General Geology and Determination of Landslide Susceptibility using Geographical Information System at Bechah Kelubi, Gua Musang, Kelantan

by

Angela Vidda anak Chuwat

A thesis report submitted in fulfilment of the requirement for the Bachelor Degree of Applied Science (Geoscience)

Faculty of Earth Science

Universiti Malaysia Kelantan

2017

Table of Content

DECLARATION

I declare that, this thesis entitled "General Geology and Determination of Landslide Susceptibility at Bechah Kelubi, Gua Musang, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and not concurrently submitted in candidature of any other degree.

Signature :

Name :

Date :

Acknowledgment

Thank God for the opportunities given to me for accomplishing this final year project report. I would like to express my gratitude to my supervisor and former supervisor, Sir Arham Muchtar Bahar and Madam Zaitul Zahira for their supervision in guiding me to accomplish this thesis. I also would like to express my thanks to both of my parents and love one for supporting me throughout this thesis accomplishment. Never forget to all my friends who involved directly or indirectly in this thesis accomplishment, being companion for fieldwork and being able to encourage me to finish the task required by university.

List of Table

List of Figures

General Geology and Determination of Landslide Susceptibility Using Geographic Information System at Bechah Kelubi, Gua Musang, Kelantan

Abstract

The study is about the general geology and determination of landslide susceptibility by using the Geographic Information System in Bechah Kelubi. The coordinate of study area is located at (4˚ 47’ 30” – 4˚ 50’ 30”) N and (101˚ 57’ 00” – 102˚ 00’ 00”) E. The purpose of the study is to update the geological map of study area and determine the limestone geohazard within the study area. Geological map is produced by geological mapping, fieldwork observation and collecting the rock sample. The rock sample is collected then cut for thin section for petrography analysis whereas the data collected such as strike and dip from the field observation are used for structural analysis. The potential of landslide susceptibility is detected by the data collected from certain parameter such as land use map, soil map and rain distribution data in order to produce a geohazard map using Geographical Information System (GIS). The data collected and map produced is important to contribute for the understanding of study area and may assist for developer in future development.

Abstrak

Kajian ini mengenai geologi am dan pengetahuan tentang kecenderungan tanah runtuh dengan menggunakan Geographic Information System (GIS) di Bechah Kelubi. Lokasi kawasan kajian terletak di koordinate (4˚ 47’ 30” – 4˚ 50’ 30”) N dan (101˚ 57’ 00” – 102˚ 00’ 00”) E. Tujuan kajian ini dijalankan adalah untuk menghasilkan sebuah peta geologi kawasan kajian dan untuk mengetahui potensi geobencana batu kapur dalam kawasasn kajian. Peta geologi ini dihasilkan menerusi pemetaan geologi, pemerhatian kerja lapangan dan pengumpulan sampel batuan di dalam kawasan kajian. Pengumpulan smapel batuan digunakan untuk proses keratan nipis untuk analisis petrografi, manakala, pengumpulan data di kawasan kajian seperti bacaan strike dan dip diambil untuk tujuan analisa struktur.

CHAPTER 1

INTRODUCTION

1.1 General Background

This research is about General Geology and Determination of Limestone Geohazard in Bechah Kelubi, Gua Musang, Kelantan. The study is located at the Southern of Kelantan in Gua Musang town area. Gua Musang district is one of well-developed town in Kelantan with population of people approximately 114,500 people at year of 2014.

A formation known as Gua Musang Formation in this district is mainly covered by limestone. Limestone tower and karst can be found nearby the town area and within the residential area. Yin (1965) stated the formation of Gua Musang is estimated at thickness of 650 meter, which consist of crystallized limestone, interbedded of thin bed of shale, tuff, chert and subordinate sandstone and volcanic rocks in age of Middle Permian to Upper Triassic. The occurrence of limestone in Gua Musang can be found is lenses, forming cliff-bound ridge and isolated tower like hills in Gua Musang district. Formerly, Gua Musang is developed during the Upper Paleozoic shelf of East Malaya, where the occurrence of volcanic activities and basinal instability. The volcanic rock is classified as vary from rhyolitic to andesitic that including tuff, lava flow and agglomerate. The grain size is from fine to medium grained crystal lithic tuff and sometimes might interlaminated with dark grey tuffaceous shale and black carbonaceous shale.

Apart from that, some of pyroclastic rocks that associated with marine sediments are fossiliferous with fragmented crinoid ossicles, bryzoa and brachiopods of Upper

Paleozoic creatures. The Gua Musang formation is laterally similar to pyroclastic Aring Formation and Telong Formation in South Kelantan. According to Aw (1990), the formation of Aring is dominated by pyroclastic lava, dolomitic marble and argillite which is at 3000 meter thick. The stratigraphic is same with the Gua Musang Formation which is calcareous –argillaceous.

The selected study area is located at Bechah Kelubi, which is nearby to the R&R Gua Musang. Instead of limestone, the study area had other lithology which are volcanic rock and interbedded sandstone. Bechah Kelubi is covered by the vegetation such as rubber estate, farming activities. The area is surrounded by industrial factories.

1.2 Problem Statements

Study area selected is Bechah Kelubi which located in Gua Musang Kelantan. Study area is surrounded with rubber estate and farms, where the agricultural activities is conducted. The location is easy to access because the road is connected within the estate.

Gua Musang is well known with its formation which is dominated with limestone within the area. In Gua Musang, hazard can be found in several location according to previous case study. Hazards that usually occurred are such as landslide, rock falls or the limestone hazard itself are consist of sinkhole, cavities and karst.

The purpose of this study is to update the map of study area. Fieldwork is conducted to inspect the study area and to update the change occurred within the study area. Significant change of the study area is compared with the previous information. The information of the map used is from JUPEM (Jabatan Ukur dan

Pemetaan Malaysia), which published in year of 1995, and had been updated in year of 2004.

Selected study area had very limited references for future researcher or developers, therefore the fieldwork conducted is very important in order to get the updated information for study area. The map is very important to determine the potential hazard or landslide susceptibility within the study area. Furthermore, the produced map also can help people to aware with the hazard in their surroundings.

1.3 Research Objectives

i. To update geological map in study area to the scale of 1:25,000

ii. To identify the karst surface condition using satellite imagery SPOT 5

iii. To produce potential landslide susceptibility using Geographical Information System (GIS) Analysis

1.4 Study Area

The study area is located between N 04° 52’00”, N 04° 49’30”, E 101° 59’00” and E 102° 02’00” which covered 25 km^2 (5km x 5km). In the study area, it is covered with the rubber estate and it is a rural area undergo development surrounded with Chinese citizens. Figure 1.1 had shown the base map of study area which show the river, railway, main road and the plantation.

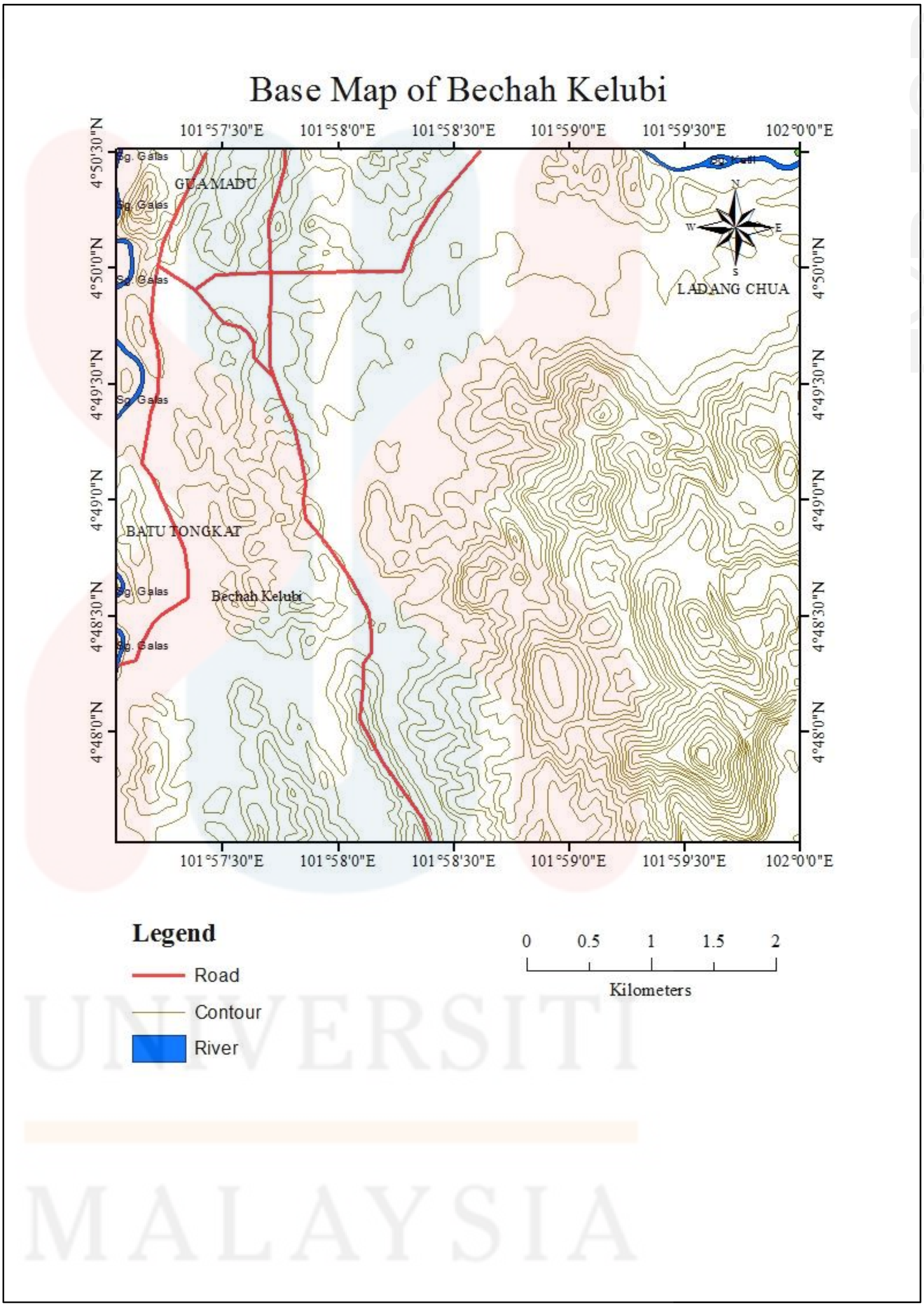


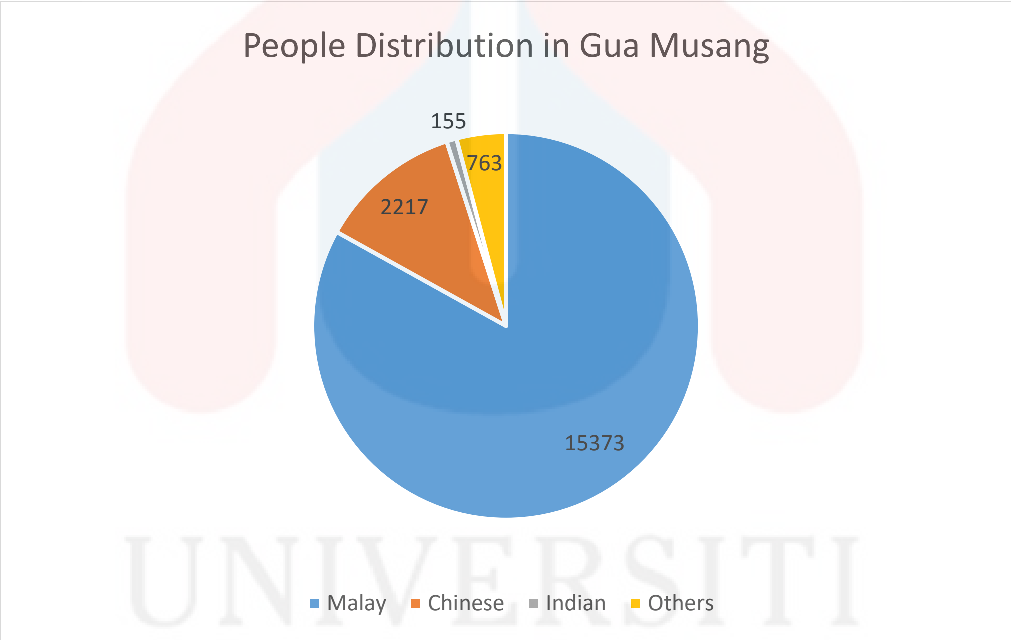
Figure 1.1 Base map of Bechah Kelubi, Gua Musang, Kelantan

(Source: ArcGIS Shapefile Data)

1.5 Geography

a) People Distribution

Total population in Gua Musang district are 18420 people including Malay, Chinese, Indians and others residential. Each population is estimated as 15373 people are Malay, 2217 people are Chinese, 763 people are others and 155 are Indians residential. The highest population in Gua Musang is dominated by Malay residential. The chart below (Figure 1.3) shows the statistic of people distribution in Gua Musang.



