Geology and Geoheritage of Bukit Marak, Bachok, Kelantan.

By

Muhamad Alif bin Ramli

E13A119

A report submitted in fulfillment of the requirements for the degree of

Bachelor of Applied Science (Geoscience) with Honours

Faculty of Earth Science
UNIVERSITI MALAYSIA KELANTAN

2017

DECLARATION

I declare that this thesis entitled "Geology and Geoheritage of Bukit Marak, Bachok, Kelantan"is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : _____

Date : _____

ACKNOWLEDGEMENT

In the name of Allah, the Most Gracious and the Most Merciful

Alhamdulillah, all praise to Allah for strengths and His blessing in completing this proposal. Special appreciation goes to my supervisor, Miss Zakiyah Binti Ainul Kamal, for her supervision and constant support. His invaluable help of constructive comments and suggestions throughout the experimental and thesis works have contributed to the success of this research.

I would like to express my appreciation to all lab assistant and office staff of University Malaysia Kelantan for their co-operation, support and help towards my research.

Sincere thanks to all my friends for their kindness and moral support during my study. Thanks for the friendship and memories.

Last but not least, my deepest gratitude goes to my beloved parents; Mr. Ramli Bin Mat Shadid and Mrs. Rozita Binti Abu Sari@Sa'ari and also to my brother for their endless love, prayers and encouragement. To those who indirectly contributed in this research, your kindness means a lot to me. Thank you very much

TABLE OF CONTENTS

LIST OF TABLES

List of Figures

LIST OF ABBREVIATIONS

UNESCO	United Nations Educational, Scientific and Cultural Organization
HCl	Hydrochloric acid
GPS	Global Positioning System

ABSTRACT

GEOLOGY AND GEOHERITAGE OF BUKIT MARAK, BACHOK, KELANTAN

Geological heritage or also known as geoheritage is one of the subdiscipline in geology. It focuses on the developing and conserving geological sites that have the geoheritage values. Sites that have numbers of unique geological features such as karst landform, granite hills and rivers are conserved and developed for future generation. The objectives of the study are clear as to produce an updated geological map and to identify the geoheritage and geotourism potential of the study area. The study area was maped as it has an outdated geological data. Bachok is mainly known for the groundwater aquifer in terms of geology. But, some places in Bachok such as Bukit Marak can be a good geoheritage sites as it possesses so many geological features that can linked up with geoheritage values and able to attract visitors. In order to recognize any geoheritage sites, there are several systematic steps which are inventory, characterization, classification, assessment, and evaluation of potential geoheritage resources in the study area. These methods were used to verify whether Bukit Marak can be a good geoheritage site or not. The analysis is clear that the study area can be a good potential of geotourism and need to be conserved and developed for the visitors.

ABSTRAK

GEOLOGI DAN GEOWARISAN BUKIT MARAK, BACHOK, KELANTAN

Warisan geologi atau juga dikenali sebagai geowarisan adalah salah satu subdisiplin dalam bidang geologi. Ia memberi tumpuan kepada kawasan yang memelihara dan membangunkan geologi yang mempunyai nilai-nilai warisan geo. Tapak yang mempunyai nombor ciri-ciri geologi yang unik seperti bentuk muka bumi kars, bukit granit dan sungai dipelihara dan dibangunkan untuk generasi akan datang. Objektif kajian ini adalah jelas untuk menghasilkan peta geologi yang telah dikemaskini dan untuk mengenal pasti geowarisan dan potensi pelancongan geologi kawasan kajian. Kawasan kajian telah dijalankan aktiviti pemetaan kerana ia mempunyai data geologi yang lama dan tidak relevan. Bachok lebih dikenali bagi akuifer bawah tanah dari segi geologi. Tetapi, beberapa tempat di Bachok seperti Bukit Marak boleh menjadi tapak geowarisan yang baik kerana ia mempunyai banyak ciri-ciri geologi yang boleh dikaitkan dengan nilai-nilai geowarisan dan mampu menarik pengunjung. Dalam usaha untuk mengenali mana-mana kawasan geowarisan, terdapat beberapa langkah-langkah sistematik iaitu inventori, pencirian, pengelasan, pentaksiran dan penilaian sumber geowarisan yang berpotensi di kawasan kajian. Kaedah-kaedah ini telah digunakan untuk mengesahkan sama ada Bukit Marak boleh menjadi tapak warisan geo yang baik atau tidak. Analisis ini adalah jelas bahawa kawasan kajian boleh menjadi potensi pelancongan geologi yang baik dan perlu dipulihara dan dibangunkan untuk pengunjung.

CHAPTER 1

INTRODUCTION

1.1 General Background

Geoheritage is one of the subdiscipline in geology. It focuses on the developing and conserving geological sites that have the geoheritage values. The sites must have numbers of good geological features such as karstic landform, granite hills and rivers. Those localities and objects of geological features will give special insight into the evolution of the Earth (ProGEO, 2011). Langkawi Island is one of a good and world class example of geoheritage sites. It has been recognized and gazetted by UNESCO as Geopark in 2007.

Generally in Kelantan, there are not much effort had been done by the state government to recognize any geoheritage sites. They are promoting certain places like Gunung Reng in Jeli as an attraction but the conservation is very poor. Although, many places in Kelantan possesses so many geological attraction that in needs of development and conservation, like Bukit Marak in Bachok. Such place need to be developed as an attraction to tourists and can provide a good opportunity for the locals to raise money.

The purpose of the study is to provide an effort on how to develop and conserve the area based on its geological features and geoheritage values. This effort is important as for the sites to not be further damaged in future and can provide attraction to tourists and for the locals to gain more money.

1.2 Problem Statement

General descriptions of the dominant geomorphic process reflect to the nature, origin and development of the landforms. Geomorphic process types are fluvial, glacial, periglacial, lacustrine, tectonic, volcanic, mass wasting, coastal marine, solution and aeolian. But the geological map is outdated so it needs to be updated.

Bukit Marak has its own unique geomorphological features. Besides that, Bukit Marak also provides a nice hilltop view of paddy field. This place is very famous among the locals alongside its legendary tales of Puteri Sa'adong. Unfortunately, Bukit Marak is not exposed enough to the outsiders even among geologist. So, the state government holds the responsibility to introduce this site to the public.

Bukit Marak supposed not having any problem to attract crowds because it is located not far away from Kota Bharu, which is the capital city of Kelantan. However, the lacks of facilities like toilets or pavements along the way to the top of the hill make Bukit Marak not attractable for visitors. Besides that, the poor accessibility of Bukit Marak will surely making it more difficult to attract visitors. First time visitors will find it hard to locate Bukit Marak as there are several other hills located near Bukit Marak.

The local authority also did not have a good planning on how to develop and conserve Bukit Marak as one of the attraction in Kelantan. Bukit Marak can be developed as a recreational place for the public or a good site of educational matters for geologists. In order to protect the site, public awareness should be raised (Neches, 2013). The local authority should provide educational materials for the visitors such as signboard of information of Bukit Marak.

1.3 Research Objectives

The objectives of this study are as follow:

1. To produce a geological map of the study area with the scale of 1:25 000
2. To identify the geoheritage and geotourism potential of the study area.

1.4 Study Area

1.4.1 Location

This study is carried out in Bukit Marak, Bachok, Kelantan at area of 5 km × 5 km (25 km^2). The area is mainly flat ground with several mountainous features. These low-lying areas represent depositional terrain and overlying unconsolidated alluvial, coastal and marine sediments of variable thickness. While the mountainous terrain mean elevation is more than 301 m. These mountains exist in the southeast part as granite intrusion (MacDonald, 1967) known as Bukit Marak and Bukit Kechik with elevation of 373 m and 307 m. Figure 1.1 refers to the base map of Bukit Marak.

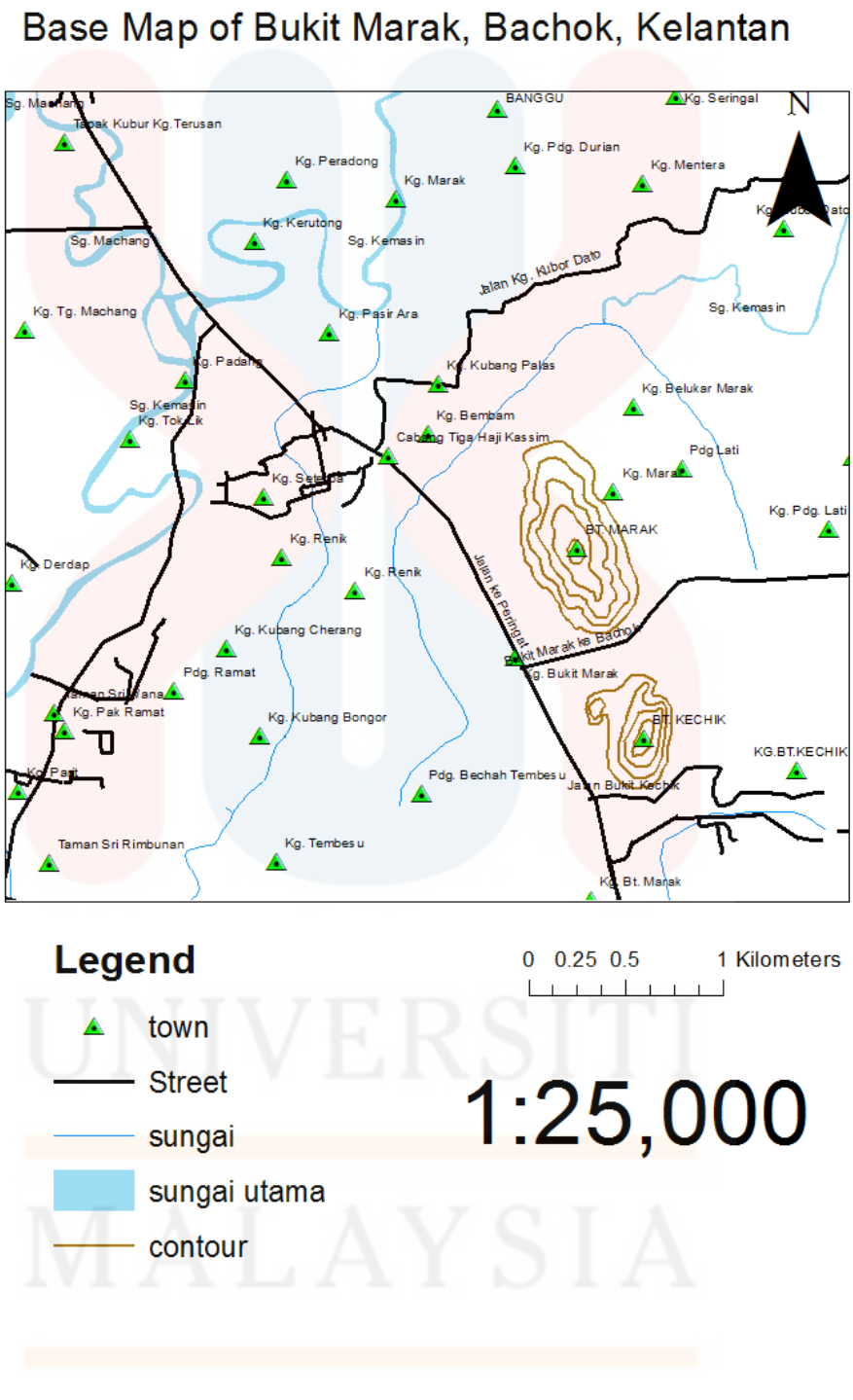

Figure 1.1: Base Map of Bukit Marak

1.4.2 Demography

The data for this part is taken from the Department of Statistics Malaysia for the state of Kelantan. Table 1.1 shows the people distribution according to the district subdivision in Kelantan. From the data, it shows that Tepus has the highest people distribution with 6957 while Pauh Lima has the lowest people distribution with 1439. Gunong sits on second with 5171 while Badak mati rank third in total people distribution with 3560.

Table 1.1: People distribution according to the subdivision of district in Kelantan (*Source: Department of Statistics Malaysia, 2010*)

District Subdivision	Total People Distribution
Pauh Lima	1439
Gunong	5171
Tepus	6957
Badak Mati	3560

1.4.3 Rainfall

The annual average rain distribution in the state of Kelantan is 291.27 mm per month. In the district of Gua Musang, the annual total rain for the year 2014 is 3220.0 mm that is average compared to Gunung Gagau district with total rain exceeding 5000 mm. The least rain-affected district is Laloh with total rain of 2417.0 mm. February is the least rained month in Gua Musang with only 3.0 mm of rain and December recorded the most rained month with rain total of 591.0 mm. The second most rained month is August with more than 600 mm total rain. It can be said that Gua Musang experiences rain in monthly basis with frequent rains toward the end of the year. Table 1.2 shows the percentage of annual average rain in Kelantan for the year 2014.

