GEOLOGY AND GEOHERITAGE ASSESMENT OF LATA KEDING, KELANTAN

By

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THESIS DECLARATION

I declare that this thesis entitled "**GEOLOGY AND GEOHERITAGE ASSESMENTS OF LATA KEDING, JELI, KELANTAN**" is the result of my own research except as cited in thereferences. 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

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Geology and Geoheritage Assesments of Lata Keding, Jeli Kelantan

ABSTRACT

The study area of Lata Keding boasts numerous one-of-a-kind geological features, with a variety of geological structures present. The area is located in the Jeli District of Kelantan and sits on the border of Kelantan and Perak, with coordinates 101°55'42.28''E, 5°43'35.35''N, 101°51'0.47''E, 5°43'36.13''N, 101°55'42.76''E, 5°45'21.12''N, 101°51'01.56''E, and 5°45'19.16''N. The topography ranges from a height of 480 meters to a low of 40 meters. The research was focused on general geology and geoheritage value of Lata Keding and the objective was to create a new geological map of the area at a scale of 1:25,000 and analysis of the potential for geotourism. Geoheritage refers tothe geological and geomorphological features of a particular area that have scientific, educational, cultural, and/or aesthetic value. It encompasses a wide range of natural features, including rocks, minerals, fossils, landforms, and geologic processes, as well as the cultural and historical significance of these features. ArcGIS software and Digital Elevation Model data were used to produce maps and gather information. The study area is composed of five distinct types of rock units including hornfels, gneiss, schist, Meta alkali feldspar granite, and meta quartz-rich granitoid. Additionally, Jeli Granite is a part of the Jeli Igneous Complex and located around 1km north of Jeli town. The complex also include other granitic units such as Noring Granite, Kenerong Leucogranite, and Berangkat Tonalite. Using both qualitative and quantitative methods to evaluate the geoheritage value of Lata Keding, the results suggest that the area has high aesthetic and recreational value. The main attraction of the area is the beautiful cascades and unique rock structures. Activities such as swimming, picnicking, and photography are popular there. Thus, it's important to protect and preserve Lata Keding to maintain its natural integrity, particularly against any rapid development that may occur.

Geologi dan Penilaian Geowarisan Lata Keding, Jeli Kelantan.

ABSTRAK

Kawasan kajian Lata Keding mempunyai pelbagai ciri geologi yang unik, dengan kehadiran pelbagai struktur geologi. Kawasan ini terletak di Daerah Jeli Kelantan dan terletak di sempadan antara Kelantan dan Perak, dengan koordinat 101°55'42.28''E, 5°43'35.35''N, 101°51'0.47''E, 5°43' 36.13''N, 101°55'42.76''E, 5°45'21.12''N, 101°51'01.56''E dan 5°45'19.16''N. ketinggian bentuk muka bumi berjulat dari 480 meter hingga 40 meter. Penyelidikan ini tertumpu kepada geologi am dan geowrisan Lata Keding dan objektifnya adalah untuk mencipta peta geologi baharu kawasan tersebut pada skala 1:25,000 dan analisis potensi geopelancongan. Geowarisan merujuk kepada ciri geologi dan geomorfologi kawasan tertentu yang mempunyai nilai saintifik, pendidikan, budaya dan/atau estetik. Ia merangkumi pelbagai ciri semula jadi, termasuk batu, mineral, fosil, bentuk muka bumi, dan proses geologi, serta kepentingan budaya dansejarah ciri-ciri ini. Perisian ArcGIS dan data Model Ketinggian Digital telah digunakan untuk menghasilkan peta dan mengumpulkan maklumat. Kawasan kajian terdiri daripadalima jenis unit batuan yang berbeza termasuk hornfels, gneiss, syis, meta granit alkali feldspar, dan meta granitoid kuarza. Selain itu, Jeli Granite adalah sebahagian daripada Kompleks Igneus Jeli dan terletak sekitar 1km di utara bandar Jeli. Kompleks ini juga termasuk unit granit lain seperti Granit Noring, Kenerong Leucogranite, dan Berangkat Tonalite. Dengan menggunakan kaedah kualitatif dan kuantitatif untuk menilai nilai geowarisan Lata Keding, dan keputusan menunjukkan bahawa kawasan itu mempunyai nilai estetika dan rekreasi yang tinggi. Tarikan utama kawasan ini adalah lata yang indahdan struktur batu yang unik. Aktiviti seperti berenang, berkelah dan fotografi popular di sana. Oleh itu, adalah penting untuk melindungi dan memelihara Lata Keding untuk mengekalkan integriti semula jadinya, terutamanya terhadap sebarang pembangunan pesat yang mungkin berlaku.

