GEOLOGY AND GEOHERITAGE POTENTIAL OF FOSSIL SITE IN ARING 4, GUA MUSANG, KELANTAN

by

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DECLARATION

I declare that this thesis entitled "GEOLOGY AND GEOHERITAGE POTENTIAL OF FOSSIL SITE IN ARING 4, GUA MUSANG, KELANTAN" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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APPROVAL

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

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GEOLOGY AND GEOHERITAGE POTENTIAL OF FOSSIL SITE IN ARING 4, GUA MUSANG, KELANTAN

ABSTRACT

Geoheritage is described as a contemporary concept for conservation of the nature due to its historical value. As proposed by McBriar (1995), geoheritage comprises of minerals distribution, rocks, fossils, landforms and unique geomorphological features, which portrayed the effect of Earth forces during the past and the present. This research is conducted at Aring 4, Gua Musang, Kelantan. The research is done by the interpretation of geological map and also involves secondary data, which the data has been collected by the previous researchers in the study area. The data obtained will be processed in ArcGIS software. The objectives of this research are as following: 1) To update a geological map with a scale of 1:25 000, 2) To identify the potential of Aring 4, Gua Musang as a geoheritage site, and 3) To assess the significant values in several aspects which is by qualitative assessment of paleontological heritage. The methods that will be applied during conducting the research is map interpretation using ArcGIS and Data Elevation Model (DEM), and the qualitative assessment of geoheritage potential based on the heritage parameters which are focusing on the paleontological criteria. The parameters will be given ranking score, based on the geoheritage characterization assessment guide by Endere & Prado (2014). By the result of geological map interpretation, the study area is dominated by mainly mudstone, which are classified into two units which are tuffaceous mudstone and carbonaceous mudstone. The geoheritage potential of Aring 4 is considered as low, as the area only obtains a total score of 24.

Keyword: Geoheritage, Fossil, Paleontological Heritage, Aring 4, Gua Musang

GEOLOGI DAN POTENSI GEOWARISAN KAWASAN FOSSIL DI ARING 4, GUA MUSANG, KELANTAN

ABSTRAK

Geowarisan digambarkan sebagai konsep kontemporari untuk pemuliharaan alam kerana nilai sejarahnya. Seperti yang diusulkan oleh McBriar (1995), geowarisan terdiri daripada pengedaran mineral, batuan, fosil, bentuk muka bumi dan ciri geomorfologi yang unik, yang menggambarkan pengaruh kekuatan bumi pada masa lalu dan masa kini. Penyelidikan ini dilakukan di Aring 4, Gua Musang, Kelantan. Penyelidikan ini dilakukan dengan pentafsiran peta geologi dan juga melibatkan data sekunder, yang mana data tersebut telah dikumpulkan oleh penyelidik sebelumnya di kawasan kajian. Data yang diperoleh akan diproses dalam perisian ArcGIS. Objektif penyelidikan ini adalah seperti berikut: 1) Untuk mengemas kini peta geologi dengan skala 1:25 000, 2) Untuk mengenal pasti potensi Aring 4, Gua Musang sebagai tapak geowarisan, dan 3) Untuk menilai nilai signifikan dalam beberapa aspek iaitu dengan penilaian kualitatif warisan paleontologi. Kaedah yang akan diterapkan selama melakukan penyelidikan adalah interpretasi peta menggunakan ArcGIS dan Model Data Elevasi (DEM), dan penilaian kualitatif potensi geowarisan berdasarkan parameter warisan yang memfokuskan pada kriteria paleontologi. Parameter akan diberikan skor peringkat, berdasarkan panduan penilaian pencirian geowarisan oleh Endere & Prado (2014). Dengan hasil interpretasi peta geologi, kawasan kajian didominasi oleh batu lumpur, dan diklasifikasikan menjadi dua unit iaitu batu lumpur bertuff dan batu lumpur berkarbon. Potensi geowarisan Aring 4 dianggap rendah, kerana kawasan ini hanya memperoleh skor keseluruhan 24.

Keyword: Geowarisan, Fosil, Warisan Palaeontologi, Aring 4, Gua Musang

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CHAPTER 1

INTRODUCTION

1.1 General Background

Geoheritage is described as a contemporary concept for conservation of the nature due to its historical value. As proposed by McBriar (1995), geoheritage comprises of minerals distribution, rocks, fossils, landforms and unique geomorphological features, which portrayed the effect of Earth forces during the past and the present. Dixon defines geoheritage as the natural geodiversity with significant values of scientific research, aesthetic, cultural, education and the sense of place experienced by the community (Geological World in Global Framework, 2005).

This research is conducted at Aring 4, Gua Musang, Kelantan. The research is done by the interpretation of geological map and also involves secondary data, which the data has been collected by the previous researchers in the study area. It also comprises some online sources such as journal article and government sources, which the data obtained will be processed in ArcGIS software.

On top of that, the study on geoheritage potential that will be carried out can contribute to the knowledge about the geological process which will be derived from the outcrops, fossil assemblage and landscapes. This approach can enhance the local and foreign tourists' interest to have more understanding on the Earth's process that affects the landforms and its surface. This can also become a part of education especially to the students who visit the site to learn about fossil physically.

In the meantime, Aring 4, Gua Musang has been chosen as the study area for geoheritage due to its occurrence of invertebrate fossils discovered at the area. Fossil is important as it is an indicator for the depositional environment, history and the Earth process. Generally, the living species that has become extinct is almost 99%, (Benton and Harper, 1993) which makes fossil as the remaining species left for the future as a heritage record.

1.2 Study Area

1.2.1 Location

The research area is carried out in the state of Kelantan, where it is located at Aring 4, Gua Musang, with coordinates of 4°52'15.47''N, 102°20'53.97''E as shown in Figure 1.1. The study area that will be covered is measured by $25km^2$. The area located is surrounded with oil palm plantation and the elevation has a range of 50m to 600m. Besides, the route of Felda Aring from Gua Musang is approximately 60km, which takes about 54min to reach the study area from Gua Musang.

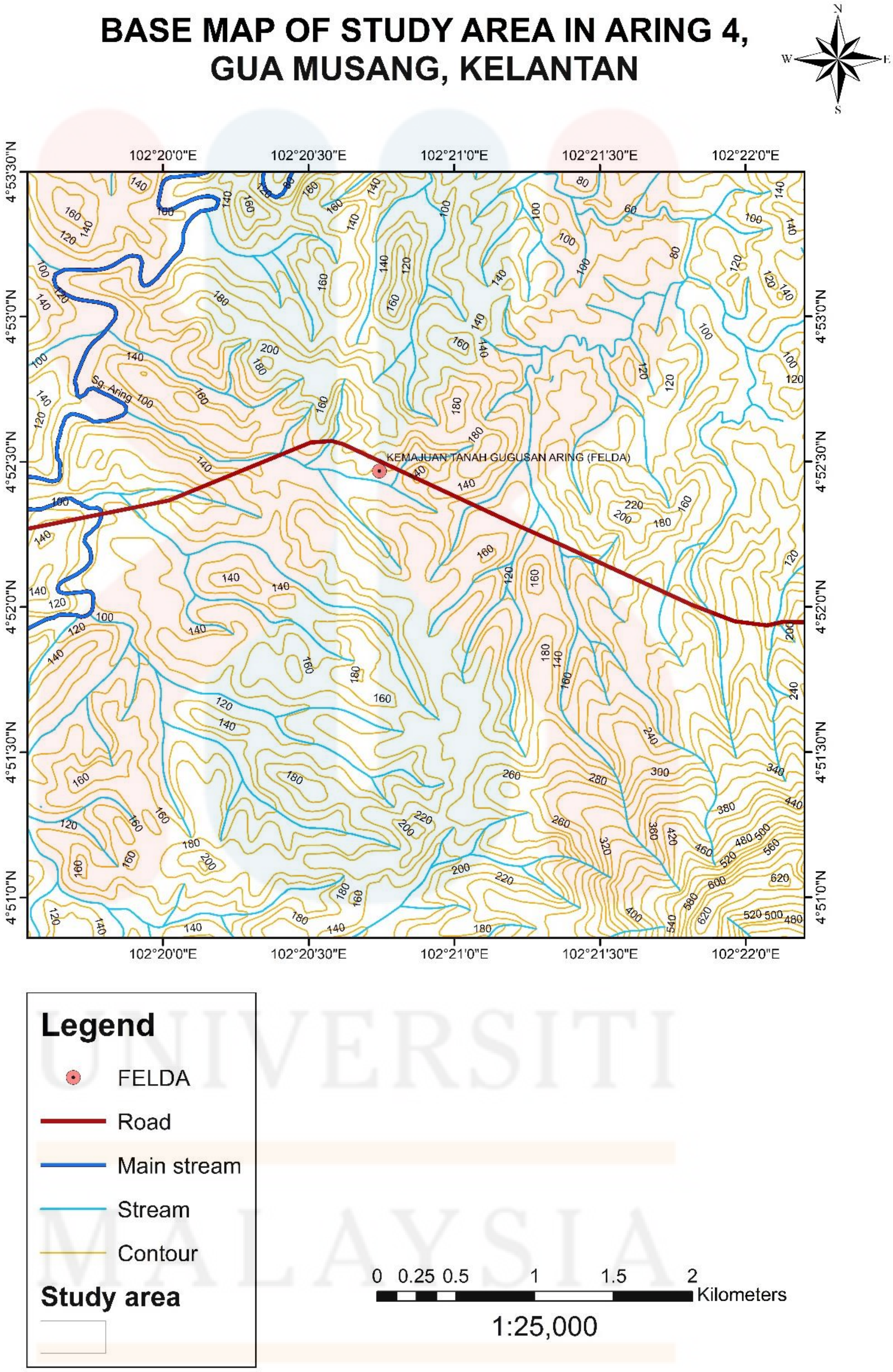


Figure 1.1: Base map of study area in Aring 4, Gua Musang. Kelantan

1.2.2 Accessibility

The study area can be easily accessed through two main highways which are East-West Highway and Gerik-Jeli Highway. The study area can also be accessed from through East-West Highway if travels from Kuala Berang to Chiku, which the road will pass Jalan Aring 8 and Jalan Aring 5.

1.2.3 Demography

Gua Musang is the largest district in Kelantan. It consists of various ethnic's population which are Malay, indigenous, Chinese, Indian and others group. The population ethnic is shown in Table 1.1. The population is also consisting of various age group, as shown in Table 1.2.

Table 1.1 Population of various ethnic in Gua Musang

Ethnic Group	Population
Malay and indigenous	76,823
Chinese	3,870
Indian	350
Others	161

Source: Department of Statistic Malaysia (2017)

Table 1.2 Age groups of population in Gua Musang

Age Group	Population
0-14	30,389
15-64	53,458
65 and above	2,342

Source: Department of Statistic Malaysia (2017)

1.2.4 Land use

Land use is influenced by the human activities, that had causes changes to the landform itself. In the study area, the land use is covered with oil palm plantation and rubber plantation. The plantation activity is managed by the government, which is under Felda Global Ventures Plantations (Malaysia) Sdn Bhd. Besides, based on the study area, mining activities are not visible, so there is just plantation that cover the study area, including forest.

1.2.5 Social Economic

KESEDAR and FELDA had played such important roles in developing the land for the benefit of economy. FELDA had developed several lands including Kemahang, Chiku 1, Chiku 2, Chiku 3, Chiku 4, Chiku 5, Chiku 7, Aring and Perasu. 84% of land developed by FELDA is mainly oil palm plantation, which is the main source of income for some communities who live in the area. 67% of developed area is built by KESEDAR, which mainly consists of rubber plantation.

1.3 Problem Statement

The problem that presents at this research area is the study area is still not clearly discovered about its potential to become a geoheritage site, even though the area has fossil distribution which is vulnerable to the threat such as the way the fossils are collected for the purpose of education.

1.4 Objective

1. To update a geological map with a scale of 1:25 000.
2. To identify the potential of Aring 4, Gua Musang as a geoheritage site.
3. To assess the significant values in several aspects which is by qualitative assessment of palaeontological heritage evaluations.

1.5 Scope of Study

This research will be focusing on the interpretation of geological map and the production of other thematic map as well that shows the types of rocks, geological structures and patterns by while conducting a geoheritage potential research towards the significant values that can be pointed out at Aring 4.

1.6 Significance of Study

Discovering the potential Aring 4 as geoheritage site is very important and meaningful, since the location has occurrence of fossils. This can also allow the tourists to develop their experience on geological aspects, since most people are very unaware with the importance of geological knowledge, including the characters of its heritage value.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This section will discuss on the topic of previous research that has been done by previous researchers, including the previous study on the geoheritage evaluation at the study area. The purpose of writing this section is to help the readers understand the particular study that is going to be carried out. The source of literature review is obtained by reviewing journal and research article.

2.2 Regional Geology and Tectonic Setting

The regional geology of Kelantan is primarily comprising of sedimentary and metasedimentary rock. On the western and eastern part, it is bounded by granite of the Main Range and Boundary Range. The regional geology of Kelantan is connected with regional geology of north Pahang, where it is a continuation with granite belts and the country rocks, as shown in Figure 2.1. Meanwhile in the western and central part of Kelantan, the belt elongates northward into the southern part of Thailand. However, at the eastern part of Kelantan, the coastal alluvium of Sungai Kelantan overlaid the Boundary Range Granite.

