GENERAL GEOLOGY AND PHYSICAL PROPERTIES OF LIMESTONE AT GUA PANJANG, GUA MUSANG KELANTAN

by

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DECLARATION

I declare that this thesis entitled "title of the thesis"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 Physical Properties of Limestone at Gua Panjang,Gua Musang Kelantan

ABSTRACT

Gua Panjang is located 15 km from the Gua Musang town. Gua Panjang represents the series of Gua Musang Formation, which aged from the Middle Permian to Upper Triassic. It is predominantly consists of limestone and sandstone interbedded with silt. The limestone found are mostly dark gray and milky white colors which have indicated that there is a process of metamorphism is present in this study area. The objective of this research is to produce the geological map of the study area and also to determine the physical properties of limestone in terms of their porosity, density, water content and slake durability. The result from the research is to compare if there is a different between the weathered rock and the fresh rock of limestone and to recommend the most suitable limestone for construction materials. The methods used in conducting the research are preliminary research, random sampling, slake durability test, porosity test, density test and water content test. The discussion of the physical properties of limestone is based on tables and a calculation of the data from the laboratory test. From the discussion, it shows that the porosity of limestone is averagely 51.21%, as for density 0.14 kg/m^3, water content having an average of 0.10% and lastly slake durability index having an average of 99.31%. Based on the results the limestone in each three location is predominantly a pores type because the porosity is averagely 51.21%, which is the value is bigger than 2%. An increase in porosity is typically accompanied with an increase in deformability and permeability and abatement in quality. The decrease in strength with an increase in porosity was seen by Howarth (1987b). He also found that drilling rate increases with rock porosity. The density of limestone is typically 2.5 to 2.7 Kg/cm3, but the results from the experiments shows that it's approximately 0.14kg/m^3. This means that the limestone in this area is highly porous. Based on the results for slake durability, the limestone in this area is categorized to be having a very high durability nature.

General Am dan Ciri-ciri Fizikal Batu Kapur di Gua Panjang, Gua Musang Kelantan

ABSTRAK

Gua Panjang terletak 15 km dari bandar Gua Musang. Ia mewakili siri pembentukan Gua Musang, yang berumur dari Permian Tengah ke Trias Atas. Kawasan ini terdiri daripada batu kapur dan batu pasir yang saling berlapis dengan kelodak. Batu kapur yang ditemui adalah kebanyakannya berwarna kelabu gelap dan putih susu yang menunjukkan bahawa terdapat satu proses metamorfisme berlaku di kawasan kajian ini. Batu Kapur adalah sejenis batu yang mempunyai pelbagai kegunaan. Ia adalah salah satu komponen penting dalam pembinaan dan asas bangunan. Walau bagaimanapun, ia adalah penting untuk mengetahui dulu mengenai sifat-sifat fizikal batu kapur sebelum ia digunakan dalam apa-apa bahan binaan atau sebagai asas untuk mana-mana pembinaan bangunan. Objektif kajian ini adalah untuk menghasilkan peta geologi kawasan kajian dan juga untuk menentukan sifat-sifat fizikal batu kapur dari segi keliangan, ketumpatan, kandungan air dan reda ketahanan. Hasil dari kajian ini adalah untuk membandingkan jika terdapat perbezaan di antara batu terluluhawa dan batu segar batu kapur dan untuk mencadangkan batu kapur yang paling sesuai untuk bahan-bahan pembinaan. Kajian ini menggunakan kaedah penyelidikan awal, persampelan secara rawak, reda ujian ketahaan, ujian keliangan, ujian ketumpatan dan ujian kandungan air. Sifat-sifat fizikal batu kapur diperbincangkan berdasarkan kepada jadual dan pengiraan data dari ujian makmal Dari perbincangan itu, ia menunjukkan bahawa keliangan batu kapur adalah secara purata 51,21%, seperti untuk ketumpatan 0.14 kg / m^3, kandungan air yang mempunyai purata 0.10% dan akhir sekali indeks ketahanan mempunyai purata 99,31%. Berdasarkan hasil kajian batu kapur dari setiap tiga lokasi, kebanyakannya jenis liang kerana keliangan adalah secara purata 51.21%, iaitu nilai lebih besar daripada 2%. Peningkatan keliangan biasanya diiringi dengan peningkatan dalam perubahan bentuk dan kebolehtelapan dan pengurangan dalam kualiti. Penurunan kekuatan dengan peningkatan keliangan dilihat oleh Howarth (1987b). Beliau juga mendapati bahawa kenaikan kadar penggerudian dengan keliangan rock. Ketumpatan batu kapur biasanya 2,5-2,7 Kg / cm3, tetapi keputusan dari hasil kajian menunjukkan nilai lebih kurang 0.14kg / m^3. Ini bermakna bahawa batu kapur di kawasan ini adalah sangat berliang. Berdasarkan keputusan untuk indeks ketahanan, batu kapur di kawasan ini dikategorikan untuk mempunyai sifat ketahanan yang sangat tinggi.

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CHAPTER 1

INTRODUCTION

1.1 General Background

This study is focused on geology and physical properties of limestone in Gua Panjang, Gua Musang, Kelantan. Geological study is conducted to reveal about geomorphology, drainage pattern, lithostratigraphy, structural geology, land use, petrography and other geological features of the study area which is in Gua Panjang, Gua Musang, Kelantan and its surrounding area within 5km x 5km.The study of the geology is important in order to produce a latest geological map. This research is conducted by using field observation, mapping and laboratory analysis.

The specification of this study was to determine the physical properties of limestone such as porosity, density, water content, and slake durability at Gua Panjang and its surrounding area. This study examined the rock samples which are taken during field mapping observation. The rock samples have then been taken to a laboratory for further experiments of physical properties test. The observation of the experiment was analyzed and the interpretation of data was made to determine the physical properties of limestone.

General Geology is the study of various aspects of geology and Earth Sciences, from the formation of the universe and solar system down to the rocks and minerals of the geological processes and hazards (Stelling Pete et al., 2004). Geological mapping is one of the important steps for a geologist to investigate the geological research.

Geologists need to understand the geological history characterized by geomorphological and geological structure. The better they can comprehend Earth's history the better they can anticipate how occasions and processes of the past might impact the future. In understanding the process and structure of the Earth, geologists recorded their observations of the study area on the map that is known for geological maps. This map is a special-purpose map for people understand and see better about the sights and the information content of geological features that describe a topographic map of the rock units in the mainland, the types of contacts between them, the relationship of the earth, and surficial deposits, as well as the location of geological structures (folds, faults, shear zones), fossil beds, fountains, mineral resources. Rock units or geological strata demonstrated by color or symbol to show where they are uncovered at first glance on the Earth surface. Geological map is the main source of information on various aspects of natural resources and land use decisions.

According to the Garba (2013), Kelantan is located in the northeast of the Peninsular Malaysia and its coordinate is located on latitude 50˚ 15’ 0”N and longitude 10˚ 20’ 0”E. Iwan (2001) stated that, the total of the land area of Kelantan state is approximately 1, 493, 181 ha. In the east of the Peninsular Malaysia, Gua Musang is included as the part of Kelantan region. Gua Musang formation lies on Sibumasu plate, it occurs resulting from the collision of two huge terranes which are Sibumasu and Indochina. Gua Musang contains several caves which are composed mainly of limestone with interbeds of shale and volcaniclastic at about 900 m thick (Yin, 2000). Most of limestone in Gua Musang is in Permian age. Some of limestone caves which are located in Gua Musang are Gua Panjang, Gua Cha, Gua Madu and Gua Ikan.

Limestone is a sedimentary rock made basically out of calcium carbonate (calcite) or the twofold carbonate of calcium and magnesium (dolomite). It is for the most part made of little fossils, shell pieces and other fossilized waste. These fossils are as often as possible unmistakable to the unaided eye on close examination of the stone surface, however this is not the situation generally. A few assortments of limestone have an amazingly fine grain. Limestone is generally dark, yet it might likewise be white, yellow or cocoa. It is a delicate rock and is effortlessly scratched. It will bubble promptly in any normal corrosive. Limestone may change incredibly in surface and porosity from coquina, which is a network of entire or bits of ocean shells in exactly solidified by calcite, to oolitic limestones and microcrystalline limestones whose structures are fine to the point that they can be seen just under amplification. Limestone deposits can experience metamorphism during major topographical occasions bringing about a crystallizing as marble. Limestone is generally utilized as a part of structural applications for dividers, embellishing trim and lacquer. It is less as often as possible utilized as a sculptural material, in view of its porosity and delicate quality, in any case, it is a typical base material. It may be found in both bearing (structural) and veneer applications.

1.2 Problem Statement

This study area is believed not were explored thoroughly reliable. The earth is also evolving to this day; the geological processes continue to change until there are no new data and information about the area in terms of regional geology, roads and geomorphological study area. Besides that, the area is continuously exposed to the weathering and erosion that change the landform of the Earth, so the existing geological map of the area is needed to be updated. In addition, the stratigraphy of Gua Musang Formation at Gua Musang district is not yet completed and unformalized. According to Nuraiteng (2009), the lithostratigrapic unit of Gua Musang was not designated and its development during Permian-Triassic transition was still under discussions. In this manner, an upgraded guide ought to be created for giving the most recent data of the review region.

Other than that, knowledge of the physical properties of the rock especially limestone is very important in geology. This includes understanding the density and porosity of the reservoir rock to estimate their hydrocarbon potential. This research study will determine whether the area is worth exploring in the future for building construction and academic purposes.

1.3 Research Objective

The objectives of this research were as follows:

1. To produce a detail geological map with scale 1 : 25 000 of the selected area in Gua Panjang, Gua Musang, Kelantan.
2. To determine physical properties of limestone such as porosity, density, water content, and slake durability.

1.4 Study Area

1.4.1 Location

Figure 1.1 shows a location map of Kelantan. The study area of the research study is located at Gua Panjang, Gua Musang, Kelantan. It is located 15km from Gua Musang town. Indraneil Das and Nirsham Yaakob (2003) stated that Gua Musang of Kelantan state is located in the northern of the Peninsular Malaysia. The coordinates of the study area are 4° 48' 56.4762"N and 102° 0' 17.3772"E. It covers the area in the box of 25 km per squares which had a length and width of 5km x 5km. A base map with the scale of 1:25 000 was constructed using ArcGIS software as shown in Figure 1.2.

1.4.2 Demography

The geography is a field of studies that devoted to the study of the Earth's lands, the features, inhabitants, and its phenomena. In geographical research there are four historical traditions which are the special analysis of the natural and the human phenomena known as the study of the distribution, area studies to know the places and regions, the study of the human-land relationship, and research in the Earth sciences.

Geography separates into two fundamental branches which is human geology and physical geography. The geography is extraordinary on the grounds that it is connecting the sociologies known as human geology with the natural sciences known as physical geography. Human geography concerns the comprehension of the elements of societies, social orders and economies, and physical geography concerns the comprehension of the flow of the physical landscape and the environment.

Fundamentally, Gua Panjang is situated in Gua Musang in the hilly locale. There are more than 85 % of the zone are secure by vegetation. The essential stream of the audit locale is Sungai Ketil and Sungai Bertam. Different offices are additionally accessible, for example, the street association, the railroads and houses.

- **People Distribution**

In general, according to the Jabatan Perangkaan Malaysia (2010), the population of this Gua Musang area are about 86, 169 people until 2010 (Table 1.1). As stated in the statistic information provided on the official website of the Gua Musang District Council, the dominant race in Gua Musang is Malay which has a total of 64, 253 people. Then followed by indigenous with a total of 12, 570 people, follow-ups 3, 870 Chinese, 350 Indian people, 161 people from other ethnic groups and 4, 985 people from non-Malaysia citizens (Department of Statistic Malaysia, 2010).