Table 1.2: Percentage of annual average rain in Kelantan for the year 2014

(Source: Department of Statistics Malaysia (web))

PERATUS JUMLAH HUJAN TAHUNAN
NEGERI KELANTAN BULAN 31 DISEMBER 2014

BIL.	NAMA STESEN	BULAN												JUMLAH
		JAN	FEB	MAC	APR	MEI	JUN	JULAI	OGOS	SEPT	OKT	NOV	DIS	
1	Kota Bharu @ Jeti Kastam	80.0	2.0	30.0	6.0	127.0	146.0	74.0	239.0	121.0	264.0	837.0	994.0	2,920.0
2	Tumpat @ Pengkalan Nangka	69.0	1.0	58.0	8.0	75.0	118.0	138.0	140.0	137.0	278.0	660.0	803.0	2,485.0
3	Pasir Mas @ Kasar	135.0	0.0	39.0	0.0	75.0	193.0	148.0	166.0	112.0	367.0	586.0	959.0	2,780.0
4	Machang @ Kusial	316.0	6.0	58.0	40.0	117.0	195.0	221.0	283.0	237.0	280.0	487.0	1686.0	3,926.0
5	Bachok @ Serdang Gunung Barat	45.0	0.0	30.0	1.0	152.0	312.0	120.0	237.0	165.0	216.0	1021.0	970.0	3,269.0
6	Pasir Puteh @ Bkt. Gedombak	262.0	1.0	60.0	21.0	122.0	176.0	234.0	314.0	443.0	197.0	816.0	1236.0	3,882.0
	a. **PURATA PANTAI**	**151.17**	**1.67**	**45.83**	**12.67**	**111.33**	**190.00**	**155.83**	**229.83**	**202.50**	**267.00**	**734.50**	**1108.00**	**3,210.33**
	b. **PURATA PANTAI TERKUMPUL**	**151.17**	**152.83**	**198.67**	**211.33**	**322.67**	**512.67**	**668.50**	**898.33**	**1,100.83**	**1,367.83**	**2,102.33**	**3,210.33**	**267.53**
1	Dabong	178.0	0.0	16.0	0.0	146.0	129.0	56.0	427.0	258.0	227.0	262.0	967.0	2,666.0
2	Jeli	432.0	6.0	225.0	245.0	368.0	251.0	198.0	446.0	301.0	451.0	442.0	1542.0	4,907.0
3	Gua Musang	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
4	Laloh	152.0	8.0	74.0	98.0	199.0	73.0	151.0	282.0	172.0	148.0	354.0	706.0	2,417.0
5	Aring	174.0	5.0	251.0	144.0	206.0	251.0	130.0	306.0	495.0	545.0	233.0	881.0	3,621.0
6	Gunung Gagau	171.0	22.0	208.0	59.0	461.0	192.0	317.0	341.0	562.0	252.0	579.0	2686.0	5,850.0
	c. **PURATA PENDALAMAN**	**207.17**	**7.33**	**161.67**	**119.17**	**267.50**	**185.17**	**157.00**	**403.33**	**379.50**	**322.67**	**340.83**	**1228.83**	**3,780.17**
	d. **PURATA PENDALAMAN TERKUMPUL**	**207.17**	**214.50**	**376.17**	**495.33**	**762.83**	**948.00**	**1,105.00**	**1,508.33**	**1,887.83**	**2,210.50**	**2,551.33**	**3,780.17**	**315.01**
	e. **PURATA KESELURUHAN**	**179.17**	**4.50**	**103.75**	**65.92**	**189.42**	**187.58**	**156.42**	**316.58**	**291.00**	**294.83**	**537.67**	**1168.42**	**3,495.25**
	f. **JUMLAH PURATA TERKUMPUL**	**179.17**	**183.67**	**287.42**	**353.33**	**542.75**	**730.33**	**886.75**	**1,203.33**	**1,494.33**	**1,789.17**	**2,326.83**	**3,495.25**	**291.27**
	g. Peratus = Purata x 100 / 2700	**6.64**	**0.17**	**3.84**	**2.44**	**7.02**	**6.95**	**5.79**	**11.73**	**10.78**	**10.92**	**19.91**	**43.27**	**129.45**
	h. **PERATUS PURATA TERKUMPUL**	**6.64**	**6.80**	**10.65**	**13.09**	**20.10**	**27.05**	**32.84**	**44.57**	**55.35**	**66.27**	**86.18**	**129.45**	**129.45**

1.4.4 Land Used

Land Use in Bachok can be divided into 5 main types of agricultural use involving a land area of 20, 330.6 hectares or 76.8% of the total land area in Bachok. Table 1.3 shows the main types of land used and its percentage. From the table below, most of the parts in Bachok are used for marginal land area and government land area with 16.5%. Ranked second is the land reserve area with 5% usage. Housing area covers 0.9% of total area while the lowest percentage is manufacturing companies area with usage of 0.1%

Table 1.3: Land Used in Bachok, Kelantan

(*Source*: *Pejabat Tanah dan Jajahan Bachok, 2007*)

Category	Area	Percentage (%)
Housing	242.6 hectares	0.9
Manufacturing Companies	23.4 hectares	0.1
Marginal Land	4375 hectares	16.5
Government Land Area	4375.66 hectares	16.5
Land Reserve	1490 hectares	5

1.4.5 Social Economics

The economic sector of the residents in the study area is mainly from agricultural source. Most residents in the study area work as rubber tappers and some have their own paddy field. Paddy field in Bachok covers an area of approximately 7,000 hectares. Bachok paddy production is between 3.8 and 4.0 tonnes / hectare per year.

1.4.6 Road Connection

Road connection in this district can be divided into three and the road connection is shown in figure 1.2:

1. Federal Road

   Federal road is a major road in the East Coast of Peninsular Malaysia linking of states in the East Coast into bachok through Pak Badol of Pasir Puteh and out through Melor to Kota Bharu. The length of the road is 2.99 km.

2. State Road

   State road is the road which connect all the places in Bachok district. The length of the road is 130.85 km.

3. Local Authority Road and Village Road

   Road through housing area and road that connect between places that not connected by the federal and state road.

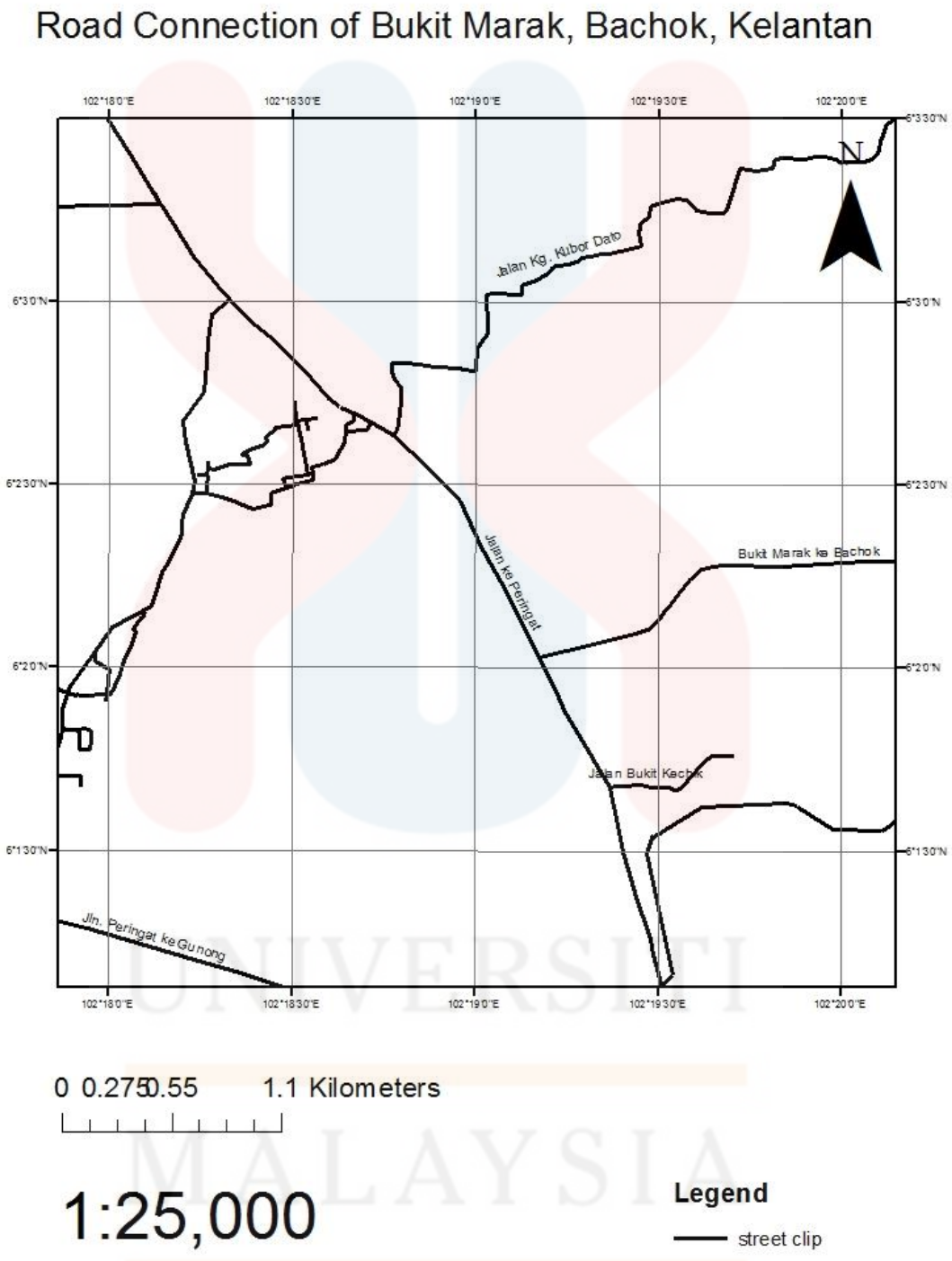

Figure 1.2: Road connection of study area

1.5 Scope of Study

The study is to focus on the geological features and geoheritage of Bukit Marak whether it is relevant or not to recognize Bukit Marak as a geoheritage site. Geoheritage site must have three important values that are scientific values, educational values and aesthetic values.

Scientific values mean that particular site has geological features that can be analyze scientifically. Educational values means that the site can provide a good educational matter such as the geomorphology of the Earth to the public especially for geology students. Aesthetic value means the site has a special geological feature that can attract visitors to the site such as waterfall and hot spring. There are other geoheritage values that can be used to recognized geoheritage sites such as recreational values, cultural values, economic values and religious values.

In order to support the idea of geoheritage in Bukit Marak, geological mapping need to be done to recognized the geological features of Bukit Marak and the surrounding area. Outcrops that found during the geological mapping need to be analyzed in laboratory to know the types of rock and the mineral constituent.

1.6 Research Importance

In order to develop and conserve a geological site, must first prepare a geological map of study area so that we can identify the geological features of the study area. The geological map also prepared for the tourists to know the geology, geodiversity and socio-economy of the study area.

Although Bukit Marak looks like a normal hill but it has some features that can be an attraction for the tourists to visit this place. The nice view of paddy field from the hilltop is one of many special features that can attract visitors apart from its geological features. The geological features also must possess particular occurrences of minerals, rocks, fossils, soils, landforms and geological processes with exceptional values (Brilha, 2013). The location is near the city of Kota Bharu is also one of the good reasons Bukit Marak can be develop as geotourism site.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

A literature review is comprehensive and indirect to indicate that considerable research that determination of geoheritage resources has been carried out throughout the world. Detailed about geoheritage resources and geoheritage values obtained from literature review can be so helpful in geoheritage research.

2.1.1 Regional Geology and Tectonic Setting

Peninsular Malaysia is an integral part a plate known as Sundaland which is the Eurasian Plate, the South-East Asian part (Hutchison C. S., 1996). There is no tectonic significance of the shallow Straits of Malacca and the geology of Peninsular Malaysia continues into Sumatra. In previous study prove that there are no similarities in stratigraphic between Peninsular Malaysia and Sarawak.

There are several similarity and differences between both Sumatra and Peninsular Malaysia. Most obvious difference between them is the large Tertiary oil basins of North, Central and South Sumatra, that reflects the down-faulted of Sumatra. Geological features of Peninsular Malaysia disappear beneath these large Tertiary basins of Sumatra.

The Bentong-Raub Suture is one of the important geological features in Peninsular Malaysia where it represents the Palaeo-Tethys of Peninsular Malaysia. It is the extension of Nan-Uttaradit and Sra Kaeo sutures of Thailand to south. Bentong-Raub

Suture contains oceanic ribbons chert dated by radiolaria aging from Upper Devonian to Upper Permian (Metcalfe, 1999).

Previous study suggests that there is no significance difference in stratigraphic between the East Malaya Block and the Indochina Block of eastern Thailand, Laos, Cambodia and Vietnam. The East Malaya is separated from its ancestral Indochina Block by the Gulf of Thailand.

The regional geology of Kelantan generally consists of a central zone of sedimentary and metasedimentary rocks bordered on the west and east by granites of the Main Range and Boundary Range respectively. Within the central zone, there are several known intrusive granite that are UIu Lalat (Senting) batholith, the Stong Igneous Complex and the Kemahang pluton. These belts of granite and country rocks are basically the continuation of the regional geology of north Pahang. In west and central Kelantan, the belts continue northward into south Thailand but in the east the Boundary Range granite is overlain by the coastal alluvial flat of Sungai Kelantan.

The oldest rocks in Kelantan are of Lower Paleozoic age, outcropping as a northerly-trending belt bordering the foothills of the Main Range and extending eastward up to Sungai Nenggiri. Rare occurrences of amphibolite and serpentinite have been recorded (Macdonald, 1967). Predominantly Permian volcanic-sedimentary rocks occur extensively on the eastern side of Kelantan, and overlying uncomformably, the Lower Paleozoic sequence in southwest Kelantan. The Taku Schist, dominates in the central north Kelantan and arguably aged pre-Triassic.

The youngest rocks recorded in Kelantan are the Jurassic-Cretaceous continental rocks which overlie the Boundary Range Granite and Triassic sediments in the Gunung Gagau area at the common state boundary between Kelantan, Terengganu and Pahang and to the west in the Gunung Perlis and Gunung Pemumpu areas. Figure 2.1 shows the geological map of Kelantan obtained from Jabatan Mineral dan Geosains from 2003 data.

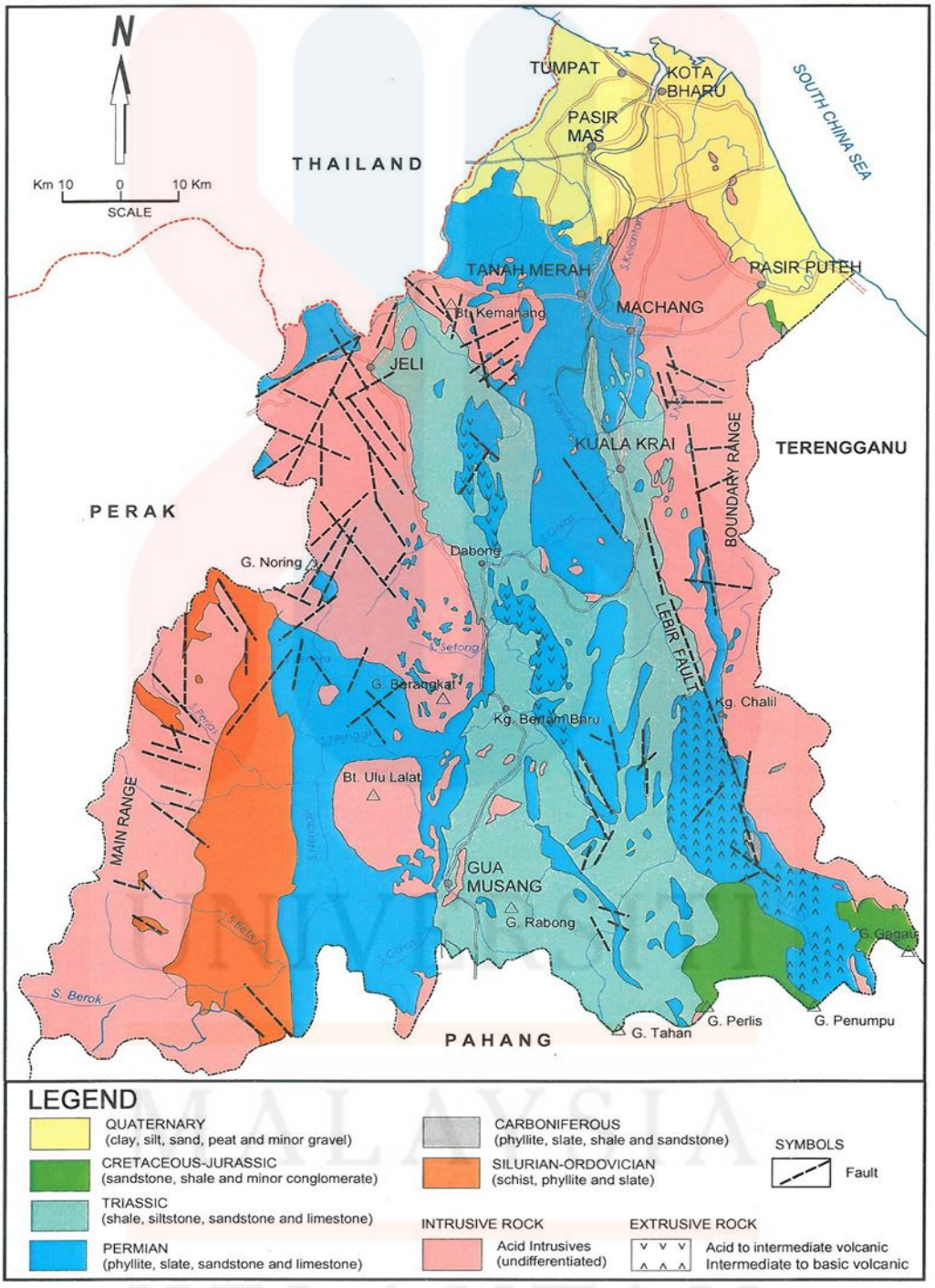

Figure 2.1: Geological Map of Kelantan

(*Source: Minerals and Geosciences Department, 2003*)

2.1.2 Historical Geology

The peninsular Malaysia was a part of the Eurasian Plate and also the Sundaland which was located at the South-East Asia region (Hutchison C. S., 1996). The Sunda Shelf continues towards east and south of Sumatra, Natuna and western Borneo which was less than 200-metre water depth. The edge of the Sunda Shelf extend N-S in a short distance east of Vietnam and curved eastwards to Baram Line. The eastern part of the Sunda Shelf edge showed continental crust to the eastward.