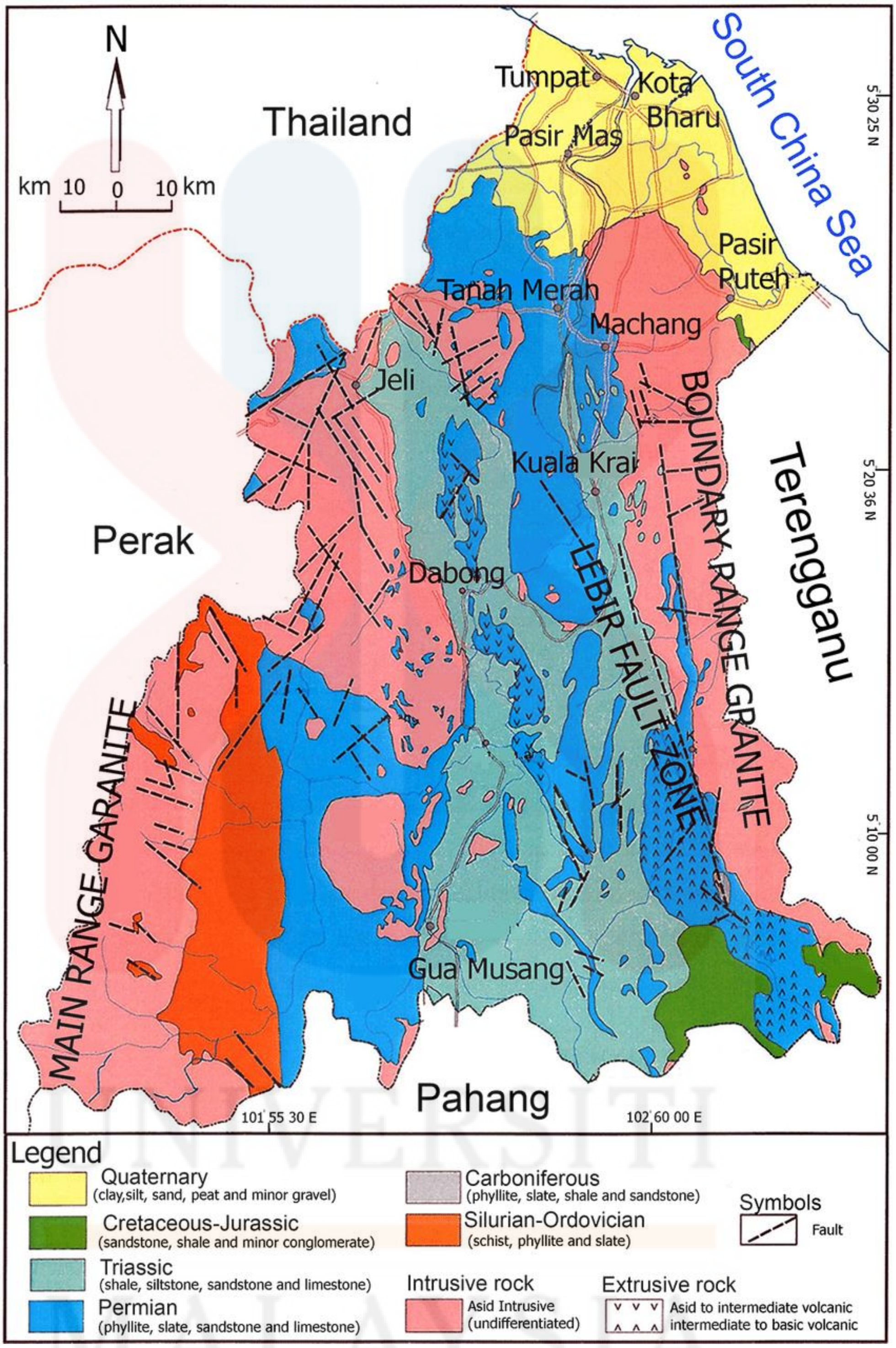


Figure 2.1 The geological map of Kelantan

(Source: Department of Minerals and Geoscience Malaysia, 2003)

In the state of Kelantan, the oldest rock formation that has been identified is during the Lower Palaeozoic age. This rock formation extends eastward, reaching to Sungai Nenggiri, where the foothills of the Main Range is bounded by the trending belt. Generally, the rocks that presents are mostly metapelites, and minor volcanic fragments, arenaceous and calcareous intercalations. As recorded by MacDonald (1967), there are also amphibolite and serpentinite can be found, but the occurrences are quite thin on the ground, which is minor to be discovered.

On the eastern part, it is dominantly distributed by volcanic-sedimentary rocks of Permian age, while on the central-north of Kelantan, it is dominated by the Taku Schist formation. This formation ages in Triassic, which comprises argillo-arenaceous sediments with interjected of volcanic and limestone (MacDonald, 1967).

2.3 Stratigraphy

2.3.1 Aring Formation

As proposed by Aw P.C (1976) Aring Formation is consisting of a sequence of predominantly pyroclastic, which are located in Sg. Lebir Valley, lower reaches of Sg. Aring and Sg. Relai in south Kelantan. The thickness of the formation is approximately 3000m, which consists of predominant pyroclastics, minor lavas and dolomitic marble and argillite. Moreover, a basal section has been identified by Aw, which is composed of dolomitic marble where tuff and calcareous argillite had lied on top of the marble. This dolomitic marble has a thickness of 270m.

An argillo-tuffaceous limestone unit formed the top layer of Aring Formation, with the thickness of 1000m. While major pyritiferous tuffs that has a fine to coarse texture cover the remaining part of the formation. There are also interbedded lavas that are composed of rhyolite to andesite, argillite and limestone. The rock sequence of

Aring Formation is similar to the Gua Musang Formation, where the sequence is dominantly calcareous-argillaceous sequence. Aring Formation formed during the period of Late Carboniferous to Early Triassic, which is indicated by the occurrence of foraminifera and bivalves.

2.3.2 Nilam Marble Formation

The Nilam Marble Formation is named by the Sungai Nilam, which has the age of Middle Permian to Late Triassic. This formation is however does not overlaid by any formation, which makes the bottom and top boundary are unexposed. The correlation of Nilam Marble Formation with Aring Formation and Telong Formation is derived, where the lower part of Nilam Marble Formation has the same age and origin as the Aring Formation, while the upper part is same to the Telong Formation.

As discussed by Aw (1990) on the occurrence of argillite-volcanic-carbonate in Permian-Triassic, the rock that is dominantly formed in this formation is metamorphosed limestone, there is distribution of calcitic marble interbedded with tuff and argillites. Meanwhile, the argillaceous facies such as shale, mudstone, siltstone, slate and phyllite only presents as interbeds or lenses in Nilam Marble Formation. The thickness of interbedded calcite marble with tuff and argillites is about 600m.

2.3.3 Telong Formation

Telong Formation is defined by Aw (1990), which is the sequence of rocks that is mainly consists of argillite, low-grade metasedimentary and meta-volcanic rocks. In Kelantan, the distribution of this formation is discovered in Kampung Legeh, and broaden eastwards to Tanah Merah. The age of this formation is believed to be Permian to Late Triassic.

As mapped by Ab. Halim Hamzah and Mustafar Hamzah during early 80's, four facies have been differentiated which are argillaceous, arenaceous, calcareous and volcanic facies. The colour that appears on these argillaceous facies is greenish to reddish grey, and to black slate, phyllite, hornfels and schists. There is abundance of pyrite that can be identified in carbonaceous rocks.

2.3.4 Gua Musang Formation

As proposed by Yin (1965), located in Gua Musang area, there is a predominant argillaceous and calcareous sequence interbedded with volcanic and arenaceous rocks. The colour of shale here is usually grey but it also appears in another colour which is black when it happens to be carbonaceous. Metaquartzites are commonly found in sandstones, including greywacke, protoquartzites and orthoquartzites. Meanwhile, the composition of volcanic rock in Gua Musang Formation is vary from rhyolitic to andesitic. This also happens to tuff, lavas, and agglomerates. This rock unit broadens to northern part of Kelantan and southwards to north Pahang. The period of Middle Permian to Middle Triassic is indicated by the existence of fossils such as ammonoids and pelecypods. Besides, the predominantly pyroclastic makes Gua Musang Formation similar to Aring Formation. The thickness of the formation is about 650m.

2.4 Structural Geology

In the Central Belt where Kelantan state is located, it consists of a major fault that trends north-south. It has also been discussed that some of the faults elongates into Thailand. In the western part, there is a presence of major fault of Karak-Kelau that trends north-south (Tija, 1972). At the north, there is Lebir Fault that go after the Lebir Valley, which the structure is developed during pre-late Triassic.

2.5 Historical Geology

The Aring area has abundance of fossil, which mainly from Triassic fossil that can be found in the Central Belt of Peninsular Malaysia. In Aring, the Triassic age of ammonoids has been recorded, which is written in report by Sato (1964). The age of rock formation during Triassic is determined by the index fossils. The age of the fossils is mostly Middle Triassic, and has been discovered within mudstone of Telong Formation. As reported by Ishibashi (1975), four species of ammonoids that have been identified are Halilucites cf. ornatus, Pseudoaplococeras sp., Frechites? sp. and Acrochordiceras (Paracrochordiceras) cf. anodosum which ages of Anisian (Middle Triassic and Hoplotropites aff. auctus of Carnian (Late Triassic)

2.6 Geoheritage

Geographically, geoheritage is focusing on the essential aspects which are in the perspective of geology and geomorphology. Nowadays, geoheritage is very important for the purpose of local cultural, natural resource management, land management, research, education and tourism (Brocx, 2007). In promoting geoheritage sites to the public, various international and intra-national bodies had collaborated on the idea of potential, conservation, collaboration with universities and governmental initiatives.

As described by the international literature, geoheritage is related with mineral and fossil sites, which explains the Earth process and the environment. In Malaysia, fossils are quite rare to be found in most rocks (Lee, 1992). Table 2.1 shows different states of Malaysia that has selected areas for fossil conservation (Lee, 1992). The fossils are commonly found are small invertebrates, including trace fossils that indicates the movement and activity of animals in the past. In the meantime, fossils can be found in mostly unmetamorphosed sedimentary rocks. These rocks are such sandstone, mudstone, siltstones, limestone or shale.

In Aring area, the fossil sites are mainly located along the road, which is along the connection of Gua Musang town and Kuala Berang. The fossil sites are located along the roadcuts, which is surrounded by area of plantation. The fossils distribution that are dominant are ammonoids, bivalves and gastropods.

Table 2.1 Selected areas for fossil conservation in different states of Malaysia (Lee, 1992)

STATE	FOSSIL AREA
Johor	Gunung Sumalayang - Gunung Belumut area
Perlis	Hutan Haji area, South Kangar
	6.8 km Wang Kelian to Kaki Bukit Road, North Perlis
	Bukit Temiang
Kedah	Pulau Langgun, Langkawi
	Merdeka Waterfall, Gurun Quarry, Gunung Jerai
	Bukit Hantu, Kodiang
Perak	Kampar area
Terengganu	Bukit Bucu, Batu Rakit
	Pasir Kechil, Pulau Redang
	Tanjung Mat Amin, Chukai
Selangor	Batu Arang
Pahang	Bukit Charas, Panching
	Jengka Pass
	Golden Bricks Factory, Lanchang
	Bukit Kepayang, JKR Quarry, Kampong Awah
	Sungai Kenong, Kuala Lipis
Sabah	Gomantong
	Sungai Palangan and Sungai Sapulut
	Middle Malubuk area
	Madai-Baturong
Sarawak	Bau
	Kampong Krusin, Mongkos Road
	Mile 19, Kuching - Serian Road, Siburan
	Gunung Selabor, Terbat
	Gunung Subis, Niah
	Batu Gading, near Long Lama on the Baram

Table 2.2 The assessment value and description for geoheritage (Komoo, 2003)

Value	Description	Depiction
Outstanding	The uniqueness in scientific record, geological features, landform features, significant distribution or ecological purpose.	Geotope
High	The rarity in scientific record, geological features, landform features, significant distribution or ecological purpose.	Geosite
Medium	Consists of important scientific record and acceptable for the purpose of education and research activity.	Significant geological site
Low	Consists of useful scientific record that develops knowledge and acceptable for research purposes.	Geological site

2.6.1 Geoconservation

According to Semeniuk (1996) and Semeniuk & Semeniuk (2001), geoconservation is the preservation of the significance of geoheritage based on the features of Earth Science, for the benefit of heritage, science and education. Geoconservation has to do with the protection of important site, which includes geoheritage evaluation in order to conserve the important site. Although conserving the significance of geoheritage site is one of the main deals for geoconservation, however it also involves the environmental management such as geohazard, sustainability and natural heritage, as it is associated with biodiversity and ecosystem.

2.6.2 Geodiversity

Geodiversity is the combination of geological and geomorphological diversity, which comprises of geological such as fossil, rocks and minerals, and also geomorphological such as landform and its processes, and the feature of soils. As recorded by Gray (2004), it is associated with their assemblage, properties, interpretation and systems. These varieties of fossils, minerals, soils and landform are important as they act as a life marker that provide evidence, which explains the geological setting, processes, geomorphology, soils, climate and surface water (Postgate, 1994). The value of geoheritage can be appreciated, if the geodiversity is properly developed by the human societies. For instance, fossils assemblage provides the understanding towards the geological environment that has changed over time.

According to Sharples (1995), the term of geodiversity is made and had been replaced the term geoheritage. It is followed after the term of geoconservation has been introduced, which defines the geological features preservation for the sake of values in intrinsic, ecological and geoheritage. However according to Brocx & Semeniuk (2007), geodiversity and geoheritage both embrace different meaning, since geodiversity is associated with the diversity while geoheritage is associated with the heritage. Both geodiversity and geoheritage have different specific concept, thus the term is not being simply replaced.

2.6.3 Geology Scope in Geoheritage

As discussed by Brocx & Semeniuk (2007), the concept of geoheritage and geoconservation have a relationship with geology, thus it will be beneficial to explore the science of geology. This will expose to the relationship between geology towards the geoheritage and geoconservation.

Geology is comprised of scientific discipline, which all are included with igneous geology, sedimentary geology, metamorphic geology, petrology, structural geology, palaeontology, mineralogy, geomorphology, paedology, sedimentology and hydrology (Bates & Jackson, 1987). These significant disciplines that covers under the field of geology are essential, where they explained the tectonics evolution, mountain building and landscape evolution. They also include the process that happened on the Earth surface such as weathering, erosion and sedimentation, which are influenced by water, wind and ice. The scale is also involved diagenesis, crystal defects and mineral deformation where these have been undergone with alteration (Wilson, 1954).

As described by Semeniuk & Semeniuk (2001), in order to identify the scope of geology that has to do with geoheritage features, the identification of geological features that lies under geoheritage is essential. The geological features are comprised with type of rocks itself, such as igneous, metamorphic and sedimentary rock. It also includes the location of mineral, fossil, and stratigraphic type.

2.6.4 Geoheritage Assessment Values

As proposed by Gray (2004), there are different approaches on the values based on the analysis and discussion, which explained the importance of geodiversity. The values that are included in the geoheritage assessment are such scientific value, cultural value, aesthetic value, economic value, and educational value.

Scientific value is identified based on the understanding of the process or evolution that presents in the area. Scientific value is very important as it represents, the process, uniqueness and palaeogeographical significance for a better understanding on the geological event occurred during the past.

Cultural value, aesthetical value, economic value and educational value are considered as the additional values. For the cultural value, it is related with the archaeological or historical features that is found in the area. As analysed by Piacente (2005), together with Panizza and Piacente (2005), cultural value is important as it has connection that explained the geological, geomorphological features and processes in the area.

As for the aesthetical value, it is the assessment towards the features of contrast in colour, space structure or heterogeneity of the site. As discussed by Reynard et al, (2003), Pralong and Reynard (2003) along with Panizza and Piacente (2008), the economic value is associated with its potential for the site to be utilized and recognized as geotourism site. Table 2.3 shows the assessment on geoheritage based on significant values that are suggested by Zouros (2007).