1.4.3 Rain Distribution

Based on the data on rain distribution of year 2014 and 2015 from Department of Irrigation and Drainage (DID) Kelantan, it shows that in the year 2014 the total of rainfall (mm) is higher than in the year 2015. This is because in the year 2015, our Earth is experiencing a very hot weather that is known as El Nino crisis. Thus, in the year 2015 the total of rainfall (mm) in Gua Musang was less than the normal level. The data about

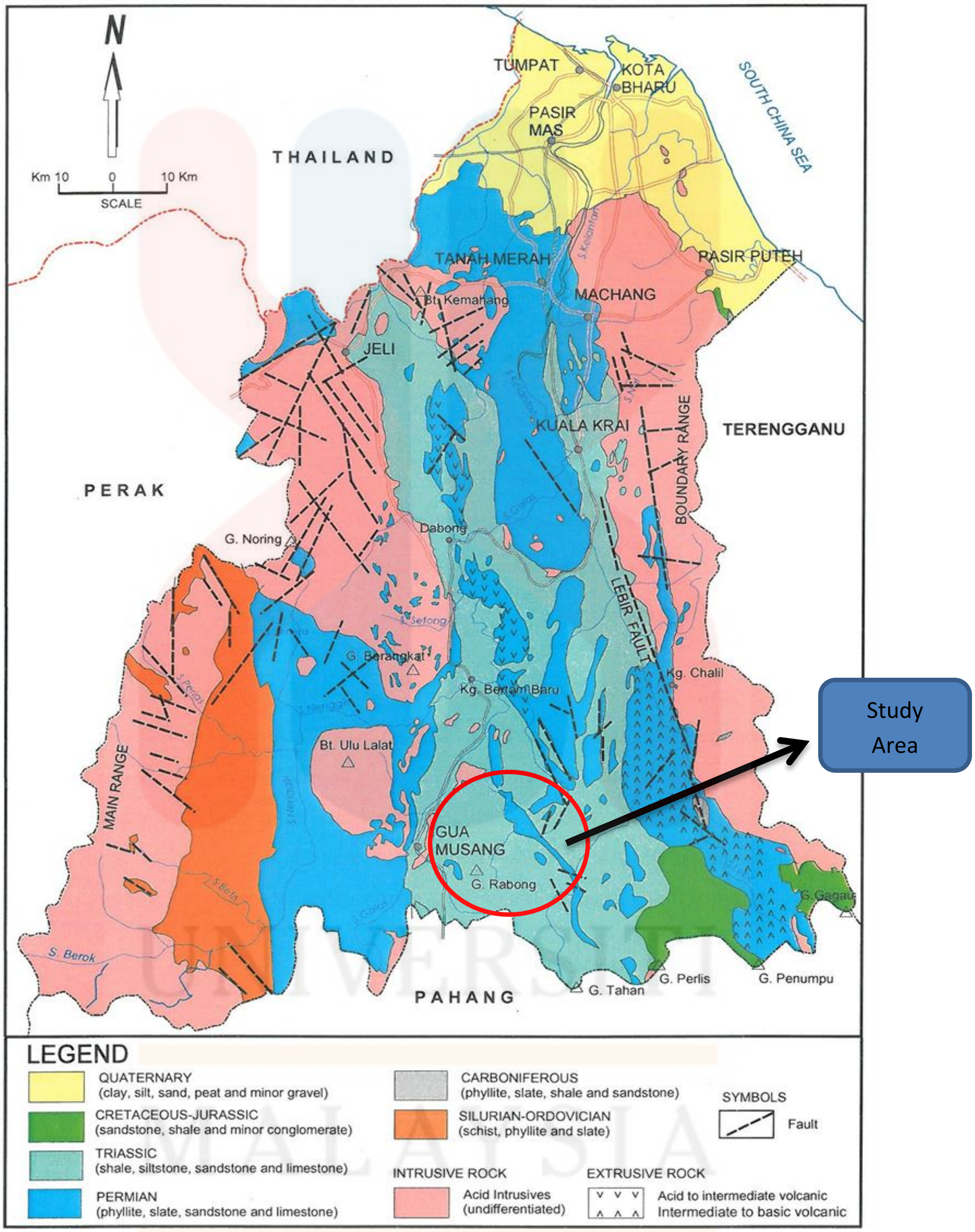

Figure 1.1: Geological map of Kelantan

the rain distribution of the year 2014 and 2015 can be referred on the Table 1.2. The rainfall pattern in a certain area will give an effect to the weathering process of the area.

Based on monsoon season which start from October to December, the amount of rain distribution in December 2014 may lead to major flood event in Gua Musang especially at lowland area. It is also cause the increasing of weathering and erosion process to some geological features.

1.4.4 Land Use

According to the Land Use Information Division (2012), the total land area of Gua Musang is 8 214.3 km². The surrounding area of study area is mostly covered with forest. Figure 1.3 shows a box where the study area is located. Based on the box, the area is 85 % covered with vegetation which is an oil palm plantation, rubber plantation and forest. There were also a main river that is known as Sungai Ketil, irrigation, and drainage. In addition, 10 % of the areas are covered by the village, and roads for transportation.

1.4.5 Social Economic

The greater part of the living arrangement of Kampung Lepan Jaya is independently employed. In fact, large portions of the general population around there are filling in as a worker or temporary workers. In any case, there likewise a large portion of them are working in farming movement. The farming exercises included are oil palm estate and elastic ranch. The greater part of the say social movement is for the most part commanded by Malay and Chinese races. While, the indigenous individuals, which is the real home in this review region are chipping away at their unique monetary movement, for example, angling, chasing, gathering herb, planting and other action. Logging is also included as one of the activities in the study area because the area is mostly covered by forest.

1.4.6 Road Connection

In the study area, the vast majority of the street found is an unpaved street. In any case, there still somewhat of a cleared street which discovered situated in the town region. The street in the review region is utilized to interface the local location to the town. There is likewise a railroad that can be found close to the primary stream.

Figure 1.3: Railways trail

Table 1.1: Total population by ethnic group, Local Authority area and state, Malaysia, 2010
State: KELANTAN

Local Authority Area	Total	Malaysian citizens							Non-Malaysian citizens
		Total	Bumiputera			Chinese	India	Others	
			Total	Malay	Other Bumiputera				
Gua Musang									
M.D. Gua Musang	**86,189**	**81,204**	**76,823**	**64,253**	**12,570**	**3,870**	**350**	**161**	**4,985**
Batu Papan	2,594	2,543	1,520	1,512	8	883	132	8	51
Bertam	1,142	1,133	1,131	1,131	-	1	1	-	9
Chegar Bongor	494	426	398	398	-	24	-	4	68
Gua Musang	**18,420**	**17,775**	**15,373**	**15,285**	**88**	**2,217**	**155**	**30**	**645**
Kerinting	157	144	128	128	-	1	15	-	13
Limau Kasturi	975	905	893	893	-	5	-	7	70
Paya Tupai	337	325	325	325	-	-	-	-	12
Remainder of M.D.	62,070	57,953	57,055	44,581	12,474	739	47	112	4,117

Table 1.2: Total Rain Distribution data in Gua Musang of year 2014 and 2015 (Department of Irrigation and Drainage Kelantan, DID)

Year	Month												Total (mm)
	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	
2014	136.0	3.0	196.0	169.0	225.0	215.0	90.0	618.0	489.0	313.0	175.0	591.0	3,220.0
2015	0.0	0.0	42.0	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	NIL	42.0

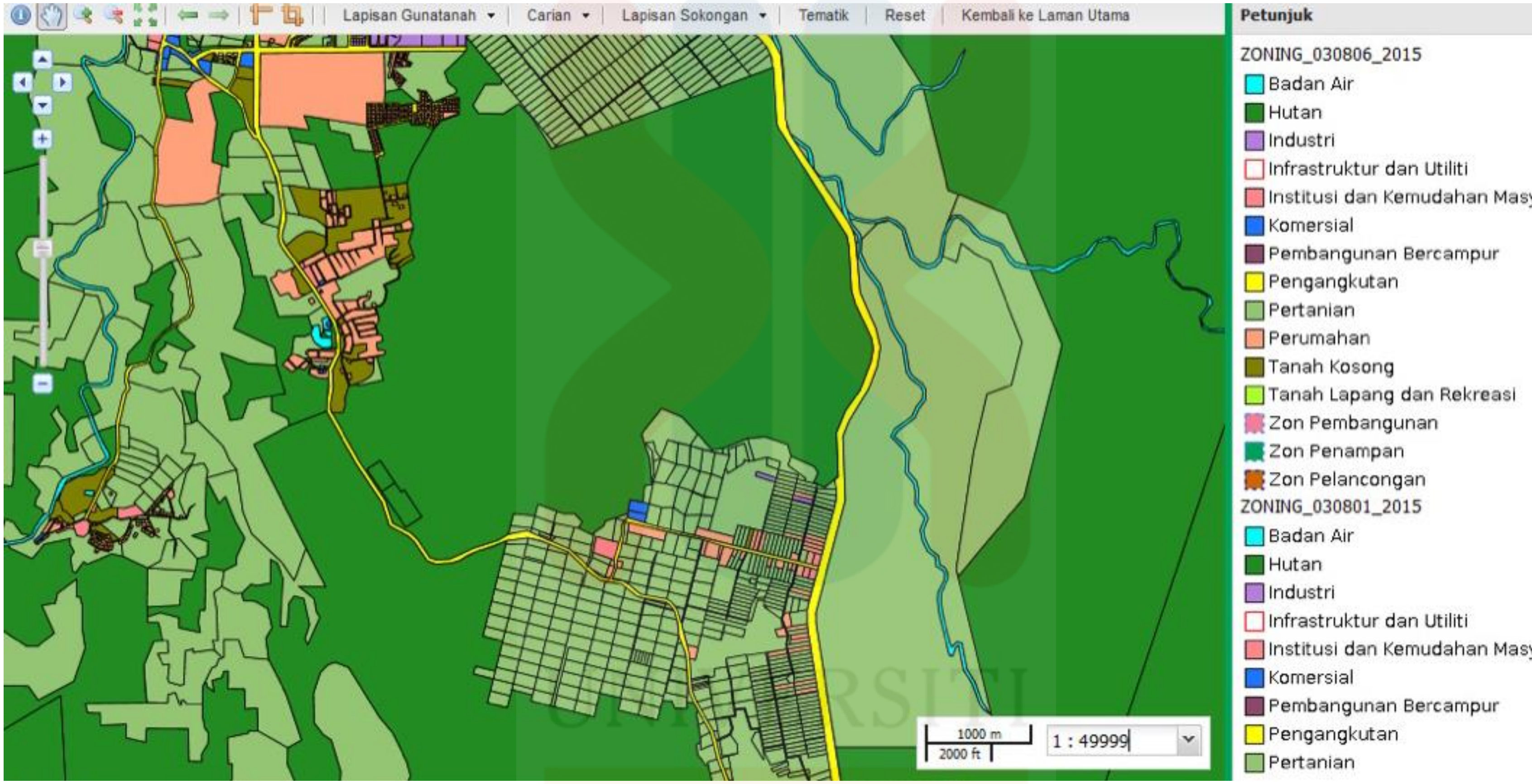

Figure 1.4: Map of land use that shows a box where the study area is located.

1.5 Scope of the study

This research study is at Gua Panjang, Gua Musang, Kelantan and its surrounding area which is within the area of 5km x 5km, with the latitude of 4° 48' 56.4762"N and 102° 0' 17.3772"E. The geology, petrography and physical properties of limestone in the surrounding area were studied.

The geological study dealing with geomorphology, drainage pattern, lithostratigraphy, structural geology, land use, petrography and other geological features of the study area by field observation, geological mapping, sampling and laboratory analysis. The study of the geology is important to produce a latest geological map. Petrography study involves using the petrographic microscope to study the thin section of the rock sample.

1.6 Research Significance

This study is conducted to understand the general geology of Gua Panjang, Gua Musang Kelantan. This research will provide the latest information which includes about geomorphology, drainage pattern, lithology of the rock and structural geology in the area.

