GENERAL GEOLOGY AND INFLUENCES OF GRAIN SIZE DISTRIBUTION ON PERMEABILITY OF SOIL AT KAMPUNG SUNGAI TERAH, GUA MUSANG, KELANTAN.

by

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

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DECLARATION

I declare that this thesis entitled "General Geology And Influences Of Grain Size Distribution On Permeability Of Soil At Kampung Sungai Terah, Gua Musang, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________________

Name : ________________________________

Date : ________________________________

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ABSTRACT

The properties of soil are important in an area. Thus, it is important to study the permeability of soil and their grain size distribution in an area. The study area is located at Kampung Sungai Terah, Gua Musang, Kelantan within the latitude 4° 53' 14.5" N to 4° 55' 57.5'' N and longitude 101° 55' 53.5" E to 101° 58' 36.5'' E which comprised approximately 25km^2. The objectives of this research are to produce a geological map of study area at scale 1:25,000 and to investigate the influence of grain size distribution on permeability of soil. The methods that used to produce geological map is by field mapping and Geographic Information System (GIS). The field mapping includes the observation of lithology, geomorphology, and structural geology. The lithology found at study area is granite, limestone, shale and sandstone. Soil analysis is done by laboratory test which is falling head permeability test and sedimentation test. The falling head permeameter is used for permeability test of soil and sedimentation test by pipette is used for grain size distribution of soil. This research showed that the study area is mostly consisted of clays with fine grain soil and have low permeability rate.

Keywords: Soil, Permeability, Grain size

GEOLOGI AM DAN PENGARUH TABURAN SAIZ BUTIRAN TERHADAP KEBOLEHTELAPAN TANAH DI KAMPUNG SUNGAI TERAH, GUA MUSANG, KELANTAN

ABSTRAK

Sifat-sifat tanah adalah penting dalam sesebuah kawasan. Oleh itu, adalah penting untuk mengkaji kebolehtelapan tanah dan taburan saiz butiran tanah di sesuatu kawasan. Kawasan kajian terletak di Kampung Sungai Terah, Gua Musang, Kelantan dengan latitud 4° 53' 14.5" N hingga 4° 55' 57.5" N dan longitud 101° 55' 53.5" E hingga 101° 58' 36.5" E yang terdiri daripada kira-kira 25km^2. Objektif kajian ini adalah untuk menghasilkan peta geologi kawasan kajian pada skala 1: 25,000 dan untuk menyiasat pengaruh taburan saiz butiran ke atas kebolehtelapan tanah. Kaedah-kaedah yang digunakan untuk menghasilkan peta geologi adalah dengan pemetaan lapangan dan Sistem Maklumat Geografi (GIS). Pemetaan lapangan termasuklah pemerhatian litologi, geomorfologi, dan geologi struktur. Litologi yang didapati di kawasan kajian adalah granit, batu kapur, syal dan batu pasir. Analisis tanah dilakukan dengan ujian makmal iaitu ujian kebolehtelapan dan ujian pemendapan. Meter telap digunakan untuk ujian kebolehtelapan tanah dan ujian pemendapan oleh pipet digunakan untuk taburan saiz butiran tanah. Kajian ini menunjukkan bahawa kawasan kajian adalah kebanyakannya terdiri daripada tanah liat dengan tanah yang mengandungi saiz butiran halus dan mempunyai kadar kebolehtelapan yang rendah.

Kata kunci: Tanah, Kebolehtelapan, Saiz butiran

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LIST OF ABBREVIATIONS

GIS	Geographic Information System
IUGS	International Union of Geological Sciences
GPS	Global Positioning System
HCl	Dilute Hydrochloric Acid
N	North
S	South
E	East
W	West

LIST OF SYMBOL

m	Metre
µm	Micro metre
cm	Centimetre
mm	Millimetre
ml	Milliliter
%	Percent
°C	Degree celcius
g	Gram
s	Second

CHAPTER 1

INTRODUCTION

1.1 General Background

Permeability is the property that represents the ease with which water flows through porous media. It is one of the important physical properties used in soil engineering as some of the major problems of soil mechanics are directly connected with it.

Design of the construction of highways, dams and airports depend upon the permeability of soil. It is necessary for estimating the quantity of underground seepage under various hydraulic conditions, for investigating problems involving these constructions.

Soils are permeable due to the existence of interconnected voids which water can flow through it. A material is said to be permeable if it contains continuous voids. Since such voids are contained in all soils including the stiffest clay, all these are permeable. Gravels are highly permeable and stiff clay is the least permeable soil. Hartkamp et al. (1993) state that different styles of natural grain packing influence sample permeability, obscuring relationships between grain sorting and permeability.

1.2 Problem Statements

Soil is consist of different-sized particles depends on the proportion of sand, silt and clay-sized particles and organic matter in the soil. Soil has the properties of permeability in which permeability varies with particle size. It is logical that the smaller the grain-size, the smaller the voids and the lower the permeability. Different soils give different permeability due to influence of grain size distribution in soils. Besides that, the structural properties or characteristics of the rock or soil such as faults, folds and joints are also influence their permeability rate. In changing of time, there are new outcrop exist in an area and this give the changing of lithology at the area. In order to verify the existing data, this research needs to be conduct so that the new data can be obtained. The geological information at study area needs to be updated according to changes that happen at that area. So, the new geological map of study area needs to be produce.

1.3 Research Objectives

The objectives of this research are:

i. To produce geological map of study area at scale 1:25,000.

ii. To investigate influence of grain size distribution on permeability of soil.

1.4 Study Area

1.4.1 Location

The study area is located at Kg. Sungai Terah, Gua Musang, Kelantan. Gua Musang is a town and territory in Kelantan, Malaysia. It is the largest district in Kelantan. Gua Musang district is bordered by the state of Pahang to the south, Terengganu to the east and Perak to the west. It is a small railway town about 160 kilometers south of Kuala Krai.

The study area gives the total area of 25 km^2. This area is located near Gua Musang town. Figure 1.1 shows the study area.

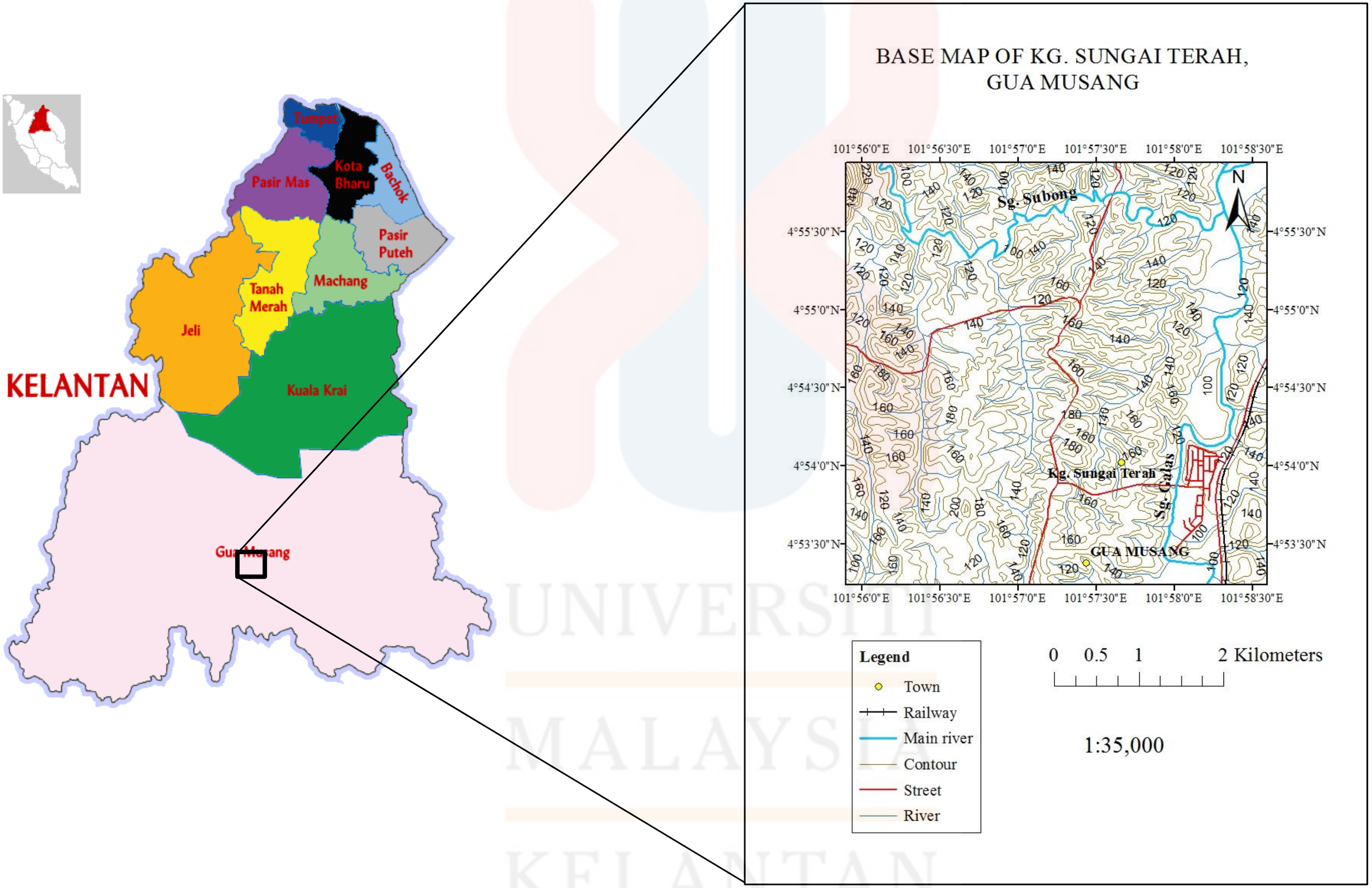

Figure 1.1: Base map of Kg. Sungai Terah, Gua Musang

1.4.2 Demography

People distribution is the population of people in an area. Total population of people in Gua Musang district is 86 189 people which is including area of Batu Papan, Bertam, Chegar Bongor, Gua Musang, Kerinting, Limau Kasturi and Paya Tupai. Table 1.1 shows the people distribution of Gua Musang district based on the races. People distribution of Gua Musang is divided into two which are Malaysian citizens and non-Malaysian citizens. Most of population in Gua Musang are from Malay race which is 64 253 people whereas the other bumiputera is about 12 570 people. Other ethnics such as Chinese are about 3870 people, Indians are 350 people and others are 161 people. For non-Malaysian citizens, there are about 4985 people in this district.

Table 1.1: Total population by ethnic group distribution in Gua Musang

Source: Department of Statistic Malaysia, 2010

Local Authority Area	Total	Malaysian Citizens					Non-Malaysian Citizens
		Bumiputera		Chinese	Indians	Others	
		Malay	Other Bumiputera				
M.D. Gua Musang	86,189	64,253	12,570	3,870	350	161	4,985
Batu Papan	2,594	1 ,512	8	883	132	8	51
Bertam	1,142	1 ,131	-	1	1	-	9
Chegar Bongor	494	3 98	-	24	-	4	68
Gua Musang	18,420	1 5,285	88	2,217	155	30	645
Kerinting	157	1 28	-	1	15	-	13
Limau Kasturi	975	8 93	-	5	-	7	70
Paya Tupai	337	3 25	-	-	-	-	12
Remainder of M.D.	62,070	4 4,581	1 2,474	739	47	112	4,117

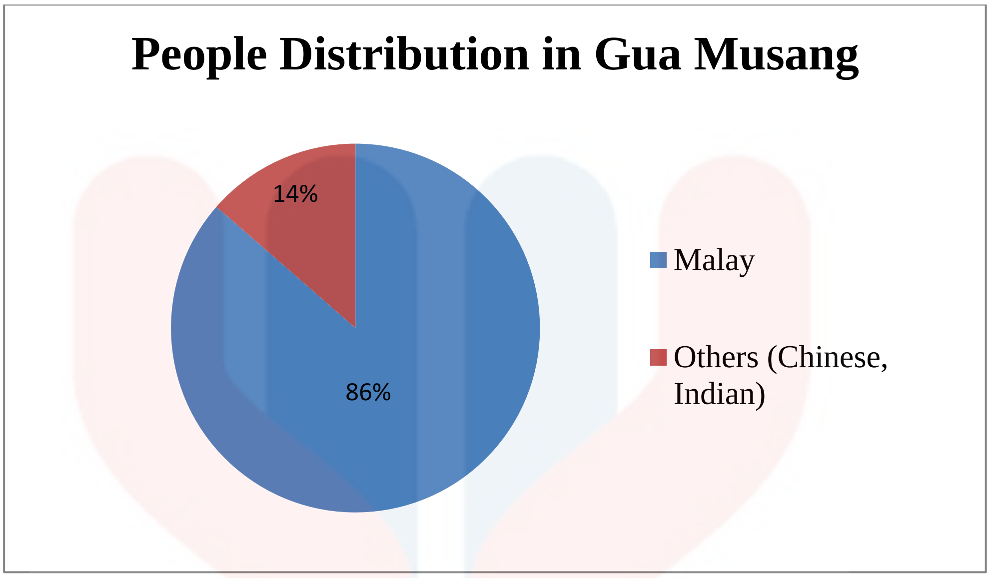

Figure 1.2: People distribution in Gua Musang

1.4.3 Rainfall

Table 1.2 shows the rainfall distribution at Gua Musang District among year of 2014. The total rain distribution of Gua Musang area is 3220 mm. Based on Table 1.2, the highest reading of rain distribution is on August which is 618 mm whereas the lowest reading of rain distribution is on February which is 3 mm. August and December show high rate of rainfall distribution caused by monsoon climate within these months.