Table 2.3 The assessment on geoheritage based on significant values (Zouros, 2007)

Significant value	**Criteria**
Scientific and educational value	Integrity
	Representativeness
	Rarity
	Exemplarity
Geodiversity value	The number of phenomena in the area
Ecological and aesthetical value	The presence of natural heritage sites or nature reserves
Cultural value	The presence of cultural heritage sites
Potential threats and protection need	A legal protection
	Vulnerability
Potential for utilization	Recognizable
	Geographical distribution
	Accessibility
	Economy

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

The methods that will be applied during conducting the research is map interpretation and the assessment of geoheritage potential based on significant values. This involves secondary data, which are essentially obtained from journal article, thesis writing and agencies. In conducting geological map interpretation, the methodology comprises data collection, data processing and data analysis, while the study of geoheritage potential of Aring 4 comprises the assessment of paleontological parameter which are palaeontological, geological, contextual, integrity, sociocultural and socioeconomical.

3.2 Materials

a) ArcGIS software

ArcGIS software is used to process the data and produce a geological map including topography map, structural map and cross-sectional map.

b) Secondary Data

I. Topography map

Topography map is used to for study area that shows elevation of contour and also geographic features such as main roads, rivers and stream as an overview of the terrain.

II. Digital Elevation Model (DEM)

DEM is a digital model that shows the surface elevation of a land, based on the topography.

3.3 Methodology

In methodology section, it focuses on the detailed ways and explanation on how the research will be conducted in order to obtain the results. This section is written to propose the understanding, efficient and acceptable procedure in approaching the research problem. It comprises preliminary studies, data preparation, data collection, data processing, data analysis and interpretation and report writing.

Geological map interpretation is essential in identifying the rock distribution, including the structures that presents at the area such as faults, folds and joints. Thus, a base map needs to be produced by using ArcGIS software, so the features can be seen geographically such as contours elevation, roads, rivers and streams. Regional geological map is studied, since it provides information as an overview on the significant rocks that can be interpreted in the map.

Besides, a topography map is produced as some information can also be gathered such as the presence of forest and the identification of lineament. By studying the contour lines that refers to the elevation, the surface of the land whether it is slope or flat surface can be determined. Structural map is also produced as it is crucial to show the geological structures that present in the study area such as faults, folds and lineaments. When the map is processed, it can be interpreted whether there is any crustal movement that has caused the reshape of the terrain. A scale of 1:25 000 has been made for the study area, so it will be the only covered area in identifying geological structures, types of rocks and the availability of fossil distribution.

Geological interpretation is done by using remote sensing, which the data are obtained from satellite and aerial remote sensing. Since the Aring 4 area is mainly consists of plantation, the geological interpretation can be quite difficult due to the vegetation, and also the thick soil that are mostly had weathered. This weathered soil will inhibit the spectral information towards the rock unit that would like to be identified. The interpretation is based on some values which comprises tone, shape, size, texture, and pattern, which contributes to the identification of geological features by the help of satellite imagery. The interpretation is also including drainage pattern, landform, and vegetation.

In determining terrain attributes such as elevation and slope, a Digital Elevation Model (DEM) data is used. DEM is used to as to appear in the form of 3D model of terrain's surface. This data can also extract terrain features such as drainage basin, so the collection of water into the river can be identified. Besides, DEM data is also being applied in ArcgGIS software in order to interpret the landform visible in the study area, whether there is hilly area or low land. DEM data is important as it helps in the interpretation of regional map and lithological distribution of the study area.

In the specification section, the determination of geoheritage potential of the study area is done by conducting qualitative assessment. In qualitative assessment, it is determined by the heritage parameters which are focusing on the paleontological criteria. The parameters will be given ranking score, based on the geoheritage characterization assessment guide by Endere & Prado (2014).

3.3.1 Preliminary Studies

Preliminary studies are essential, which will easier the researcher to understand the geology of the study area. Literature review is done by understanding the data collection that is done by the previous researchers, so an overview of any geological features that present in the study area can be understood.

3.3.2 Data Preparation

The preparation of data is the creation of base map before conducting the interpretation of geological map. The base map is the overview of the study area as it shows elevation contour, river, stream and main road.

3.3.3 Data Collection

The data collection involves secondary data, where the DEM data is collected from USGS website, while the other data are obtained by reviewing journal article and questionnaires. For geoheritage specification, the data is collected by obtaining from secondary data.

3.3.4 Data Processing

Once the data has been collected, they will be processed by using ArcGIS software. DEM data is also included in data processing. This is to ensure that a geological map can be produced. In geoheritage assessment, elevation class, viewshed map and fossil localities map are generated by using ArcGIS.

3.3.5 Data Analysis and Interpretation

The data that has been collected and processed will be analysed and interpreted. The geological map that has been produced is interpreted, by identifying the geological structures such as fault, fold and lineament that are available in the map. The types of rocks and its distribution in the study area is also can be interpreted based on the map that has been processed and produced.

For geoheritage specification, based on the data collected from secondary data, the evaluation of potential geoheritage is by qualitative analysis, which is the characterization based on 6 criteria proposed by Endere & Prado (2014). The criteria suggested are palaeontological, geological, contextual, integrity, sociocultural and socieconomical. Each criterion is determined based on the value, which zero represents the lowest value, and the increasing number represents the increasing value. By summing up all the values obtained, the scores must have a total of 25 and above to be considered as having a potential to become a geoheritage site (Endere & Prado 2014).

Table 3.1 Parameters used for palaeontological heritage assessment (Endere & Prado, 2014)

Parameter		Grades	Score
Palaeontological	Nature of fossil	Lack of scientific significance	1
		Moderate scientific significance	2
		High scientific significance	3
	Preservation	Poor or fragmental fossils	0
		Good preservation, complete fossils	1
		Exceptional preservation, articulate specimens	2
	Diversity of fossils	Low	0
		Medium	1
		High	2
	Localities type	None	0
		One species	1
		Two or more species	2
	Taphonomy	Common stratified localities	0
		High taphonomic value	1
		Exceptional taphonomic value	2
Geological	Geological significance	Local	1
		Regional	2
		National	3
		International	4
	Geological integrity	Extensive site	0
		Limited site	1
		Integrity site	2
	Scientific potential	Poor	0
		Fair	1
		Good	2
		Excellent	3

Contextual	Context	Low: Groups having little scientific or public value; consist of partial remnants of associated set of features	0
		Moderate: Groups having moderate scientific or public value; consist of partly intact of associated set of features	1
		High: Groups having exceptional scientific or public value; characterized by a large intact and associated set of features	2
	Visual contribution to landscape	Low: Barely visible on the ground	1
		Medium: Only visible at close view	2
		High: Clearly visible from some distance	3
		Iconic: Stands out monumentally in the landscape	4
	Association with archaeological remains	Not associated with other heritage	0
		Associated with an archaeological site	1
		Associated with more than one archaeological site	2
Integrity	Geographic situation	Too small that prevents the development of infrastructure	0
		Moderate and has possibility for infrastructures development	1
		Extensive and has complementary infrastructures and domestic routes	2
	Vulnerability	Less vulnerable	0
		May vulnerable to fossil collecting	1
		Very vulnerable to fossil collecting	2

Sociocultural	Historical	None	0
		Local	1
		Regional	2
		National	3
		International	4
	Educational	Poor	0
		Fair	1
		Moderate	2
		Excellent	3
	Touristic	Lack of tourist interest	0
		Has accessibility and connection even though there is no infrastructure	1
		Filled requirements and enough infrastructure	2
	Complementary	None	0
		Possibility of association with heritage value such as geological or archaeological	1
		Near to other heritage sites such as national park	2
	Community	Unfamiliar by the local	0
		Slightly known by the local	1
		Moderate: Has association with the local	2
		Good: Has significant value for the local	3
		High: Has significant value for regional or national community	4

Socioeconomic	Urban value	No potential of preservation	0
		Low potential for preservation	1
		Has potential for field museum development	2
	Mineral value	None	0
		Fossil found in abandoned mines	1
		Fossil found in mineral exploitation	2
	Public	None	0
		May have potential for heritage assist	1
		Potential for heritage assist, building an interpretation centre	2

3.3.6 Report Writing

Report writing is done as the final task, where all the data collected by using secondary data will be discussed in detailed in the form of writing.

RESEARCH FLOWCHART

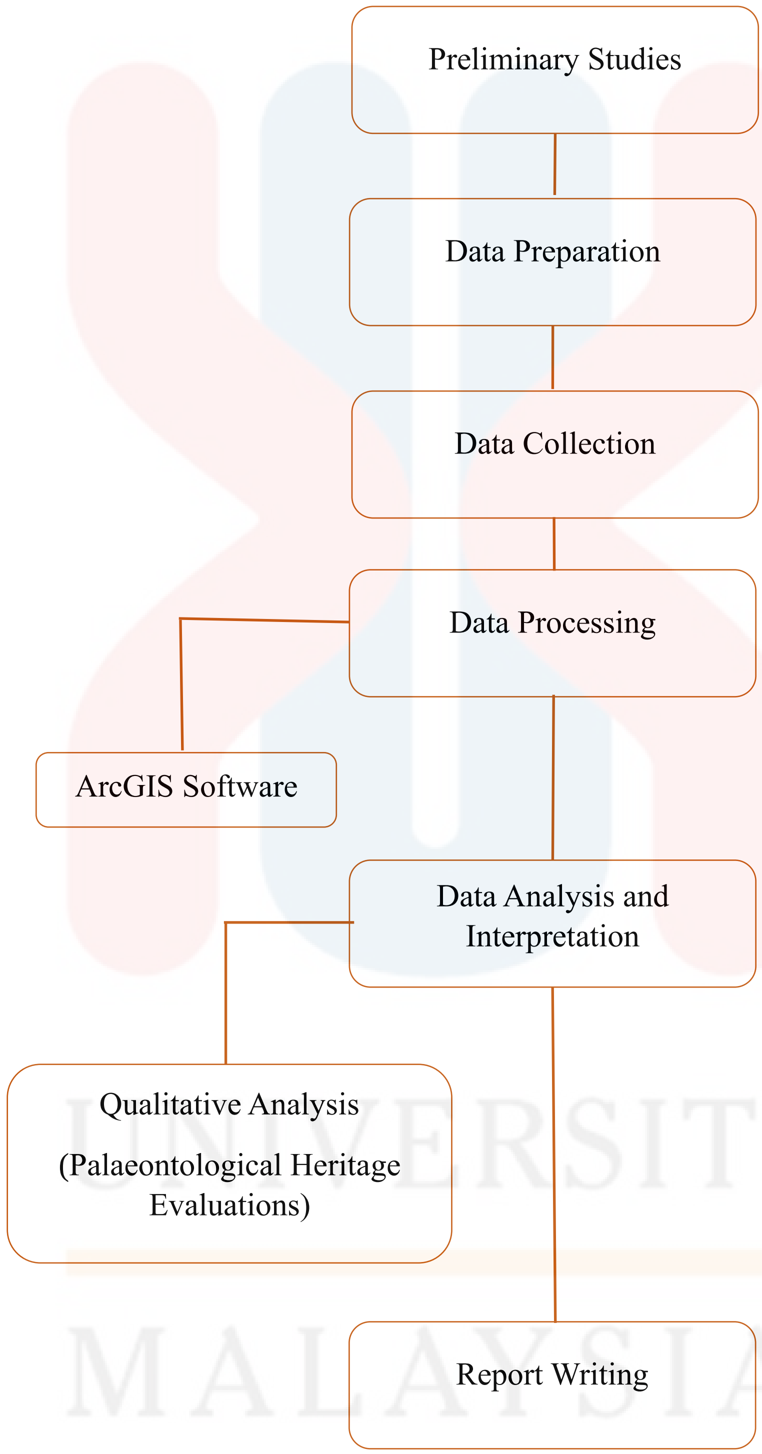


Figure 3.1: Flowchart of conducting research

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter will be discussing about the general geology of the study area. The important sections that will be further explained in general geology are geomorphology, lithostratigraphy, structural geology and historical geology. These are explained based on the interpretation of geological map, including secondary data obtained.

4.1.1 Accessibility

The study area can be accessed easily, which is by the main road that connect Gua Musang and Kuala Berang, as shown in Figure 4.1. It can also be accessed through the road junction, which connects Aring 4 and Aring 5 from the south, including Aring 4 and Aring 6 from the north, as shown in Figure 4.2

Figure 4.1: The main road that connects Gua Musang to Kuala Berang in Aring

(Source: Google Maps)

Figure 4.2: Road junction in Aring 4 which connects to Aring 5 (to the left) and Aring 6 (to the right)

(Source: Google Maps)

4.1.2 Settlement

There is no housing area nor a community that reside the study area. The study area is majorly occupied with forest and palm plantation, including rubber plantation that is just minorly inhabit the area. This agriculture development lies under the Kemajuan Tanah Gugusan Aring (FELDA).

4.1.2 Forestry

Forestry is the utilization of land whether they have been used, managed and conserved for the benefits of environment and economy. The study area is dominantly covered by oil palm plantation of Ladang Aring 4 which makes about 80% while the reserve forest covers about 20% at the south-east of the study area. The oil palm plantation is developed by FGV Holdings Berhad, and it is operated and managed by FGVPM Aring 2 and FGVPM Aring 3 located at the north-east nearby the study area. The land use map explains the location of oil palm plantation and the reserve forests in the study area, as shown in Figure 4.3.

