GEOHERITAGE AT KM 185 GUA MUSANG-CAMERON HIGHLAND ROAD, LOJING

by

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

FACULTY OF EARTH SCIENCE
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DECLARATION

I declare that this thesis entitled "**GEOHERITAGE AT KM 185 GUA MUSANG-CAMERON HIGHLAND ROAD, LOJING**" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

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

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Name of Supervisor 1: IR Arham Bahar Muchtar
Date :

Signature :
Name of Supervisor 2 :
Date :

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ABSTRACT

Geology is scientific study of the Earth, includes the compositions, structure, physicals properties and history. Geological heritage or geoheritage is an applied science that focus on geosite that has its own uniqueness, specialties and representativeness. The research study is conducted in Lojing-Gua Musang which is located in Kelantan. Five steps to study geoheritage are inventory, characterization, classification, assessment and evaluation. Most of study area are covered by hilly and mountainous landforms. Three lithologic unit are schist, sandstone and quartzite. The geologic structures involved are reverse fault. As for the result, the geological heritage feature found are quartzite, coal and graphite. Based on the result of questionnaires, the geoheritage features in study area are abundance in scientific values and aesthetic values. Research study used qualitative assessment and quantitative assessment parameter as analysis of data that get from survey and questionnaires. Final score of quantitative assessment advocate the feature to appear high in value same in grave concerning to development of geoconservation. Then, geological map of KM185 Jalan Gua Musang- Cameron Highland, Lojing at scale of 1: 25000 was constructed and geoheritage features of study are analyzed.

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ABSTRAK

Geologi adalah kajian saintifik Bumi, termasuk komposisi, struktur, sifat fizikal dan sejarah. Warisan geologi atau geoheritage adalah sains gunaan yang memberi tumpuan kepada geosit yang mempunyai keunikan tersendiri, kepakaran dan perwakilannya. Kajian penyelidikan dijalankan di Lojing-Gua Musang yang terletak di Kelantan. Lima langkah untuk mengkaji geoheritage adalah inventori, pencirian, klasifikasi, penilaian dan penilaian. Kebanyakan kawasan pengajian diliputi oleh bentuk tanah berbukit dan pergunungan. Tiga unit lithologic adalah batu permata, batu pasir dan kuarsazit. Struktur geologi yang terlibat adalah kesalahan terbalik. Hasilnya, ciri warisan geologi yang ditemui adalah quartzite, arang batu dan grafit. Berdasarkan hasil soal selidik, ciri geoheritage di kawasan pengajian banyak terdapat dalam nilai saintifik dan nilai estetika. Kajian kajian menggunakan penilaian kualitatif dan parameter penilaian kuantitatif sebagai analisis data yang diperolehi dari tinjauan dan soal selidik. Nilai akhir penilaian kuantitatif menyokong ciri ini untuk kelihatan bernilai tinggi yang sama di kubur berkenaan dengan pembangunan geoconservation. Kemudian, peta geologi KM185 Jalan Gua Musang-Cameron Highland, Lojing pada skala 1: 25000 telah dibina dan ciri-ciri geografi warisan dianalisis.

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LIST OF ABBREVIATION

E	East
GIS	Geographic Information System
GPS	Global Positioning System
ICOMOS	International Council or Monument and Sites
KFC	Kentucky Fried Chicken
km	kilometre
m	metre
N	North
sq	Square

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CHAPTER 1

INTRODUCTION

1.1 Background of study

Geology is one of the branches of scientific study that focus on compositions, structure and physical properties and history. Geology are included the several parts of our lives. It is divided into two types of study which is physical geology and historical geology. Study about earth materials and rock are examples of physical study including process that happen within the earth and on the earth surface. The study about the evolution of earth and its origin, about the continents, atmosphere and life are examples about historical geology.

Our Earth has a system. The system is the combination of related parts that give interaction to each other in an organized way. There are several subsystems of Earth which is atmosphere, biosphere, lithosphere, mantle and core. All of this subsystem gives different role to our Earth. Examples of their role are atmospheric gas contribute to the weathering of rock, organisms break down rock into soil, distribution of mountain affects the weather platforms.

Geology also study about the plate tectonic that driven by the convection in the mantle and in turn drives mountain-building and associated igneous and metamorphic activity. There was some effect of plate movement which is the formation of landscapes, distribution of Earth biota, effects size, shape and

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distribution of ocean basins, distributions of mineral resources, oceanic circulations patterns and plate tectonic movement also effect the global climate.

Geology also study about rocks and minerals. Rock is a mineral that naturally occur. They are also inorganic substance. Rocks are crystalline solid that have its own physical and chemicals properties. Minerals involve in the formation of rocks are oxygen, silicon, aluminum and others. They are three group of rocks identified in geology which is igneous rock, sedimentary rocks and metamorphic rock. For the igneous rocks, it is formed when the magma crystallized or the volcanic ejecta such as ash accumulate and consolidated. For the sedimentary rock, the rocks formed in three ways which is consolidation rock fragment, precipitation mineral matter from solution, compaction of plants and animals remain. For the metamorphic rock, it is results from the alteration of other rocks which is happened beneath the Earth surface, by heat and pressure.

Geological heritage or geoheritage is an applied science that focus on geosite that has its own uniqueness, specialties and representativeness. This is one of the branches of science of geology. Geoheritage is one of the natural heritages involving the Earth which is including the rocks, minerals, fossils and landscape. Geoheritage also defined as general but descriptive term applied to geologic sites or areas of geologic features with the important of several values such as scientific values, educational values, aesthetic values, recreational values and cultural values by the Geological Society of America.

Malaysia and other countries like China, concern about the conservation of geosites and their development of the geosites especially for the geotourisms purpose. One of the early efforts in Malaysia about geoheritage conservation are start in Third Malaysian Plan (1976-80) to protect geological monuments and the

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landscapes through the provision (Ibrahim, 2004). Started in 1996, systematic effort for promoting geoheritage conservation started with the establishment of Malaysian Geological Heritage. Starting from that effort, many research study on geoheritage sites are conducted for conservation and their development of geoheritage site.

The research study is conducted in Lojing-Gua Musang which is located in Kelantan. Kelantan consists of central zone of sedimentary rock and metasedimentary rocks based on west and east by granites of Main Range and Boundary Range respectively. The study area which is Lojing located at the foot of Main Range (Titiwangsa Range) and adjacent to Cameron Highland. The name "Lojing" was used before 1990 from name of Temiar's family head called Ajing. He is the first pioneer of Sg. Belatop. Then it becomes Lojing.

Area size of Lojing are 1817sq km, which is located in south-western corner of Kelantan State. Sultan Kelantan officially launched Lojing on 5th August 2010 as a subdistrict of Kelantan. Its takes only 22.4% from Gua Musang district with 610-1500m from sea level. The temperature range of Lojing area are between 18˚-25˚C. Three areas in Lojing area are Betis area, Hau area and Sigar area.

The Gua Musang Formation in South-Kelantan – North-Pahang mapped by Yin (1965) to describe Middle Permian to Later Triassic argillite, carbonate and pyroclastic volcanic facies within Gua Musang area. Now, nearly all the Permo-Triassic carbonateargillite –volcanic across northen Central Belt Peninsular Malaysia. The Gua Musang groups include Gua Musang Formation, Aring Formation, Telong Formation and Nilam Marble.

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1.2 Study Area

1.2.1 Location

This geological research titled “General Geology and Geoheritage at KM 185 Gua Musang-Cameron Highland road, Lojing. It is a subdistrict that located in southern part of Kelantan. The size of study area is 5km x 5km. The latitude and longitude of the study area are 101° 41’ 19.827” E, 4° 44’ 59.181”N and 101° 44’ 3.498” E, 4° 42’ 17.52”N.

Based on the base map, the main road in the study area is Kuala Betis-Pos Blau- Lojing road. There is Sg. Betis reserve forest in north-west. While in southeast, there is Sg. Brooke reserve forest. Based on the geologic map, the nearest town is Kg. Pos Blau. The only one town in the study area is Kg. Jeram Gajah which is located in the Sg. Brooke reserve forest. The river in the study area name Sg. Brooke.

The highest elevation in the study area is 520m above sea level which is located in west of study area. The lowest peak of the study area is 200m above the sea level which is located in south-west of the map.

The lithologies of the study area are schist, quartzite and sandstone. The vegetation of study area is palm oil plantation, rubber plantation and reserve forest. The reserve forests cover 50% of the study area. The geomorphologies of study area are dominated by hills and mountains.

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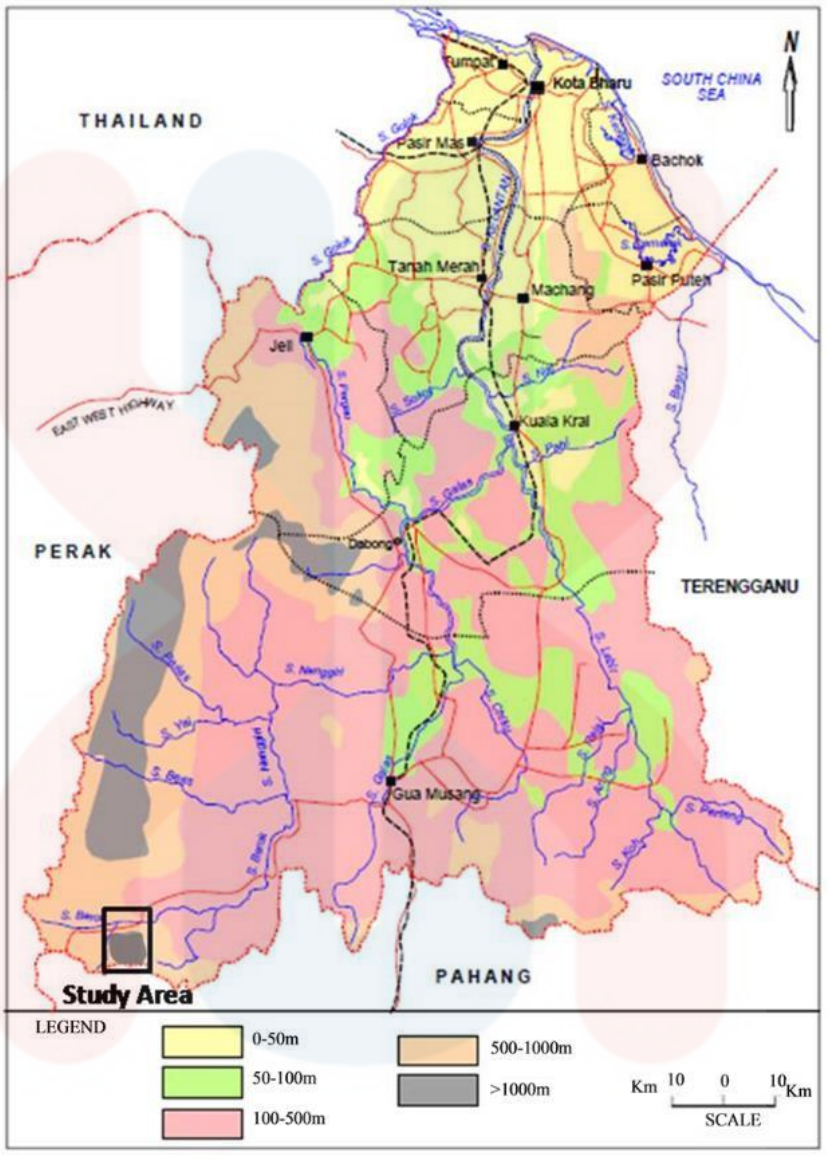

Figure 1.1: Study area (Scientific Research Publishing, 2 June 2014)

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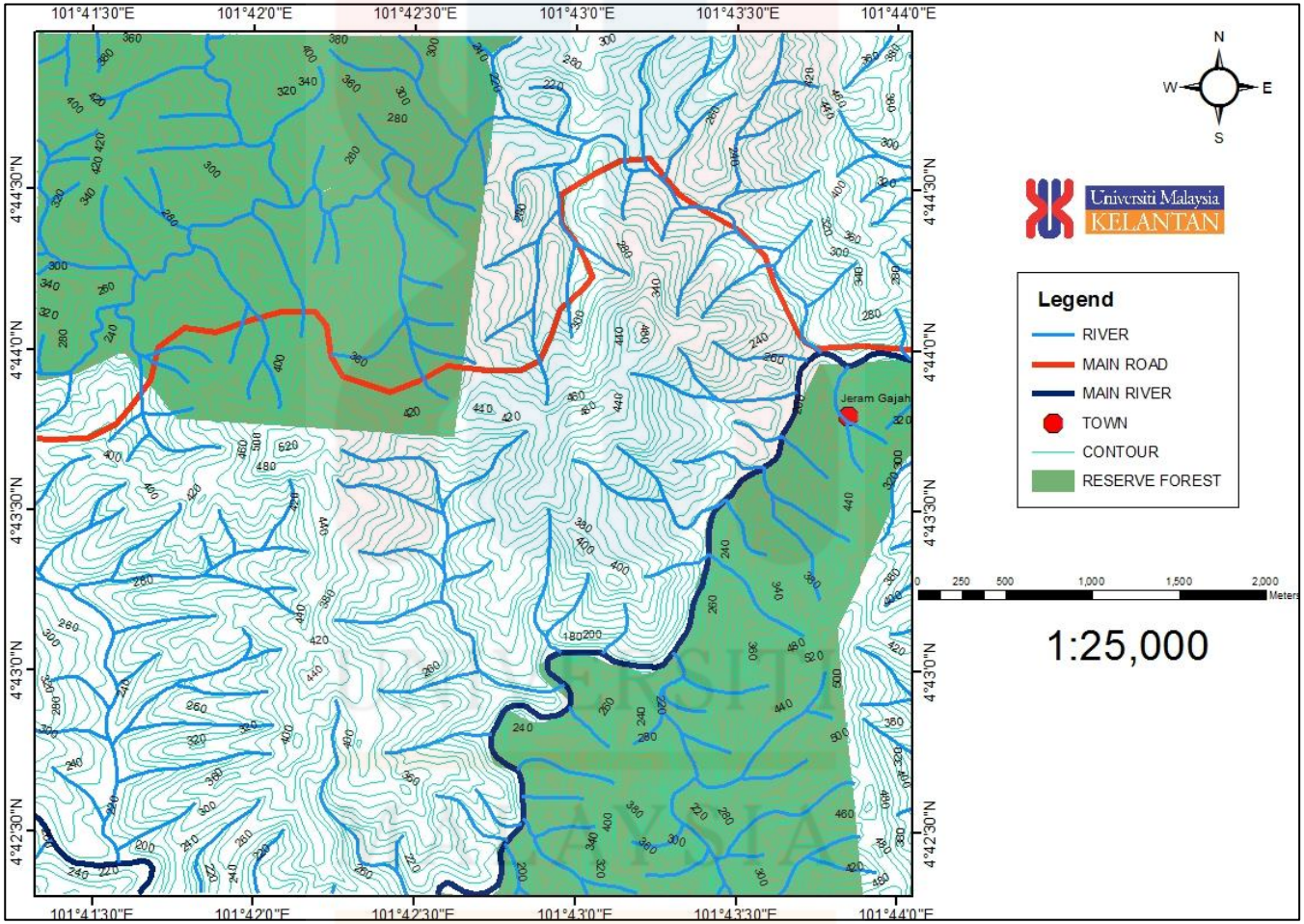


Figure 1.2: Base map of Study area (Source: Produce using ArcGIS 10.2)

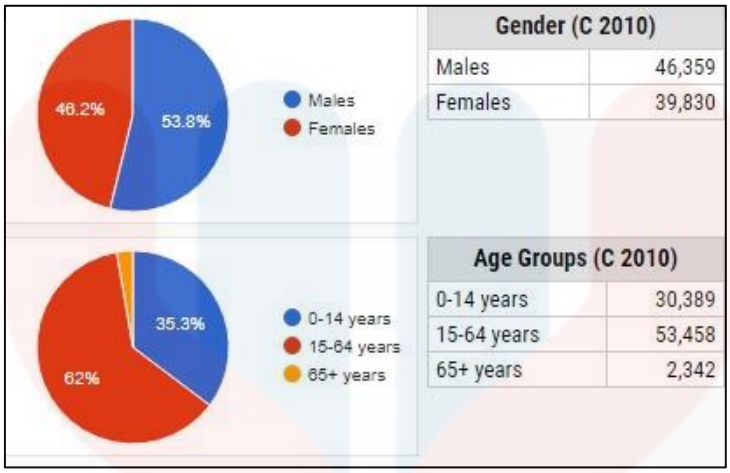
1.2.2 Road connection / accessibility

Gua Musang is the largest district in Kelantan. Lojing is sub district that located at western part of Gua Musang. The Gua Musang – Cameron Highload highway was built to connect the peoples from Kelantan to Pahang. It is also one of the accessibility for people to reach Lojing as shown in Figure 1.3. The road can be access by vehicles such as car, motorcycles, lorry and the others. Along the highway, the palm plantation, reserve forest and logging activities can be seen.

Figure 1.3: The path of Gua Musang- Cameron Highland highway in Lojing (Source: Abdul, 2011)

1.2.3 Demography

Area size of Lojing are 1817sq km, which is located in south-western corner of Kelantan State. Sultan Kelantan officially launched Lojing on 5th August 2010 as a sub-district of Kelantan. Its takes only 22.4% from Gua Musang district with 610-1500m from sea level. The temperature range of Lojing area are between 18˚-25˚C. Of the 5613 people recorded as residents here, 4,113 of them are the indigenous race, Temiars.



Gender (C 2010)	
Males	46,359
Females	39,830

Age Groups (C 2010)	
0-14 years	30,389
15-64 years	53,458
65+ years	2,342

Figure 1.4 Demographic population in Gua Musang, (Sources: Department of Statistics Malaysia)

Predominant population in Gua Musang area are Malay people. 94% population in Kelantan are Malays ethic. Under Malaysian Constitution, all Malays in Gua Musang are muslim. Minority ethnic are Thai centered in coastal town of Tumpat area. Chinese ethnic also have in Gua Musang area. Population in Gua Musang shows in Figure 1.4 are about 86189 peoples.

1.2.4 Land Use

The landuse in Gua Musang district are the shrub area increased by 181.14% from 1990 to 1997. The newly cleared area, rubber and oil palm increased by 91.37%, 45.9% and 44.72%. Other land use in Gua Musang district classed by the mix horticulture, diversified outcrops, urban, paddy increased by 38.82%, 11.95%, 10.30% and 4.70%. The extent undisturbed and disturbed forest reduced by 8.10% and 27.70% during the same period. The shrub shows increasing trend of land use while forest area decreased in area compared with other land use classes. Rapid land use change in northern part of Gua Musang nearly 36% changes associated with

shrub, oil palm and rubber land use conversion (Kamaruzaman Jusoff, 2003) (Figure 1.5)

Figure 1.5 Land use in Lojing which is palm oil plantation

1.2.5 Social Economic

The social economic in Gua Musang district are the peoples in the study area works in palm oil and cocoa farm. The planting helps them from household to earn a living. Then, the practiced subsistence agriculture in the form ordinary farming as sources their income. The peoples in Gua Musang district also involve in agropolitan development based on agriculture in rural area. Then, it created farming areas. The peoples in Gua Musang district also work in the grocery store in town and Lojing area. They start up their own business to earn a living. The peoples also works in the fast food department such as Kentucky Fried Chicken (KFC), Secret Recipe, Pizza Hut and others that have in town of Gua Musang (Fauzi Hussin, 2012)

1.3 Problem Statement

The problems that can be identified for this research are there was no research study has been done about geological heritage of study area. Some research study

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was done in same area but not in the same interest. This research proposal is a new idea about geological heritage of study area.

Then, the geologic map provided is a little bit different from actual geological aspect in study area. For examples, the lithology of study area and the roads are slightly no the same with the mapped in the recent geological. In addition, an existing of geology data on that particular area is not complete. Most of data is not updated.

Besides, there was not enough information that related to this study in that area. Based on preliminary study, geological heritage value of study area was difficult to be decided because there is lack of geological heritage resources.

1.4 Objectives

The objectives of this research are:

1. To produce geological map of KM185 Jalan Gua Musang- Cameron Highland, Lojing at scale of 1: 25000
2. To analyse geological heritage features in the study area.

1.5 Scope of Study

This research will cover the area nearby Pos Blau which is located in Gua Musang district of Kelantan with a dimension of 5km (width) x 5km (height) which cover a part of East-West Highway and Cameron Highland-Gua Musang Road area. The latitude and longitude of the study area are 101° 41' 19.827" E, 4° 44' 59.181"N and 101° 44' 3.498" E, 4° 42' 17.52"N.