The Strait of Malacca was shallow showed no significant tectonic movement and the geology of peninsular Malaysia can be correlated with Sumatra (green). The young active Andaman Sea marginal Basin located at the western side of Langkawi islands which separated the Acheh district of Sumatra from the delta region of Myanmar which was dominated by right lateral wrench fault which continued southwards also known as the Sumatran Fault System and northwards into Myanmar called Sagaing Fault.

2.1.3 Regional Stratigraphy

Stratigraphy of the study area represents Cenozoic stratigraphy. Cenozoic sedimentary rocks occur both offshore and onshore. Generally, the Peninsular onshore has entirely emergent throughout the Cenozoic era. Tertiary sedimentary rocks recorded ten localities but, recent study indicates that only seven are proven to have sedimentary rocks of Tertiary age. The onshore basins can be separated into four broad groups: a northwestern occurrence at Bukit Arang, a north-central group comprising Lawin and Enggor, a central occurrence at Batu Arang and a southern group comprising Kampong Durian Chondong, Kluang-Nyior and Layang-Layang.

The offshore Tertiary sedimentary rock mostly occurs in the Straits of Malacca and South China Sea. In the Straits of Malacca alone, there are 15 grabens and half grabens recorded. These offshore grabens are possibly related to the Sumatra basins in Indonesia. The offshore grabens are much bigger than the onshore basins. The two major Tertiary basins are known as the Malay basins and the Penyu basins both occur at the South China Sea. These two basins are different from the onshore basins and the offshore grabens.

Extensive deposits of unconsolidated to semi-consolidated of boulders, gravel, sand, silt, and clay which underlie the coastal, inland plains and infilled valleys representing the Quaternary Period. In Kelantan, the sediments occupy in the north of Kelantan state and along the river valleys (Md Hashim, 2002).Such sediments may form beach ridges and river terraces. The fact that these sediment are early known from Quaternary Period but, a few ongoing research suggest that some of them may be much older ranging from Middle to Late Tertiary.

2.1.4 Structural Geology

Granitoids of eastern belt start at north of Kelantan at about 19 km away from Kota Bharu and trend southwards west of Gambang to Kota Tinggi, Johor. The mineralization generally occur in and along the eastern fringes of major granitoids outcrop and one of the most significant characteristics of this belt is the development of tin-iron mineralization complex (Senathi Rajah, 1977).

Granitic intrusives of the Eastern Belt form discontinuous mountain ranges parallel to the coast line of the east coast. There are 10 major granitoids masses of this belt and the nearest major granite of the study area is Boundary Range Granite.

Boundary Granite Range trend from north of alluvial Kelantan plain to near Gunung Gagau is the largest and most important granitic bodies that form mountainous country along Kelantan-Terengganu boundary. In the southern part of the granitoid, quartz diorite and other hybrid rocks are common (Senathi Rajah, 1977). (Macdonald, 1967) described that this body as grodiorite complex which possess several compositional and textural variations.

2.2 Specification Review

2.2.1 Geoheritage

Geology is a basic part of nature, and geological heritage is an integral part of the global natural heritage (ProGEO, 2011). It possesses the geological features that can define the history of the Earth including rocks, minerals, fossils and landform. Geoheritage can be in-situ (geosites) or ex-situ (museums). Geoheritage is an applied scientific discipline which focuses on unique, special and representative geosites, supporting the science of geology and its place in modern culture (ProGEO, 2011).

Scientifically and educationally significant geoheritage sites includes those with textbook geologic features and landscapes , distinctive rock or mineral types, unique or unusual fossils, or other geologic characteristics that are significant for education and research. Culturally significant geoheritage sites are places where geologic features or landscapes played a role in cultural or historical events. Cultural values may originate

from folklore associated with the origin of rock formations or landforms, links between rock sites and archaeology and the spiritual values of geological features (Gray, 2005).

Recreational values can be described as a place or site where the tourist can perform an activity and leisure in its vicinity. Aesthetically significant geoheritage sites can include landscapes that are visually appealing because of their geologic features or processes.

Many geoheritage sites can be tourist destinations and provide local and regional economic benefits. Geoheritage sites serve the public interest to advancing knowledge about natural hazards, groundwater supply, soil processes and other aspects of the nature and history of the Earth. Such sites have very high potential for scientific studies, use as outdoor classrooms, enhancing public understanding of science, recreation and economic support to local communities (Aspect, 2011).

2.2.2 Geotourism

One of the utilization of geoheritage resources is for geotourism development other than research and education. geotourism the ‘geo’ part pertains to geology and geomorphology and the natural resources of landscape, landforms, fossil beds, rocks and minerals, with an emphasis on appreciating the processes that are creating and created such features (Dowling, 2005). Geotourism can also include visits to road cuttings and quarries in order to view exposed rocks that may show folds, faults, phenocrysts and distinctive assemblages of minerals (Dowling, 2005).

2.2.3 Geosite

Geosite is an area showing geological features of intrinsic scientific interest, feature that make people understand the key stages in the evolution of the Earth. Such important geosites normally protected under national conservation legislation. Geosite is a neutral term for geological sites. A geosite can be small (monument, site, geotope) or large (park, reserve, protected area). Large or small, they are distinguished by their characteristic interest, or great vulnerability combined with their high importance of science (ProGEO, 2011).

2.2.4 Geodiversity

Geodiversity is a term that recognizes the infinite complexity of geology such as sedimentation, volcanicity and landscape change. Biodiversity is one dimensional, describing biotic diversity at the present day only, while geodiversity involves an appreciation of the Earth and its environmental, ecological and biological. Geoheritage deals with the special heritage, the special places that need protection, while geodiversity describes a wider general context (ProGEO, 2011).

2.2.5 Geoconservation

Conservation concerns the protection and management of natural resources. It is the preservation of special geological sites, areas, specimens for scientific research, education and training. Geoconservation involves the protection from damage of internationally and nationally significant geosites, their physical management, and their enhancement for scientific and educational uses (ProGEO, 2011).

Geoconservation is an approach to the conservation management of rocks, landforms and soils which recognizes that diversity has nature conservation values. Considering nature conservation to necessarily comprise both geoconservation and bioconservation provides a more holistic approach to nature conservation. This approach is philosophically distinct from other earth science-based approaches to land management such as soil conservation, environmental geology and geomorphic hazards management, which is essentially focused on utilitarian or anthropocentric values that is, these latter approaches seek to prevent degradation of landforms, waters and soils so as to minimize the effects that such degradation may have on human use of the land. The essential distinction is that geoconservation seeks to prevent or minimize degradation in order to protect the natural and intrinsic values of bedrock, landforms and soils rather than only to maintain their usefulness to humans (Sharples, 2002).

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

Materials and methods are fundamentals in any research analysis. It is the most important element of carrying out a research and is very crucial to be taken note before starting a research. In this research of Geology and Geoheritage of Bukit Marak, Bachok, several materials are needed to be used to be able to carry out the investigation thoroughly. Some methods with several steps are also important to be closely followed to ensure the completion of the research

3.2 Preliminary Research

Preliminary research had been done as a first step before anything else in carrying out this research. Information from books, journals and internet was used thoroughly. Internet was used as an early research of data and information of the study area. Books and journals research was also used for references. Geological map such as topography map and geological data was obtained from Jabatan Ukur dan Pemetaan Malaysia and Jabatan Mineral dan Geosains. Figure 3.1 shows the research flow chart for this study.

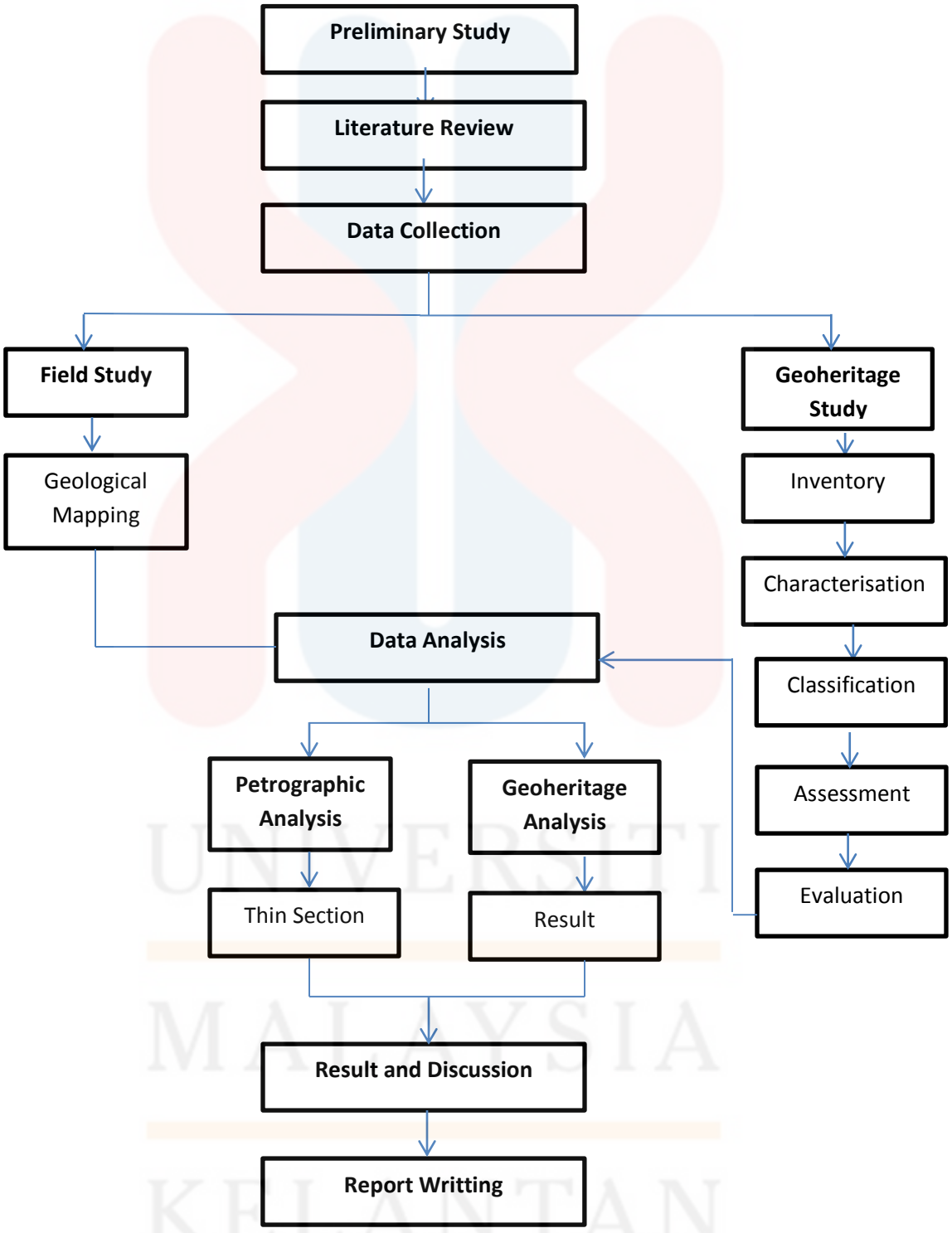

Figure 3.1: Research Flowchart

3.3 Materials and Equipments

1. Topographic Map
    - Contour lines and other map symbols can give clues about its geological features and geomorphology of the study area
2. Field equipments
    I. Hammer
    - To break outcrop

Figure 3.2: Geological Hammer

II. Geological Compass (Brunton)
- To take bearing and elevation

Figure 3.3: Brunton Compass

III. Hand lenses

- To magnify small objects
- To observe minerals at the field

Figure 3.4: Hand Lenses

IV. Measuring tapes

- To measures anything from grain size to bed thickness

Figure 3.5: Measuring Tape

V. Field Notebook

- To jot down every data and information at the field

VI. Hydrochloric acid

- The acid must contain small amount of 10% of HCl. Only a few drops of acid use to test sample at the field.

Figure 3.6: HCl

VII. Global Positioning System (GPS)

- To locate the coordinates on map
- To mark each and every outcrop found at the field

Figure 3.7: GPS

VIII. Sample bag

- To keep sample of outcrop taken at the field

IX. Permanent Marker pen

- To write the sample information on the sample bag

X. Camera

- To capture the geological features found at the field

Figure 3.8: Camera

3.4 Methodology

3.4.1 Geological Mapping

A geological mapping is a graphic representation of selected geological features within a desired surface or subsurface. The relative position and size of each feature on the map correspond to its correct geographic situation according to an established scale and projection. Commonly, geological features cannot be measured continuously over large areas, so their delineation is interpreted using available evidence. Geological maps describe the distribution of geological features within a landmass. Information from surface mapping is commonly used to postulate the distribution of geological features in the subsurface. Geological mapping is important in this research. Mapping also can relate the methods in geoheritage.