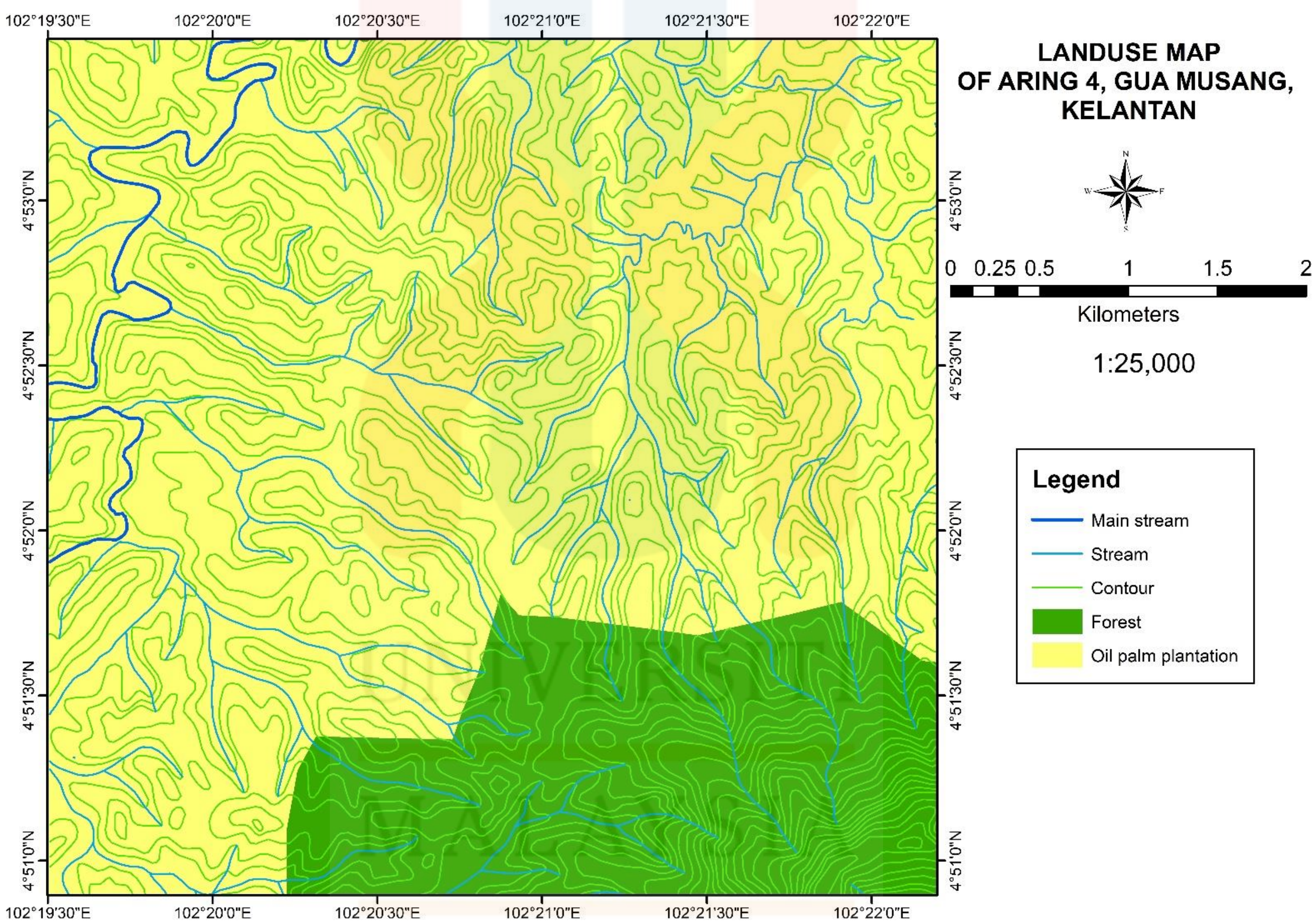


Figure 4.3: Land use map of Aring 4, Gua Musang, Kelantan

4.2 Geomorphology

The understanding of geomorphology is important as it explains the processes that caused a significant formation and sediments that deposited at a particular area. The factors that lead to landform are erosion, deposition and weathering, which the agents that influence the shape of landform are such moving water, air, and ice. The geomorphic process takes a long period of time, and it can also give the ideas on the determination of past climate change that occurred at the area.

4.2.1 Geomorphologic Classification

The physical features of the study area are described in a topography map, as shown in Figure 4.4. The elevation changes are featured in topography map, which is represented by the contour lines. The lowest elevation is 60m while the highest elevation is 620m. The topography of the study area is influenced by weathering process, erosion and deposition of sediments.

The landscape unit classification on the geomorphology of the study area is determined by using Van Zuidam classification, as shown in Table 4.1. This classification is commonly used by researchers for a medium scale map which is 1:25,000. In the study area, there are three types of landforms can be classified which are undulating hills, hilly and mountainous. Based on the elevation of the study area, the undulating hills is at the elevation of 60m to 200m, the hilly is at 200m to 300m and mountainous at 350m to 620m, as displayed in geomorphology map in Figure 4.5.

Table 4.1 Van Zuidam Classification

SLOPE (%)	UNIT MORPHOLOGY
0-2	Plain
3-7	Gentle slope
8-13	Wavy slope
14-20	Hilly
21-55	Mountainous
55-140	Steep mountainous
>140	Very steep mountainous

(Source: Listyani, 2019)

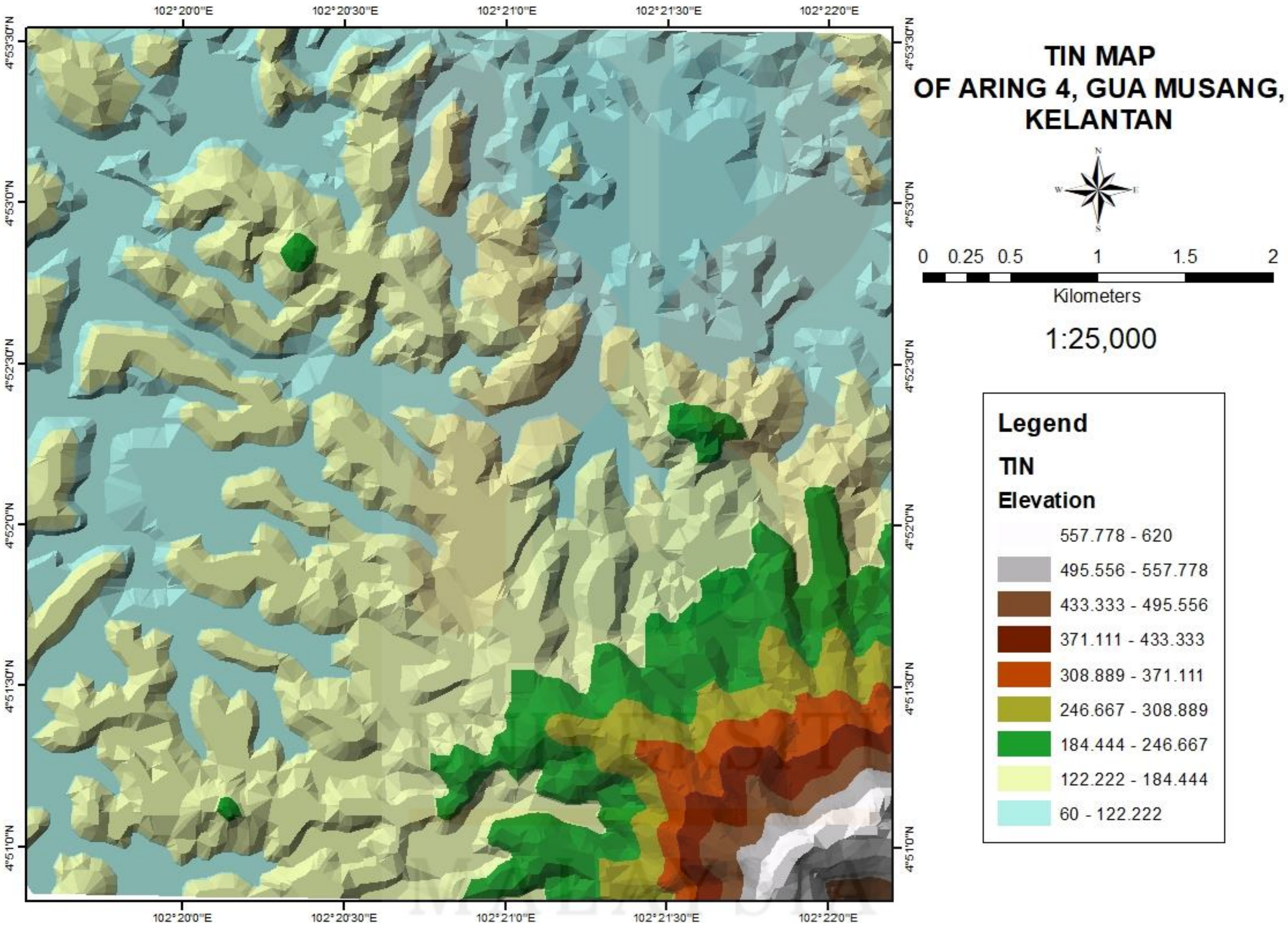


Figure 4.4: TIN Map of Aring 4, Gua Musang, Kelantan

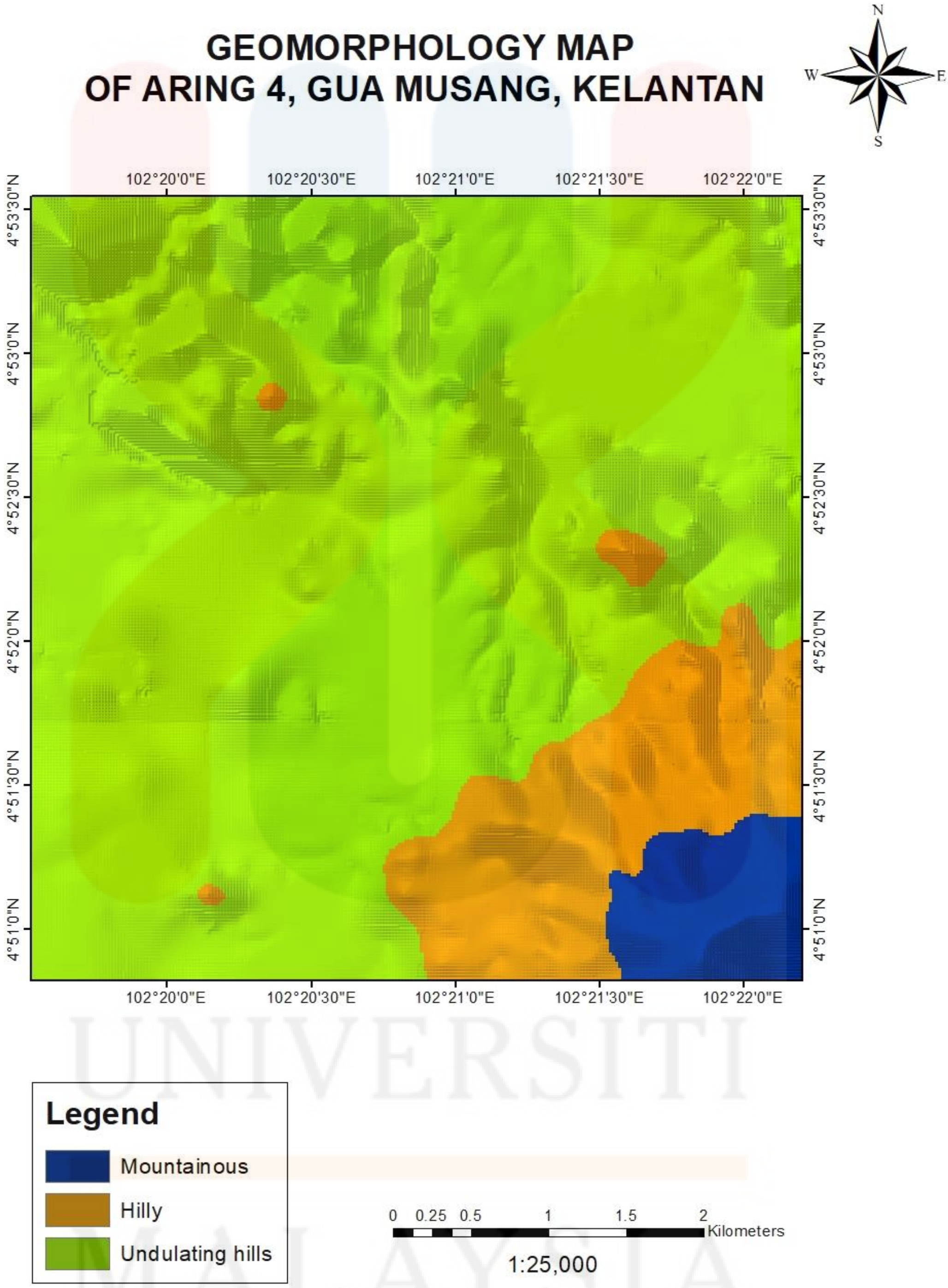


Figure 4.5: Geomorphology map of Aring 4, Gua Musang, Kelantan

4.2.3 Drainage Pattern

The analysis of drainage pattern can be used in interpreting structural occurrence as it provides information on the structural features, whether it is exposed on the surface or buried beneath the rock. Drainage pattern is the pattern that is formed by stream erosion, which resulted in the specific characteristics of rocks and structures that occur in the area.

There are two types of drainage pattern described by Zernitz (1932), which are basic pattern and modified basic pattern. The examples of basic patterns are dendritic, parallel, rectangular, radial, trellis and annular, as shown in Figure 4.6. This formation of basic structures is influenced by the regional structure. Modified basic pattern is the pattern that originated from basic pattern but has slightly change, such as the formation of small parallel tributaries in the pinnate-dendritic pattern.

In the study area, there are two types of drainage pattern that can be classified which are dendritic pattern and rectangular pattern. Based on the designed pattern, dendritic is easily classified as it appears in a branching pattern of tree roots. Meanwhile, rectangular pattern is formed where the area has undergone faulting, so the small streams bend and enter the main stream at high angle. It is a result of structural joints and faults in bedrock. The drainage pattern in the study area is described as in Figure 4.7.

