UNIVERSITI MALAYSIA KELANTAN

GENERAL GEOLOGY AND KARST GEOMORPHOLOGY OF PADANG KUALA SEMOR, GUA MUSANG KELANTAN

by

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DECLARATION

I declare that this thesis entitled General Geology and Karst Geomorphology of Padang Kuala Semor, Gua Musang,Kelantan is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________________

Name : ________________________________

Date : ________________________________

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GENERAL GEOLOGY AND KARST GEOMORPHOLOGY OF PADANG KUALA SEMOR, GUA MUSANG, KELANTAN

ABSTRACT

Geological and Geomorphologic Mapping-based methodology has been used in the process of identifying karsts formation/landform. The study area was located at Padang Kuala Semor, Gua Musang, Kelantan. The main purposes of this study are to update geological map of the study area, to identify karst formation/landform and to produce karst geomorphologic map of Padang Kuala Semor. The geological mapping was conducted at the study area to determine the geology and followed by making a conclusion about formation of the area. The study area is included t the Gua Musang formation based on the type of rock that has been identified at Padang Kuala Semor, surface karst, subsurface karst and surficial landform. Geomorphologic mapping was successfully done with the help of interpretation from Google Earth in order to identify karst formation/landform.

KAJIAN GEOLOGI DAN KARST GEOMORFOLOGI DI PADANG KUALA SEMUR, GUA MUSANG, KELANTAN

ABSTRAK

Pemetaan geologi dan geomorfologi telah digunakan dalam proses mengenal pasti pembentukkan /rupa bentuk muka bumi karst.Kawasan kajian ini terletak di Padang Kuala Semor,Gua Musang,Kelantan.Objektif utama kajian ini adalah untuk memperbaharui peta geologi di kawasana kajian,untuk mengenal pasti pembentukan / rupa bentuk muka bumi karst dan untuk menghasilkan peta geomorphologi karst di Padang Kuala Semor.Pemetaan geologi telah dijalankan dikawasan kajian untuk menentukan geologi kawasan tersebut dan membuat kesimpulan tentang formasi pembentukan kawasan tersebut.Kawasan kajian dikatakan termasuk dalam formasi Gua Musang berdasarkan jenis batuan yang ditemui.Terdapat tiga jenis pembentukan/rupa bentuk muka bumi karst yang telah dikenal pasti di Padang Kuala Semor,karst permukaan,karst di bawah tanah dan rupa bentuk muka bumi surfisial.Pemetaan geomorfologi telah dijayakan dengan pentafsiran daripada Google Earth telah digunakan untuk mengenal pasti pembentukan /rupa bentuk muka bumi.

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LIST OF ABBREVIATIONS

3D	3 Dimensions
AGI	Glossary of Geology
Ca^{2+}	Calcium ion
$CaCO_3$	Calcite
$CaMg (CO_3)_2$	Calcium Magnesium Carbonate
CO_2	Carbon Dioxide
E	East
FELDA	Federal Land Development Authority
GIS	Geographic Information System
GPS	Global Positioning System
HCL	Hydrochloric Acid
Inch	Inches
KESEDAR	South Kelantan Development Authority
km	kilometre
km^2	kilometre square
m	metre
mm	milimetre
N	North
NE-SW	North East-South West
N-S	North-South
NW	North –West
NW-SE	North West-South East

NW-SW	North West-South West
SE	South - East

LIST OF SYMBOLS

^{0}	Degree
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 General Background

The research entitled "General Geology and Karst Geomorphology of Padang Kuala Semor,Gua Musang,Kelantan" will be submitted in fulfilment of the requirements of the Degree of Bachelor of Applied Sciences (Geosciences) with honours from Faculty of Earth Sciences of University Malaysia Kelantan. Gua Musang is bordered by the state of Pahang, Terengganu and Perak. The formation is resulted from the collision between Sibumasu and Indochina tectonic plate. The upper part of Gua Musang formation is interfingering with the Semantan Formation, Telong Formation and Gunung Rabong Formation. The age of the rock is between the Upper Carboniferous until the lower Triassic.

Karst is characterised by the predominance of rock dissolution over mechanical erosion, and is typical of present temperate weather it is cold or warm and tropical environments (Ford, 2007). In karst terrains, surface and subsurface geomorphology is largely governed by dissolution of carbonate and evaporite rocks. In the most classical situation, surface waters, acidified by CO_2 from the air and soil, slowly dissolve carbonate rocks while percolating downwards and flowing down-gradient in the phreatic (saturated) zone towards the discharge points, typically springs. There are more prominent outcrop of limestone in the study area and it is formed the topography Karst, and easily recognizable. These rock units identified as Gua Musang Formation.

1.2 Problem Statement

Based on preliminary study of journals and articles, the problem that being face at the study area is the existing geology data on that particular area is not complete. Data is not updated and it is slightly different from the map if compared to the place at the field. According to previous research, the available data are not updated since the last research at study area is a few years. There is a few research that was carried out from previous geologist around the study area include the study on gold deposit at Pulai. By doing this research, new map can be produced and after that people can refer the map to make a research.

Besides that, the lack of through study about karst geomorphology at Padang Kuala Semor in Pulai, Gua Musang. Improper study and interpretation has led to unsuitable planning on the area. The karst landform of Padang Kuala Semor and its nearby can give many advantages towards economic development in that particular place. The landform is not only good for agricultural and gold mining only but also can give advantage in field of tourism and groundwater.

1.3 Research Objectives

a) To update a geological map of the research area 5x5km map scale of 1:25 000.

a) To identify the karst/landform/formation in Padang Kuala Semor.

b) To produce karst geomorphologic map of Padang Kuala Semor.

1.4 Study area

The area of research will be at Padang Kuala Semor and its nearby area including a part of Pulai in Gua Musang, Kelantan. The study area is at longitude and latitude of 101°54'30" E and 4°46'30"N. In this general geology study, the area will be minimize into 5 km x5 km square which in the map scale of 1:25000.This area can be accessed by using car, motorcycle and other small transportation. The study area is in the plantation area and also located at nearby small town. Figure 1.1 shows the base map of the study area.

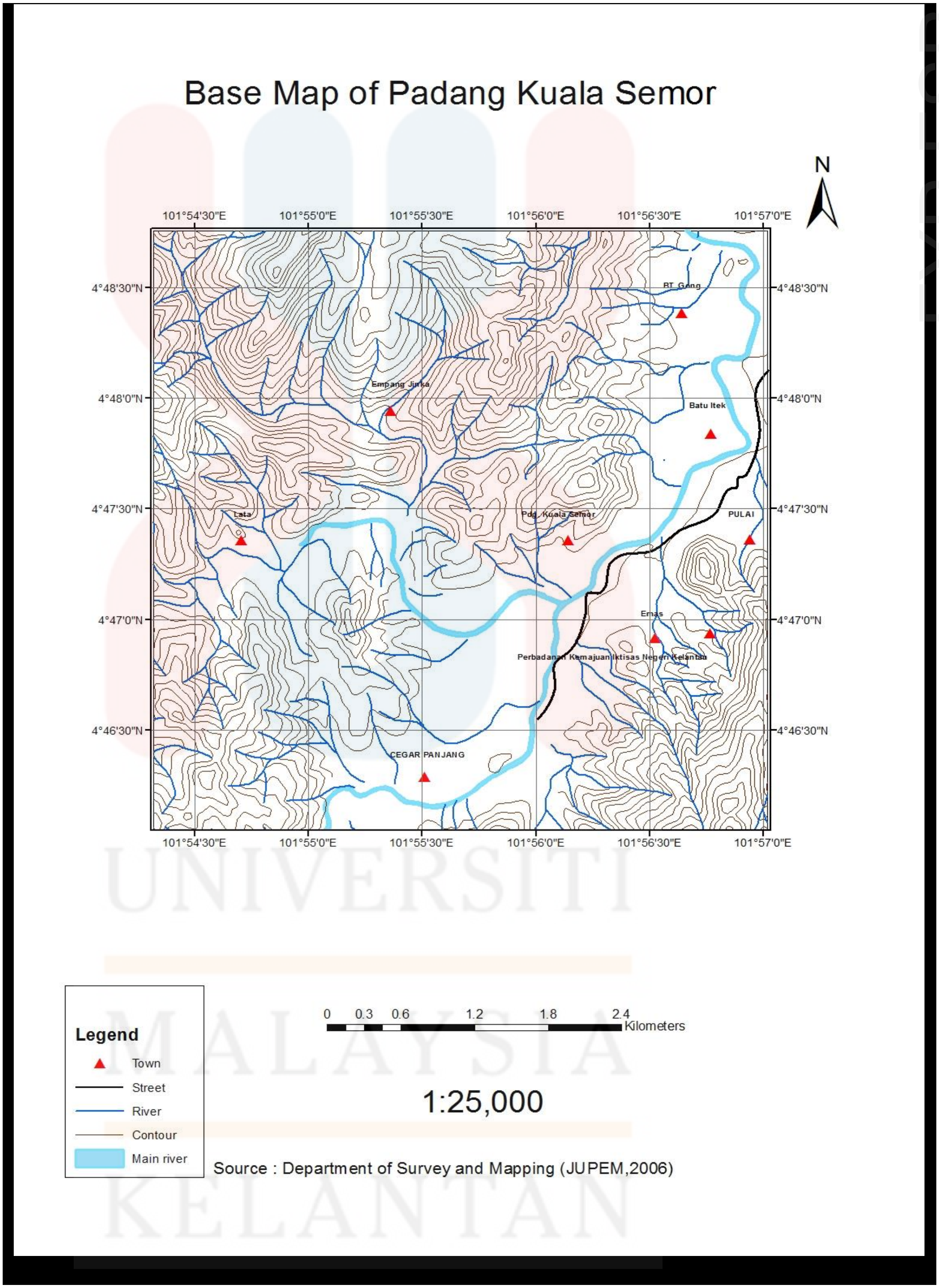

Figure 1.1: Base Map of Padang Kuala Semor

1.4.1 Geography

This research will provide the data for people distribution, rain distribution, land use, social economic and road connection. The study about geographical area is important to know the processes involved in the deformation of the earth and evolution of the surface morphology research area.

a) People Distribution

Kelantan is one of fourteen states that comprise Malaysia. Kota Bharu is the capital city of Kelantan. Kelantan occupies a total area of 14,922km2 and has a population of 1,635,000 people. Kelantan is positioned in the north-east of Peninsular Malaysia. It is bordered by Narathiwat Province of Thailand to the north, Terengganu to the south-east, Perak to the west, and Pahang to the south. To the north-east of Kelantan is the South China Sea. Kelantan has a total of ten districts that includes Gua musang, Bachok, Jeli, Kota Bharu, Kuala Krai, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, and Tumpat. Total area of Gua Musang is 8177 km^2.Gua Musang is town, district and constituency in southern Kelantan, Malaysia. It is the largest district in Kelantan. Gua Musang is administered by the Gua Musang District Council. The population 76655 people in the year of 2000 and 90057 people in the year of 2010.The population increases about 13402 people in the range of 10 years. Table below shows people distribution in southern region of Kelantan that is Gua Musang, Jeli and Kuala

Krai. The populations of the people in this part of Kelantan have increased even though it is a rural area. Table 1.1 shows the population at Gua Musang by district 1991 until 2000.

Table 1.1: The population by district 1991 and 2000

(Source: Department of Statistics, Malaysia: Population Census)

Region	District	Population		Area (Hectare)
		1991	2000	
Southern	Jeli	32.7	36.5	131 800
	Kuala Krai	90.8	93.6	227 700
Kelantan	Gua Musang	63.9	76.7	817 700

b) Land use

Department of Mineral and Geosciences (2003),45% of the land in Kelantan is under state land status,21 % under alienated land,1 % under other status and 33% under reserved land. Some 60 % of the State is under forest cover, located in the districts of Jeli,Kuala Kerai and Gua Musang.

Table 1.2: Category of Land Use

(Source: Kelantan Socio-Economic Profile 2001,Kelantan)

Category	Area(Hectare)	Percentage %
Forest Reserve	894 271	59.5
Agriculture	335660	22.3
Urban	4967	0.3

c) Social Economic

Economy in Kelantan dominated by rice, rubber and tobacco. Besides that, fishing also important activity to generate economy in Kelantan. In Kelantan economy also dominated by the cottage industries. Cottage industries such as traditional skills in handicraft production such as batik, woodcarving and songket weaving are also evident. Federal Land Development Authority (FELDA) and the South Kelantan Development Authority (KESEDAR) are among the agencies involved in the development of the rural communities.

d) Road Connection

At Padang Kuala Semor do not have main road. It only has small roads, paved or unpaved road and the transportation that can be used are car and motorcycle. The road the study area almost unpaved because it is the plantation area. Figure 1.2 shows the road connection to the study area.

Figure 1.2: Road connection to Padang Kuala Semor

1.5 Scope of Study

The scope of this research is focused on study of geology which included structural geology, lithology, topography, geomorphology of the study area at Padang Kuala Semor, Gua Musang. Furthermore, the research is on the karst geomorphology of Padang Kuala Semor.

1.6 Research Importance

This study will help the geologist and academy have an updated geological data about study area especially lithology, geomorphology, stratigraphy and structural geology of the study area that vital and relevant for the further study and future research. Furthermore from this research, the karst geomorphology of the study area will be analyzed.

Geographic Information System (GIS) has become a powerful tool for effective analysis and prediction associated with the study of geologic hazards. This is not only because GIS has excellent data structures and spatial data processing abilities, but also because the collection, manipulation and analysis of the environmental data. (Carrara, 1995).

Identifying karst formation/landform and produce geomorphologic map are two main scope of study in this research. This method applies in this study are geological mapping and geomorphological mapping. Geological mapping will be carried doing traversing while geomorphological mapping will be carried out by observing, identifying the karst formation /landform all the way in the field and using Geographic Information System(GIS).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter it is focusing on the preliminary studies. Preliminary study should be done before conduncting the research. The study include about the past researches, articles, journals and book at library and internet.