Geological mapping is the process of making observations of geology in the field and recording them so that one of the several types of geological map can be produced. The information recorded must be factual, based on an objective examination of the rocks and exposures. The studied region in mapping depends upon the types of mapping been carried out. A reconnaissance map is based on a fewer observations.

a) Reconnaissance Survey

During reconnaissance survey, reconnaissance map is needed in order to know the geological traverse of the study area. This survey is done to make sure the progress during the geological mapping will be running smoothly. This survey also is to recognize any outcrop or significant geological features at the study area. All

the information regarding the observation during the survey need to be written down in field notebook.

b) Geological Fieldwork

Before starting this fieldwork, a proper planning needs to be done in to make sure the progress in geological mapping runs smoothly. A proper traverse plan must be planned before start traversing. During this fieldwork, the geomorphology of the study area needs to be recorded. When encounter an outcrop, sketch the outcrop first and describe the characteristics of the outcrop such as, the color, texture, composition and type of rock. Sample of each outcrops need to be taken to the lab for further study. The coordinates of each outcrops also need to be marked in the GPS to be plotted in base map.

3.4.2 Geoheritage Mapping

Geoheritage and geoconservation have become significant endeavours in the conservation of important geological features (Brocx, 2011). In order to recognize any geoheritage sites, there are several systematic steps which are inventory, characterization, classification, assessment, and evaluation of potential geoheritage resources in the study area (Adriansyah, 2015).

The mapping concept of geoheritage mapping is about the same as geological mapping. The objective of geoheritage mapping are to identify and characterized the geological resources and landscapes based on geoheritage values. The focus is more on how to determine the geoheritage values and its rank. The five systematic steps in geoheritage are as follow:

I. Inventory

The inventory in geological heritage resources in study area are the identification, listing and mapping of the selected geological features/sites which are based on the previous study from published literatures and other resources such as web. It also must complimented by discussion with other geologists and fieldworks of study area.

II. Characterisation

In characterization, previous literatures and geological mapping of the study area was collected for its geological information. From the description of study area, special geological features which possess geoheritage values such as scientific, educational and aesthetic values were selected. Biological features of the study area were stated to support the description of the geological features selected.

III. Classification

In classification, the selected geological features in study area are classified into their geodiversity (Gray, 2005). The selected features can also be classified into their scale and scope (Brocx, 2007).

IV. Assessment

There are two principles to assess potential geoheritage resources.

- Qualitative method

  Focused on geoheritage values and levels of significance should be assigned to rank the geoheritage resources.

- Quantitative method

  Assessing the geological features numerically and to rank the geological features based on their geodiversity and geoheritage values.

V. Evaluation

In evaluation, SWOT analysis is used to evaluate the strength, weakness, opportunities and threats of the potential geoheritage resources in study area.

3.5 Laboratory Investigation

3.5.1 Petrographic Analysis

Petrographic analysis can be done in the laboratory. Selected rocks samples were utilized for thin section preparation. The thin sections were examined utilizing a petrological microscope under plane polarized light and crossed polarized light. The thin section was ready to describe the texture of mineralogy, alteration and deformation of rock samples. There are several steps in making thin section. The steps are as below:

1. Cutting the rock

   The sample taken from field was clamped to the holder so that the line is parallel to the saw blade. The cover was closed to make sure the sides and the bottom were tucked in inside the lip. The cutting can be done by switching on the machine.

2. Clean the slab

   The slab needs to be washed to remove any oil and grit from the slab saw process. Next, the leftover rock was set and the first cut piece on a towel to dry it and the sample number was marked on a paper.

3. Cutting chip

   The size of the slab need to be reduced to a bit smaller than the thin section by using a special rock cutting blade made up of metal wit embedded diamond. During this process, protective eye and ear gear must be wore until the process was done. After the cutting process, the side of the thin section needed to be polished to remove marks from the blade.

4. Prepare and frost the glass slide

   Water was sprayed to the rough surface of the mirror until it's wet. Some abrasive was sprinkle on the mirror. The glass slide was put on the mirror and the glass slide was turned 360˚.

5. Glue the slide to the chip

   The chip is heated on a hot plates with the polished side facing upward. A batch of epoxy is mixed. Few drops of epoxy is spread on the warm side of the chip and wait for it to soak in then more epoxy is dropped. The slide is placed frosted side down on the epoxy. The epoxy will cure in 20-30 minutes.

6. Cutting the chip from the slide

   A blank glass was placed on the grinder to block the vacuum. Turn on the water to the cut-off saw. The slide was placed on the cut-off saw and turn on the vacuum to hold it. The machine was turned on and the handle was used to move the chip to the blade. Once done, the slide is rinsed to remove any particles.

7. Grinding the slide to the correct thickness

   A blank glass was placed on the cut-off saw to block the vacuum. The water was turned on and the turn was controlled by handler. The slide was placed on the grinder. The slide was moved back and forth once the grinder was turned on. The slide was removed and tested under the microscope to see the identification of mineral was seen or not.

8. Adding cover slip

   The section must be clean from dirt and grit. The section was placed on the hot plate. A small batch of epoxy and hardener is mixed and put on the section. A cover slip was placed on the section. The cover slip was moved to expel bubbles.

3.6 Data Analyses and Interpretation

The data which was collected in the field and also through the laboratory study were analyzed. The data collected should be kept and grouped into systematically way which made the analysis of the data easier. The analyzed data from both field and laboratory study were then be used in the discussion and also conclusion part of the report. The data analysis and interpretation should be related to the study area.

3.7 Report Writing

Report writing was the last process for the final year project research. All the findings and result were written into the report. Besides, the format of the report writing had followed the guidelines and format which had been set by the Faculty of Earth Science, Universiti Malaysia Kelantan. This report consists of six chapters which were introduction, literature review, materials and methodology, general geology, results and conclusion.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter, activities in the field for geological mapping and the collected data from field observation are presented. All the data and the collected samples are identified through observation and measures taken for geological mapping. The method that was used to map the study area is traversing method.

Before traversing, the base map of the study area was done using Arcgis software. The study area then was analysed to make sure there will be much easier to traverse. The base map was analyzed to identify the accessibility of the study area, land used and the residential area of the study area.

In general, the study area partially covered with paddy field and it cause limited access to traverse. The residential areas cover most of the study area where the accessibility is high. Bukit Marak and Bukit Kechik cover only a small area in the study area where it can still be traversed as shown in the traverse map in figure 4.1.

4.2 Geomorphology

Geomorphology is the study of surface landforms, processes and landscape evolution of the earth. This section will provide information about the geomorphological processes that has taken place in the study area. It includes the topography of the study area, weathering processes and also the drainage pattern.

Geomorphology of the study area is not complicated. Basically, quaternary deposits cover the most part of the study area. There are also two granite hills that have elevation around 100m to 300m high. `

4.2.1 Topography

The topographic features of North Kelantan are low-lying unit with mean elevation less than 15m. These low lying areas represent depositional terrain and overlying unconsolidated alluvial, coastal and marine sediments of variables thickness. The mountainous terrain mean elevation is more than 301 m where it represents the granite intrusion. There are two hills present which are located at the South-East of the research area The mountainous terrain will be Bukit Marak and Bukit Kechik with the elevation of 373 m and 307 m respectively.

The high elevations are Bukit Marak and Bukit Kechik where the peak of Bukit Marak was once a place where a castle of one of the family members of sultan Kelantan named Puteri Sa'adong was located. Bukit Marak used to be a favourite place for Puteri Sa'adong and the local villagers. By traversing method, it can be identified that the low areas in the study area are mostly covered by paddy field and residential area. The low elevations or flats area are dominant in the study areas as it covers more than half of the area. The 2D topography of the study area is shown in figure 4.1 while figure 4.2 shows the 3D topography map of the study area.

Bukit Kechik is used by Air Kelantan Sdn Bhd (AKSB) to keep water in a massive tank at the peak. The water tank supply clean water to the surrounding residential area.

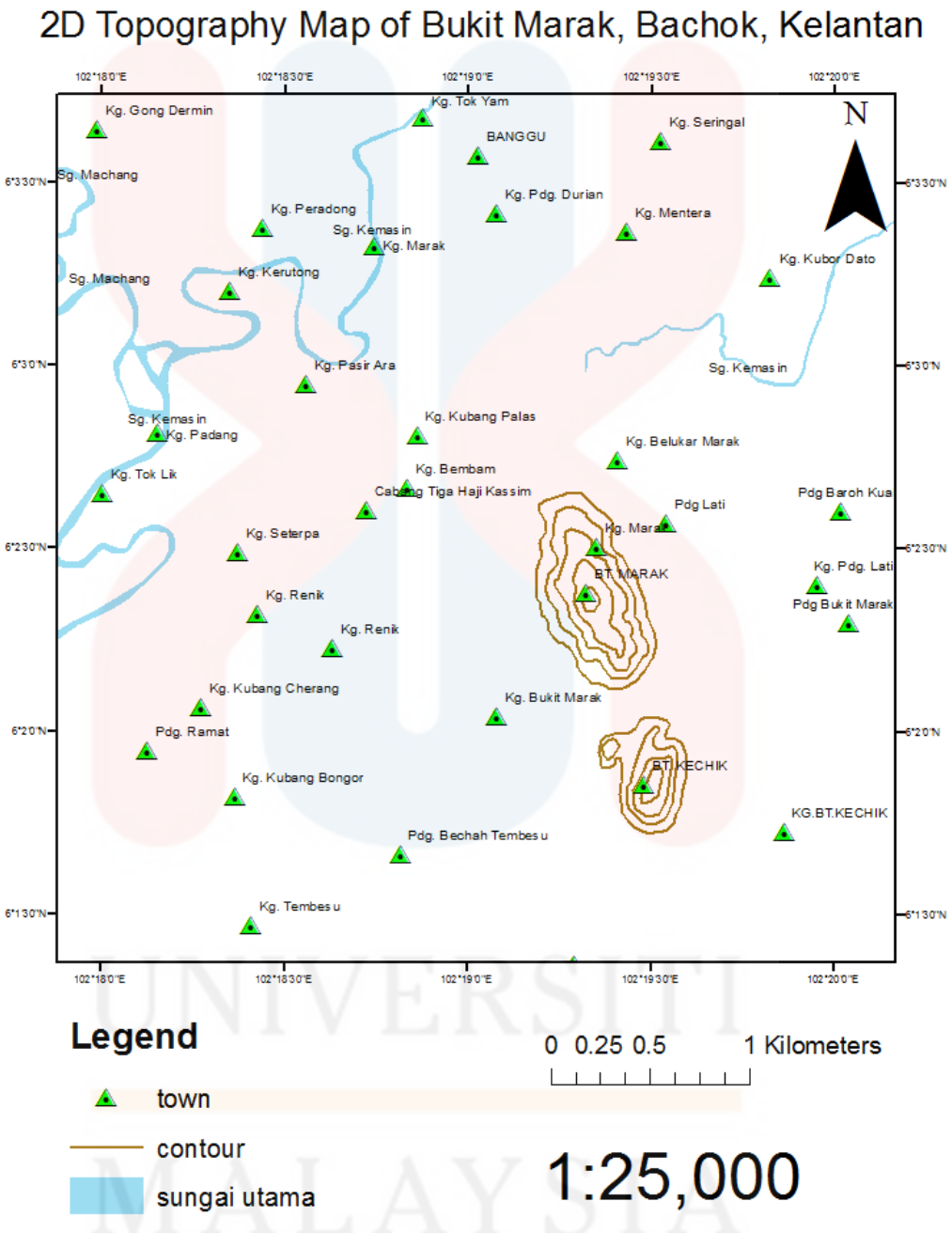

Figure 4.1: 2D Topography Map of Study Area

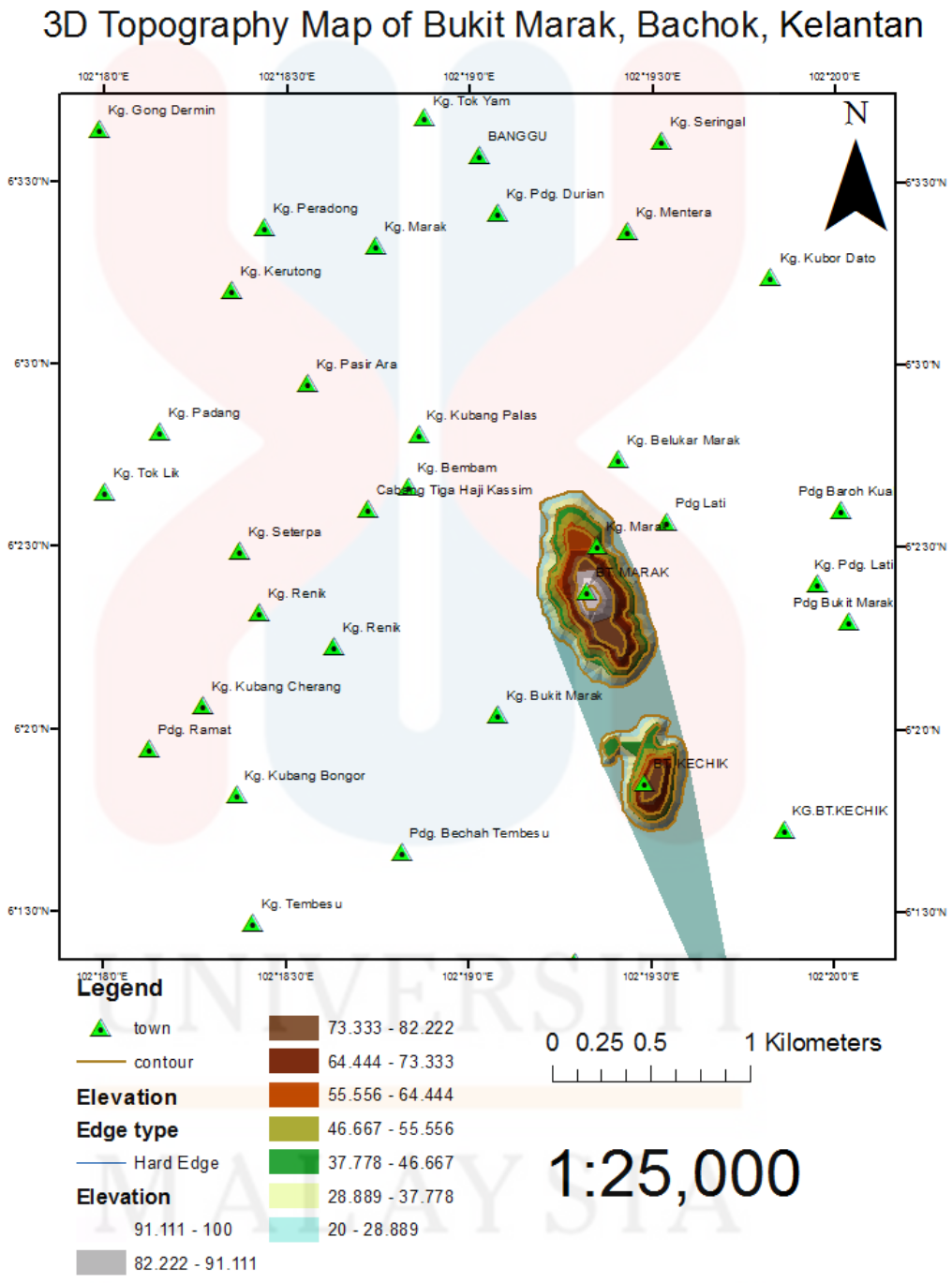

Figure 4.2: 3D Topographic Map of Study Area

4.2.2 Drainage System

River systems or mainly known as drainage systems are the pattern that formed by the flow of streams, rivers and lake at a particular drainage basins. The drainage systems are governed by the geomorphology of that particular area such as topography of the land and the type of rocks whether it is hard or soft rocks. Streams and rivers are often viewed by geomorphologists and hydrologists as being part of drainage basins (Pidwirny, 2006).

