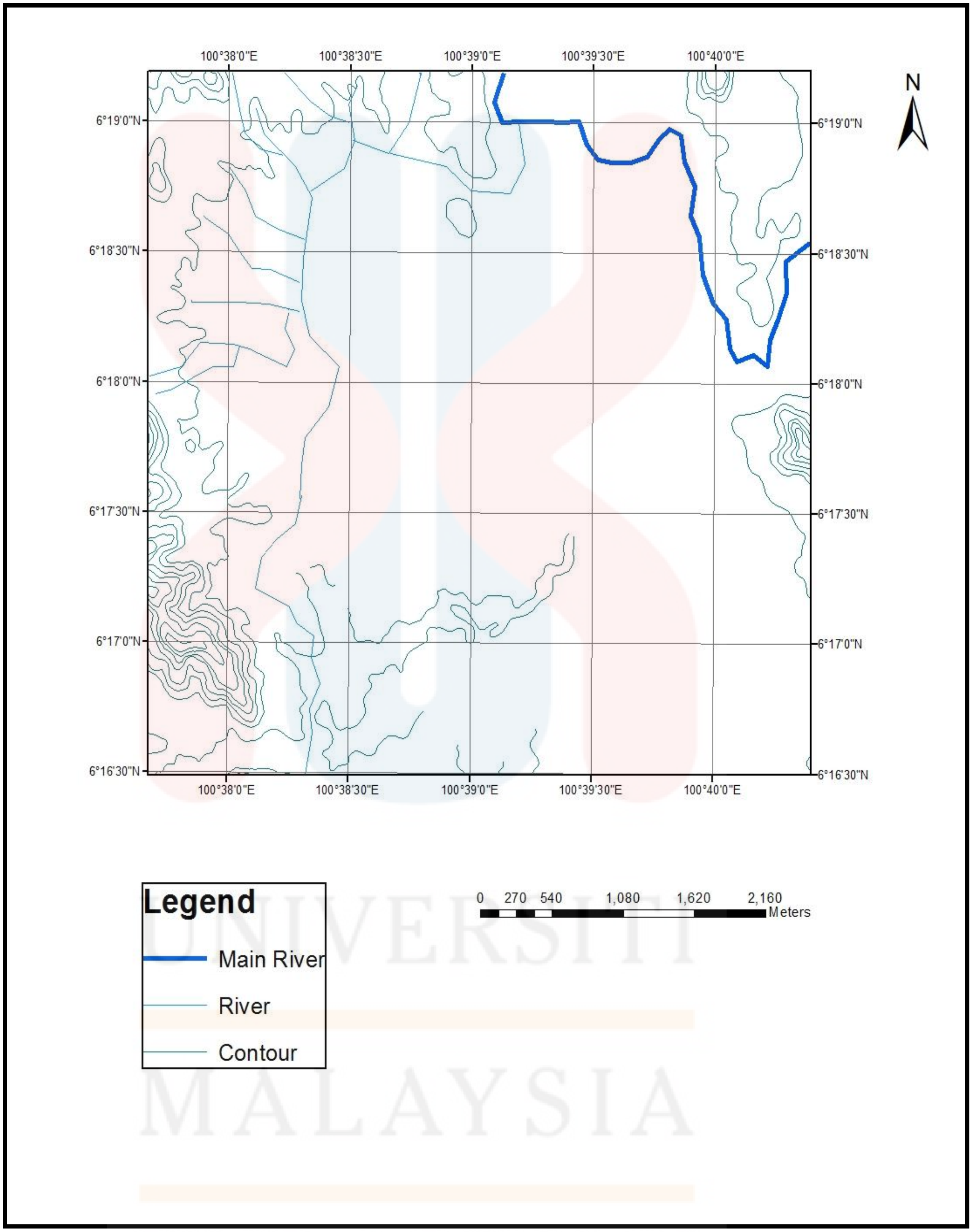


Figure 4.2: Topographic Map of Bukit Kepah, Kuala Nerang

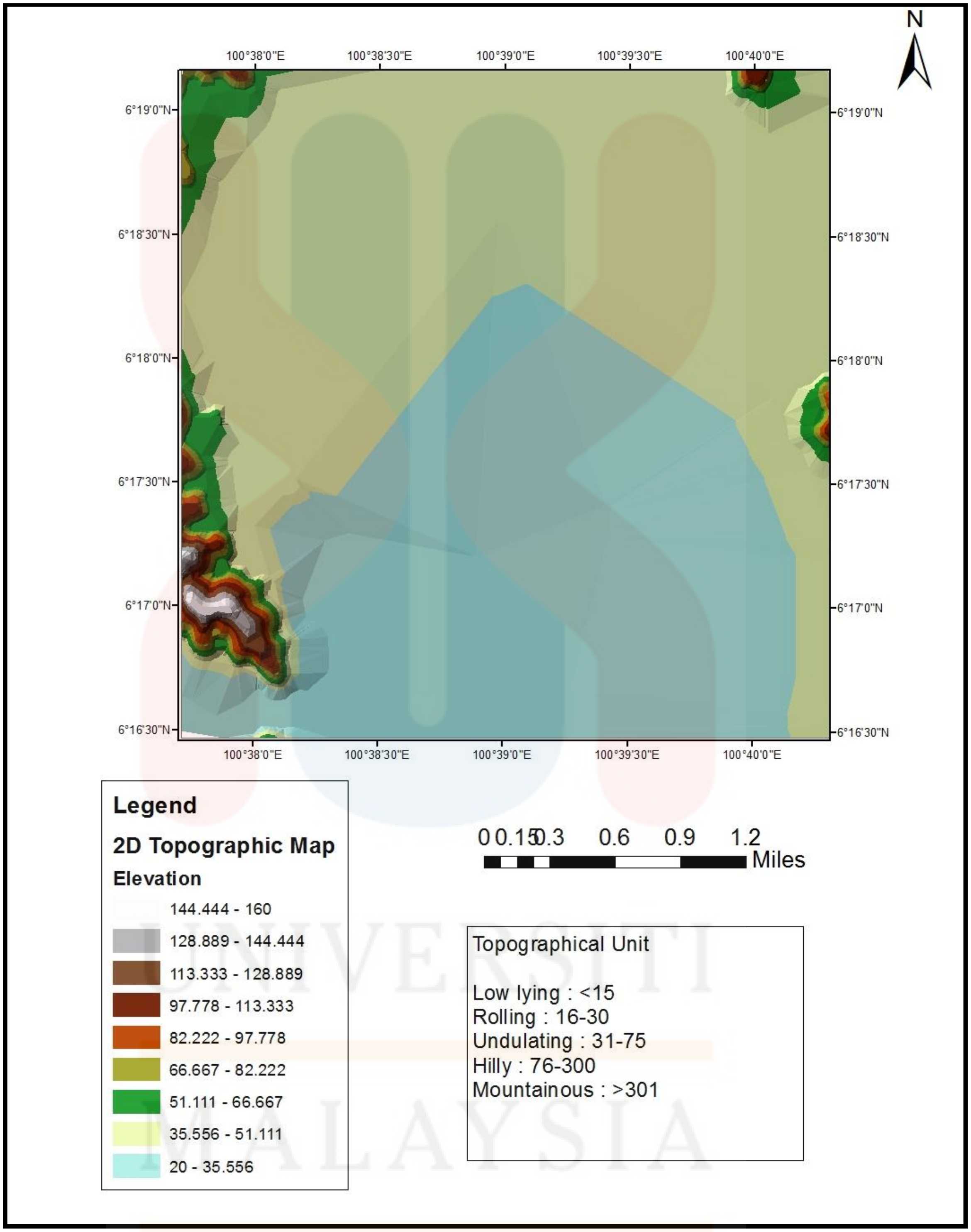


Figure 4.3: 2D Topographic Map of Bukit Kepah, Kuala Nerang. It also shows the morphological unit according to its colour respectively.

Based on topographic map of Bukit Kepah, topography unit of the study area can be divided into rolling-undulating, and hilly topographic unit. Distance between contour line can be observed from the map to distinguish topographic unit in the study area. If the contour line is near between two lines, it indicates high elevation or steep sided of hills while if the contour line is far between two lines, it indicates lower elevation or flat area. Moreover, topographic unit is controlled by geological conditions where specific features in an area is described by the tectonic structures and lithology.

Based on 2D topographic map, rolling-undulating area covers 70% of study area on the middle and west part. Rolling-undulating area with range elevation of 20 m to 60 m above sea level is mainly controlled by rock structures. This area is covered by alluvium deposits in flood plain and main rivers which is Sungai Sari. The deposition consists of clay sediments which have been deposited from the weathering and erosion process in hilly or higher elevation area. The area also is consumed as rubber plantation and paddy field due to soil fertility and nutrient contents such as potassium.

Hilly only covers 30% of study area on the east part as shown in the maps. Hilly topographic unit with range elevation of 80 m to 160 m characterize area high undulating and mild slope. East part of the area shows contour line further between the lines compare to the north part. The contours deform ridges and river valleys. Ridges at coordinate N 6° 16’ 48” E 100° 38’ 3” characterize interbed of sandstone and shale with thin siltstone.

4.1.2 Drainage System

Generally, the surface of the earth consists of drainage system that are formed by several processes that such as water stream and formed various type of drainage system. It also shows various streams, tributaries. sub tributaries that join to create a network of river. Drainage pattern present weak zone that allowed water flows to penetrate in. Another factors influence is slope stability, rainfall distribution, weathering process and human activities contribute to formation of drainage system. Drainage pattern also can be observed from the satellite imagery as the direction and flow can be clearly seen from aerial photograph.

The pattern of drainage is depends on elevation and rocks that made the surface of the area. They are also classified from the form and texture. The common types of drainage usually identified area dendritic, parallel, and trellised.

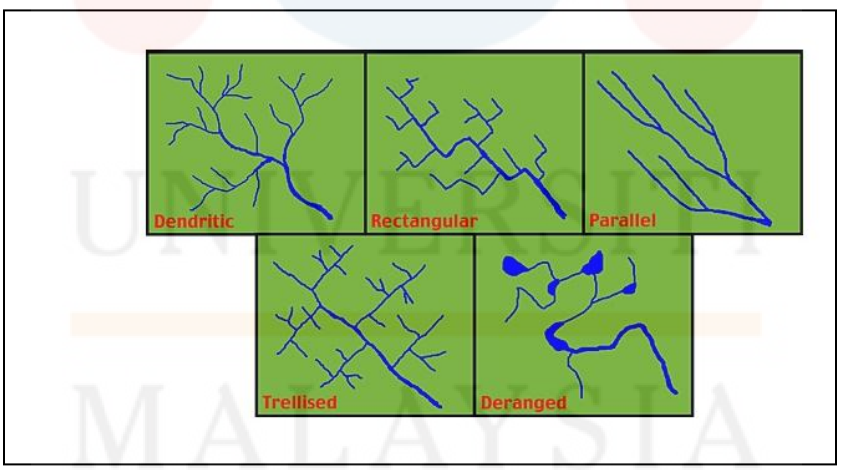


Figure 4.4 shows the types of drainage pattern to be classified

Generally, the main rivers that flow through in Kuala Nerang area Sungai Padang Terap, Sungai Durian Burung, Sungai Aning, Sungai Badak, and Sungai Pasir Putih. Sungai Pedu is the longest river in Kuala Nerang.

