GEOLOGY AND DETERMINATION OF ROCK MASS STRENGTH AT KAMPUNG LUBOK BONGOR, JELI, KELANTAN.

by

NORAINI BINTI MAT DERIS

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

FACULTY OF EARTH SCIENCE
UNIVERSITI MALAYSIA KELANTAN

2017

DECLARATION

I declare that this thesis entitled "Geology and Determination of Rock Mass Strength at Kg Lubok Bongor, Jeli, 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 : ______________________________

ACKNOWLEDGEMENT

Alhamdulillah, all praises to Allah the Almighty God that I finally manage to finish my Final Year Project (FYP) within the time given. Firstly, I would like to thank my supervisor, En. Shukri Bin Ma'ail, for his advices, support and guidance throughtout the preparing and writing this thesis. All his guidance helped me a lot in finishing the research for almost a year.

Secondly, I would like to thank to all lecturers of Geoscience for directly or indirectly teaching and guiding us. All the knowledge given by the lecturers either in class, at field, etc, at any times, I will use them wisely now and also in the future.

My sincere thanks to my family, especially my parents, who give endless support, advices, and especially helping in financial throughout my study especially for my FYP.

Last but not least, thanks a lot to my friends and all the coursemate of SEG especially Nadia, Maryam, Fatin, Aiman, Wahida and Hasmimi who always accompany me to the site and finishing the research together.

Lastly, thanks to all that involved in finishing the research directly or indirectly. Thanks to the villagers of Kg Lubok Bongor who always warmly welcome us and showing us the route.

GEOLOGY AND DETERMINATION OF ROCK MASS STRENGTH AT KG LUBOK BONGOR, JELI, KELANTAN.

ABSTRACT

This study is entitled " Geology and Determination of Rock Mass Strength at Kg Lubok Bongor, Jeli, Kelantan". The aims of the study are to conduct and produce geological mapping of study area to scale of 1:25,000, and to determine the rock mass strength within study area. The area studied lies between longitude of 101^0 51'30'' E to $101^0$54'0'' E and the latitude of $5^0$35'0'' N to $5^0$33' 0'' N. The methods used in this study are geological mapping, petrographic studies and statistical analysis. Hornfels outcrop was exposed near TNB mini power station at Renyok waterfall. Biotite granite outcrop was exposed along the slope in the study area including as intrusive veins on hornfels outcrops of Renyok waterfall. The main alluvial sediments are sourced from Pergau river, poorly sorted sediments. For specification, there are four main parameters that were analyzed at the rock mass. They are spacing of discontinuities, infilling material of discontinuities, surface roughness of discontinuities and water condition of the discontinuities. These parameters are elaborated for each selected rock mass within study area. Rock Quality Designation (RQD) is calculated as one of the parameter of Rock Mass Rating (RMR). In conclusion, granite rocks have higher RMR compared to the metasedimentary rock. Granite rock can be classified as good rock meanwhile the metasedimentary rcok can be classified as fair rock.

Keywords: Rock Quality Designation (RQD), Rock Mass Rating (RMR).

GEOLOGY AND DETERMINATION OF ROCK MASS STRENGTH AT KG LUBOK BONGOR, JELI, KELANTAN.

ABSTRAK

Kajian ini bertajuk "Geologi dan Penentuan Kekuatan Jisim Batu di Kg Lubok Bongor, Jeli, Kelantan". Tujuan kajian ini adalah untuk menjalankan dan menghasilkan pemetaan geologi kawasan kajian dalam skala 1: 25.000, dan untuk menentukan kekuatan jisim batuan pada beberapa jasad batuan di dalam kawasan kajian. Kawasan kajian yang dikaji berada di antara longitud $101^{0}51'30''$ E sehingga $101^{0}54'0''$ E dan di antara latitud $5^{0}35'0''$ N to $5^{0}33'0''$ N. Kaedah yang digunakan dalam kajian ini ialah pemetaan geologi, kajian petrografi dan analisis statistik. Singkapan Hornfels telah didedahkan berhampiran stesen kuasa mini TNB di air terjun Renyok. Singkapan Biotit granit telah didedahkan di sepanjang cerun di kawasan kajian termasuk sebagai veins pada singkapan hornfels daripada air terjun Renyok. Sedimen aluvium utama diperoleh daripada Pergau sungai, enapan kurang disusun. Untuk spesifikasi, terdapat empat parameter utama yang dianalisis di jisim batu. Iaitu jarak ketidakselanjaran, pengisian tanah bahan ketidakselanjaran, kekasaran permukaan ketidakselanjaran dan keadaan air yang tidak berterusan. Parameter ini dihuraikan bagi setiap jasad batuan dipilih dalam kawasan kajian. Rock Quality Designation (RQD) dikira sebagai salah satu parameter of Rock Mass Rating (RMR) itu. Kesimpulannya, batu granit mempunyai lebih tinggi RMR berbanding batu metasedimentary itu. Batu granit boleh diklasifikasikan sebagai rock baik manakala batu metasedimentary boleh diklasifikasikan sebagai batu adil.

Kata kunci: Rock Quality Designation (RQD), Rock Mass Rating (RMR).

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATIONS

GIS Geographic Information System

GPS Global Positioning System

RMR Rock Mass Rating

RQD Rock Quality Designation

UCS Uniaxial Compressive Strength

LIST OF EQUATIONS

CHAPTER 1

INTRODUCTION

1.1 General Background

The title of the Final Year Project research is Geology and Determination of Rock Mass Strength in Kg Lubok Bongor, Jeli, Kelantan. The scope will focuses on the determination of rock mass strength on a few rock mass within study area . The rock mass strength is dependent on the structural geology, lithology, topography and the geomorphology of the study area. Field observation and mapping were done in this particular area of Kg Lubok Bongor which is around 25 km^2 to acquire the geology data information. In specific, the study area is situated in central part of Kelantan, the distance is about 98 km from Kota Bharu and around 15 km from the Universiti Malaysia Kelantan of Jeli Campus.

According to Goodman (1989), rock mass strength depends on the strength of intact rock and the strength of rock discontinuities. In general, compared to intact rock, a rock mass has reduced tensile strength (almost zero), and reduced shear strength especially along discontinuity planes. Furthermore, if a rock mass is cut by directional joint sets, the rock mass strength is anisotropic. Rock mass strength is scale dependent and varies with the volume of rock under consideration. Rock masses are far from being continue and consist essentially of two constituents, intact rock and discontinuities (plane of weakness).

In this study, a 1:25,000 geological map of Kg Lubok Bongor, Jeli was produced. Geological map is useful to understand the geology of an area such as the land use, lithology and road connection by geological mapping method. Measurement and observation at the field should be specific on detail observation and expected accurancy.

1.2 Problem Statement

This research was done order to get the detailed information on the rock mass strength on a few rock mass within study area as there might have been changes occur in this region over the period. The outcrop in Kg Lubok Bongor and the surrounding area is moderately exposed due to the high weathering activity. This is due to the result of the hot and humid climate condition in Malaysia and they also have structures that will technically affect to the strength of rock mass such as joint and fault. There is also no updated geological data at the study area. Thus, this study also conducted to produce the new geology information for that area.

1.3 Research Objectives

The objectives of this research is:

I. To produce geological mapping of study area in the scale of 1:25,000.

II. To determine the rock mass strength on a few rock mass within the study area.

1.4 Area of Study

The area of study is located in Kg Lubok Bongor and its surrounding, Jeli, Kelantan. Jeli is run by the District Council bordered by Perak in the west, Thailand to the north, Tanah Merah and Kuala Krai to the east and southeast. It is located about 98 kilometers from the city of Kota Bharu through the East West road. Almost

82% of its terrain is covered by hills, forests and rivers. The highest elevation of the study area is 500m whereas the lowest elevation of the study area is 40m. It is located in the longitude of $101^{\circ}51'30''$ E to $101^{\circ}54'0''$ E and the latitude of $5^{\circ}35'0''$ N to $5^{\circ}\ 33'\ 0''$ N as shown in Figure 1.6.

The main rivers are Pergau River and other few rivers do exist in this area such as Renyok river, Ayeran river, Raja river, Seting river, Buang river, Temang river, Jetek river, Gorok river, Chita river and Senor river. There are a few villages exist in surrounding area such as Kampung Renyok, Kampung Batu Dara, Kampung Jebang and Kampung Jabir.

1.4.1 Location

The geography covers the distribution of the people, rain distribution, land use, social economic and road connection.

1.4.2 Demography

The study area is located in Jeli. In 2010, Jeli has a population of 3810 peoples. Among this, 3685 peoples are Malay. Table 1.1 shows the detailed distribution of people according to ethnic group.

Table 1.1: Total distribution of population in Jeli.

Ethnic	Population (People)
Malay	3685
Chinese	38
Indians	9
Non- Malaysia Citizen	75
Others	125

(Source: Local Authority area and state, Malaysia, 2010)

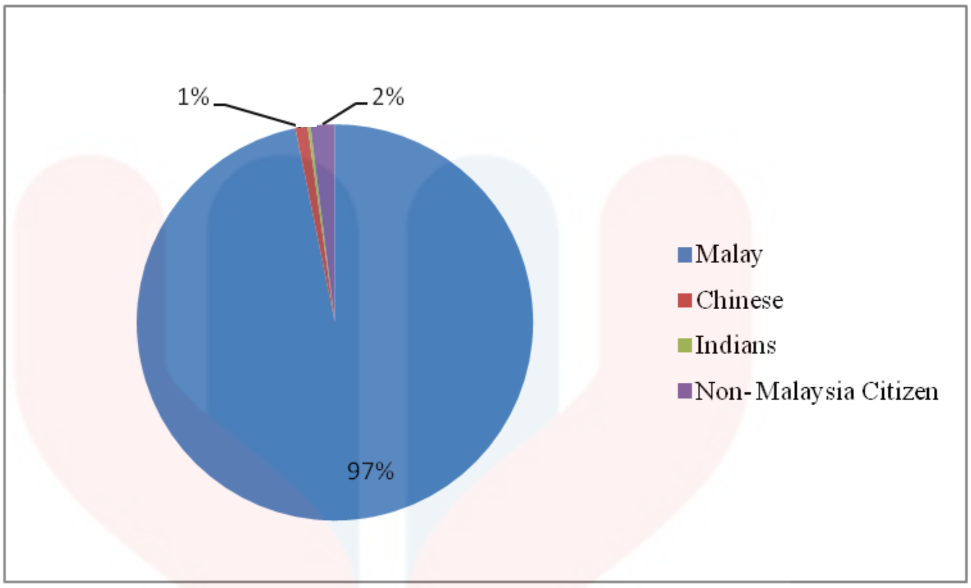


Figure 1.1 : Total distribution of population in Jeli.

1.4.3 Rainfall

Rain usually falls heavily according to the certain month in every year in Kelantan. The months that will always received heavy rainfall are November, December and January. It known as wet monsoon season. In 2014, the rainfall shows the highest number in the month of December which is 1542.0 mm due to the wet monsoon season that occur at that month. Figure 1.2 indicates line graph of rainfall in Jeli.

Table 1.2: Distribution of rainfall in Jeli monthly for the year of 2014.

Month	Rain Distribution (mm)
January	432.0
February	6.0
March	225.0
April	245.0
May	368.0
June	251.0
July	198.0
August	446.0
September	301.0
October	451.0
November	442.0
December	1542.0
Total	4,907.0

(Source: Department of Mineral and Geoscience Malaysia, 2014)

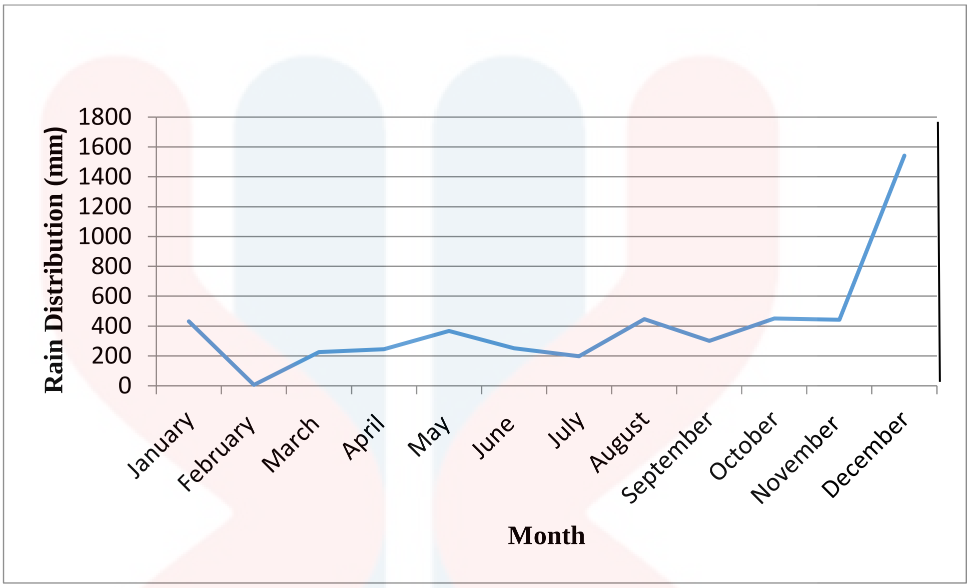


Figure 1.2: The distribution of rainfall in Jeli.

Figure 1.2 shows the distribution of rainfall in Jeli. The graph shows that the fluctuatate pattern graph rain distribution among the month January until October. Meanwhile, the rain distribution started to increased in November and December due to the wet monsoon season that occur at that month.

1.4.4 Landuse

Research area has been dominated by agriculture activities. Rubber plantation covered almost 50% of the area. The rubber plantation is mainly being planted in the flat area. Bush and shrubs are present almost in every part of the area. Other than that, there is corn cultivation and vege tables that cover the area. Figure 1.3 shows the landuse within study.

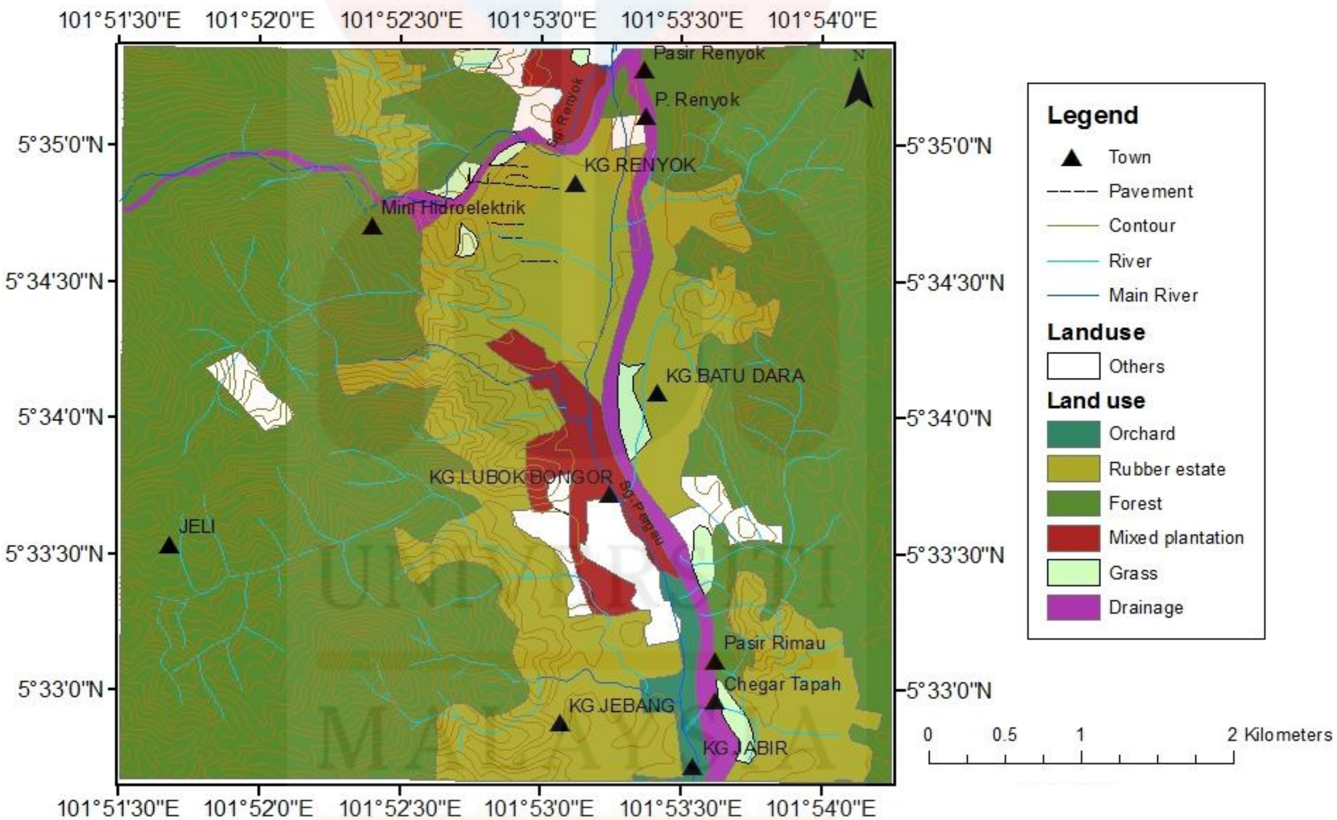


Figure1.3: Landuse map of the Kg Lubok Bongor.