Table 1.2: Rainfall distribution in 2014 at Gua Musang

Source: Department of Irrigation and Drainage

Month	Rainfall distribution, mm
January	136
February	3
March	196
April	169
May	225
June	215
July	90
August	618
September	489
October	313
November	175
December	591
Total	3,220

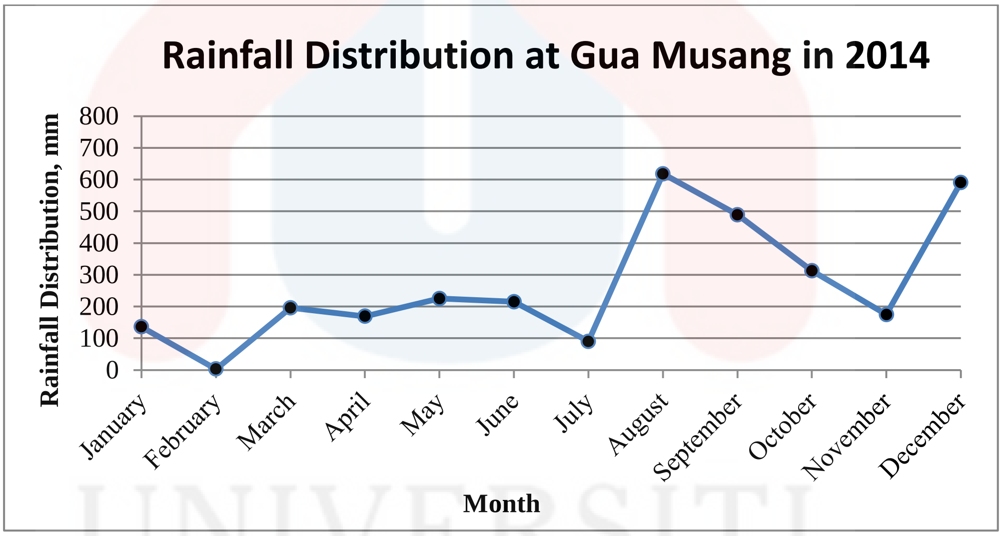

Figure 1.3: Rainfall distribution in 2014 at Gua Musang

1.4.4 Land use

The land use in the study area is consisted of forest, plantation, residential and construction area. The study area is mostly covered by forest which is consisted of rubber plantation and oil palm. There are also the residential area of several small villages that associated by many human population. Residential land uses involve small area but consist of compacted housing area which contributes to many population. The study area also covered by construction area of some new buildings due to this area that near Gua Musang town. The other areas are covered by roads and others.

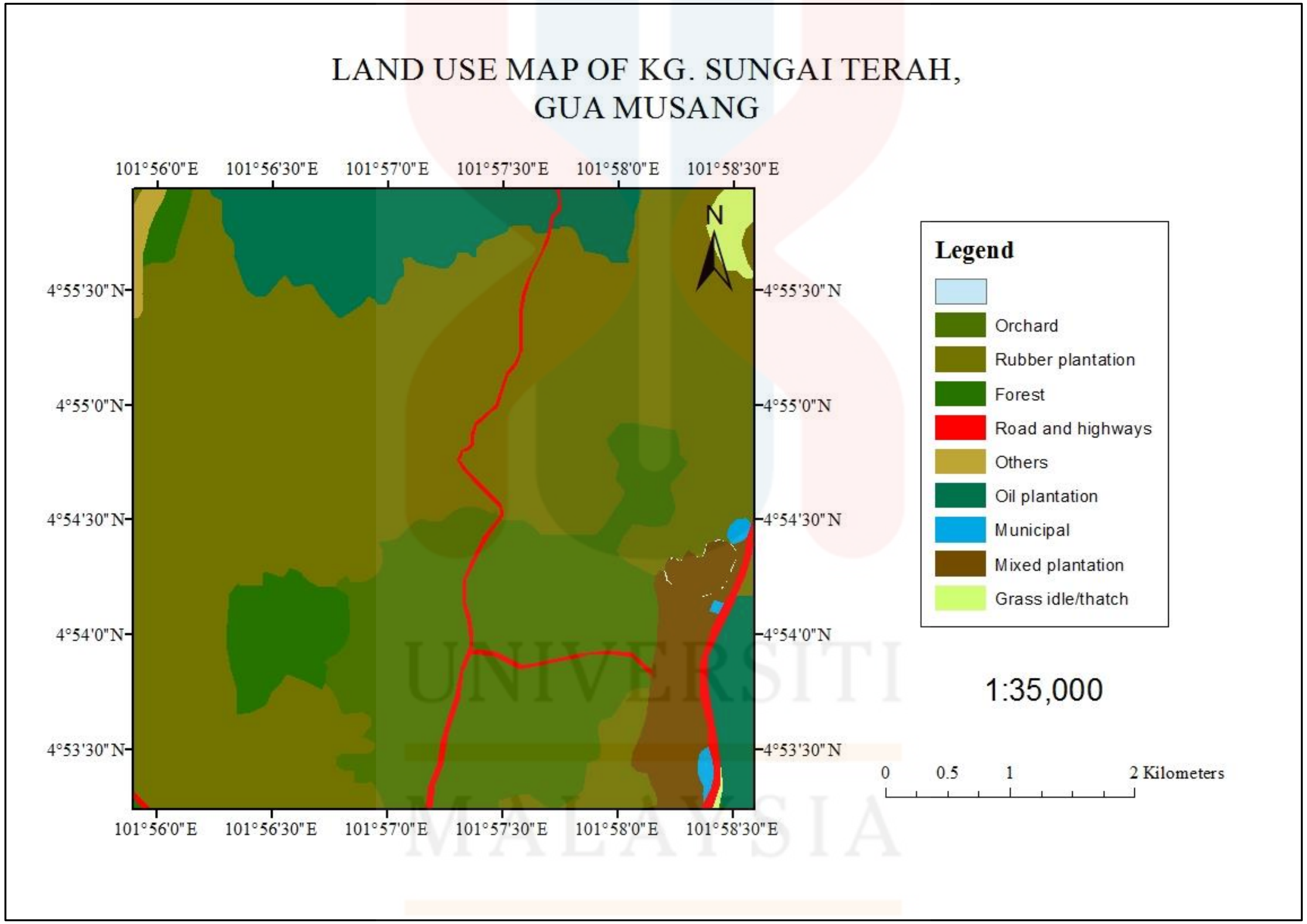

Figure 1.4: Land use map of Kg. Sungai Terah, Gua Musang (Source: DSMM 2006, DATUM: KERTAU RSO)

1.4.5 Social Economic

Particular areas of land can be utilized by humans in diverse ways. Some of the social economics at study area are in the sector of business, agriculture and government. Some of the villagers are involved in rubber plantation and oil palm. Besides some of them have their own farm within that area. The study area is near Gua Musang town. So, some of them are in involve in government sector. Besides that, they are also had their own business by open the retail store or restaurant.

1.4.6 Accessibility

The road is important at an area to connect one place to other places. The study area consists of Gua Musang-Jelawang road as a main road at study area. This road is connecting Gua Musang area to Jelawang and Dabong area. There are also the roads that connect the villages within the study area. So, the people can access to other places such as Gua Musang town and others. Besides that, the study is also consisted of railway. This railway is connecting Gua Musang area with another area.

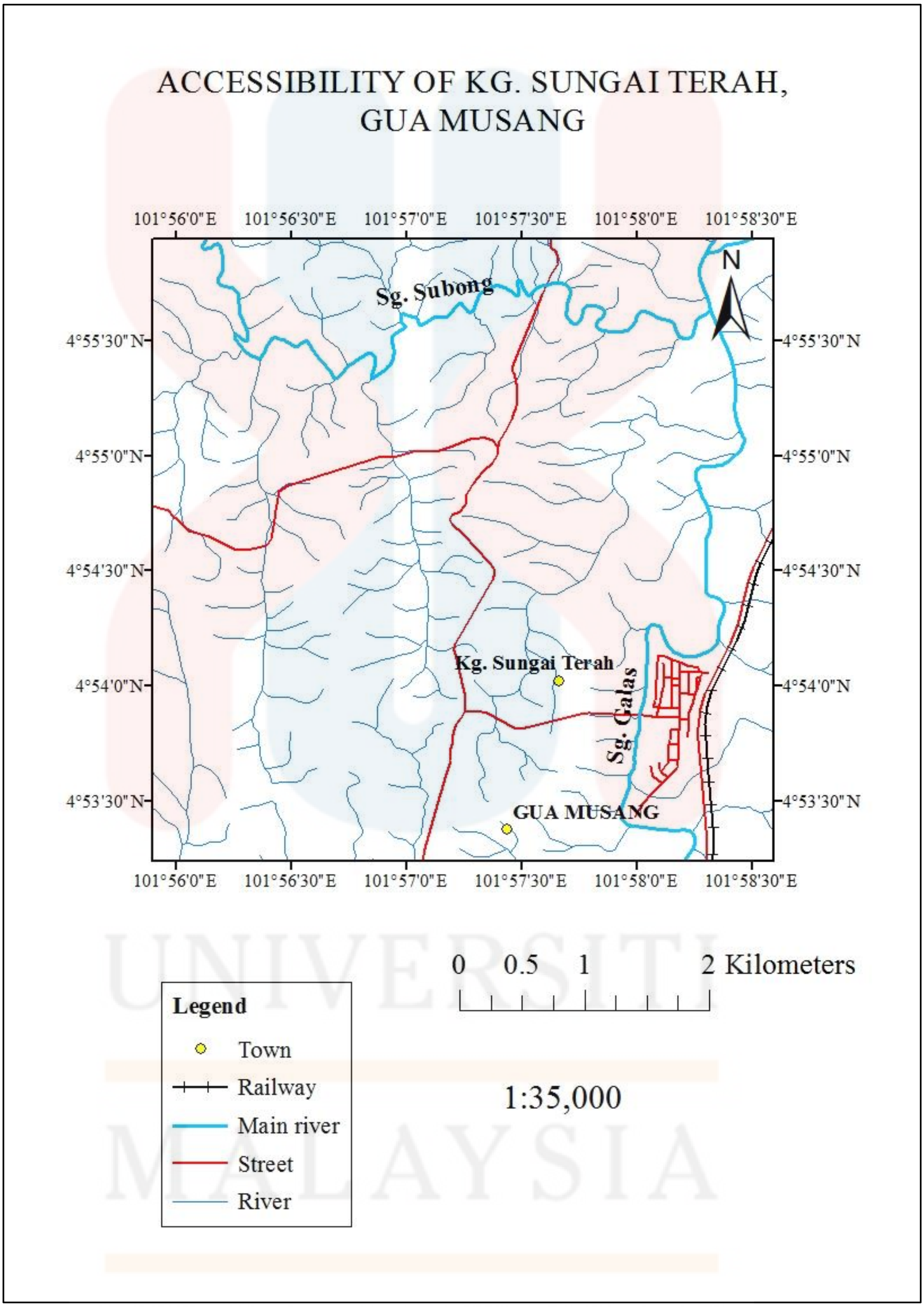

Figure 1.5: Road connection to access of study area

1.5 Scope of Study

This research is focusing on general geology of study area and the permeability of soil at study area. General geology is including the geological mapping in order to collect the data for the study area. This research is important to identify the properties of soil within an area in order to know how grain size distribution influences the permeability of soil.

1.6 Research Importance

It is important to provide latest information about geology of study area in order producing a latest geological map so that it can be used for future research. Understanding permeability in order understanding the structure of the soil and how water passes through different layers is also important. Determination of soil permeability enables the possibility of construction or designation of dams, highways or airports.

1.7 Conclusion

Soil is an important element on earth's surface in term of the structure, strength, porosity and permeability. This is because it can determine the condition of an area whether it safe or not for any activities or constructions. It is important to study the permeability of soil at study area in order to know the condition of soil at there in term of engineering geology.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, there is some detail information explaining about the general geology of the study area and also engineering geology focusing on permeability of soil. General geology part is including the regional geology and tectonic setting, historical geology, stratigraphy and structural geology of study area. Engineering geology part is discussing on the permeability soil analysis that focusing on grain size distribution of soil at study area.

2.2 General Geology

2.2.1 Regional Geology and Tectonic Setting

Peninsular Malaysia is divided into three belts. There are Eastern Belt, Central Belt and Western Belt. Kelantan is located between Eastern Belt and Central Belt. Gua Musang Formation is located at Central Belt of Peninsular Malaysia.

According to Metcalfe (2000), Gua Musang is represents Bentong–Raub Suture zone. This zone is from the Foothills Range than interpreted as a subduction zone by Haile (1973) and Hutchison (1973). Then, it recognized as the central Malaya suture and known as the "Bentong-Raub Line" (Hutchison, 1975). The Bentong-Raub suture represents the Palaeo-Tethys in Peninsular Malaysia. It is a southwards extension of the Nan-Uttaradit and Sra Kaeo sutures of Thailand. The Bentong-Raub Suture Zone is well-exposed at road-cuts along the Gua Musang-Cameron Highland road, Karak Highway and Bentong-Raub road (Jasin, 2013).

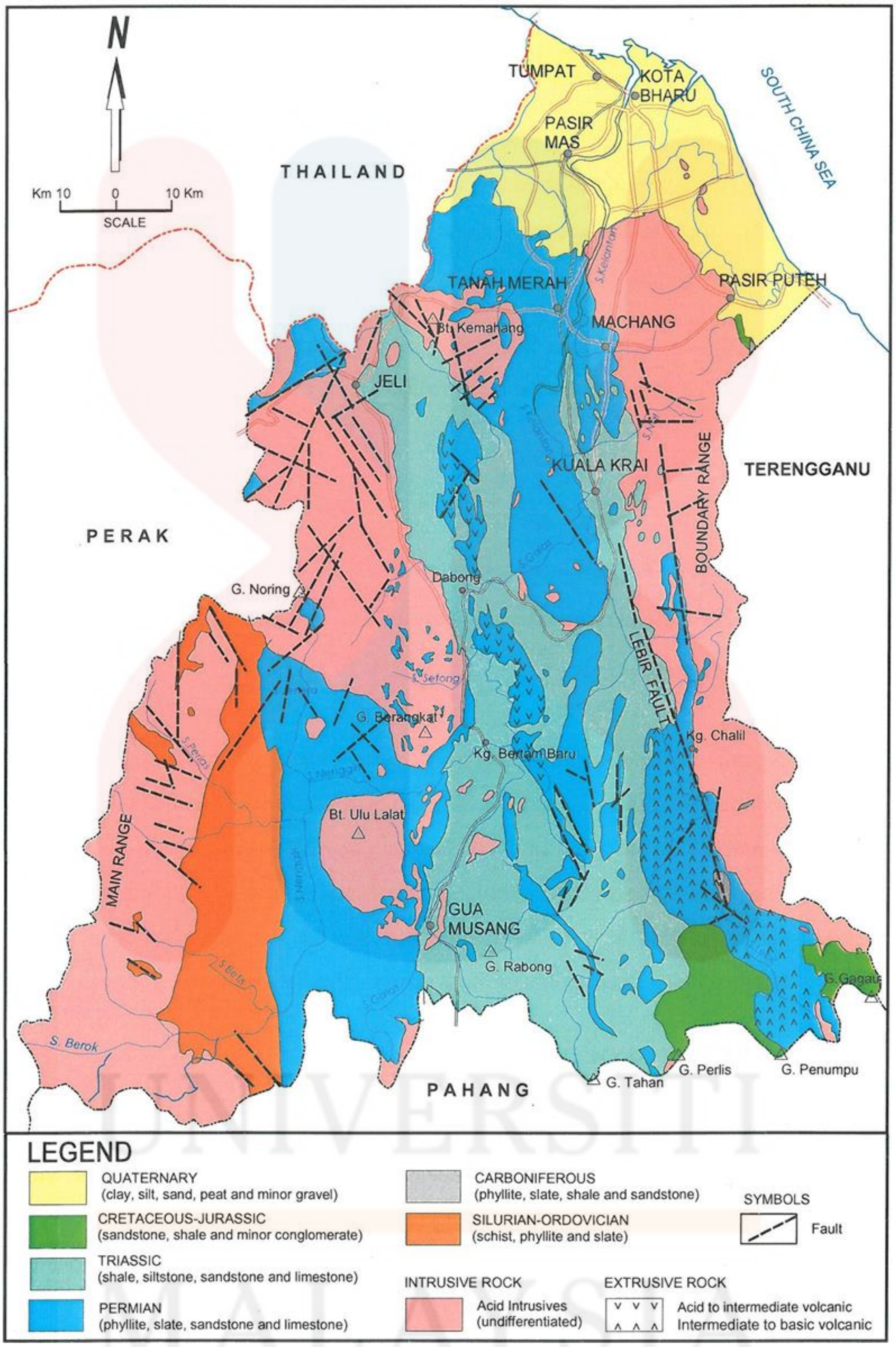

Figure 2.1: The geological map that shows the different distribution of rock of Kelantan

Source: Department of Minerals and Geoscience, 2003

2.2.2 Historical Geology

The geological formation of Kelantan can be divided into three main chronologies which are Paleozoic, Mesozoic and Cenozoic. The age of Gua Musang Formation is from the Middle Permian to Upper Triassic (Mohd Shafeea Leman, 1993 and 2004). According to Hutchison & Tan (2009), in the western part of the Central Belt are Upper Paleozoic rocks of the Gua Musang and Aring Formations in south Kelantan and Taku Schist in east Kelantan. The Upper Paleozoic rocks are predominantly of argillaceous strata and volcanic rocks. During Mesozoic, Gua Musang Formation is a part of Gua Musang-Semantan depocentre that lays east of the Bentong-Raub Suture within Central Belt which exposures of Middle Permian to lower Middle Triassic (Anisian) rocks in Gua Musang area. It composed predominantly of calcareous and argillaceous rocks with subordinate arenite, pyroclastics and lava flows (Yin, 1965).