Based on geological mapping at Bukit Kepah, the main river observed is Sungai Sari which is located on North part of study area. Drainage pattern that have been observed is only parallel as shown in drainage map of Bukit Kepah. It can be observed on North – South of study area. Parallel is type of drainage pattern that caused by steep slope with some relief. Due to the steep slopes, the streams are swift and straight with very few tributaries and flow in the same direction as shown in map.

Drainage system in the study area is affected by effect of combination of lithology and structures, topography and erosion process. This type of pattern river indicates matured to old age of river. This is due to the moderate elevation of slope and it enables not only fine grain sediments but also pebbles and cobbles. Another proof are with the existence of flood plain at the river. A parallel pattern sometimes can indicates major fault that cuts across an area of folded rock but not in the study area. Transition can occur between parallel, dendritic, and trellis pattern rivers.

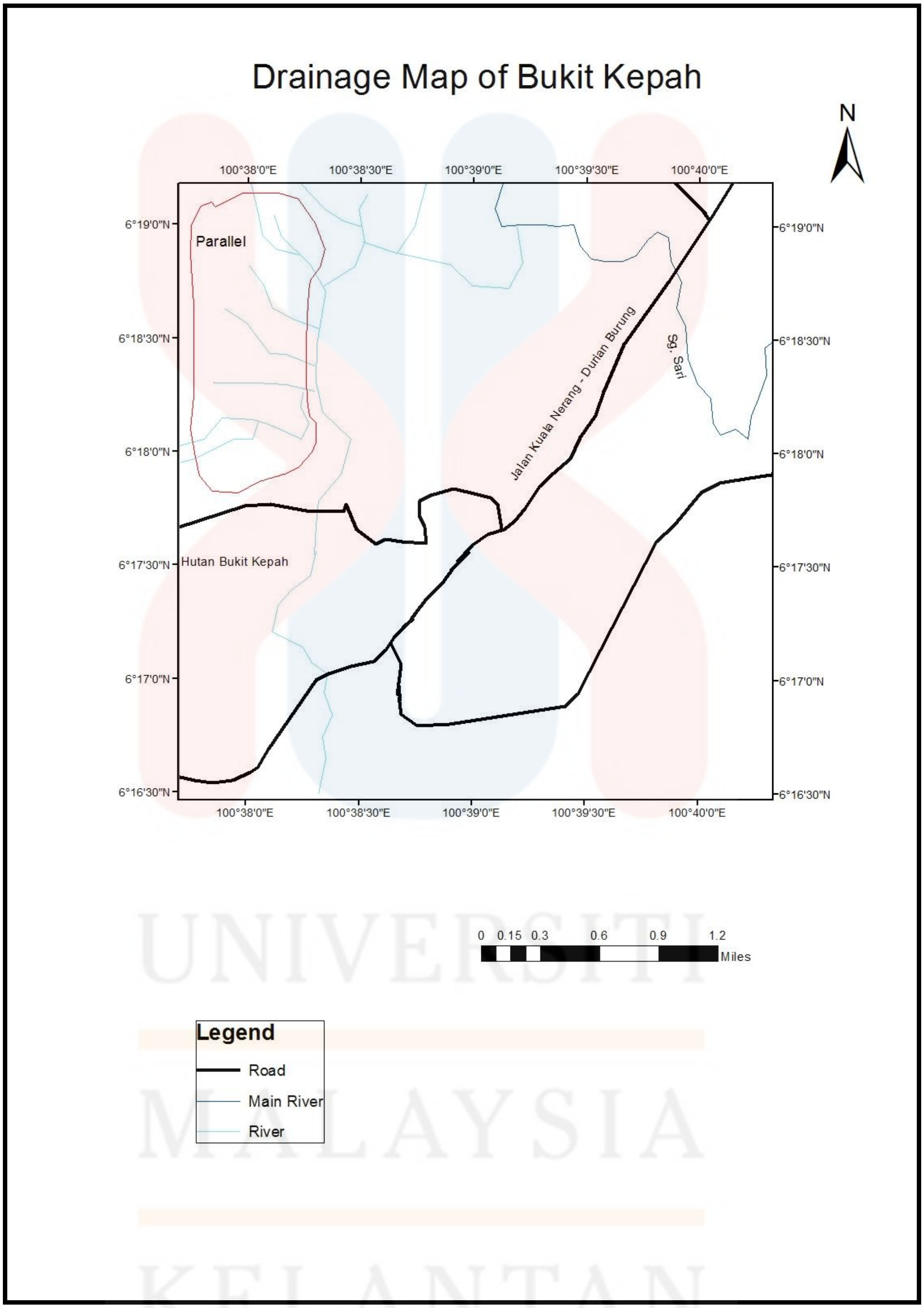


Figure 4.5: Drainage map shows the only drainage pattern exist in the study area which located in the North – West part.

4.1.3 Geomorphological Process

Geomorphological process is all physical, chemical, and biological processes that led to changes on Earth surface (Tjia,1987). These processes will always continually shape the Earth's surface. Physical process happened when there is movement from inside of the Earth and also from outside of the Earth such as meteorite impact. It is the other way of chemical process in which it is the decay of rock forming minerals caused by water, temperature, oxygen, and hydrogen. Carbonation, solution, hydration, and oxidation are the example of chemical processes. While biological process caused by the presence of vegetation or to a lesser extent animals including root wedging and production of organic acids. The main processes that shaped the geomorphological features in the study area are weathering, erosion and organism activity.

Physical Weathering

Physical weathering process can cause rock decomposition and together with chemical weathering, they changes rocks from a hard state to become much more softer and weaker thus making rocks more easily eroded. In the study area, weathering factors are influenced by rock structures, rock contents, climate, topography and vegetation.

Physical weathering gives effect to rocks in Semanggol Formation. Clastic sedimentary rock which have soft texture and easily weathered formed into light grey to yellowish white clay sediments due to physical weathering. It also contribute to exfoliation on the surface on rocks.

Figure 4.6 : Physical weathering cause accelerated disintegration

Biological Weathering

Biological weathering is caused by the presence of vegetation or extent animals. The roots of bushes or trees that grows from cracks in rocks will push open the cracks thus cause rocks to disintegrate. This is because the growing roots exert stress and pressure to the rocks. Burrowing animals can cause rocks to be exposed thus enhance physical weathering. Moreover, microbial activity such as fungi also lead to biological weathering. Fungi release chemical cause breakdown of rock minerals. By time as the process continue, holes and gaps are formed and expose the rocks to chemical and physical weathering.

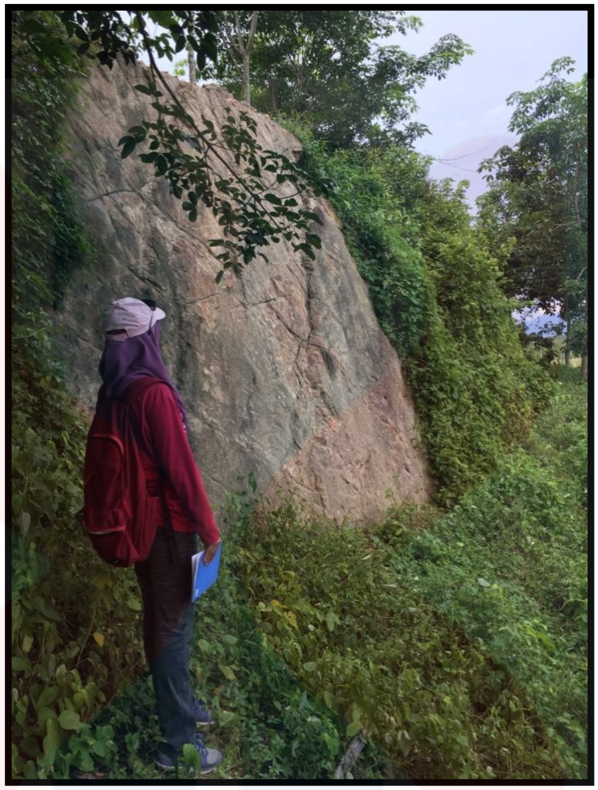


Figure 4.7: Biological weathering by vegetation

Erosion

Erosion process happened after weathering process. It happens when rocks and sediments are picked up and transported to another place by ice, water, wind, or gravity. Malaysia is among the country having humid tropical climate and flow of water is the main agent for erosion that changes surface of the earth due to hydraulic action.

Exogenous process from organism activity are human activities and vegeatation contribute to erosion process. Development or construction of main road and agricultural activities also lead to erosion process.

4.2 Stratigraphy

The stratigraphy in Bukit Kepah is determined by abundant of fossil crinoids found. Analysis of lithology, structural, and features are also used to describe the stratigraphy of study area. Stratigraphic column was constructed based on the analysis that have been interpreted.

The oldest rock unit found in Bukit Kepah is Semanggol Formation. It is composed of Rhythmite Member which are interbedded sandstone with siltstone and shale. Generally, clastic sedimentary rock which are sandstone, siltstone, and shale in Semanggol Formation composed of rock fragments and medium sorted deposit. Their age is between Early Triassic to Middle Triassic based on abundant crinoids found on shale rock.

While the volcanic ash and alluvium deposit area the youngest deposition. They started to deposit during Tertiary to Quaternary. They are deposited horizontally along some place in the study area and formed horizontal deposition.

