GEOLOGY AND GEOHERITAGE POTENTIAL OF KAMPUNG PULAI, GUA MUSANG

By

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A report submitted in fulfilment of the requirements for the degree of Bachelor of Applied Science (Geoscience) with Honours

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DECLARATION

I declare that this thesis entitled "**GEOLOGY AND GEOHERITAGE POTENTIAL OF KAMPUNG PULAI, GUA MUSANG**" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

"I hereby declare that I have read this thesis and in our opinion this thesis is sufficient I term of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honours"

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Date :

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GEOLOGY AND GEOHERITAGE POTENTIAL VALUE OF KAMPUNG PULAI, GUA MUSANG

ABSTRACT

The study area is located in Gua Musang, Kelantan, within 4°47'26.26"N and 101°56'56.09"E coordinates. This 5x5km^2 study area is surrounded by plantation like palm plantation and rubber plantation and also heavy forests. The lowest elevation of the study area is 120m while the highest is 440m. The study focuses on the general geology and geoheritage potential of Kampung Pulai. The objectives of the research are: i) to create an updated geological map of Kampung Pulai,Gua Musang and ii) to assess geodiversity values of study area for geoheritage potential. The geology of the study area was determined by interpretation of secondary data and previous researches. There are four types of lithology found which are alluvium, rhyolite, limestone and slate. In this study, geodiversity index mapping is used to determine the geoheritage value of the study area. The geodiversity value in the study area was achieved by assessing the geomorphology index, hydrology index, lithology index and speleothem index. As a result, geodiversity index map is produced and geoheritage potential is determined.

GEOLOGI DAN GEOWARISAN NILAI POTENSI KAMPUNG PULAI, GUA MUSANG

ABSTRAK

Kawasan kajian terletak di Gua Musang, Kelantan, dalam koordinat 4 ° 47'26.26 "N dan 101 ° 56'56.09" E. Kawasan kajian seluas 5x5km2 ini dikelilingi oleh perkebunan seperti kebun sawit dan kebun getah dan juga hutan tebal. Ketinggian terendah di kawasan kajian ialah 120m manakala yang tertinggi ialah 440m. Kajian ini memfokuskan pada potensi geologi dan geoheritage umum di Kampung Pulai. Objektif penyelidikan adalah: i) membuat peta geologi terkini dari Kampung Pulai, Gua Musang dan ii) untuk menilai nilai geodiversiti kawasan kajian untuk potensi geoheritage. Geologi kawasan kajian ditentukan oleh tafsiran data sekunder dan penyelidikan sebelumnya. Terdapat empat jenis litologi yang dijumpai iaitu alluvium, rhyolite, batu kapur dan batu tulis. Dalam kajian ini, pemetaan indeks geodiversiti digunakan untuk menentukan nilai geoheritage kawasan kajian. Nilai geodiversiti di kawasan kajian dicapai dengan menilai indeks geomorfologi, indeks hidrologi, indeks litologi dan indeks speleothem. Hasilnya, peta indeks geodiversiti dihasilkan dan potensi geoheritage ditentukan.

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E	East
GIS	Geographic Information System
GPS	Global Positioning System
KM	Kilometre
N	North
W	West
S	South

LIST OF SYMBOLS

%	**Percentage**
′	**Minutes**
″	**Second**
°	**Degree**

CHAPTER 1

INTRODUCTION

1.1 General Background

Geoheritage is a study of geological features that related to the heritage that can be transmitted from the past or handed down by tradition. Geological heritage comprises significant geological structures, landforms and ecosystems of our nation that are protected for the full range of values that society puts on them, including scientific, aesthetic, cultural, ecosystem, educational, recreation, tourism, and other values. Geo-heritage sites are moderated with the intention of maintaining their exercises and magnificence as a heritage for who and what is to come. Geoheritage sites are essential to understanding the powerful earth frameworks, the progression and a decent variety of life, climatic changes after some time, the advancement of landforms, and the cause of mineral stores.

Geoheritage sites serve general society interest. The places are important for propelling knowledge on characteristising risks, groundwater availability, soil practices, climate and biological changes, development of life, sources of minerals and vitality, and numerous parts of the Earth's environment and history. The destinations have high potential for logical contemplates use as open-air study halls, improving open comprehension of science, recreational use, and economic support to local communities.

In addition, geo-heritage is also a fundamental component of the geological heritage, including unique sites and artefacts that play an important role in our understanding of the nature of the earth, such as rocks, minerals, fossils and ecosystems. In addition, geo-heritage is a significant feature of geo-tourism growth.

Potential geoheritages were portrayed by watching and depicting the destinations in details, and upheld by data from the past literary works. This progression was led to give considerable topographical data to each site. The locals get exceptional consideration for the rational (and instructive) principles (giving opportunities for study and training reasons behind them), however a few destinations were also selected for their trendy (the visual interests provided by the physical conditions) and recreational qualities (using the physical scenes for recreational exercises).A few destinations on different hands display social/verifiable (physical situations with social or network hugeness in at various times social orders), monetary (budgetary esteems relying upon the idea of the materials in question), and practical value (significant utilitarian jobs in ecological framework including to human culture).

Geological map is known as the specially created map showing the study area's geological features. The geological characteristics that can be seen by such maps include structural geology, limits of lithology, the areas covered in the study and others. Varieties of unit rocks are seen in the diagram, utilizing separate colors of code for each lithology. Other than that, the geological map will show different degrees of contour lines that suggest the strata's sub-surface topographic patterns.

The state of Kelantan in Malaysia has several different and interesting geological sites and features with potential for geo-heritage and geotourism. Gua Musang, in southern Kelantan, Malaysia, is an industrial, rural, and government constituency. It is one of the main Kelantan districts. For example, Gua Musang has its own attractions, the flora and fauna that can enhance the current heritage value.

1.2 Study Area

The research was carried out at the district of Gua Musang, in Kampung Pulai area. Inside a 5x5km^2 box, the research was held and the box filled approximately 25 km per square. In Figure 1.1, it shows the base map with a few elements, such as the river and main road.

a) Location

The research area is located at Kampung Pulai, Gua Musang. Kampung Pulai in the region of Kelantan is located in Malaysia - some 119 mi (or 191 km) North of Kuala Lumpur, the country's capital city. The lowest elevation in the study region is 120m while the highest elevation is 440m

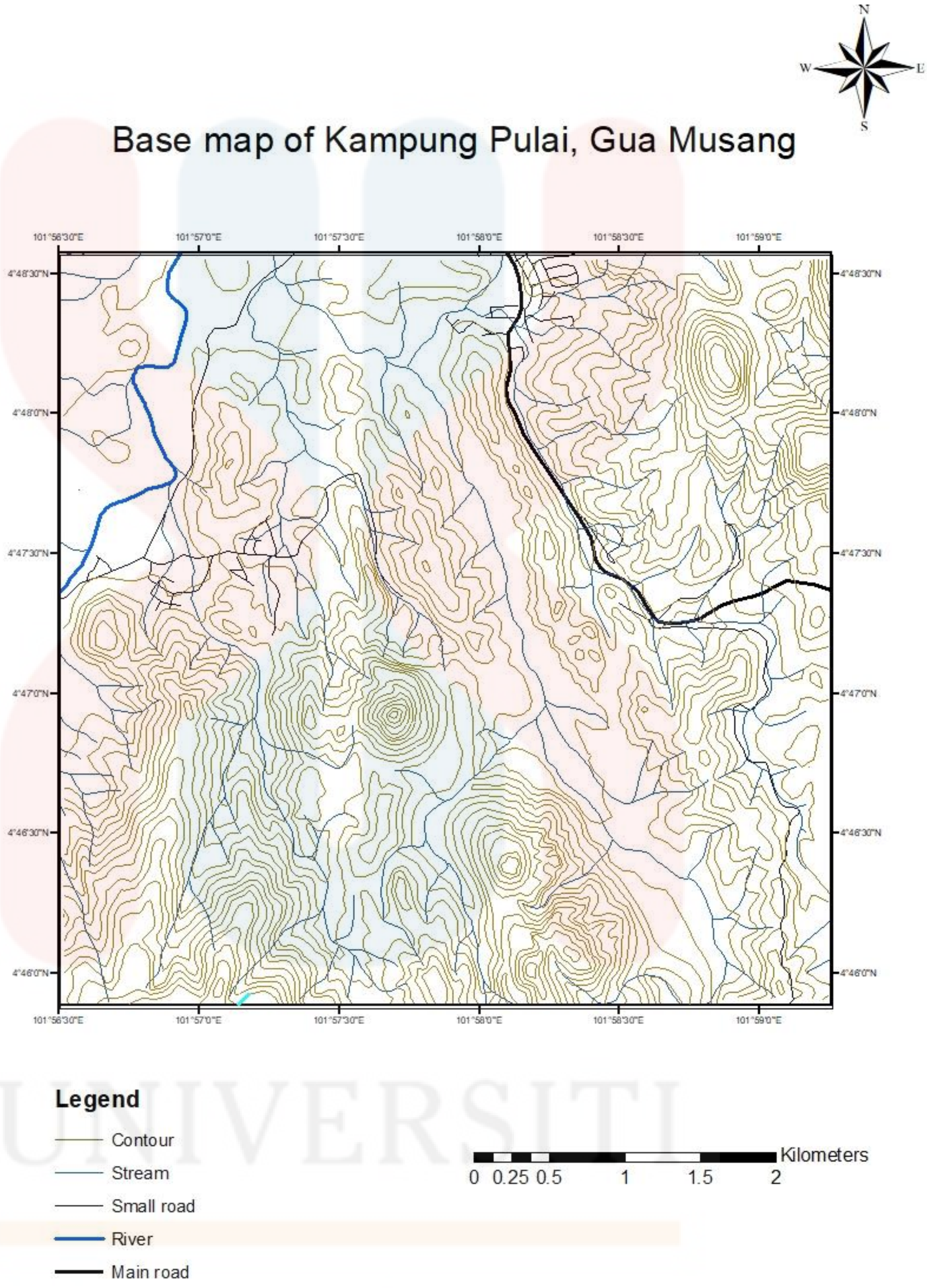


Figure 1.1: Base map of the study area

b) Road Connection

Gua Musang is located in the south of Kelantan, bordered by the Pahang, Terengganu and Perak state borders. Gua Musang, Kuala Lumpur. The road connects Gua Musang and is accessible from the Merapoh-Gua Musang Highway. The study area can be reached from Jeli via the Dabong-Gua Musang Highway. With the assistance of a good availability, the area of research can be entered.

c) Demography

Kelantan occupies an area of 15,0999 km²and is situated in the northeast region of the Malaysian Peninsular. Kelantan is bounded by a certain proportion of Southern Thailand, Perak to the west, Pahang to the south and Terengganu to the south. There are ten administrative areas in Kelantan, namely Kota Bharu, Gua Musang, Machang, Tanah Merah, Pasir Mas, Pasir Puteh, Bachok, Jeli, Kuala Krai and Tumpat. In the southern part of Kelantan hilly landscapes are located. These are divided by the Titiwangsa Mountain.

The regional geology is characterised by the rich coastline in the plain downstream. Paddy production, rubber, oil palm, tropical fruit, and hardwood govern the river valley. All the significant streams are Sungai Nenggiri, Sungai Lebir, Sungai Golok, Sungai Kelantan, Sungai Kemasin, Sungai Semerak, Sungai Pergau, Sungai Pengkalan Chepa, and Sungai Pengkalan Datu. The population distribution in the state of Kelantan is endorsed with many factors listed by district population, economic opportunities and territory. These all decides the community that migrates to the area. The rate of population growth at Gua Musang is shifting from 103,300 in 2010 to 114,500 in 2014 from Table

1.1. This shows that accelerated development offers job prospects for locals and outsiders that have led to population growth in Gua Musang district.

Table 1.1: Total population in Kelantan district

District	Year				
	2010	**2011**	**2012**	**2013**	**2014**
Bachok	142,100	146,000	149,900	153,800	157,700
Kota Bharu	509,600	522,000	534,500	547,200	560,100
Machang	101,300	103,900	106,400	109,000	111,700
Pasir Mas	212,000	217,300	222,800	228,300	233,800
Pasir Puteh	134,200	137,700	141,100	144,600	148,200
Tanah Merah	133,400	136,700	140,000	143,300	146,700
Tumpat	137,200	177,700	182,200	186,800	191,400
Gua Musang	103,300	106,000	108,800	111,700	114,500
Kuala Krai	120,800	123,700	136,500	129,500	132,400
Jeli	48,000	19,300	50,600	51,900	53,200
TOTAL	**1,641,900**	**1,690,300**	**1,772,800**	**1,806,100**	**1,849,700**

(Source: Jabatan Perangkaan Penduduk Negara, Negeri Kelantan, 2014)

d) Land-use

Land-use involves the management and alteration of natural or wasteland areas in built environments such as villages and semi-natural landscapes such as arable land, pastures and forest management. It was also described as the overall arrangements, activities and inputs that people undertook in a specific form of land cover. Rubber plantation and palm plantation dominate land-use activity in Gua Musang plantation in Gua Musang, and economic improvements; land use development is rapidly growing. In the study site, the dominant land-use area is forestry, rubber plantation and oil palm plantation.

e) Social Economic

Presently, Gua Musang is experiencing rapid growth. The good urbanisation effect in the Gua Musang district offers potential for native and outsider jobs. The plantation is divided into two forms in the research field: oil palm and rubber plantation. The biggest contributor to the social-economic activity of the district of Gua Musang is the rubber plantation. The plantations are well established in many places and the development of the plantation provides job shortages for local, whether they are employed in the estate or the factory.

1.3 Problem Statement

The study area is located Kampung Pulai, Gua Musang. This study is focused at Kampung Pulai as it has a potential geoheritage site. This study area is expected to have geological element that can be identified by the geodiversity index .Next, the geological map existed needed to be update to identify the changes of the geological features. At the other side, the Earth is complex and there is an abrupt shift in the Earth cycle which does not enable the geological map results to remain the same as before. This research also conducted to increase awareness and knowledge to people about the importance of geological sites.

1.4 Objectives

The main objectives of the study are:

i. To create the updated geological map of Kampung Pulai ,Gua Musang with the scale of 1: 25000 based on interpretation.

ii. To assess geodiversity value of study area for geoheritage potential.

1.5 Scope of Study

The study is about creating the geological maps of the study area by gathering the secondary data. The data will be transferred into ArcGis. Beside, this work also focuses on the valuation and protection of nature or heritage value in the Kampung Pulai region, Gua Musang, Kelantan and on geodiversity, since it play an important role in education towards society. In addition to education, geo-heritage provides opportunities to citizens of different scales. The most commonly reported advantages relating to nature and landscape were often leisure and tourism. Throughout the sense of geology, it helps to include evidence on geological formations, occurrences and past because the Earth is complex.

1.6 Significant of Study

The significance of this research is to produce the updated geological maps of the study area with a scale of 1:25000 and to determine the geoheritage potential value of Kampung Pulai, Gua musang. It is important to update the geological maps by providing the latest outcome of the lithology, structural geology and geomorphology as the Earth is dynamic, and changes over time.

Geoheritage itself will increase the socio-economy value with the educational, cultural and aesthetic value of the places. It will help in increasing the awareness and understanding the full scope of the heritage itself and indirectly benefits the community there.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The literature review known as body of the research. It is available from a variety of sources, including books, newspapers, articles, the Internet and other scientific resources related to and relevant to a particular issue, area of study also theory. The purpose of literature review is to identify theoretical and scientific knowledge and it is made for better understanding about the research paper..

Geology is used for the study of past and present development. Generally, geological studies are based on desktop study as the data is collected from the previous studies, books, and scientific reports. In order to provide a better understanding of general geology in Kelantan, especially in the study area, all the information is collected and surveyed.