2.2.3 Stratigraphy

There are two formation located at Gua Musang which is Gua Musang Formation and Gunung Rabong Formation. The Gua Musang Formation is in the western part and the Gunung Rabong Formation is in the eastern part of Kelantan state.

Gua Musang Formation estimated to be 650 m thick, is made up of crystalline limestone, interbedded with thin beds of shale, tuff, chert nodules and subordinate sandstone and volcanics (Hutchison & Tan, 2009). According to Yin (1965) the Gua Musang Formation was described as a Middle Permian-Upper Triassic aged sedimentary formation consisting mainly of argillaceous facies, mudstone and pelitic hornfel, slate and phyllite, sandstone and metasandstone rocks. Some occur as outcrops through the Triassic cover of Gunung Rabong Formation in the eastern area.

Yin (1965) also states that in the eastern side, the Middle-Upper Triassic age Gunung Rabong Formation sedimentary rocks consist mainly of sandstone with subordinate shale, mudstone, and siltstone, conglomerate and volcanic.

2.2.4 Structural Geology

The major faults are divided into three types, which are terrane-bounding, terrane-parallel and terrane-crossing faults (Hutchison & Tan, 2009). Terrane-bounding faults are the faults that divide the Peninsula into three belts or terrane which consisting of Bentong-Raub Suture Zone and Lebir Fault Zone.

Based on Tan (1976) and Harbury et al. (1999), Bentong–Raub Line represents a major normal fault. It forms the western boundary of a Mesozoic graben and then the geology reveals a major orogeny in the Permian and a less severe deformation in the Cretaceous (Harbury et al., 1990). The Bentong-Raub Line is a distinct N–S lineament along the eastern foothills of the Main Range (Hutchison, 1975) and it separates the Western from the Central Belt.

The boundary between the Central and Eastern Belts is marked by the Lebir Fault Zone. According to Hutchison and Tan, (2009) the Lebir Fault Zone can be traced on the RADARSAT imagery as broad zone of NNW-SSE-trending curvilinear lineaments along Sungai Lebir near Manek Urai in Kelantan. The lineaments can be continuously traced to the south, passing along the remarkably straight boundary of the granite batholiths east of Sungai Lebir.

2.3 Engineering Geology

2.3.1 Permeability of soil

Soils are permeable due to the existence of interconnected voids through which water can flow from points of high energy to points of low energy. Permeability is a property of the ease in which water can flow through a soil. It is a parameter in soil mechanics to determine the water flow rate within soil medium. It controls the strength and deformation behavior of soils. An excavation depends on the quantity of water that flows toward it, whereas in dam construction, design of cutoffs beneath it is important in order to know the possibility of permeable soil.

In tunneling construction, the excavated soil is required in the bulk chamber behind the cutter head which characterized by deformation behavior to be able to apply the needed stabilizing pressure to the face (Merritt and Mair, 2006; Vinai et al., 2008; Peila et al., 2007; Cardu et al., 2009; Fuoco and Oreste, 2009). So, a soil with low permeability is able to correctly apply the counter-pressure to the front when underground water is present in the soil and can prevent the filtration from the front towards the bulk chamber (Quebaud et al., 1998; Peila et al., 2009). Filtration in these conditions causes destabilizing forces in the soil volume ahead of the tunnel face and requiring the theoretical application of higher stabilization forces. Anagnostou and Kovari, 1996 stated that using the limit equilibrium method and the silo-theory, a value of the permeability coefficient equal to 10^{-5}msec^{-1} is able to prevent the filtration flow and therefore the induced destabilizing force are eliminated.

Soil bulk density is commonly used as a measure of soil compaction. Soil compaction reduces pore space within the gross and can cause a new frequency distribution of effective pore sizes. The smaller the void ratio, the more difficult is yet further reduction. The magnitude of bulk volume affects the amount of further possible change in specific bulk volume of a soil and the work required to produce the additional change (Bodman and Rubin, 1948). Particle size distribution will influence the minimum bulk volume obtainable under given conditions of compaction. After compaction with a kneading compactor, the maximum and minimum bulk volumes are obtained at different moisture contents for each member of the texture series except pure sand. The minimum bulk volumes are related to the proportions of different size classes present.

Soil also can be related to the landslide occurrence. It is widely recognized that geological parameters greatly influence the occurrence of landslides, because lithological and structural variations often lead to a difference in strength and permeability of rocks and soils (Pradhan et al., 2010). Some slope failures mobilize into flows, while others slide and deposit material immediately down slope. Debris flows typically mobilize from slope failures that lose strength as they deform. According to Roscoe et al. (1958), critical-state soil mechanics state that as soils shear, grains are rearranged and approach specific, critical-state porosities (alternative measures include void ratio and density) which depend on physical properties of the soil, effective normal stress, and the stress history of the material.

The effects of grain size on pore-pressure generation and failure behavior of a slope failure are related to induce rainfall. Those rainfall-induced slope failures where silty soils control the triggering and movement of the slope failures mass. These are determined from the sands of different grain sizes and mixtures of sandy silt with loess by different weight, with emphasis on pore-pressure generation and on movement of the displaced landslide mass. In the analysis of pore pressure generation during slope failure and sliding, Iverson et al. (1997) stated that the pore pressure depends on the rate of landslide movement and soil deformation as well as the permeability of soils. If a failed landslide has equal moving velocity, the soil with higher permeability will have quicker dissipation, and thus smaller pore pressure is build-up.

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

There are a few materials and methods used in conducting this research. This chapter involves collecting of data, processing of data and analysis of data. It is very important to identify the right materials and methods so that the research can be conducted very well.

3.2 Materials

Table 3.1: Materials and tools used during the research

NO.	MATERIALS/TOOLS	USES
i.	Geological hammer	For collecting the sample of the rocks
ii.	Compass (Suunto/Brunton)	For direction finding and navigation and measure strike and dip of geological structure
iii.	Global Positioning System (GPS)	For determine coordinates, tracking structures and measuring elevation
iv.	Hand lens	To make the first analysis of rock samples in the field before further analysis in the laboratory
v.	Sample bags	To store the sample of rock or soil
vi.	Measuring tape	To take actual measurements of lithology and structures at the field
vii.	Dilute Hydrochloric Acid (HCl)	To test if a rock contains carbonate minerals
viii.	Field notebook	To write down the important data or observations at the field
ix.	Camera	To take photographs of all important features at field
x.	ArcGIS Version 10 software	A geographic information system (GIS) used for producing the base map of the research area
xi.	Base map/topological map of study area	As a reference in conducting the research at study area
xii.	Sieve	For grain size analysis
xiii.	Pipette	For sedimentation test
xiv.	Falling head permeameter	For measure permeability of soil

3.3 Methodology

3.3.1 Preliminary Study

Preliminary study is the first stage in this research. It provides an initial overview of the study area. This study has been done through the process of reading of previous reports, thesis, journals, proceedings and a reference library. It includes the observation of topographic map and geological map and also from the satellite image. Knowledge gained from the reading of the past researches also helped us to know our research area better and prepare the materials to bring and the methods used for the field mapping.

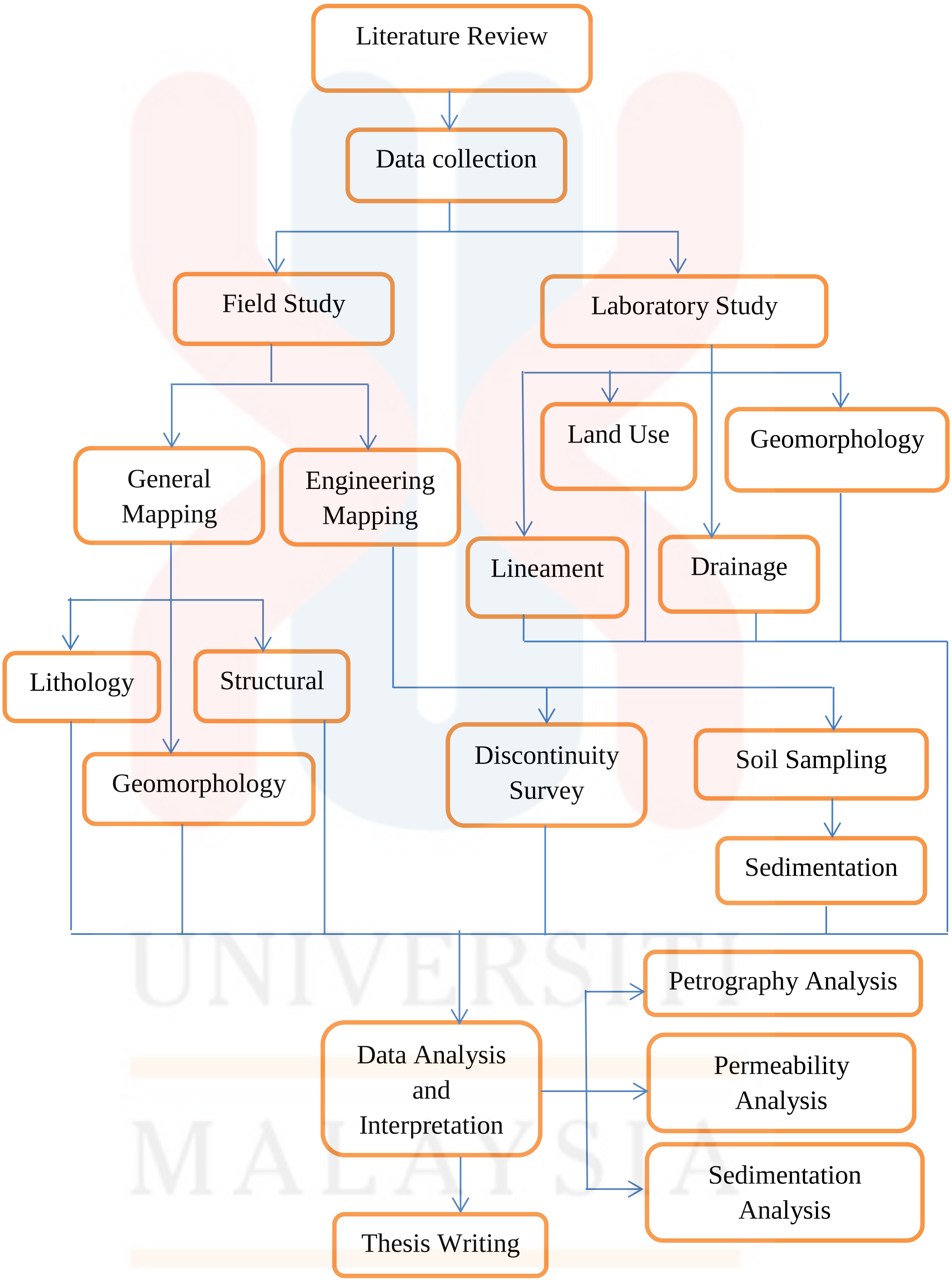

Figure 3.1: Research flow chart

3.3.2 Field Mapping

a) Geological mapping

Geological mapping is the process of making observations of geology in the field by using the equipment that needed at the field. Using the techniques of geological mapping, the study area is observed. This mapping is to find out a more details about the study area. This mapping is done by traversing using GPS and compass and also other equipment. The Global Positioning System (GPS) is a satellite-based system that used to locate any positions on the earth. GPS is used in geological field mapping for finding ones position, mapping the lithology, tracking the structures, measuring an elevation, storing sampling points and descriptions of formations when samples are collected.

The base map of study area is used in an observation at the field. Base map is based on the map that produced from ArcGIS software and the map is obtained from Google Earth. This base map is focusing on the study area. In geological mapping, the geological aspects are given attention to such as the lithology, structural geology and geomorphology. The general geology also is observed at the study area. By this mapping, the structural geology such as fault, fold and lineament is observed. The data collected from these geological aspects is used to produce the several different types of geological map.

b) Engineering geological mapping

i) Discontinuity survey

The deformation that acts on the rocks can cause the occurrence of slope failure. So, the identification and characterization of structural geology at the study area are very important. The structures include faults, folds, joints and foliation is observed on the outcrop. A discontinuity is like a bedding, foliation, joint, cleavage, fracture, fissure, crack, or fault plane. The properties of the discontinuities in the rock are important in determining the mechanical behavior of rock mass. This mapping is to identify the underlying subsurface geometry of rock units and the deformation and stress experienced in an area.

ii) Sampling

The samples of the outcrop or soil at study area are collected for further analysis at the laboratory. For any outcrop that found at research area, the sample of the outcrop must be the fresh one and not weathered so that the data analysis resulted from laboratory analysis is correct. Soil samples also are collected at the field for further laboratory analysis such as permeability analysis and grain-size analysis. The soil sample is collected in several areas at the study area.

