GENERAL GEOLOGY AND KINEMATIC STABILITY ANALYSIS OF CUT SLOPES AT KAMPUNG PULAI, GUA MUSANG, KELANTAN.

by

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

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DECLARATION

I hereby declare that the work embodies in this report is the result of the original research and has not been submitted for a higher degree to any university or institution.

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I certify that the Final Year Project Report entitled "General Geology and Kinematic Stability Analysis Of Cut Slopes At Kampung Pulai, Gua Musang, Kelantan" has been examined and all the correction recommended by examiners have been done for the degree of Bachelor Applied Science (Geoscience), Faculty of Earth Sciences, University Malaysia Kelantan.

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ABSTRACT

Kampung Pulai is an area covered mostly by hilly area which has been placed by some of agricultural activities. This research has been conducted to update the geological map of Kampung Pulai and to analyse structures of the slope at the study area. Methodology of this research is geological mapping which have been conducted to analyse geological structure and geomorphology of the study area and to analyse slope stability. Petrography analysis has been done to identify type of rock. GIS have been used to update geological map. Stereonet has been used to analyse area that has slope stability or slope failure.

Keyword: Kampung Pulai, Engineering Geological Mapping, Slope Stability, Slope Failure.

ABSTRAK

Kampung Pulai merupakan sebuah kawasan yang hampir kesemuanya kawasan berbukit-bukau dan telah digantikan dengan kawasan pertanian. Kajian ini telah dijalankan untuk mengemaskini peta geology di Kampung Pulai dan mengenalpasti struktur cerun di kawasan kajian. Metodologi kajian ini adalah pemetaan geologi telah dijalankan untuk mengenalpasti struktur geologi dan geomorfologi kawasan kajian untuk mengetahui kestabilan cerun. Analisis petrografi dijalankan untuk mengenalpasti jenis batua. GIS digunakan untuk mengemaskini peta geologi. Stereonet digunakan untuk mengenalpasti cerun yang stabil dan cerun yang tidak stabil.

CHAPTER 1

INTRODUCTION

1.1 General Background

Slope stability is really important in every country to take care of it since there are many effects will occur if the slope is not stable. However, there are certain causes and reasons that the slope will not be stable because of infrastructure or natural hazards.

Example of natural hazard is landslide. Landslides usually happen because of water level change, volcanic eruption, earthquake and intense rainfall. Nevertheless, in Malaysia landslides often happen because of intense rainfall since Malaysia does not have active volcanoes or water level change not affect it much.

Since natural hazards are uncontrollable, human beings need to be aware mostly people that are living around suspected areas. So, they need to strengthen themselves physically and mentally if anything might happen.

So, for the area that landslide always happen, people living around have to take precaution by moving or at least plant grasses that can help to root for the soil. Landslide also will give worst damaged mostly in infrastructure and also environment, lives lost, long term or short term injury to the people and also decreased of economic activity (Varnes, 1984).

1.2 Problem Statement

The previous data of this research not being updated. In order to get an updated geological map is from geological mapping that will be done. To avoid from hazardous accident, an action need to be taken. Since, many natural hazards happen in Malaysia. In case involving slopes, there are several landslides that occur. This may affect people that are living around the suspected area. There are several factors that trigger this phenomenon. For example are water level change, volcanic eruption, earthquake, intense rainfall and rapid snowmelt. However, in Malaysia the main factor is because of intense rainfall. If the slope is not stable, there are several disasters that will happen and may affect people like losing their properties or loss of life. So, this research is important for human to take precaution and if needed there are several techniques that will be used in order to prevent from the slopes sliding.

1.3 Significant of Problem

Slope stability mainly close related to natural hazards or human made that causes this to happen. The slope failure also closely related to the rainfall, runoff, infiltration and their contributions to pore-water pressure (Yeh *et al.,* 2008). Example of natural hazard in Malaysia that always happen is landslide and mainly causes by intense rainfall. While, human made is construction or excavation at certain area involving higher elevation. So, this research is important to prevent from such disaster happen. Besides, this research will help in getting an updated geological map of the study area, Gua Musang Baru, Kelantan. Geological mapping is one of the ways to get the best result. Among the information that will be updated including drainage patterns, types of rocks present, geomorphology and structural geology of the study area. If this research is done earlier, many natural hazards can be preventing and people can take precaution. So, many of their properties will be saved.

1.4 Research Objective

There are two objectives for this study. The objectives are as stated below:

i. To update geological map of Kampung Pulai at scale 1:25 000

ii. To analyse structures of the slope at the study area

1.5 Study Area

The study area is located at Pulai village in Gua Musang, Kelantan with coordinate N 4°49'27.393", E: 101°56'38.017" and N 4°46'45.019", E 101°59'19.468". Gua Musang is a town, district and parliamentary constituency in southern Kelantan, Malaysia. Gua Musang is administered by the Gua Musang District Council. Gua Musang district is bordered by the state of Pahang to the south, Terengganu to the east, Perak to the west and the Kelantanese districts of Kuala Krai and Jeli to the north.

There are several villages involving in this study area are Bechah Kelubi village, Batu Tongkat Village and Batu Itek village. The study area location is nearer to Bandar Baru Gua Musang. It takes about 30km from the town to the study area. There is also a construction site for feldspar in the study area. The study area covered about total of 25 km^2. Figure 1.1 shows the location of study area in Kelantan while Figure 1.2 shows the base map of study area.

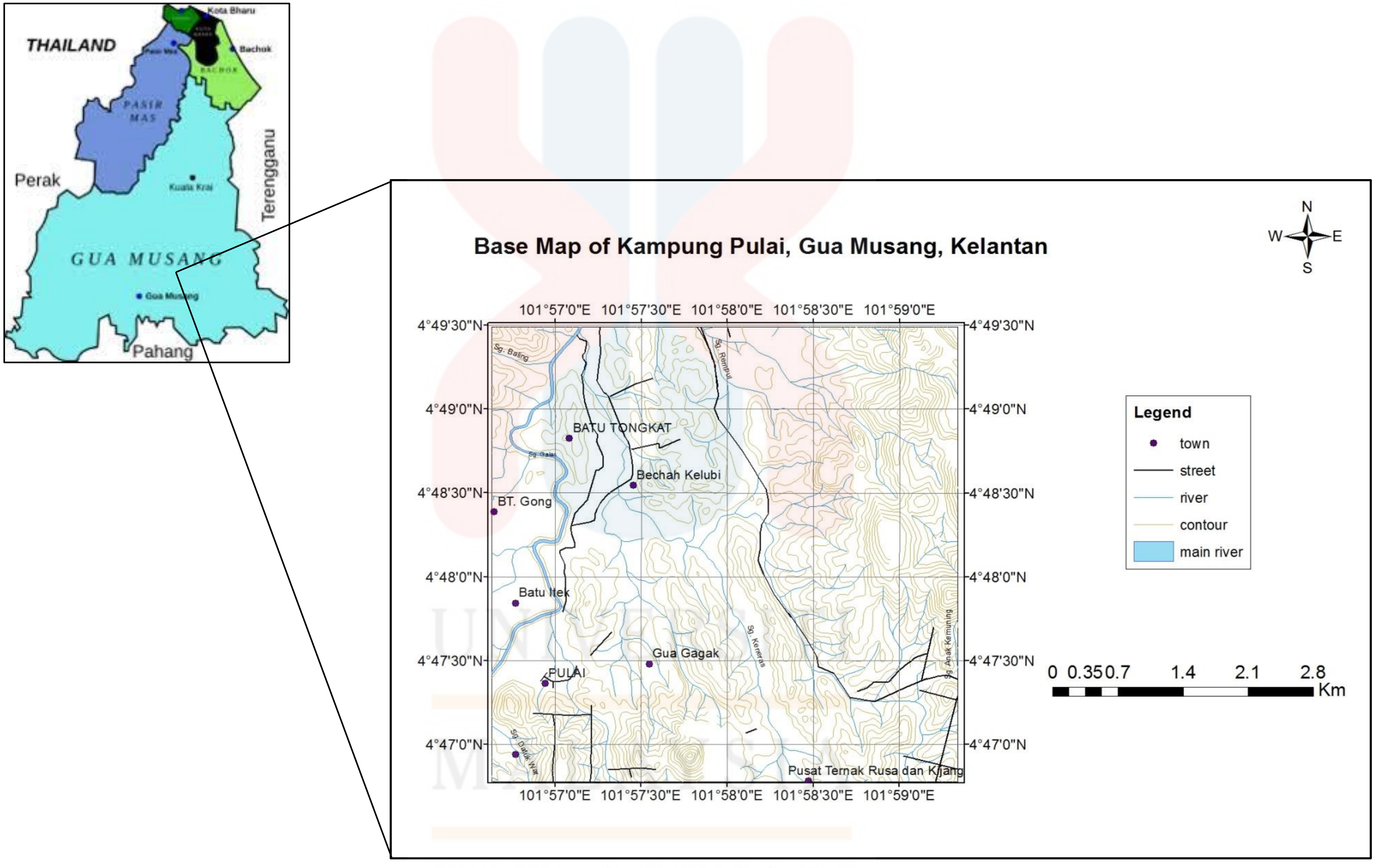


Figure 1.1: Location of study area in Kelantan

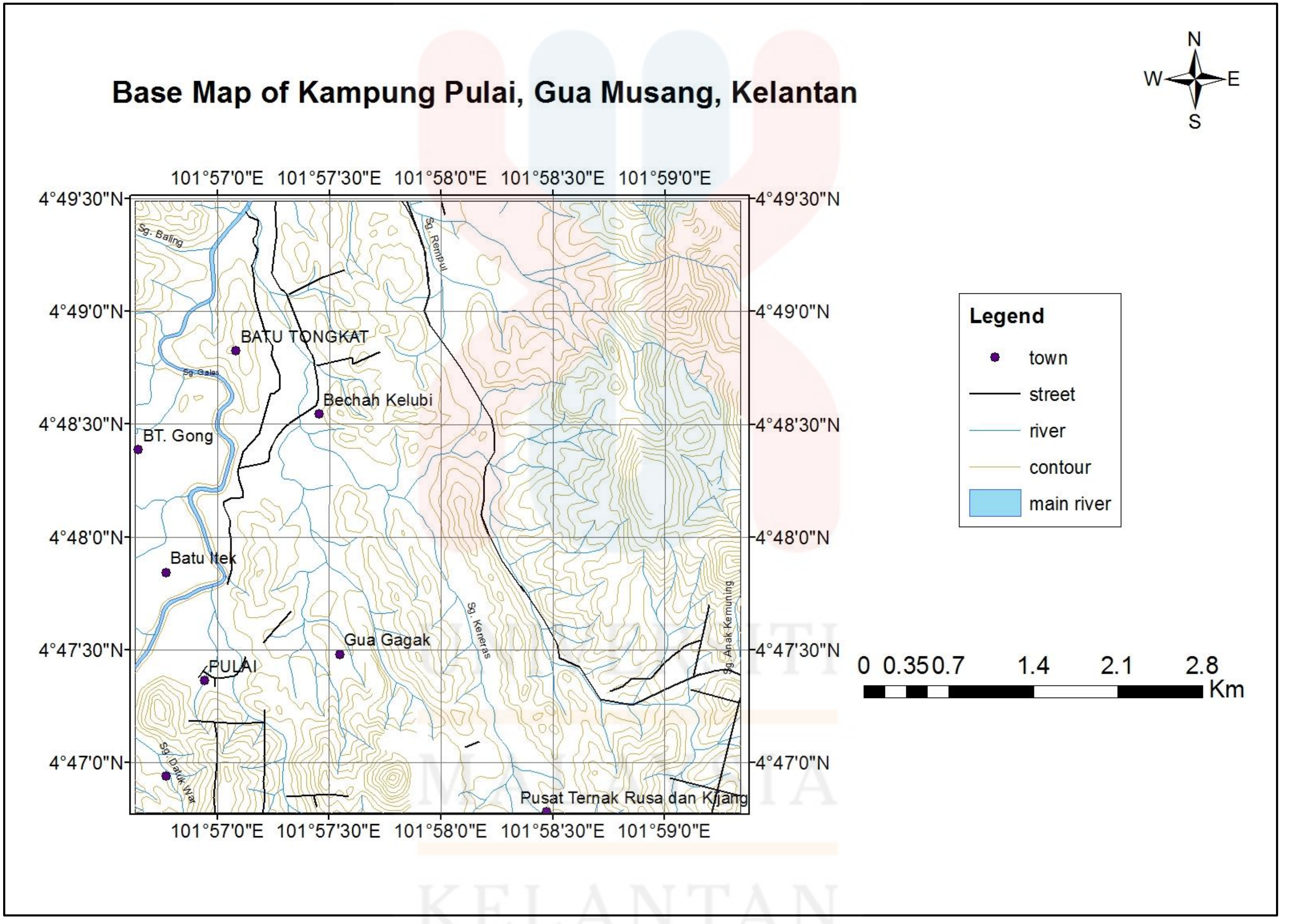


Figure 1.2: Base Map of Study Area.

1.6 Geography

1.6.1 People Distribution

People distribution is population of people in the study area that comprises different backgrounds such as age, races and sex. Total population in Gua Musang is about 62070 people. Most of the ethnic covered by bumiputera which is malay that is about 44581 people and other bumiputera which is 12474 people. Followed by non-bumiputera citizens that are chinese 739 people, Indians 47 people and others 112 people. While non-citizen is consist of 4117 people.

From the distribution data, people distribution in Gua Musang city is the most part that consist of people lives which is 18420 people. This is because of the development and necessities in that area.

Table 1.1: Total Population by Ethnic group 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

1.6.2 Rain Distribution

Malaysia is a tropical country which raining throughout the year. The total rainfall distribution in Gua Musang in 2014 is 3220mm that shows in Table 1.2. The highest rain distribution is recorded on August which is 618mm followed by the end of the year which is December that is 591mm. The lowest rainfall distribution recorded in Gua Musang is during February that is 3mm only. This rainfall also may affect the stability of the slope during raining seasons.

Table 1.2: Rainfall distribution in 2014 at Gua Musang area

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

1.6.3 Land Use

The land use in the study area is divided into several categories. Among the categories are for agricultural, residential, recreational, transport, commercial use and vegetation land. Most of the land is covered by forest either natural forest or rubber plantations. The residential area is widely distributed in the research area since most people living in that area dependable on the natural sources. Examples of work that village people are working on are farming and rubber tapper. However, there are some residential people making their own life by doing business. While recreational land is used for human pleasure including parks, sports grounds and the sites for other activities that are not essential for life but pleasurable. Transport land is used for roads and railways. This is to make the people living there easier to connect with other cities. Figure 1.3 shows the land use image obtained from google earth.

Figure 1.3: Land use of study area

Source: Google Earth 2016

1.6.4 Socioeconomic

Socio-Economy in the research area that was done by the residents is mostly farming or starting their own business. While doing this, they also can increase their own earnings to increase their lives prospects. This also leads to increase in productivity and competitiveness among the villagers. So, this also may increase the facilities around the area to fulfil their life needs.