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LIST OF ABBREVIATIONS

DEM	Data Elevation Model
CFBG	Coarse Grained Foliated Biotite GraniteGrey
GM	Microgranite
MFBG	Medium Grained Foliated Biotite Granite
HBBD	Hornblende Biotite Basaltic Dyke Strength
SWOT	Weakness Opportunity Threats Universiti
UMK	Malaysia Kelantan Geographic Information
GIS	System
N	NorthEast
E	West
W	South
S	

CHAPTER 1

INTRODUCTION

1.0 General Background

Malaysia is regarded as part of the Southeast Asian country because it shares boundaries with Thailand, Brunei, and Indonesia. The geographical location of Malaysia, to the south of the significant typhoon track and to the north of the Ring of Fire, as well as beyond the Ring of Fire, is advantageous for the country. The analysis is now being carried out in the Jeli region of Kelantan, located in the northern part of the state of Kelantan, Malaysia.

The essential aspects of that kind of study are the geology and possible geoheritage sites that can be found in Lata Keding, which is located in Jeli, Kelantan. The study of the Earth, including its make-up, the structure of its many parts, and the processes that take place in their interaction with it, is known as geology. In addition to other things, it requires the observation of preserved paleo-organisms from the past. Geology is the study of how the Earth's materials, structures, processes, and species have changed over time and these changes have occurred (King, 2005).

In the meantime, the second section of the study is focused on the specification that is geoheritage. One definition of geological heritage is "heritage that stresses particular areas' unique geological elements," including a location's environmental, cultural, heritage, and aesthetic significance. Geoheritage is also known as "geological heritage." People come to this location because of its one-of-a-kind qualities, including heritage values that need to be preserved for a substantial period. In order for a location to be considered desirable and have the potential to be designated as a geoheritage site, as well as have the ability to entice visitors, the society should be informed about the existence of feature elements regarding geological asset.

The term "geoheritage" refers to geological features at any size, including global, national, state-wide, and local geology features. These geology features are either inherently important locations or culturally significant places that provide knowledge or observations about the origin of the Earth.

Several important criteria must be consider before a given location may be declare a geoheritage area. The need for conservation and preservation arises from the fact is one of the main ways to demonstrate to new generations about the process of geological landform formation on our planet, which can take anywhere from one hundred to one thousand years. Furthermore, the locations that were selected typically have a geological value because it was possible to identify prospective geoheritage resources at such locations. In addition, the values are close to the geodiversity values. Geodiversity can be defined as the variation of materials that makeup the earth, including the many different types of rocks, minerals, fossils, and landforms. Scientific value, educational value, aesthetic value, recreational value, and cultural value are the values that must be considered to transform geosites into geoheritage places.

Geomorphology is the study of the Earth's surface and its processes, including weathering, erosion, and sedimentation. It is a branch of physical geography that deals with the processes that shape the Earth's surface, including weathering, erosion, and sedimentation. Geomorphologists seek to understand how these processes have shaped the Earth's surface over time, and how they continue to shape it today." (Johnson, R.G.,

& DuBray, E.A. (2017). The concept "geoheritage" refers to the geomorphological landforms that have scientific, cultural, historical, artistic, and/ social/economic significance as a result of human activity. The geoheritage of the study area will be analysed to determine the viability of the area as a geoheritage site. In addition, there is a significant need to do research into the general geology of the study area to create a geological map with a scale of 1:25000 updated.