1.4.5 Social economic

There are large area used for agriculture so that most of the villagers are farmers. As the study area is located at the alluvium-rich area, so the area is suitable for farming. Business activities are very important here. The local peoples open small stall selling fruits and foods near the road. These are coordinate at the agriculture area, $101^0 59'23.1''$ E and $05^0 06'35.0''$ N.

Figure 1.4: Corn cultivation at the Agriculture area.

1.4.6 Accessibility

The main road to access the study area is Jalan Jeli to Kuala Balah. The study area are located near the main road but for the agriculture area need to access by unpaved road. Some areas are only accessible by easy walking especially at rubber estate. Figure 1.5 shows the accessibility map.

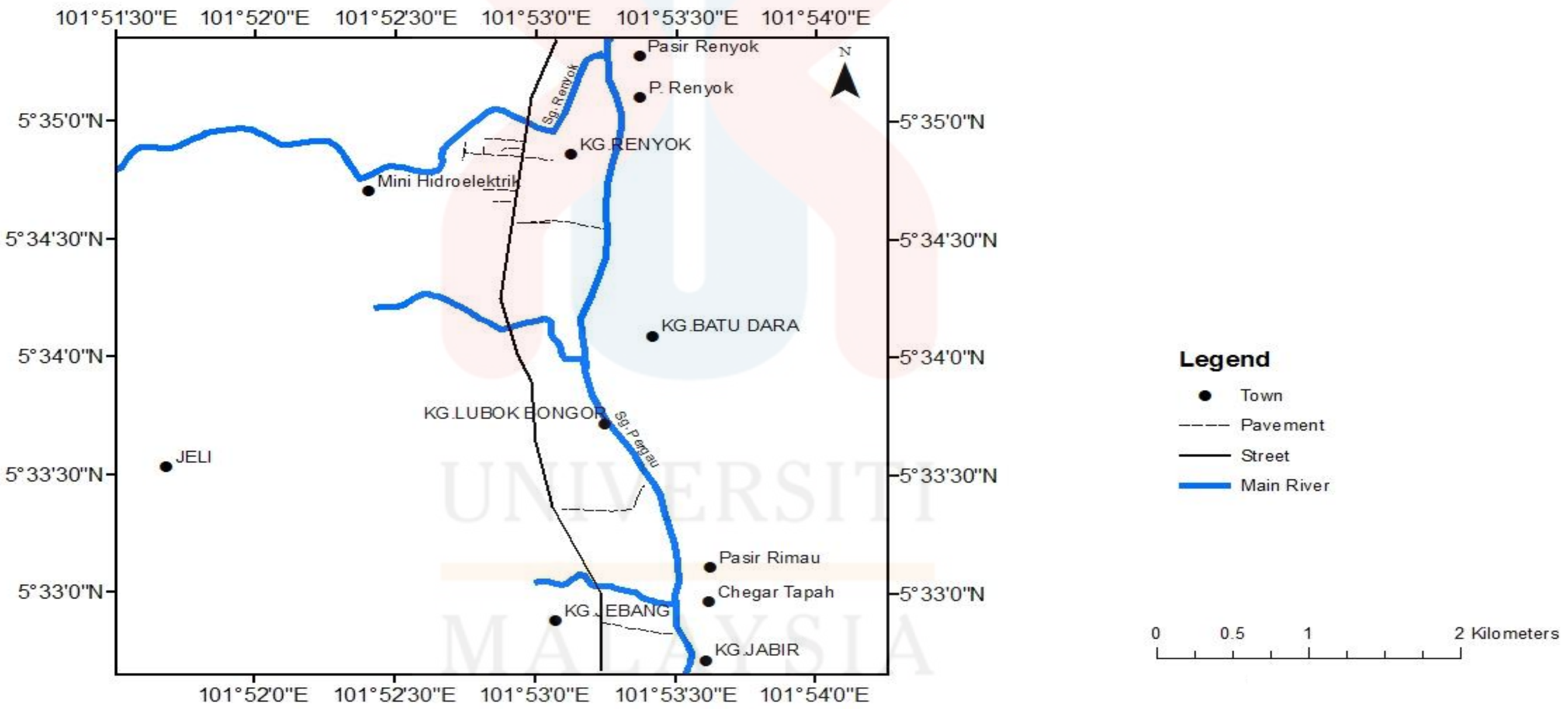


Figure 1.5: Accessibility map at Kg Lubok Bongor.

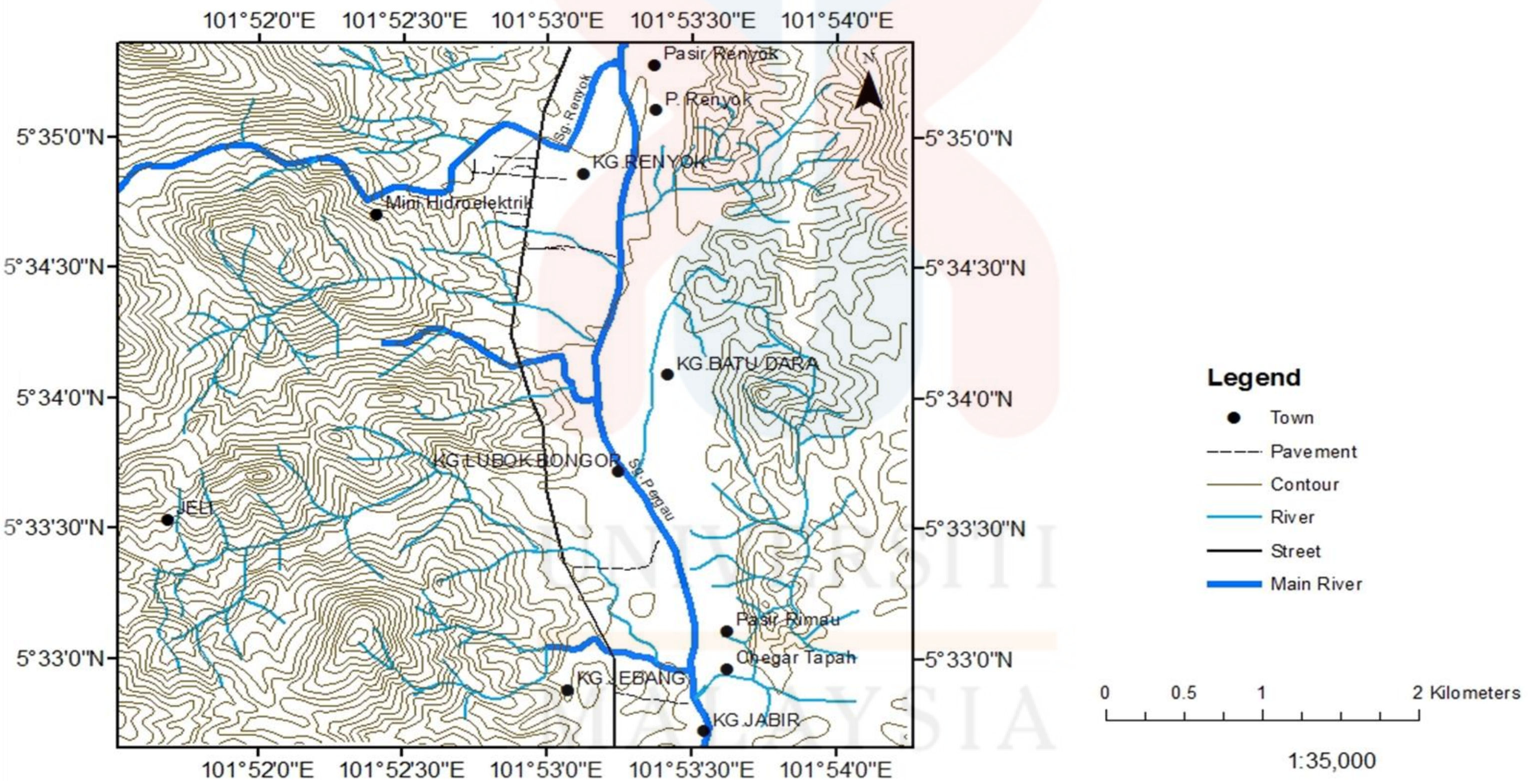


Figure 1.6: Basemap of Kg Lubok Bongor, Jeli, Kelantan.

1.5 Scope of Study

The study was limited to the producing of geological map and determination of rock mass strength on a few rock mass within study area. The scope of this study is about 25km^2 of Kg Lubok Bongor, Jeli, Kelantan for geological mapping. For the specification of study, it focused on determination of rock mass strength on a few rock mass within study area.

1.6 Significant of Study

The research was done to determine the rock mass strength on a few rock mass within study area. The geology study need to be carried out in order to produce the geology map of particular area in Kg Lubok Bongor and surrounding area. As there might have been changes occur in this region over the period where the latest previous map was produced.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Geology is the Earth's study about the composition, structure, history and the processes involved in shaping the Earth. The process occur on Earth today can't be proved to be same as processes occur million yeras ago. The materials discussed are the elements, minerals, rocks and water. The processes that act are plate tectonics, volcanic eruptions, earthquakes, mountain building, the rivers action, glaciers, oceans, wind, weathering and erosion.

2.2 Regional Geology and Tectonic Setting

2.2.1 Geology of Kelantan

According to Hutchison and Tan (2009), Malaysia are divided by two which is Peninsular Malaysia and East Malaysia (Sabah and Sawarak). Peninsular Malaysia is part of the Eurasian Plate. The South-East Asian part is known as Sundaland. Peninsular is connected by Isthmus of Kra due to submerge southeastern extension of the Asian continental. The Peninsular Malaysia consists of Western Belt, Central Belt and Eastern Belts.

The geology of the state (Kelantan) can be classified into several different types of rock and each type of rock cover up the whole area of Kelantan in their respective portion of occupancy. Kelantan predominantly with sediment or metasedimentary rocks that can be found at north-south central portion. It bordered on the west and east part with the granites that located in Main Range and Boundary Range.

Within the central zone, there are windows of granitic intrusives, the more prominent of these being the Ulu Lalat batholith, the Stong Igneous Complex and the Kemahang pluton. These belts of granite and country rocks have a north-south trend and are essentially the northern continuation of the regional geology of north Pahang. In west central Kelantan, the belts continue northward into south Thailand but in the east the Boundary Range granite is overlain by the coastal alluvial flat of Sungai Kelantan.

The study area is located at Jeli district. Jeli is a town in Kelantan, Malaysia. Jeli is run by the District Council bordered by Perak in the west, Thailand to the north, Tanah Merah and Kuala Krai to the east and southeast, while on the south side is border by the Gua Musang district.

2.3 Stratigraphy

Formation of Jeli district is Kemahang- granite. The Carboniferous- Permian clastic rocks occur in the western and southeastern parts of the Transect area. The rock units in the western part are enclosed by two granitic belts, between the Kemahang Granite/Sukhirin granite and the Merah granite/ Bu Do granite. The succession is subdivided into three formations, in ascending order: the Mangga formation. The three formations are found to be stratigraphically equivalent and are known as the Mangga Formation (The Malaysia Thailand Border Joint Geological Survey Commitee, 2006).

2.4 Structural Geology

In Peninsular Malaysia, most of the major fault zones experienced multiple deformation that generated a diverse variety of fault rocks. The microstructure and texture of the fault rocks can be used as indicators for the condition and mechanism of deformation (Mustaffa Kamal Shuib, 2000).

The localized structure include folds and joint in sedimentary rock whereas joint and fault occurs in granitic rocks. The faults may be reverse, oblique-slip and conjugate strike-slip, with slickenslided surface (Hutchison and Tan, 2009).

Kinematic study on the Kg Renyok especially at Lata Renyok waterfall concludes that the rocks there have undergone a minimum of four deformation phase. The first deformation event resulted in isoclinal folding of the metasediment foliation and reverse sinistrial oblique-slip faults along the contact between metasediment and veins while the second and third deformation resulted in conjugate strike-slip faults, drag and ptygmatic folds (Mustaffa Kamal Shuib, 2009).

2.5 Petrography

In Jeli, most of the rock found is igneous rock. Igneous rock is formed through the cooling and solidification of magma or lava. The large distribution of igneous rock is granite with course grained (phaneritic) and contain of major mineral which is feldspar and quart (Ibrahim and Jatmika, 2003).

2.6 Rock Mass Strength

The strength of rock masses depend on the behavior of these discontinuities or planes of weakness. Behavior of rock can be influence by a several factors such as characteristic of rock which is rock material structure like lithology, cracks and pores, rock mass structure like discontinuities (joints, faults, bedding planes and others) which is consider their type, orientation, continuity, roughness, spacing and length (Priest, 1993).

Discontinuities are usually categorized according to the manner in which they were formed. The following are standard definitions of the most commonly encountered types of discontinuities:

a) Fault

A discontinuity along which there has been an observable amount of displacement. Fault are rarely single planar units : normally they occur as parrallel or sets of discontinuities along which movement has taken place to a greater or less extend.

b) Joints

A joint is a discontinuity in which there has been no observable relative movement. A series of parallel joint is called a joint set: two or more interesting sets produced a joint system. Two sets of joint approximately a right angle to one another are said to be orthogonal. Joint may be formed in a systematic way (fracture occur in sub parallel joint or irregular geometry) or non-systematic way (non-parallel joint or irregular geometry).

c) Bedding plane

This is surface parallel to the surface of deposition, which may or may not have physical expression. Note that the original atitude of the bedding plane should not be assumed to be horizontal.

d) Foliation

Parallel orientation of platy minerals, or minerals banding in metamorphic rock.

The strength of rock material can be determined by using Schmidt hammer. There are several important parameters that considered to analyses the strength of rock mass of cut slope (Bieniawski, 1989). The parameter used are based on

1) Strength of intact rock
2) Rock quality designation, RQD
3) Spacing of discontinuities
4) Condition of discontinuities
5) Groundwater

In applying this classification system, the rock mass is divided into a number of structural regions and each region is classified separately. The boundaries of the structural regions usually coincide with a major structural feature such as a fault or with a change in rock type. In some cases, significant changes in discontinuity spacing or characteristics, within the same rock type, may necessitate the division of the rock mass into a number of small structural regions or domains.

The Rock Mass Rating (RMR) system is presented in Table 2.2, giving the ratings for each of the parameters listed. These ratings are summed to give a value of RMR. The following example illustrates the use of these tables to arrive at an RMR value.

2.6.1 Strength of Intact Rock

a) Point load test

The test consists of compress pieces of rock diametrically between two hardened steel cones. For this test, rock pieces must have a length at least 1.4 times of their diameter. Rock specimens break since tensile cracks develop parallel to the loading direction. Hence, the results of point load tests are usually presented in terms of a reference diameter equal to 50 mm. If the diameter is not equal to 50 mm, a correction is required (Broch and Franklin, (1972).

b) Uniaxial compressive strength

The uniaxial compressive strength (UCS) tests conducted on samples of about 10 cm long and if the discontinuity spacing is less than 10 cm the core may include discontinuities and this will be rock mass rather than intact rock strength. Samples tested in the laboratory tend to be of better quality than the average rock because poor rock is often disregarded when drilled cores or samples breaks and can not be tested. The intact rock strength measured depends on the samples orientations if the intact rock exhibits anisotropy.

2.6.2 Rock Quality Designation (RQD)

An estimate of RQD is often needed in areas where line mapping or area mapping has been conducted. In these areas it's not necessary to use core since a better picture of the rock mass can be obtained from scanline data. Priest and Hudson, (1976) found that an estimate of RQD could be obtained from the discontinuity of spacing measurements made on an exposure.

2.6.3 Spacing of Discontinuities

The perpendicular distance between adjacent discontinuities is refering to the discontinuity spacing. Spacing of discontinuity determines the dimensions of blocks in the slope or excavation which in turn influences the scale of potential rock falls. Discontinuity spacing was measured as the difference between successive distance measurements where the discontinuities intersect the scanline.

2.6.4 Condition of Discontinuities

Joint and fracture condition is examined with respect to the fracture sets influence the work. In general, the description of joint surface roughness and coating materials are weighted toward the smoothest and weakest joint set.

2.6.5 Groundwater

Groundwater can strongly influence rock mass behavior. The groundwater rating varies according to the conditions encountered (dry, damp, wet, dripping, or flowing), with the higher rating for a dried rock mass.

Rating adjustment for discontinuity orientations of slopes are defined as Table 2.2.