The study is focus on general geology of the study area and its geologic features that can be found in the study area. The research is focused more on

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geological heritage potential in the study area. The method that had been used in this study are involved field observation, geological mapping and laboratory test. The maps produced by using ArcMap 10.2 software with the information got from Department of Mineralogy and Geoscience.

1.6 Significant of Study

This research is in Lojing area which is mainly consists of Malay people and Orang Asli. After research is done in this area, the peoples will know about the potential of geological heritage site. The peoples can generate income when they start up a business. Some of the economical values can be seen in this area.

Then, a details and updated map can be published and also can be used by the other researcher as their references while doing the research in same study area. The data can show the significant of the study are to be conserved and become a geoheritage site.

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CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In peninsular Malaysia, Kelantan located in east of Peninsular Malaysia. In Kelantan, the igneous rock are distributed in west and east border of the state which is known as Main Range Granite and Boundary Range Granite. It is also occur in the center of the state. Kelantan also have granitic rocks. For granitic rocks, it can be divided into two main bodies which is granite bodies within Main Range and Boundary Range. For the Main Range of the granite bodies, it is located at the west of Kelantan while granite body for Boundary Range located at northeastern border to Terengganu. The formation of Gua Musang lies within the Central belts of Bentong – Raub Suture.

There are seven formation that built up stratigraphy of Kelantan which were Aring Formation, Taku Schist, Gua Musang Formation, Telong Formation, Gunung Rabung Formation, Koh Formation and Badong Conglomerate. Yin (1965) give the name for Gua Musang Formation based on Gua Musang town which located at South Kelantan. According to Tjia and Syed Sheikh (1996), they showed that the rock within the suture along the East – West Highway can be divided into at least 7 tectonic unit that form an imbricate structure.

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2.2 Regional Geology and Tectonic Setting

2.2.1 Kelantan

Kelantan position in eastern of Peninsular Malaysia. The regional geology of Kelantan consists of central zone of sedimentary rock and metasedimentary rock boarded on the west and east by the granites of the Main Range and Boundary Range respectively. (Geological Society of Malaysia Bulletin 52 June 2006).

Che Abdul Rahman and Kamal Roslan Mohamed (2001) explained that the state of Kelantan consists of various rocks, including igneous, sedimentary and metamorphic rocks. The rocks in Kelantan are distributed in a north – south trend. For igneous rocks in Kelantan, they are distributed in the west and east borders of the state (the Main Range granite and the Boundary Range granite) and also occur in the centre of the state.

The geology of Kelantan can be broadly classified into four rock types, they are: (1) Unconsolidated sediment; (2) Extrusive rocks (volcanic rocks); (3) Sedimentary/ metasedimentary rocks; and (4) Granitic rocks. For granitic rocks in Kelantan, they can be divided into two main bodies: the granite bodies within the Main Range and the Boundary Range. The Main Range granite is generally of a Late Triassic age, between 200 and 250 million years ago (Dept. of Minerals and Geoscience Malaysia, 2003).

Furthermore, 51% of the land of Kelantan State is covered with sedimentary or metasedimentary rocks with age of Ordovician to Cretaceous. (Geology and Minerals Distribution Map of Kelantan, 2000). Granitic rocks are occupy 33% of Kelantan which divided into two main bodies. The main granite body is within Main

Range which located at west Kelantan, while another granite body located within Boundary Range which is located at northeastern border to Terengganu.

2.2.2 Gua Musang

The main area of Gua Musang Formation included Gua Musang, Aring, Gunung Gagau and Kuala Betis. Only Gua Musang will be highlighted through this research as the study area is located there. Yin (1965) is ones who responsible giving the name of Gua Musang Formation which the name encompassing an exposure of rock between age of Middle Permian to the Upper Triassic (Mohd Shafeea Leman, 1993 and 2004). The formation of Gua Musang lies within the Central belts of Bentong – Raub Suture and the formation was reported by Yin (1965) mainly subdivided into calcareous facies, argillaceous facies, arenaceous facies, volcanic facies and metamorphic facies. Based on the Department of Minerals and Geosciences Malaysia (2003), Permian sedimentary rocks occur extensively on the eastern side of Kelantan which they are unconformably overlie the Lower Paleozoic sequences in southwest Kelantan and grouped as Gua Musang Formation. This formation is made up of argillaceous with bedding, pyroclastic rocks and Taku schists.

2.2.3 Bentong-Raub Suture Zone

The Bentong–Raub Suture Zone (Metcalfe, 2000) extends from Tomo, southern Thailand southwards through Bentong and Raub to Melaka (Tjia, 1989). It is an extension of the Nan-Uttaradit suture of Thailand. The Bentong-Raub line was proposed by Hutchison (1973) as the major tectonic boundary between the Western and Central belts of Peninsular Malaysia. Hutchison (1975) named it the

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BentongRaub ophiolite line. Tjia (1989) extended to the suture further south to Bengkalis, Sumatra and named it the Bentong-Bengkalis suture. The suture zone extends northwards to Lancangjian, Changning–Menglian, Yunnan Province Southwest China and Chiangmai, north Thailand (Metcalfe, 2000). The Lancangjian, Changning–Menglian, Chiangmai and Bentong-Raub suture Zones represent the main PalaeoTethys ocean. The Bentong-Raub suture Zone in Peninsular Malaysia is located between the Sibumasu Terrane and the East Malaya (Indochina) Terrane. The Sibumasu terrane was attached to the Cimmerian plate and the East Malaya terrane attached to the Indochina and the South China plate. The Sibumasu and East Malaya blocks were separated by an ocean called Paleo-Tethys. The opening of the PalaeoTethys was initiated when the sliver of North and South China, Indochina and Tarim plate rifted from Gondwanaland during Devonian. The Palaeo-Tethys was diminished when the Sibumasu terrane The Bentong-Raub Suture Zone is well-exposed at roadcuts along the Gua Musang-Cameron Highland road, Karak Highway and Bentong- Raub road.

The suture is an approximately13 km wide zone of deformed rocks consists of schist, phyllite, meta-sedimentary rocks, sandstone, cherts, olistostrome and mélange (Tjia & Almashoor, 1996). Metcalfe (2000) estimated the suture to be approximately 20 km wide. Small serpentinite bodies are also found in the suture zone at Pos Mering, Sungai Cheroh, Durian Tipus and Bukit Rokan (Metcalfe, 2000). But there is little evidence to support the presence of true ophiolites along the Bentong–Raub Suture Zone. The Bentong-Raub Suture Zone is marked by a belt of mélange and olistotrome which comprise blocks or clasts of cherts, sandstone, limestone, conglomerate, interbedded sandstone and mudstone and tuffaceous mudstone embedded in a sheared matrix of mudstone. The sizes of clasts vary from a

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few cm to hundreds of meters. The most important clasts/ blocks are cherts which are considered to represent the oceanic sedimentary rocks.

2.3 Stratigraphy

Geology Peninsular Malaysia is divided into three belt which is East, Central and West Malaya belt. Stratigraphy of Western and Central are well known in Peninsular.

Stratigraphy of Kelantan built up by seven formation which those formations were Aring Formation, Taku Schist, Gua Musang Formation, Telong Formation, Gunung Rabung Formation, Koh Formation and Badong Conglomerate. Exclude of Taku Schist and Aring Formation which formed during Palezoic era, the others are formed during Mesozoic era. By this research, only Gua Musang will be further discuss. Based on the information compiled, the age of Gua Musang Formation is from Middle Permian to the Upper Triassic (Mohd Shafeea Leman, 1993 and 2004). The area of this formation at South Kelantan which extended to North Kelantan and North Pahang. Yin (1965) give the name for Gua Musang Formation based on Gua Musang town which located at South Kelantan. According to previous research, Yin (1965), Burton (1973a), Khoo (1983), Fortain et al. (1986 and 1994), Metcalfe (2000) and Mohd Shafeea Leman (1993) have listed all stratigraphy characteristics for Gua Musang Formation and the most important evidence in Gua Musang is the discoveries of different fossils type and depositional that will explain about the lithology of this formation. Mustaffa Kamal Shuib wrote in book of Geology of Peninsular Malaysia about the thinly – bedded chert overlies massive shale.

Basir Jasin and Che Aziz Ali (1997) proved that there are Permian chert recorded in Pos Blau which contained microfossils of radiolarian. The estimated of

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the chert blocks cannot be properly as the lacking outcrops was existed. According to Basir Jasin (2004), the chert block in Pos Blau exhibits bedded chert with siliceous mudstones and tuffaceous mudstones as it was exposed.

2.4 Structural Geology

According to Tjia and Syed Sheikh (1996), they showed that the rock within the suture along the East – West Highway can be divided into at least 7 tectonic unit that form an imbricate structure. They are high angle fault contact with each other. Mustaffa Kamal (1994) state that zones of sub – verticle to steep NE- dipping reverse to dextral reverse phyllonites and or myllonites, striking NW-SE, separate them. Mustaffa (1994c); Jatmika and Ibrahim Abdullah (2003), state that the detail structural studies of deformation within Bentog raub Suture zone shows that the suture zone had undergone progressive – transpressive deformation.

Mustaffa Kamal Shuib, (1994c) wrote in book of Geology of Peninsular Malaysia, along East – West Highway and Cameron Highland - Gua Musang Road, the thinly bedded chert overlies massive shale and this chert was deformed by bedding – parallel thrusting and duplexing. Along the same road, he also wrote that the bedded chert shows an isoclinals fold that had been refolded by steep N-S reverse dextral fault. Aw (1973) state that follows to the western contact of Boundary Range of Granite in Lebir Velley, the fault zone are the most prominent and the fault an inferred trace 42 km. it represent a part of larger Lebir Fault Zone extending to southward Pahang and covers about 420 km in distance (Lee 1990).

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2.5 Historical Geology

Nuraiteng Tee Abdullah (2009) wrote that the upper and lower boundaries of the formation are not exposed in the type of area as she had written the sedimentology information in the book of Geology of Peninsular Malaysia. According to Aw (1974), Abdul Rahim et. Al (1994), to the west of Gua Musang town in Kuala Betis are rocks familiar to and identified as Gua Musang Formation that overlie conglomerate sandstone sequence conformably. Nuraiteng Tee Abdullah (2009) then explained about east part of Gua Musang Formation which sediment of Nilam Marble and Telong Formation are similar to the rock of Gua Musang Formation.

Foo (1983) then suggest that the Telong Formation is synonymous with Gua Musang Formation as the age of depositional environment of Nilam Marble are comparable to carbonate of Gua Musang Formation. According to Yin (1965), she discovered the calcareous rock to be the most intensive facies of Gua Musang Formation with widespread development in the Middle Permian and Triassic time.

2.5.1 Calcareous Facies

These facies consists predominantly of limestone with subordinate calcareous shale and sandstones. According to Yin (1965), it is the best developed in the neighbourhood and south of Gua Musang Village with further extensive tracts to the northwest and northeast covering surface area approximately 100 square miles. Most of the limestone occur in the form of hills and most of this limestone hills on low ground are further limestone deposits.

Yin (1965) said that to the south of Gua Musang, the limestone hill name Gua Panjang is an excellent examples of the lateral lithofacies change from calcareous to

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non-calcareous deposits. The beds have a northerly strike direction. At the northern end, white to light grey limestones are exposed and toward the south these fairly pure limestones are partially rplaced by lenses of black limestones and finally by bed of black limestones containing small lense of calcareous shale. (Hutchison, 2009)

2.5.2 Argillaceous facies

Based on Yin (1965) research, this argillaceous facies are often found intimately associated with the calcareous facies, which best developed in the region west of Sungai Galas but also present further to the east and northeast of it. The dominant rock type is shale, but silty shale and sandstones also fairly common. Mudstone and cherts also occur but are not in common. The shale usually grey in color consisting of fine quartz set in the laminated carbonaceous-sericite matrix.

Besides, the black shale is generally more carbonaceous while pale-grey type are more siliceous. Some of the shale composed mainly of well – aligned sericite. Occasionally, fine fragments of feldspar, quartzite and volcanic rock are found in shales. In this present day, the weathering had altered much of shales into soft brownish to yellow-brown clays rocks, but where fresh exposures are found the shales are often seen to possess a high degree of fissilty. Current bedding and fine color banding are not uncommon especially in the siltier shales. Thinly laminated tuffaceous varieties are frequently found interbedded with them.

2.5.3 Arenaceous Facies

Yin (1965) reported that, occasionally there are found grits, impure quartzite, subgreywackes and greywackes that interbedded and occurring as lenses in the shale. They are constitute the arenaceous facies which is sporadic in outcrop and limited in

extend. These facies is more closely associated with the argillaceous facies with the calcareous. Quartzites are the most abundant composing predominantly of quartz with the small amount of argillaceous matter, sericite, chlorite, feldspar and iron oxides while tourmaline, carbon and calcite are occasionally noted.

Besides, according to Yin (1965), the greywackes are generally well-bedded but constituents in the rocks which are ill – sorted. While the composition of subgreywackes is similar to greywackes but in some instances, difficulty is experience in differentiating the tuffaceous from immature sediments. Furthermore, grits occur but not in common. They are fine to medium grain, consisting angular to sub-angular quartz and subordinate feldspar set in an argillaceous.

Based on Department of Minerals and Geosciences (2003), Gua Musang is made up of argillaceous with calcareous bedding, pyroclastic rocks and Taku schisht. Besides, Mustaffa Kamal Shuib, (1994c) wrote in book of Geology of Peninsular Malaysia, along East – West Highway and Cameron – Gua Musang Road, the thinly bedded chert overlies massive shale where it located in Pos Blau area. So most of the rocks in study area are from sedimentary types of rocks. However, Yin (1965) reported that facies existed in Gua Musang mainly subdivided into calcareous facies, argillaceous facies, arenaceous facies, volcanic facies and metamorphic facies which means there are also igneous and metamorphic rock also existed in Gua Musang. All these rocks existed in the study area will make the petrography study as important to update the lithology in the study area.

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2.6 Geoheritage

The geological heritage conservation is to protect the geological resources for its heritage, and ecological values. Geological conservation focus on protect geologic features in order to maintain natural ecological process important for nature conservation. Definition of geoheritage by Thomas Hose (2005). He stated that 'landforms and geophenomena often have older mythological, religious and more recent aesthetic significance. These scientific and cultural elements when combined create a major global geoheritage.

The scientific value are refers to important of geological records and history of the Earth such as fossil, rocks types and unconformity. For the aesthetic value, it is refers to breathtaking and unusual landscapes examples mountain, valleys, lakes, rivers, waterfall and beaches. For the recreational value, the landscape are suitable for various nature recreation examples mountain hiking, rock climbing, white-water rifting and swimming.

The conservation terms that comes from Badan Warisan and International Council or Monument and Sites (ICOMOS) as mention by Ibrahim (2007), in accord with the Burra Charter. There are four major physical activities stressed by Ibrahim for fundamental conservation process are preservation, restoration, reconstruction and adaptation.

For the preservation, it is more stress about the existing of heritage maintenance and lower the deterioration. For the restoration, the process involve are return back existing heritage to the previous state or used back the existing component without introduce new material. For reconstruction, it is the process which is recreate again the heritage that not survive or conservation area as can to be

conserve to the earlier state that have been known. For the adaptation, it is stressed about mark the modification to suitable place with the great used.

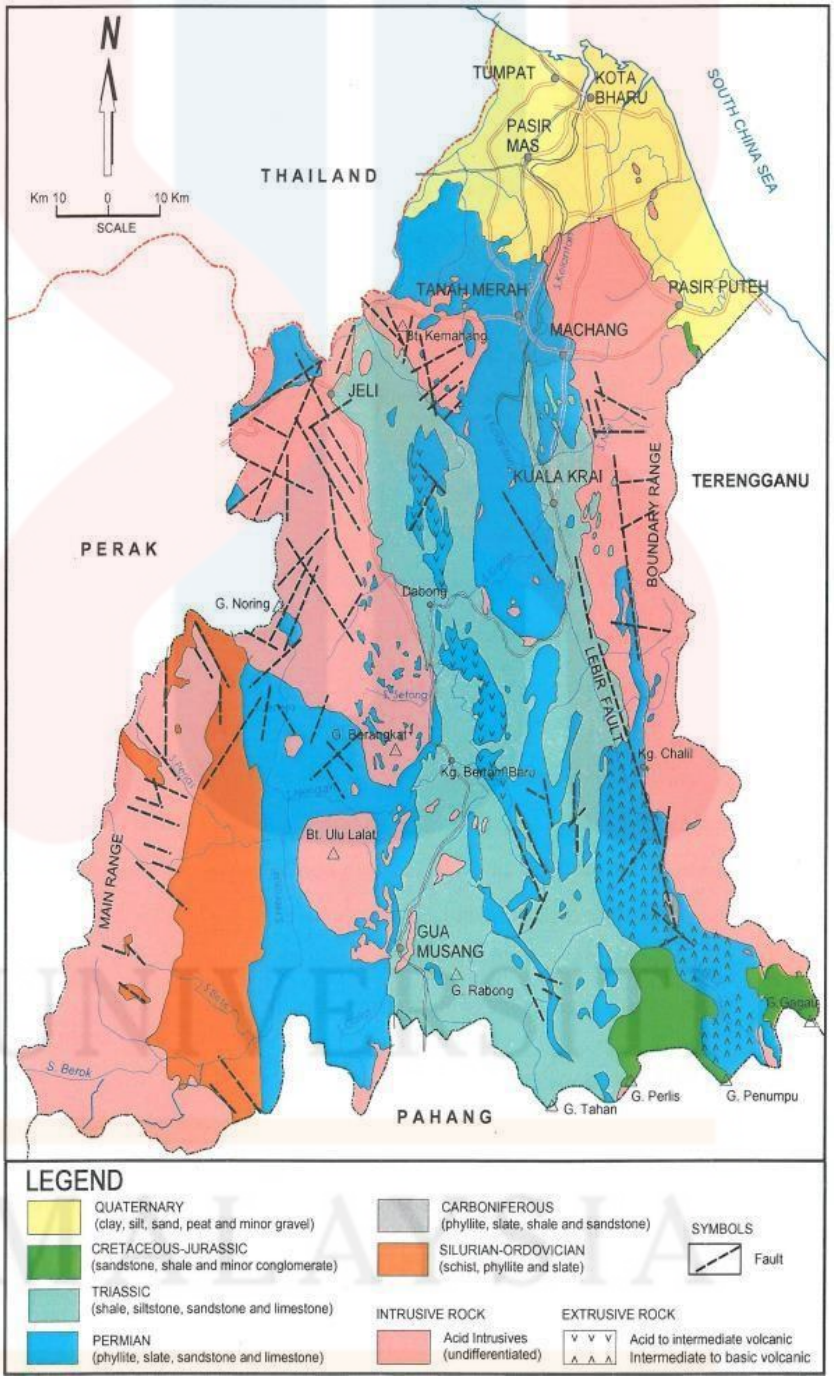

Figure 2.1: General geology of Kelantan (after Dept. of Minerals and Geoscience Malaysia, 2003).

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

In order to complete the report of General Geology and Geoheritage at Km 185, Gua Musang- Cameron Highland Road, Lojing, several materials and methods was used. The materials used are ArcGis version 10.2, tip point hammer, measuring tape, sample beg, digital camera, field notebook, stationary, base map, topographic map, GPS, compass, hand lense, 1 mol HCL and Microsoft excel. The method was shown in the workflow below (Figure 3.1).

3.2 Materials and Equipments

Materials and software that have been used in geological mapping are:

Table 3.1: Materials and software and its uses

No.	Materials and Software	Uses
1	Topographic map	It is used as references about the study area.
2	Base map	It is important when we are field. We can use map to locate our position. Then, we can know the barrier incoming because we can refer on the map.

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3	Global Positioning System (GPS)	Used to determine the location of the study area and record track. Then to mark the location.
4	Compass	Used to measure strike and dip, to shoot outcrop, know the angle, to know the dip direction, to know our location in field in traditional way instead of GPS.
5	Chisel hammer	It is used to obtain fresh outcrop. Used as scale in field to know the real size of outcrop.
6	Hand lens	Used to observe samples that cannot be seen with naked eyes.
7	1 mol HCL	Used to test the presence of carbonate materials in rock. If it freezing, there is carbonate materials in that sample.
8	Pencil and sketching paper	It is used to sketch outcrop, mark outcrop in map, sketch geomorphology.
9	ArcGIS 10.2 software	Used to generate map and find contour with the states of elevation. To know the lithology boundary. To know the highest and lowest elevation before go to site.
10	Microsoft excel	Used to tabulate data such as data of strike and dip taken in field. Data of joint analysis that important to make rose diagram and know the force direction.