On top of that, the physical properties of the rock are an important input parameter in the branch of science and technology, especially in the field of geology. For example the exploration of hydrocarbons, geothermal and mineral reservoirs, as well as determine the type of rock for future construction in the area. This valuable information will help engineering geologist to relate the rock physical potential hazards in the area such as landslide, sinkhole, and foundation settlement before making any construction. The research study will also benefit for the academic purpose for geologist to make as a reference in the future.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, it consists of the review of the preliminary study, which are related to the research that were carried out. The review is practically related to the objective, problem statements and methodology of the research. Moreover, this review is analyzed to fulfill the gap and thus get a better result.

In this literature review, it is done based on several aspects which is includes the regional geology and tectonic setting, historical geology, stratigraphy, structural geology, petrography and physical properties of limestone in the study area. The studies from the former researchers aids in giving the information for the occurrence of the past activities and others geological information regarding the study area for further understanding about geology.

2.2 Regional geology and tectonic setting

The peninsular Malaysia is a part of the Eurasia Plate, the Southeast Asian part which is known as Sundaland (Hutchison, 1973). Peninsular Malaysia is otherwise called West Malaysia. Peninsular Malaysia is circumscribed in the north by Thailand and Singapore towards the south. While the Malaysian conditions of Sabah and Sarawak situated in the northern part of the island of Borneo are isolated by 500 kilometers of the South China Ocean from Peninsular Malaysia.

The Peninsular Malaysia has been divided into three types of zones. The three zones are north, south and lastly is trending. This zone is divided based on their differences of stratigraphy, mineralization and structure. The picture of the zones can be referred in Figure 2.1. These three zones can also be referred as the Western, Central and Eastern “Belt”, “Zones”, or “Domain”. The present Peninsular Malaysia nowadays are resulted from the collision between the two terranes which is Sibumasu and Indochina, which forming the Bentong-Raub Suture that arose at the end of the age of Permian. (Figure 2.2)

Kelantan consists of 4 major areas that took into consideration to tell the story of whole Kelantan. The area is Kuala Betis, Aring, Gua Musang, and last not least Gunung Gagau. As this research is concerned on Gua Musang, only this area is highlighted to tell more of the places. This formation is located at the depocentre part of Gua Musang-Semantan formation that lies in the east of Bentong-Raub suture within the central belt. The one that is responsible in giving this formation’s name is Yin (1965). Gua Musang formation is composed of calcareous and argillaceous rocks with a bit of arenite, pyroclastic flow, and lava flows as reported by Yin (1965).

Figure 2.1: North-south trending zones.
(Sources: Metcalfe, 2000**)**

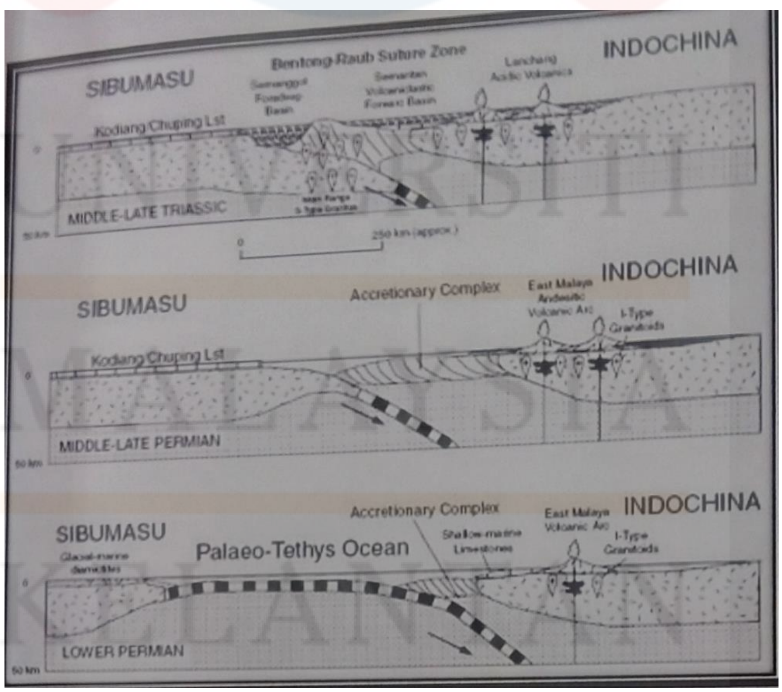

Figure 2.2: Subduction of Sibumasu into Indochina plate

2.2.1 Stratigraphy

The Peninsular Malaysia is divided into three belts, which is western belt, central belt and eastern belt. This three belt is differentiated by their stratigraphy. The vast majority of Kelantan stratigraphy lies in the focal belt with some minor on the other two belts. The focal belt is flanked by Bentong suture in the west and Lebir blame in the east.The Bentong suture separated the continental of Godwana in the west from the remainder Peninsular that in late Palaeozoic was already part of Laurasia (Tjia, 1989). As stated by Mohd Shafeea Leman & Kamal Roslan Mohamed (1995), central belt mostly belongs to the age of Permo-Triassic Gua Musang Formation, which consists of three main facies which are limestone, argillaceous and volcanic facies

2.2.2 Structural Geology

Kelantan state is traced with fault such as Lebir Fault Zone, Galas Fault zone and Bok Bak Fault Zone as the major fault zones in Kelantan. The fault zone that takes after the western contact of the Boundary Range of Granite in Liberia Valley are the most unmistakable. The trace of the fault is 42km. It represents the part of the larger Lebir fault zone that extending to southwards Pahang and covers about 420 m in distance (Lee, 1990)

2.2.3 Historical Geology

The central part of Gua Musang is suggested to have volcanic activity; this is stated by Lim & Nuraiteng (1994). This is a direct result of the high topographic that permit the limestone bodies on top of the Gua Musang basin.

2.3 Engineering Geology

Engineering geology is a branch of geology that deals with soil and mechanics, strength of materials and theory of structures (Sawant, 2011). Engineering geology is divided into two important field of activity. The first is engineering project that works with ground constitutes the construction materials, foundation and storage. On the other hand, the second one is associated with prevention, mitigation and controls the geological hazards and predicts the environmental impacts of the hazards (Vallenjo and Ferrer, 2011). Geological hazard is danger to humans and their construction or works. The human activity the causes that leads to this hazard, but natural event can also become a trigger to this danger (Hunt, 2007)

2.4 Physical Properties of rock

The physical properties of rock are included in this branch of engineering geology based on the properties such as porosity, water content; slake durability, and density. Through laboratory experiments, the physical properties can be determined. According to the West (2010), rock is used as a foundation for engineering structures. The porosity and permeability is measured by calculating its specific gravity under dry condition and saturated condition.

a) Porosity

Porosity is one of the most important properties of rock in describing porous media which are defined as the ratio of the pore volume to the bulk volume of a rock sample. The porosity is actually a dimensionless quantity which can be expressed as decimal or percentage. Moreover, it is best to just represent the porosity as a volume ratio of pore space to the bulk space. The illustration of porosity is shown in Figure 2.3.

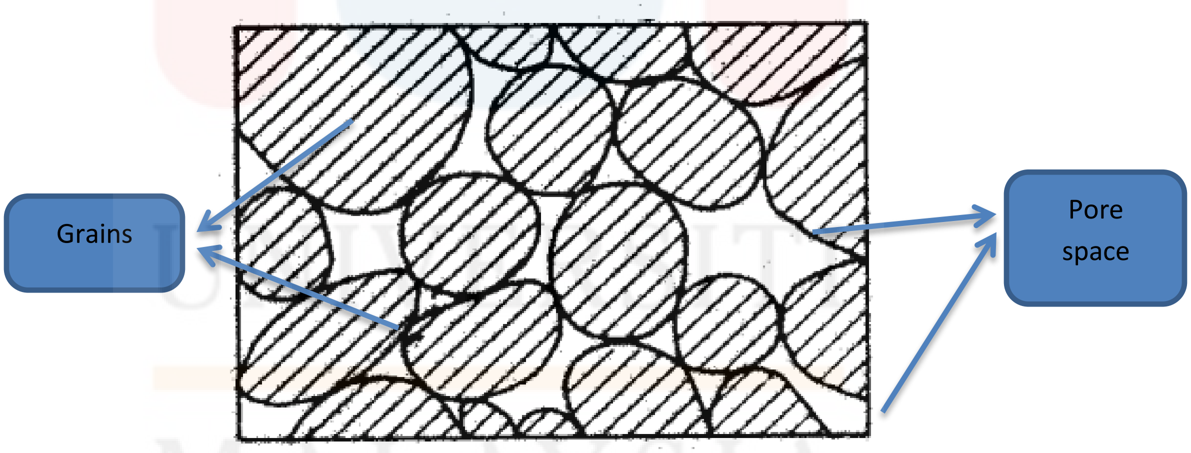

Figure 2.3: Cross-sectional view of a porous media

The oil, gas or water is living inside the pore spaces which are accessible. Whence, the essential application for the porosity is to measure the capacity limit of the rock and thus to characterize the volume of hydrocarbon accessible to be created..

a) Density

The density of rock is normally expressed as specific gravity. This is because the water's density is equal to 1 gram per cubic centimeter (1 g/cm^3). Therefore, these numbers can translate directly to g/cm^3 or tonnes per cubic meter (t/m^3). For engineers, the rock densities are very useful. Same goes to the geophysicist since they are basic for the individuals who need to model he rock of the Earth's crust layer.

b) Water content

Water content or also known as moisture content is actually the amount of water that are contained in the materials (rocks). Water substance is generally utilized as a part of a scope of logical and specialized territories and its communicated as a proportion. The range is from 0 which are absolutely dry to the estimation of the materials (rocks) porosity at drenching.

c) Slake durability test

The slake durability test is valuable in deciding the breaking down nature of the rocks when it is subjected to drying and wetting conditions alongside the development. This test legitimately characterizes the weathering conduct of rocks. Be that as it may, the systems required in this slaking test have not been completely seen yet even after so many years. The component developments of the rocks inside the device are seen, yet its impact on weathering is still obscure. Franklin and Chandra (1972) demonstrated that the systems in slake-durability tests are subjected to particle trade and slender pressure. For rocks containing dirt materials, the trading of cations and anions happen with the absorption and assimilation of water, which makes the rock swell in size and slaking happens. With the length of the trial of just ten minutes, the wetting procedure may break parts of the rocks, especially for the surface part, yet because of the proper pivot speed and the level of the water a large portion of the parts of the stones get wet.

Arrangements on the premise of slake sturdiness record. As per Bet (1971), slake durability record is a shift of the entire range from 0 to 100%. There are no obvious associations amongst sturdiness and geographical age, however durability, expanded straightly with thickness and contrarily with characteristic water content. In light of the outcomes, Bet (1971) proposed a grouping of slake durability as given in Table 2.1. The slake strength arrangement is valuable in the determination of rock aggregate, rail line, concrete and shotcrete.

Table 2.1: Gamble's Table

Gambles' Slake Durability Classification

Group Name	% retained after one 10 min cycle (dry weight basis)	% retained after two 10 min cycle (dry weight basis)
Very High Durability	>99	>98
High Durability	98 - 99	95 - 98
Medium High Durability	95 - 98	85 - 95
Medium Durability	85 - 95	60 - 85
Low Durability	60 - 85	30 - 60
Very Low Durability	<60	<30

(Source: Goodman, 1980)

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

To complete this research study, there are several methods that are used to make sure that the execution of the study can be done in an orderly manner and systematic way. The methodology of this research study has included the preliminary study, materials, field study, sampling, laboratory investigation, analysis and interpretations. Figure 3.1 shows the Flow Chart of the research.

3.2 Materials

The final year project used some of the equipment for mapping and collecting observation data in the study area. The equipment that are needed for geological mapping are base map, geological hammer, compass, hand lens, camera, Global Positioning System (GPS), hydrochloric acid (HCl), measuring tape, stationary, and sample bag. As for the laboratory, the materials used are the rock samples.

The reasonable material is essential amid this examination furthermore picked system so as to investigation the outcome. The materials that list will be used at the site to collect and record the data before doing the laboratories test. There a few materials that related to a general geology method that applied in the field.