2.2 Regional geology and Tectonic Setting

In the state of Kelantan, there are four distributions of the rock types and the effect of weathering on these rocks (Quarry Resources Planning for the state of Kelantan, 2003). As stated on the map in Figure 2.1, the geology of Kelantan state can be classified as T able 2.1.

Table 2.1 : Rock types in the state of Kelantan

Rock type	Area	
Granitic rocks	33%	Total km : 15 022km²
Sedimentary/metasedimentary rock	51%	
Extrusive rocks (volcanic rocks)	10%	
Unconsolidated sediment	6%	

(Source : Quarry Resources Planning for the state of Kelantan, 2003)

Approximately 15,022km² of Kelantan State are cover by all type of rocks. The sedimentary/ metasedimentary rock is the highest percentage and the prevalent type of rock which occupies the Kelantan north-south central portion. The granites of the Main Range and Boundary Range bordered the state on the west and east respectively. At the north-south direction, these belts of granite and other country rocks trend and also truncated to the north by unconsolidated sediments of the Kelantan Alluvial Plain.

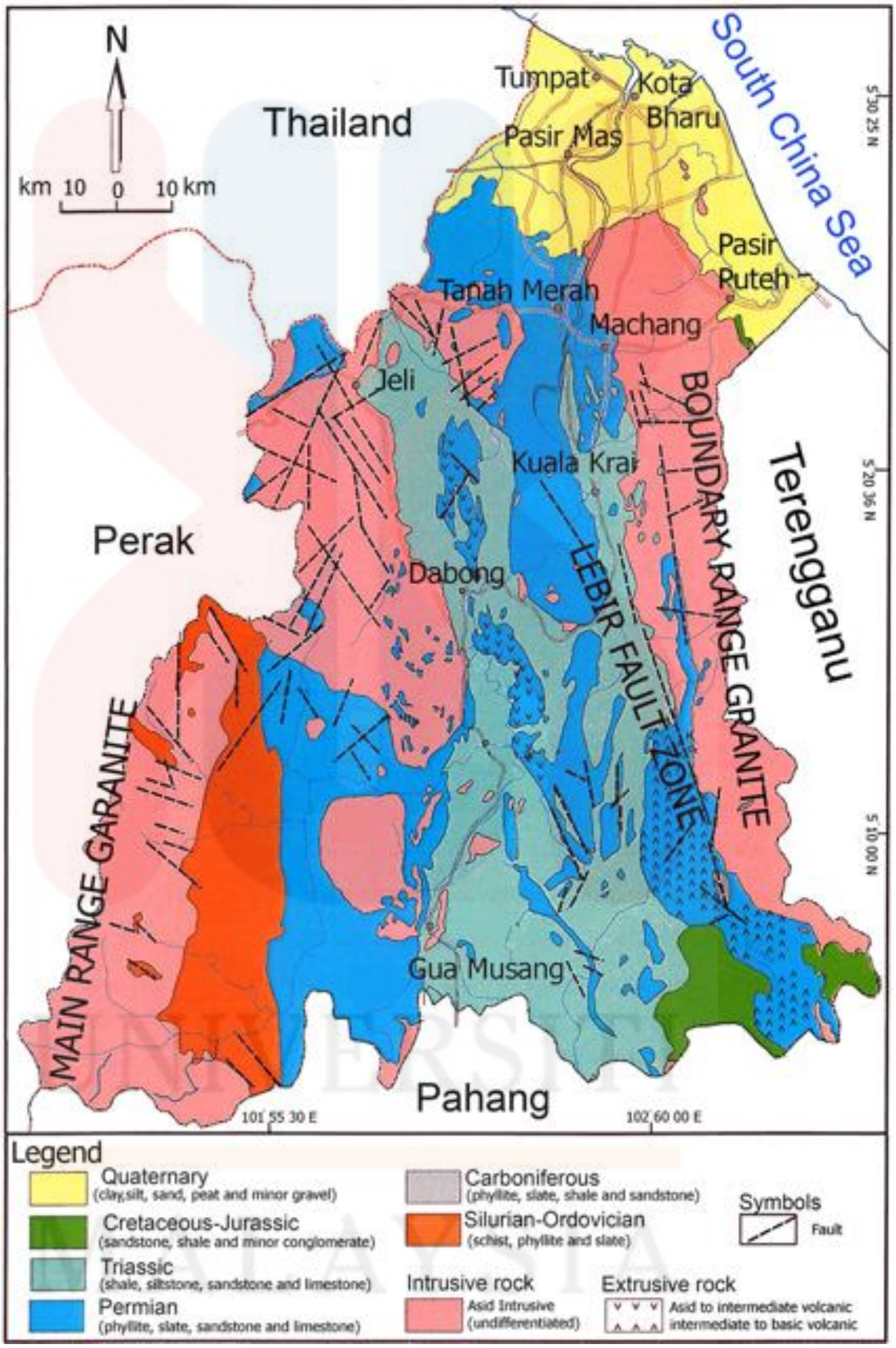


Figure 2.1: Regional Geology Of Kelantan

(Source: Minerals and Geoscience Department Malaysia, 2013)

Based on Hutchison (1989), the key part of Eurasian plate is Peninsular Malaysia, and Sundaland is the south-eastern part of Asia. Peninsular Malaysia are divided into 3 longitudinal belts which are eastern belt, western belt and central belt. Each of the belt has its own geological development and distinctive characteristic as stated by Hutchison (1898). The distribution is based on the geology and distribution of rocks.

According to Metcalfe, & Azhar (1994), in peninsular Malaysia, during the Permian to Triassic period, deep marine is a typical formation. The Semantan and Semanggol Triassic Deposits are researched from sedimentology and paleontology and are known as deep-sea sediments. Generally. Malaysia is part of eastern Malaysia and the Sibumasu tectono-stratigraphic terrain

Tectonically, Peninsular Malaysia is part of the Eurasian Eastern Plate, north of the active subduction arc zones of Sunda (Kamar Shah Ariffin 2012). Located in the southern Kelantan district, Kampung Pulai, Gua Musang is part of the Kelantan Central Belt. The recently proposed classification of argillite-carbonate-volcanic deposits during the Permo-Triassic period was part of the Gua Musang Group. It consists of argillaceous, carbonate, volcanic or pyroclastic features, and is classified into four forms: Aring Formation, Telong Formation, Gua Musang Formation and Nilam Formation (Mohamed, et al., 2016).

In Figure 2.1, Kelantan's general geological map is shown. This geological map reveals the lithological variants in the state of Kelantan consisting of metamorphic rock, igneous rock, and well-formed sedimentary rocks in the state of North-South Kelantan. These three types of rock are geologically graded by area, forming sedimentary or metasediment rock, granite rock, extrusive rock, and unconsolidated sediment.Igneous rock is the dominant rock. Localization of sedimentary rock joint and fault geological characteristics thus distribution of granite rocks in the western (Main Range Granite) and eastern boundaries of the Boundary Range Granite (Department of Minerals and Geoscience) of Kelantan State.

Hutchison (1973) also proposed the Bentong-Raub axis as the main tectonic boundary between the western and central belts of Peninsular Malaysia. Hutchison (1975) named this as the ophiolite chain, the Bentong-Raub. The Suture Zone of Bentong-Raub (Metcalfe, 2000) stretches from Tomo south through Bentong and Raub to Melaka (Tjia, 1989). It is an extension of a Nan-Uttaradit suture from Thailand. The suture field spreads south to Lancangjian, Changning-Menglian, Yunnan Province of Southwest China, and Chiangmai of Northern Thailand (Metcalfe, 2000). Palaeo-Tethys' primary sea is defined by Bentong-Raub suture zones and Lancangjian, Changning - Menglian, Chiangmai

The Bentong-Raub suture region of Peninsular Malaysia lies between the Terrane of Sibumasu and the Terrane of East Malaya (Indochina). The Sibumasu terrane was linked to the map of Cimmeria and the terrane of eastern Malaya related to the map of Indochina and southern China. An ocean called Paleo-Tethys broke the blocks Sibumasu and Malaya to the East. The opening of the Palaeo-Tethys was produced during the North and South China, Indochina, and the plate sliver of Tarim rifted from Gondwanaland during Devonian. The Palaeo-Tethys reduced when the Sibumasu terrane clashed with East Malayan terrane or identified as Indochina during the Triassic.

Figure 2.2: Bentong-Raub Suture Zone and the radiolarian chert blocks localities. (Source: Bulletin of the Geological Society of Malaysia, 2013)

Radiolarian fragments of chert are the remnants of oceanic sediments deposited in the Palaeo-Tethys Sea, in the Suture zone of Bentong-Raub. The Palaeo-Tethys were well known to the Late or Early Devonians. The Palaeo-Tethys was a sea, where the first chert of radiolarias was formed in Mid Frasnian (Late Devonian). In the Carboniferous Era the Palaeo-Tethys became broader. In Late Permian, Palaeo Tethys' oceanic crust collapsed beneath East Malaya Terrane and weakened eastward. During the Early Triassic era, the Palaeo-Tethys was a shallow ocean dominated by fragmented limestone fossils (Fontaine et al., 1995). During the Triassic period, the closure of Palaeo-Tethys and Bentong was finalized, and the Bentong-Raub Suture Zone was developed.

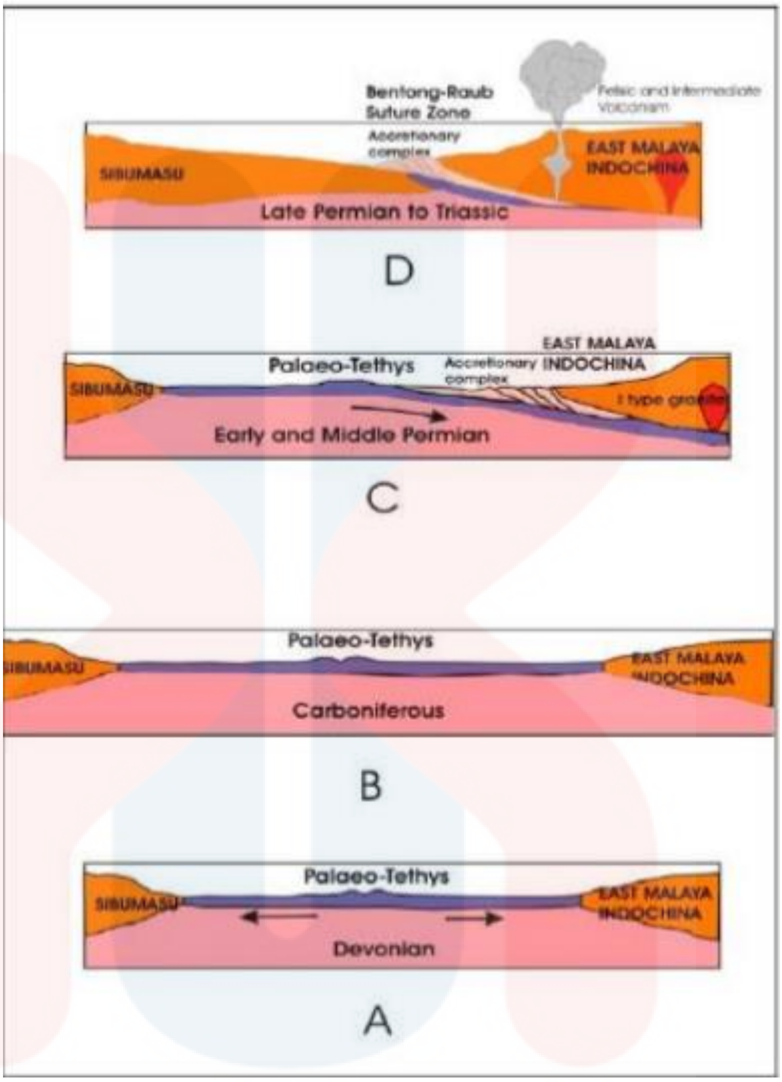


Figure 2.3: Evolution of the Palaeo-Tethys based on radiolarian cherts. A. Opening of Palaeo-Tethys during Devonian, B. Palaeo-Tethys became wider ocean during Carboniferous, C. The Palaeo-Tethys subducted under the East Malaya / Indochina Terrane, D. Collision between Sibumasu and East Malaya terranes during Late Permian- Triassic. (Source: Bulletin of the Geological Society of Malaysia, 2013).

2.3 Stratigraphy

In the region of Gua Musang there are two formations which are Gua Musang Formation and Gunung Rabong Formation. According to Yin (1965), Gua Musang Formation consists of argillaceous and calcareous intercalation of volcanic and in the south of Gua Musang , there is arenaceous rock. The units stretch to north of Pahang from the north and south of Kelantan. Fossil appearance, such as ammonoids and pelecypods, indicates Permian to the Middle Triassic period. The Gunung Rabong Formation overlaid the Gua Musang Formation in the stratigraphy layer and is named after the town of Gua Musang, in the south of Kelantan. The Gunung Rabong formation consists of primarily arenaceous and argillaceous composition in the southern Kelantan district of Gua Musang with subordinate calcareous, volcanic, and rudaceous bands.

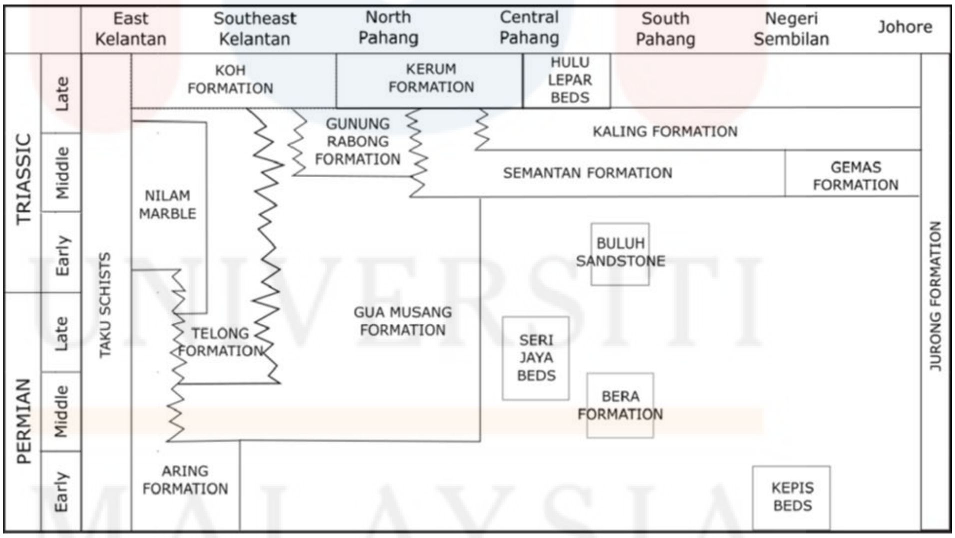


Figure 2.4: Permo-Triassic stratigraphic correlation chart of Central Belt Peninsular Malaysia. (Mohamed, et al., 2016).

In the west to Gua Musang, Nenggiri and Kuala Betis, Aw (1972) discovered the Permo-Triassic rock consisting of argillite rocks, calcareous stone and conglomerates. Many of such rock units are coated in tuff. Yin (1965) said Gua Musang Formation's upper boundary is covered by Gunung Rabong Formation. In line with the conglomerate-sandstone sequence, the rock range of Kuala Betis is related to the west of the town of Gua Musang and is renowned as the Gua Musang Formation Aw (1974), Abdul, (1994). This division was known as the conglomerate of Gunung Ayam, translated as the basal conglomerate of Aw (1974), containing the oldest divisions of Gua Musang, Aw (1974), (Abdul(1994). On Paleozoic metamorphic deposits, the conglomerate was unconformable. The basal conglomerate was uncovered and the westernmost degree of formation was enclosed by the Bentong-Raub Suture, where it was defective or uncomfortable on older rocks.