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3.3 Methodology

3.3.1 Preliminary Studies

Preliminary study is done to get the better understanding on the geoheritage potential and the study area. The preliminary study was done by reading the numerous reports in literature research on previous work: Bulletin of the Geology Society Malaysia and manuscript from Minerals and Geoscience Department Malaysia. The topographic map and the base map was generate by using ArcGis 10.2.

3.3.2 Field Studies

The geological mapping is used in this research. There are many ways in the geological mapping method. Mapping is based on GPS reading. At the field, the sample of an outcrop was collected. All of the geology structure, features geology, lithology were carefully described in the field. All the structures were documented using digital camera. Strike and dip is measured to determine the direction of force and further analysis. The structure element was measured to get more information data about the study area. The study area are covered 5kmx5km and the scale is 1 : 25000. By the end of this research, the new map of the study are with detail information regarding geology will be produced.

3.3.3 Geological mapping

Field study for geological mapping included traversing, sampling and mapping. Traversing is important to get know about the study area before mapping. While traversing, the morphology and geologic structure can be observed. For

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sampling, the outcrop was broken down using hammer and the sample taken to the laboratory test. Geoheritage mapping is quite same as geological mapping. The differentiation is that to identify the geological features such as resources and landforms in respect of geheritage values that are available. Besides that, there are five step to study geoheritage which are inventory, characterization, classification, assessment and evaluation (Komoo,2003).

The first step is inventory. This process involved the process of listing the potential geosite, reviewing previous literature, then conducting the geologic mapping in the study area. During the inventory step, the rarity, uniqueness and existence of geologic features need to be considered (Brock,2011). Next, characterization was executed which is comprises of identifying the geologic feature of study area. This aided by referencing the previous study done as well as reconnaissance of field work site.

Next step is classification which is covers three aspects such as geodiversity, class and scale. The study area then classified based on the geoheritage potential obtain in study area. The scale was give based on the size and region of study area. The, assessment is the process of valuing the geoheritage feature in the study area. Qualitative and quantitative assessment used in this research study.

3.3.4 Laboratory work

The rocks collected through sampling were be further identified by doing thin sections of the rocks. Thin section is a very thin slide of rocks mounted onto the glass slide. The process involved the preparation of rock samples taken in field into the range of thickness that can be identify under the polarizing microscope. Under the polarizing microscope, the thin section reveals structure, texture and mineralogical

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composition of a rock. This is to identify more precisely the minerals type and names of the rocks obtained in the field.

3.3.5 Data Processing

Data processing is included in the methodology. During the field investigation, collecting the samples of rocks for later investigations of features is compulsory. In the field, the samples of each rocks specimen need to be mark clearly with a sequential number by using marker pen and also to record with coordinates the rock types and the location in the note book. All of the data will be process and will be tabulate to be easy understand it.

3.3.6 Data Analysis and Interpretations

Data analysis and interpretation are done after all the data collecting and sampling are collected from the study area. GIS software also used to generate map. The data obtain from the study of lithology, geology structures and all the aspects of geology will be interpreted by using Geographic Information System (GIS) software. Geographic Information System (GIS) refer to systems used for storing, retrieving, analyzing and displaying spatial data. (Joao, 1998). The GIS software for database management provides user with the means to define the contents and modify the content of the database (Star and Estes,1990). Making maps with GIS is much more flexible. In addition, the entire place that have geoheritage potential will be shown in GIS software. The areas that have the geoheritage potential will be marked by using GPS.

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CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter, all of the geologic feature of study area such as geomorphology, lithostratigraphy, structural geology and historical geology been discussed. All of the data were taken from the field observations and geological mapping. The information taken from the literature review of journal and articles are proven through geological mapping. Some of the differences of geologic feature that had been observed in the field need to be identified in order to update the geological map of study area. The rock sampling, locality information, field observation and analysis of rock structure were some of the activities during the geological mapping.

The study area was covered 50% by the reserve forest. Therefore, some places cannot be access easily by any vehicles. However, there was main road which is the Gua Musang- Cameron Highland highway and some places and can be access easily by any vehicles.

4.1.1 Accessibility

Gua Musang- Cameron Highland road (Figure 4.1) is the highway that connected Kelantan and Pahang. Lojing are the subdistrict involved. The highway can be access by car, motorcycle, lorry, Hilux, and others. Along the highway, it was

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clearly seen the palm oil plantation (Figure 4.2), the logging activities and unpaved road that connected to the palm plantation (Figure 4.3). There were also village road that connected the village to the main road such as Pos Blau, Pos Brooke and Pos Mering.

In the study area, there was reserve forest of Sg. Betis in north-west. While in south-east, there is reserve forest of Sg. Brooke. So, it can be access through the unpaved road. The unpaved road (Figure 4.3) usually used by the workers or villagers. While in reserve forest, there are some places that have villagers. Therefore, they do not give permission easily to go through their area due to some issue. Certain areas that are thick forest were not easily access and cannot be reaching.

Based on the geologic map, the nearest town is Kg. Pos Blau and the only one town in the study area Kg. Jeram Gajah in the reserve forest of Sg. Brooke. The area has high elevation of contour which is the highest elevation in the study area 520m above sea level which is located in west of study area. The lowest peak of the study area is 200m above the sea level which is located in south-west of the map.

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Figure 4.1: The main road in study area

Figure 4.2: The palm oil plantation seen from the main road.

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Figure 4.3: The unpaved road used by the worker in palm oil plantation

4.1.2 Settlement

There was only one village in the study area which is Kg Jeram Gajah. Therefore, only a few settlement found which were worker accommodation (Figure 4.4) that came from other countries such as Bangladesh, Vietnam, Indonesia and others. There was also office found in study area. As the study area located 35km from the town, there was only an indigenous people's village of Pos Blau.

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Figure 4.4: The office of palm oil plantation's manager and worker.

4.1.3 Forestry (or vegetation)

Forestry is about the environmental component and process such as biological process, chemical process and chemical process that can affect the environment. There are two types of forestry which natural forest and human made forest. The natural forest are the untouched land that form billion years ago which are well preserved and conserved. For the human made forestry, it is consists of recreate soil as agricultural purpose land or for exploitations of natural resource such as logging activities.

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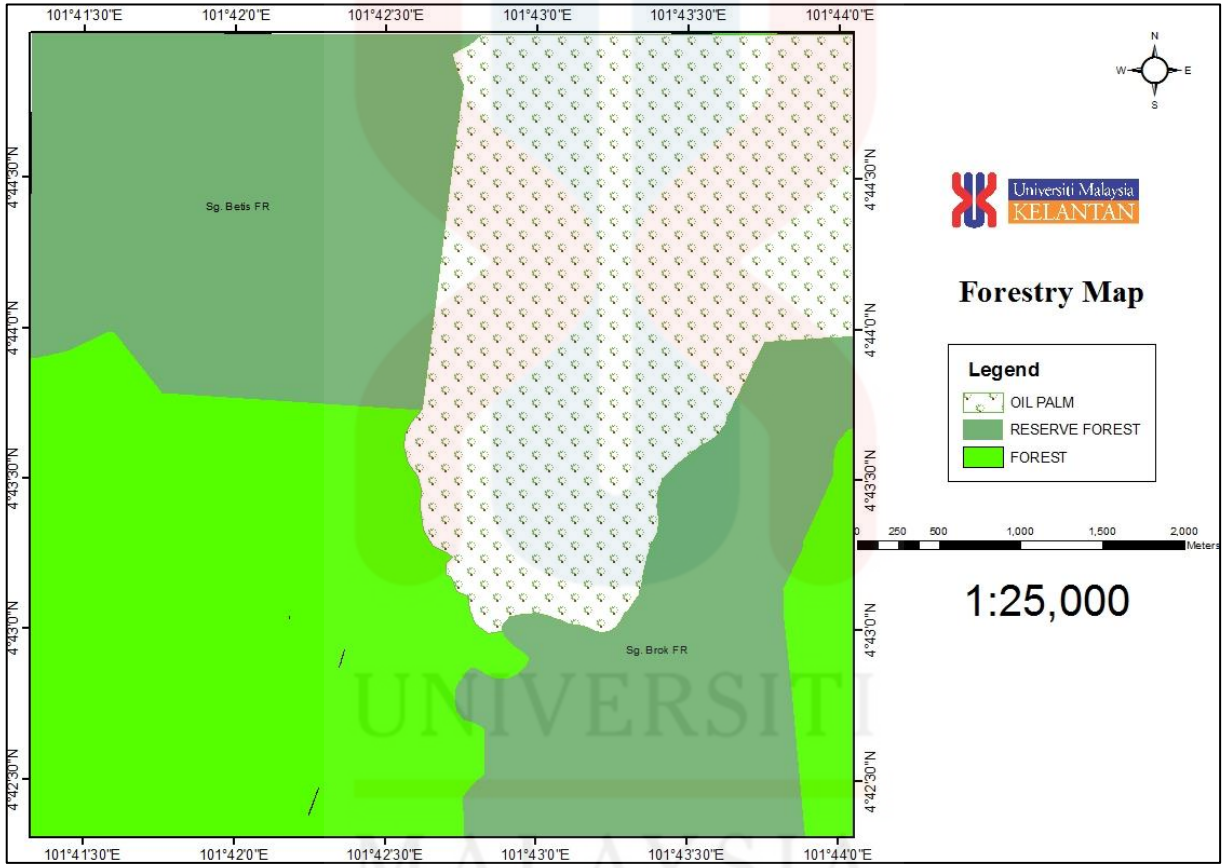

Figure 4.5: Map of forestry

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Almost 50% of study area was covered by the reserve forest. The rest are palm oil plantation, and some logging activities. Figure 4.6 shows oil palm plantation in the study area. Almost 25% of study area are covered by the oil palm plantations. Figure 4.7 shows the unpaved road used in the reserve forest. Some area in the reserve forest can be accessed by using the unpaved road. Figure 4.8 shows the area of reserve forest. It is in the logging area. It can be access using village road. Figure 4.9 shows the area of logging activities.

Figure 4.6: The oil plantations in the study area.

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Figure 4.7: The unpaved road used in the reserve forest.

Figure 4.8: The area of reserve forest that can be access

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Figure 4.9: The area of logging activities.

4.1.4 Traverses and observation

Traverse is important to cover the study area and collect all the data. At every places, the data taken such as coordinate, elevation, date, weather, time, weathering process happened and geological structure in study area. Figure 4.10 shows traverse map.

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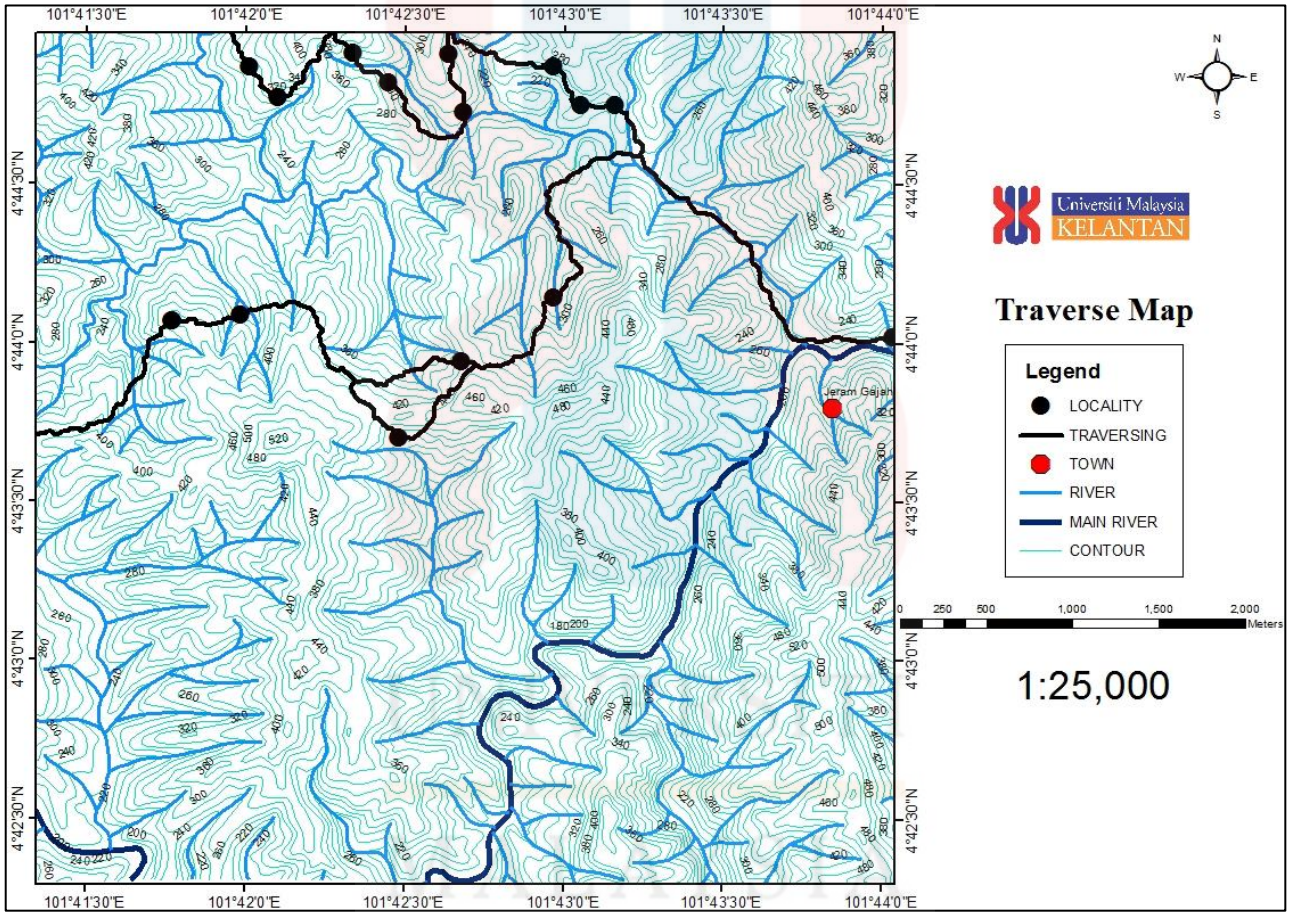

Figure 4.10: The traverse map

i. Location 1

Coordinate	04° 44’ 09.1”N 101° 42’ 57.4” E
Elevation	301m
Description	It was on 18 July 2018. It was hot sunny day. The outcrop is massive schist. The colour was dark grey. The grains size was coarse grain. This outcrop has no bedding.

ii. Location 2

Coordinate	04° 44’ 04.0” N, 101° 41’ 48.1” E
Elevation	326m
Description	The outcrop was schist. The schist was altered to graphite. It has high organic content.

iii. Location 3

Coordinate	04° 43’57.2” N 101° 42’36.5” E
Elevation	356 m
Description	Salt intrusion observed

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iv. Location 4

Coordinate	04° 44’ 04.1” N 101° 41’ 46.2” E
Elevation	333 m
Description	The outcrop is schist. The colour is dark grey. There are some chemical weathering observed. The attitudes of foliation are 60° dip direction and dipping 31°. The morphology observed is road cut and reserve forest.

v. Location 5

Coordinate	04° 44’04.5” N 101° 41’ 54.2” E
Elevation	330 m
Description	The outcrop is sandstone. The colour is brownish. It is highly weathered sandstone due to chemical weathering. The location is exposed. Quartz ridge are identified.

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vi. Location 6

Coordinate	04° 44’ 05.2” N 101° 42’ 01.1” E
Elevation	327 m
Description	The outcrop has moderate biological weathering. The attitude of bedding are 295° direction and dipping of 26° Structural geology observed are gash fracture.

vii. Location 7

Coordinate	04° 44’ 07.4” N 101° 42’ 40.8” E
Elevation	354 m
Description	Time taken is 14:34. The attitudes of bedding are 163° strike and dipping of 50°. The outcrop is schist.

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Figure 4.11: Graphite schist outcrop

viii. Location 8

Coordinate	04° 42’ 09.1” N 101° 42’ 57.4” E
Elevation	301 m
Description	The outcrop is massive schist. The colour is dark grey. The outcrop are highly compact Structural geology observe are quartz vein It have foliation with attitude (228°, 72), (200°, 30°), (200°, 40°) Stylolite observed Structure is schistost Texture are crystalloblastic

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ix. Location 9

Coordinate	04° 44’ 01.3” N 101° 44’ 01.6” E
Elevation	192 m
Description	The outcrop is coal. Chemical weathering observed.

x. Location 10

Coordinate	04° 44’ 56.8” N 101° 42’ 57.4” E
Elevation	310 m
Description	The weather was good Taken 24/7/2018 at 11:00 The kink fold observed The attitudes of bedding are 48° dip direction and dipping of 55°.

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Figure 4.12: Highly weathered mica schist

xi. Location 11

Coordinate	04° 44’ 53.9” N 101° 42’ 26.9” E
Elevation	303 m
Description	Taken at 11:27 The outcrop are quartz vein The attitudes of bedding are 83° dip direction and dipping of 40°.

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Figure 4.13: The quartz vein

xii. Location 12

Coordinate	04° 44’ 45.6” N 101° 42’ 38.1” E
Elevation	254 m
Description	Hot sunny day Taken at 14:12 The outcrop are quartzite The attitudes of bedding are 60° dip direction and dipping of 30°.

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xiii. Location 13

Coordinate	04° 44’ 48.5” N 101° 42’ 37.7” E
Elevation	239 m
Description	Taken at 14:23 The attitudes of bedding are 97° dip direction and dipping of 20°.

Figure 4.14: Bedding plane on schist outcrop

4.2 Geomorphology

Geomorphology is the study of landforms and the process of formation at the surface of the earth. Landforms are formed from the erosion or deposition as the rocks worn away by the earth surface process then transported and deposited. Most

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geomorphic process operates at slow rate but large events such as landslide or flood can cause rapid change to the environment. The geomorphology of an area can be analysed through topography, weathering and drainage patterns. All of the three items are related to each other in various process and evidence.

4.2.1 Geomorphologic classification

Topography is one of the study about the land surface on earth. The origin of topography refers to “topo” for place and “graphia” for writing. It is really related to geology and surveying which concerned measuring the land surface. Slope and elevation are the important factor in topographic map. In other words, topography are specific arrangements of landform in study area. Examples, the topography refers to mountains, valley, hilly or rivers on the surface. The placement of contour line and other element such as main road, main stream and town can determined the type of landforms. In figure 4.13 shows different topography in an area. I can be seen clearly the differences places with different topographic unit.

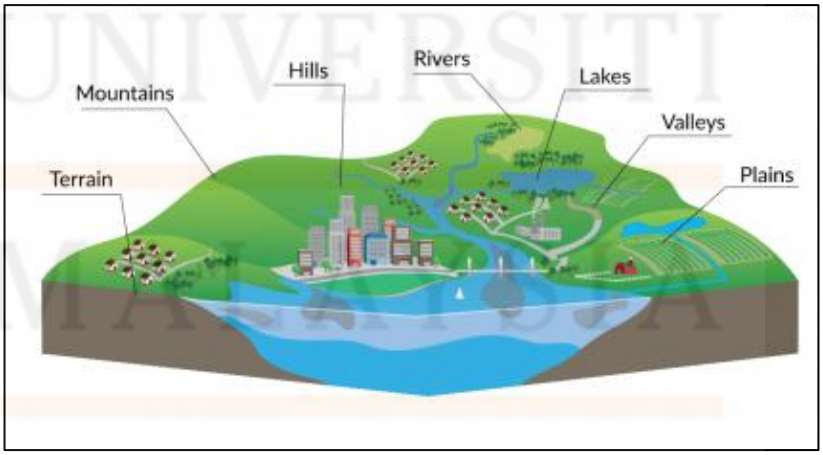

Figure 4.15: Different topography in an area. (Source : Google)

Table 4.**1**: Topographic unit based on mean elevations.

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

Source : (Fatt,2009)

Five types of topographic unit can be distinguish based on its mean elevation (Table 4.1) This is important to classify the difference of landform in the study area. Low lying areas which mean elevation <15 represent alluvial and marine sediments of variable thickness. The hilly to mountainous area which mean elevation >76 represents area of inland hilly to mountainous terrain and coast. Figure 4.16 shows the topography in study area. Mostly in study area are highly dominated by hilly and mountainous.