Table 2.1 : The rock mass classes.

RMR	Classification
100 – 81	Very good rock
80 – 61	Good rock
60 – 41	Fair rock
40 – 21	Poor rock
< 20	Very poor rock

Source: (After Bieniawski, 1989)

Table 2.2 : Rock Mass Rating System

A. CLASSIFICATION PARAMETERS AND THEIR RATING								
Parameter	Range of values							
Strength of intact rock material	Point load strength index (MPa) >10 Mpa		4-10 MPa	2-4 MPa	1-2 MPa	For the low range, uniaxial compressive is preffered		
	Uniaxial compressive strength (MPa)	>250 MPa	100-150 MPa	50-100 MPa	25-50 MPa	5-25	1-5	<1
	Rating	15	12	7	4	2	1	0
Drill core quality, RQD		90 %-100%	75%-90%	50%-75%	25-50	<25		
	Rating	20	17	13	8	3		
Spacing of discontinuities		>2m	0.6- 2m	200-600mm	60-200mm	<60mm		
	Rating	20	15	10	8	5		

Source: (After Bieniawski, 1989)

Table 2.2 : Rock Mass Rating System (continuation)

Parameter						
Condition of discontinuities		Very rough surfaces, not continuous No separation Unweathered Wall rock	Slightly rough surfaces Separation <1 mm Slightly weathered Wall rock	Slightly rough surfaces Separation <1 mm Highly weathered Wall rock	Slickensided surfaces or gouge < 5 mm, continuous Separation 1- 5 mm	Soft gouge > 5mm thick or Separation > 5mm continuous
	Rating	30	25	20	10	0
Groundwater	Inflow per 10m tunnel length	None	<10	10 – 25	25 - 125	>125
	Ratio (joint water pressure) (major principal stress)	0	<0.1	0.1 - 0.2	0.2 – 0.5	> 0.5
	General condition	Completely dry	Completely dry	Damp	Dripping	Flowing
	Rating	15	10	7	4	0

Source: (After Bieniawski, 1989)

Table 2.2 : Rock Mass Rating System (continuation)

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATION						
Strike and dip orientations		Very favourable	Favourable	Fair	Unfavourable	Very unfavourable
Ratings	Tunnels & mines	0	-2	-5	-10	-12
	Foundations	0	-2	-7	-15	-25
	Slopes	0	-5	-25	-50	
C. ROCK MASS CLASSES DETERMINED FROM TOTAL RATINGS						
Rating		100 - 81	80 - 61	60 – 41	40 - 21	<21
Class number		I	II	III	IV	V
Description		Very good rock	Good rock	Fair rock	Poor rock	Very poor rock
D. MEANING OF ROCK CLASSES						
Class number		I	II	III	IV	V
Average stand- up time		20 yrs for 15 m span	1 year for 10 m span	1 week for 5 m span	10 hrs for 2.5 m span	30 min for 1 m span
Cohesion of rock mass (kPa)		> 400	300 - 400	200 - 300	100 - 200	< 100
Friction angle of rock mass (deg)		> 45	35 - 45	25 - 35	15 - 25	< 15

Source: (After Bieniawski, 1989)

Table 2.2 : Rock Mass Rating System (continuation)

E. GUIDELINES FOR CLASSIFICATION OF DISCONTINUITY CONDITIONS					
Discontinuity length (persistence) Rating	< 1 m 6	1 – 3 m 4	3 – 10 m 2	10 – 20 m 1	>20 m 0
Separation (aperture) Rating	None 6	< 0.1 mm 5	0.1 – 1.0 mm 4	1 – 5 mm 1	>5 mm 0
Roughness Rating	Very rough 6	Rough 5	Slightly rough 3	Smooth 1	Slickensided 0
Infilling (gouge) Rating	None 6	Hard filling <5mm 4	Hard filling < 5mm 2	Soft filling < 5mm 2	Soft filling > 5m 0
Weathering Ratings	Unweathered 6	Slightly weathered 5	Moderately weathered 3	Highly weathered 1	Decomposed 0

F. EFFECT OF DISCONTINUITY STRIKE AND DIP ORIENTATION TUNNELLING			
Strike perpendicular to tunnel axis		Strike parallel to tunnel axis	
Drive with dip – Dip 45 – 90º	Drive with dip – Dip 20 – 45º	Dip 45 – 90º	Dip 20 -45º
Very favourable	Favourable	Very unfavourable	Fair
Drive against dip – Dip 45 – 90º	Drive against dip – Dip 20 – 45º	Dip 0 – 20 – Irrespective of strikeº	
Fair	Unfavourable	Fair	

Source: (After Bieniawski, 1989)

The following parameters are considered:

a) Rock type

The rocks are classified on the basis of the characteristics of intact rock as well as the discontinuities present such as joint, fault, materials, particle size and textures.

b) Intact rock strength

The strength of the intact rock is tested by using Schmist hammer rebound test. Schmidt hammer is the instrument used to test bearing capacity of siterock mass by rebound test. There are two ways of testing by Schmidt hammer. One is uniaxial test and the other is triaxial test.

c) Spacing

It is the perpendicular distance between the two adjacent discontinuities of the same set. The space between the discontinuities set in the same direction also causes variation in the strength of the rock. The rock material in between the discontinuity is intact material. The volume of the intact materials governs the strength of the rock.

d) Aperture

Aperture is the open spacing present in the rock due to discontinuity present in it. Depending upon space it is classified as widely open (> 1 cm), open (2mm – 1 cm), close (<2mm), tight (<1mm). The apertures which are wide and open causes the mechanical discontinuity as no stress is transferred all over the rock. However if the open discontinuity is filled with any other material then the strength, the stability of the rock increases depending upon the material type filling the aperture.

e) Roughness

It is one of the characteristics of the discontinuity surface. In rough discontinuity surface due to low friction, shear strength is high. Generally there are of two types of roughness – rough planar (rough surface with a plane flow) and rough wavy (rough surface with a wave like flow).

f) Seepage

The flow of water under gravitational forces in a permeable medium. Flow of water takes place from a point of high head to a point of low head. The flow is generally laminar. A flow line represents the path taken by a water particle.

g) Infilling materials

This are the materials filled in the open apertures of discontinuities. If there is no fill material. it is called clean material. If the rock has mineralized discontinuity (rock fragment) the strength may be considerably high. If the rock is powdered material (e.g soil) and mineralized or both, the rock may be either cohesive or non- cohesive. Tensile strength of soil is low.

2.7 Schimdt Hammer / Rebound Hammer

Schimdt hammer is a device to measure the elastic properties or strength of concrete or rock, mainly surface hardness and penetration resistance. The hammer mesures the rebound of a spring-loaded mass impacting against the surface of the sample. The test hammer will hit the concrete at a defined energy. Its rebound is dependent on the hardness of the concrete and is measured by the test equipment. When conducting the test the hammer should be held at right angles to the surface which in turn should be flat and smooth. The rebound reading will be affected by the orientation of the hammer, when used in a vertical position (on the underside of a suspended slab for examples) gravity will increase the rebound distance of the mass and vice versa for a test conducted on a floor slab. The rebound value can be used to determine the compressive strength by reference to the conversion chart in Figure 2.1.

The Schmidt hammer is an arbitary scale ranging from 10 to 100. The test is sensitive to other factors:

a) Water content of the sample, a saturated material will give different results from a dry one.
b) Local variation in the sample. To minimize this, its recommended to take a selection of reading and take an average value.

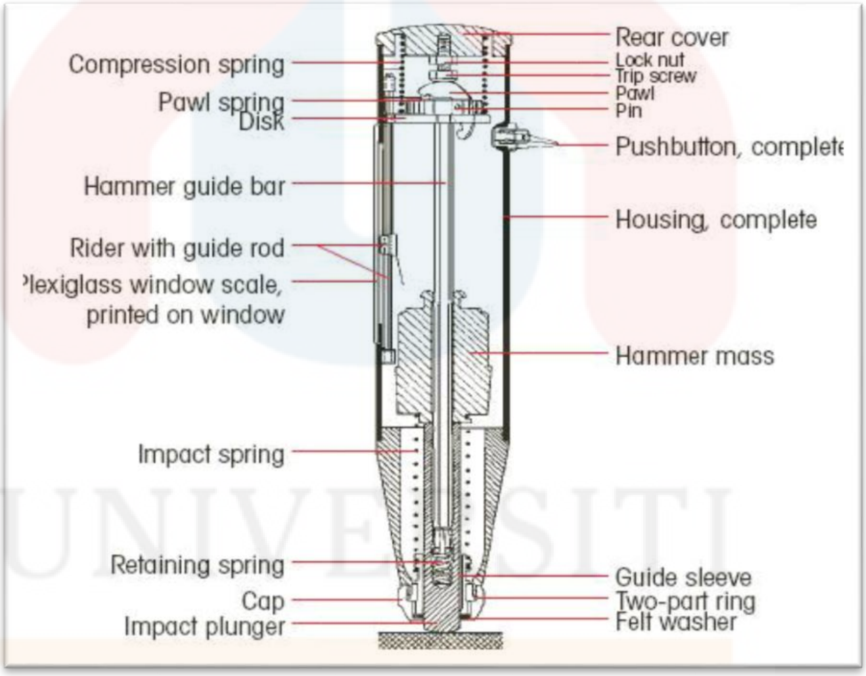


Figure 2.1: Schmidt Hammer.

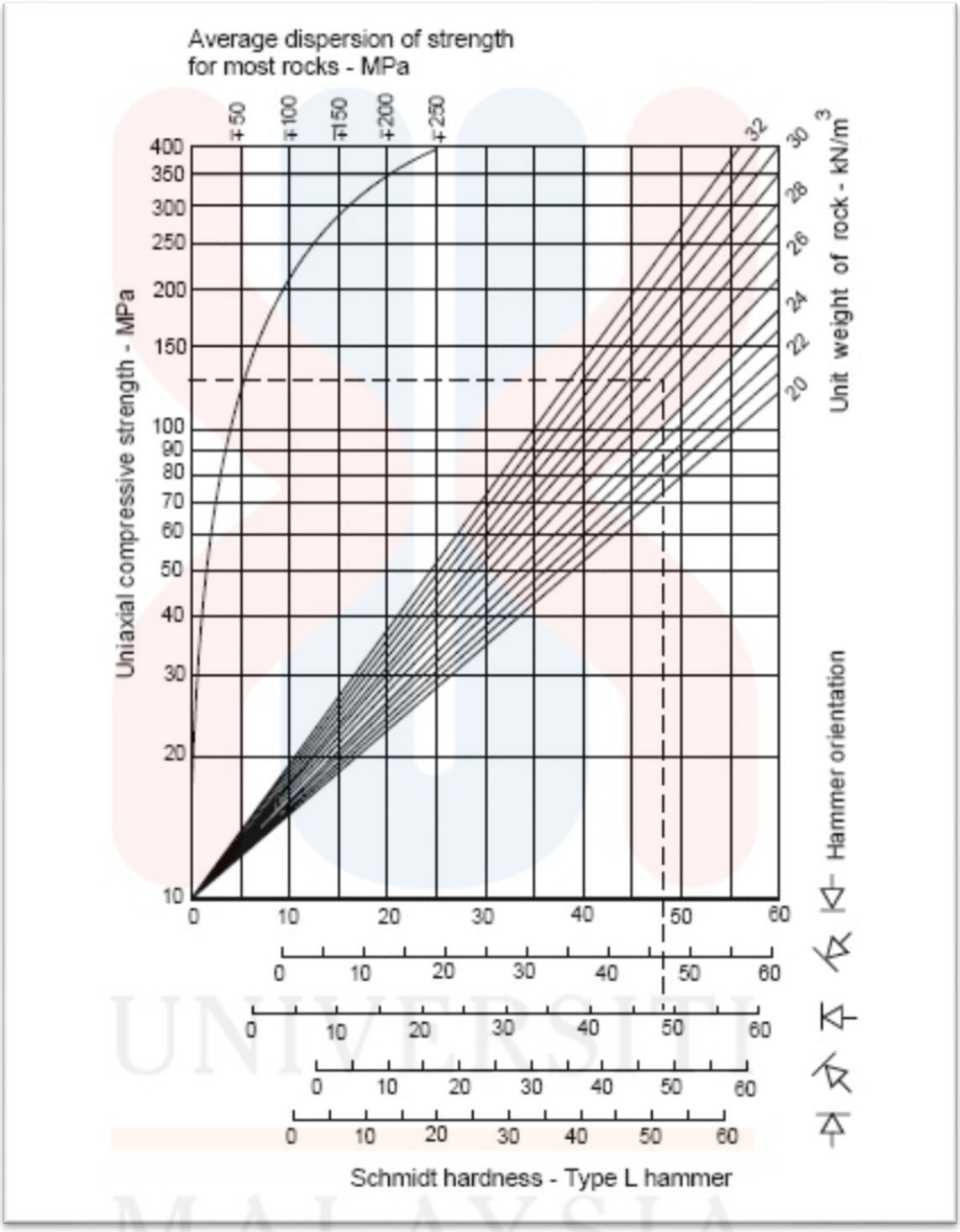


Figure 2.2 : Calibration Chart of Schmidt Hammer.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

In order to complete the research, suitable materials and methods must be followed. Materials are the equipments and items used to collect data and information for the research. Meanwhile, methodologies are the procedure and steps that must be followed in order to achieve the accurate results.The components of research of methodology should include preliminary researches, materials and methodologies, field study, laboratory analysis and data analysis. This is important in order to conduct the research. Figure 3.1 refers to flowchart of research methodology.

3.2 Preliminary Studies

Preliminary researches must be done before carrying out this research. The preliminary researches were done by studying the previous study conducted by the previous researchers in the study area or about the specification study which is determination of rock mass strength. This is very important in order to get clear description about the research area in terms of general geology and determination of rock mass strength.

3.3 Research Flow Chart

The flow chart for used this study was shown below.

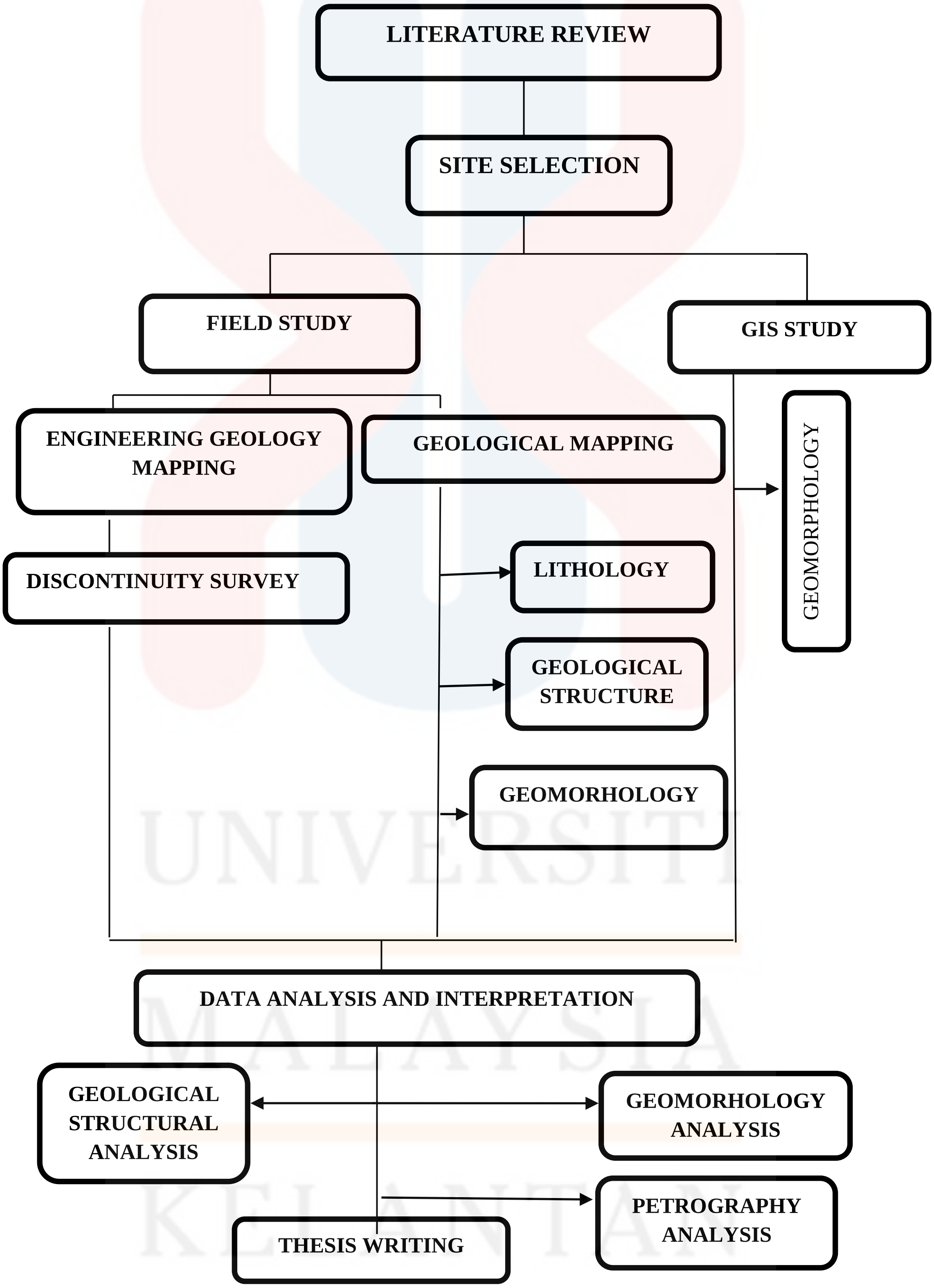


Figure 3.1 : Research Flow Chart

3.4 Materials and Method

3.4.1 Materials for Geological Mapping

Figure 3.2 : Geological Hammer.

a. Geological hammer - Geological hammer is use to break the rock outcrop for the sampling. Most of the pattern of this hammer is has one square faced end and one chisel end. This hammer also can be used for the dinging. Geologist's hammers are also sometimes used for scale in a photograph.

