Geology and Paleontology of Sungai Relai East, Gua Musang, Kelantan

by

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

FACULTY OF EARTH SCIENCE
UNIVERSITY MALAYSIA KELANTAN
2019

APPROVAL

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

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DECLARATION

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

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ACKNOWLEDGEMENT

Alhamdullilah, thanks to the Almighty, The Most Gracious and The Most Merciful for giving me the strength, patience and encouragement to complete my final year project successfully. As the time pass by, I have gained many experience, great memories which I believe will be useful for my future and career life.

First and foremost, I would like to express my highest gratitude to my supervisor, Dr Sufiah Bte Sulaiman for her guidance, ideas, supervision, advice and patience through the study. Without her guidance and encouragement, all this work would be impossible to be accomplished.

Secondly, I would like to dedicate my appreciation to all staff of geoscience department, Faculty Earth Science especially En Aizzudin and En Faathrio who have given me assistance and guide through the research. Thank you to drivers, En Fazly and En Firdaus for driving us to the study area.

A million thanks to my beloved parents, En Jeffri Bin Din and Pn Latifah Zamrah Binti Abdul Aziz, and to my siblings for their continuous support, advice, motivation for me to complete the study.

Finally, my appreciation goes to all lectures ,my classmates SEG4 and my roommates for their guidance and advice. Thanks to my fossil hunter mates, Syahirah Zulaikha, Syahirah Muhamimi, Juliana, Syamimi, Hisham and Shila for their kindness assistance, accompany me in mapping and help throughout this project. This thesis would not have been possible without the guidance and help of those I stated above. Thank you very much. I love all of you.

GEOLOGY AND PALEONTOLOGY OF SUNGAI RELAI EAST, GUA MUSANG, KELANTAN

ABSTRACT

The geology of Sungai Relai, Kelantan was obtained by carried out the geological mapping. The data include of structural geology, geomorphology, and lithology of Sungai Relai area was recorded. There are five type of lithology in the study area which are phyllite, tuff unit, mudstone unit, shale unit, and limestone unit. The data was analyse and interpret to produce geological map with scale of 1:25000. Ten *Daonella* bivalva species was found in the shale unit belonging to Telong Formation.Ten species of *Daonella* have been identified ie : *Daonella pichleri, Daonella* cfr. *kotoi*, *Daonella multilineata, Daonella pahangensis, Daonella indica, Daonella lommeli, Daonella* cfr. *pectinoides, Daonella procteri, Daonella sakawana* and *Daonella burtoni*. Books and journals have been review to identify and naming the species of each fossil. Based on these species, the depositional environment have been identified. These species usually found in deep marine environment in the age of Middle Triassic.

GEOLOGI DAN PALEONTOLOGI DI SUNGAI RELAI TIMUR, GUA MUSANG, KELANTAN

ABSTRAK

Geologi Sungai Relai, Kelantan di peroleh dengan menjalankan pemetaan geologi. Data yang di peroleh seperti geologi struktur, geomorfologi, dan lithologi telah di rekodkan. Data tersebut untuk di analisa dan di tafsir untuk menghasilkan peta geologi yang berskala 1:25000. Sepuluh spesies Daonella bivalvia di temui di dalam syalunit Formasi Telong. Sepuluh spesies Daonella telah di kenalpasti iaitu *Daonella pichleri, Daonella* cfr. *kotoi*, *Daonella multilineata, Daonella pahangensis, Daonella indica, Daonella lommeli, Daonella* cfr. *pectinoides, Daonella procteri, Daonella sakawana* dan *Daonella burtoni.* Buku dan journal telah di gunakan untuk mengenal pasti dan melakukan penamaan species setiap fossil. Berdasarkan spesies ini, kawasan persekitaran boleh di kenalpasti .Spesies ini selalu di jumpai di kawasan lautan dalam pada zaman Trias Tengah.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

General geology was concerning all the geological structure, geomorphology, sampling, composition, lithology and physical properties. The study was conduct at Sungai Relai in Gua Musang District in the Southern of Kelantan. According to Dony Adriansyah & Ahmad Rosli (2014), the study area was located in Aring at Central Belt of Peninsular Malaysia and well known as abundant fossil which is age of Triassic. However, Sungai Relai located near to Aring 5.

Fossil was significant sources that indicates geological time past of the certain environment. Different types of fossil have different age. Index fossils acts as tools to determine the age of rocks layers. These fossils existed only during specific span of life and occurs in geographical area. Some example of index fossils were trilobites, brachiopods, echinoids, and corals (Ghosh, 2006). Mostly, fossil preserved in sedimentary rocks due to compaction of sediments. Fossil can be found in different bedding of sedimentary rocks.

According to Kamal Roslan Mohamed *et.,al.* (2016), southern of Kelantan stratigraphy was divided into four area which was Kuala Betis, Gua Musang, Aring and Gunung Gagau. Aring was located at Central Belt of Peninsular Malaysia and this area become most abundant Triassic fossil. The rock distribution was

sedimentary rocks. Aring area was Telong Formation that consists of predominantly argillite associated with some tuff. The argillaceous facies in study area are consists of shale, siltstone, slate and mudstone.

1.2 Study Area (if applicable)

The study area was in Sungai Relai which located southern Kelantan in District of Gua Musang. The area was covered by hilly area and cover about 5km x 5km. Many hills was covered by palm plantation and thick forest. Sungai Relai flow from north to south of the study area. The highest elevation in this area was about 480 meter while the lowest is 140 meter. Figure 1.1 shows the basemap of the study area. The main town was Bandar Baru Gua Musang. The main road before junction of study area was Kota Bharu - Gua Musang highway while the accessibility of study area was a road connecting Gua Musang Town - Kuala Berang, Terengganu.

a) Location

The study area lies between the coordinates of N 4°50’44.3” E 102°11’2.9”, N 4° 50’ 44.3” E 102° 13’ 46.2”, N 4° 48’ 2.8” E 102° 13’ 46.6” and N 4° 48’ 3.4” E 102° 11’ 2.24”. Study area was located at Sungai Relai, Kelantan. The main town of this study area was Gua Musang. The geomorphology of Gua Musang consist of karst limestone, hill area, and mountains. In study area, the geomorphology that can been observed was hills with palm plantation and rivers which was Sungai Relai. The community that live near the study area was FELDA Aring 5. The study area consist of road connection from Gua Musang to Kuala Berang, Terengganu as shows in figure 1.2.

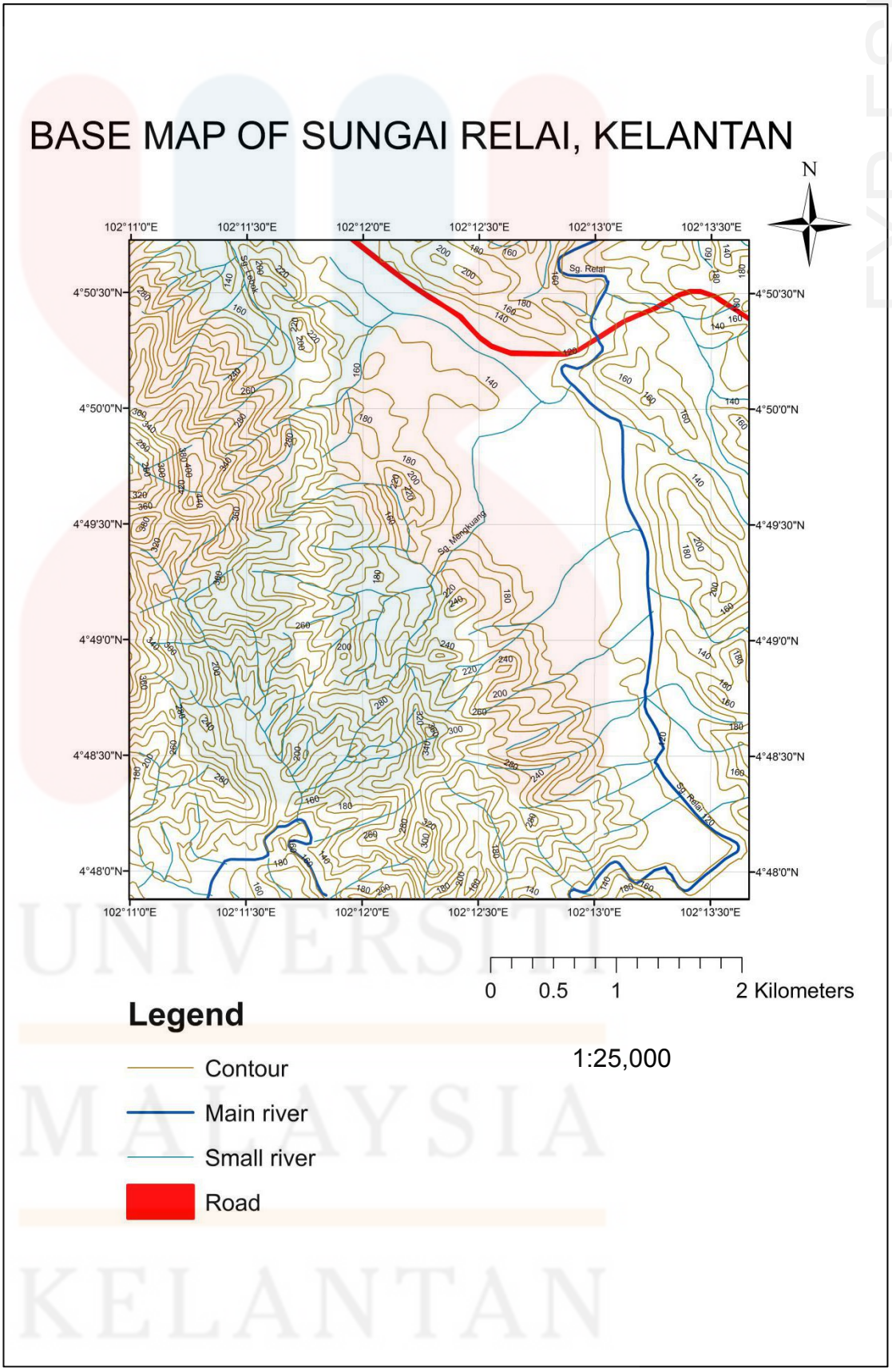

Figure 1.1 *:* The base map of study area.

Figure 1.2: The location study area with road accessibility.

b) Road connection

Gua Musang was the urban area while Sungai Relai was rural area. Accessibility to Sungai Relai was easier because of the road was all paved and can be access by car. From UMK Jeli, take a road to Jalan Sungai Sam-Dabong- Jeli and enter the junction of Kota Bharu- Gua Musang Highway. After entering the Laluan Persekutuan 8 Kota Bharu- Gua Musang Highway, take a junction to Felda Aring 5. From the junction to Felda Aring 5, its take about 5 kilometers to reach study area. Along this road, there were private oil palm plantation and covered by thick forest.

c) Demography

In majority, the population of each district will increase each year. Table 1.1 shows the people distribution in each district of Kelantan.

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

Bil	JAJAHAN	2000	2010	2015
1	Bachok	111,040	133,152	149,400
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
	Jumlah	1,313,014	1,539,601	1,718,200

(Source : Jabatan Perangkaan Malaysia Negeri Kelantan, 2016)

Based on Table 1.1, from year 2000's until 2015, the people distribution of Gua Musang district was rapidly increase. In year 2000's, it consist of 76,655 people while in year 2010 consists of 90,057. While in 2015, the recorded data for people distribution was increase to 104,400.

d) Land Use

The soil use in Sungai Relai area was mostly for oil palm plantation, rubber state and covered by thick forest. Along the road of study area, there were private oil palm plantation can be seen. Mostly, resident of Sungai Relai works as worker or settler of private company of oil palm plantation. Due to increasing demand of oil palm, Tradewinds Plantation Sdn Bhd, Keruing Estate Divison (B) Sdn Bhd, Ladang GM 02 Padang Mutiara Sdn Bhd, and Bee Garden Plentiful Plantation Sdn Bhd are the example of private companies that have their own oil palm plantation in Sungai Relai area. However, some of the study area still covered with thick forest.

e) Social Economic

Most of the population in Sungai Relai area was a settler community and work as settler. Most of them work in private oil palm plantation company. There were Ladang Sungai Relai East by Tradewinds Sdn Bhd, Ladang GM 02 by Padang Mutiara Sdn Bhd, Ladang Keruing Teknik and Bee Garden Plentiful Gold-Class Berhad. Overall in Gua Musang area, government had been introduced Federal Land Development Authority (FELDA) and Lembaga Kemajuan Kelantan Selatan (KESEDAR) for reduce poverty and increase the living standard for the social development. Table 1.2 shows the production of oil palm plantation and rubber for both agencies, FELDA and KESEDAR.

Table 1.2 : The production of oil palm plantation

Scheme	Average 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	17,104.71
Chiku 5	1217.63	1217.63	13,886.43
Chiku 6	832.56	832.56	19,226.22
Chiku 7	1106.85	1106.85	11,684.57
Perasu	806.67	806.67	11,586.64
Aring	832.46	832.46	11,586.64
Total	10552.5	10552.5	158,904.32

(Source : A Gua Musang office, June 2009)

1.3 Problem Statement

This research was focused in Sungai Relai because previous research had been done along the road of Gua Musang- Kuala Berang in Aring. There were insufficient geological information such as lithology, structure, sedimentary rocks and fossil analysis at Sungai Relai. Furthermore, there was no literature review mention about palaeontology of Sungai Relai. Most literature review are focus on Aring which was the outcrops are located along road within Felda Aring 5.

A few researchers have done some research on paleontology in Aring area (Dony Adriansyah Syah & Ahmad Rosli, 2014 & Mohd Shafeea, 2010). The discovery of Aring area started in 2008 until 2010, when construction of new road connecting Gua Musang- Kuala Berang. This construction have reveal the fresh outcrop of sedimentary rocks along the road.

1.4 Objectives

a) To update geological map to the scale 1:25000.

b) To identify species of the fossil in study area.

c) To identify the depositional environment based on fossil occurrences.

1.5 Scope of Study

The study area that focus on fossil analysis was at Sungai Relai, Aring. The fossil sample must be identify by observe the similiarities structural of organism and must labeling the geological information such as coordinates, lithology of the fossil found. The result of identification will have naming for the fossil. By this data, the interpretation for depositional environment at study area can be done. The study area is cover 5km x 5km square. The method use to conduct this research are by

preliminary study, field work such as geological mapping, laboratory works such as thin section, fossil analysis, data analysis and interpretation and writing process. The material use in geological mapping were geological hammer, Global Positioning System (GPS), compass, hand lens, sample bag, hydrochloric acid (*HCl*) and many more.

1.6 Significance of Study

The research of general geology was to know the types of rock and geology structure in the study area. The study of palaeontology can determine the past deposition environment and the age of the rocks. Besides that, it will able to understand more about correlation of rock by determine the age of the fossils.

In addition, the significant of the research was to update geological information in Sungai Relai area hence this study area is rural and remote area. The geological information such as lithology, geological structure, geomorphology, types of rock and fossil analysis. These data were important to produce geological maps.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review comprises the regional geology and tectonic setting, stratigraphy, structural geology, historical geology and research specification. This information was collected from journals, bulletins, articles, books and thesis.

2.2 Regional Geology and Tectonic Setting

According to Heng, Hoe, & Wan Hassan (2006), the regional geology of Kelantan consists of central zone of sediment and metasediment rocks bordered on the west and east by granites of the Main Range and Boundary Range respectively as shown in figure 2.1. There was windows of granitic intrusive in the central zone. These belts of granite and country rocks have north-south direction and Boundary Range granite was truncated to the north by unconsolidated sediments of Kelantan alluvial plain.