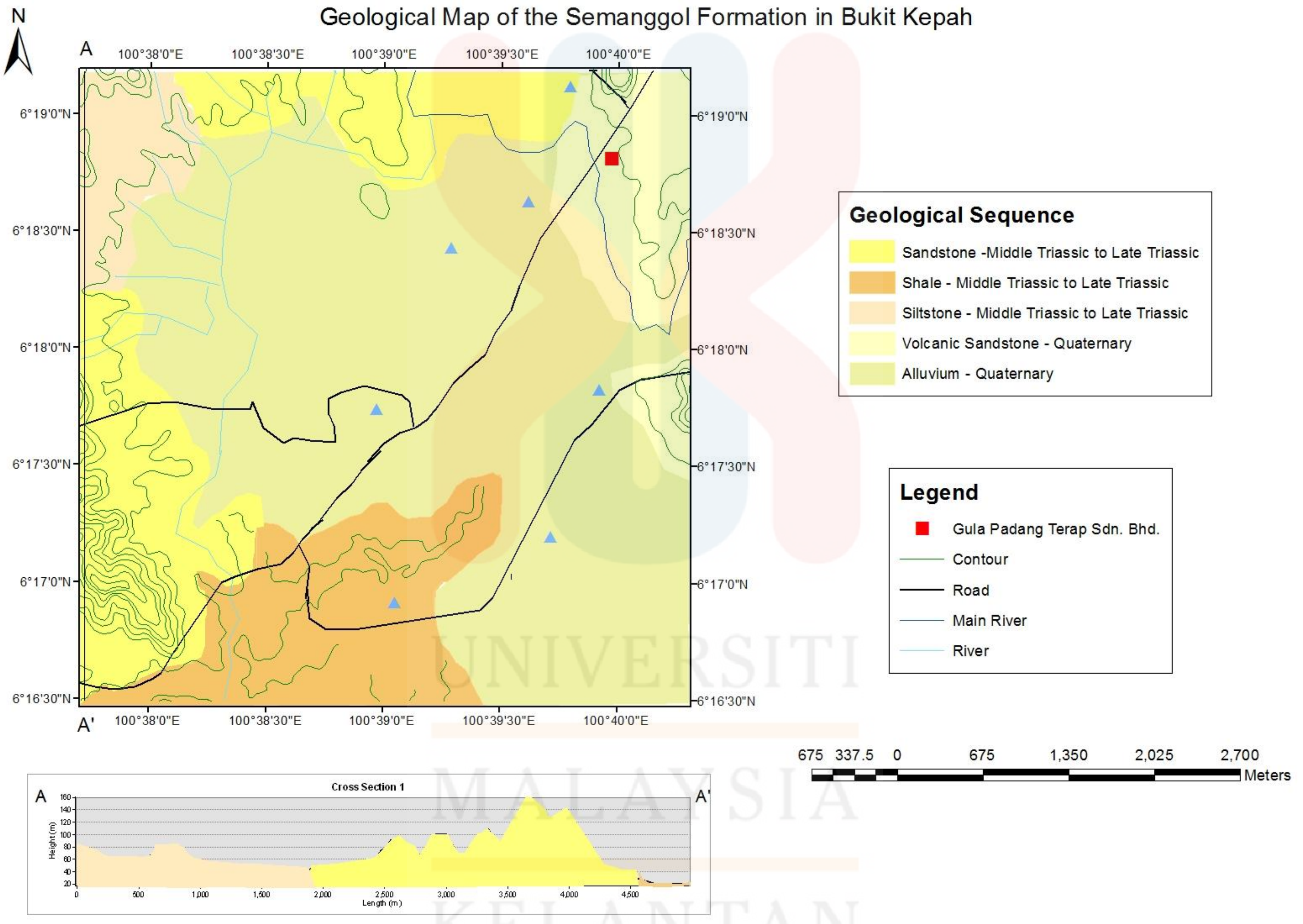
4.2.1 Lithostratigraphic unit

Lithostratigraphy is the fundamental kind of stratigraphic study by recognition, subdivision, and correlation of sedimentary rocks on the basis of the lithology. The term lithology is used to refer the physical characteristics which are colour, mineral composition, and grain size. Lithostratigraphic unit are rocks units defined by their physical properties and lithostratigraphy deals with the study of the stratigraphic relationships among strata that can be identified on the basis of lithology.

AGE	LITHOLOGY	DESCRIPTION	FORMATION
Quaternary		Volcanic sandstone and alluvium deposits	
Middle Triassic to Late Triassic		Rhythmite unit: Interbedded of clastic sedimentary rock: Sandstone with shale and siltstone Fossil: Crinoidal stem fragments	Semanggol

Table 4.2: Lithostratigrahic unit of the Semanggol Formation in the study area

There are two types of lithologies in the study area which are clastic sedimentary rock and volcanic sedimentary rock. Clastic sedimentary rock is the oldest rock consist of sandstone, siltstone, and shale. Volcanic sedimentary rock and alluvium deposits are the Quaternary deposits. Volcanic sandstone deposited from volcanic activity that emit materials such as lava, gases, and pyroclastic rocks. The distribution of lithostratigraphy unit is shown on the geological map.


Geological Map of the Semanggol Formation in Bukit Kepah
N
A
A'
100°38'0"E
100°38'30"E
100°39'0"E
100°39'30"E
100°40'0"E
6°19'0"N
6°18'30"N
6°18'0"N
6°17'30"N
6°17'0"N
6°16'30"N
Geological Sequence
Sandstone -Middle Triassic to Late Triassic
Shale - Middle Triassic to Late Triassic
Siltstone - Middle Triassic to Late Triassic
Volcanic Sandstone - Quaternary
Alluvium - Quaternary
Legend
Gula Padang Terap Sdn. Bhd.
Contour
Road
Main River
River
675 337.5 0 675 1,350 2,025 2,700
Meters
Cross Section 1
Height (m)
Length (m)

- **Sandstone unit**

Based on outcrop, the bedding shows coarsening upward sequences which means the coarser grain sandstone is younger. Presence of iron on the sandstone shows high oxidation process and caused the sandstone to be reddish brown in colour. Planar cross bedding was found in a bed of sandstone. The individual thickness of strata range from 2cm to 100 m. Based on the observation on hand specimen, the colour range of sandstone shows white colour to dark grey. More composition of sandstone than mudstone indicates arenaceous sandstone. The grain size observed shows size from very fine to medium grain size. The mineral found are quartz, biotite, and alkali feldspar.

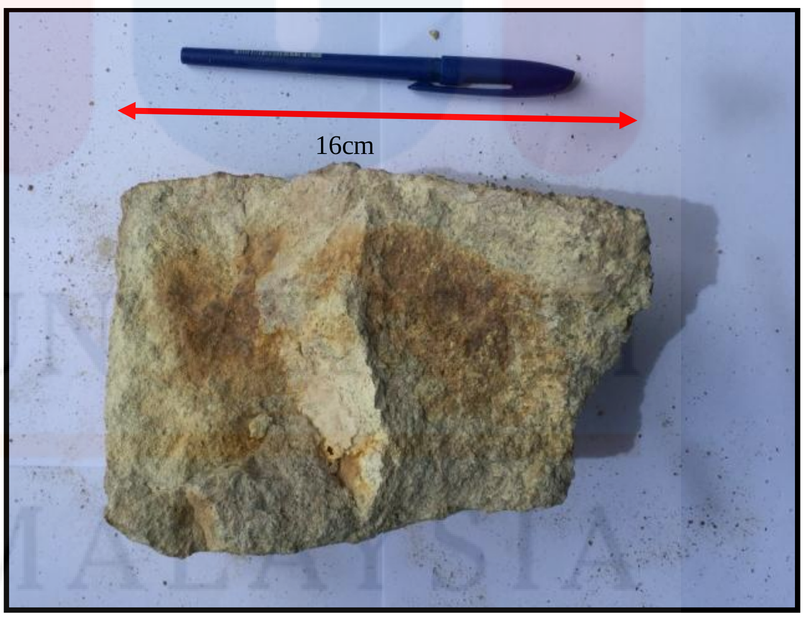


Figure 4.9 shows hand specimen of sandstone with weathering effect

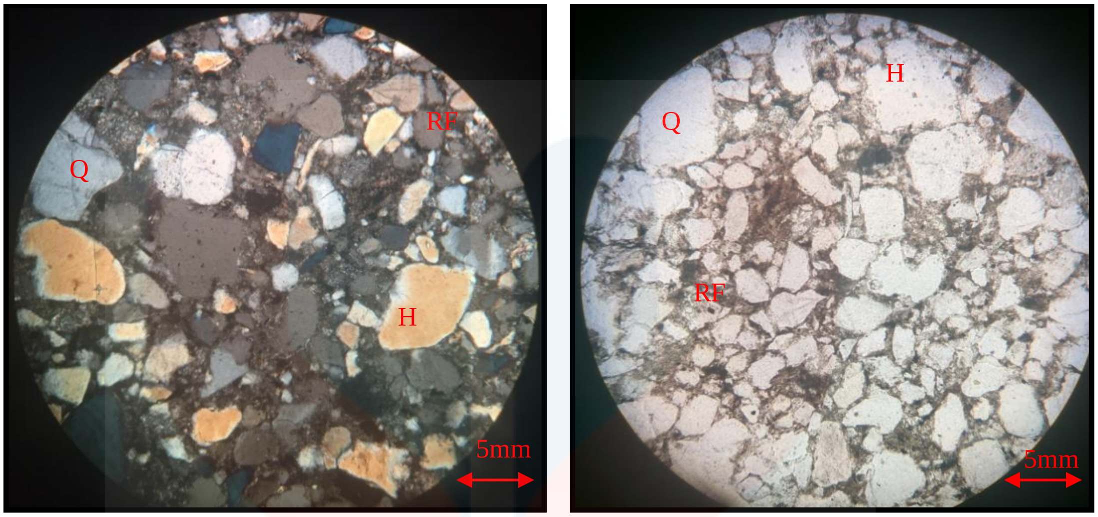


Figure 4.10 (a) Fined-grain sandstone under microscope with cross-polarized light and plane polarized light (x10 magnification)

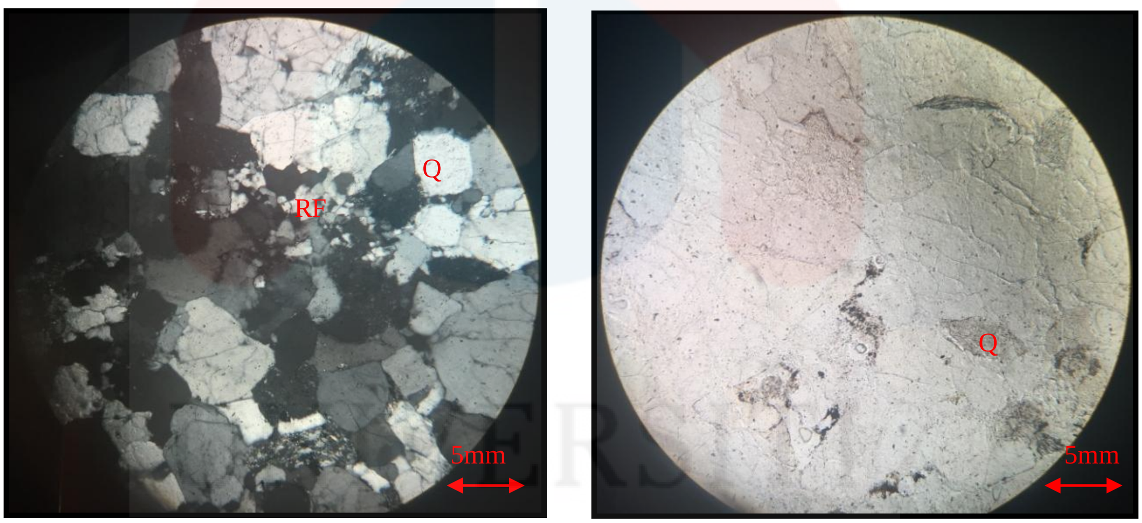


Figure 4.10 (b) Medium grain size sandstone under microscope with cross-polarized light and plane polarized light (x10 magnification)

Based on the petrography analysis, the minerals present in Figure 4.8 (a) are quartz and hornblende. In the figure quartz is represent by Q and hornblende is H. Quartz are white while hornblende are brownish orange. The minerals present in figure b are Q only. Both of the sample has rock fragments. Rock fragments indicates the pre existing rock. Rock fragments is represented by RF. The samples shows subangular shaped which reflects on the time of sandstone being transported. Both of the samples is well sorted as the size of grain distribution. Thus the porosity and permeability is high.