1.6.5 Road Connection

Road connections help people to interact or communicate with others easier to carry out their daily activity. There are the main roads that connect people in the research area to people far away and to the city. So, this is making their daily life easier. Figure 1.4 shows the road connection at the study area.

Figure 1.4: Road connection to access to the study area

Source: Google Earth 2016

CHAPTER 2

LITERATURE REVIEW

2.1 Regional Geology and Tectonic Setting

The regional geology of Kelantan consists of a central zone of sedimentary and metasedimentary rocks border East-south on the west and east. It is bothered by granites of Main Range and Boundary Range. Then, Peninsular Malaysia is a part of the Eurasian Plate, the South-East Asian part which is known as Sundaland (Hutchison, 1973).

According to Tjia & Syed (1996), the Bentong-Raub line was proposed as the major tectonic boundary between the western and central belt of Peninsular Malaysia .The Bentong suture line actually is a subduction of plate margin mainly due to basis of serpentinite and other metabasic bodies. Figure 2.1 shows geological map of Kelantan.

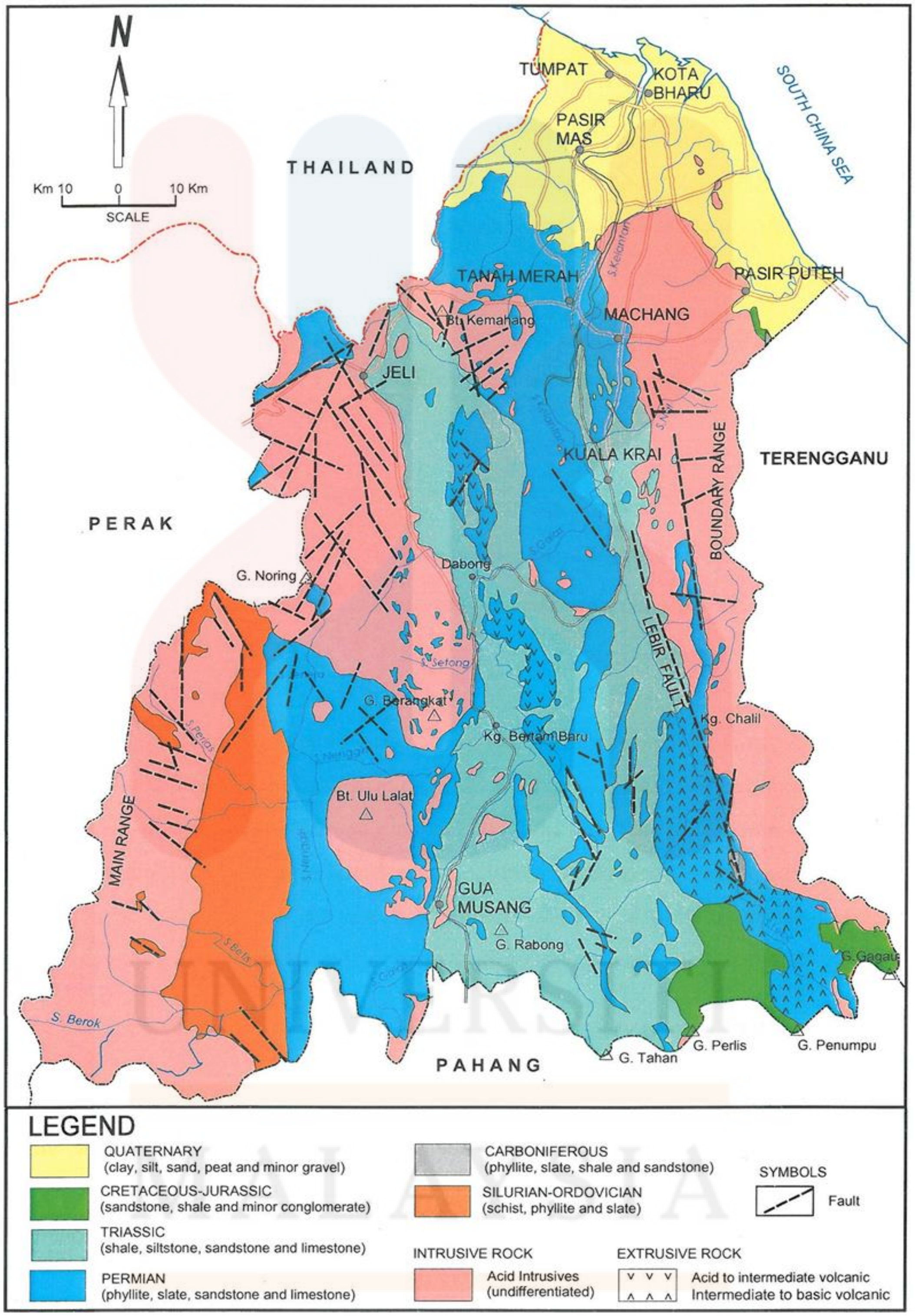


Figure 2.1: Rock distribution and geology of Kelantan

Source: Department of Minerals and Geoscience (2003)

2.2 Historical Geology

The state of Kelantan belongs to the Eastern region of Peninsular Malaysia. The State of Kelantan is divided into north and south, and composed of ten districts. Gua Musang is one of the districts in Kelantan. The geological formation of Kelantan ranges from Lower Paleozoic until Quartenary and can be divided into three main chronology; Paleozoic, Mesozoic and Cenozoic.

According to Hutchison and Tan (2009), the Paleozoic formation in Kelantan was found in the central belt of Peninsular Malaysia. The bulk of the Upper Paleozoic sediments consist of marine Permian strata that occur as linear belts flanking Mesozoic sediments in the Central Belt. The Upper Paleozoic rock consists of Gua Musang Formation and Aring Formation in the south of Kelantan, while Taku Schist in eastern part of Kelantan. The Upper Paleozoic formation is dominated by argillaceous and volcanic facies while the rest belong to calcareous and arenaceous facies. The depositional environment is typically shallow marine area with intermittent active submarine volcanism starting in the Late Carboniferous and reaching its peak in the Permian and Triassic.

2.3 Stratigraphy

The Peninsular is divided into three belts which are western belt, central belt and eastern belt. Most of the Kelantan stratigraphy lies on the central belt with some minor stratigraphy. The Bentong Suture separates a continental Gondwana sliver in the west from the remainder of the Peninsular that in late Paleozoic was already part of

Eurasia according to Tjia (1989). The latest wrench motion within the Bentong Suture was right lateral (Tjia, 1984). In Kelantan, there are nine formations are present in Gua Musang. The formations are Gua Musang Formation, Gunung Rabong Formation, Koh Formation, Aring Formation, Gua Musang Formation, Taku Schist Formation, Badong Conglomerate, Gunung Rabong and Telong Formation.

Gua Musang Formation is actually from prominent limestone hill in South Kelantan and its body extended southward to central Pahang and northward from Gua Musang. Its age is Permian sedimentary rocks. According to Geology of the Malay Peninsula, it appears to the east and north of Gunung Stong as phyllite and meta-volcanic rock near Dabong. Richardson's (1950) stated that the volcanic rocks of the Gua Musang Formation are mainly tuff of trachytic, trachyandesitic and andesitic composition.

2.4 Structural Geology

Structural geology of Gua Musang includes many structures. For example are joint, fault and bedding. Kelantan state is traced by major faults like Lebir Fault Zone, Bok Bak Fault Zone and Galas Fault Zone. The predominant rock in Kelantan is sediment or metasedimentary rocks that can be found at north-south central portion. It has been bothered on the west and east part with the granites that located in Main Range and Boundary Range.

The Bok Bak Fault zone is a sigmoidal NW-SE striking fault. it shows a sinistral strike-slip displacement with net displacement was 55km (Burton, 1965).

2.5 Engineering Geology

2.5.1 Slope Stability Analysis

Slope stability is the potential of soil covered slopes to withstand and undergo movement. Stability can be determined by the balance of shear stress and shear strength. This research will be done also in order to help ensure the safety of the pedestrian and the road user. In tropical areas such as Malaysia, slope failure is either initiated by natural processes or by human activities (Jasmi, 2000). External causes which lead to increase in shear stress on the slope usually involve a form of disturbance that may be either natural or induced by man (Majeed *et al.*, 1998).

Slope stability is the resistance of the slope from collapsed or falling. So, there must be steps that need to be taken in order to prevent slope instability or the landslides. Landslide generates a small but important component of the spectrum of hazard and increasing risk that faces mankind (Alcantara-Ayala, 2002). It is also rest upon the ability of a slope to resist stress excess to what is normally acceptable for the material property of the soil to the construction slope. Table 2.1 shows the types of landslides and Figure 2.2 shows the mechanism of slope failures.

According to Raj (2000), these failures are best classified as debris flows and have occurred along, or close to, the valley floors of small streams where shallow unconfined groundwater tables and a thin layer of weathered materials over bedrock is found. Mokhtar (2006) stressed that, main factor that caused slopes failure at numbers site in hill side development in Malaysia are rainfall and storm water activities.

Table 2.1: Types of landslides

Sources: Varnes, ,1978

TYPE OF MOVEMENT		TYPES OF MATERIAL		
		BEDROCK	ENGINEERING SOILS	
			Predominantly coarse	Predominantly fine
FALLS		ROCK FALL	Debris fall	Earth fall
TOPPLES		ROCK TOPPLE	Debris topple	Earth topple
SLIDES	ROTATIONAL	ROCK SLIDE	Debris slide	Earth slide
	TRANSLATIONAL			
LATERAL SPREADS		ROCK SPREAD	Debris spread	Earth spread
FLOWS		ROCK FLOW (deep creep)	Debris flow (soil creep)	Earth flow (soil creep)
COMPLEX	Combination of two or more principal types of movement			

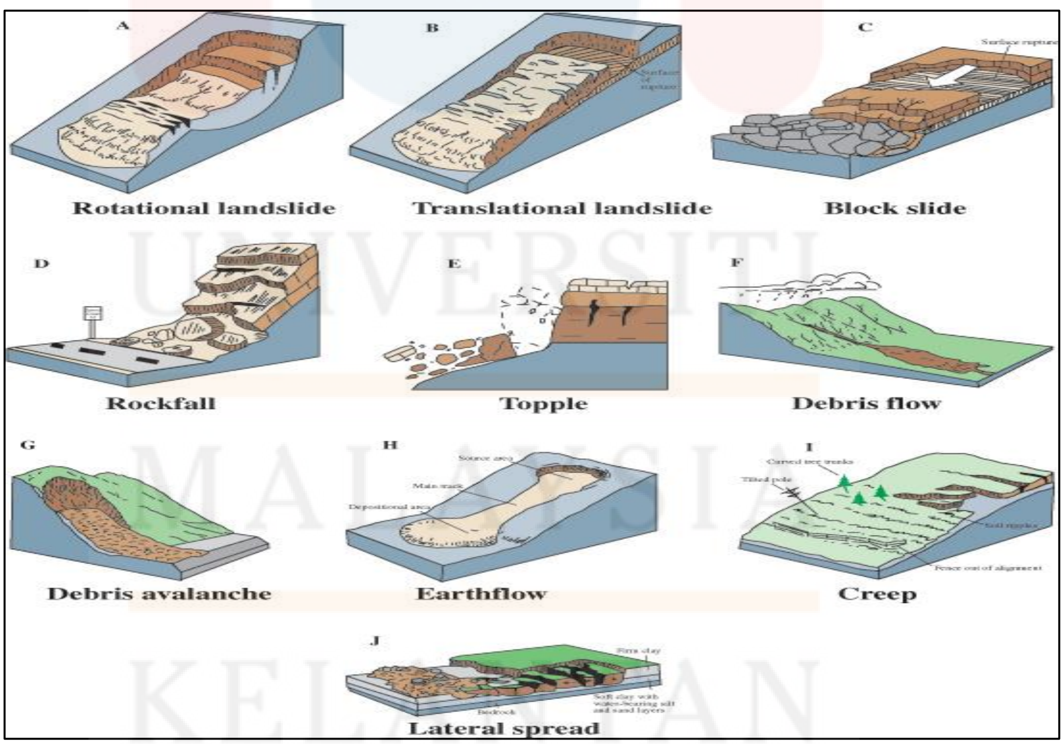


Figure 2.2: Mechanism of slope failure

Source: Varnes, 1978

2.6 Kinematic Stability Analysis

This analysis is useful for preliminary stability assessment of slope stability, to detect the unstable elements or critical planes of weakness in slope and to interpret the likely mode of slope failure. Slope failure may occur due to the presence of unfavourably oriented as joints, faults, bedding planes, shear zones and foliation that serve as failure planes. Slope failure also divided into three modes which are plane failure, toppling failure and wedge failure.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Materials

Materials that are used for the research are list in the table below:

NO.	MATERIALS/TOOLS	USES
a.	Compass (Suunto/Brunton)	To find direction and navigation and measure strike and dip of geological structure.
b.	Geological hammer	To collect sample of the rocks.
c.	Global Positioning System (GPS)	To determine coordinates, tracking structures and measuring elevation.
d.	Sample bags	To keep the samples either rocks or soils.
e.	Hand lens	To make first analysis of rock samples in the field before making further analysis.
f.	Measuring tape	To measure distance of lithology and structre in the field.
g.	Dilute Hydrochloric Acid (HCl)	To test if a rock contains carbonate minerals.
h.	Camera	To take pictures of samples and important features at the field.
i.	Field notebook	To jot down important data at the field.
j.	ArcGIS Version 10 software	A geographic information system (GIS) used for producing base map of the research area.
k.	Base map/topological map of study area	As a guide in conducting the research at study area.