The sedimentary/metasedimentary rocks can grouped as follows:

i. Oldest rocks : Lower Paleozoic age

Mainly metapelites with lasser volcanic fragments and minor arenaceous and calcareous intercalations. Rare occurences of amphibolite and serpentinite had been .recorded.

ii. Permian volcanic sedimentary rocks (Gua Musang Formation)

This formation was mainly consists of argillaceous bedding pyroclastic rocks and Taku Schists

iii. Triassic sedimentary rocks (Gunung Rabong Formation)

This formation was mainly consists of argillo-arenaceous sediments with intercalated volcanics and limestone

iv. Youngest rocks : Jurassic-Cretaceous continental rocks in Triassic sedimentary rocks (Gagau Formation)

This formation was mainly consists of conglomerate overlain by sandstone with sporadic volcanic intercalation

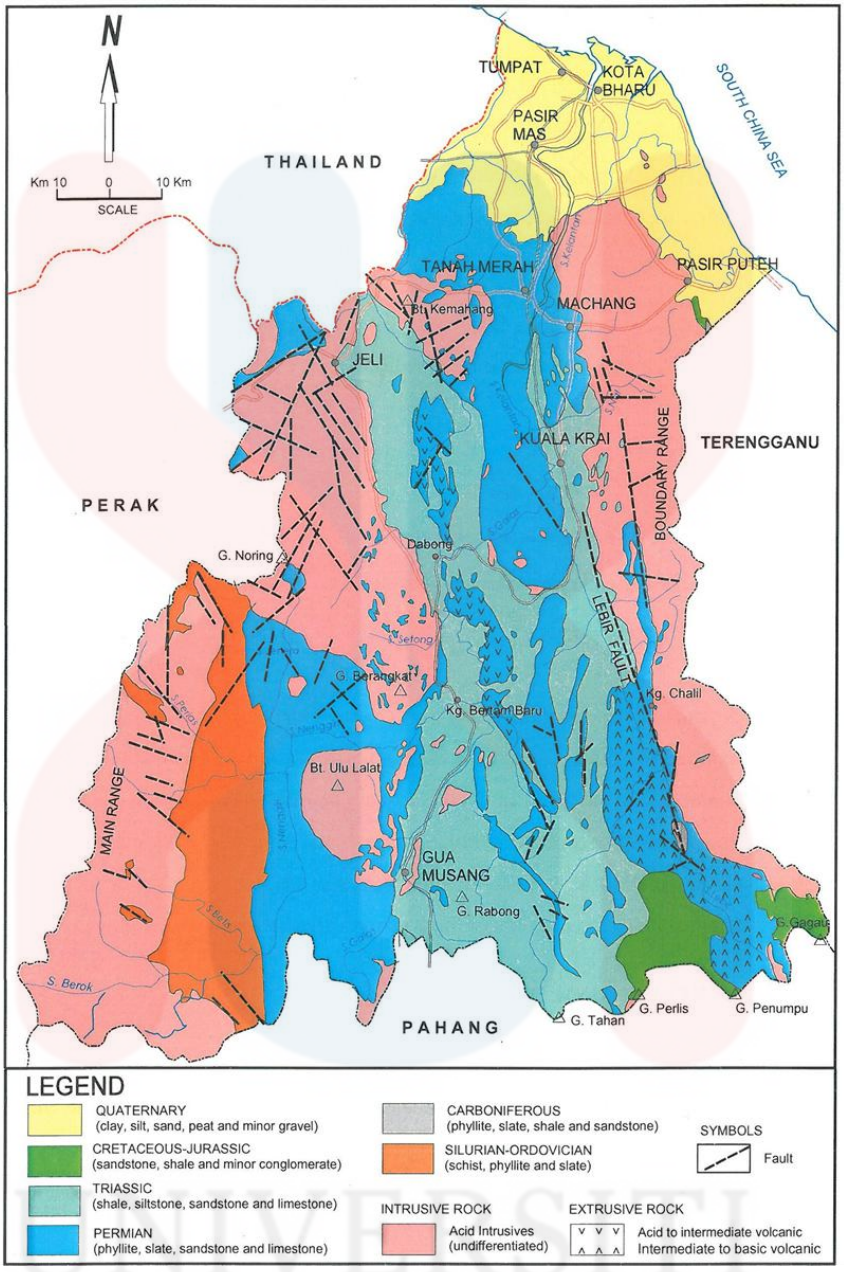

Figure 2.1 : Regional Geology of Kelantan (Source: Quarry Resources Planning for the State of Kelantan , June 2003)

2.3 Stratigraphy

According to Tan & Khoo (1983), The Central Belts of Peninsular Malaysia started from Kelantan to Johor between the eastern foothills of the Main Range. The Central Belts was underlain predominantly Permian - Triassic clastics, volcanic and limestones. In the western part of Central Belts are Upper Paleozoic rocks of

Gua Musang and Aring Formation in south Kelantan and Taku Schist in east Kelantan.

Southern of Kelantan were divided into four area which was: Kuala Betis, Gua Musang, Aring and Gunung Gagau according to Kamal Roslan Mohamed (2006). Sungai Relai was located near to Aring which located at Central Belt of Peninsular Malaysia which rock unit composed by dominant volcanic facies and interlayered with carbonate and argillite. Pyroclastic facies exist as tuffs, lapilli, volcanic breccia and agglomerates.

Aw (1990) was mapped and divided into four rock units which are Aring Formation, Telong Formation, Nilam Marble Formation and Koh Formation. Following are the formation at Gua Musang :-

i. Aring Formation

Name of Aring Formation was taken from Sungai Aring, south Kelantan (Tan & Khoo, 1983). There were two area of sections along tributaries of Sungai Lebir which was Sungai Nuar and Sungai Relai (Aw,1990). Numerous fossil were recorded in this area such as brachipods and fusulinids which assumed in Lower Carboniferous until Early Triassic.

ii. Telong Formation

The age of Telong Formation was assumed in Permian? and Late Triassic due to fossil records which found ammonoids , gastropods, pelecypods and brachiopods (Kamal Roslan Mohamed, 2006). The rock unit was dominated by

argillite with some thin tuff and marble. Telong Formation was lateral equivalent to Gunung Rabong Formation and Semantan Formation (Kamal Roslan Mohamed,2016). Telong Formation and pyroclastic Aring Formation are lateral equivalent Aw (1990) in the south Kelantan (Khoo, 1983).

iii. Nilam Marble Formation

The origin name of Nilam Marble Formation was taken from Sungai Nilam (of Sungai Chiku). According to Aw (1990), Nilam Marble was divided into two types which is Permian marbles and Upper Triassic marble. The lithlogy of Nilam Marble Formation was calcitic marble interbedded with tuff and argillite (Kamal Roslan Mohamed *et., al.*, 2016)

iv Koh Formation

Koh Formation was taken from Sungai Koh, a tributary of Sungai Lebir in southern Kelantan. The lithology of Koh Formation was consist of mudstone interbedded in and the base of this formation consists argillaceous limestone (Aw,1990). In Aring area, these formation was the youngest formation (Figure 2.2).

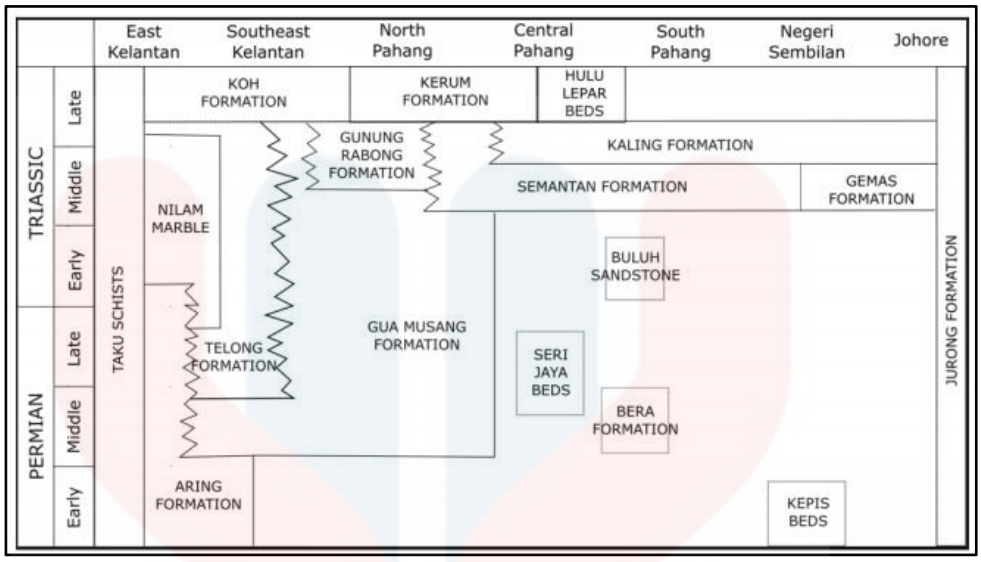

Figure 2.2: Permo Triassic stratigraphic correlation chart of Central Belt Peninsular Malaysia.

Metcalfe &Hussin (1995)

Based on study area, Sungai Relai was cover by Telong Formation. The origin of name of Telong Formation was from Sungai Telong, South Kelantan (Aw, 1990). According to geological map of Felda Aring prepared by Aw (1990), the area of east and west of Sungai Relai located in Telong Formation and the age of Late Permian until Late Triassic. This formation overlie Gua Musang Formation in lower boundary and Koh Formation in top boundary. It was believe that the thickness of Telong Formation was about more than 1000 meter with predominantly sequence of argillite with associated with tuff (Khoo,1983).

To the East of type of area, sediments of the Nilam Marble and the Telong Formation were similar to rocks of the Gua Musang Formation. Foo (1983) suggest that the Telong Formation is synonymous with the Gua Musang Formation. The Nilam Marble and the Telong Formation had been mapped as far south as the Kuala Lipis Tembeling area (Jasmi, 1992).

Based on Aw (1990), Telong Formation dominantly argillite with sandstone, siltstone and limestone. Part of argillite was associated with tuff and carbonates (Figure 2.3) . The depositional setting of Telong Formation was in shallow marine environment with occasional pyroclastic (Kamal Roslan Mohamed *et., al*., 2016).

Based on Aw (1990), in upper reaches of Sungai Aring and the middle reaches of Sungai Relai, found tuffaceous and locally, carbonaceous argillite containing tuff interbeds and occasional beds and lenses of marble/limestone , were mapped as Telong Formation. Ammonites and bivalves were locally reported present with abundant. About 1km of Triassic strata was recorded in type section of Telong Formation.

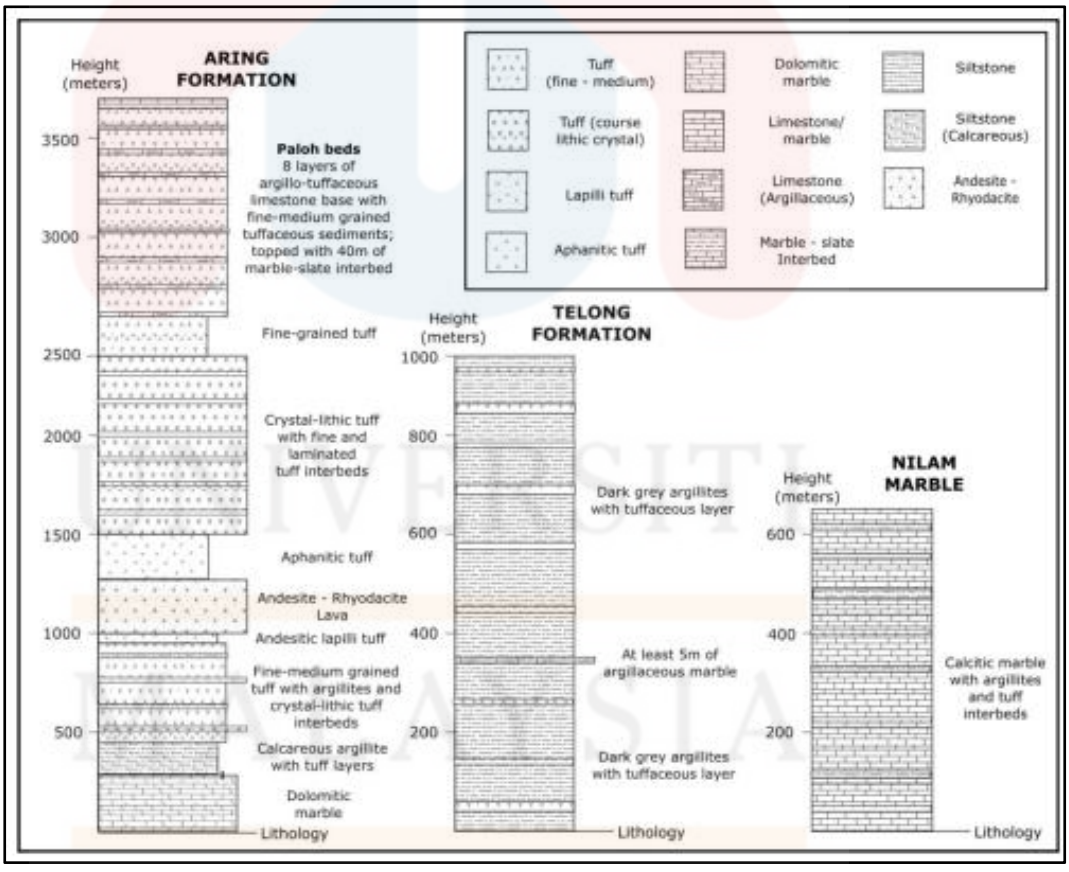

Figure 2.3: Comparison of type section for Aring, Telong, and Nilam marble formation, Gua Musang formation has been assigned with any types section. Source : Aw (1990).

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2.4 Structural Geology

The structural geology in Peninsular indicates that deformation of the structure are long, in complex tectonic evolution possibly started from early of Cambrian until Cenozoic. The structural geology reflects interpretation and tectonic hypotheses attributes of previous researcher. During the Upper Triassic Indosinian Orogeny, the western Gondawana part of the Malay Peninsular collides with the Indochina continental block (East Malaya). Based on Hutchison (1975), the collision of suture zone made up the Bentong- Raub Line. Bentong- Raub Line could represent as major normal fault (Tan,1976 ; Harbury *et al*., 1990). Along the Gua Musang-Cameron Highlands road, The Bentong- Raub Suture was expose as 20-km wide zone deformed rocks. Based on Tija (1996) and Syed Sheikh (1996), the suture in rocks were divided into at least 7 tectonic units. Schist and phylitte sequences, olistrostrome, and bedded chert with clastic intercalations were composed of one complete tectonic units.

According to Tija (1996) and Syed Sheikh (1996), the western boundary of the suture zone of an Upper Triassic-Jurassic granitoid injection complex. They also believed that the suture zone originated from a Lower- Middle Palaeozoic oceanic region which closed to Lower Triassic collision between Gondawana and Cathaysian plates. As the absence of deep ocean radiolarian at the suture, they suggest the suture was started deformed in Late Permian, and the tectonic process completely discontinues their activity at Late Triassic.

Lebir Fault Zone was a curve linear lineaments along Sungai Lebir near Manek Urai in Kelantan. The lineaments can be traced from south, passing the remarkable straight boundary of granite batholiths east of Sungai Lebir, western margin of the Gagau Formation and the eastern margin of the Koh Formation. Based on geological

map by Singh (1985), the Triassic rock boundaries shows displaced sinistrally for about 20km along the Lebir Fault. Based on Tija (1969), based on tension fractures and drag features, the fault zone has a sinistral slip. In Sungai Aring, there is fault zone that become evidence for sinistral movement (Aw,1990). Along exposed road cuts, present of slickensides on the fault surface indicates the movements of sinistral.

2.5 Historical Geology

Historical geology was the branch of geology concerned with the evolution of the earth and its life forms from its origin to the present.

Ladinian-Carnian bivalves, which belonging to *Costatoria-Anodontophora* assemblage, were found in various locality of Sungai Telong (Aw, 1990). These includes, *Costatoria pahangensis, Etholium* and *Neoschizodus*. These were Carnian ammonites , *Amonotis* and *Anatomites* (Aw,1990). By present of these bivalves, it indicates that the sediments of Telong Formation were deposited in shallow water. But, north of the area, turbidites mapped as part of Telong Formation and containing Anisian and Ladinian ammonites. Predominantly Telong Formation was shallow-water deposited but it contain localised areas of deep water facies. From Permian to Late Triassic, deposition of the Telong Formation occurred and coeval with deposition of Gua Musang.

Based on Yin (1965) ,areas lying between Gua Musang and the upper reaches of Sungai Relai- Sungai Aring are underlain the argillaceous succession, which Yin (1965) mapped and named as Gunung Rabong Formation and in age of Triassic and Ladinian- Carnian argillaceous succession. This formation identified as flysch, based on the occurences of sandstone and presence of turbidites. Yin (1965) states that the sediments of Gunung Rabong Formation bear a strong resemblance to the localised

Triassic turbidites found within Telong Formation as well to the turbidites in the Semantan Formation.