2.2 Regional Geology and Tectonic Setting

Regional geology of Gua Musang has two sedimentary formations in the study area the Gua Musang Formation in the western part and the Gunung Rabong Formation in the eastern part. Granitic intrusives are located in the northeast part of the study area. The Gua Musang Formation consisting mainly of argillaceous facies, mudstone and pelitic hornfel, slate and phyllite, sandstone and metasandstone rocks. Some occur as outcrops through the Triassic cover of Gunung Rabong Formation in the eastern area. In the eastern side of the study area, the Middle-Upper Triassic age Gunung Rabong Formation sedimentary rocks consist mainly of sandstone with subordinate shale, mudstone, siltstone, conglomerate and volcanic. Triassic limestone occurs as lenses, forming cliff-bound ridges and rows of isolated tower-like hills. Several inliers of limestone rocks are found cropping out through the Permian sedimentary cover in the southwest area. Intrusive rocks of several small granitic stocks are scattered among the sediments and metasediments. Generally, there are two set of fault trends in the area; N-

S to NW-SW and the NE-SW. According to (Hutchison, 1957), the N-S to NW-SE direction is the dominant geological structural trend, which has occurred as a result of past orogeny.

2.2.1 Stratigraphy

The stratigraphy of Gua Musang consists of a calcareous-argillaceous sequence of crystalline limestone with interbedded argillites and subordinate sandstones and volcanics. The shales are usually grey but can vary to black carbonaceous. The sandstones include greywacke, protoquartzites and orthoquartzite but metaquartzites are the most common. The volcanics vary in composition from rhyolitic to andesitic and include tuffs, lavas and agglomerates. A late Carboniferous to Triassic age is indicated by fossils present. The formation is the lateral equivalent of the Aring formation which is pyroclastic. It can also be considered to be synonymous with the Telong formation of which estimated a thickness of about 650 m for the unit in south Kelantan. Gua Musang Formation and Aring Formation both were in the south of Kelantan. Both of the formation dominated by argillaceous and volcanic facies while the rest were calcareous and arenaceous facies. The depositional environment is typically shallow marine with intermittent active submarine volcanism Lee (2004).Based on (Aw, 1990) the formation is the lateral equivalent of the pyroclastic Aring Formation and is synomymous with Telong Formation.

According to (Yin, 1965), Gua Musang Formation has long been introduced to rocks around Gua Musang. Gua Musang Formation is not well understood and its development during the Permian-Triassic transition remains a problem. Evidence given below shows Gua Musang Formation consists from several units or different limestone facies. Table 2.1 shows the sequence stratigraphy formation of Gua Musang. Figure 2.1 shows the formation in Central Belt.

Table 2.1: Sequence Stratigraphy Formation of Gua Musang by (Yin, 1965)

Time	Lithology
Middle Triassic	Limestone, shale, volcanic rock
Early Triassic	Argillaceous limestone, shale, volcanic rock
Late Permian	Shale, siltstone
Middle Permian	Limestone with some shale.

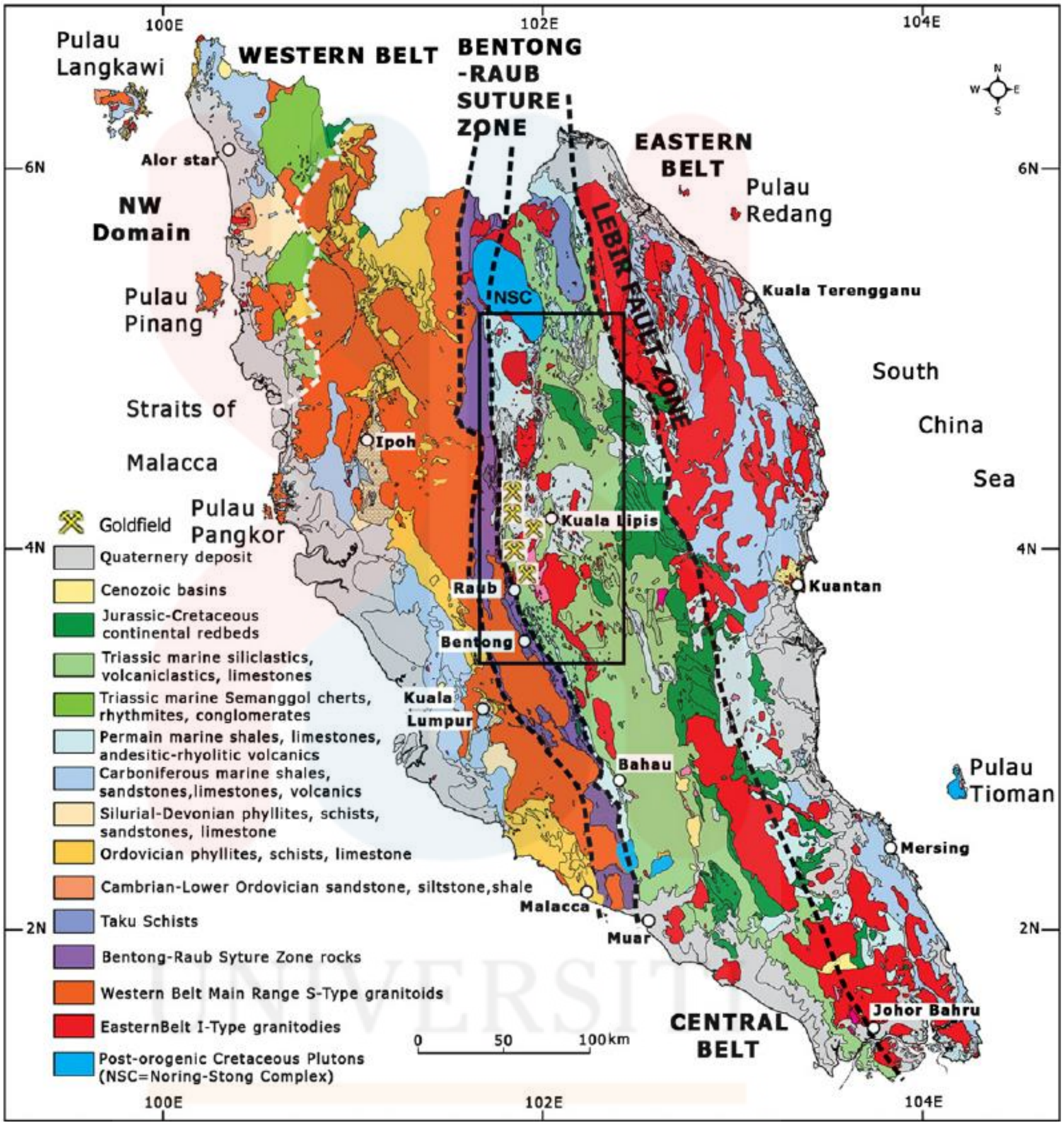

Figure 2.1: Formation in Central Belt

2.2.2 Structural Geology

Peninsular Malaysia is the resulted collision between Sinoburmalaya and Indochina based on The Malaysia and Thai Working Group (2006).The collision zone is represent by Bentong Raub Suture zone. The Bentong Raub Suture Zone of Peninsular Malaysia is one of the major structural zones in Sundaland, Southest Asia.It forms the boundary between the Goundwana derived Sibumasu terrane in the west and Sukhothai Arc in the east. The Bentong Raub Suture Zone is related to the sediment-hosted or orogenic gold deposits associated with the major lineaments in the Central Gold Belt of Peninsular Malaysia.Major structural lineaments such as Bentong Raub Suture Zone and Lebir Fault Zone, ductile deformation related to crustal shortening.

2.3 Research Specification

2.3.1 Sedimentology

Sedimentology is the study of sedimentary rocks with the processes by which they were formed include their description, classification and interpretation of sediments based on Glossary of Geology, AGI (1974).The regional geology of Kelantan consists of a central zone of sedimentary and metasedimentary rocks bordered on the west and east by granites of the Main Range and Boundary Range respectively. Gua Musang Formation consists of crystalline limestone interbedded with thin beds of shale, tuff, chert nodules and subordinate sandstone and volcanic (Hutchison, 1957). The deepwater Semantan basin to the south of Gua Musang platform was formed on an Upper Palaeozoic basement during the Anisian. The growth and development of the basin was strongly affected by instability of its margins and volcanisms that contributed a tremendous supply of tuffaceous sediments into the basin. According to (Roslan, 2006), the Semantan Formation has been interpreting as shallow marine deposits.

2.3.2 Paleontology

Fossil is the naturally preserved remains or traces of animals or plants that lived in the geologic past. There are two main types of fossils that are body fossil and trace fossil. Body fossils include the remains of organisms that were once living and trace fossils are the signs that organisms were present for example tracks, trails, footprints and burrows. Fossil are not common occurrence in Malaysia rocks based on (Lee, 1992). The most common occurrence of fossils is within unmetamorphosed sedimentary rocks such as limestone, sandstone, siltstone and shale or mudstone which cover large parts of both East and West Malaysia. Vertebrate fossils are very rare and no dinosaur remain has been discovered to date although such fossils have been found in similar rocks in adjacent Thailand. Almost all fossils reported to date are of small invertebrates and plants as well as trace fossils of past animal activities. A fossil site in Aring area is located along the road connecting Gua Musang town and Kuala Berang.

2.3.3 Karst

In prehistoric times the human impact on the karst environment was very limited, like the probability of properties and people being damaged by karst processes (e.g. subsidence, flooding).25% of the Earth's population lives on or nearby karst areas and increasing exploitation of karst resources, such as water and building material, is leading to severe environmental impacts and unsustainable based on (Ford D.C, 2007).Characteristics of limestone that experience karstification are lacking surface drainage, have a patchy and thin soil cover, containing many enclosed depressions and supporting a network of subterranean features include caves and grottoes. Exposed human elements augment and anthropogenic changes in the karst systems frequently result in hazard enhancement. Karst geomorphologists and hydrologists can play a decisive role in preventing natural disasters in karst areas, particularly those induced by human activities such as dams with leakage and sinkhole problems ,mines and tunnels that will affected by flooding and subsidence, high-speed railways built in sinkhole-prone areas or development of sinkholes at huge rates induced by lake level water table declines.

Karsts evolve in carbonate rocks and sometimes in evaporate rocks. Limestone is a sedimentary rock. Limestone and dolomite are a diverse group of rocks. Limestone composed of calcite ($CaCO_3$) and may form inorganically. Many types of limestone appeared. The various types of limestone happen because of the variety of condition under which it is produced. Dolomite contain at least 50 % calcium-magnesium carbonate ($CaMg(CO_3)_2$).Pure dolomite also called as dolostone. Dolostone contain at least 90% dolomite.

Karst divided into two form that are surface karst form and subterranean karst form. Doline, polje, karren, urvala and many more that appeared at surface karst form. While water from stream sink into limestone flow through a karst drainage system. For example of subterranean karst form are caves and its features such as flowstone, cave, popcorn, dripstones and others. Figure 2.2 shows the schematic diagram of karst features.

Figure 2.2: Schematic diagram of karst features

(Source: Goggle)

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

Methodology is the most important part in conducting a research. This chapter will mainly described about the procedure and materials used in determining the geology of Padang Kuala Semor and how explorations of karst geomorphology are managed using Geographic Information System (GIS) method. The methodology of this research can be divided into a few divisions. Figure 3.1 shows the flow chart of the research. The flow chart shows the preliminary studies that divided into field assessment, laboratory investigation, software application, data interpretation, report writing until submission thesis and final presentation.

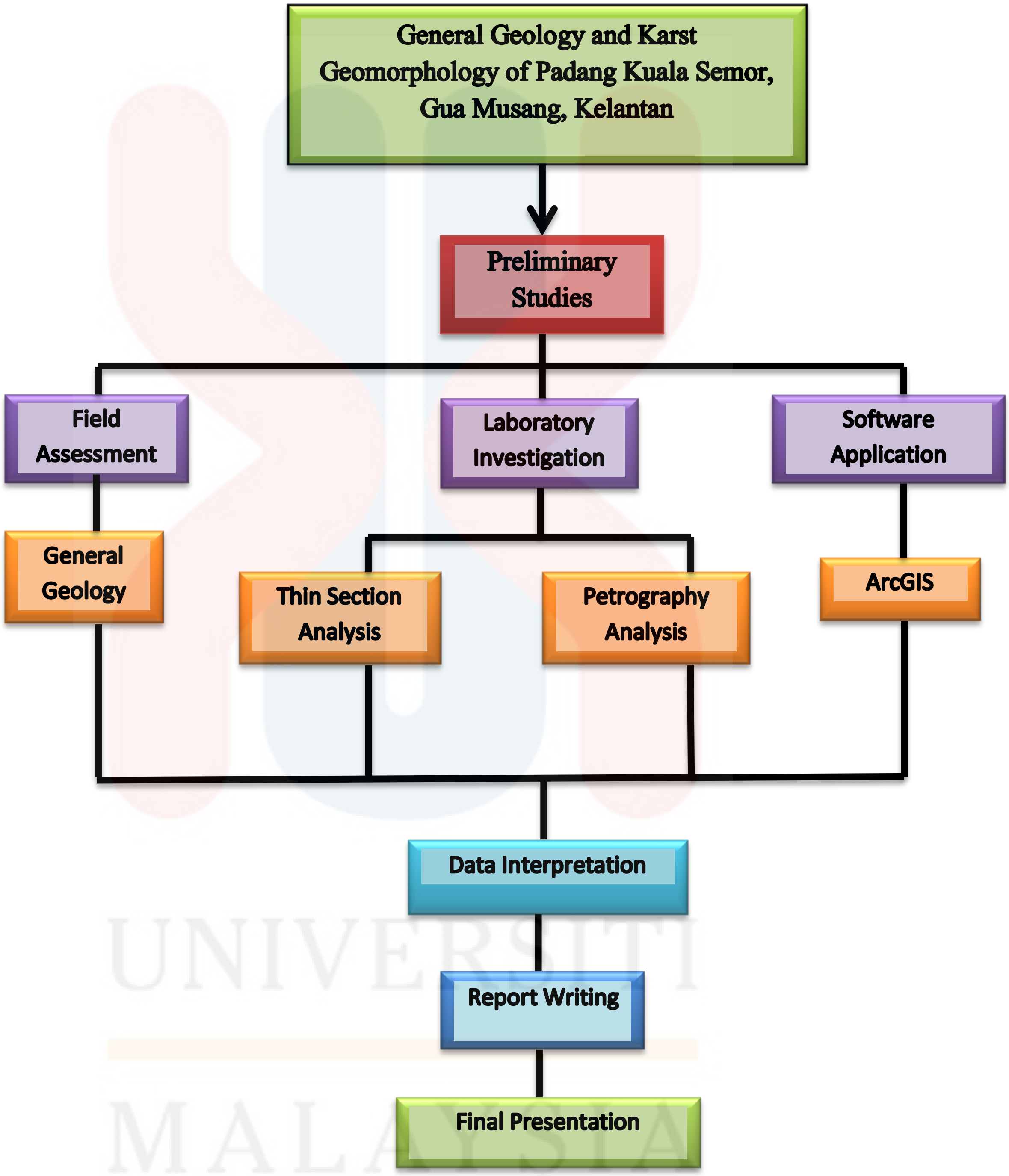

Figure 3.1: Flow chart of the research

3.2 Materials

There were several geological tools are used in this research. The tools used by the geologist in order to collect the field data at the research study area.

a) Base maps

Base maps are important used as preliminary study the morphology of the study area. Figure 3.2 shows the base map. It was produce by ArcGIS application.