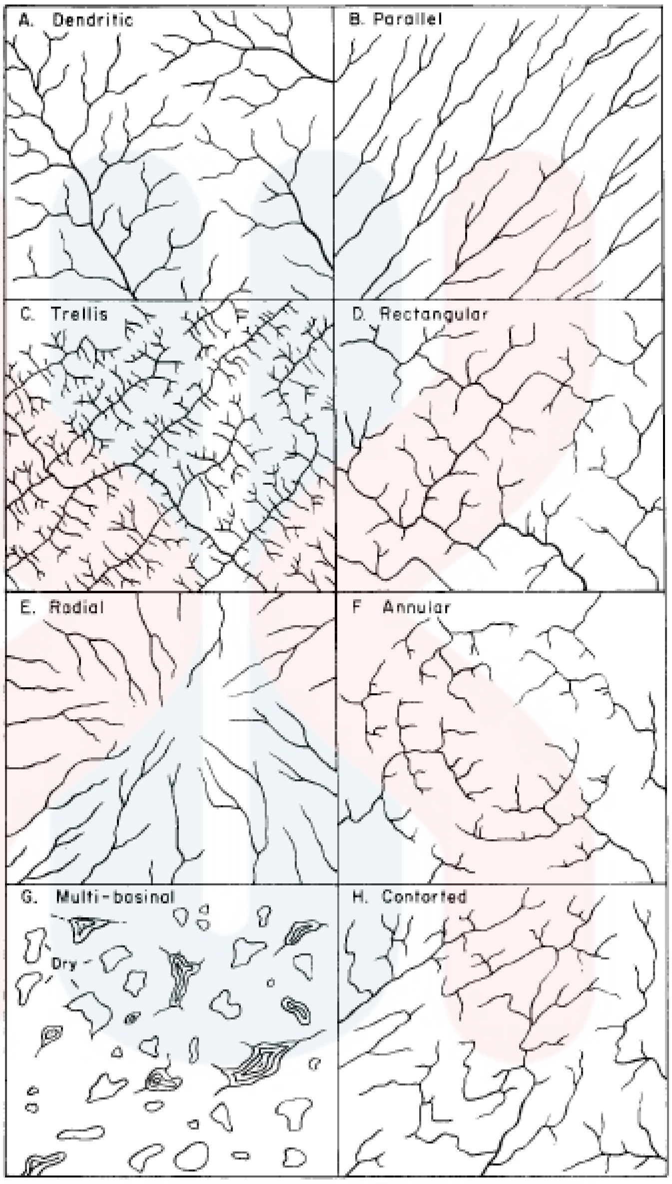


Figure 4.6: Examples of drainage patterns

(Source: Howard A.D, 1967)

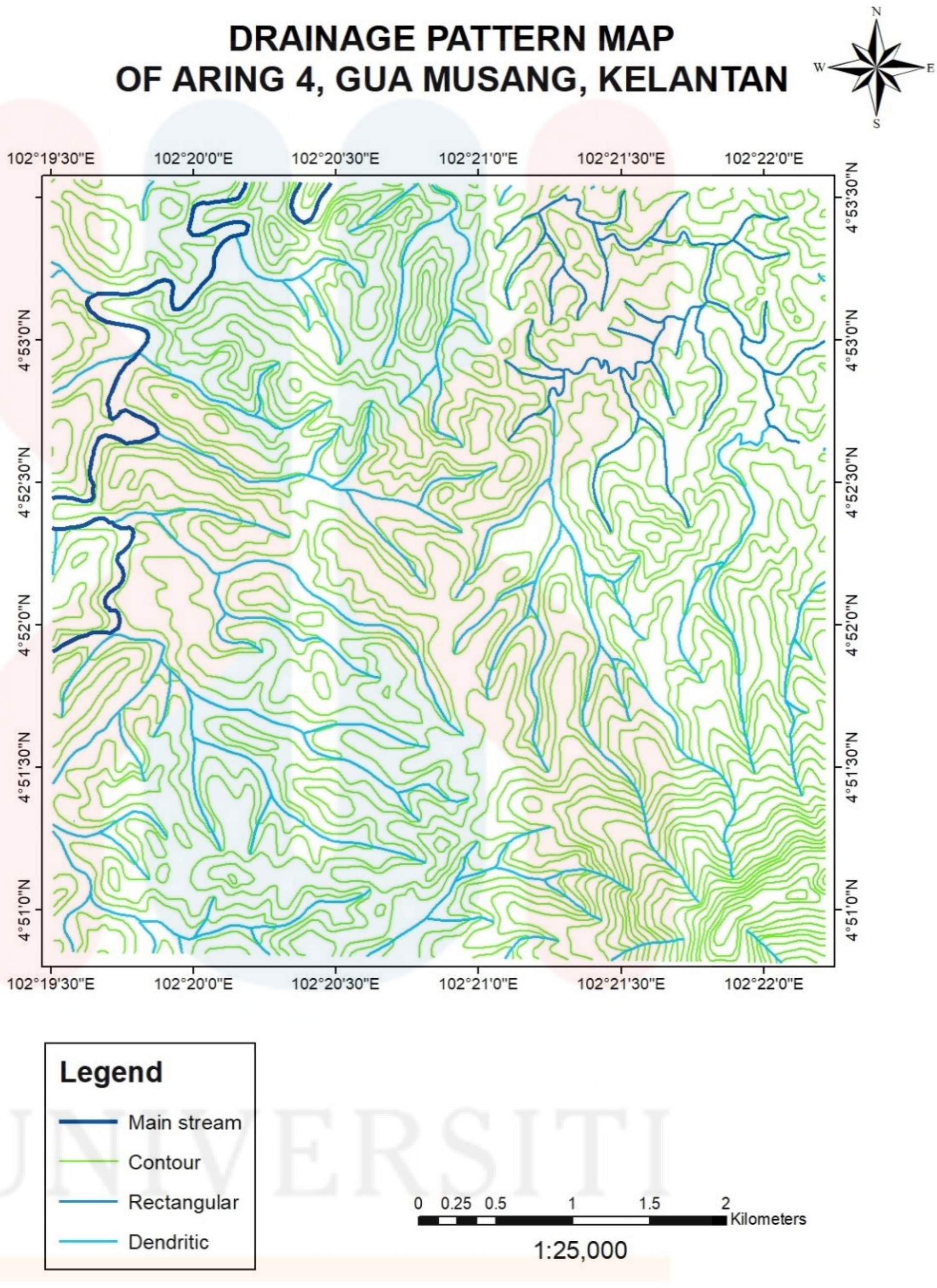


Figure 4.7: Drainage pattern of Aring 4, Gua Musang, Kelantan

4.3 Lithostratigraphy

Lithostratigraphic unit is the body of rocks which is defined based on its lithologic properties and stratigraphic relations, which consists of igneous, sedimentary or metamorphic rocks (Salvador, 1994). Stratigraphic unit is the bodies of rocks which is classified based on the distinct properties possessed by the rocks. It is important in geological studies as it helps to understand the sequence of events in the history of the Earth. Lithostratigraphy is consist of sediment or rock strata that is classified based on the lithology such as colour, texture, grain size and composition (Henrich, 2015).

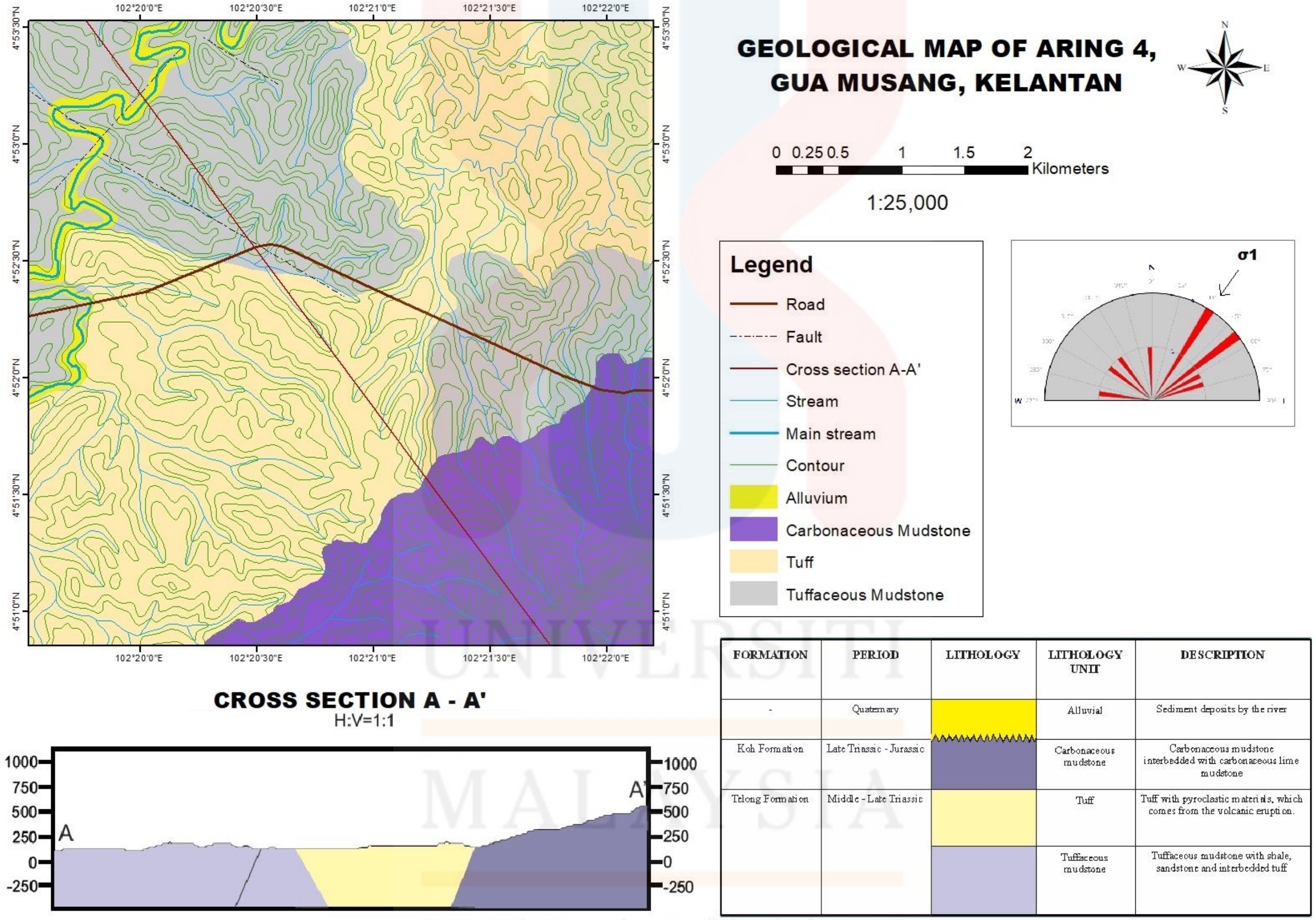
4.3.1 Stratigraphic Position

The stratigraphic unit of the study area is ordered according to the law of superposition, which defines that the oldest rocks will be on the bottom while the youngest rocks will be at the top layer. In the stratigraphic column featured in Table 4.2, the geologic sequence is explained, which the lithology unit has been ordered from the oldest at the bottom to the youngest at the top.

There are two formations that has been determined in the study area which are Telong Formation and Koh Formation. The age of Telong Formation is remarked as Middle to Late Triassic, while the Koh Formation is remarked as Late Triassic to Jurassic. According to Aw P.C (1972), Telong Formation is described as having dominant argillite associated with some tuffs located along the area of Sg. Aring. Koh Formation is described as a sequence that consists of mudstone that interbedded with the argillaceous limestone.

Table 4.2 Stratigraphic column of the study area

FORMATION	PERIOD	LITHOLOGY	LITHOLOGY UNIT	DESCRIPTION
-	Quaternary		Alluvial	Sediment deposits by the river
Koh Formation	Late Triassic - Jurassic		Carbonaceous mudstone	Carbonaceous mudstone interbedded with carbonaceous lime mudstone
Telong Formation	Middle - Late Triassic		Tuff	Tuff with pyroclastic materials, which comes from the volcanic eruption.
			Tuffaceous mudstone	Tuffaceous mudstone with shale, sandstone and interbedded tuff



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Telong Formation	Middle - Late Triassic		Tuff	Tuff with pyroclastic materials, which comes from the volcanic eruption.
			Tuffaceous mudstone	Tuffaceous mudstone with shale, sandstone and interbedded tuff

Figure 4.8: Geological map of Aring 4, Gua Musang, Kelantan

4.3.2 Unit Explanation

a. Tuffaceous Mudstone

Mudstone is a fine-grained sedimentary rock which is composed of clay, silt-size particles which is less than 0.063mm. Generally, the shape of particles in mudstone is angular. This is because it has been altered by sediment transport and erosion, thus mostly clay minerals in the mudstone has a very low sphericity. According to Mohamad Khalim N.S (2018), the study area is dominantly consisting of mudstone. The mudstone unit dominates about 60% of the study area, which mainly has been discovered along Sg. Aring, along the road cutting located at the main road of the study area, and some parts of Ladang Aring 4 including the reserve forest. The mudstone unit that has been discovered are well-bedded mudstone as shown in Figure 4.9, and tuffaceous mudstone in Figure 4.10.

Figure 4.9: Well-bedded mudstone discovered along Sg. Aring

(Source: Mohamad Khalim N.S., 2018)

Figure 4.10: Tuff (pinkish colour) interbedded in mudstone

(Source: Mohamad Khalim N.S., 2018)

Tuffaceous mudstone is also been discovered along the main road of the study area, which has been exposed by the road cutting, as shown in Figure 4.11. According to the previous researcher, the well-condition outcrop has a minor impact of weathering, but still preserves the sedimentary structures on the surface of the mudstone. The tuffaceous mudstone at the area is said to be brittle and easily broken into small pieces.

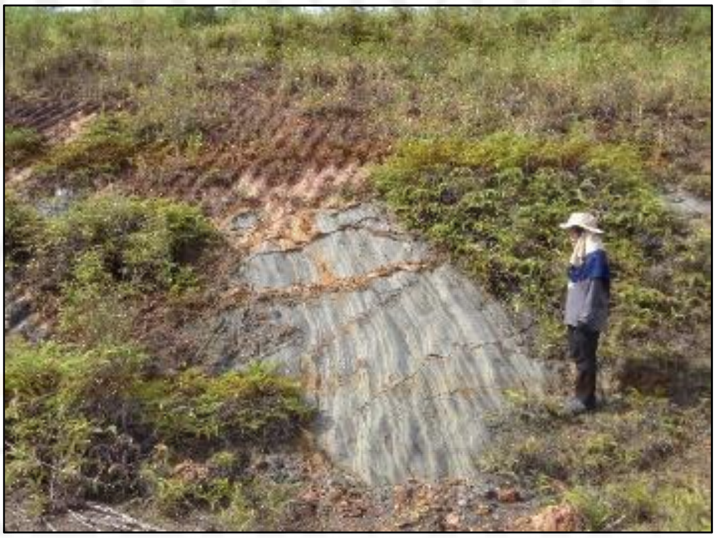

Figure 4.11: Tuffaceous mudstone discovered at the road cutting of the study area

(Source: Mohamad Khalim N.S., 2018)

Based on the previous researcher's finding in Figure 4.12, the depositional environment can be interpreted as tidal environment. This is proven by the feature of primary sedimentary structure which is lamination. The laminated mudstone is formed when fine-grained clay particles settled out in the calm water environment. The tidal environment can also be interpreted by the lenticular lamination of sand in the mudstone. According to Reineck and Wunderlich (1968), lenticular lamination is formed during the initiation of slack water and water turbulence, where suspended mud begins to deposited on the layer of sand when the velocity of water has reached zero.

Figure 4.12: Parallel-laminated mudstone with lenticular lamination of sand (Source: Mohamad Khalim N.S., 2018)

b. Carbonaceous Mudstone

There are two types of mudstone unit that has been discovered in the study area, which are tuffaceous mudstone that has been explained in the previous section, and carbonaceous mudstone which will be furthered explained in this section. Both mudstone unit have different in formation, as tuffaceous mudstone is correlated with Telong Formation while carbonaceous mudstone is correlated with Koh Formation. They are differentiated by the composition of argillaceous materials that associates with either tuff or limestone.