3.3.3 Laboratory Investigation

a) Thin Section

Thin section is used for laboratory preparation of rock or soil sample. This is done by microscopic examination of thin section. This method is used for identifying the lithology which is the type of rock of different location at the study area. A thin section is prepared in which the rock sample is cut and attached to the glass slide to be observed under microscope. A thin section or petrographic thin section is a laboratory preparation of a rock, mineral, soil, pottery, bones, or even metal sample use a polarizing petrographic microscope, electron microscope and electron microprobe. A thin sliver of rock is cut from the sample with a diamond saw and ground optically flat. It is then mounted on a glass slide and then ground smooth using progressively finer abrasive grit until the sample is only 30 μm thick. Typically quartz is used as the gauge to determine thickness as it is one of the most abundant minerals.

b) Permeability test

There are two general types of permeability test methods that are routinely performed in the laboratory. First is the constant head test method, and second is the falling head test method. The constant head test method is used for permeable soils and the falling head test is mainly used for less permeable soils. Since the study area consist of fine soil, the falling head test is used in the laboratory.

The sample is compacted in the lower chamber section of the permeameter apparatus within the lower chamber rim. An appropriate tamping device is used to compact the sample to the desired density. The upper section of the chamber tie rods is removed and the upper porous stone is placed on the specimen, securing the upper section of the chamber with spring to the unit. The length of the specimen is measured and recorded. The clamp is used to attach the falling head standpipe to the support rod. The standpipe is positioned as high as is possible for practicality. The meter stick is placed directly behind the standpipe, so the height of water in the standpipe above the chamber outflow port may be read. Then, the specimen is saturated. The heights of the water levels from the outflow level are measured.

Figure 3.2: Permeability test apparatus

Figure 3.3: Soil compaction for permeability test

c) Sedimentation

Sedimentation is a method for soil tests in which to determine the particle size distribution of the soils. To measure soil properties correctly, a standard laboratory technique is required by precise sampling methods. Sedimentation by pipette test method is used for the soil samples.

Sedimentation is a test for fine grain soil such as clays. In sedimentation test, before proceeding with pipette sedimentation test, the soil is chemically treated to remove organic matter to ensure that discrete particles are separated. This process is known as pretreatment. In sedimentation test, the test specimen is obtained from the air-dried original sample by riffling, or by cone-and-quartering using the fraction which passes a 2 mm sieve. It is not necessary to determine the exact mass at this stage unless the losses due to pretreatment are required.

In pipette test, the soil is placed in a 650 ml conical beaker and 50 ml of distilled water is added. The suspension is boiled gently until the total volume is reduced is about 40 ml. The suspension is allowed to cool and then 75 ml of hydrogen peroxide is added. After that, the suspension is covered with a cover-glass and allowed to stand overnight. For pretreatment for calcareous matter, a check should always be made for reaction with hydrochloric acid (HCl) by dropping a few spots of HCl on to a small portion of the sample. If there is no effervescence, acid treatment is not required. A visible reaction indicates the presence of calcareous compounds.

The contents of conical beaker are transferred to the funnel, rinsing the beaker with little distilled water to ensure that no soil is lost. If acid treatment has been carried out, the washing must continue until all traces of acid are removed. The residue is transfer to evaporating dish and then is dried in oven, cool and weigh. The dry mass of prepared soil is calculated. When the soil has been filtered, it is transferred from the evaporating dish to a suitable container, such as conical flask with stopper and shaked vigorously at least 4 hours until all soil is in suspension.

Then, the soil and suspension is transferred to a 63 μm sieve, nested on a receiver, without loss of soil. The soil is washed with distilled water, until all fine material is washed through the sieve. The material collected in the receiver is used for the appropriate sedimentation test. The material retained on the 63 μm sieve is transferred to evaporating dish, dried and weighed. The suspension of pretreated soil passing 63 μm sieve is transferred with a glass funnel from the receiver into a 500 ml sedimentation cylinder. The water level in the cylinder is made up to the 500 ml calibration mark. The sedimentation cylinder is shake and the zero time (t=0) is started.

Pipette samples are taken at three specified time intervals from zero time for each sample. The times are depended by the specific gravity of the particles in the suspension as shown as Table 3.2. The samples then transferred into evaporating dish, dried in oven, cooled and weighed.

Table 3.2: Pipette sampling times (Head, 1980)

SG of silt and clay fraction	*Times after shaking of starting sampling operation*					
	1st sample		*2nd sample*		*3rd sample*	
	min	*s*	*min*	*s*	*h*	*min*
2.50	4	30	50	30	7	35
2.55	4	20	49	0	7	21
2.60	4	10	47	30	7	7
2.65	4	5	46	0	6	54
2.70	4	0	44	30	6	42
2.75	3	50	43	30	6	30
2.80	3	40	42	0	6	20
2.85	3	35	41	0	6	10
2.90	3	30	40	0	6	0
2.95	3	25	39	0	5	50
3.00	3	20	38	0	5	41
3.05	3	15	37	0	5	33
3.10	3	10	36	0	5	25
3.15	3	5	35	0	5	18
3.20	3	0	34	30	5	10

Figure 3.4: Soil preparation for sedimentation process

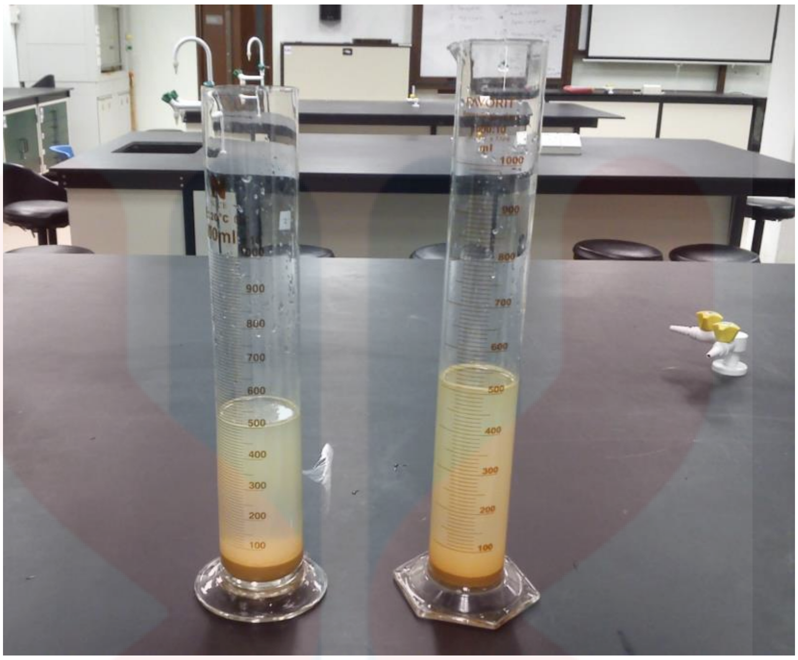

Figure 3.5: Pipette test

3.3.4 Data analysis

a) Petrography analysis

The purpose of petrography is to analyze the description and classification of rocks. This is done by microscopic examination which is by thin section. The thin section is prepared from the sample obtained from the study area to be analyzed at the laboratory. This method is to determine the minerals in the rock sample and analyze their description and classification of rocks. By doing the petrography, the rock sample is classified according their rock types based on their mineral composition. The Streckeisen Classification System is used to identify these rocks by the rock triangle classifications. The naming of the rock is based on triangle classification by The International Union of Geological Sciences (IUGS).

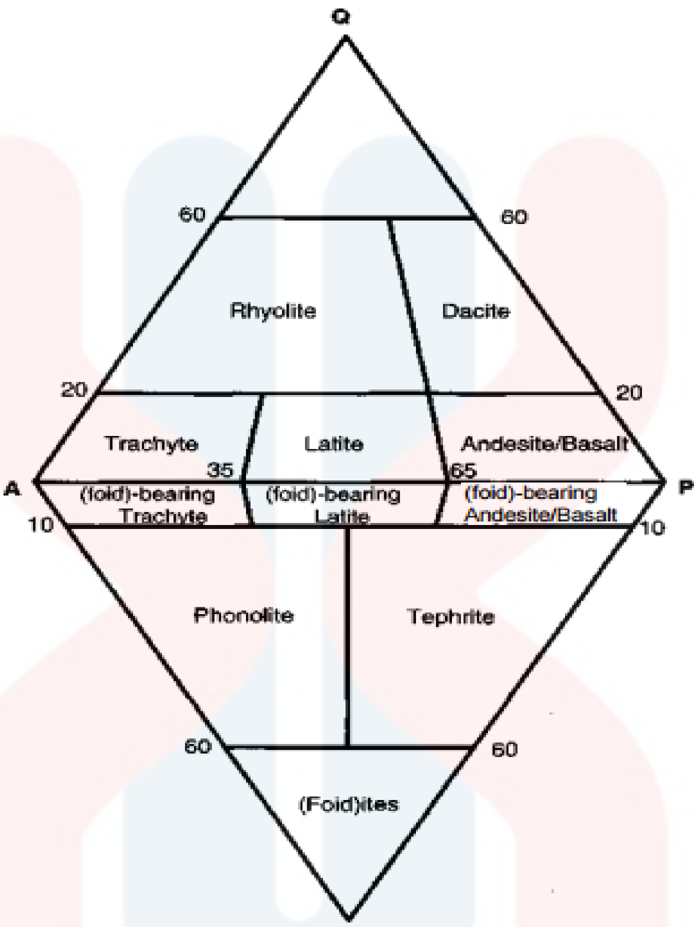

Figure 3.6: IUGS classification in An Introduction to Igneous and Metamorphic Petrology (Winter, 2014)

b) Permeability Analysis

Permeability is defined as a capacity of soil to allow water passes through it such as quantity of flowing for a unit of soil surface under a pressure of 1 unit hydraulic gradient. Permeability is also known as hydraulic conductivity.

Sample calculation is done by using the formula. Table 3.3 is showing the calculations pertinent to the permeability of the soil. The average value of permeability is calculated. The void ratio by oven drying the specimen is calculated and the dry mass is taken.

The viscosity of the water changes with temperature. As temperature increases, the viscosity decreases and the permeability increases. The coefficient of permeability is standardized at 20°C and the permeability at any temperature, T is related to $K_{20°c}$ by the following ratio:

$$k_{20°C} = k_{T°C} \frac{n_{T°C}}{n_{20°C}} \tag{3.1}$$

where,

$k_{T°C}$ = measured permeability at the actual water temperature in the lab

$k_{20°C}$ = permeability at the standard temperature of 20°C

Table 3.3: Correction Factors for Water Temperature

Test Water Temperature, T (°C)	**$n_{T°C}/n_{20°C}$**
15	1.135
16	1.106
17	1.077
18	1.051
19	1.025
20	1.000
21	0.976
22	0.953
23	0.931
24	0.910
25	0.889
26	0.869
27	0.850
28	0.832
29	0.814

The permeability of soil is determined by the coefficient of permeability where this coefficient value is calculated using Equation 3.2.

$$k = \frac{aL}{At} ln \frac{h_0}{h_1} \tag{3.2}$$

where,

K = Coefficient of permeability

a = Area of the standpipe

L = Length of soil column

A = Area of the soil column

h_0 = Initial height of water

h_1 = Final height of water = h_0 - Δh

t = Time required to get head drop of Δh

The results from the calculation above determine the rate of permeability of soil sample. Table 3.4 shows coefficient of permeability, k and the degree of permeability and their soil type. So, the results show the permeability rate of soil sample and this soil sample is determined whether it is gravel, sand, silt or clay. The degree of permeability also is determined either it is high, medium, low and very low permeable or impermeable.

Table 3.4: Typical permeability coefficients for different soils (Terzaghi and Peck, 1967)

Soil Type	Typical Permeability, k (cm/sec)	Degree of Permeability
Gravels and coarse sands	$>10^{-1}$	High
Fine sands	10^{-1} to 10^{-3}	Medium
Silty sands	10^{-3} to 10^{-5}	Low
Silts	10^{-5} to 10^{-7}	Very low
Clays	$<10^{-7}$	Practically impermeable

c) Sedimentation Analysis

Sedimentation analysis is a grain-size analysis in which determining the particle size distribution of the particles within a soil. This analysis is performed to determine the percentage of different range size which is coarser-sized particles and finer-sized particles within the soil sample. Additionally, susceptibility of soils can be fairly accurately predicted from the results of the analysis. Grain size analysis provides the grain size distribution in order classifying the soil within the soil types. The particle size distribution of a material is important in understanding its physical and chemical properties. The grain size characteristics of soils that are predominantly coarse grained are evaluated by a sieve analysis.

The percentages of the particle size distribution are determined from the result of the soil sieve test at the laboratory. The percentage retained in each sieve is calculated to find the percent of aggregate passing through each sieve by using Equation 3.3.

$$\text{Percentage of weight retained (\%)} = \frac{\text{Weight retained on each sieve (g)}}{\text{Original sample weight (g)}} \times 100\% \qquad (3.3)$$

Then, the cumulative percent of aggregate retained in each sieve is calculated. The total amount of aggregate that is retained in each sieve and the amount in the previous sieves are adding up. Equation 3.4 shows the cumulative percent passing of the aggregate is found by subtracting the percent retained from 100%.

$$\text{\% Cumulative Passing} = 100\% - \text{\% Cumulative Retained} \qquad (3.4)$$

Results are displayed by plotting the percent passing (on a linear scale) against the sieve opening size (on a log scale) and connecting the plotted points with a smooth curve. The values are plotted on a graph with cumulative percent passing on the y axis and logarithmic sieve size on the x axis. The graph is known as grading curve or grain-size distribution curve.

Table 3.5: Standard sieve size (Sam, 2007)

Sieve No.	Opening Size (mm)
4	4.75
10	2.00
20	0.85
40	0.425
60	0.250
80	0.180
100	0.150
120	0.125
140	0.106
170	0.090
200	0.075

Table 3.6: Types of soil and the corresponding range of grain size (Laurence, 2010)

COARSE-GRAINED SOILS Non-cohesive soils				FINE-GRAINED SOILS Cohesive soils	
Gravel	Sand			Silt	Clay
	Coarse	Medium	Fine		
6	2	0.6	0.2	0.06	0.002
Size limits (mm)					

Table 3.7: Grain Size of Soil (USGS,1985)

Very coarse soils	Boulders		>200 mm
	Cobbles		60 – 200 mm
Coarse soils	Gravel	Coarse	20 – 60 mm
		Medium	6 – 20 mm
		Fine	2 – 6 mm
	Sand	Coarse	0.6 – 2.0 mm
		Medium	0.2 – 0.6 mm
		Fine	0.06 – 0.2 mm
Fine soils	Silt	Coarse	0.02 – 0.06 mm
		Medium	0.006 – 0.02 mm
		Fine	0.002 – 0.006 mm
	Clay		< 0.002

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter provides the detail information of general geology such as geomorphology, petrography, stratigraphy, structural geology and historical geology of study area that is obtained from the analysis of data of geological mapping.