According to a geological map that was created in 2003 by the Department of Mineral and Geosciences, the research region is made up of Permian sedimentary rock that is located beneath the Gua Musang Formation. This formation is predominantly made up of argillaceous rocks, but it also contains some calcareous rocks (Dony Adriansyah Nazaruddin et al., 2018). Jeli is composed of three distinct lithologies, all of which are sedimentary rocks that date back to the Triassic period and fall under the Gunong Rabong Formation. These rocks include shales, mudstone, sandstone, and limestone. Aside from that, the Jeli region consists of sedimentary rocks that date back to the Permian period and are buried beneath the Gua Musang Formation. These rocks include slate, sandstone, and limestone. In addition, the Jeli district also is home to granitic rocks, which are classified as acid intrusive and are composed of phyllite, slate, and sandstone (Nursufiah Sulaiman et al., 2020).

1.1 Study Area

1.1.1 Location

This research is being conducted at Lata Keding, Jeli, Kelantan. Jeli District is located in western Kelantan and is one of the state's ten districts, with an area of roughly 129,680.26 acres. Furthermore, the Jeli District is bounded by the Kelantan-Perak state border and divided into three sub-districts: Jeli, Batu Melintang, and Kuala Balah (Nazaruddin, 2015). The coordinate of study area is 101°55'42.28''E, 5°43'35.35''N, 101°51'0.47''E, 5°43'36.13''N, 101°55'42.76''E, 5°45'21.12''N, 101°51'01.56''E, and 5°45'19.16''N. Figure 1.1 depicts a map of Kelantan, whereas Figure 1.2 depicts the study area's base map. It is located nearby Kampung Gemang, Gemang subdistrict, and bordered by the East-West Highway in the northwestern corner of Kelantan. There are few villages in the studyarea such as Kampung Lakota, Kampung Gemang Lama, Kampung Wakaf Zin, and Kampung Buluh. There is also a stream known as Lata Keding, which is the focused area for the specification in this study area. This stream consists of igneous and metamorphic rock and has many geological features. Lata Keding, Bukit Kudung also holds various natural and historical treasures. Other than that, Bukit Kudung used to be a stronghold and hiding place for the communists in the past and many still do not know about this history. Behind the beauty of Bukit Kudung which is 480 meters high, there is also a border stone known as Batu 73 which borders Thailand for 2.3 kilometers. Generally, this study area has some flat area and hilly area.