- **Siltstone unit**

Siltstone in the block of study area was interbed with sandstone and shale. The thickness ranges from 0.5 mm to 2 cm. From the hand specimen observation, it is milky white to brownish yellow in colour. In coordinate, N 6° 18’ 41” E 100° 38’ 5” the siltstone found is in milky white and it is interbeds with very fine grain sandstone. The texture is silty and gritty. It indicates that siltstone is easily eroded and washed away.

Figure 4.11: Interbedded of sandstone with alternating thin layer of siltstone and shale

- **Shale unit**

Shale is an argillite that is easily break when hold it when it is tap with hammer. Usually it appears with lamination and exist in several colours which are grey and red. In the several place in study area, it is interbeds with sandstone and siltstone. Fossil crinoids found in shale shows shallow marine deposition. Sedimentary structures found in shale are lamination and wavy bedding. The thickness of shale lamination is range from 0.3 mm to 0.9 mm. Lamination is a fine grain structure thus it is easily eroded by bioturbation. The wavy bedding shows that the composition of sandstone and mudstone in the outcrop is 50% and 50% respectively. Abundant fossil of crinoids found in bed shale.

Figure 4.12: Bed of light grey shale in where crinoidal strem fragments found.

- **Volcanic Sandstone unit**

In newer sandstone, there are interstitial space between the empty grain. When volcano in Toba, Sumatra erupts it emitted variety of volcanic product such as lava, gases, and pycroclastic rock. The product might compacted into the interstitial space and through time, it becomes compacted. It results in formation of volcanic sandstone. The volcanic sandstone observed in the study area is massive and almost structureless. This type of rock comprised of sand-sized grain soft material cemented together. The colour observed is reddish white and the grain size is medium-grained. Presence of iron indicated the rock is highly weathered where oxidation has occurred and water plays the role as weathering agent.

Figure 4.13 shows the volcanic sandstone comprised with sand-sized grain

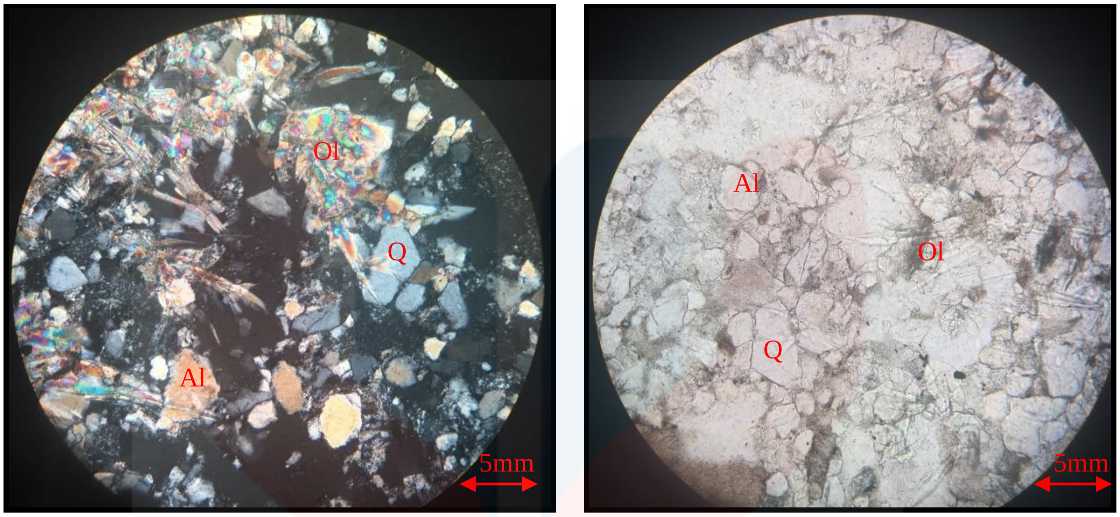


Figure 4.14 shows volcanic sandstone under cross polarized light and plane polarized light (x10 magnification)

Based on the petrography analysis, the minerals of volcanic sandstone observed under microscope is quartz, alkali feldspar, and olivine. There are also some rock fragments observed. This type of grain would be a main component of a lithic sandstone. The lithic fragments consists of fine grained sedimentary rock. The cemented material for this rock are biotite and alkali feldspar.

- **Alluvium**

The distribution of alluvium covers almost 70% in the block of study area. In the geological map, the boundary of alluvium deposits is determined by topography analysis. Generally, deposits of alluvium in the Bukit Kepah area can be divided into four which are river alluvium, swamp alluvium and volcanic ash.

River alluvium was found by the river bank which consists of sediment sized of sand, clay, silt, and gravel. Muddy alluvium basically always compose of area contain shale while sandy alluvium cover area compose of granite. The factor that contribute to this deposition was form hilly area such as Bukit Lebai Husin and Bukit Lebai Hassan. The sediment was transported as alluvium deposition.

Swamp alluvium is the dominant type of alluvium found in Bukit Kepah area. It covers wide area middle of the study area and also the combination of alluvium from river and fluviatil that has been deposited in swamp area. This type of alluvium usually composed of grey to yellowish clay, silt and sand together with mixed of carbon and rotten plant. Part of the alluvium were cover with fine to medium grain sand, sandy clay, and silty clay together with pebble, quartz, sandstone, and shale.

Figure 4.15 shows swamp alluvium which is suitable for paddy plantation.

Volcanic ash deposits in the block of study area exhibits friable characterization. One of volcanic ash outcrop located at N 6° 18’ 13” E 100° 39’ 26” in Kampung Padang Nyior, Kuala Nerang have height of 2 meters above sea level with thickness of 1.5 to 3.5 meters. The deposition unconformably overlaid sand and clay alluvium.

The volcanic was believed deposited from Toba, Sumatra volcanic activity. In correlation of history, the volcanic ash has the same with several series of Toba eruption during 75 000 years ago (Debaveye *et al.*, 1986). The volcanic ash contain SiO_2 (69.1%), Al_2O_3 (16.7%), Fe_2O_3 (1.83%), TiO_2 (0.15%), Na_2O (1.52%), K_2O (4.12%), CaO (3.93%) and MgO (0.36%).

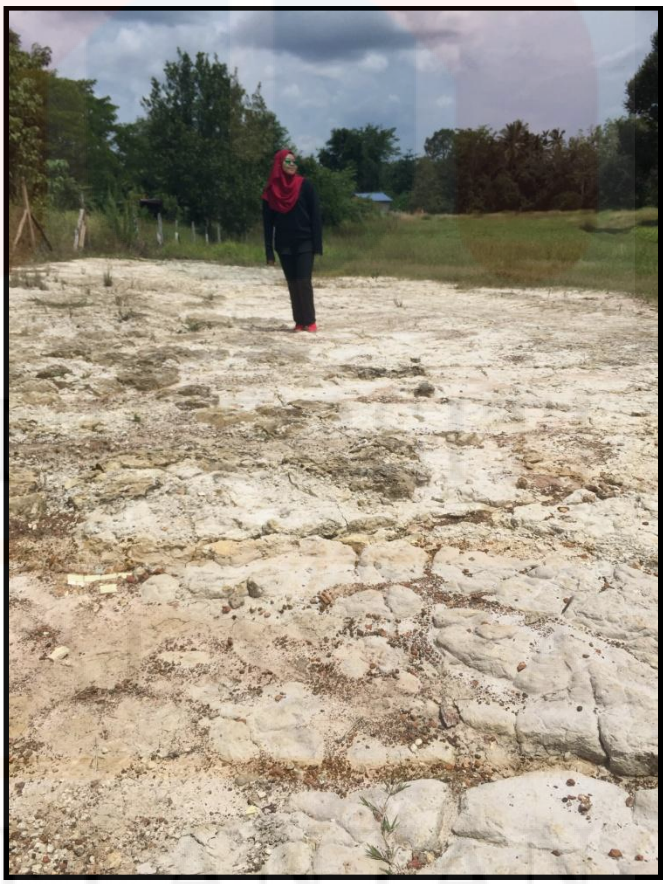


Figure 4.16: Volcanic ash deposit in Kampung Padang Nyior

4.3 Stuctural Geology

Stuctural geology aims to characterize deformation structure to characterize flow paths of the deformation and to infer the direction and magnitude of the forces involved to contribute to the deformation. It also describe and analyse 3D structures and microstructures. From geological mapping, structural geology concerns with features resulting from deformation. These includes fractures, faults, folds, shear zones, cleavages, foliations and lineations. With software approaches such as GeoRose and Streonet, the structural data gained from geological mapping are analyzed.

4.3.1 Fault Analysis

A fault is a fracture across in which two blocks of rock have slipped, the displacement of adjacent blocks is parallel to the fault plane. Faulting reflects to the brittleness failure of rock formation or in the other way, it involves frictional sliding on a pre existing fault plane. It can be in very large scale and can be only observed by the aerial photography or in micro scale microscope to identify. Significantly displacement of the fractures are results from the tectonic forces acting on the volume of the rocks.

For the study area, a major fault has been observed at hill cutting slope of interbedded of sandstone and shale. The type of the fault is normal fault. Normal fault indicates the hanging wall has moved downward relative to the footwall. The normal fault also caused drag fold.

Figure 4.17 shows normal fault

4.3.2 Fold Analysis

Folding is a type of earth movement resulting from the horizontal compression of rock layers by internal forces of the earth along plate boundaries. Upon folding, rock formations are bended and buckled into a series of antiform and synform folds. It may occur under varied conditions such as stress, hydrostatic pressure, pore pressure, and temperature gradient. Based on the study area, the obvious folding observed were at locality of interbedded sandstone – shale at hill cutting slope, Bukit Kepah. The type of fold is anticline. Reading of dipping and strike are 29° and 136° respectively.

Figure 4.18 Folding at interbedded of sandstone – shale outcrop. **(N6° 16' 48" E 100° 38' 3")**

4.3.3 Bedding Analysis

Bedding is a structural features occur in sedimentary rocks which every bedding may represent significant and specific details of the depositional environments and to understand paleocurrent and paleoenvironment. The layers have details about composition, grain sizes, and facies. Principally the depositional of sedimentary layers are horizontally but the effect of Earth movement exposure might be in tilted position. To determine the younger layers, the rule of younging direction is used to identify every specific characteristics in each layer. Characteristics such as composition, grain sizes, colour, and fossils were observed. According to Bouma sequence, if normal sedimentation cases sedimentary rocks will represent fining upwards order.