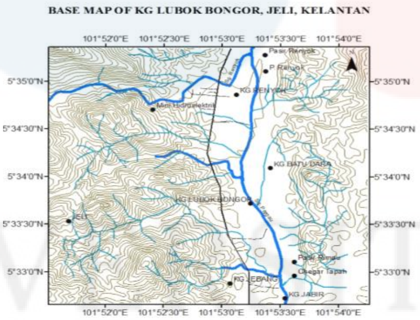


Figure 3.3 : Base Map.

b. Base map - Base map or also known as topographical map is represented the study area.

Figure 3.4 : GPS.

c. Global Positioning System (GPS) - The GPS is a device that used the radio signals from orbiting satellites that continuously give the exact time and their position. Used to identify the position at the study area.

Figure 3.5 : Brunton and Suunto Compass.

d. Brunton / Suunto compass - Compass is used to measure the orientation of geological planes and lineation. Most of the compass can give the bearing direction so that can plotted directly onto a map by using the compass itself as a protractor. The Pocket Transit may be adjusted for declination angle according to one's location on the earth.

Figure 3.6 : Hand Lenses.

e. Hand Lenses - The hand lens is used to identify the mineral characteristics that relate to the grain size or crystal size at the rock samples in the study area.

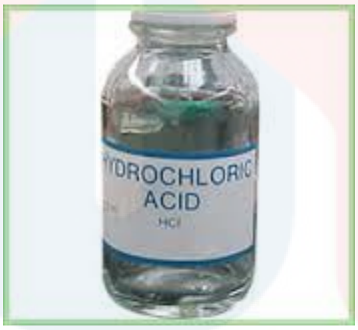


Figure 3.7 : Hydrochloric Acid.

f. Hydrochloric Acid (HCL) - To characterized the features of the rock by evidence of reaction. Placing a drop of dilute (5% to 10%) bydrochloric acid on the rock or mineral and watching for the bubbles of carbon dioxide gas to be released. The bubbles signal the presence of carbonate minerals such as calcite and dolomite.

Figure 3.8 : Measuring Tapes.

g. Measuring Tapes - Tape is used to measure everything from grain saiz until to the thickness of the bed. Its design allows for a measure of great length to be easily carried in pocket or toolkit and permits one to measure around curves or corners.

Figure 3.9 : Sample Bags.

h. Sample bags - To carry out the collected sample of rock or soil.

Figure 3.10 : Field Notebook

i. Field Notebook - It is for the field work data collection for the further study in the laboratory.

Figure 3.11 : Stationaries.

j. Stationaries - To collect the data by writing and measuring.

Figure 3.12 : Digital Camera.

k. Digital camera - A digital camera (or digicam) is a camera thet encodes digital image and videos digitally and stores them for later reproduction. It will used to snap a picture at the study area.

Figure 3.13 : Schimdt Hammer.

l. Schimdt Hammer - A Schimdt hammer is a device to measure the elastic properties or strength of concrete or rock, mainly surface hardness and penetration resistance. The hammer measures the rebound of a spring-loaded mass impacting against the surface of the sample.

3.4.2 Field Geological Tools

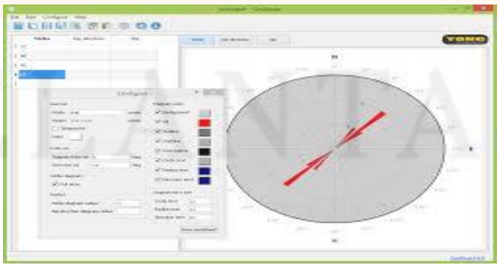
During the field work research, there is few equipment or tools that will be used in order to get the information at the study area.

3.4.3 Software

Software that is going to be use in this research are as stated as below.

a) AcrGIS version 10 – Geographic Information System (GIS) for working with maps and geographic information. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering information, using maps and geographic information in a range of applications and managing geographic information in database.

b) Microsoft Office Excel- It features calculation, graphing tools, and pivot tables.



c) Georose – User friendly tool to display, change and analyze orientational data. It displays the data in different views as text, in equal area/equal angle upper/lower hemisphere projection.

3.5 Field Studies

To get the exact data fieldwork is important method and must be get at the field. At the field, many data being collected such as lithology, morphology and structural geology.

a) Mapping

To acquire geology data of the studied area for instance, type of rock found and structural geology. Route tracking (traverse) by using GPS also has been carried out. The reading of strike and dip was obtained by using compass.

b) Discontinuity Survey

According to Goodman (1976), discontinuity data can be collected using detail line survey methods. The detail line survey method provides spacial control necessary to accurately portray and analyze site discontinuities. Each geologic feature that intercepts a usually linear traverse is recorded. The traverse can be a 1m tape placed across an outcrop. The mapper moves along the line and records everythings.

c) Sampling

Sampling method is used for rock specimen of every identified rock for further laboratory analysis and hand specimen analysis. There are two common method that previous work do for sampling which are random sampling, a nonsystematic distribution of sampling method, and the second one is systematic sampling which used a regularly spaced distribution of sampling location (Allaby, 2006). The rock samples are taken to identify the density of intact rock. The sample of rock will be taken to measure the strength of the rock by using point load test in laboratory.

3.6 Laboratory Investigations

The process was done to study the petrography of the rock discovered and to know the strength of intact rock. It needs to be done to identify what kind of rock by determining the characteristic under microscope observation. Samples of rock specimen were prepared by cutting it with a specific rock cutting machine and thinned by specific method of thin section preparation for further petrographic analysis.

For testing the rock strength, laboratory tests were also carried out at moisture contents as close as possible to those which occur as in the field. Many rocks show a significant strength decrease with increasing moisture content and tests on samples, can give a misleading impression of the intact rock strength. Once five or more triaxial test results have been obtained, it can be analysed to determine the uniaxial compressive strength.

3.7 Data analysis and Interpretations

Geology data – the acquired geology data in the fieldwork has been recorded in the software of Geographical Information System (GIS) and the trend of geologic data changes or the extent for any of the geological data over the area.

Petrogaphy data – the mineral content of the rock were identified through the observation of the thin section under the microscope.

The strength of rock mass data – the data of the strength of rock mass then were analysed through the several parameter such as rock intact strength, RQD, spacing of discontinuities, condition of discontinuities and groundwater data.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this section, detail information of general geology which are involves part of geomorphology, petrography, stratigraphy, structural geology and also historical geology of the research area is obtain from the observation of field mapping and analysis of data.

Rocks can be classified into three types which is igneous, sedimentary and metamorphic rock. Kg Lubok Bongor was composed mainly of igneous rock and small occurrence of metamorphic rock. The rock in Kg Lubok Bongor and surrounding area are moderately exposed due to the high activity of weathering process which is biological weathering and chemical weathering that effect to the strength of rock.

4.2 Traverse Mapping

Traverse map shows the location of observation during the field mapping (Figure 4.1). All the data collected was pointed into traverse map as shown in Table 4.1. Most of the outcrop found are in West part of the map. Geomorhologic observation have been done in all part of the study area and there was two mass movement and cut slope in the study area. The outcrop found can be classified as granite and hornfel based on the characteristic of the rock.

Table 4.1 : Activities of each stations that was point at the traverse map.

Station (S)	Coordinates	Activities / Observation
S1	N 05^{O} 33' 47.5'' E 101^{O} 52' 54.8''	Geomorphologic observation.
S2	N 05^{O} 33' 46.3'' E 101^{O} 52' 26.6''	Observation on cut slope.
S3	N 05^{O} 32' 50.6'' E 101^{O} 53' 12.2''	Geomorphologic observation.
S4	N 05^{O} 34' 59.9'' E 101^{O} 52' 45.3''	Geomorphologic observation.
S5	N 05^{O} 34' 58.2'' E 101^{O} 52' 57.8''	Geomorphologic observation.
S6	N 05^{O} 34' 25.0'' E 101^{O} 52' 46.5''	Outcrop observation.
S7	N 05^{O} 34' 35.1'' E 101^{O} 53' 12.4''	Outcrop observation.
S8	N 05^{O} 34' 34.1'' E 101^{O} 53' 13.6''	Geomorphologic observation.
S9	N 05^{O} 33' 52.5'' E 101^{O} 53' 09.1''	Geomorphologic observation.
S10	N 05^{O} 34' 20.1'' E 101^{O} 52' 46.2''	Outcrop observation.
S11	N 05^{O} 34' 22.1'' E 101^{O} 52' 43.0''	Outcrop observation.
S12	N 05^{O} 34' 13.9'' E 101^{O} 52' 35.1''	Mass wasting observation.
S13	N 05^{O} 34' 12.6'' E 101^{O} 52' 32.4''	Outcrop observation.
S14	N 05^{O} 34' 22.4'' E 101^{O} 52' 42.6''	Outcrop observation.
S15	N 05^{O} 34' 21.3'' E 101^{O} 52' 43.7''	Outcrop observation.
S16	N 05^{O} 34' 16.1'' E 101^{O} 52' 54.4''	Mass wasting observation.
S17	N 05^{O} 32' 42.8'' E 101^{O} 53' 07.4''	Outcrop observation.
S18	N 05^{O} 32' 43.3'' E 101^{O} 53' 05.6''	Outcrop observation.
S19	N 05^{O} 32' 46.2'' E 101^{O} 53' 00.2''	Outcrop and geomorphologic observation

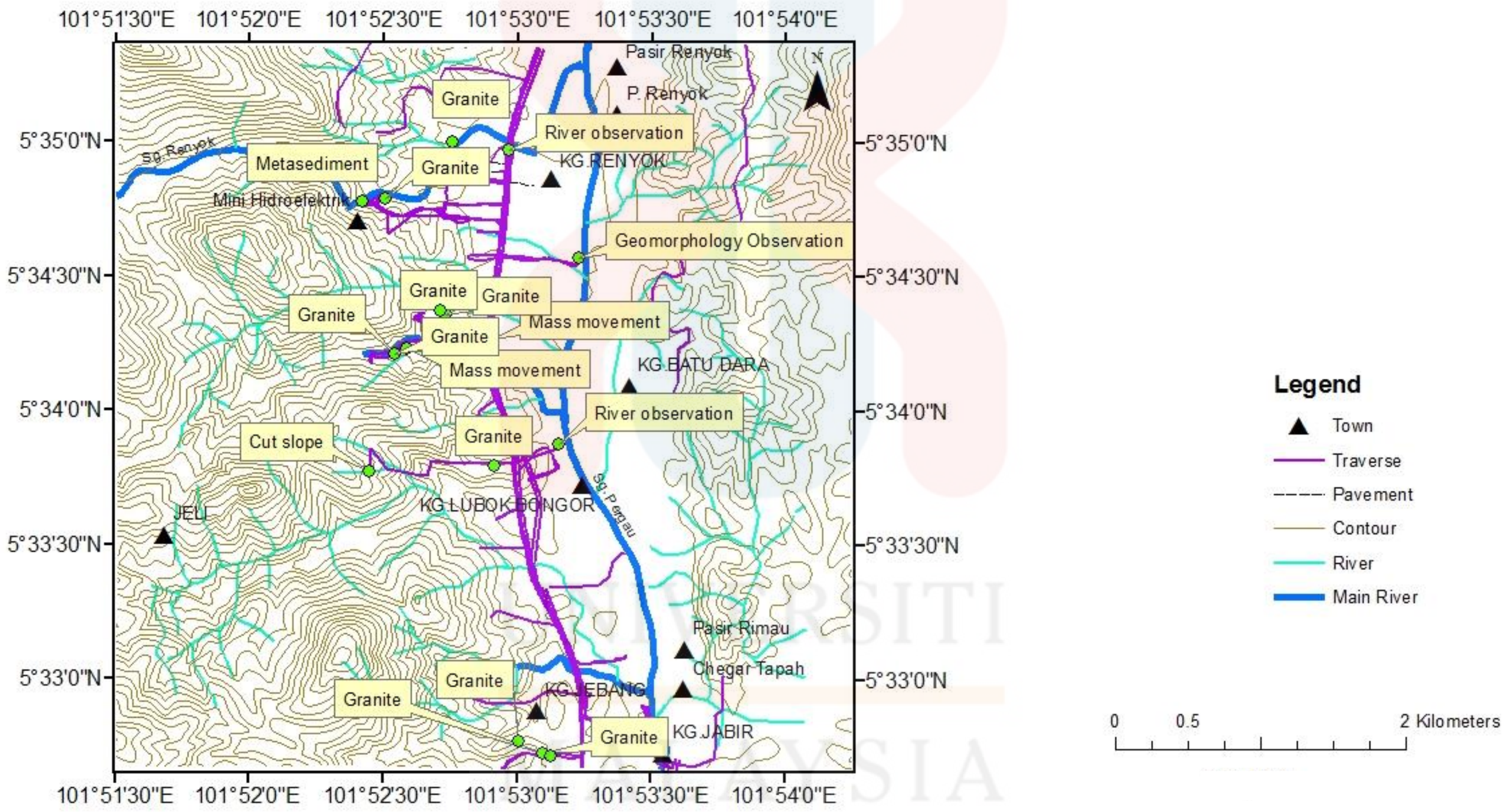


Figure 4.1: Traverse map of Kg Lubok Bongor.

4.3 Geomorphology

Geomorphology is defined as the science of landforms with an emphasis on their evolution, origin, form and distribution across the physical landscape. The study of geomorphology is broken down into the study of various geomorphologic processes. Most of these processes are considered to be interconnected and are easily observed. In addition, the individual processes are considered to be either erosional, depositional or both.

An erosional process involves the wearing down of the earth's surface by wind, water or ice. A depositional process is the laying down of material that has been eroded by wind, water or ice. According to Bocco et. all (2001), there are two broad groups of major landforms, with and without important relief expression. For the first group, it includes four geomorphologic regions, which are very low hills, low hills, high hill and sierras. While for the second group, it was formed by four other regions, valleys, plains, highplains, and piedmonts which have their own criteria.

The landform of Kg Lubok Bongor is classified based on table 4.2. It is divided into very low hill and low hill. Mostly, Kg Lubok Bongor has very low hill area with a relief amplitude of is less than 250 m.

In this chapter, geomorphology process will be described from topography, drainage system and weathering process in the study area.

Table 4.2 : Major landforms with prominent relief expression

Unit Name	Relief Amplitude (m)	Slope Steepness	Dominant Lithology
Very low hills	<250	3 – 8	Volcanic
Low Hills	250 – 500	6 – 20	Volcanic
High Hills	500 – 1000	20 – 45	Various
Sierras	1000 – 4000	>30	Various

(Source : Bocco et. all, 2001).

4.3.1 Topography

Topography is a field of earth science comprising the study of surface shape and features of the earth. It is also the description of such surface shapes and features. Topography specifically involves the recording of relief or terrain, the three- dimentional quality of the surface and the identification of specific landforms. Surface shape of study area was hilly type which is there are many hills there. Topography of the area was present in the form of 3D topographic map as shown in the (Figure 4.2).

Based on landform classification, the highest peak of contour is 500m while the lowest peak is 40m from sea level. Based on the landfrom class map of Kg Lubok Bongor, the distribution of the steep – moderately sloping was almost same in the map. Table 4.3 shown the topography unit classification (Hutchison and Tan, 2009).