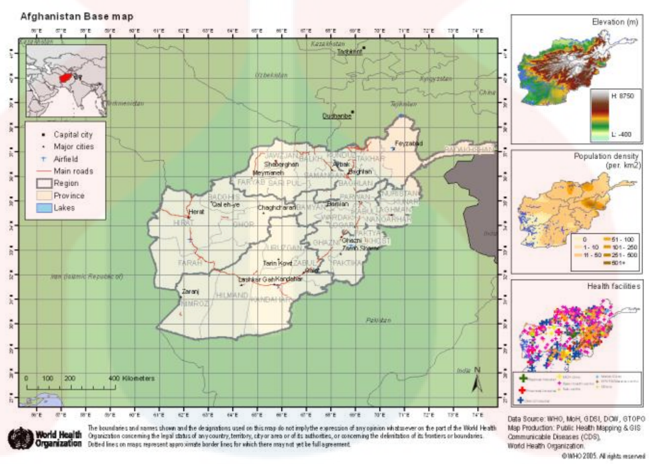

Figure 3.2: Base Map

b) Geological Hammer or chisels

Geological hammer or chisels is basic tool for geologist to collecting the samples. Table 3.1 shows the function of hammer.

Table 3.1: Function of hammer

Chisel head	•Useful for clearing covering vegetation from exposures • Sometimes used to pry open fissures. •Some rocks can be easily split, like slate or shale, to reveal any fossils.
Pick head	•Which terminates in a sharp point to deliver maximum pressure •Often preferred for harder rocks. • A geologist's hammer bearing a pick end is often referred to as a rock pick or geological pick instead of a geologist's hammer.
Flat head	•Used to deliver a blow to a rock with the intention of splitting it. •Specimens or samples can be trimmed to remove sharp corners or reduce in size.

c) Brunton compass

This compass is use to determine the direction of north, east, west, and south. Figure 3.3 shows the Brunton compass. It is also is use to take measurement of strike and dip of the features such as, joint, fracture, fault plane and bedding plane.

Figure 3.3: Brunton compass

d) Hand lens

This lens is used to make the first analysis of rock and mineral grains that can be seen with our naked eye. Figure 3.4 shows the hand lens that used in this research.

Figure 3.4: Hand lens

e) Garmin GPS

GPS (Geographic Positioning System) is a satellite based navigation system. Data such as coordinate, elevation, tracking routes and marking checkpoint will take using GPS. Figure 3.5 shows the Garmin GPS.

Figure 3.5: Garmin GPS

f) Measuring tapes

Measuring tape usually used to takes the measurement of lithology and structures at the study area. Figure 3.6 shows the measuring tape.

Figure 3.6: Measuring tape

g) Samples bags

Figure 3.7 shows the sample bag. Sample bag is used to collect rock sample or any sample required for research analysis with jot down the location and position of the samples.

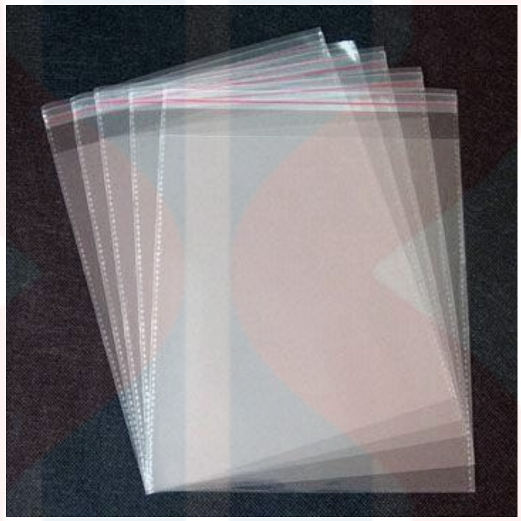

Figure 3.7: Sample bag

h) Acid bottles

Acid bottle is containing 10 % concentration of hydrochloric acid in order to detect presence of carbonate rocks. Figure 3.8 shows the acid bottles.

Figure 3.8: Acid bottles

i) Field notebook

Field notebook is use to note all important information during observation in the field such as sketches of outcrop, and other features related to field study. Figure 3.9 shows the field notebook that being used in this research to write down data and information.

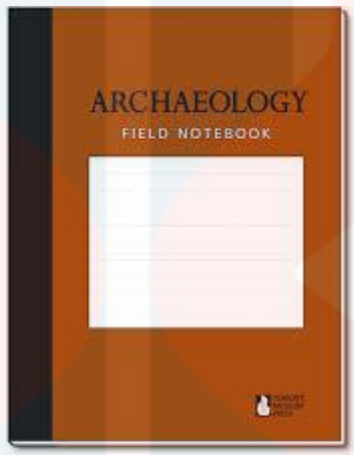

Figure 3.9: Field Notebook

j) Field camera

Camera is used to snap picture in the field. Figure 3.10 shows field camera that used to take picture of sampling, outcrop, landscape, and structure important to take with scale as evidence during writing and presentation.

Figure 3.10: Field camera

k) Stationary

In order to write in field note and on map, selection for appropriate stationary such as pen, pencil, marker and eraser are important. Figure 3.11 shows the stationary that used in this research.

Figure 3.11: Stationary

l) ArcGIS 10

ArcGIS 10 used to generate map the study area. Data from Global Positioning System (GPS) will transfer to the Geographical information System (GIS) to analysis. Several data such as coordinate, elevation, tracking routes and marking checkpoint will take using GPS. All data then will insert into GIS software called ArcGIS. Data will digitize using this software to produce geological, geomorphology, transverse and slope map. Figure 3.12 shows the ArcGIS 10.

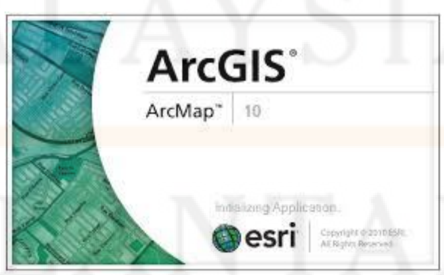

Figure 3.12: ArcGIS 10

3.3 Methodology

Field investigation is an important method that must be done in this research. Field investigation need to analyze the general geology of Padang Kuala Semor, Gua Musang. Field mapping are run in the first part of research focusing on the study area using base map of Padang Kuala Semor. The steps in field studies involve mapping, sampling, and recording data. Mapping of study area must be done to acquire geological data of studied area. These include the type of rock found, structural geology, and measurement of lineament in that particular area. Traversing using GPS has also been carried out. Strike and dip reading was obtained using a compass. The image for every rock samples and its outcrops in field were taken for study. The samples taken from field will be made into thin sections and later analyzed using microscope in the laboratory for petrologic test. The results from observations are important in determining the types of rock in the area.After the type of lithology is identified, the data will be inserted in ArcGIS for better understanding. Not only the lithology, field investigation for morphology, topography, drainage pattern and other geological structure will also be identified.

3.3.1 Preliminary studies

Preliminary studies is done to collect the data of the study area and to get a better understanding about the study. Besides that, preliminary studies also being done with going through the journal, books, thesis and previous report. Its show that there has a research has been carried out on fluvial geomorphology in different area. There a studies been carried out on karst geomorphology of Padang Kuala Semor, Gua Musang using Geographic Information System (GIS). GIS techniques are the proven efficient tools to produce karst geomorphologic map of Padang Kuala Semor. GIS technique also can used to identify the landform of the study area.

3.3.2 Field Studies

Two types of field studies used in this research that are geological mapping and geomorphological mapping. Geological mapping involves plotting the location and attitude of the various rock units, faults, and folds on a base map. Geologic maps are used to investigate geologic hazards, mineral resources, groundwater aquifers, and just plain science. Geological maps divided into four main groups. These are the reconnaissance maps which are made of regional geology, large-scale maps of limited areas, and maps made for special purposes. Small-scale maps covering very large regions are usually compiled from information selected from one or more of these groups. The data of the traverse then are recorded by using GPS before the data is transferred into the computer. The results that get after the geological mapping such as strike and dip, lithology boundaries was taken during the mapping time. The study area is 5km x 5km that have to be mapping.

Geomorphological mapping is carried out by doing observation and identification of karst landform/formation in the field. GIS software also used to help the interpretation from Goggle Earth and Google Maps. The karst/landform/identified in the study area such as surface karst, subsurface karst, and surficial landform .GPS used to as tools to provide reading such as of the latitude and longitude of Earth.

3.3.3 Laboratory work

Samples rock that was gathered will then further with petrography investigation by doing the slight area process. The thin section is slim cut of rock that mounted on the glass slide that was readied to examine the mineralogy synthesis. It is produced using little sections of a stone specimen stuck to a glass slide (~1 inch by 2 inches), then ground to a predefined thickness of 0.03mm (30 microns).At this thickness, the most mineral will then recognized their mineral on the grounds that it turned out to be pretty much straightforward and can then be concentrated on by a magnifying lens utilizing transmitted light. The recognizing process, for example, mineral sorts and the name of the stones will happen to utilize polarizing magnifying instrument as appeared as a part of Figure 3.13.

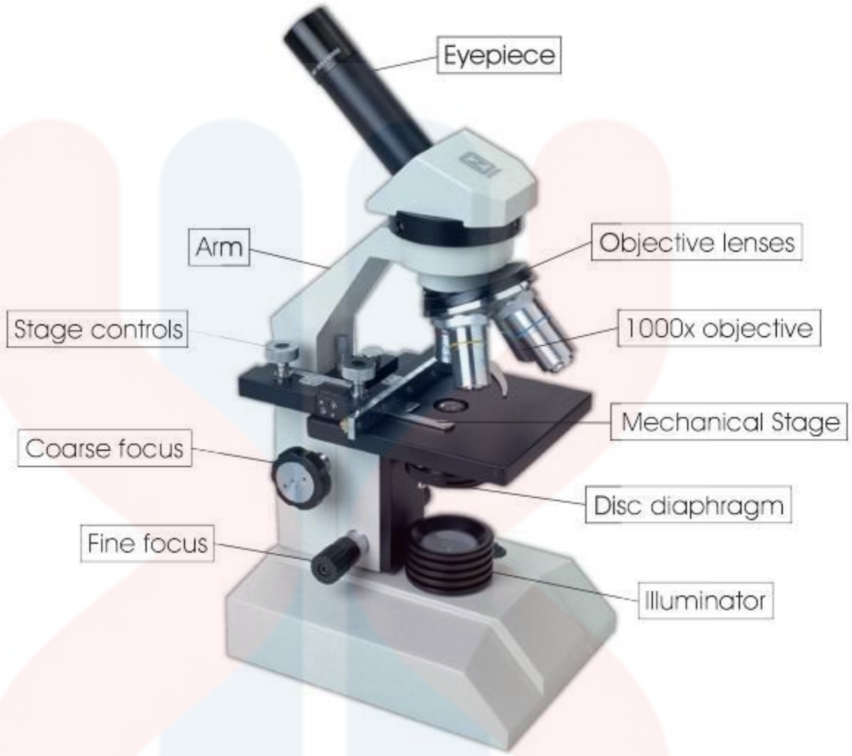

Figure 3.13: Microscope

(Sources: https://www.tes.com/lessons/YCmmWt39I4HrPQ/b1-01-using-a-microscope)

3.3.4 Data Analyses and Interpretations

Data analyses and interpretation are done by using GIS software. GIS is designed to retrieve, manage, store, display and analyse all the types of geographical and spatial data. The data is transferred into GIS software and GPS which analysed digital data in the form of digital maps and satellite images. The tool has been used to generate data and develop river drainage basin management strategies.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General Geology is involving the field survey of the composition, structure, physical properties, and history of Earth's components, and the processes by which they are shaped. It is typically study of rocks, so the study should focus on outcrops at Padang Kuala Semor and its nearby include part of Kampung Pulai because it is significant studies of general geology of the location.

4.2 Geomorphology

Geomorphology is the scientific study of the landforms of the surface of the Earth and includes the large scale landform. Geomorphology divided into two types that are landforms and landscapes. The definition for landforms are natural features of the landscape, natural physical features of the earth's surface, for example, valleys, mountains, plains, hills, and glaciers. The landforms came into existence due to natural processes such as wind, rain, weather conditions such as ice, frost and chemical actions and erosion. The various shapes of the land being created by natural events and disasters such as earthquake and eruption of volcanoes. Figure 4.1 shows the various types of landforms.