Analysis of bedding can be measured through reading of strike – dip. Bedding of the outcrop shows coarsening sequence as the grain size change from very fine to medium grain size. The colour of shale changes from greyish white to light grey.

Figure 4.19 Alternating of shale and siltstone in sandstone bed **(N6° 16’ 48” E100° 38’ 3”)**

4.3.4 Joint Analysis

Joint are significant structural geology refer to fracture that forming in the outcrops caused by tensile stresses have orientation of geometry. The geometry of orientation of the joints includes nonsystematic joints, systematic joints, and columnar jointing are recognized in geology field. Moreover, joint control on weathering and erosion of bedrock which apply a strong control on topography and morphology of landscapes developing.

The joint analysis is based on investigation of set of joint to evaluate the direction of the forces acted on a body of an outcrop at study area. 100 measurements of strikes were taken at the study area and the data was generated by Rose Diagram to determine the forces act on. From the diagram constructed from Figure 4.4, it represents the joint analysis and it can be interpret the geometrical orientation of the joint is systematic joints.

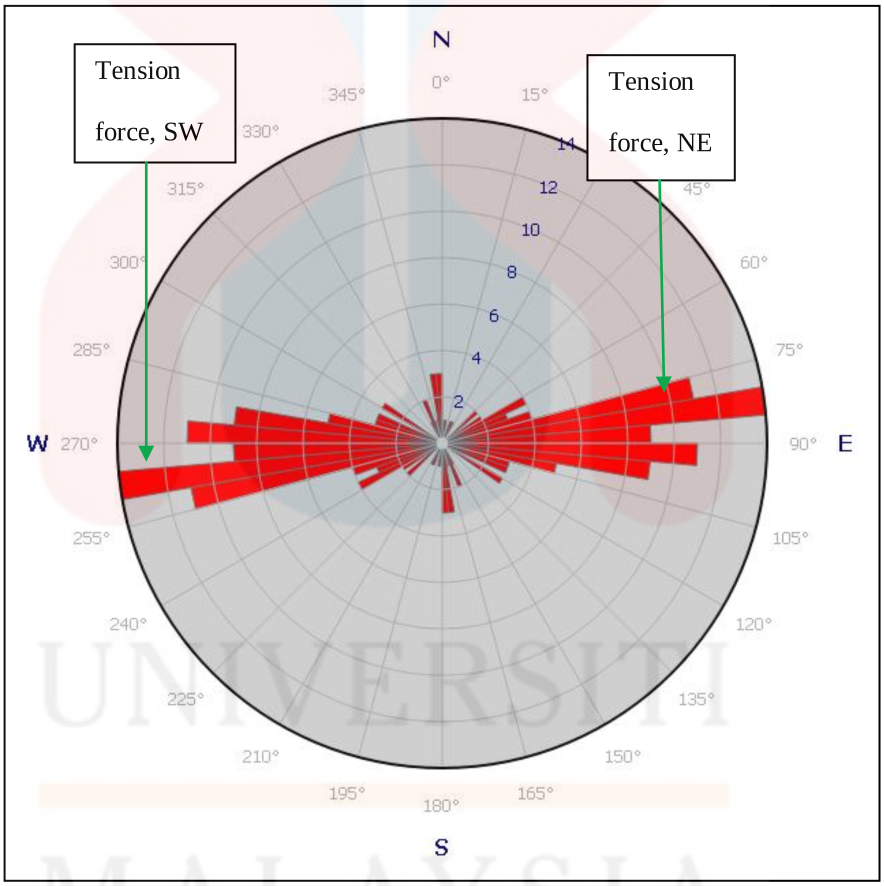


Figure 4.20 Rose diagram of joint at study area **(N6° 19’ 36” E100° 39’ 56”)**

Figure 4.21 Outcrop where the set of joints are measured.

4.3.5 Lineament Analysis

A lineament is a surface appearance of fracturing in the form of alignments of topography and lineament, linear trends of vegetation and soil moisture anomalies, and truncations of rock outcrops. Basically, lineaments can be observed from satellite imagery. Crests of ridges or boundaries of elevated areas, drainage lines, coast lines, fracture zones, shear zones, and granite intrusion are included as lineament.

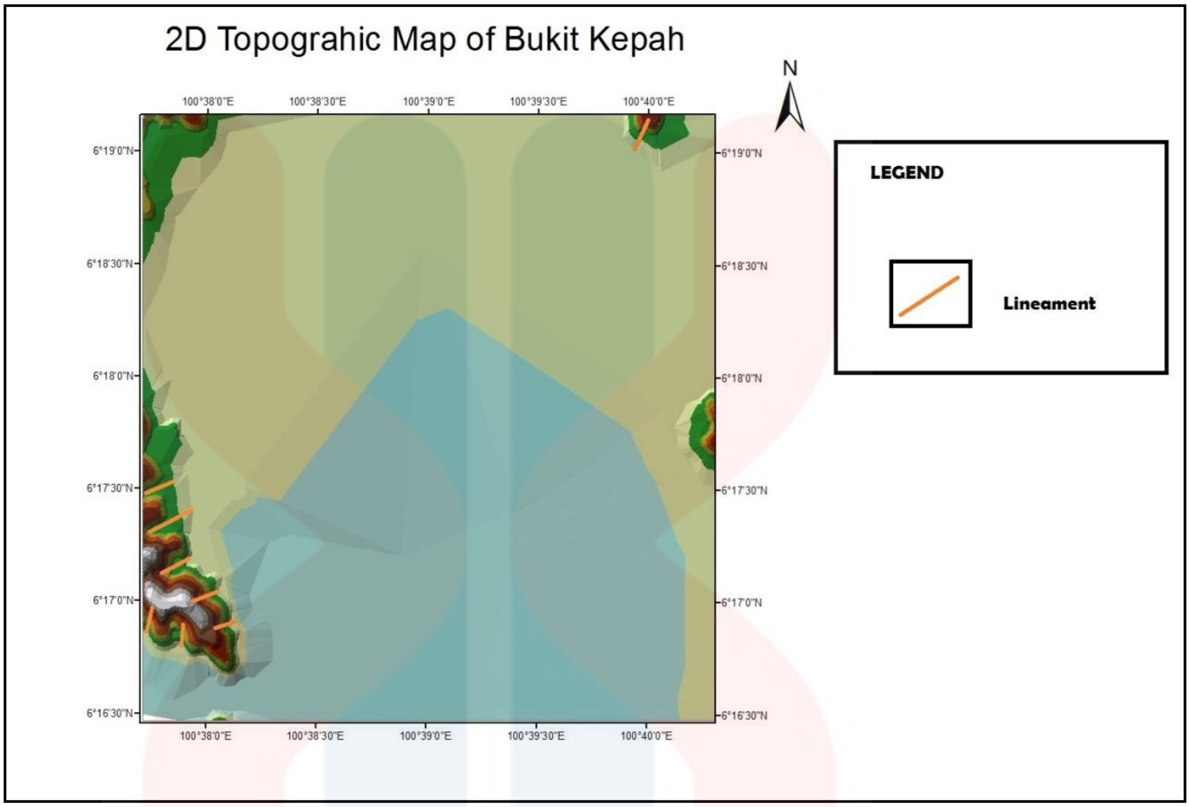


Figure 4.22: Negative lineament at Bukit Kepah

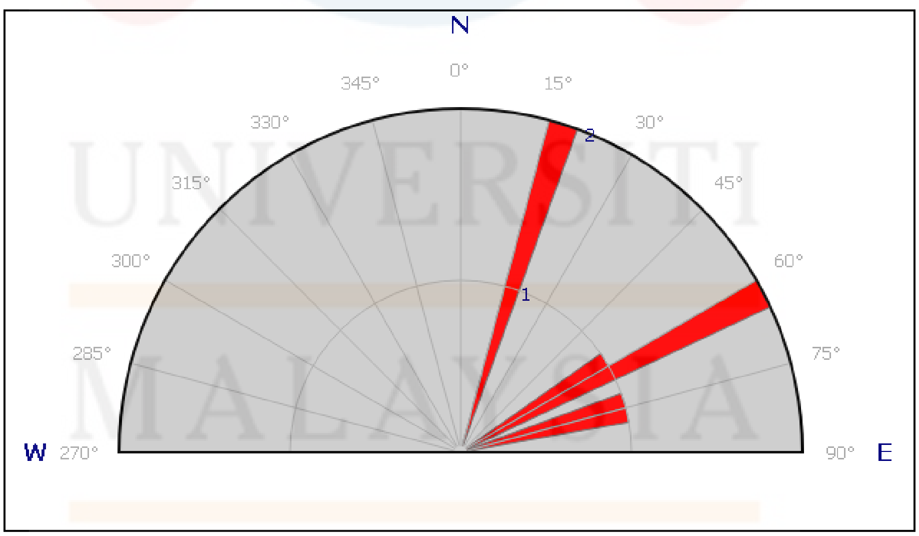


Figure 4.23 shows interpretation of lineament analysis using GeoRose software. The direction of the lineament shows North – East direction.

Lineament in the study area can be divided into positive and negative lineament. In the study area, positive lineament indicates crest of ridges while negative lineament indicates drainage lines or river valley. The direction of the lineament is interpreted using GeoRose software to know the direction of stress and tension of the lineament. Figure 4.20 shows interpretation of negative lineaments which shows North – East direction. The study area is lack of lineament structures thus there are less interpretation on lineament analysis.

4.4 Historical Geology

During Devonian, a tectonic movement activity caused lifting, folding, and erosion. After deposition process of Upper Paleozoic unit, an orogeny process occurred during Early Triassic or Middle Triassic and caused Paleozoic rock had been uplifted, folded and faulted. Weathering and erosion process to the rock unit caused unconformity.

The study area, Bukit Kepah exposed to Mesozoic rock unit which is Semanggol Formation and Quaternary rock units which area volcanic ash and alluvium. The main lithologies of Semanggol Formation composed of Rhythmite Member and Chert Member. However there were no Chert Member found in the study area. Chert Member was older and composed of chert and sometimes chert interbedded with siltstone, mudstone, and shale. While Rhytmite Member composed of interbedded sandstone with siltstone and shale. Generally, sandstone in Semanggol Formation composed rock fragments and medium sorted deposition.

The strong process of chemical weathering in the study had caused the outcrops to be affected. Quaternary deposit that formed mostly in the middle of study area composed of vary sizes. Deposit was formed from process of erosion happened during Semanggol Formation.

CHAPTER 5

DEPOSITIONAL ENVIRONMENT OF THE SEMANGGOL FORMATION IN BUKIT KEPAH, KUALA NERANG

Through time, sediments transported and deposited in a wide range in surface of the earth which can be defined in term of geomorphology such as rivers, lakes, coasts, shallow sea, aeolian, glacial, and many more. The physical, chemical, and biological processes which leads to deposition have to be analyse and study in order to determine history of the environment. The depositional environment can be determine by interpreting the lithology including the texture and bedding feature, sedimentary structures and presence of fossils.