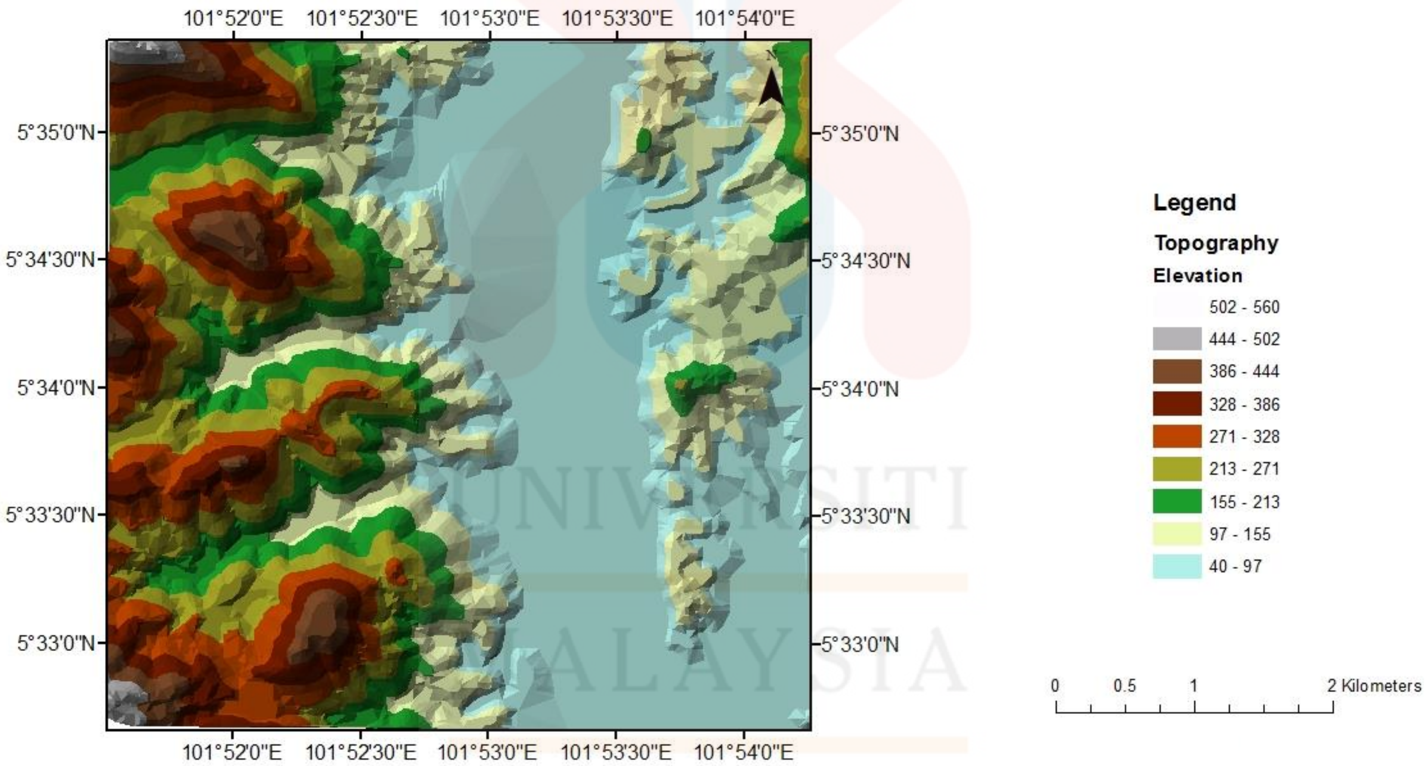


Figure 4.2: 3D Topography map of Kg Lubok Bongor

Table 4.3 : Topography unit classification (Hutchison and Tan, 2009)

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

4.3.2 Drainage System

Drainage system is the pattern formed by the streams, rivers and lakes in a particular drainage basin. A drainage basin is the topographic region from which a stream receives run-off, through flow and groundwater flow. Drainage basins are divided from each other by topographic barriers called a watershed. A watershed represents all of the stream tributaries that flow to some location along the stream channel.

The number, size and shape of the drainage basins found in an area vary and the larger the topographic map, the more information on the drainage basin is available. There are different types of drainage system according to their pattern which are dendritic, parallel, trellis, rectangular, radial, centripetal, deranged, annular and discordant. Figure 4.3 shows the difference drainage pattern. Different pattern will indicate different geomorphology. The collection of stream pattern shown in drainage map (Figure 4.4) indicate an overall complex drainage pattern in the study area. This is because groups of dissimilar patterns were formed at adjoining areas. This pattern indicate the study area may be controlled by more than one structure.

Sungai Seting in this area forms a sub-dendritic pattern. This pattern indicates the bedrock are uniformly resistant, and the deviation from dendritic pattern was a result of secondary control, such as structure. Sungai Renyok shows contorted pattern, common in coarsely layered metamorphic rock. Dikes, veins and migmatized bands also causes resistance in this layers.

Dendritic pattern were formed in the study area. This pattern suggests the locality around this rivers may have bedrocks horizontal sediments or uniformly resistant, crystalline rocks. The main river in the study area, Pergau River, shows alternating, meandering and braided pattern. This may indicate difference in stream sediments being supplied to the stream, possibly due to differing lithology along the river.

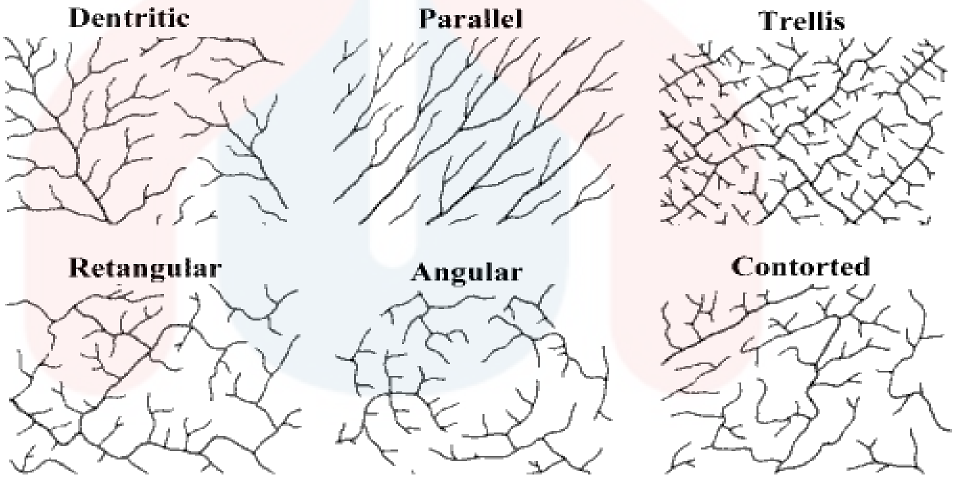


Figure 4.3 : Drainage pattern.

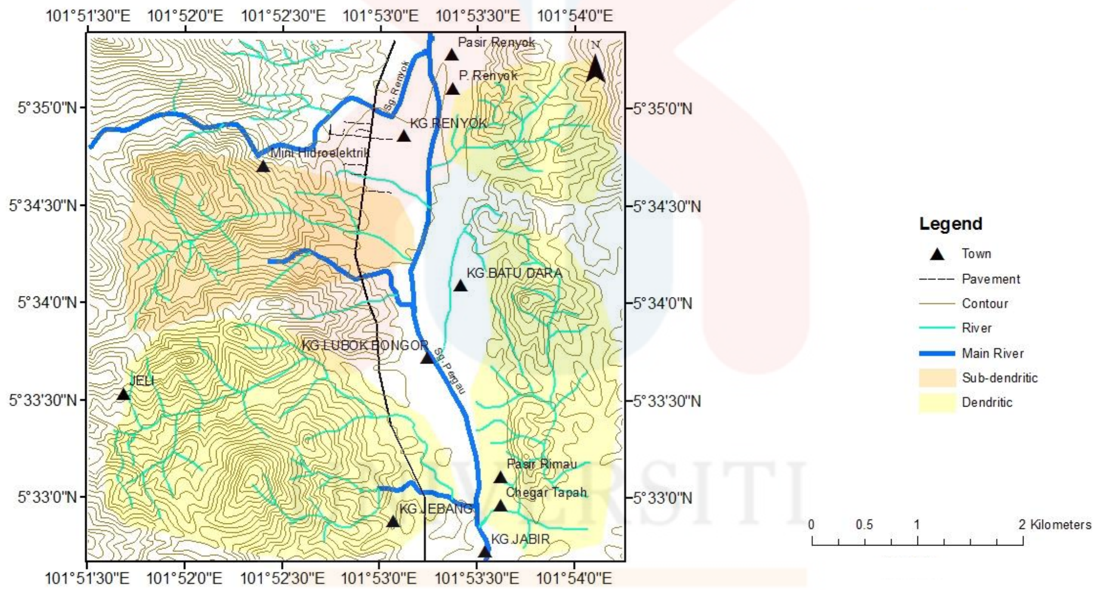


Figure 4.4: Drainage pattern. (Source: DSMM 2006, DATUM: KERTAU RSO)

Figure 4.5 : View one of the hill at the study area (101^{0}52’46.2’’ E and 5^{0}34’20.1’’ N).

Figure 4.6 : View from main river which is Pergau River (101^{0}53’13.6’’E and 5^{0}34’34.1’’N).

Figure 4.7: Deposition of river pebbles (101^{0}53’09.1’’ E and 5^{0}33’52.5’’ N)

4.3.3 Weathering Process

Weathering is the breakdown of rock minerals and rock masses when exposed to the atmosphere. Weathering occur “in situ,” meaning it occurs without major movement of the rock materials. Weathering happens through processes or sources in the environment, including events like wind and objects like the roots of plants. Weathering is either mechanical, in which rocks are broken down through an external force, or chemical, which means rocks are broken down through a chemical reaction and change. It will changes rocks from a hard state to become much weaker, make it more easily eroded.There are three types of weathering which was physical, chemical and biological weathering. Under the effect of weathering, the strength, density and stability of rock will reduce.

Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. Biological weathering combines both mechanical and chemical weathering and is caused by plants or animals. As plant roots grow deeper to find sources of water, they push through cracks in rocks, applying force to push them apart. As the roots grow, the cracks become larger and break the rocks into smaller pieces. When plants die, they produce acid as they decompose, causing a chemical reaction in the rock that further dissolves parts of rocks. Essentially plants can make their own soil in this way, allowing the crumbling crack to be more hospitable to the next seed that lodges there. Animals, including humans, can also cause biological weathering through frequent movement over a rock. This friction wears away bits of surface material. Trees and other plants can grow within the cracks in a rock formation. Biological weathering is caused by the presence of vegetation or to lesser extent animals including root wedging and the production of organic acids. Physical weathering also known as mechanical weathering. Physical weathering is caused by the effects of changing temperature on rocks, causing the rock to break apart without changing chemical properties.

Chemical weathering is the breakdown of rock by chemical mechanisms. It does not break rocks into smaller fragments through wind, water and ice, instead, it changes the chemical composition of the rock, usually through carbonation, hydration, hydrolysis or oxidation. Chemical weathering refers to the process by which rocks break down through chemical reactions; this weathering happens on a molecular level. This type of weathering causes rocks to decompose and occurs most often in warm and humid climates. All rainfall contains carbonic acid, which chemically reacts with the calcium carbonate in rocks like chalk and limestone through a process called carbonation. The rock becomes soluble in water, so the rock gradually dissolves as rain falls on it. Rocks that contain iron minerals oxidize, or rust, which chemically changes the structure of the rock and causes it to break apart. Figure 4.8 shows the biological weathering processes that effect the outcrop, as well as rock of study area. Figure 4.9 shows physical weathering process and Figure 4.10 shows chemical weathering process.

Figure 4.8: The biological weathering (101^{0}54'0'' E and 5^{0}35'0'' N).

Figure 4.9: Weathered outcrop - physical weathering (101^{0}52’32.4’’ E and 5^{0}34’0’’ N).

Figure 4.10: Chemical weathering (101^{0}52’54.4’’ E and 5^{0}34’16.1’’ N)

4.3.4 Mass Wasting

Mass wasting, also known as slope movement or mass movement, is the geomorphic process by which soil, sand, regolith, and rock move downslope typically as a mass, largely under the force of gravity, but frequently affected by water and water content as in submarine environments and mudflows. Types of mass wasting includes creep, slides, flow, topple, and falls, each with its own characteristic features. Mass wasting may occur at a very slow rate, particularly in areas that are very dry or those areas that receive sufficient rainfall such that vegetation has stabilized the surface. It may also occur at very high speed, such as in rockslides or landslides, with disastrous consequences, both immediate and delayed, e.g., resulting from the formation of landslide dams. Factors that change the potential of mass wasting include: change in slope angle, weakening of material by weathering, increased water content; changes in vegetation cover, and overloading. Figure 4.11 shows the landslide occur in study area.

Figure 4.11: Landslide (101^{0}52’35.1’’ E and 5^{0}34’13.9’’ N).

4.4 Stratigraphy

4.4.1 Petrographic Analysis:

In this section, petrography techniques were used to determine the minerals compassing the rock. Petrographic analysis aids in naming more specifically the rock found in the study area. Table 4.4 shows the lithostratigraphy of Kg Lubok Bonggor and Figure 4.24 shows the geological map of the study area.

a) Hornfels

Hornfels is a metamorphic rock formed by the contact between mudstone and shale, or other clay-rich rock, and a hot igneous body, and represents a heat-altered equivalent of the original rock. This process is termed contact metamorphism. Because pressure is not a factor in the formation of hornfels, it lacks the foliation seen in many metamorphic rocks formed under high pressure and temperature regimes. Pre-existing bedding and structure of the parent rock is generally destroyed during the formation of hornfels. The hand specimen of hornfel shows banded layering due to intrusive vein deforming along with the host rock. The contact between the leucogranite and host rock varies from gradational to sharp.

The type of contact between leucogranite and the country rock, observed from hand specimen is gradational. Petrographically, this hornfels contains quartz, plagioclase, hornblend and biotite as essential mineral. Biotite mica could be identified based on its shiny nature and its abundant in the dark layers. This light layers consist of leucogranite with large biotite and quartz crystals. The minerals form characteristic texture associated with contact metamorphism. Based on petrographic analysis, the hornfel studied can be categorized into amphibolite facies. The composition of the mineral in this sample is Biotite = 30%, Quartz = 45%, alkali feldspar = 15%, Plagioclase = 10%.

Figure 4.12 : Hornfel outcrop located at Lata Renyok ($101^0$52'46.5'' E and $5^0$34'35.1'' N).

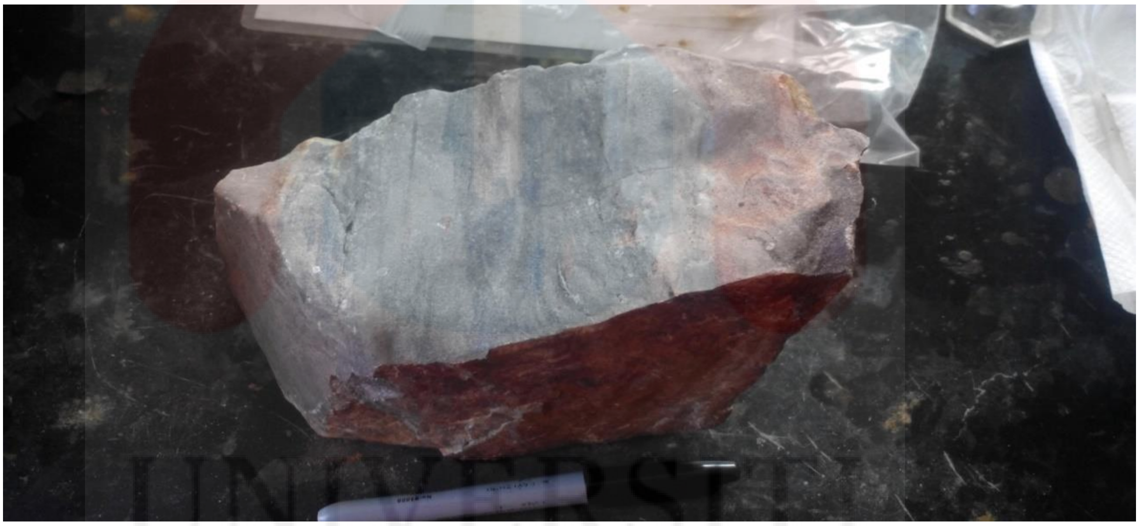
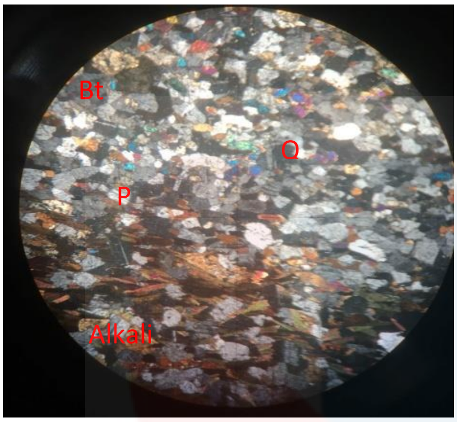


Figure 4.13: Hornfel hand specimen.