2.6 Research Specification

In paleontology, the fossil identification is started when the fossil is identify according to taxonomy classification. Taxonomy classification defined as hierarchical system that deals with classification, identification, and description of organism. Swedish biologist name as Linnaeus establish a system for classifying and naming the organism based on structural similiarities of organism as shows in figure 2.4. Until today, all naming system of living things are according to binomial structural. Binomial structure defined as method use to giving naming by organism, plant, and living things. In binomial nomenclature, there are two name of system for identifying organism which are the genus and the species name. The first part of the name is called as the genus while the second part of the name called the species. The scientific name of each species must be italicized and the genus must be capitalized.

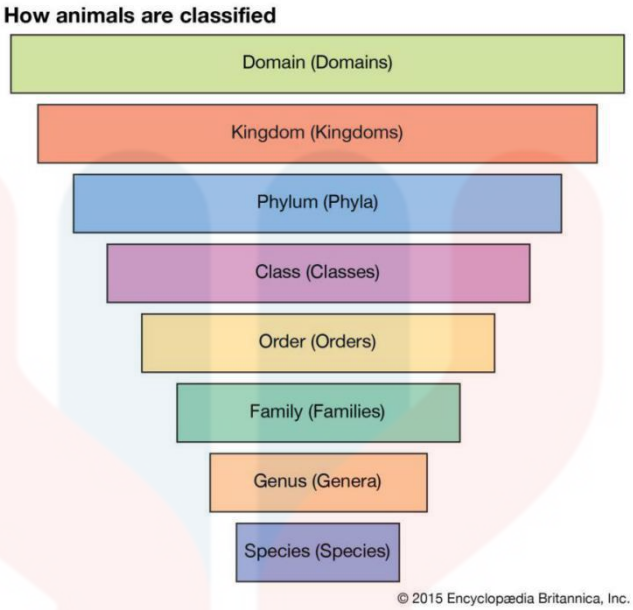


Figure 2.4 : Linnaean taxonomy rank

The research was conduct to focus on geology of study area and palaeontology study. In 1975, Tamura *et.,al.* recorded all ammonoid fossil in the age of Triassic in Malaysia for the first time. In Kelantan, there were two location that recorded contain Triassic fossil which was Gua Panjang and Aring. Hada (1966) state that discovey ammonoid fossil in the age Smithian, Early Triassic in Gua Panjang. Besides, Sato (1964), Ishibashi (1975), and Aw (1990) found ammonoid fossil in the age of Triassic. According to Ishibashi (1975), there are four species ammonoid which was *Halilucite*s of *ornatus*, *Pseudoaplococeras* sp. , *Frechites*? sp. and *Acrochordiceras* (*Paracrochordiceras*) cf a*nodosum* in the age of Anisisn.

In research that had been done by Ahmad Rosli & Mohd Shafeea (2010), Telong Formation consists of sedimentary rock layers that have fossil. Figure 2.5 and figure 2.6 shows two location which contain abundance ammonoid fossil. Sungai Relai was located between these two location. In QZ467, the fossil ammonoid found in thin layers of dark grey tuffaceous mudstone while QZ480, found in bedding of shale.

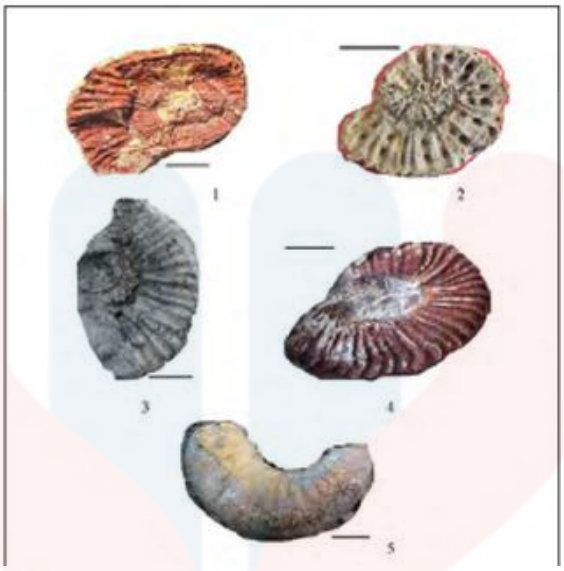


Figure 2.5 : Species ammonoid in site QZ480, Telong Formation, Aring.

[Scale bar represent 1 cm]. 1) *Balatonites* cf. Balatonicus (Mojsisovics), 2) *Kellnerites samneunsis* Mansuy, 3) *Danubites kansa* Diener, 4) *Acrochordiceras* sp., 5) *Hollandites* sp. (from Ahmad Rosli &Mohd Shafeea, 2010)

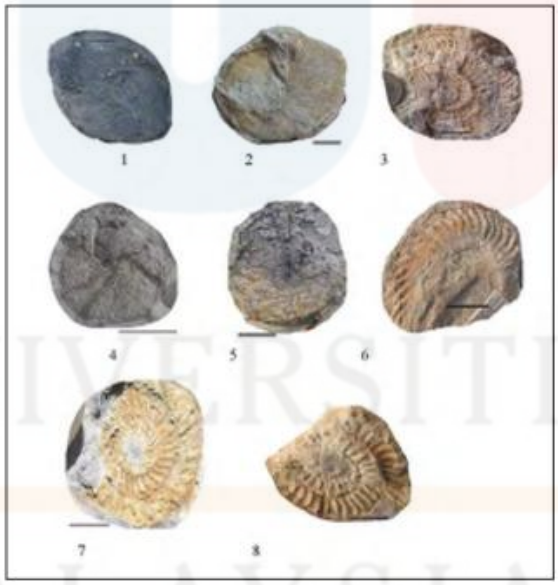


Figure 2.6 : Species ammonoid in site QZ467,Telong Formation, Aring.

[Scale bar represent 1 cm]. 1) *Frankites regoledanus* (Mojsisovics), 2) *Frankites apertus* (Mojsisovics), 3)*Protrachyceras costulatum* Mansuy, 4) *Joannites* sp., 5) *Megaphyllites jarbas* Mojsisovics, 6) *Anolcites* sp., 7)*Clionitites* sp., 8)*Celtites epolensis* Mojsisovics. (from Ahmad Rosli &Mohd Shafeea, 2010)

Another research that had been done by Ahmad Rosli & Mohd Shafeea (2009), found Middle Triassic Bivalve *Danoella pahangensis* Kobayashi in Aring, Gua Musang, Kelantan. This single species of *Danoella pahangensis* Kobayashi found in strata of sedimentary rock in the age of Triassic. The fossil was found at outcrop with localities of QZ467 was overlay of Telong Formation. In Kelantan, this was the first discovery of this species besides those describes by Kobayashi (1964) in Temerloh Pahang. This bivalve fossil found in bedding of grey tuffaceous mudstone with strike from 340˚-350˚ and dip, 25˚-30˚ to the northeast.

Based on mapped that had be done by Aw (1990), Aring was overlay the Telong Formation and lateral equivalent to Semantan Formation. Bivalve *Danoella pahangensis* Kobayashi found with ammonoid fossils in the age of Late Ladinian such as *Frankites regoledanus* (Mojsisovics*), Protrachyceras costulatum* Mansuy, *Daxatina* sp., *Protrachycer*as cf. *pseudo-archelaus* Mojsisovics, *Anolcites* sp., *Joannites* sp., *Clinonitities* sp*., Zestoceras* sp. and *Megaphyllites jarbas* Mojsisovics. (Ahmad Rosli & Mohd Shafeea Leman, 2008). From previous research, Triassic Bivalve *Doenella* was recorded found in Perak, Kelantan, Pahang and Kedah. According to Jones *et al.,* Jones stated that Kobayashi recorded a discovery of *Daonella indica* Bittner at Kuala Nerang, Kedah. However, Kobayashi (1964) and Jaafar Ahmad (1976) were recorded discovery of a few species *Daoenella* that found by Procter in a few localities at Temerloh, Pahang.

In Kelantan, in Sungai Lebak, Kobayashi *et al.,*(1966) recorded discovery of *Daonella sp*. while in Sg Chiku, Gua Musang, Yin (1963) found *Daonella cf. indica Bittner.* Based on discover of these *Daonella* species, *Daonella* that found in Aring area, Gua Musang, Kelantan had similar morphology with *Daonella pahangensis* Kobayashi as shown in figure 2.7.

Ammonoid *Frankites regoledanus* (Mojsisovics) was the one of species of ammonoid that familiar that can be found in Paleo-Tethys ocean. This can indicates subzone for Regoledanus subzone and Protrachyceras zone (Mietto & Marfin 1995). Based on Kobayashi (1964), group of *Daonella* species in Malaysia, was the belong to Group *Daonella struria- Danonella lommeli*.

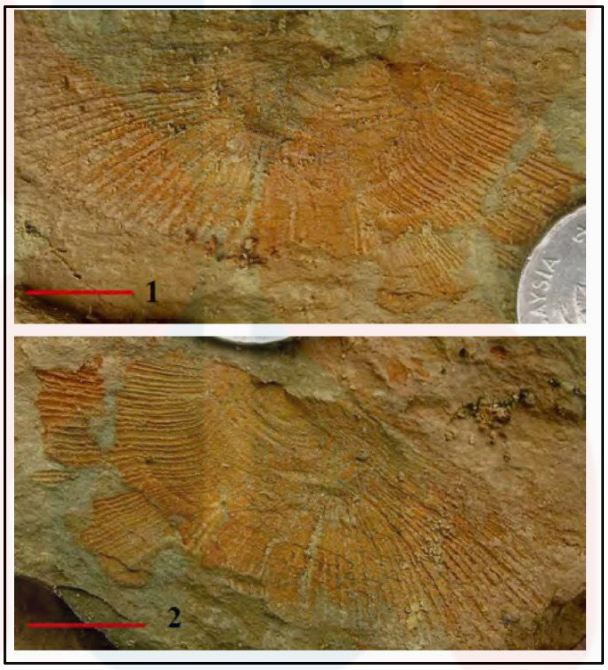


Figure 2.7: *Daonella pahangensis* Kobayashi 1964. Scale bar represent 1cm. Location: QZ467, Telong Formation, Aring,Gua Musang, Kelantan. Picture 1: Internal mould, right valve, specimen QZ467/B1. Picture 2: External mould, left valve, specimen QZ467/B1

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

In this research, there are a several steps and analyses were taken to ensure the objective can be achieved. In this chapter, there are several steps included methods materials, preliminary study, literature review, data collection, data processing, data analysis and report writing. Figure 3.1 shows the research flow chart in conducting this research.

Before conduct the geological mapping, it is important to have preliminary study of study area. It will bring more knowledge about formation, stratigraphy, sedimentology, geomorphology of study area with reading many journal, newspaper, articles and books about the geology of study area and specification of research.

Field work was done include all mapping activities such as geological mapping. All data from study area was collected and be resulted in the end of research.

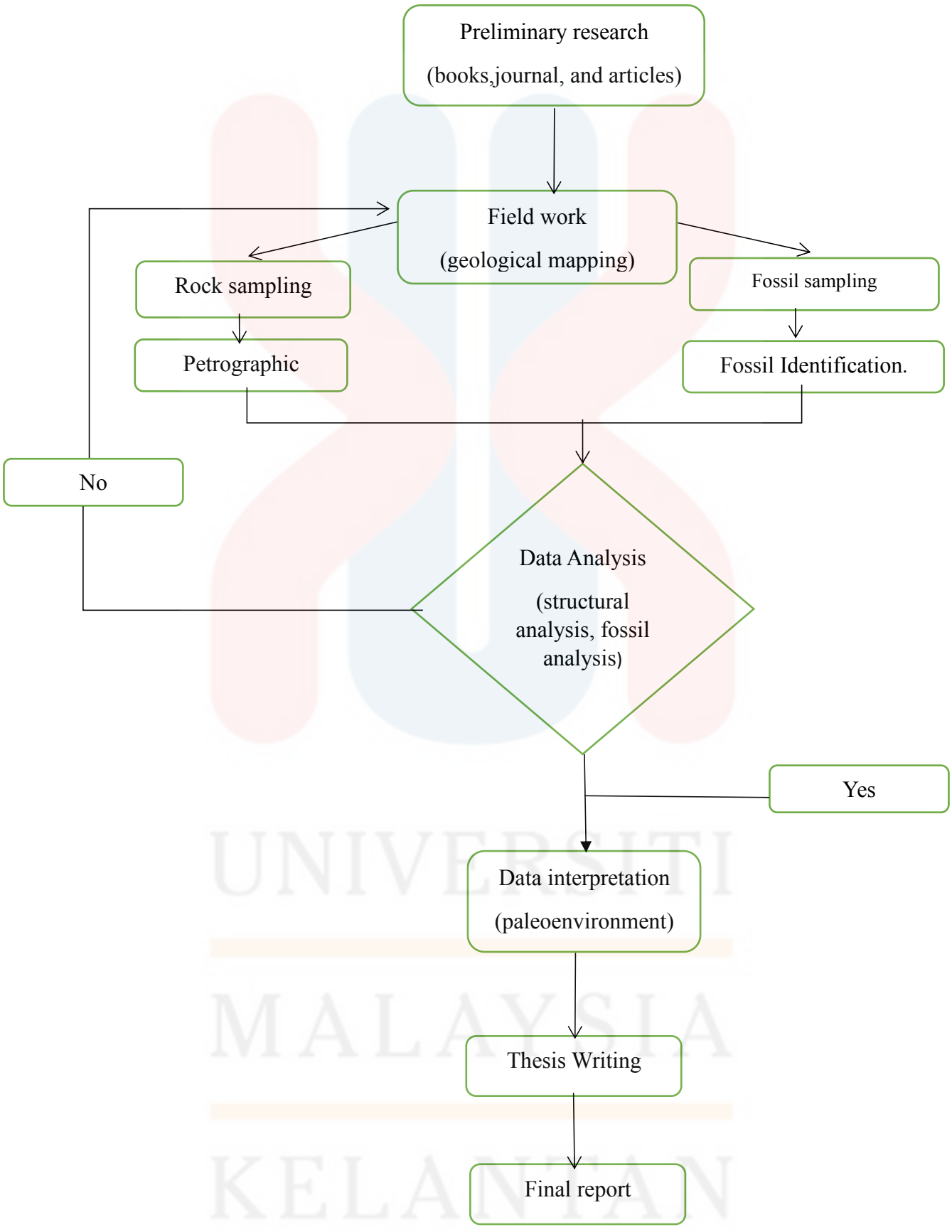


Figure 3.1: The flowchart of research study.

3.2 Material and Equipment

a) Topographic map (base map)

For a geological work, base map is used for know our study area (coordinates) and to record the location of outcrop in the base map.

b) Global Positional System (GPS)

GPS is satellite navigation system that used to locate position, to mark an outcrops location, provides elevation in each area and for tracking.

c) Geological hammer.

Geological hammer was the most important materials during mapping. The uses of this hammer was to collect sample from the outcrops. There was two types hammer which was chisel and tip point. In fossil collecting and mineral collecting, they break the rocks with aim to revealing what inside the rock. Sometimes, hammer was used as a scale of structure in the outcrop.

d) Compass

Compass was a materials that use for determine direction. Its also can measure strike and dip at surface outcrop such as fault plane, bedding and joint.

e) Hand lens

Hand lens were used to observe minerals grains or fossil content in a rock surface that difficult to see with our naked eyes.

f) Hydrocloric acid (*HCl*)

Hydrochloric acid (*HCl*) was used to determine the present of calcite in rock or structure that have carbonates rocks. When a few drop *HCl* hit a rock which contains carbonates or calcite, the rock will bubbly and produce fizzy sound.

g) Sample bag

Sample bag was important for store rock sample in each outcrops. The labelling of each rock sample was to avoid from mixing from other sample and locations.

h) Measuring tape.

Measuring tape is used for measuring the distance and width of a outcrop. Furthermore, measuring tape important in litholog which need accurate and precise the thickness of each bedding.

i) Camera

Camera was use to capture image of outcrop or structure to documentation in report writing. The picture was taken with suitable scale so that readers know the actual size of outcrop or structure.

j) Field Note Book

Field notebook was important to note all the details, description, sketches of the outcrops so that the data will be not forgotten after doing fieldwork. It easily to recall in writing process.

k) Coins

Coins was used for scale of the fossil so that the readers know the actual size of the fossil.

l) Newspaper

The rock unit that contain fossil must be wrap with newspaper to reduce crack of the rock.