After geological mapping have been done, the two most significance outcrops were chosen to be interpreted the depositional environment. The outcrops were chosen based on the huge scale, well bedded and presence of fossils. Two outcrops are located in Bukit Kepah at coordinate N 6° 16’ 48” E 100° 38’ 3”and N 6° 16’ 41” E 100° 38’ 5”. First outcrop approximately is 45 m width and 100 m height while outcrop is only 15 m width and 10 m height. Both outcrops are near to each other and located in the same contour. It is easy to access as they are located by the roadside. The two pictures below show two outcrops chosen.

Figure 5.1: First outcrop in Bukit Kepah with 45 m width and 100 m height (N 6° 16’ 48” E 100° 38’ 3”).

Figure 5.2 : Second outcrop in Bukit Kepah with 5 m width and 10 m height (N 6° 16’ 41” E 100° 38’ 5”).

5.1 Lithology

Two stratigraphic column were constructed based on the lithology of the outcrop. The relationship between stratigraphic column with the rock properties will give rise on the constitution of the depositional process history. The dominant lithology in the study area is sandstone which also the oldest rock unit aged Middle Triassic to Middle Triassic. It follows by mudstone unit which has the same age.

a. Sandstone

Sandstone is the dominant and oldest rock unit in the study area. Based on the outcrop observed in first locality, the thickness measured range from 2 cm to 60 m. Reading of dip and strike of the sandstone bed is 270° dipping and 55° strike. The colour observed is reddish brown and light brown. Reddish brown indicates it is altered by weathering process. Presence of iron indicates oxidation process occurred until it changes colour to reddish brown. The minerals observed are quartz and alkali feldspar.

The bedding of the outcrop shows coarsening upward sequence. This means the grain size of sandstone is increasing from very fine to medium grain sand. The thickness of bed also increasing from bottom to top of bedding. Sandstone bed is interbed with shale and siltstone. Abundant fossil of crinoidal stem fragment are found in shale bed which shows animals lives in coastal water environment. Further discussion on fossil found will be discussed in fossil section. Sedimentary structure found in sandstone bed is planar cross bedding while lamination and wavy bedding are found in shale bed.

The same size of clast indicates well sorted sandstone. This indicates transportation of sediments in water flow. The same size of clast formed when the gravel or coarser sediments is deposited first before finer sediments as the energy is getting low down the elevation. The sandstone unit also shows rounded clast characteristic. This is due to long time of deposition in the study area.

The second stratigraphic log constructed based on second outcrop shows that it is well bedded. The lithology consist of 50% sandstone and 50% mudstone and shows wavy bedding. Reading of dip and strike is 48° and 170°. Bed of sandstone has range of 2 cm to 30 cm thickness. Based on observation, the colour of sandstone is milky white. There is some part of sandstone is red colour which indicates oxidation process of iron oxide. Iron oxide also indicates oxygenated environment which is usually in shallow marine environment.

b. Mudstone

Mudstone which composed of shale and siltstone is the second rock unit in the study area. For the first lithostratigraphy log, shale and siltstone interbed with sandstone alternately. Thickness of individual strata of shale range from 10 cm to 30 cm. The colour observed for shale and siltstone is greyish white to light grey. The grain size for shale is in clay size particle while siltstone is in silt. The mineral consists of clay minerals, quartz, and alkali feldspar.

Both shale and siltstone are fine sediments. This indicates that both of the bed deposited in low energy current flow. As the coarser grain need more energy to be transported hence, they will transported first before fine sediment. The fine sediment will be transported during low energy current of flow on low relief area.

Second stratigraphic column shows mudstone with alternating layer of shale and siltstone. It well bedded because the ratio amount of 50% shale and 50% siltstone. The colour of shale is grayish white while colour of siltstone is light grey. From observation, grain of siltstone are in silt size particle and composed of clay mineral, quartz, and alkali feldspar.

5.2 Sedimentary Structure

a. Planar Cross Bedding

Cross bedding are group of inclined layers where the inclined layers are known as cross beds. Cross bedding is a type of sedimentary structure that can be observed in sandstone or conglomerate. Cross bedding is widespread in many environments such as river, tidal flat, and marine. It plays a role to interpret the flowing medium was water or wind. If the cross bed is large enough in scale, it can be interpret as water flowing medium.

It can be divided into planar cross beds and trough cross-beds. Planar cross bedding is recognized by the large scale and has curved foreset of lamination and tangential to the basal surface. Trough cross bedding is recognized by sediment layers that are inclined relative to the base and top of the bed that are associated with. The inclination of the cross beds will indicate the transport direction and the current flow, the grain size of cross beds indicates current velocity, and orientation of cross beds indicates direction of paleoflow.

The cross bedding observed in first outcrop is in sandstone. The thickness is approximately 5 m. It is classified as planar cross beds due to curved foreset of bedding observed. Based on the cross bedding observed, the inclination shows right to left direction. Thus, the transport direction and current flow is from left to right. Fine grain sandstone of the cross beds indicates low current velocity. During deposition, the river carries coarse grain of sediments or gravel due to high energy of water in high elevation environment. By time down the elevation, the water lose its energy and thus deposited the coarse sediments. As energy getting low, water will deposited finer sediments over the bed. Hence fine grain sediments indicates low current velocity.

Figure 5.3 : Planar cross bedded with inclined layers

b. Lamination

Lamination is a sedimentary structure which is thin layers and generally less than a centimeter in thickness. The type of lamination observed is planar lamination. Based on observation, structure of lamination found in shale. The thickness range from 3 mm to 9 mm. Shale is a fine sediments thus it indicates the presence of current for transporting sediments is low. Whenever sediments are transported from the above, it deposits coarser sediments first due to high energy of current to transport it. Slow settling of fine sediments lead to deposition in quiet water which indicates low energy of current. Thus, probably it is deposited in deep marine, bottom of lake or tidal flat.

Figure 5.4: Lamination in shale bed with thickness of 3mm to 9 mm.

c. Wavy bedding

Interbedded layers of shale and sandstone can be divided into three types which are flaser, wavy, and lenticular bedding. They are forms due to alternate process sediment supply and tidal velocity. Thus, it is common that the deposition formed mainly in tidal flat. The three types of bedding are distinguished based on the ratio volume of sand and mud contents. The flaser bed indicates amount of sand is more than mud, wavy bedding indicates same volume of sand and mud while lenticular bed shows more amount of mud over sand.

Based on observation from outcrop from second locality, the bedding is classified as wavy bedding due to same amount of sand and mud. The ratio shows 50% of sand and 50% of mud. It shows that mud is deposited alternately same with bed of sand. The deposition might be happen during alternate between relatively strong current energy followed by a long period.

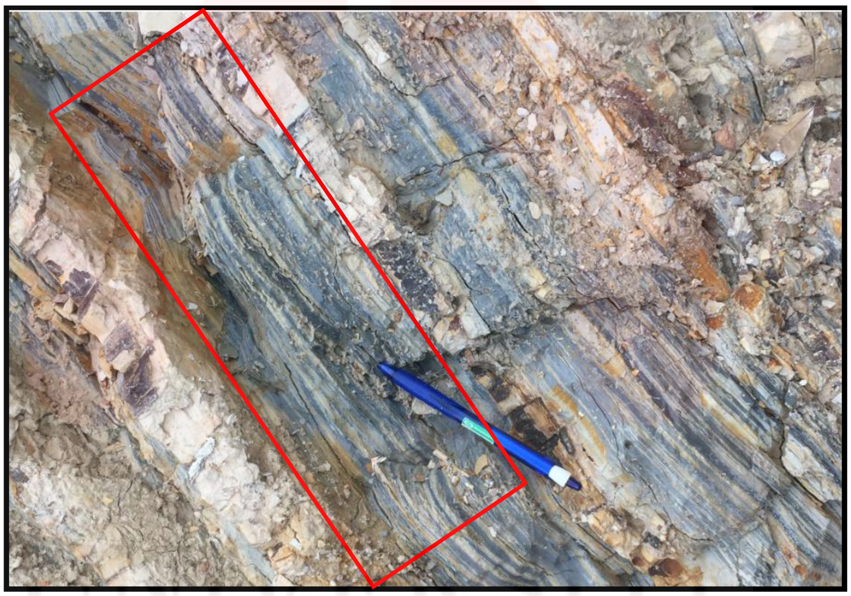


Figure 5.5 shows wavy bedding between sandstone and mudstone strata

5.3 Fossil

Fossil also plays a role in determining the depositional environment. Abundant fossil of crinoidal stem fragments of found in beds of shale at first outcrop at coordinate N 6° 16' 48" E 100° 38' 3". Crinoids belong to kingdom Animalia and phylum Echinodermata. It is related to starfish and echinoids. The crinoids is divided in three parts which are stem, a calyx or body, and arms. But the only part found in shale bed is stem part probably due to transport process that breakdown other part of crinoids. It is approximately 5 cm long. Another proof the fossil is crinoidal stem fragments are because of the presence of traits such as tube feet and the radial symmetry.

The environment origin of crinoids is shallow marine. The crinoids found at outcrop are only the stem fragment that maybe have been breakdown when transport. During in high tidal period, crinoids will find a calm sea as defense mechanism for itself. Unfortunately, it cannot move any further as the wave energy is too strong and transport crinoids away thus it tries to attach itself beneath it which is tidal flat. As time goes, it dies and finally submerged under bed of sediments by the next high tide.

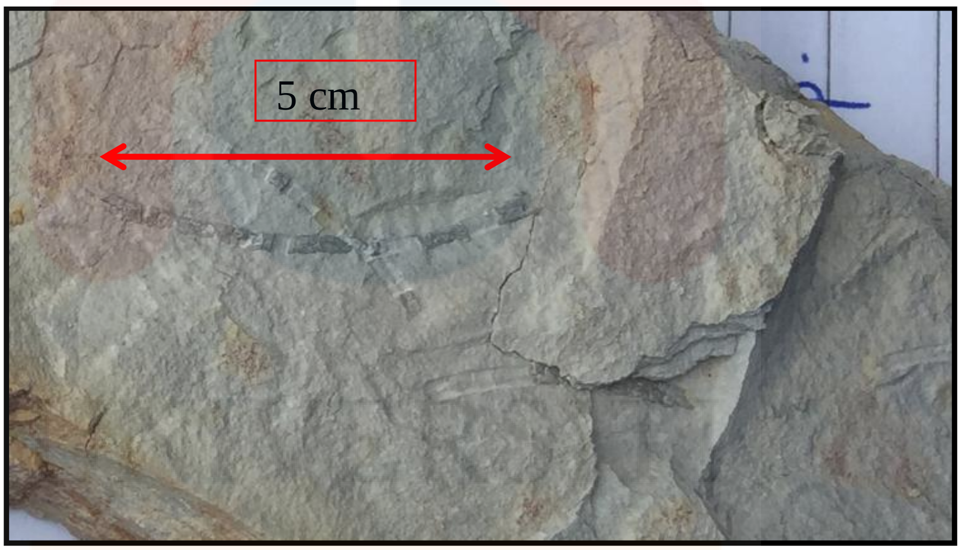


Figure 5.6 shows abundant of crinoidal stem fragments found in shale bed.