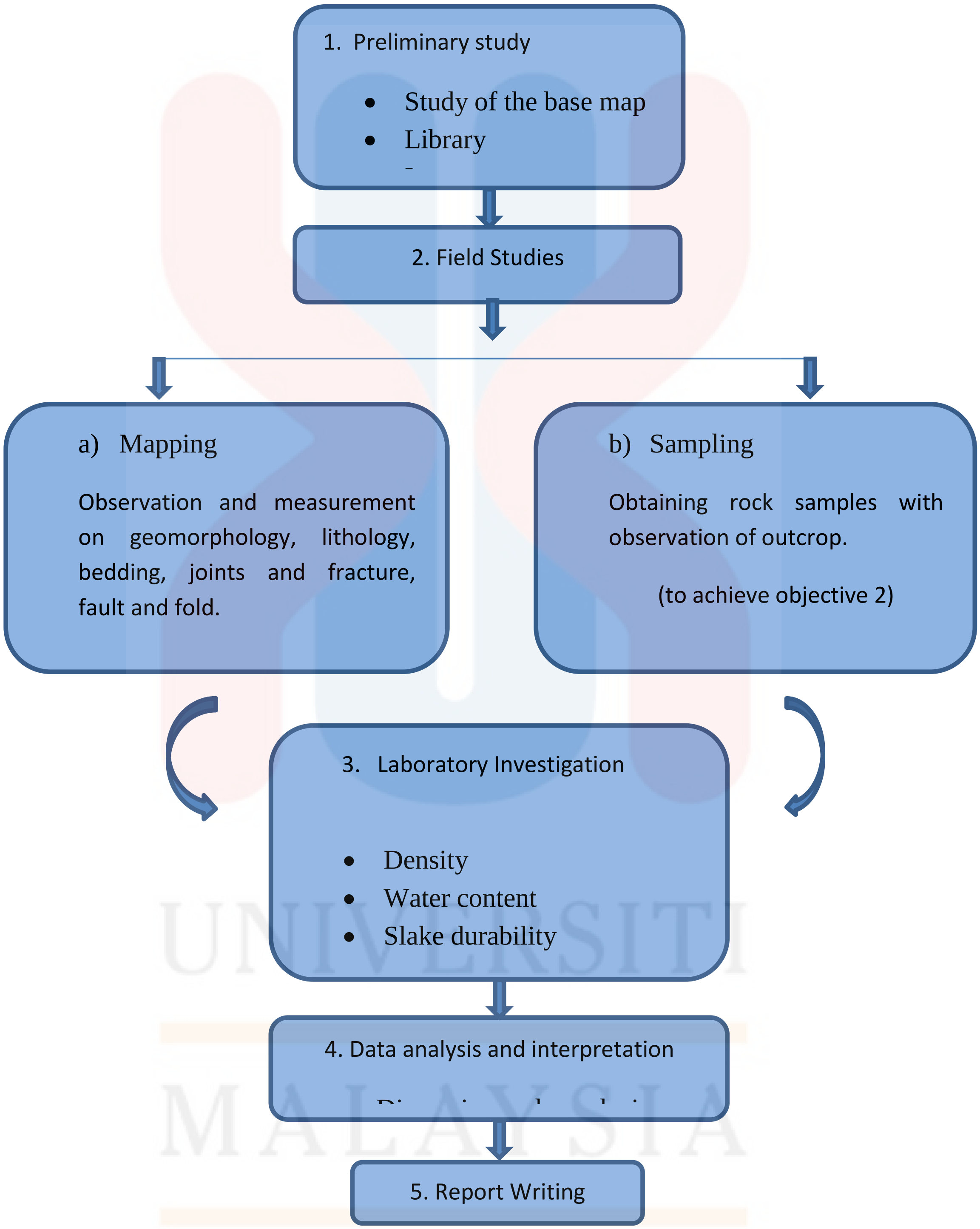

Figure 3.1: Flow chart of research study.

3.2.1 Base map of study area.

- The base map of the study area is produced by using GPS application. This base map contains a couple of essential data, for example, river, elevation of contour, main rivers and the village around the study area. It also can be as a reference to know the topographic condition of the study area. It shows the rough idea about the study area and what point to reach, the data will be collected and a few steps of the mapping process.

3.2.2 Geological Hammer.

- The geological hammer is the basic equipment during mapping and it is the tool used for collecting samples and for chipping away the weathered rock surface to obtain the fresh surface. The common type of geological hammer is a chisel head made of a hardened steel and rubber at the bottom make easy to handle (Figure 3.2)

Figure 3.2: Geological hammer (Chisel head)

3.2.3 Compass.

- The compass is used to measure the orientation geological planes and the lineation with respect to north, calculate the strike and dip of geological features and use to marker for azimuth reading. The compass likewise can be used to decide precisely area in view of topographic map. Usually, there are two main type of compass use in mapping activity that a Brunton and Suunto. (Figure 3.3)

a) b)

Figure 3.3: a) Suunto compass; b) Brunton compass.

3.2.4 Hand lens.

- The main function of hand lens is to make a first observation and analysis of the rock sample in the field before doing the analysis in the laboratories (Figure3.4). A good hand lens with a moderate magnification (X10) is absolutely essential for the examination of a fresh rock surface to determine the grain shape and micro fossil in a rock because it cannot be seen by naked eyes.

Figure 3.4: Hand lens

3.2.5 Global Positional System (GPS).

- The GPS will be used to produce valuable information to the geologist during the field work (Figure 3.5). A few function of GPS, it can record the waypoint, tract, map the location of the sample that be taken, elevation of the area, the direction of the location and the latitude and longitude value and other information.

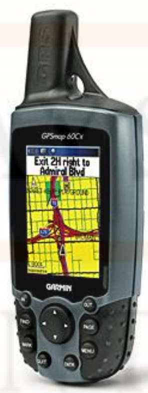

Figure 3.5: Global Positioning System (GPS)

3.2.6 HCL Solution.

- This solution will be used to detect the presence of calcium carbonate in mineral or rock (Figure 3.6). For example HCL can detect limestone rock and calcite mineral.

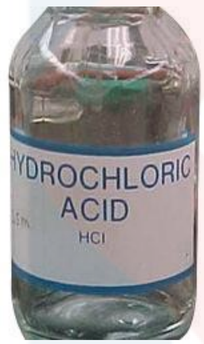

Figure 3.6: Hydrochloric acid (HCl)

3.2.7 Measuring tape.

- Measuring tape usually use to measure the width of the outcrop. It can be used to measure the length of joint, fault line or any thickness of layer on the sedimentary outcrop (Figure 3.7).

Figure 3.7: Measuring tape

3.2.8 Dual Blade Rock Saw

- Dual blade rock saw are used to cut a rock to make a thin section of the rock sample that used to observed in microscope (Figure 3.8)

3.2.9 Single blade Rock Saw

- Single blade rock saw has the same usage as the dual blade rock saw. It used to cut a rock to make it as a thin section sample that can be observed under the microscope (Figure 3.8)

Figure 3.8: Dual and single blade rock saws for cutting samples to the required size

3.2.10 Field book, log book and proper attire.

- Field book go about as a scratch pad that contains the vital data in view of the past writing survey. The log book is important to record location, physical properties of the location, number of sample and any sample taken. The correct clothing need as a wellbeing and secure path amid field work.

Meanwhile, there are several software will be used to present all the information that was collected during the field work

3.2.11 ArcGIS 10

- This is actually software that are usually used to generate a map of the study area. All of the maps are important to this research as it will explain the objective of this research.

  There are many types of map can be generated using this software such as:

  - Geological map
  - Traverse map
  - Geomorphology map
  - Drainage pattern map
  - Geomorphological constraint map

3.3 Methodology

3.3.1 Preliminary Researches

The preliminary study of the research was in a few several ways, which involved searching the information in the library, through the internet, studying the aerial photo an preparing the base map of the study area.

The library of the University Malaysia Kelantan (UMK) is used to search for the information regarding this research study. Books, journals, dictionary and map of the study area provide more knowledge on the geology and the physical properties of limestone. Furthermore, there is so much information that can be found through the internet which is online articles, journals, e-book, proceeding and thesis that were downloaded and used as references.

3.3.2 Field Studies

The study area basically was traversed and the coordinate of outcrops with different lithology or distinctive geological structure is marked using the Global Positioning System (GPS) device during the field visit. Using this equipment, precise location for localities can be determined on the map. The study area will be observed from high ground to low ground for understanding the geomorphological of the study area. Next, the type of lithology, drainage pattern, formation and geological structure are observed directly. The orientation (strike and dip) of a geologic feature such as foliation of outcrop will be taken for structural analysis. The preparation of thin section for this research study can be done by taking the rock sample in the study area for microscopic details.

3.3.3 Laboratory Investigation

a) Porosity

A few methods exist to gauge rock porosity on attachments penetrated from recuperated centers. In any case, just a single technique that will be connected in my examinations are displayed here water immersion technique. A dry rock sample is weighed and after that vacuum-immersed with water. The water-soaked specimen is weighed and the distinction between both weights is the heaviness of water inside the pores. Knowing the thickness of the water, the volume of water including the pore space of the rock is figured. This procedure likewise gives the successful pore space of the rock. Figure 3.9 demonstrates of the mechanical assembly to soak the specimen.

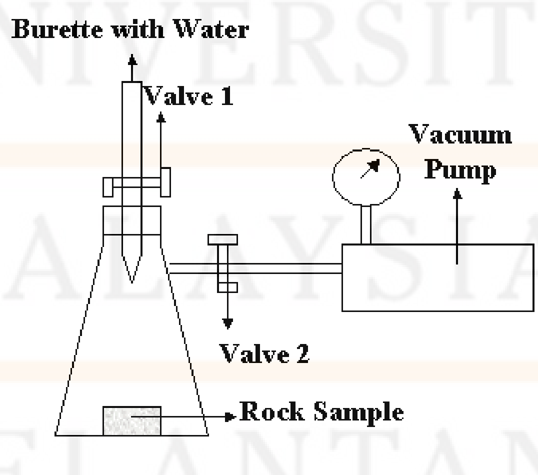

Figure 3.9: Saturation Device

b) Density

Determine the density of rock using saturation and buoyancy techniques as per IS-13030-1991. Apparatus used are:

- Oven (capacity 105±3^{0}C)
- Balance (Accuracy of 0.01% of the sample weight)
- Non credible sample container
- Vacuum vessel for immersion of sample (capacity 0.8 kPa)
- Immersion bath, wire basket for determination of saturated-submerged weight)

c) Water content

Water content or moisture content is the amount of water contained in a material, for example, soil (called soil moisture), rocks, earthenware production, or wood on a volumetric or gravimetric premise. The property is utilized as a part of an extensive variety of logical and specialized regions, and is communicated as a proportion, which can extend from 0 (totally dry) to the estimation of the materials porosity at immersion.

Volumetric water content, θ, is defined mathematically as:

$$\theta = Vw/VT$$

where Vw is the volume of water and VT = Vs + Vv = Vs + Vw + Va is the total volume (that is Soil Volume + Water Volume + Void Space). Water content may also be based on its mass or weight.

d) Slake-durability test

The slake durability test is valuable in deciding the breaking down nature of the rocks when it is subjected to drying and wetting conditions along development. This test appropriately characterizes the weathering conditions of rocks. The test has comprised at least of 10 rock lumps, each measuring 40 to 60 g to give an aggregate specimen weight of 400 to 600 g. Rocks lumps should be circular and corners of rocks irregularities should be adjusted off amid readiness. Figure 3.10 shows the apparatus of Slake Durability.

