Geology and Karst Geomorphology of Kampung Gua Air, Gua Musang, Kelantan

by

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APPROVAL

“I/ We hereby declare that I/ we have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honors”

Signature : ……………………………........

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DECLARATION

I declare that this thesis entitled Geology and Karst Geomorphology of Kampung Gua Air, 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.

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GEOLOGY AND KARST GEOMORPHOLOGY OF KAMPUNG GUA AIR, GUA MUSANG, KELANTAN

ABSTRACT

Geological and geomorphological mapping has been used in the process of identifying the karst geomorphology. The study area is located in Kampung Gua Air, Kelantan Gua Musang. The main objective of this study is to update the geological map in the study area and to identify the karst geomorphology of the earth. Geological mapping was conducted in the study area to determine the geology of the study area and to conclude the formation of the study area. The study area is under the Gua Musang formation based on the type of rock found. There are several types of karst that have been identified in Kampung Gua Air namely caves, spleothems, dissappearing streams, towers and many more. Some of the methods that used to study the karst towers are by using the Google Earth and also the Arcscene.

GEOLOGI DAN KARST GEOMORPHOLOGI DI KAMPUNG GUA AIR,

GUA MUSANG, KELANTAN

ABSTRAK

Pemetaan geologi dan geomorfologi telah digunakan dalam proses mengenal pasti bentuk muka bumi karst. Kawasan kajian ini terletak di Kampung Gua Air, Gua Musang Kelantan. Objektif utama kajian ini adalah untuk memperbaharui peta geologi di kawasan kajian, untuk mengenal pasti bentuk bumi karst. Pemetaan geologi telah dijalankan di kawasan kajian untuk menentukan geologi kawasan tersebut dan membuat kesimpulan tentang formasi pembentukan kawasan tersebut. Kawasan kajian dikatakan termasuk dalam formasi Gua Musang berdasarkan jenis batu yang ditemui. Terdapat beberapa jenis bentuk muka bumi karst yang telah dikenal pasti di Kampung Gua Air iaitu gua, ‘spleothems’, sungai yang hilang, menara dan banyak lagi. Beberapa cara digunakan untuk mengkaji menara karst antaranya dengan menggunakan Google Earth dan juga Arcscene.

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CHAPTER 1

INTRODUCTION

1.1 General Background

Kampung Gua Air is located in the Mukim Pulau Stelu, Gua Musang District and close to Gua Musang Town. Kampung Gua Air is near the road of Jalan Jelawang-Gua Musang. This research is proposed to do the geological mapping and karst geomorphology of Kampung Gua Air.

Karst is characterized 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 and William, 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 Study Area

1.2.1 Location

The study are is located in the latitude between 5°3'22.683"N and 5°0'41.586"N and the longitude between 101°54'55.2"E and 101°57'38.593"E. It covers an area of about 5 × 5 km. The highest elevation in the study area is 580 meter and the lowest elevation is 80 meter. In Figure 1.1 shows the location map of the study area while the Figure 1.2 shows the basemap of the study area.

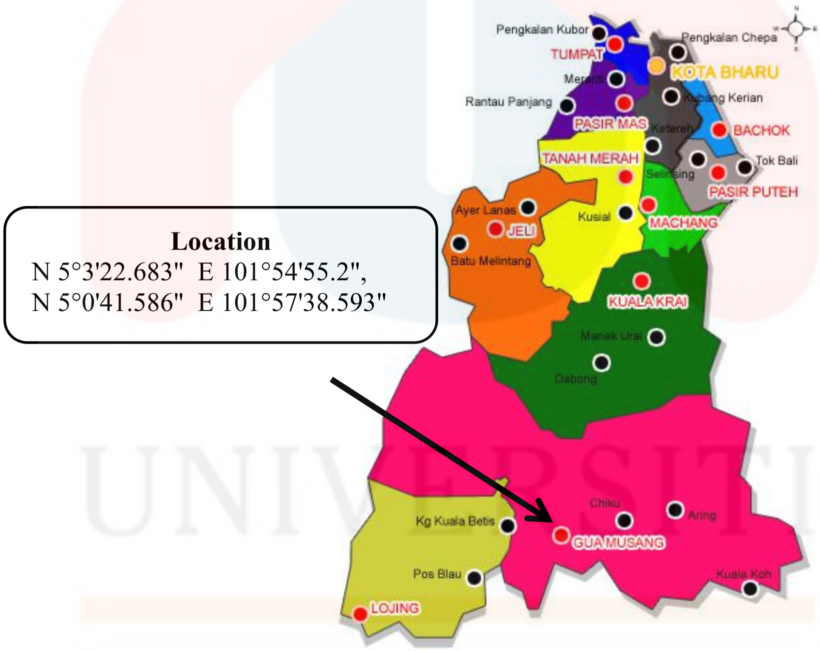


Figure 1.1 : Location map of the study area (Office Director of Land and Mines of Kelantan, 2016)

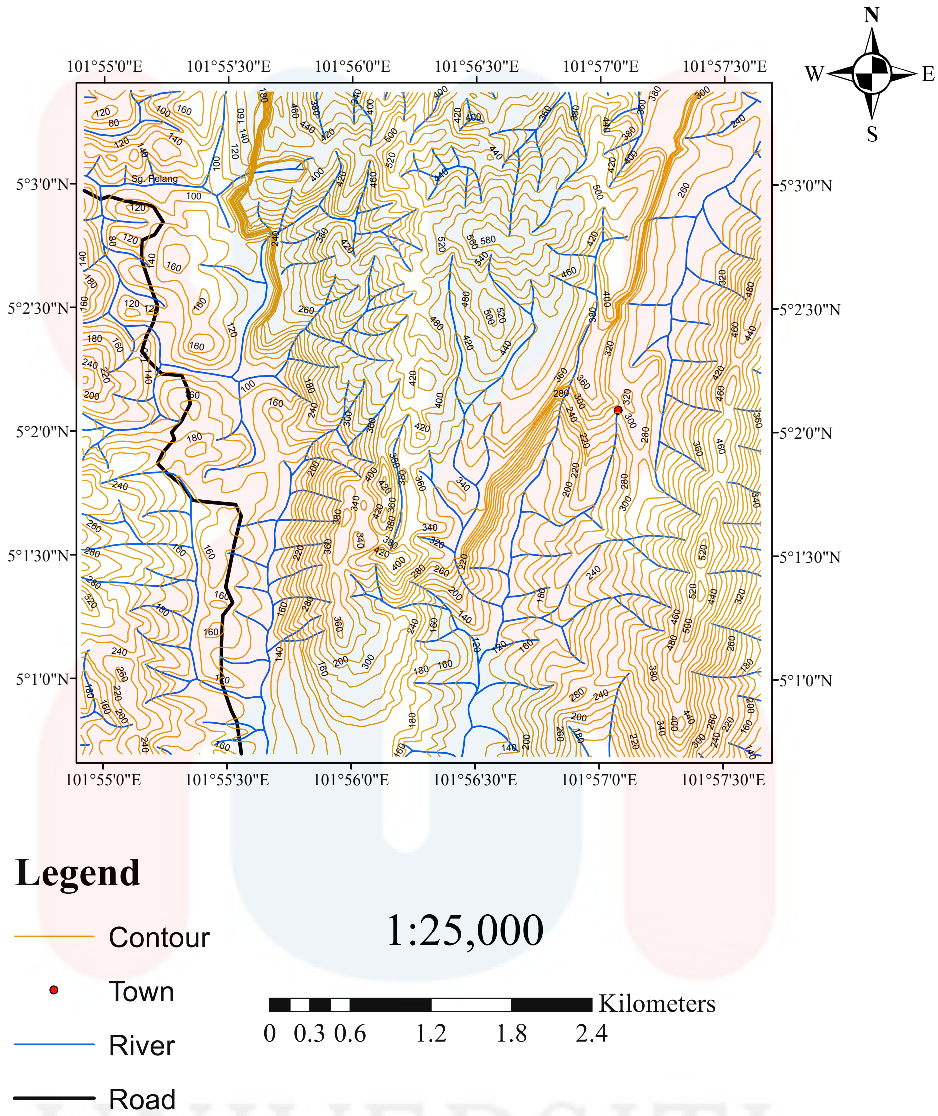


Figure 1.2 : Basemap of the study area

1.2.2 Road connection / Accessibility

Kampung Gua Air is located in the Mukim Pulau Stelu, Gua Musang District and close to Gua Musang Town. Kampung Gua Air is near the road of Jalan Jelawang-Gua Musang. The study area can be reach by going from Jeli through Jalan Sungai Sam, Dabong , Jeli/Laluan 66 dan Jalan Jelawang- Gua Musang. It is for about 1 hours 13 minutes and around 110.8 kilometers by using a car. After reach the Jalan Jelawang- Gua Musang, the unpaved road need to go through in order to reach the study area. The unpaved is about 7 km and for about 20 minutes. The accessibility of the study area is quite difficult because it do not consist of main road and only consist of unpaved road in order to reach the study area. 4x4 car need to be used.

1.2.3 Demography

Gua Musang District is located in the south of Kelantan and separated from the central state administration in Kota Bharu. This area was placed under the administrative centre of Ulu Kelantan District covering Kuala Krai and Gua Musang before 1976. Kuala Krai was the administrative centre at that time. In 1976, Gua Musang sub-district was changed to full-district and it was the ninth district in Kelantan. In this area, most of people distributions are from the settler community own by the two larger agencies which is FELDA and KESEDAR.

The total population of Gua Musang is 86,189 peoples which are divided into two gender which are males and females. Males are 46,359 peoples while females are 39,830 peoples as shown in the Figure 1.3. The ethnic in Gua Musang are divided into Malay, Chinese, Indian and others. Malay & other indigenous (Bumiputera) are 76,823 peoples, Chinese are 3,870 peoples, Indian are 350 peoples and other are 161 peoples as shown in Figure 1.4. The age distribution of peoples in Gua Musang are divided into three categories which are 0-14 years, 15-64 years and 65 and above as shown in Figure 1.5. The total of people which the age of 0-14 years are 30,389 peoples while the total of people which the age of 15-64 years are 53,458 peoples. Next, the total population of people which the age of 65 and above are 2,342 peoples. The population of people in the study area is quite little because it is located inland.

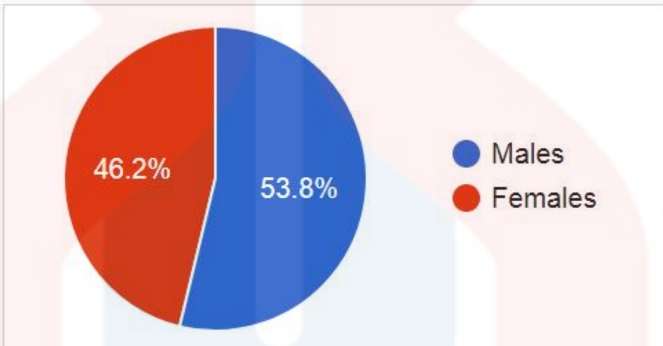


Figure 1.3 : Percentage of gender in Gua Musang (Department of Statistics Malaysia, 2010)

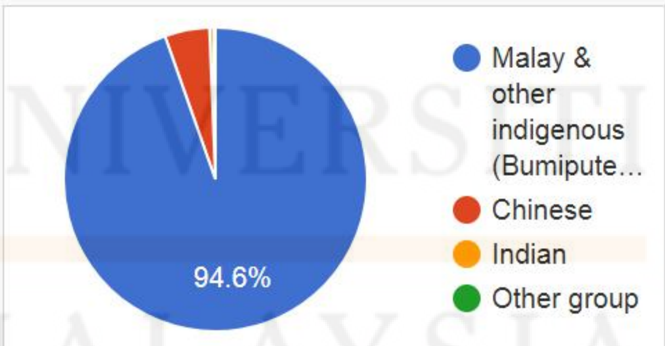


Figure 1.4 : Percentage of ethnic in Gua Musang (Department of Statistics Malaysia, 2010)

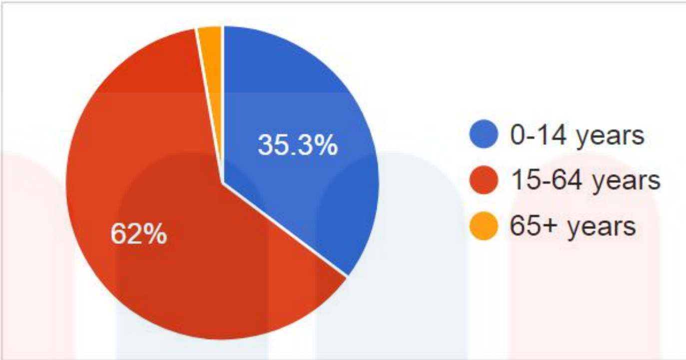


Figure 1.5 : Percentage of age distribution in Gua Musang (Department of Statistics Malaysia 2010)

1.2.4 Landuse

Gua Musang District area was owned by the two large agencies which are FELDA and KESEDAR. Most of the schemes under the FELDA (Federal Land Development Authority) were planted with oil palm while the rest was planted with rubber tree. While, for KESEDAR (South Kelantan Development Authority), most of the schemes was planted with rubber tree and the rest was planted with oil palm. The main purpose of establishing FELDA was to develop new land to make agricultural estates more productive, built effective farm management between the settlers. While the main purpose of KESEDAR is for seeking balance composition of population in the south and north of Kelantan and to eradicating to poverty and restructuring the society. The table 1.1 shows the acreage planted with oil palm and rubber in Gua Musang in the years of 2008.

Table 1.1 : The acreage planted with oil palm and rubber in Gua Musang in 2008 (Kesedar Gua Musang, 2008)

Scheme	Number of settlers	Category of crops (hectares)	
		Palm oil	Rubber
Paloh 1	267	1203.88	429.70
Paloh 2	302	1113.80	480.86
Paloh 3	315	1420.14	942.86
Chalil	188	1136.80	462.59
Lebir	189	-	473.21
Meranto	-	-	-
Sungai Terah	357	12	910.67
Renok Baru	-	-	-
Jeram Tekoh	356	182.66	1655.60
Limau Kasturi	446	-	3895.0
Sungai Asap	250	-	1377.40

1.2.5 Social Economic

Most of the peoples in Gua Musang are works as a settlers. Most of them are planted their own plantation as their income. The example of plantation are rubber and oil palm. This FELDA and KESEDAR were introduced from government to reduce the poverty and improved living standard for the social development. The education level of the people is in the middle stage and some of them become a teacher. This is because there is a school located near the study area. Table 1.2 shows the numbers of settlers in Gua Musang.

Table 1.2 : The numbers of settlers in Gua Musang in 2008 (Kesedar Gua Musang, 2008)

Scheme	Number of settlers
Paloh 1	267
Paloh 2	302
Paloh 3	315
Chalil	188
Lebir	189
Meranto	-
Sungai Terah	357
Renok Baru	-
Jeram Tekoh	356
Limau Kasturi	446
Sungai Asap	250

1.3 Problem Statements

The map is incomplete which that there is no updated road connection and village. Next, the logging activity that always occur exposure to new rock and geological structure. The area might be changes from time to time.

Besides that, no previous study about karst geomorphology at the study area. The karst landform at the study area can give many advantages towards economic development in that area.

1.4 Objectives

i. To update the geological map of Kampung Gua Air with the scale of 1:25000.

ii. To identify the karst landform in Kampung Gua Air.

1.5 Scope of Study

This study is focus on geology which are mapping, structural geology, petrographic, stratigraphy and lithology at the study area. The study is also focus on identifying karst landform in the study area. The method use are preliminary research, fieldwork, rock sampling, data analysis, writing and final report.