There several types of drainage patterns in geomorphology which are dendritic, parallel, trellis, rectangular, radial, deranged, angular and discordant. In the study area, there are no distinctive patterns as there are not much of rivers and streams. Thus, a drainage pattern cannot be generated from the study area. Figure 4.3 shows the example of drainage pattern.

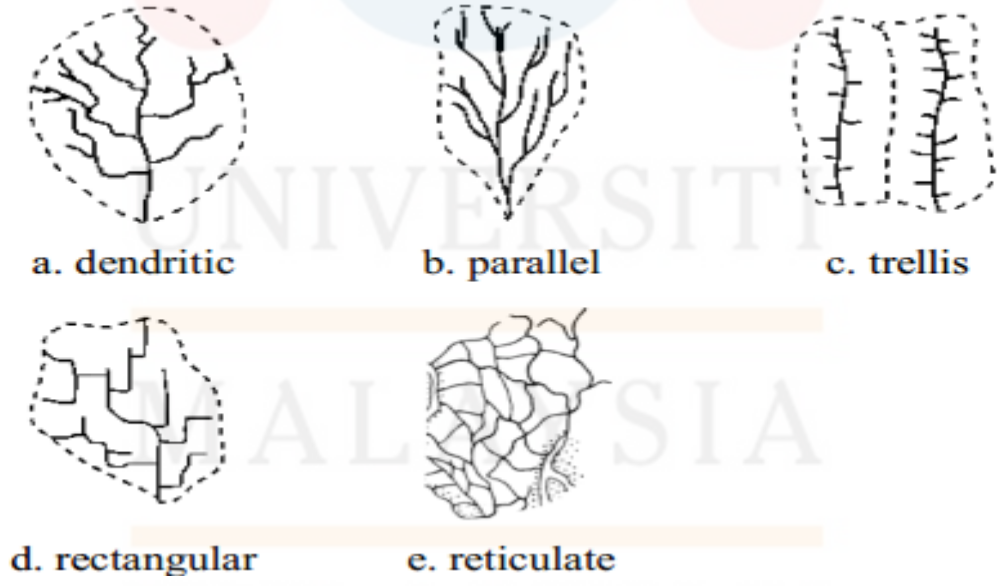

Figure 4.3: Drainage pattern

In the study area, only small rivers and ditches exist along the paddy field and some villages. The ditches connected to the small rivers which then flow into the main river which eventually drains out to the South China Sea. The drainage map is plotted by digitizing the drainage system through satellite image using GIS as shown in figure 4.4.

Base on the drainage systems of the study area, the flow of the rivers mainly from southwest to northeast where the river flow from Sungai Kemasin to the nearest coastal area which is Pantai Kemasin. At the northwest of the study area, Sungai Machang flow towards Sungai Kemasin from northwest to southeast. From Sungai Kemasin, the river then flow towards the South China Sea. The energy flow of Sungai Kemasin and Sungai Machang are low mainly because of the flat plains of surrounding area.

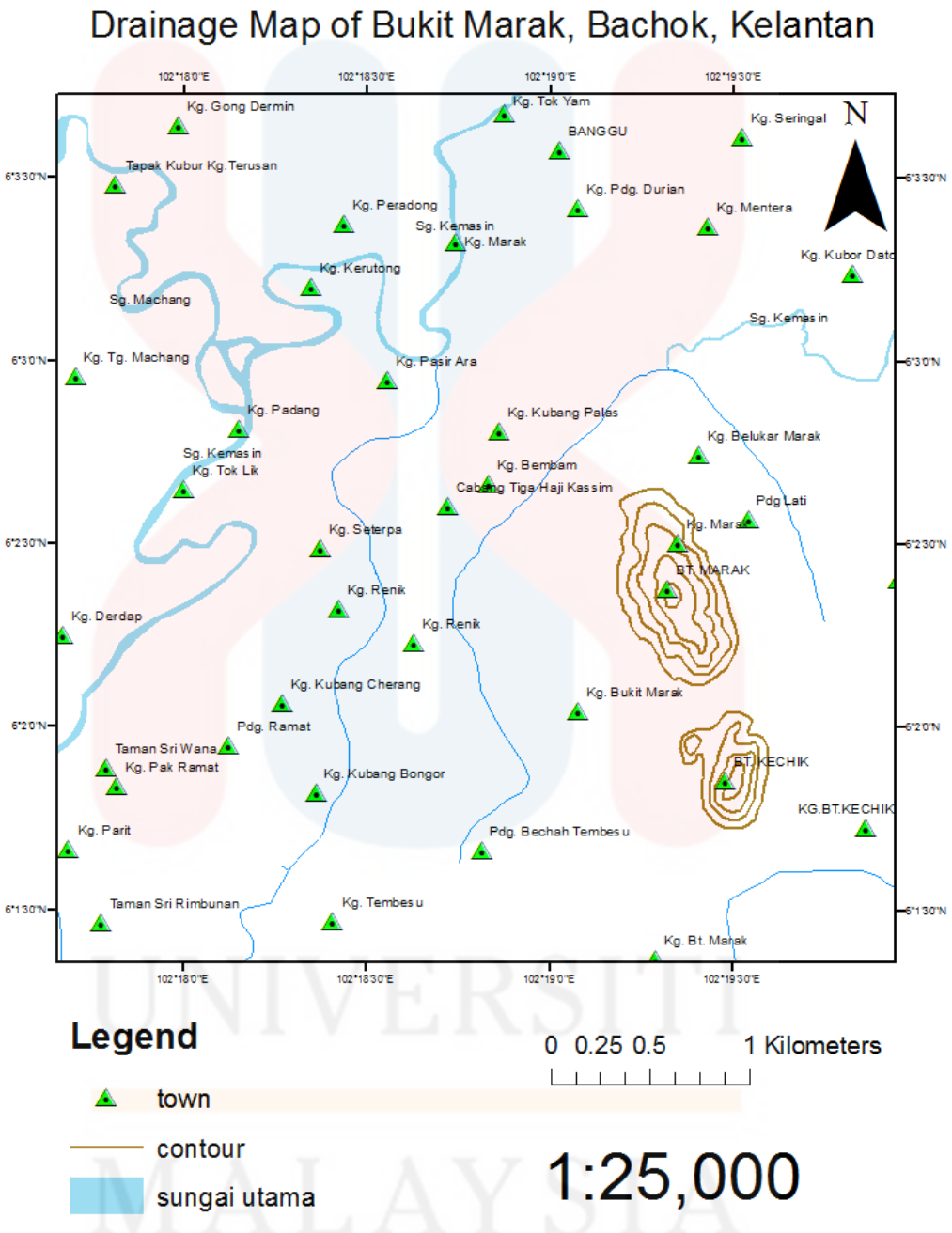

Figure 4.4: Drainage System of Bukit Marak

4.2.3 Weathering Processes

Weathering is the physical disintegration or chemical alteration of rocks at or near the Earth's surface. There are three types of weathering which are mechanical weathering, chemical weathering and biological weathering. The term weathering implies when a rock is exposed to surrounding weather. Rock must first be exposed at the surface in order to experience weathering process.

In the study area, evidence of weathering processes can only be found at Bukit Marak, Bukit Kechik and the area around them. Mainly, the type of weathering found in the study area is biological weathering. As can be seen, trees are growing at Bukit Marak and Bukit Kechik where they both are Granite intrusion. They grow within the cracks of the granite. As the roots grow bigger, they open up the crack and overtime, the growing tree will eventually breaks the rock. The evidence of biological weathering can be seen in figure 4.5.

Furthermore, water also helps accelerate the weathering process of granite at Bukit Marak. There several areas that the granite form like a massive pot holes or like a pond where it can accumulate water in it as in figure 4.6. There is no evidence of chemical weathering in the study area. The only outcrop that can be found in the study area is granite that consists of quartz minerals. According to the Bowen Reaction Series, quartz is located at the end of the series which means that quartz is highly resistance to pressure and temperature. Quartz minerals are considered as stable thus, quartz could be completely resistant to chemical weathering.

Figure 4.5: Biological weathering at Bukit Marak

Figure 4.6: Pond-like structure at Bukit Marak

4.3 Stratigraphy

Stratigraphy is the study of rock layers and stratification. Lithostratigraphy is the study of sequences of rock layers and the orders of events that had taken place to the particular outcrop based on its physical characteristics. As in the study area, Bukit Marak and Bukit Kechik are among the hills that have visible granite rock in Bachok, Kelantan while the rest of the study area covered with quaternary deposits.

Regionally, Bukit Marak and Bukit Kechik are part of the eastern belt. The group of granite range in the eastern of Kelantan is called boundary range granite located at the northern part of eastern belt. Mainly, the Eastern Belt granite at Kelantan is Gagau Group that named after Gunung Gagau. Gunung Gagau is composed of two different formations which are the older Badong Conglomerate and the overlying Lotong Sandstone (Hutchison, 2009).

The quaternary deposits of nothern part of Kelantan are elongated from the north of Terengganu. The coastal plain are linear stretches of sandy beaches which then interrupted river mouth and small headlands at Bukit Merang and Bukit Keluang (Hutchison, 2009). The Simpang Formation is found within the broad valley of Sungai Kelantan and its Delta with low ridges that extends from Selising of Bachok to the Bachok-Kubang Kerian road (Hutchison, 2009) which include the study area.

The Simpang Formation was first introduced by Suntharalingam and Teoh (1985) for a unit of gravel, sand, silt and clay overlying bedrock of Taiping area. Simpang Formation was formerly known as Old Alluvium.

The unconsolidated sediments increase in thickness eastwards in the Kelantan Delta with the deepest bedrock encountered at a depth of 150 m (Bosch, 1986). The sediments consists of gravel coarse sand and thin beds of clay beds at the depth of 50-60 m, although a 10 m thick clay layer occurs at a depth of 130 m (Bosch, 1986).

4.4 Structural Geology

Structural geology is the three-dimensional study of processes and products of deformation of sedimentary, magmatic and metamorphic rocks. Structural geology is used to uncover the historical geology of certain area, the deformation of rock and the understanding of regional stress field (Verner, 2013). In engineering geology, structural geology also plays and important role which that to know the physical and chemical properties of rocks.

The study of structural geology mainly focuses on the earth's crust. However, structural geology also dealt with the deformation of the entire earth and not limited to certain area (Nevin, 1942). Deformation can be described as modification of shape and original structures of rock as the effect of regional stress-field (Verner, 2013). Deformations include stress and strain, fault, fold and joint.

4.4.1 Cracks Analysis

Crack analysis is to known the force that given the stress to the rock mass and energy release. From the hydrogeological point view, fractures and discontinuities are among the most important of geological structures. Most rock possesses fractures and other discontinuities which facilitate storage and movement of fluids through them. Porosity, permeability and groundwater flow characteristic of fractured rocks,

particularly their quantitave aspects. Main flow path in fractured rocks are along joint, fracture, shear zone, faults and other discontinuities (Singhal, 2010).

Crack is a break where the sides pull apart as the crack opens, breaking bonds to create the crack. The significance to study the crack is that the direction of the force can be determined and can analysed whether it is save or not to build structure or building near the outcrop.

The strike of joint and fracture of the rock unit have been collected and been interpret using rose diagram. Based on figure 4.7 and 4.8, the maximum tension is shown on the rose diagram direction, northeast of the area. The force applied on the area produce a significant amount of tension of the crack. The arrow shows the direction of force.

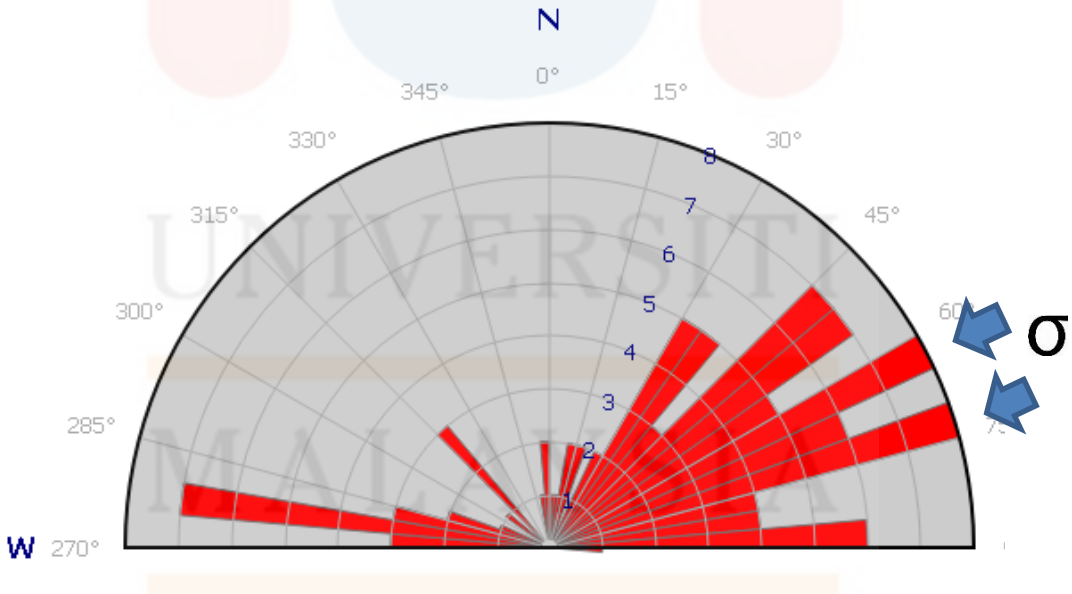

Figure 4.7: Cracks analysis at coordinate N 6° 2’ 23”, E 102° 19’ 15”

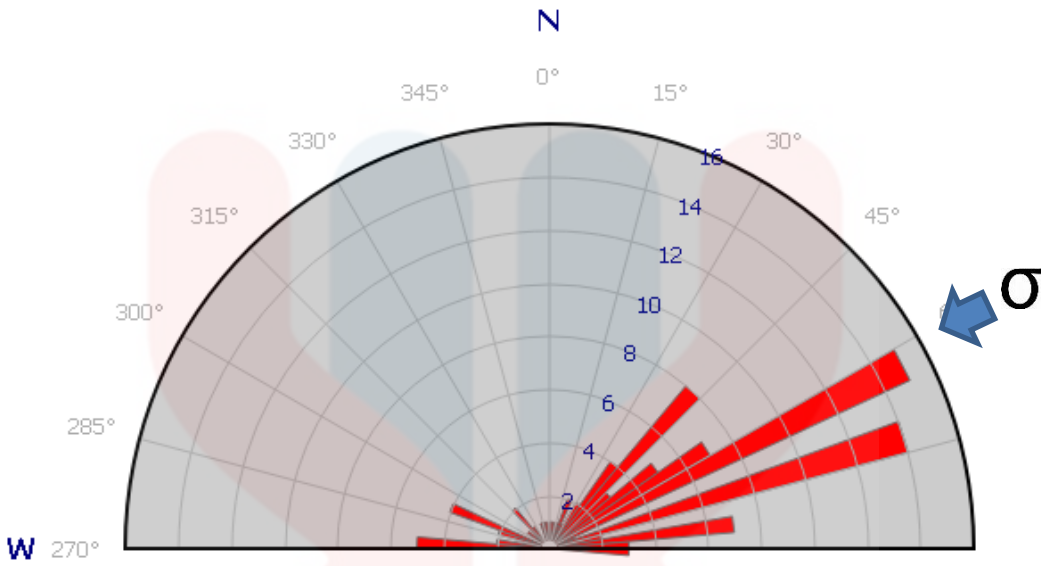

Figure 4.8: Crack analysis at coordinate N 6° 1’ 44”, E 102 ° 19’ 25”

4.4.2 Lineament Analysis

lineament is a pattern or "figure" in a factual representation of either the earth's surface or a subsurface datum and the figure must be linear, continuous, reasonably well expressed and be related to features of the solid earth (Christopher, 1982). Lineaments are correlative with the individual faults and the aggregate fault patterns at the regional of the study area.