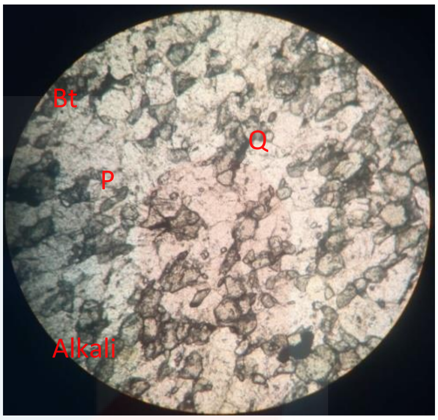


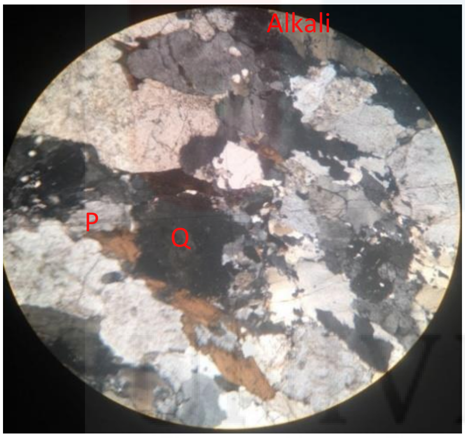
Figure 4.14 (a): Hornfel under cross thin section **Figure 4.14 (b):** Hornfel under plane thin section.

b) Biotite granite porphyry

In hand specimen, the rock has porphyritic texture. The phenocrysts is alkali feldspar while the groundmass is biotite mica and quartz. The alkali feldspar is replaced with white coloured kaolinite due to weathering. Porphyritic texture of alkali feldspar was shows under the microscope. Besides alkali feldspar, quartz mineral also present in abundance. Most of the quartz exhibit undulatory extinction, indicating deformation. Other microstructures indicating deformation were microfaults on the surface of plagioclase. The QAP composition for this rock is Quartz = 50%, Plagioclase = 10% and Alkali Feldspar = 40%.

Figure 4.15 : Biotite granite outcrop ($101^0 53'07.4''$ E and $5^0 32'42.8''$ N).

Figure 4.16 : Hand specimen of biotite granite.



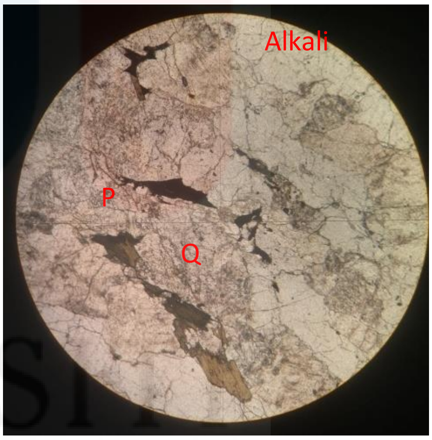


Figure 4.17 (a): Mineral under cross thin section. **Figure 4.17 (b):** Mineral under plane thin section.

4.5 Lithostratigraphy

Lithostratigraphy of the study area was proposed based on outcrop study, hand specimen analysis and literature reviews. The rock units exposed in the study area are grouped into two main categories : (1) the metasedimentary rocks and (2) the igneous rock. The characteristics of rocks exposed will be described below in detail.

a) Hornfels

Hornfels outcrop is exposed near TNB mini power hydro station at Lata Renyok waterfall. The outcrop as about 50 60 60 meter wide, more than 159 meter long and trends approximately NE – SW. It is characterized by banding throughout the unit. Heating process that caused ductile deformation has resulted in folding while outcrops has undergone compression and shortening along the boudinage that lies parallel to the foliation of the hornfels. The outcrop exposed are heterogeneous, continuous exposure. The heterogeneous components include the hornfels as well as granitic veins. Hornfel in Lata Renyok varies based on the host rock composition. Based on field observation, there are two tyoes of hornfels which is Calcium – Silicate Hornfel and Biotite Hornfels. Shearing on the surface of Biotite Hornfels leads to it acquiring schistose characteristics.

Figure 4.18: Folding structure ($101^0$53’12.4’’ E and $5^0$35’35.1’’ N).

a) Biotite Granite porphyry

Biotite granite outcrop was exposed along the slope in the study area. The outcrop was about 1 m wide and partially covered by vegetation. The outcrop is homogeneous grey granite, greyish probably due to the presence of biotite. Minor joints were exposed on the rock surface. The joints was filled with quartz vein. No contact found along this outcrop.

Figure 4.19: Joint and quartz vein (101^{0}53'12.4'' E and 5^{0}34'35.1'' N).

b) Quaternary alluvium sediments

The alluvium sediment being deposit presently within the study area include poorly sorted sediment deposited along the streams, alluvial fans, river and valleys. The main sediments were formed adjacent of Pergau river. Figure 4.20 shows the alluvium sediment at Pergau river.

Figure 4.20 : Alluvium sediment at Pergau river (101^{0}53’13.6’’ E and 5^{0}34’34.1’’ N).

Table 4.4 : Lithostratigraphy of Kg Lubok Bonggor.

Geological Time		Formation	Lithology	Description	Igneous Intrusion	Description
Quarternary	Recent	Quartenary Alluvial deposit		Alluvial sediments		
	Pleistocene					
Triassic		Telong formation		Hornfels		
Permian						Biotite granite porphyry
Carboniferous		Mangga formation				

4.6 Structural Geology

4.6.1 Linemant Analysis

Based on observation from Google Imagery, lineaments control the topography towards the Western part of the study area but shows no influence on the Eastern part of the study area. Linear trends of topographic highs such as strikes ridges, dykes and usually represent the exposure of resistant rock units. Linear trends of topography lows such as straight valleys usually represents exposures of non-resistant rock units or planes of weakness such as fault and fracture. Figure 4.22 shows the rose diagram for lineamant analysis. The major force oriented in NE while the minor forces 90 degrees from the major force which is NW. Figure 4.21 shows the lineamant trend around the study area.

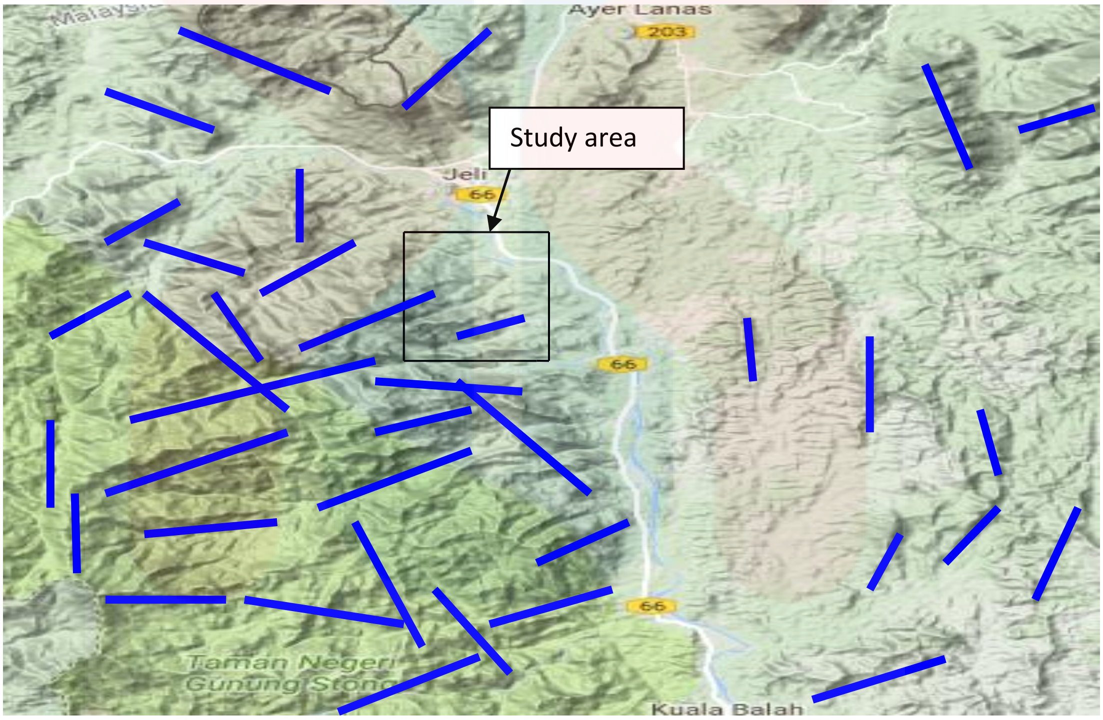


Figure 4.21 : Lineamant trend around the study area. Black box shows the study area.

Source: Google imagery, date accessed 28 November 2016

σ 3

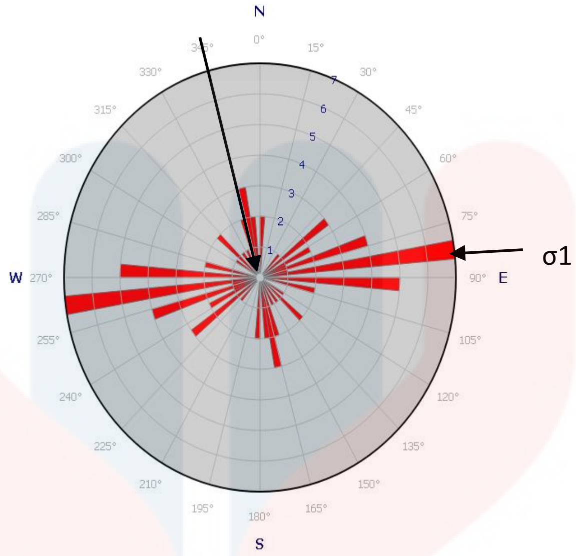


Figure 4.22: The rose diagram shows that the major forces of the lineament is NE direction.

4.6.2 Foliation

Foliation in the rocks is been observed by the preferred orientation of dark and light coloured minerals. The light coloured minerals are the quartzo-feldsparthic minerals (quartz and feldspar) while the dark coloured minerals are the ferromagnesian minerals (hornblende and biotite). Foliation in the hornfels were penentrative. The general trend of foliation is seen to be generally constant throughout the study area. The origin of foliation is related to be due to faulting along the plane of the foliation. These early fault induced foliation has similar characteristic features, such as boudinage, similar as those in the well foliated calcite-silicate hornfels.

4.6.3 Boudinage

Lineation features most extensively present on the outcrop was boudinage. Boudinage is a structures formed by extension. These structures are related to plastic deformation of the vein involved since the boudin forms necking structure, with adjacent foliation bending in towards the boudin neck. Boudins are typical features of sheared veins and shear zones where, due to stretching along the shear foliation and shortening perpendicular to this, rigid bodies break up. This causes the resulting boudin to take a characteristic sausage or barrel shape. They can also form rectangular structures, ductile deformation conditions also encourage boudinage rather than imbricate fracturing.

4.6.4 Joint analysis

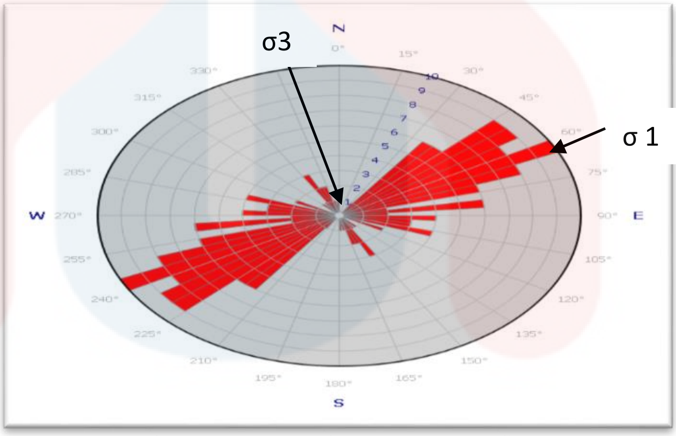


Figure 4.23: Rose diagram of joint analysis.

Joint can divides the rock into two or more pieces. A fracture that sometimes form a deep fissure or crevice in the rock. Commonly caused by stress exceeding the rock strength, causing the rock to lose cohesion along its weakest plane. The joint analysis displayed on Rose Diagram had the compression forces associated with this joint. The major force oriented in NE while the minor forces 90 degrees from the major force which is NW. Figure 4.23 shows the ros diagram of joint analysis.

4.7 Historical Geology

The geology of the state (Kelantan) can be classified into different types of rock and each type of rock cover up the whole area of Kelantan in their respective portion of occupancy. Kelantan predominantly with sediment or metasedimentary rocks that can be found at north-south central portion. It bordered on the west and east part with the granites that located in Main Range and Boundary Range. Within the central zone, there are windows of granitic intrusives, the more prominent of these being the Ulu Lalat batholith, the Stong Igneous Complex and the Kemahang pluton. These belts of granite and country rocks have a north-south trend and are essentially the northern continuation of the regional geology of north Pahang. In west central Kelantan, the belts continue northward into south Thailand but in the east the Boundary Range granite is overlain by the coastal alluvial flat of Sungai Kelantan.

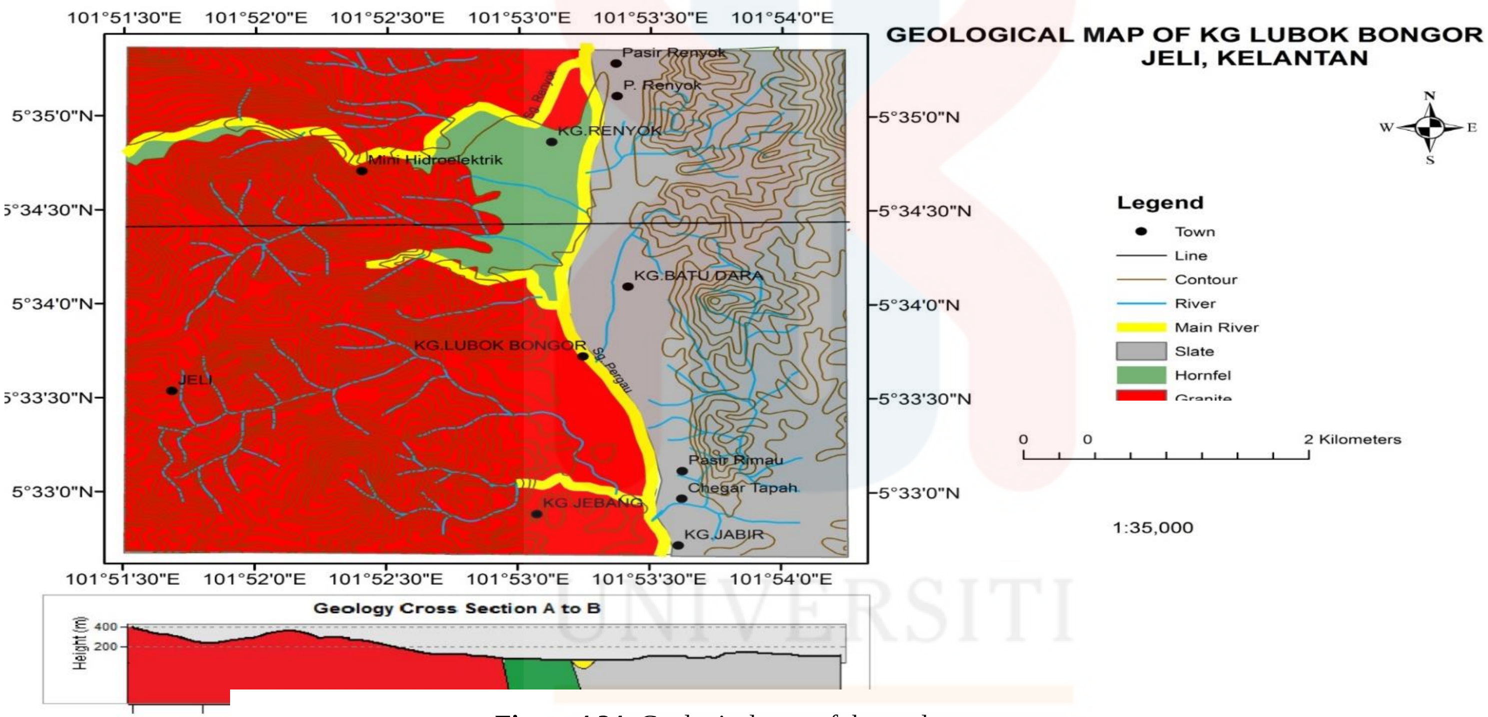


Figure 4.24: Geological map of the study area.

CHAPTER 5

ROCK ENGINEERING

5.1 Introduction

The chapter discussed on the rock engineering specification which is determination of rock mass strength on a few rock mass within the study area. The strength of rock masses depend on the behavior of these discontinuities or plane of weakness. Behavior of rock can be influence by a several factors such as characteristic of rock which is rock material structure like lithology, cracks and pores, rock mass structure like discontinuities (joints, faults, bedding planes and others) which is consider their type, continuity, spacing, orientation, roughness and length.