1.6 Significant of Study

This research will contribute to produce a new geological map of the study area. It will give some information about general geology of the study area and shows the geological features of the study area. Next, the possibility of the geological hazards at the study area can be guide based on the geological map that contain information about structural geology and the type of rocks. Then, the research also can revealed the karst geomorphology at the study area as for now there is no karst geomorphology research that had been discovered at the Kampung Gua Air.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review documents the state of the art with respect to the topic that are writing about. Literature review consists of regional geology and tectonic setting, stratigraphy, structural geology, geomorphology, historical geology, sedimentology, paleontology, paleoenvironment and research specification.

2.2 Regional Geology and Tectonic Setting

The state of Kelantan is located at the north-eastern corner of Peninsular Malaysia with the longitude of 101 20' to 102 41' E and latitude 4 33' to 6 14' N. Kelantan State share the boundaries with the other states like the States of Perak to the west, Pahang to the south and Terengganu to the east. The area of this state is 15,022 sq km and divided into ten administrative districts. The northern parts of the district are Tumpat, Kota Bharu, Pasir Mas, Bachok. Tanah Merah, Machang and Pasir Puteh. The southern part of the states are Jeli, Kuala Krai and Gua Musang (Department of Minerals and Geoscience Malaysia, 2003).

The tectonic evolution of the Malay Peninsular began when the Indochina Block together with South China, North China and Tarim separated from Gondwana in the early Devonian when the Palaeo-Tethys ocean opened. In the late Early Permian, Sibumasu separated, as part of the elongate Cimmerian continental strip, from Gondwana and the Meso-Tethysocean opened. Subduction of the Palaeo-Tethys beneath Indochina continued in the Permian as the Cimmerian continent translated northwards and the Meso-Tethys widened, the Sukhothai Arc continued to develop with andesitic volcanism in East Malaya and the arc was separated from Indochina by a narrowback arc basin and I-Type subduction related granitoids were generated in East Malaya. During initial collision of Sibumasu and East Malaya, the leading edge of Sibumasu became depressed as it was dragged into the subduction zone. Thick Middle to early Upper Triassic felsic volcaniclastics accumulated in the Central Belt documenting a change from andesitic volcanism in the Permian to felsic volcanism in the Triassic (Metcalfe, 2013).

Cretaceous tectonic modification of the Peninsula involved a significant Late Cretaceous thermotectonic event that included folding and faulting that affected the Triassic granitoids, folding of Jurassic–Cretaceous red bed sequences, emplacement of isolated granitoid plutons in the Central and Eastern belts of the Malay Peninsula and widespread re-magnetisation of rocks of all ages. Cenozoic tectonics in the Malay Peninsula is essentially restricted to faulting (Zaiton, 2002). Figure 2.1 shows the Tectonic evolution of Sundaland (Thailand–Malay Peninsula) and evolution of the Sukhothai Arc System during Late Carboniferous–Early Jurassic times.

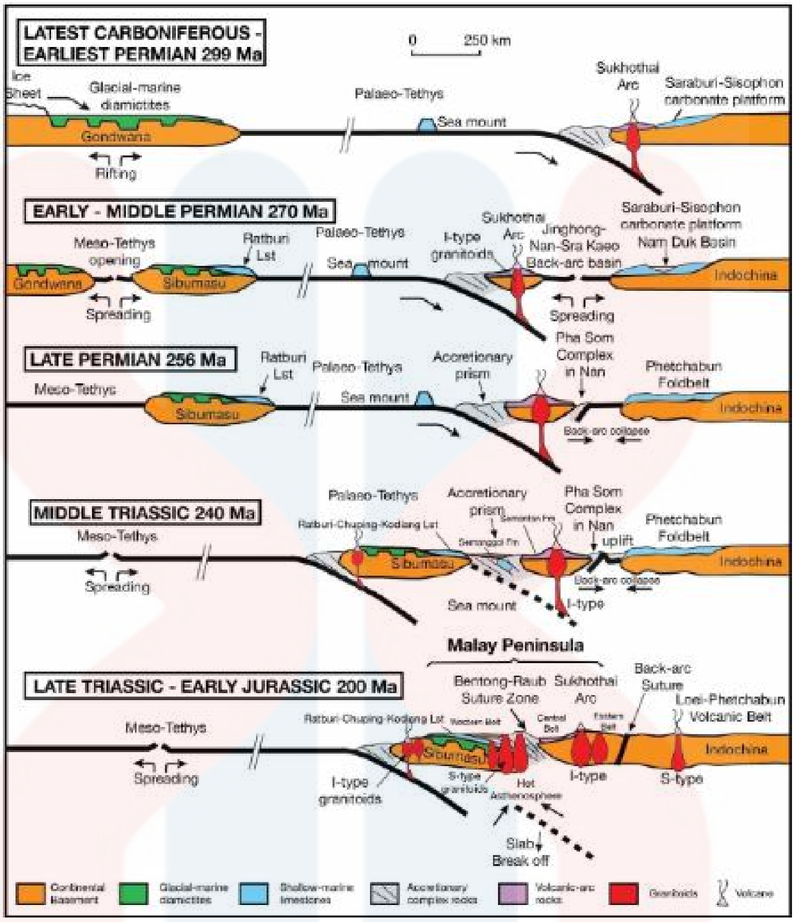


Figure 2.1 : Tectonic evolution of Sundaland (Thailand–Malay Peninsula) and evolution of the Sukhothai Arc System during Late Carboniferous–Early Jurassic times (after Ueno and Hisada (1999), Metcalfe (2002a, 2011a, 2011b, 2013), Sone and Metcalfe (2008), and Searle et al. (2012).

The Peninsular Malaysia can be divided into 3 longitudinal belts, Western, Central and Eastern, each of which has its own distinctive characteristics and geological development. The Western Belt can be divided into a northwest sector and a Kinta-Malacca sector. The northwest sector is underlain by clastics, limestones and minor volcanics. In the Kinta-Malacca sector, there was deposition of argillaceous and calcareous sediments in the early Palaeozoic followed by more limestone deposition in the Kinta region but by clastics in the Kuala Lumpur area.

The Central Belt is underlain predominantly by Permian-Triassic clastics, volcanics and limestones. The Eastern Belt is largely underlain by Carboniferous and Permian clastics and volcanics (Khoo & Tan, 1983).

2.3 Stratigraphy

The Central Belt stretches from Kelantan to Johor between the eastern foothills of the Main Range, forming its western boundary, to its eastern boundary marked by the Lebir Fault in the north down to the western boundary of the Dohol Formation in the south. The Palaeozoic rocks consist largely of Permian clastics with sporadic outcrops of Carboniferous limestone that occur as linear belts flanking Mesozoic sediments on both edges of the belt. In the western part of the Central Belt are Upper Palaeozoic rocks of the Gua Musang and Aring Formations in south Kelantan and Taku Schist in east Kelantan, and further south are the Raub Group in west Pahang and Kepis Beds in Negeri Sembilan. The Upper Palaeozoic rocks are predominantly of argillaceous strata and volcanic rocks, with subordinate arenaceous and calcareous sediments deposited in a shallow-marine environment, with intermittent submarine volcanism, starting from the Upper Carboniferous and peaking in the Permian to Triassic. Lower Triassic lava unconformably overlies Permian phyllite in south Pahang and Johor, marking a change from submarine to subaerial volcanism in the south (Foo, 1983).

2.4 Structural Geology

Kelantan is a northern state of Peninsular Malaysia. The boundary of this state to the north is Thailand, Terengganu is the eastern part, Pahang is a southern part and Perak and Kedah are a western part. Geologically Kelantan are consist of west Kelantan Olistostrom, Taku Schist and Gua Musang Formation. The type of igneus rocks in Kelantan are granite, ignimbrite, diorite porphire, andesite, and dolerite. Structurally Kelantan are bounded by olistostrom in the west and Lebir Fault Zone in the east. Gua Musang Formation is mainly separate in Kelantan. Main fold of Gua Musang Formation in the middle part towards northsouth up to north-northwest – south-southeast. In the northern part of this main fold turned by granite intrusion and diorite pophire towards NE-SW. The main of fault in the Gua Musang Formation are dexstral fault with strike N30-45º E and diping 60-70º to SE and of sinistral fault with strike N330-340º E and diping 60-80º to ENE-WSW. In the area bounded by igneus granite intrusion and near than main fault, Gua Musang Formation formed the compact and strongly folding. Intrusion of diorite pophire towards NE-SW have to turned the main fold of Gua Musang Formation to follow this intrusion. The main compression who formed the folding and faulting of the Gua Musang Formation towards between WNW-ESE up to ENE-WSW (Geological Society of Malaysia, 2010).

2.5 Geomorphology

Geomorphic classification system has four components which is geomorphic process, landform, morphometry and geomorphic formation (Haskins et.al, 1998).

Geomorphic process is the dominant internal or external geologic force that has interacted with the existing geologic structural framework to shape the earth surface. This classification has two elements which is geomorphic process type and geomorphic subprocess.

Landform is directly link to the geomorphic process element. It has two components which is landform and element landform.

Morphometry consist of measurements or characterization of landform or portions of landform including relief, elevation, aspect, slope gradient, slope position and others.

2.6 Petrography

Petrographic is a detailed study of rocks, mostly on microscopic scale. The descriptions started with the field notes at the outcrop and include description of hand specimen. Petrography is usually by using microscopic microscope to identify the mineral content of the rock. Not all of the mineral can be seen through naked eyes especially sedimentary rock like siltstone, mudstone, shale and sandstone. This petrographic study is able to identified mineral composition of the rock and also can know the rock name based on the mineral content (Balasubramaniam, 2017).

2.7 Historical Geology

The Central belt of Peninsular Malaysia is stretched from Kelantan to Johor. In the Western part of the Central Belt are Upper Paleozoic rocks of the Gua Musang and Aring Formation in south Kelantan and Taku Schist in East Kelantan (Hutchison & Tan, 2009). The Gua Musang name is discovered during the olden times which the name believes extracted from a geoart of civet found in the massive limestone towers over above it. From an archeologist perspective, Davidson (1990) mention that a town park if imaginatively created would provide recreational area for the urban population as well as enchancing the beauty and tourist potential of the town. From his statement, it was proven that the myth was fascinated the tourist to come and explore the cave, hence led the Gua Musang town to be a fast expanding town present in the few green and open arcas.

2.8 Sedimentology

The Gua Musang Formation is estimated as 650 meter thick and it is made up of crystalline limestone, interbedded with thin beds of shale, tuff, chert nodules and subordinate sandstone and volcanic (Hutchison & Tan, 2009). According to Khoo (1983), Gua Musang is mostly dominant by argillaceous and calcareous sequence interbedded with volcanic and arenaceous rock. But when referring to the Provisional Draft of Gua Musang by Yin (1965), the research revealed that the Gua Musang Formation comprises a thick succession of limestone and shale with subordinate pyroclastics and quartzites, representing deposition under a quiet neritic-shelf environment. (Metcalfe, 2000) stated that the limestone of Gua Musang Formation emerge to deposit on top of accreationary complex. Next, the top of Gua Musang Formation is made up of a thick sequence of limestone, which dated to be of late of Scythian age (Aw, 1990). (Yin, 1965) stated that the main succession of Gua Musang Formation are are found in the western portion of the region. It is overlain by younger sediments on the central part and they are forms a synclinorium at the northeast part. The argillaceous succession is more extensive than limestone and form the bulk of the sequence in the south of the Gua Musang to Merampoh area (Hutchison, 2004).

2.9 Paleontology

The Middle Permian to Late Triassic age of the Gua Musang formation and its lateral equivalents were determined based on fossil findings. Among them are Middle Permian fauna in Sungai Toh, Sungai Yu, and Padang Tengku (Leman,1993; Campi et al., 2000, 2002, 2005); Upper Permian fossils in Terenggun, Merapoh, Penjom, and Padang Tengku (Husin,1990,1994; Leman, 1991, 1993, 1994; Abdullah, 1993; Lim & Abdullah, 1994; Fontaine & Amnan, 1994; Leman et al., 2004); Lower Triassic conodants and bivalves in Merapoh, Chegar Perah, Gua Sei and Aring (Igo et al., 1966; Tamura, 1968, 1973; Aw, 1990; Metcalfe, 1992, 1995); Middle Triassic fauna in Jerus, Gua Bama, Felda Aring, and Merapoh (Metcalfe, 1990; Fontaine & Amnan, 1994; Sone & Leman, 2004; Othman & Leman, 2010); and Lower Triassic bivalves in Sungai Telong (Aw,1990). In Table 2.1 shows the fossils in Gua Musang. The G is symbol for fossil in Gua Musang Formation, T is fossil in Telong Formation, A is fossil in Aring Formation and N is fossil in Nilam Formation.

Table 2: Diagnostic fossils in Gua Musang Group. G: Gua Musang; T:Telong;A:Aring; N:Nilam.

Period	Epoch	Stage	Macrofossils		G	T	A	N	Microfossils		G	T	A	N
Triassic	Late	Rhaetian												
		Norian												
		Carnian	Bivalvia	*Trigonodus* sp.	■									
			Bivalvia	*Entolium* sp.	■	■								
	Middle	Ladinian	Bivalvia	*Daonella* sp.	■	■	■							
			Bivalvia	*Lima* sp.	■		■							
			Bivalvia	*Costatoria quinquicostata*	■	■								
		Anisian	Ammonoid	*Balatonites* sp.	■	■			Conodont	*Neogondolella excelsa*	■			
	Early	Olenekian							Conodont	*Neospathodus waageni*	■			
		Induan	Bivalvia	*Claraia* sp.	■		■		Conodont	*Isarcicella isarcica*	■			
									Conodont	*Hindeodus parvus*	■			
Permian	Lopingian	Changhsingian	Brachiopod	*Haydenella minuta*	■		■		Foraminifera	*Colaniella parva*	■		■	
			Brachiopod	*Marginifera* sp.	■		■		Foraminifera	*Paleofusulina sinensis*	■			
			Brachiopod	*Meekella* sp.	■		■		Foraminifera	*Reichelina* sp.	■			
		Wuchiapingian	Brachiopod	*Transennatia gratiosa*	■				Foraminifera	*Misella* sp.			■	■
	Guadalupian	Capitanian	Brachiopod	*Vediproductus* sp.	■				Foraminifera	*Verbeekina* sp.	■		■	■
		Wordian	Brachiopod	*Neoplicatifera* sp.	■				Foraminifera	*Neoschwagerina* sp.			■	■
		Roadian	Brachiopod	*Phricodothyris* sp.	■		■							
	Cisurian	Kungurian							Foraminifera	*Paleotextularia* sp.	■		■	■
									Foraminifera	*Glomospirella* sp.			■	■
									Foraminifera	*Schwagerina* sp.			■	■
		Artinskian	Brachiopod	*Reticulatia uralica*	■		■							
		Sakmarian	Brachiopod	*Neochonetes* sp.			■							
		Asselian	Brachiopod	*Schizophoria* sp.			■		Foraminifera	*Tricitites* sp.			■	
Carboniferous	Pennsylvanian	Gzhelian	Brachiopod	*Choristites* sp.			■							
		Kasimovian												
		Moscovian							Foraminifera	*Fusulinella* sp.			■	
									Foraminifera	*Fusulina* sp.			■	
		Bashkirian												

Table 2.1 : The Diagnostics Fossils in Gua Musang Group The G is symbol for fossil in Gua Musang Formation, T is fossil in Telong Formation, A is fossil in Aring Formation and N is fossil In Nilam Formation. (Kamal Roslan Mohamed *et al.*, 2016)

2.10 Research Specification

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 & William, 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.