The satellite image of regional area is obtained from the terrain map of google earth. From the study area, there are not much lineaments so to study the lineaments, satellite image of regional area taken is very wide. The image then inserted in Arcgis software to make a proper lineaments map as shown in figure 4.9.

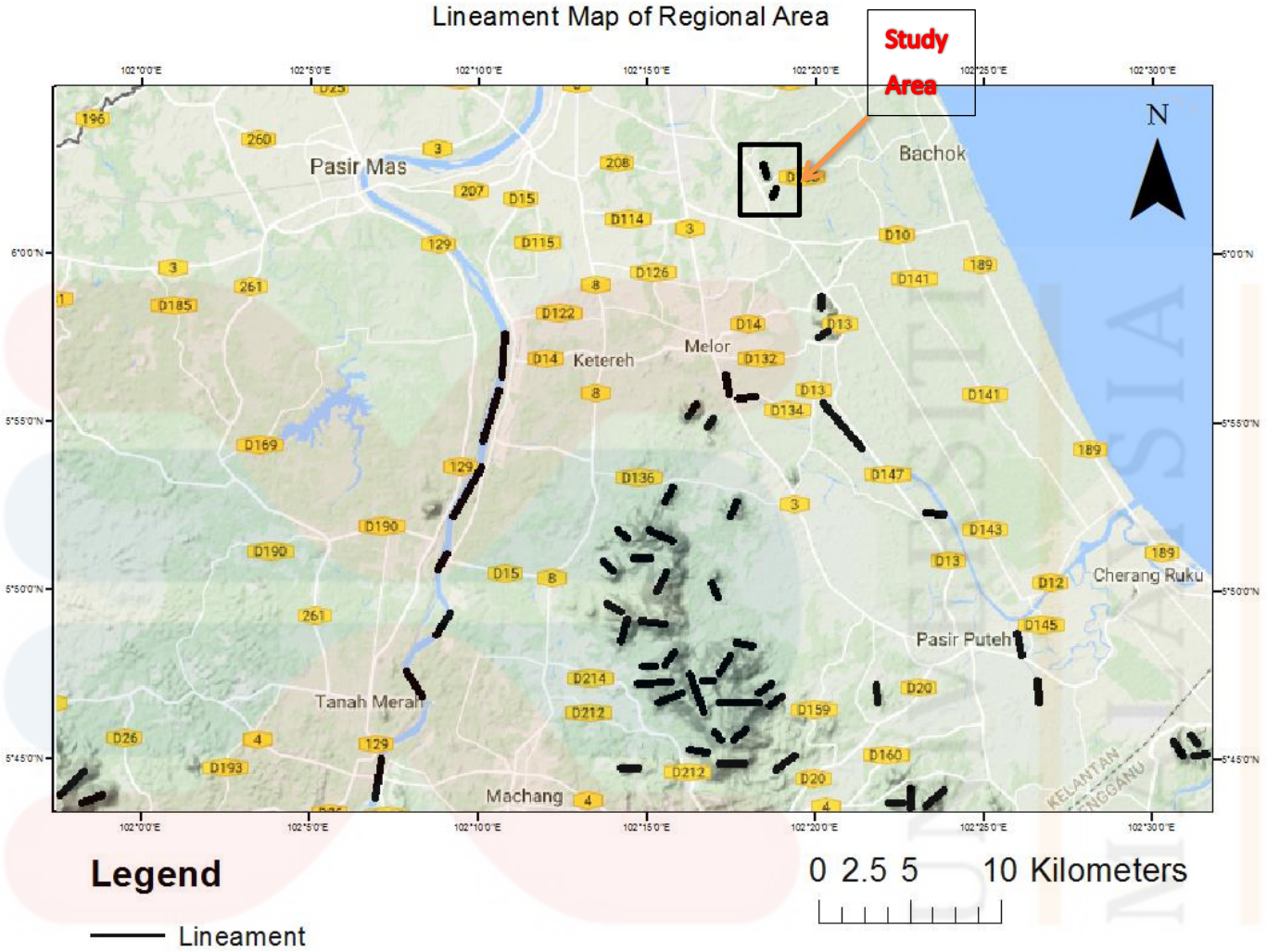

Figure 4.9: Lineament map of regional area

The lineaments in the regional area is then measured the dip direction and the direction is shown in figure 4.10 in rose diagram. The arrows show the direction of force of the lineament.

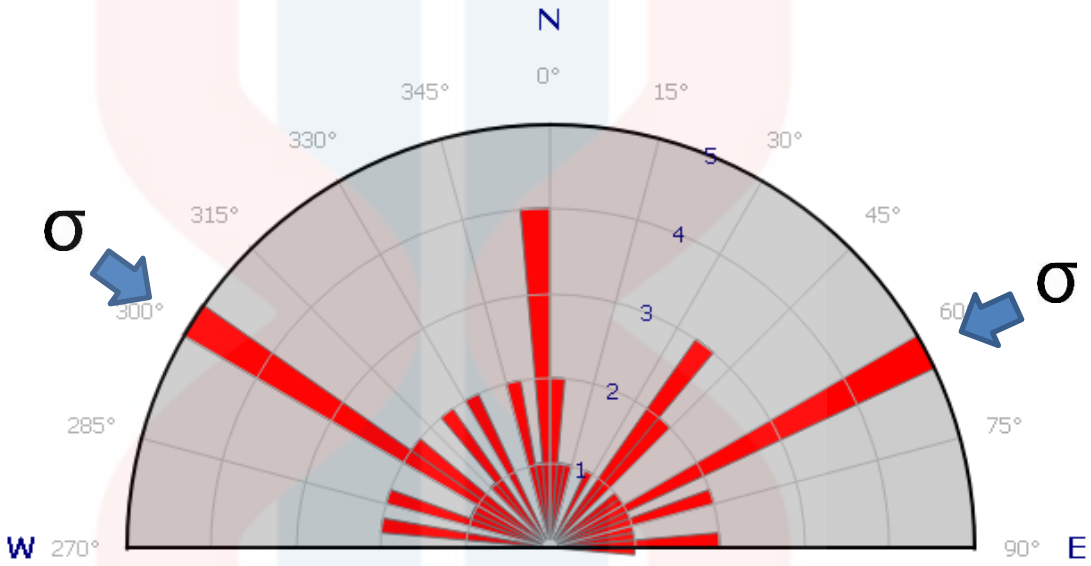

Figure 4.10: Rose diagram of lineament analysis

4.5 Historical Geology

Historically, the granite intrusion of Bukit Marak and Bukit Kechik are predominated first at the study area where they are from Mesozoic era. The age of Bukit Marak and Bukit Kechik are Triassic age. In the recent time, the deposition of sand and gravel occur to make the alluvium plain of the study area. The alluvium plain is quaternary deposits where they came only when quaternary period.

4.6 Petrography

In the study area, rock samples were collected only at Bukit Marak and Bukit Kechik and their surrounding as this is the only part were outcrop can be found. The rock samples of the study area were classified as intrusive igneous rock. The granite composition from the study area can be compared to the Main Range granite as granite

from Bukit Marak and Bukit Kechik considered as Eastern Belt granite. The most notable difference between granite from Eastern Belt and granite from Main Range is that the rocks are texturally more equigranular and smaller grain size (Hutchison, 1977).

During geological mapping, two rock samples are taken from two different locations as shown in figure 4.11.

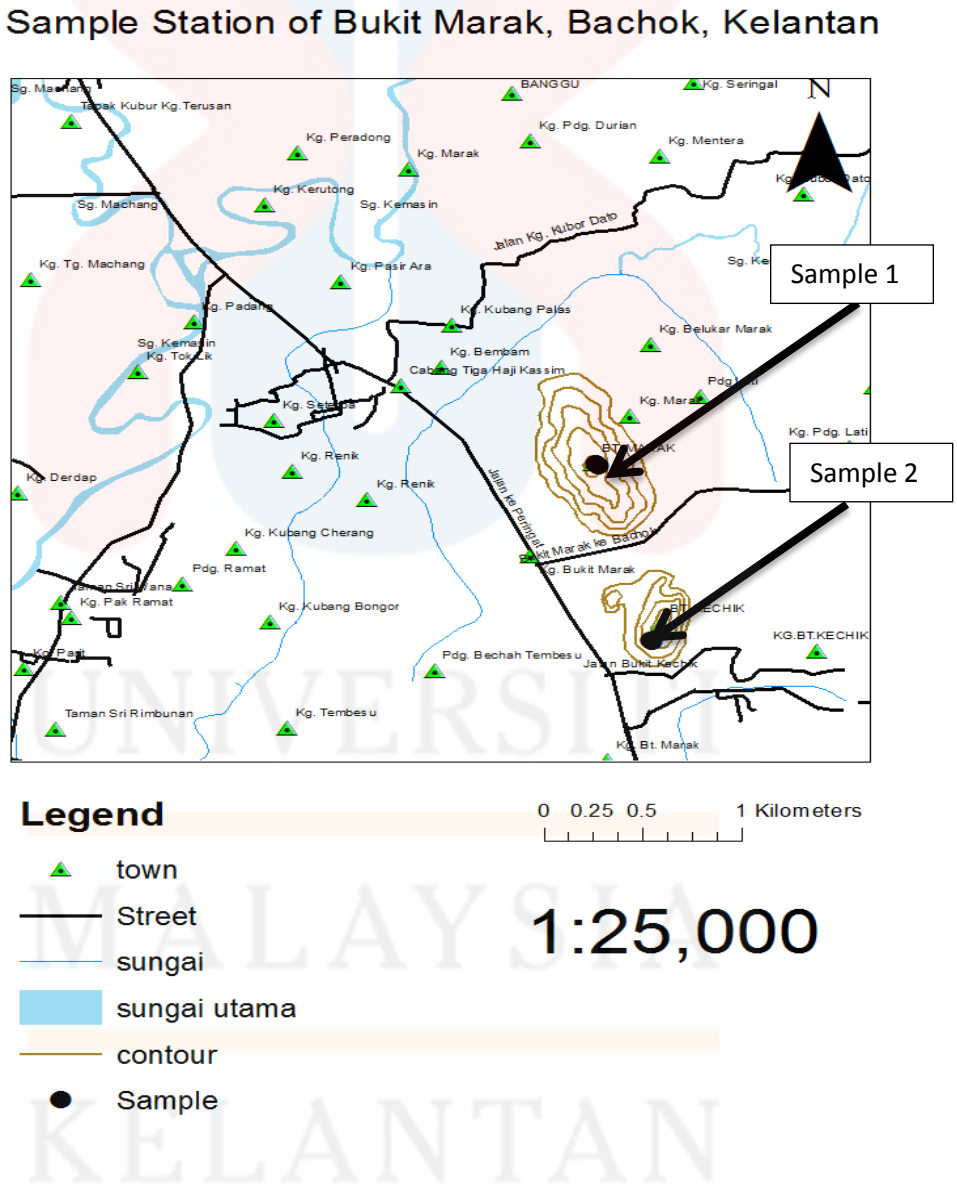

Figure 4.11: Sample Station of study area

The rock samples were then processed for mineral identification under microscope. Thin section had been made and both samples were observed under the light microscope.

Sample 1

Figure 4.12 shows the outcrop of sample 1 of study area located at coordinate N 6° 2’ 19”, E 102° 19’ 16”.

Figure 4.12: Outcrop of sample 1

Figure 4.13 shows the hand specimen of sample 1 taken from the study area.

Figure 4.13: Hand specimen of sample 1

Sample 1 is examined under plane polarized and cross polarized light microscope and the minerals are identified and label as shown in figure 4.14 in cross polarized and in plane polarized.