Even if there are many arguments to specify the age of crinoids, almost of the researcher and paleontologist had established the age is crinoids is from Paleozoic era which began 542 million years ago. The crinoids still exist until this day because they survived from mass extinction at the end of Permian.

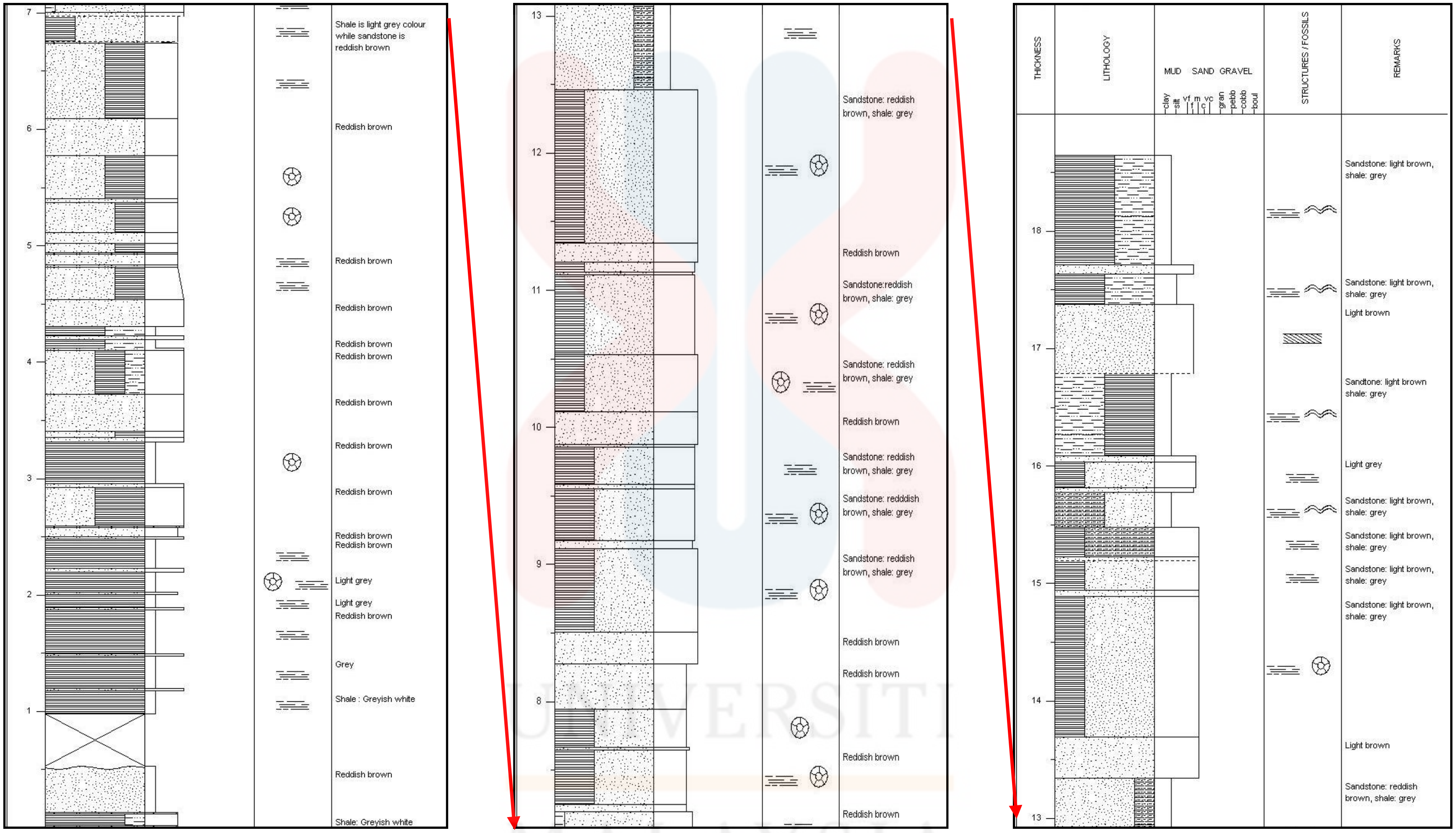


Figure 5.7 shows stratigraphic column for outcrop 1 at N 6° 16’ 48” E 100° 38’ 3”

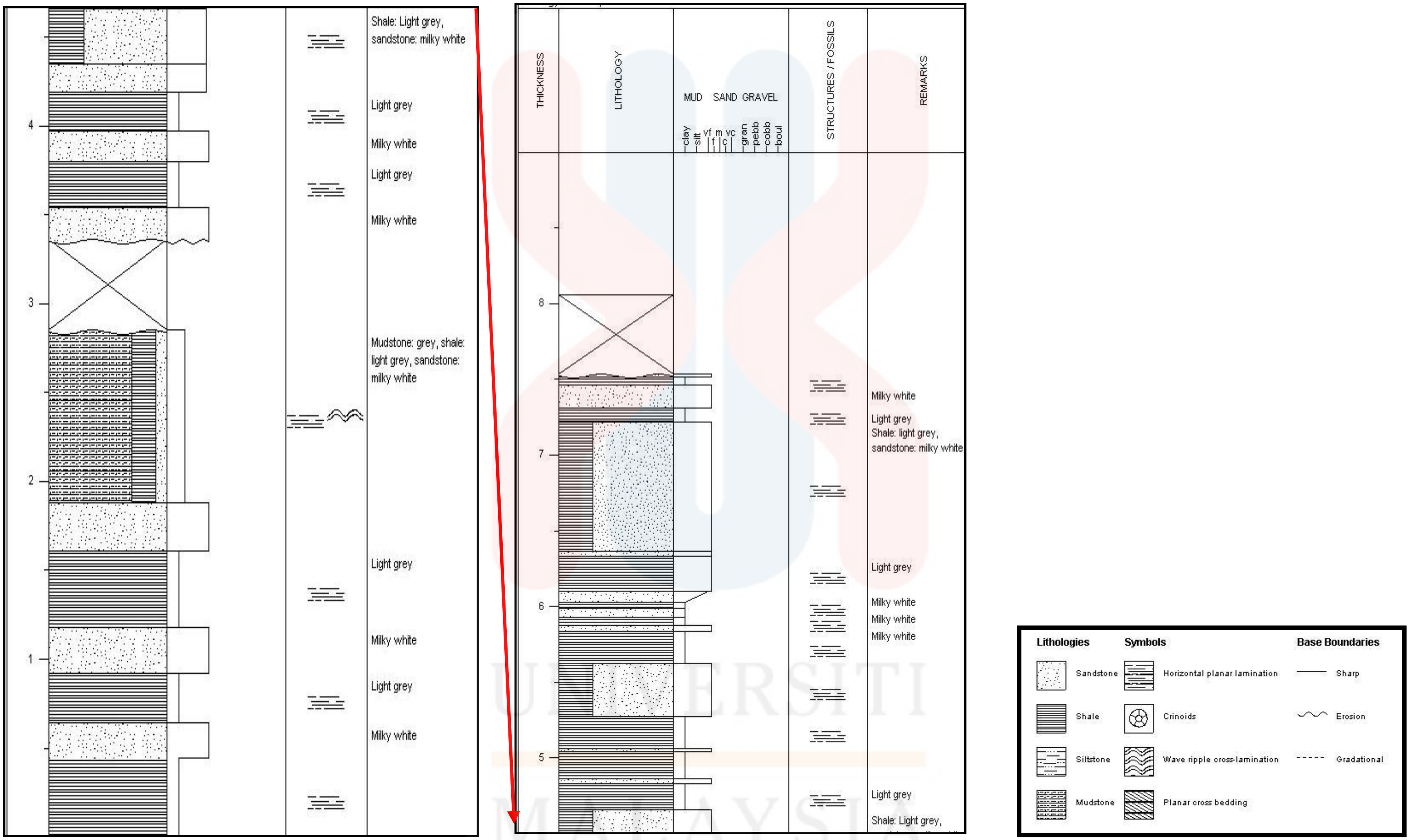


Figure 5.8: Stratigraphc column for outcrop 2 at N 6° 16’ 41” E 100° 38’ 5”

5.4 Depositional Environment of the Semanggol Formation at Bukit Kepah

Depositional environment is important for reconstructing earth history, understanding earth processes, and help human survive and prosper on earth. It can be identified by observation and analysis of lithology, sedimentary structures, and presence of fossil. Based on lithology interpretation, sedimentary structure observation and presence of fossil, depositional environment have been analyzed and identified. The age of Semanggol Formation was Middle Triassic to Late Triassic when the deposition process occurred from 255 million years ago.

Depositional environment can be divided into three categories which are marine, transitional, and continental environment. Based on lithology interpretation, clastic sedimentary rocks of both outcrop chosen has fine to medium grain size. It indicates that the deposition process occur in low current energy and low relief environment. Large scale of planar cross beds show the flowing medium for transportation and deposition is water. Fine grain sandstone of cross beds and lamination in shale indicate that sediments were transported in low energy current. Wavy bedding indicates alternate high and low tidal level in a long period. Crinoidal stem fragments may have been transported from of sea floor to low energy of water velocity due to its imperfect physical.

Hence the depositional environment of Bukit Kepah, Kuala Nerang could be in tidal flat environment. Tidal flat has low energy of current velocity and low relief. Tidal flat environment can be divided into three zones which are subtidal, intertidal, and supratidal. The subtidal zone shows part of tidal flat which is normally lies below mean low tide level. Next zone is intertidal zone which is lies between mean high and low tide levels. Lastly, supratidal is lies above normal high-tide level but is incised by tidal channels and flooded by extreme tides. The deposition process of Semanggol Formation occur between subtidal to intertidal due to low enery current velocity and alternate high and low tide levels based on wavy bedding found. Figure below shows the 3D model or schematic diagram of tidal flat environment.