Figure 4.1: Types of landform

Landscape is a part of the Earth's surface. Landscape consists of a variety of geographical features that are characteristic of an area. Landscape is divided into two main categories that are natural and human. Human landscape is sometimes also referred to as cultural landscape. The types of landscape are desert landscape, riverine landscape, tropical rainforest landscape, karst landscape, mountain landscape, build landscape and coastal landscape.

4.2.1 Types of Weathering

Weathering process is the processes that act on the earth's surface that causes physical breakdown and chemical decomposition of geologic materials. Weathering is the fundamental process that shapes landforms. In the geological cycle it is the precursor to erosion, transport and sedimentation. Weathering also the principal agent in karst formation. It is also essential to soil and regolith development and in the alteration of monumental rocks (Turkington, 2005).Weathering processes, especially chemical weathering, produce highly weathered rock. Rock decomposition results from high precipitation and temperatures and the response of vegetation to these factor. Weathering processes can be divided into three types that physical, biological and chemical, and all of them can act simultaneously.

Mass wasting, which is sometimes called mass movement or slope movement, is defined as the large movement of rock, soil and debris downward due to the force of gravity. In other words, the earth's outer crust is being 'wasted' away on a 'massive' scale and falling to lower elevations. Mass wasting is a type of erosion and it is capable of making big changes to the side of a mountain. These changes can happen suddenly, as in one minute the rock is there and the next it is gone, or it can happen more slowly over time. Gravity is constantly trying to pull rock and debris down the slope of a mountain. At the same time, the resistive forces of the mountain, including the cohesive strength and internal friction between the materials, referred to as the mountain's shear strength, constantly pulls back against gravity. The shear strength works to maintain the slope's stability and keep the materials in place.

This is a lot like a mountain climber gripping onto the side of a mountain and resisting gravity. The climber uses his grip strength to resist gravity, like the mountain uses its shear strength. For instance, increased slope steepness increases mass wasting simply because the gravitational force acting on a steep slope is greater than the force acting on a gentle slope. Increasing the steepness of a slope is one way man can increase mass wasting. Increased water is another factor that plays an important role in mass wasting. Water can wash away small particles that help keep the mountainside intact. This is similar to what happens when a wave comes ashore and washes away a sandcastle. The abundant water breaks apart the small sand particles and destroys the structural stability of the castle you spent the afternoon building. In my area, the mass wasting occurred will caused the landslide. Figure 4.2 show type of landslide in the area and is rotational landslide.

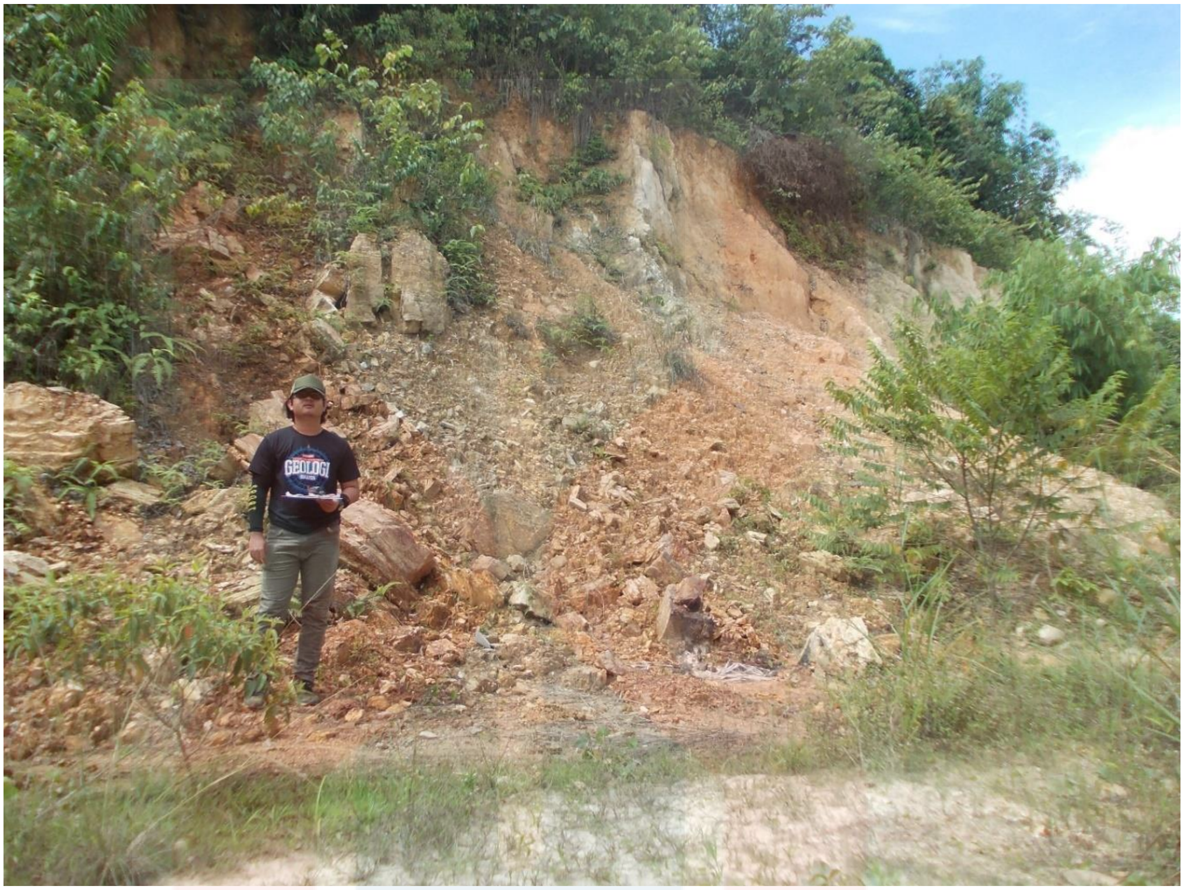

Figure 4.2: Mass Wasting (Landslide)

Erosion is the process by which soil and rock particles are worn away and moved elsewhere by gravity, or by a moving transport agent. Transport refers to the processes by which the sediment is moved along such as for example, pebbles rolled along a river-bed or sea shore, sand grains whipped up by the wind, salts carried in solution. Erosion involves removal of solid material by a transporting agent. Weathering is the breakdown of rock into fragments at the Earth's surface. No movement is involved in weathering. Deposition is the process by which sediment settles out of the water or wind that is carrying it, and is deposited in a new location.

Transportation of material in a river begins when friction is overcome. Material that has been loosened by erosion may be then transported along the river as shown in the Figure 4.3. There are four main processes of transportation. There are suspension, solution, saltation and traction. Suspension is when material made up of very fine particles such as clay and silt is lifted as the result of turbulence and transported by the river. Faster happen when the flowing, turbulent rivers carry more suspended material. Solution is when dissolved material is carried by a river. This often happens in areas where the lithology unit is limestone and is dissolved by slightly acidic water. Saltation is when material such as pebbles and gravel that is too heavy to be carried in suspension is bounced along the river by the force of the water. Traction is when large materials such as boulders are rolled and pushed along the river bed by the force of the river. Figure 4.3 shows the transportation process in Sungai Galas. When the rock being deposited, next it will transported. The size of the rocks that transported is in medium size. The figure shows the transportation happen at the middle of the sea, the water will flow beside the transportation area.

Figure 4.3: Transportation in Sungai Galas

4.2.1.1 Physical Weathering

Physical weathering is a term used in science that refers to the geological process of rocks breaking apart without changing their chemical composition. Over time, movements of the Earth and environment can break apart rock formations, causing physical weathering. Physical weathering can also refer to other things in the environment breaking down, like soil and minerals. Pressure, warm temperatures, water and ice can cause physical weathering. The rock for example, shale, is fissile and can be broken into slices. Figure 4.4 shows the result from physical weathering.

Figure 4.4: Physical weathering process

4.2.1.2 Biological Weathering

Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. Growing plant roots can exert stress or pressure on rock. Although the process is physical, the pressure is exerted by a biological process. Biological processes can also produce chemical weathering, for example where plant roots or microorganisms produce organic acids which help to dissolve minerals. Figure 4.5 shows the biological weathering by plants and figure 4.6 shows the root wedging.

Figure 4.5: Biological Weathering process

Figure 4.6: Root wedging

4.2.1.3 Chemical Weathering

Chemical weathering changes the composition of rocks, often transforming them when water interacts with minerals to create various chemical reactions. Chemical weathering is a gradual and ongoing process as the mineralogy of the rock adjusts to the near surface environment. New or *secondary minerals* develop from the original minerals of the rock. In this the processes of oxidation and hydrolysis are most important. Chemical weathering is enhanced by such geological agents as the presence of water and oxygen, as well as by such biological agents as the acids produced by microbial and plant-root metabolism.

The process of mountain block uplift is important in exposing new rock strata to the atmosphere and moisture, enabling important chemical weathering to occur; significant release occurs of Ca^{2+} and other ions into surface waters.

4.2.2 Topography

Topography of the study area can be represented by topographic map. Figure 4.7 shows the topographic map of the study area. Elevation of each contour is shown in the topographic map. The contour shows the lowest and highest elevation. The highest elevation in the study area is 460 metres and the lowest elevation is 120 metres. Figure 4.8 shows the highest elevation at the study area.

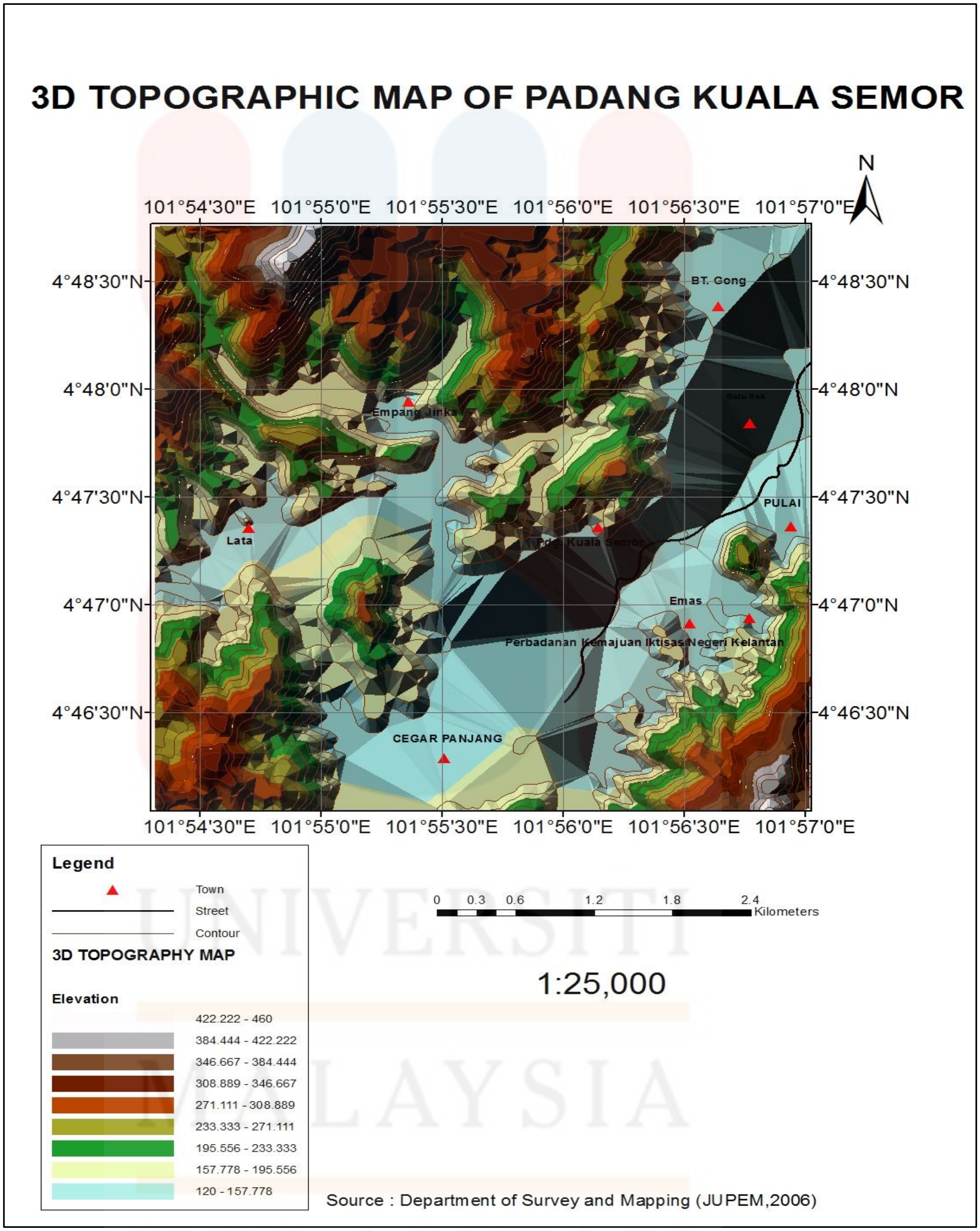

Figure 4.7: The topographic map of Padang Kuala Semor

Figure 4.8: The highest elevation at Padang Kuala Semor.

4.2.4 Landform

a) Hill

Hill is landform types that have very high relief more than 300m that have moderate slopes and erosional stream channel that form a dendritic tributary network. The elevation in the topographic map shows that the lowest elevation is 120 m and the highest elevation is 460 m. Figure 4.9 shows the karst hill that can see clearly from the area.

Figure 4.9: Hill Landform

b) Karst landform

A karst is an area of land formations created by eroding and dissolving portions of limestone or other soluble rock layers above or below the ground. Dissolving soluble rock can take place above and below the ground to create formations and changes in the landscape. Above ground formations may be weathered and shaped by wind, rain, waves and running water, as well as freeze-thaw erosion.