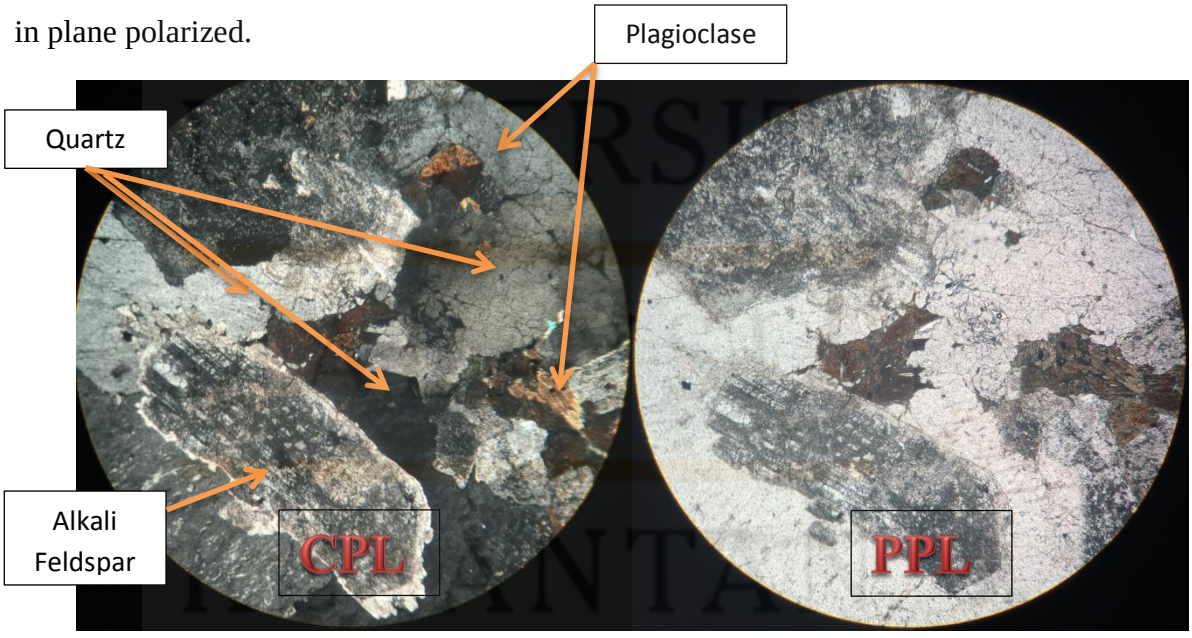

Figure 4.14: Minerals under cross polarized and plane polarized view

The mineral composition in sample 1 is examined and the type of rock is identified in QAP triangle as shown in figure 4.15. The compositions of minerals are 45% of Quartz, 40% of Alkali Feldspar and 15% of Plagioclase. Hence, the rock name is identified as granite.

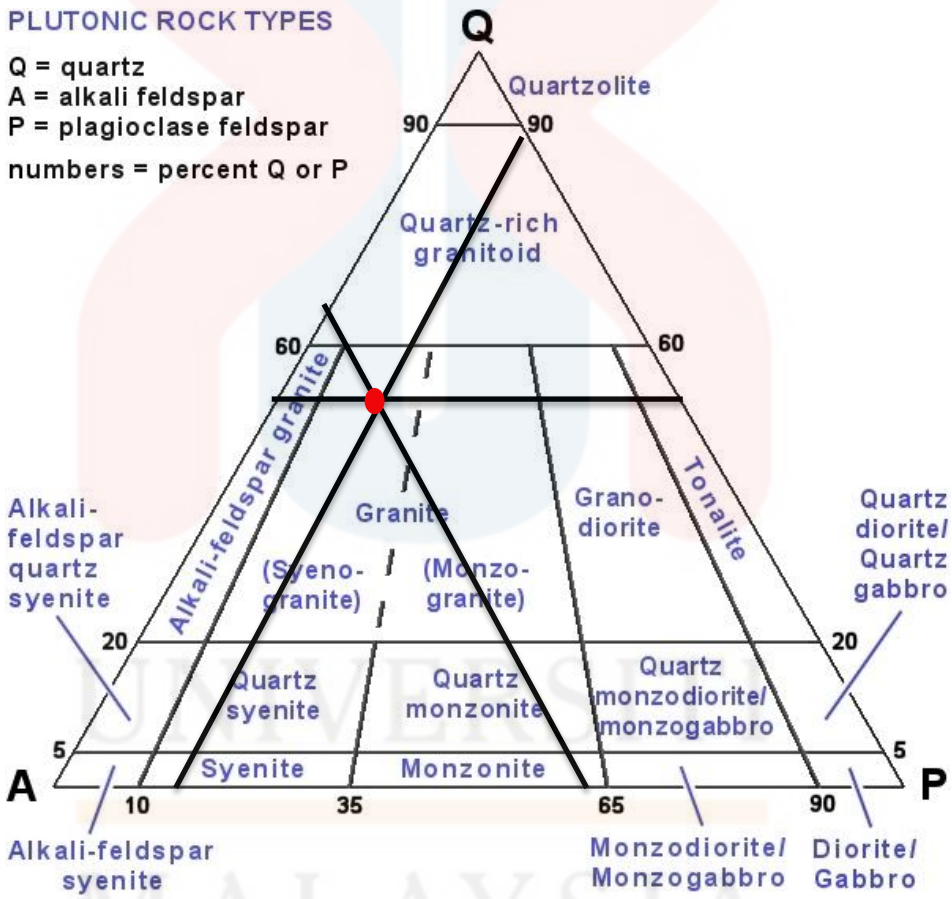

Figure 4.15: Plotted QAP diagram of sample 1

Sample 2

Figure 4.16 shows the outcrop of sample 1 of study area located at coordinate N 6° 1’ 44”, E 102° 19’ 25”

Figure 4.16: Outcrop of sample 2

Figure 4.17 shows the hand specimen of sample 2 taken from the study area.

Figure 4.17: Hand specimen of sample 2

Sample 2 is examined under plane polarized and cross polarized light microscope and the minerals are identified and label as shown in figure 4.18 in cross polarized and in plane polarized.

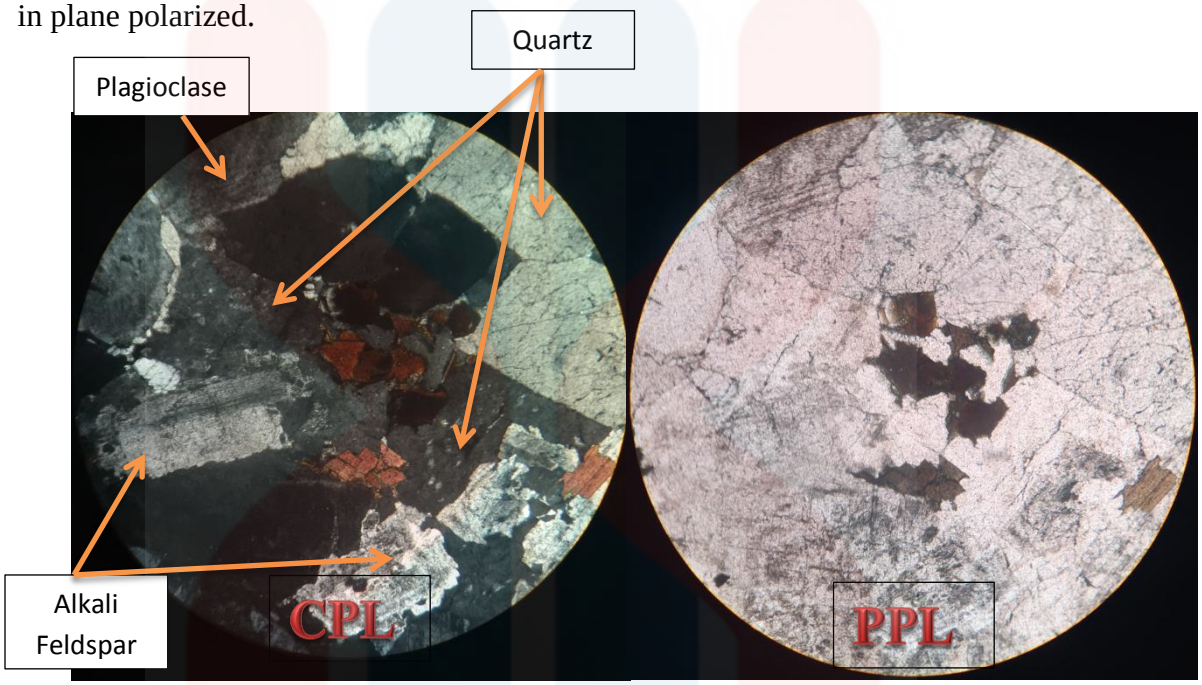

Figure 4.18: Minerals under cross polarized and plane polarized view

The mineral composition in sample 2 is examined and the type of rock is identified in QAP triangle as shown in figure 4.19. The compositions of minerals are 50% of Quartz, 40% of Alkali Feldspar and 10% of Plagioclase. Hence, the rock name is identified as granite.

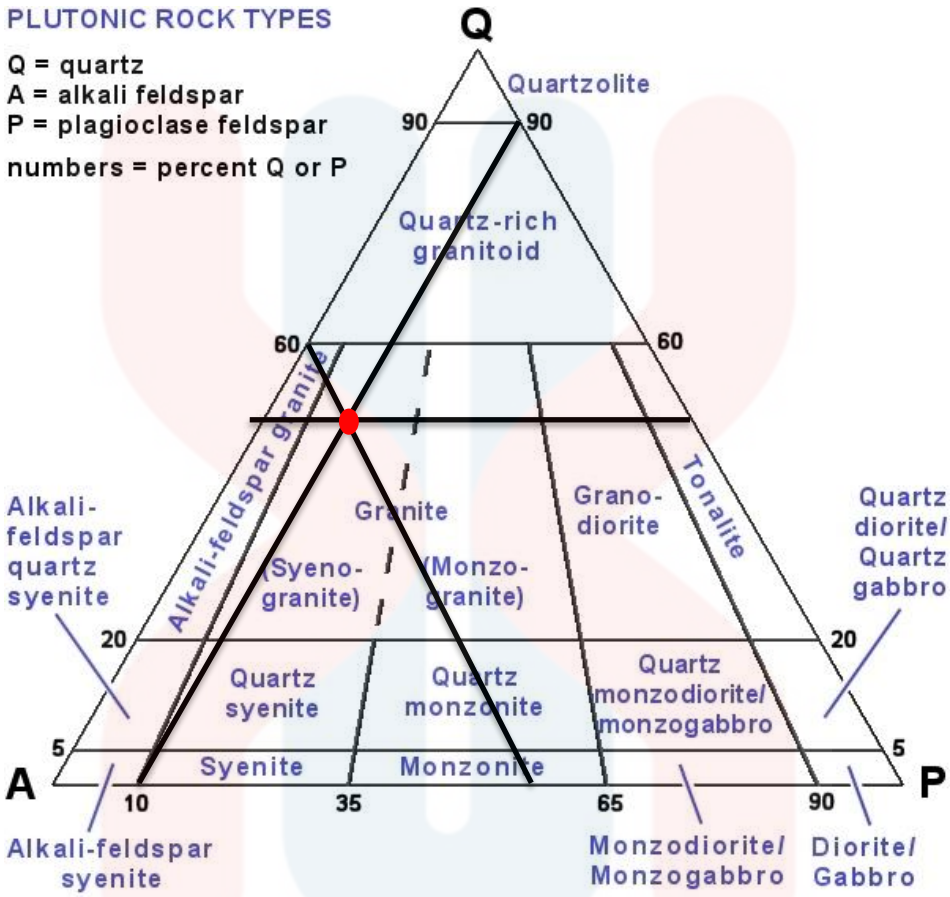

Figure 4.19: Plotted QAP diagram of sample 2

CHAPTER 5

RESULT AND DISCUSSION

5.1 Introduction

According to Brocx and Semeniuk (2007), geoheritage is a concept concerned with the preservation of features with importance to Earth science, such as landforms, natural and artificial exposures of rocks and sites where geological features can be examined.

Generally, the earth geological resources had been used for development, industrial and modernization of human. But, we actually need to preserve the geological resources as it can gives knowledge about the history of the earth not only for recent generation but also for the future generation. Some geological sites have a very unique and rare features and history that need to be preserved for future generation.

This chapter provided discussion and analysis of geoheritage of Bukit Marak, Bachok. In the study area, Bukit Marak is chosen as a geoheritage site because it possesses several geoheritage values and can be a good attraction for tourist to come to Bukit Marak. So, Bukit Marak is indeed in need of a conservation plan so that it can be preserved as a geological heritage site.

5.2 Geoheritage Values of Bukit Marak, Bachok

Bukit Marak possesses several geoheritage values that can act as attractions to local and the outsiders to visit Bukit Marak. The values are scientific value, educational value, aesthetic value, recreational value and cultural value. These values are focused on

Bukit Marak and its features. Table 5.1 shows all the geoheritage values and related features at Bukit Marak.

Table 5.1: Geoheritage values of Bukit Marak, Bachok

Geoheritage Values	Features
Scientific Value	Intrusion of Granite in the middle of quartenary deposits
Aesthetic Value	Unique geological features such as granite pond and caves
Educational Value	The local can learn how to appreciate such unique features at Bukit Marak
Recreational Value	Visitors can do hiking and witness beautiful scenery of paddy field on top of Bukit Marak.
Cultural Value	Related to folk tale or legend of Puteri Sa'adong who live on top of Bukit Marak

5.2.1 Scientific Values

Generally, every geosite must have its own scientific value or it will not be known as geoheritage site. The scientific values that can be seen from the study area are some intrusion of granite and few other intrusions of granite in Bachok. Bachok is generally a flat plane where most of them are residential area and paddy field. But, some part of Bachok has granite intrusion such as Bukit Marak, Bukit Kechik and Bukit

Gunong. These granite intrusions can only be explained by geologists on how it occurs or are they different from the eastern belt granite.

Geoscientists can take samples from the intrusion to make further research on the composition of minerals and make a conclusion about the type of granite that occur in Bachok. The granite may differ from every intrusion so petrographic analysis must be done. Further analysis such as crack analysis also can be done at the study area to identify the direction of stress. Figure 5.1 shows the granite sample taken from Bukit Marak.

Figure 5.1: Granite sample of Bukit Marak

On the other hand, the historical geology of the study area can be reveal so that the visitors can increase their knowledge about Bukit Marak when they visit to do some activities. The authority can provide an information board full with details about geological features and geological history of Bukit Marak, Bachok.

5.2.2 Aesthetic Value

Aesthetic value is related to features, landforms or landscapes that are visually appealing because of their geologic features or processes. Bukit Marak possesses few unique geological features that can attract people to visit Bukit Marak. The unique features such as naturally occurs flat rock that look like it has been cut by human as in figure 5.2, granite caves as can be seen in figure 5.3 and big pot holes as in figure 5.4.

These aesthetic features are very close related to the cultural values. Some of the features are believed to be related to some folk tales or legends. Geologically, many needs to be explained by these features such as how does a cave can occur in a granite hill or how does the formation of flat rock that it appear clean-cut like.

Figure 5.2: Flat Rock

Figure 5.3: Granite Cave

Figure 5.4: Big Pot Hole

Figure 5.5: Pond on granite

5.2.3 Educational Value

By conserving Bukit Marak, the visitors can be educated to appreciate the nature and the geological features not only at Bukit Marak but at any geosite. Bukit Marak also possesses variety of floras where visitors also can learn more about floras at Bukit Marak like herbs, bonsai and mushrooms.

Furthermore, visitors also can learn and practice to hike as Bukit Marak also can gives the visitors the experienced hiking on it. Although it is not as tough or as high as other hills or mountains in Malaysia it but can be a good place for beginner hikers to practice hiking before taking down higher hills or mountains.

5.2.4 Recreational Value

Visitors can experience the challenging track and witness the spectacular views of paddy field on top of Bukit Marak. Bukit Marak provides few different tracks with different degrees of difficulties for nature lover or nature seeker to hike. Bukit Marak can be a good place for beginner hikers to hike.