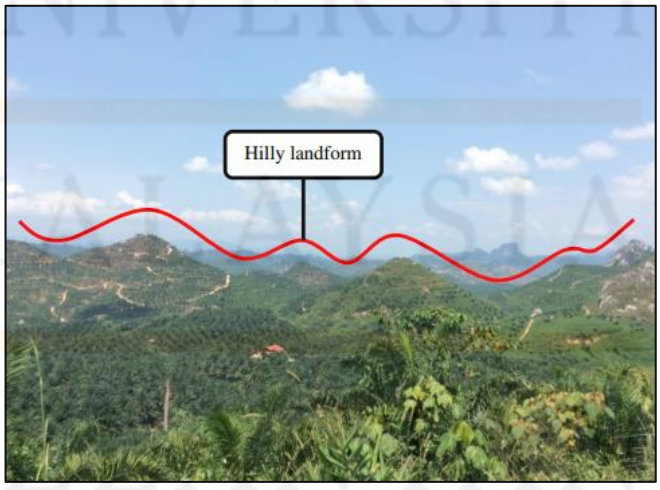

Figure 4.16 : The topography in study area.

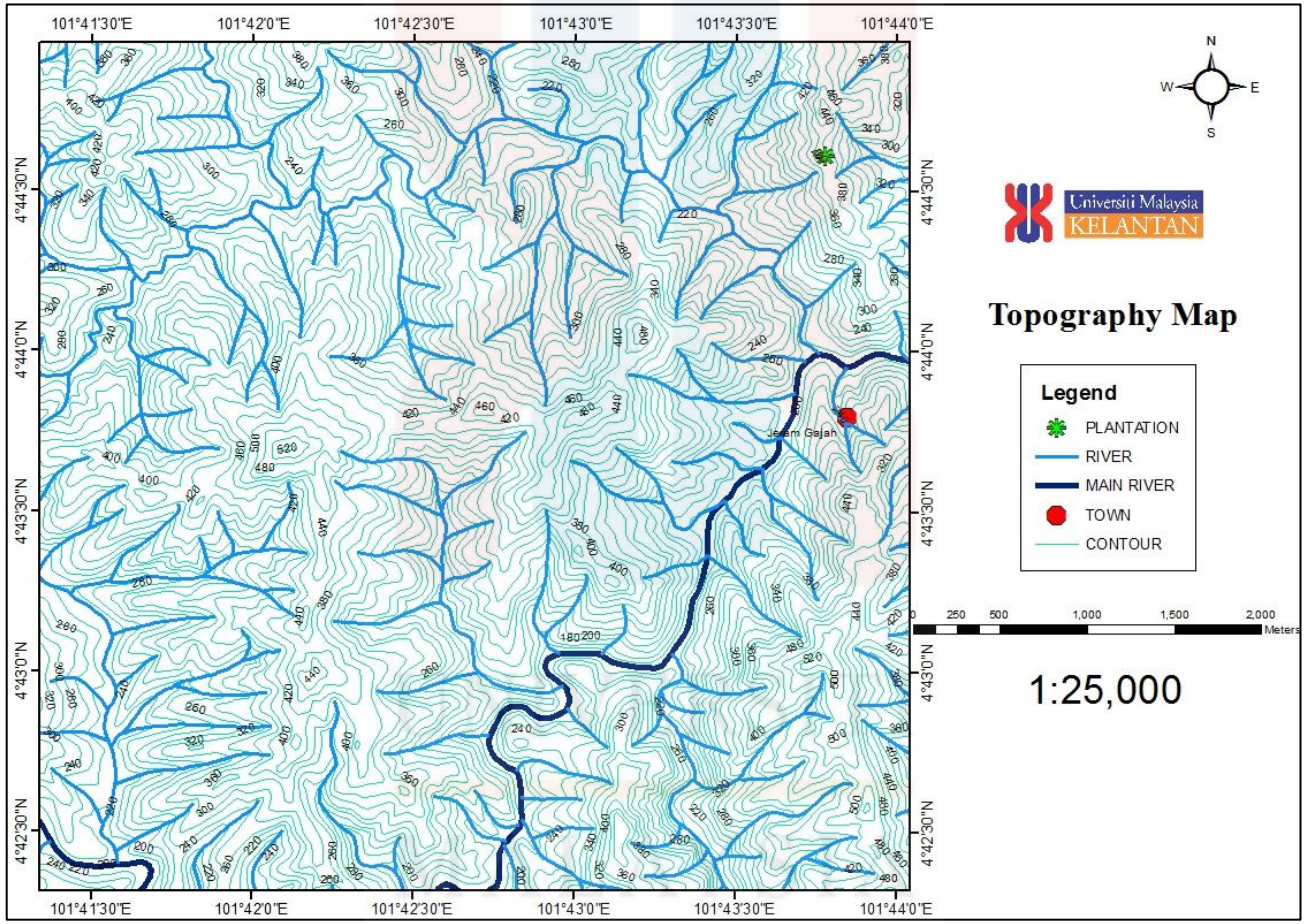

Figure 4.17: Topography Map

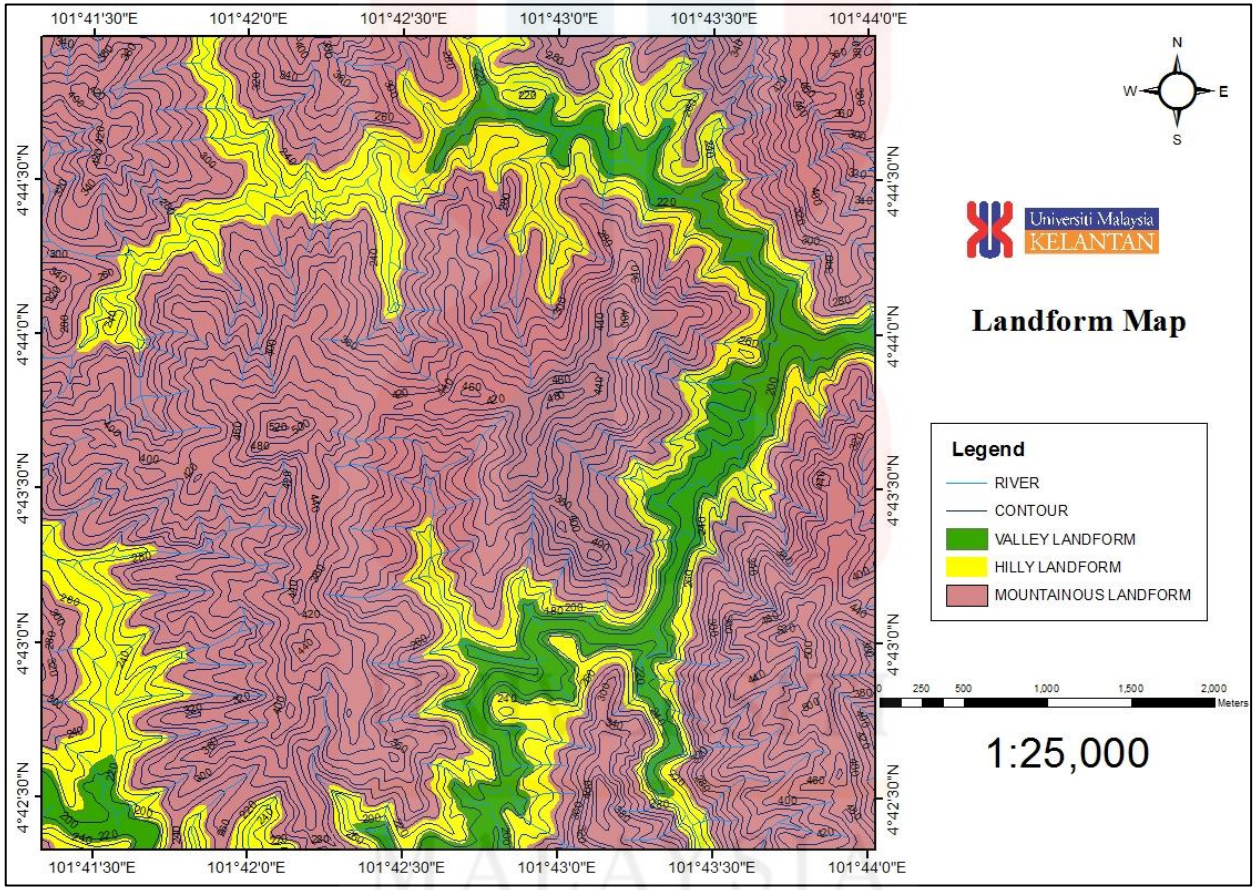

Figure 4.18: Landform Map

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4.2.2 Weathering

Weathering involves physical and chemicals process that alter the earth surface. Thus, interactions of the earth materials with the hydrosphere, biosphere and atmosphere caused the rocks and minerals breakdown physically and change chemically. The process of weathering was continuously at variables rate on all surfaces of rocks and minerals.

Form the other point of view; weathering was important group of process that interacts among the earth's systems. It was an important part in rock cycle. The parent rock exposed to the weathering, the rocks and minerals break down into small pieces or dissolve. In addition, weathering was responsible for the origin of soils.

There were three types of weathering which is physical or mechanical weathering, chemical weathering and biological weathering. For physical weathering, it is physical changes which reduce size of rock without changing the chemical composition. Examples were exfoliation, frost wedging and abrasion. For chemical weathering, the rocks were alters, decomposes, dissolves or weaken through chemical process forming residual materials. Examples of chemical weathering were carbonation, hydration, hydrolysis, oxidation and solution. For biological weathering, it was the disintegration or decay of rocks and minerals caused by chemicals or physical agents of organisms. The grade weathering from fresh rock, slightly weathered, moderately weathered, highly weathered, and completely weathered to residual soil (NZ Geotechnical Society Inc, 2005).

In study area, weathering involves was biological weathering. Since most of the outcrops beside the main road are well exposed, the living organisms activity give high affect to rock body. In other words, biological weathering also about the simple breaking of particle, by the consumption of soil particle by animals. Biotic

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life such as plants, animals and microorganism increase the acidity of causing the rocks to contain organic materials. The reaction between biotic and abiotic components is proved by the formation of coal that is organic origins. Figure 4.19 shows biological weathering in study area.

Figure 4.19: Biological weathering

4.2.3 Drainage pattern

The drainage pattern are the pattern that formed by the stream erosion as time passed. The pattern follows the rock characteristics and geologic structures of study area. There are several types of drainage pattern in Appendices. Dendritic drainage pattern (Figure 4.20) formed in area which is the rock beneath the stream does not have any particular geological structure and can be eroded equally and easily in different directions. Examples are volcanic rock and sedimentary rock that are not folding.

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Figure 4.20: Dendritic drainage pattern

For rectangular drainage pattern (Figure 4.21), it is formed in areas that have a little topography and have some structural geology formed such as bedding, fractures or fault. All of this structural geology formed the rectangular network.

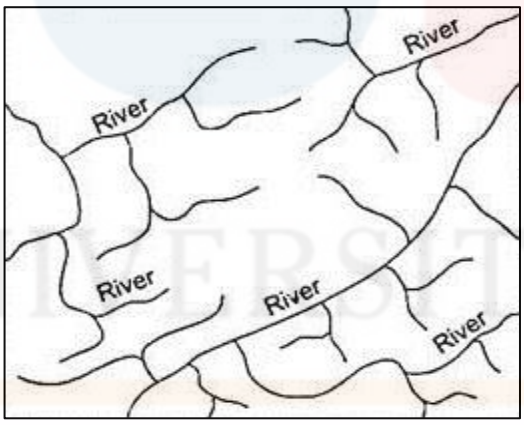

Figure 4.21: Rectangular drainage pattern

For parallel drainage system, the formation involves the steep slope with some relief. The steep slope caused the streams swift and straight and all flow in same directions. Parallel drainage pattern also form in regions of parallel and elongate landforms.

For trellis drainage pattern, it formed when sedimentary rocks had been folded and eroded depends on its strength.

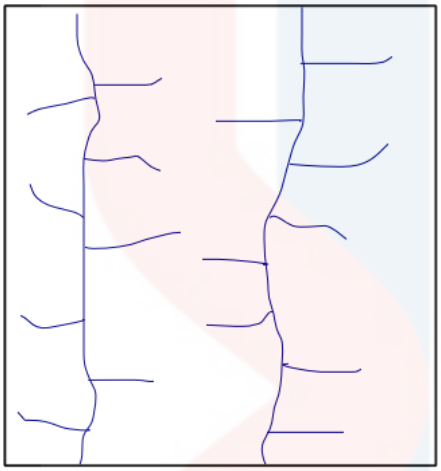

Figure 4.22: Trellis drainage Pattern

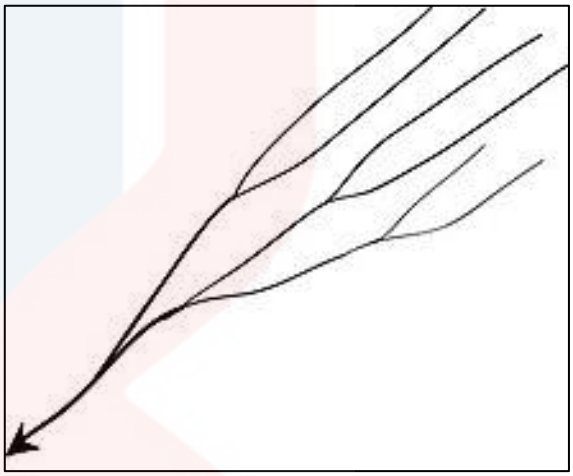

Figure 4.23: Parallel drainage Pattern

For angular drainage pattern, it is formed when the joints and faults of bedrock intersect at more acute angles than rectangular drainage pattern. Both are less than 90 degrees.

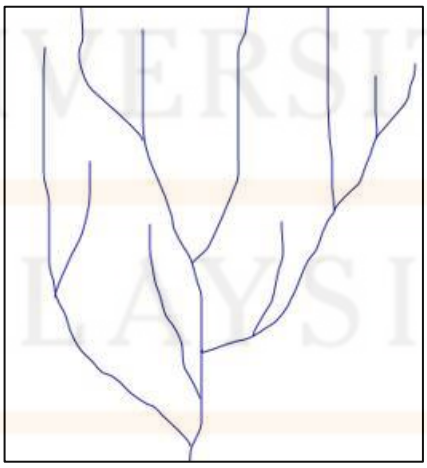

Figure 4. 24: Angular drainage pattern

There are main stream in study are which is Sg. Brooke as shown in Figure 4.25. Small stream and canal can be found in study area become the source of flowing water.

Figure 4.25 : Sg. Brooke (main river)

Figure 4.26 show two drainage pattern in the study area which is rectangular drainage pattern and dendritic drainage pattern. The mountainous and hilly landform in study area amplifies the stream flow direction, and create these types of drainage pattern. The first drainage pattern is dendritic. The second drainage pattern is rectangular. Hard rocky mountain in study area caused the shape of the stream become rectangular. These drainage flows in zone of watershed as in Figure 4.27. Study area has four watershed zone.

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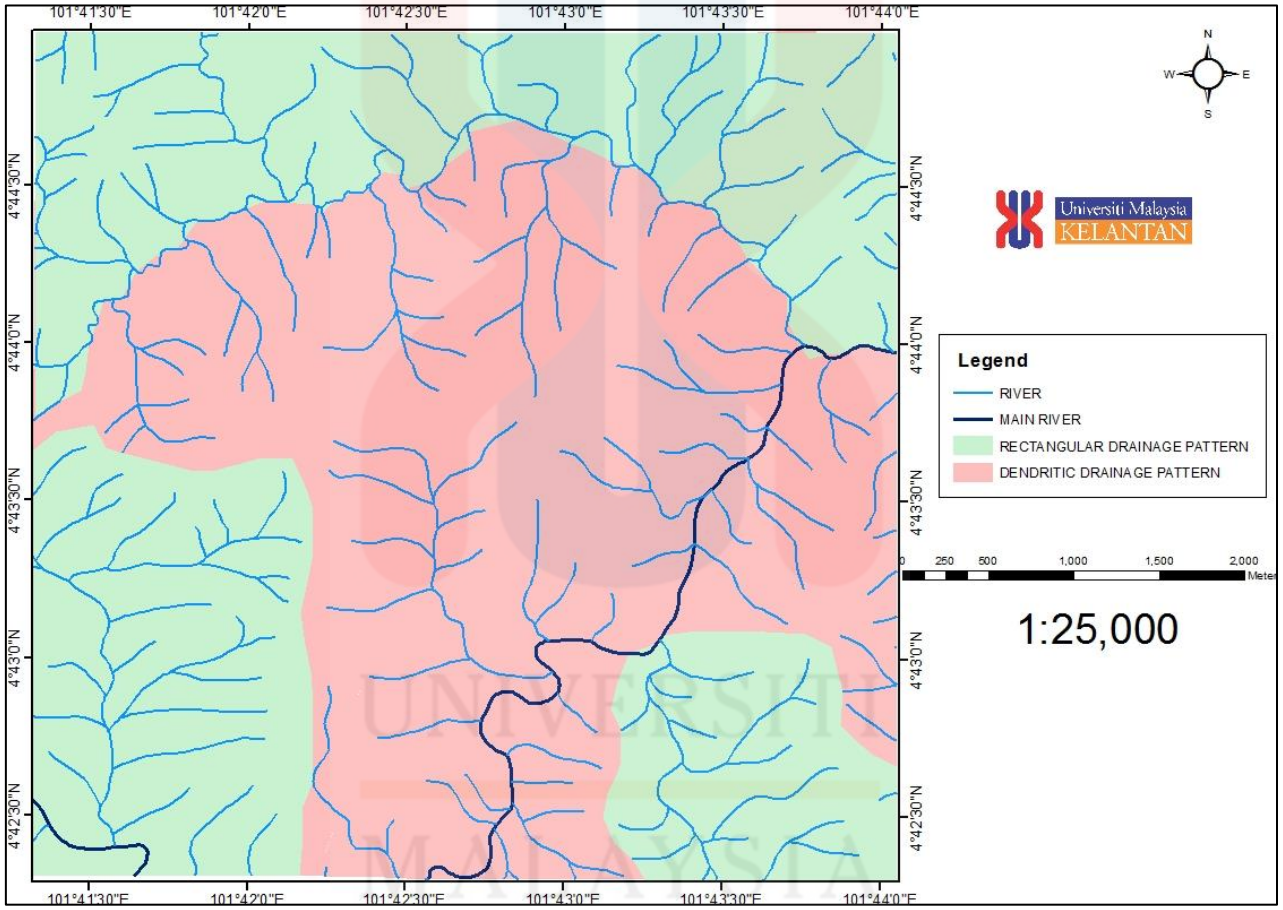

Figure 4.26 : Drainage Pattern

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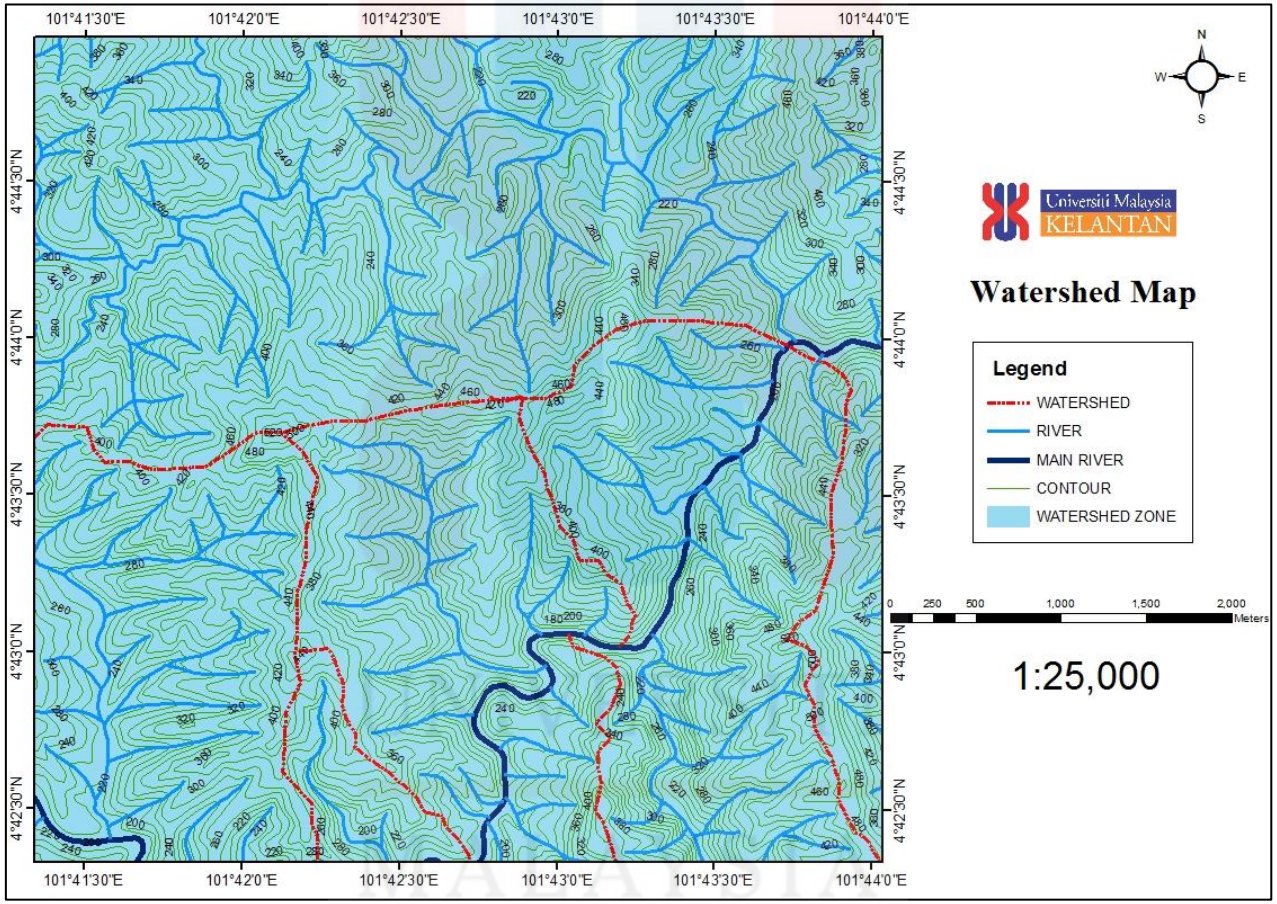

Figure 4.27: Watershed Map

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4.3 Lithostratigraphy

Lithostratigraphy is study about the rock strata or rock layer in the study area. The lithostratigraphic unit may have igneous rock, sedimentary rock and metamorphic rock. Geological condition or geological history of the area can be determined from these sequences of different rocks. The different lithostratigraphic unit of study area are identified by their physical appearances and features. They also identified by the laboratory analysis, petrography, mineralogy, lateral variation and the relationship with adjacent units either horizontally and vertically.