Source: Department of Statistic of Malaysia, 2010

Figure 1.2 People distribution of Gua Musang

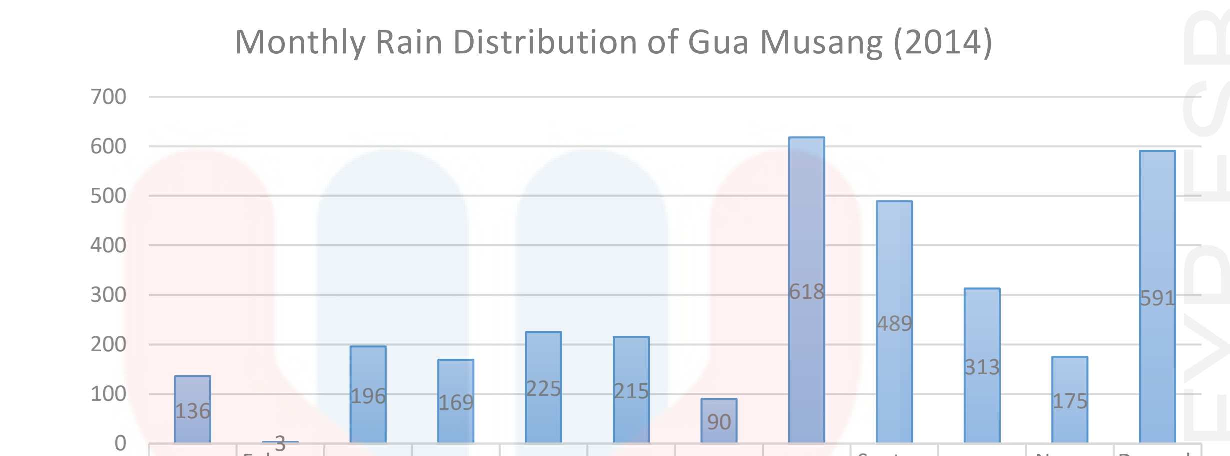
b) Rain Distribution

Rainfall in Gua Musang area is mainly affected by climate and wind velocity. Table 1.1 show the monthly rain distribution in 2014. The most humid month in 2014 is during August which can be considered as rainy season. In February, the maximum rain collected is 3.0 mm, and it show the least rain collection of the year in 2014. The total precipitation in 2014 is 3220.0 mm.

Table 1.1: Monthly rain distribution of 2014

Average Monthly Precipitation in 2014	
Months	Maximum Rain (mm)
January	136.0
February	3.0
March	196.0
April	169.0
May	225.0
June	215.0
July	90.0
August	618.0
September	489.0
October	313.0
November	175.0
December	591.0
Total	**3220.0**

Source: Department of Irrigation and Drainage, 2014



	January	February	March	April	May	June	July	August	September	October	November	December
Series1	136	3	196	169	225	215	90	618	489	313	175	591

Figure 1.3 Graph of rain distribution in Gua Musang (2014)

c) Landuse

Landuse in study area is mostly covered by vegetation. Some portion of the land which is 50 percent of land in study area is used for estate such as rubber estate and palm oil plantation. However, the villagers in the study area is actively in farming, therefore, some part of the land is used for mix farming. The remain land is covered by unpreserved forest and wild vegetation. Some part of the empty land is the left behind of previous mining activity.

d) Social Economic

In this study area, the main economic for residents is industrial aspect which is plantation. The economic is supported by government or private works within the area.

e) Road Connection

Study area is an accessible area which located within the Gua Musang town. The road connection in Bechah Kelubi, for instant is mostly a tar road in moderate maintenance. The road in village area is not in well condition, which is more in the rubber estate plantation. The road is not well maintained and need to get repair in order to access into the study area location.

1.6 Scope of Study

The main scope of the study is to determine the possibility of the limestone geohazard in study area by using the application of Geographical Information System (GIS). The information will be collected by conducting the geological mapping in the study area. The method of application is using the data of satellite imagery SPOT 5 and ArcGIS 10.2 software to create and update the map of study area.

The karst landscape is formed due to the dissolving of limestone and the physical contact with the surrounding. Karst topography had precipitate the calcium carbonate and it will dissolve to build the concentration in the water to produce stalactites and stalagmites.

1.7 Research Importance

The information gathered and the updated data from geological mapping of the area is used for future reference as an alternative of geological map. The map with scale of 1:25,000 may give more details. The geological map from previous map had been reviewed and it is only stated the previous landmark such as drainage pattern and land use. The previous unseen lithology is needed to be update in the study area for further review. The digitization of previous map can be referred in Figure 1.1.

Using the Geographical Information System software can help to provide the detailed map by converting the 3D model of georeference to identify the geohazard potential of limestone. As the map will be published, it is very useful for the future references and guideline to the developers.

1.8 Summary

This chapter had explained about introduction of the research area, problem statement of research study and the objectives of the research. The location of the study area also had been included in digitized base map as shown in Figure 1.1. Besides, the geography of study area such as land use, rain distribution also had been explained for this research.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is discussed about the geological review of limestone and karstic features, the characteristic of potential limestone geological hazard, Geographical Information System and its application on potential limestone geological hazard.

2.2 Geological Review

Gua Musang, Kelantan is composed of marine sedimentation which known as Gua Musang – Semantan depocenter in the central belt**.** Gua Musang – Semantan is developed in age of Upper Paleozoic and known as very extensive area within the Gua Musang itself. The example of occurrence that had been found are tuff, associated lava, conglomerate and tuffaceous siliciclastic (Lee Chai Peng, 2009).

However, at the deeper part of the Gua Musang – Semantan depocenter area had a very thick of accumulated turbidites which also known as flysch. The Gua Musang formation is developed in age of Middle Permian to Upper Triassic. The formation is made up of crystalline limestone, interbedded with thin beds of shale, tuff, chert nodules, and subordinate sandstone and volcanic. This thickness of the beds in Gua Musang formation is approximately 650 thick (Lee Chai Peng, 2009).

On the other hand, the southern part of Gua Musang to Merapoh area had found extensive limestone and bulk sequence. The thin bedded with laminated and fissile shale is found, which commonly greyish in colour. The argillaceous sandstone, with grains size of very fine to medium fine and angular quartz. The existence of previous creature also can be determined where the identification by fossil occurrence (Lee Chai Peng, 2009).

2.3 Limestone

According to Ronov, limestone is dominant during the age of Mesozoic and Cenozoic which it had the past life forms of fossils record (Ronov, 1983). Limestone has the considerable economic condition because it can act as a reservoir of rocks for petroleum reserve. It also can be the host of ore deposits such as epigenetic leads and zinc deposits (Sam Boggs, 2009).

2.3.1 Components of Limestone

Carbonate rock such as limestone is classified into several major components which are carbonate grains, microcrystalline carbonate and sparry calcite. The terminology of carbonate grains are peloids, coated grains, grain aggregates, clasts and skeletal grains. The coated grains had subdivided into cortoids, oncoids, ooids and pisoids.

Microcrystalline carbonate rock is also known as mud limestone or lime mud. The texture of lime mud contained is analogous to clay size matrix which is in siliciclastic sedimentary rocks. Lime mud is mainly composed of aragonite needle which about in length of 1 to 5 microns. In Folk's classification, the contraction for microcrystalline calcite is called as micrite, which may indicates the signification of very fine grain of carbonate sediments. The characteridtc of micrtie is grayish to brownish and found as subtranslucent appearance under microscope. Some of limestone may composed of micrite, which is typically occurred as matrix in the carbonate grains. There are two type of micrite which are seafloor micrite and internal micrite. Seafloor micrite is deposited at the sediments-water interface, whereas internal micrite is accumulated inside cavities and intergranular pores (Neumann, 1975).

According to Neumann, they had interpreted the lime mud contribution processes that need certain mechanism of fine carbonate sediment which include the disintegration of hard part invertebrates, breakdown of skeletal grains, boring of carbonate grains by fungi, algae and invertebrate, the physical abrasion of larger particle and the production of micrite size skeletal test by microorganism and nano-organisms (Neumann, 1975).

In limestone, the other major constituent, instead of carbonate grains and micrite, it also contains sparry calcite. Sparry calcite is a large crystal compared to micrite, with size of 0.02 to 0.1 millimetre, and it appeared clear or white in plane light under the polarizing microscope. Sparry calcite is commonly cemented among the carbonate grains of the limestone such as oolites, which deposited in in agitated water to prevent the micrite from filling the pore spaces. Sparry calcite also may form in varies of cementation fabrics which are commonly in type of granular or mosaic cement, bladed cement and syntaxial cement. Sparry calcite in limestone is cemented by precipitation into the pore cavity. For instant, the sparry calcite which is referred as neospar may originate through the recrystallization of micrite or carbonate grains (Neumann, 1975).

2.3.2 Classification of Carbonate Rocks

Carbonate rock is classified into two major classifications which are Folk's classification and Dunham's classification. The Folk's classification is useful in primary thin section analysis and not suitable in field classification. Folk's classification is required abundance of carbonate grains, micrite and sparry calcite cement. In the other hand, Dunham's classification is based on the depositional textures which consists of the grain packing and abundance of carbonate grains relative to micrites and depositional binding of grains.

2.3.2.1 Folk's Classification

The Folk's classification of carbonate rocks is only applicable for thin section analysis. The Folk's classification is not suitable to be conducted in the field. The understanding of Folk's classification is used in abundance of carbonate grains and the relative abundance of micrite and sparry calcite cement in the carbonate rocks. This classification can be simplified as shown in the Table 2.1 (Sam Boggs, 2009).

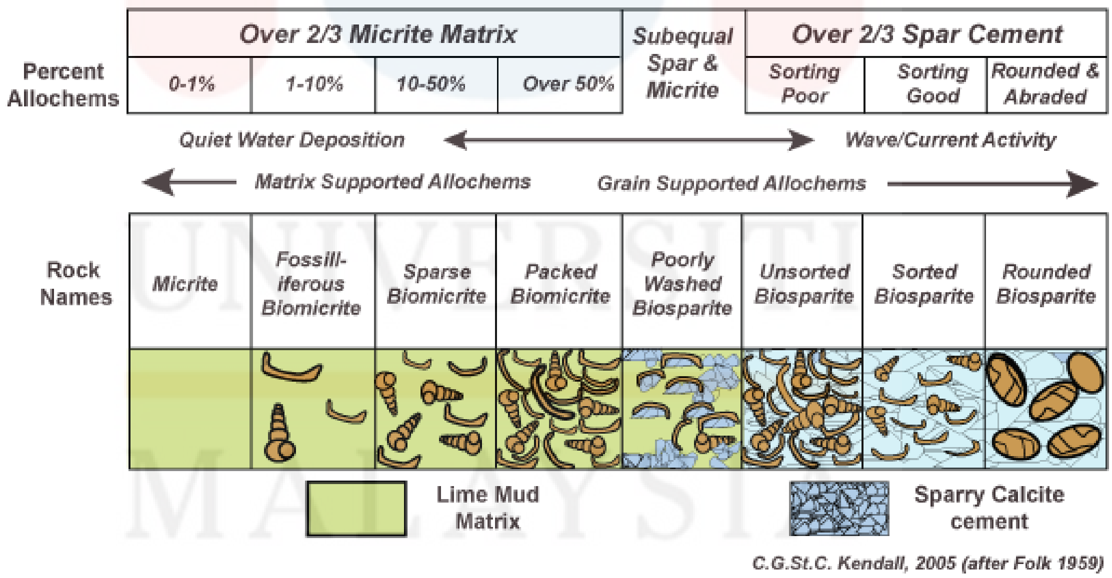


Table 2.1 Folk's classification of carbonate rocks

2.3.2.2 Dunham's Classification

Dunham classification is another apporach to classify the carbonate rocks. Dunham stated the classification of carbonate rocks is focusing on the depositional limestone textures rather than to identity the specific kind of carbonate grains. Dunham had considered in two aspects upon the texture which are (1) the grain packing and relative abundance of grains and micrite and (2) the depositonal binding of grains (Sam Boggs, 2009).

This classification is used to determine the original compostion of limestone either it can or cannot be bounded during the time of deposition. For instance, the components which does not bounded together during the depostion is classified into lime mud or lack mud. This type of rock is either can be mud supported or grain supported. In order to determine the type of fabric support, the fabric is visualized under the microscope which can be appeared in three dimenion (3D) or two dimension (2D) of thin section plane. The Table 2.2 is the simplified of Dunham's classification accordign to its grain size (Sam Boggs, 2009).

<table>
<tr><td colspan="6">Allochthonous Limestone
Original components not organically bound during deposition</td><td colspan="3">Autochthonous Limestone
Original components organically bound during deposition</td></tr>
<tr><td colspan="4">Less than 10% >2 mm components</td><td colspan="2">Greater than 10% >2 mm components</td><td rowspan="4">By organisms that build a rigid framework</td><td rowspan="4">By organisms that encrust and bind</td><td rowspan="4">By organisms that act as baffles</td></tr>
<tr><td colspan="3">Contains lime mud (<0.03 mm)</td><td>No lime mud</td><td rowspan="4">Matrix-supported</td><td rowspan="4">Supported by grain components coarser than 2 mm</td></tr>
<tr><td colspan="2">Mud-supported</td><td colspan="2" rowspan="3">Grain-supported</td></tr>
<tr><td rowspan="2">Less than 10% grains (>0.03 mm <2 mm)</td><td rowspan="2">Greater than 10% grains</td></tr>
<tr><td colspan="3">Boundstone</td></tr>
<tr><td>Mudstone</td><td>Wackestone</td><td>Packstone</td><td>Grainstone</td><td>Floatstone</td><td>Rudstone</td><td>Framestone</td><td>Bindstone</td><td>Bafflestone</td></tr>
</table>

Table 2.2 Dunham's classification of carbonate rocks

2.4 Geographic Information System

Geographic Information System or GIS is a computer system which designed to store, capture, retrieve, manage, display and analyse all types of geographic and spatial data. GIS software has the capabilities to visualize the spatial data or analyse the geographic data. Features in GIS can be classified into points, lines or raster images. For instance, the city data and road data can be stored as points or lines, whereas the raster image is stored as a scanned map from the aerial photo (Tarum Kumar Raghuvanshi, Lensa Negassa, P.M. Kala, 2015).

GIS software has its own specification to analyse the geographic data or spatial data. Geographic analysis tools is used to analyse the geographic components of data. The visualization of GIS software in imagery and database may enhance the result of analysis. For example, the imagery data is visualized the imagery layer which captured using the aerial photo. The image server also support the Google Earth map services, which can be used as basemap in the GIS software (Tarum Kumar Raghuvanshi, Lensa Negassa, P.M. Kala, 2015).