Figure 3.10: Slake durability test apparatus

Method of Calculation

- Initial weight taken = A
- Weight after 1st cycle = B
- Weight after 2nd cycle = C
- Weight of drum = D

- % retention after 1st cycle =(A-B)/A x 100
- % retention after 2nd cycle=(B-C)/B x 100
- Slake durability index, I (%) = (C-D)/(A-D) x 100

3.3.4 Data Analyses and Interpretations

For mapping method, the data analysis is a collectable data from the field mapping activities. From the field mapping information, the information that are being gathered are the cross information which can demonstrate any momentous point and the tracks of the territory. Other that the physical identification, the laboratory investigation is also needed to determine the types of rock in the study area. The geomorphology observation is likewise assumes its imperative part to decide the landforms of the study area.

Furthermore, the data that get from the sample of the study area were analyses and interprets by a laboratory analysis to know the physical properties of the rock.

3.3.5 Report Writing

At the end of the dissertation, report writing is done according to the topic and subtopic that are provided. The report writing covers the topography aspect and the detail point of the research. Every one of the information and the discoveries that had been investigations were being presented in the report writing.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter, the general geology of the study area is analyzed and discussed. The general geology provides many geological information which covers geography parts of the area, geomorphological processes, field observation and mapping, structural geology, petrography and any extra information that are necessary to be discussed in this chapter. Geomorphology is a science that concerned with the understanding the form of the Earth's surface and the processes which it was shaped, both at the present as well as the past. On the other hand, basic topography is the reviews on the lineament, bedding, crack and fault analysis. The formations of these structures were mostly due to tectonic movement. Stratigraphy is the knowledge about rock strata, their relative and absolute ages, and the relationship between the strata. Stratigraphy can be used to correlate the past environment with what have been seen today. It is analyzed from the physical characteristic of the rock itself.

In general, the types of lithology found within the area of Gua Panjang are limestone, sandstone, mudstone, siltstone and coal. Limestone predominantly exists within Gua Panjang.

4.2 Geomorphology

Geomorphology is really a logical investigation of the beginning and advancement of topographic and bathymetric elements made by physical, compound or natural procedures working at or close to the World's surface. A comprehension of geomorphology and its procedures is along these lines fundamental to the comprehension of physical geography. Its covers any related data to the landform of the review territory and Gua Musang in an entirety. The geomorphology forms itself more often than not told about the procedures that make the landform of one place. The vast majority of these procedures is thought to be interconnected and are effortlessly watched and measured by present day innovation. There are many variables utilized as a part of acquiring the geomorphological guide of the review range. The height or geology guide will give the data about the geomorphological unit. In this chapter, geomorphologic process is described from topography, drainage system and weathering process in the study area.

4.2.1 Landform

Topography is the investigation of the earth science involving the investigation of surface shape and features of the Earth. The topography of a region can likewise mean the surface shapes and features itself. Topography particularly includes the recording of alleviation or territory, the three-dimensional nature of the surface and the identification of particular landform (Figure 4.1). The elevation of the study area is discussed and analyzed in this part. The topography puts a major part in the geomorphology study as it the main criteria to class the geomorphological unit either in physical criteria, hydrology criteria and also any hazard susceptibility zone in the study area. The topography can distinguish many landform types and criteria of a place. The history of the landform processes also can be obtained by analyzing the topography at one place.

According to Raj (2009), topography unit can be classified into five units by considering the mean elevations. The classification of the mean elevations can be referred in Table 4.1

Table 4.1: The topograpgy unit based on elevations (Raj, 2009).

Class	Landform Classification	Mean Elevation (above sea level,m)	Landform classification of study area
1	Low Lying	<15	-
2	Rolling	16-30	-
3	Undulating	31-75	-
4	Hilly	76-300	55
5	Mountainous	>301	10

(Source: Raj, 2009)

The study areas, 65% of the area are surrounded by hilly mountain with the highest peak, which recorded 540 meters in elevation and is located at the west part of the study area. The elevation of the study area has ranged from 140 meters to 540 meters. The study area are considered as a mountainous area because it mostly had an elevation more than 301 meters. The landform map of the study area is shown in Figure 4.1.

4.2.2 Drainage Pattern

Geomorphology of drainage is a pattern forms by the streams, waterways, and lakes in a specific seepage bowl. They are administered by the geography of the land, whether a specific area is dominated by hard or delicate rocks and the angle of the land. Geomorphologists and hydrologists regularly see the streams as being a piece of the drainage basin. A drainage basin is the topographic locale from which a stream gets overflow, through stream, and groundwater stream.

Drainage Pattern is controlled by a couple of components which incorporated the sorts of lithology, cracks, faults, and different variables. The incline and structure decided the waterway designs and spatial courses of action of the stream diverts in the scene. The sorts of drainage pattern which is controlled by the slant or structure are dendritic, centripetal, distributary, radial, centrifugal, trellis and annular. The picture of the types of drainage pattern is shown in Figure 4.2.

Based on my observation on a map of drainage pattern, there are three types of drainage pattern that had been identified. The first drainage pattern in the study area is a dendritic pattern which resembled a tree and they develop where the river follows the slope of the terrain. This pattern is also resembles horizontal sediment or beveled, uniformly and crystalline rock type (Howard, 1967). The second pattern is trellis pattern. It is formed in areas of alternating geology. The main river flows straight down hill, subsequent streams develop perpendicular to the main river forming vales. Last but not least, the third pattern radial pattern, but only half is shown. The map of drainage pattern is shown is Figure 4.3.

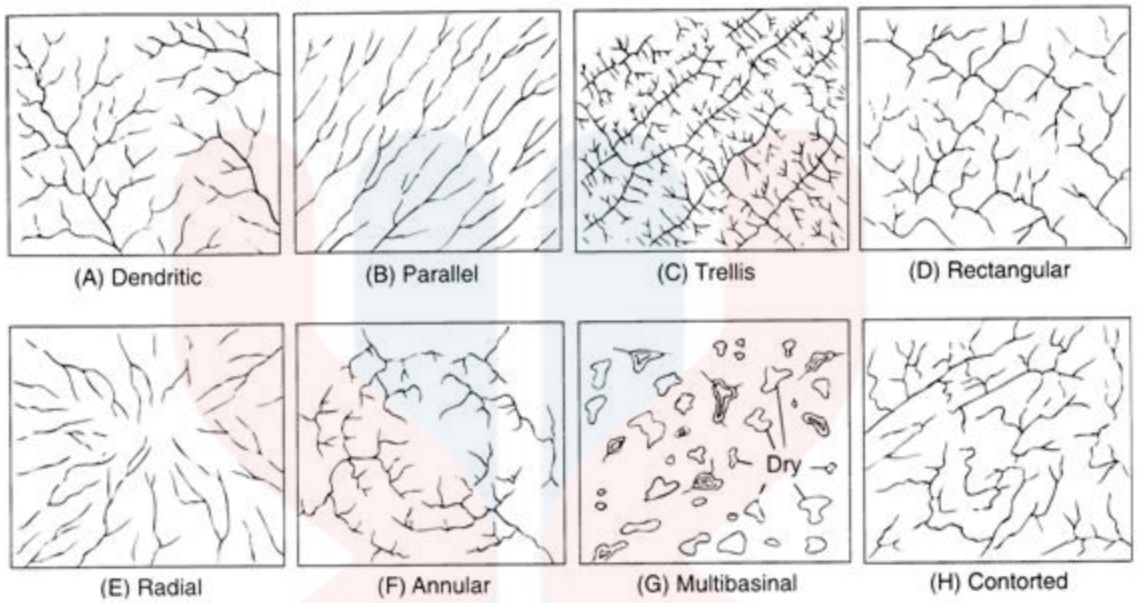

Figure 4.2: Types of Drainage pattern

4.2.3 Weathering Process

Weathering processes are characterized as the breakdown of rocks, soils, and minerals and additionally wood and counterfeit materials through contact with the Earth's atmosphere, waters and biological organisms. Weathering happens *in situ* (on site) that is, in a similar place, with practically no development, and in this way ought not to be mistaken for erosion, which includes the development of rocks and minerals by agents such as water, ice, snow, wind, waves and gravity and afterward being transported and deposited in different areas. As indicated by Mayhew (2006), weathering process was the process where the breakdown of rocks into littler parts. There were three sorts of weathering process which are physical weathering, chemical weathering and biological weathering. Physical weathering is a procedure where the rocks are broken down into

little pieces without the contribution of chemical response. Though, chemical weathering is the progressions of rocks or mineral piece which includes a chemical reaction process (Nicholas, 2009). Biological weathering is a procedure where the rocks are breaking down because of the activity of living life forms such as plants and creatures as they infiltrate or tunnel into the dirt individually.

a) Physical Weathering

Physical weathering is a type of weathering that are resulted due to the mechanical disruption of the rock cause of rain, wind, temperature, pressure and others. For example, on figure 4.4 it shows the outcrop of sandstone is cracked due to the differential of temperature and pressure occurs between days and night. The weathering was resulted from the expansion and contraction of rock caused by temperature changes in the surroundings. For instance, the heating of rock by sunlight can cause expansion of their constituent minerals. As some of the minerals expand more than the others, temperature changes set up differential stresses that eventually cause the rock to crack apart.

Other than that, another type of physical weathering that had been identified in the study area is the aggressive friction and the repeated impact of the rock that usually occurs in the river during the water movement. The bed of the river carried pebble and boulders that may collide during high velocity of water. Hence, aggressive collisions of the rock cause the presence of the smaller rock in the river. The Figure 4.5 shows the physical weathering occurs at the rock in the river.

Figure 4.4: Physical weathering on sandstone outcrop.

Figure 4.5: Physical weathering occurs due to the aggressive collision in the river during water movement and does become pebble and cobbles.

a) Chemical Weathering

Chemical weathering is the root of rock forming minerals cause by water, temperature, oxygen, hydrogen and gentle acids, for example, carbonation, oxidation and hydration. The chemical weathering process that happened in the study area is carbonation. Refer figure 4.6, the carbonation happens on limestone which contain calcium carbonate, $CaCO_3$. The weathering happens when the downpours combine with carbon dioxide, CO_2 or a natural corrosive to shape a feeble carbonic corrosive which responds with calcium carbonate and in this way create calcium hydrogen carbonate, $Ca(HCO_3)_2$. Calcium hydrogen carbonate can without much of a stretch break up in water. This reaction is soon or later will form a cavity on limestone thus formed caves.

The reaction as shown as follows:

$CO_2 + H_2O \rightarrow H_2CO_3$

Carbon dioxide + water → carbonic acid

$H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$

Carbonic acid + calcium carbonate → calcium bicarbonate

a) Biological Weathering

Biological weathering is the process of root penetration during plant growth exerts pressure on the rocks that subsequently breaks them apart. It is common to see some roots growing within the face of a rock. Well, such plant activity contributes to biological weathering. The roots of plants and trees penetrate into the soil in search of nutrients and water. As the roots penetrate the soil, they go through cracks or joints in the rocks and as they grow they progressively crack the rock apart. Bigger growing roots can also exert pressure on the adjacent rocks. Some plant roots also emit organic acids that aid to dissolve the rock's minerals. Biological weathering in study area can be seen in Figure 4.7(a) and 4.7(b) respectively.