3.2 Methodology

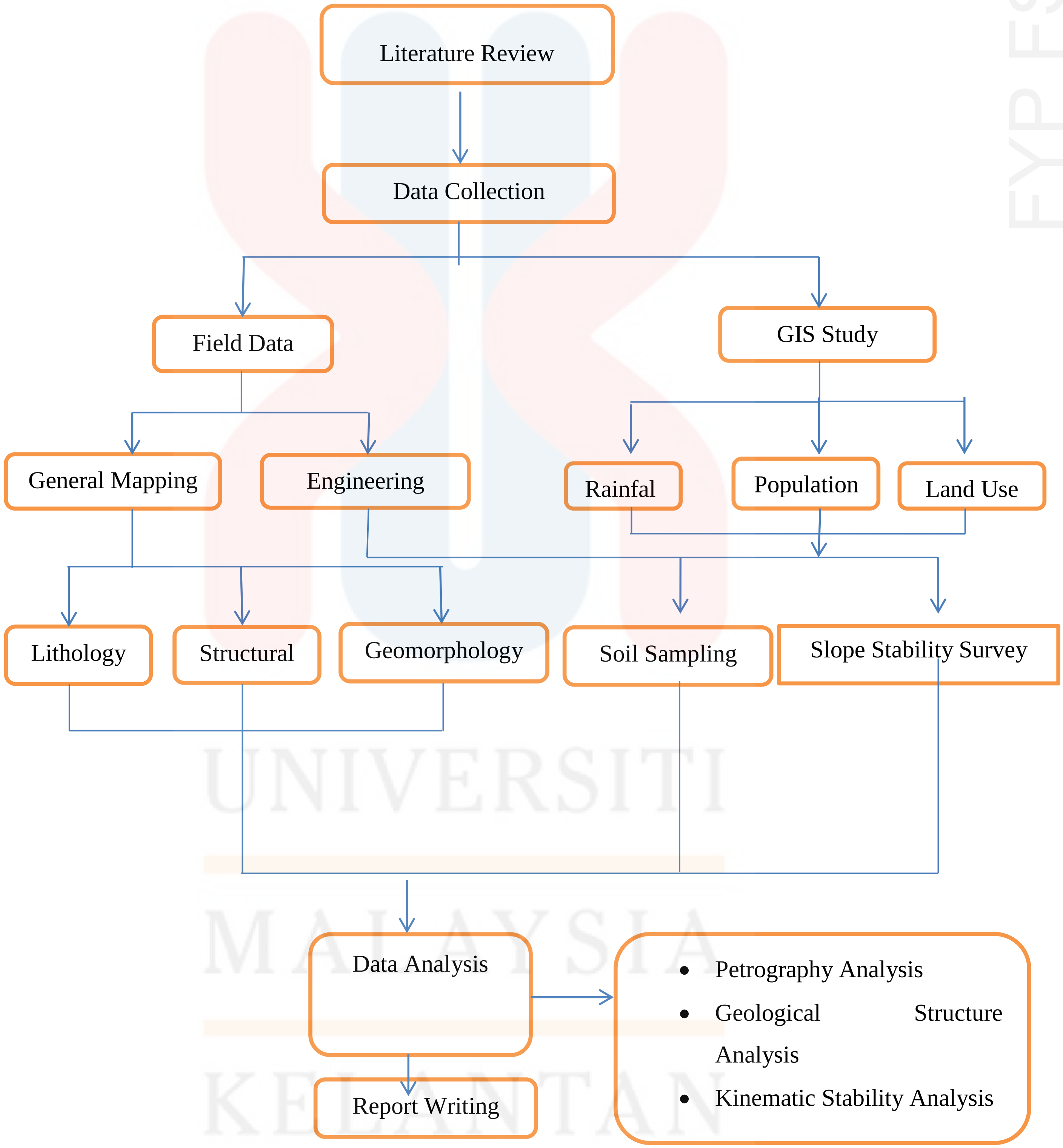


Figure 3.1: Research flow chart

3.2.1 General Geological Mapping

Field work is really important in doing the research to get the detailed information about the study area and to update geological map. Also to evaluate again the base map. This is because the probability of the study area is already changes are high. Then, it is important to make further investigations about the study area. A general field mapping is going to be conducted on the 25 km² of the study area.

Then, route tracking which is traverse using GPS also has been carried out. During the field work, all lithology, geological structures and information are identified and described in notebook for references.

Besides, geological mapping is done to get the reading for structural analysis (strike and dip) and information about the geological structure (folds, faults and etc). Then, rock and soil samples needed in making petrography analysis to get the thin section.

However, the topological map will be studied first in order to make assumption of what type of rocks might present in that area before truly getting the actual data of type of rocks. The checkpoint also will be marked using Global Positioning System (GPS).

3.2.2 Engineering Geology

Engineering geology is now well known as a branch of geology that deals with soil mechanics, strength of materials and theory of structures (Sawant, 2011).

i) Soil Sampling

Samples can be either rocks or soils. The samples that will be taken must be fresh to ensure that the samples are not weathered and eroded. So, the result will be correct. Soil sample must be collected at the field study for further analysis such as grain size analysis. The soil and rock samples are collected for every area that present of slope stability.

ii) Slope Stability Survey

The survey is conducted to identify the area with slopes. The slope stability survey can be identified by observing the slope steep, slope angle and strength of the slope. The structures present at the slope will affect the slope stability. Among the structures are joints, fissures, faults, fractures, shear planes, cleavages, foliations and bedding.

Besides, slope stability analysis also performed to access either it is the safe slope naturally or from human-made and the equilibrium conditions. Examples of human-made slope are road-cut slopes, excavation sites and landfills. Slope stability survey also important to find endangered areas, to determined slope sensitivity to different triggering mechanisms and to investigate potential failure mechanisms.

For slope stability survey, the slope requires the geological information and site characteristics. Examples are groundwater conditions, properties of soil or rock, structures present like faults, joints or discontinuity systems. The groundwater condition is really important since Malaysia having intense rainfall during raining seasons. This will effect on slope stability. Water that act on the slope will reduce the strength of materials of the slope.

3.2.3 Data Analysis and Interpretation

i. Petrography Analysis

The samples that will be getting will undergo further laboratory analysis in order to identify the minerals content that will indicate the type of rocks. The thin section methods (thickness: 0.03mm) will be done using polarized microscope. The thin section preparation will be done first which are involving three stages which are sectioning, grinding and lapping. Thin section preparation is really important. Since, the results will provide an overview of the process of rock formation and mineral composition. Figure 3.2 shows the IUGS classification for igneous and volcanic rocks.

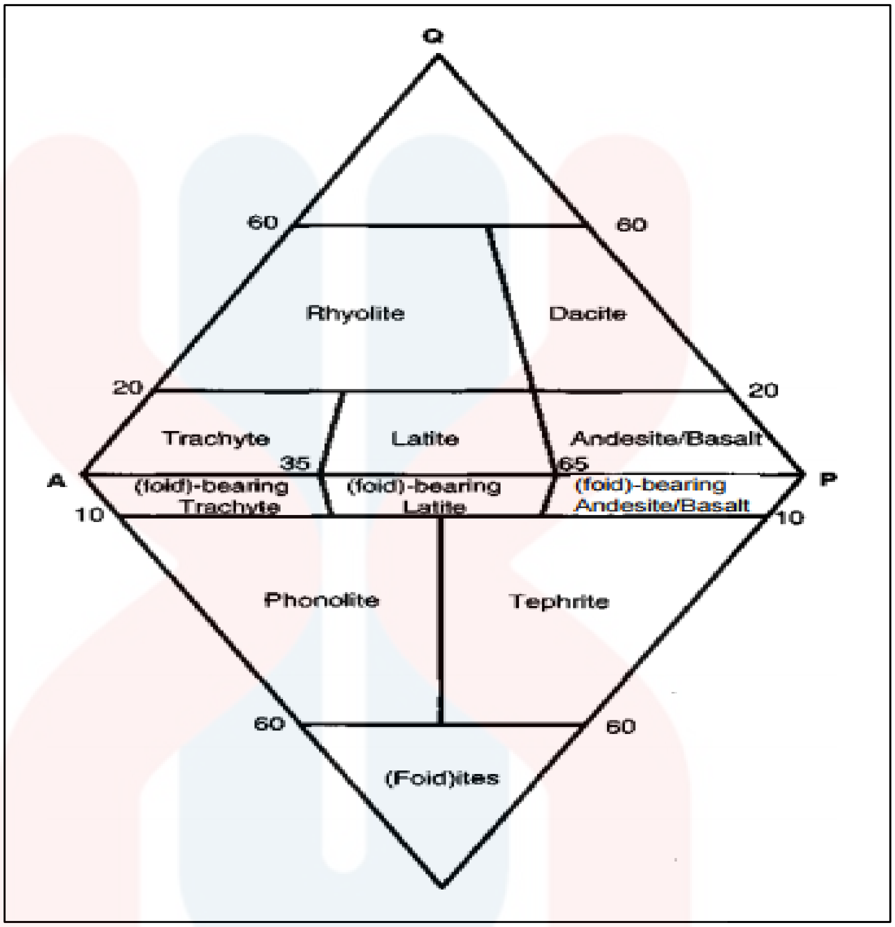


Figure 3.2: IUGS classification in An Introduction to Igneous and Metamorphic Petrology (Winter, J., 2014)

ii. Geological Structure Analysis

From mapping that will be conducted, the data of the structures that present at the study area will be recorded and analyse in detailed. This is because to check either the structures that present will affect until the slopes will collapsed. There are several structures that presents at the study area such as joints, fissures, faults, fractures, shear planes, cleavages, foliations and bedding.

iii. Kinematic Stability Analysis

Orientation data which is strike and dip either for fault, joint and vein from structural mapping or discontinuity survey is particularly useful in kinematic stability of slopes. This analysis is useful for preliminary stability assessment for slopes in rocks, to select the best orientation for slope, to detect unstable elements or critical planes of weakness in slope, and to interpret the likely mode of slope failure.

Kinematic analysis method is used to analyze the potential for the various modes of rock slope failures as plane failure, wedge failure and toppling failure as shows in Figure 3.3 that is slope failures associated with unfavorable orientation of discontinuities Illustration modes of slope failure (Hoek and Bray, 1981).

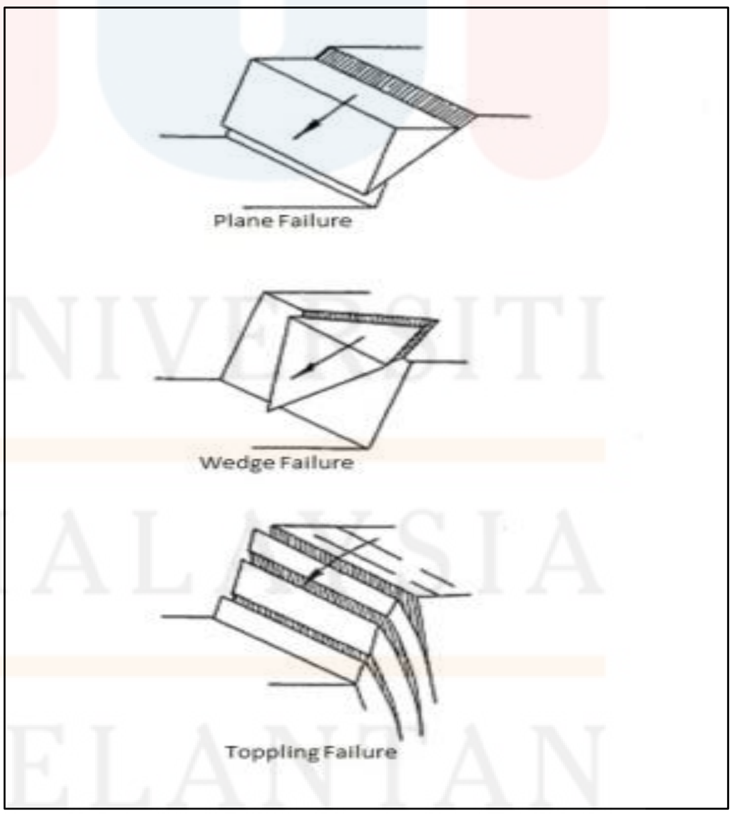


Figure 3.3: Illustration modes of slope failure (Hoek & Bray, 1981)

Markland's test shows that a plane failure is likely to occur when a discontinuity dips in the same direction within 200 as the slope face, at an angle gentler than the slope angle but greater than the friction angle along the failure plane (Hoek and Bray, 1981).

Stereonets are used for graphical kinematic analysis. While using the orientation data which is strike and dip readings that got from the field mapping to construct on the stereonets. Actually, it used the dip direction which is direction of inclination of a plane and dip which is inclination of a plane from the horizontal stereonets will show the circular graphs for plotting planes.

Formation of great circles, poles or dip vectors will show the orientations of discontinuities that can be represented on a stereonet. Clusters of poles of discontinuity orientations on stereonets are identified by visual investigation or using density contours on stereonets (Hoek and Bray, 1981). Single representative orientation values for each cluster set is then assigned. These single representative orientation values can be the highest density orientation value within a cluster set or the mean dip direction/dip of a pole cluster as calculated using equations in Borradaille (2003).

Great circles for representative orientation values along with great circle for slope face and the friction angle are plotted on a stereonet paper to know the potential for discontinuity-orientation dependent values

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will explain about geomorphology, petrography, stratigraphy, structural geology and historical geology. Kampung Pulai located in Gua Musang in Kelantan and about 5.3 kilometres from main Gua Musang town. It is also near the Gua Musang R&R, Sekolah Menengah Sains Gua Musang and also is the main road to Kuala Lumpur via Kampung Tanah Puteh, Gua Musang.

Some area in Pulai Village and Tanah Puteh Village is used for rubber tree plantation, agricultural, residential, recreational, transport, commercial use and vegetation land. Generally, geology of Kampung Pulai and part of Kampung Tanah Puteh that i have covered consist of limestone, slate and tuff. The highest contour value is 420 while the lowest contour value is 120. Mostly the structures that are found in the study area are joints, faults, fracture and bedding.

4.1.1 Survey Traverse

There are several rock samples that have been collected from the field work. Station map in figure 4.1 shows the observation station and sampling station. Road and river traverse used in geological mapping in order to identify types of rocks and structures that are exist in the study area in order to get rock samples. There are limestone, slate and tuff that have been found from this traverse. This types of rocks are classified based on its' textures and grain sizes that are vary from each other.