Similarly, the Nilam Marble and Telong Formation sediments in the east were similar to the Gua Musang Formation rocks. The Telong Formation is known to be the same as the Gua Musang Formation, according to Foo (1983), as the deposition state and age of Nilam Marble is similar to the Gua Musang Formation carbonate. From Nilam Marble and Telong Formation, Jasmi (1992) was mapped as far south as Kuala Tembeling district. A transitional overlay of the Semantan Formation region of Kuala Lipis is the Gua Musang Formation. Gunung Senyum limestone from Middle Triassic to Late Triassic was dated from Kota Gelanggi and taken from Kuala Tembeling to Triassic Limestone. In the Gua Musang Formation, they are known as Triassic Progression. Furthermore, the Gua Musang Group is also recognized as the recently formed stratigraphic formation for the PermoTriassic Northern Central Belt, Malaysia Peninsula, Gua Musang Formation, Telong Formation, Aring Formation and Nilam Marble Formation.

The strong relationship between Gua Musang formation, Telong formation, Aring Formation and Nilam marble represents the improvements in the lateral facies between these formations. For example, similar lithology to Gua Musang 's Formation at Felda Aring is called Aring Formation, while those in Sungai Telong are called Telong Formation (Aw, 1990). Mohamed and Leman (1994) and later Mohamed (1995) clarified that as long as they are preserved in shallow marine environments, these lateral facial modifications can be accumulated within the same community.

2.3.1 Gua Musang Formation

Based on Lee, (2004), the origin of name of the formation is after Gua Musang town in south Kelantan. The age is Middle Permian to Upper Triassic. The type area is Gua Musang area, south Kelantan (extended to north Kelantan and north Pahang . The boundaries of formation are Lower boundary is not known; Upper boundary is overlain by the Koh Formation (nature of boundary is not known) (Lee,2004). The correlation of formation is the upper part of Gua Musang Formation is interfingering with the Semantan Formation,Telong Formation and Gunung Rabong Formation. The lithology is argillaceous and calcareous rocks interbedded with volcanic and arenaceous rock (Lee, 2004).

2.3.2 Aring Formation

The origin of formation name was named after Sungai Aring, south Kelantan (Lee,2004). The age of the formation is Upper Carboniferous to Lower Triassic. The type area of the formation is Sungai Aring, south Kelantan (Lee,2004). The type section are Sungai Nuar and Sungai Relai (upper section) (Lee,2004). The boundaries of formation are Lower boundary unexposed. Tectonized upper contact with overlying Telong formation of Upper Triassic age and probable unconformable contact with Koh formation to the south. The correlation is Gua Musang formation in Kelantan and Pahang Volcanic series in northwest and west Pahang and metasediments in southeast Pahang . The Thickness of the formation is 3000 m.

2.3.3 Telong formation

The origin of formation name was named after Sungai Telong, South Kelantan (Lee,2004). The age of formation is Permian to Upper Triassic (Carnian). The type area is Sungai Telong, the upper reaches of Sungai Aring in south Kelantan . The boundaries of formation are lower boundary and unconformably overlying the Gua Musang Formation and unconformably overlain by the Koh Formation (Lee,2004). The correlation of formation is lateral equivalent to Gunung Rabung Formation and Semantan Formation (Lee, 2004). The lithology of formation is sequence of predominantly argillite associated with some. The environment of deposition is stable shallow marine environment with occasional supply of fine pyroclastic material.

2.3.4 Nilam marble

The origin of the formation name is Sungai Nilam (of Sungai Chiku) (Lee,2004). The age of the formation is Permian to Late Triassic. The boundaries of formation are unexposed bottom and top boundary (L. The correlation of the formation is lower part coeval with Aring Formation, upper part coeval with Telong Formation . The lithology is calcitic marble interbedded with tuff and argilites. The type area is upper reaches of sungai nilam.

2.3.5 Gunung Rabong Formation

The origin of name is after Gunung Rabong in south Kelantan (Lee,2004). The age of formation is middle Triassic (Ladinian) to upper Triassic (Carnian). The type area is Gunung Rabong area in south Kelantan. The boundaries of formation unconformably overlying the Gua Musang Formation. The correlation of formation is lateral equivalent to Telong Formation and Semantan Formation. The Lithology is predominantly arenaceousargillaceous rocks sequence with subordinate calcareous (Lee, 2004).

2.4 Structural Geology

The state of Kelantan is situated in the northeastern region of the Malaysian peninsula. The major compressional force impacts Peninsular Malaysia's land area. The field and locally, the results of this force are created by fold and fault. The geological structures of the region formed in sedimentary rocks while in fault and joint exist in granite rocks. Different rocks have different characteristic and structure form because of their minerals, the ways rocks was formed, and the processes that acted on the rock. From N-S to NW-SE the dominant structure was created in the past via the orogenesis phase (The Department of Minerals and Geoscience Malaysia ,2003). This involves a collective series of geological processes called orogenesis when a continental plate crumbles and is pushed upwards to form one or more mountain ranges, an orogenic or orogenic belt develops. Orogeny is the primary process by which mountains are formed on continents.

As per Hamblin (1994), the joints form by strain when the rock is uplifted, folded or fractured using tectonic activity. A joint is a geological fracture which separates rock into two parts which move away from one another. A joint does not involve removal of the shear and forms when tensile stress breaks the threshold. Tjia, (1986) said Peninsular Malaysia 's dominant strike and fold axis exists mainly in the Gemas and Semantan Structure that dominated Malaysia Peninsula.

Moreover, as the state of Kelantan is positioned on Peninsular Malaysia's central belt, major structural areas have emerged, recognized as the Bentong-Raub Suture Area. The Bentong-Raub Suture Area is entirely accessible along the Gua Musang-Cameron Highland Route, Karak Highway, and Bentong-Raub road for road cutting. The suture is an area of about 13 km long deformed rocks consisting of schist, phyllite, meta-sedimentary rocks, sandstone, cherts, olistostrom and melange (Tjia & Almashoor,1996). Metcalfe (2000) estimated that the length of the suture will be about 20 km. The Bentong-Raub Suture Zone makes evident a belt of melange and olistotrome, consisting of blocks or clasts of cherts, sandstone, calcareous, conglomerate, interbedded sandstone and mudstone, and tuffy mudstone set in a mudstone sheared matrix. Clast sizes are diverging from a few cm to hundred metres.

2.5 Historical Geology

Gua Musang has distinct morphological features, such as the hills and surrounded by karstic morphology in the limestone regions, which has several geological characteristics. In Peninsular Malaysia, Sabah and Sarawak, lime-stone landscape or karst topography is also well developed. Kelantan can be divided geomorphologically into four categories of landscape: mountainous, hilly, plain, and coastal regions (Tanot et al., 2001). In Gua Musang district, in addition to the coastal areas that grow primarily in the northern part of Kelantan, both of these types of landscape exist.

According to Malaysia's Minerals and Geoscience Department (2003), the Main Range Granite was from the Late Triassic Age between 200 and 230 million years ago. Geologically the Kelantan rock units were broken into four forms, separating into unconsolidated sediments, extrusion rocks which are volcanic minerals, limestone, and metasedimentary minerals. Two primary groups, the Primary Range and the Boundary Range define the granite rock at Kelantan.

Unconsolidated sediments are layers produced from secondary sedimentation and repositioning of weathered rocks or from biochemical deposition and chemical solutions. They were not compacted, so lithification. The unconsolidated sediments construct the coastal region which extends from the Thailand border to the Terengganu border and conquers the northern part of the state of Kelantan. In Quaternary era, the sediment reflects the flat alluvial plain which overlays the granite bedrock. Whereas, in the centre area and on the eastern side of the state bordering the Granite Boundary Range, the extrusion rocks developed an elongated structure to the north south. They are Permian in age (Kelantan's Geology and Mineral Distribution Map, 2000). 51% of the ground field of the state is dominated by sedimentary or metasedimentary rocks from Ordovician to the Cretaceous period for the distribution of sedimentary and metasedimentary rocks (Kelantan's Geology and Mineral Distribution Map, 2000). These rocks filled the entire north-south region of the Kelantan Province.

2.6 Geoheritage and Geodiversity

There are extraordinary geological landscapes, incredible geological phenomena and geomorphological aspects that make our Earth more amusing and can become tourist destinations of a location, country or state. Potential geological heritage could be geological resources that have their own attractions, a geological concept that emphasizes unique, distinctive and figurative geological characteristics (ProGEO, 2011) with numerous values such as scientific, educational, aesthetic, recreational, cultural, economic, religious and functional values (Gray, 2004, Gray 2005; GSA 2012).

Malaysia is one of the countries that successfully conserves and improves its geo-heritage capital in. Komoo (2004) said early attempts were undertaken in the Third Malaysian Plan (1976-1980) to preserve geological resources in Malaysia by providing for the need to protect geological memorials and the landscape. The formation of the Malaysian Geological Heritage started in 1996 with formal determinations to support the conservation of the geological heritage. Subsequently, several research studies were undertaken to review and identify other maintenance and development sites in the geo-heritage.

There are many captivating ecological and geological characteristics of the state of Kelantan. The main part of this work is to update the geological map of the 1:25000 scale research zone and to define the value of the study area as a geo-heritage site by geological mapping and geo-diversity assessment. Some geological features have geo-heritage values and can be used as geo-tourism sites. One way to refining the socio-economic level of the local community is to promote geotourism in this area. Geoheritage therefore involves the economic, environmental, science and artistic importance of the natural geological structures that will have to be taken care of for centuries to come. The abiotic component of the natural world is basically geodiversity; it is related to biodiversity which is the physical setting for life itself. The natural diversity or abundance of geological characteristics (rocks, minerals, fossils, structures), geomorphological characteristics (forms and processes of land), soil and water that make up and structure the physical landscape can be described. Geoheritage deals with the special heritage, the special places that need protection, while geodiversity describes a wider general context (ProGEO, 2011).

CHAPTER 3

MATERIAL AND METHOD

On this chapter, it will focus about material and method that be used to complete the research. The method had been used are current heritage method of a study area and method based on the conservation geology approach.

3.1 Material

3.1.1 Topography Map

Used for information about conditions, location, distance, travel routes and communication. Topographic maps also display regional variations, vegetation cover levels and differences in contour height.

3.1.2 Arcgis Software

ArcGIS is a platform for organizations to create, manage, share, and analyze spatial data. It consists of server components, mobile and desktop applications, and developer tools

3.1.3 Secondary Data

Data that was gathered from online database like USGS (United States Geological Survey) or from agencies such as JUPEM (Jabatan Ukur dan Pemetaan Malaysia) and JPS (Jabatan Pengairan dan Saliran Malaysia). The data is used to process, analyze and interprete the geology study area. The data is collected in spatial and attribute data.

3.2 Methodology

The method that was used are geological mapping using secondary data interpretation and geodiversity mapping assessment. To fill the existing gaps in term of geology, geological resources, features and structure of the area, geology mapping was held. By the analysis and collection of secondary data, geodiversity index method was used to publish the area at Kampung Pulai as geoheritage site.

3.2.1 Preliminary studies

The first step in carrying out this work was a preliminary study. It acts as a desktop study that was obtaining data about the study area. The objective of running this method is to gain a better understanding of the topics and the scope of the study. This method was carried out by referring to the previous research study. All the information was gathered from previously published literatures There are many sources of information, in particular from books, papers, journals, geological maps and web sources. The assumption can be made when conducting primary studies.

3.2.2 Data collection

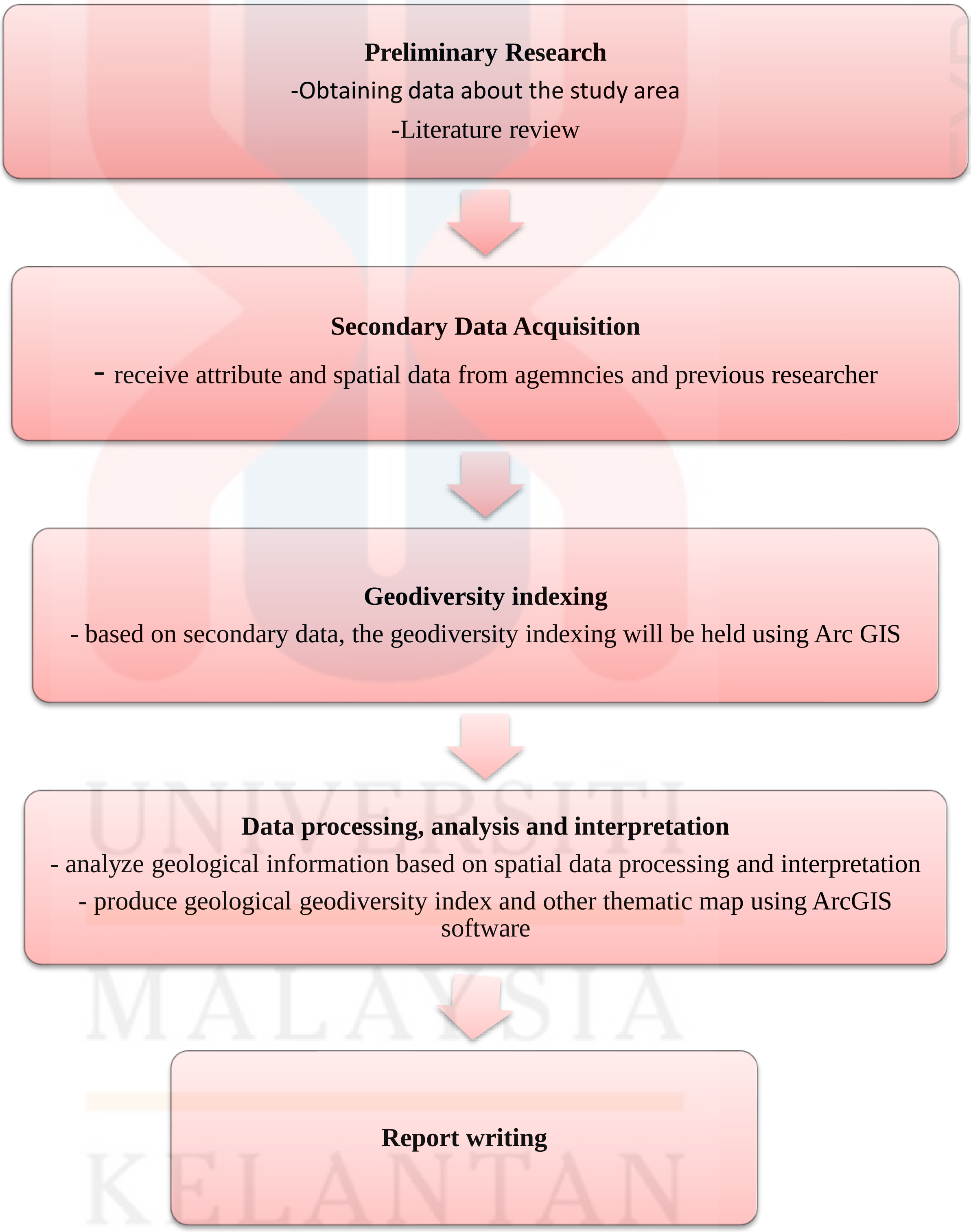
At this stage, all the secondary data were collected. Some of the data were collected from the previous research and other journal. Some data were obtained from agencies, for example, data lithology was obtained from JMG (Jabatan Mineral dan Geosains Malaysia). Next, hydrology data and riverflow from JPS. The aerial photo karst data from JUPEM. Landsat data from USGS also were obtained.