The database is used to modify the tools include the ability to add or delete the records, filtered the records, apply the look-up table coding and define the field header balloon pop-up text. Database in GIS software can be aggregate or non-aggregate as one-to-one, one-to-many or many-to-one joins. Topological layers such as points or lines in editing tools are able to be used in digitizing, merge or split the features, add or delete the features, clipping or masking the geography by region and undo or redo the edits. Apart from that, there are comprehensive projection, datum, and coordinate system to support the import or export the map (Tarum Kumar Raghuvanshi, Lensa Negassa, P.M. Kala, 2015).

2.4.1 GIS Analysis

GIS software can be used to analyse the measurement, layer statistic, queries, buffering, filtering, map overlays, transformation and reclassification. These features are important in order to do the analysis of geographic data. Several types of analysis in GIS software are such as the network analysis, spatial interpolation, grid analysis, surface analysis and analytic modelling (M. Ghafoori, 2006).

GIS analysis is used in the spatial and non-spatial attribute data that may lead to high quality of information in the context of complete analysis strategy (M. Ghafoori, 2006).

2.5 Landslide Susceptibility

Landslide is a hazard where the condition of the past landslide within the area is reoccurred that may cause another landslide nearby the previous landslide. The previous study for landslide hazard is evaluated using several causative factors that may include lithology, soil mass, slope, elevation, aspect and landuse. Landslide hazard zonation is derived according to the causative factor class where each of the class then combined using overlay method in GIS software to produce the landslide susceptibility map. This map is used to determine the potential of landslide within the area (Tilahun Hamza, 2016).

The method used is utilizing the weightage of each classes which calculated by weightage overlay. Calculation of the causative factors is considered as the potential of landslide to occur by using the raster calculator in ArcGIS. Furthermore, the analysis between causative factors will correlate where the potential landslide to occur. The raster map is produced in order to proceed with the normalization of maximum values to get the hazard index (Tilahun Hamza, 2016).

On the other hand, the interpretation of landslide is conducted by understanding the mechanism and conditions of landslide in the area. The physical factors that need to consider are bedrocks, slope steepness and past history of the hazard condition. These factors are important to get the indication for the potential landslide. Other consideration such as the vegetation, slope orientation and the precipitation zone is indirectly may enhance the potential of landslide to occur (M. Ghafoori, 2006)

CHAPTER 3

METHOD AND METHODOLOGY

3.1 Introduction

This chapter discuss on the process and methods on conducting the research. This research progress were including preliminary study, literature review, mapping, sampling, data collection and identification of potential hazard within the study area, laboratory work, data interpretion and discussion and lastly thesis submission. The flow of research is shown in Figure 3.1. The field information is gathered, whereas the petrography analysis and structural analysis were conducted.

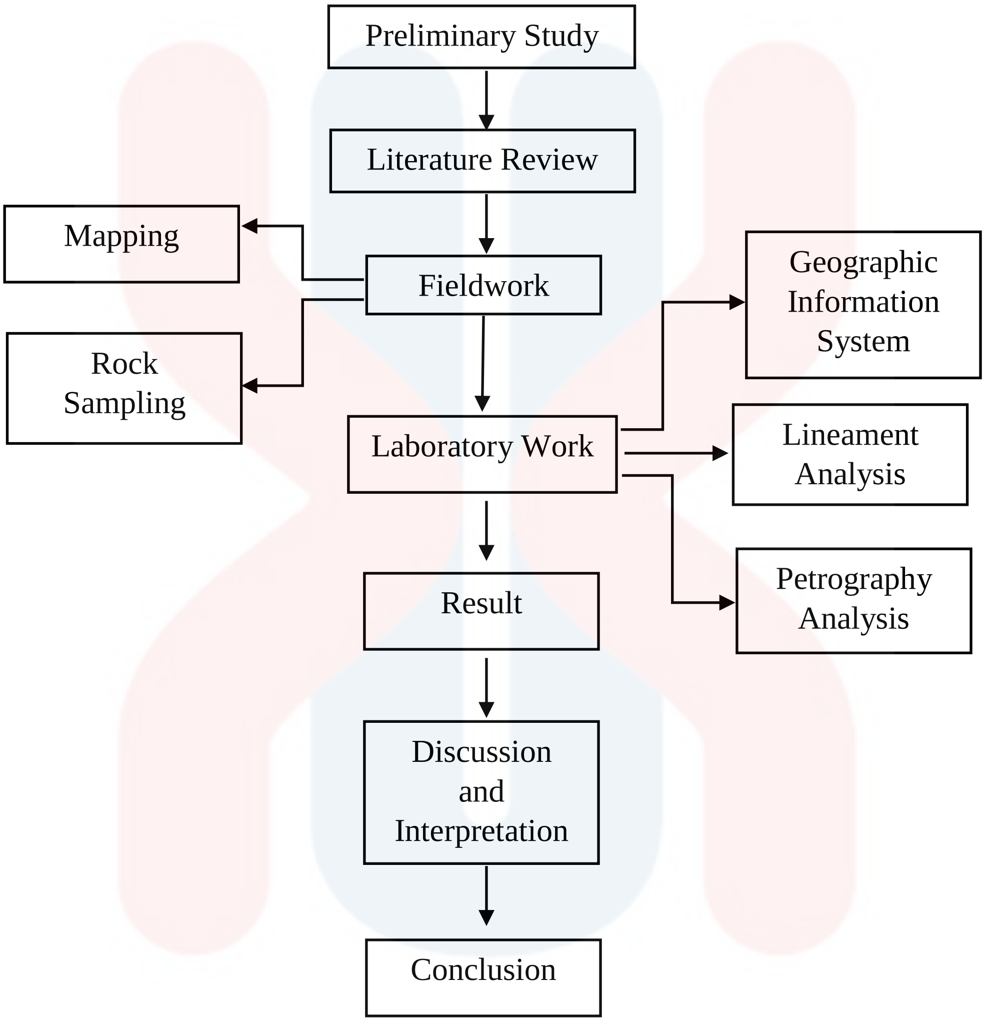


Figure 3.1 Research flowchart

3.2 Materials

Equipments used for the research purpose were divided into 2 parts which consist of fieldwork and software. Fieldwork equipment is consist of geological hammer, brunton compass, Geological Positioning System (GPS), hydrochloric acid (HCl), hand specimen plastic bag and hand lens. Whereas for the software part, ArcGIS version 10.2 is used to digitize the map of study area and supported with the data of satellite imagery SPOT 5. The satellite imagery will provide the information and facilitated the process of field investigation especially monitoring the potential of rock falls and identifying the karstic features across the landscape of Gua Musang in Bechah Kelubi area. The information of the karstic feature will be updated in the map as it can be published for reference for the developers in Gua Musang. The other used of software in research is rose diagram. Rose diagram is used to identify the internal forces from the movement of tectonic activity. The data needs for the software is structural features such as joints or fractures of the structure.

The collected data from the field such as joint or fracture was used for structural analysis. The analysis is important to identify the physical features of the structure which is to determine the forces applied to the structures. The Geographical Information System had several parameters needed to produce the layout of the geological hazard map. These indicators are consists of lithology, landuse data, rain distribution data, slope stability and topography.

3.3 Methodology

3.3.1 Fieldwork Equipment

Field equipment (Figure 3.2) are including Brunton compass, Hydrochloric acid solution (HCl), Geological hammer, hand lens, sample bag and safety goggle.

(a) (b) (c)

(d) (e) (f)

Figure 3.2: Fieldwork equipment. (a) Brunton Compass (b) Hydrochloric Acid Solution (c) Geological Hammer (d) Hand Lens (e) Sample Bag (f) Safety goggle

3.3.2 Laboratory Equipment or Software

For laboratory equipments, the thin section machines were used to produce the thin section from rock samples as well the microscope will be used for thin section observation. Besides, software such as ArcGIS 10.2 and SPOT 5 data were provided from the laboratory. Apart from that, for analysis software is consist of Georose software which was used for structural analysis. ArcGIS was used to identify the lineament form the satellite imagery.

(a) (b)

Figure 3.3: Laboratory equipment/software. (a) ArcGIS Software (b) Microscope

3.3.3 Data Inventory

Data inventory is the data of topographical sheet, field data, shapefile data and statistic data which collected from different sources.

Table 3.1: Data Inventories

No	Type of Data	Data Description	Source
1.	Topographical Sheet	Merapuh Map. Series L7030, Edition 1-PPNM, Sheet 3863	Department of Survey and Mapping Malaysia (JUPEM)
2.	Field Data	Strike and dip of structures such as joint, fracture or fault)	Study Area of Bechah Kelubi
3.	Shapefile Data	Contour, river. road	GIS shapefile data
4.	Statistic Data	Rainfall distribution	Department of Irrigation and Drainage

3.4 Field Study

Research study is divided into 2 part which are geological mapping and the specification study, which specified in Geographical Information System (GIS) by using its software.

Geological mapping was done in study area to collect the new data and review the previous map for updates. Geological mapping was done by traversing throughout the study area. Fieldwork was conducted to identify the type of lithologies and the changes in drainage system in study area. The dip and strike data were collected for fracture analysis and joint analysis occured in the study area. The traverse routes throughout the study area are tracked by using the GPS.

After mapping was done, the information is gathered and the routes tracked by the GPS was transferred into the ArcGIS 10.2 software to allocate the potential of geohazard into the map.

3.5 Laboratory Investigation

Laboratory investigation is commonly a process of laboratory work where thin section is taken part in the laboratory. However, the geological map of study area was updated by using the software of ArcGIS.

3.5.1 Thin Section Preparation

Thin section is one of a process to obtain for petrography analysis. The rock samples were included in a vacuum in polyster resin. As the resin polymerised, it will harden the compact blocks and conserve the structure without alteration. Main steps of thin section preparation are including:

i. Preparing sample

   The commercial resin is used to fix the sample. Firstly, the sample need to be dry with freeze drying.

ii. Cutting

   A suitable size slab is used for mounting on the slide which is cut from a piece of rock or drill core with a diamond saw.

iii. Polishing

   Section is placed in a holder and spin into a polishing machine using nylon cloth and diamond paste until a suitable polish is achieved under microscope observation.

iv. Final Cutting

   Final cutting is done either the remaining of the slide is needed to be cut or extra polish.

3.5.2 Updating Geological Map

Geological map of study area was updated for several purposes such as development planning, environmental assessment or landuse. Information of geological map is important to ensure the study area can be a strategic development site in the future.

3.5.3 GIS Data Development

GIS data is important as it will give an accurate data. Several ways to interpret the spatial data into GIS. However, there are several factors that will lead to difference of projection. Global Positioning System (GPS) is needed to gather the accurate linear and point location data. GPS is a rapid and accurate method for data collection as it can record the traversing information in study area. Digitizing also one of a method to derived the database into an initial digital image. Image processing had a process which called as supervised classification which user can use a sampling pixel to identify the type of vegetation or landuse.

3.6 Analyses and Interpretation

Analysis and interpretation will be conducted as the data and information is gathered from fieldwork. In this research, data analysis and interpretation including petrography analysis, structural analysis and GIS analysis. The raw data of strike and dip or rock samples are needed to proceed with structural analyses.

3.6.1 Petrography Analysis

Petrography analysis is an essential tool to evaluate or determine the minerals contain, rock's texture and characteristic inside the rocks. Petrographic analysis is an examination of microstructural of rock by optical microscope.

3.6.2 Kinematic Analysis

In structural geology analysis, it is used to measure the rock geometries to uncover the information of deformation in rocks. Structural geology data is usually collected in measurement of joints, fractures, fault plane, or bedding plane. These data collected will be analysed using the software of georose or rose diagram to determine the forces act upon the structure.

3.6.3 GIS Analysis

Geographic Information System (GIS) analysis is a process to create and export the updated information in study area. The GIS analysis can interpret the data in study area into a 2D or 3D model. Besides, in this analysis, the process of producing the potential of landslide susceptibility of limestone map also can be used.

3.7 Report Writing and Thesis Submission

In this part, all the chapters in the thesis from chapter 1 until chapter 6 were written and submitted to the University to fulfill the requirement of the University.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

Study area is located in Bechah Kelubi, Gua Musang where it is accessible by traversing and transportation by main road. Study area is mainly covered with rubber estate. Other than that, the study area also covered by forest and there is one part of the landuse is mining area. The landuse map is shown in Figure 4.1.