As discovered by Mohamad Khalim N.S (2018), carbonaceous mudstone is found in the reserve forest, where the outcrop has undergone weathering, as portrayed in Figure 4.13. The surface color of the outcrop seems to have discoloration due to rainfalls that react chemically with the carbonaceous mudstone. As mentioned by the previous researcher, there is no lamination nor bedding on the carbonaceous mudstone. However, it is said to have higher resistant from breaking compared to tuffaceous mudstone.

Figure 4.13: Carbonaceous mudstone with surface discoloration due to weathering

(Source: Mohamad Khalim N.S., 2018)

Figure 4.14: Rock sample of carbonaceous mudstone

(Source: Mohamad Khalim N.S., 2018)

c. ***Shale***

As discovered by Mohamad Khalim N.S (2018), shale is found to be interbedded in the carbonaceous mudstone. The outcrop is located at the hill cutting, which seems to have undergone physical weathering, resulting the rocks to appear in broken pieces. Shale is differentiated with mudstone by the fissility possessed by shale, since mudstone has no fissility. Fissility is described as the tendency of rock to split along flat planes, which is shown in Figure 4.15. As stated by Pettijohn (1975), fissility of shale is associated with the orientation of micaceous minerals contained in it.

Figure 4.15: The outcrop of shale interbedded in mudstone

(Source: Mohamad Khalim N.S., 2018)

Figure 4.16: Rock sample of shale featuring its fissility

(Source: Mohamad Khalim N.S., 2018)

d. Tuff

Based on the discovery of tuff by Mohamad Khalim N.S (2018), the outcrop in Figure 4.17 is found exposed at the hill cutting, thus it has been exposed to intense weathering. Geologically, tuff is pyroclastic igneous rock that is formed during the volcanic eruption, ejecting the volcanic materials to the air and deposited at the surrounding area. It then undergoes cementation and compaction to form a rock. The texture of tuff discovered in the study area is soft and porous, while the color is reddish brown, which is believed to have experience chemical weathering

Figure 4.17: The outcrop of weathered tuff exposed at the hill cutting

(Source: Mohamad Khalim N.S., 2018)

Figure 4.18: Rock sample of tuff

(Source: Mohamad Khalim N.S., 2018)

e. Limestone

Limestone is a sedimentary rock that is chemically composed of calcium carbonate ($CaCo_3$), which the mineral formed is recognized as calcite. In the study area, limestone is discovered in the reserve forest, which the appearance can be confused with Quartzite due to the similar properties in color and fine-grained texture. However, according to Mohamad Khalim N.S (2018), the outcrop as shown in Figure 4.19 is believed to be limestone as it is easily scratched with a pen-knife, as limestone has a hardness scale of 3 while quartz is 7, making it to be harder to be scratched than limestone. Besides, the limestone outcrop has been proven by the reaction of hydrochloric acid (HCl), which releases fizzling bubble on the rock surface, while quartzite does not leave a reaction towards the HCl.

Figure 4.19: Carbonaceous mud limestone discovered in the study area

(Source: Mohamad Khalim N.S., 2018)

Figure 4.20: Rock sample of carbonaceous mud limestone

(Source: Mohamad Khalim N.S., 2018)

According to the previous researcher, the name of mud limestone that is obtained in the field is classified based on Dunham's classification in Figure 4.21. Some part of the rock sample of limestone appears with greyish colour, which is interpreted as carbonaceous behaviour. The mud limestone is interpreted either by the mud-supported or grain-supported.

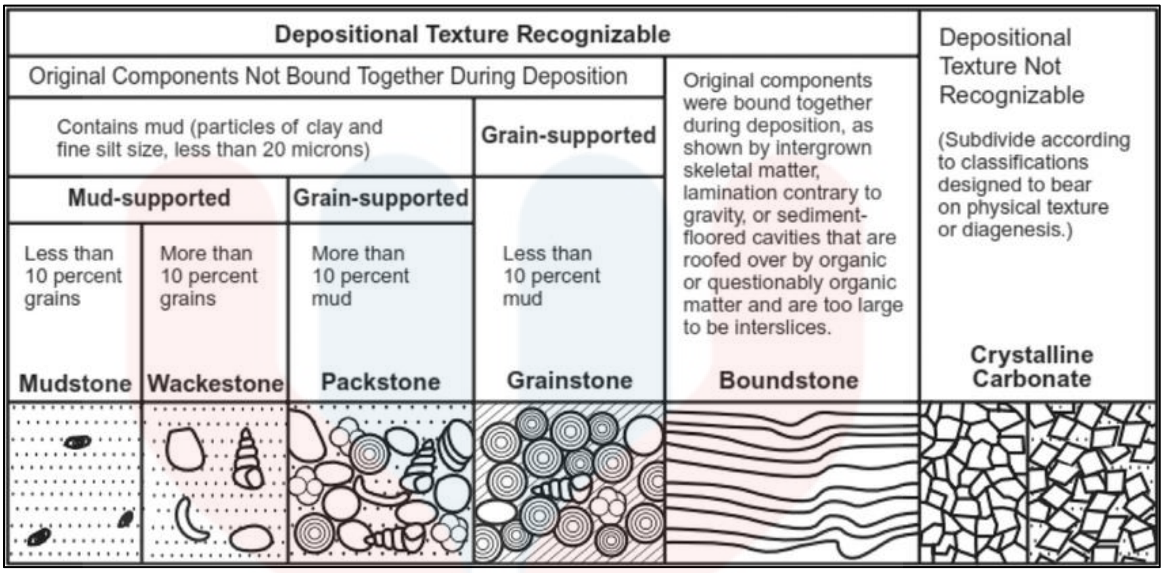

Figure 4.21: Classification of carbonate rock according to Dunham's classification

(Source: Al Omari, 2016)

4.4 Structural Geology

Tectonic interpretation is done by using lineament analysis by referring to linear features, and the result is shown as in the Rose Diagram in Figure 4.23. Lineament is interpreted based on satellite imagery, terrain map and relief map, as displayed in Figure 4.22. The lineament is interpreted as associated system with fractures due to tectonic stresses, based in Figure 4.25. A rose diagram with dominant orientation of lineament is produced, the result is shown as in the first quadrant (0°-90°), which shows the direction of force is coming from N-E. In Figure 4.24 shows a rectangular drainage pattern that can give information about the structural feature presents at the field. This type of drainage system is the result of structural joints and faults. This is because the compressed meandering stream is formed when sediments are eroded and deposited inside the bending stream.

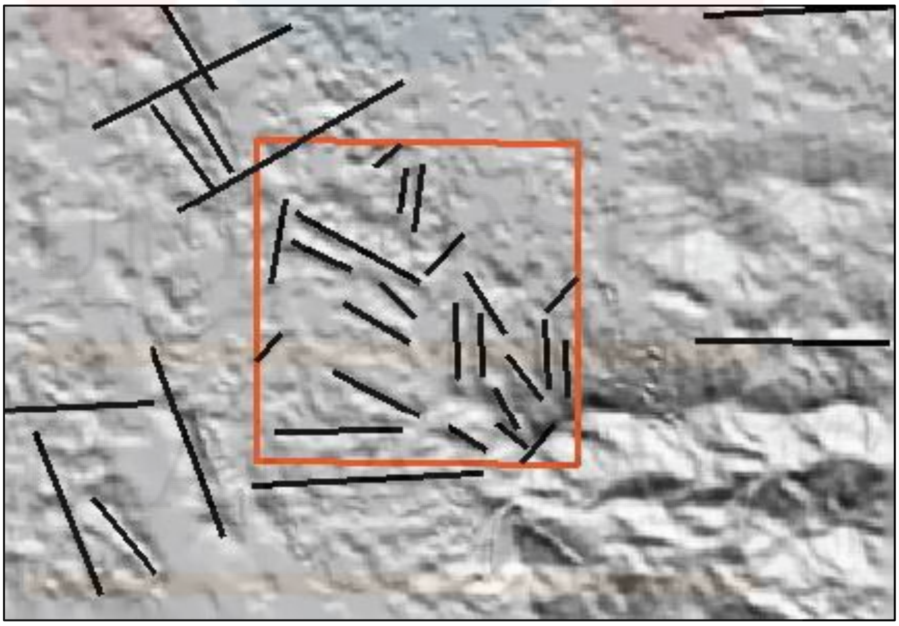

Figure 4.22: Lineament analysis from hill shade map

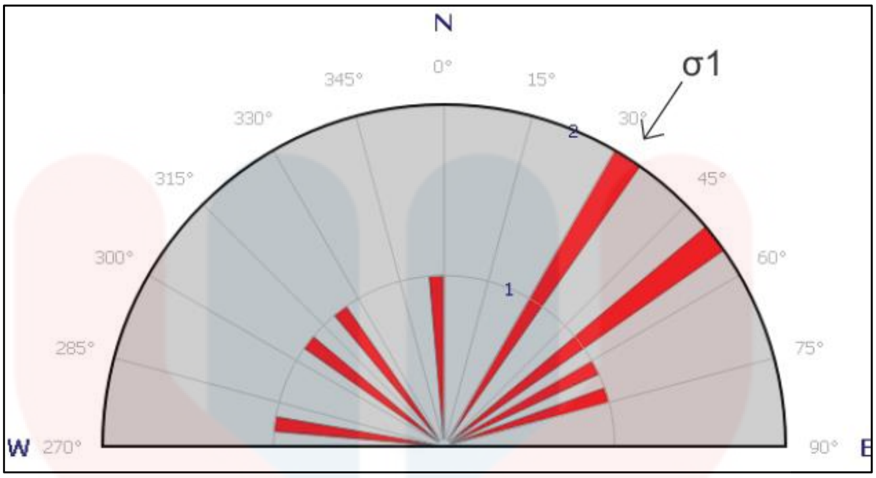

Figure 4.23: Rose Diagram of lineament

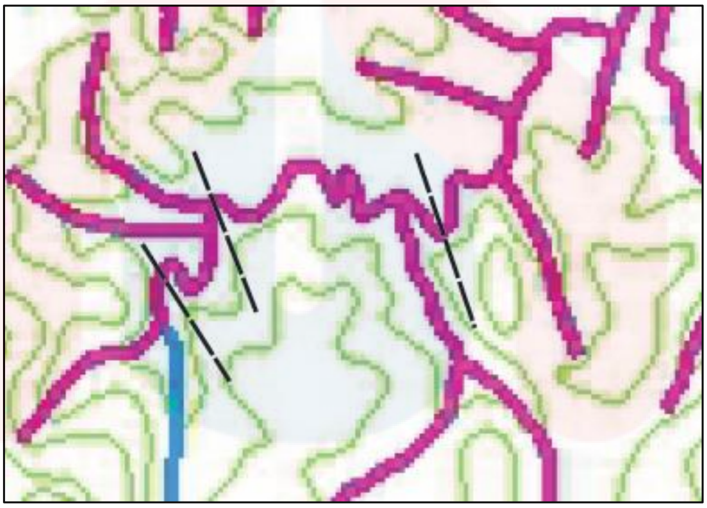

Figure 4.24: Structural joints and faults in rectangular drainage pattern in some part of study area.

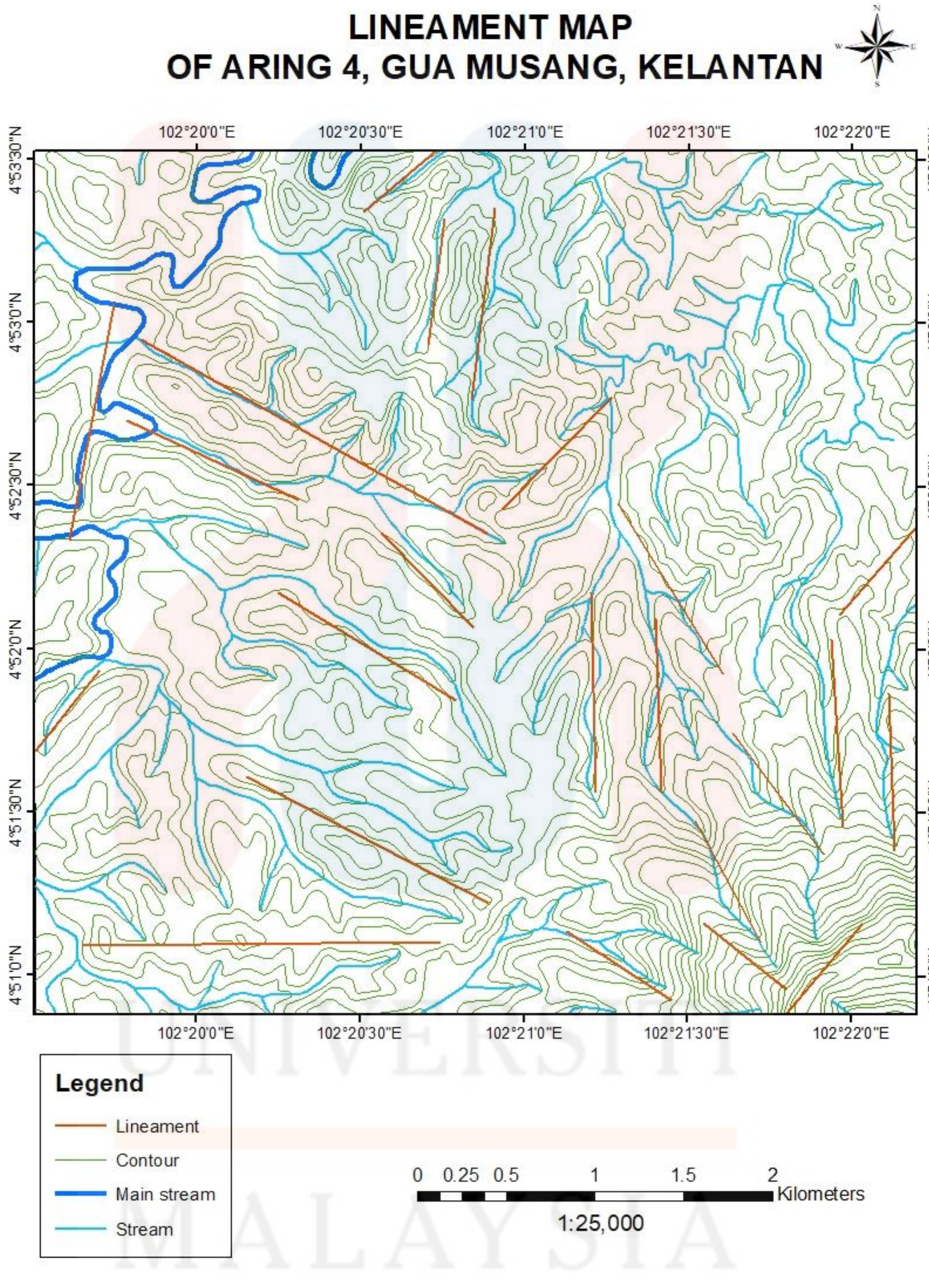

Figure 4.25: Lineament Map of Aring 4, Gua Musang, Kelantan

4.5 Historical Geology

The historical geology contributes to the understanding of the geological history and the process that influenced the landform, and the occurrence of particular structures. In the study area, Telong Formation and Koh Formation contribute to important elements in the historical geology.