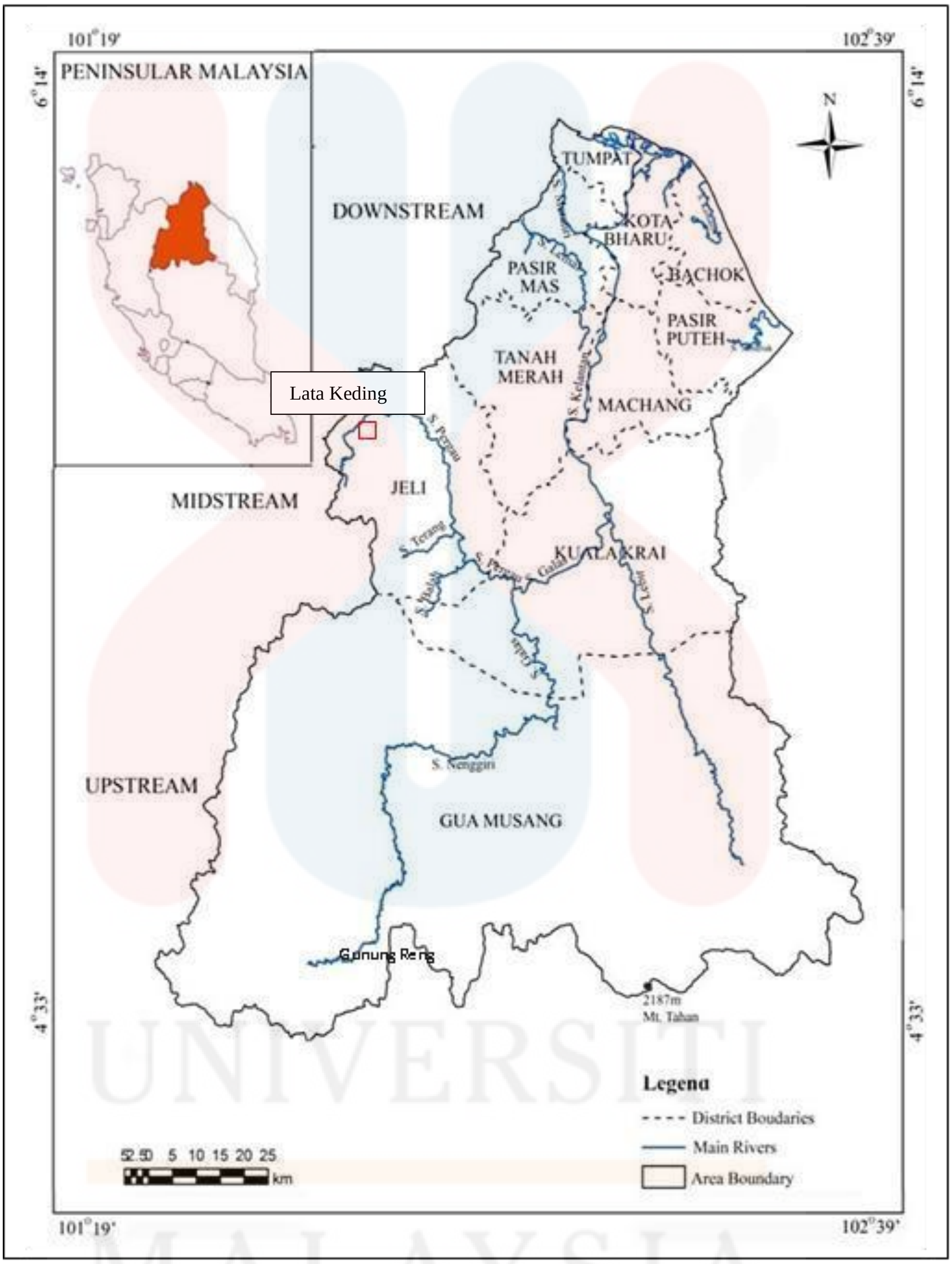


Figure 1.1: Base map of Kelantan (Sources: Mohd Talha Anees et. al, 2017).

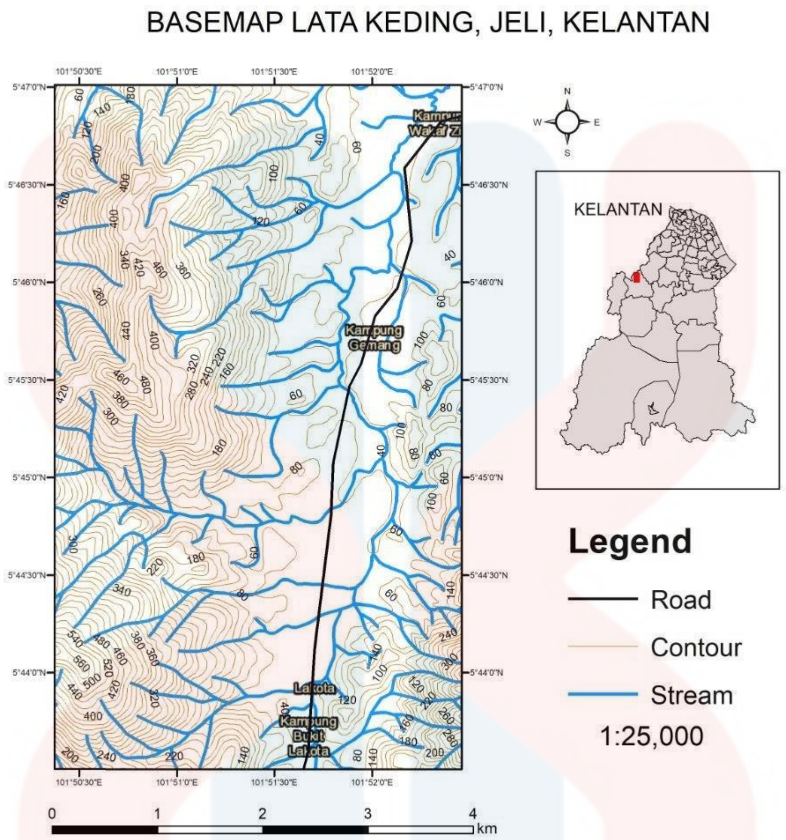


Figure 1.2: base map of study area.