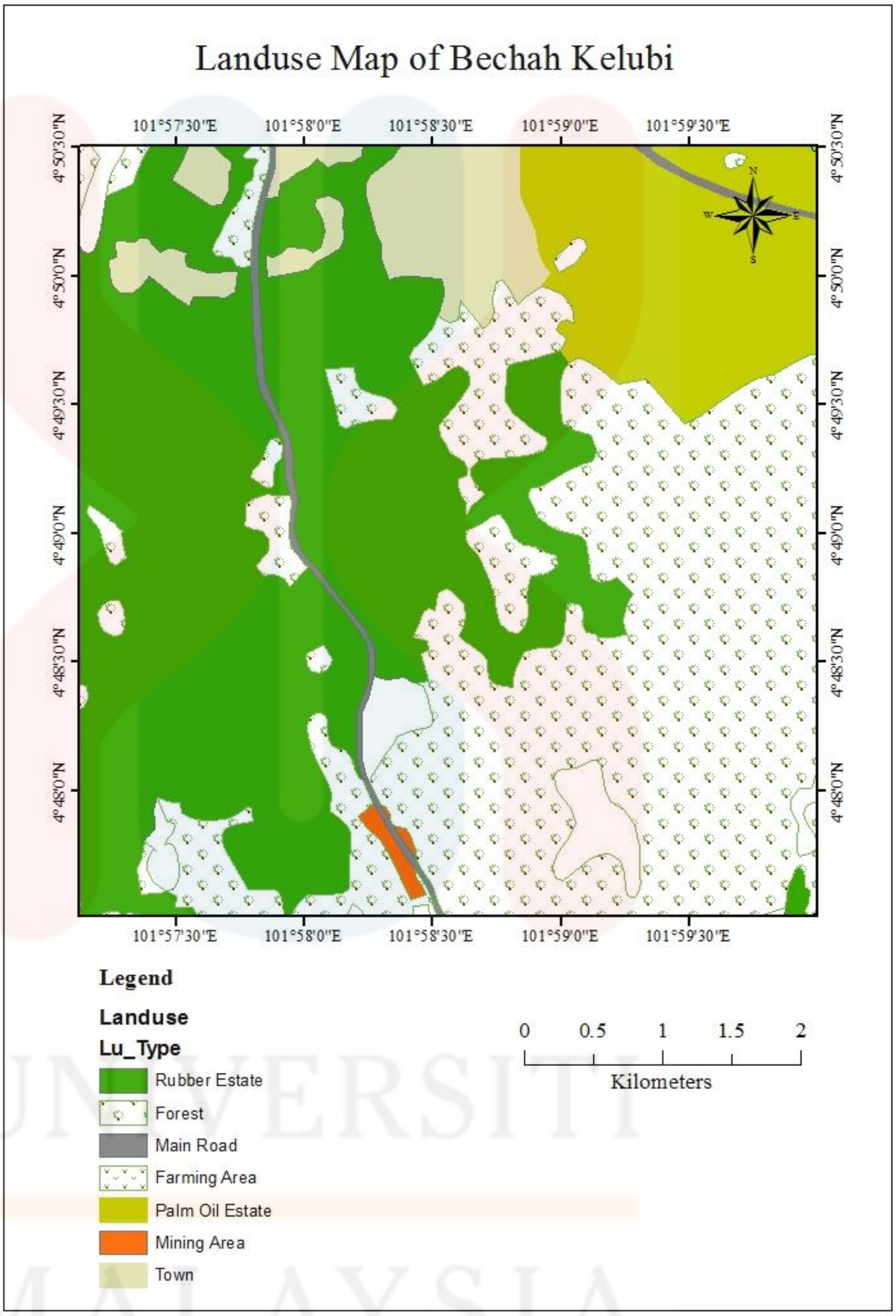


Figure 4.1: Landuse map of Bechah Kelubi

(Source: ArcGIS Shapefile Data)

4.2 Geomorphology

Geomorphology is defined as the study of the Earth's physical land surface features, such as rivers, hills, plains, beaches, sand dunes and others. In geomorphology, it is investigated the landforms and processes. The interrelation between the understanding of origin and development of landforms which consists of three facets, the constitution, configuration and mass flow and the dynamic variable of geomorphic processes.

4.2.1 Denudation Process

Denudation processes had occurred in the study area, which include mechanical weathering, biological weathering and chemical weathering. Physical weathering that occurred in the outcrop, especially in limestone can be clearly seen. Karstic features have mostly occurred in the caves or tower karst.

4.2.2 Drainage Pattern

Drainage pattern is a topographical feature where the runoff of stream or groundwater flow that can be classified as topographic barriers called watershed. Drainage pattern is controlled by the topography, slope, structural control, nature of rock and the geological history of the region. The drainage pattern are consist of dendritic, parallel, trellis, rectangular, angular and contorted (Figure 4.2).

However, the drainage pattern in the study area is can be classified as dendritic pattern. The pattern of drainage is shown in Figure 4.3. This may indicate the river had branched in many direction and flow in with the direction of the valley.

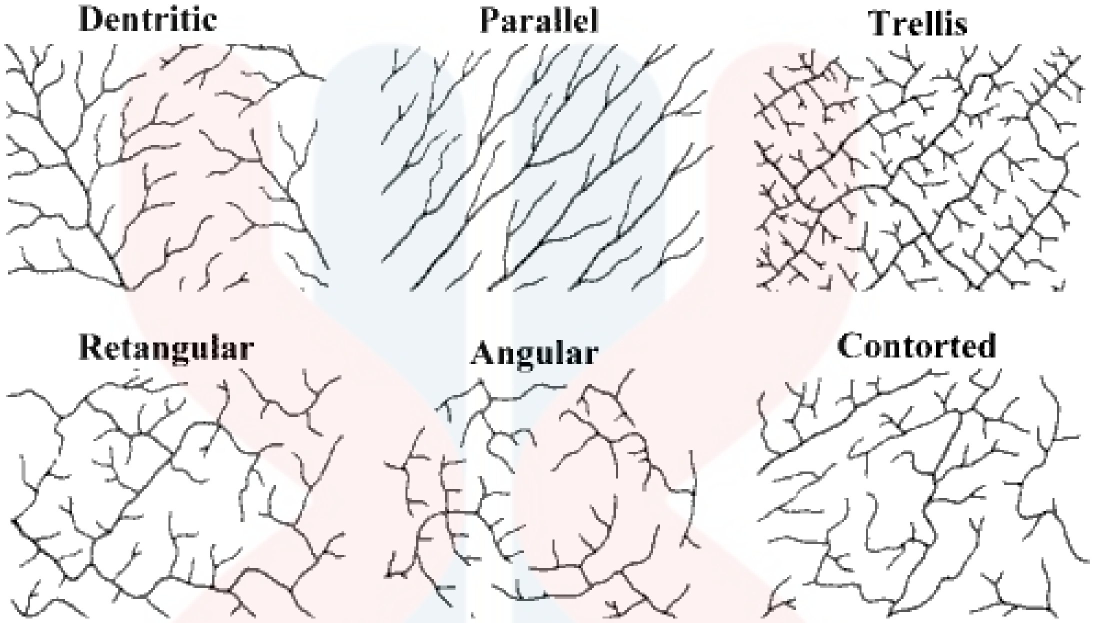


Figure 4.2: Drainage Pattern

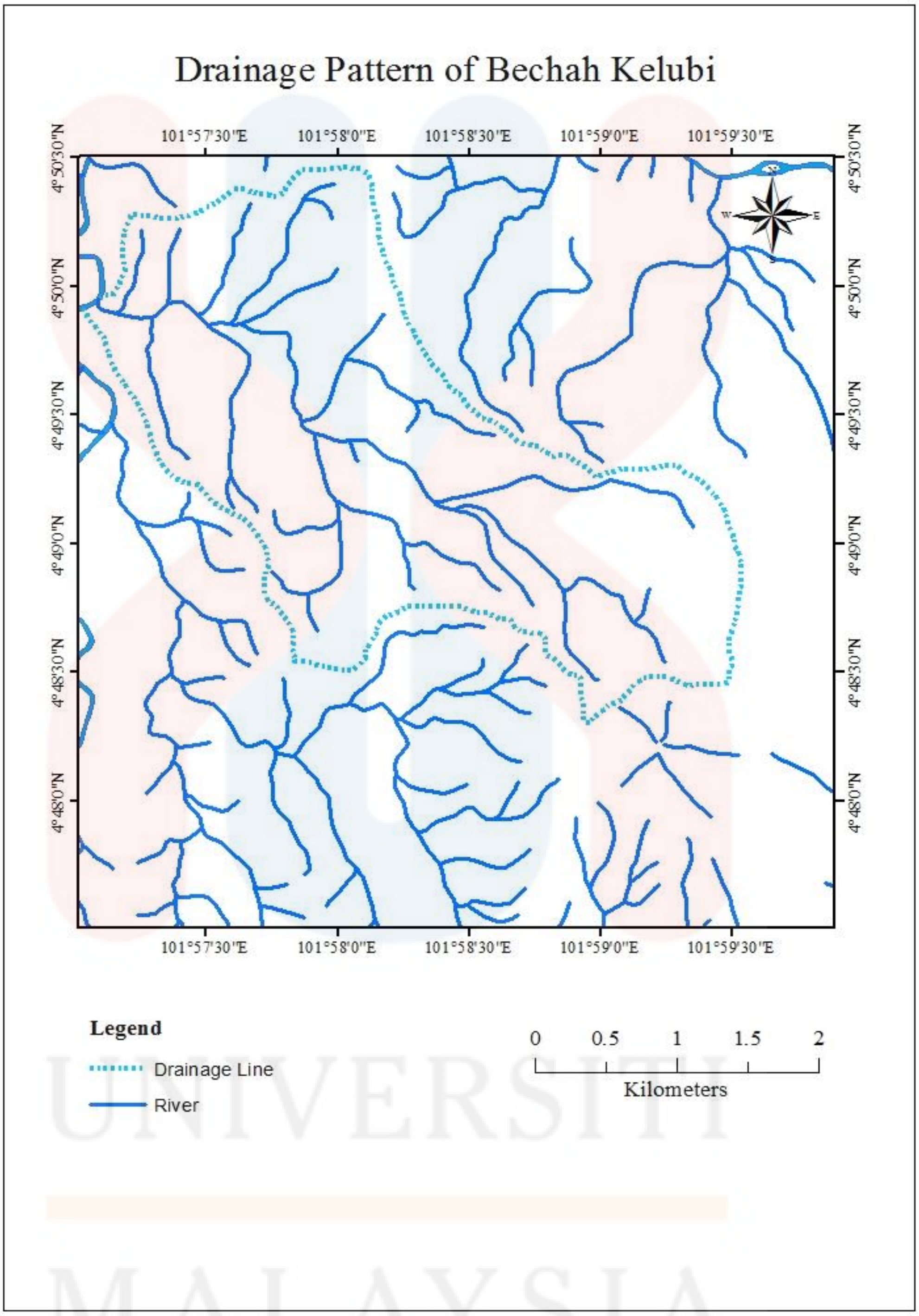


Figure 4.3: Drainage Pattern of Bechah Kelubi

(Source: ArcGIS Shapefile Data)

4.3 Stratigraphy

Stratigraphy in the study area is mainly covered with limestone. However, certain area had found plutonic rocks, metamorphic rock and other sedimentary rocks such as interbedded sandstone with siltstone.

4.3.1 Lithostratigraphy

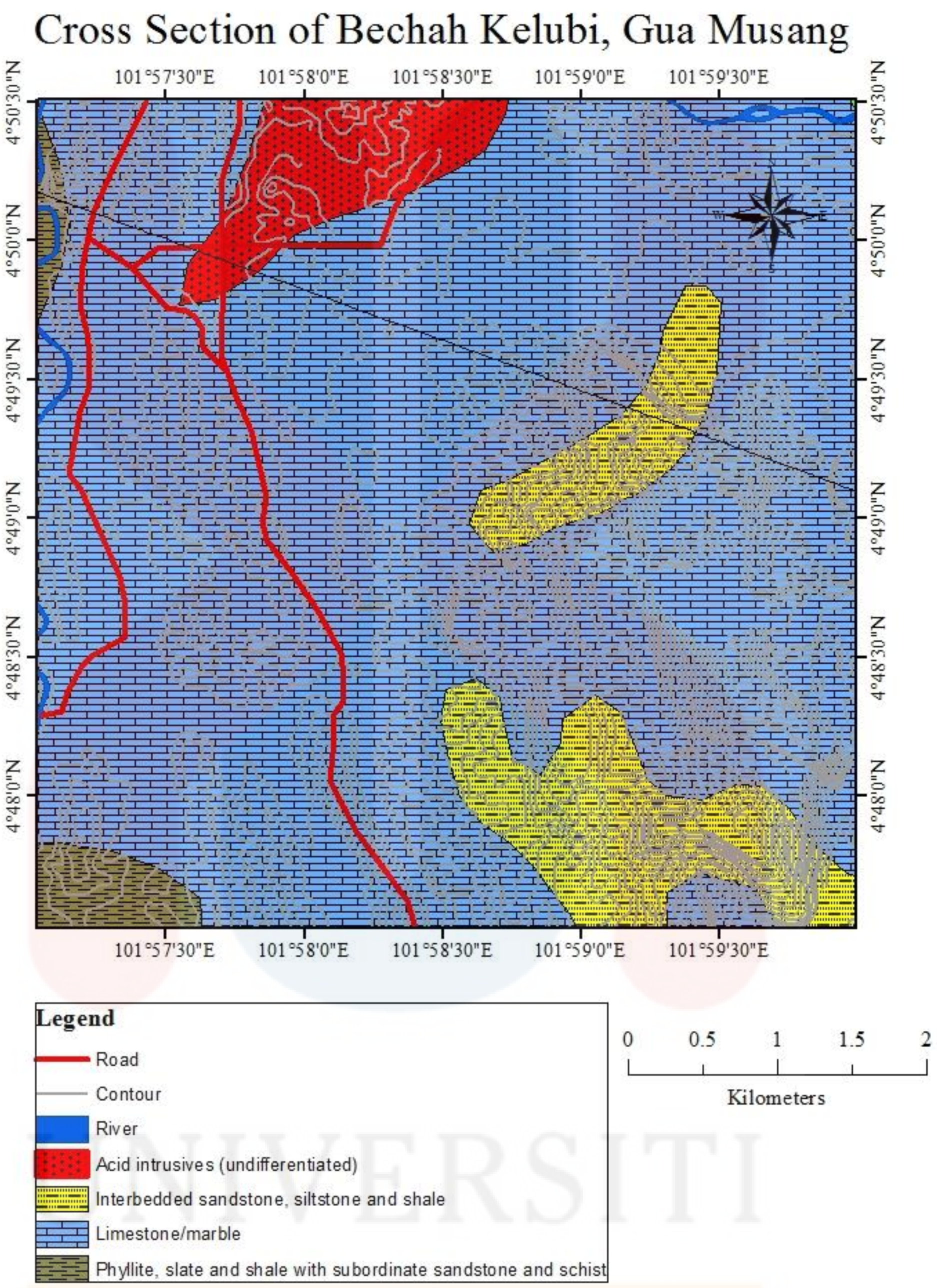
Lithostratigraphy is describe the relationship of the strata with the stratigraphic position according to their age in stratigraphic column. Stratigraphic column is representing the geology and the stratigraphy to describe the vertical location of rock. In Bechah Kelubi, different type of rocks compose of the geological record, including the sedimentary rock and granite and slate.