Where water collects on the surface, potholes in exposed rock layers can be formed by bacteria, fungi and algae that remove silica from rock minerals.

Soluble rock layers below the ground can be exposed to running water and collapse to form sinkholes and other changes in the landscape. A karst is where several or more of these changes occur in the same location to alter the appearance of the land. Figure 4.10 shows one of the karst hills that available in the area.

Figure 4.10: Karst Landform

c) Alluvial landform

While at the alluvium area, sedimentary rocks were found which are shale. The rocks that were found at the hilly area have high resistant to the weathering process and does not weathered easily compared to the rocks that were found at the alluvium area. Figure 4.11 shows the landform map of study area.

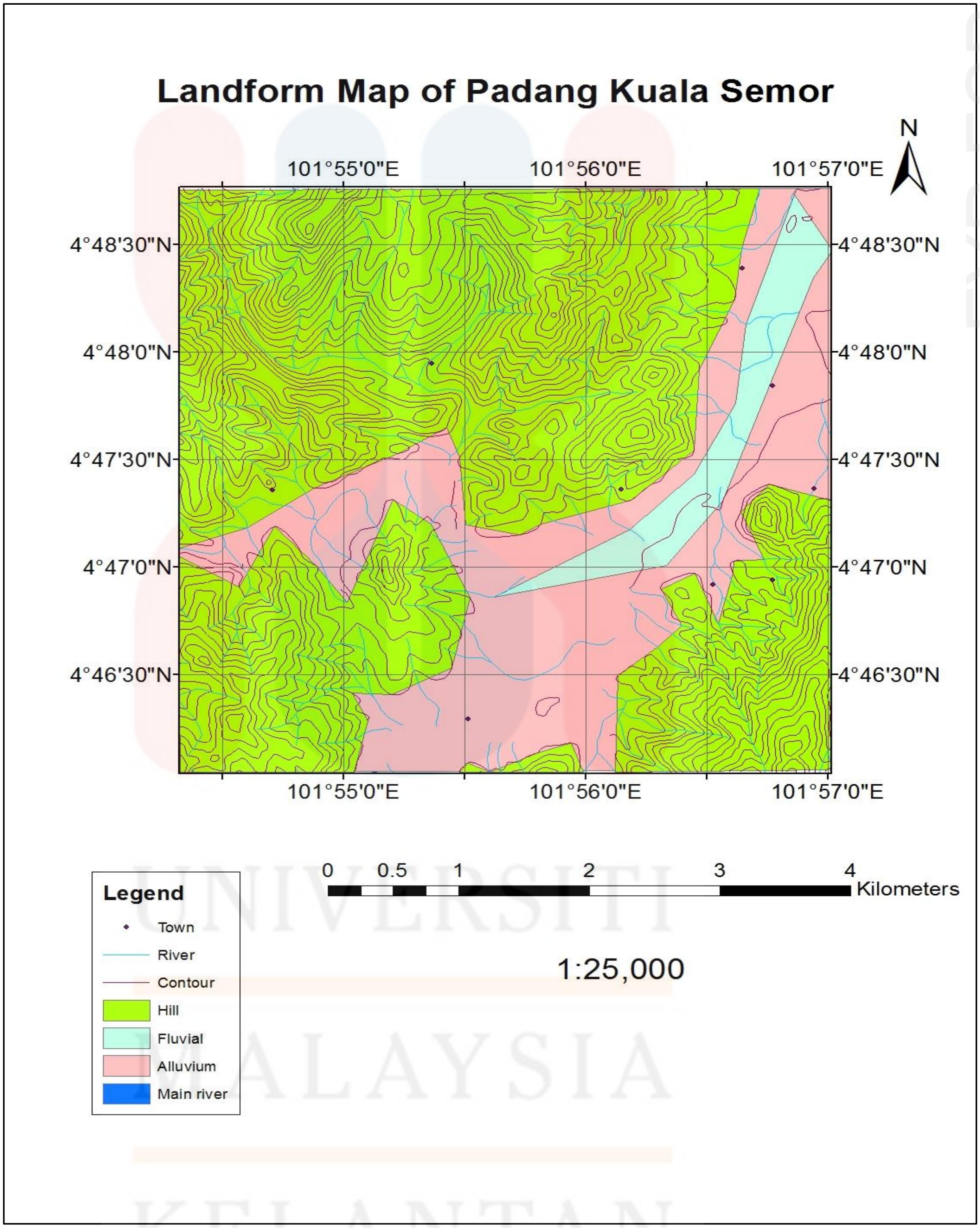

Figure 4.11: Landform Map of Padang Kuala Semor

4.3 Stratigraphy

Stratigraphy is a branch of geology which studies rock layers (strata) and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks. Stratigraphy has two related subfields, that are lithologic stratigraphy or lithostratigraphy, and biologic stratigraphy or biostratigraphy.

Variation in rock units, most obviously displayed as visible layering, is due to physical contrasts in rock type (lithology). This variation can occur vertically as layering (bedding), or laterally, and reflects changes in environments of deposition (known as facies change). These variations provide a lithostratigraphy or lithologic stratigraphy of the rock unit. Key concepts in stratigraphy involve understanding how certain geometric relationships between rock layers arise and what these geometries imply about their original depositional environment. The basic concept in stratigraphy, called the law of superposition, states: in an undeformed stratigraphic sequence, the oldest strata occur at the base of the sequence.Biostratigraphy is based on fossil evidence in the rock layers. Strata from widespread locations containing the same fossil fauna and flora are said to be correlate able in time. Biologic stratigraphy was based on William Smith's principle of faunal succession, which predated, and was one of the first and most powerful lines of evidence for, biological evolution. It provides strong evidence for the formation (speciation) and extinction of species. The geologic time scale was developed during the 19th century, based on the evidence of biologic stratigraphy and faunal succession. This timescale remained a relative scale until the development of radiometric dating, which gave it and the stratigraphy it was based on an absolute time framework, leading to the development of chronostratigraphy. Figure 4.12 shows geological map in the study area.

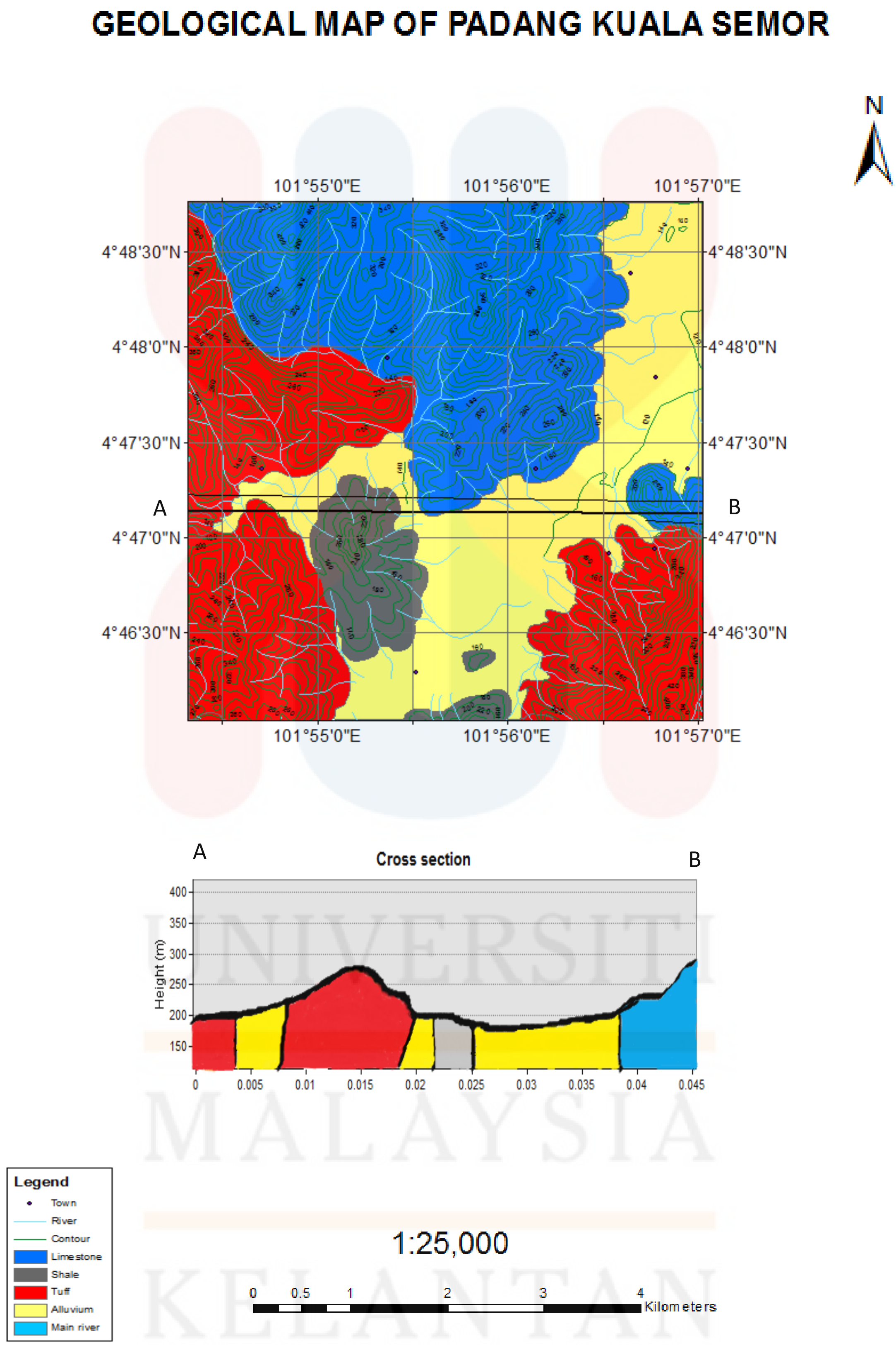

Figure 4.12: Geological Map

4.3.1 Stratigraphic Column

Table 4.1: Lithostratigraphy column

<table>
<tr><th>Era</th><th colspan="2">Period</th><th>Lithology unit</th><th>Formation</th></tr>
<tr><td>Cenozoic</td><td colspan="2">Quaternary</td><td>Alluvium</td><td rowspan="5">GUA MUSANG FORMATION</td></tr>
<tr><td rowspan="2">Mesozoic</td><td>middle</td><td rowspan="2">Triassic</td><td rowspan="2">Limestone, shale, Tuff</td></tr>
<tr><td>early</td></tr>
<tr><td rowspan="2">Palaeozoic</td><td>late</td><td rowspan="2">Permian</td><td>Shale</td></tr>
<tr><td>middle</td><td>Limestone with some shale</td></tr>
</table>

Based on the Table 4.1, the oldest rock age in range middle Permian period that is limestone. Then during period of late Permian, Shale starts to develop. In period of Triassic the development of limestone. Shale and tuff begin. Any loose sediment and clay that found at river and stream area is in the age of Quaternary deposit.

4.3.2 Lithology

a) Limestone

Limestone is a sedimentary rock, composed mainly of skeletal fragments of marine organisms such as coral, forms and molluscs. Its major materials are the minerals calcite and aragonite, which are different crystal forms of calcium carbonate ($CaCO_3$).About 10% of sedimentary rocks are limestones. The solubility of limestone in water and weak acid solutions leads to karst landscapes, in which water erodes the limestone over thousands to millions of years. Most cave systems are through limestone bedrock. Figure 4.13 shows the outcrop of the limestone in form of karst. Figure 4.14 shows the hand sample of the limestone and figure 4.15 its thin section observe by the microscope under magnification of 4x10. In this area there are also found fossils in one of the karst. Figure 4.16 shows the image of the fossils that are found lies on the limestone. It is believed that the fossils are bivalve that are being recorded found in lithology unit of shale in Telong formation. Since the formation of Gua Musang have similarity with the Telong formation, so it can be conclude that the fossil are the same that is species named *Claraia greisbachi concentrica*. The species live in early Triassic age. The same fossils can also be found in Sg Aring, Gua Musang, and Kelantan.