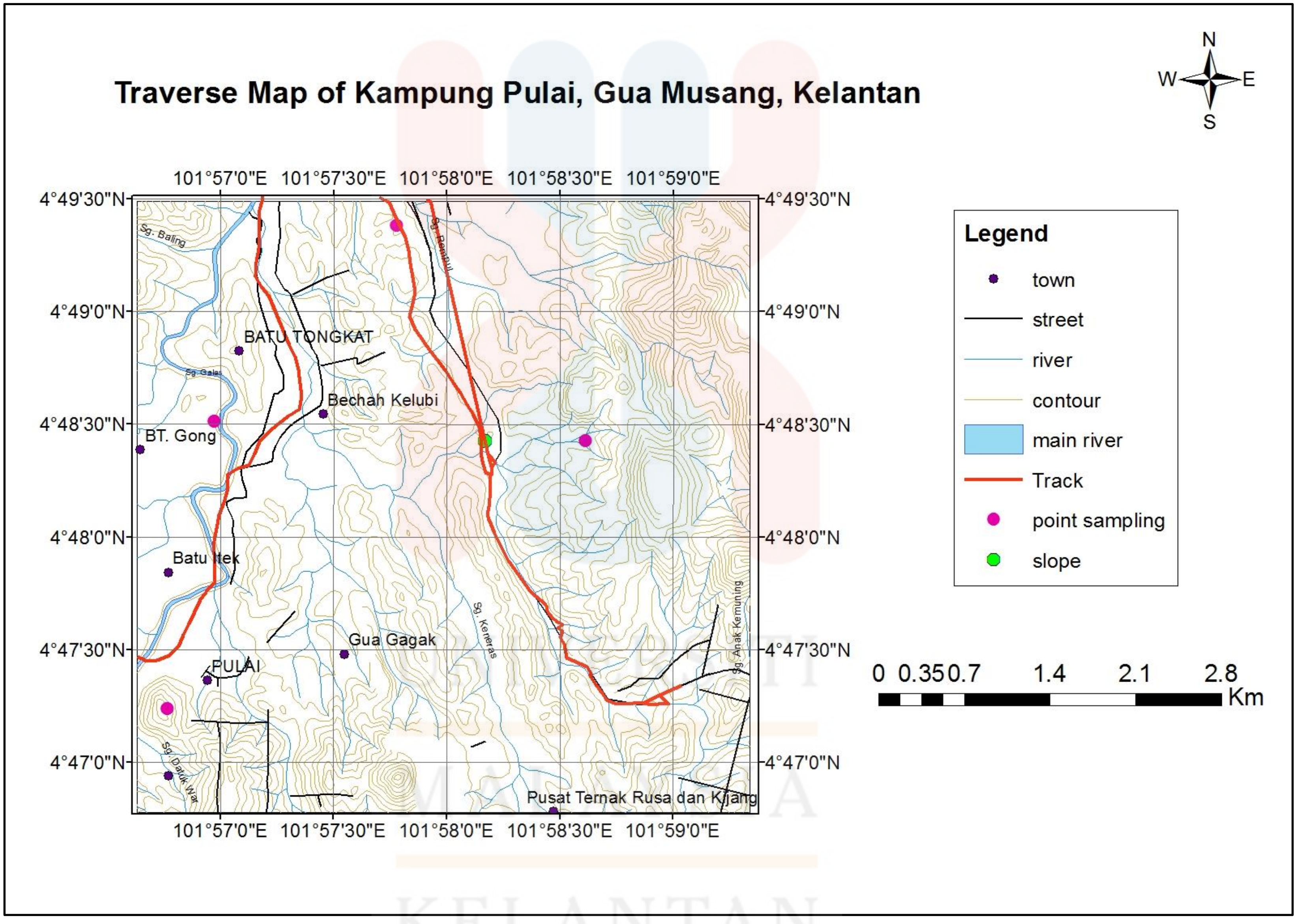


Figure 4.1: Traversing Map and Sampling Point

4.2 Geomorphology

4.2.1 Introduction

Geomorphology can be defined as the processes and condition that influence the landform development, physical, morphological and structural characteristics of landform which is the process that shape the landform. Landform consist of various parts such as mountains and valley, rifts and scraps, lake basins and river channel profiles and pattern that make up the landscape. Geomorphology also practiced within physical geography, geology, engineering geology, archaeology and geotechnical engineering.

Geomorphology can be divided into morphology, morphometry, morphochronology and morphodynamic according to (Van Zuidam, 1985). Morphology is the study of landform such as rivers, mountains, valleys and rifts while morphometry is the study of dimension and measurement of strike and dip of a landform. Morphochronology is the study of age of each landform and the occurrence of landform. Lastly, morphodynamic is the study of formation process of landform either it is still active or may be active in the future.

According to (Tanot *et al.*, 2001) there are four types of geomorphology landscape in Kelantan state which are mountainous areas, hilly areas, plain areas and coastal areas. Figure 4.2 below shows the morphology map of Kampung Pulai, Gua Musang

There are nine aspects of geomorphology that are:

1. Fluvial Geomorphology
2. Hill Slope Geomorphology
3. Glacial Geomorphology
4. Tectonic Geomorphology
5. Quantitative Geomorphology (Civil Engineering)
6. Coastal Geomorphology
7. Desert Geomorphology
8. Biogeomorphology/ Landscape Ecology
9. Karst Geomorphology

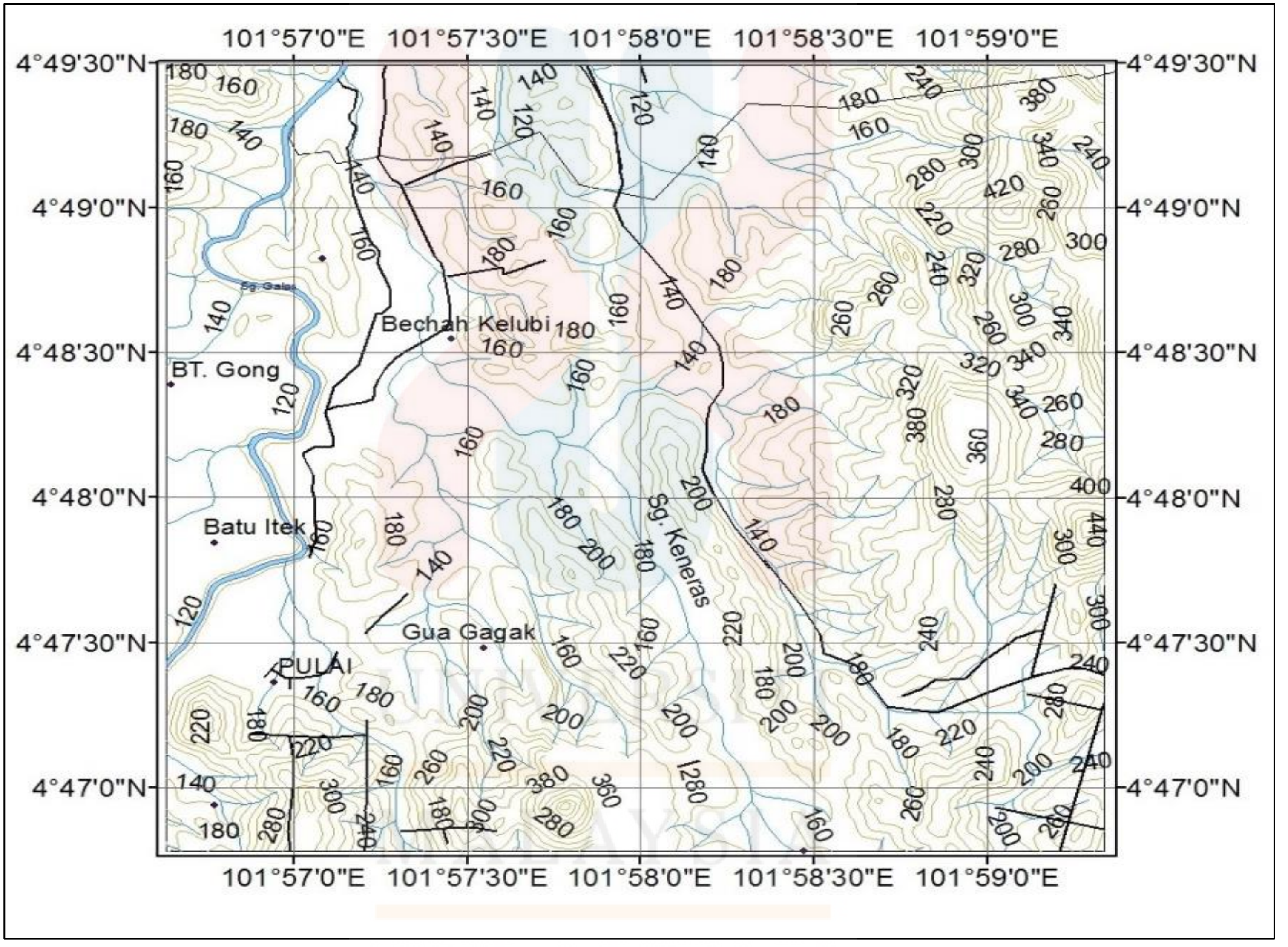


Figure 4.2: Morphology Map of Kampung Pulai, Gua Musang

4.2.2 Topography

Topography can be defined as the natural development or physical features of the earth surface. It also includes a variety of different features or landforms. The characteristic and type of landform can be identified by contour pattern of the study area. Based on the observation at the study area, it can be characterized as hills, steep slope and two hills with a dip in between. Figure 4.3 shows Landform based on contour pattern (State of New Wales, Department of Education and Training, 2009)

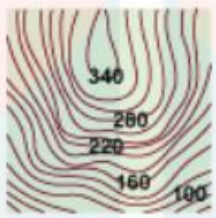
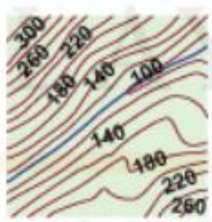
Landform	Contour pattern	Description	Picture
Steep slope		Contour lines close together	
Gentle slope		Contour lines far apart	
Hill		Rounded area projected above surrounding land	
Valley		V shaped in Australia, caused by water erosion	

Figure 4.3: Landform based on contour pattern (State of New Wales, Department of Education and Training, 2009)

Furthermore, on western part of the study area composed of lowest contour value since it also have river that goes down through it. Characteristic of river that are corrosive and intense rainfall also affect the area by time. Besides, outcrops that are found in this area is limestone beside the river. While on eastern part of the study area consists of steep slope and hill with the highest elevation that are 420. Table 4.1 shows the relationship with the absolute height morphology (Source: Van Zuidam, 1985). Then, Figure 4.4 shows the topographic map of the study area. Figure 4.5 shows the 3-D Topography Map.

Table 4.1 Relationship with the absolute height morphology

Source: Van Zuidam, 1985

Absolute Altitude (Meter)	Morphology Element
<50	Lowland
50-100	Lowland Inland
100-200	Low Hill
200-500	Hill
500-1500	High Hill
1500-3000	Highland
>3000	High Mountain

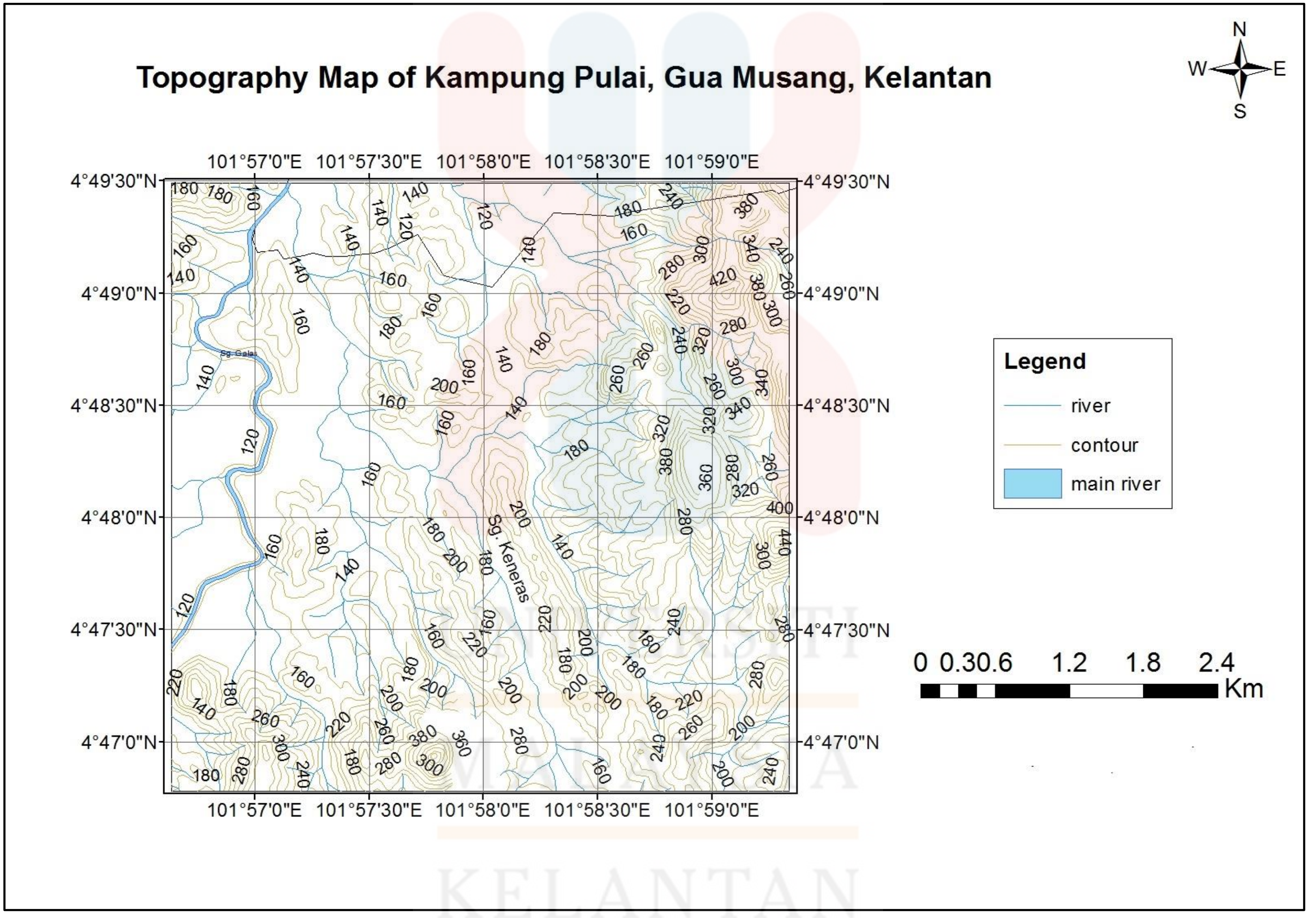


Figure 4.4: Topography Map of Study Area

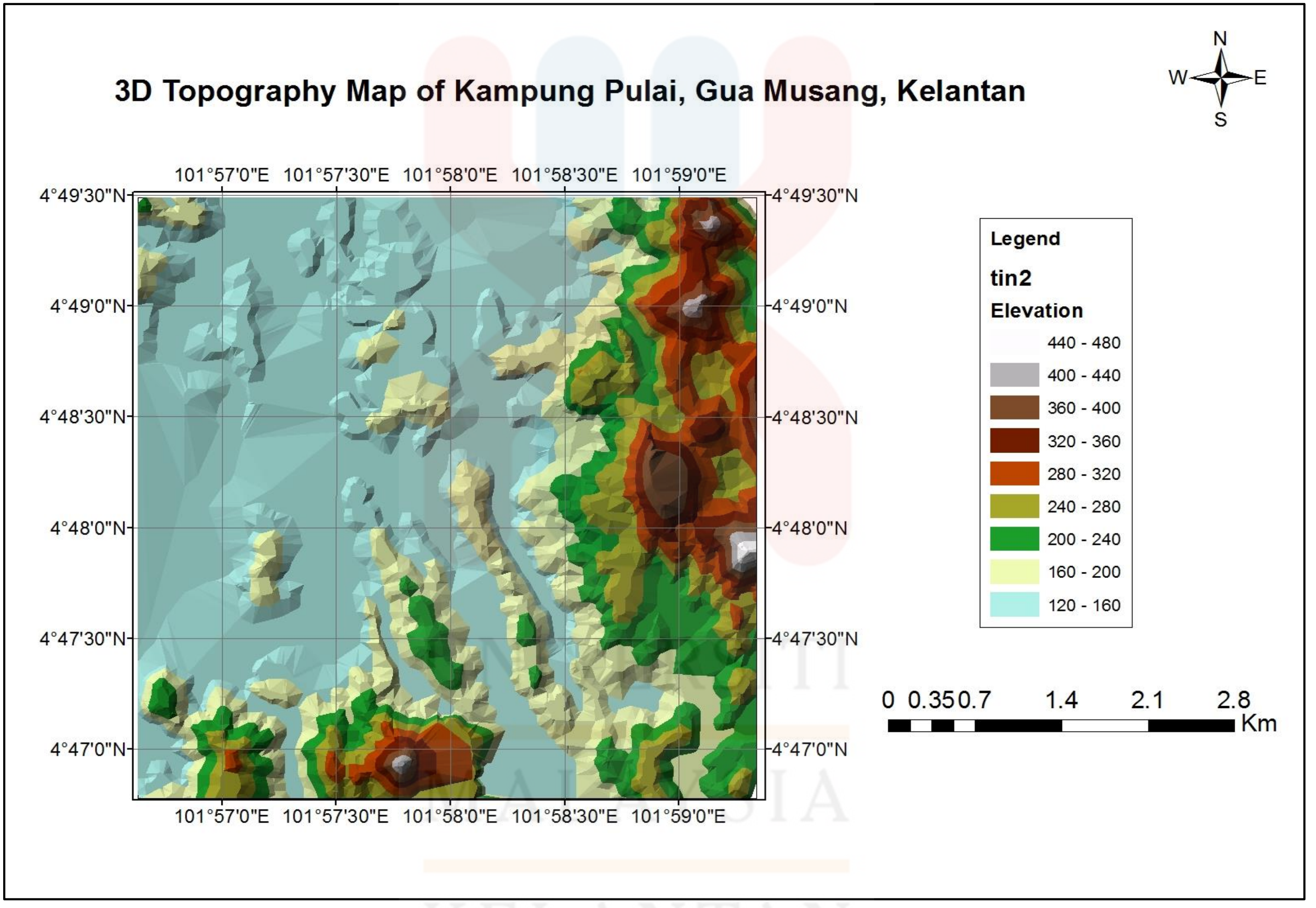


Figure 4.5: 3D Topography Map of Study Area

4.2.3 Drainage System

Formation of drainage pattern is controlled by several factors that are:

1. Rock Distribution
2. Rock Type
3. Location Of Rock At Surface

However, drainage pattern actually caused by the plane of weakness in the rocks which are bedding planes, joints, folds, faults and other factors that are erosion and rainfall. Besides, drainage basin also can be classified into four that are:-

1. magnitude and stream order,
2. drainage density,
3. drainage basin pattern and
4. drainage frequency.