4.2 Traverse Mapping

Traversing was done around the study area either on pave or unpaved road. The observation, measurement and sampling are done along traversing. Figure 4.1 shows the traverse map of study area during the field mapping. Table 4.1 shows the coordinate of stations of observation, measurement and sampling taken during traversing at study area.

Table 4.1: Activities of each station during the traversing

Station	Coordinates	Elevation	Activities/Observation
S1	N 4° 53’ 34.1” E 101° 57’ 9.9”	139 m	Observation on geomorphology
S2	N 4° 53’ 49.3” E 101° 57’ 13.4”	145 m	Collecting of rock sample (Shale)
S3	N 4° 53’ 20.8” E 101° 58’ 16.3”	104 m	Collecting of rock sample (Limestone)
S4	N 4° 55’ 7.9” E 101° 57’ 0.8”	166 m	Collecting of rock sample (Granite)
S5	N 4° 54’ 59.3” E101° 57’ 23.8”	170 m	Collecting of rock sample (Shale)
S6	N 4° 53’ 23.4” E101° 58’ 0.3”	122 m	Observation on geomorphology
S7	N 4° 54’ 35.6” E101° 55’ 58.2”	159 m	Observation on geomorphology
S8	N 4° 54’ 40.2” E101° 56’ 48.1”	162 m	Observation on geomorphology

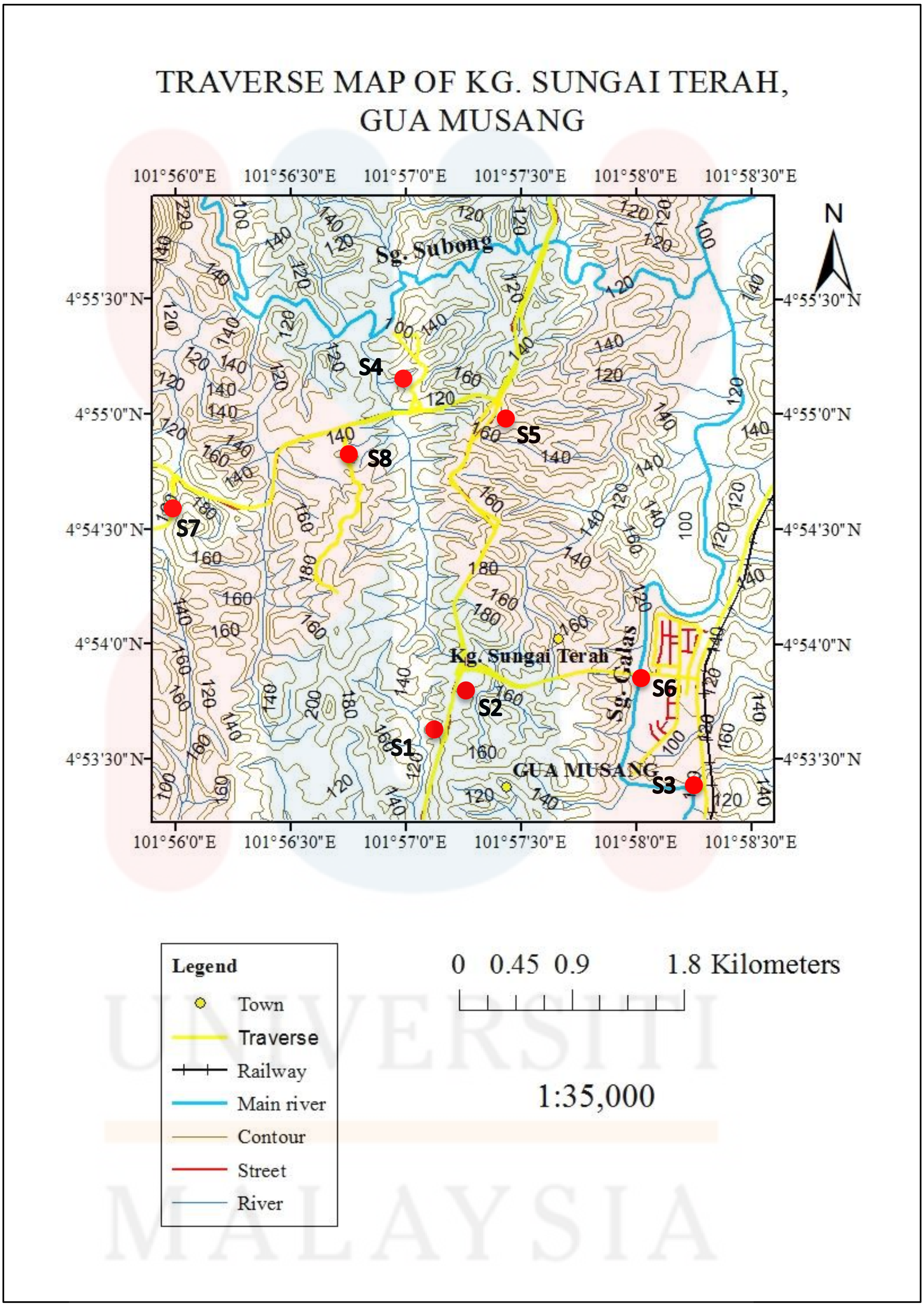

Figure 4.1: Traverse map that shows the traversing during the field mapping

4.3 Geomorphology

4.3.1 Topography

Topography is a term that used to describe the Earth surface that includes the variety features known as landform. It is measured at the difference elevation across the earth surface where the difference between high and low elevation is referred as the changes in relief. There were five types of classes in topographic unit which is showing different in mean elevations. Table 4.2 below is the summary that showing the topographic units.

Table 4.2: Topography unit classification (Hutchison and Tan, 2009)

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

Figure 4.2 shows the 3D topography of the study area. Based on the map, the contour of study area is range between 100 to 260 m in elevation. The topography in study area mainly consists of hilly area. Based on Table 4.2 above, hilly area is started from 76 to 300 m. In this study area, lowest elevation starting from 100 m and highest elevation is 260 m. At the study area, the elevation ranging from 100 m mostly located at the north and south-east part and for 260 m elevations it can be found mainly at the north-west part of study area.

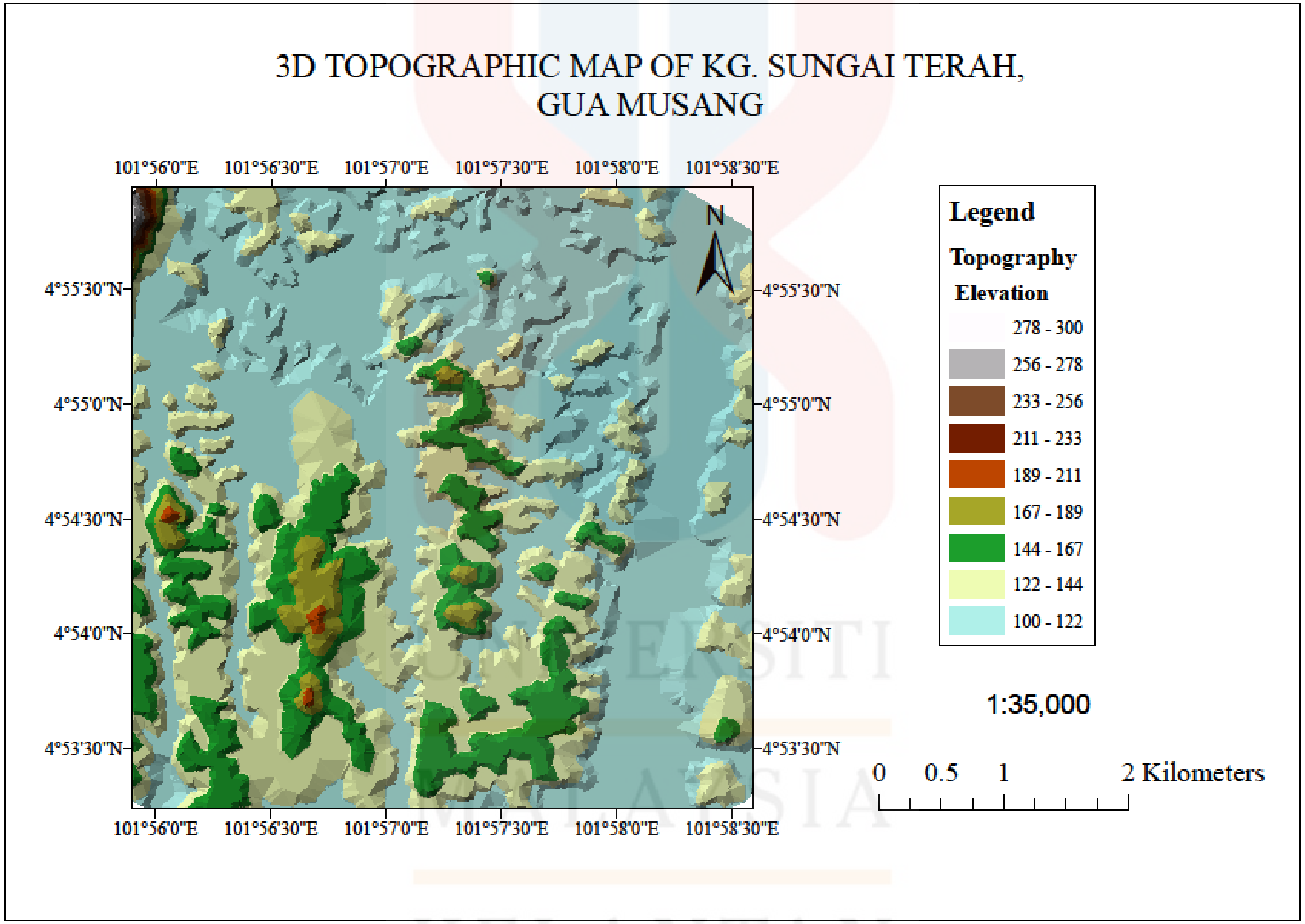

Figure 4.2: 3D topographic map of Kg. Sungai Terah, Gua Musang

4.3.2 Drainage Pattern

Drainage patterns are formed by the streams, rivers and lakes in a particular drainage basin. The topography and gradient of the land affects the drainage pattern whether a particular region is dominated by hard or soft rocks. A stream system achieves a particular drainage pattern to its network of stream channels and tributaries as determined by local geologic factors. The drainage pattern of a river determined by many factors such as the slope of the land, the nature of the soil, the nature of the rocks over which the river is flowing and the structure of the rock.

Figure 4.3 shows the drainage pattern of study area. The study area is dominated by dendritic and trellis drainage pattern. A dendritic drainage pattern occurs when the tributary systems subdivides headway like the limbs of a tree. The term "dendritic pattern" is especially associated with the pattern water takes as it drains off of land, but dendritic patterns are extremely common throughout nature. Dendritic patterns form when a kind of random motion occurs. These patterns usually form in horizontal sedimentary rock or in intrusive igneous rocks where the rock mass is reasonably homogeneous. The tributaries in steep terrains tend to be subparallel and join at acute angles. Any marked structure such as joints and faulting also contribute to this drainage pattern.

The trellis drainage pattern occurs when the geometry of drainage system is similar to that of a common garden trellis used to grow vines. The smaller tributaries feed into strike valley from the steep slopes on the sides of mountains. These tributaries enter the main river at approximately 90 degree angle and causing a trellis-like appearance of the drainage system. Figure 4.4 shows the view of Galas River located at study area.

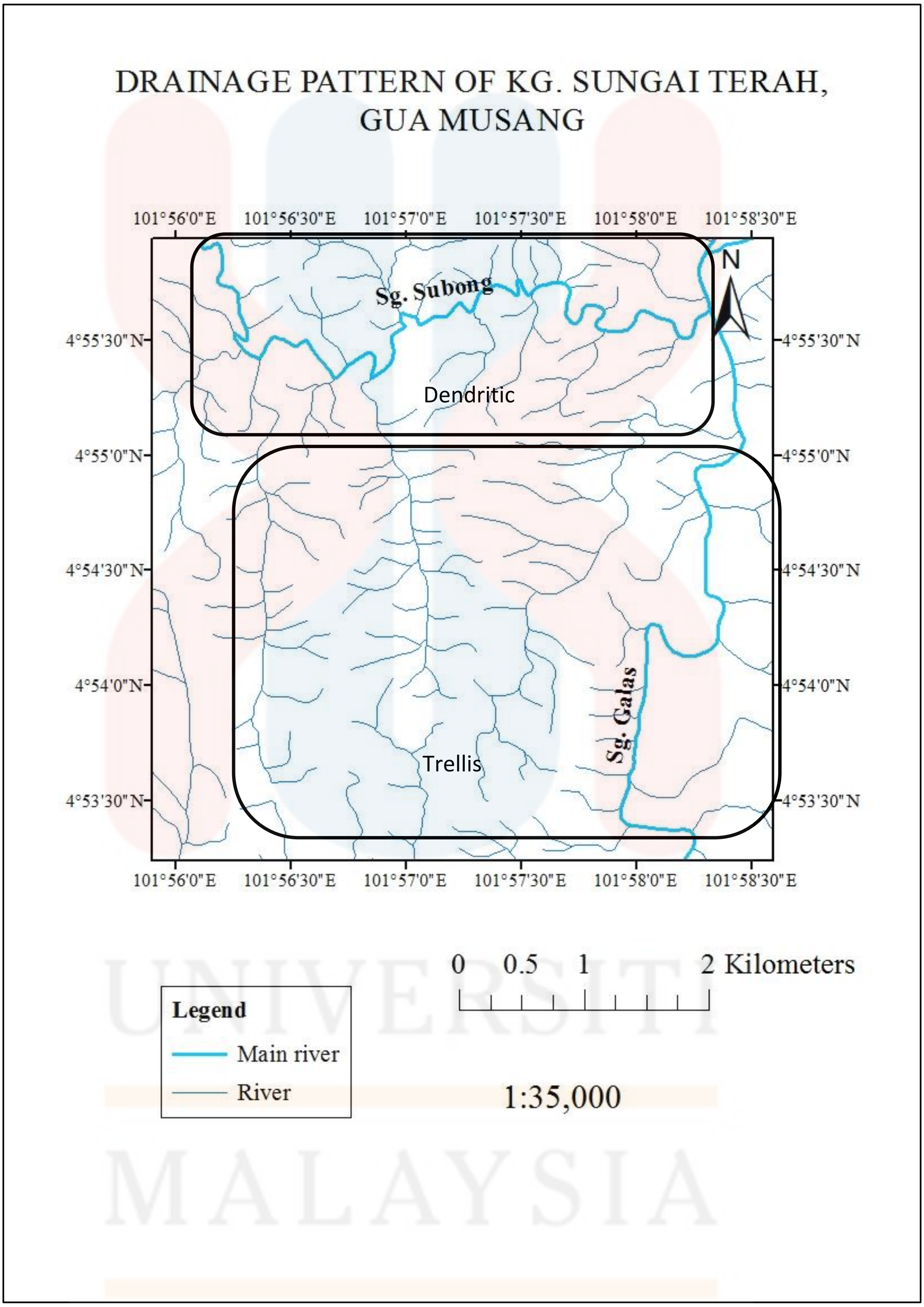

Figure 4.3: Drainage pattern of Kg. Sungai Terah, Gua Musang

Figure 4.4: View of Galas River in study area

4.3.3 Weathering Process

Weathering is the process of disintegration of rock from physical, chemical, and biological stresses. This process is influenced by temperature and moisture/climate. As rock disintegrates, it becomes more susceptible to further physical, chemical, and biological weathering due to the increase in exposed surface area.

a) Physical weathering

Physical weathering is caused by the effects of changing temperature on rocks, causing the rock to break apart without changing their chemical composition. Over time, the Earth movements and environment can break apart rock formations, causing physical weathering. The process is sometimes assisted by water. Physical weathering is also caused by thermal stress which is the contraction and expansion effect on the rocks that caused by changes in temperature. Due to uneven expansion and contraction, the rocks crack apart and disintegrate into smaller pieces. Physical weathering can also refer to other things in the environment that breaking down, like soil and minerals. This weathering is caused by pressure, warm temperatures, water and ice.