Bechah Kelubi is included in Gua Musang Formation. Gua Musang Formation is found by Yin (1965) due to its predominant argillaceous and calcareous sequence that intrbedded with volcanic and arenaceous rock in south Kelantan. During the age of middle Permian to middle Triassic, fossil such as ammonoids and pelecypods are found. It is also stated that the formation of Gua Musang is unconformably overlain by the Gua Rabong formation in south of Kelantan (Peng, 1983).

According to Leman (2014), the age of lithostratigraphy in Gua Musang is found in Middle Permian to Upper Triassic. However, the lithology of the study area can be found are such as limestone, interbedded siltstone and sandstone, volcanic rock and granite. The lithostratigraphy column is shown in Table 4.1.

Table 4.1 The lithostratigraphy column of study area

Era	Period	Formation	Lithology	Lithostratigraphy Column	Description
Mesozoic	Triassic	Gua Musang Formation	Granite		Coarse grain with greyish in colour
Paleozoic	Permian		Limestone		Fine crystalline texture, greysih in colour
			Tuff		White in colour
			Slate		Medium grey to dark colour
			Interbedded sandstone, siltstone		Fine grain, with brown to reddish brown in colour



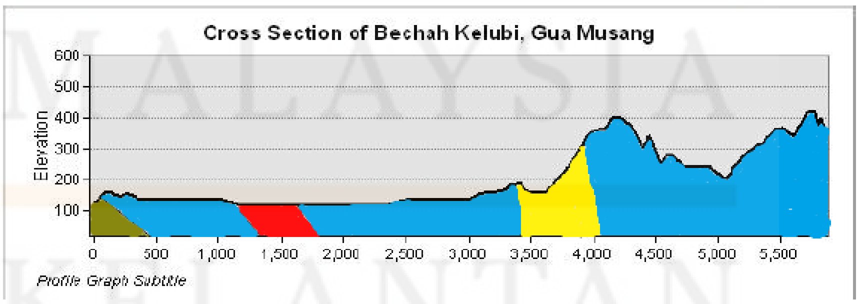


Figure 4.4: Cross section of Bechah Kelubi

4.3.2 Petrography

a) Locality 1

The sample taken is taken at coordinate of N 04 50’ 17.5” E 101 58’ 12.7”, where it is located in industrial area. The locality was an abandoned miming pond.

Based on the hand specimen, granite have a greyish colour and the textures are phaneritic and holocystaline. The minerals can be determined by the naked eyes for example quartz, alkali feldspar, plagioclase and biotite. Granite also have medium grain size.

Under the microscope, the textures of the rock is phaneritic. Minerals are quartz, alkali feldspar, plagioclase and biotite. The rock also have secondary mineral which is sericite. Sericite can be observed inside weathered plagioclase and alkali feldspar. This also can indicate the rock is highly weathered. Plagioclase have a shape of subhedral and the colour under cross polorized is grey. The shape of alkali feldspar also subhedral and the colour also grey under cross polorized. But for plagioclase, sericite change some part of the plagioclase because the colour of sericite is colourful from second order to third order in Michelle Levy Chart. Quartz is anhedral in shape and fill up most of the space in the rock.

Figure 4.5: Structure of granite

Figure 4.6: Outcrop of granite

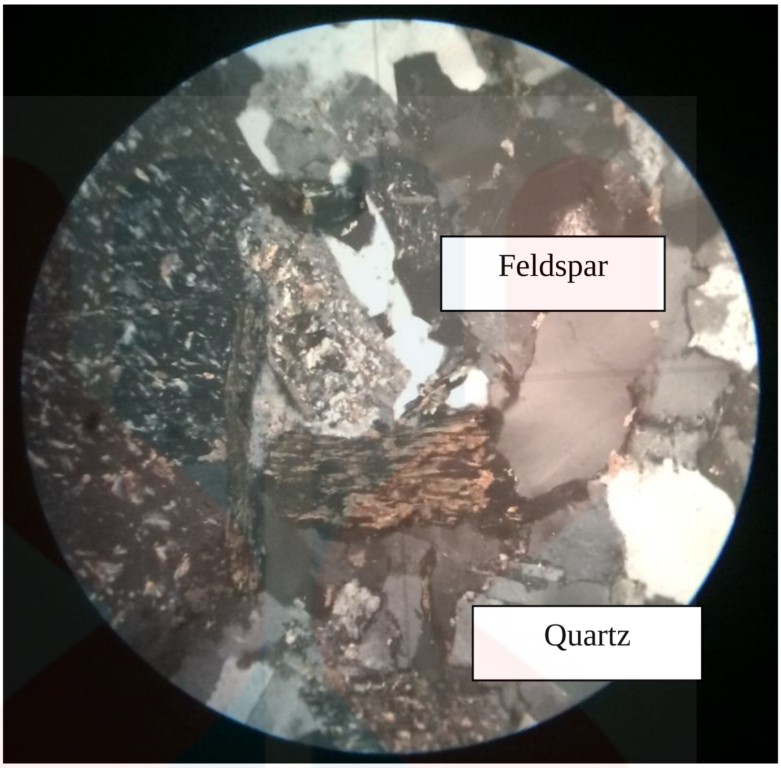


Figure 4.7: Structure granite minerals under microscope

b) Locality 2

The sample of the interbedded sedimentary rock is taken in housing area, which located at coordinate of N 04 48’56.8” E 101 58’02.5”. The outcrop found is spatially weathered. The bedding structure with orientation of 346/68 is determined in this locality.

Based on the hand specimen of sedimentary rock, this rock have a red greyish in colour. This rock is a bit brittle because it is located near the contact between granite and interbedded sedimentary rock. Most of the crack of the granite is filled with iron oxide. This rock is medium grain size and have a phaneritic texture.

Under the microscope, some of the minerals have been recrystallize for example quartz. Alkali feldspar and plagioclase are still the same. But some part of the alkali feldspar and plagioclase are altered by sericite. The matrix of the granite are biotite and sericite. Iron oxide also fill up some of the fracture in the rock.

Figure 4.8: Outcrop of sedimentary rock

Figure 4.9: Structure of pegmatite vein

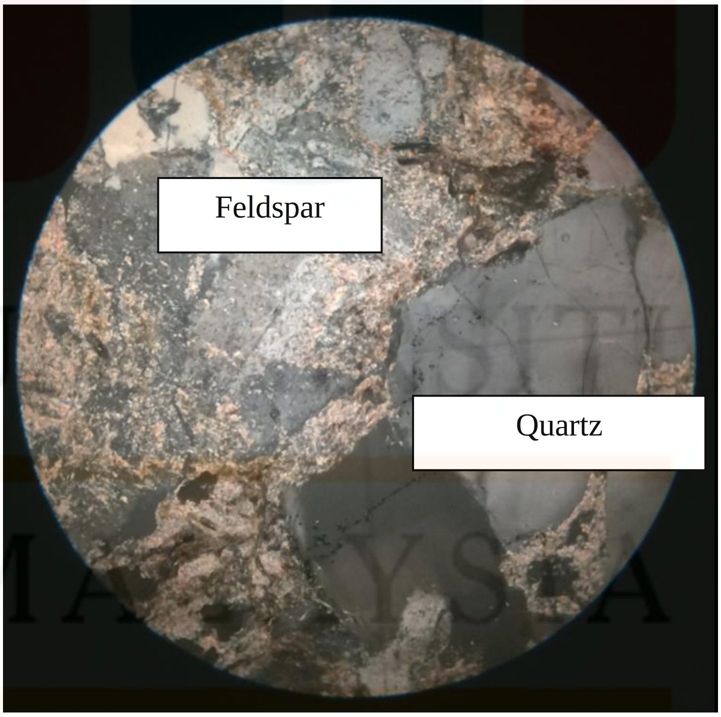


Figure 4.10: Structure of sedimentary rock under microscope

c) Locality 3

Two sample are taken in this locality which located at N 04 49’38.7” E 101 57’29.9 and it is surrounded with residential area. The samples taken are tuff and slate. However, there are weathered intruded rock can be found in the structure. The orientation of anticline folding are 80/34 and 144/29 for both side respectively.

Based on the hand specimen tuff, the rock have a phaneritic texture which is the quartz as a phenocryst and the mass is cannot be seen in a naked. The rock is white in colour (fresh).

Under the microscope, the matrix of the rock cannot be determined. But the phenocryst is consist of quartz. The shape of the quartz also indicate that this rock is the from the explotion of volcanic eruption. The shape of the quartz are subhedral and euhedral. The size of quartz is range from 0.9 mm – 1.2 mm.

Based on the hand specimen slate, the rock have a very fine grain size. The rock also have a weak foliation. The colour of the rock is grey. Under the microscope, the foliation can be seen and minerals are allign together. Mineral are very fine and cannot be determine under microscope.

Figure 4.11: On ground outcrop

Figure 4.12: Intruded rock in sedimentary structure

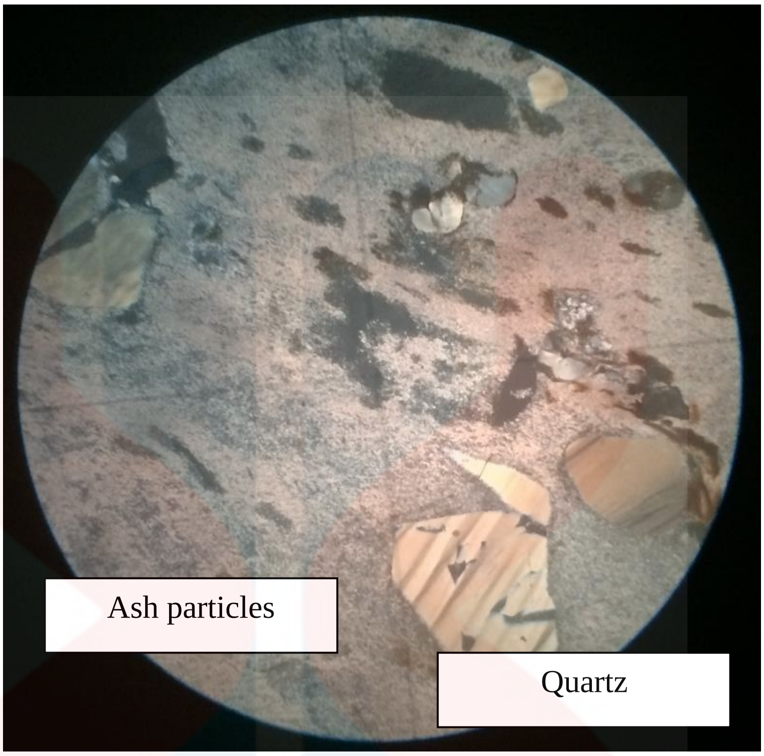


Figure 4.13: Mineral structure of tuff under microscope

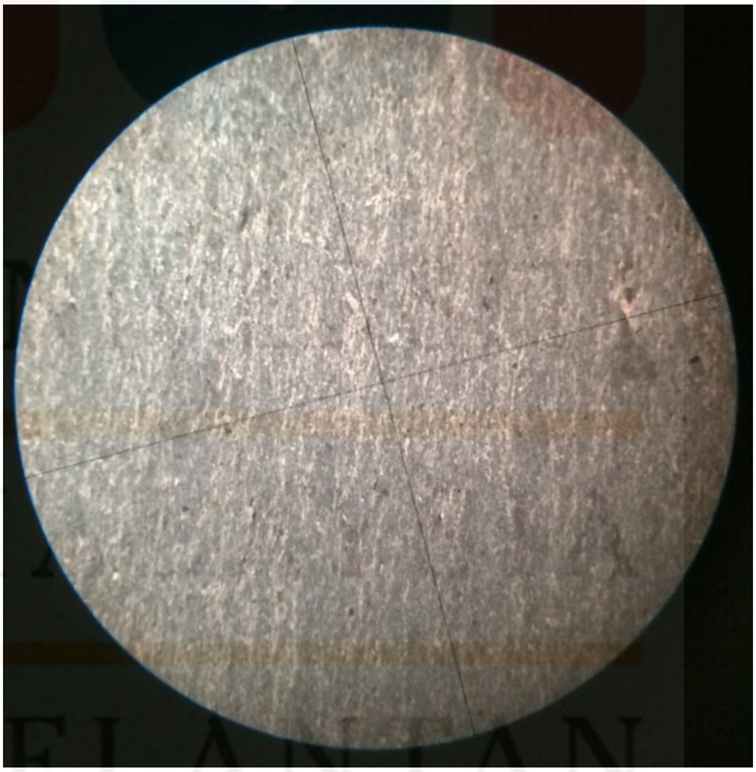


Figure 4.14: Strucutre of slate under microscope

d) Locality 4

The sample of limestone is taken in coordinate of N 04 47’46.3 E 101 57’31.3”, which is surrounded with rubber estate area. The sample is tested with hydrochloric acid, which it is reacted vigorously.

On the hand specimen, the limestone is greyish in colour. The grain size is very fine and cannot determined by the naked eyes. Limestone also have impurity of black in colur inside the rock. Based on under the microscope, most of the minerals are calcite with minor iron oxide (black line in thin section). Almost all calcite have been recrystallize making the shape of the calcite a bit subhedral and have angle between the edge of calcite.