3.2.3 Data processing, analysis and interpretation

At this point, the data collected from the sites processed, evaluated and interpreted to obtain all the details on the geological characteristics of the study region. Analysis and interpretation of lithology and stratigraphy information in the area of study help to understand the past depositional condition and the occurrence of tectonic change in the area of study. A map of regional geology, drainage, topography and geomorphology was created with the use of ArcGis 10 software. Geologic mapping is a scientific process that can generate a variety of map items for many different purposes using secondary data analysis. The observation of geology in the field were made and recorded to produce different type of geological map. The data must be accurate based on the examination of the rock and exposure and factual. This research follows the Pereira et al. (2013) methodology developed, then improved by Silva et al. (2013, 2015) and Araujo and Pereira (2018). In specific, geological (minerals, rocks and fossils), geomorphological (landforms and processes) and pedological variables were used to assess geodiversity. This definition became popular and generalized in academic circles, where early research centered on techniques that evaluated geodiversity spatial variation, with a specific emphasis on quantitative aspects. The methodology also quantitatively assessed the importance of geomorphological unit boundaries, the hydrography and the existence of minerals, thermal waters and geological energy resources. The values obtained for the six partial indices were equalized to five classes from the Natural Breaks classifier (jenks) before the final sum. All the procedures of this upgrade for examining and counting were carried out using Arcgis 10.2.

Counting the number of various units and occurrences allowed four partial diversity indices to be defined which are first is lithology index, which corresponds to the number of lithological or stratigraphic units represented on a 1:25000 geological map. The second is geomorphological diversity index, which is the sum of geomorphology that represented on a 1: 1:25000 map of geomorphological units; the fluvial hierarchy index value (Strahler 1957) divided by two is used for the hydrographic sub-index. The third is hydrological diversity index, which corresponds to stream order represented on a 1:25000 hydrological map. Last is speleological diversity index, which corresponds to the number of limestone units represented on a 1:25000 geological map.

3.3.4 Research Flow Chart



CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology essentially addressed the details, data collection and interpretation of secondary data obtained from previous research and agencies related. As this chapter cover the research area's geomorphology, stratigraphy, structural geology and historical geology, this chapter became one of most important chapter.

Geomorphology is a study of the landform and its process, especially in the study field related to origin and evolution. We may understand the mechanism that contributed to earth changes through the study of geomorphology. Stratigraphy is an analysis of rock strata, their families and absolute age and strata relationships. Lithostratigraphy is used in this research to classify the association between strata.

Structural geology is concerned with the structure of earth, with rock geometries to explain the history of deformation. The knowledge obtained is important for interpreting historical events. All geomorphology, stratigraphy and structural geology knowledge is combined to expose past occurrences in geology.

4.1.1. Accessibility

In the southern part of Kelantan, Gua Musang is connected by the Gua Musang-Merapoh highway. The study area can be reached by the transport network via Gua Musang-Lojing Highway. In addition, accessibility is available via unpaved roads that help to access the study area. Field analysis can also be accessed in the research area by walking around.

4.1.2. Settlement

The settlement at the study area are Kampung Tanah Puteh and Kampung Pulai. These areas are village where have residents. Even though most of the study area is covered with limestone karst and oil plantation but there are still have settlement.

4.1.3. Forestry or vegetation

In the study site, the dominant land-use area is forestry, rubber plantation and oil palm plantation. In the Gua Musang plantation in Gua Musang, rubber plantations and palm plantations dominate land-use operation and economic changes. Rubber plantations dominate the study field. In this area, most of the forests were irrigated, converted into oil palms and some were planted as rubber plantations.

4.2 Geomorphology

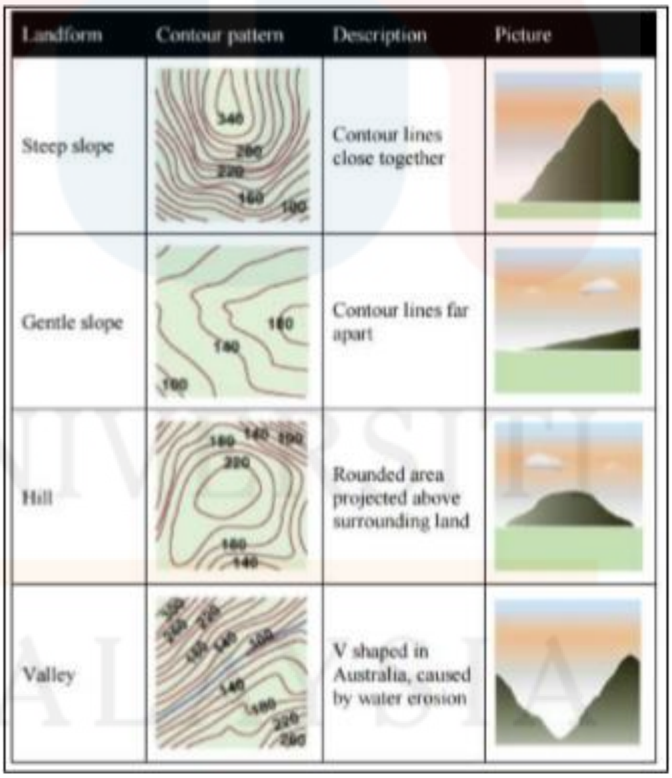
Geomorphology can be defined as the processes and conditions that enhance the development of the landform, the physical, morphological and structural characteristics of the landform that shape the landform process. Landform consists of different elements, such as mountains and valleys, rifts and scraps, lake basins and profiles of water courses and vegetation patterns. Geomorphology also practiced within physical geography, geology, engineering geology, archaeology and geotechnical engineering.

4.2.1 Geomorphological classification

Based on geomorphological conditions, such as topography, drainage patterns, river structure and vegetation of the research area, the geomorphology of the study area is discussed. There were many techniques used to assess the geomorphology of the study area, including field observation, topography map analysis and imagined satellite imagery. According to Tanot et al., (2001) there are four types of geomorphology landscape in Kelantan state which are mountainous areas, hilly areas, plain areas and coastal areas.

4.2.2 Topography

Topography may be characterized as the natural development of the surface of the earth or its physical characteristics. It also contains a number of different features or landforms. The characteristics and type of landform can be described by the study area's contour pattern. It can be described as hills, steep slopes and two hills with a dip in between, based on observations in the study field. Figure 4.1 shows landform based on contour pattern (State of New Wales, Department of Education and Training, 2009)



Landform	Contour pattern	Description	Picture
Steep slope		Contour lines close together	
Gentle slope		Contour lines far apart	
Hill		Rounded area projected above surrounding land	
Valley		V shaped in Australia, caused by water erosion	

Figure 4.1: Landform based on contour pattern (State of New Wales, Department of Education and Training, 2009)

In comparison, the lowest contour value is comprised of the northwest section of the research area as it also has a river that passes down through it. River characteristics that are corrosive and heavy precipitation often impact the area from time to time. In addition, the outcrops located in this area are limestone beside the river. Whereas the research area is on the north-east section of the steep slope and hill with the peak elevation of 440m. Table 4.1 shows the relationship with the absolute height morphology (Source: Van Zuidam, 1985). Next, the figure 4.2 shows the topographic map of the research area. Figure 4.3 shows the 3-D topography map.

Table 4.1 Relationship with the absolute height morphology

Absolute Altitude (Meter)	Morphology Element
<50	Lowland
50-100	Lowland Inland
100-200	Low Hill
200-500	Hill
500-1500	High Hill
1500-3000	Highland
>3000	High Mountain

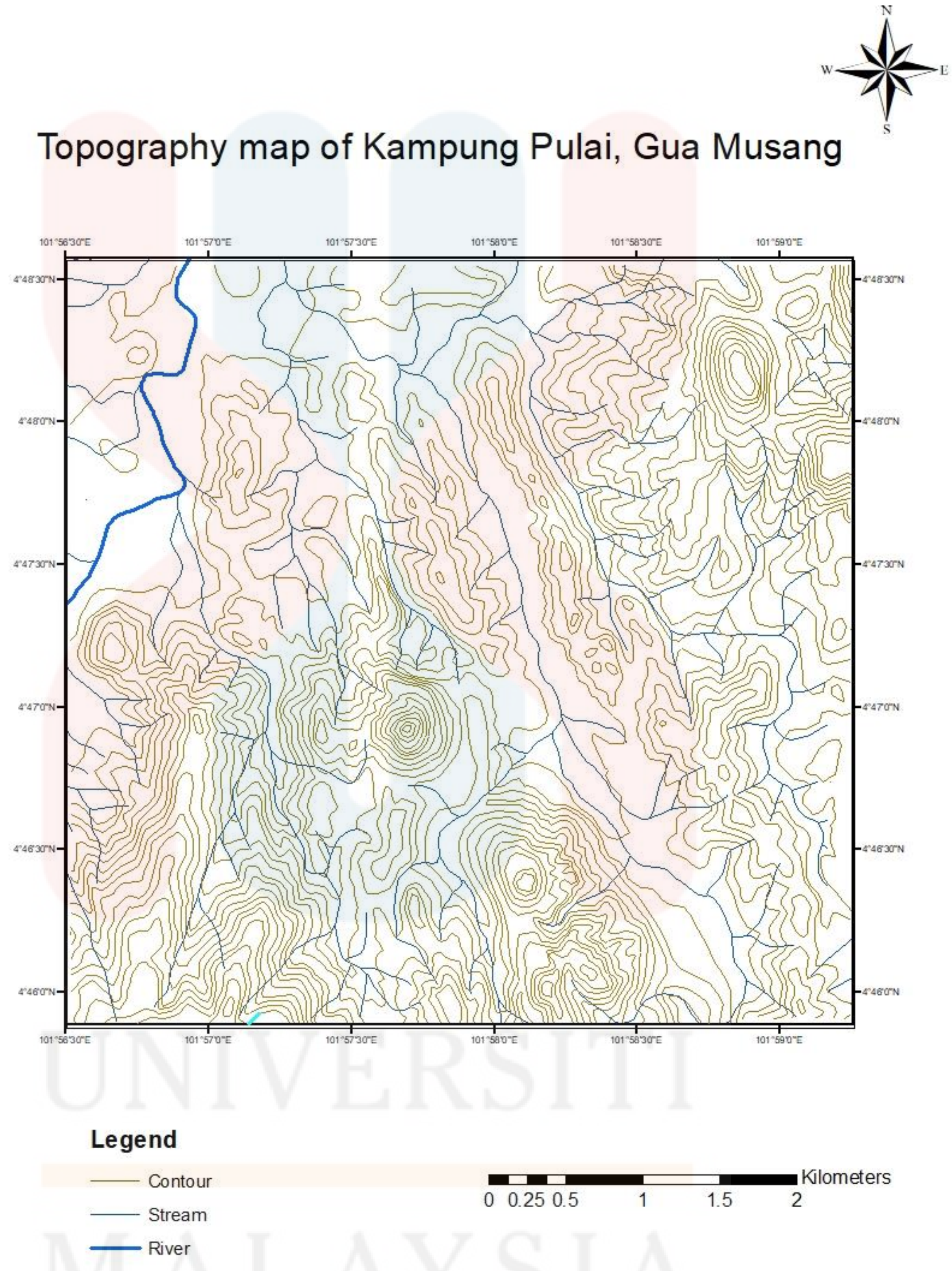


Figure 4.2: Topographic map of the research area

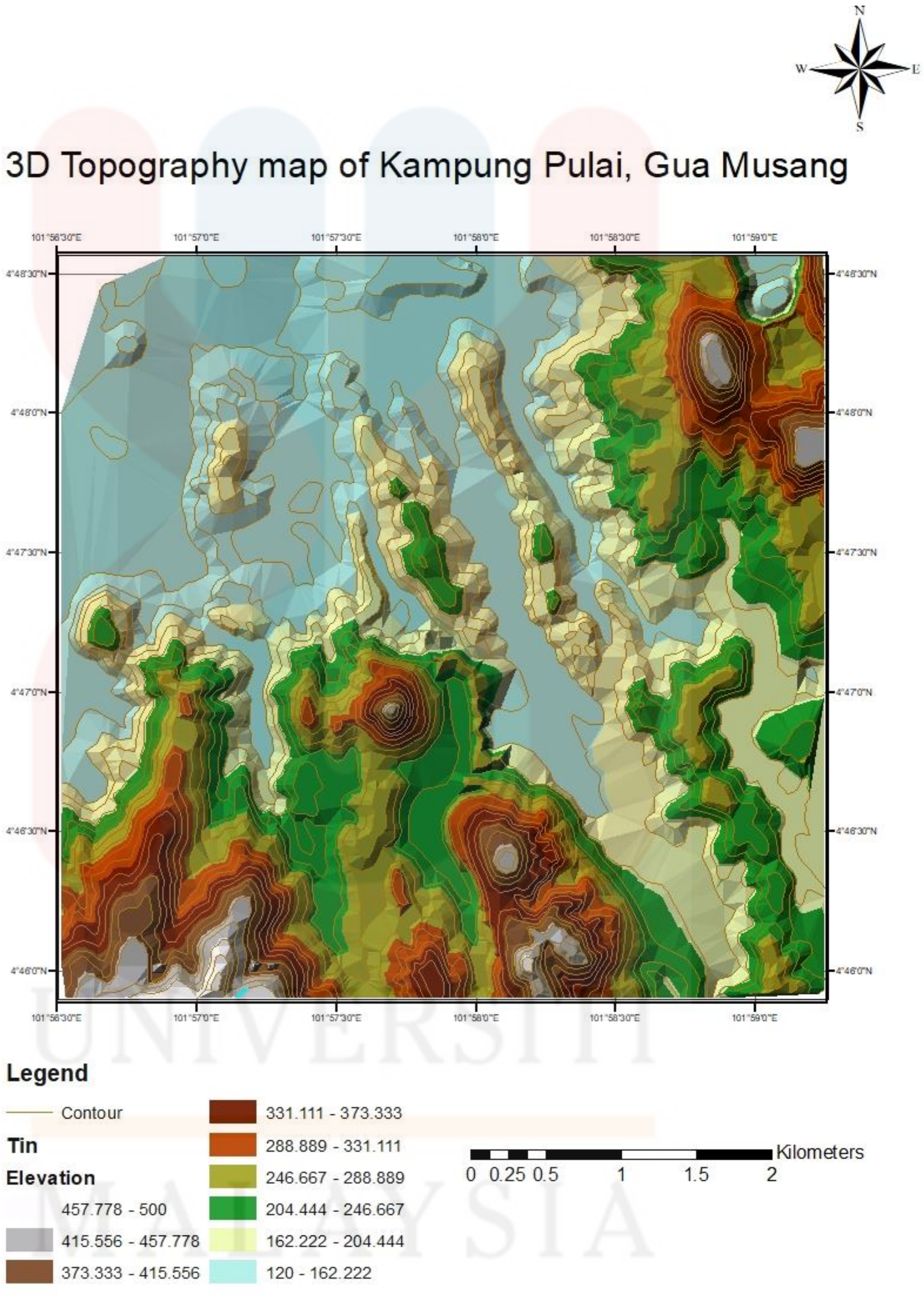


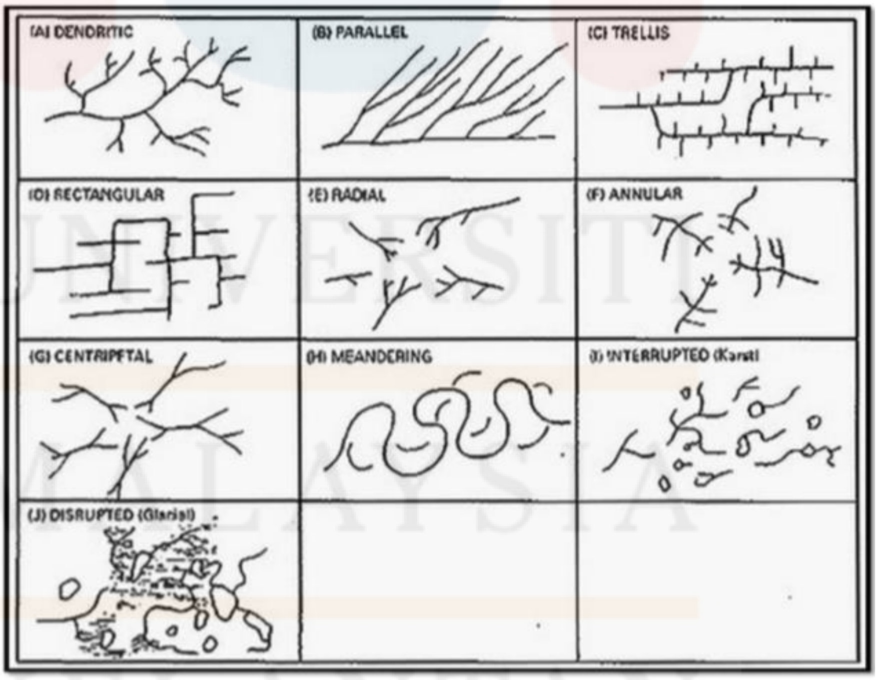
Figure 4.3: 3D topographic map of the research area

4.2.3 Drainage pattern

The drainage pattern is the pattern of streams, rivers, and lakes found in a single drainage basin. By a topographical barrier called a watershed, drainage basins are isolated from each other.