Figure 4.6: Chemical weathering on limestone caves

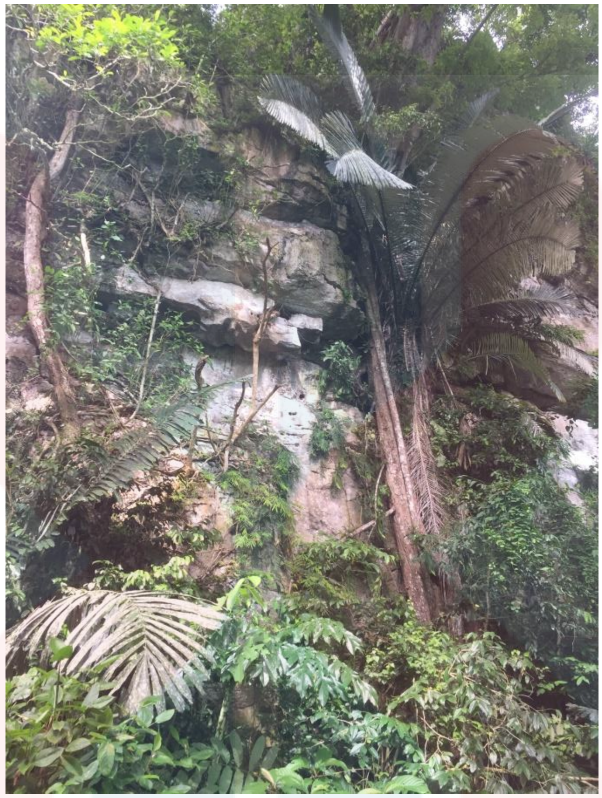

Figure 4.7(a): The roots of plants penetrated limestone cliff

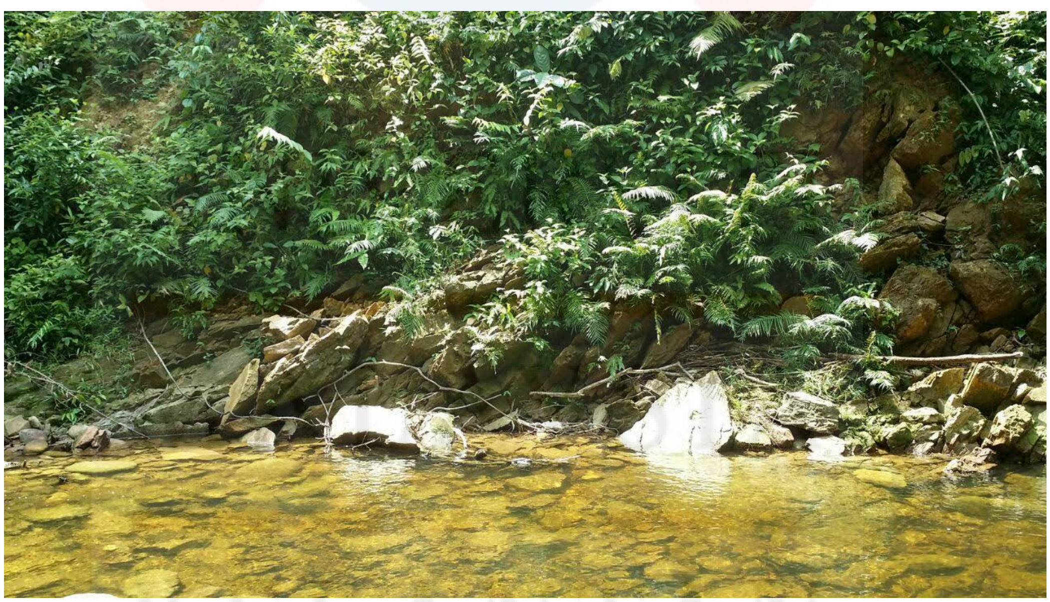

Figure 4.7(b): The Plant penetrated Sandstone outcrop

4.3 Field Observation and Mapping

Field observation and mapping are the important aspect in geological research. Furthermore, the field observing and mapping was used as one of the methodology in this study. The field observation had to be done to accomplish the mapping part in this dissertation. Other than that, is it also needed to get the information for the lithostratigraphy and structural geology in the study area. From the field observation, we can analyze geological patterns of the study area such as geomorphology, lithostratigraphy and drainage pattern. Traverse method was being used to cover all parts within the study area. The traverse map of the study area is shown in Figure 4.8.

4.3.1 Lithostratigraphy

Lithostratigraphy refers to the study of the rocks and the description of rock units in terms of their compositional, lithological features and textural characteristic as well as their correlation. Each of the rock unit can be classified into the same method of stratigraphy which is based on their lithology and similarities in color, mineral composition, and grain size information. The step to describe the lithostratigraphy unit is to ensure the information regarding their lithological characteristic including petrography, mineralogy observation, geochemistry and fossil content.

From the observation in the study area, the lithology units found are sedimentary rock which is mudstone, siltstone, clay, sandstone, coal and limestone. Other than that, metamorphic rock can also be found in study area which is a marble and phyllite. The geological map of the study area is shown in Figure 4.9

4.4 Stratigraphy

Based on the lithostratigraphy that was being identified in the study area, the stratigraphy of the study area can be identified. The correlation of the one rock unit to the other rock unit can form a stratigraphy column in the area (Table 4.2). From the lithostratigraphy and the interpretation of the lithology boundary, the rock age can be guessed and this can give an early picture of the geological condition of this place. Thus, from the lithostratigraphy unit, the correlation between the rock units that found in the study area have been made.

Table 4.2: Stratigraphy column of Gua Panjang, Gua Musang Kelantan

Era	Lithology	Formation/Unit	Period
Mesozoic		Gua Musang Formation	Quaternary
			Tertiary
			Createaceous
			Jurassic
	Limestone/Marble Interbedded sandstone, siltstone and shale.		Triassic
Upper Pleozoic	Phyllite		Permian
			Carboniferous
			Devonian

a) Limestone

Limestone is a sedimentary rock, made predominantly out of skeletal fragments of marine life forms, for example, coral, forams and molluscs. Its significant materials are the minerals calcite and aragonite, which are distinctive precious stone types of calcium carbonate (CaCO3). Around 10% of sedimentary rocks are limestones. The solvency of limestone in water and feeble corrosive arrangements prompts to karst landscapes, in which water disintegrates the limestone over thousands to millions of years. Most cave systems are through limestone bedrock.

Limestone is one of the type of rock that can be easily recognized in hand specimen or outcrop. This is due to the composition of limestone that has high solubility in hydrochloric acid, HCI. A few drop of HCL were placed on limestone will resulted in fuzzing sound and this is due to the carbon dioxide, CO_2 gas was released. Limestone is predominant rock unit that are found in the study area. The limestone units found in study area are mostly greyish, dark grayish and milky white in color. The picture of limestone hills in study area is shown in Figure 4.10.

The limestone covers about 75% of the study area and it was a dominant rock found in Gua Panjang.

b) Mudstone

Mudstone is a kind of mud rock, which is a fine-grained sedimentary rock whose unique constituents were clays or muds. Grain size is up to 0.0625 mm (0.0025 in) with individual grains too small to possibly be recognized without a magnifying instrument. With an expanded weight after some time, the platy earth minerals may get to be distinctly adjusted, with the presence of fissility or parallel layering.

This finely bedded with material that parts promptly into thin layers is called shale, as unmistakable from mudstone. The absence of fissility or layering in mudstone might be because of either unique surface or the disturbance of layering by tunneling life forms in the residue preceding lithification. Mud rocks, for example, mudstone and shale include approximately 65% of every single sedimentary shake. Mudstone looks like solidified mud and, contingent on the conditions under which it was shaped, it might indicate breaks or gaps, similar to a sun-prepared earth store.

Mudstone that are found in the study area are consists of red color mudstone. Some of mudstone found is interbedded with sandstone and siltstone. The picture of an outcrop hand specimen of mudstone can be seen in Figure 4.11(a), (b) and (c) respectively.

Figure 4.10: Limestone hills in study area

Figure 4.11(a): Outcrop of mudstone

Figure 4.11(b): Mudstone outcrop is found in drainage

Figure 4.11(c): Mudstone found at laying at a surface

c) Siltstone

Siltstone is a clastic sedimentary rock. As its name suggests, it is basically created (more noteworthy than 2/3) of sediment estimated particles, characterized as grains 2–62 µm or 4 to 8 on the Krumbein phi (φ) scale. Siltstones vary essentially from sandstones because of their smaller pores and higher propensity for containing a significant clay fraction. Albeit regularly mixed up as shale, siltstone does not have the fissility and overlays which are run of the mill of shale. Siltstones may contain solidifications. Unless the siltstone is reasonably shale, stratification is probably going to be dark and it tends to climate at sideways points random to bedding. Mudstone or shale are rocks that contain mud, which is material that has a range of silt and clay. Siltstone is differentiated by having a majority silt, not clay.

The siltstones found in the study area are mostly interbedded with sandstone. The outcrop and hand specimen of the rock can be seen in Figure 4.12.

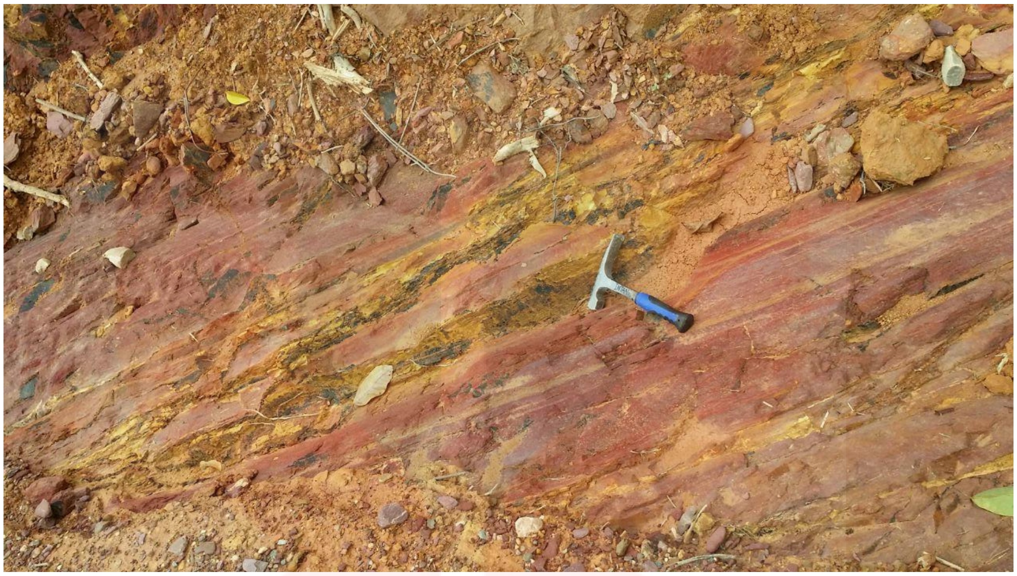

Figure 4.12: Siltstone interbedded with sandstone

a) Sandstone

Sandstone (once in a while known as arenite) is a clastic sedimentary rock made fundamentally out of sand-sized minerals or rock grains. Most sandstone is made out of quartz or feldspar in light of the fact that these are the most well-known minerals in the Earth's surface layer. Like sand, sandstone might be any color, however the most widely recognized hues are tan, cocoa, yellow, red, dim, pink, white, and dark. Since sandstone beds frequently shape very noticeable bluffs and other topographic elements, certain shades of sandstone have been emphatically related to specific locales. Rock developments that are principally made out of sandstone more often than aren't permit permeation of water and different liquids and are sufficiently permeable to store vast amounts, making them significant aquifers and petroleum supplies. Fine-grained aquifers, for example, sandstones, are better ready to sift through poisons from the surface than are rocks with splits and holes, for example, limestone or different rocks cracked by seismic movement. Quartz-bearing sandstone is changed over into quartzite through warming and weight normally identified with structural pressure inside orogenic belts.

The sandstone outcrop in the study area is mostly weathered. Sandstone comprises the second highest percentage of sedimentary rock found in the study area, but most of them were already highly weathered and turned into soil. The sandstone outcrop and hand specimen can be refers to Figure 4.13(a), (b) and (c) respectively.

Figure 4.13(a): Sandstone outcrop found in oil palm plantation area

Figure 4.13b): Sandsrone outcrop interbedded with silt

Figure 4.13(c): Sandstone outcrop with a bit of coal deposits found near the river

a) Clay

Clay is a fine-grained characteristic rock or soil material that joins at least one or more clay minerals with traces of metal oxides and organic matter. Clay are plastic because of their water content and turn out to be hard, weak and non–plastic after drying or terminating. Geologic clay deposits are mostly made out of phyllosilicate minerals containing variable measures of water caught in the mineral structure. Contingent upon the clay's substance in which it is discovered, earth can show up in different hues from white to dull dim or cocoa to profound orange-red.