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

In order to complete this study, several methods are used to ensure that the implementation process of the research can be done with an organized and systematic manner. Figure 3.1 shows the research flow chart.

3.2 Material/Equipment

i. Map

Map which is basemap is used as a reference.

ii. Compass

Compass is use for determining direction and also for taking the reading of dip direction, dip angle and strike of the bedding.

iii. Global Positioning System (GPS) and battery

Gps is use in geological field mapping for find the ones position, map the lithologies, track the structures, measure the elevation, store the sampling points and descriptions of formations when samples are collected.

iv. Hand lens

Hand lens is use to make the first analysis of the rock samples in the field before doing further analysis in the laboratories.

v. Hammer

Hammer is use for collect the samples in the field.

vi. Brush

Brush is use for cleaning the rock from other unnecessary thing.

vii. Sample bags

Sample bags is use for store all the samples that have been collect during field works.

viii. Camera

Camera is use to snap the picture of the outcrops and any geological features at the field.

ix. Hcl

Hcl is used to test the rock in order to known that the rock is carbonate or not.

x. Pen and notebook

Pen and notebook is used for taking a note during the field works.

xi. Marker pen

Marker pen is used for labelling the samples before put into the sample bags.

xii. Coin

Coin is used as a scale for a small geologic features such as fossil.

xiii. Measuring tape

Measuring tape is use for taking the actual measurements of the outcrops, lithologies and structures.

3.3 Methodology

The method of research are covering the preliminary research, field study, sampling, laboratory investigation and data analysis.

3.3.1 Preliminary Studies

The preliminary is start by finding information or any literature review from previous study that relate with the study. The source are either from journals, books, internet sources, newspaper or any trusted sources. This is to make sure that there is no research that overlap and also to get more information that relate with the research.

i. Library

There are many information that can gain from the library as the library is well known as a place for getting information. The source of information are from books, journals and articles.

ii. Internet Sources

Internet is the important source in order to get more information and knowledge either from our country or other country. The information are either in the e-books, journal or article. Thus, this sources can be as a references for the study and also can be as the literature review for the study.

iii. Preparation of Base Map

Before going to the study area, the base map is produced earlier. This is because to make us familiar with the study area and can do some revision before going to the mapping. Next, to avoid visit for a many time to the study area for a researcher that need to do a research far from their hometown in order to save the budget and time. The base map is make by using ArcMap10 software which can give the best detail about the study area. The base map is include the topography, river, road, town and the other important features.

3.3.2 Field Work

A field studies is the investigation of the study area instead of in the laboratory by visiting the study area and making an interpretation and do the observation at the study area. The fieldwork include the observation of the outcrop and the structure that can be found at the study area. The fault and crack analysis can be done if the study area is containing the fault and crack. The joint analysis using Rose Diagram application can be done if the joint is presence at the study area. Besides, take the sample from the outcrop and the coordinate of the sample and also the picture as an evidence to support the report. A base map is use for field studies as a guide during field studies. Other than that, the sample of rock is taken for petrographic analysis.

i. Rock Sampling

The rock is obtained using geological hammer by breaking the outcrop into small pieces to take as a sample. A petrographic analysis was analysed after taking the sample of the rock. The rock sample must be in a great condition and also in a fresh rock state. This is because the mineral of the rock clearly can be seen if it is not weathered. The sample that is collect will be label with the coordinate location and the date.

3.3.3 Data Analysis

i. Geological Mapping

In order to produce geological map, the geological mapping must accomplish first. The idea about the geology that need to be mapped is already keep in mind due to the published map from the previous research and the idea is improve by going to the site and do the rock sampling to identify the rock type. Thus, the lithology of the study area can be identify.

ii. Structural Analysis

The structural analysis is based on the measuring of strike and dip, formation of fault and joints in the study area. Structural analysis is analysed to know the direction of the force to the rock formation. This can be determine by measuring the joint and do a rose diagram. From the rose diagram the direction of the force can be determine.

iii. Petrographic Analysis

This is about the study of the rock with the deepest investigation on the rock sample by doing the thin section.The rock sample is analysed after finish the thin section. The importance of petrographic analysis is to identify the type of the rock in the study area. Then the mineral can be identify by using petrographic microscope. Due to the mineral contain, the rock can be name.Step to do thin section:

a) Prepare the glass slide
b) Cleaning the grinding wheel
c) Frost the glass slide
d) Mark the rock

e) Cut the slab

f) Clean the slab

g) Cut the chip

h) Glue the slide to the chip

i) Cut off the chip from the slide

j) Grind slide to the correct thickness

k) Add a cover slip

l) Polish for electron microprobe/SEM-EDS analysis

m) Clean up the place

iv. Karst landform analysis

This is about the study of karst geomorphology such as types of karst landform.

3.3.4 Data Interpretation

i. Karst landform is interpret based on the result of karst landform analysis.

3.3.5 Research Flow Chart

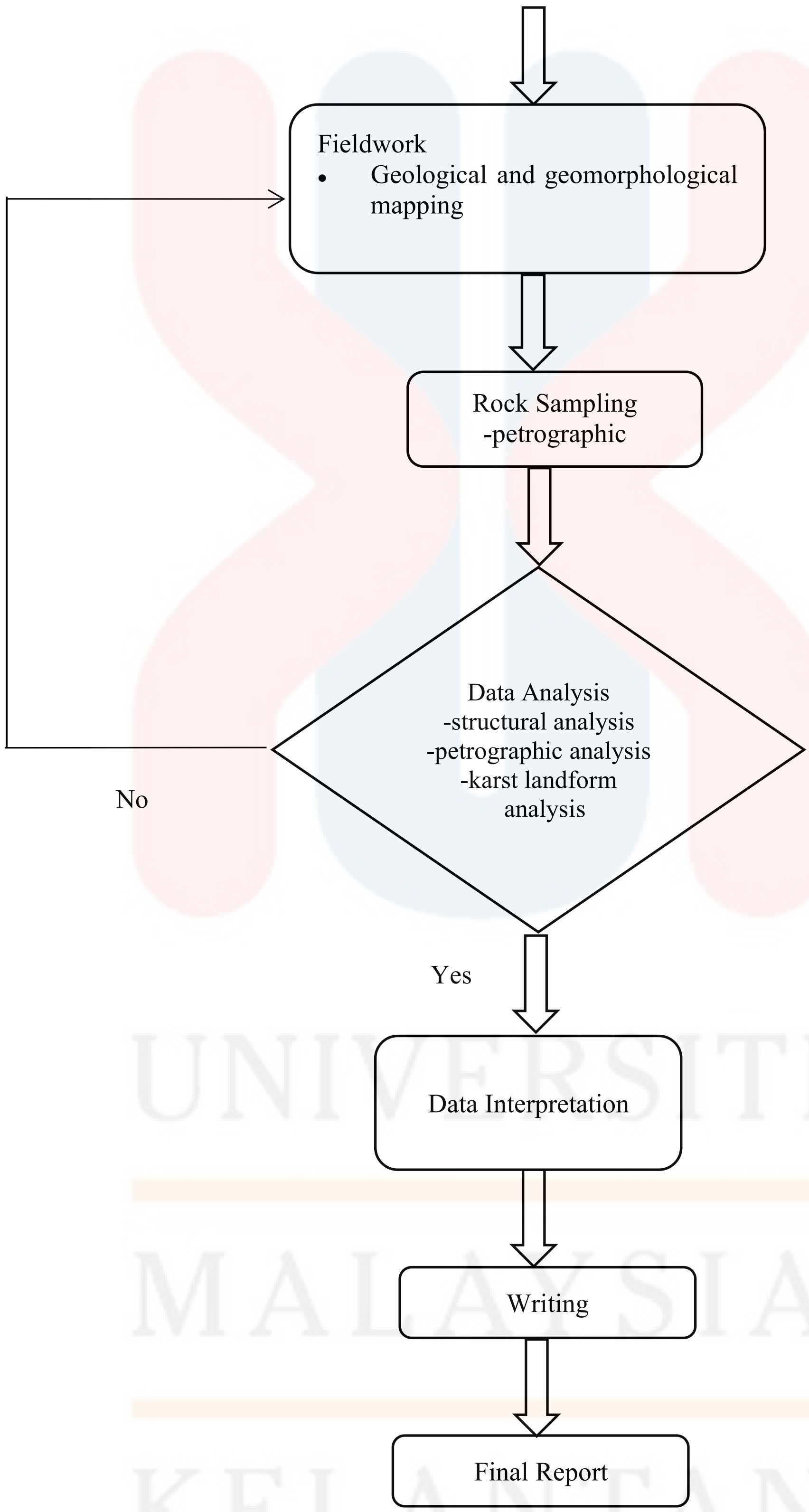


Figure 3.1 : Research flow chart

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The general geology of Kampung Gua Air, Gua Musang describe the study of Earth science that relate with its material made, the structure found of the materials and the process acting and change over time found in the study area. It is a part of Gua Musang Formation. This chapter will discuss about the information of geology, geomorphology, lithostratigraphy, structural geology and other geology element contain in the study area.

4.1.1 Accessibility

The study area is located about 7 kilometers from the main road, Jalan Jelawang-Gua Musang. The study area is located in the logging area. Figure 4.1 shows the unpaved road in the study area. The lorry and the truck used the road to transport the timber. The road also used as a road connection to the native people village named Pos Pulat and native people school which is Sekolah Kebangsaan Pulat. Since the road is regularly used by the lorry, truck and also other heavy vehicles, there are many potholes on the road. Because of this situation, it took a longer time in order to reach the study area for about 20 minutes.

Figure 4.1 : Unpaved road in the study area

4.1.2 Settlement

In the study area, there is a residential area that consists only one house as shows in figure 4.2. This is because the owner of the house opened a food and groceries stall in the study area. The concentration of the settlement is mostly at the Pos Pulat which is about 10 kilometers from the study area.

Figure 4.2 : The residential area

4.1.3 Forestry/Vegetation

The study area consists of three section which area reserved forest, banana plantation and palm oil plantation. 70 percent of the study area is dominated by the reserved forests which are Sungai Terah Reserved Forest and Nenggiri Reserved Forest as shows in figure 4.3. The next 20 percent is dominated by the banana plantation as shows in figure 4.4 and another 10 percent is dominated by the palm oil plantation as shows in figure 4.5.

Figure 4.3 : Reserved forests

Figure 4.4 : Banana plantations

Figure 4.5 : Oil palm plantations

4.1.4 Traverses and Observation

Figure 4.6 shows the traverse map which consist of the covered area during mapping. Several station which indicate as sampling station were marked with green circle. On the other hand, several station which indicate as observation station were marked with yellow circle. Table 4.1 shows the coordinate of sampling and observation station conducted in the study area.

Table 4.1 : Coordinate of sampling and observation station conducted in the study area

STATION	COORDINATE	
Sampling ●	LATITUDE	LONGITUDE
	N 05º 01’ 04.1’’	E 101º 55’ 39.6’’
	N 05º 01’ 04.4’’	E 101º 55’ 38.6’’
	N 05º 01’ 04.1’’	E 101º 55’ 39.3’’
	N 05º 01’ 04.2’’	E 101º 55’ 39.2’’
	N 05º 01’ 03.9’’	E 101º 55’ 39.1’’
	N 05º 01’ 07.1’’	E 101º 55’ 17.7’’

	N 05º 01’ 58.3’’	E 101º 55’ 30.5’’
	N 05º 00’ 13.1’’	E 101º 56’ 12.7’’
	N 04º 59’ 48.7’’	E 101º 56’ 51.3’’
	N 05º 00’ 36.0’’	E 101º 57’ 36.5’’
Observation	N 05º 01’ 42.9’’	E 101º 55’ 23.7’’
	N 05º 02’ 21.8’’	E 101º 55’ 10.2’’
	N 05º 01’ 43.3’’	E 101º 55’ 27.4’’
	N 05º 01’ 57.8’’	E 101º 55’ 29.9’’
	N 05º 00’ 58.5’’	E 101º 55’ 28.0’’
	N 05º 01’ 25.5’’	E 101º 55’ 06.7’’

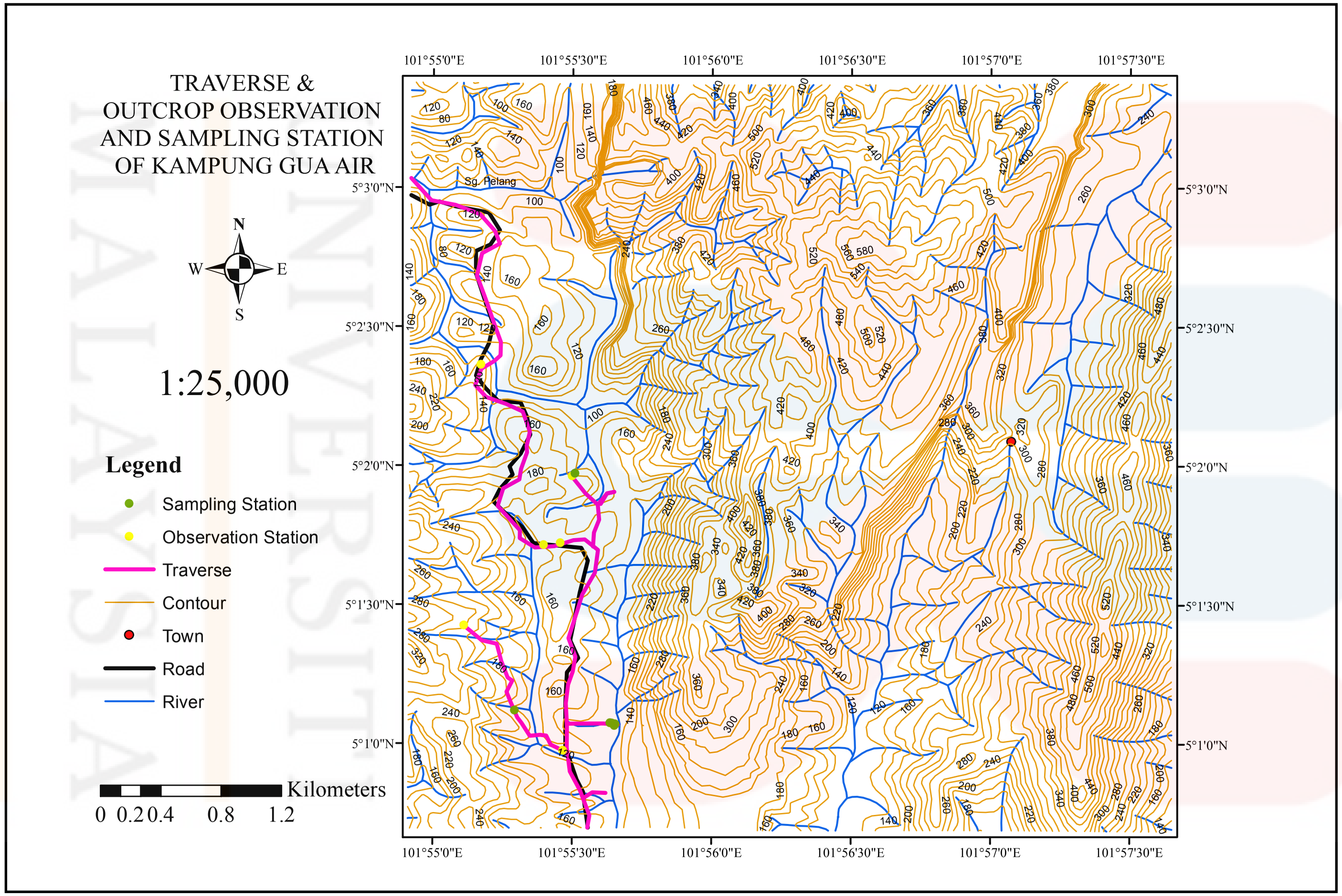


Figure 4.6 : Traverse & outcrop observation and sampling station map of study area

4.2 Geomorphology

This section is described about geomorphological process occur in the study area such as the process which changes the landform include weathering and erosion process, uplifting, sediment unloading and stratigraphic unconformity. The geomorphological process is really importand to understand in order to interpret the evolution or the ancient process that cause the event to happen.