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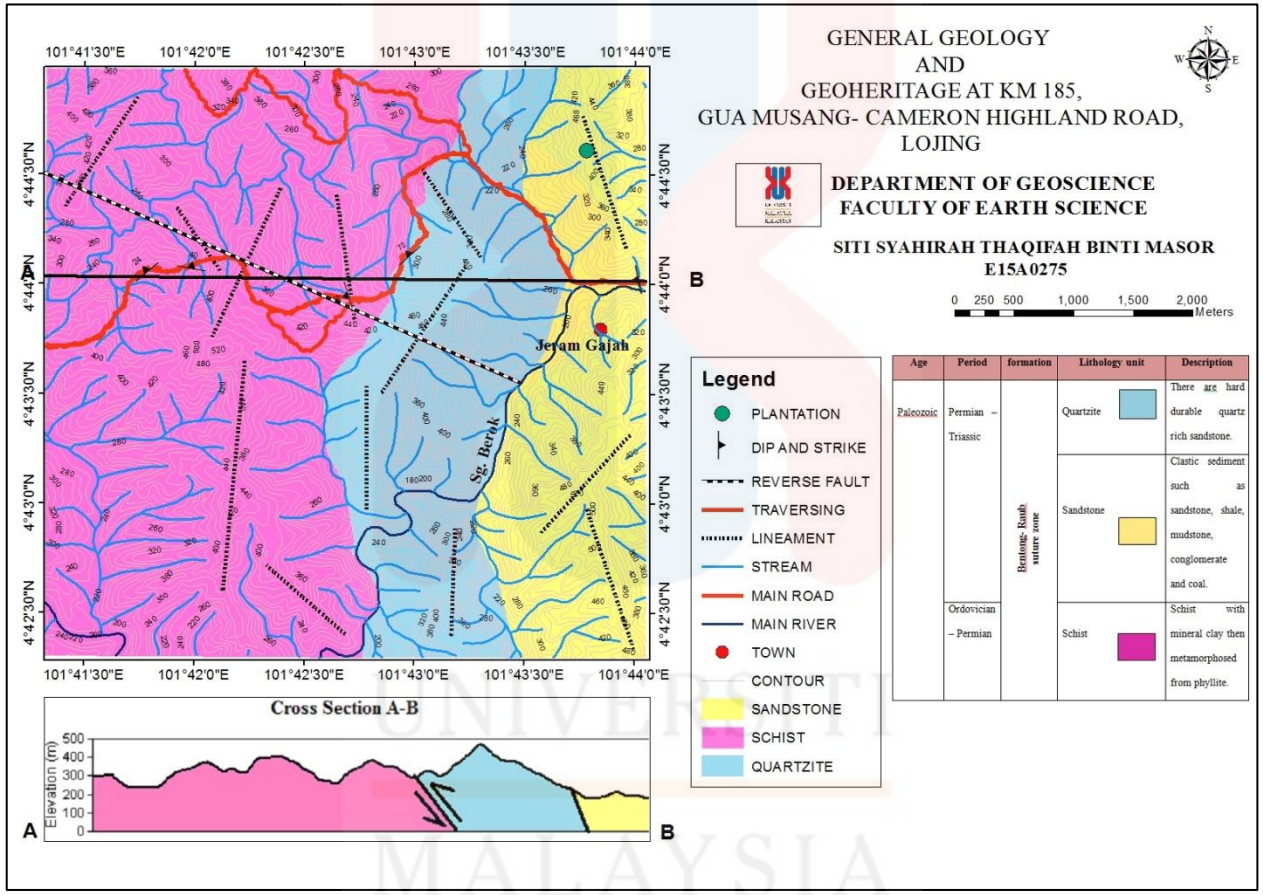

Figure 4.28: Geologic Map

Table 4.2: Stratigraphic Unit in study area.

Age	Period	formation	Lithology unit	Description
Paleozoic	Permian – Triassic	Bentong- Raub	Quartzite 	There are hard durable quartz rich sandstone.
			Sandstone 	Clastic sediment such as sandstone, shale, mudstone, conglomerate and coal.
	Ordovician – Permian		Schist 	Schist with mineral clay then metamorphosed from phyllite.

4.3.1 Alluvium

Basically alluvium are materials that deposited by the rivers in study area. It is also refers to the clay, silt and gravels that deposited by the stream or other water bodies. It is also derive from the erosion of rock and soils in the upper reach of river basin. It is developed in lower part of the river forming the deltas and floodplain. It is also may be deposited in the lake. In the study area, there are main river name Sg. Brook and stream. Examples of the stream (Figure 4.29) in study area was Parat river.

When the alluvium particles are fine grain forming clay, the clays can be used in industry for making the bricks and pottery. For the gravels, it is can be excavated for road aggregate and raw materials for building. The erosion of alluvium may have sufficiently minerals rich for warrant extraction. This also can be heritage potential area. The economic value can be determined.

Figure 4.29: Sungai Parat (river)

4.3.2 Clastic Sediment Unit (Sandstone)

Clastic sediment of study area was dominant of sandstone with subordinate of mudstone, shale and conglomerate. All of this type of rock was formed from the mechanical weathering debris. The clastic sedimentary rocks were classified based on their grain size of the sediment and the rock fragments that makeup the sediment (Table 4). The grain size important as the function of distance how far it can be transported. The smaller and rounded the particles, the far the particles can be transported. Table 4. shows the difference type of clastic rock and their characteristics.

Table 4.3: Particles Sizes in Clastic Sedimentary Rocks

Particle Sizes in Clastic Sedimentary Rocks			
Diameter (mm)	**Particle Type**	**Sediment Name**	**Sedimentary Rock**
More than 256	Boulder	Gravel	Conglomerate or Breccia
64 to 256	Cobble		
4 to 64	Pebble		
2 to 4	Granule		
$\frac{1}{16}$ to 2	Sand	Sand	Sandstone
$\frac{1}{256}$ to $\frac{1}{16}$	Silt	Mud	Siltstone, Shale, or Mudstone
Less than $\frac{1}{256}$	Clay		

In study area, examples of clastic sediment are sandstone with subordinate mudstone, shale, conglomerate and coal. Around 20% of study area was covered by the sandstone. From the Figure 4.30, it can be seen clearly that the outcrop undergone biological weathering due to the biotic activities on the outcrop.

Figure 4.30: Sandstone outcrop

For the sandstone in the study area, it is medium grain size of rocks that contains rocks particles sized of sand. The sandstone found near the stream.. It is form in several depositional environments. In the study area, the outcrop was taken in depositional environment of stream. It is also one of the geoheritage potential because it was mined for manufacturing. Sandstone is a common sedimentary rock that can easily be recognized by its appearance and feel.

For the conglomerate, the grain size also coarse grain. It has rounded gravel pieces. In the study area, the conglomerate was found near the sandstone and tuff. Conglomerate can have variety of minerals composition examples are feldspar or they are can be sedimentary rocks, metamorphic or igneous segment. The most common in the study area are the clast of quartzite and sandstone.

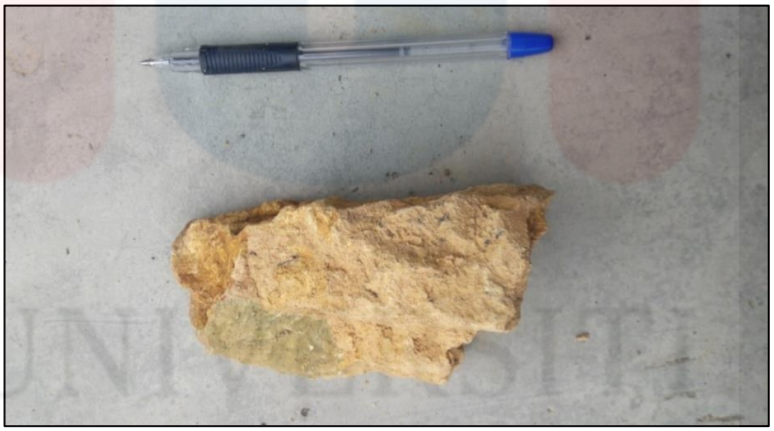

Figure 4.31: Hand Specimen of sandstone

Figure 4.31 shows hand specimen of sandstone in the study area. The sandstone is yellowish in colour. The hardness of this sandstone found in study area is moderate as it exposed and weathered. Due to the weathering process undergone by this sandstone as well, the bedding of the outcrop not clearly identified and none of sedimentary features present. The physical weathering caused the upper part of the

sandstone weathered becoming soil. The sandstone is rarely consists of sufficient thickness or lateral bedding. Besides that, the presence of bituminous coal can be found withing the sandstone as shown in Figure 4.32.

Figure 4.32: Outcrop of coal.

Coal is biochemical sedimentary rocks because it was formed million years ago from the compression and alteration of remain land plants. The coal formed in swamps area. When the plants in study area grew up, some are died and fell into the swamp. The thick layer of died plant rotting in the swamp. Then the decaying process started when the water and dirt washed in. million years later, a few rock layer was formed. Chemical and physical changes occur due to heat and pressure in rock layers. It forced the oxygen out and left the rich carbon deposits. As time being, the plants materials had change and become coal.

Table 4.4: The main types of clastic sedimentary rocks and their characteristics.

Group	Examples	Characteristics
Mudrock	mudstone	>75% silt and clay, not bedded
	shale	>75% silt and clay, thinly bedded
Coal		dominated by fragments of partially decayed plant matter, often enclosed between beds of sandstone or mudrock
Sandstone	quartz sandstone	dominated by sand, >90% quartz
	arkose	dominated by sand, >10% feldspar
	lithic wacke	dominated by sand, >10% rock fragments, >15% silt and clay
Conglomerate		dominated by rounded clasts, pebble size and larger
Breccia		dominated by angular clasts, pebble size and larger

4.3.3 Quartzite

Quartzite was one type of metamorphic rocks that was non-foliated which is contain almost entirely quartz. It is formed when the quartz rich sandstone were altered by the heat, pressure and metamorphism process. Quartzite are under medium to high grade metamorphic conditions during contact or regional metamorphism. The crystalline structure of quartzite makes it become hard, tough and durable. According to Mohr scale, quartzite have hardness at 7 and breaks through grains when strike. The colour of quartzite was grey. The other impurities can make the quartzite become different colour such as reddish brown, orange and yellow. This quartzite (Figure 4.33) has geoheritage value which is economic value and aesthetic value. It is commonly for foundation material for road and railways beds.

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Figure 4.33: Outcrop of quartzite vein

Quartzite in study area are exposed in very huge with more than 100 m wide and 50 m high and occur as quartz vein. The rock is very hard and solid. Due to that conditions, it is difficult to crack the outcrop for sampling. Figure 4.34 shows the hand specimen of quartzite outcrop obtain from the field. The colour of the quartzite is milky white, grey and pink.

Based on previous study, similar lithologies have been mapped. The conclusions that have been made are the Main Range Granite intruded into deep water formations. The deep-water formations rapidly give way westward to calcareous more appropriately interpreted as the shelf of the Sibumasu terrain. Generally, the calcareous rocks are excluded from the Bentong-Raub suture.

Large enclaves of metasediment occur within the Main Range granite (Roe, 1951). They occur near Kuala Kubu Baharu. The rocks are shale, schist, phyllite and chert with layers of metaquartzite and schistose coarse sandstone. Some of the shale and schist are carbonaceous. They are hornfelsed near the granite contact.

Figure 4.34 : Hand specimen of quartzite

4.3.4 Schist

Schist is one examples of metamorphic rock. It is foliated metamorphic rock. It is made up of minerals grains with plate-shape. It can be seen with unaided eyes. Schist is one of the products of metamorphism process. It is started with the shale, then metamorphosed become slate. The slates also undergo metamorphism process become phylite. After phylite undergo the same process, it becomes schist. If the process further, the schist become the gneiss.

Schist does not have specific composition. It only had enough platy minerals in alignment to exhibit distinct foliation. The platy minerals can be phylite or hornblende. The figure 4. Shows the hand specimen of schist taken from the field.

Schist covered approximately 60% of study area. Figure 4.35 Shows outcrop of schist found in the study area. The outcrop found in the small stream in the study area. It located at west of study area and in the reserve forest. The grade of this metamorphic rock is medium and appeared in dark and black coloured. The hardness

is moderate and medium grain size. Biological weathering is most common found in study are.

Figure 4.35 : Outcrop of schist in study area

Two schist type found in study area and name given based on their appearance are white schist and black schist. Figure 4.36 Shows hand specimen of white schist found in study area. The physical appearance of rock are can be seen by naked eye. Colour of the rock are milky white and weathering part are orangish in colour. Shiny to light reflections can be observed due to the presents of mica plates. The rock is low in hardness and be brake by hands.

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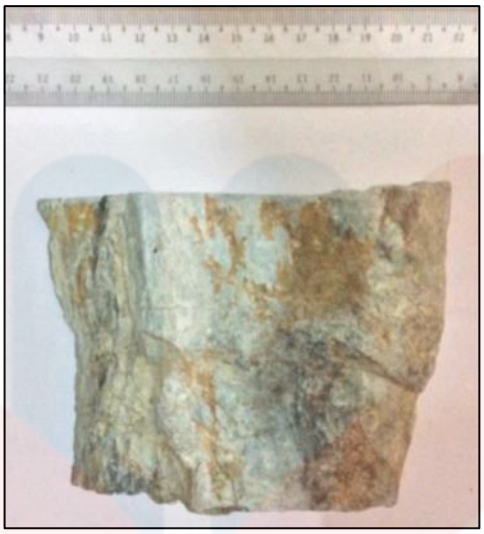

Figure 4.36: Hand specimen of white schist

Figure 4.37 shows result thin section of white schist obtain from the field. Muscovite mica is the mineral that can be observed from the optical petrography. Colour of mica in PPL is dark grey and white. For XPL, the colour of mica is blue, purple and pink. It has high relief. The muscovite mica is euhedral with well form crystals. Extinction angle of the minerals is 3. Muscovite mica consists of 25% of rocks and 75% of feldspar.

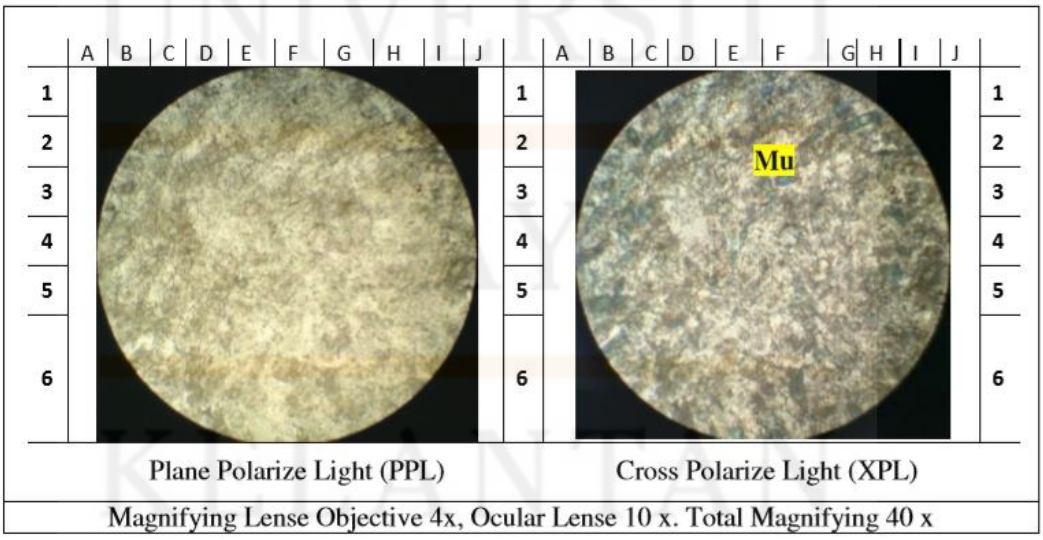

Figure 4.37 : Optical petrography of white schist

Hand specimen of black schist shown in figure is dark grey in colour. The minerals which are slaty dark minerals can be seen with naked ayes. There are foliations which make the schistosity of the rock high. The hardness of the rocks also high which is needed hammer to crack it.

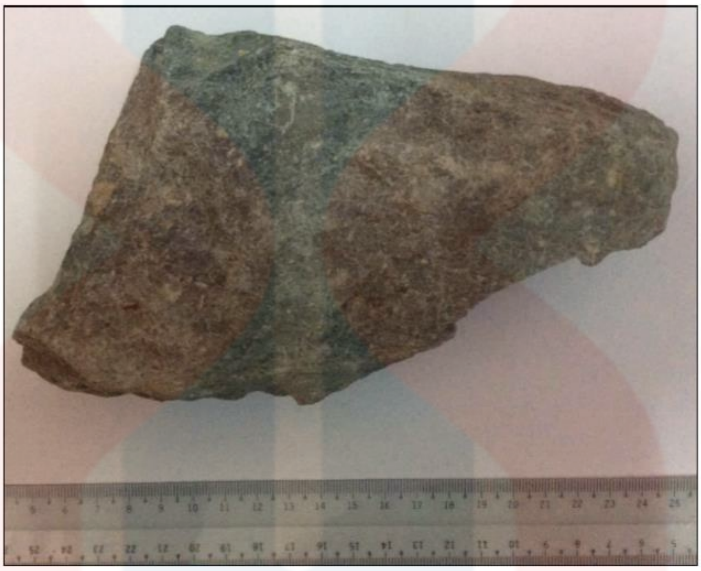

Figure 4.38 : Hand specimen of black schist

Figure 4.39 shows the thin section of black schist. For PPL, the observations were carried out at 10x ocular magnification and 5x objective magnification and at observations of the foliation structure (schistose), palimset texture (blastopsamit) including grain size <1/256 - 1/3 mm, medium sorting. Minerals that can be identified are quartz (A10), serpentin (A5), silica clay (B10) and serisit clay (F8). Quartz in the observation of white PPL, the colour is white while in XPL, the colour is gray to black. It is low relief without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. It have 25% abundance in the rocks.