According to Mohamad Khalim (2018), the mudstone unit that dominated the study area has shown significant evidence towards the historical geology. The rock unit is mainly dominated by the deposition of fine-grained mudstone and shale. This indicates that the depositional environment of the study area was a shallow marine environment.

As proposed by to Mohamad Khalim (2018), the discovery of sedimentary structures such as lenses lamination, parallel lamination and wavy bedding show stronger evidence that the area is historically was a shallow marine. This is because these structures formed when fine-grained sediment settle down in the quiet water, with lower to zero energy. Besides, the crinoid fossils discovered in the study area makes the evidences clearer that the environment was a shallow marine environment.

CHAPTER 5

GEOHERITAGE

5.1 Introduction

This chapter will be explaining about the research specification of the study area. The main purpose of this section is to discuss about the geoheritage assessment and its significance value for the suitability of the area to be suggested as a geoheritage potential site. For the fossil distribution, the study area will be expanded, which will include Aring 1, Aring 4 and Aring 5.

5.2 Fossil Value

Fossils are the remains of ancient animals and plants that are preserved and buried within the rocks which lives on the Earth at the past geological age. The discovery of fossils is very important as it helps geologists to understand the history, evolution process, age of strata, the relationship between taxa and the depositional environment of the area of interest. The body fossils are the preserved parts of the dead animals such as shells, bones and teeth, whether the part has been altered or remain unaltered due to the chemical changed during the burial. Meanwhile, trace fossils are the fossils that does not appears physically, but it shows the evidence of activities and their behaviours such as footprints, sign of burrowing, walking, or resting.

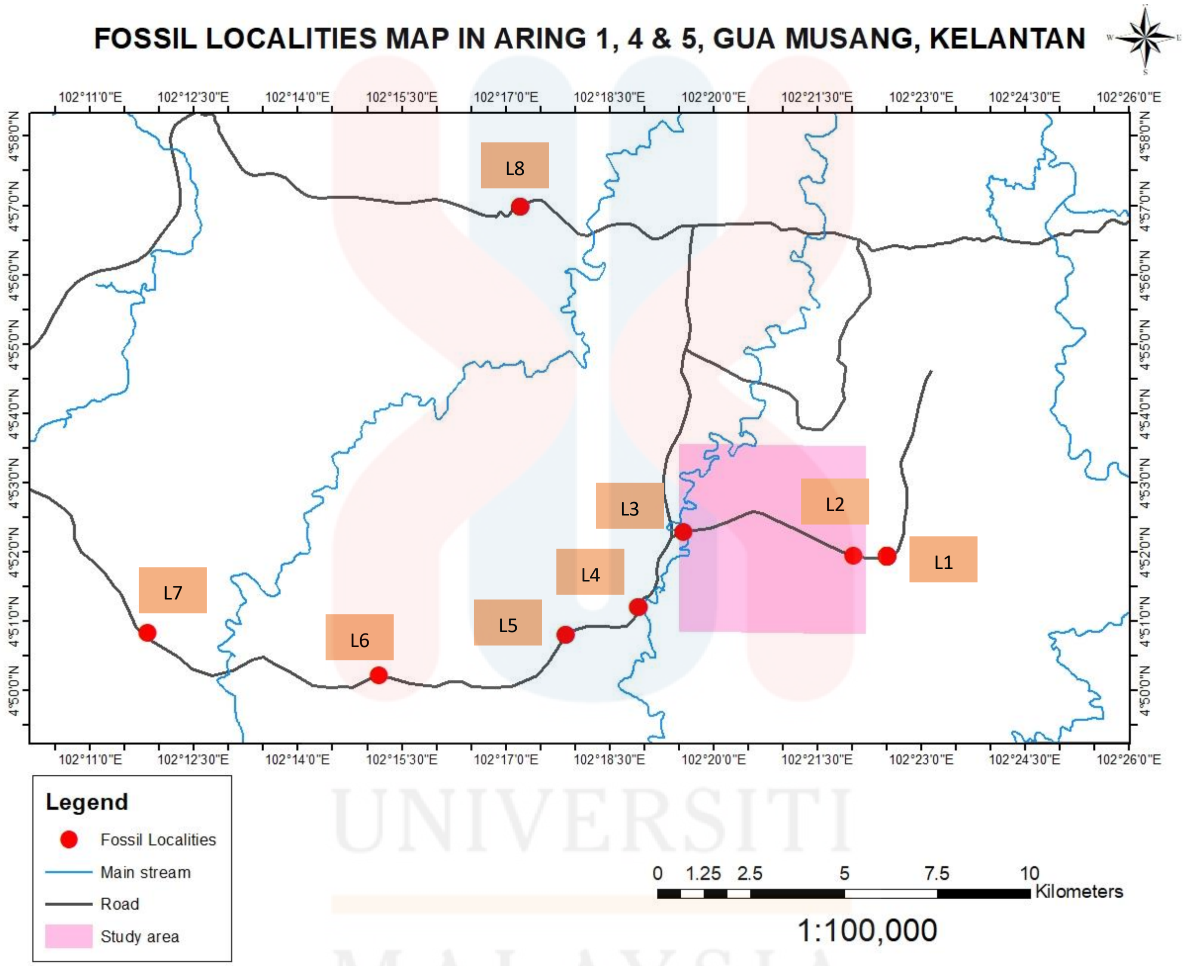

Figure 5.1: Fossil localities map in Aring, Gua Musang, Kelantan

(Modified by Mohamad Khalim N.S. & Jamaluddin N. A. F., 2018)

Table 5.1: Fossil distribution in different localities in Aring, Gua Musang

Locality (L)	Name of Rock	Types of Fossil (Phylum)	Distribution	Percentage Distribution	Total Distribution
L1 N 04˚ 41’ 58.0” E 102˚ 22’ 26.1”	Limestone	Porifera	69	28%	249
		Echinodermata	158	63%	
		Mollusca	8	3%	
		Brachiopod	12	5%	
		Trace fossil	1	3%	
		Arthropod	1	3%	
L2 N 04˚ 51’ 5.2” E 102˚ 22’ 02.1”	Shale	Echinodermata	47	94%	50
		Porifera	3	6%	
L3 N 04˚ 52’ 16.9” E 102˚ 19’ 35.0”	Tuffaceous shale	Mollusca	42	44%	95
		Brachiopoda	23	24%	
		Cnidaria	15	15%	
		Porifera	10	10%	
		Echinodermata	5	5%	

L4 N 04˚ 51’ 11.8” E 102˚ 18’ 55.8”	Mudstone	Porifera	3	4%	73
		Mollusca	23	32%	
		Echinodermata	47	64%	
L5 N 04˚ 50’ 53.8” E 102˚ 15’ 8.55”	Mudstone	Porifera	7	7%	97
		Mollusca	1	1%	
		Echinodermata	89	92%	
L6 N 04˚ 50’ 52.6” E 102˚ 17’ 51.9”	Mudstone	Mollusca	24	67%	36
		Echinodermata	12	33%	
L7 N 04˚ 51’ 3.8” E 102˚ 11’ 52.0”	Mudstone	Mollusca	6	100%	6
L8 N 04˚ 57’ 05.0” E 102˚ 17’ 13.0”	Shale	Cnidaria	3	38%	6
		Brachiopod	5	63%	

(Source: Mohamad Khalim N.S. & Jamaluddin N. A. F., 2018)

5.2 Palaeontological Heritage Evaluation

The qualitative assessment of geoheritage potential is evaluated based on six criteria proposed by Endere & Prado (2014) which are comprised of palaeontological, geological, contextual, integrity, sociocultural and socioeconomic. The evaluations result is shown as in Table 5.3.

In this study, the heritage potential is focused on the paleontological feature as Aring is familiar for the occurrence of invertebrates' fossils among the geologists. In the study area, there is only two fossil localities discovered by Mohamad Khalim N.S & Jamaluddin N. A. F (2018), as shown in Figure 5.1. According to Leman M.S (2010), fossils contain scientific values, as it is used as an age indicator in the biostratigraphy correlation, paleoclimate indicator, paleobiogeography indicator, evolutionary record material and fossils as a specimen reference.

In the term of geological history, the fossils discovered in Aring is believed to age from Middle Permian to Middle Triassic. The distribution of ammonoids fossils is focused on the sedimentary formation, as the area is used to be a wide and deep ocean (Leman M.S., 2010). This species plays an important role as an age indicator and biostratigraphy zoning, especially when they are discovered in a particular rock strata.

Table 5.2: Results of for the qualitative assessment based on suggested parameters for palaeontological heritage assessment

Parameter		Score	Total Score
Palaeontological	Nature of fossil	3	6
	Preservation	1	
	Diversity of fossils	0	
	Localities type	2	
	Taphonomy	0	
Geological	Geological significance	2	5
	Geological integrity	1	
	Scientific potential	2	
Contextual	Context	1	2
	Visual contribution to landscape	1	
	Association with archaeological remains	0	
Integrity	Geographic situation	1	2
	Vulnerability	1	
Sociocultural	Historical	2	6
	Educational	3	
	Touristic	1	
	Complementary	0	
	Community	0	
Socioeconomic	Urban value	2	3
	Mineral value	0	
	Public works	1	

5.2.1 Palaeontological Value

The nature of fossils is given as score 3 due to its high scientific significance, which shows that the fossils are important to acquire special consideration for the purpose of geoheritage potential. The preservation criteria scores 1 as the condition of the fossils discovered by the recent researcher are mentioned as well preserved in mudstone, limestone and shale.

The diversity of fossil in the study area is scored as 0 which is ranked as low diversity. This is because there are only invertebrate fossils that present in the study area. The type of localities gathered score of two, which signifies that the localities contain more than two species. According to Jamaluddin N. A. F (2018), different species are found in different localities. As located in the study area which is Locality 3, different phylum is discovered in this locality, which has a total of 5 which comprising of Mollusks, Brachiopod, Cnidaria, Porifera and Echinodermata (Figure 5.2).

As defined by Dixon (1996), taphonomy is the natural range of geological, geomorphological, assemblages and process which associates with the evidence towards the history and process of the Earths and landform. Taphonomy can give information towards the condition and rate of fossil preservation after burial. The criteria for taphonomy scores 0 which means that it has common stratified localities. This is because in the different phylum can be found in the same rock layer. This group of fossils in the same rock may indicate that the sediment accumulation happened rapidly and subsequently undisturbed (Brett, 2003). Figure 5.5 shows a concave-shell of brachiopod. When a gentle wave lifts the shells, it allows the shells to settle from suspension allowing free-fall, resulting into concave accumulation (Brett, 2003).

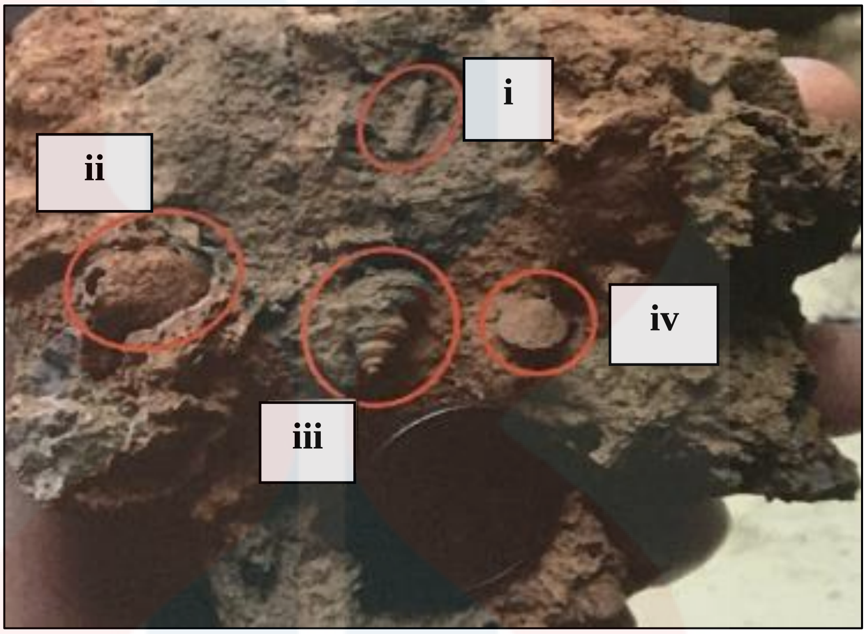

Figure 5.2: Different phylum of fossils in a rock sample

i) Cnidaria, ii) Porifera, iii) Gastropod iv) Brachiopod

(Source: Jamaluddin N. A. F., 2018)

Figure 5.3: Body fossil of gastropod

(Source: Mohamad Khalim N.S., 2018)

Figure 5.4: Body fossil of trilobite

(Source: Mohamad Khalim N.S, 2018)

Figure 5.5: Body fossil of articulated brachiopod in concave-shell

(Source: Mohamad Khalim N.S, 2018)

5.2.2 Geological Value

Geological significance will be the importance of the feature to the perception towards the geology and the Earth's evolution, whether they are locally, regionally, nationally or internationally important to the people. According to Brocx & Semeniuk (2015), for regional significance, it may present one or two states, even though it is quite common globally. Therefore, the geological significance for Aring area gathers a score of 2 which is a regional importance. This is because the marine fossils assemblage is quite rare in Malaysia and have been discovered in several localities in Kelantan, Kedah, Langkawi Island, Perlis and Pahang.

Geological integrity scores 1 which is limited sites. According to Endere & Prado (2014), the limited sites is considered as a site that has significant feature but the removal of materials can lead to reduction of the feature's occurrence. According to Nazaruddin, D. (2014), Aring area is threaten with development such as retaining walls, concrete and grass seed spraying. Since the area is mostly covered with oil palm plantation, several hill cuts had been made for accessibility, which this action may have destroyed the fossils within the rock.

Scientific potential criteria scores 2 which defines as good potential. It refers to the potential of the site to provide the information and understanding if the research is continuously done by the next researchers. This is because even though the fossil diversity in the study area is low, it is still very useful to provide the understanding of the ancient living things at the past geological age.