There are four main parameters that were analyzed at these rock slopes. There are spacing of discontinuities, infilling material of discontinuities, surface roughness of discontinuities and water condition of the discontinuities. This survey carried out by scanline survey technique in which a line is drawn over an outcropped rock surface and all the discontinuities intersecting it are measured and described. This research carried out about rock mass strength of rock mass. To assess the strength of rock materials, Schimdt readings were then converted to Uniaxial Compressive Strength (UCS).

5.2 Rock Mass Strength

Figure 5.1(a) shows rock mass in location 1 respectively. Meanwhile figure 5.1 (b) shows rock mass in location 2.

Figure 5.1(a) : Rock mass 1 (101^{0}53’12.4’’ E and 5^{0}35’35.1’’ N).

Figure 5.1 (b): Rock mass 2 (101^{0}52’32.4’’ E and 5^{0}34’12.6’’ N).

5.3 Spacing of Discontinuities

Spacing of discontinuities influences the rock mass strength. The wider the spacing, the weaker the rock mass. These parameter is divided into five classes which is wide (> 200 mm), moderately wide (60 – 200 mm), moderately narrow (20 – 60 mm), narrow (6 – 20 mm), very narrow (2 – 6 mm) and tight (< 2 mm). Figure 5.2 shows spacing discontinuities of slope 1. Discontinuities with tight opening is the most, followed by very narrow, narrow and moderately narrow. Since most of the openings are tight, it gives tremendous strength to the rock mass.

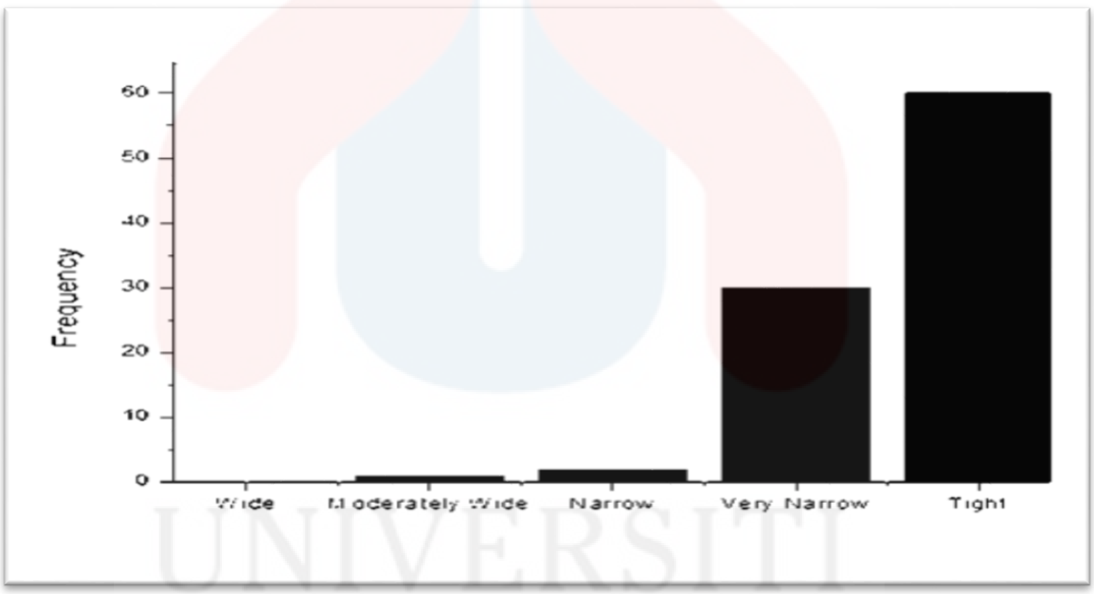


Figure 5.2 : Spacing of discontinuities of rock mass 1.

Figure 5.3 shows spacing discontinuities of rock mass 2. Discontinuities with tight opening id the most, followed by wide, moderrately wide, narrow and very narrow. Tight opening gives tremendous strength of the rock mass.

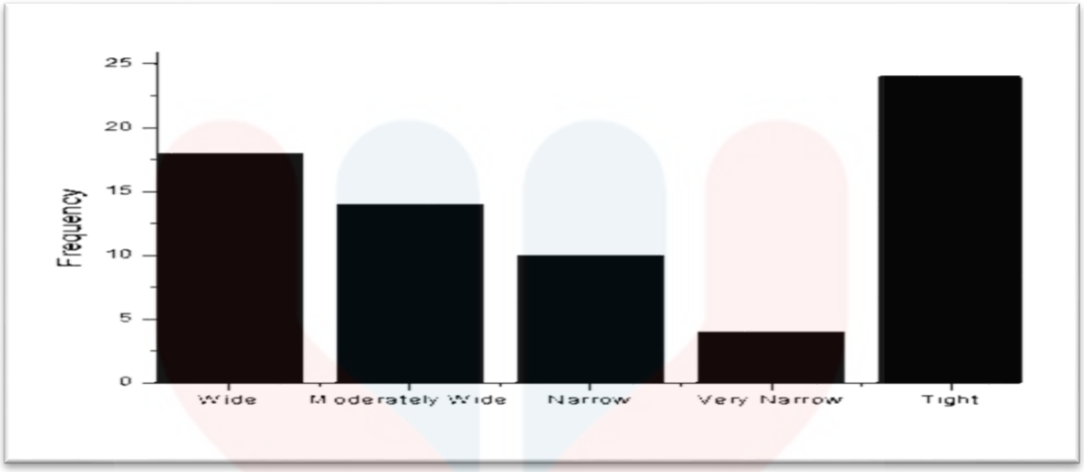


Figure 5.3 : Spacing discontinuities of rock mass 2.

5.4 Filling Material of Discontinuities.

Filling material in discontinuities also affect the rock mass strength. There are many types of filling materials such as active clay, sand, cement, chloride, gypsum, fault breccia and others. Presence of clay material can cause swelling when interact with water and reduces the strength of the rock mass. Figure 5.4 (a) shows filling material in discontinuities of slope 1. There are filled with sand and having clean discontinuities. Rock mass 2 also filled with sand and clean discontinuities as stated at Figure 5.4 (b).

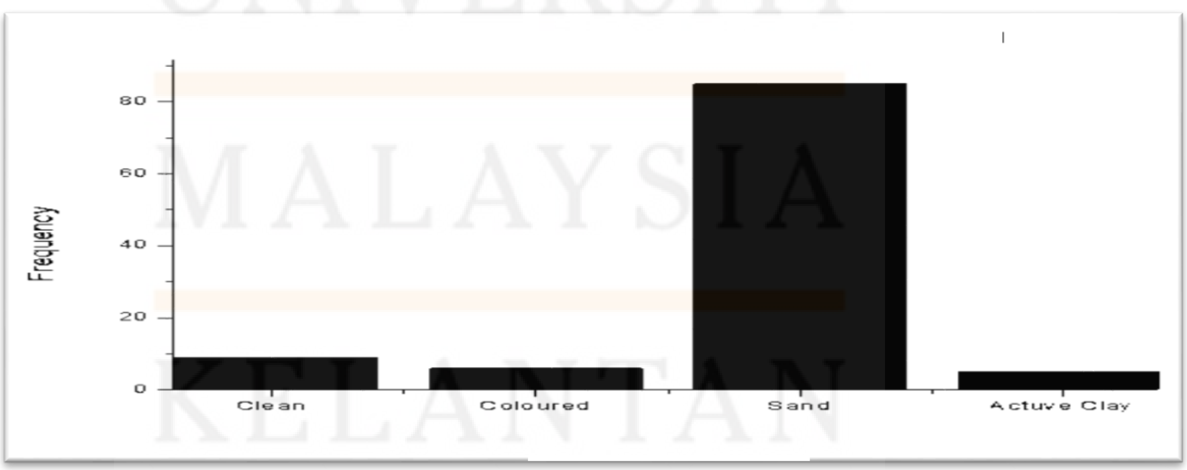


Figure 5.4 (a) : Types of fillings material for rock mass 1.

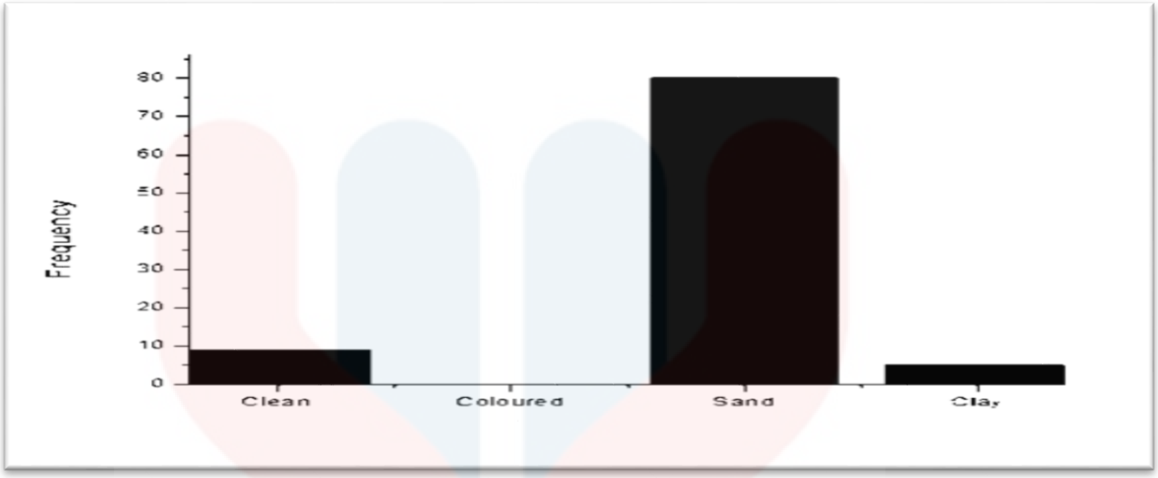


Figure 5.4(b): Types of fillings material for rock mass 2.

5.5 Surface Roughness of Discontinuities

The friction force between the two rocks in the rock mass is affected by surface roughness. Smooth surface facilitates rocks to easily slide over one another along the discontinuities. Meanwhile, rough surface has higher friction force that keeps the rock in position. Most of the surface roughness of discontinuities for both slope are rough surface.

5.6 Groundwater condition of discontinuities

Groundwater condition can influence the strength of rock maass by intensifying weathering process. Water condition of the discontinuities are caused by several factors such as weather, occurrence of natural springs and seeepage. The water condition is categorized into dry, damp, wet and flow. Most of the discontinuities in slope 1 and 2 are flow and damp.

5.7 Rock Mass Rating (RMR)

There are five parameters used to classify a rock mass using the RMR system which is strength of intact rock, Rock Quality Designation (RQD), spacing of discontinuities, groundwater conditions dan condition of discontinuities.

5.7.1 Strength of intact rock material (Uniaxial Compressive Strength)

Strength of intact rock material is obtained by conducting Schmidt Rebound Test. But, Schmidt Rebound readings giving no unit value. Therefore, the value has to be converted to UCS values with MegaPascal (MPa) units. Density test is conducted to convert the readings using UCS graph.

a. Slope 1

Figure 5.5 shows Schmidt reading for slope 1. Since the Schmidt reading are bimodal, the formula to find the mode is :

$$\text{Mode} = L + \left(\frac{d_1}{d_1 + d_2}\right) \times C \qquad (5.1)$$

Where,

d_1 = frequency of the modal class – frequency of the class before

d_2 = frequency of the modal class – frequency of the class after

L = Lower boundary of the modal class

C = The width of the modal class

Therefore, the mode is 21.2 .

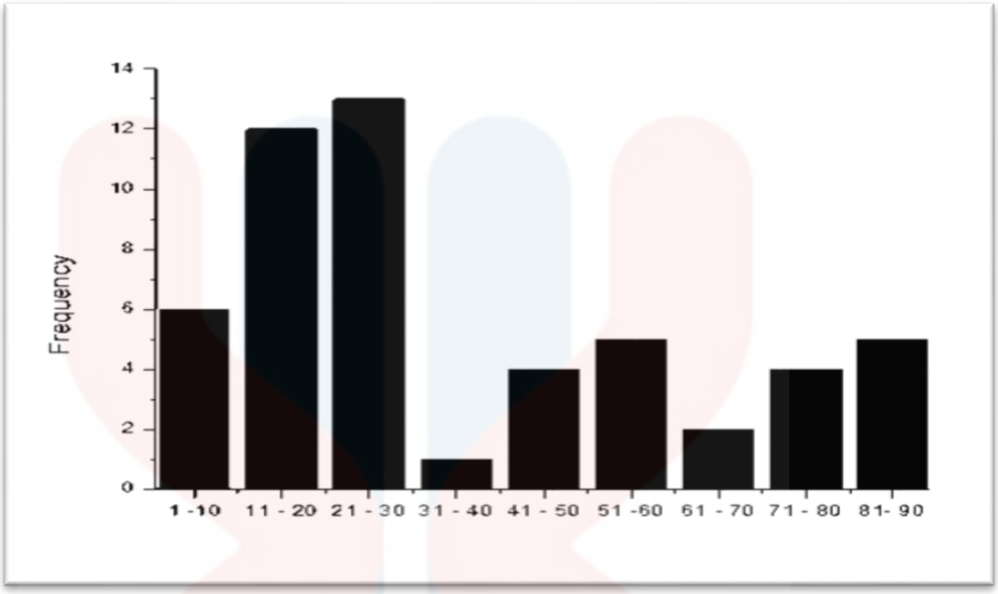


Figure 5.5: Schmidt reading for location 1

Density test is carried out for converted Schmidt Rebound Readings to UCS. Table 5.1 shows the density of the samples taken at the right, centre and left of the outcrop.The average density obtained is 21.417 kN/m^3.

Table 5.1 : The density of the samples of rock mass 1.

Sample	**Mass (kN)**	**Volume (m^3)**	**Density (kN/m^3)**
Right	0.0056	0.0004	14.000
Centre	0.0130	0.0005	26.000
Left	0.0097	0.0004	24.250

Figure 5.6 shows the graph of convertion of Schmidt average reading to UCS. The UCS reading is 49 MPa.

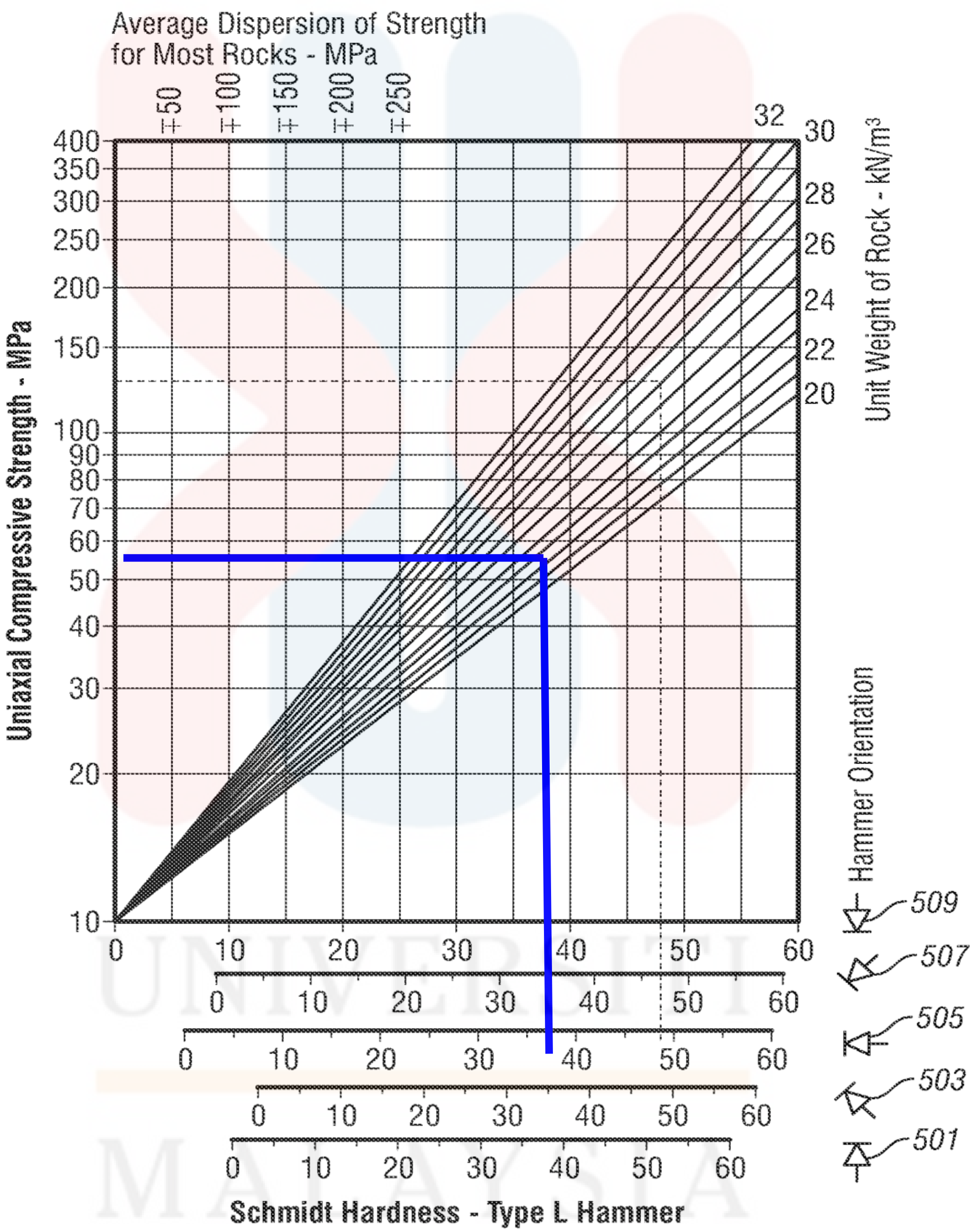


Figure 5.6 : Graph of conversion of Schmidt average reading to UCS for rock mass 1.

b. Rock mass 2

Figure 5.7 shows Schmidt reading for rock mass 2. The mode is 72.31.