Based on Table 4.2, there are seven types of drainage which are dendritic, radial, rectangular, trellis, parallel, annular, meandering and more. Dendritic is a randomly established, tree-like pattern consisting of branching tributaries and a main stream. It is the most common drainage pattern that is representative of essentially flat-flying or mostly homogenous rock and impermeable soils. Radial drainage consists of streams radiating towards the outside from a central hill, dome, or volcanic cone.

Table 4.2: type of drainage pattern



Major streams trending in the same direction, such as parallel, are characterised by another drainage pattern. Tributaries usually join the main stream at approximately the same angles. In addition, the trellis pattern is a modified variant of the dendritic pattern. It produced folded rock strata in the field. In addition, annular pattern is a primary stream that forms around an uplifted dome of sedimentary rocks in the concentric, circular joints.

Three drainage patterns which are dendritic, parallel and radial in the study area are identified based on the map in Figure 4.4. In figure 4.4, the dendritic pattern is colored by orange lines, parallel pattern is colored by blue lines and radial pattern is colored by purple line.

a. Dendritic

In the study region, the dendritic drainage pattern is dominant. In the southeast and northwest of the sample field, two major dendritic patterns were located. The direction in which water flows southward. In areas where the rock (or unconsolidated material) under the stream has no specific fabric or shape and can be eroded equally easily in both directions, the dendritic pattern is by far the most frequent.

b. Parallel

A pattern of rivers with some relief caused by steep slopes is the parallel drainage system. Because of the steep slopes, with a few tributaries, the streams are fast and straight and all flow in the same direction. Where the surface has a pronounced slope, parallel drainage patterns form. A parallel pattern also develops in regions of parallel, elongated landforms such as outcropping resistant rock bands. By observing the study area, the parallel pattern is located mostly at the center of the study area.

c. Radial

Radial pattern is a pattern marked by rivers flowing out, analogous to the spokes of a wheel, away from a central point. On the flanks of a dome or volcanic cone, it tends to develop. On the study area, it can be observed that this pattern exists at the north east of the study area.

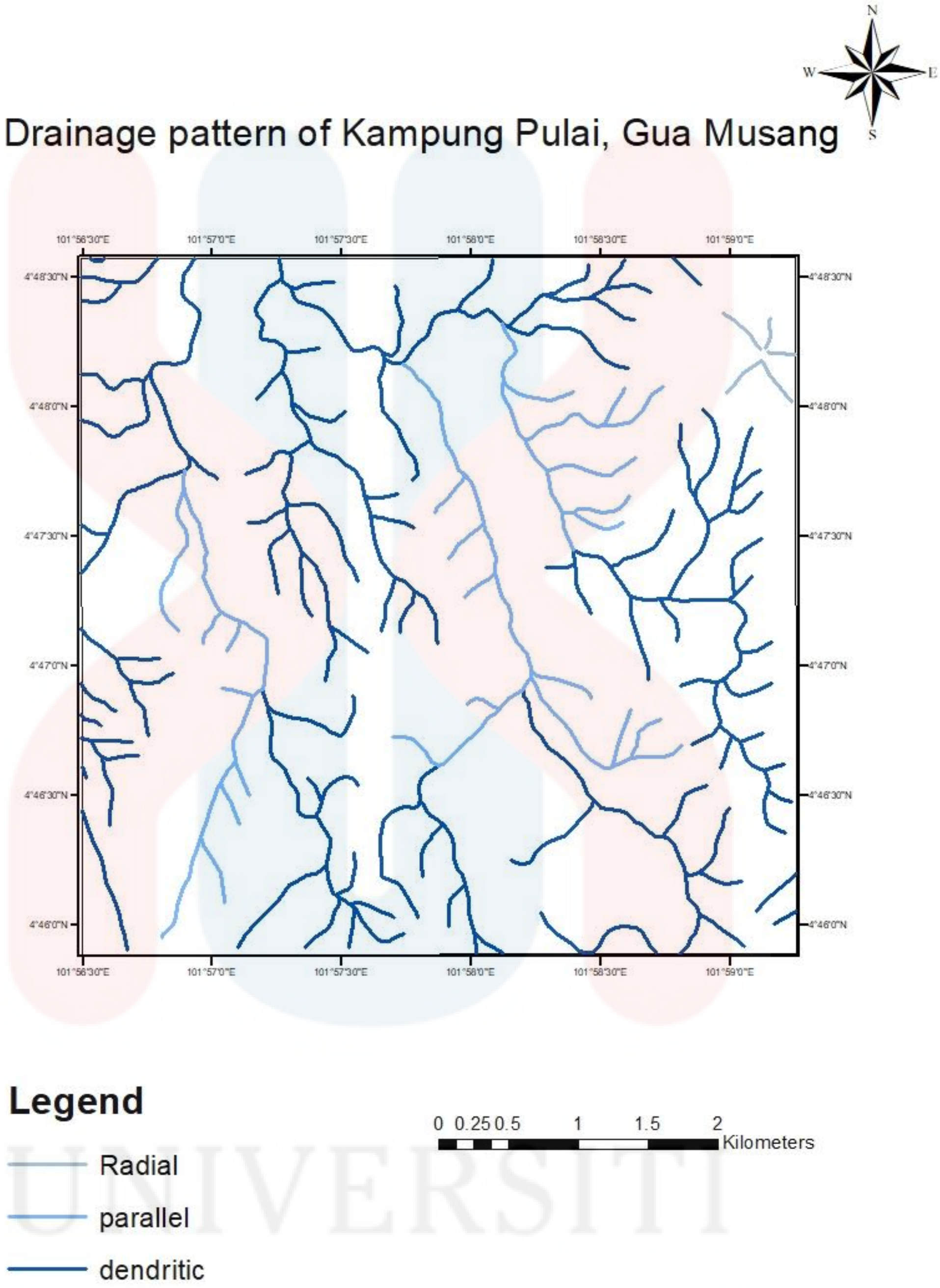


Figure 4.4: Drainage pattern map of study area

4.3 lithostratigraphy

Lithostratigraphic units are rock bodies, which are described and classified based on their lithological characteristics and stratigraphic relationships. Lithostratigraphic units are the basic units of geological mapping. By using interpretation of the secondary data and previous research, the distribution of rock types in the study area was recognised. The rocks are defined as a unit of alluvium, a unit of limestone, a unit of slate and a unit of rhyolite rock. Figure 4.5 shows the geological map of the study area.

The geological map reveals the rock lithology, structural geology, cross-section and column of stratigraphy that helps to explain the study area's geology. The study area's stratigraphy column corresponds to the Gua Musang Formation that was studied by previous researchers. Technically, to describe the categories of lithology, rock definition is required to define the types of lithology.

4.3.1 Unit explanation

a) Quaternary Alluvial deposit

Quaternary alluvial deposits are the current type of deposit where alluvial exposure is exposed to the surface of the earth and leading to weathering. Small particles that occur in the form of sediment are the result of weathering. The sediment ranges from clay to boulder in size. This sediment is moved by the water and collected at the bottom of the stream. For the velocity and the condition of water, the sizes of deposit materials vary.

b) Rhyolite

A feldspar quarry occurs in the south of the study area, based on the previous study. As in the formation of gua musang, the lithology is argillaceous and calcareous rocks combined with volcanic rocks. Rhyolite is a relatively frequently occurring volcanic rock. It is the chemical equivalent to granite. Although the two rock types have the same chemistry, rhyolite is extrusive and granite is intrusive. While granite has crystals that are typically simple to see, the crystals in rhyolite are often too small to see. This is due to the quicker cooling of the rhyolite lava compared to granite's slower magma cooling.

c) Limestone

Karst topography and cave formation are indicative of the presence of limestone in the study region, since it is soluble in acidic water or groundwater. Limestone primarily contains calcite mineral which makes a hissing sound when reacting with hydrochloric acid (HCL). Limestone is a sedimentary rock composed mainly of calcium carbonate in the form of the mineral calcite ($CaCO_3$). In clear, humid, shallow marine waters, it most commonly forms. Relate to the depositional condition of the formation of gua musang, which is shallow seawater, Lee (2004).

d) Slate

In the study area, slate is at south west. The topography of the area can be the indication of identification of the metasediment rock. The interpretation of the previous research also resulted to the identification of the rock lithology. Slate is a fine-grained, foliated, homogeneous metamorphic rock formed from an initial shale-type sedimentary rock composed of clay or volcanic ash, from low-grade regional metamorphism.

4.3.2 Stratigraphy column

Based on the interpretation on secondary data and previous research, the research area is consisting of four types of lithology which are alluvium, rhyolite, limestone and slate. Table 4.3 shows the stratigraphy column of Kampung Pulai, Gua Musang, Kelantan. Slate deposit is the oldest rock that discovered at the research area followed by limestone, rhyolite and the youngest rock is alluvium deposit. Slate and limestone are in same period which is Permian. Rhyolite is in Triassic period and Alluvium is in Quaternary period.

Table 4.3: stratigraphy column of study area

Era	Period	Lithology	Rock
Cenozoic	Quartenary		Alluvium unit
Mesozoic	Triassic		Rhyolite
Palezoic	Permian		Limestone
			Slate

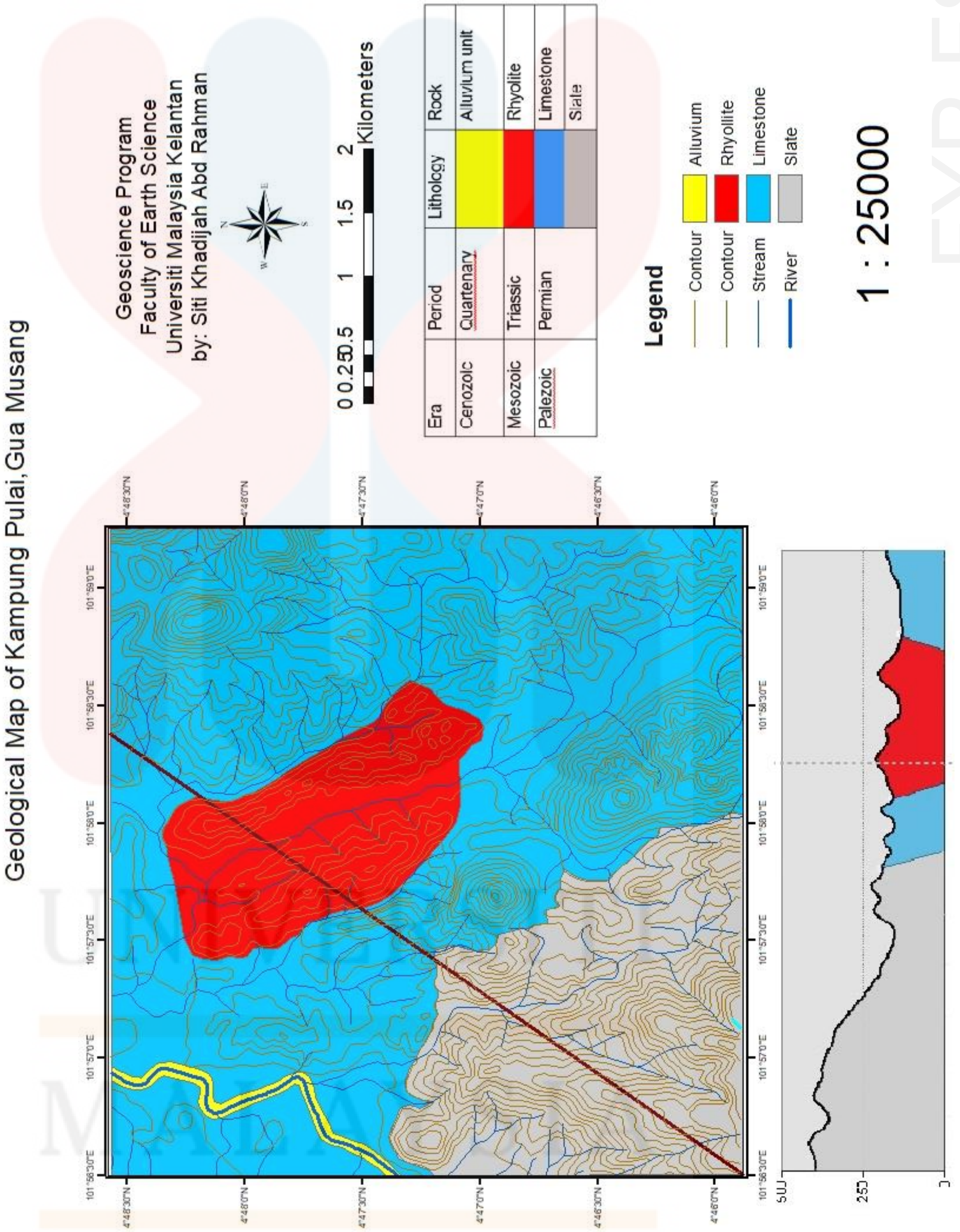


Figure 4.5: Geological map of the study area

4.4 Structural Geology

The study of the mechanisms that contribute to the formation of geological formations and how they impact rocks is structural geology. In general, the strong tectonic movements that occur in the earth are the result of geological systems. These movements are folding and cracking rocks, creating fundamental faults, and raising mountains. The effect is structural features such as lineament, fold, fault and fracture due to past geological events such as plate tectonic or earthquake. This structures are created because of the force acting on the rock or tectonic plate bodies. The force of lineament fault analysis will be interpreted under this subtopic.

4.4.1. Fault

A separation between two blocks of rock in which the displacement took place is a fault. Faults are known as normal, reversing and thrust fault faults. This fault is characterised by the type of stress acting on the earth's crust and its orientation. It is difficult to identify fault during field observation in the study area, so the lineament analysis is used for understanding. In the research area, this study is used to determine the predicted location of faults. Lineament is characterized as a line formed in linear and semi-linear types of landscape, such as slopes and valleys. A lineament analysis is generally used in structural landform studies to denote a landform that is related to the properties of the underlying rock. Because the lineament is the representative pattern of the surface of the earth, the lineament interpretation of the research area is interpreted as in Figure 4.6 by the lineament map.