3.3 Methodology

There were several steps and analyses to ensure the objective of research was achieved. The example of important steps are including preliminary study, field work, laboratory works, data processing, data analysis and interpretation and writing process.

3.3.1 Preliminary study

Before started the research, important to do preliminary study on literature review in journals, articles, books, website, and newspaper. The advantages of preliminary study was to get more understanding about study area, and topic of the research. In addition, preparation maps of study area with ArcGIS and field preparation important before started geological mapping.

3.3.2 Field studies

The most important methods is in field studies which was geological mapping. The geological mapping was the process of collecting data in study area. It consists

of primary data such as geomorphology, stratigraphy observation, sampling, measurements and observation of structure geology in field. In every outcrop that found, it important to take strike and dip to know the direction of the structure.

3.3.3 Laboratory works

After done geological mapping, thin section must be done. Thin section was laboratory preparation process for see minerals rocks by using polarizing petrographic microscope. Samples of the rocks specimen were cut by a specific rock cutting machine and were thinned by specific method for preparation of thin section.

i) Thin Section

The thin slice of rock was cut off by using the diamond saw, one side was polished to perfectly smooth, flat surface and then was attached to a thin glass (75m x 25mm) using cement. Then, the slide was mounted in a machine where specimen was further reduced in thickness either by milling action or grinding with different grades of carborandum powder (an abrasive composed of silicon carbide crystals. When a specimen was very thick which was almost transparent, it was removed and finished to the correct thickness by hand grinding on a glass plate until its thickness by hand grinding on a glass plate until its thickness is approximately 0.03mm. Then, its washed and dried and covers the surface with a thin glass cover slip and attached with the same cement as before. The thin section was ready.

3.3.4 Data Processing

After all data geological mapping were collected, the data must be processing. By rock sample, data was collected by process through thin section. By the result of the thin section, the minerals contain in rocks can be observed clearly. For palaeontology, the rock that contain fossil must be wrap with newspaper to prevent the fossil crack . Then, the fossil sample found must be identify according to the structural organism and naming the species. Next, the depositional environment of study area will be determined. Data input from software such as ArcGIS can produce geological map, topography map, geomorphology map, lithology map of the study area.

3.3.5 Data analysis and interpretation

After all data are collected, the data will undergo data analysis. In data analysis, data that obtained was from structural geology measurement and observation, lithology, sedimentary structure, fossil that found in field must be analysis with details. With data that have been analysis, interpretation of study area on deposition environments, geological time age can be interpret based on result of sedimentary and fossil analysis.

3.3.6 Writing process

The last step that should be done is writing process. All the data, interpretation must be write on final year project report. This report must be submitted to supervisor according to its due date.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter will discuss details about general geology of the Sungai Relai. Geological mapping activities include geomorphological, lithostratigraphy, structural geology, and historical geology. Each part of content was provided with maps and figure.

4.1.1 Accessibility

In study area, there are one main road which known as Gua Musang- Kuala Berang as shown in figure 4.1. Many motorcycle, car, truck and lorry using this main road to the plantation. This road was paved. Another road in the study area, was the unpaved road in oil palm plantation as shown in figure 4.2. This road was use by lorry and truck to carry oil palm to the factory.

Figure 4.1 : Main road highway connecting Gua Musang - Kuala Berang

Figure 4.2 : The unpaved road to access the oil palm plantation area.

4.1.2. Settlement

In study area, there is a few settlement due to oil palm plantation and rubber plantation. Most of community of settlement in Sungai Relai, consists of workers of oil palm plantation and rubber plantation. Along the main road of Gua Musang-Kuala Berang, there are a few food stalls may found in the study area as shown in figure 4.3.

Figure 4.3 : The food stall located along the main road in the study area.

4.1.3 Forestry

Study area composed of three types of vegetation. Most of study area was covered by oil palm plantation as shown in figure 4.4 . This oil palm plantation was handle by Tradewinds Plantation Sdn Bhd, Ladang GM 02 Padang Mutiara Sdn Bhd, Bee Garden Plentiful Garden Sdn Bhd, and Keruing Teknik Estate Division (B) Sdn Bhd. Rubber plantation covered about 25 percent ,oil palm plantation was 50 percent and the rest was covered by forest and farm.

Figure 4.4 : The oil palm plantation area

4.1.4 Traverses and observation

This traverse process had been conducted through mapping. Mapping activities started to observed all the lineament and contour on the maps before enter the study area. All the geological data in traverse must be recorded and measured. In mapping, all the traverse that have been done was recorded by GPS. The result of mapping produce the traverse map as shows in figure 4.5. The traverse was include the paved road, unpaved road, the Sungai Relai river, and the oil palm plantation area. Some area didn't discover due to thick forest and higher elevation.

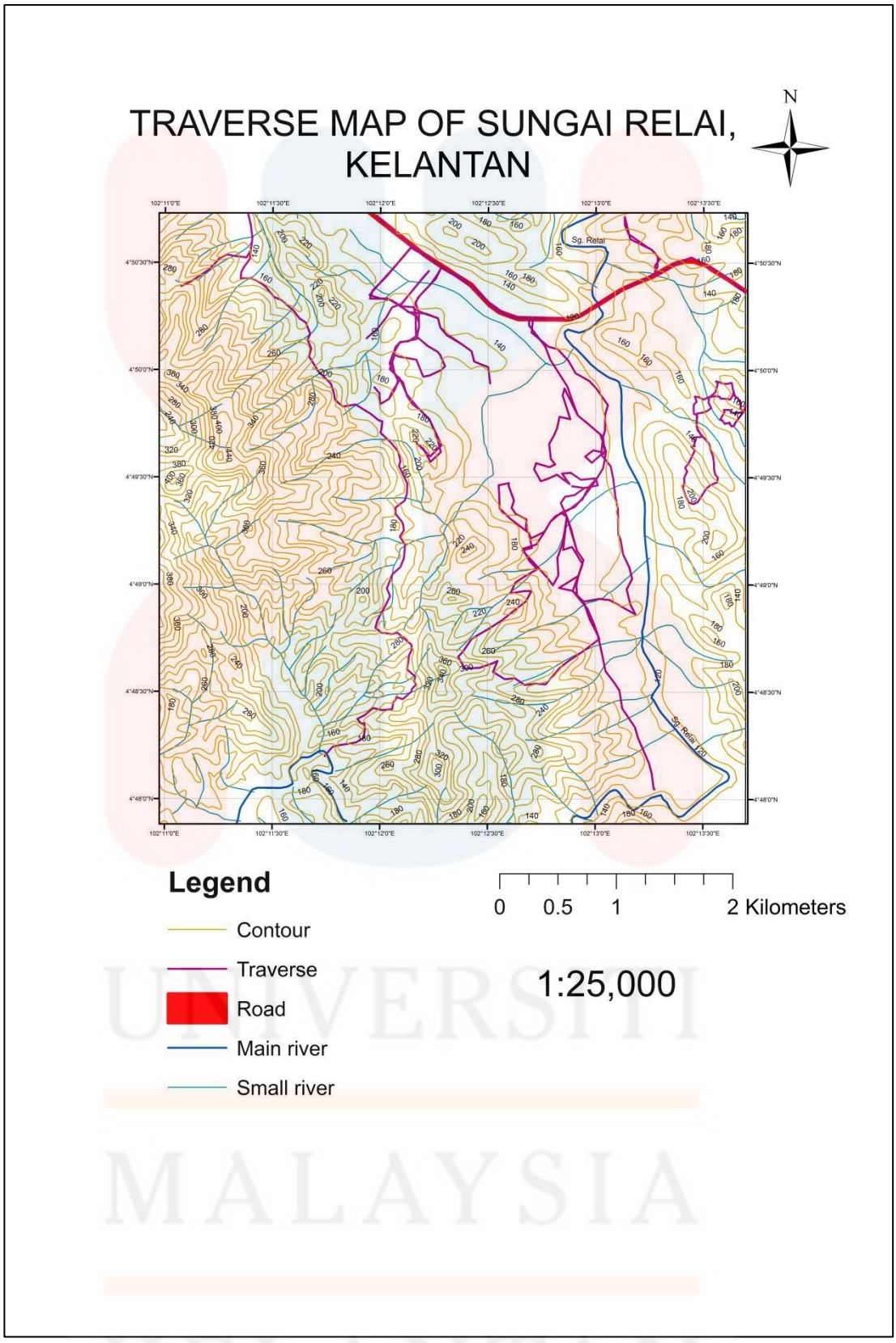


Figure 4.5 : The traverse map of Sungai Relai

4.2 Geomorphology

Geomorphological process is identify the elevation and contour on the maps. This process must be done by mapping activities.

a. Geomorphologic classification

The geomorphological in study area can be divided into two which is mountainous and hilly. Table 4.1 shows the topographic units based on mean elevation. The highest elevation in this study area was 480m which located at oil palm plantation as shown in figure 4.6. The mountainous geomorphology is the highest elevation in range of more than 301m, while the hilly geomorphology is in range 76m to 300m . The hilly area was consists of low lying area, forestry and farm as shown in figure 4.7. The topography maps shows in figure 4.8 based on elevation and contour. In figure 4.9, shows the geomorphological maps divided into two part which mountainous and hilly.

Table 4.1 : Topographic units based on mean elevation

	Topographic unit	Mean elevation (m above the sea)
1	Low lying	<15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	>301

Figure 4.6 : Mountainous area in study area.

Figure 4.7 : The hilly and low lying area in study area.

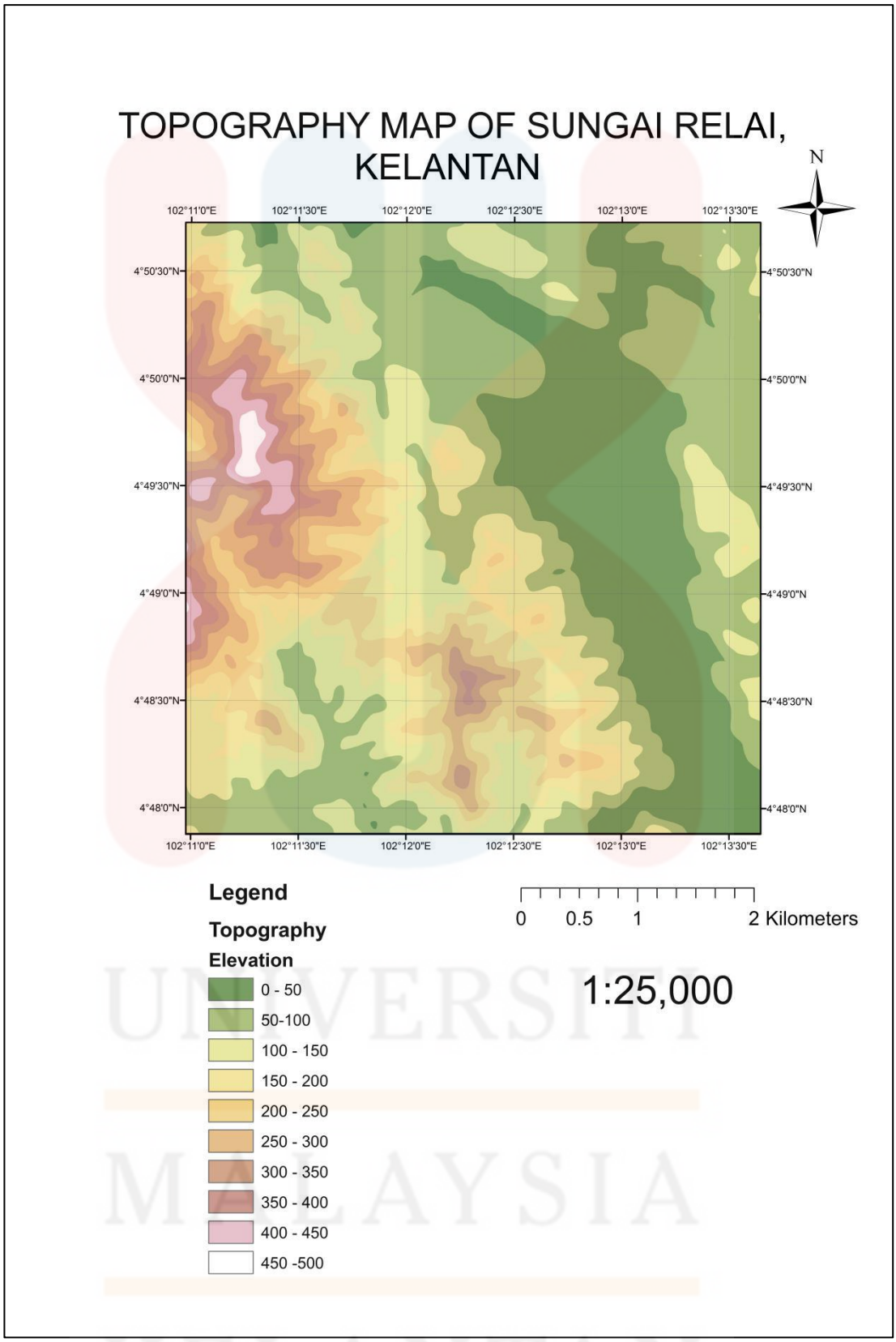


Figure 4.8 : The topography map of Sungai Relai, Gua Musang

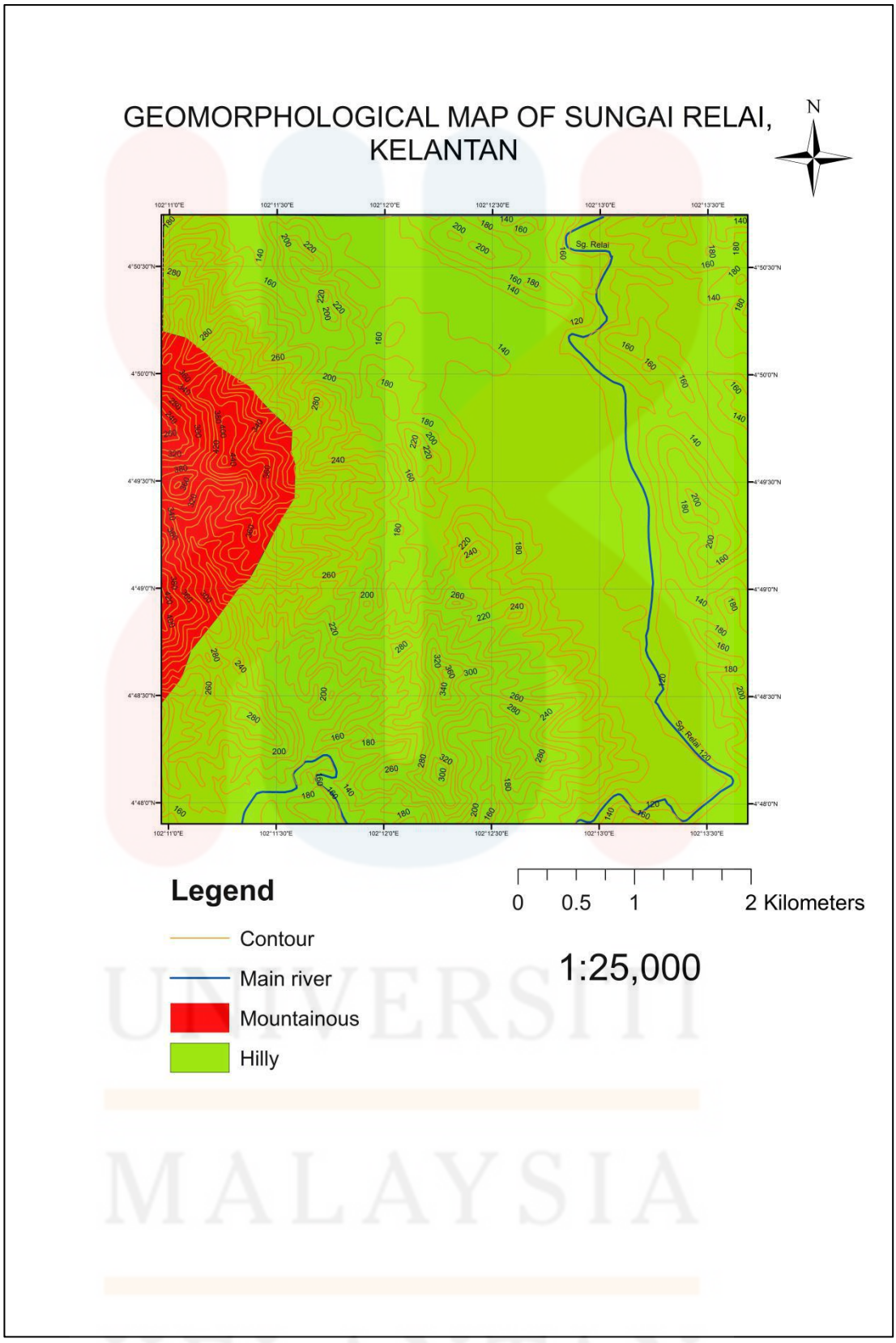


Figure 4.9 : The geomorphological map of the study area.

b.Weathering

Weathering process was common occur in the study area which are in area of oil palm plantation and rubber plantation. All the rocks and soil exposed to the biological, physical, chemical weathering.