Hills and channels at the study area are also the main channel for the water to flow to rivers near the surrounding.

According to (Horton, 1935) devised a system for classifying tributaries based on their order in the of drainage hierarchy. A fingertip tributary is a first order while second order stream lies below the confluence of two first order streams. Next, third order below the confluence of two second order streams. This order of the streams indicate that the increase the number of stream order, the older the streams. Based on the drainage map, the number of order stream is 3.

There are several drainage patterns that are commonly found which are trellis, parallel, rectangular, angular and dendritic. However, drainage pattern that can be found at the study area is dendritic and pattern. Dendritic pattern is a random and tree-like branching pattern river. Figure 4.4 shows the drainage pattern map at the study area.

Watershed can be defined as the area or ridge of land that separates the waters to flow to different basins, rivers or seas. Ridges and hills that separate two watersheds called as the drainage divide because of its character. The watershed also consists of streams, reservoirs, lakes and wetlands and all the underlying groundwater. Table 4.2 below shows the Drainage Pattern Classification according to (Ling Zhang and Eric Guilbert, 2012). Figure 4.6 below shows Drainage Map of Kampung Pulai, Gua Musang.

Table 4.2: Drainage Pattern Classification (Ling Zhang and Eric Guilbert, 2012).

Drainage Pattern	Geometric and Topologic Characteristic
Dendritic	• Tributaries joining at acute angle
Parallel	• Parallel like • Elongated catchment • Long straight tributaries • Tributaries joining at small acute angle
Trellis	• Short straight tributaries • Tributaries joining at almost right angle
Rectangular	• Tributary bends • Tributaries joining at almost right angle
Reticulate	• Tributaries cross together forming a cycle.

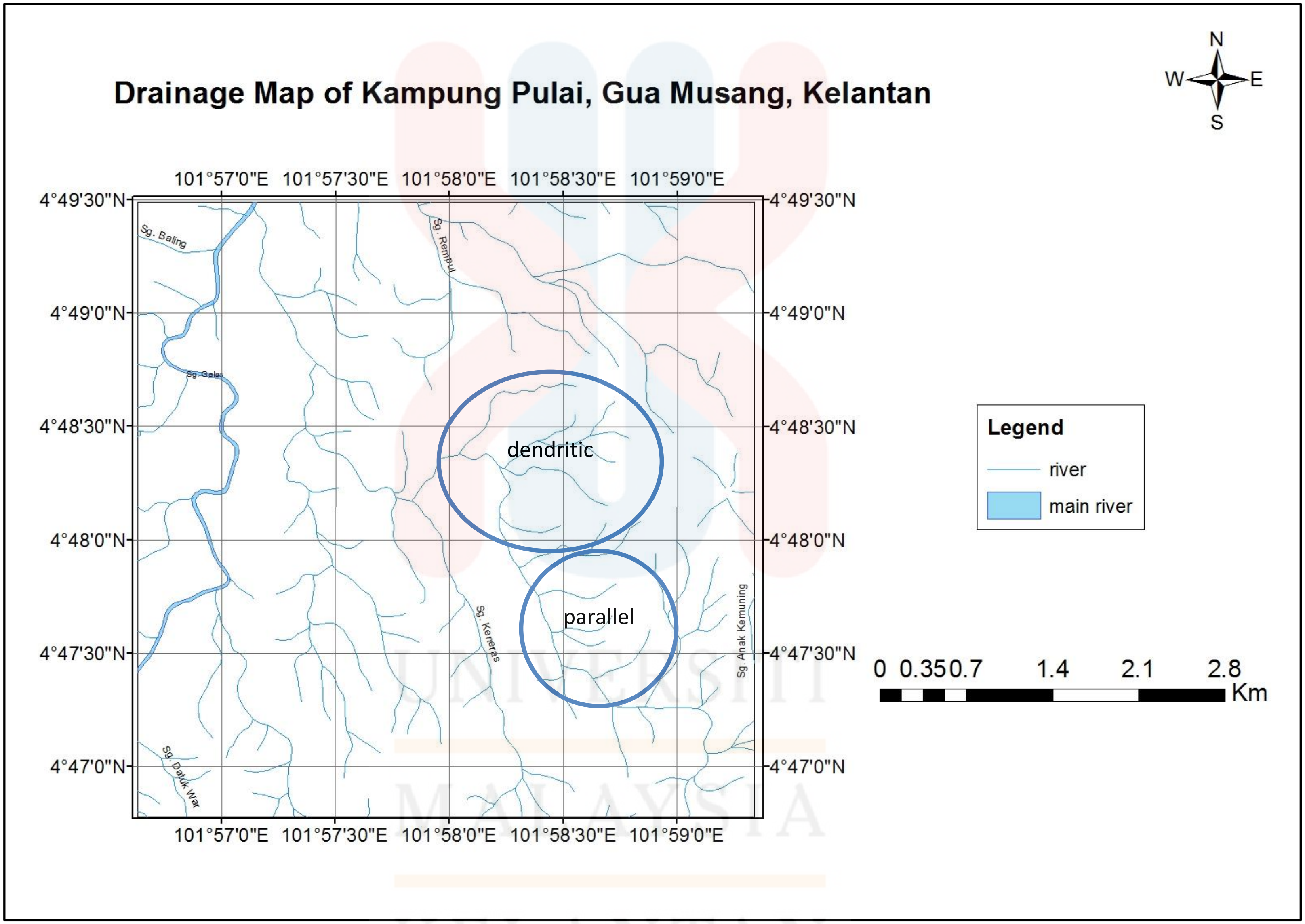


Figure 4.6: Drainage Map of Study Area

4.2.4 Weathering Process

Denudation can be defined as the long term sum of processes that cause the wearing away of the Earth’s surface by moving water, ice, wind and waves leading to a reduction in elevation and relief of landforms and landscapes. Denudation also called as degradation. Endogenous processes such as volcanoes, earthquakes, and plate tectonics uplift and expose continental crust to the exogenous processes of weathering, erosion, and mass wasting. These three processes are responsible for denudation to the Earth’s surface.

First of all, one of the processes that responsible for denudation is weathering. Weathering can be defined as the process where rock is dissolved, worn away or broken down into smaller and smaller pieces. There are three types of weathering which are physical or mechanical weathering, chemical weathering and biological weathering. Then, factors that affecting weathering processes are strength and resistance of rocks, climate (especially temperature and humidity regimes), slope and relief of the land and type and density of vegetative cover.

However, rocks in Malaysia mostly have weathered because of the humid weather throughout the year. Due to physical and chemical weathering process, there are so many changes in index properties such as density, void ratio, clay content and seismic velocity may be reflected towards the rocks. Several weathering indices have been devised for quantifying the changes in the intrinsic properties of weathered rocks according to Tecer, 1999., Gupta and Rao, 2001; Tecer and Cerit, 2002; and Ceryan *et al.* 2005. Chemical changes during weathering and hydrothermal alteration are quantified in several ways including the normalized value of element (or oxide) using their parent rock concentrations or immobile element concentrations in the sample according to Krauskopt (1967) and Minarik *et. al* (1983) .

Weathering process is very important for engineering purposes. The first step in classification is to determine the parameters of rocks related to classification purpose and to define the rock according to those parameters and properties (Lee, 1987; Anon, 1995; and Ceryan, 1999).

i. Physical Weathering

Physical weathering also known as mechanical weathering. It is the process of the breakdown of rocks into soils without changing chemical properties of rock. There are several agents of physical weathering that are wind and water. The examples of physical weathering are abrasion, joints, frost, wedging and exfoliation. Figure 4.7 below shows that the rock has undergo physical weathering as the wind is the agent. When the wind blow is brought along the small particles such as dust that may cause physical contact with the rocks surface.

Figure 4.7: Physical Weathering Process

ii. Chemical Weathering

Chemical weathering is caused by rain water reacting with the mineral grains in rocks to form new minerals (clays) and soluble salts. These reactions occur particularly when the water is slightly acidic. Chemical weathering that acts on the rocks that exist at my study area is oxidation. This is where the breakdown of rock by oxygen and water, often giving iron-rich rocks a rusty-coloured weathered surface. Figure 4.8 below shows the chemical weathering that acts on the rocks:

Figure 4.8: Chemical Weathering

iii. Mass Wasting

Another denudation process that present at my study area is mass wasting. Mass wasting also known as slope movement or mass movement where the process of soil, regolith, sand and rock that move downward under the force of gravity. However, it is also affected by water and water content as in submarine environments and mudflows. Figure 4.9 below shows mass movement at the study area:

Figure 4.9: Mass Movement

4.3 Lithostratigraphy

4.3.1 Lithology

The study area is located in Kampung Pulai, Gua Musang which is an area of quite acidic intrusive area. So, the lithology that can be found there are tuff, granite and limestone.

i. Tuff

This sample was found beside a cemetery in Kampung Puteh at coordinate 04° 48’ 48.3” N and 101° 57’ 54.1” E. This sample was found at a landslide area. This landslide maybe was induced by the intense rainfall and there is lack of vegetation that triggered the slope to fail even if the slope height is only about five metres. This sample coloured is reddish brown. The rock type is actually igneous which is pyroclastic volcanic rock where it is a type of rock that formed from the volcanic ashes. It is also contain of aphanitic texture which is of very fine-grained rock texture. Figure 4.10 above shows the Hand Specimen of Tuff. This rock sample is igneous rock type which is the rock formed from volcanic ashes ejected from an event of volcanic eruption. Then, the ashes are compacted into a solid rock in a process called consolidation. This rock sample is brownish yellow in colour. It is also consists of lapilli which is in the form of ‘dots’ that are black in colour. Figure 4.11 shows Tuff Sample under Microscope.

Figure 4.10: Hand Specimen of Tuff

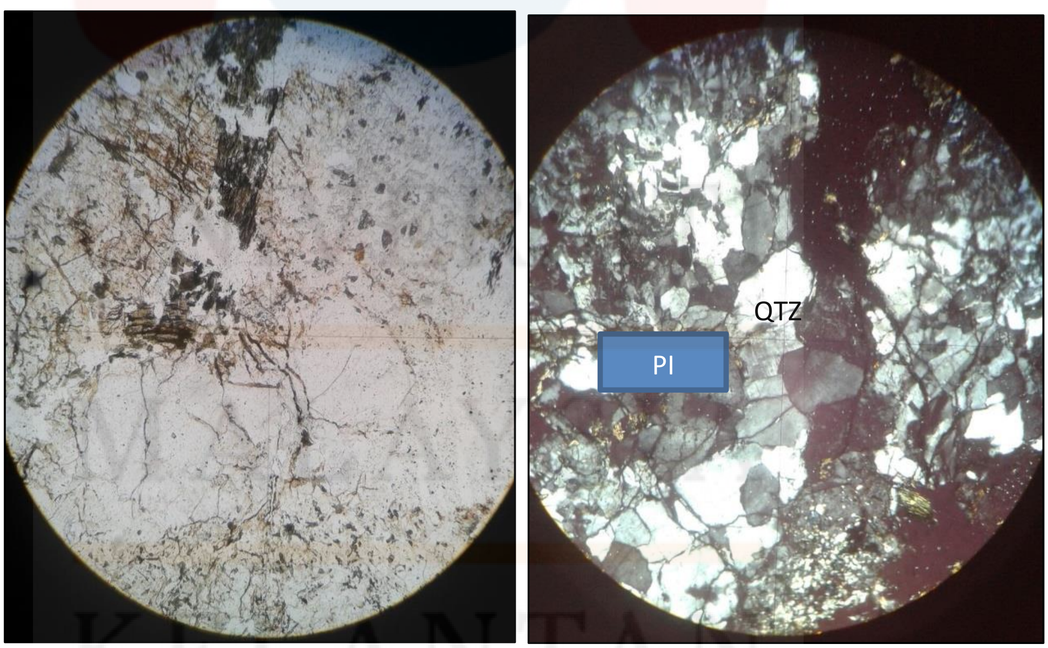


Figure 4.11: Tuff Sample under Microscope

ii. **Limestone**

For this sample was found at coordinate 04° 48’ 26.9” N and 101° 56’ 55.3” E. this sample is light grey limestone where it is react with hydrochloric acid (HCL) when tested. The bubble is formed because the carbonate reacted with the acid. This rock also has aphanitic texture which is contain of very fine-grained. This rock also found beside the Pulai River. Figure 4.12 shows the hand specimen of limestone. While Figure 4.13 shows the Limestone Sample Under Microscope.