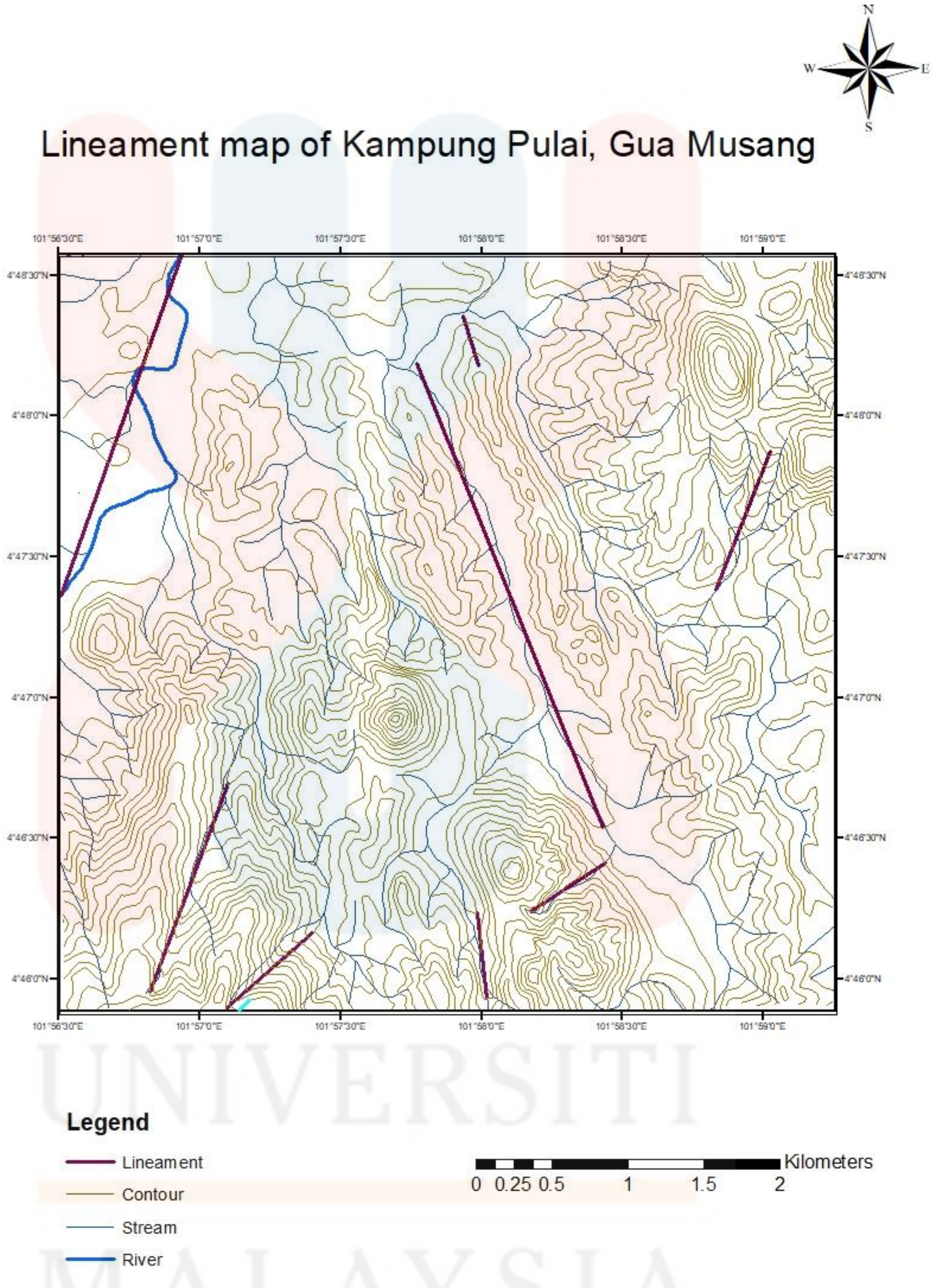


Figure 4.6: Lineament map of study area

4.4.2. Mechanism of structure

In the study area, the structural mechanism is interpreted as occurring due to uplifting during tectonic movement. After the force was released from the crust underneath the ground, the earth's surface is lifted to create a hilly terrain in the study area. Lineament analysis is often used as a guideline in the study area to locate the expected fault. Due to the formation of ridges and valleys, this expected fault can occur in the study field.

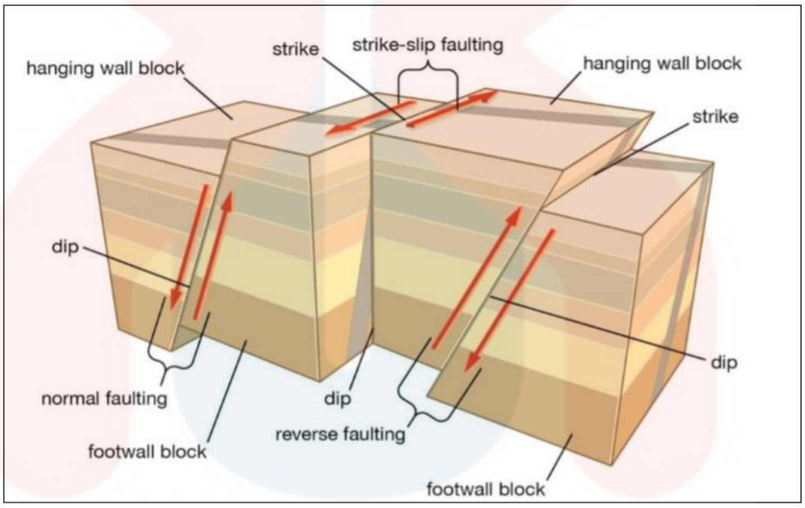


Figure 4.7: Fault mechanism (Source: Britannica, 2015)

As there was a shift in the structure of the contour due to a fault displacement, a fault known as a thrust fault occurred in the study area. A dip-slip fault is a thrust fault in which the upper block moves up and over the lower block, above the fault plane. In areas of compression, this sort of faulting is normal.

4.5 Historical Geology

The study area, Gua Musang is a formation that are develop during the PermianTriassic transition (Simon, 2013). This region is situated within the Peninsular Malaysian Central Belt. The bulk of the Upper Paleozoic sediments consist of Permian marine strata which occur in the Central Belt as linear belts flanking Mesozoic sediments. In the south of Kelantan, the Upper Paleozoic rock is the Gua Musang Formation, while in the east of Kelantan it is the Taku Schist. Argillaceous and volcanic facies dominate the Upper Paleozoic formation, while calcareous and arenaceous facies belong to the remainder. Usually, the depositional climate is shallow marine with occasional active underwater volcanism beginning in the Late Carboniferous and peaking in the Permian and Triassic to meet it. This region is covered entirely by limestone.

CHAPTER 5

GEOHERITAGE POTENTIAL VALUE OF KAMPUNG PULAI, GUA MUSANG, KELANTAN

5.1 Introduction

The geoheritage potential of Kampung Pulai, Gua Musang, Kelantan was covered in this chapter. On the basis of interpretation of secondary data and previous research and geodiversity index assessment, the possibilities of geodiversity in the research area are recognised. In the study area, geoheritage resources consist primarily of rocks, minerals, soils, landforms or landscapes, and geological occurrences.

Basically, the geoheritage value is related to the properties of geodiversity. In the study area, the estimation of geoheritage value is based on the evaluation of geodiversity index on geosites and geomorphosites. The geodiversity index assessment is used, depending on the evaluation, to assess the potential of geoheritage resources in the study area.

5.2 Geoheritage

Geological heritage is a term that can be applied to natural geological or geomorphological features of aesthetic, intrinsic or science and educational value, as well as giving unique insight into geological processes that impact the evolution of the Earth (ProGEO, 2011).

The term geological site or geosite, meanwhile, refers to the geological site of interest. Geosites are usually geo-heritage resources based on Bruno (2015) that should be studied, surveyed, protected, and developed to ensure that future generations will continue to study the Earth's geological past, appreciate the natural beauty of the sites, and promote socio-economic growth.

5.3 Geodiversity Index

By geodiversity index, the geosite can be identified. There are four partial indices that area calculated which are lithological index, geomorphological index, hydrological index and speleological index. Calculating the number of distinct units and occurrences makes it possible to identify four partial indexes of diversity, the first is the lithology index, which refers to the number of lithological or stratigraphic units shown on a geological map of 1:25000. The second is the geomorphological diversity measure, which is the amount of geomorphology depicted on a geomorphological unit map of 1: 1:25000. The third is the index of hydrological diversity, referring to the stream order shown on a hydrological map of 1:25000. Lastly, the speleothem diversity index refers to the number of units of limestone shown on a geological map of 1:25000. All the index value will be sum up and the result shows the high geodiversity area which shows the potential geoheritage area on the study area.

5.3.1 Geomorphological index

For this index, there are two class of index which is low hill and hill. This class is according to the Van Zuidam classification. The regular grid of 10x10 at the 5x5km study area in order to quantify the diversity of geomorphology. As shown in figure 5.1, each box of grid has value 1 and 2 respectively. The value was given based on the number of geomorphologies occurred in respective area. For value 1, it is given when the occurrences of the geomorphology only have one in the grid. For value 2, it is for grid area that have two occurences of geomorphology. 50% of the study area have one geomorphology diversity while 50% other of the study area have two geomorphology diversity. Figure 5.2 shows the geomorphology index according to the class given.

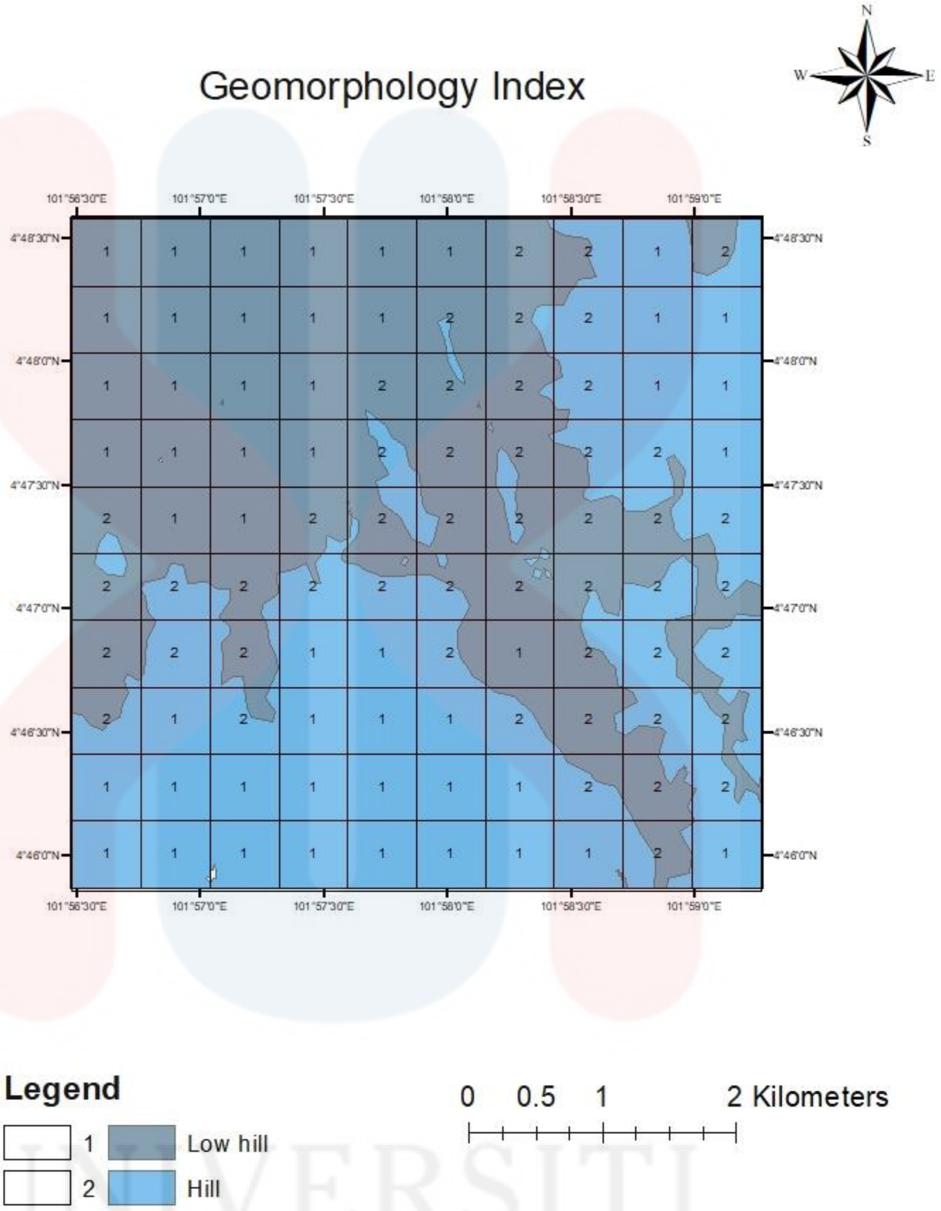


Figure 5.1: Geomorphology index map

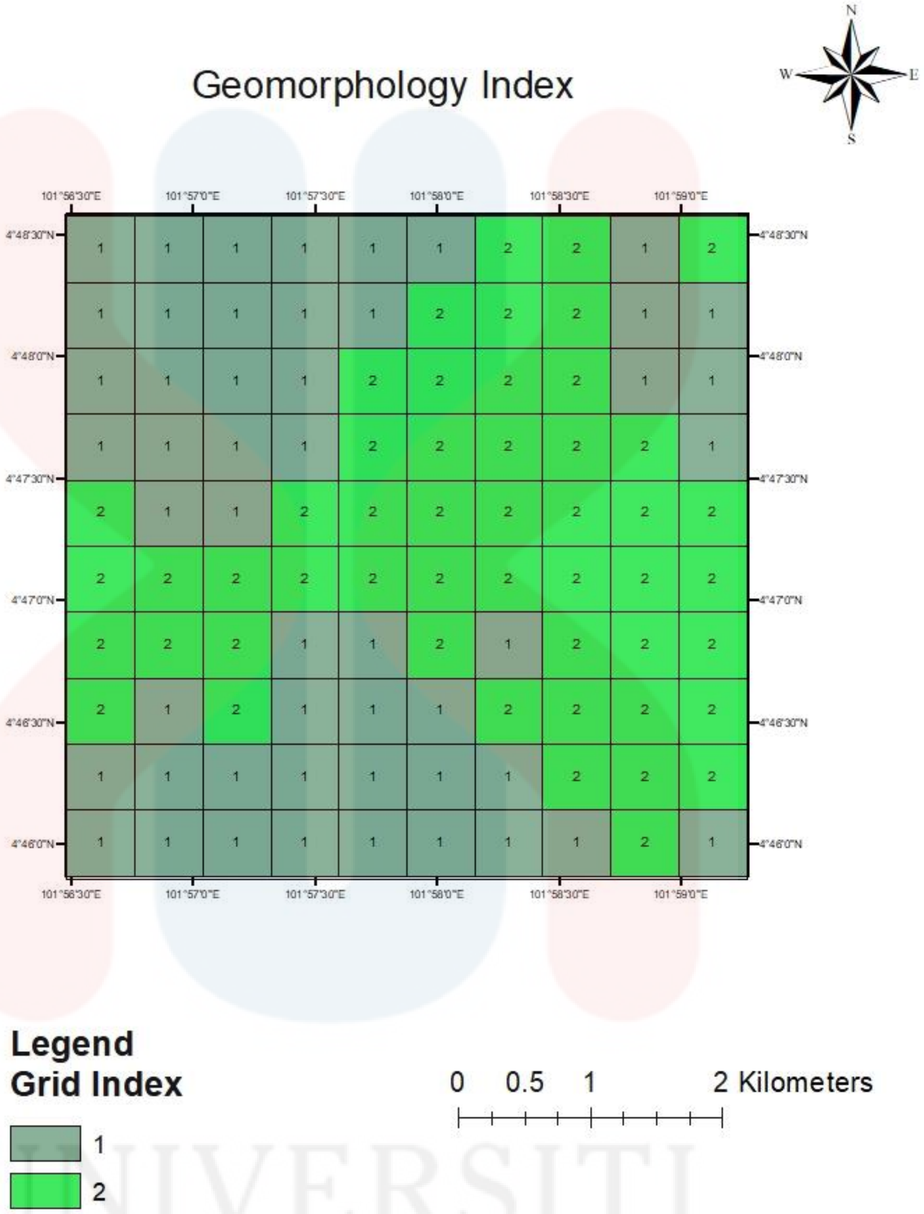


Figure 5.2: Geomorphology index map

5.3.2 Hydrological index

Hydrological index refers to the Stahler stream order in the hydrological map in Figure 5.3 processed using DEM data. The value given in each grid is according to the highest stream order occur in the specific area. In figure 5.4, it shows the highest stream order is 4 while the lowest is 1. The grid area which absence of any stream order is given 0 value. The grid area which has the highest stream order is first stream order will be given 1 value. The grid which the highest stream order is second stream order will be given 2 value. For third stream order that highest in the grid area, it will be given 3 value. Lastly for the highest value, 4 will be given to the area which have the fourth stream order as the highest stream order. The grid index is 10x10 accordingly with the study area 5x5km. There are 25% of the study area that doesn't have the occurrences of the stream order and was given 0 value. Value 1 covered 35% of the study area with highest stream order is one. 14% of the study area is covered with 2 value. For value 3, it covered 21% of the study area and lastly for the highest value, it only covered 5% of the study area.