Figure 4.13: Limestone karst outcrop

Figure 4.14: Hand sample of limestone

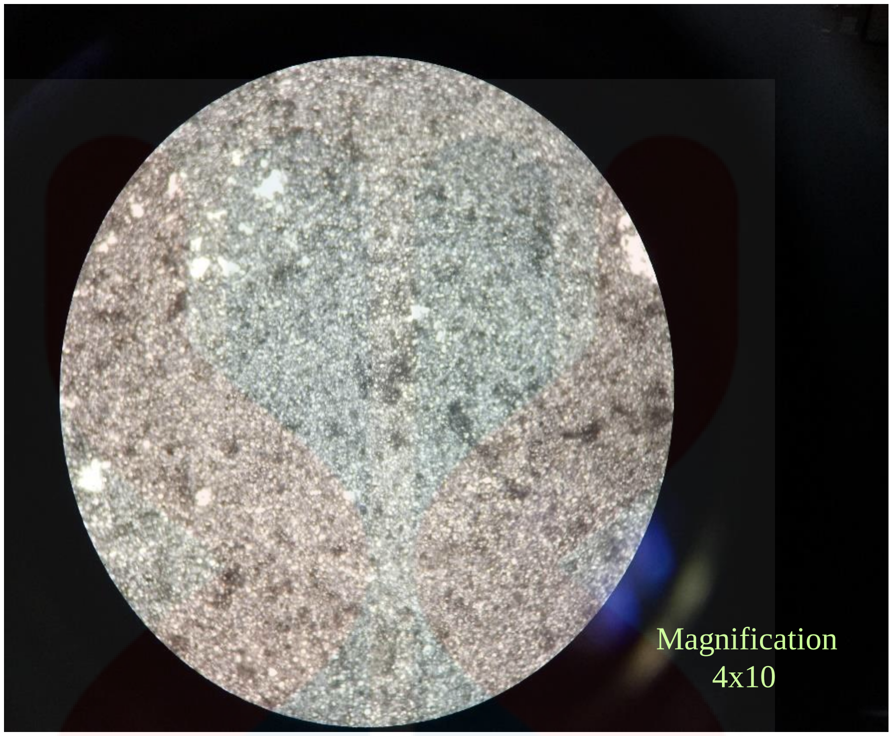

Figure 4.15: Thin section of limestone

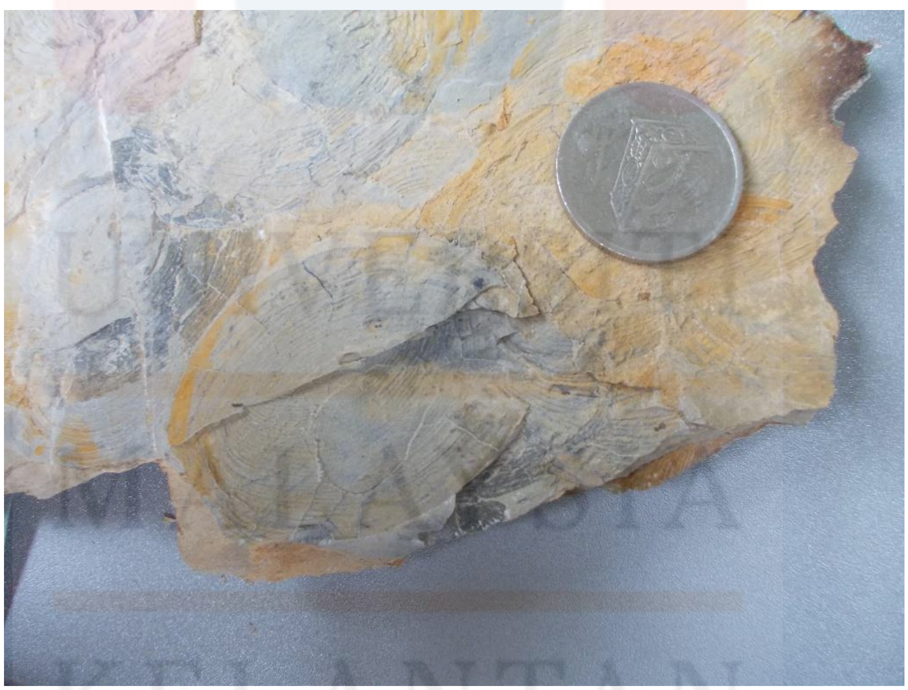

Figure 4.16: Fossil on limestone

b) Shale

The thin sections were observed under microscope. Do not have any mineral in the thin section, but shale always have calcite and quartz mineral. From the mapping, three samples of shale were collected from the study area. It can be conclude that the study area were mostly covered by shale since all the three samples collected in different location were the same type of rock. Mostly the outcrops were weathered since the outcrops overlain with weathered soil and contact with river water. The color of shale is black. Figure 4.17 shows the checkpoint for the sample of shale that has been taken on the lithology map, figure 4.18 shows the sample of shale and figure 4.19 shows the thin section of the sample.

Figure 4.17: Outcrop of shale

(Coordinate: N 04º 56’ 20.3”, E 101º55’54.0”)

Figure 4.18: The sample of shale

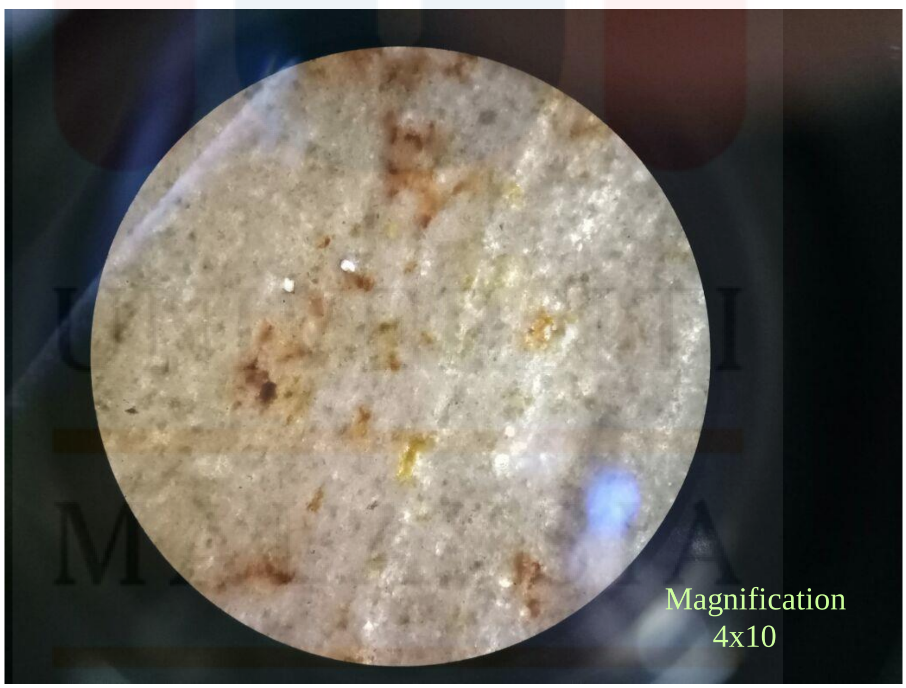

Figure 4.19: Thin section of shale

c) Tuff

Tuff is an igneous rock that forms from the products of an explosive volcanic eruption. In these eruptions, the volcano blasts rock, ash, magma and other materials from its vent. This ejecta travels through the air and falls back to Earth in the area surrounding the volcano. If the ejected material is compacted and cemented into a rock, that rock will be called "tuff". Figure 4.20 shows the outcrop from the checkpoint in the study area. Figure 4.21 shows the sample of tuff and figure 4.22 shows the thin section of tuff.

Figure 4.20: Outcrop of tuff

(Coordinate 04º 46' 36.7", E 101º 56'19.3")

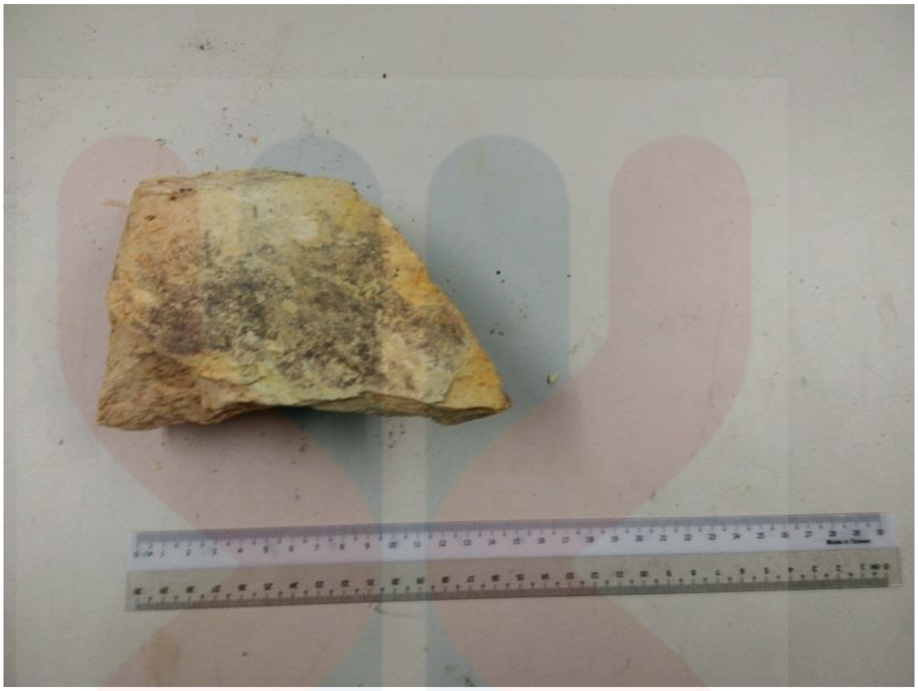

Figure 4.21: Sample of tuff

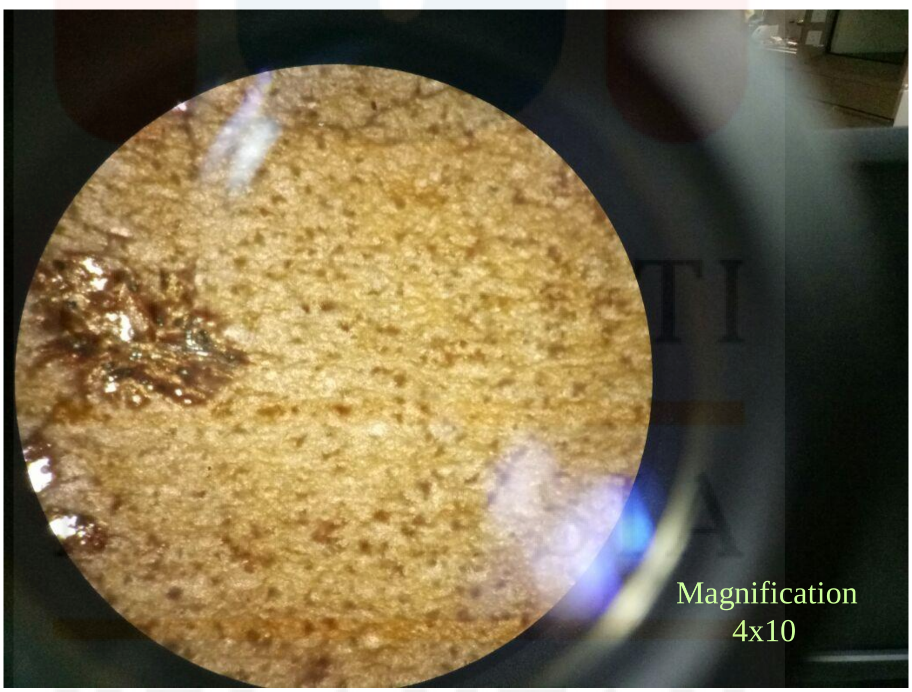

Figure 4.22: Thin section of tuff

4.3 Structural Geology

Structural geology is a branch of geology that deals with the form, arrangement, and internal structure of rocks. The primary goal of structural geology is to use measurements of present-day rock geometries to uncover information about the history of deformation (strain) in the rocks, and understand the stress field that resulted in the observed strain and geometries. This understanding of the dynamics of the stress field can be linked to important events in the regional geologic past. Common goal is to understand the structural evolution of a particular area with respect to regionally widespread patterns of rock deformation due to plate tectonics.

4.4.1 Crack Analysis

Crack analysis of the position N04°47'36.2", E101°56'31.4" with elevation 134 meter, and the data in table 4.2 had been collected during mapping. Figure 4.23 was shown the outcrop whereby 100 reading of crack were taken for making an interpretation of crack analysis. The strike of the crack of the rock unit has been collected and being interpreted by using rose diagram whereby it presents the directions of strike which shows in Figure 4.24. Table 4.3 shows the frequencies of the crack readings.

The maximum of rose petals direction shows the maximum tensions that occur. The tension occurs due to the force applied on the two directions as shown on the figure respectively. The rose diagram shows that the maximum rose petal directions on north-west (NW) and south-east (SE).

Table 4.2 shows the data of crack of the rock unit

324°	219°	118°	282°	338°	122°	89°	265°	177°	187°
311°	221°	114°	279°	339°	109°	98°	258°	167°	160°
317°	76°	112°	273°	330°	110°	234°	271°	181°	158°
337°	69°	114°	183°	332°	346°	243°	294°	184°	132°
334°	73°	112°	286°	336°	310°	262°	275°	186°	130°
333°	87°	111°	232°	349°	332°	258°	249°	192°	205°
335°	67°	255°	252°	344°	322°	270°	181°	195°	298°
316°	105°	246°	337°	338°	287°	267°	191°	194°	280°
326°	108°	277°	342°	250°	285°	270°	181°	169°	302°
313°	112°	273°	333°	123°	227°	266°	197°	183°	300°

Table 4.3 shows the frequencies of the crack of the rock unit

0°-10° (181°-190°)	8
11°-20° (191°-200°)	5
21°-30° (201°-210°)	1
31°-40° (211°-220°)	1
41°-50° (221°-230°)	2
51°-60° (231°-240°)	2
61°-70° (241°-250°)	6
71°-80° (251°-260°)	6
81°-90° (261°-270°)	8
91°-100° (271°-280°)	8
101°-110° (281°-290°)	8
111°-120° (291°-300°)	10
121°-130° (301°-310°)	5
131°-140° (311°-320°)	5
141°-150° (321°-330°)	4
151°-160° (331°-340°)	14
161°-170° (341°-350°)	6
171°-180° (351°-360°)	1