In additional to that, there are some places in Bukit Marak can be upgraded to become rock climbing site. Visitors can try to climb rock on the granite intrusion. The local authority can add rock climbing at the area where it will surely increase the amount of visitors to Bukit Marak. Figure 5.6 shows the views from the top of Bukit Marak and also a suitable place for rock climbing.

Figure 5.6: View from the top of Bukit Marak

5.2.5 Cultural Value

Bukit Marak is closely related to the legendary story of Puteri Sa'adong. Bukit Marak possesses so many cultural values as it believed to be a place where Puteri Sa'adong of Kelantan royal family live in her castle on top of Bukit Marak. Because of no preservation being done by local authority, the building is now destroyed by its ages. There are still proves of some part of the concrete building of her castle as shown in figure 5.7.

According to the folk tale, after the death of her husband Raja Abdullah, Puteri Sa'adong left her previous castle to live in Bukit Marak. She is guarded by Awang Selamat who is described as a very big person and very loyal servant to Puteri Sa'adong. He also has magical power that made him a very powerful man. Figure 5.8 shows crack on a rock that believed to be a proved how powerful Awang Selamat was. He cut the rock into two by using his blade.

There is also an area at Bukit Marak called Taman Lagenda Bukit Marak. That area used to be very beautiful where the area was full with beautiful flowers just like a garden or a park. It was a favourite place for Puteri Sa'adong where she likes to hang out. Unfortunately, because of the irresponsible act of some locals, the area were destroyed and become banana plants area.

Figure 5.7: Destroyed structure of Puteri Sa'adong's Castle at the top of Bukit Marak

Figure 5.8: A rock cut into two found at the top of Bukit Marak

5.3 Geoheritage Mapping

Geoheritage has its own mapping method to analyze and evaluate whether the study area can be considered as geoheritage site or not. There are five mapping method that are used to determine the geoheritage of the study area which are inventory, characterisation, classification, assessment and evaluation.

Before geoheritage mapping could be done, several research of the study area need to be made to ease the geoheritage mapping process. Several literature review and articles about the study area are collected and studied. From the literature review, the most significant value that can be determined from the study area is cultural value.

5.3.1 Inventory

In inventory, all geological features that are identified as good geological heritage resources from the study area are listed down. The basis for the inventory of geoheritage sites is geodiversity. Geodiversity includes minerals, rocks, fossils, soils, landforms and geological processes are listed down from the study area. Almost all subdisciplines in geology such as petrology, mineralogy, sedimentology, paleontology, structural geology and geomorphology are vital to establish the list.

According to Brocx and Semeniuk (2011), identification of sites of geoheritage significance may be based on unique occurrence, rarity, or representativeness of some geological features. The list of inventory of the study area is listed as shown in table 5.2. Potential geological heritage resources could be simple or complex with different geological heritage values.

Table 5.2: List of inventory of the study area

Geoheritage Resources	**Geoheritage Value**
Cave	Scientific and education values
Hill Landform	Scientific, education and recreational values
Puteri Sa'adong's Trails	Cultural value
Granite Outcrop	Scientific and educational values

5.3.2 Characterisation

The selected features from list of inventory above were then described in details in characterisation. The selected site, which is Bukit Marak, possesses so many features that can attract locals and tourists to visit Bukit Marak. The selected features are granite caves, hill landform, Puteri Sa'adong's trails and granite outcrop.

In Bukit Marak, there are so many granite caves that can be found either it is a big caves or small caves. According to the locals, there thirteen caves located at Bukit Marak including small caves. There is still not much study about caves in granite hills and Bukit Marak can be a good geological site for geologists and geoscientists to study more about the caves.

The hilly landform of Bukit Marak can be a good attractor for tourists to hike to the peak of Bukit Marak. There are so many diversities of living organisms that live in Bukit Marak where it is a good indicator of a very good habitat to some living organisms. Thus, it is important to implement conservation and preservation programme to Bukit Marak.

The most significant features possesses by Bukit Marak is the cultural value of Puteri Sa'adong's trails. Bukit Marak is well-known for the locals as the place where Puteri Sa'adong used to live. But, that cultural value seems to fade nowadays. The young locals did not know the historical story of Bukit Marak and Puteri Sa'adong whom loved by the locals many years ago. Some of the locals did not even know who Puteri Sa'adong was. The historical features of Bukit Marak need to be preserved for future generation.

Last but not least, the granite outcrop found in Bukit Marak still need to be further studied as there is still not much reference in any literature about geology of Bachok especially for the granite.

5.3.3 Classification

All geological heritage resources can be classified in term of geodiversity by Gray (2005), scope by Brocx and Semeniuk (2007) and scale also by Brocx and Semeniuk (2007).

Classification by diversity is simply based on the occurrence of rocks, minerals, fossils, landforms, landscapes, processes and soils. Classification by scope is based on the main subdiscipline in geology such as geomorphology, paleontology, hydrogeology, mineralogy and sedimentology. Then the classification can also be made by scale where according to Brocx and Semeniuk (2007), there are six different scales that can be used as shown in table 5.3. Table 5.4 shows the classification of geoheritage resources in the study area.

Table 5.3: Classification by scale according to Brocx and Semeniuk (2007)

Scale Term	**Frame of Reference**	**Examples**
Regional Scale	100 km x 100 km or larger	Mountain range scale
Large Scale	10 km x 10 km	Limestone barrier
Medium Scale	1 km x 1 km	Small mesas and adjoining plain
Small Scale	100 m x 100 m	Outcrop scale
Fine Scale	1 m x 1 m	Bedding scale
Very Fine Scale	1 mm x 1 mm or smaller	Crystal features

Table 5.4: Classification of geoheritage resources in the study area

Geosite	**Geodiversity (Gray, 2005)**	**Scope (Broncx and Semeniuk, 2007)**	**Scale (Broncx and Semeniuk, 2007)**
Bukit Marak	Granite (rocks)	Petrological site	Small scale
	Caves	Structural site	Small scale
	Hill landform	Geomorphological site	Large scale
	Puteri Sa'adong's trails	Cultural site	Large scale

5.3.4 Assessment

There are two way to assess geoheritage resources of the study area which are qualitative method and quantitative method.

Qualitative method focused on some geodiversity and geoheritage values, mainly scientific and educational values and additional values such as aesthetic, recreational, cultural, historical, economical, functional, and so on (Gray, 2005). In addition, levels of significance should also be assigned for the ranking of geoheritage resources, such as international, national, state, regional, and local (Brocx and Semeniuk, 2007). Table 5.5 shows the qualitative assessment of the study area.

On the other hand, quantitative method related to the need to assess the geological features numerically by valuing and to rank the features. This approach was conducted by assessing numerically the potential geoheritage features based on their geodiversity and geoheritage values. In the study area, the value which had been establish to rank the features are: 0 = none; 1 = very bad; 2 = bad; 3 =fair; 4 = good; and 5 =very good as shown in table 5.6.

Table 5.5: Qualitative assessment of the study area

Geosite	**Scientific and educational value**	**Aesthetic value**	**Recreational value**	**Cultural value**	**Level of significance**
Bukit Marak	Granite intrusion, cave and hill formation	Cave in granite hill	Hiking and rock climbing	Related to the legend of Puteri Sa'adong	State

Table 5.6: Quantitative Assessment of the study area

Geosite	**Scientific and educational values**	**Aesthetic value**	**Recreational value**	**Cultural value**
Bukit Marak	4	4	5	5

5.3.5 Evaluation

In this part, SWOT analysis should be constructed to evaluate the strengths, weaknesses, opportunities and threats of potential geoheritage resources. The geoheritage evaluation also recommends and proposes the type of geoheritage conservation to a site, such as geosites, geotope, geological monument, geopark,

National Park or World Heritage Site (ProGeo, 2011). The SWOT analysis is constructed in table 5.7.

Table 5.7: SWOT analysis of the study area

No.	**SWOT**	**Remarks**
1.	Strengths	➢ Good potential for research and education ➢ High aesthetic value ➢ Good recreational site ➢ Rich in cultural value ➢ Good accessibility to the site
2.	Weaknesses	➢ Lack of promotion ➢ No conservational programme ➢ No support from the authority ➢ No public utilities such as toilet
3.	Opportunities	➢ Suitable for recreational activities such as rock climbing and hiking ➢ Promotion can increase attraction to the site ➢ Suitable for research and education of cultural value
4.	Threats	➢ Potential of becoming rubbish dump area ➢ Potential of vandalism ➢ Potential of sand mining activities

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

Based on the results and discussion above, Bukit Marak have enough geoheritage values that can be highlighted as the attraction for the locals and tourists to visit Bukit Marak not only to do some recreational activities but to know more about the history of Puteri Sa'adong who was very famous long time ago.

Malaysian people are very attracted to peculiar and historic things. So, there will be no problem at all for Bukit Marak to shine as an historic place as Bukit Marak is rich of historical and cultural stories including Puteri Sa'adong of the royal family of Kelantan and her loyal servant and guardian Awang Selamat.

Other reason that could be an attraction to Bukit Marak is there are so many food stalls and restaurants that served good food that can also be one of the reasons why people should come to Bukit Marak. Some restaurants also went viral because of the good food that they served. One of the famous restaurants is Maggie Belut Bukit Marak that located few kilometres from Bukit Marak.

The location of Bukit Marak also located near Kota Bharu which is the state capital of Kelantan which only 20 minutes away drive. It is also a good reason as tourists can also go shopping at Kota Bharu after having a recreational activity at Bukit Marak. Tourists also have option to stay in a homestay in Bachok or in a hotel in Kota Bharu.

So, as a conclusion, Bukit Marak can be a good geoheritage site that possesses so many geoheritage values and geoheritage resources and geotourism potential are successfully identified.

6.2 Suggestion

Although Bukit Marak can easily attract visitors, there are many improvements that can be made to make Bukit Marak more attractive and more convenient to visitors. First, the local authority need to construct a solid conservation and preservation programme for Bukit Marak as it is vulnerable to any vandalism and exploration of sand mining activity. They need to ensure that Bukit Marak is protected from any threats of irresponsible entity so that the cultural and historical values of Bukit Marak can be preserved for future generation.

A few things also can be added up to Bukit Marak for the convenient towards visitors such as public toilet, children playground and also rock climbing area. Some parts of Bukit Marak are too extreme to hike so the local authority can upgrade the area to become rock climbing area.

After conserving and preserving Bukit Marak, the only thing that can attract people to Bukit Marak is to make a good advertisement or publicity towards Bukit Marak. They can promote all the recreational activities such as rock climbing and hiking or they can also promote the historical story behind Bukit Marak and why it is so important to the Kelantanese people.

REFERENCES

Adriansyah, N. D. (2015). Systematic Studies of Geoheritage in Jeli District, Kelantan Malaysia. *The European Association for Conservation of the Geological Heritage*.

Aspect, P. P. (2011). Geoheritage. *Geological Society of America, Position Statement Draft (5)*, 56–58.

Bosch, J. H. (1986). Young Quaternary Sediments In The Coastal Plain of Kelantan, Peninsular Malaysia. *Geological Survey of Malaysia*, 42.

Brilha, J. (2013). Principles of a national geoheritage program. *the Global Geoparks Networks, the IUGS Task Group, and ProGEO*.

Brocx, M. ,. (2007). Geoheritage and geoconservation : history, definition, scope and scale. *Journal of the Royal Society of Western Australia, 90*, 53 - 87.

Brocx, M. ,. (2011). Assessing Geoheritage Values: a Case Study Using the Leschenault Peninsula and its Leeward Estuarine Lagoon, South-western Australia. *Proceedings of the Linnean Society of New South Wales 132*, 115-130.

Christopher, C. S. (1982). *Lineament Analysis and Inference of Geologic Structure - Examples From Balcones/Ouachita Trend of Texas.* Texas: Bureau of Economic Geology, The University of Texas.

Dowling, R. K. (2005). *Geotourism.* Oxford: Elsevier Butterworth-Heinemann.

Gray, M. (2005). Geodiversity and Geoconservation: What, Why, and How? *The George Wright Forum, Volume 22* .

Hutchison. (1977). Granite Emplacement and Tectonic Subdivision of Penisular Malaysia. *Geological Society of Malaysia Bulletin, 9*, 187-207.

Hutchison, C. S. (1996). Geological evolution of South-East Asia. *Geological Society of Malaysia*, 369.

Hutchison, C. S. (2009). *Geology of Peninsular Malaysia.* Kuala Lumpur: University of Malaya and Geological Society of Malaysia.

Macdonald, S. (1967). Geology and Mineral Resources of North Kelantan and North Terengganu. *Geological Survey Malaysia District Memoir 10*.

MacDonald, S. (1967). Geology and Mineral Resources Of North Kelantan and North Terengganu. *Geological Survey Malaysia, District Memoir 10*.

Md Hashim, M. A. (2002). Geologi dan geomorfologi kawasan Kuala Besar hingga Kuala Pengkalan Pengkalan Besar dengan penekanan permatang-permatang Holosen dan perubahan pantai. *Universiti of Malaya*.

Metcalfe, I. (1999). The Palaeo-Tethys in East Asia. *Geological Society of Malaysia Bulletin*, 131 - 143.

Neches, I. M. (2013). From Geomorphosite Evaluation to Geotourism Interpretation, Case Study: The Sphinx of Romania's Southern Carpathian. *GeoJournal of Tourism and Geosites*, 145-162.

Nevin, C. M. (1942). *Principles of Structural Geology.* New York: John Wiley & Son Inc.

Pidwirny, M. (2006). The Drainage Basin Concept. In M. ,. Pidwirny, *Fundamentals of Physical Geography.*

ProGEO. (2011). CONSERVING OUR SHARED GEOHERITAGE – A PROTOCOL ON. *The European Association for the Conservation of the*.

Senathi Rajah, S. F. (1977). The Granitoids and Mineralization of the Eastern Belt of Peninsular Malaysia. *Geological Society of Malaysia Bulletin 9*, 209 - 232.

Sharples, C. (2002, September). *CONCEPTS AND PRINCIPLES OF GEOCONSERVATION*. Retrieved from Tasmanian Parks & Wildlife Service: http://dpipwe.tas.gov.au/Documents/geoconservation.pdf

Singhal, B. ,. (2010). *Applied Hydrogeology of Fractured Rocks.* Netherlands: Springer.

Suntharalingam, T. &. Teoh (1985). Quaternary Geology of The Coastal Plains of Taiping. *Geological Society of Malaysia, 1*, 64.

Verner, K. (2013). The Mapping Of Geological Structures. *Czech Geological Survey in Prague*, 32-213.

APPENDICES

Figure a: Granite boulder

Figure b: Plantation around Bukit Marak

Figure c: Information board of Bukit Marak