Physical weathering happens especially in places where there is little soil and few plants grow, such as in mountain regions and hot deserts. In mountains, this type of weathering occurs either through repeated melting and freezing of water. At hot deserts, the expansion and contraction of the surface layer of rocks that are baked by the sun can cause this weathering.

Figure 4.5 shows the physical weathering occurred on the outcrop at this area. The force that act due to the changes of temperature and pressure cause the rock mass to break along the plane, directly change the original structure of the rock. While Figure 4.6 shows the mud cracks occur on the soil due to heavy rainfall and wet and dry climate at study area.

Figure 4.5: The rock that had undergo physical weathering

Figure 4.6: Mud cracks formed due to wet and dry climate

b) Chemical weathering

Chemical weathering occurs when rocks are broken down by a chemical change. This weathering is triggered by rainwater. Rainwater usually is acidic which formed from the absorption of carbon dioxide in the atmosphere that reacts with the mineral grains in the rock. Therefore, new minerals and salts are formed. The degree of chemical weathering depends on the type of rock and also the temperature as the chemical reactions occur more quickly in areas of high temperatures.

Figure 4.7 shows the chemical weathering occurred on the rock mass. The rock is triggered by continuous flowing water or heavy rainfall that give the curve shape to rock and cause the rock become soft and easy for erosion process to occur.

Figure 4.7: The rock that had undergo chemical weathering

c) Biological weathering

Biological weathering occurs when rocks are worn away by living organisms. As the cracks are present among the rock body, the trees and other plants can grow within the cracks. As the roots grow bigger, the cracks in the rock are slightly opened and become wider and deeper. Over time, the growing tree eventually gives the rock apart. The tiny organisms such as bacteria, algae and moss also can grow on the rocks and produce chemicals which can break down the surface layer of the rock. The burrowing animals such as rabbits can accelerate the formation of cracks.

Figure 4.8 shows the biological weathering occurred on the limestone outcrop. It is common to see some roots growing within the face of a rock. Well, such plant activity contributes to biological weathering. The roots of plants and trees penetrate into the soil in search of nutrients and water. As the roots penetrate the soil, they go through cracks or joints in the rocks and as they grow they progressively crack the rock apart. Bigger growing roots can also exert pressure on the adjacent rocks. Some plant roots also emit organic acids that aid to dissolve the rock's minerals.

Figure 4.8: The rock that undergo biological weathering

4.4 Stratigraphy

Stratigraphy is defined as the description of rock successions and their interpretation in terms of a general time scale. Stratigraphy deal primarily with sedimentary rocks but may also encompass layered igneous rocks such as those resulting from successive lava flows or metamorphic rocks formed either from such extrusive igneous material or from sedimentary rocks.

4.4.1 Lithostratigraphy

Lithostratigraphy is the element of stratigraphy that deals with the description and nomenclature of the rocks of the Earth based on their lithology and their stratigraphic relations. Lithostratigraphic is classified based on their lithostratigraphic unit which is a body of rocks that is defined and recognized on the basis of its lithologic properties or combination of lithologic properties and stratigraphic relations.

Table 4.3 shows the stratigraphic column of study area. The lithology of study area comprised of two periods which are from Permian to Triassic. The study area composed of the rocks involved a part of Gua Musang Formation. Granite is composed in Permian whereas limestone is from Permian to Upper Permian. In Triassic, there is shale is formed from Triassic to Upper Triassic. The alluvial consist of alluvium is comprised of Quaternary period.

Table 4.3: Lithostratigraphic column

ERA	PERIOD	UNIT	LITHOLOGY	DESCRIPTION
Cenozoic	Quaternary	Alluvial		Alluvium consist mainly of sand, silt and clay
Mesozoic	Triassic	Gua Musang Formation		Shale
Paleozoic	Permian			Limestone
				Granite

4.4.2 Petrography

Petrography is the study of rock mineral and their composition. Petrography gives the description and interpretation of rock samples from hand specimen and aided by the microscopic examination of thin sections.

a) Granite

The characteristics of granite according to Figure 4.10 are the colour is light. The grain size is phaneritic which is clearly seen with naked eyes even they are too small. The minerals that composed in granite are is quartz, alkali feldspar and biotite. Feldspar is in light and dull milky white and grey in colour while biotite shows shiny black and quartz shows shiny milky white in colour. Figure 4.11 shows the thin section of the rock sample. This rock sample was observed under 4×10 magnification. According to QAP diagram, the sample shows it is granite rock type with Q (quartz) – 45%, A (alkali feldspar) – 40% and P (plagioclase feldspar) – 15%.

Figure 4.9: Outcrop of granite in study area

Figure 4.10: Hand specimen of granite sample that was collected in study area

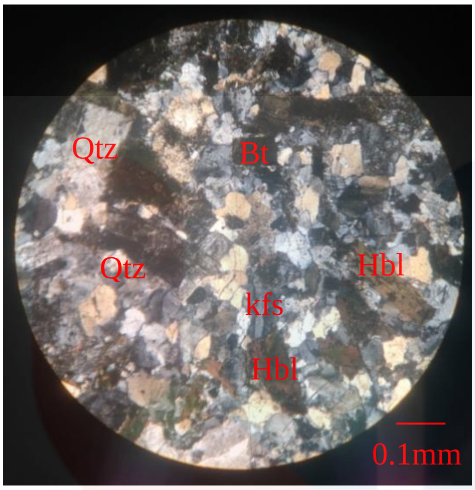

Figure 4.11(a): Thin section of granite sample under cross-polarized

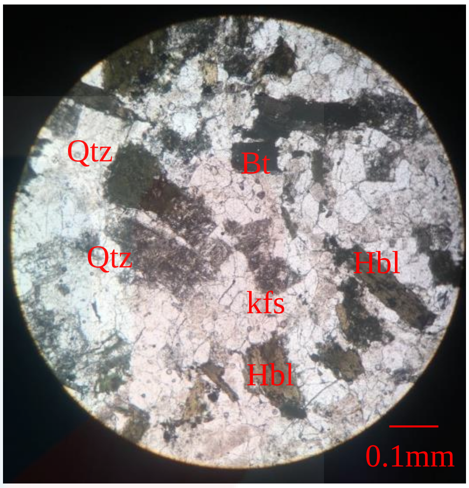

Figure 4.11(b): Thin section of granite sample under plane-polarized

b) Limestone

Limestone is a sedimentary rock composed primarily of calcium carbonate ($CaCO_3$) in the form of the mineral calcite. It is consisting of more than 50% CaCO3. Carbonate rocks where the dominant carbonate is dolomite (calcium magnesium carbonate) are named dolomite rock. Figure 4.13 shows the rock sample collected at study area. This rock is limestone because it dissolved with hydrochloric acid (HCl). Limestone is light in colour which is light grey and have smooth to rough surface and also hard. Figure 4.14 is the thin section of limestone sample and this figure shows this sample under microscope under 4×10 magnification.

Figure 4.12: Outcrop of limestone in study area

Figure 4.13: Hand specimen of limestone sample that was collected in study area

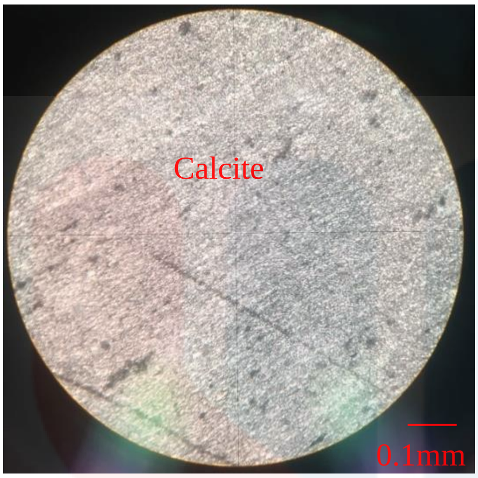

Figure 4.14(a): Thin section of limestone sample under cross-polarized

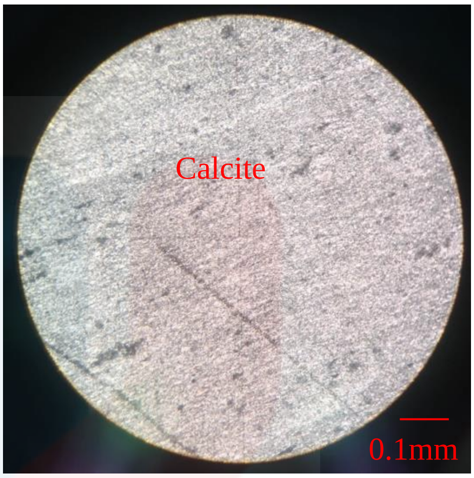

Figure 4.14(b): Thin section of limestone sample under plane-polarized

c) Shale

Shale is a sedimentary rock that forms from the compaction of silt and clay-size mineral particles which is mud. Shale is fine-grained rock, dark in colour and breaks along thin laminae or parallel layering which less than one centimeter in thickness. Figure 4.15 shows the rock sample of shale. This sample is known as black shale. Black shale contains organic material. This shale obtained the black colour from tiny particles of organic matter that were deposited with the mud from which the shale formed. As the mud was buried and warmed within the earth, some of the organic material was transformed into oil and natural gas.

Figure 4.15: Hand specimen of shale sample that was collected in study area

4.5 Structural Geology

Structural geology is the study of the structure and distribution of the rocks that make up the crust of the earth. Structures are the observable products of deformation that formed from their tectonic history, past geological environments and events that could have changed or deformed them. These can be dated to determine when the structural features formed. Heat from the Earth's interior is released through the processes of volcanic eruptions and motions of the lithospheric plates. As stress is applied to crustal rock, deformation occurs and forms the structures. These structures are consisting of bedding, fault, fold, foliation, relict structure, lineament and joint.

4.5.1 Joint

Joint is a brittle-fracture surface in rocks along which little or no displacement has occurred. Joint presents on rocks surface and extend in various directions. Joints are generally formed more toward the vertical direction than to the horizontal direction. Joints may have smooth, clean surfaces, or may be scarred by slickensides, or striations. Figure 4.16(a) and 4.16(b) shows the joints structure on the limestone outcrop. The measurements were constructed in Rose Diagram as shown on Figure 4.17. This figure shows that the joint had compression force, σ_1 in N-S direction which is North (N) and South (S) whereas tension force, σ_3 is in E-W direction which is East (E) and West (W).

Figure 4.16(a): Joint structure in limestone outcrop

Figure 4.16(b): Joint structure in limestone outcrop

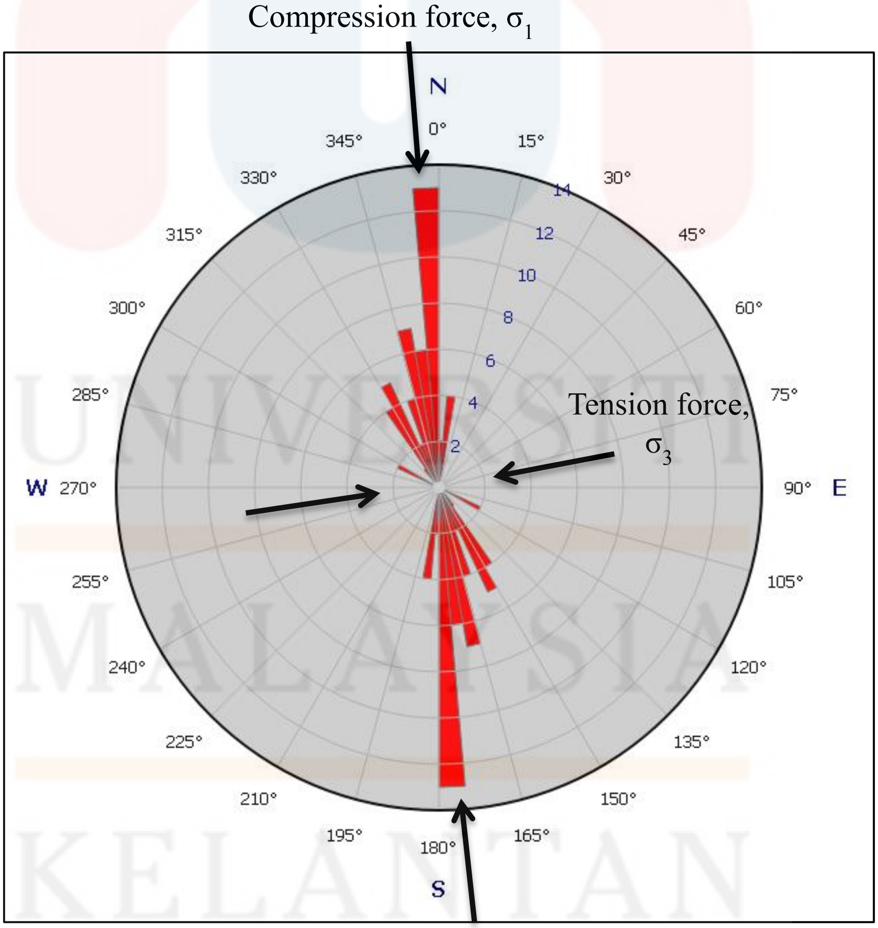

Figure 4.17: Rose Diagram for joint analysis

4.5.2 Bedding

Bedding or stratification is a layer of sediment or volcanic material that is distinctly separate from other layers. Beds can vary in thickness from 1 cm thick to over 3 meters thick. Beds can be differentiated in various ways, including rock or mineral type and particle size. Bedding also varies in texture and their resistance to weathering from one bed to another. The bedding plane separates beds and is an area easily fractured. Figure 4.18 shows the bedding structure on the outcrop.