Figure 4.15: Outcrop of limestone

Figure 4.16: Structure of joint on limestone

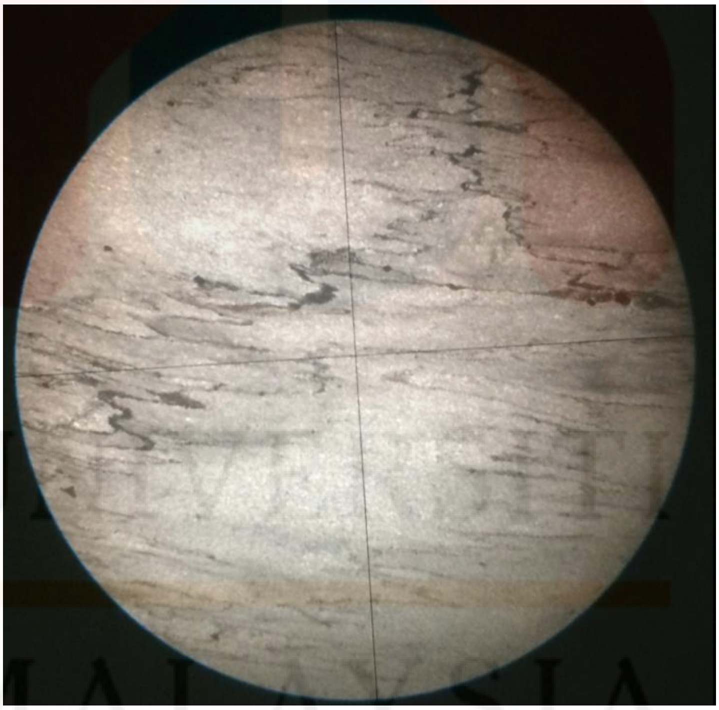


Figure 4.17: Limestone under microscope with lense of 10x

4.4 Structural Geology

In structural geology, the deformation process of rock can be studied. Deformation is the changes in shape of rock mass. The geological structure is classified into primary structure and secondary structure. Primary structure is produce during the formation of rock body such as depositional contact, unconformable contact, cross bedding or vesicle in basalt, whereas the secondary structure is produced after the rock body that affected. For example, the fault contact, folds, joints or shear fracture and tectonite fabric.

4.4.1 Lineament Analysis

Lineament is a linear feature that underlying geological structure, for example fault. The combination of these lineaments will contribute to fracture zones, shear zone or igneous intrusion. Lineaments are mapable at scale of 1:25,000 or in smaller scales, which is simple or composite linear of the surface (O' Leary, 1978).

4.4.2 Joint Analysis

Joint analysis is used to identify the orientation of tectonic stress. The significance of the joint analysis is the determination of the geologic hazard, such as shear fracture. Strike and dip are the measurement taken for joint orientation.

The joint analysis in the figures had shown the forces that acted upon the structure or outcrop. The higher the value of strike and dip, then it may show the massive force is acting on the structure.

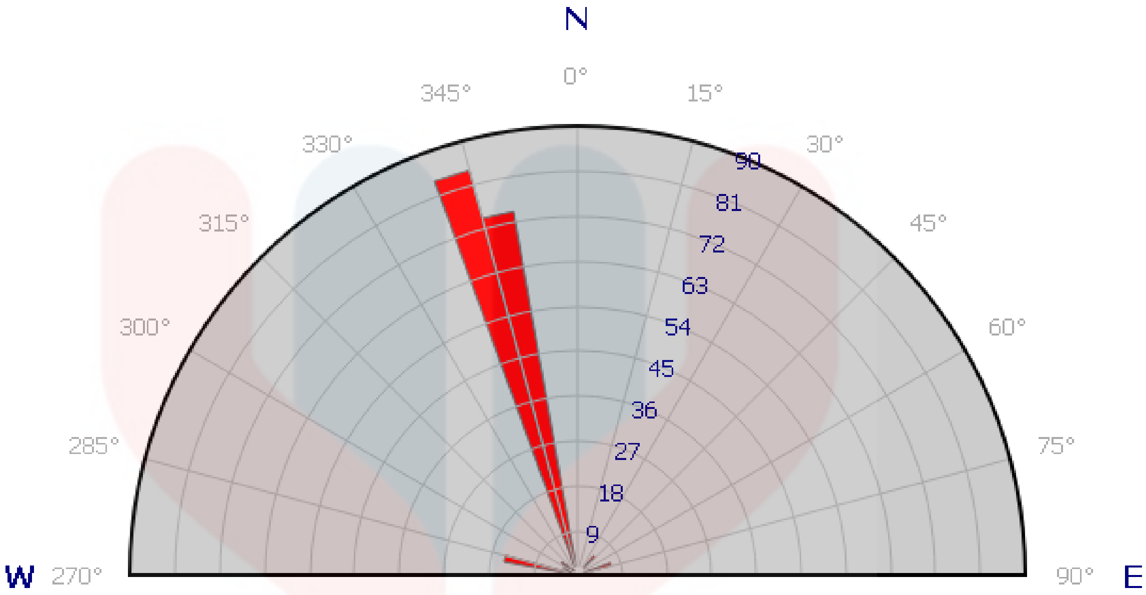


Figure 4.18: Outcrop 1

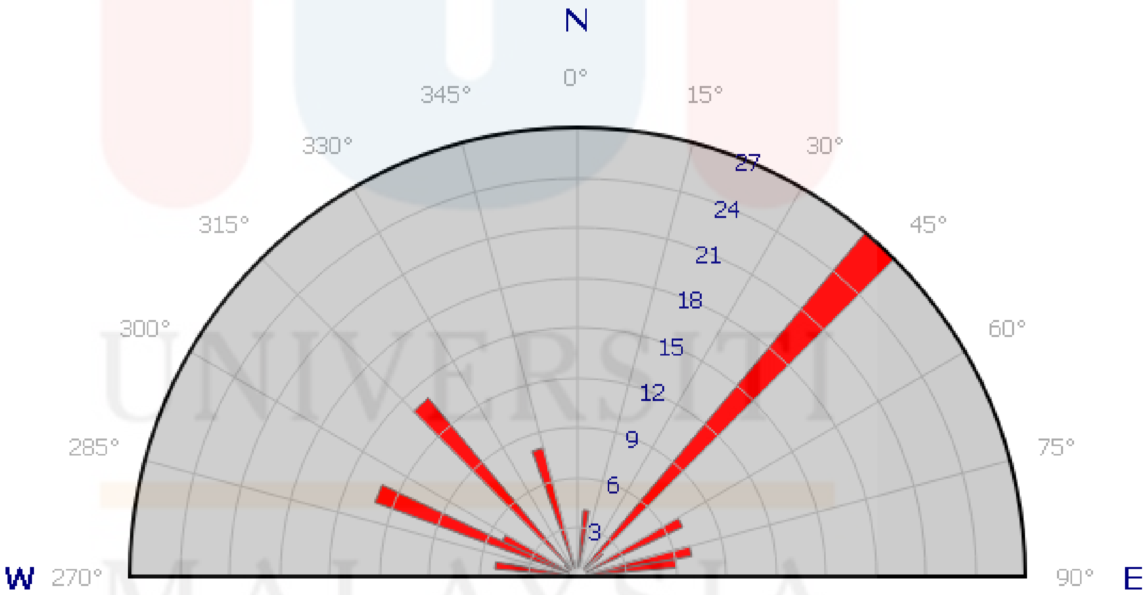


Figure 4.19: Outcrop 2

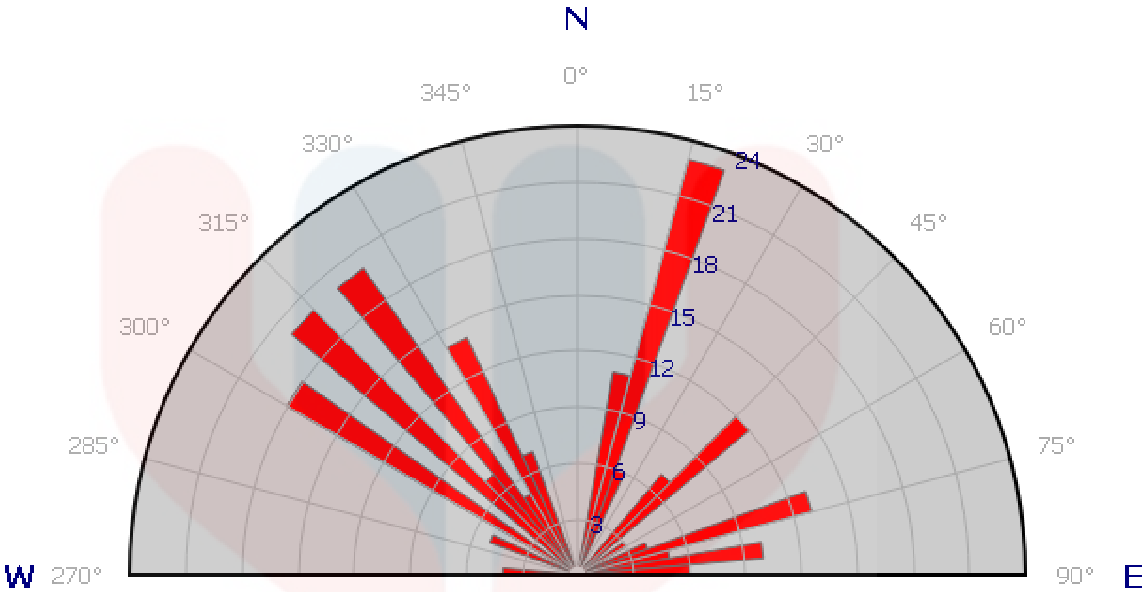


Figure 4.20: Outcrop 3

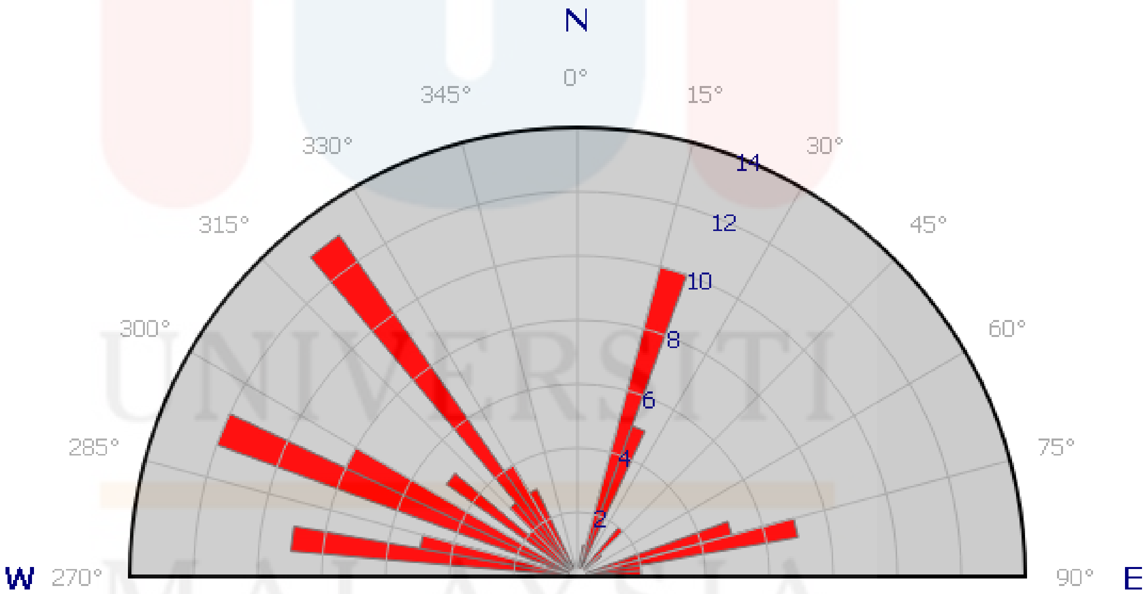


Figure 4.21: Outcrop 4

CHAPTER 5

LANDSLIDE SUSCEPTIBILITY USING GEOGRAPHIC INFORMATION SYSTEM

5.1 Introduction

Hazard in limestone is easily can be detected when it is exposed to the water and surrounding, where the exposed area is easy to weathered. This chapter will explain the potential of landslide susceptibility of limestone in Bechah Kelubi. The parameter used to determine the potential of landslide susceptibility is included with its own specific ratings and the zonation of landslide susceptibility is determined.

5.2 Overlaying of Thematic Maps

In this study, the thematic maps used are including lithology map, landuse map, rainfall, soil map and slope morphometry. Each of the thematic maps are classified according to their own specific rating scheme of landslide hazard evaluation factor (LHEF). This rating scheme is based on the major of inherent causative factor of slope stability that include the lithology, slope and landuse. These parameters are considered to contribute the potential or failure of the landslide.

5.2.1 Lithology Map

Lithology is very important in order to control the stability of slope. The rock unit is controlled by the weathering and erosion, where the maximum weightage of lithology is 4. The causative factor of lithology is classified into three classes. Type I indicates the limestone or granite, where it is a strong and stable rock. However, the type III is indicate the weathered rocks such as weathered phyllite, shale or silt. These types of rock may be the indicator of high potential hazard to occur. Furthermore, the behaviour of instable lithology such as clay, shale also may contribute to high potential of hazard.

5.2.2 Landuse Map

Landuse map is produce to determine the type of activities conducted on land. The main activity in the study area is rubber estate. The other land cover is such as forest, palm oil estate and mining area. The identification of these landuse is to enhance the process of overlaying the map to produce the landslide susceptibility in order to determine the potential spot of hazard to occur.

5.2.3 Contour Map

Contour map is produce in order to identify the highest elevation within the study area. The highest elevation in the study area is 600 meters, whereas the lowest elevation is 120 meters above the sea level. The highest elevation of the study area is usually indicate the limestone karst or limestone cave in the area.

5.2.4 Slope Morphometry

Value of slope has maximum potential for slope failure to occur. The factor is being classified into several classes according to its weightage. The high weightage is 5, where more than 45˚ of slope, whereas the weightage of value 1 is indicate less than 15˚.