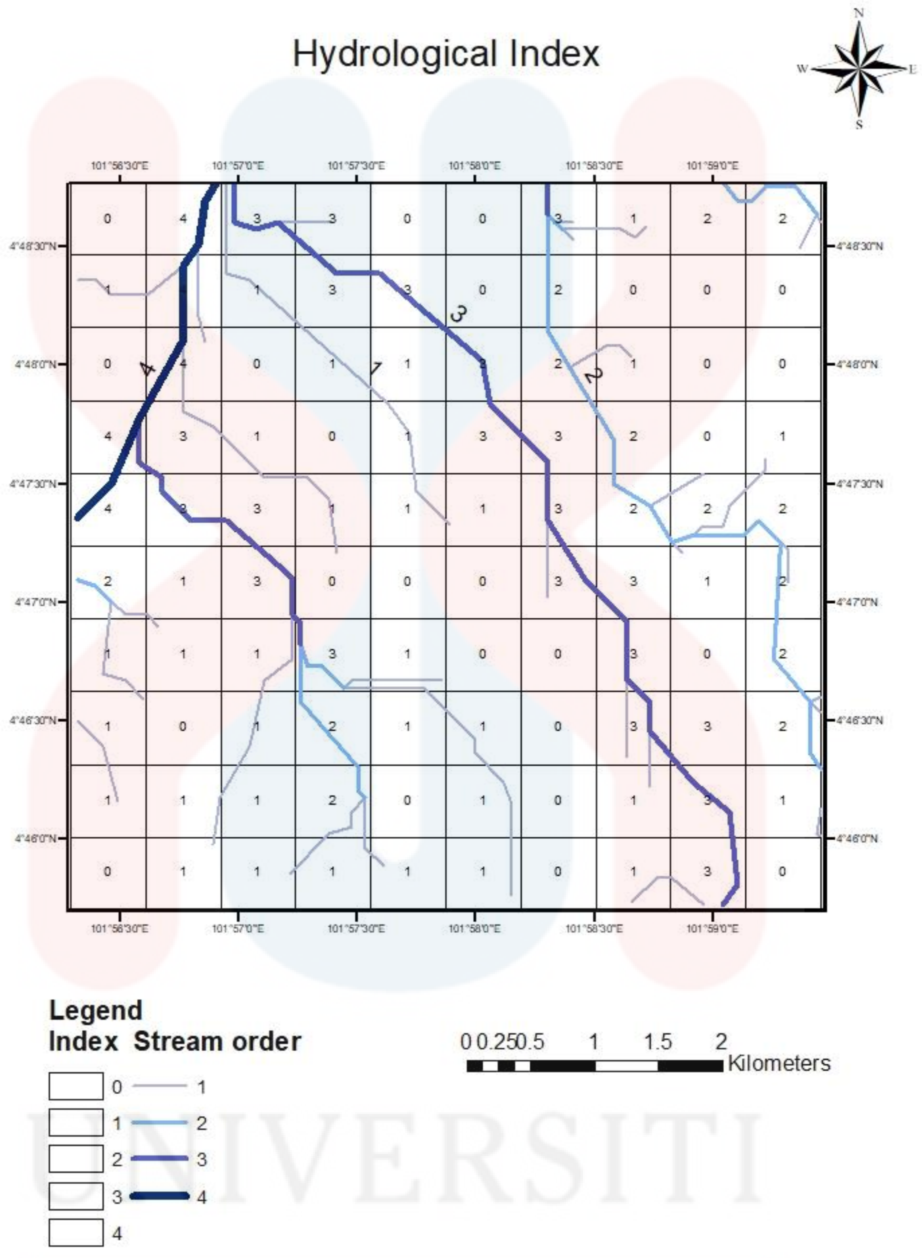


Figure 5.3: Hydrological index map

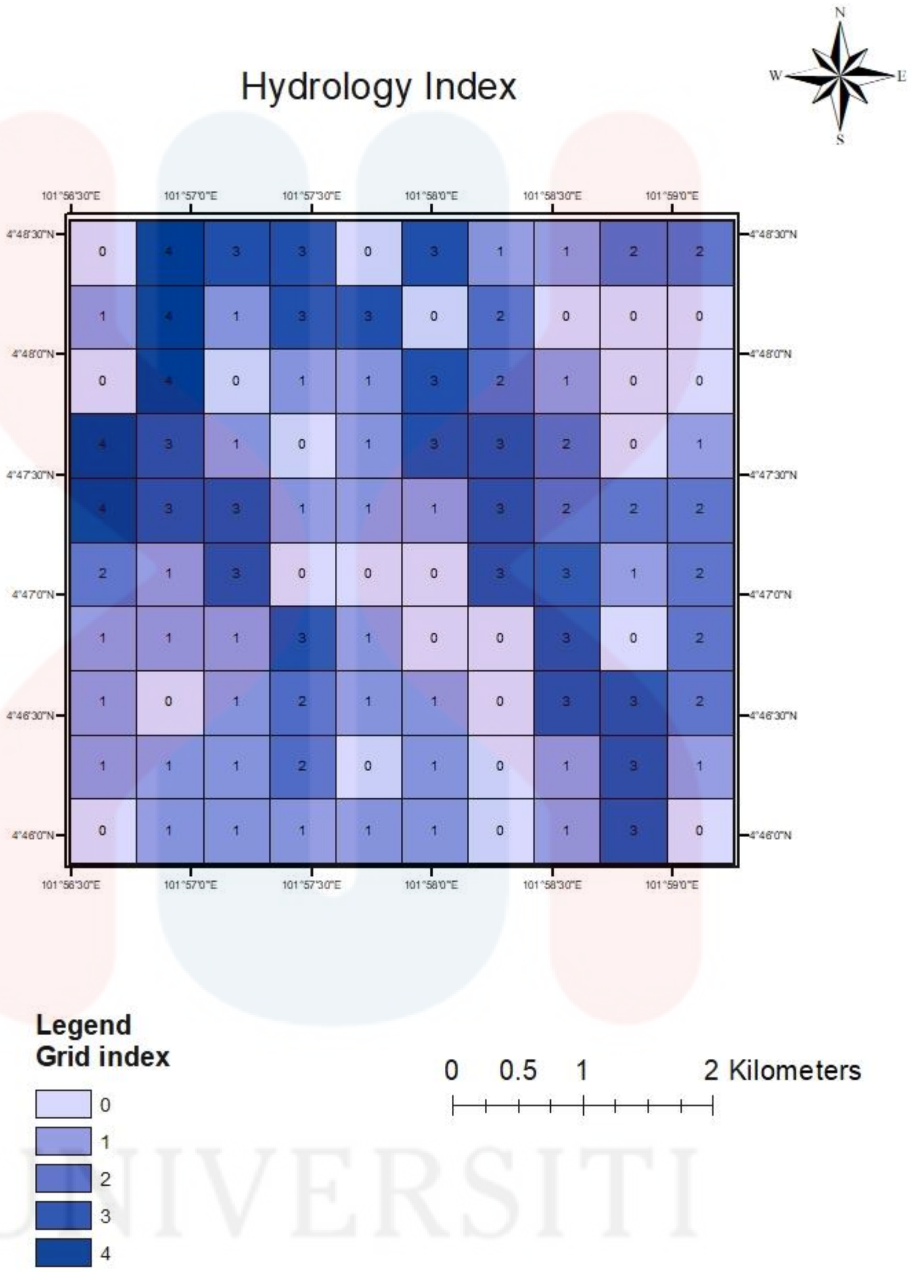


Figure 5.4: Hydrological index map

5.3.3 Lithological index

For lithology index, as shown in Figure 5.5, the value is given based on the occurrences of rock lithology in the respective grid area. The lowest number value of grid is 1 which shows the grid area only have one lithology while the highest is 3 which shows there are three lithology in the grid area. For grid area that have 2 occurrences of lithology, the value given is 2. As in Figure 5.6 shows that 64% of the study area covered with one lithology which was given 1 value. For value 2, it covered 35% of the study area. Lastly, the highest value which is 3 only covered 1% of the study area.

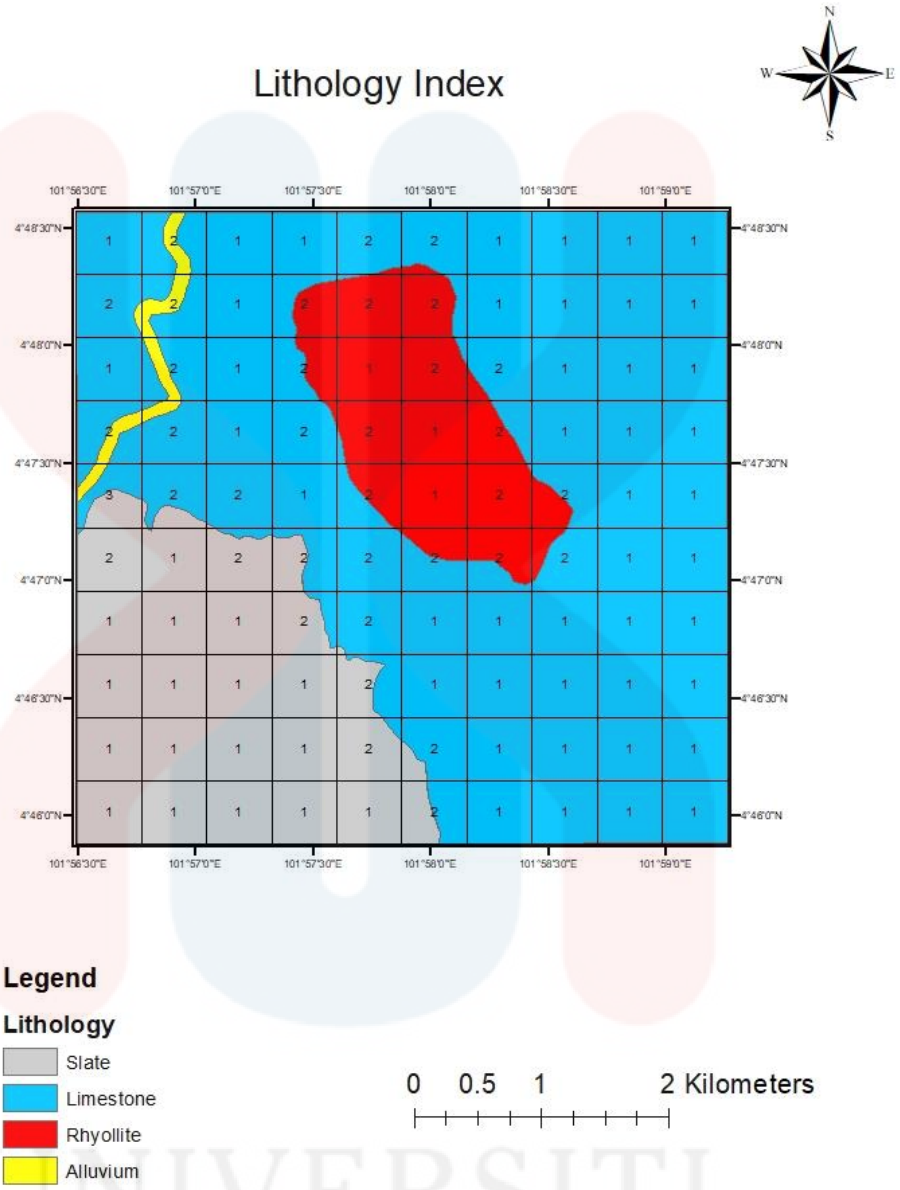


Figure 5.5: Lithology index map

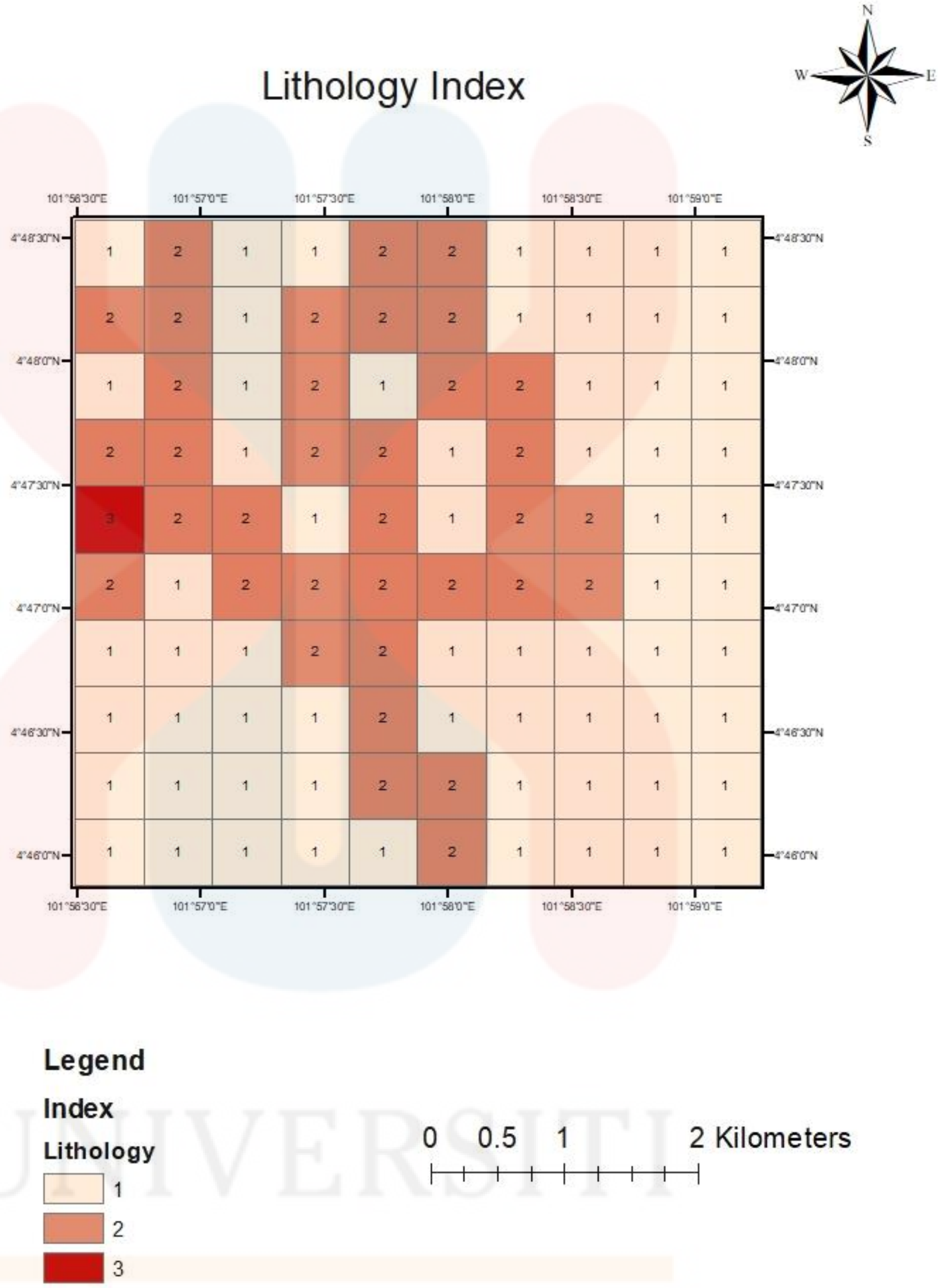


Figure 5.6: Lithology index map

5.3.4 Speleothem index

This index is referring to the occurrences of limestone unit in the grid area. The value for is given accordingly. For 0-10% grid area cover by limestone unit, the value given is 1. For 11-20% of the grid area that cover with limestone, value is 2. For 21-30% of the grid area that consist of limestone, value is 3. For 31-40% that have limestone covered the grid area, value given is 4. For 41-50% of the grid area that consist of limestone, value given is 5. For 51-60% grid area cover with limestone, value given is 6. For 61-70% of grid areathat covered with limestone, value given is 7. For 71-80% occurrences of limestone in the grid area, the value given is 8. For 81-90% of grid area that covered with limestone, value given is 9 and lastly for 91-100% of grid area covered with limestone, the value given is 10. Figure 5.7 shows the value given to the grid area. Based on Figure 5.8, it shows that 48% of the study area covered with the highest value which is 10. For value 9 and 3, it only covered 1% of the study area. For value 8 and 4, these only covered 3% of the study area. For value 7 and 2, it covered 4% of the study area. For value 6, it covered 6% of the study area. 2% of the study area is covered with value 5. Value 1 covered 8% of the study area. Lastly, the lowest value is 0 and it covered 20% of the study area where in this area, there is no occurrences of limestone in the grid area.