Malaysia have tropical climate, humid, hot through the year and sometimes rain fall. This factors affect the rate of weathering in study area and also alternate the chemical and physical composition of the outcrop.

Chemical weathering happen when the chemical composition in the rock alternate the original minerals to the new minerals. Solution, oxidation and hydrolysis are types of chemical weathering. The result of this process in change of composition, structure, or both parent materials. In study area, the outcrop along the road experience oxidation. This oxidation happen when present iron (Fe) is oxidized by water and oxygen. This reaction process produce the reddish brown colour in the exposed surface that as shown as figure 4.10. This rocks become more brittle and weakens.

Figure 4.10 : Chemical weathering that altered the colour of the rock.

Physical weathering hits exposed outcrop when thermal stress, expansion and contraction process that can change and breaks the rocks but its remain the composition. In study area, physical weathering acted on oil palm plantation when all the mudstone was breaks down due to expansion and contraction process as shown in figure 4.11. The heats higher outsides compare to outsides of the rocks. Thus, the surface of outcrop expand more than the interior and producing stress that may cause many fracturing at the rock. Rock is a poor conductor of the heat. Mineral colour composition also effect this process. The dark minerals absorb more heat faster then light colour.

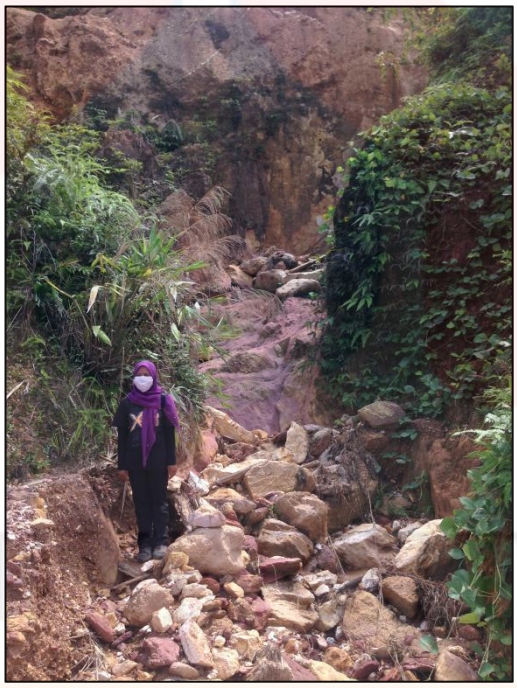


Figure 4.11 : Thermal expansion in physical weathering on mudstone.

Biological weathering happen when breakdown and weakening of rock by living organism. Majority of study area were covered by oil palm plantation. On the top of soil, there were many plants, trees and roots from oil palm plantation grow to the soil. The biological weathering process in study area was shows in figure 4.12.

Figure 4.12 : Biological weathering covered on outcrop of tuff unit.

c. Drainage pattern

The main river in study area was Sungai Relai which flow from south to north on the map. Sungai Relai flow from Gunung Rabong and distribute. The small rivers in study area consists of Sungai Labok and Sungai Mengkuang. Based on identification of drainage pattern on the map, there were three types of drainage pattern which is radial, dendritic and parallel.

Sungai Relai was interpreted by the mature rivers stage due to the 'U' shaped. The characteristics of mature rivers is the velocity of the river flow is calm , the river depth is increasing, and the formation of meandering river as shown in figure 4.11. Due to depositional and erosional process, there were alluvium deposit along the main river as shown in figure 4.13. The alluvium deposits consists of sand, clay, silt, gravel and organic matter as shown in figure 4.14..

Figure 4.13 : Meandering river due to erosion and depositional process

Figure 4.14 : The alluvium deposition along Sungai Mengkuang

Dendritic drainage pattern looks like a lot of branches of trees that came from on source which is main river, Sungai Relai. This type of pattern is mostly common in drainage system and its occur in gently sloping surface that contains materials that have more or less homogeneously to erosion, such as area underlain by horizontal sedimentary rock.

Radial drainage pattern occur when the the tributaries flow from isolated mountains or higher contour. By radial drainage pattern, its can develops to become another types of drainage pattern. The streams from radial drainage pattern follow downward to the slope. Type of drainage are shown in figure 4.15.

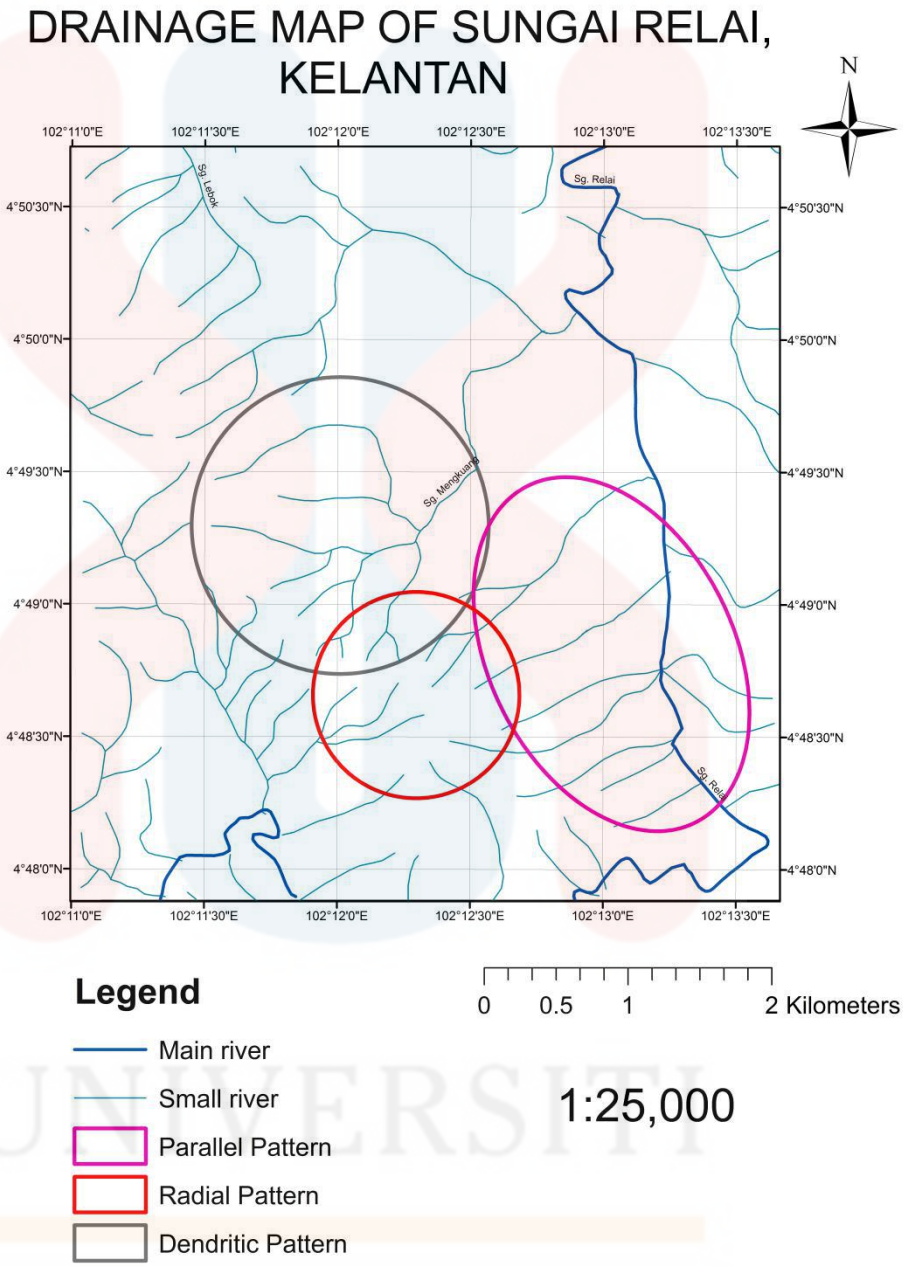


Figure 4.15 : Drainage map of Sungai Relai, Kelantan

4.3 Lithostratigraphy

Based on Boggs (2006), lithostratigraphy explained about the pysical properties of the strata and the organization of the rocks unit into the basic lithology characteristics. The lithology map is shows as figure 4.16 while the geological map of the Sungai Relai area is shows as figure 4.17.

4.3.1 Stratigraphic position (of all units)

Stratigraphic positions shows the arrangement vertical rocks according to the law of superposition. Law of superposition is when the the youngest rock on the top while the oldest rock on the bottom. The stratigraphic position also correlate with geological age as shown in table 4.2.

The study area consists of two types of rocks which is sedimentary rocks and meta sediment. The sedimentary rocks composed of limestone, shale, tuff, and mudstone. While metamorphic rocks are composed of phyllite. In study area, its composed of Telong Formation.

Table 4.2: The stratigraphic column of study area

Age		Rock unit in the study area	Description
Era	Period		
Mesozoic	Quarternary		Alluvium deposit
	Late Triassic		Limestone : Consists of thick bedded
	Triassic		Shale
	Middle Triassic		Mudstone: Consists of tuffaceous mudstone
	?Early Triassic		Tuff unit
	? Pre-Mesozoic		Metamorphic rock unit : Composed of phyllite

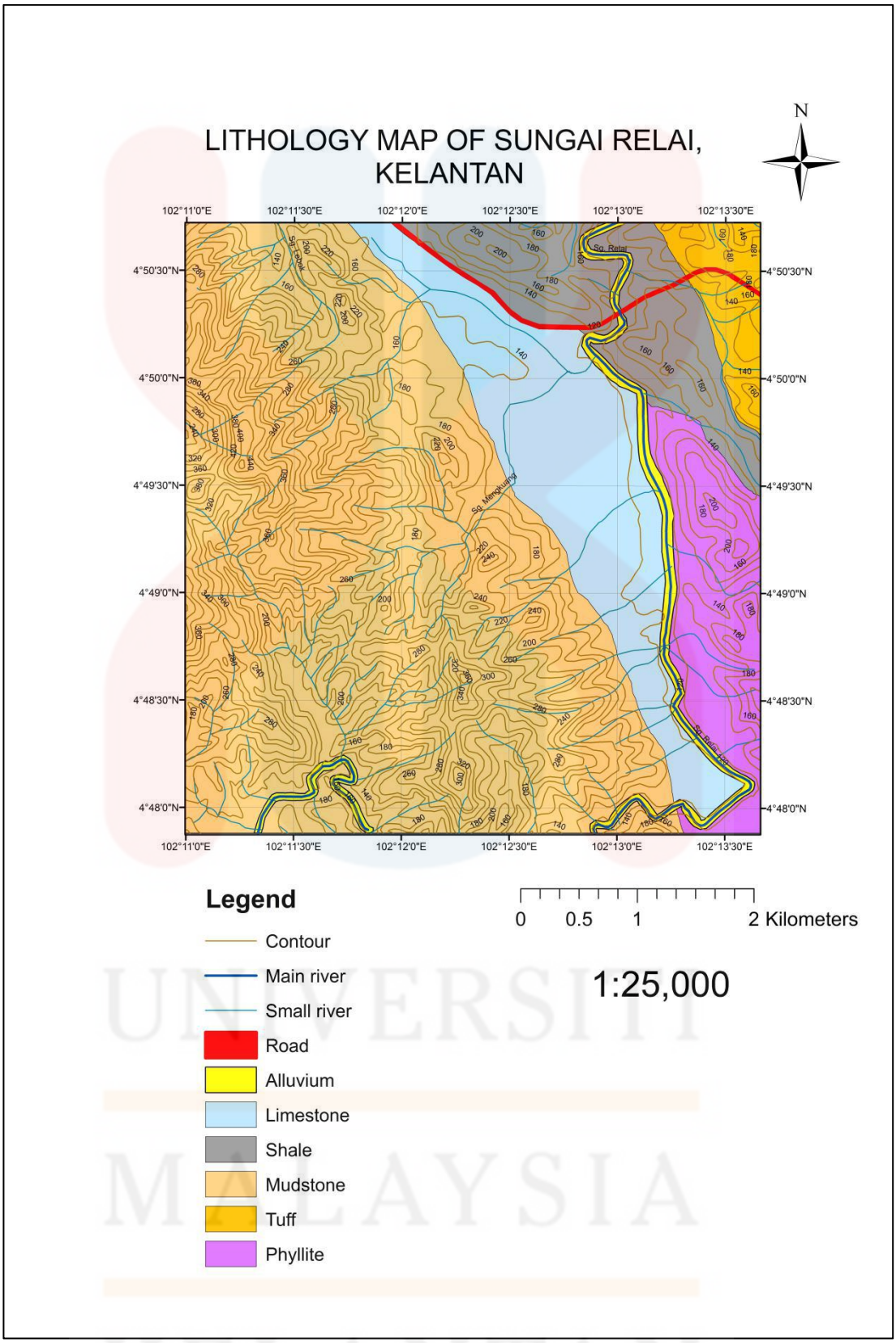
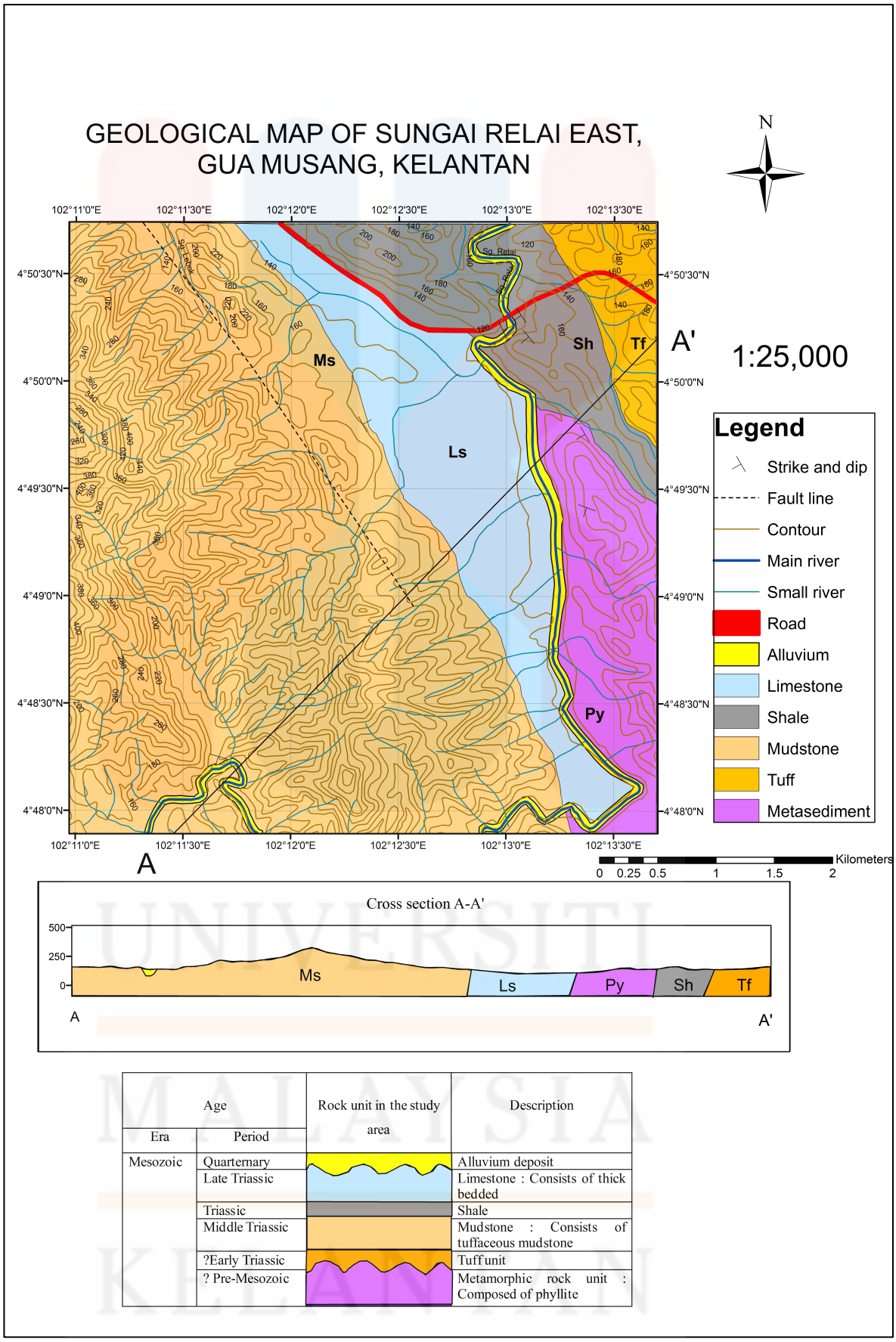


Figure 4.16: The litholog map of Sungai Relai



Age		Rock unit in the study area	Description
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	Middle Triassic		Mudstone : Consists of tuffaceous mudstone
	?Early Triassic		Tuff unit
	? Pre-Mesozoic		Metamorphic rock unit : Composed of phyllite

Figure 4.17: Geological map of Sungai Relai

4.3.2 Unit explanation

a) Metamorphic rocks

Metamorphic rocks was define as transformation of pre-existing rocks due to temperature and pressure. Metamorphic rock occur beneath of earth and closely link with plate tectonics. Foliation is one of characteristic metamorphic rocks. In study area, almost 20 percent was covered by metamorphic unit. However, this metamorphic unit was consists of metamorphic rocks that transform into sedimentary rock that call metasediment. Metamorphic unit that found in this study area were varied with metasediment which composed of well bedded phyllite as shows as figure 4.18.