Table 5.1: Weightage of lithology

Class	Rock Type	Weightage
Type I	Quarzite/Limestone	1
	Granite/Gabbro	
Type II	Interbedded sandstone with thin claystone	2
	Interbedded sandstone with shale or clay	
Type III	Slate or phyllite	3
	Schist	
	Shale with interbed of claystone or non-clay materials	4
	Shale, phyllite and schist (Highly weathered)	

Table 5.2: Weightage of slope morphometry

Type of Slope	Class	Weightage
Escarpment, cliff	> 45˚	5
High angle	36˚ - 45˚	4
Moderate angle	26˚ - 35˚	3
Low angle	16˚ - 25˚	2
Very low angle	< 15˚	1

Table 5.3: Weightage of landuse

Type of Landuse	Weightage
Agricultural	1
Residential	2
Thick vegetated	3
Moderately vegetated	4
Sparsely vegetated	5
Barren land	6

5.3 GIS Overlay Analysis

The correlation of landslide hazard zonation is produced by the grid overlay method and GIS modelling, where the analysis is compared to access the suitability of the two approaches (Tarum Kumar Raghuvanshi, Lensa Negassa, P.M. Kala, 2015). The parameters are classified according to their own specific rating. The summation of these parameters is used to obtain the suitability value to determine the possible location to have the landslide in study area.

The landslide hazard zonation can be calculated by using the equation:

$$\text{Hazard zonation (x)} = F(x) \sum_{j=1}^{6} \frac{\left((Wj \times Hji)x\right)}{\sum_{j=1}^{6}(Wj)}$$

Whereas, the potential landslide susceptibility can be calculated by using the equation:

Potential hazard = Weightage of (lithology + slope morphometry + landuse)

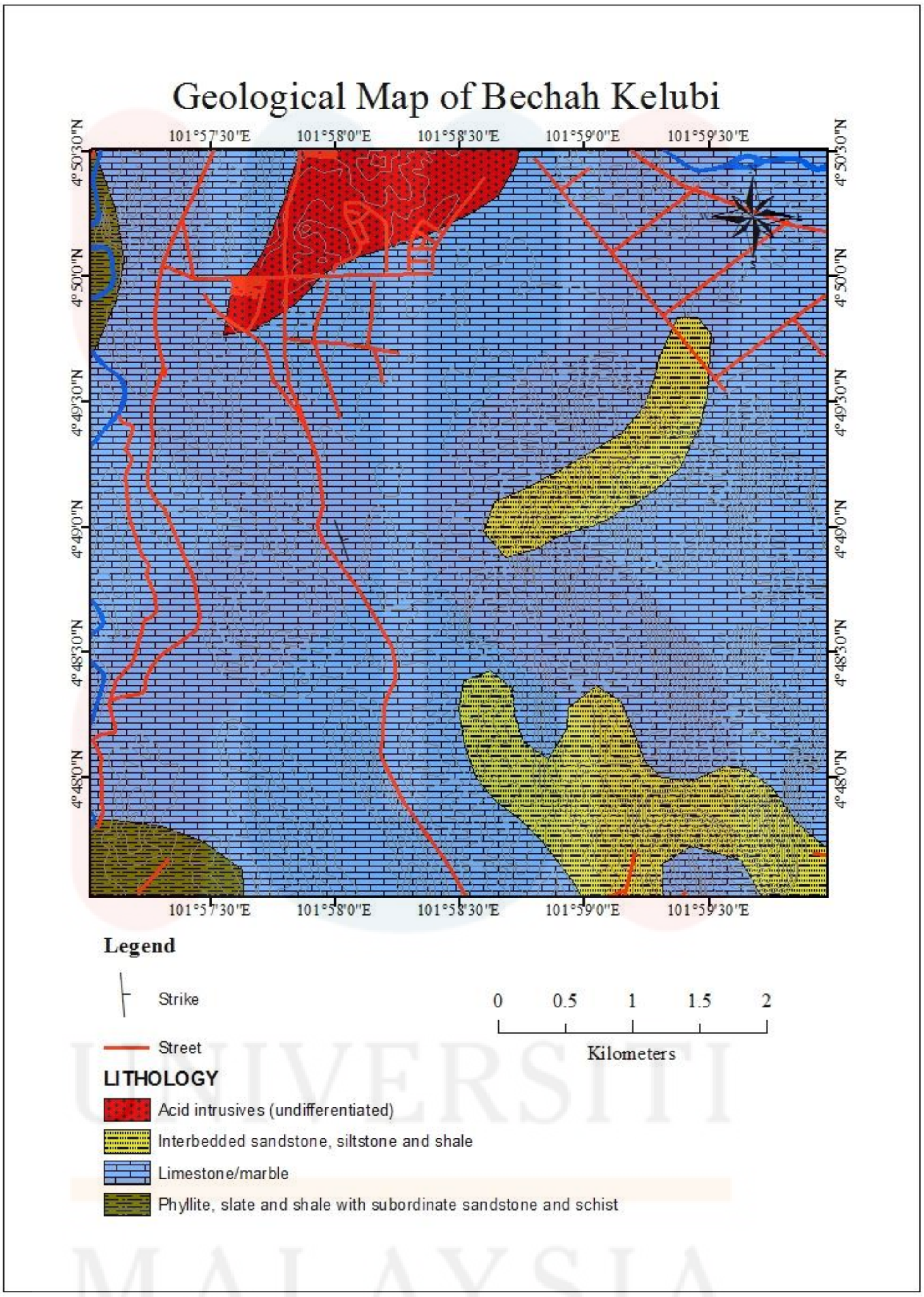


Figure 5.1: Geological map of Bechah Kelubi

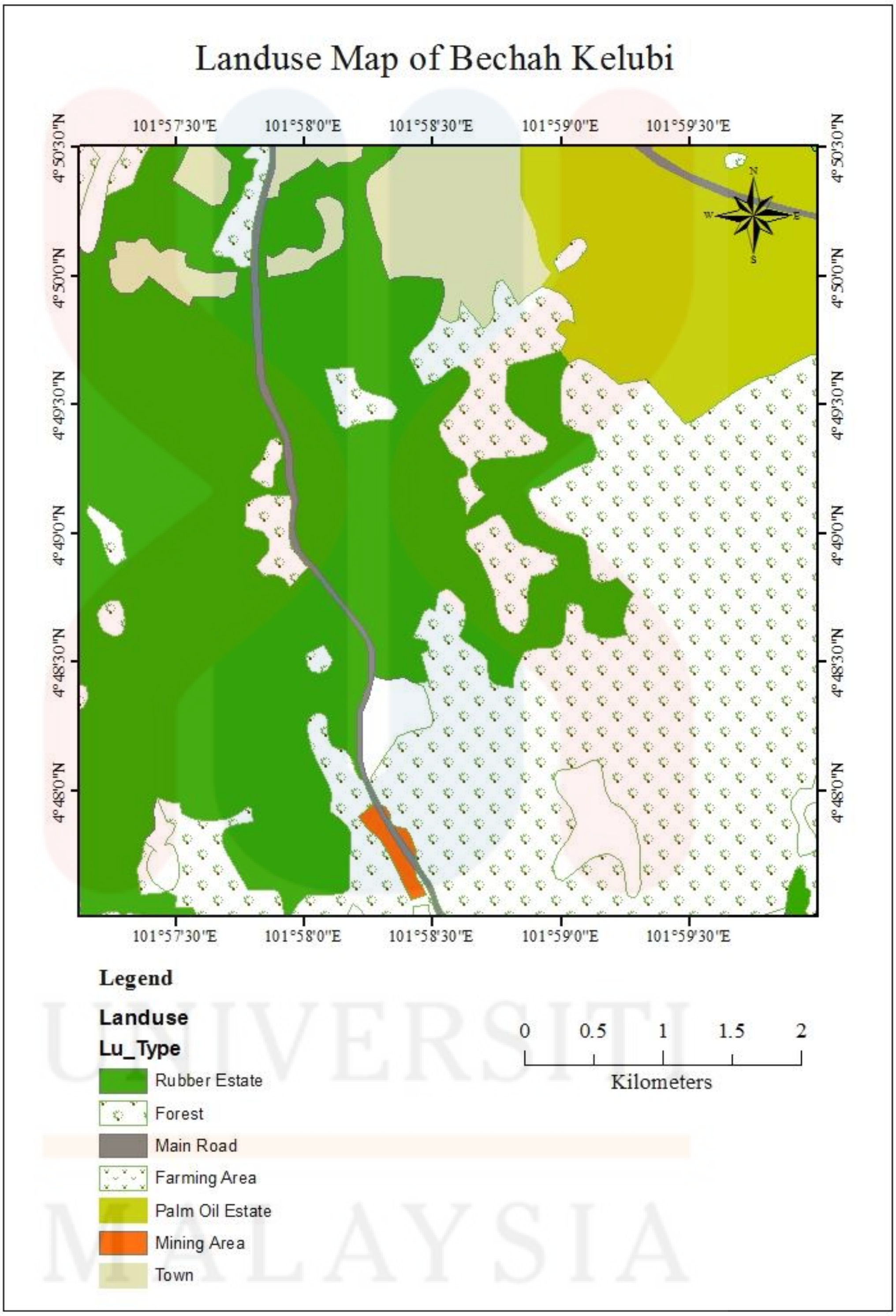


Figure 5.2: Landuse map of Bechah Kelubi

(Source: ArcGIS Shapefile Data)

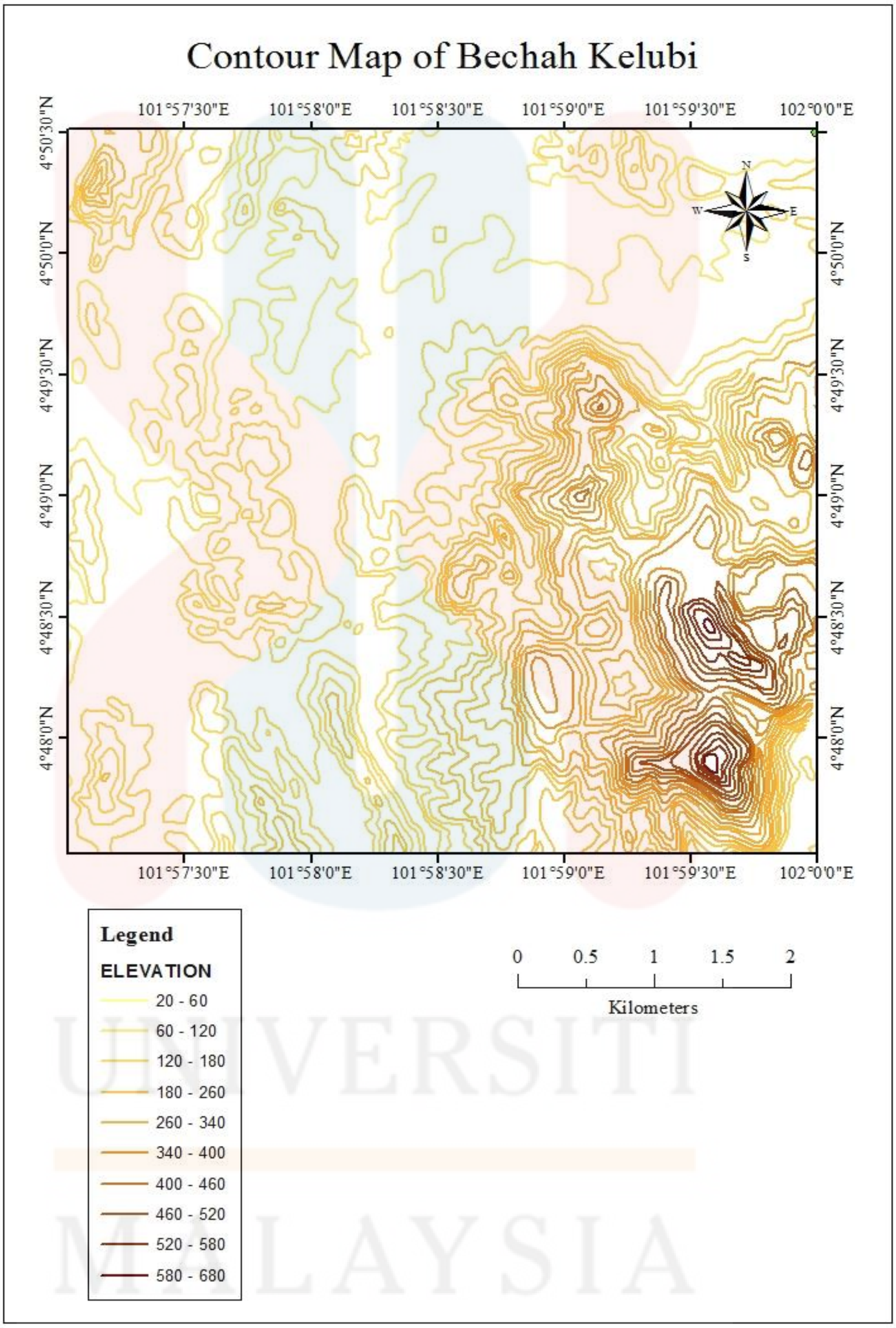


Figure 5.3: Contour map of Bechah Kelubi

(Source: ArcGIS Shapefile Data)