4.2.1 Geomorphology Classification

The study area is divided into two main landscapes which are hilly and mountainuous landscape. Hilly landscape is located at the Eastern and Western part of the study area with the elevation from 800 meters until 300 meters. On the other hand, the mountainuous landscape is at the eastern part of the study area with the elevation greater than 300 meters. The highest peak of the mountainuous landscape is 520 meters. Karst landform is located at the center of the study area. Figure 4.7 shows the mountainous and hilly landscapes in the study area.

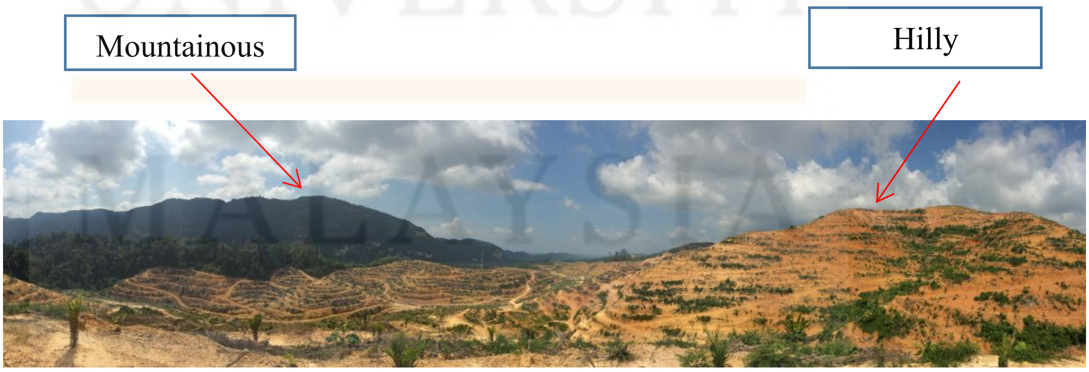


Figure 4.7 : Mountainous and hilly landscapes of the study area

4.2.2 Weathering

Weathering can be defined as a process that breakdown the rocks and minerals on the earth surface either by physical, chemical or biological weathering. Erosion is a process that transport the weathered rocks and minerals by the agent such as flowing water, wind, glaciers and gravity. The weathered rock can be transported either in a short or long distance from the source.

Physical weathering is the process that breakdown rock into small part without changing their chemical composition. The common action of physical weathering are exfoliation, abrasion, frost wedging and thermal expansion and contraction. In figure 4.8 shows the phyllite has broken down into smaller fragment due to the thermal expansion and contraction during hot weather.

Figure 4.8: Thermal expansion and contraction of physical weathering on phyllite outcrop

The chemical weathering occur when water and air react chemically with rocks and minerals and cause their chemical contents to change. Another factors that help the process of chemical weathering are rainfall and temperature. The rate of chemical weathering can rise when the temperature is higher and the precipitation is greater. Rock in the tropical region such as Malaysia are most exposed to chemical weathering because they were exposed to period of heavy rainfall and higher temperatures which cause the rock to weather faster compared to the similar rock found in cold region.

Oxidation is the most common chemical weathering occur on rock body. Oxidation process happen when rock is exposed to atmospheric oxygen. Amphibole, pyroxene and olivine are the example of minerals with abundant of iron. When the iron is exposed to the atmospheric oxygen, the rusting process occur where the iron and oxygen combined together and formed iron oxide (rust). Iron react with iron-bearing minerals which formed mineral hematite (Fe_2O_3). It cause the minerals to alter and the colour become rusty brown to reddish (Crawford M.J., 1998). In figure 4.9, the phyllite outcrop turn into reddish colour due to the oxidation of the metallic minerals in the rock. In humid region and dessert sediments, iron oxide minerals were normally seen as reddish brownish colour. The chemical equation of oxidation in metallic mineral in rocks is shown as follows:

$$4Fe + 3O_2 = 2Fe_2O_3$$

Figure 4.9 : Oxidation of metallic minerals in phyllite

Carbonation also is a type of chemical weathering. The study area is covered by 40% of carbonate rock. The rainwater usually slightly too acidic properties dissolve the calcite minerals in the carbonate rock forming the stalactites and stalagmites as shown in figure 4.10.

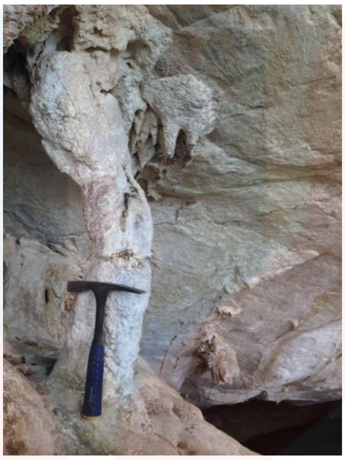


Figure 4.10 : Stalactite and stalagmite

Next, biological weathering occur due to the action of animals, plants and microbe. The biological weathering caused the leeching or discolouration of the rock surface. Figure 4.11 shows the biological weathering on phyllite outcrop. Figure 4.12 shows the geomorphological map of the study area while 4.13 shows the 3D topography map of the study area.

Figure 4.11 : Biological weathering show with arrow cause the discolouration on the surface phyllite outcrop

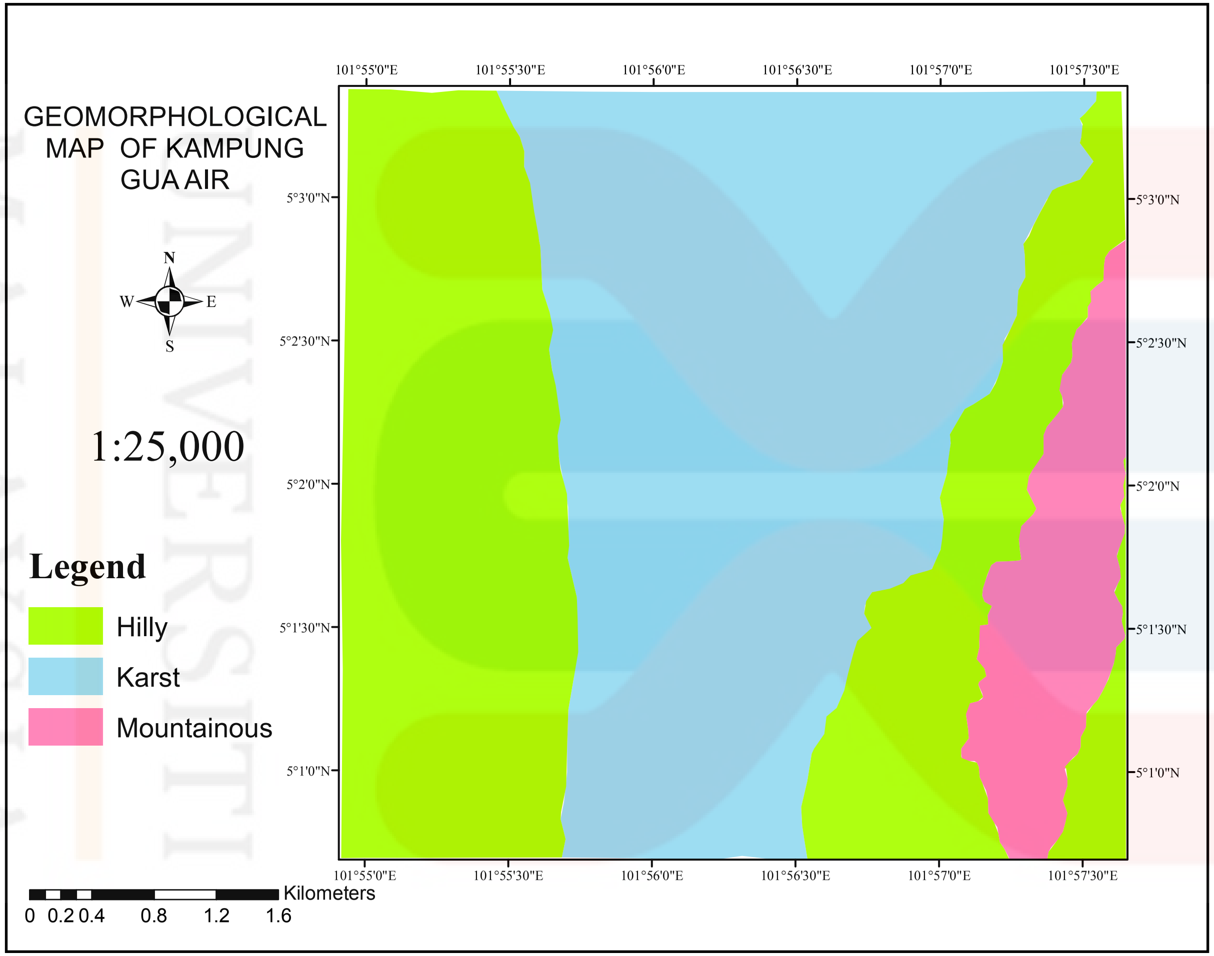


Figure 4.12 : Geomorphological map of study area

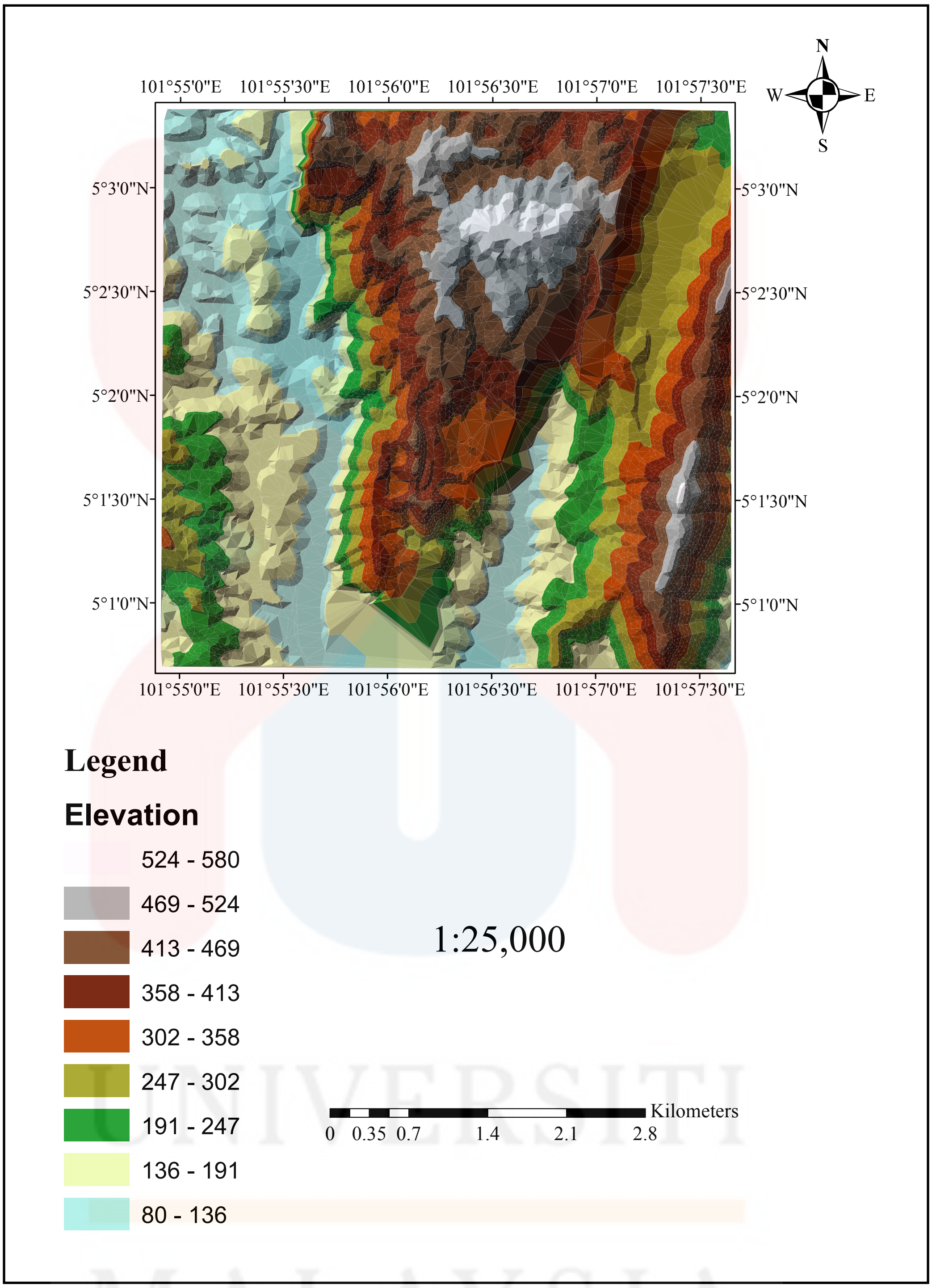


Figure 4.13 : 3D Topography Map of Kampung Gua Air

4.2.3 Drainage Pattern

Drainage pattern is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. There are few types of drainage pattern classified according to their form, texture, topography and geology of the land. In the study area, there is no main river. It only consists of small rivers named Sungai Pelang, Sungai Lenggeram and Sungai Kelasa that can be part of drainage system. There is only one type of drainage pattern based on analysis and identification on the map and also by mapping method known as dendritic pattern.

Dendritic pattern is a drainage pattern that look likes a branching tree with a bunch of twigs. The contributing streams (tree twigs) are joining together to tributaries of the main river at acute angle ($<90^{o}$). Figure 4.14 shows the drainage map of the Kampung Gua Air.