For the serpentin, in observations the colour or serpentin in PPL are white-brown, while green colour in XP. It has low relief and difficult hemisphere observed.

It has weak pleocroism, spotted present in the incision. It is 5% abundance in the rocks.

For the silica clay, it is white-gray colour in PPL, in XPL it is gray-black colour. It has relief-pleocroisme-shape crystals and parts are not visible, present spread in the incision. It is15% abundance in the rock. For the serisit clay, in observations of brownish-white in colour for PPL, while brown-red-gray in colour for XPL. It is low relief, moderate pleocroism, unobserved cleavage and anhedral crystalline form. It is present in diffuse.

For the chlorite clays (D1) in XPL, in the observation it is greenish brown in PPL - blackish, greenish. In XPL, it is blackish in colour. It is 1-way hemisphere with no moderate relief, moderate-weak pleocroism, present spreading in the incision. It is 30% abundance in the rocks. For the opaque minerals (J1, in observations PPL and XPL look dark, present in the incision spread. It is 15% abundance in the rock.

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PPL (Plane Polarized Light) XPL (Cross Polarized Light)

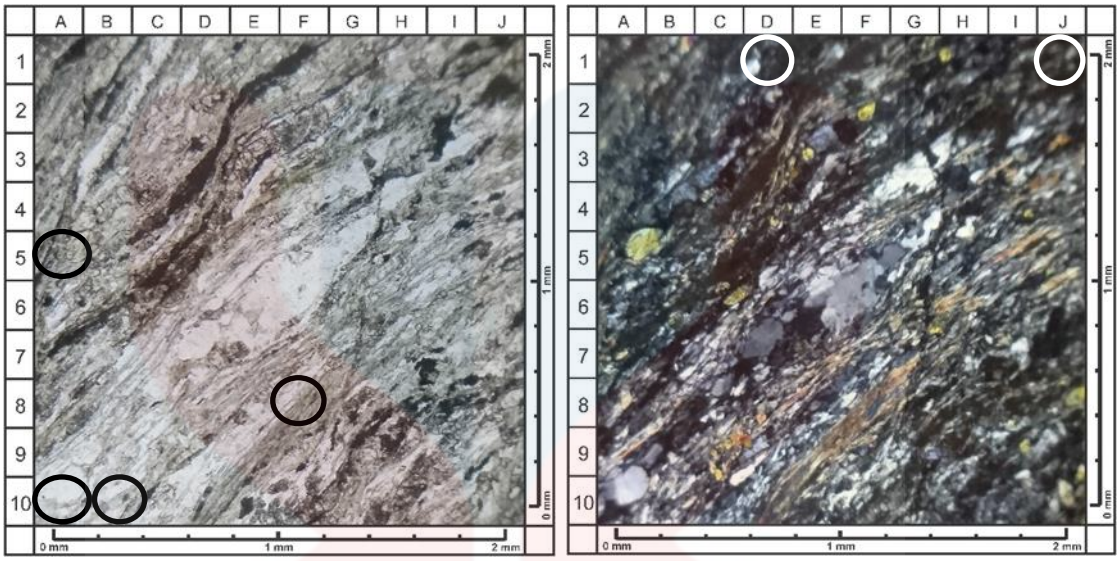

Figure 4.39 : Optical petrography of black schist.

4.3.5 Mylonite

Mylonite is one type of metamorphic rock that formed during folding or faulting process. The process termed are cataclastic or dynamic metamorphism. It is foliated metamorphic rock. The colour are grey to black. Attitude of folding are 210/70. For microscopic observations, the observations were carried out at 10x ocular magnification and 5x objective magnification and on observations of the foliation structure (slaty-schistose), palimset texture (blastopsamit-blastopellite) including grain size <1/256 - 1/32 mm, good sorting. Based on optical petrography, the minerals observed are quartz (G3), silica clay (J10), opaque mineral (A3), oxide layer (D1) and there are fracture in (C1).

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PPL (Plane Polarized Light) XPL (Cross Polarized Light)

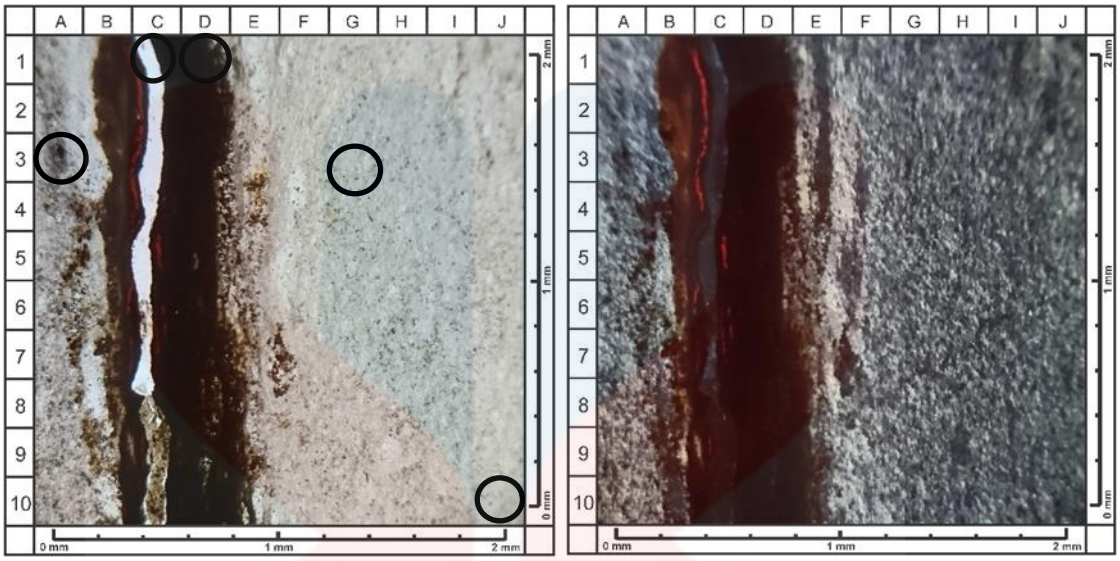

Figure 4.40 : Optical petrography of mylonite.

For quartz in mylonite, in the observation of white PPL, white XPL in gray – black in colour. It has low relief without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. Quartz have 3% abundance in the rocks. For silica clay, in the case of white-gray PPL, in XPL the gray-black color, relief-pleokroisme-shape crystals and parts are not visible, present spread in the incision. Slica clay have 75% abundance in the rocks. For the opaque minerals, in observations PPL and XPL look dark, present in the incision spread. It has 3% abundance in the rock. For oxide layer in rock, in observations PPL and XPL look dark, present in the incision spread. It has 15% abundance in rocks. There are fractures observed in the rocks. In the observation of white PPL and XPL it looks dark, spotted in an incision. 4% abundance in rocks.

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4.3.6 Hornfels

Hornfels is examples of metamorphic rock. The grain size is fine-grained. It is not a rock that deposited to the environment. It is a rock that form when the other rock are metamorphosed. It is refer to parent rock or protolith. Sedimentary rock, igneous rock or metamorphic rock can be protolith of hornfels. The protolith of this hornfels in the study area are can be the sandstone, mudstone, shale or schist.

PPL (Plane Polarized Light) XPL (Cross Polarized Light)

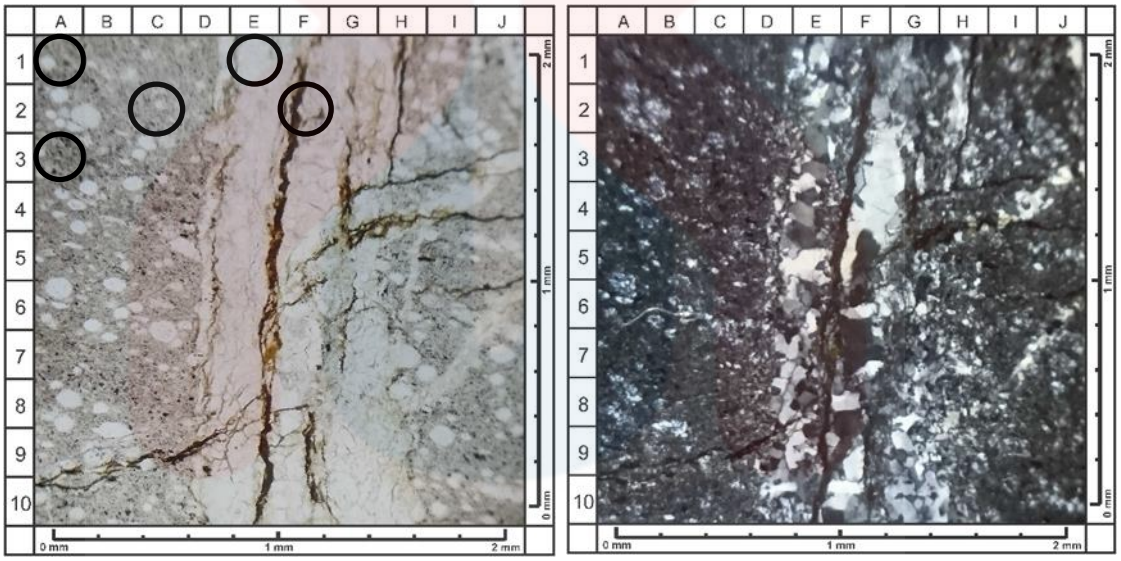

Figure 4.41 : Optical petrography of hornfels

In these observations, it is carried out at 10x ocular magnification and 5x objective magnification and on observations of nonfoliating (hornfelsic) structures, palimset (blastopellite) textures including grain size <1/256 - 1/6 mm, good sorting. The minerals observed are quartz (C2), silica clay (A1), opaque minerals (A3). There are vein oxide (F2) and quartz vein (E1).

Figure 4.41 shows optical petrography of hornfels. For quartz, in the observation of white PPL, white XPL, it is gray – black in colour. It has low relief

without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. It is 20% abundance in rocks. For silica clay, in the case of white-gray PPL, in XPL the gray-black in colour, relief-pleokroisme-shape crystals and parts are not visible, present spread in the incision. It has 48% abundance in rocks. For opaque minerals, in observations PPL and XPL it is look dark, present in the incision spread. It has 1% abundance in rocks. For the oxide vein in rock, in observations PPL and XPL look dark, present in the incision spread. It has 6% abundance in rock. For quartz vein, in the observation of white PPL, white XPL is gray – black in colour, low relief without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. It has 25% abundance.

4.4 Structural Geology

Structural geology is about the distribution of different types of rock in study area. The composition inside the rock bodies, their tectonic history that make the structural geology to form. Dating of structural geology also can be determined.

4.4.1 Vein

Vein are minerals deposits that form when an existing fracture were filling by the new minerals materials. The minerals deposit fills the crack on the host rock but do not extend into the host rocks. Vein deposit form when the aqueous solutions carrying the minerals particles and migrate through fissures in rock. All the minerals particles then deposited onto the fissure walls. Hot, rising water escaping from cooling igneous plutons may deposit minerals as it ascends through the crust. When the heated magmatic water rise, the temperature and pressure are decrease then minerals crystallized. All of the mineralization process occured are called

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hydrothermal replacement deposit. Quartz filling indicates fissures that occur on deformed rocks. Small scale of quartz vein from 1cm wide to 100m of huge quartz vein was found.

Figure 4.42: Vein

4.4.2 Joint

Joint is brittle-fracture on the surface that does not have any displacement. For sedimentary rock, the joint show to set of joint. Each of it was perpendicular to the bedding. One of the joint are follow direction of dip, the other one are follow direction of strike. For igneous rock, the joint was quite irregular. It is forming cross joint which is affects from the weathering process.

4.4.3 Fault

Fault is the fracture that formed between two block of rock. This can cause the block move relative to each other. The movement can cause a big impact to earth surface or minor impact to earth surface depend on the strength of the faulting process. Types of fault can be determined by its strike and dip reading. Examples types of fault are (Figure 4.36) normal fault, reverse fault, sinistral strike-slip and dextral strike slip.

In study area, the fault involve are reverse fault in outcrop of tuff. The attitude of fault was strike 325 and incline 50-55 toward NE. Reverse fault is a dip slip fault where the rock falls shifted vertically. The mylonitic olistostrome represents a low-angle reverse fault zone that according to its phyllonite foliation. The attitudes of foliations are 310/20. The left lateral slip detected as youngest fault motion in the outcrop. Figure 4.43 Shows reverse fault in outcrop found in study area.

Figure 4.43 : Reverse fault found in study area.

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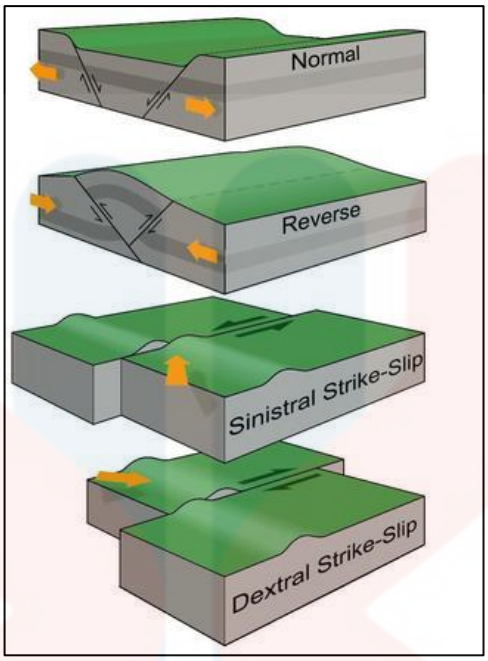

Figure 4.44: Types of fault (Sources : University of Otago (Richard Sibson))

4.4.4 Fold

Folding are the process that make the stratified rock on earth crust become wavy. The stratified rocks are form from the sediments that deposited in the study area. The fold can be classified based on its axis (reading of dip and strike) and their appearance. There are several types of folding (Figure 4.45) which is symmetrical fold, asymmetrical fold, isoclinal fold, overturned fold, recumbent fold and chevron fold.

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4.45 : Folding

4.4.6 Mechanism Structure

Lineament is elongate landforms in form of hills and mountain range or valleys. Positive lineament indicates high elevation while negative lineaments indicate lower elevation. The analysis of lineament can determined the directions of force that caused the deformations of rock. Figure 4.46 Shows map of lineament.

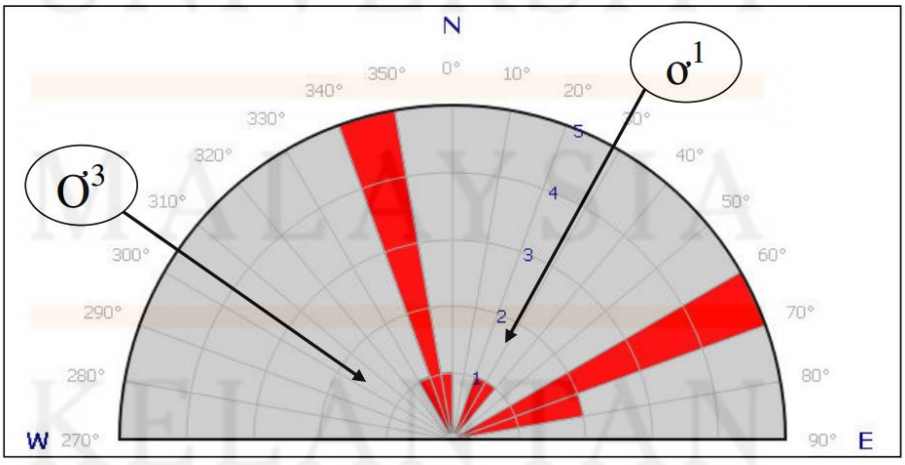

Figure 4.46 : Lineament analysis of study area using Georose software.

Based on Figure 4.46 shows the major force stipulates from the north – east direction of 30 degree. This means that compression force is at the north – east direction, while extensional or minor force is perpendicular to the major force which heads from 300 of north – west. The reading of lineament in Appendix G.

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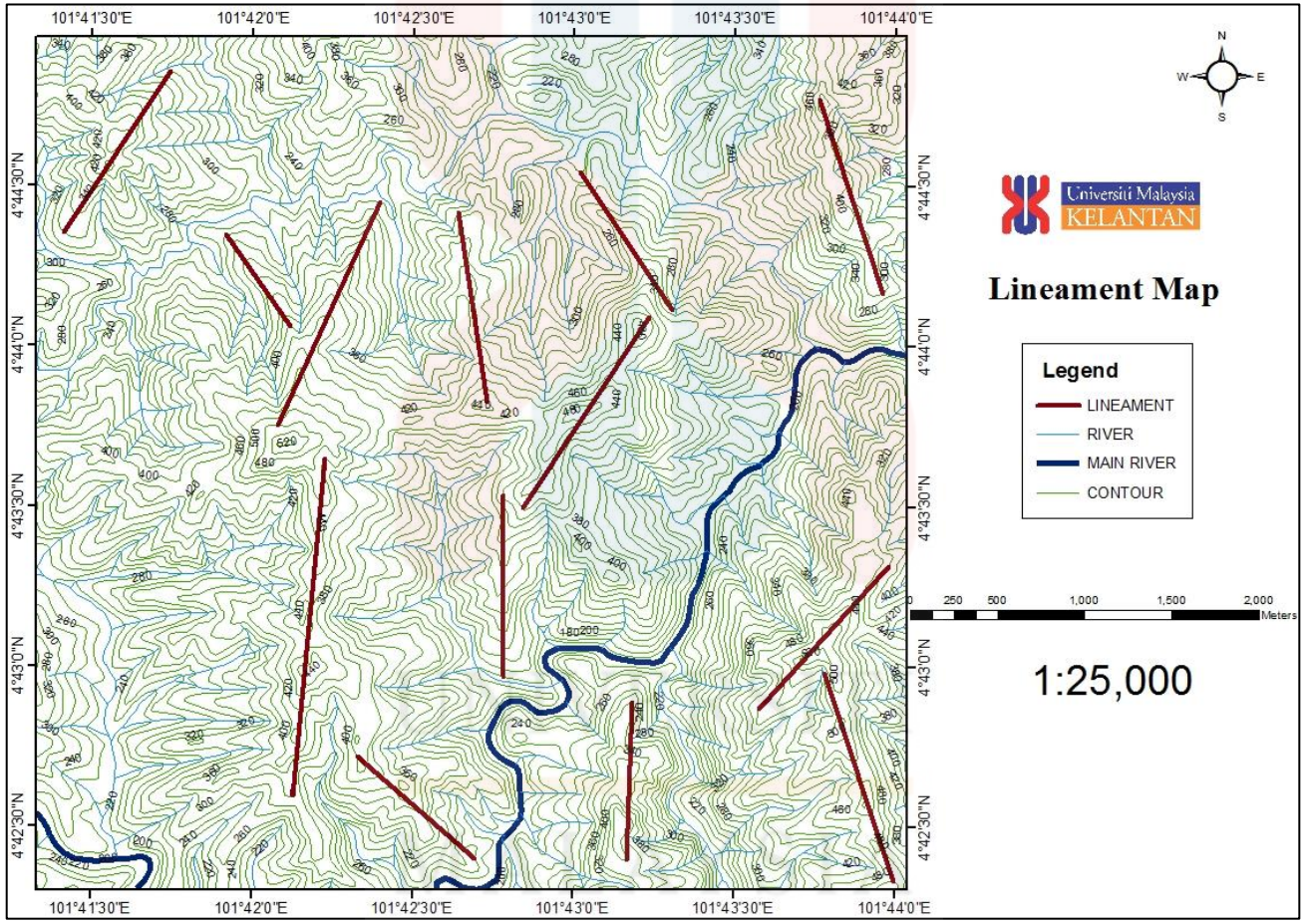

Figure 4.47: Lineament Map

4.5 Historical Geology

Yin (1965) state that the formation of Gua Musang lies within the Central belts of Bentong – Raub Suture mainly subdivided into calcareous facies, argillaceous facies, arenaceous facies, volcanic facies and metamorphic facies. The Bentong-Raub suture Zone in Peninsular Malaysia is located between the Sibumasu Terrane and the East Malaya (Indochina) Terrane. The Sibumasu terrane was attached to the Cimmerian plate and the East Malaya terrane attached to the Indochina and the South China plate. The Sibumasu and East Malaya blocks were separated by an ocean called Paleo-Tethys. The opening of the Palaeo-Tethys was initiated when the sliver of North and South China, Indochina and Tarim plate rifted from Gondwanaland during Devonian. The Palaeo-Tethys was diminished when the Sibumasu terrane collided with East Malaya (Indochina) terrane during the Triassic. The remnant of Palaeo-Tethys was only preserved in the chert blocks in the Bentong-Raub Suture Zone. This suture deformed rocks consists of schist, phyllite, meta-sedimentary rocks, sandstone, cherts, olistostrome and mélange (Tjia & Almashoor, 1996). The dominant rocks types are mica schist, quartzmica schist and metaquartzite. They are strongly foliated. The Schist Series commonly also composed of phyllite and slate.