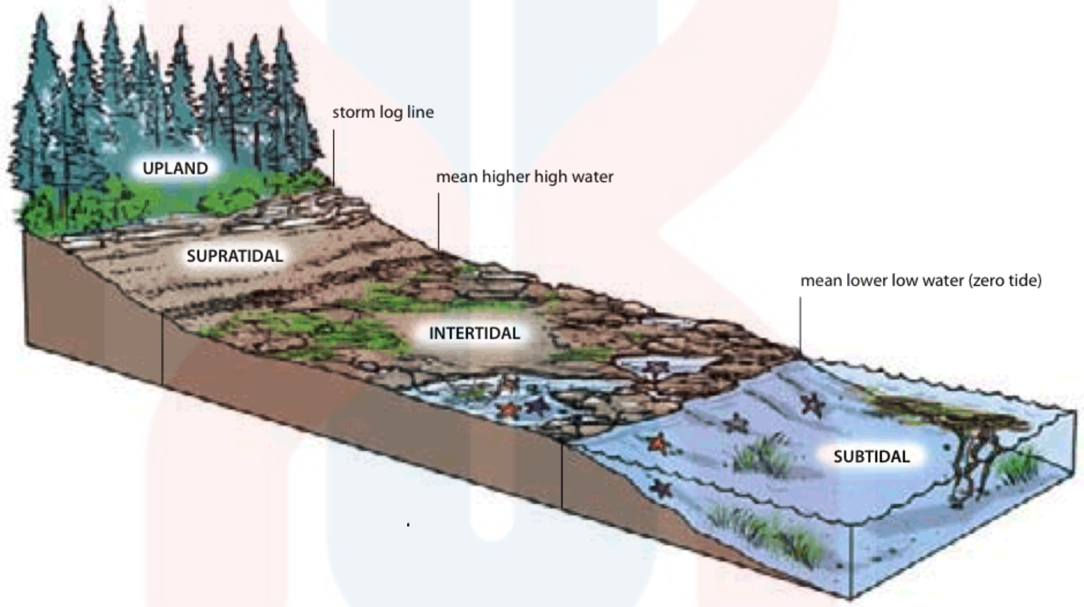


Figure 5.9: 3D model of tidal environment where the deposition of the Semanggol Formation occur. The deposition range from subtidal to intertidal zone.

CHAPTER 6

CONCLUSIONS AND RECOMEMENDATIONS

6.1 Conclusions

In conclusion, the objectives for this research has been achieved. Updated geological map was produced and the depositional environment of the Semanggol Formation have been determined. The geological map was produced to highlight the geomorphology of the study area such as topography, drainage system, and lineament. Based on geological mapping, the Semanggol Formation in the study area observed are clastic sedimentary rocks which area sandstone, shale, and siltstone. Sandstone is the oldest unit rock in the study followed by shale, and siltstone. These rock unit aged is from Middle Triassic to Late Triassic. Volcanic sandstone and alluvium are Quaternary deposits. Volcanic sandstone is deposited from the volcanic activity in Toba, Sumatra. Alluvium in the study area can be divided river alluvium, swamp alluvium and volcanic ash.

The depositional environment of the Semanggol Formation could be tidal flat environment based on the lithology, sedimentary structures, and presence of fossil. The lithology composed of dominant clastic sedimentary rock. The very fine to medium grain size of sandstone shows that sediments are deposited in low energy environment. The sedimentary structures shows interpretation that the flowing medium for sediment is water and also indicates low energy environment. The sediments could be deposited in subtidal and intertidal which shows water environment and low energy environment.

6.2 Recommendations

Further research and analysis should be conducted using absolute or isotope dating to determine the age of a rock to get a better data and interpretation. This method helps to give rocks an actual date, in number of years. The rate of decay of an isotope in a rock can help to measure the proportion of parent and daughter isotope and hence when the rocks were formed can be calculated. Next, the other method is by studying the provenance of a formation. Provenance study can be divided into petrography method and geochemical method. Lastly. the other way to determine the depositional environment is determining the paleocurrent flow. It is the indicator of direction of flow at the time the sediment was deposited. The flow direction of sedimentary structure could give an interpretation of depositional processes.

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APPENDICES

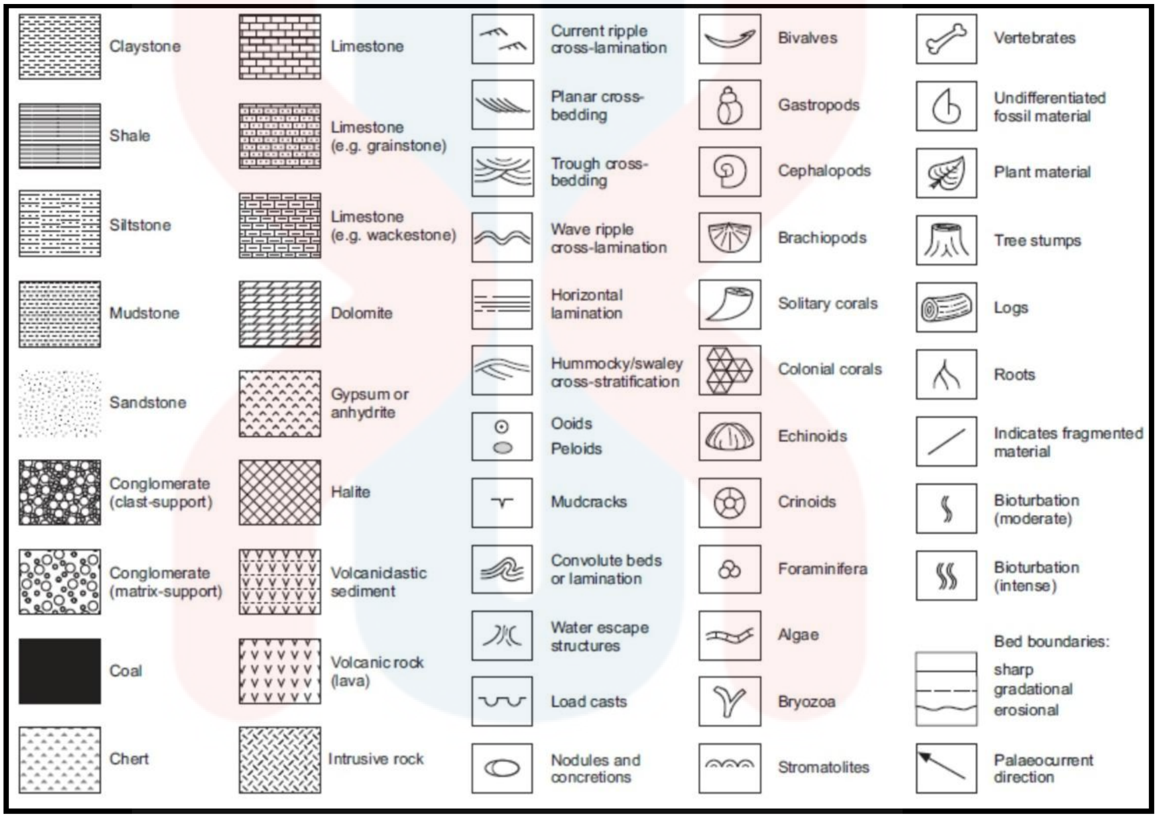

Figure A Examples of patterns and symbols used on litholog (Federal Geographic Data Committee, 2006)

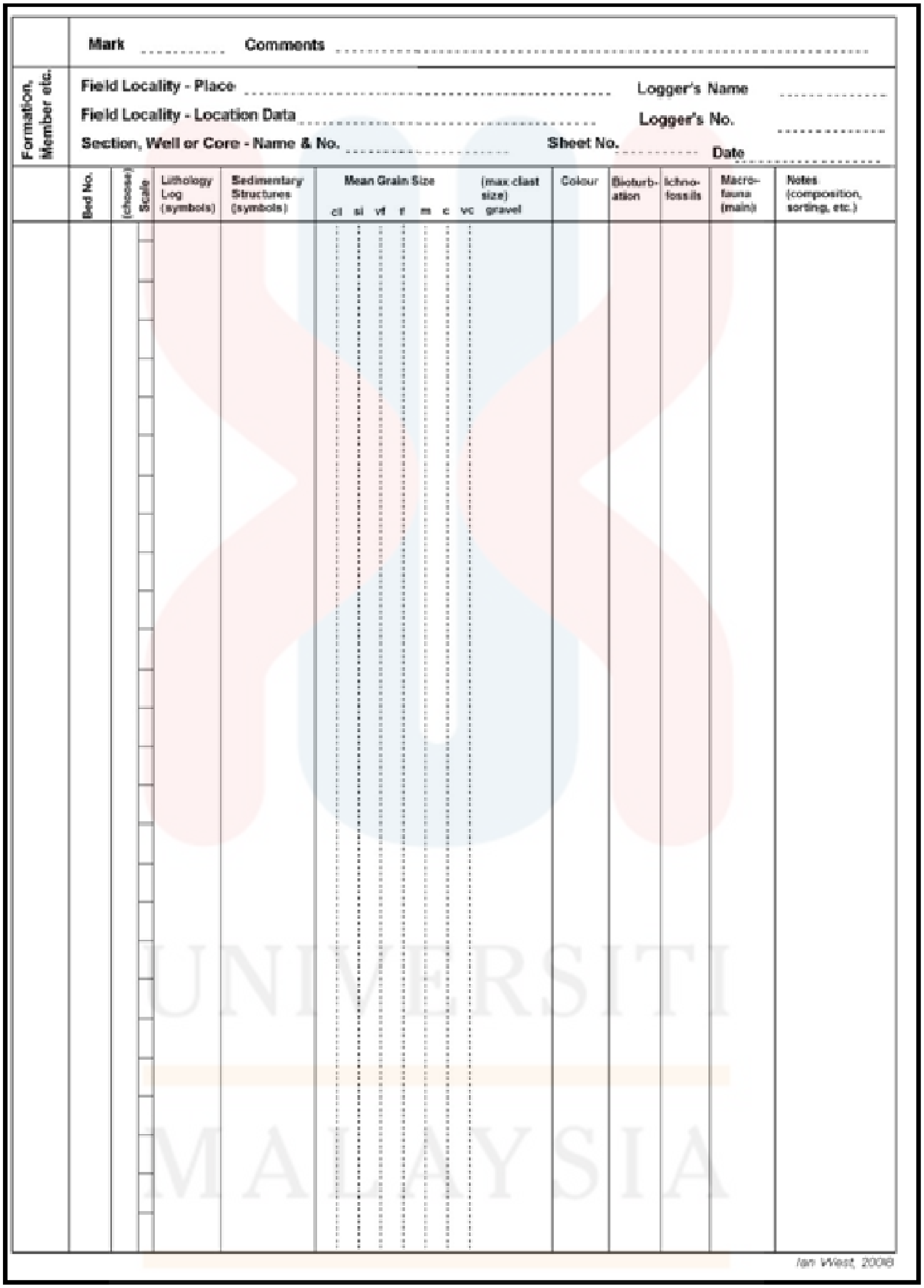
Mark .... Comments ....
Formation, Member etc.
Field Locality - Place .... Logger's Name ....
Field Locality - Location Data .... Logger's No. ....
Section, Well or Core - Name & No. .... Sheet No. .... Date ....
Bed No. | (choose) | Scale | Lithology Log (symbols) | Sedimentary Structures (symbols) | Mean Grain Size cl si vf f m c vc | (max clast size) gravel | Colour | Bioturbation | Ichnofossils | Macrofauna (main) | Notes (composition, sorting, etc.)
Ian West, 2008

Figure B: The stratigraphic column sheet to represent series of bed of sedimentary rock (Ian West, 2001)