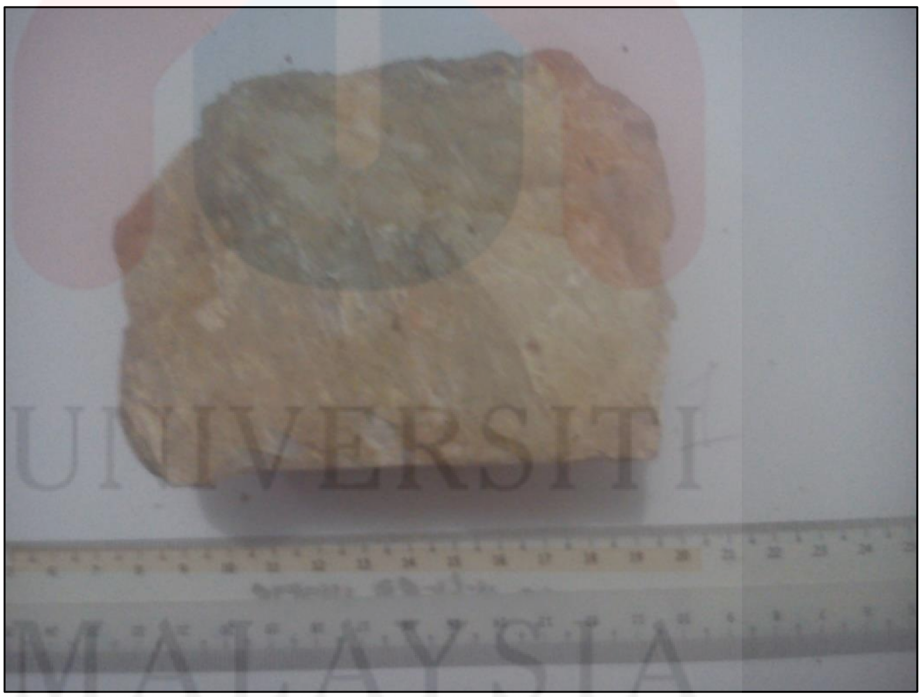


Figure 4.12: Hand Specimen of Limestone

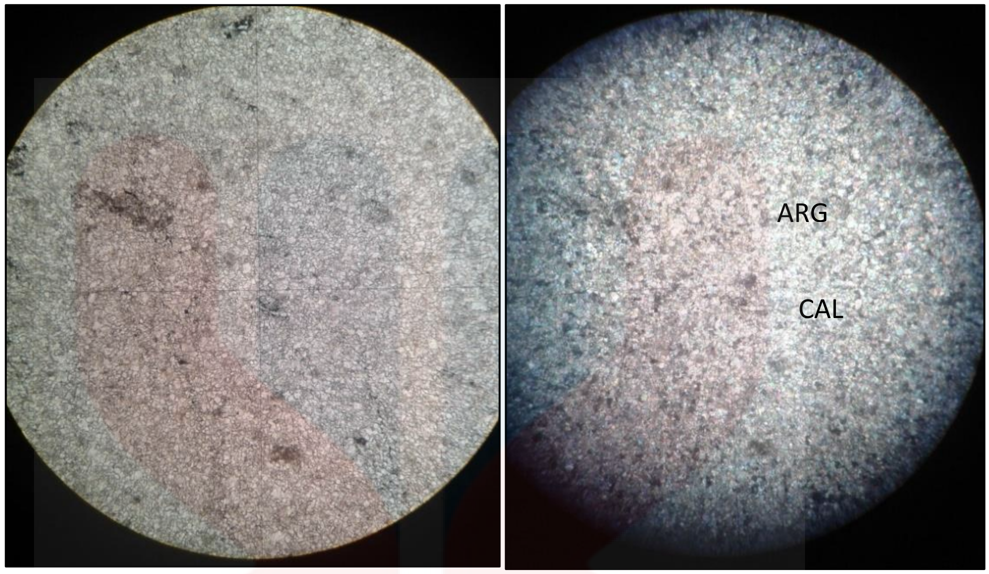


Figure 4.13: Limestone Sample under Microscope

iii. Granite

This rock sample has been found in Kampung Tanah Puteh at a coordinate of 04° 49’ 26.7” N and 101° 57’ 47.9” E. Granite is a common type of felsic intrusive igneous rock that is granular and phaneritic in texture. Figure 4.14 above shows Hand Specimen of Granite. Figure 4.15 shows Granite Sample under Microscope.

Figure 4.14: Hand Specimen of Granite

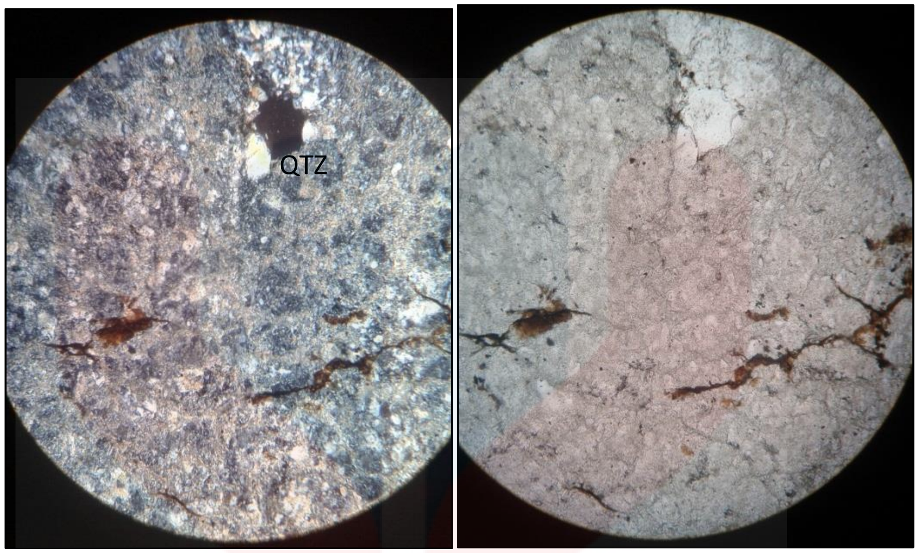


Figure 4.15: Granite Sample under Microscope

4.3.2 Stratigraphy Column

Based on the field observation and data that have been collected, the study area is covered by three types of rock which are tuff, limestone and granite. Table 4.3 shows Lithostratigraphy of Kampung Pulai. Granite rock is the oldest rock that is found at study area. Continue by limestone and tuff. However, all the three rocks are of the same period which is Permian.

Table 4.3: Lithostratigraphy of Kampung Pulai

ERA	PERIOD	LITHOLOGY	COLOR
Paleozoic	Permian	Tuff	
		Limestone	
		Granite	

4.4 Historical Geology

For this study area, it is under formation of Gua Musang. For Gua Musang formation it is consists of sandstone, schist, shale, limestone and andesite. Gua Musang comprise the argillaceous outcrops are much more extensive than the limestone and the thin-bedded, laminated and fissile shale is usually grey in colour but is black when carbonaceous according to (Foo, 1983).

The bulks are fine-grained to medium-grained crystal lithic tuff which is sometimes interlaminated with dark grey tuffaceous shale and black carbonaceous shale. According to Gobbett (1973), flow-banded spherulitic rhyolite trachyte, trachyandesite and andesite lavas are associated with shale and water deposited tuff and probable were extruded on the sea floor. The ages of study area are Permian and Triassic.

Gua Musang formation also consists of different lithology that is made up of argillo-arenaceous sediments with intercalated volcanic and limestone aged Permian-Triassic.

- Volcanic rock which is made up andesite and rhyolite
- Metamorphic rock (slate)
- Sedimentary rock (limestone)

4.5 Structural Geology

4.5.1 Lineament Analysis

According to Ibrahim and Juhari (1990), lineament is a large scale and clearly shown at the Earth's surface. Lineament can be divided into two which is positive lineament and negative lineament. Positive lineaments represent features of ridge and range while negative lineaments represent rivers, valleys and faults. Fracture zones, shear zones and igneous intrusions such as dykes can also give rise to lineaments. Figure 4.16 shows lineament analysis map of Kampung Pulai.

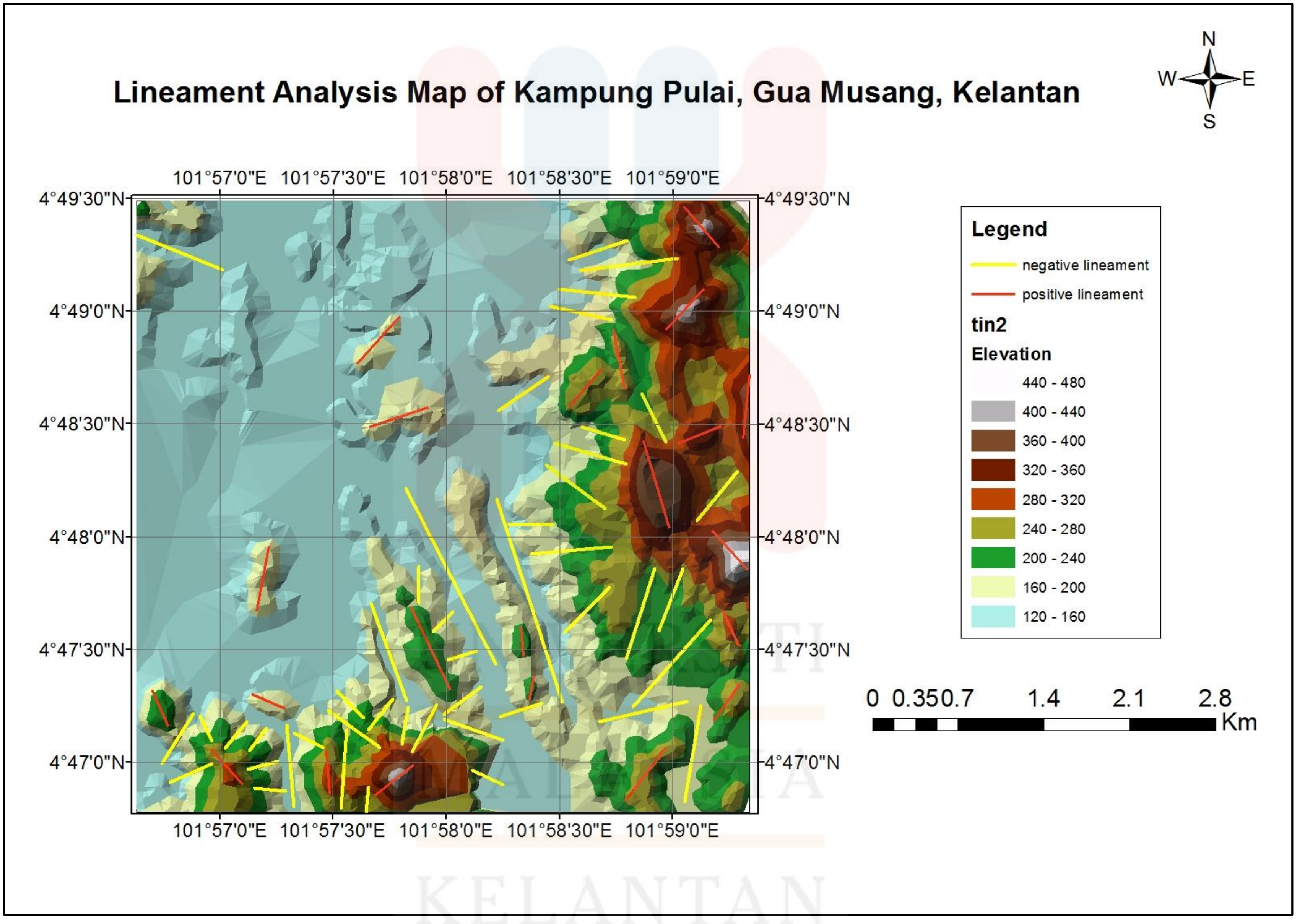


Figure 4.16: Lineament Analysis Map of Study Area

4.6 Joint Analysis

There are several joints that have been found at this study area. Joint at this area mostly form as the result of brittle from a rock body or layer as the result of tensile stresses which called as secondary structure. Geometry of joints refers to the orientation of joints either they are plotted on rose diagram or stereonet. There are three types of major joints which are non-systematic joint, systematic joints and columnar joints

There are two stations that the reading of strike and dip have been taken. Since there is a little structures that can be seen physically at the study area. The maximum and minimum force will be determined from the rose diagram.

i. Station 1

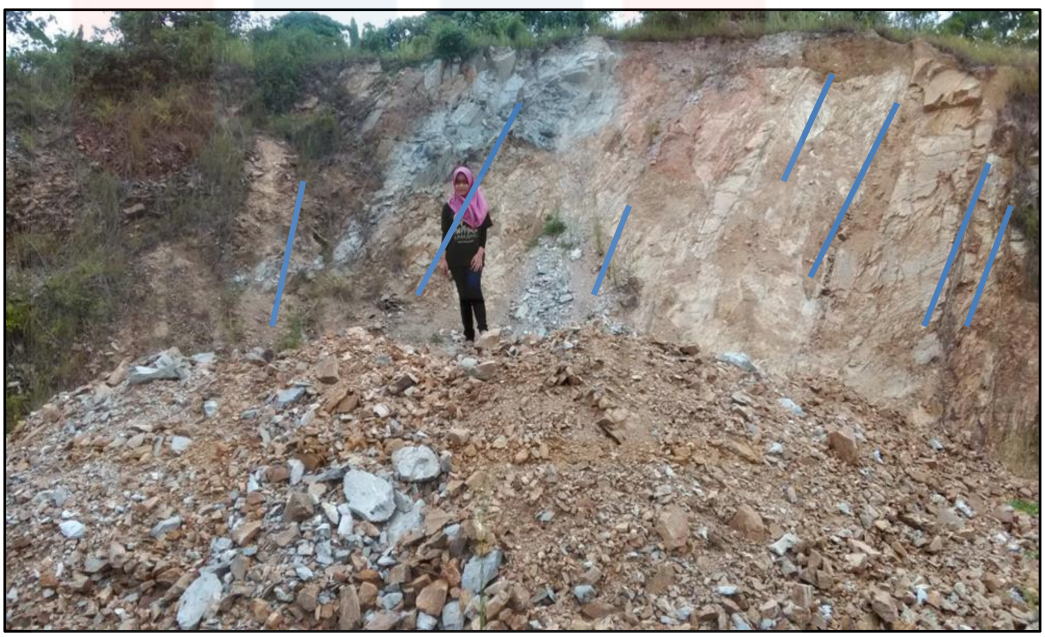


Figure 4.17: Joint Structure at Station 1

This structure is located at a coordinate of 04° 49’ 26.7” N and 101° 57’ 47.9” E. Rocks that have been found here are lapilli tuff and granite. The grain size is fine-grained to medium-grained. It is also irregular in geometry and spacing. Figure 4.17 above shows Joint Structure at Station 1.