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CHAPTER 5

GEOHERITAGE AT KM 185 GUA MUSANG-CAMERON HIGHLAND ROAD, LOJING

5.1 Introduction

This chapter are the explaination about of geoheritage of study area. Some of the geologic feature and geoheritage feature had been observe during mapping. Some of the geoheritage value such as scientific value, aesthetic value, recreational value, cultural value and commercial value were observe.

5.2 Geoheritage of rock

For each geological site and feature, there are some values can be determined. By knowing the values, the geoheritage potential of the area can be identified easily. It is important to keep the geology resources for the future used.

5.2.1 Scientific value

For the scientific value, it is related to the geologic features and geoheritage features. Then, the landscape of study area also can have the scientific value. The distinctive rock or minerals that have in the study area also one of the scientific values. Then, the other geologic characteristics that are unique and rare also contribute to the scientific value.

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5.2.2 Aesthetical value

For the aesthetical value in various aspect of natural environment, the geologic features and geological features are more scenery and scenic views. Then, the landscape in the study area are beautiful and interesting. The traits of rocks such as its colour or shape and size give a pleasant scenery. A geological structure also can give beautiful scenery in the study area and aesthetical value can be determined (Jamaluddin,2004).

5.2.3 Recreational value

For the recreational value, it is involved the area in the study area that can make the people do recreation activities during their leisure time. The characteristics of natural features of particular area are major factor of recreational value. The outdoor activities such as jogging, rock climbing and caving can be done. This also support geotourism which is can provide sources of employment.

5.2.4 Economical value

For the economical values, the rocks and minerals that found in the study area can be used in industry or can be used in future used. The distinctive rock that found can be conserve by the right person. This can generate income for the community. Economy of community can be upgrade. It can be conserved in the right place.

5.2.5 Cultural value

For the cultural value, it is associated with geosites that have major development in geoscience. The geologic heritage or rocks and minerals within the study area and conservation of cultural landscapes can contribute to the cultural value of the area. It

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can be expressed through the natural features in the study area such as mountains, waterfalls and rock formations.

5.3 Potential of Geoheritage Feature

Basically, some of the geoheritage potential of study area had been found. Some heritage values can be determined. Examples of geoheritage features that had been found are graphite, coal and quartzite. Basically the inventory, characterization, and classification phase are conclude in this section.

5.3.1 Quartzite Vein

The quartz vein is another outstanding geological feature that found in the study area. Entangling of the outcrop with surrounding vegetation creates nice scenery as in Figure 5.1. the structure is related with Bentong – Raub Suture zone as part of the metamorphism process that produce shiny crystallized quartzite. Occurrence of this geological feature is rare in Kelantan and Malaysia. Existence of huge quartzite vein can add Malaysia number one of huge minerals veins as it is also nation's geoheritage.

Figure 5.1 : Quartzite Vein

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5.3.2 Coal and Graphite

In the study area, coal is found in which the mineral itself is a rare occurrence. Coal is also one of heritage in geodiversity (Gray, 2013). The coal is shown in Figure 5.2 resides within the weathered tuff, are identified either bituminous or anthracite based on physical appearance because it is carbonaceous. The small amount of coal found is suitable for scientific purpose such as education for geology students and further research in mineralogy. Industrial, metallic and precious minerals can be considered the heritage of geodiversity (Gray, 2013). Graphite is carbonaceous schist form from mineralization of the sedimentary rock. It has scientific values and considered rare minerals. The graphite is shown in Figure5.4. Scientific research in mineralogy can be performed to grade the quality as these mineral resources as they may have commercial values.

Figure 5.2: Outcrop of coal within tuff

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Figure 5.3: Outcrop of coal

Figure 5.4: Outcrop of Graphite

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5.4 Assessment Geoheritage Value

5.4.1 Qualitative Assessment

The geoheritage value get from the field mapping then undergo next process which is qualitative assessment and quantitative assessment. The qualitative assessment of study area was based on the result of questionnaires survey. The parameter for qualitative assessment as shown in Table 5.1 below.

Table 5.1: Geoheritage values and level of significant

Geoheritage Values	Level of Significant
▪ Scientific and educational values ▪ Aesthetical values ▪ Recreational values ▪ Cultural values ▪ Historical values ▪ Economical values ▪ Functional values ▪ Religious values	▪ Local ▪ Regional ▪ National ▪ International

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Table 5.2: Qualitative Assessment

Geoheritage feature	Scientific value	Aesthetical value	Recreational value	Economical value	Cultural value	Level of significant
Quartz vein	Educational purpose for geology and mineralogy.	Huge and long quartz vein. Beautiful view from the highway.	-	Can be excavate	-	Regional
Coal	Educational purpose for geology and mineralogy.	Very rare occurrence in study area.	-	Can generate income	-	Regional
Graphite	Educational purpose for geology. Can be more focused on mineralogy.	Very rare occurrence in study area.		Can generate income, industrial uses.	-	Regional

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5.4.2 Quantitative Assessment

The next assessment was quantitative assessment. The heritage value get from the study area are evaluated in respect of their parameters (Ali,2016). For the questioner, each of the Q, are represent 10 persons. Examples, Q1 represent 10 persons. Scoring from 0-10 was broken into 0, 2.5, 5, 7.5 and 10 are given for parameter of the quantitative method. The parameter of geoheritage values are defined in Appendix C and scoring is given based on Appendix D.

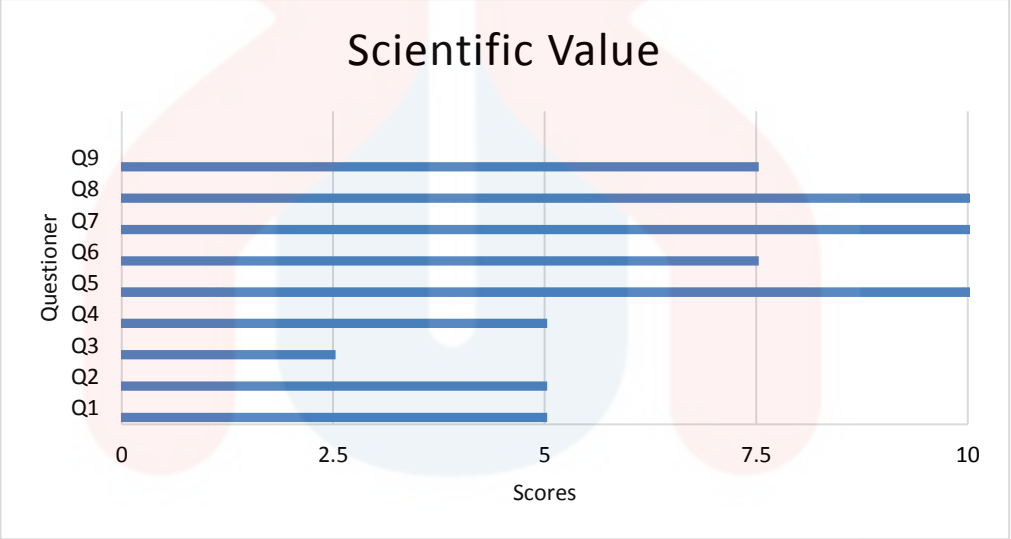

Figure 5.5: Score rank for scientific value.

The score for scientific value is shown in figure 5.5. There are ninety questioners that give score for scientific value of geological heritage in the study area. The accumulated score of all nine questioners are 62.5 scores of 90. There are 10 person scores for 2.5 out of ten. Score of 5, there are 30 person which is equal to total of person that score for 10. 7.5 score have 20 persons out of 90.

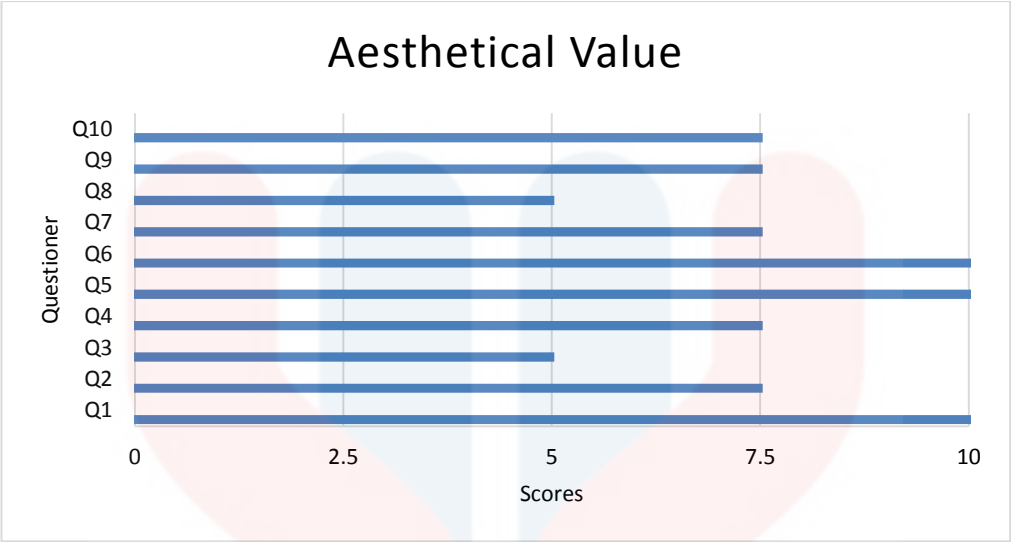

Figure 5.6: Score rank for aesthetical value

The score rank for aesthetical value shown in Figure 5.6 of study area has total of 77.5 scores of 100. There are 30 persons that score for 10. The 7.5 score have the highest person which is 40 persons out of 100. There are 20 person that vote for 5 scores and there is no person vote for 2.5 score.

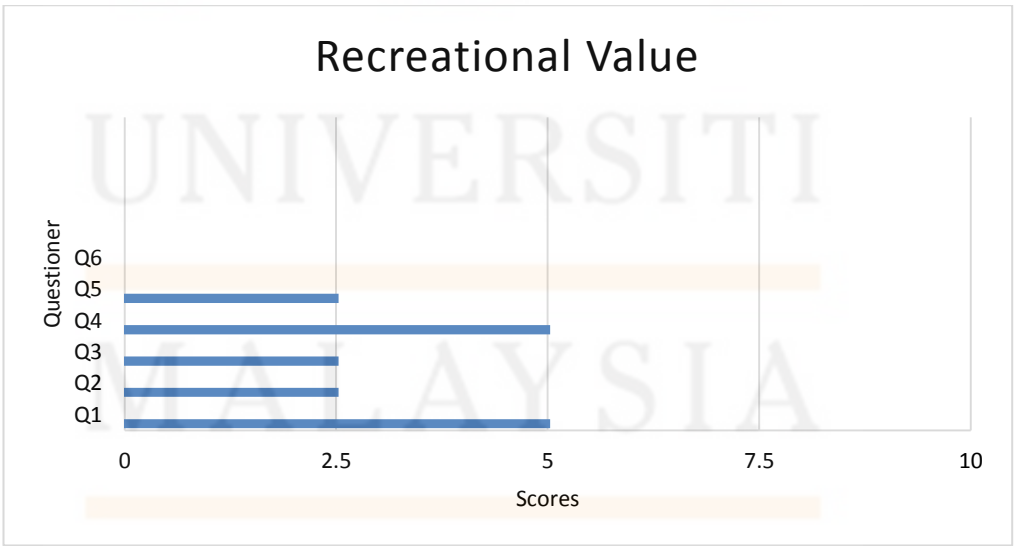

Figure 5.7: Score rank for recreational value

Next**,** the accumulated score for recreational value in the study area are 17.5 of 60 which is quit low. The score for recreational value shown in figure 5.7 are only 60 questioners involve. 30 persons out of 60 persons are score for 2.5 while the rest are vote for 5. There are no questioners score for 7.5 and 10.

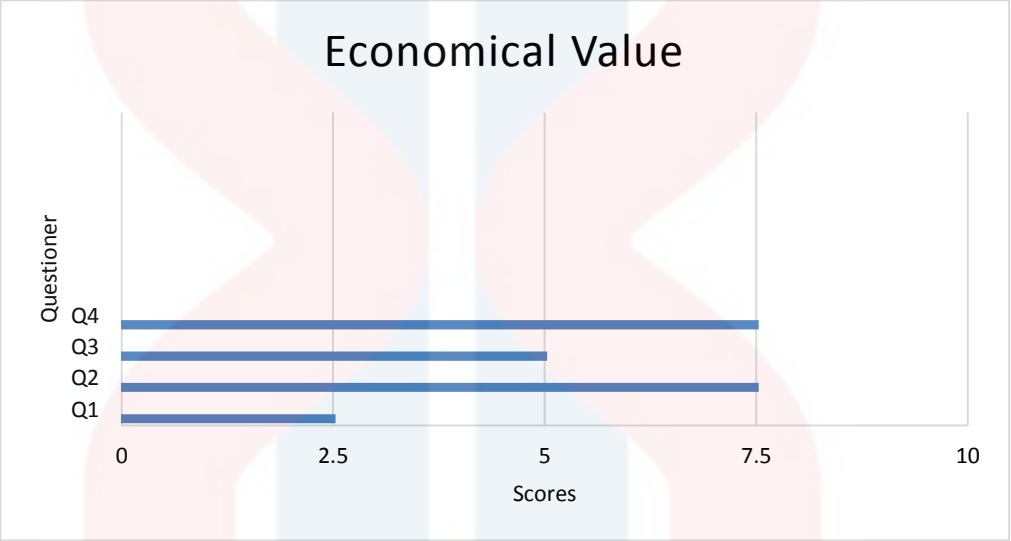

Figure 5.8: Score rank for economical value.

For the economical value, the total score are 22.5 of 40 marks from all questioners. The score rank shows in figure 5.8 are only 40 questioner's give score for economical value in study area. Score 2.5 only have 10 questioners same as scores of 5. Only 7.5 scores have 20 questioners out of 40.

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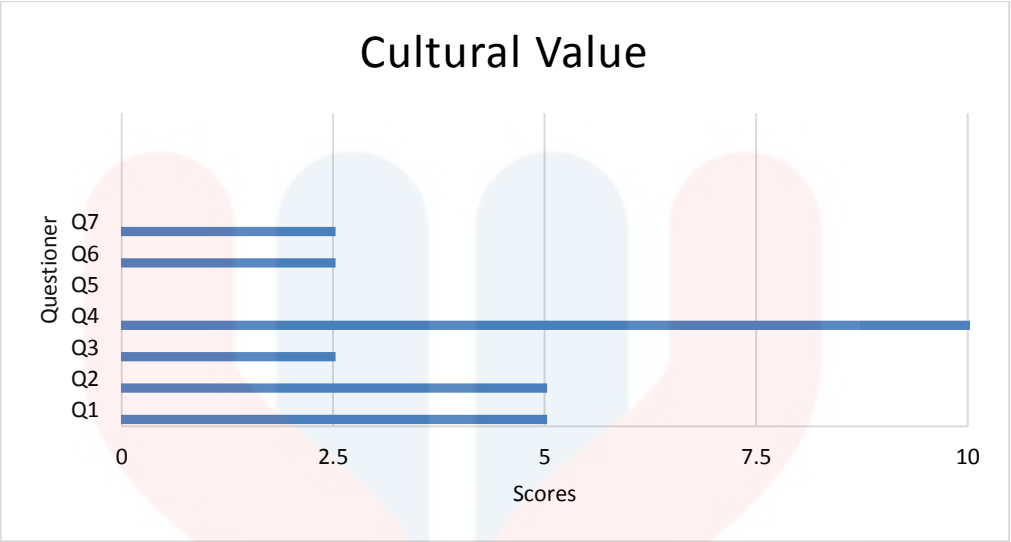

Figure 5.9: Score rank for cultural value.

For score rank of cultural value in study area, there are 70 questioners give scores. The total scores are 27.5 from 70. 2.5 scores have 30 questioners that give scores for cultural value in the study area. For scores of 5 have 20 questioners out of 70 and for the highest rank which is score of 10, has 10 questioners out of 70.

The total score of each geoheritage value will be calculated to identify the Total Heritage Value Rank (HvT) and Total Heritage Value Rank for Development (HvD) as shown in Appendix.

Two formulas involved to calculate the total score are Total Heritage Value Rank (HvT) and other Total Heritage Value Rank for Development (HvD).

Formula of Total Heritage Value Rank

$$(HvT) = (ScV) + (AsV) + (RcV) + (EcV) + (CuV) \quad (5.1)$$

Formula of Total Heritage Value Rank for Development (HvD)

$$(HvD) = \frac{[(ScVx40) + (AsVx25) + (RcVx15) + (EcVx5) + (CuVx10)]}{100} \quad (5.2)$$

5.5 Discussion

$$(HvT) = (ScV) + (AsV) + (RcV) + (EcV) + (CuV)$$

$$= 62.5 + 77.5 + 17.5 + 22.5 + 27.5$$

(HvT) = 207.5

$$(HvD) = \frac{[(ScVx40) + (AsVx25) + (RcVx15) + (EcVx5) + (CuVx10)]}{100}$$

$$(HvD) = \frac{[(62.5x40) + (77.5x25) + (17.5x15) + (22.5x5) + (27.5x10)]}{100}$$

(HvD) = 50.875

The value of Total Heritage Value Rank (HvT) is 207.5 and the result of Total Heritage Value Rank for Development (HvD) after calculated is 50.875. Based on Appendix E , the total can be used to determine the rank of both (HvT) and (HvD). The score 207.5 for (HvT) of geoheritage features in the study area are in high rank category which is set to earlier of 191 to 250. For the Total Heritage Value Rank for Development, the result gives value of 50.875. According to the rank in Appendix F, (HvD) is considered high. The result for both Total Heritage Value Rank (HvT) and Total Heritage Value Rank for Development (HvD) are in same rank which is high rank.

Based on the result of questionnaires, the geoheritage features in study area are abundance in scientific values and aesthetic values. For recreational value, it is not suitable for recreational activities due to the remote location and dangerous location. Geodiversity in the research area is more to the scientific study and conserve the existing geological heritage features as well. In contrast, the high rank of (HvT) and (HvD) shows that the aesthetic values and scientific need to maintain

and conserve in the study area. The logging activities in the study area was a threat and its make crucial to do further research for geoconservation. The geological structure and minerals that are unique occurrences such as a huge quartzite vein, graphite and coal are need to be concern more on geologic factor. It is for the countries' geoheritage purpose instead of exploitation activities of nature resources by those people who lacks of geology knowledge.

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CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

This research had undergone several steps which is preliminary studies, geological mapping and laboratory and data analysis to achieve the objective of research study. Several steps to study geoheritage such as inventory, characterization, classification, assessment and evaluation had been done. The study area are in Bentong-Raub Suture zone have geomorphologhy of mountainous, hilly and valley. Dominant lithology in the study area are schist unit, clastic sediment unit which is sandstone and quartzite unit. The Bentong-Raub Suture Zone is marked by a belt of mélange and olistotrome which comprise blocks or clasts of cherts, sandstone, limestone, conglomerate, interbedded sandstone and mudstone and tuffaceous mudstone embedded in a sheared matrix of mudstone.

Structural geology found in the study area vein of small quartz until the huge quartz vein and it is mappable. The other structural geology are joints, folding and faulting. The types of fault found in study area are reverse fault. Geoheritage features discovered are huge quartzite vein, coal and graphite. Final score advocate Final score advocate the feature to appear high in value same in grave concerning to development of geoconservation. Based on the results, it shows that the geoheritage features in study area has scientific, aesthetic and cultural values. As the study area is

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prosperous with scientific values, improvements in research are well needed to maintain the aesthetical aspects of geoheritage features from further menace. Overall, the objective achieved.