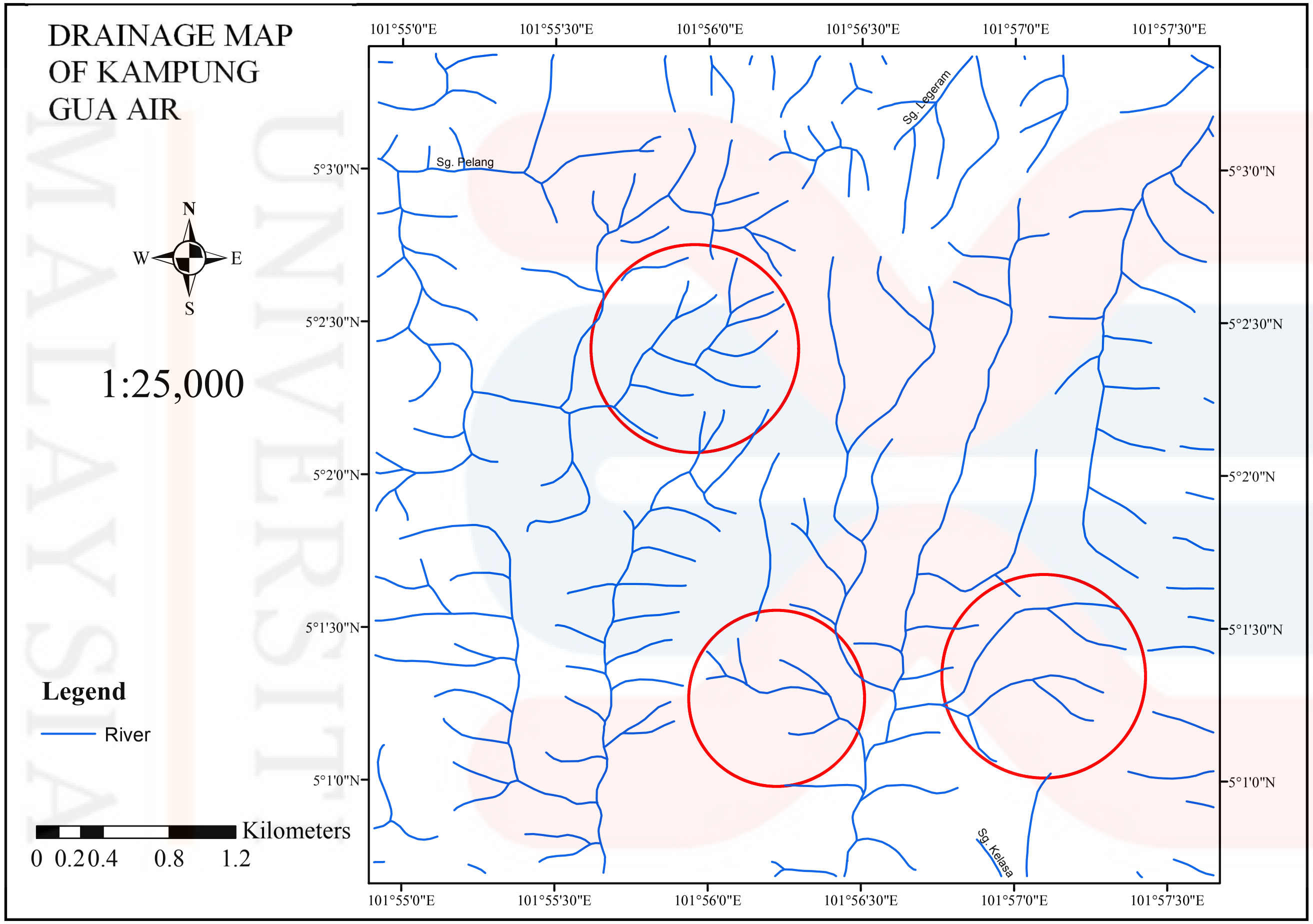


Figure 4.14 : Drainage map of the Kampung Gua Air

4.3 Lithostratigraphy

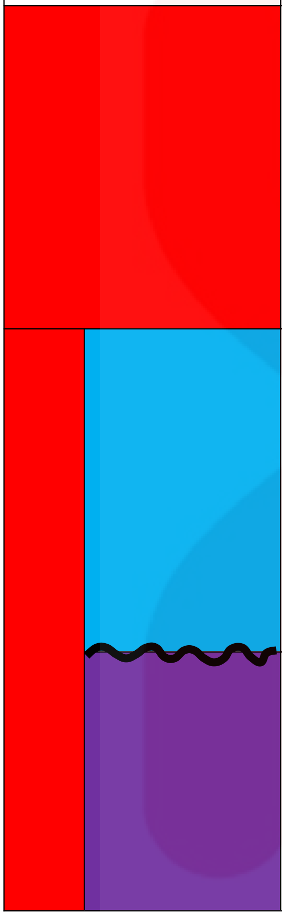
According to Boggs (2006), lithostratigraphy explained about the physical properties of the strata and the organization of the rock units into its basic lithology characteristics. The lithostratigraphy is important in order to construct geological maps and make a lithostratigraphic correlation of an area over time (Nichols, 2009).

4.3.1 Stratigraphic Position

Stratigraphic units of the study area show the vertical distribution of the study area in geological time age. The correlation were made within the lithology of each rock unit with existed geological formation in the study area mentioned in the previous literature review. The rock unit were arranged based on the law of superposition where the older rock unit were placed at the bottom and at the top is the youngest deposition at the particular area.

The formation that was determined in the study area area Gua Musang Formation. The formation was in the period of Permian, Late Triassic and Cretaceous. According to Khoo (1983), Gua Musang is mostly dominant by argillaceous and calcareous sequence interbedded with volcanic and arenaceous rock. The stratigraphy column of the study area are shown in the table 4.2. Figure 4.24 shows the geological map of study area.

Table 4.2 : The stratigraphy column of the study area

LITHOLOGY	LITHOLOGICAL UNITS	DESCRIPTION	PERIOD
	GRANITE	Grey granite, coarse grain, intrusive igneous rock.	Cretaceous
	LIMESTONE	Thick-bedded, fine grain, dolomite.	Late Triassic
	PHYLLITE	Very fine grain.	Permian

4.3.2 Unit Explanation

a) Phyllite unit

Phyllite is a metasediment rock and it is very fine grained. It is foliated and reddish orange in colour. It is highly weathered. It is found in the oil palm plantation and at the foot hill. The outcrop is located at the West direction on the map. The length of the outcrop is 5 meters while the height is 3 meters. The age of the rock is Permian. The percentage of the rock distribution in the study area was 10%. The figure 4.15 shows the phyllite outcrop and its hand sample.

a) b)

Figure 4.15 : (a) Phyllite outcrop (b) Hand sample of the phyllite rock

Figure 4.16 shows the phyllite under plane polarized light (PPL) and figure 4.17 shows the phyllite under cross polarized light (XPL). The minerals present in the phyllite are quartz, feldspar and muscovite. Quartz can be described as colourless in PPL, low relief, anhedral, no cleavage and first order birefringence. Next, feldspar also colourless in PPL, low relief, anhedral, first order birefringence and Carlsbad twinning. Muscovite is no pleochroism, light brown colour in XPL, high relief, two cleavage, subhedral, second order birefringence.

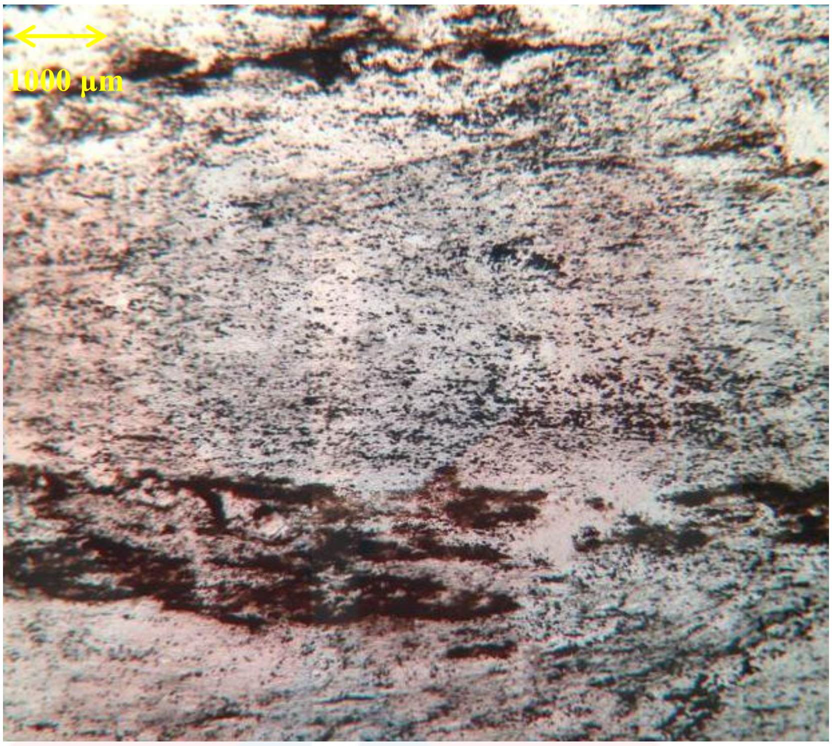


Figure 4.16: Phyllite under PPL

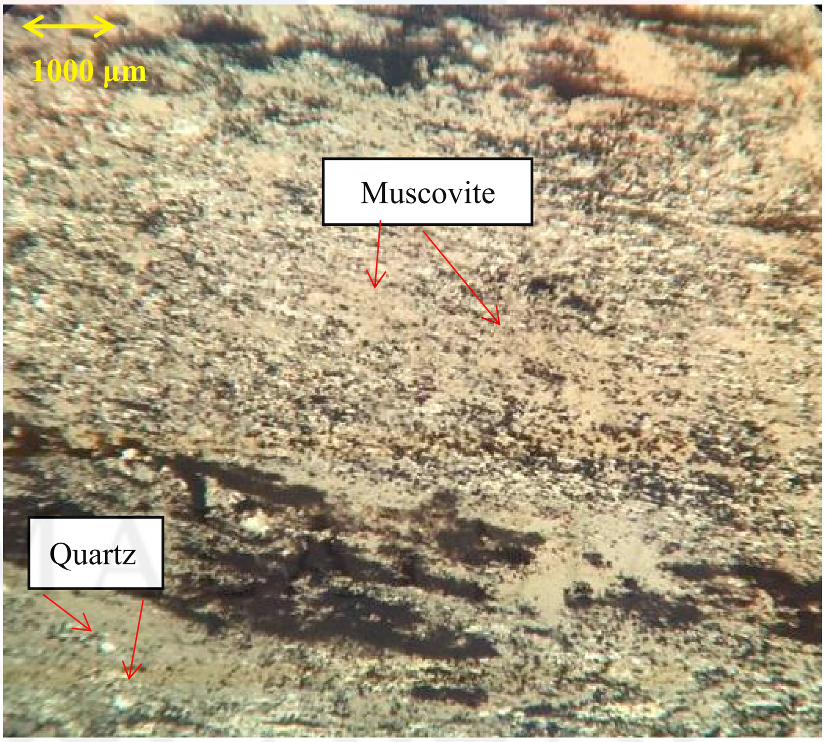
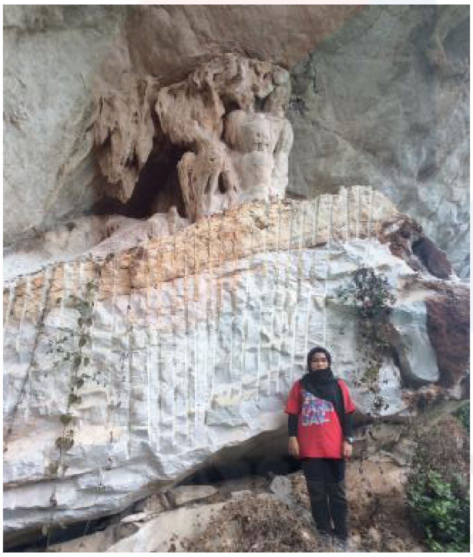


Figure 4.17 : Phyllite under XPL

b) Limestone unit

Limestone is a sedimentary rock. It is very fine grained and grey in colour. It is already transform to dolomite and is a thick-bedded. The rate of weathering is low. The outcrop is located in the banana plantation. The limestone is a karst and it is next to the unpaved road. The outcrop dimensions is 50 meters in length and 120 meters in height. The age of the rock is in the period of Late Triassic and it is located in the North-South area of the map. The percentage of the rock distribution in the study area is 40 %. The figure 4.18 shows the limestone outcrop and its hand sample.

a)



b)

Figure 4.18 : (a) Limestone outcrop (b) Hand sample of the limestone rock

Figure 4.19 shows the limestone under plane polarized light (PPL) and figure 4.20 shows the limestone under cross polarized light (XPL). The minerals present in the limestone are barite, calcite and pyrite. Barite can be described as colourless, high relief, low birefringence and 90 degree cleavage angels. Next, calcite is colourless, high birefringence, and perfect rhombohedral. Pyrite is an opaque, brass yellow, euhedral crystals and one poor cleavage.

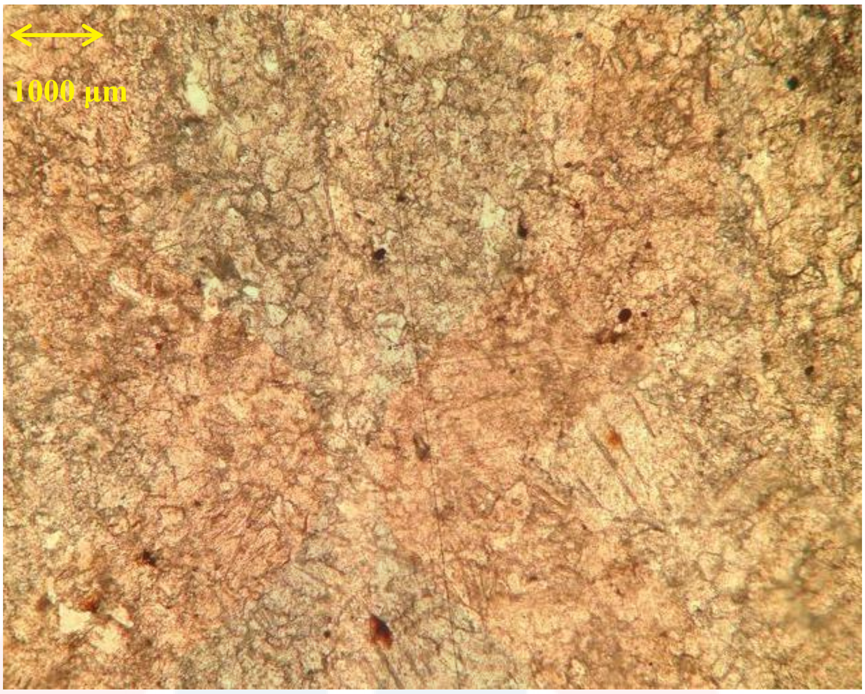


Figure 4.19 : Limestone under PPL

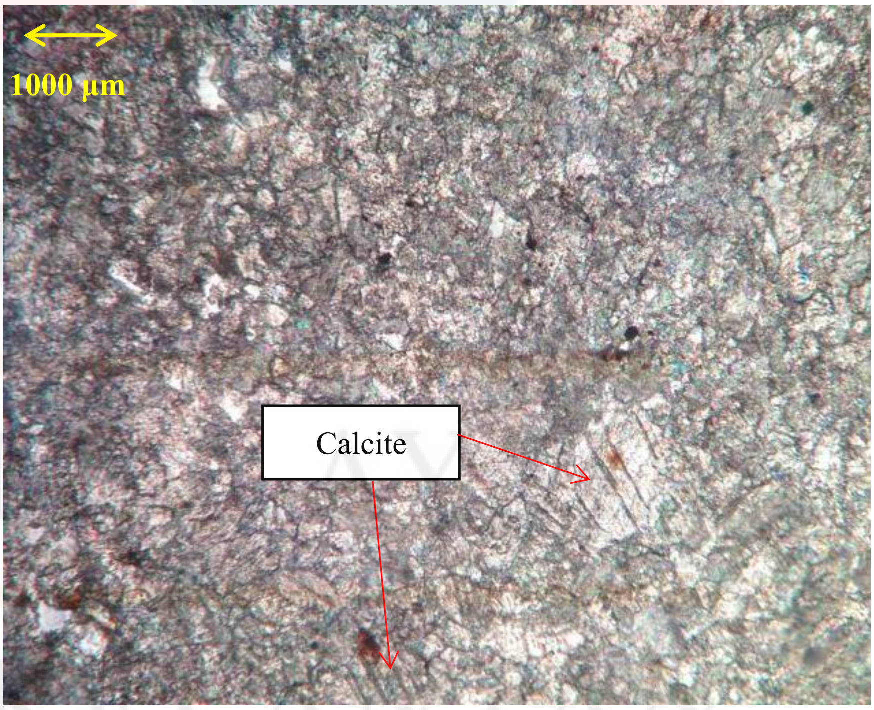


Figure 4.20 : Limestone under XPL

c) Granite unit

Granite is a intrusive igneous rock. It is grey in colour it is coarse grained. The texture is granular and phaneritic. The mineral composition are mostly quartz, feldspar (mica and amphiboles) and biotite. The degree of crystallinity are holocrystalline, hypocrystalline and holohyalline. It is moderately weathered. It is located in banana tree plantation and at the foot of the hill. The type of contact is intrusion and the age of the rock is in the period of Cretaceous. The location of the rock is at the Earth of the map. The percentage of the rock distribution in the study area is 30%. The figure 4.21 shows the limestone outcrop and its hand sample.

a)	b)
	

Figure 4.21 : (a) Granite outcrop (b) Hand sample of the granite rock

Figure 4.22 shows the granite under plane polarized light (PPL) and figure 4.23 shows the granite under cross polarized light (XPL). The minerals present in the granite are quartz, feldspar and biotite. Quartz can be described as colourless in PPL, low relief, anhedral, no cleavage and first order birefringence. Next, feldspar also colourless in PPL, low relief, anhedral, first order birefringence and Carlsbad twinning. Biotite is pleochroic (pale green), hexagonal plates, moderate relief and no twinning.