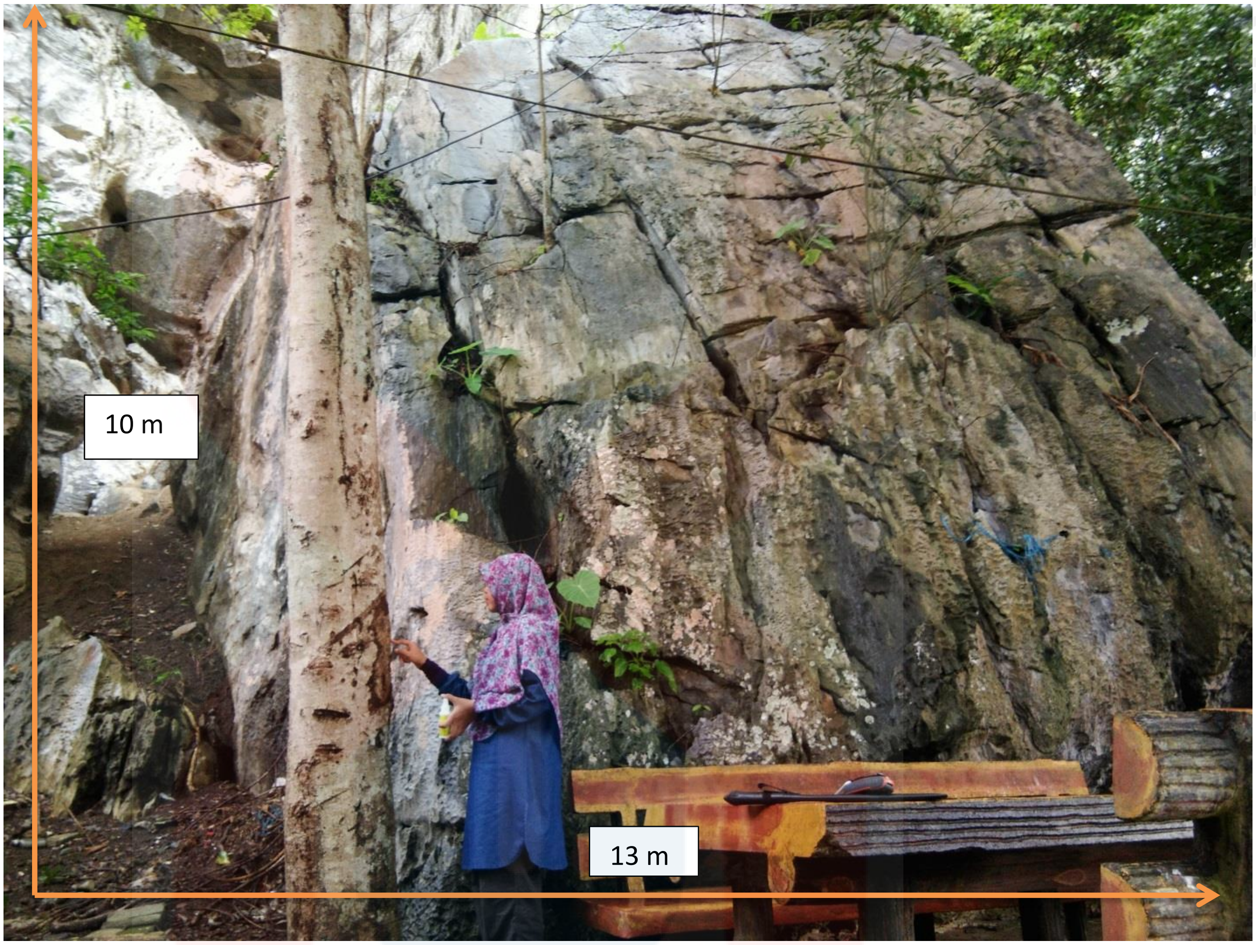

Figure 4.23: Outcrop whereby 100 reading of crack were taken for crack analysis

Coordinate:

N 04°47’36.2”

E 101°56’31.4”

Elevation: 134 m

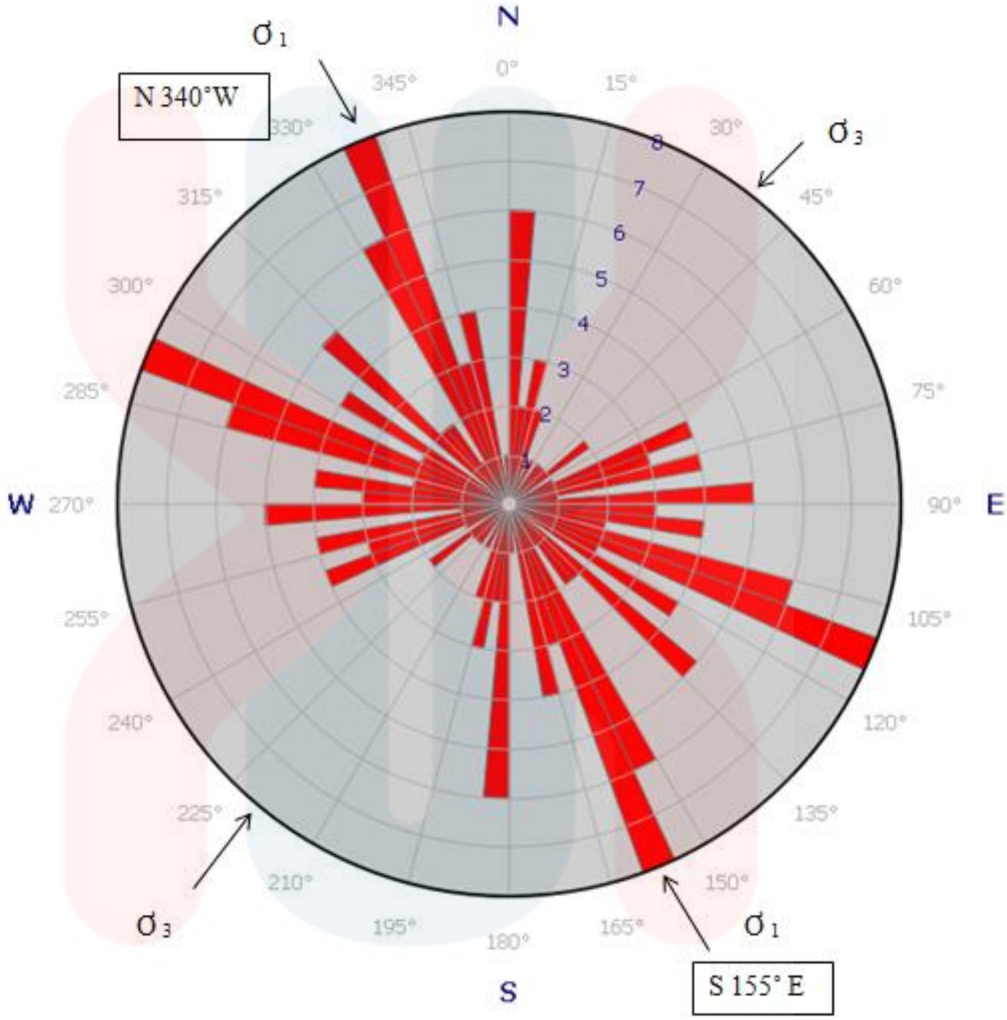

Figure 4.24: force direction

The σ_1 which is the main force of deformation are from S 155° E and N 340° W. While σ_3 which is the minor force of deformation are from N 35° E and S 220° W.

4.4.2 Lineament Analysis

Lineament is a linear feature in a landscape which is an expression of an underlying geological structure such as a fault. Fracture zones, shear zones and igneous intrusions such as dykes can also give rise to lineaments. Positive and negative lineaments are often apparent in geological or topographic maps and can appear obvious on aerial or satellite photographs. Lineament divided into two that are positive lineament and negative lineament. Figure 4.25 shows the positive lineament. Figure 4.26 shows the lineament map of the area.

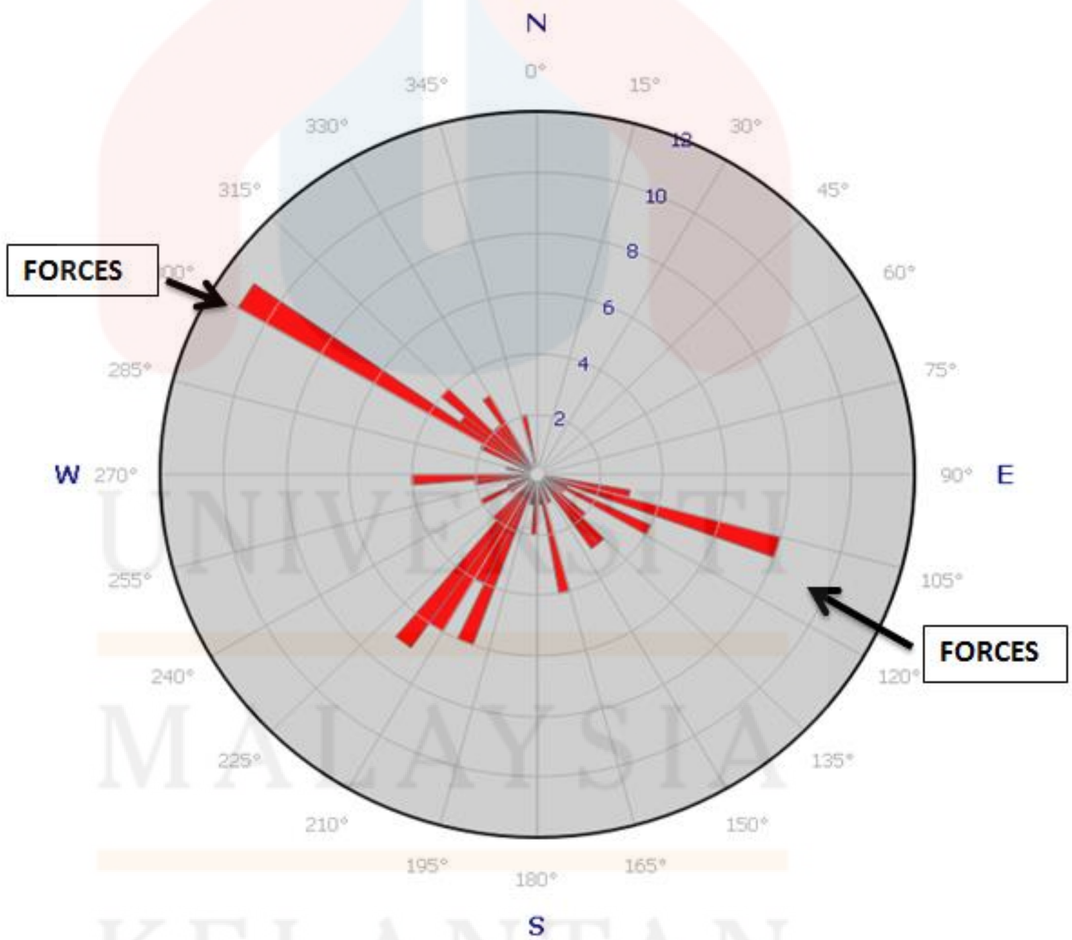

Figure 4.25: Positive lineament

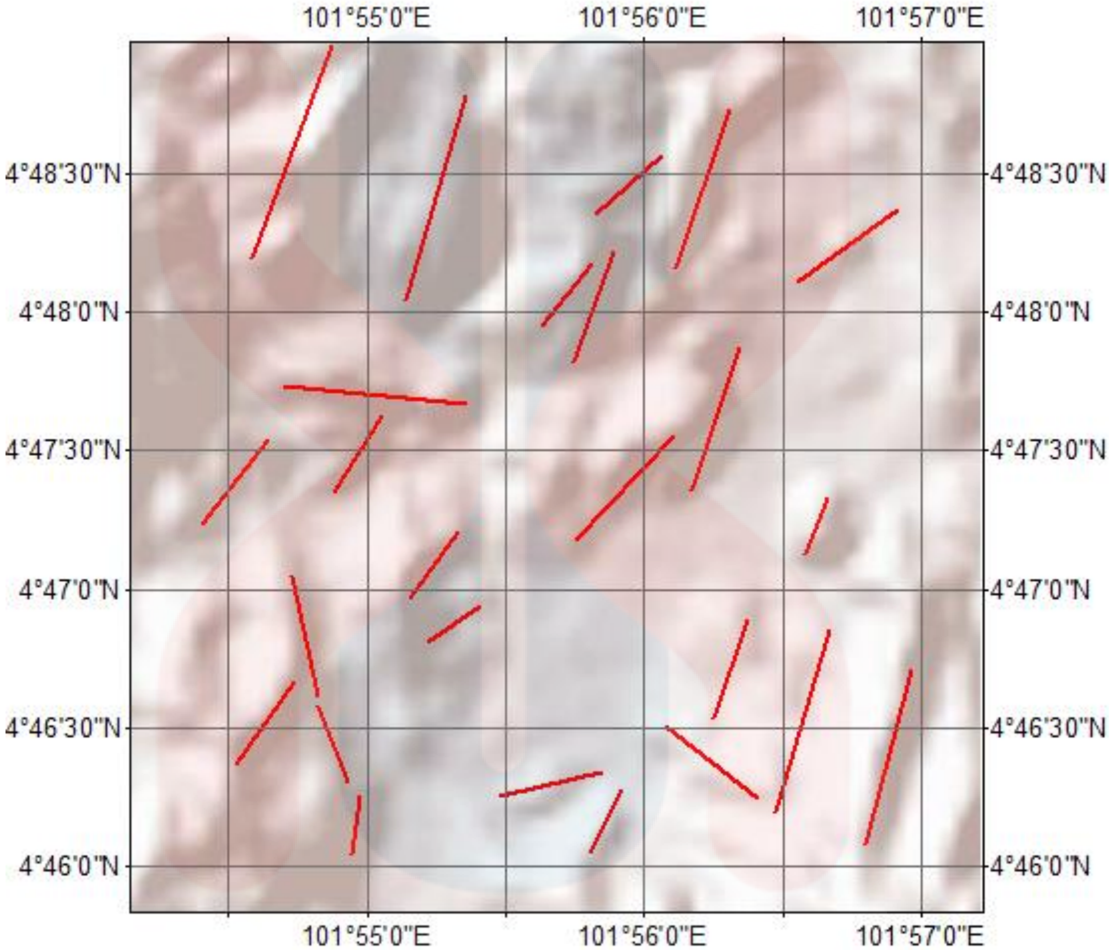

Figure 4.26: Lineament Map

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

Karst landforms are produced by weathering and erosion in region of carbonate rocks and evaporate. Karst landscape can be categorized as fluted and pitted surface, sinkholes, sinking streams, springs, subsurface drainage systems and caves .The process involved are defines as karstification and happened mainly below the ground surface. Figure 5.1 shows view of the typical karst landscape.