Metamorphic rock unit can be found at exposed outcrop in oil palm plantation. The colour of metamorphic rock is grayish to dark grey colour shown in figure 4.19. Due to exposed to the sunlight, the rocks unit on the outcrop were highly weathered but some of the rocks were unweathered.

Figure 4.18 : The hand specimen of phyllite

Figure 4.19 : The well bedded outcrop of phyllite

Petrography of phyllite

Under the thin section of phyllite, its hard to identify the minerals But, there were some minerals that can be identified under the mircoscopic. In figure 4.20, its shows the thin section of phyllite. Under plane polarized light (PPL) and cross

polarized light (XPL), the feldspar mineral can be observed due to a few changes in colour in XPL from dark grey to pale gray. Quartz minerals shows colourless in both polarized light.

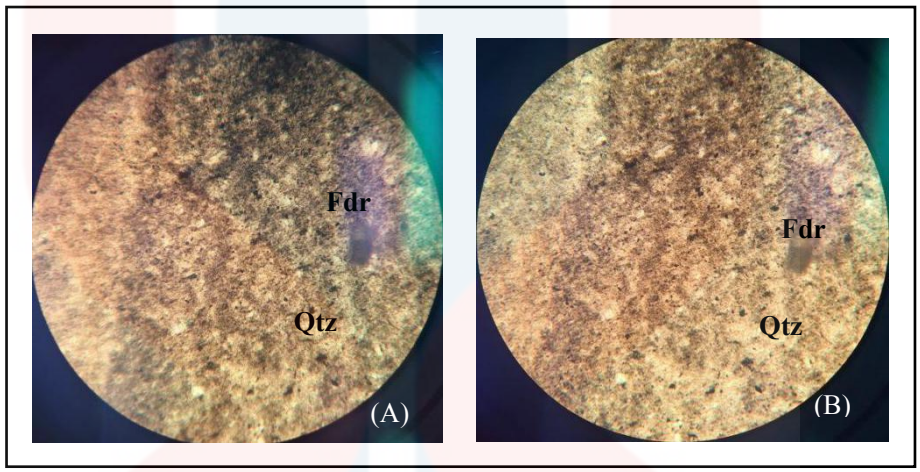


Figure 4.20: Mircosphotographic thin section of tuff under plane PPL (A) and plane XPL (B) with magnificent 10x

b) Tuff unit

Tuff unit was the minority in the study area. Tuff unit is a volcanic rocks that made up from volcanic ash and other material during volcanic eruption happen. The ash and dust from volcanic will compacted and will undergo consolidation process to become a solid rock. The tuff unit was exposed in 300m and 20m in height of outcrop as shown in figure 4.21. Both hand specimen that shown in figure 4.22 was so soft and brittle. Tuff unit must be handle properly because it easily to broken into small fragment if stress hit the rocks. The colour of tuff in study area reddish brown with interbedded with white tuff.

Figure 4.21 : The interbedded tuff exposed at oil palm plantation

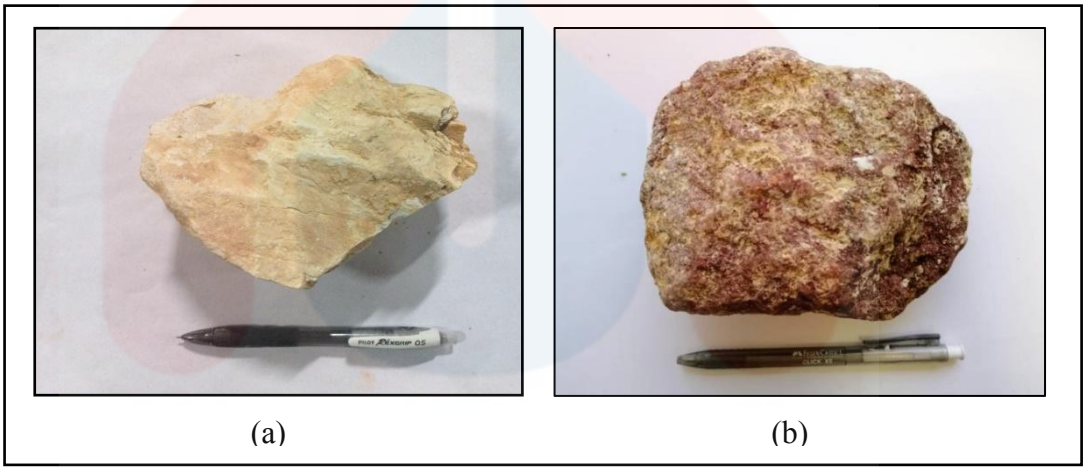


Figure 4.22 : (a) The white tuff that found interbedded in the outcrop. (b) The red tuff that found interbedded with white tuff.

Petrography of tuff

The petrography of tuff was shows in figure 4.23. Tuff is a type of volcanic rock that composed with ash which have been erupt from a volcano. Tuff form from consolidation process where the ash have been compacted. In thin section below, tuff was weathered. Besides that, the minerals content was hard to observed and identify.

Quartz minerals was identify as colourless in both plane polarized light (PPL) and cross polarized light (XPL). Minerals pyroxene was identify as no colour PPL but in XPL its change to brown colour due to birefringence. Muscovite was observed in PPL as transparent but in XPL its change into bright colour which is pale gray. Based on thin section of tuff, its can be classified as crystal tuff because the minerals still can be observed and identified in figure 4.24.

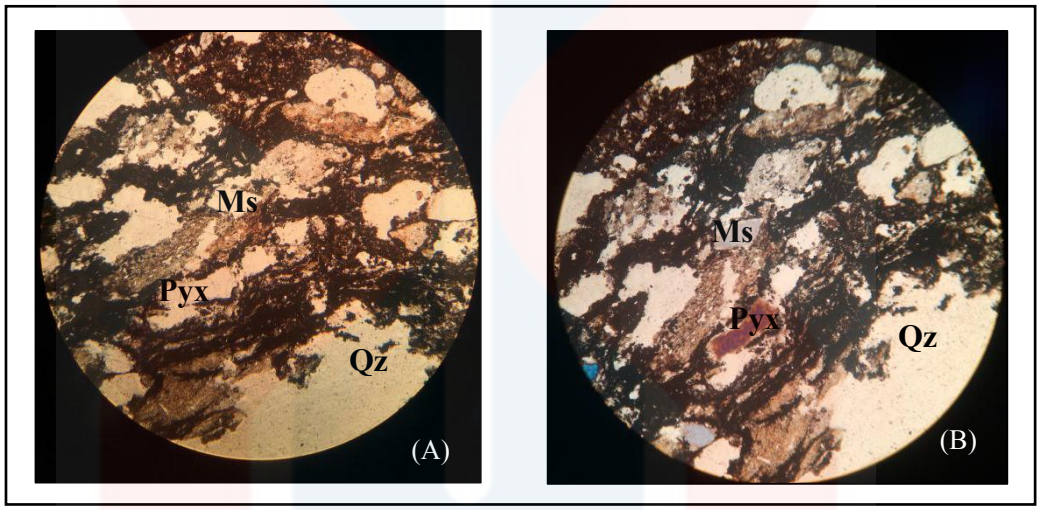


Figure 4.23 : Mircosphotographic thin section of tuff under plane PPL (A) and plane XPL (B) with magnificent 10x

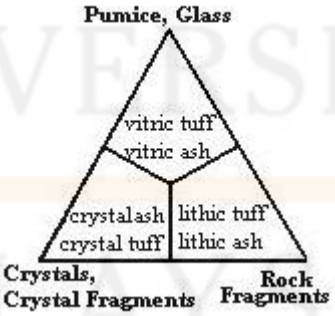


Figure 4.24 : The classification of tuff.

c) Mudstone

Mudstone unit was the majority unit in the study area. Mudstone is fine grained and made up from clay, silt, mud, have composition 50% of siliclastic grain and have size usually less than 0.062mm (Boggs,. 2006). About 50 percent of study area made up from mudstone. Most mudstone unit was covered in area along Sungai Relai, and Keriung Estate oil palm plantation which formerly used as Gunung Rabong forest reserved. Figure 4.25 shows the hand specimen of mudstone that found on the outcrop. Mudstone unit found in the study area was consists of well bedded mudstone, and well bedded tuffaceous mudstone as shown in figure 4.26.

Figure 4.25: Hand specimen of mudstone

Figure 4.26 : The mudstone outcrop in oil palm plantation

d) Shale

Shale unit was found along Sungai Relai.The outcrop seems have been hit by biological weathering and chemical weathering by water as an agent. Mudstone and shale have same composition but shale have fissility. Fissility is a thin laminae with thin bedding when its breaks.Shale have very fine grained compare to the mudstone. Fossil that found in study area was in shale unit.

Petrography of shale

In thin section of shale shows in figure 4.27, the minerals can be observed and identify clearly. There are some minerals found in shale thin section, which are quartz, and pyroxene. Pyroxene in PPL was colourless but when birefringe of minerals is focus in XPL, the minerals changes into blue colour. Quartz minerals shows as in PPL and XPL in colourless colour.

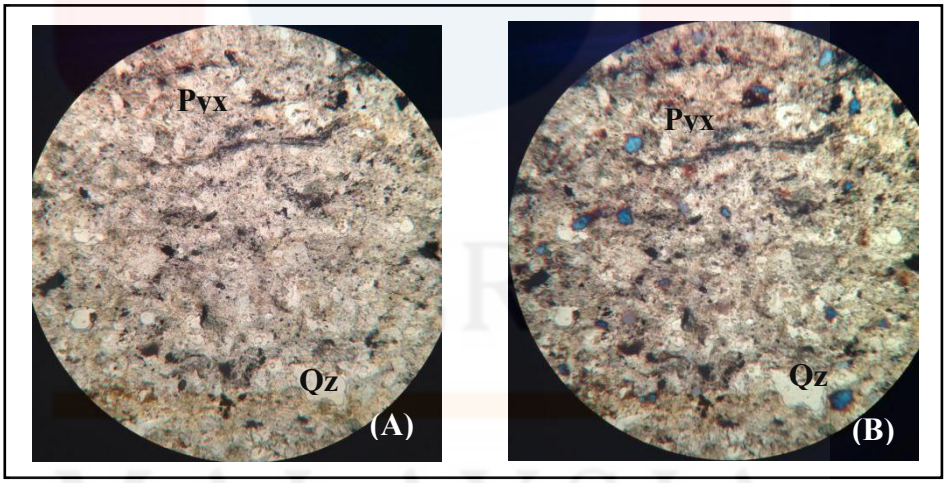
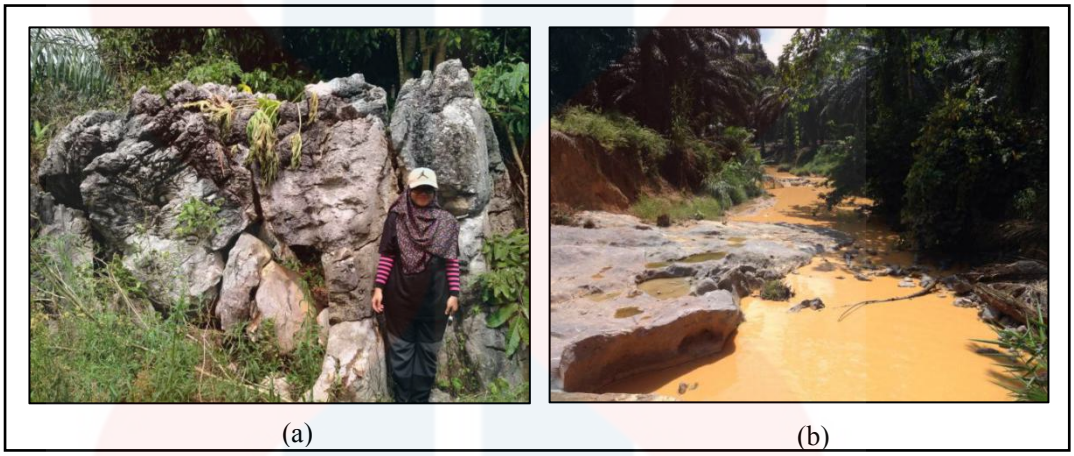


Figure 4.27 : Mircosphotographic thin section of shale under plane PPL (A) and plane XPL (B) with magnificent 10x

e) Limestone

Limestone is sedimentary rock that mainly composed of calcium carbonate (CaCO3). This limestone unit covered the Ladang GM 02, Padang Mutiara from the

entrance until the end of oil palm plantation area. Limestone outcrop was exposed to the area of oil palm plantation as shown in figure 4.28(a) and small river in the plantation as shows in figure 4.28(b) . Limestone will react with hyrdrocloric acid (HCl) and produce the bubbly and 'hissing' sound. Limestone in the study area usually in greyish colour to the dark grey as shows as figure 4.29.



(a) (b)

Figure 4.28: (a) The limestone outcrop in oil palm plantation area. (b)The limestone outcrop in small river

Figure 4.29 : The hand specimen of grey limestone

Petrography of limestone

Based on thin section of limestone in figure 4.30, the mineral hard to identify due to no color changes in PPL and XPL. The fragment of limestone under thin section can

be observed as small and poorly sorting. The calcite minerals shows in both PPL and XPL due to its its perfect cleavage. The feldspar is shows in XPL in pale gray and colourless in PPL. Quartz also shows in Figure 4.30 in PPL and XPL.