Albeit many actually happening deposit incorporate both silt and clay, clays are recognized from other fine-grained soils by contrasts in size and mineralogy. Silts, which are fine-grained soils that do exclude clay minerals, have a tendency to have bigger molecule sizes than clays. There are nonetheless, some cover in molecule measure and other physical properties. The qualification amongst silt and clay fluctuates by discipline. Geologists and soil researchers typically consider the division to happen at a molecule size of 2 μm (clays being finer than silts), sedimentologists frequently utilize 4–5 μm, and colloid scientific experts utilize 1 μm. Geotechnical engineers recognize residues and muds in view of the pliancy properties of the dirt, as measured by the dirts' Atterberg limits. ISO 14688 evaluations mud particles as being smaller than 2 μm and sediment particles as being bigger.

The clay that are found in the study area is a milky white in color. It is actually found near the mudstone outcrop. The picture of the clay outcrop and the hand specimen can be seen in Figure 4.14

Figure 4.14: Clay outcrop

a) Coal

Coal is a flammable dark or tanish dark sedimentary rock usually occurring in rock strata in layers or veins called coal beds or coal seams. The harder structures, for example, anthracite coal, can be viewed as metamorphic rock as a result of later introduction to raised temperature and weight. Coal is made basically out of carbon, alongside factor amounts of different components, primarily hydrogen, sulfur, oxygen, and nitrogen. A fossil fuel, coal frames when the dead plant matter is changed over into peat, which thus is changed over into lignite, then sub-bituminous coal, after that bituminous coal, and in conclusion anthracite. This includes natural and topographical procedures that happen after some time.

In the study area, the coal is found on the sandstone outcrop which also interbedded with siltstone. The coal is only distribute a bit on the bottom of the sandstone outcrop. The picture of the coal in sandstone outcrop and hand specimen can be seen in Figure 4.15.

Figure 4.15: Coal deposit in sandstone outcrop with a layer of siltstone

b) Marble

Marble is a rock that metamorphoses from a sedimentary carbonate rock, most regularly limestone or dolomite rock. Metamorphism causes variable recrystallization of the first carbonate mineral grains. The subsequent marble rock is normally made out of an interlocking mosaic of carbonate gems. Essential sedimentary surfaces and structures of the first carbonate rock (protolith) have regularly been adjusted or annihilated.

Immaculate white marble is the aftereffect of metamorphism of an extremely unadulterated (silicate-poor) limestone or dolomite protolith. The trademark twirls and veins of kaleidoscopic marble assortments are typically because of different mineral polluting influences, for example, clay, silt, sand, iron oxides, or chert which was initially present as grains or layers in the limestone. Green hue is frequently because of serpentine resulting from initially magnesium-rich limestone or dolostone with silica impurities. These different polluting influences have been assembled and recrystallized by the exceptional weight and warmth of the metamorphism.

In the study area, marble can be found near the limestone outcrop. The marble are hard to distinguish with limestone because their appearances are almost similar. The picture of the marble outcrop and hand pecimen can be seen in Figure 4.16.

c) Phyllite

Phyllite is a kind of foliated metamorphic rock made from slate that is further metamorphosed so that fine grained white mica accomplishes a favored introduction. It is fundamentally made out of quartz, sericite mica, and chlorite. Phyllite has fine-grained mica chips in a favored orientation, while slate has to a great degree fine clay pieces that accomplish a favored orientation, and schist has vast drops in a favored orientation. Among foliated metamorphic rocks, it speaks to a degree at the level of changeability amongst slate and schist. The moment precious stones of graphite, sericite, or chlorite, or the translucent fine-grained white mica, confer a sleek, infrequently brilliant sheen to the surfaces of cleavage, called "phyllitic radiance".

The protolith (or parent rock) for phyllite which is originated from a shale protolith is shale or pelite, or slate, its constituent platy minerals are bigger than those in slate however are not obvious with the naked eye. Phyllites are said to have a surface called "phyllitic sheen," and are generally delegated having shaped through poor quality changeable conditions through provincial transformative nature transformative facies. Phyllite has great fissility (a propensity to part into sheets). Phyllites are generally dark to dim or light greenish dim in shading. The foliation is usually crinkled or wavy in appearance.

The phyllite found in the study area is gray in color. It is found in the palm oil plantation. This area is not fully explored because there is less accessibility. According to Yin (1965), assignated this type of rocks into arenaceous facies that deposited in a marine environment.these units of rocks are determining as Permian age. The picture of outcrop and hand specimen can be refers at Figure 4.17(a) and 4.17(b).

Figure 4.16: Marble outcrop found near the river

Figure 4.17(a): Phyllite outcrop at Oil Palm Plantation

Figure 4.17(b): Phyllite outcrop

4.5 Structural Geology

Structural geology is the investigation of the three-dimensional circulation of rock units concerning their deformational histories. The essential objective of structural geology is to utilize estimations of present-day rock geometries to reveal data about the historical backdrop of misshaping (strain) in the rock, and at last, to comprehend the anxiety field that brought about the watched strain and geometries. This comprehension of the elements of the anxiety field can be connected to imperative occasions in the geologic past; a shared objective is to comprehend the basic development of a specific range as for territorially across the board examples of rock misshaping for instance mountain building and breaking because of plate tectonics.

4.5.1 Lineament analysis

A lineament is a straight component in a feature which is a statement of a hidden geological structure, for example, a fault. Straight elements can be perceived by aerial phograph, satellite imaginary and in addition topographic map. The lineaments generally show up as a straight lines or "edged" on the guide. As per Koike et al. (1995), a constant straight valley is the clearest elements as an essential distinguishing proof foundation in feature handling for lineaments. Commonly a lineament will contain a fault adjusted valley, a progression of fault or overlay adjusted slopes, a straight coastline or without a doubt a mix of these components. Break zones, shear zones and molten interruptions, for example, dykes can likewise offer ascent to lineaments.The lineament of the study area is shown in Figure 4.18.

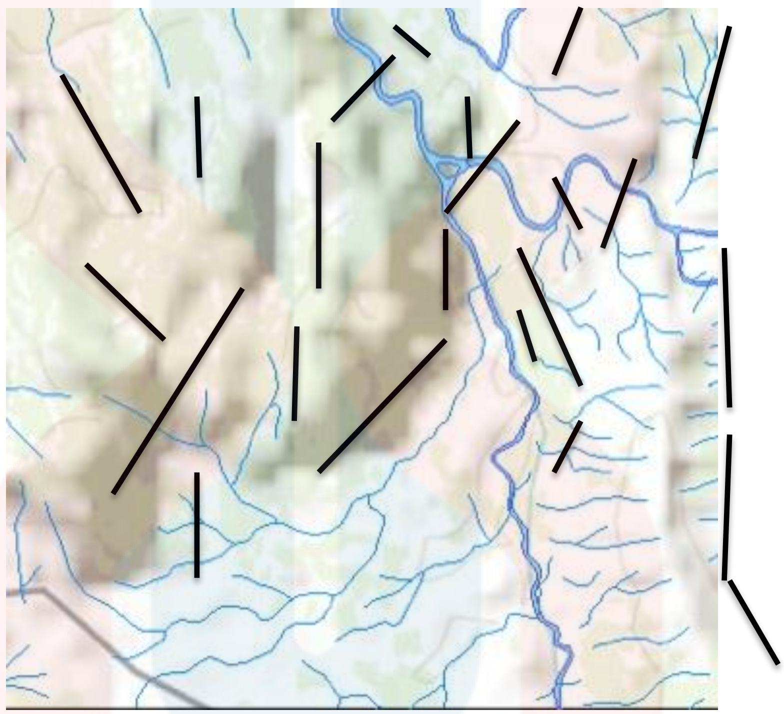

Figure 4.18: The lineament of stufy area. (Terrain map adopted from Googgle Map)

4.5.2 Fold

A geological fold occurs when one or a stack of originally flat and planar surfaces, such as sedimentary strata, are bent or curved as a result of permanent deformation. Synsedimentary folds are those due to slumping of sedimentary material before it is lithified. Folds in rocks vary in size from microscopic crinkles to mountain-sized folds. They occur singly as isolated folds and in extensive fold trains of different sizes, on a variety of scales.

Folds form under varied conditions of stress, hydrostatic pressure, pore pressure, and temperature gradient, as evidenced by their presence in soft sediments, the full spectrum of metamorphic rocks, and even as primary flow structures in some igneous rocks. A set of folds distributed on a regional scale constitutes a fold belt, a common feature of orogenic zones. Folds are commonly formed by shortening of existing layers, but may also be formed as a result of displacement on a non-planar fault (fault bend fold), at the tip of a propagating fault (fault propagation fold), by differential compaction or due to the effects of a high-level igneous intrusion e.g. above a laccolith.

During the field observation, the structure fold are found on the sandstone outcrop near the river. The structure of the fold is is mostly found are anticline type of fold. Figure 4.19(a), (b) and (c) showed the fold in study area respectively.

Figure 4.17(a): Anticline fold

Figure 4.17(b): Another anticline fold

Figure 4.17(c): Complicated fold found on the sandstone outcrop

4.5.3 Bedding

Bedding found in the outcrop of sandstone near the river. Refer the Figure 4.20(a) the bedding of sandstone. Strike and dip reading for this bedding is 190º/57º.

Figure 4.20(a): Bedding of sandstone

CHAPTER 5

PHYSICAL PROPERTIES OF LIMESTONE AT GUA PANJANG, GUA MUSANG KELANTAN

5.1 Introduction

Limestone is the main focus of this research; there are three different locations where the sample is taken. All of them were chosen randomly on different places. From the field observation they differ in colors, grain and texture or the rock. Each locations one or two hand specimens were taken for further investigation.

For data analysis, the data is calculated and interpreted. The result is presented in the table. Each rock samples were compared and conclusion were made which rock samples and location had a better physical properties of limestone in terms of their porosity, density, water content and durability of the rock.

5.2 Porosity of rock

Porosity of rock is characterized as a solidified rock (e.g. sandstone, shale, granite or limestone) conceivably has more intricate "double" porosities, as contrasted and alluvial sediment. This can be part into associated and detached porosity. Associated porosity is all the more effectively measured through the volume of gas or fluid that can stream into the stone, though liquids can't get to detached pores. Porosity values for different rock types are given in Table 5.1 (Costa and Baker, 1981).

Table 5.1: Porosities for Different Rock Types

ROCK TYPE	POROSITY (%)
Granite	0.4 – 4.0
Andasite	0.1 - 11
Gabbro, Diorite, Diabase	0.1 – 1.0
Basalt	0.2 – 22
Limestone	0/2 – 4.4
Sandstone	1.6 - 26
Chert	4
Gneiss	0.3 – 2.2
Marble	0.3 – 2.1
Quartzite	0.3 – 0.5
Slate	0.1 – 1.0

(Source: Costa and Baker, 1981)

There are two types of calculation can be used to calculate the porosity, which is firstly n=e/ (1+e) and n=Vp/t x 100%. According to Murthy, V. (2003), the equation of n=e/ (1+e) is used to calculate the porosity for soil. Based on Porosity and Density Determination of Rock Using Saturation And Buoyancy Techniques, (2014, May 06), the calculation used to calculate porosity of rock is n=Vp/t x 100%. For my research, the equation used to calculate the porosity is the one that are for rock.

Porosity is the proportion of pore volume to its total volume. Porosity is controlled by: rock type, pore distribution, cementation, diagenetic history and sythesis. Porosity is not controlled by grain size, as the volume of between-grain space is connected just to the technique for grain pressing.

To test the porosity of rock, all six rock samples which are weathered rock sample and fresh rock sample are taken from three different locations and were tested in the laboratory. The results are shown in a table 5.2 and 5.3. The calculation of the data can be referred in appendix 1 and 2. The equation for the calculation to calculate porosity is as follows:

$$\text{Porosity} = \frac{Pore\ Volume, Vp}{Total\ Volume, Vt} \times 100\%$$

Table 5.2: Porosity percentage of weathered rock sample of limestone in each three location

Location	Volume of Rock, (kg/m³)	Pore Volume, Vp	Total Volume, Vt	Porosity Percentage, % (Vp/Vt x 100)
1	0.17	0.14	0.31	45.16
2	0.12	0.16	0.28	57.14
3	0.14	0.14	0.28	50

Based on the table 5.1, the porosity of limestone is ranging from 45.16% to 57.14%. This can be that the limestone is having a high possibility for the rock to easily break down due to the high percentage of porosity which content many pore spaces.