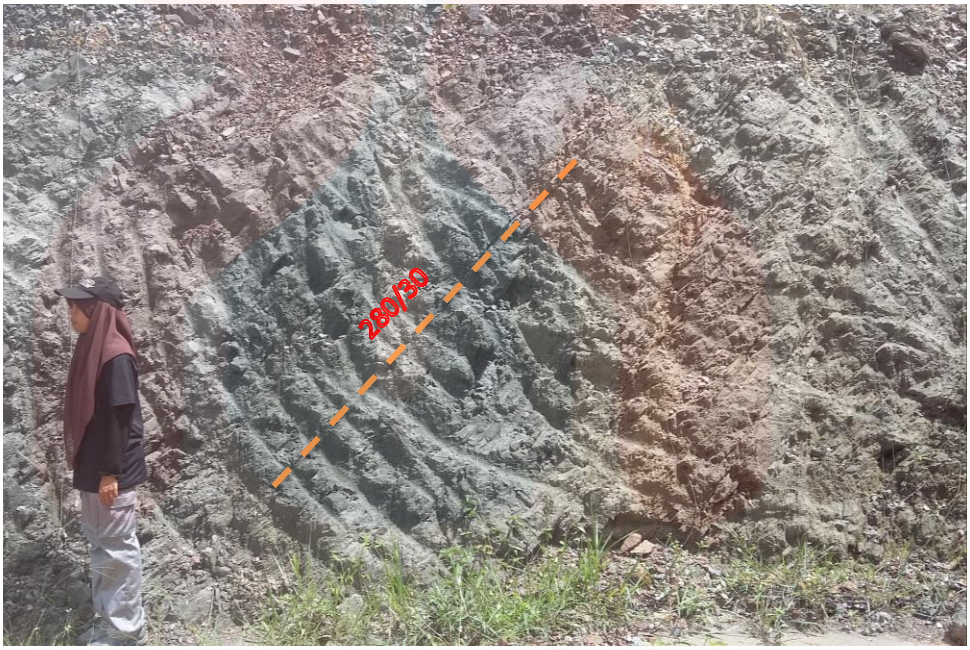

Figure 4.18: Bedding structure at the outcrop

4.5.3 Foliation

Foliation is a planar arrangement of structural or textural features in any rock type, but particularly that resulting from the alignment of constituent mineral grains of a metamorphic rock of the regional variety along straight or wavy planes. Foliation often occurs parallel to original bedding, but it may not be ostensibly related to any other structural direction. As the pressure squeezes the flat or elongate minerals within a rock, the foliation formed become aligned. The direction of this pressure gives a platy or sheet-like structure on the rocks. Non-foliated metamorphic rocks do not have a platy or sheet-like structure. Some rocks, such as limestone are made of minerals that are not flat or elongate. Figure 4.19 shows the foliation on the rock.

Figure 4.19: Foliation structure on the outcrop

4.5.4 Lineament

Lineament is a pattern that present in photograph, map or model of earth's surface or subsurface and must be linear, continuous, well exposed and related to earth's features (Caran et al., 1982). The lineament reflects the geological structure such as faults or fractures. Typically a lineament will comprise a fault-aligned valley, a series of fault or fold-aligned hills, a straight coastline or indeed a combination of these features. Lineaments can be obtained from aerial or satellite photographs or in geological or topographic maps. Lineament measurements are taken to identify the compression and extension forces. Compression force is the force that squeezes one with another while extension force is the force that acted perpendicular to the compression force.

Figure 4.20 shows the lineament that existed around the study area. Figure 4.21 shows the Rose Diagram for the lineament measurement that taken from Figure 4.20. The lineament analysis shows that the compression forces act from North-East (NE) and South-West (SW) while the extension forces act perpendicular to compression forces at North-West (NW) and South-East (SE).

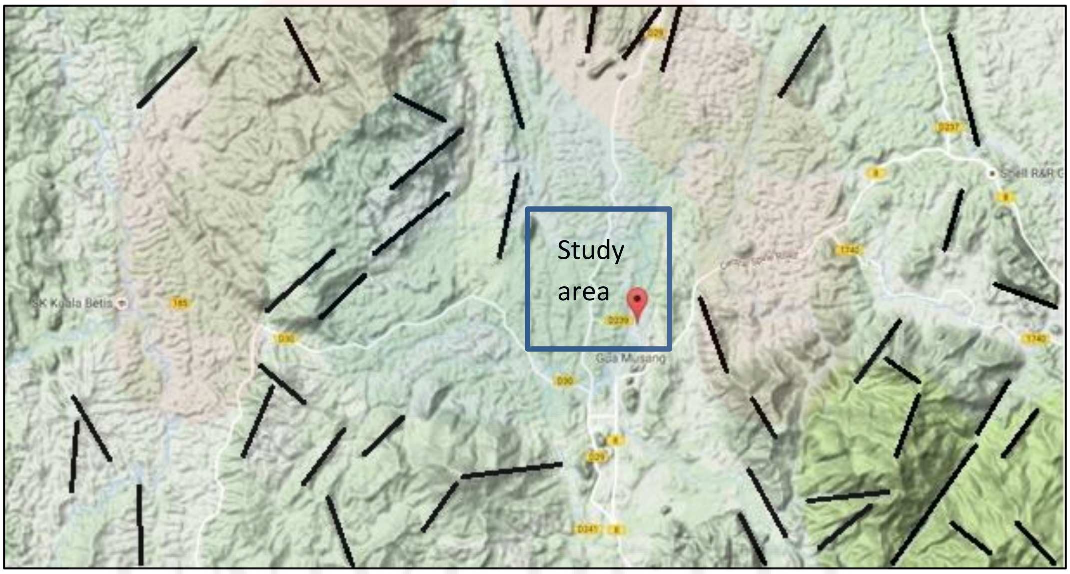

Figure 4.20: Lineament analysis from aerial photo

Source : Google Maps 2016

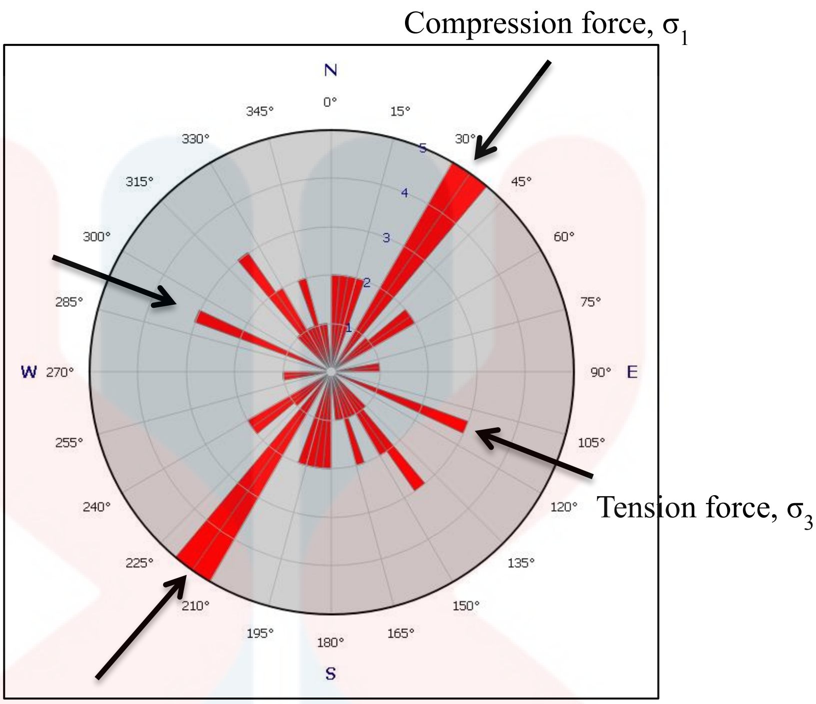

Figure 4.21: Rose Diagram for lineament analysis

4.6 Historical Geology

The rock sample in the study area composed of igneous, sedimentary and metamorphic rock type. The geological formation of study area can be divided into two chronologies which are Paleozoic and Mesozoic. Study area is consisting of Gua Musang Formation. The age of Gua Musang Formation is from the Middle Permian to Upper Triassic. The Upper Paleozoic rocks of Gua Musang Formation are predominantly of argillaceous strata and volcanic rocks. During Mesozoic, Gua Musang Formation exposures the Middle Permian to lower Middle Triassic rocks in Gua Musang area which composed predominantly of calcareous and argillaceous rocks with subordinate arenite, pyroclastics and lava flows.

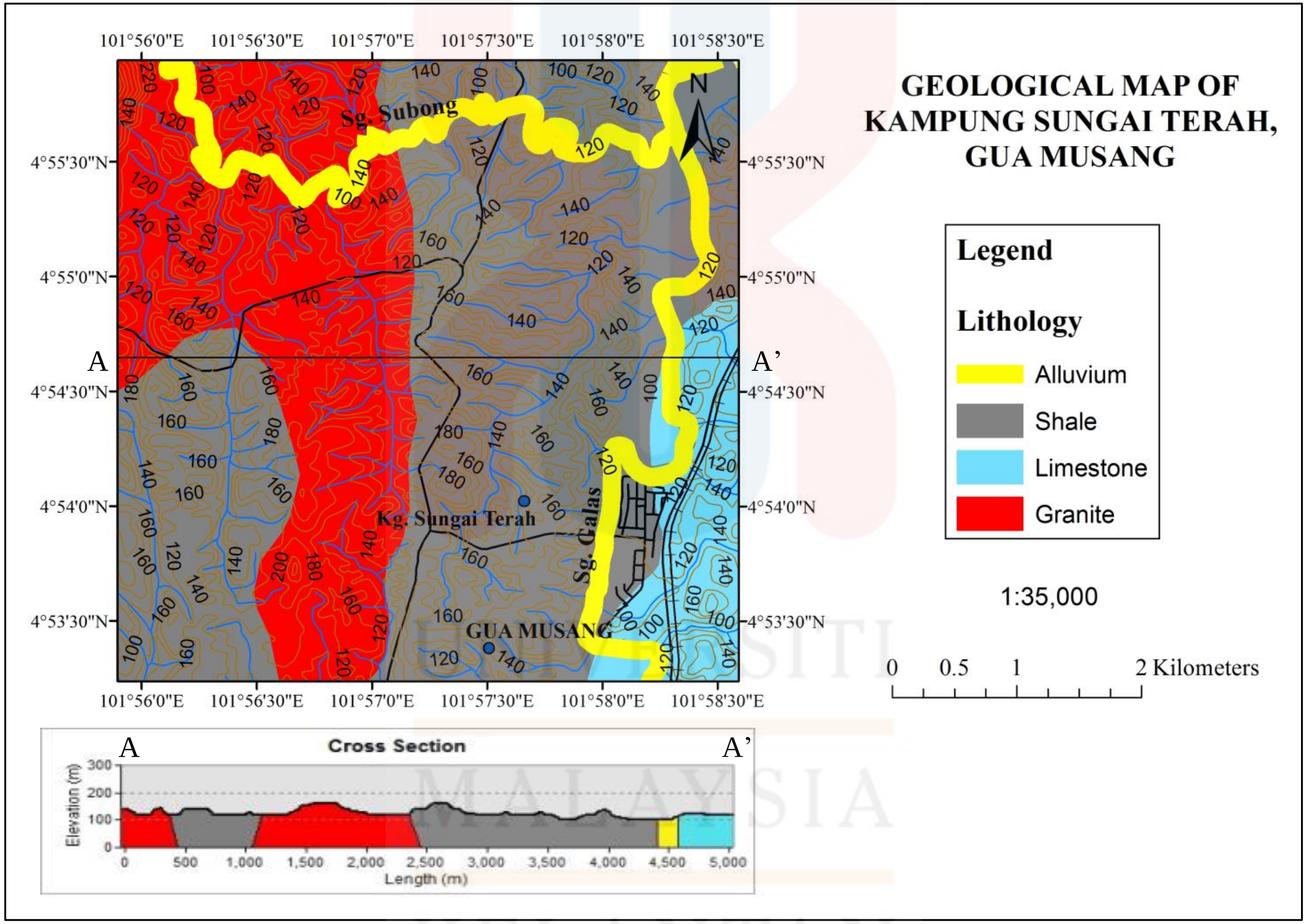

Figure 4.22: Geological map and cross section of Kg. Sungai Terah, Gua Musang

CHAPTER 5

INFLUENCES OF GRAIN SIZE DISTRIBUTION ON PERMEABILITY OF SOIL

5.1 Introduction

This chapter is focusing on engineering geology which is discussing about soil mechanics. The soil analysis is resulted from some laboratory test conducted during this study which is permeability test and sieve test. For permeability test, permeability analysis on soil is discussed in term of permeability rate. For sieve test which is sedimentation test, the grain size distribution in the study area is analysed. The results from these two tests are discussed together and correlated each other.