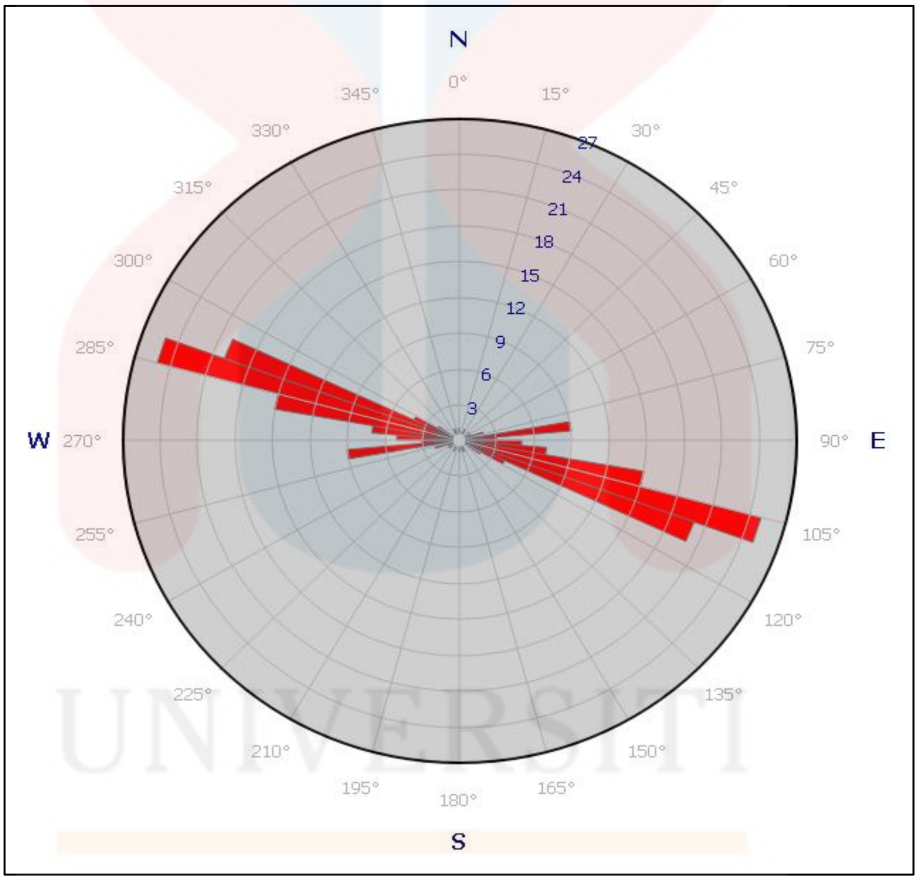


Figure 4.18: Rose Diagram for Station 1

For station 1, there are two forces that acting on the rock that causes the rock to form joints and fractures. These structures caused the slope to be unstable. By time, there is high probability that the slope will fail. Figure 4.18 shows Rose Diagram for Station 1.

ii. Station 2

Figure 4.19: Joint Structure at Station 2

This structure is located at coordinate of 04° 47’ 46.7 N and 101° 57’ 2.0” E. Type of rock that have been found here is slate where it is dark grey in colour. This sample has a really fine-grained texture. Figure 4.19 shows the Joint Structure at Station 2.

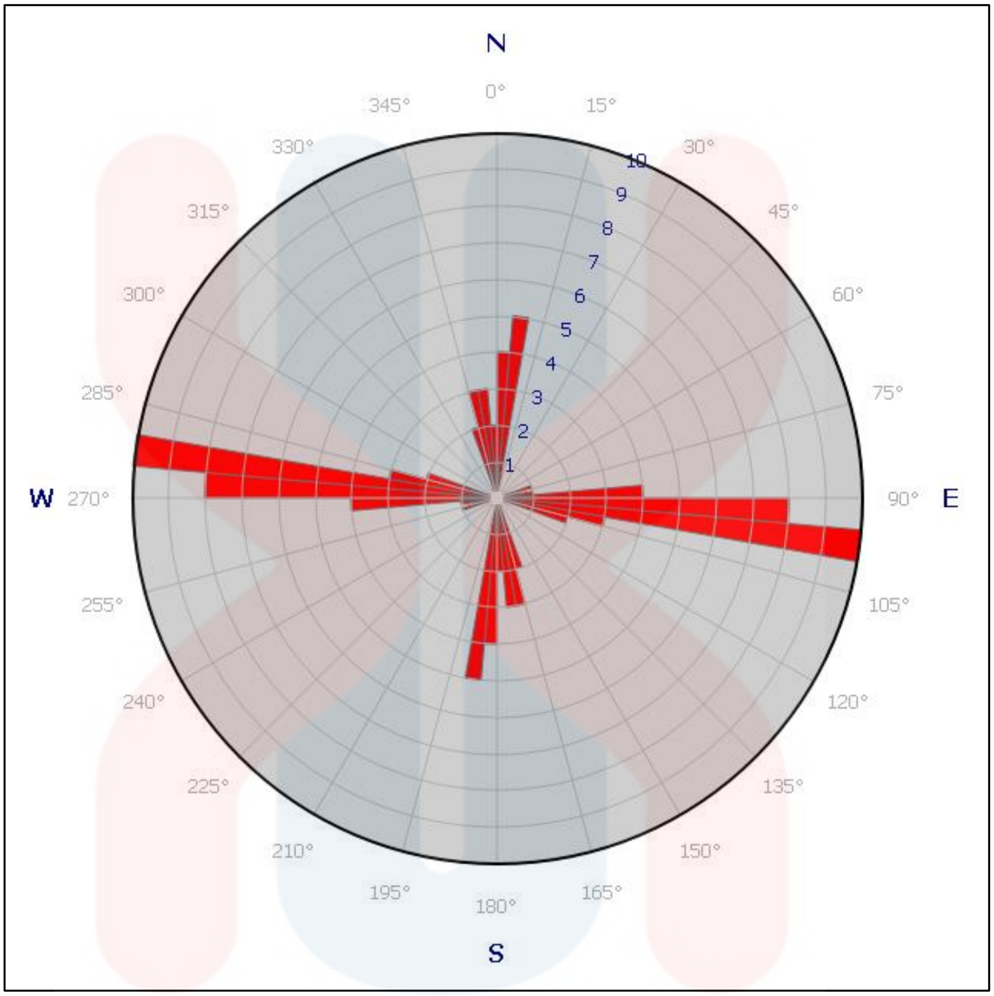


Figure 4.20: Rose Diagram for Station 2

Joints and fractures that has been found at the study area caused by the outer tension to the rock. There are two forces that are acting on the rock that causes it to formed joints and fractures. Figure 4.20 above shows Rose Diagram for Station 2.

4.7 Geological Map

Geological Map below shows all the characteristics that exist in the study area. The cross section of the study area also can be observed in the geological map. Tuff is represents by light orange color while limestone represent by blue color. Lastly, granite is represents by red color. Figure 4.21 below shows the Geological Map of Kampung Pulai, Gua Musang, Kelantan.

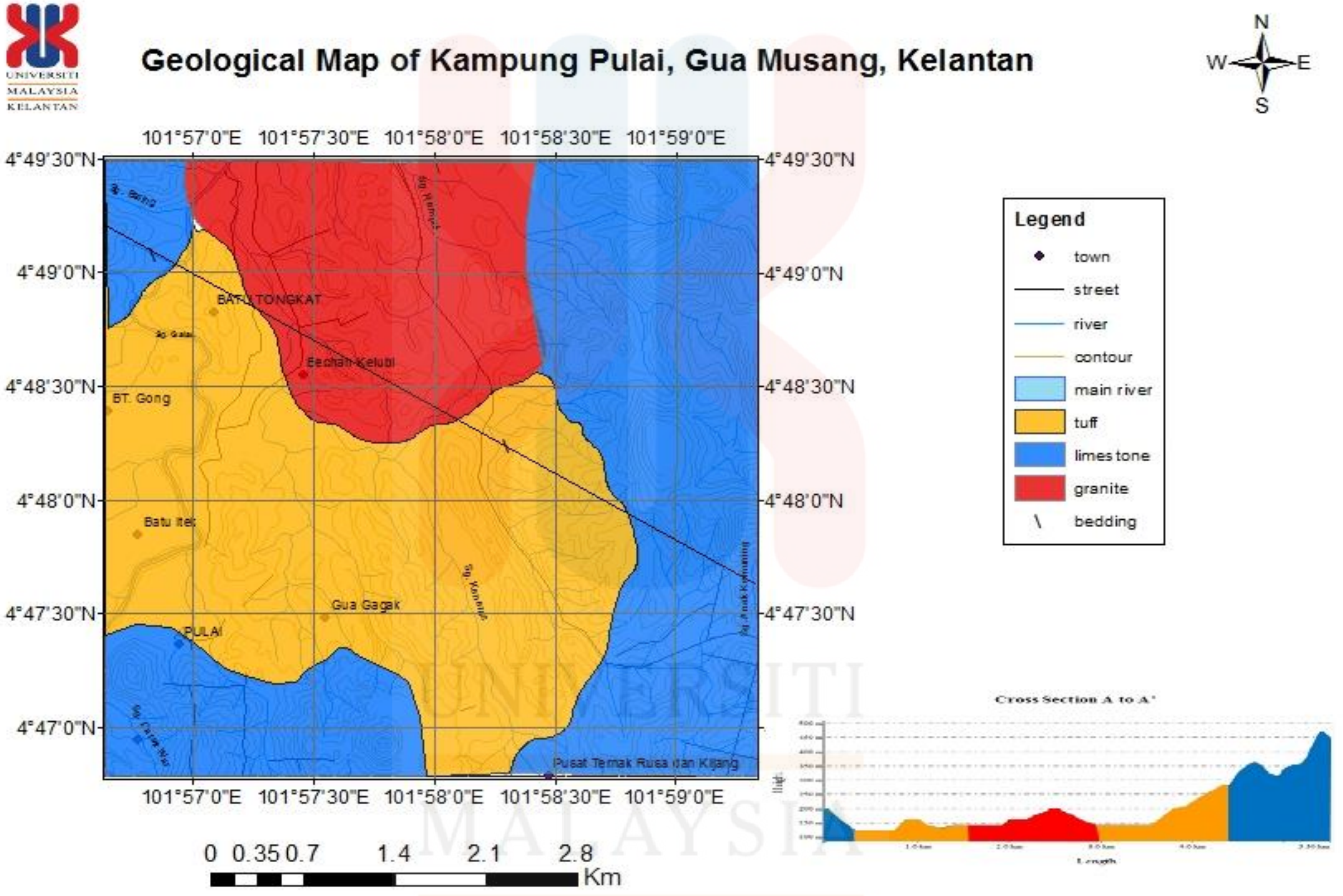


Figure 4.21: Geological Map of Kampung Pulai, Gua Musang, Kelantan

CHAPTER 5

KINEMATIC STABILITY ANALYSIS

5.1 Introduction

This chapter will explain more about structural geology that found at Kampung Pulai, Gua Musang. The structural geology will be identify and analyse using a suitable method. The structural geology that has been found in the study area are joints, faults and folds. Method that has been used to analyze this structure is by using Geo-Rose. By using Geo-Rose or Rose Diagram, the direction of maximum and minimum force that acts on the structures can be identified. In this chapter also will describe the observation of structures in the study area and analysis of structures reading.

5.2 Kinematic Stability Analysis

5.2.1 Cut Slope 1

Figure 5.1: Station 1

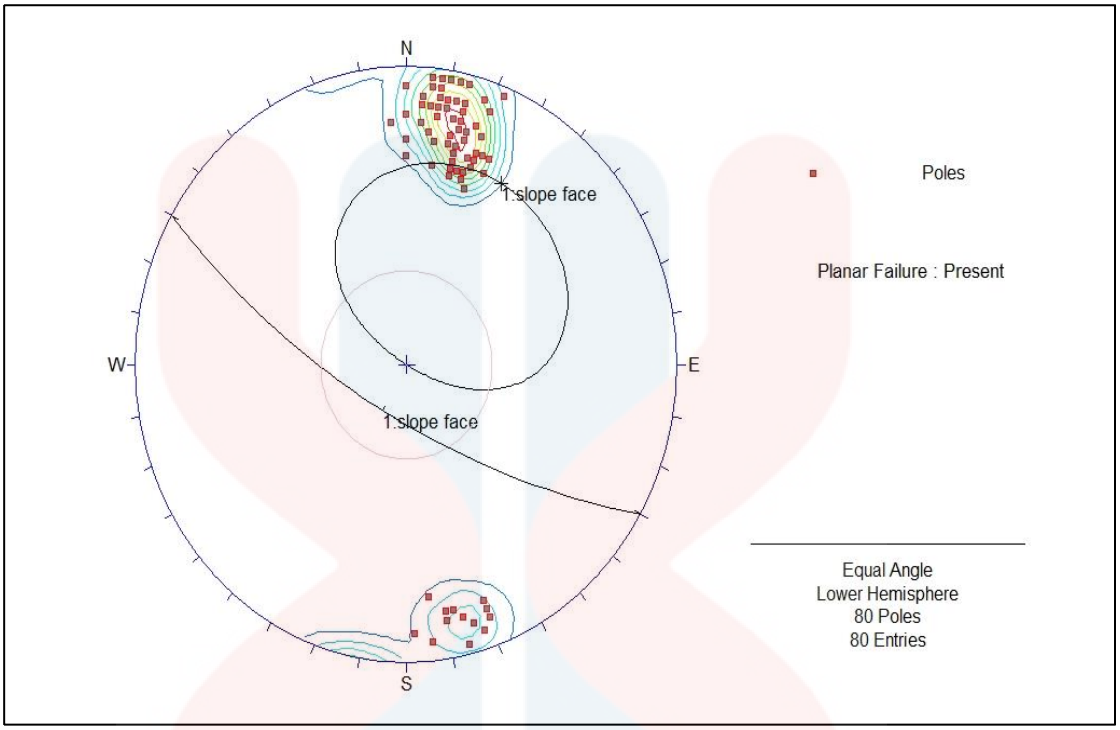


Figure 5.2: Planar Failure at Station 1

Figure 5.2 shows the analysis strereonet for planar failure above shows that planar failure is possible to occur in the future. So, this means that this slope is unstable since the slope will undergo slope failure in the future.