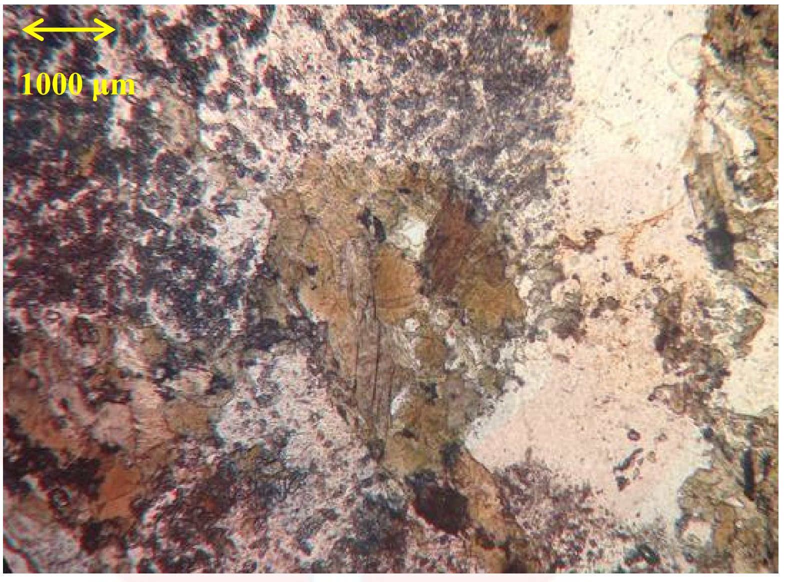


Figure 4.22 : Granite under PPL

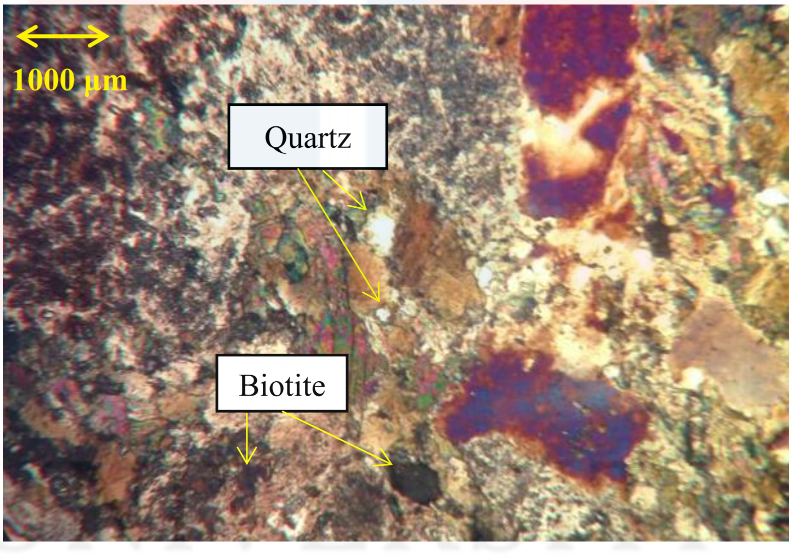
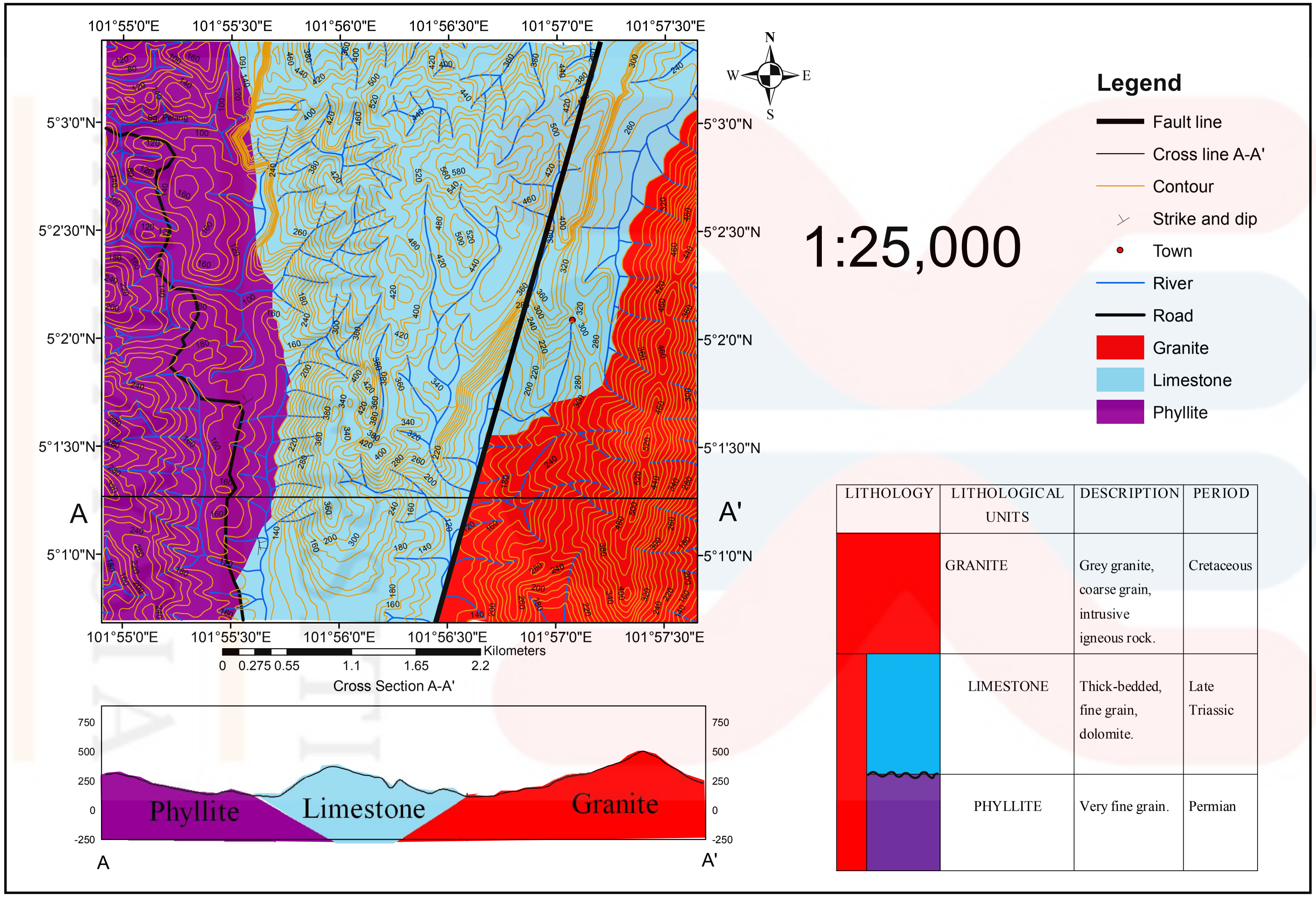


Figure 4.23 : Granite under XPL



LITHOLOGY	LITHOLOGICAL UNITS	DESCRIPTION	PERIOD
	GRANITE	Grey granite, coarse grain, intrusive igneous rock.	Cretaceous
	LIMESTONE	Thick-bedded, fine grain, dolomite.	Late Triassic
	PHYLLITE	Very fine grain.	Permian

Figure 4.24 : Geological Map of Kampung Gua Air

4.4 Structural Geology

Structural geology is the study of formation of geological structure and the affect structures to the rocks process. This study important to recognize the field stress that resulted in strain and geometries observation, to disclose information of deformation rocks history and the past geologic event which help to structural evolution in certain area by the process of present-day rock geometries measurements. Geological structures have variety of features such as fracture, joint, vein, fault and fold. These features may occur due to brittle or ductile materials the formation.

4.4.1 Lineament Analysis

Lineament is a reflection of phenomena occurred subsurface and a linear surface features that mappable in a landscape which differ from nearby features (O'Leary et al. 1976). It commonly apparent in topographic or geological map or express clearly on aerial or satellite photographs.

For the study area, the lineament analysis is done by using the aerial photograph from Google Map terrain in 3-D since the lineament cannot be investigate by observation in local area. Then, the strike is calculated and plotted by GeoRose software. During field work, the evidence of tectonic activity can be observed. From the data collected, the structure and observation can be predict and help to understand the geomorphology of the area better. All the data and observation found near the lineament analysis is recorded, interpreted and been discussed as follow. Figure 4.25 shows the lineament analysis map while figure 4.26 shows their rose diagram. From the rose diagram, it shows that the orientation of the major compressional force of σ^1 is coming from the direction of 10º NE.

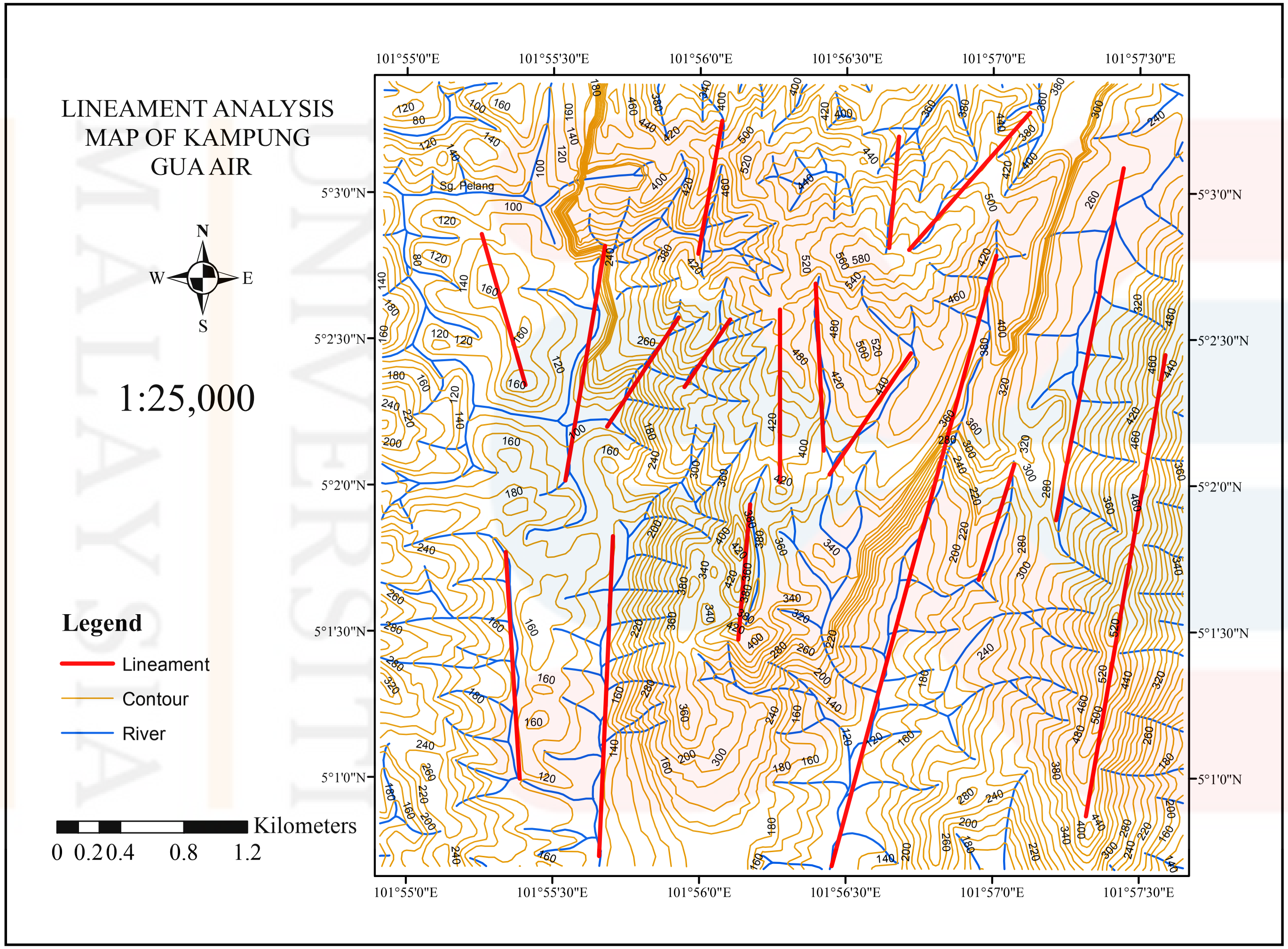


Figure 4.25 : Lineament analysis map of Kampung Gua Air

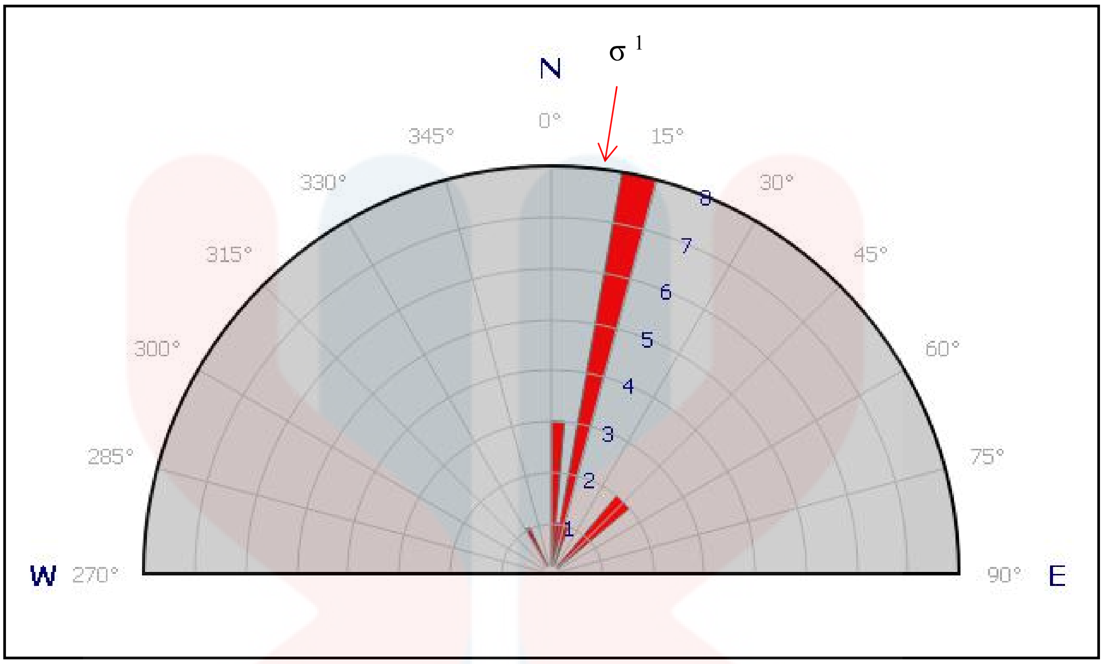


Figure 4.26 : Rose diagram of lineament analysis

4.4.2 Joint

Joint is known as a break or fracture of natural form in continuity either in layer or rock body that lack of any observable movement parallel to fracture surface or plane. It is separated into two parts but do not moved away from each other. Joint is form because of tensile stress break the threshold and does not involve shear displacement. Joint may push out in many direction, usually vertical and have smooth surface or scratch from sliding against another. Figure 4.27 shows the joints in study area.