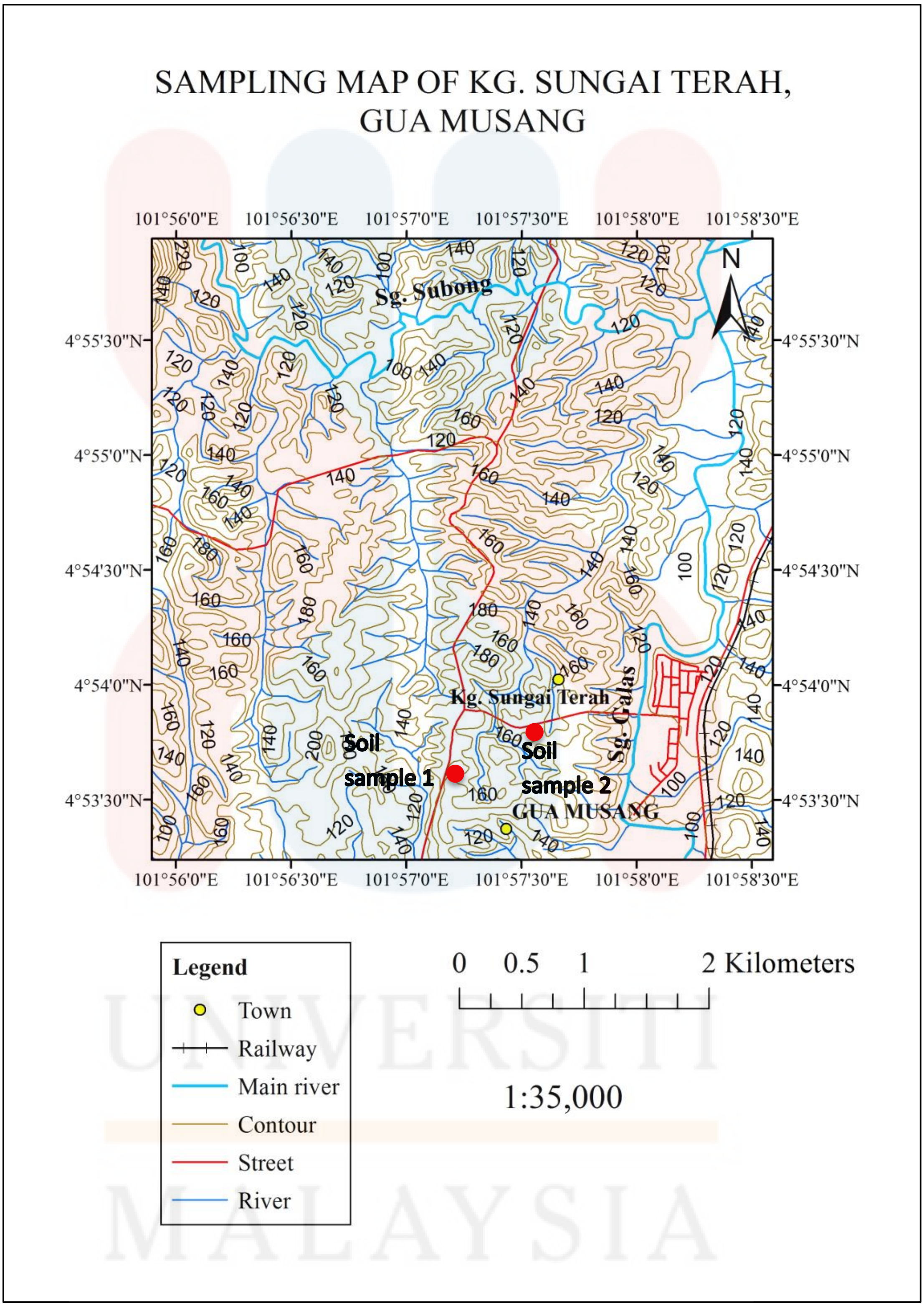

Figure 5.1: Soil sampling map of study area

5.2 Permeability Analysis

5.2.1 Falling head permeability analysis

Table 5.1: Result of falling head permeability result of soil sample 1 and 2

Sample	Test no.	Initial height of water, h_0 (cm)	Final height of water, h_1 (cm)	Time required to get head drop of Δh, t (sec)	Coefficient of permeability, k (cm/sec)
1	1	75.8	66.2	7460	1.02×10^{-7}
	2	77.3	67.3	7508	1.03×10^{-7}
	3	75.4	66.7	7412	9.26×10^{-8}
2	1	88.6	55.4	4512	5.83×10^{-7}
	2	85.7	50.2	4124	7.23×10^{-7}
	3	86.3	49.2	4444	7.08×10^{-7}

Permeability test of soil consisting of two test which is falling head test and constant head test but this research only focusing on falling head permeability test using falling head permeameter. Falling head permeameter is using to test the permeability on fine soil whereas constant head permeameter is for testing on permeability of coarse sand. Since the study area mostly consisted of fine-grain soil, the falling head permeameter is used in this test besides it is suitable for less permeable soils.

Table 5.1 showed the result of permeability test on two samples which is sample 1 and sample 2. The permeability of soil is determined by the coefficient of the permeability on soil samples. The value of coefficient of permeability, k is obtained by testing the soil sample on falling head permeameter test. This value is showing the result whereby the degree of permeability on soil sample is determined. Each sample is tested about three times that gives three test readings.

The value of coefficient of permeability, k of three test of sample 1 is 1.02×10^{-7} cm/sec (Test 1), 1.03×10^{-7} cm/sec (Test 2) and 9.26×10^{-8} cm/sec while sample 2 is 65.83×10^{-7} cm/sec (Test 1), 7.23×10^{-7} cm/sec (Test 2) and 7.08×10^{-7} cm/sec (Test 3). Based on Table 3.4 in Chapter 3, sample 1 is catogerized as clays because it has the value of k with lower than 10^{-7}. So, degree of permeability of sample 1 is practically impermeable and sample 2 is silty clays with very low permeability. Both of two samples have consisted of clay particles which are fine grain soil and these clays have low rate of permeability.

5.3 Sedimentation analysis

i) Sample 1

Table 5.2: Percentage of grain size of soil sample 1

Size of grain (mm)	Percentage Passing (%)	Cumulative Percentage Passing (%)
0.002 (clay)	50.3	50.3
0.006 (fine silt)	18.3	68.6
0.02 (medium silt)	10.2	78.8
0.06 (coarse silt)	34.1	84.4
0.2 (sand)	15.6	100

ii) Sample 2

Table 5.3: Percentage of grain size of soil sample 2

Size of grain (mm)	Percentage Passing (%)	Cumulative Percentage Passing (%)
0.002 (clay)	43.2	43.2
0.006 (fine silt)	19.1	62.3
0.02 (medium silt)	15.3	77.6
0.06 (coarse silt)	6.2	83.3
0.2 (sand)	16.2	100

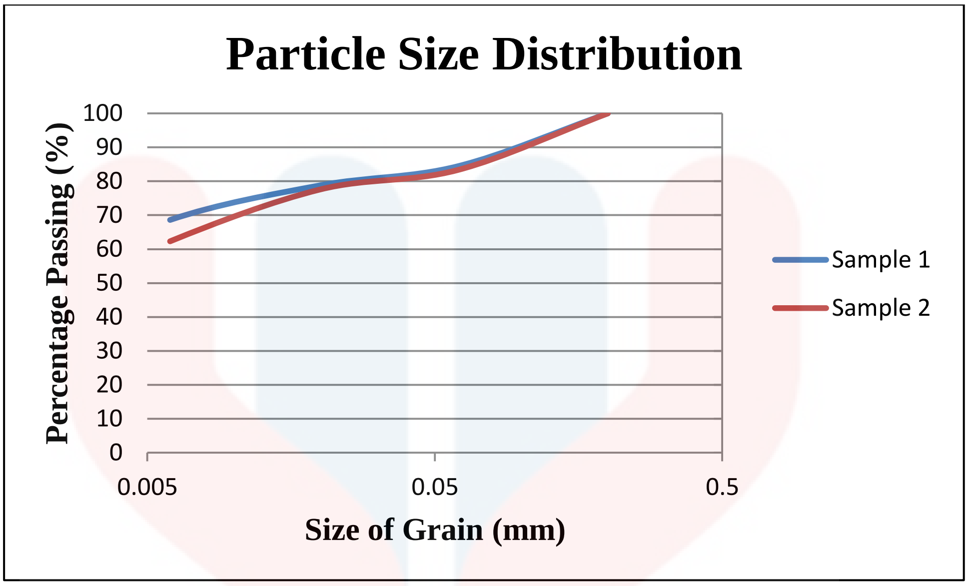

Figure 5.2: Particle size curve from sieve analysis of soil sample 1 and sample 2

Table 5.2 and 5.3 shows the percentage of grain size of soil sample 1 and 2 respectively. Figure 5.2 shows the particle size curve plotted from the calculation from Table 5.2 and 5.3 respectively. The graph of percentage passing corresponding to a grain size is plotted which give the curve of grain size distribution of soil samples. The graph is plotted on grain size of 0.002 mm, 0.006 mm, 0.02 mm, 0.06 mm and 0.2 mm. The result of this test gives readings on these grain sizes that are the points on the grading curve sheets. The grading curve shows the distribution of grain size from clay to sand range which is 0.002 mm shows the grain size of sample in clay range, 0.006 mm is fine silt, 0.02 mm is medium silt, 0.06 mm is coarse silt and 0.2 mm is sand range. These results are obtained from sieve testing on pipette sampling.

Based on Table 5.2, sample 1 has highest percentage of grain size of clays (50.3%) with range less than 0.002 mm followed by fine silt (18.3%), sand (15.6%), medium silt (10.2%) and coarse silt (5.6%) respectively. Whereas, based on Table 5.3, sample 2 also has highest percentage of grain size of clays (43.2%) with range less than 0.002 mm followed by fine silt (19.1%), sand (16.2%), medium silt (15.3%) and coarse silt (6.2%) respectively. So, from the result of these percentage from the sedimentation test, the cumulative percentage of these samples are obtained and the grain size curve are plotted which give the curve shape on the graph. The graph in Figure 5.2 shows the percentage of sample passing through the grain size range during the sieve test. These samples are showing a similar pattern on the grading curve.

From both test which are permeability test and sieve test, it can be concluded that both of sample 1 and sample 2 are consisting of clays soil type. Sample 1 is mostly clays because this soil sample is consisting highest percentage of amount of clay size of grains while sample 2 is silty clays where the soil sample 2 is approximately consisting of similar percentage of silt and clay size of grains.

5.4 Grain size analysis

Soils are formed from materials that have resulted from the disintegration of rocks by various processes of physical and chemical weathering. The nature and structure of a soil depends on the processes and conditions that formed it. Soil is made up of different particles size distribution. The proportion of sand, silt and clay-sized particles and organic matter in the soil determine the texture of a soil. The different combinations of sand, silt and clay particles give the different composition in soil. All soils contain mineral particles, organic matter, water and air. These combinations determine the soil's properties such as permeability.

Permeability is an important physical property of soil. Permeability is a measure of how easily water can pass through a porous medium. The permeability rate of soil is depending on the grain size or particle size distribution of soils. The loose soil with coarser grain has high permeability while dense soil with finer grain has low permeability. Permeability varies with the grain size. The smaller the grain size, the smaller the voids and the lower the permeability. Permeability and grain size are related each other where grain size distribution affects the permeability of soil.

In soils, the interconnected pores provide passage for water. The permeability is obtained from a large number of such flow paths that act together, and the average rate of flow. It is a measure of the ease that the soil provides to the flow of water through its pores. The value of coefficient of permeability (k) depends on the average size of the pores and is related to the distribution of particle sizes, particle shape and soil structure. The ratio of permeability of typical sands/gravels to those of typical clays is of the order of 10^6. A small proportion of fine material in a coarse-grained soil can lead to a significant reduction in permeability.

Soil composition influences the permeability of soil. Gravels, sands, and silts have little significance on soil composition, unless mica and organic matters are present. However, in clays, this characteristic is important thing in permeability aspects. Montmorillonite has the least permeability with sodium as the exchangeable ion which less than 10^{-7} cm/sec. This gives the low permeability to clays. Therefore, sodium montmorillonite is used as an additive to other soils to make them impermeable. For kaolinite, it is hundred times more permeable than montmorillonite.

Fabric or structural arrangement of particles is also influencing permeability of soil. This characteristic is important especially fine-grained soils. At the same void ratio, it is logical to expect that a soil in the most flocculated state will have the highest permeability and the one in the most dispersed state will have the lowest permeability. The permeability of soil can be reduced invariably by remoulding of a natural soil. The stratification or macrostructure also influence the permeability of soil. It is more parallel to stratification than that perpendicular to stratification.

Entrapped air gives effect on permeability. It reduces the permeability of soil. The entrapped air is produced from the present of organic foreign matter. This matter also has the tendency to move towards flow channels and choke them, thus decreasing the permeability rate. In the field, the natural soil deposits may have some entrapped air or gas whereas in the laboratory, air-free distilled water may be used as vacuum applied to achieve a high degree of saturation. However, in this case, the permeability of a natural soil deposit not truly estimated.

Soil texture can influence the permeability whether the soils are free draining or hold water and how easy it is for plant roots to grow. Sand particles consist of larger size. Then, pore spaces between the particles in sandy soils are also quite large. The water tends to drain quickly and then, the air enters the soil. Silt particles are too small size. Silt soils have much smaller pore spaces but a lot more of them. Clay particles are smaller than 0.002 mm in diameter. Clay soils are poorly drained and hold on to the water in their pore spaces for much longer. However, they can become very hard if they dry out.

Clays and organic matter in the soil contain negative charges. Water in the soil dissolves the nutrients and other chemicals within the soil. Nutrients like potassium and ammonium have positive charges. They are attracted to the negatively charged organic and mineral matter, and this prevents them from being lost through leaching as water moves through the soil. Nitrate has a negative charge so it is not protected from leaching in most soils. Over time, as minerals are leached away, the soil can become more acidic.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The geological map of study area is produced at scale 1:25,000. From the geological map, the study area is composed of three types of rock which are granite, limestone and shale. These rocks are in age of Permian to Triassic. The study area is mostly composed by hilly area which is range from 100 m to 260 m. The drainage system of study area is dendritic and trellis pattern. There are also weathering process occurred at study area which is physical weathering such as mud cracks and break rocks, chemical weathering and biological weathering such as the growth of roots within rock mass. The structures found are joint, bedding and foliation. The joint analysis showed the compression force (σ_1) is N-S direction and tension force (σ_3) is E-W direction whereas the lineament analysis showed the compression force (σ_1) is NE-SW direction and tension force (σ_3) is NW-SE direction.

Besides, the permeability of soil is determined in term of grain size whereby the grain size distribution is influencing the permeability of soil in an area. The laboratory test shows that study area mostly consist of clays and have low permeability and impermeable soils. Permeability is one of the important physical properties of soil in some of the major problems of soil mechanics. Besides that, it is important to know the characteristics of soil at an area before do any construction or activities.

6.2 Suggestion

Soil has a layered structure and its composition. Determination of permeability in term of fluid-flow characteristics through a soil mass helps in improving workability of the soil. In engineering and agricultural, soil is important element where the determination of permeability of soil helps in retaining optimum water content within soil, so that best possible results are achieved in the minimum time.

In agricultural terms, permeability helps in determining the amount of water soaked in by the soil. If the soil is not permeable and allows water to stay on its surface, it will affect plant growth. Therefore, the water-logging must be avoided on the soils. The water entryways and water storage techniques must be improved at the field to reduce the effect of water-logging on crops. Cover crops also can help farmers and agriculturists to improve permeability of soil and reduce soil surface strength as well.

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APPENDIX A

Strike readings on joint structure

174	149	160	175	189
169	154	158	178	188
170	154	168	173	186
167	152	169	170	185
165	150	164	173	183
164	148	168	175	182
117	148	171	176	178
147	150	169	176	176
115	159	175	176	177
142	160	177	175	178

APPENDIX B

Strike readings on lineament structure

39	170	38	5	34	2
339	13	80	113	140	147
47	17	12	39	136	4
37	146	36	113	163	32
112	30	7	19	142	55
50	55	33	87	143	32
52	169	163	32	152	