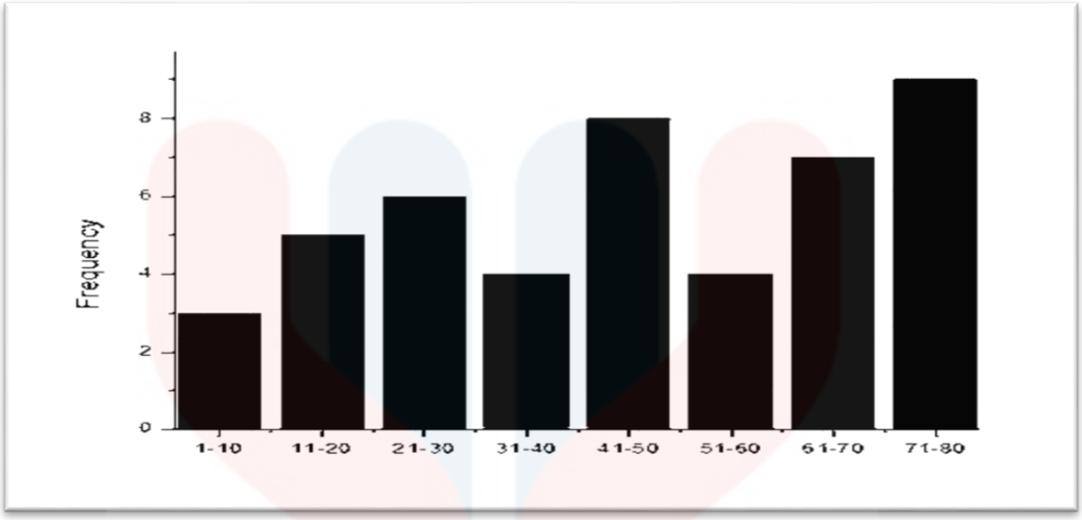
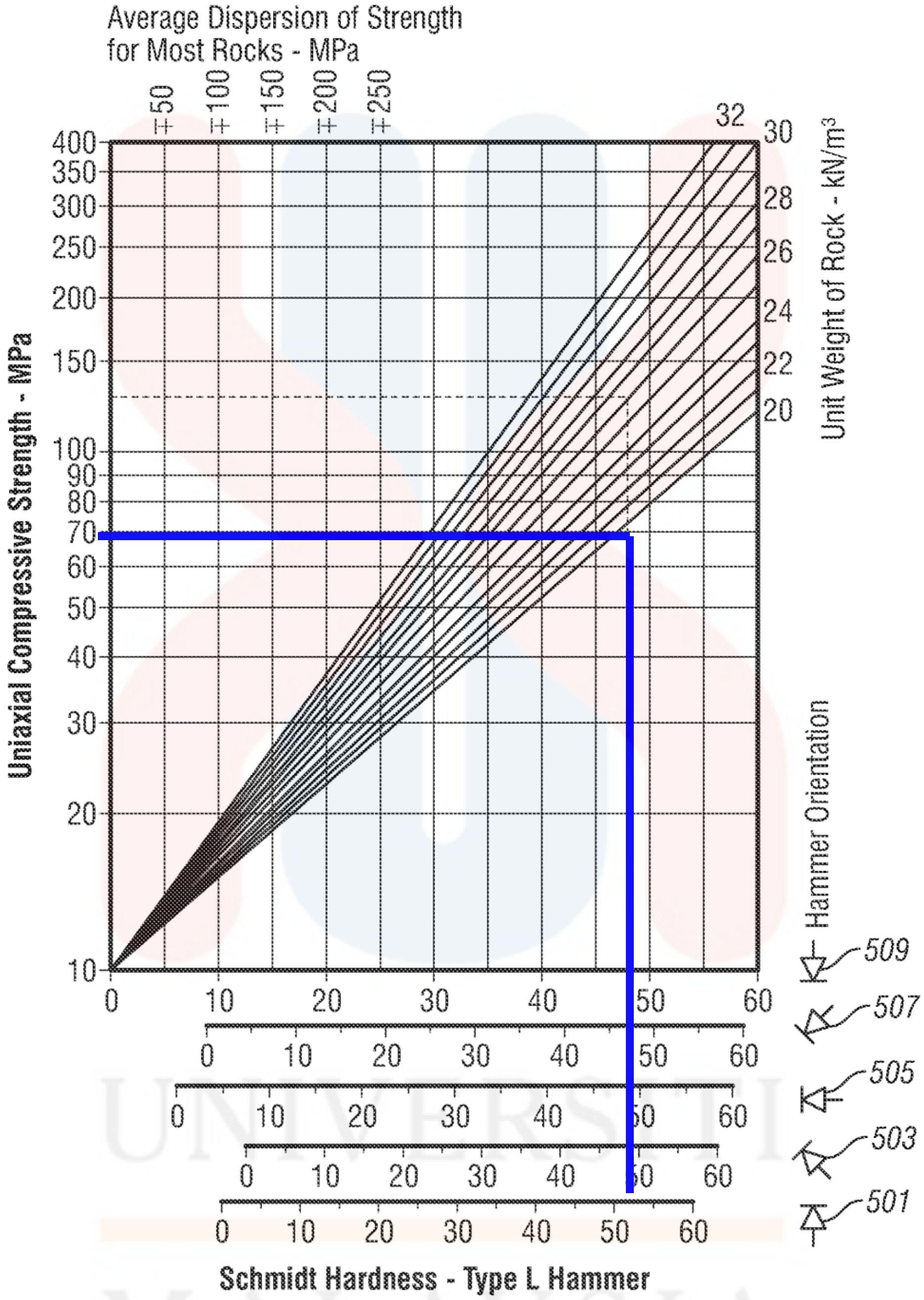


Figure 5.7 : Schmidt readings for rock mass 2.

Table 5.2 shows the density of the samples taken at the right, centre and left of the slope.The average density obtained 24.444 is kN/m3.

Table 5.2: The density of the samples of slope 2.

Sample	**Mass (kN)**	**Volume (m^3)**	**Density (kN/m^3)**
Right	0.0080	0.0004	20.000
Centre	0.0076	0.0003	25.333
Left	0.0028	0.0001	28.000



.

Figure 5.8 : Graph of conversion of Schmidt average reading to UCS for rock 2.

Figure 5.8 shows the graph of conversion of Schmidt average reading to UCS for slope 2. The UCS reading is 115 Mpa and Table 5.3 shows the UCS readings for each rock mass. Rock mass 2 has the highest reading which is 115 Mpa and slope 1 is 49 Mpa.

Table 5.3 : UCS readings for each rock mass with its RMR rating.

Slope	UCS (MPa)	Rating
Slope 1	49.000	4
Slope 2	115.000	12

5.7.2 Drill Core Quality (Rock Quality Designation)

The formula for Rock Quality Designation (RQD) is shown below:

$$\text{RQD} = \frac{\sum \text{Length of core pieces} > 10\ cm\ length}{\text{Total length of core run}} \times 100 \qquad (5.2)$$

Table 5.4 shows the typical value of RQD for each rock with its respective rating in Rock Mass Rating (RMR). The typical value taken from others case study due to the absence of tools. Slope 2 has the highest RQD with 90.6440% and the rated 20 in RMR classsification.Meanwhile, the value for slope 1 is 81.8530% and rated 17 in RMR classification.

Table 5.4 : RQD value for each slope with Rock Mass Rating (RMR)

Slope	**RQD (%)**	**Rating**
Slope 1	81.8539	17
Slope 2	90.6440	20

5.7.3 Spacing of Discontinuities

Table 5.5 shows mode of spacing, size of spacing and its Rock Mass Rating for each slope. Both slope have tight mode of spacing.

Table 5.5 : Mode of spacing, Size of spacing and Rating.

Slope	Mode of spacing	Size of spacing	Rating
Slope 1	Tight	< 2 mm	5
Slope 2	Tight	< 2 mm	5

5.7.4 Condition Of Discontinuities

Table 5.6 shows the mode of surface roughness of each slope with its RMR rating. All the slopes have rough surface.

Table 5.6 : Mode of surface roughness with RMR rating.

Slope	Mode of surface roughness	Rating
Slope 1	Rough surface	25
Slope 2	Rough surface	25

5.7.5 Groundwater of Discontinuities

Table 5.7 shows the groundwater conditions of the discontinuities at each slope. Slope 1 and 2 are damp.

Table 5.7: Groundwater conditions of discontinuities

Slope	Conditions	Rating
Slope 1	Damp	10
Slope 2	Damp	10

5.7.6 Rating Adjustment for Discontinuities Orientation

Table 5.8 shows rating adjustment for discontinuities orientation for each slope. Both slope has favourable discontinuity orientation.

Table 5.8: Rating adjustment for discontinuity orientations

Slope	Discontinuities Orientation	Rating
Slope 1	Favourable	-5
Slope 2	Favourable	-5

5.7.7 Total RMR

The total RMR are calculated by the given formula:

$$RMR = A_1 + A_2 + A_3 + A_4 + A_5 + B_1 \quad (5.3)$$

Where, A_1 = Strength of intact material

A_2 = Rock Quality Designation (RQD)

A_3 = Spacing of discontinuities

A_4 = Condition of discontinuities

A_5 = Groundwater of discontinuities

B_1 = Rating adjustment for discontinuity orientation

Table 5.9 shows the RMR value as well as rock mass class for each slope. It can be concluded that slope 1 is a fair rock while slope 2 is a good rock.

Table 5.9 : RMR value as well as rock mass class

Slope	$A_1 + A_2 + A_3 + A_4 + A_5 + B_1$	RMR	Rock Mass Class
Slope 1	4 + 17 + 5 + 25 + 10 + (-5)	56	Fair rock
Slope 2	12 + 20 + 5 + 25 + 10 + (-5)	67	Good rock

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Geological map of Kg Lubok Bongor produced summarized all the geology in the study area and determination of rock mass strength on a few rock mass within study area have been identified which resulting in achieving the objective of this project. The study area of Kg Lubok Bongor is majority covered by granite.This survey carried out scan line technique and taken into several parameters. The data obtained on the discontinuity survey were then used to determine the rock mass strength. In conclusion, granite rocks have higher RMR compared to the metasedimentary rock. Granite rock can be classified as good rock meanwhile the metasedimentary rcok can be classified as fair rock.

6.2 Recommendation

In a future research, it recommended to do the same research but for rock slope stability to determine the slope stability within the area to prevent any hazards occurs. The research must using point load test in order to determine intact rock material because the reading given by point load test material more accurate than Schmidt hammer. A lot of software related to geology is created and most of the software created is for structural analysis such as stereo32 etc. Method of integrating this software with GIS will benefit to researcher in analyzing the structural in the study area.

REFERENCES

Allaby , M. (2006) , Oxford dictionary of earth sciences. New York: Oxford University Press Inc.

Burton, C.K. (1967). The Mahang Formation: a mid-Palaeozoic euxinic facies from Malaysia-with notes on its conditions of deposition and palaeogeography. *Geologie en Mijnbouw*, 46, 167–187.

Bieniawski, Z.T. (1973). "Engineering Classification of Rock Masses". Trans S. Africa Institute Civil Engineers, 15(12),44,335.

Bieniawski, Z. T. (1989). *Engineering Rock Mass Classifications*. New York: John Wiley & Sons.

Best, M. G. (2003), Igneous and Metamorphic Petrology, 2nd Edition, Wiley- Blackwell, pp. 103.

Bocco, G. Mendoza, M., Velazquez, A. (2001). Remote Sensing and GIS- Based Regional Geomorphological Mapping – a tool for land use planning in developing countaries. Geomorphology, 39: 211 – 219.

Broch, E. and Franklin, J.A. (1972) The point load strength test, *Int. J. Rock Mech. Min. Sci.*,Vol. 9, pp. 669-697.

Deere, D.U., Henoron, A.J., Pation, F.D.Andcording, E.J., (1967). Design of surface and near surface construction in rock. *Proceeding of* 8'i'*us Symposium of Rock Mechanics.* AIME, New York, 237-302.

Foo, K. Y (1983). The Paleozoic sedimentary rocks of Peninsular Malaysia – stratigraphy and correction. Proceedings of the workshop on stratigraphic correlation of Thailand and Malaysia, 1: Tecnical papers : Geological Society of Thailand & Geological Society of Malaysia, 1-19.

Goodman, R.L. (1976), *Methods of Geological Engineering in Discontinuous Rock.*

Goodman, R. E. (1989) *Introduction to Rock Mechanics*, Wiley, 2nd. Ed.

Hutchison, C.S., Tan, D.N.K (2009). Geology of Peninsular Malaysia. Kuala Lumpur: the University of Malaya and the Geological Society of Malaysia.

Ibrahim Abdullah & Jatmika Setiawan (2003). The kinematics of deformation of the Kenerong Leucogranite and its enclaves at Renyok waterfall, Jeli, Kelantan. Geology Society of Malaysia Bulletin, 46, 307-312.

JMG. (2014). Quarry Resource Planning For The State Of Kelantan. Department of Mineral and Geosciences Malaysia.

Khoo, T.T. (1983). Metamorphic episodes of the western foothills of Gunung Ledang (Mt.bOphir), Johore–Malacca, with a background account on the geology. *Geological Societybof Malaysia Bulletin*, 16, 117– 138.

Khoo, T.T. (1983). Nature of the contact between the Taku schist and adjacent rocks in the Manik Urai area, Kelantan and its implications. *Bulletin of the Geological Society of Malaysia*, 16,139-158.

Local Authority area and state, Malaysia, 2010.

MacDonald, S. (1967). Geology and mineral resources of North Kelantan and North Terengganu. Geological Survey Malaysia Memoir, Vol. 10, pp. 202.

Mustaffa Kamal Shuib (2009). *Structure and Deformation in Geology of Peninsular Malaysia*. Editors Charles Strachan Hutchison, Denis Ngoh Kiat Tan, Publisher University of Malaya.

Mustaffa Kamal Shuib (2000). The Mesozoic Tectonics of Peninsular Malaysia – An overview. In*: GSM Dynamic Stratigraphy & Tectonics of Peninsular Malaysia. The Mesozoic of Peninsular Malaysia*, *Geological Society of Malaysia Warta Geologi*, 26, 5.

Priest, S.D. (1993). *Discontinuity analysis for rock engineering*, Chapman & Hall.ISBN 0412 47600 2.

Priest, S.D. and Hudson , J.A. (1976), Discontinuity spacing in rock . Int. J. Rock Mech.Min., 13, 135-148.

The Malaysia – Thailand Border Joint Geological Survey Committee (2006).

APPENDIXES

Lineament analysis data.

50	180	90	180	75
80	40	80	140	60
133	70	70	80	90
65	80	90	90	100
62	165	100	50	120
130	73	90	70	150
50	75	165	80	170
172	160	160	165	180

Schmidt Hammer Reading

Schmidt Rebound Number Reading (Slope 1)				
62	60	30	54	50
47	72	69	56	45
66	60	65	20	65
58	61	47	35	34
68	65	63	63	64
34	47	53	54	25

Schmidt Rebound Number Reading (Slope 2)				
60	64	78	89	34
68	34	80	67	45
78	45	56	45	22
45	65	87	86	34
30	67	46	87	56
67	35	35	56	45

JOINT ANALYSIS DATA (STRIKE (^{O}))

119	249	150	145	265	164	244	252
218	284	284	152	359	237	250	258
244	107	288	169	258	56	246	234
246	283	298	333	155	54	243	248
220	279	248	158	279	64	247	241
226	250	287	220	268	250	241	236
217	288	274	162	270	252	216	222
216	272	264	135	241	224	225	223