Figure 4.27 : Joint in study area

In figure 4.28 shows the joint reading is taken on the limestone outcrop. From the rose diagram, it shows that the orientation of the major compressional force of σ^1 is coming from the direction of 323º NW.

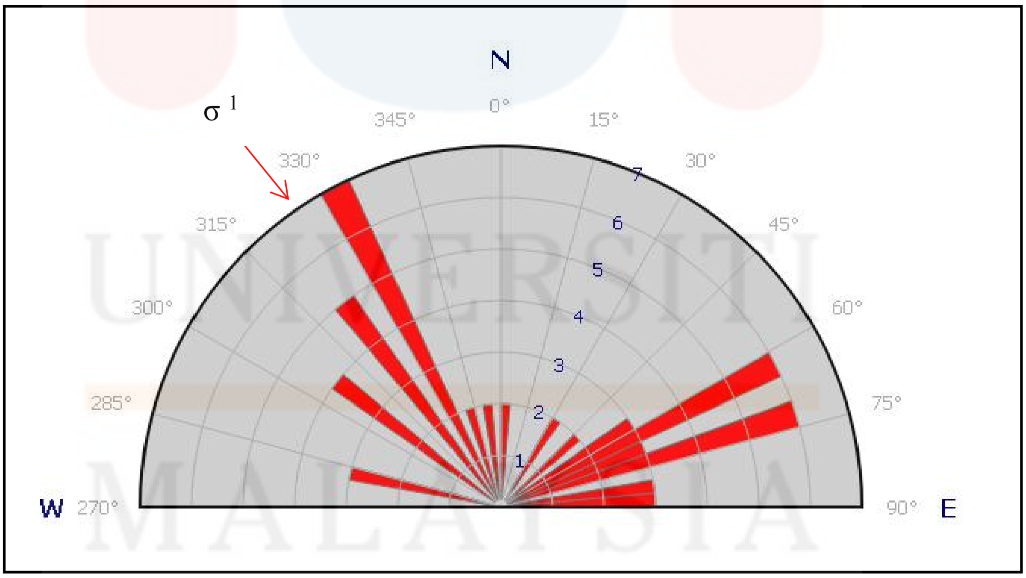


Figure 4.28 : Rose diagram of the joint reading

4.4.3 Bedding

Bedding is a beds or strata of rock that usually found arranged in different layers. It is commonly vary in thickness and distinguish by numerous ways such as rock type, mineral type and its particle size. Bedding is commonly used for sedimentary strata but also can applied for ash layers or volcanic flows. Figure 4.29 shows the bedding in the study area.

Figure 4.29 : Bedding in the study area

4.4.4 Vein

Vein is a discrete crystallised mineral deposit. It is form when pre-existing fracture or crack is filled with with new mineral material within a rock. The mineral constituents form was carried by an aqueous solution which involved hydraulic flow and hydrothermal circulation, and precipitate the deposited. Figure 4.30 shows the vein in the study area.

Figure 4.30 : Vein in the study area

4.4.5 Fault

Fault is a vertical horizontal rock crack with discrete displacement. There are three classification of fault which are normal fault, reverse fault and strike slip fault. Each of the resemble different orientation and direction of the stress acting on the earth crust either push or pull or slide past to one another.

During mapping activity, fault are hard to locate in the study area. Thus, lineament study are used as guideline to determine the area of expected fault zone. Based on lineament analysis and also image from the terrain map, the strike-slip fault which is sinistral is being detected. Figure 4.31 shows the image of the strike-slip fault in the study area from terrain map.

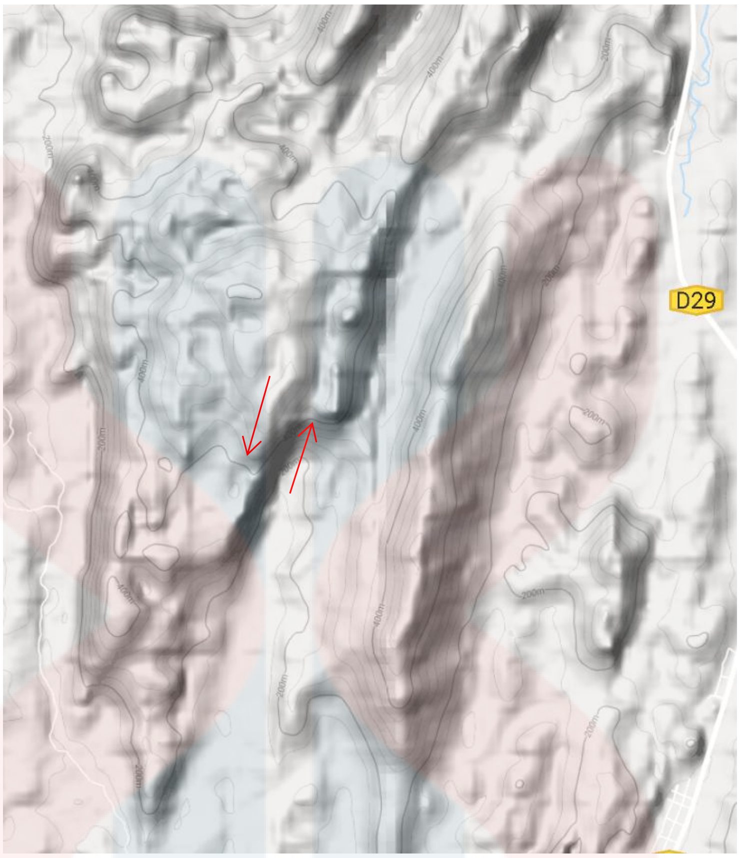


Figure 4.31 : Strike-slip fault from terrain map

4.4.6 Mechanism of Structure

The mechanism of structure happen in study area are due to the activity of tectonic uplifting and downloading. Force exerted from the movement of the earth crust cause the earth surface to uplift to form the mountain. As seen in the study area, the mountainous area located to the eastern part of the study area must have formed from the ancient movement of plate tectonic. Two opposite force acted on one another force the earth crust to move upward.

Besides that, the lineament analysis also found some indicator or tectonic movement such as expected fault zone beneath the earth force which have given rise to the formation of ridge, valley and shear zone in the study area. Megascopic structures such as vein and joint observed and measured in the study area are example of geological structures occur in the study area. Joint reading analysis taken from location at the study area provide the idea to determine the major compressional force acted on the earth surface which detail of the analysis has been discussed in section 4.4.2.

4.5 Historical Geology

The historical geology of the study area begin during period of Permian and ended during Cretaceous of Gua Musang Formation. The formation of the study area started with the presence of phyllite unit which is metamorphic rocks that undergo high pressure and high temperature that occur beneath to the earth.

The formation within the study area has a shallow marine depositional environment due to the thick bedded limestone that can be found in the study area during Late Triassic. The geomorphology of the study area is dominated by the karst. The formation of the karst morphology occur by chemical weathering which is dissolution of carbonate rock by groundwater activity.

During Cretaceous, the granite which is the youngest rock unit is presence in the study area as an intrusion.

CHAPTER 5

KARST GEOMORPHOLOGY

5.1 INTRODUCTION

Geomorphology is one type of geological field studies that involve of field works to determine the cave characteristics such as shape and dimension as principal criteria to discover the cave type.

Karst landform is shaped by the dissolution of the bedrock such as limestone or dolomite. It is most typically when carbonate rock is dissolved away by mildly acidic rain and groundwater. Limestone and dolomite is the type of rock consists of layers of sea shells that formed a million years ago. The factors that affecting karst processes are solubility of bedrock, climate, structure, vegetation and atmospheric. Figure 5.11 shows the karst geomorphology map in the study area.

5.2 TYPES OF KARST LANDFORM

5.2.1 Caves

i) Cave formation

The dissolution of the cave formation is commonly about the two basic types of theories that concern to the water conditions when the cave formed. The two theories are vadose and phreatic theories (Thornbury, 1965).

The cave in study area is issued to the vadose theory by comparing to the age of Bentong-Raub Suture formation (end of Permian) and Gua Musang-Semantan Depocenter (Upper Paleozoic) since the age of Gua Musang-Semantan Depocenter is younger than the uplifted of terrenes. According to the Ford, (1965), the vadose theory suggests that dissolution of the cavity is mostly filled with air.

Since the cave in the study area is issued as vadose theory, so their formation is directly subjected to the continuous and aggressive weathering process. It is referred to the rainwater from the atmosphere which is combined with carbon dioxide to form carbonic acid. The carbon dioxide probable from the air that filled in the cavity of the cave or soil where the micro-organisms undergo the respiration process and the decaying of organic matter that generate high level of carbon dioxide. As the carbonic acid percolates through the carbonates rock, it slowly dissolves the carbonate rock, thus enlarges the bedding planes, joints and fissure in the rock. When the process continuously, it will create caves with cavities that large enough to be explored.

Moreover, the number of joints and fissure in the massive bedded carbonate rock also affect the cave formation which is the cave is subjected to the highly significant of fractures on it. This process has been continuous in a long period of time without interruption of other tectonic and environments activities, allow the cave systems formed. Figure 5.1 shows the cave in the study area.

Figure 5.1 : Cave in the study area

ii) Speleothems

Speleothem is the general name for cave features. Cave features are mostly formed by the slow-moving water that contain high calcium carbonate content. Chemical changes inside the caves cause the minerals to become harden and form deposits. The speleothems can differ greatly in size, composition and color throughout the cave system.

The types of speleothems that consists in the cave of the study area are dripstones and flowstone. Dripstone is the term for calcium carbonate deposits which form when water dripped through a point of aeration. Flowstone is the term for mineral deposits that form by water flowing along the floor and sides of caves. The examples of dripstones are stalactites, stalagmites and pillars.

Stalactites grow downward from cave ceilings. Stalactites start to form as straws but finally grow into stalactites as the straw form becomes blocked with calcite. As water continues to drip down the stalactite, leaving tiny bits of calcite, the stalactite continues to thicken and grow over time. Figure 5.2 shows the stalactite in the study area.

Figure 5.2 : Stalactite in the study area

The stalagmites form when those drops of water fall from the ceiling or stalactites and deposit calcite on the floor. Stalagmites are solid dripstones that grow upwards from cave floors. As water drips onto the stalagmite from above, bits of calcite get left behind and the stalagmite continues to grow and thicken over time.

Pillars are a stalagmite and a stalagmite that have grown enough to meet in the middle. Pillars also known as a columns. Figure 5.3 shows the stalagmite and pillar in the study area.

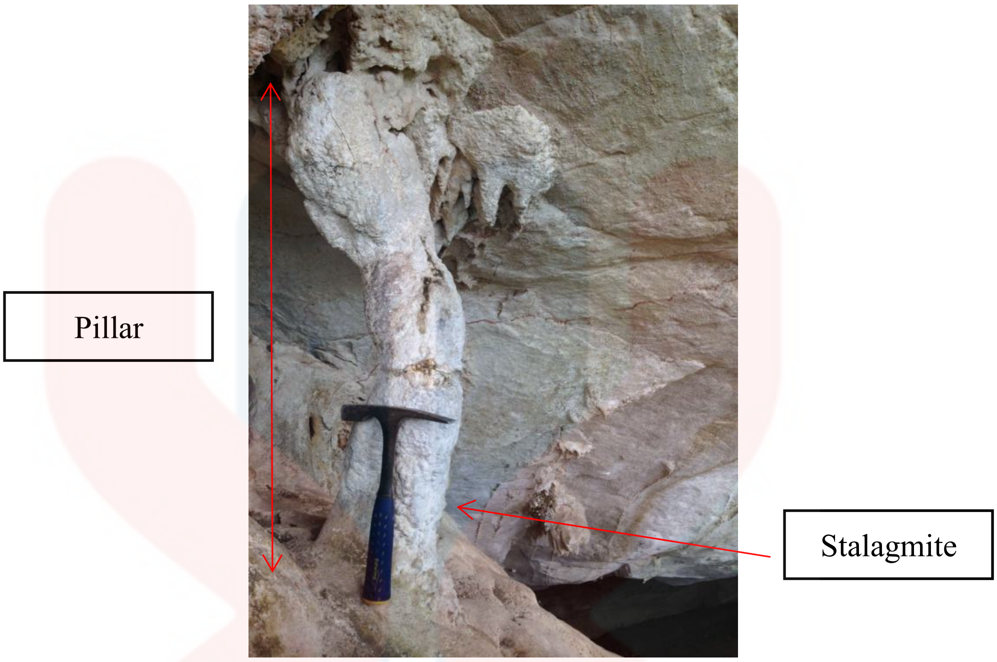


Figure 5.3 : Stalagmite and pillar in the study area

5.2.2 Disappearing stream

Disappearing streams are the surface streams that flow underground into solution cavities. The water in the disappearing streams seep into the ground and then recharges the groundwater since the water table is right below the water channel. Disappearing stream is commonly can be find in arid regions and areas with karst landscapes. Figure 5.4 shows the disappearing stream in the study area.

From the observation, the water is flowing through the joint set present in the cave. The water follows the line of the least resistance and the continuous flowing over the time will affects the hardness of joints and enlarges the major joints to form a channel.

In the cave of the study area, the river water and percolation rain water from the surface enter to the channel. However, because of the dips of carbonate rocks at the cave of study area is quite steeply to the west, thus the water flowing from the western to the eastern side of the carbonate rock ridge. Due to this, it affects the water flowing behaviors which force them to flow through the joints presents. This occur in a long period action of the force, thus the water flowing enlarge all the joint and forming a sequence of water flowing. The more joints in the cave provided a good condition for the cave development and it is predicted to be close to the water table.

Figure 5.4 : Disappearing stream in the study area

5.2.3 Towers

Towers is a type of landscape characterized by steep limestone towers or cones and occur mainly in tropical areas. It is form as residual cones and are then steepened by water table undercutting from surrounding plains. Tower karst is form in the range between 30 meters until 300 meters high towers with vertical or overhanging sides. The walls are normally bare rock because the walls are too steep for vegetation. Figure 5.5 shows the karst tower in the study area. Figure 5.6 shows the view of karst tower in google earth while figure 5.7 shows the karst profile graph in the study area. Figure 5.8 shows the view of 3D karst in ArcScene.