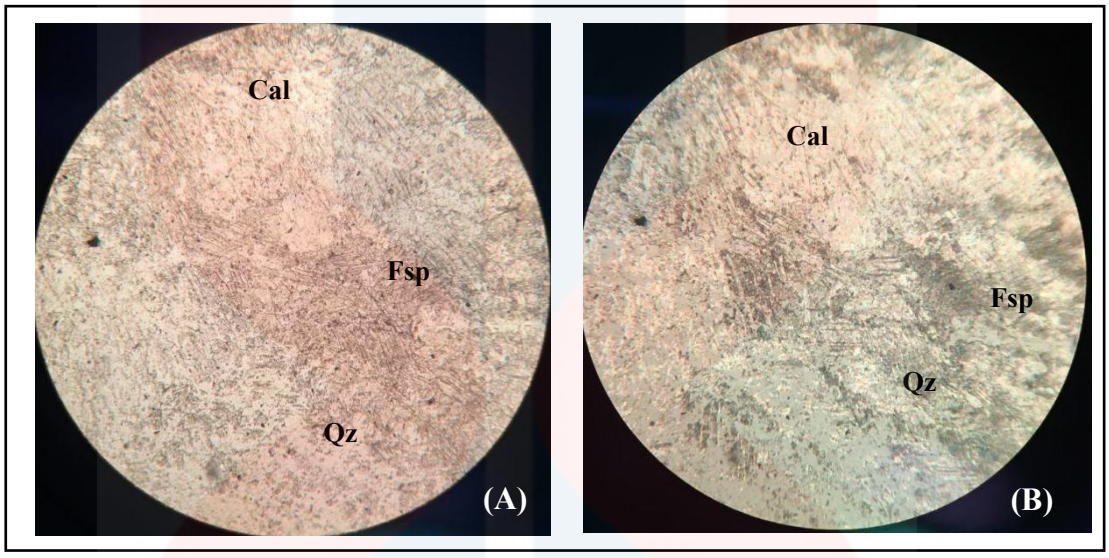


Figure 4.30：XPL-Mircosphotographic thin section of limestone under plane PPL (A) and plane XPL (B) with magnificent 10x

f) Alluvium

Alluvium recently deposited along the main river, which is Sungai Relai. Alluvium consists of fine grained sediment that deposited near the river as shown as figure 4.31. Alluvium was the youngest rock that overlay all the rock unit. The alluvium consists of boulder of rocks, gravel, sand, pebbles and clay. The alluvium occur when the water current transport all the sediment due erosion that undergo process transportation. When the velocity of water become low at floodplains area, all the sediment will deposit near the river banks and point bar. This process will Sungai Relai become meandering rivers.

Figure 4.31 : The alluvium deposition along the small river, Sungai Mengkuang.

4.4 Structural Geology

a. Vein

Vein occur when minerals crystallize in the rocks. Vein usually associated with ore minerals deposits by water. Vein usually occur by hydrothermal activity. In study area, veins were divided into two type of minerals. There were calcite veins and quartz veins. Calcite veins occur in limestone which have composition of CaCo3 as shown in figure 4.32. The quartz vein happen in many types of rocks such as mudstone as shown in figure 4.33.

Figure 4.32 : The calcite vein in the limestone unit

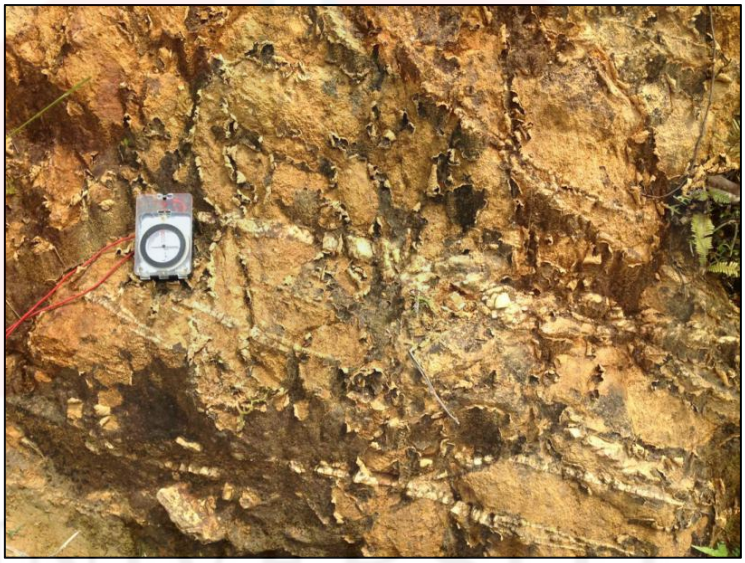


Figure 4.33 : The quartz vein in mudstone unit

b. Joint

Joint is a fracture that occur in rock surface due to stress and strain. Joint can made up from vertical and horizontal direction but no displacement occur. In study area, the joint consists of extensional joint in mudstone unit as shown in figure 4.34. During mapping, 100m measurement of joint was taken to analysis using GeoRose. The joint occur in mudstone because rock unit of mudstone easy

to fracture and have low resistance to the weathering process. Type of the joint in study area was extensional joint. Figure 4.35 shows the the joint reading in mudstone unit. The outcrop located at the top of the hill of oil palm plantation. The major compressional force of σ^1 coming from the direction of N 50° E and the minor compressional force of σ^3 coming from the direction of N 310° W.

Figure 4.34 : The extensional joint in mudstone outcrop

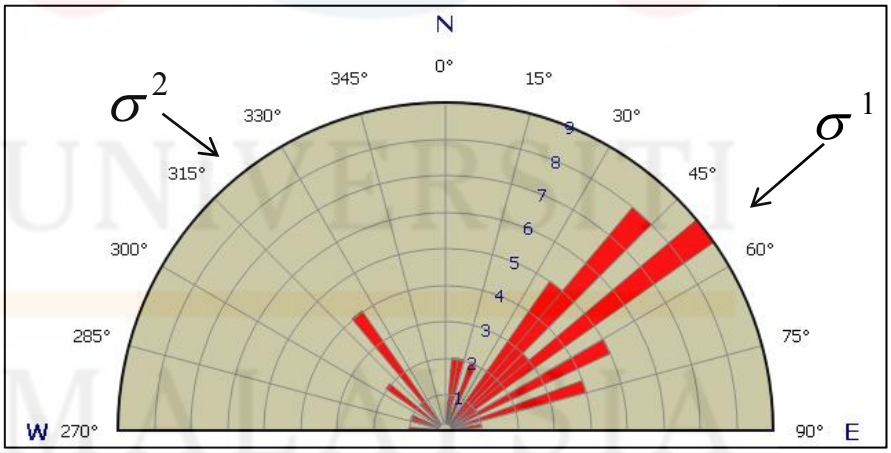


Figure 4.35 : Rose diagram of joint in mudstone unit

c. Bedding

In study area, bedding occur in exposed outcrop in the oil palm plantation and river outcrop. In addition, bedding usually occur in sedimentary rocks and

volcanic rock. The bedding outcrops in study area was shows in figure 4.36 and figure 4.37 below. For figure 4.36, the localities of bedding found at N 04°50.1°19.5°,E 102° 13° 0.1°, while localities in figure 4.37 found at N 04° 49° 48.8°, E 102° 13° 35.7°.

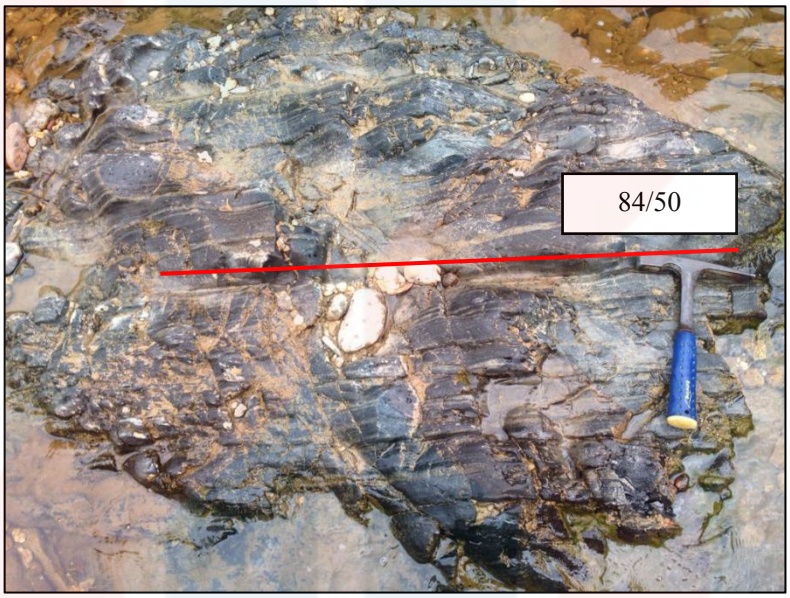


Figure 4.36: The bedding found in shale unit in Sungai Relai area.

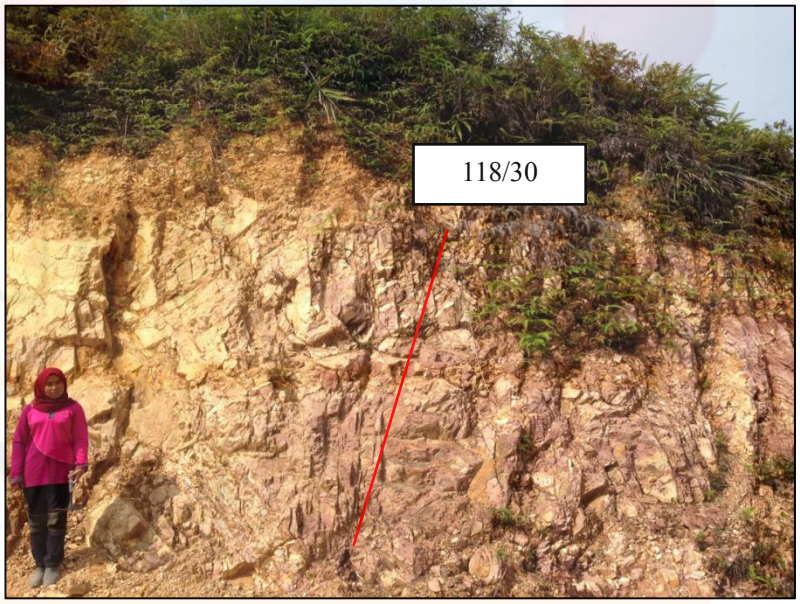


Figure 4.37 : The bedding found in tuff unit in oil palm plantation outcrop.

d. Lineament Analysis

Lineament analysis was taken by aerial photography and have been interpret into lineament maps that shows in figure 4.38. Before started the geological mapping, lineament was observed through map because its shows geological structure. This lineament analysis interpret the tectonic activity and the tectonic movement. Lineament occur in subsurface of topography surface that indicates some geological structure that may occur in the area. From the data collected, the structure, observation and predication of the study area can help to understand more the geomorphology of the area.

The bearing of the lineament was taken from maps to interpret the tectonic forces. GeoRose software was used to interpret the data as shows in figure 4.39. The major σ^1 came from N 55° E and σ^2 came from N 310° E.

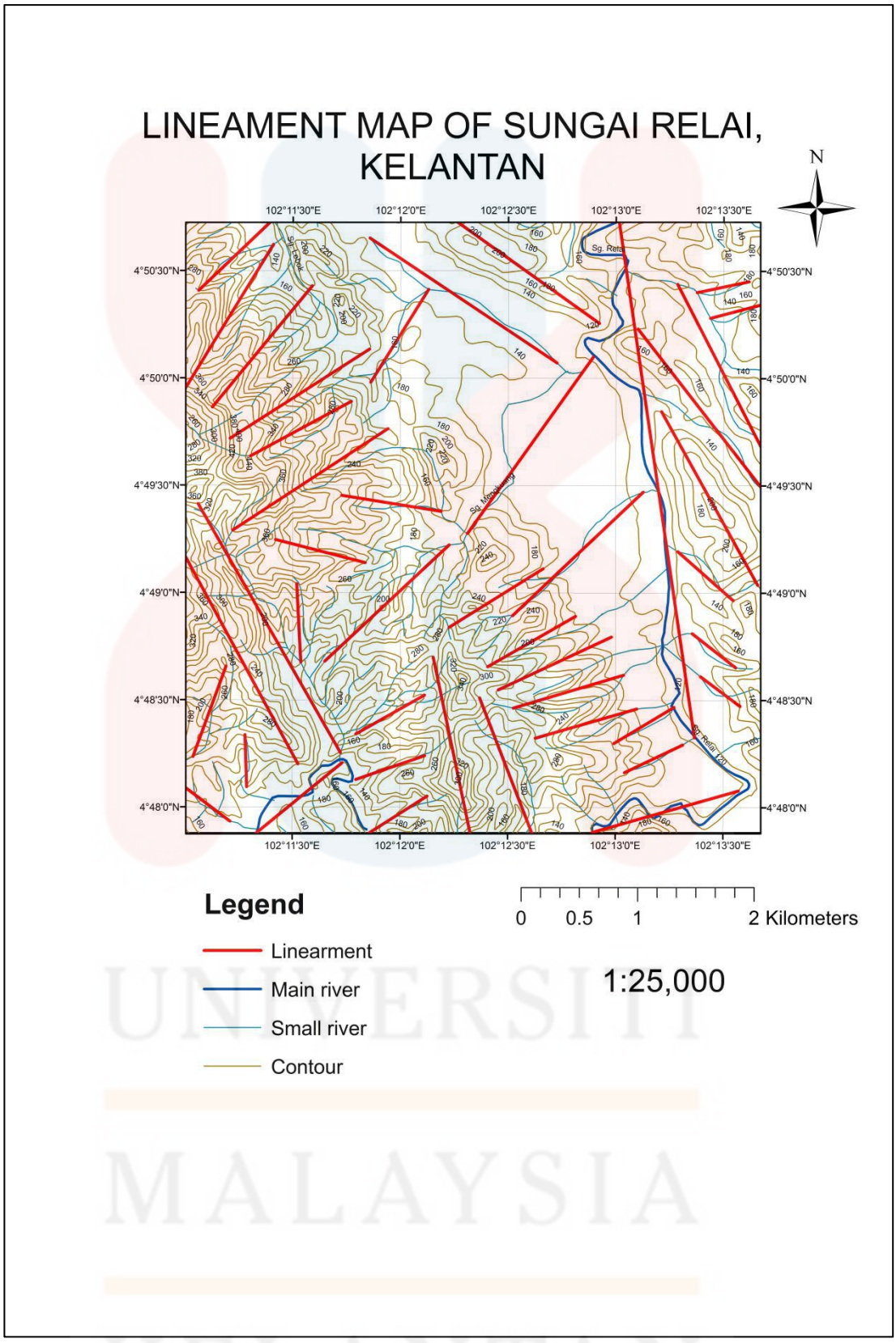


Figure 4.38 : Lineament maps in Sungai Relai area.

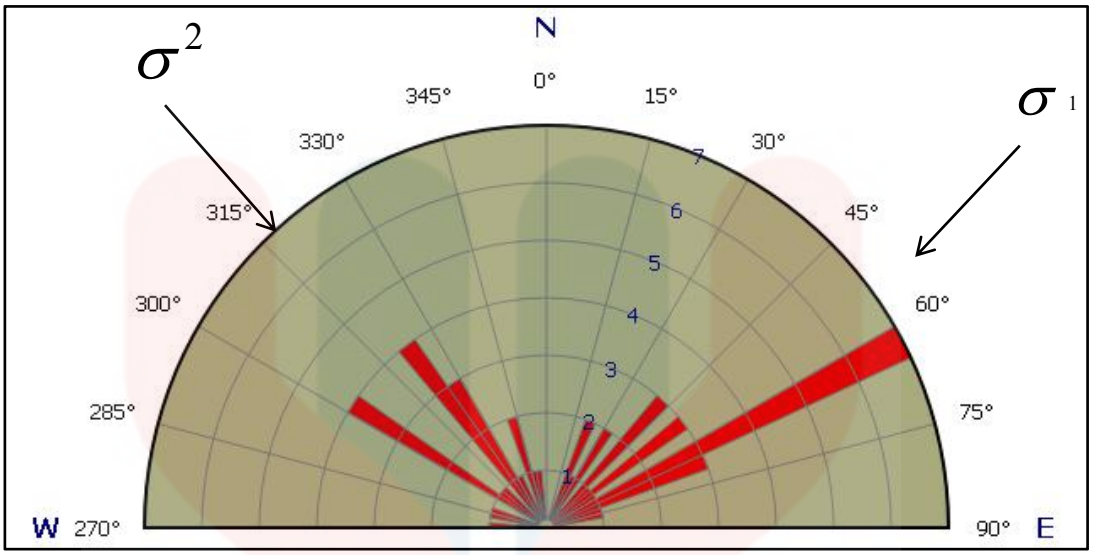


Figure 4.39 : Rose diagram of lineament in study area.

4.5 Historical Geology

The historical geology of Sungai Relai started begin from Permian until Late Triassic of Telong Formation. In Permian, the pyllite unit dominant in north west area of the maps. Phyllite unit was metamorphic rock that undergo high pressure and high temperature, that occur beneath to the earth.

Mudstone and shale of Telong Foramation was interpret as deep water environment with evidences of presence of bivalve *Daonella*.. *Daonella* was the muddy bottom lovers. But, predominantly, Telong Formation was shallow-water deposited but its contain localized areas of deeper water species. There are no sedimentary structure that shows shallow water such as wavy bedding, lamination and lenses.