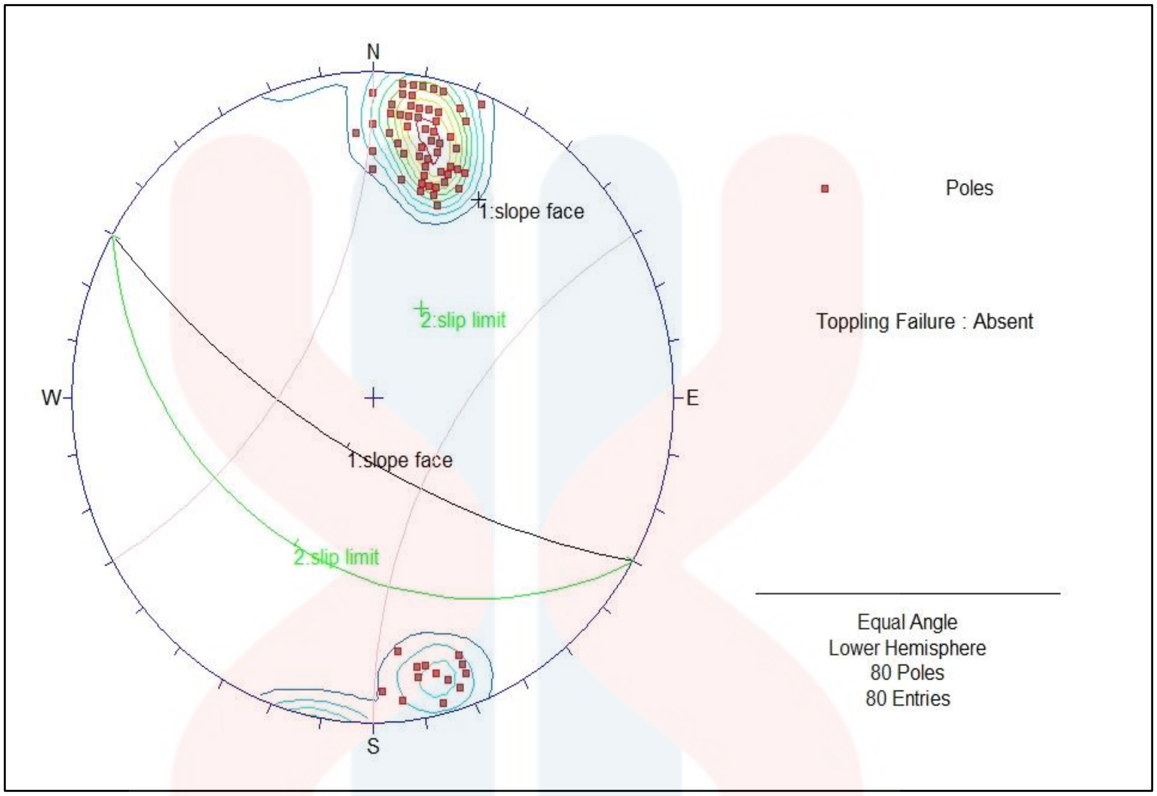


Figure 5.3: Toppling Failure At Station 1

Figure 5.3: Toppling Failure At Station 1 Shows the stereonet plot of Toppling Failure. The possibility of Toppling Failure to occur is absent. This is because poles plotting do not present at this region and not indicate the toppling risk. So, the slope is stable.

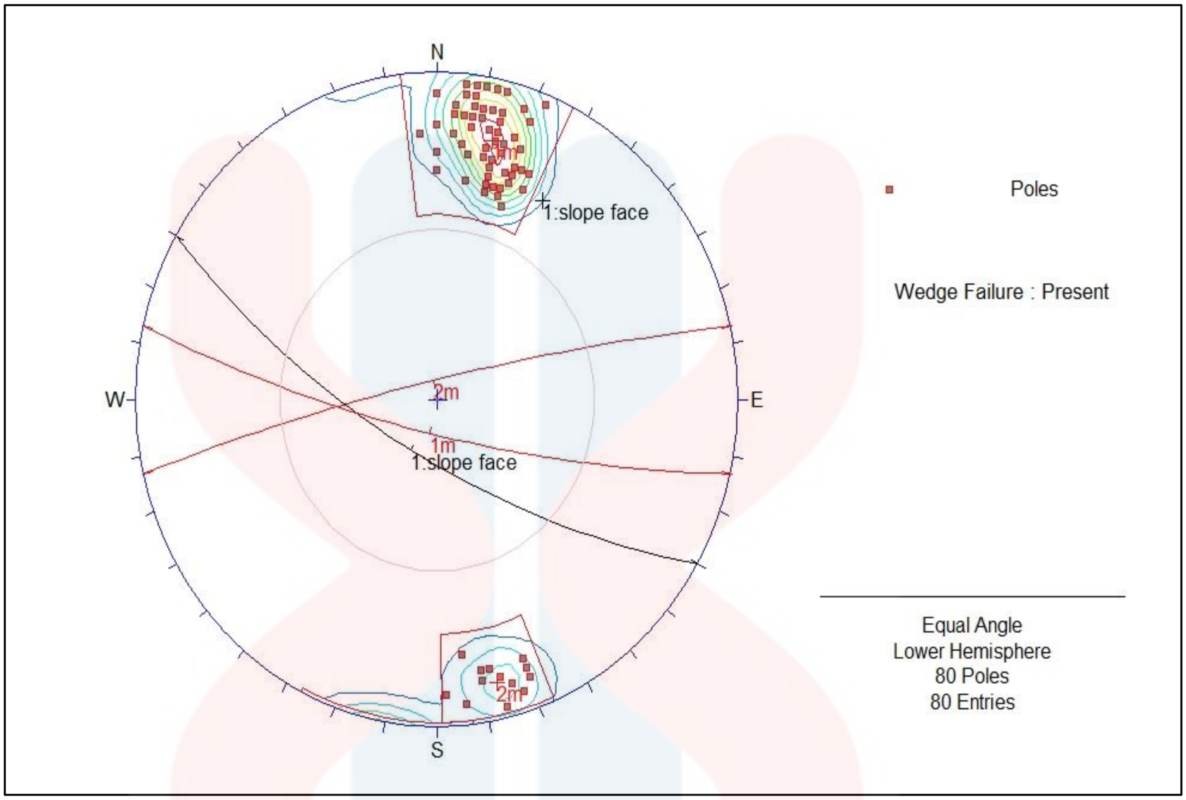


Figure 5.4: Wedge Failure At Station 1

Possibility that this slope will undergo Wedge Failure is present which means this slope is unstable. This is because the mean joint set orientation intersections fall within the zone defined by the friction cone and the pit slope. Figure 5.4: Wedge Failure at Station 1 shows the stereonet plot of Wedge Failure.

5.2.2 Cut Slope 2

Figure 5.5: Station 2

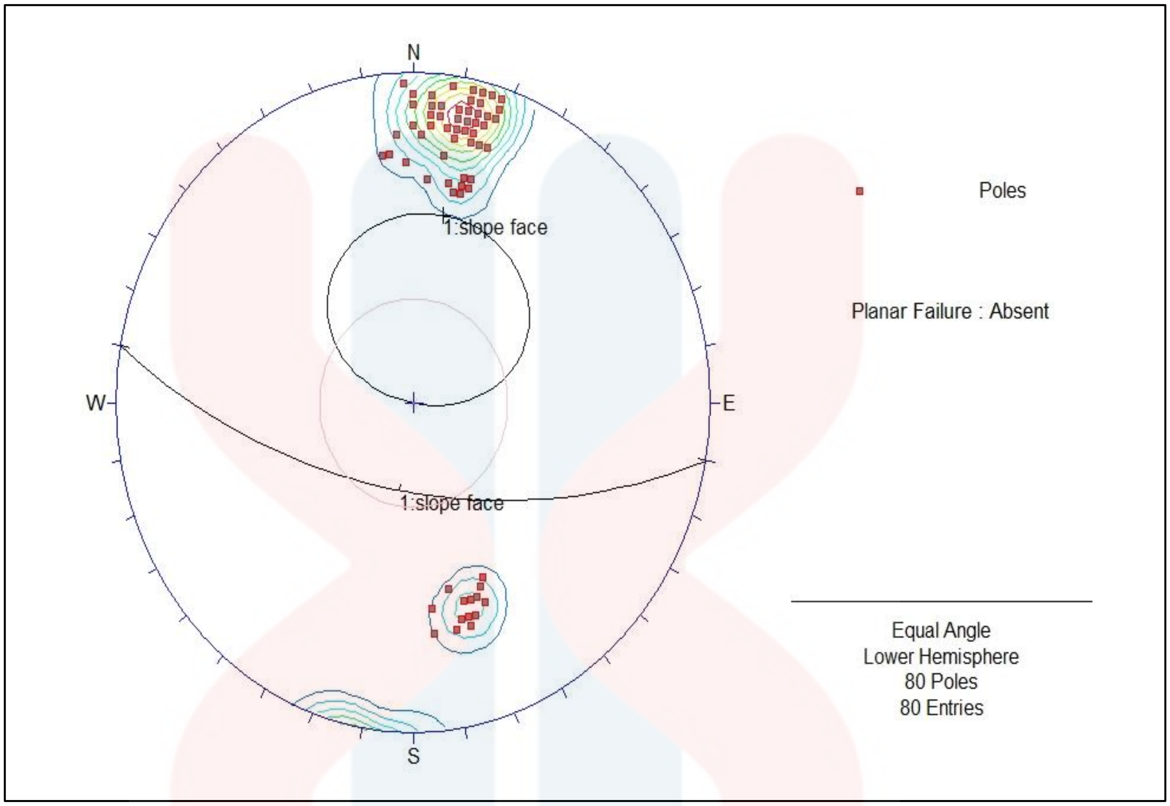


Figure 5.6: Planar Failure At Station 2

Figure above shows the Figure 5.6: Planar Failure At Station 2. The possibility of Plane Failure to occur at this slope is absent. This means that this slope is stable from planar failure to occur.

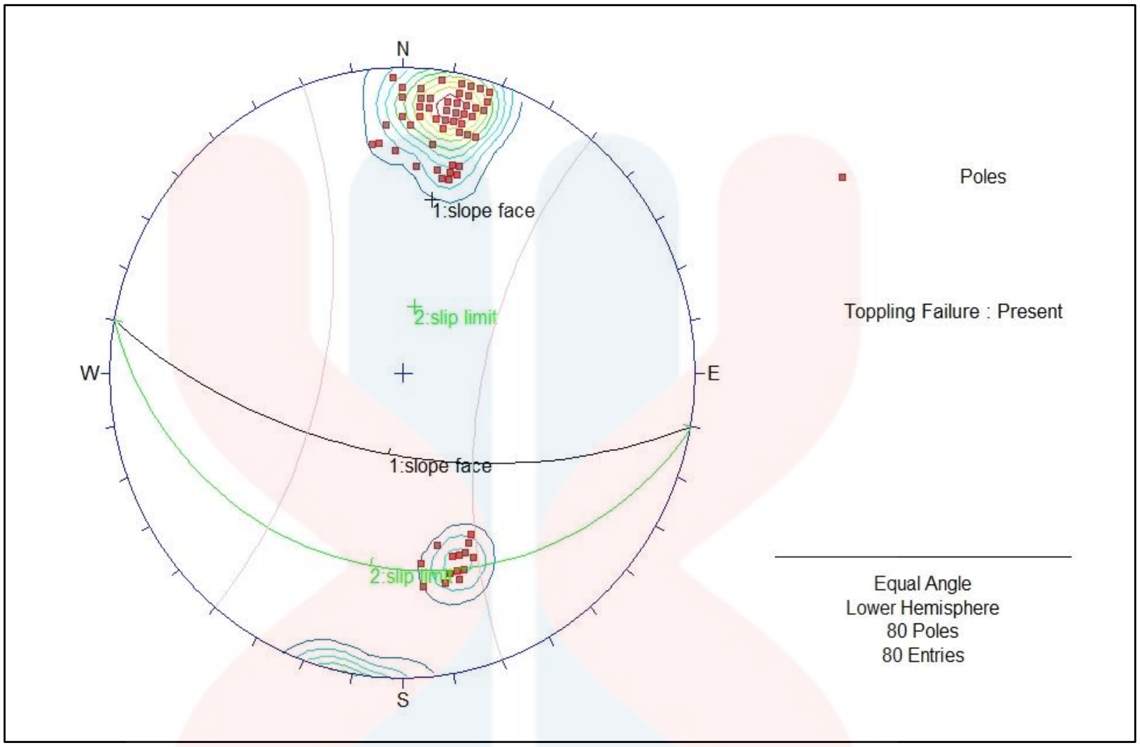


Figure 5.7: Toppling Failure At Station 2

Figure 5.7: Toppling Failure At Station 2 Shows the stereonet plot of Toppling Failure. The possibility of Toppling Failure to occur is present. This is because poles plotting present at this region and indicating the toppling risk. The slope at station 2 is unstable.

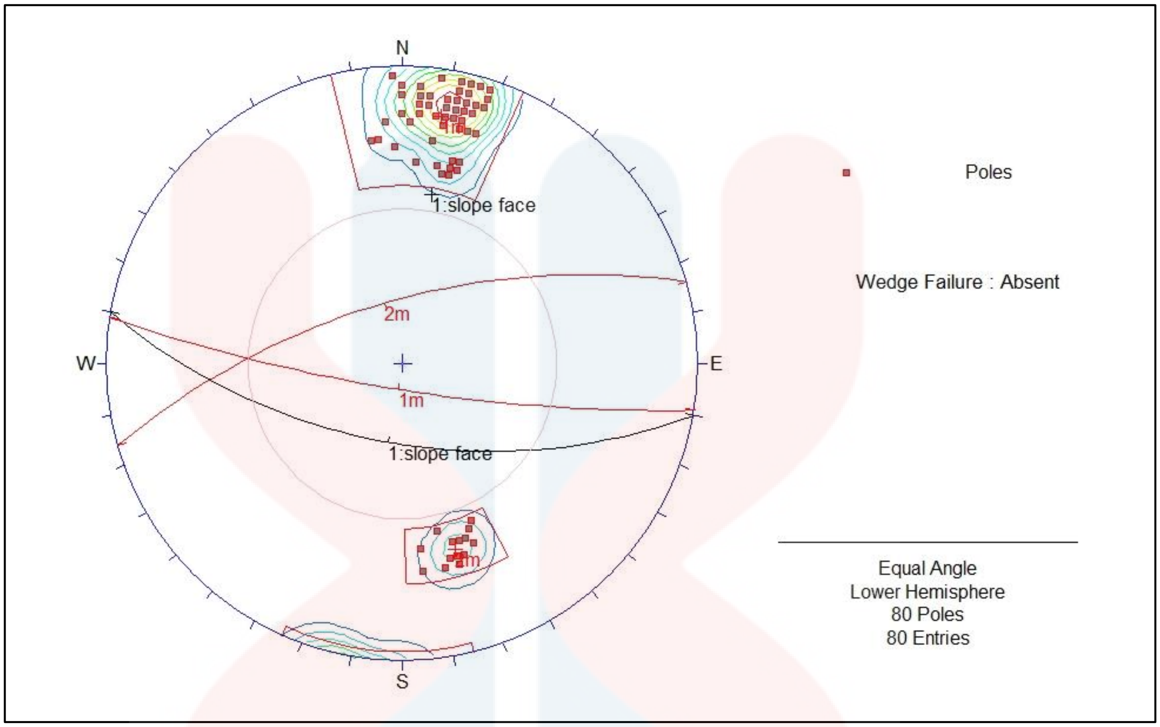


Figure 5.8: Wedge Failure At Station 2

Possibility that this slope will undergo Wedge Failure is absent. This is because the mean joint set orientation intersections do not fall within the zone defined by the friction cone and the pit slope. Figure 5.8: Wedge Failure At Station 2 shows the stereonet plot of Wedge Failure. So, this means that this slope is stable from Wedge Failure to occur.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Based on geological mapping and specification, the lithology in the study area is acidic intrusive rocks. The grain size is fine to medium grained size because of the texture itself that are formed from the compacted or consolidation process. The rocks found in this study area are mostly tuff and limestone with slate. The weathering process in this study area also high in rate since the temperature in the study area is quite high and intense rainfall. Joints can be classified into two which are tectonic process AND weathering process

However, mostly joints that formed in this study area mostly because of weathering process. This is because the rate of weathering is high in this study area.

6.2 Recommendation

For recommendation, I suggest that other students do further investigations about the structural analysis at Kampung Pulai, Gua Musang. This is because changes that occur by time can change the structures at this place. Besides, I suggest that they are also do investigations in the sub surface too other than on the surface only.

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