Figure 5.5 : Karst tower in the study area

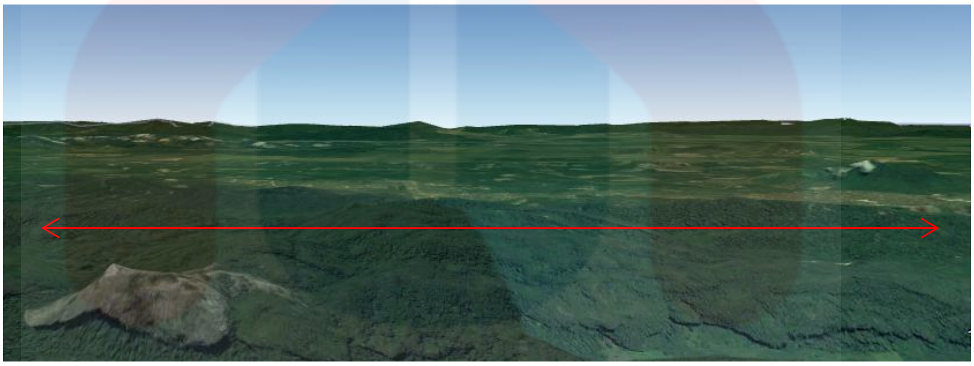


Figure 5.6 : View of karst tower in google earth

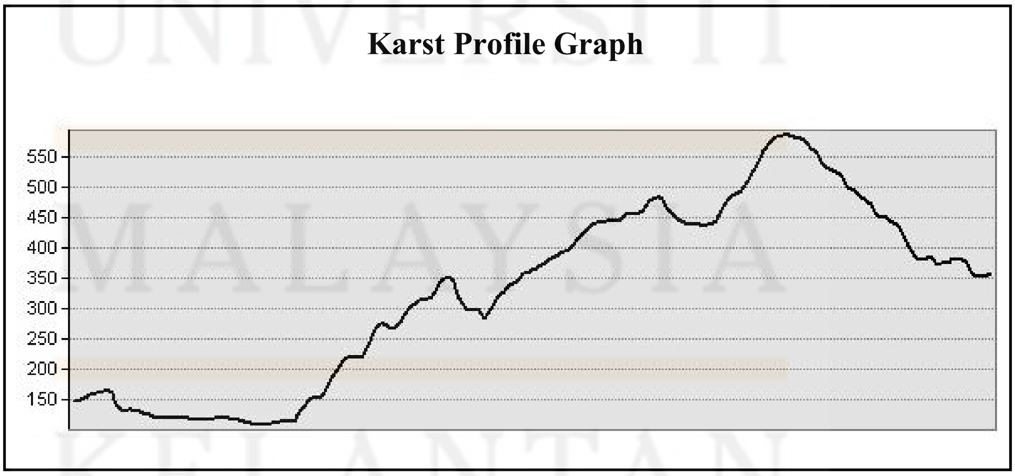


Figure 5.7 : Karst profile graph in the study area

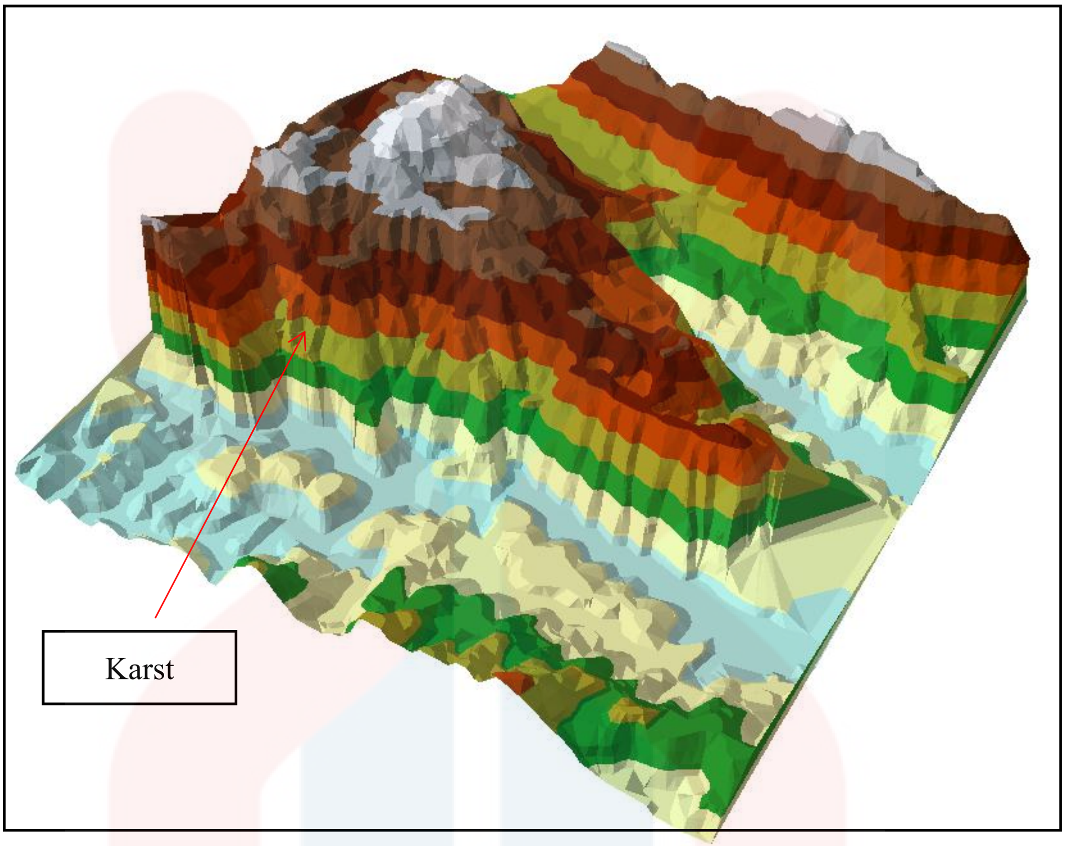


Figure 5.8 : View of 3D karst in ArcScene

5.2.4 Undulating Process

Undulating process is a process that same with abrasion which is the friction that occur between rock and moving particles by the agent. The examples of agent are wind, gravity and running water. Figure 5.9 shows the height of the karsts are differ like it moving gently up and down. The part that moving down cause by the factor of erosion by rainfall to the surface that have a lot of fracture.

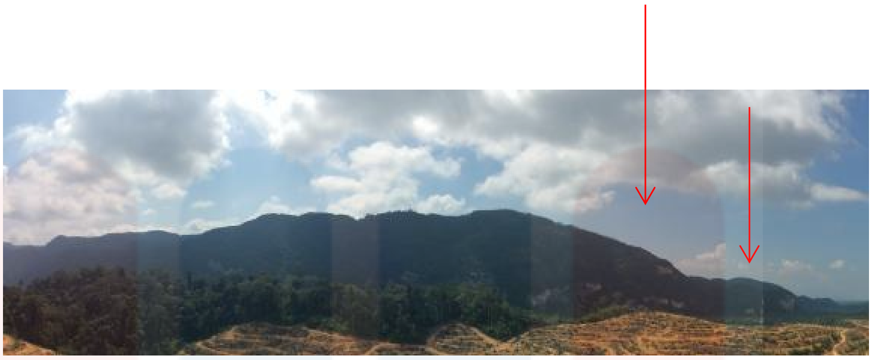


Figure 5.9 : Undulating process on karst

5.2.5 Rock Fall

The observation of the karst showed most of the area have a big fracture which cause the rock to erode or at last fall to the ground. Figure 5.10 shows the rock fall which influence by the factor of weathering and climate surrounding of the karst. Weathering process cause the rock may have a high pressure and trigger to fall which related to the discontinuities with rock mass. The rock that remain hanging above also have a potential to fall down to the ground.

Figure 5.10 : Rock fall

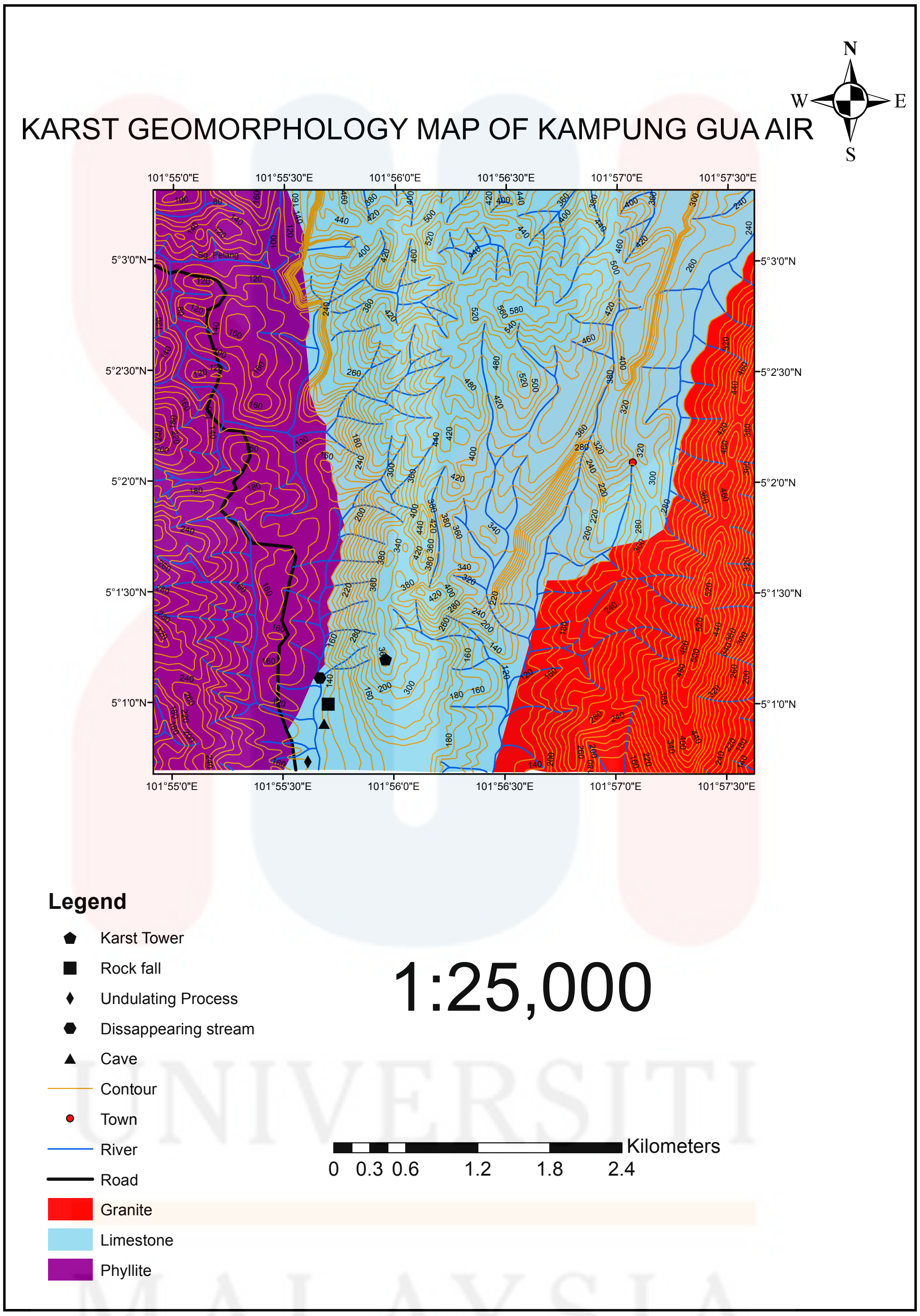


Figure 5.11 : Karst geomorphology map of the study area

5.3 Environmental history

The past history of how the cave develop is probably even when the uplifted of the tectonic plate with excessive accumulation of the skeleton after the huge collision of the two plate. In fact, under varying conditions of geology, structure and climate, landform characteristics may vary greatly even though the geomorphic process may have been acting for comparable periods of time. There are many arguments between the geomorhologists about the evolution of landform and many objections are made in order to critics the past theories.

In spite of that, based on overall observation in the field, the cave in the study area can be classify as a maturation stage. This is due to the dynamic underground action which is still occur by solution and abrasion and the channel is being enlarge and the aggressive weathering process forming the caves cavity.

The karst is determined by showed the sequences of the process with own interpretation by understanding the characteristic or behaviour of the karst landforms. Next, it supported by the cave morphology and whole karst geomorphology characteristic such as the features that made up a karst formation. The outside or surrounding of the hill also being noted their information.

Cave is the most popular place for a bat. The cave in the study area is one the place where the bat live by hanging at the cave ceiling. When enter the cave, people must put their safety because bat can fly and crash into people that came in.

The features like speleothem make the karst have a unique landfroms. Stalactites is the most common features that found at the karst compared to stalagmite. Most of the features had grows bigger due to the rapidly dissolution process take place.

People should concern this formation do not touch easily because it will disturb the growth process and remain small the beginning.

The study area is very limited to find the geomorphology features. The observation is done by observing the geomorphology of the karst. But the special features is rarely to find like the other karst all around the world. To find the various features is a little difficult but the karst still have their own characteristics.

Karst in the study area is a tower karst (conical hill). The process of the formation do not explained in detail due to the no information from the previous research about the study area. Besides, the others tower karst at different places also do not have their detailed information about how the karst formed. Most of the research only mentioned the type of karst based on the basic characteristics. All the way of formation is explained by made an interpretation supported with some theories involving all the processes take placed until the karst formed.

Geomorphology covered all the features that formed at the karst area. The morphology of the karst is basically same as others karst such as stalactite, stalagmite, pillar, flowstone and others. The condition of the cave which is small caused the various features is difficult to find.

Furthermore, the observation of the karst also showed that the karst have a fracture in a big scale and have a plant root exert on a karst. Thus, it will give effect to the stability of the karst and have a potential of rock fall (Figure 5.10) to happen. After observed the karst surrounding, many rock already fall and another still hanging with unsafe condition. The weathering process cause the outside of karst wall being dark slightly with white colour.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 CONCLUSION

By the end of the research, all the objectives are considered successful. The geological map with scale 1:25 000 is being updated with the lithology and cross section. All the information and behaviour of the study area could not be prepared without a field observation. Geographic Information System (GIS) application is helped in further explained about the geology and others characteristics of the study area.

The type of the limestone which is conical hill also being identified by showing the sequences of the process of the karst formation. Although it have less information due to the lack of the previous research about the formation of karst. The interpretation of the karst formation is done by relate with the information and understanding. All the way of process is explained but do not in detailed with supported by showing the overall pictures that take placed.

Furthermore, the karst geomorphology also being determined which are caves, disappearing stream, towers, undulating process and rock fall. Then, the features is taken and explained its characteristics and also the process that involved. The karst surrounding also being observed to support the overall geomorphology of the study area.

6.2 SUGGESTION

For the general geology, source from JUPEM should be always updated from the part of lithology, past environment and the land use. Thus, the comparison between year to years can be detected and the data do not much different. Student need to be exposed with the used of GIS application because it is really important in mapping session to create a map. The application should be updated regularly for the further purpose.

For the karst, the research needed to use an aerial photograph to get the best result for the type of karst. The aerial photograph will show the 3D diagram and from the analysis of the boundary of the karst can be done. The geomorhology of the area also can be seen but yet field observation still needed to achieve the purpose of the research.

During the field observation, the rock fall is detected at many places. This can contribute to the natural hazard. People who in charged the area should alert to try to solve the problem for the safety of the people surrounding. This is because a lot of people is work at the study area due to logging and oil palm plantation. The area that have a potential to cause hazard should be mark as a dangerous place. The construction activities near the area should concern due to the karst made up of soluble rock and have a higher potential for natural hazard to happen.

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