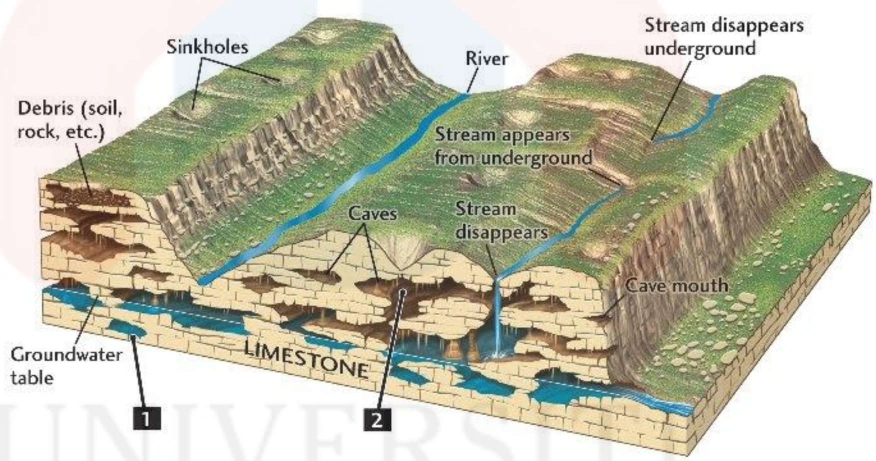

Figure 5.1: Typical Karst Landscape

(Source:http://iasmania.com/karst-topography-limestone-chalk/)

5.1.1 Condition Contribute to the Development of Karst

Few conditions that contribute to the development of karst formation/landscape that are soluble rock, dense rock, high hydraulic gradient, high rainfall, high biological activity, warm temperature, pressure and mixing of carbonate waters. Present of soluble rock at or near the surface such as dolomite and limestone. Dense rock which is highly jointed. The solution must facilitated by the concentration of groundwater along joint. High hydraulic gradient will produced by steep topography rivers. Water will corrodes for moving water much faster than standing water.

High rainfall distributions will supply more water and will produce more solution. High biological activity happen when the present of algae, plants and lichen for example will increase the amount of carbonic acid that enter the groundwater system. Warm temperatures divided into two types that are high temperature and low temperature. Biochemical activity will increase if the temperature is higher and will formed CO_2 and organic acids. The dissolution became less if the temperature is lower because less present of CO_2 to dissolve in water.

When water is under pressure, it can dissolve more CO_2 that holding more $CaCO_3$ in solution.$CaCO_3$ will formed travertine when the pressure is released. Mixing of carbonate water is a nonlinear relationship exists between Ca^{2+} and CO_2, an under saturated, aggressive body of water is produced by the mixing of two saturated water bodies

5.1.2 Climate and Karst

Polar regions, cold humid mid-latitudes, sub humid and semiarid steppe and savanna grasslands and also tropical rainforest are types of climate. Malaysia can be categorized as tropical rainforest. Karst is well developed in tropical rainforest because the amount of rain is very high. High concentration of organic acid and CO_2 happen because of the warm temperature and thick vegetation on Malaysia.

5.2 Different types of Karst Formation/Landform

Refer to figure 5.2 shows the picture on the surface of karst.

Figure 5.2: Limestone hill at Padang Kuala Semor

Karst topography most likely to occur in the humid environments. Area which have humid climates have very large amount of flowing water. Two types of humid that are the humid temperature and the humid tropical. Hills are the most dominant topography in humid tropical climates.

a) Conical hill

Figure 5.3: Conical hill karst at Padang Kuala Semor

Figure 5.3 shows the conical hill at the study area. The type of hills that has been found in the study area is conical hill. Conical hill is a landform with a distinctly conical in shape. It is usually isolated or rises above other surrounding foothills, and is often, but not always, of volcanic origin. Conical hill usually isolated or rises above other surrounding foothills, and is often, but not always, of volcanic origin. Conical hills or mountains occur in different shapes and are not necessarily geometrically and have shaped cones but some are more tower-shaped or have an asymmetric curve on one side.Figure 5.4 shows conical hills by using Google Earth.

Figure 5.4: Conical hills karst using Google Earth

b) Mogotes hill

Figure 5.5: Mogotes hill at the study area.

Figure 5.5 shows the mogotes hill at Padang Kuala Semor. Mogotes hill are isolated hill that surrounded by nearly flat area. Rounded, tower like form and steep- sided hills composed of either limestone, marble or dolomite. Figure 5.6 shows mogotes hill using Goggle Earth.

Figure 5.6: Mogotes hill by using Goggle Earth

5.2.1 Subsurface Karst

a) Cave deposit

Speleothem also name of cave deposit. Cave deposits are any of the crystalline deposits that form after the creation of the cave by itself. Figure 5.7 shows the cave that found in the area. When water encounter the cave air, then the carbon dioxide carried in the water is released. This happens to reduce the capacity of water to hold the calcite in solution and causes the calcite to be deposited. The location and pattern of formation present in the cave passage records the water flow paths. Types of deposit found in the cave of the study area that are columns or pillar, stalactites and flowstone.

Figure 5.7: Cave form in karst

b) Columns

Column is an upright pillar, typically cylindrical and made of stone or concrete, supporting an entablature, arch, or other structure or standing alone as a monument. Figure 5.8 shows the column found inside the cave.

Figure 5.8: Column

c) Stalactites

Stalactites hanging from the ceilings of caverns commonly exhibit a central tube or the trace of a former tube whose diameter is that of a drop of water hanging by surface tension. It is form due to accumulation of $CaCO_3$ and has a shape like a curtain hanging from the roof to the floor of the cave. Stalactites formed when a drop on the tip of a growing stalactite leaves a deposit only around its rim. Besides that, the downward growth of the rim makes the tube. Figure 5.9 shows the stalagtite.

Figure 5.9: Stalactites

d) Stalagmite

This stalagmite formation occurs only under certain pH conditions within the underground cavern. They form through deposition of calcium carbonate and other minerals, which is precipitated from mineralized water solutions. Limestone is the chief form of calcium carbonate rock, which is dissolved by water that contains carbon dioxide, forming a calcium bicarbonate solution in underground caverns. If stalactites grow long enough to connect with stalagmites on the floor, they form a column.

Stalagmites should normally not be touched, since the rock buildup is formed by minerals precipitating out of the water solution onto the existing surface; skin oils can alter the surface tension where the mineral water clings or flows, thus affecting the growth of the formation. Oils and dirt from human contact can also stain the formation and change its color permanently. Figure 5.10 shows the stalagmite inside the cave.

Figure 5.10: Stalagmite

e) Flowstone

Flowstones are composed of sheet like deposits of calcite formed where water flows down the walls or along the floors of a cave. This is the basic mechanism forming stalagmites as well and the two often form together. They are typically found in "solution", or limestone caves, where they are the most common speleothem. May form in any type of cave where water enters that have picked up dissolved minerals. Continuous flowstone deposits may cover vast areas of a cave floor or flow for hundreds of vertical feet down. Figure 5.11 below shows the highest flowstone found inside the cave.

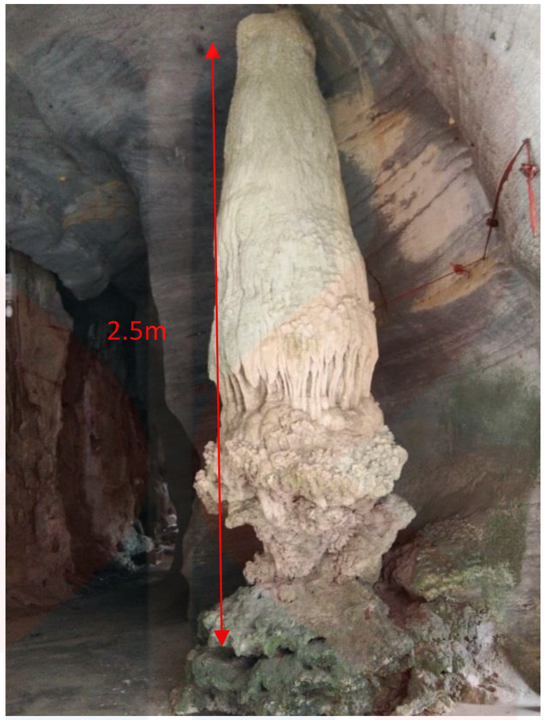

Figure 5.11: Flowstone

5.2.2 Surficial Landform

Three types of surficial landforms that are the closed depressions, karst valleys and minor solution features. Karst valleys are divided into four types that are allogenic valleys, blind valley dry valley and pocket valley. The example of closed depression is dolines, solutional collapse such as uvalas and poljes, and sinkholes. The third surficial landforms are minor solution features such as karren. Karren is the types of surficial landform that found in the study area. Figure 5.12 shows the rillenkarren at the study area. Karren is small scale solutional features and sculpturing found on limestone and dolomite surface based on (John, 2007).Figure 5.13 shows the geomorphological map.

Figure 5.12: Rillenkarren

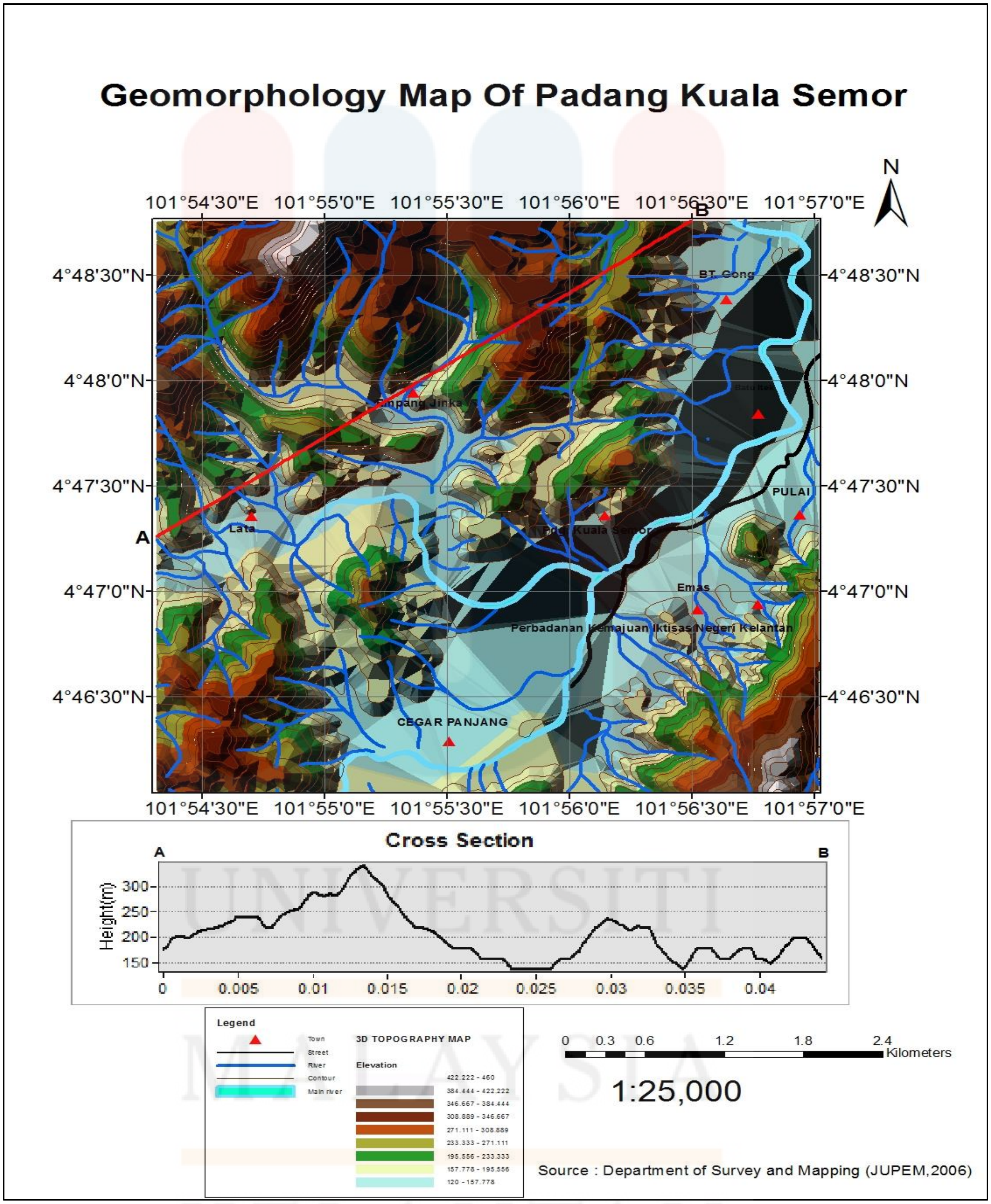

Figure 5.13: Geomorphology Map of Padang Kuala Semor

CHAPTER 6

6.1 Conclusion

As a conclusion, karst formation/landform in Padang Kuala Semor can be divide into three types that are surface karst such as conical hill and mogotes hill ,subsurface karst for example caves and its features ,lastly the surficial landform such as karren. Limestone in this area has eroded and weathered thus forming a unique karst formation /landforms at Gua Musang. Software ArcGIS being used in this research to identify karst landform such as mogotes, conical hill karst and to interpret the landform from the Google Earth is really beneficial. It so hard to identify the landform of the karst without ArcGIS. Karst formation /landform are very beneficial in tourism sector because it promises an exciting view resulted from the effects of dissolution of water on the soluble rocks. Geomorphological map has been produced can be used by the authorities in land planning or manage the water resources. We can also refer the geomorphological map to know the hazard such as sinkholes because sinkhole is categorized as one of the hazard in karst regions. Lastly, because of many karst formation/landform, it is so suitable for geology students to study geomorphology.

6.2 Suggestion

The studies on karst geomorphology in Gua Musang for specific study area that is Padang Kuala Semor should be reviewed an ongoing basis because high rates of erosion and weathering occur in Gua Musang. The erosion and weathering process will resulted the formation of new karst formation/landform and it will destroyed the karst formation /landform that have been present. For my suggestion, to used other method other else than ArcGIS software only to know the karst formation /landform. Apart from that, proper planning on geomorphological mapping must be done in future research to make sure the accuracy of data in identified the karst formation/landforms.

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