In general, cavities in an intact rock specimen can be classified into two groups: (1) cavities with more or less equal dimensions in all directions called pores and (2) cavities that are elongated called microfissures. For rocks with porosity under two percent, microfissures are predominant. Then again, for rocks with porosity bigger than two percent, pores are predominant. Porosity is very much affected by the rock texture, its age, depth, and the in situ state of stress. Based on result the limestone in each three location is predominantly pores because the porosity is ranging from 45.16% to 50%, which is bigger than 2%.

Table 5.3: Porosity percentage of fresh rock of limestone in each three location

Location	Volume of Rock, (kg/m^3)	Pore Volume, Vp	Total Volume, Vt	Porosity Percentage, % (Vp/Vt x 100)
1	0.15	0.14	0.29	48.28
2	0.14	0.14	0.28	50
3	0.13	0.17	0.3	56.67

Based on the table 5.2, the result is a bit similar to the weathered rock sample. The percentage porosity of fresh rock sample is ranging from 48.28% to 56.7%. Based on the result of the two types of sample from three locations, sample in Location 1 is having the lowest percentage of porosity which is a better limestone sample than the other 2 locations. It is better because it has low pore spaces for the water to seep in and reduce the probability for the rock to break down faster. The lower the pore spaces in limestone the better the limestone is to be used for construction materials and a base of a building construction. But if compare the percentage porosity for the reservoir, the sample in

Location 2 and 3 is much better limestone that has a high content of pore spaces. The higher the quantity of pore spaces the higher the possibility for the limestone to store water and act as a reservoir. The result also shown the difference between the weathered rock sample and the fresh rock sample which does not vary from each other.

5.3 Density

Density is defined as mass divided by volume. All six rock samples which are weathered rock sample and fresh rock sample from three different locations were tested in density measurement. Several apparatus used in this measurement such as 2000ml beaker, 250ml measuring cylinder, weight scale and others. The results is recorded in Table 5.4 and 5.5.The calculation of the data can be referred in appendix 2 and 3

Table 5.4: Density Value for weathered rock in each three location

Location	Mass (kg)	Volume (L)	Rock Density (kg/m^3)
1	0.0889	0.530	0.17
2	0.0626	0.523	0.12
3	0.0739	0.530	0.14

Based on the table 5.4, the rock density are ranging from 0.12 kg/m^3 to 0.17 kg/m^3. The density is highly related with porosity. The density of limestone is typically 2.5 to 2.7 Kg/cm^3, but the results from the experiments shows that it ranging from 0.12kg/m^3 to 0.17kg/m^3. This means that the limestone in this area is highly porous.

Table 5.5: Density Value for fresh rock in each three location

Location	Mass (kg)	Volume (L)	Rock Density (kg/m³)
1	0.0809	0.529	0.15
2	0.0717	0.530	0.14
3	0.0673	0.528	0.13

Based on the table 5.4, the results show that the density ranged from 0.13 kg/m³ to 0.15 kg/m³. Based on the results from the two tables above, sample in Location 1 is higher density value than the other two locations. Generally the density increases and porosity decrease monotonically with depth. This is expected, because differential pressures usually increase with depth. As pressure increases, grains will shift and rotate to reach a more dense packing. More force will be imposed on the grain contacts. Crushing and fracturing is a common result. In addition, diagenetic processes such as cementation work to fill the pore space. Material may be dissolved at point contacts or along styolites and then transported to fill pores.

5.4 Water Content

Water content or moisture content is the amount of water contained in a material, for example, soil (called soil moisture), rock, earthenware production, organic product, or wood. Water substance is utilized as a part of an extensive variety of logical and specialized territories, and is communicated as a proportion, which can extend from 0 (totally dry) to the estimation of the material's porosity at immersion. It can be given on a volumetric or mass (gravimetric) premise. The outcomes appeared in Table 5.6 and 5.7 respectively.

The water content shall be calculated from the following formula:

Water content,w

$$= \frac{\text{Pore water mass}}{\text{Grain mass}} \times 100\%$$

$$= \frac{M_2 - M_3}{M_3 - M_1} \times 100\%$$

M_1 = Mass in g of the container with its lid at room temperature

M_2 = Mass in g of the container with its lid and the sample at room temperature

M_3 = Mass in g of the container with its lid and the sample after drying

Table 5.6: Data result for water content of weathered rock at three different locations

Location	**M_1 (g)**	**M_2 (g)**	**M_3 (g)**	**$M_2 - M_3$**	**$M_3 - M_1$**	**$\frac{M_2 - M_3}{M_3 - M_1} \times 100\%$**
1	24.37	75.0	74.88	0.12	50.51	0.24
2	20.46	62.77	62.75	0.02	42.29	0.05
3	19.58	79.69	79.64	0.05	60.06	0.08

Based on the table 5.6, the sample rock in Location 1 is having the highest percentage of water content at about 0.24% than the other two locations. The water content are ranging from 0.05% to 24%.

Table 5.7: Data result for water content of fresh rock at three different locations

Location	M_1 (g)	M_2 (g)	M_3 (g)	$M_2 - M_3$	$M_3 - M_1$	$\frac{M_2 - M_3}{M_3 - M_1} \times 100\%$
1	18.75	60.54	60.51	0.03	41.76	0.07
2	16.42	67.63	67.58	0.05	51.16	0.10
3	59.57	101.86	101.83	0.03	42.26	0.07

Based on the table 5.7, the percentage of water content for sample in Location 2 is the highest at about 0.10% than the other two locations.

5.5 Slake durability test

The slake durability test was carried out with 3 limestone samples. Initial weights of the limestone samples were taken as given below in the table 5.8. Thus the various percentages of retention of the limestone samples were found out. The data observation and calculation cane refer to Appendix 5

At the point when the rock turns out to be more saturated, water menisci inside the rock pores increment, which then causes the lessening of narrow pressure at grain contacts and the tips of breaks. Because of the expansion in the water content in the pores, fracture creates in the rock which prompts to the weathering of rocks. This component appears to rule the durability conduct of porous rock. Water surely impacts the mechanical attributes of a rock. In any case, in the slake durability test, not just wet-dry conditions are given to the rock samples, additionally instruments relate to the drum pivot are included. These instruments have not been investigated. Such components might be affected by the shape and weight of the samples. In this manner the primary goal of the review is to decide the slake durability list of the rock samples as opposed to breaking down the components of the samples.

Table 5.8: Data result of slake durability test of fresh rock at three different locations

Location	Initial weight, A (g)	Weight after 1st Cycle, B	Weight after 2nd Cycle, C	weight of drum, D (g)	Percentage retained after 1st Cycle	Percentage retained after 2nd Cycle	Slake durability Index, I (%)
1	1854.61	1853.97	1853.09	1600.45	99.75	99.65	99.4
2	1881.24	1879.81	1879.33	1604.82	99.50	99.83	99.3
3	1883.98	1882.22	1881.84	1607.36	99.36	99.86	99.23

Based on the table 5.8, it was seen that the limestone sample percentage retention after the first cycle is ranging from 99.36% to 99.75%. The percentage retention for the second cycle is ranged from 99.65% to 99.86%. The slake durability index in sample Location 1 has the highest index about 99.4% and sample in Location 3 has the lowest percentage of slake durability index value at about 99.23%. Based on the results above, the limestone is categorized to be having a very high durability nature.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The research objectives which were stated in the Chapter 1 were able to achieve by field mapping and observation in the study area and were reported in report writing in the Chapter 4. Other than that, the second objective which is to determine the physical properties of limestone in terms of their porosity, density, water content, and slake durability is able to achieve and reported in report writing in Chapter 5.

Based on the results in Chapter 5, the physical properties of limestone are as shown in Table 6.1. It shows that the porosity of limestone is averagely 51.21%, as for density 0.14 kg/m³, water content having an average of 0.10% and lastly slake durability index having an average of 99.31%

Table 6.1: The physical properties of Limestone.

Physical properties of Limestone	Value
Porosity	51.21 %
Density	0.14 kg/m³
Water Content	0.10 %
Slake Durability	99.31%

In general, cavities in an intact rock specimen can be classified into two groups: (1) cavities with more or less equal dimensions in all directions called pores and (2) cavities that are elongated called microfissures. For rocks with porosity under two percent, microfissures are predominant. Then again, for rocks with porosity bigger than two percent, pores are predominant. Porosity is particularly influenced by the rock texture, its age, profundity, and the in situ condition of stress. Based on the results the limestone in each three location is predominantly a pores type because the porosity is averagely 51.21%, which is the value is bigger than 2%.

An increasing in porosity is ordinarily went with an increment in deformability and porousness and a reduction in quality. The reduction in quality with an increasing in porosity was seen by Howarth (1987b). He also found that drilling rate increases with rock porosity.

The density of limestone is typically 2.5 to 2.7 Kg/cm3, but the results from the experiments shows that its approximately 0.14kg/m^3. This means that the limestone in this area is highly porous. Based on the results for slake durability, the limestone in this area is categorized to be having a very high durability nature.

6.2 Suggestion

For the geological study of the study area, there were lacked of an exposed outcrop which is needed to eliminate the uncertainty for the interpretation of Gua Panjang, Gua Musang. For current interpretation, it is mostly made by estimation of the elevation of contour and not by geological evidence. Besides that, some of the limestone is hilly and

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APPENDICES

Appendix 1 – Data recorded for porosity test on weathered rock of limestone

Porosity test data for weathered rock of limestone

Location	Initial mass of rock, M1 (g)	Mass of rock, M2 (g)	Mass of water, Mw (M2 - M1) (g)	Pore volume, Vp (cm^3) (Vp = Mw)
1	57.79	57.93	0.14	0.14
2	50.69	50.85	0.16	0.16
3	56.05	56.19	0.14	0.14

Appendix 2 – Data recorded for porosity test on fresh rock of limestone

Porosity test data for fresh rock of limestone

Location	Initial mass of rock, M1 (g)	Mass of rock, M2 (g)	Mass of water, Mw (M2 - M1) (g)	Pore volume, Vp (cm^3) (Vp = Mw)
1	42.69	42.83	0.14	0.14
2	51.73	51.87	0.14	0.14
3	40.87	41.04	0.17	0.17

Appendix 3 – Data recorded for density test on weathered rock of limestone

Density data from laboratory test on weathered rock of limestone in each three location

Location	**Initial mass of rock, M1 (kg)**	**Volume of water, Vw (m^3)**	**Volume of water + sample**	**Rock density (kg/m^3)**
1	0.0889	0.5	0.53	0.17
2	0.0626	0.5	0.525	0.12
3	0.0739	0.5	0.53	0.14

Appendix 4 – Data recorded for density test on fresh rock of limestone

Density data from laboratory test on fresh rock of limestone in each three location

Location	**Initial mass of rock, M1 (kg)**	**Volume of water, Vw (m^3)**	**Volume of water + sample**	**Rock density (kg/m^3)**
1	0.0809	0.5	0.529	0.15
2	0.0717	0.5	0.53	0.14
3	0.0673	0.5	0.528	0.13

Appendix 5 – Data recorded for slake durability test on fresh rock of limestone in each three different location

Location	Value of drum, Vd (g)	Value of Rock, Vr (g)	Total value of drum and sample (Vd+Vr)	Oven dry value (Initial weight, A)	1st Rolling Value, B	2nd Rolling Value, C
1	1600.45	254.3	1854.75	1854.61	1853.97	1853.09
2	1604.82	276.75	1881.57	1881.24	1879.81	1879.33
3	1607.36	277.14	1884.5	1883.98	1882.22	1881.84