5.2.3 Contextual Value

In the criterion of context, the score gathered is 1 which is moderate. This applies to the fossil assemblage in Aring 4 which are invertebrate fossils, and they are included in the same palaeoenvironment which is shallow marine environment.

The visual contribution to landscape scores 1 which indicates low. According to Endere & Prado (2014), this score signifies that the fossils are barely seen on the ground. The score given is strengthen by the previous researcher, who mentioned that the fossils are only visible when being crushed, and they are found well-preserved in mudstone, limestone and shale. Figure 5.6 shows a viewshed map, which explains that the fossil localities that located at the road cutting cannot be observed at far distance. Figure 5.7 shows elevation map, which explains the fossil localities are discovered at low elevation ranging from 100m to 200m.

The association with archaeological remains scores 0, which signifies the localities are not associated with any humankind history. This is because there is no evidence by any documentary nor published articles that explain the association fossil in the study area with humankind history. As suggested by Endere & Prado (2014), fossils that has association with archaeological remains contains its own importance such as the human cultural activities during the past.

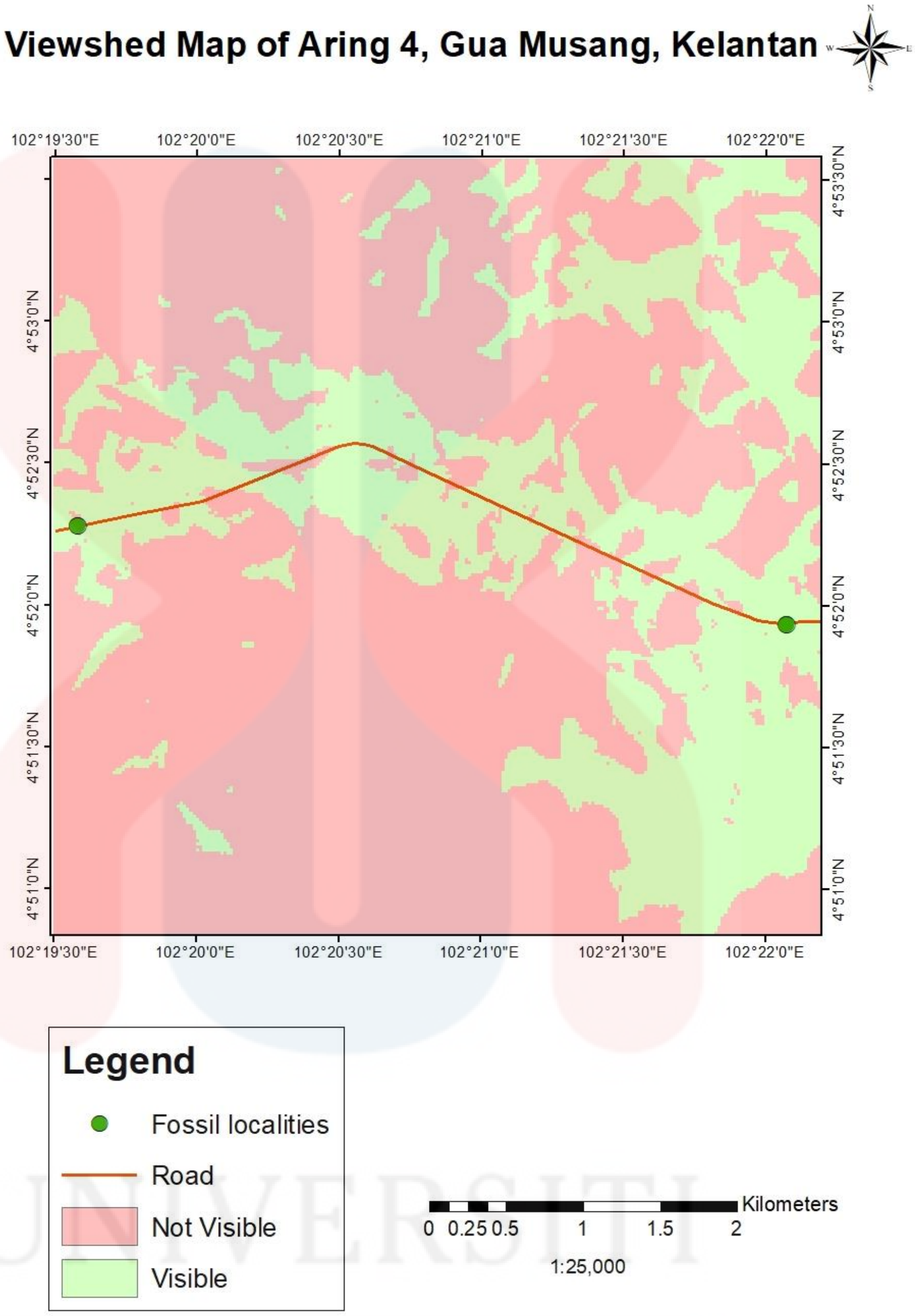

Figure 5.6: Viewshed Map of Aring 4, Gua Musang, Kelantan

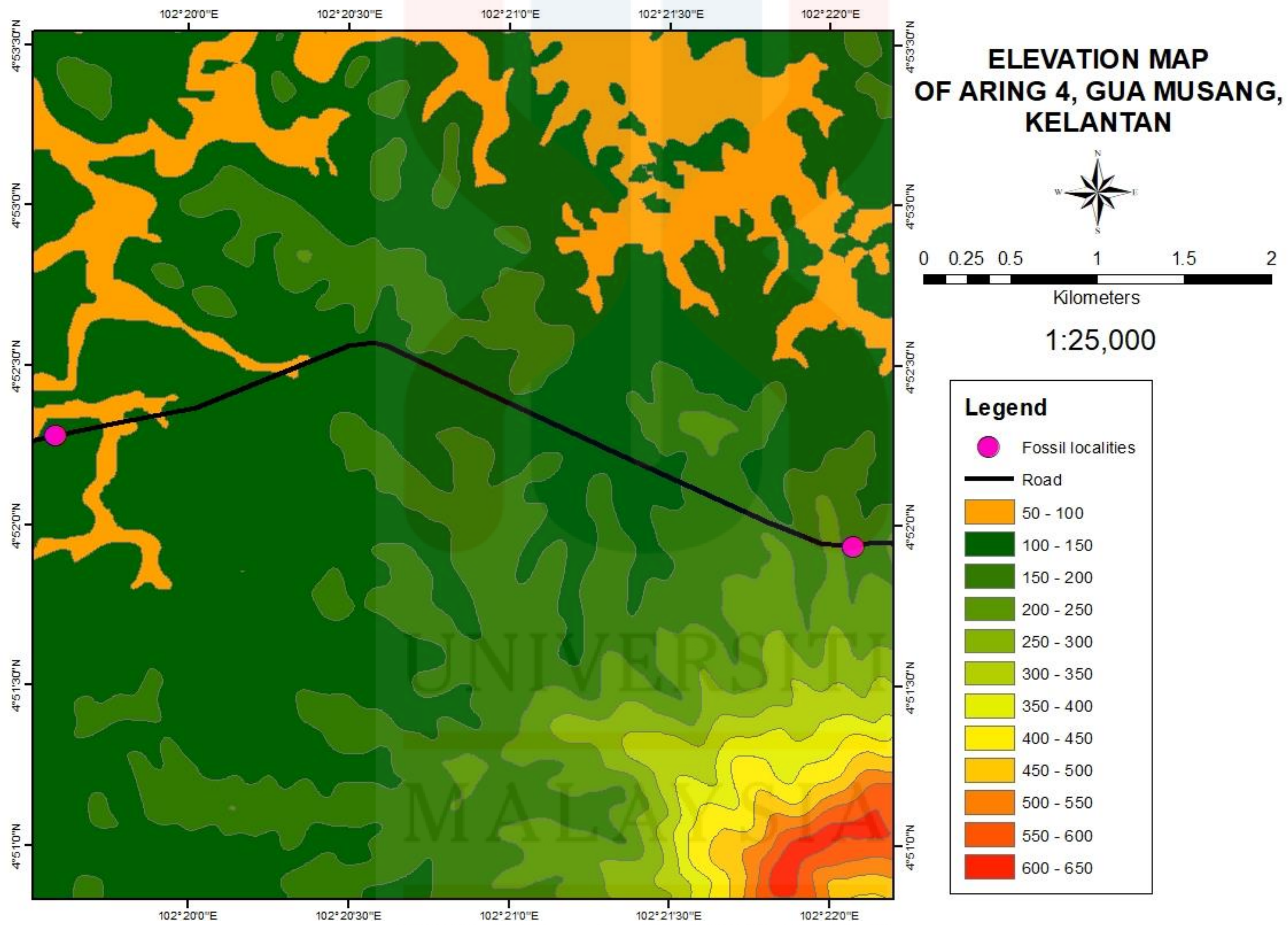

Figure 5.7: Elevation Map of Aring 4, Gua Musang, Kelantan

5.2.4 Integrity Value

There are two criteria that are also need to be considered which are geographic situation and the vulnerability. Both criteria score 1 respectively. Since the study area is majorly covered with oil palm plantation, they are located very far away from urban area, which makes the fossil localities to be less or no visitors at all. As for the vulnerability, the score is appointed as 1 because by according to Endere & Prado (2014), it means that the area is very vulnerable to fossil collecting. The fossil localities in the study area are located at the main road cutting, which is easily accessed by people. As mentioned by Nazaruddin, D. (2014), the fossil in Aring area is located on the public land which is not protected by any authorities, thus anyone can collect them. Therefore, in the study area, the fossil preserved in the original rock could become diminish due to unrestricted collecting.

5.2.5 Sociocultural Value

The educational interest is given as 3 which is excellent grade. This is because the fossil site in Aring area has a great potential to conduct educational activities. University students or tourists can be exposed with the different phylum of fossils in Aring, such as Brachiopod, Porifera, Mollusk, Echinodermata, and Cnidaria. Besides, they can also gain knowledge about the depositional environment, where the area was once a shallow marine environment. Furthermore, the students can be exposed to the fossils physically, experiencing in collecting the fossils within the rock by themselves, instead of learning theoretically in the lecture hall.

The score for touristic interest only gained 1, which signifies that the localities are easily accessed although there is no infrastructure. This criterion is considered by the accessibility and the possibility towards the attraction of fossils to the tourists (Endere & Prado, 2014). Based on the previous researcher, the fossil localities are easily accessed as they are mostly collected at the road cutting in Aring area. The historic value gathered a score of 2 which is regional significance. This criterion is concerned due to its importance that makes up as part of the history of palaeontology.

The score for both complementary value and community association with public are both 0, which signifies no value and unfamiliar by the local community respectively. There is no complementary value because the area is not protected by any authorities. Meanwhile for the community association, as mentioned previously, the fossil localities are mostly located far from the urban area, so there will be less possibility that the local community are aware with the existence of marine fossils in Aring area.

5.2.6 Socioeconomic Value

The urban value scores 2, which signifies that the area has possibility to build up a field museum. As proposed by Nazaruddin, D. (2014), a field museum must be developed as an initiative to conserve the fossil sites in Aring area. Field museum provides the data such as the trace fossils that associates with sedimentary rock characteristic and structures (Lipps, 2009). Figure 5.2 Shows the example of field museum of dinosaur trackway in Morrison, Colorado.

Figure 5.8: A field museum of dinosaur trackway in Denver, Colorado

(Source: Smith, 2009)

The mineral value is described by Endere & Prado (2014) as the sites that are associated with abandoned mines, mineral exploitation or extraction. This criteria scores 0 because based on Mohamad Khalim N.S (2018), the location of fossils discovery in the study area has no association with abandoned mines or mineral exploitation. The public works scores 1, which signifies that the area is considered to have possibility for conservation. According to Nazaruddin, D. (2014), it is important to conserve these fossils for the purpose of scientific value, as Aring is so far the only area that contains numerous of small invertebrate fossils.

5.5 Discussion

In order to determine the value that will be used to specify whether the study area has the potential to be proposed as a geoheritage site, the total score for all parameters is summed up. According to Endere & Prado (2014), the total score that qualifies a site to be a geoheritage site must obtain at least 25 scores. The total score for potential heritage value is calculated in the formula below:

Total Potential Heritage Value = Paleontological + Geological + Contextual + Integrity + Sociocultural + Socioeconomic

= 6 + 5 + 2 + 2 + 6 + 3

= 24

According to the total potential heritage value, the total score gathered is 24, which is lower than the proposed score by Endere & Prado (2014). Therefore, it can be concluded that the potential value for the study area to become a geoheritage site is low. However, the evaluation is based on secondary data, which is subjective by the interpretation, thus the total score obtained shows that the area has low potential to become a geoheritage site.

CHAPTER 6

CONCLUSION AND SUGGESTIONS

6.1 Conclusion

This chapter is the section that will conclude all findings and interpretation of the geological mapping, including the important specification in the scope of the geoheritage potential of Aring 4, Gua Musang. The interpretation of geological map processed by ArcGIS software has reveal the important significant geological features in the study area. The interpretation is comprised of geomorphology classification, lineament interpretation, drainage pattern and fossil assemblages.

By the result of geological map interpretation, it can be concluded that the study area is dominated by mainly mudstone, which are classified into two units which are tuffaceous mudstone and carbonaceous mudstone. Tuff makes the second dominant of the deposited rock. The geomorphology of the study area is classified into three which are undulating hills, hills and mountains. By the interpretation of drainage pattern, structural joints can be identified by the occurrence of rectangular drainage pattern, which makes the stream to become bended.

The assessment of geoheritage potential proposed for Aring 4 has come to the conclusion that the area has low value to become a geoheritage site, even though it can be considered by the fossil assemblage. However, the data is not sufficient for the assessment, thus the potential value can be either low or moderate.

6.2 Suggestion

Since Aring has a number of fossil assemblage, it is proper if the local authority makes a consideration in protecting the fossil outcrops. Since the area is mostly covered with oil palm plantation, the possibility that some of the fossil area to be destroyed is high. This is because there will be many road cuttings being developed for the sake of road access. Besides, for the next researchers, it will be honoured if more detailed assessment being done in this area in order to protect the value of fossil assemblages in Aring.

In the term of limitation data generally, this research requires geological mapping in the field. Despite of confronting with the pandemic of Covid-19, the Ministry of Higher Education (KPT) should have allowing the final year Geoscience students to collect the data in the field, since conducting fieldwork does not associate with people, and the students still manage to follow the standard operating procedure (SOP). The lack of data has caused so much difficulties in result interpretation and thesis writing. Therefore, a geological mapping needs to be done if the circumstances do not affect the students.

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