6.2 Recommendation

Moderate development of geoheritage in the nation makes the awareness in acknowledging of geological feature only if the area is geotouristic to civilians. The geoheritage features are evaluated using the proposed method, but maybe misinterprated in some parameters. Further research can be performed using other branch of geosciences in sedimentology, petrology, geochemistry, geophysics and geomorphology and Geological Informative System (GIS). Analysis to the geomorphology and quartzite vein by remote sensing and GIS also needed to add and improve the geoheritage values of these features. Graphite and coal are found but the chemical properties cannot be identified precisely and specifically to measure the viable economic avail. Geochemistry analysis of the mineral resources can be implemented to identify the grade and quality of the minerals. GIS and geophysical method can be used to explore the possibility of the mineral existence whether abundance or not.

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APPENDIX A

This survey is one of Final Year Project process. It is important to know your feedback by answer several questions above. Your survey will help the student analyse geological heritage in the study area.

1. Do you know the existence of graphite in the logging areas?

Yes / No

2. Do you know the important of graphite in industry or daily used? State.

……

3. Do you know what is graphite? State.

……

4. Do you think graphite have values for us?

……..

5. Based on geoheritage value I had been explain to you, what are the geoheritage values of graphite?

Scientific value	Aesthetical value	Recreational value	Economical value	Cultural value

Why?

……

6. This geoheritage feature need to be conserve or not?

Yes / No

7. What is the level of significant of this geological heritage feature?

Local	Regional	National	International

8. Ranking of graphite in geoheritage value.

0 = none	2.5 = bad	5 = fair	7.5 = good	10 = very good

Scientific value

0	2.5	5	7.5	10

Aesthetical value

0	2.5	5	7.5	10

Recreational value

0	2.5	5	7.5	10

Economical value

0	2.5	5	7.5	10

Cultural value

0	2.5	5	7.5	10

This survey is one of Final Year Project process. It is important to know your feedback by answer several questions above. Your survey will help the student analyse geological heritage in the study area.

1. Do you know the existence of coal beside the highway?

Yes / No

2. Do you know the important of coal in industry or daily used? State.

……

3. Do you know what is coal? State.

……

4. Do you think coal have values for us?

……
..

5. Based on geoheritage value I had been explain to you, what are the geoheritage values of coal?

Scientific value	Aesthetical value	Recreational value	Economical value	Cultural value

Why?

……

6. This geoheritage feature need to be conserve or not?

Yes / No

7. What is the level of significant of this geological heritage feature?

Local	Regional	National	International

8. Ranking of coal in geoheritage value.

0 = none	2.5 = bad	5 = fair	7.5 = good	10 = very good

Scientific value

0	2.5	5	7.5	10

Aesthetical value

0	2.5	5	7.5	10

Recreational value

0	2.5	5	7.5	10

Economical value

0	2.5	5	7.5	10

Cultural value

0	2.5	5	7.5	10

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This survey is one of Final Year Project process. It is important to know your feedback by answer several questions above. Your survey will help the student analyse geological heritage in the study area.

1. Do you know the existence of quartzite in the logging areas?

Yes / No

2. Do you know the important of quartzite in industry or daily used? State.

……

3. Do you know what is quartzite? State.

……

4. Do you think quartzite have values for us?

……
..

5. Based on geoheritage value I had been explain to you, what are the geoheritage values of quartzite?

Scientific value	Aesthetical value	Recreational value	Economical value	Cultural value

Why?

……

6. This geoheritage feature need to be conserve or not?

Yes / No

7. What is the level of significant of this geological heritage feature?

Local	Regional	National	International

8. Ranking of quartzite in geoheritage value.

0 = none	2.5 = bad	5 = fair	7.5 = good	10 = very good

Scientific value

0	2.5	5	7.5	10

Aesthetical value

0	2.5	5	7.5	10

Recreational value

0	2.5	5	7.5	10

Economical value

0	2.5	5	7.5	10

Cultural value

0	2.5	5	7.5	10

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APPENDIX B

Table Questioner

No	Questioner	SV	AV	RV	EV	CV
1	Mohd Zarif	5				
2	Siti Samsiah	2.5				
3	Mohd Aslam	7.5				
4	Mohd Syafizal	5				
5	Mirzanuddin	10				
6	Nur salwa	7.5				
7	Umi Kalsom	5				
8	Siti Zaleha	10				
9	Hajar Aminah	2.5				
10	Zubaidah	10				
11	Nur Sarafina	5				
12	Syaemah	10				
13	Nurul Wani	7.5				
14	Mashitah	2.5				
15	Shahruddin	10				
16	Zaleha	10				
17	Narita	5				
18	Namron	7.5				
19	Maya	7.5				
20	Izati Azwani	5				
21	Afida Zulaikha	10				
22	Federica Agnese	2.5				
23	Lukman Hakim	7.5				
24	Farah Nasha	7.5				
25	Farah Natasha	5				
26	Farah Najiha	5				
27	Farwan Muhammad	5				
28	Mohd Farwin	10				
29	Lysa Ardina	7.5				
30	Masor	2.5				
31	Syariff Sulaiman	10				
32	Abu Bakar	5				
33	Balu a/l Arunagam	5				
34	Revalina	7.5				
35	Najihah Ismail	2.5				
36	Mariam	10				
37	Kamariah	5				
38	Latifah Jusoh	7.5				
39	Hajar Nasir	5				
40	Puteri Jamali	2.5				
41	Kamaruddin Ismail	7.5				
42	Bedah Syarip	2.5				

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43	Kamal Budin	10				
44	Mala a/p Balu	10				
45	Sumita a/p Devi	5				
46	Lukman Salim	10				
47	Awang Sufi	10				
48	Sopian Ismail	5				
49	Kamaluddin Budin					
50	Karim Sulaiman	5				
51	Milah Salleh	5				
52	Adila Salleh	10				
53	Afifah Syarif	5				
54	Jah Budin	10				
55	Cik Nik Karim	5				
56	Musa Leman					
57	Qhari Ismail	10				
58	Ghani Hamzah	5				
59	Yusof	10				
60	Khadijah Nik	5				
61	Rogayah Majid	7.5				
62	Maton Saadiah	10				
63	Izatul Ghani	7.5				
64	Asma Salleh					
65	Aina Ghani	7.5				
66	Nur Awatif	2.5				
67	Din Salleh	10				
68	Lim Kit Liang					
69	Marliah Sudin	7.5				
70	Salina Khorina	10				
71	Sarah Karim	7.5				
72	Nurul Sarinah					
73	Hidayati Ismail	5				
74	Sarina Ismail	10				
75	Mohd Najmi	7.5				
76	Najmiah Ismail	5				
77	Jannatulnaim					
78	Khairul Naim	10				
79	Karim Khabir	5				
80	Bhatia a/l Raju					
81	Cakra Khairul	10				
82	Hajar Aminah	5				
83	Karim Saleh	10				
84	Lina Salleh	10				
85	Kinah Majid	10				
86	Lokman al Hakim					
87	Majidah Jusoh	10				
88	Munah Jamil	2.5				
89	Liana Kamil	7.5				
90	Tania a/p Laju	10				

91	Mohd Najmi	7.5				
92	Kamariah	5				
93	Nazaruddin	5				
94	Azmi Yani Kamal	7.5				
95	Najmiatul Najwa	5				
96	Nur Hidayu	10				
97	Lai Li Kui	5				
98	Koriah Jamal	10				
99	Laila Salim	5				
100	Limah Hasan	10				

Note:

Colour	Score
	0
	2.5
	5
	7.5
	10

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APPENDIX C

Geoheritage Values Assessment

GEOHERITAGE VALUES PARAMETER	
SCIENTIFIC VALUE	AESTHETIC VALUE
Sedimentology	Geomorphology
Stratigraphy	Integrity of features
Structure Geology and Tectonic	Colour contrast with site surroundings
Palentology	Paleontology
Mineralization	Mineralization
Petrography and Petrology	Petrography and Petrology
Plutonism and Volcanism	Plutonism and Volcanism
Metamorphism	Metamorphism
Scientific Writing	Scientific Writing
	Panoramic
RECREATIONAL VALUE	CULTURAL VALUE
Atrraction	Legends
Accessibility	Myths
Safety	Belief/traditional faiths
Calmness and Comfort	Religion
Scenery	Archaeological
Recreational activities	Documentary
	Urbanization
ECONOMICAL VALUE	RECREATIONAL VALUE
Uniqueness	Accessibility
Rarity	Vulnerability
Priceless	Legal protection
Integrity	Current condition

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APPENDIX D

SCORE FOR EACH GEOHERITAGE PARAMETERS (0-10)				
0	**2.5**	**5**	**7.5**	**10**
SCIENTIFIC VALUE				
No	Not/Less clear	Moderate clear	Clear	Very clear
0	5-10m	10-25m	25-50m	>50m
No	Less clear /localise	Clear from tectonic basin system /mountainous	Clear from continental tectonic	Clear to explain regional tectonic
No fossil	Several certain fossil	Plenty of certain fossil	Abundant with some fossil	Index fossil
Very common ordinary minerals	Special certain rock forming minerals	Physically unique minerals	Economic minerals	Unique and economic minerals
No	Less supportive to interpretation	Moderately supportive interpretation /related	Supportive /Related with interpretation	Related with interpretation
No	Passive plutonic	Active plutonic (orogeny)	Passive volcanic	Active volcanic
Low grade /regional	Moderate grade /contact	Intermediate grade /hydrothermal	Dynamic	Shock
No	<2 general report	2-3 general report	2/3 special report	> 3 special geosites report
AESTHETIC VALUE				
-	1 process	2 process	3 process	>3 process
Destroy	Strongly deteroriated	Moderately deteroriated	Weakly deteroriated	Intact
Similar colour	Almost similar colour	Different colour	Almost opposite colour	Opposite colour
-	Not clear	Moderately clear	Clear	Very clear
-	1 element	2 elements	3 elements	4 elements
No view points	1	2-3	4-6	>6
-	<50m	50-200m	200-500m	>500m
-	Narrow, <20m	Moderate, 20-50m	Wide, 50-100m	Very wide, >100m
-	Low,<10m	Moderate high, 10-30m	High, 30-50m	Very High >50m
No panoramic view	Obstructed	Moderately obstructed	Less obstructed	No obstructed

RECREATIONAL VALUE				
No attraction	Low, 1 attraction	Moderately, 2-3 attractions	High, 4-5 attractions	Very High, >5 attractions
>1km boat ride	<1km boat ride	>1km natural track	<1km natural track	Easily accessible from main road
Not secure	Low security	Moderately security	High security	Very high security
Uncomfortable	Low	Moderately	High	Very high
No scenery	Less scenery	Moderately scenic	Scenery	High scenery
0	<2	<2-3	3-5	>5
CULTURAL VALUE				
Localise	District	Division	State	National
Localise	District	Division	State	National
No	1 belief	2 beliefs	3 beliefs	>3 beliefs
No	1 religion	2 religions	3 religions	>3 religions
No	No	1 archaeological site	2-3 archaeological sites	>3 archaeological sites
No	1 document /naming	1 document and 1 naming	2 all documents	>details documents
No	1 traditional village	2 villages and 1 housing	2 villages and housings	Surrounded by new housings

ECONOMICAL VALUE				
Division	State	National	Regional	Global
>7	5-7	3-4	1-2	1(Unique)
No price	Low price	Normal price	High price	Very high price
1 Geodiversity	2 Geodiversity	3-5 Geodiversity	5-7 Geodiversity	>7 Geodiversity

Source (Ali,2016)

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APPENDIX E

Total Heritage Value Rank

Total Heritage Value Rank (HVT)	
Rank	**Value**
High	191-250
Intermediate	91-190
Low	0-90

Source: (Ali, 2016)

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APPENDIX F

Total Heritage Value Rank for Development

Total Heritage Value Rank for Development (HVD)	
Rank	**Value**
High	40-60
Intermediate	20-39
Low	0-19

Source: (Ali, 2016)

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APPENDIX G

1.	338	**21.**	68
2.	341	**22.**	67
3.	356	**23.**	66
4.	342	**24.**	64
5.	344	**25.**	34
6.	347	**26.**	33
7.	343	**27.**	66
8.	344	**28.**	65
9.	351	**29.**	69
10.	355	**30.**	71
11.	343	**31.**	44
12.	62	**32.**	65
13.	68	**33.**	28
14.	70	**34.**	67
15.	67		
16.	27		
17.	74		
18.	65		
19.	68		
20.	34		

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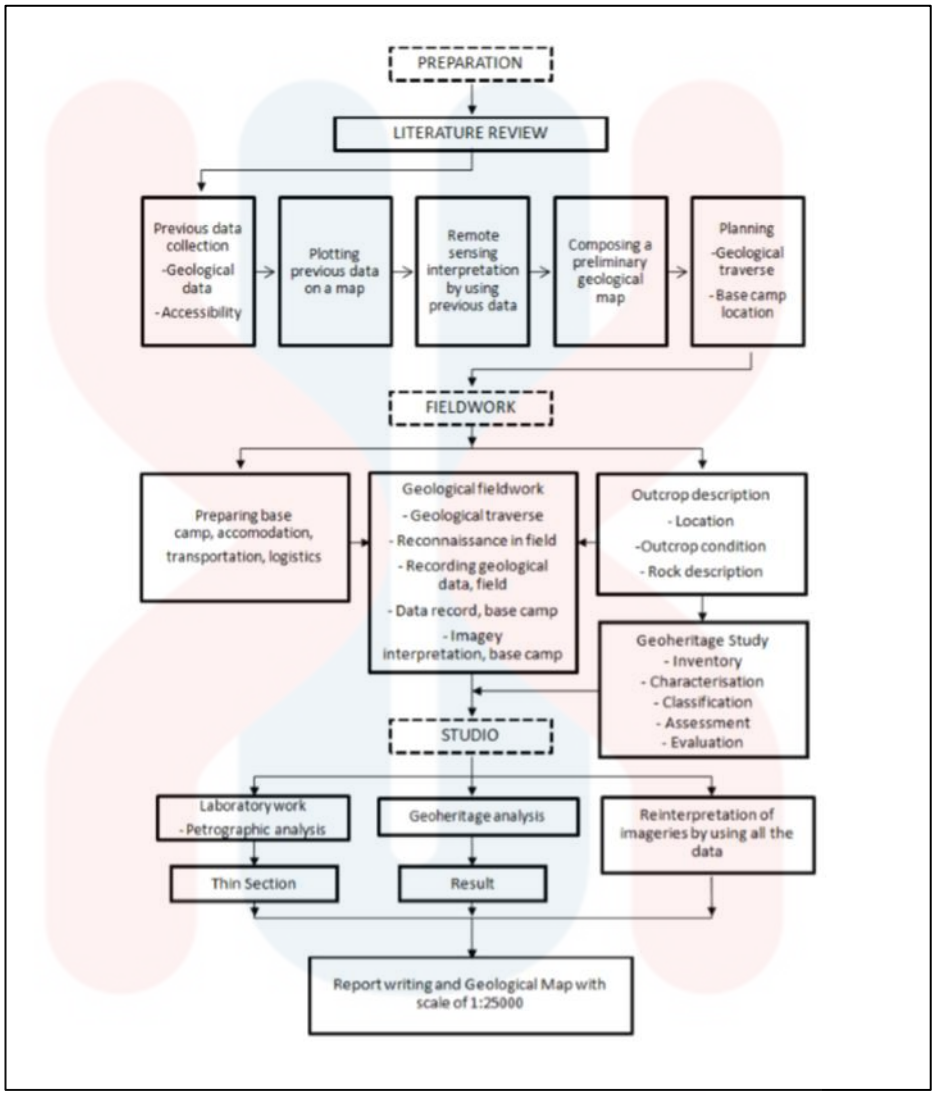
Research flow chart



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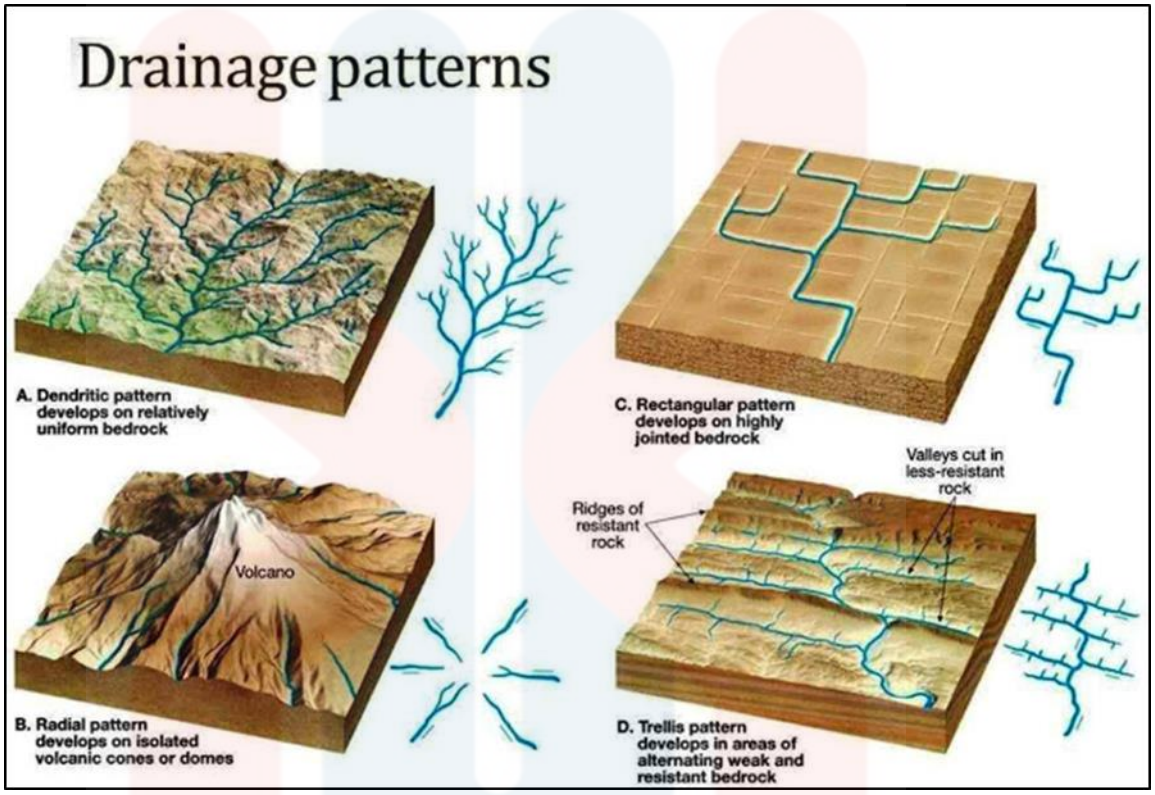
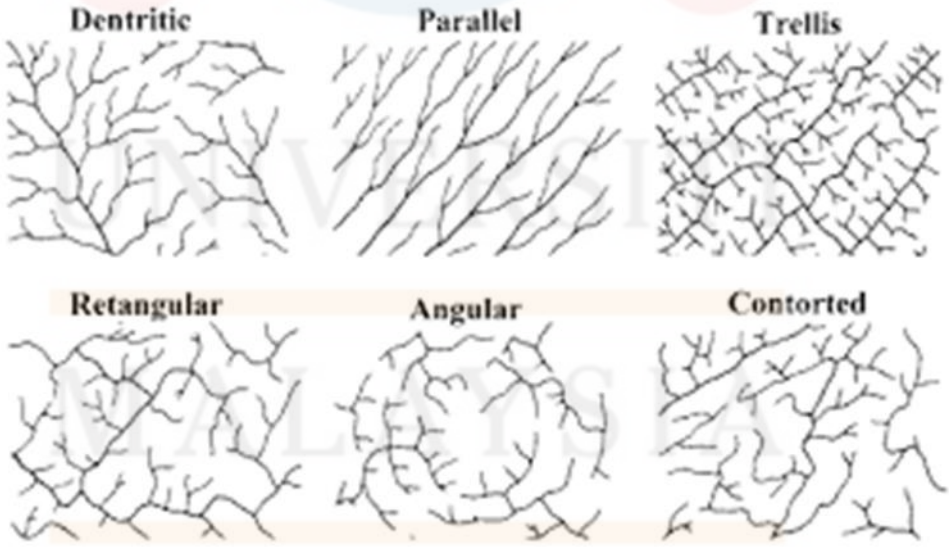
APPENDIX H


Drainage patterns
A. Dendritic pattern develops on relatively uniform bedrock
C. Rectangular pattern develops on highly jointed bedrock
Volcano
B. Radial pattern develops on isolated volcanic cones or domes
Ridges of resistant rock
Valleys cut in less-resistant rock
D. Trellis pattern develops in areas of alternating weak and resistant bedrock


Dentritic
Parallel
Trellis
Retangular
Angular
Contorted