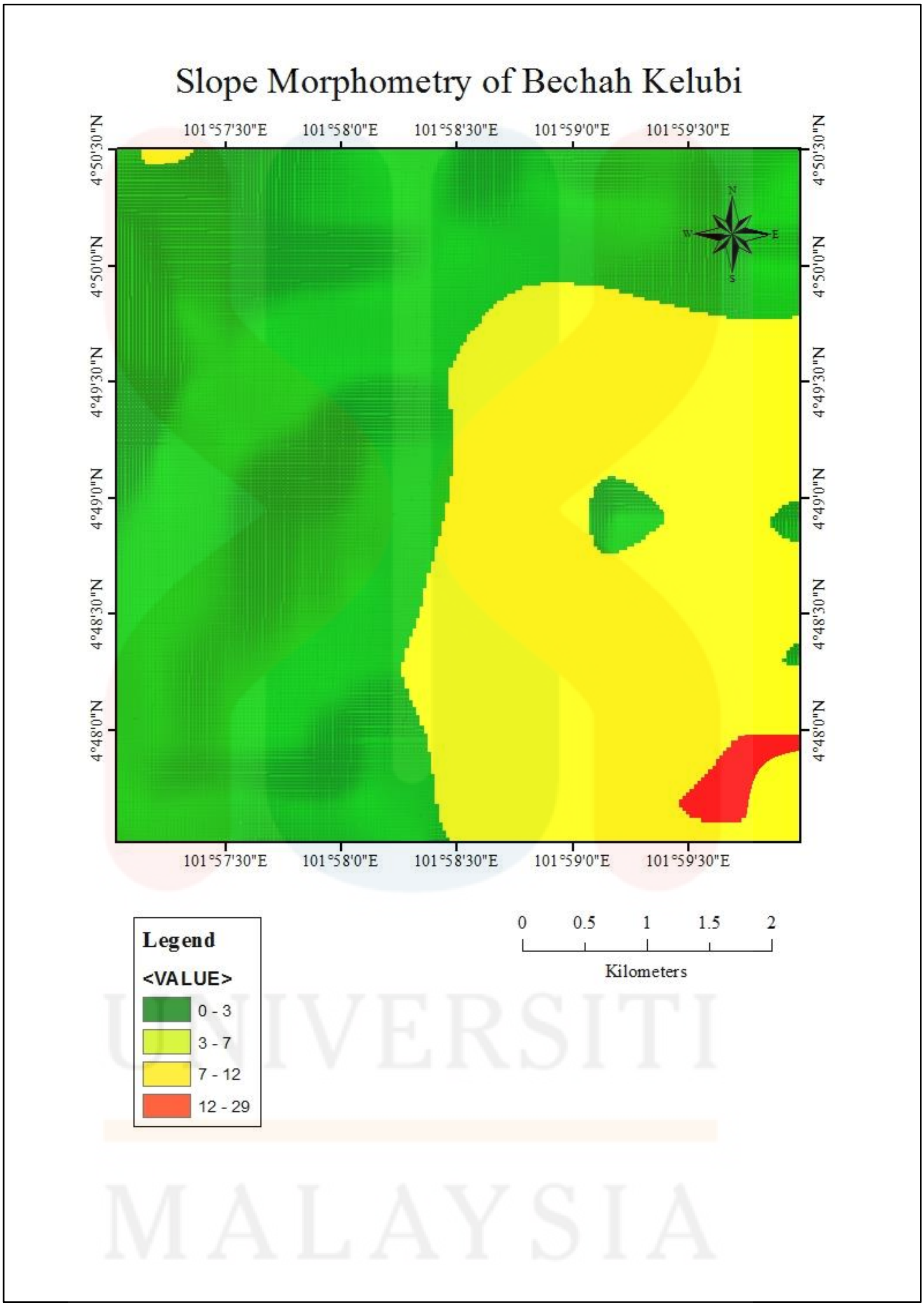


Figure 5.4: Slope morphometry of Bechah Kelubi

(Source:ArcGIS Shapefile Data)

5.4 Map Interpretation

From the results of the maps, the variables can be described as the regression coefficient is highlighted by the factors and variables that affect the potential of landslide susceptibility.

The aspect of lithologies, landuse and slopes are considered to be strongly related to the potential of the failure occurrences. The classes and its ratings such as lower potential at the sparsely vegetated area. The other classes such as agricultural is more high potential for the failure.

The aspect of the lithology where the clay or shale have the high potential for failure, and it show the positive coefficient. The lithology that consist of the limestone or granite may have lower to moderate potential of failure. This is depends on the weathering rate and its exposure. For example, limestone may have high potential of failure when it has high rate of weathering grade. This may show the high coefficient.

Slope angle also showed a significant coefficient trend. It emphasized the increment of slope angle which more than 36˚ may have the high potential for the slope failure to occur. The slope morphometry had shown the lower to high angle of the slope. The lower angle may not have significant change for potential of slope failure.

On the other hand, the quantity of rainfall distribution also may give a significant effect for the potential of slope failure. The rainfall distribution in Gua Musang at year of 2014 is reported the highest quantity compared to other years backward. The landslide also reported had occurred at several places nearby. The downpour will penetrate into the soil, which mostly covered with clay or shale. The instable behaviour of clay may have the high potential for landslide, while limestone which have the behaviour will dissolve when reacted with acid or water. This also may enhance the potential of rock fall or limestone hazard.

The combination of these factors where the coefficients with related classes and its ratings can produce the potential susceptibility map. The interpretation of susceptibility is according to the ranking of the classes which from the lowest to the highest values.

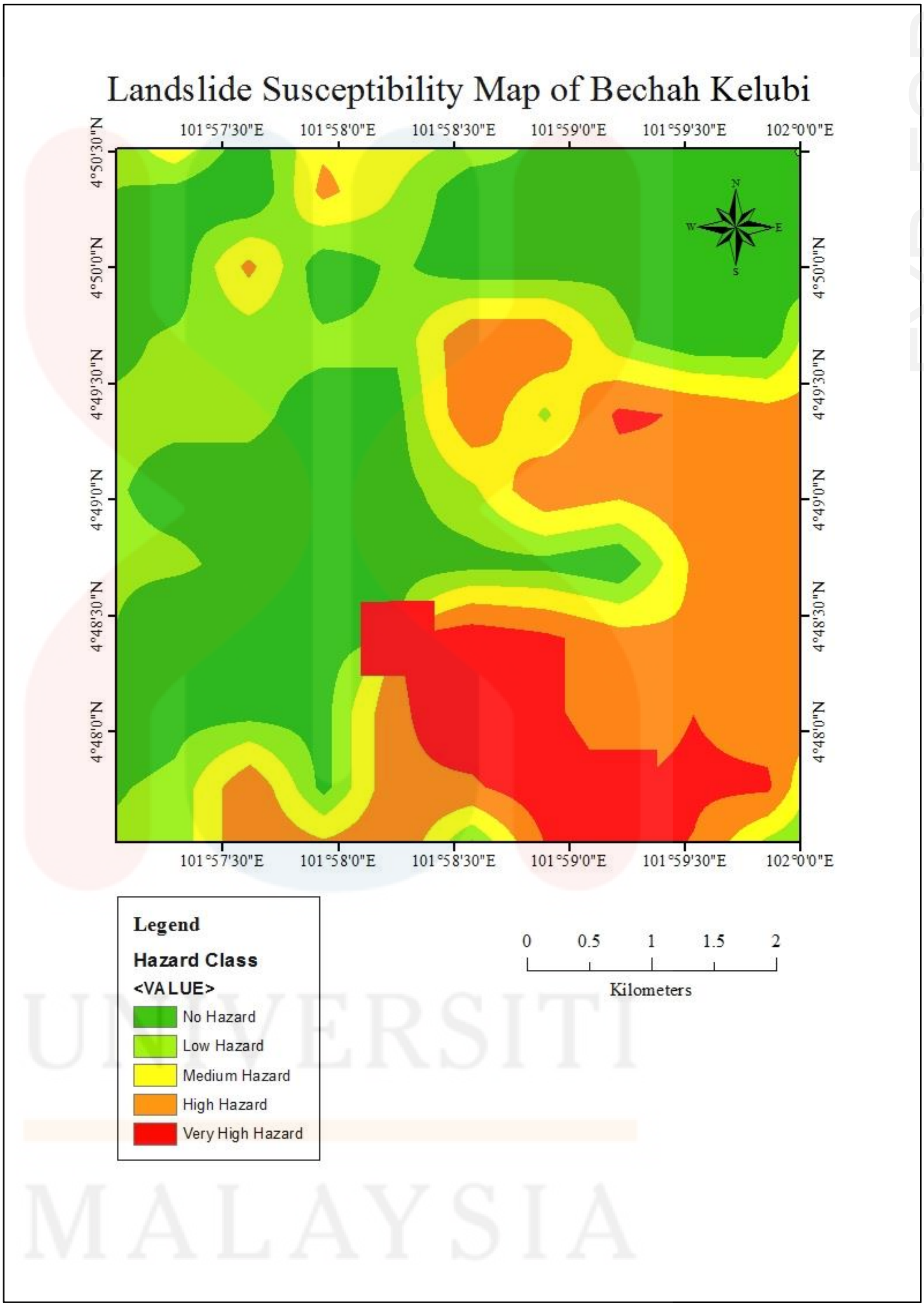


Figure 5.5: Landslide susceptibility map of Bechah Kelubi

(Source: ArcGIS Shapefile Data)

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

In conclusion, the landslide susceptibility map was produced in order to prepare the future frame of hazard in study area of Bechah Kelubi, Gua Musang. Relationship between the factors and analyses had shown through the overlaying of thematic maps. The results had proved by the combination of the regression coefficient through the factors that may contributing to the susceptibility. The final outcome of the landslide susceptibility map shown the moderate to high susceptibility where the potential of landslide may be occurred.

Several limitations are determined throughout the process of analysis. The method of input and output system were affected the final result of the analysis. Data provided in the GIS package was outdated and the analysis of the map in GIS was conducted in separate ways, which consume a lot of time to get the input and output. The small scale of study area may not give significant overview as the final result is not located within the study area. In order to gain more information of hazard, a specific scale and more physical properties of landslide hazard is needed.

6.2 Suggestion

Overall, some uncertainties for the analysis is need to consider in order to reduce the error of final potential predictions. The accessibility of input and output need to be evaluated to improve the final result of the analysis.

References

Huggett, R. J. (June 2010). *Fundamental of Geomorphology.*

M. Ghafoori, H. S. (2006). Landslide hazard zonation using the relative effect method.

Malaysia, D. o. (2010 - 2014).

Neumann, A. a. (1975). Lime Mud Deposition and Calcareous Algae in Bright of Abaco, Bahamas.

O' Leary, D. a. (1978). Towards a workable lineament symbology . *Proceeding of the third International Conference on the new basement tectonic* (pp. 29 - 31). Denver, Colorado: Basement Tectonic Committee Inc.

Peng, K. H. (1983). *Mesozoic Stratigraphy in Peninsula Malaysia.* Ipoh: Geological Survey Malaysia .

Ronov, A. (1983). *The Earth's Sedimentary Shell: AGI Reprint Series 5.*

Sam Boggs, J. (2009). *Petrology of Sedimentary Rocks* (Second Edition ed.). United Kingdom : Cambridge University Press, New York.

Smelser, D. (2014). *Landslide Mitigation Action Plan* . Washington State US.

Tarum Kumar Raghuvanshi, Lensa Negassa, P.M. Kala. (2015). GIS based Grid overlay method versus modelling approach - A comparative study for landslide hazard zonation (LHZ) in Meta Robi District of West Showa Zone in Ethiopia. *The Egyptian Journal of Remote Sensing and Space Sciences,* 235 - 250.

Tilahun Hamza, T. K. (2016). GIS based landslide hazard evaluation and zonation - A case from Jeldu District, Central Ethiopia. *Journal of King Saud University*.

Appendix

Table 4.2 Strike value for outcrop 1

Strike Values							
160	140	160	160	280	342	232	252
180	173	213	160	283	342	289	252
162	160	155	160	209	342	342	252
160	142	160	145	244	341	300	310
164	169	200	134	256	342	341	311
160	321	204	160	280	327	300	315
161	178	210	162	222	342	342	310
152	158	208	212	280	342	306	308
169	156	165	220	212	312	342	258
163	190	156	231	205	341	342	348
160	160	160	220	217	247	342	312
172	176	134	220	267	312	301	350
166	190	190	220	342	301	306	344
160	175	188	212	348	342	322	348
122	189	123	116	310	342	309	302
165	109	156	117	341	342	265	312
164	160	122	116	342	342	288	348
169	167	160	280	342	334	267	341
144	160	132	265	248	321	251	340
170	200	160	290	342	342	252	342

Table 4.3 Strike values of outcrop 2

Strike Values				
290	213	154	78	276
276	220	143	54	312
255	33	178	123	222
278	212	164	56	309
212	289	144	187	325
276	213	132	57	312
209	201	121	87	121
267	62	33	54	218
208	63	67	143	56
267	77	312	80	37
290	54	225	67	89
266	52	231	73	300
209	34	47	70	301
71	60	122	73	278
77	114	302	80	208
43	167	123	267	300
47	123	57	254	15
67	156	89	222	177
54	143	71	276	25
50	188	56	290	8

Table 4.4 Strike values of outcrop 3

Strike Values				
130	260	321	250	58
124	208	347	253	70
120	265	312	209	58
107	280	309	271	12
71	234	200	303	17
76	201	301	312	10
72	318	308	305	260
70	209	209	231	267
72	310	300	306	280
56	331	316	312	204
68	309	310	301	318
72	312	315	306	300
40	314	193	213	60
44	290	190	319	32
32	213	192	310	80
46	294	156	56	319
156	209	123	23	63
67	206	169	28	20
150	143	100	38	302
159	132	105	270	168

Table 4.5 Strike values of outcrop 4

Strike Values				
312	24	217	315	134
300	213	230	300	167
328	250	215	212	32
315	59	123	129	309
345	150	209	310	189
304	159	217	325	105
312	301	194	309	56
206	326	122	318	301
309	319	156	310	317
60	325	180	318	106
62	300	154	45	309
57	319	165	76	301
80	206	102	203	68
73	216	56	69	46
234	245	231	204	106
50	210	82	300	209
267	215	67	73	60
21	234	212	70	234
208	217	209	230	56
24	220	83	312	103