During Late Triassic, the limestone from beneath the earth surface uplift to the earth surface. Due to the tectonic forces, the limestone unit give strength evidence that the Sungai Relai area was the deep marine environment.

Recent Quarternary were found by alluvial deposition along the Sungai Relai area. Its indicates the erosional and depositional process.

4.6 Mechanism of Structure

The mechanism of structure that happen in Sungai Relai is due to tectonic activity which are uplifting. Due to limestone unit, the limestone have been uplift from beneath of the earth crust to the earth surface. Furthermore, the force exerted from the movement of the earth crust cause the earth surface to uplift to form mountain. In the study area, the mountainous area located at north west of the maps with the higher elevation 480m. There are two opposite force that can cause the rock move upward.

In addition, lineament analysis shows some indicator of the tectonic activity such as expected fault zone beneath the earth force. In study area, there area strike slip fault occur in north west area of the study area. The indicator of this fault shows the different contour on the maps. Joint reading also was measure to determine the compressional force acted to the earth surface that have been discuss in section 4.4 (b).

CHAPTER 5

PALEONTOLOGY OF SUNGAI RELAI

5.1 Introduction

Fossil can be defined as prehistoric living things such as animal, plants that preserved in earth crust in form of body fossil or trace fossil. Fossil usually found in sedimentary rocks. Sedimentary rock experience gentle pressure and low temperature that enable fossil preserved of past life forms. Fossil rarely found in igneous rock and metamorphic rock because both of the rock undergo high pressure and high temperature that can destroy the fossil.

In this chapter, the method used to analyse the fossil found in study area has been shown below (Figure 5.1)

Figure 5.1 : Fossil analysis process in flow chart.

Fossil found in study area in different localities must be record, sampling, and collected for identification and intrepretation of the fossil. For fossil sampling, it have been discuss in Chapter 3. In fossil identification, the fossil must be identify according to their taxonomy rank. Lastly, the analysis and interpretation from the fossil must been done by intrepret the depositional environment of the fossil.

5.2 Fossil Identification

In study area, fossil was found in shale unit belonging to Telong Formation. To identify and naming the species, Geology and Paleontology of Southeast Asia by Kobayashi Toriyama was used as a reference. There are 10 species found in study area.

Most of the fossil found in study area consists of phylum mollusc in class of bivalvia. Bivalves is the second largest class of molluscs, have bilaterally symmetrical and characterized by a laterally compressed body enclosed in a bivalve shell, that dorsally via a hinge and a ligament . In bivalve morphology that have been show in figure 5.2, bivalve characterized by having two shells, valves that hinged dorsally and connected by elastic ligament. The valves are open by relaxation of the compressed ligament and closed by contraction. Muscles in bivalve called as adductor muscle leave impression in the inner part of the valve and this also include pedal muscle and the pallial retractor muscle that attached in along the pallial line. Umbo is the top of the valve that located at hinges line. The growth line is the shell sculpture that occur in surface of shells and its important to identify species.

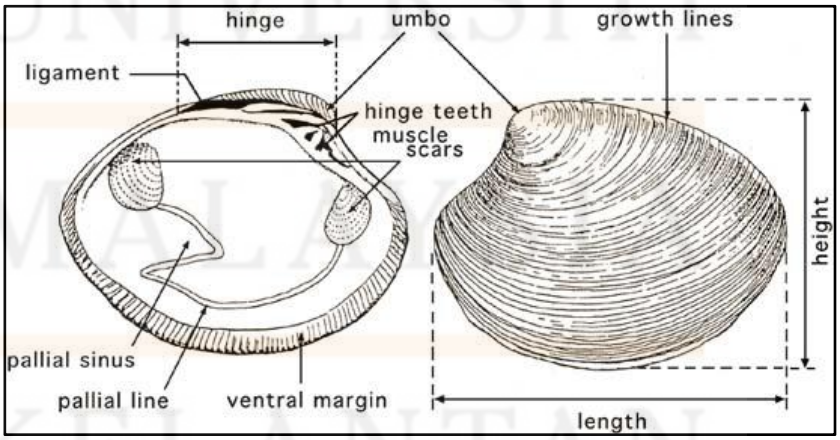


Figure 5.2 : The internal and external of the shell valves. (Cesari and Pellizzato, 1990)

Below shows the description of fossil that found in study area with taxonomy rank of species.

1) *Daonella pichleri* Mojsisovics (1964)

Description: Shell is 3cm high and the length is 5cm. The hinge margin lying the maximum length while the maximum height at about the mid-length. The umbo located at one-third the length from the front, and contains several wrinkles near to the umbo that indicates the shells broad semicircle. Table 5.1 shows the taxonomy *Daoenella pichleri* (Mojsisovics) and figure 5.3 shows the *Daoenella pichleri* (Mojsisovics) in shale unit.

Table 5.1: The taxonomy of *Daoenella pichleri* (Mojsisovics)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daoenella*
Species	*Daoenella pichleri*

Figure 5.3 : *Daonella pichleri* in shale unit

2) *Daonella* cfr. *kotoi* Mojsisovics (1964)

Description : Shell nearly equilateral, hinge line straight, slightly shorter than shell and the umbo is submedian. The height of the shell is 3.2cm and the length is 3.5cm. The umbonal area is convex. The mature form of *Daonella* cfr. *kotoi* (Mojsisovics) has more convex umbo. Table 5.2 shows the taxonomy *Daoenella* cfr. *kotoi* (Mojsisovics) and figure 5.4 shows the *Daoenella* cfr. *kotoi* (Mojsisovics) in shale unit.

Table 5.2: The taxonomy of *Daoenella* cfr.*kotoi* (Mojsisovics)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daoenella*
Species	*Daonella* cfr. *kotoi*

Figure 5.4 : *Daonella* cfr. *kotoi* in shale unit

3) *Daonella multilineata* Jones (1964)

Description: The shell having broad ovate-subelliptical outline. The height is 3.5cm and 2.5 cm while the length is 3.4cm and 4cm. The hinge margin long and straight and the umbo located to at 1:3 of the margin from anterior end. The umbonal area generally convex. The radials become simple toward hinge margin. Table 5.3 shows the taxonomy *Daonella multilineata* (Jones) and figure 5.5 shows the *Daoenella multilineata* (Jones) in shale unit.

Table 5.3: The taxonomy of *Daoenella multilineata* (Jones)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella multilineata*

Figure 5.5 : *Daoenella multilineata*

4) *Daonella pahangensis* Kobayashi (1964)

Description : Shell in large size and inequilateral, and produced posteriorly and longer high. Both of shell have same height of 4cm and the length 3.5cm and 2.5cm respectively. The hinge line shorter than shell length and usually straight. In the middle of hinge line, umbo is located. The hinge line was estimate about 7cm in length but shell length not more than 8.5cm. Table 5.4 shows the taxonomy *Daonella pahangensis* (Kobayashi) and figure 5.6 shows the *Daonella pahangensis* (Kobayashi) in shale unit.

Table 5.4: The taxonomy of *Daoenella pahangensis* (Kobayashi)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella pahangensis*

Figure 5.6 : *Daonella pahangensis* in shale unit

5) *Daonella indica* Bittner (1964)

Description : The high of shells subequilateral and regularly outline, have short hinge line, median umbo, and usually straight or numerous straight of ribs. The ribs are flat topped. Table 5.5shows the taxonomy *Daonella indica* (Bittner) and figure 5.7 shows the *Daonella indica* (Bittner) in shale unit.

Table 5.5: The taxonomy of *Daoenella indica* (Bittner)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daoenella*
Species	*Daonella indica*

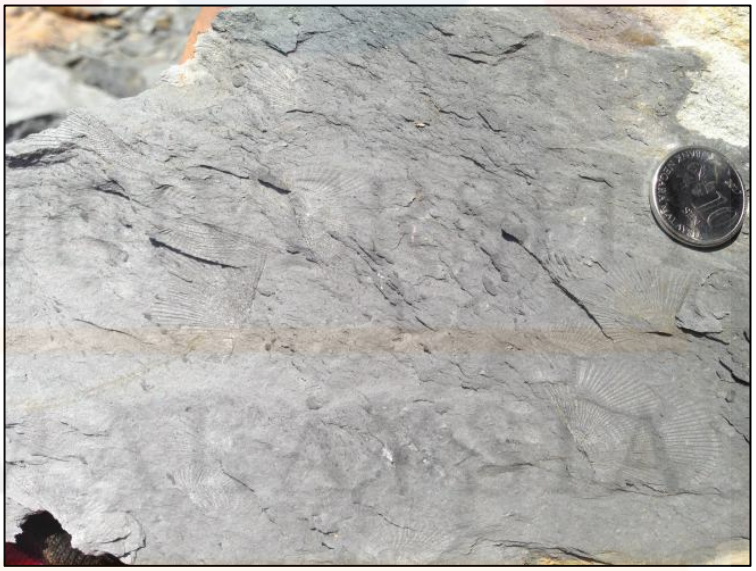


Figure 5.7 *: Daoenella indica* in shale unit

6) *Daonella lommeli* Wissman (1964)

Description : The shells is two-thirds as long as high, the length attaining the maximum below the umbo and the umbo located a little interior to the mid-length.The outline of the shell, is knows as the growth wrinkles about two-third the distance from the umbo. Table 5.6 shows the taxonomy *Daonella lommeli* (Wissman) and figure 5.8 shows the *Daonella lommeli* (Wissman) in shale unit.

Table 5.6: The taxonomy of *Daoenella lommeli* (Wissman)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daoenella*
Species	*Daonella lommeli*

Figure 5.8 : *Daoenella lommeli* in shale unit

7) *Daonella* cfr. *pectinoides* Kobayashi & Tamura (1959)

Description : The shell is small size, flat, sub quadrilateral and framed to equilateral. The hinges lines straight and more shorter than length of the shells. Small umbo but located about half from the hinge lines. The height of the shells more than 2.5 cm length and 3.5cm height. Table 5.7 shows the taxonomy *Daonella* cfr. *pectinoides* (Kobayshi & Tamura) and figure 5.9 shows the *Daonella* cfr. *pectinoides* (Kobayashi & Tamura) in shale unit.

Table 5.7: The taxonomy of *Daoenella* cfr. *Pectinoides* (Kobayashi & Tamura)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella* cfr. *pectinoides*

Figure 5.9 : *Daonella* cfr. *Pectinoides* in shale unit

8) *Daonella procteri* Kobayashi (1964)

Description: Shell subovate in outline, have straight hinge margin which nearly three-four of the shell length. The umbo located at one-third from the anterior end of the margin and projected above it. The radial ribs rounded on the top. Table 5.8 shows the taxonomy *Daonella procteri* (Kobayashi) and figure 5.10 shows the *Daonella protecri* (Kobayashi) in shale unit.

Table 5.8: The taxonomy of *Daoenella procteri* (Kobayashi)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella proteri*

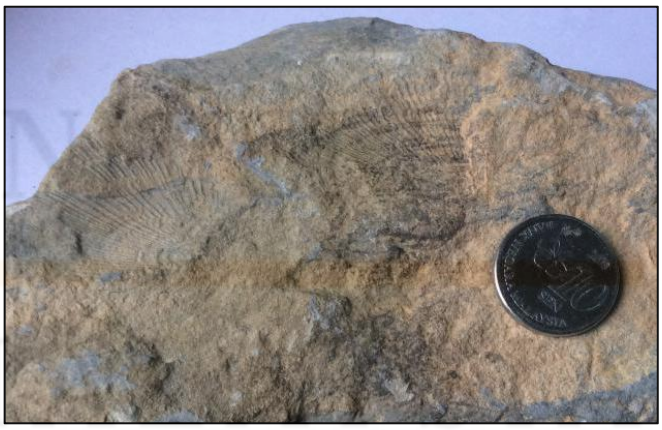


Figure 5.10: *Daoenella procteri* in shale unit

9) *Daonella sakawana* Mojsisovics (1959)

Description : Medium size of shell, sub oblique and inequalateral. Umbo located at one-third of the hinges line from anterior end. The hinges line was in the straight lines and usually shorter than length of the shells. Table 5.9 shows the taxonomy *Daonella sakawana* (Mojsisovics) and figure 5.11 shows the *Daonella sakawana* (Mojsisovics) in shale unit.

Table 5.9: The taxonomy of *Daoenella sakawana* (Mojsisovics)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella sakawana*

Figure 5.11 *: Daonella sakawana* in shale unit

10) Daonella burtoni Kobayashi & Tamura (1964)

Description : Shell ovate, oblique and slightly convex. The hinge margin about half as long as shell and the umbo located at one-fourth from the anterior end of the shell. The surface of shell have fine radial ribs. Table 5.10 shows the taxonomy *Daoenella burtoni* (Kobayashi & Tamura) and figure 5.12 shows the *Daoenella burtoni* (Kobayashi & Tamura) in shale unit.

Table 5.10: The taxonomy of *Daoenella burtoni* (Kobayashi & Tamura)

Kingdom	Animalia
Phylum	Mollusc
Class	Bivalvia
Order	Pectinoidea Rafinesque (?)
Family	Posidoniidae French
Genus	*Daonella*
Species	*Daonella burtoni*

Figure 5.12 : *Daonella burtoni* in shale unit

5.3 Depositional environment based on fossil

Eleven fossil that found in Sungai Relai consists pf phylum mollusc which more specific class name, bivalvia. Ten species of *Daonella* bivalvia and one species of *Ammonite* were found at localities near to the Sungai Relai. All fossils found in shale unit in Telong Formation, which situated at South Kelantan in zone of Triassic rocks. Based on Kobayashi (1966), *Halobia* fossil usually found many localities in Kedah and north Perak. However, *Daoenella* widely distributed not only in these states but also in Pahang and South Kelantan.

The fossils occurrence in Sungai Relai were recognized as the deep marine environment in Zone of Upper Ladinian of Middle Triassic. Based on Mc Robert (2010), the age of class *Daonella* was found in Early Anisian, Middle Triassic until Carnian in Upper Triassic. Kobayashi *et al.,* (1966) stated that, *Daonella* were widely distribute in the age of Ladinian in Southeast Asia and East Asia. Many species of *Daonella* was found in Peninsula Malaysia either in Eastern Triassic Rocks Zone, such as Semantan and Telong Formation and Western Triassic Rock Zone such as Semanggol Formation.

The valves *Daonella* that found in study area was undamaged, clear but the valves of *Daonella* weak hinges and their valves often detached. Its shows the *Daonella* lying the undisturbed local sea bed. *Daonella* are the bottom muddy lovers. Besides that, the present of limestone in the area give strong evidence that Sungai Relai area was deep marine environment due to uplifting. Thus, *Daonella* indicates that Sungai Relai area is deep marine environment in the age of Triassic.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In study area, it consist of five lithology unit which area phyllite, tuff, mudstone, shale and limestone. The first objective to update geological map with scale of 1:25000 was achieved by collecting data by conduct geological mapping activities.

Next, the second objective in this research is to identify species of the fossil in the study area. Fossil found in study area were identify by naming it species. Ten species of *Daonella* were found in study area. The fossil species were naming as *Daonella pichleri* (Mojsisovics), *Daonella* cfr. *kotoi* (Mojsisovics), *Daonella multilineata* (Jones), *Daonella pahangensis* (Kobayashi), *Daonella indica* (Bittner), *Daonella lommeli* (Wissman), *Daonella* cfr. *Pectinoides* (Kobayashi & Tamura), *Daonella procteri* (Kobayashi), *Daonella sakawana* (Mojsisovics) and *Daonella burtoni* (Kobayashi & Tamura). These fossil usually found in Middle Triassic.

The third objective of the research are to identify the depositional environment based on fossil occurrences in study area. Based on *Daonella* distribution in the study area, the valves of *Daoenella* was found undamaged but *Daoenella* have weak valves that often detached. For conclusion, the *Daoenella* life in undisturbed local sea bed. Limestone in study area shows its have been uplifting from beneath the earth to the earth surface. Its indicates that Sungai Relai is deep marine environment.

6.2 Recommendation

There are some recommendation that can be implemented. Firstly, the research of geology in terms of paleontology of Sungai Relai should be advanced to find various types of fossil that have been preserved in Sungai Relai.

Secondly, the Sungai Relai area should be gazette as geoheritage site. Fossil of Sungai Relai are very useful for educate people about paleontology. A museum of paleontology can be proposed to provide an interesting view of the life in Triassic. The museum not only educate people about the values of the fossil but can act as the centre of collaboration in research and conversation of the fossil.

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