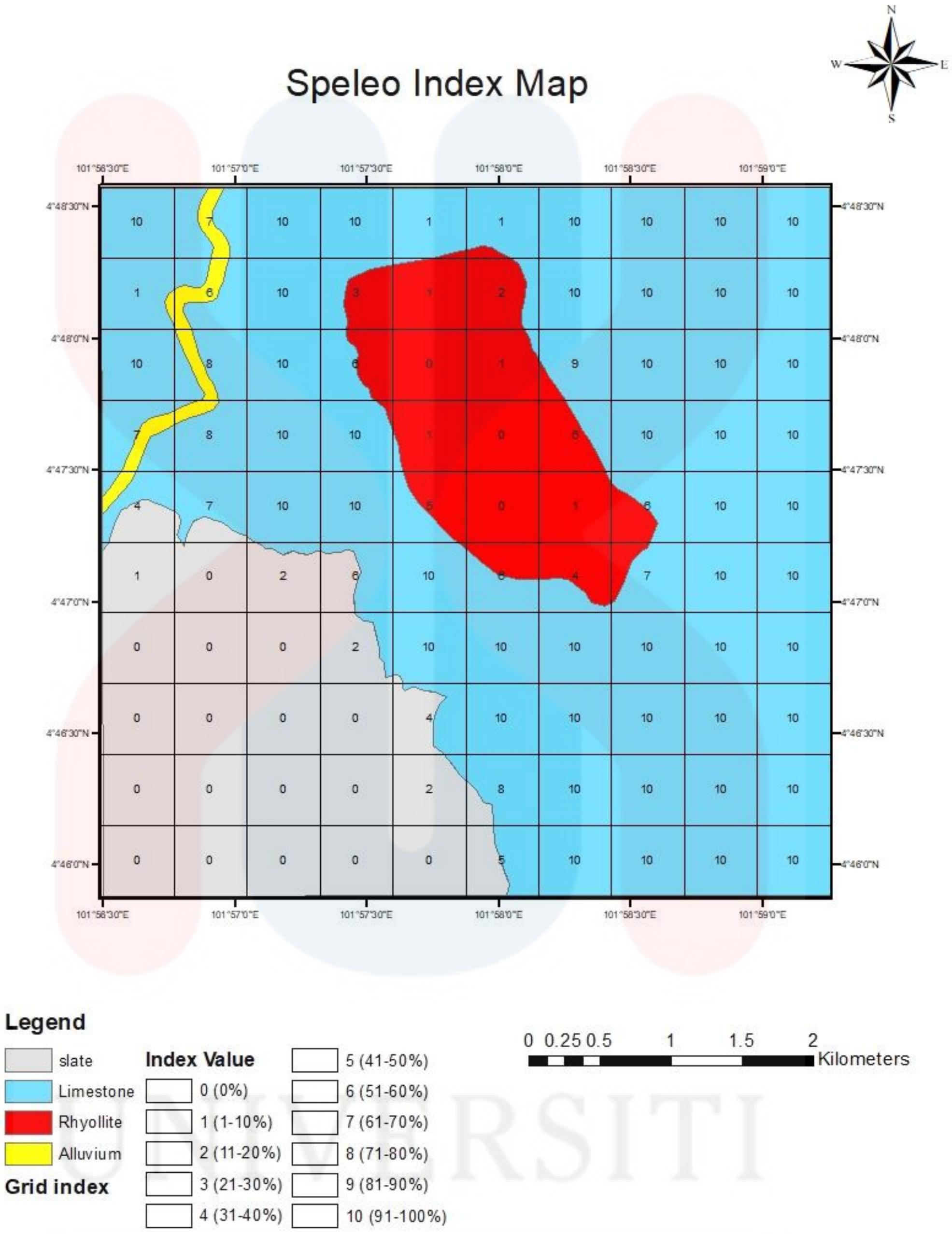


Figure 5.7: Speleothem index map

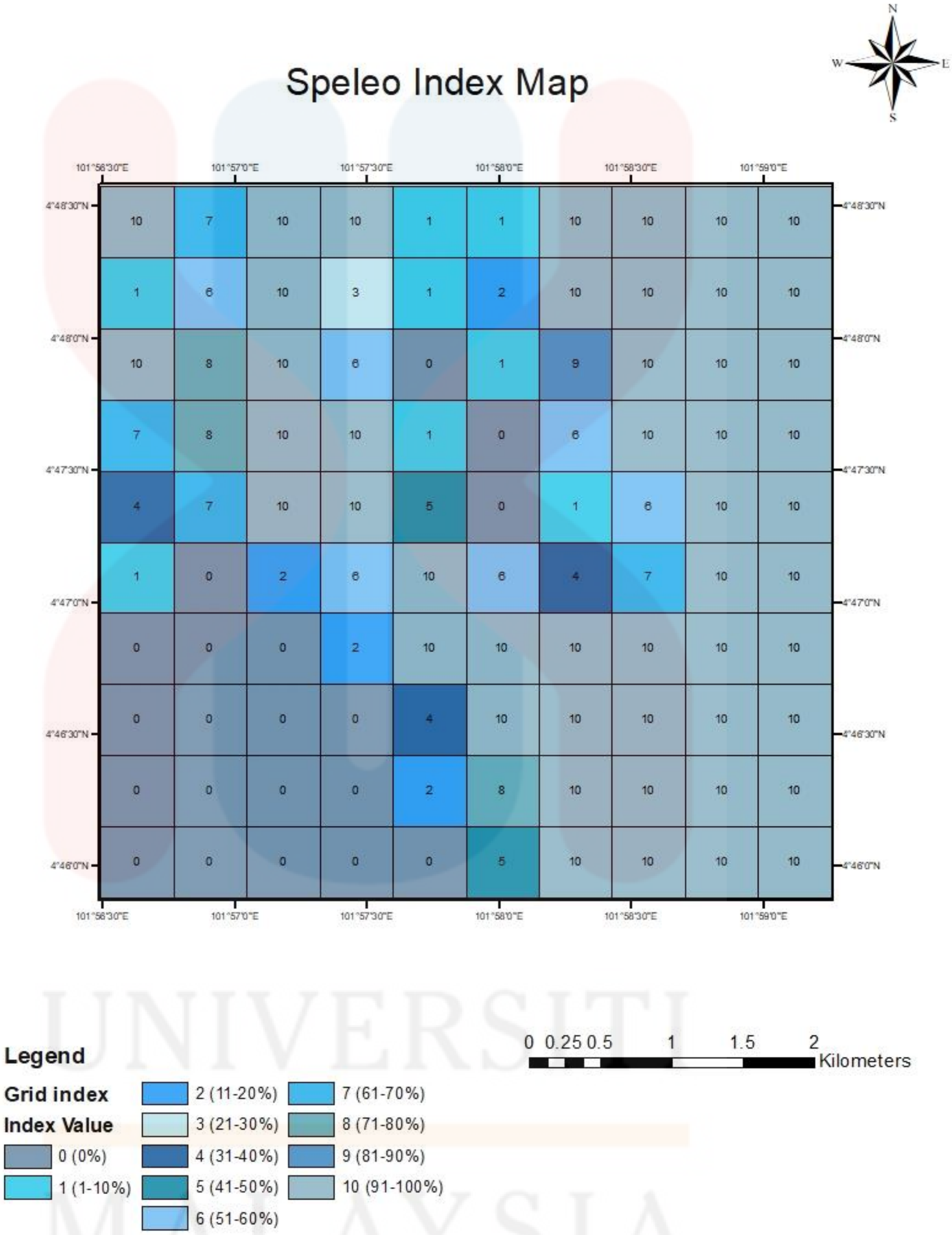


Figure 5.8: Speleothem index map

5.4 Geodiversity Index Map

For geodiversity map index, this map shows the total number of all four indices which are hydrological index, speleothem index, geomorphological index and lithological index . There are 5 classes which represent the rate of geodiversity occurrences in the study area. The lowest class which is 1 is when the total number of occurrences in the grid is from 2 to 4. Second class is when the total number of occurrences in the area is from 5-7. The third class is given when the total number of occurrences in the study area is from 8-10. The fourth class is at the area which have number of 11-13 of occurrences. The highest class is at the area which have 14-16 occurrences. As in figure 5.9, 20% of the area is covered with the lowest class which have low number of geodiversity occurrences. This class can be observed mostly at the southwest of the study area. Second class covered 8% of the study area. Third class cover 11% of the study area and observe in the middle area of the study area. Fourth class covered 27% of the study area and lastly the highest class cover 34% of the study area which at the east area of the study area.

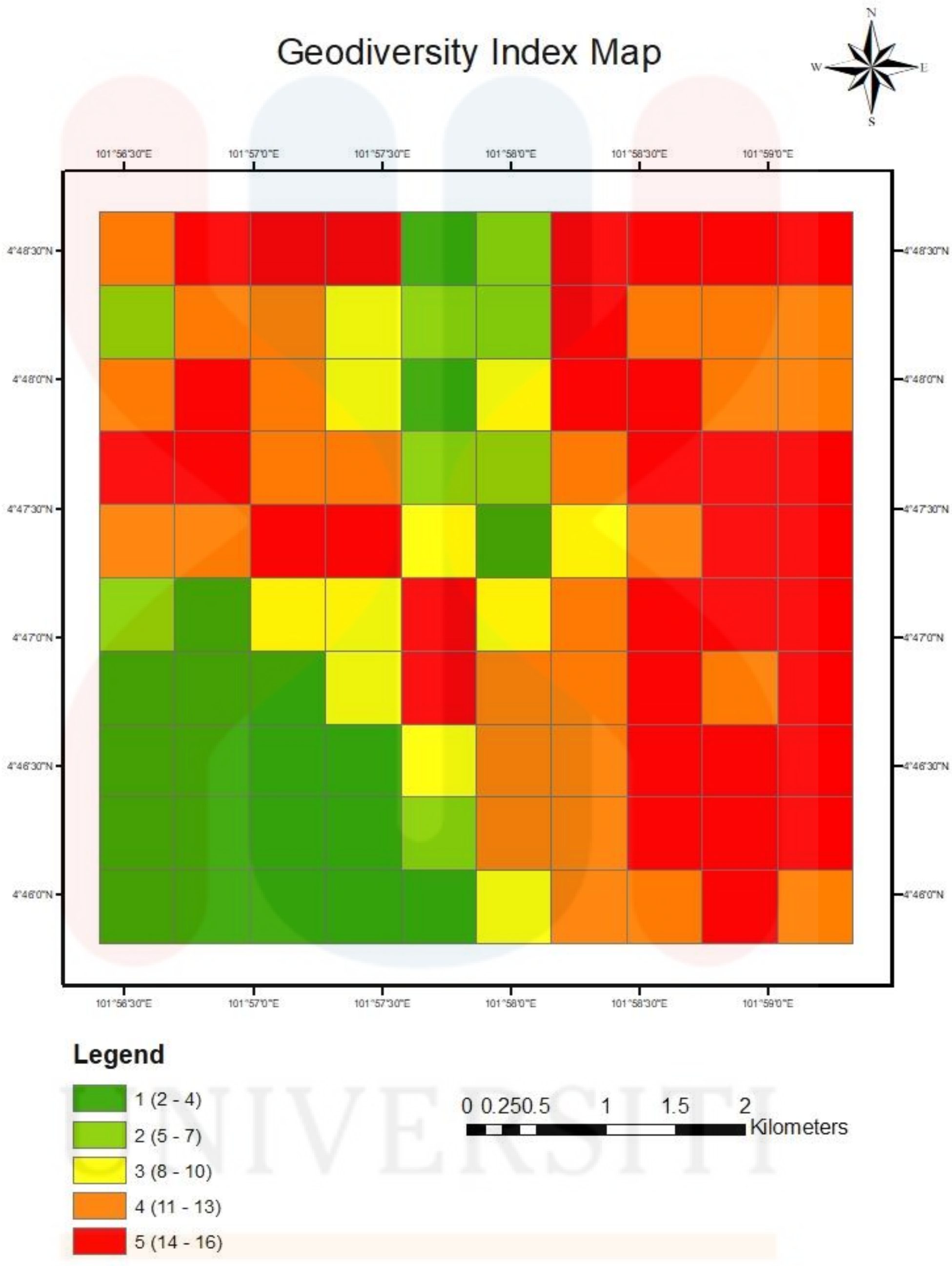


Figure 5.9 Geodiversity index map

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

To conclude, the research objective to update the geological map of the study area as well as to assess the geodiversity value in order to determine the potential and heritage interest of Kampung Pulai, Gua Musang. A geological map was complete by interpreting the secondary data from USGS and also interpreting from previous research. From the interpretation, limestone, alluvium, slate and rhyolite were the lithology found in the study area. There is also structural geology such as fault that identified by using lineament analysis at the study area. A geological map with scale 1:25000 has been produced.

Moreover, on the basis of the outcome obtained, the potential value of Kampung Pulai was identified. Focused on the geodiversity index, it indicates that the high geodiversity of the Kampung Pulai relates to the potential for geoheritage. As in the speleothem index, it shows that the study area rich with karst formation. This karst formation has its own aesthetic value and it is peculiar. It also has scientific value and educational value. The scientific and intrinsic value that makes the place in the field of research as a basis of knowledge for the next generation.

6.2 Recommendation

The recommendation for the next research, based on the current research, the geological mapping should be held or should start earlier so issue such as lack of information and inadequate data collection can be avoided. Improving the general knowledge mapping by theoretical and practical also necessary and improve in another filed of geological knowledge such as structural geology.

For the geodiversity index mapping, the index in the method can be improved by expand the parameter of the index like add mineralogical index, palaeontological index and pedological index. These will be resulted to more accurate geodiversity map. The geodiversity map that is produced during the research can be as reference for upcoming geoheritage research.

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