1.1.2 Road Connection/Accessibility

In the Jeli district of western Kelantan, not far from the Malaysian border, is where the research area located, and it is close to the East-West Highway. In the vicinity of the highway that connects from Ayer Lanas and Jeli, there is a signboard that displays the Lalang Resort. This resort serves as the gateway to Lata Keding, and the signboard is also located in front of the University Malaysia Kelantan. In addition to other conveniences, it features a shop, a food stall, and a restaurant in addition to a chalet that is considered to be among the most well-known chalets in Kelantan. The river, which was straightforward to reach due to the fact that one can see it from the entrance. As can be seen in Figure 1.3, the most significant kind of road accessibility that is presentin the region under investigation and that the local people has made use of is.

Figure 1.3: The accesibility road at Lata Keding area. (Sources: Google Earth Pro, 2023).

1.1.3 Demography

The makeup of Malaysia's population is predominantly comprised of various ethnic groups, with Bumiputera (Malays) being the largest. The population of Kelantan, specifically, is estimated to be around 1.8 million people, with Malays being the largest ethnic group, followed by Chinese, Indians, and others. Additionally, the 20-24 age group is the largest, while the 70-85 age group is the smallest.

Table 1.1: Population of Kelantan in 2018 (Source: Department of Statistics, Malaysia)

Kelantan Population ('000) : 1,856.8

Umur / *Age*	Jumlah / *Total*	Bumiputera	Chinese	India	Others	*Non-Malaysian Citizens*
		Total				
Total	1,856.80	1,730.40	55.8	4.9	11.5	54.2
0 – 4	195.9	189.6	2.6	0.2	1.1	2.4
5 – 9	187.4	180.9	3.3	0.3	1.4	1.5
10 – 14	174	167.3	3.7	0.5	1.4	1.1
15 – 19	190.6	181.4	4.2	0.5	1.1	3.4
20 – 24	203.8	190.4	5.1	0.4	0.8	7
25 – 29	173.7	157.6	4.9	0.6	0.9	9.6
30 – 34	114.5	101.9	4	0.6	0.8	7.3
35 – 39	99.6	88.7	3.8	0.3	0.7	6.1
40 – 44	86.4	77.8	2.9	0.3	0.5	4.9
45 – 49	86.1	78.5	3.2	0.2	0.5	3.6
50 – 54	85.2	77.9	3.8	0.3	0.5	2.7
55 – 59	79	72.6	3.8	0.3	0.5	1.9
60 – 64	62.4	57.2	3.5	0.2	0.4	1.1
65 – 69	47.4	43.7	2.7	0.1	0.3	0.6
70 – 74	32.7	30.1	1.9	0.1	0.2	0.4
75 – 79	19.5	18	1.1	0.1	0.1	0.1
80 – 84	10.1	9.1	0.7	0	0.1	0.1
85+	8.4	7.7	0.5	0.1	0	0.2

Source: (Department of Statistics, Malaysia)

Notes 1. The added total may differ due to rounding.

1.1.4 Land Use

Lata Keding study area consists mostly of residential, agricultural, and recreational land uses, with a small portion of commercial property. The research region's most densely inhabited land use distribution consists of a magnificent resort in the centre of Lata Keding, which flows through it. In addition, there are a few plantation lands utilised for agriculture at that location. Due to the low resolution of the imagery map, it was unable to detect the kind of plantation, and distinguishing between them is difficult. Therefore, precise geological mapping is essential in this case. Lastly, Lata Keding is considered a recreational area due to the vast number of visitors and tourists who commonly visit the waterfall for leisure activities such as jungle hiking and downstream picnics. . Figure 1.5 below as shown the image classification for land use changes in between 1984 to 2004. An overall observation of land change and land use in Jeli can be seen in Figure 1.6.

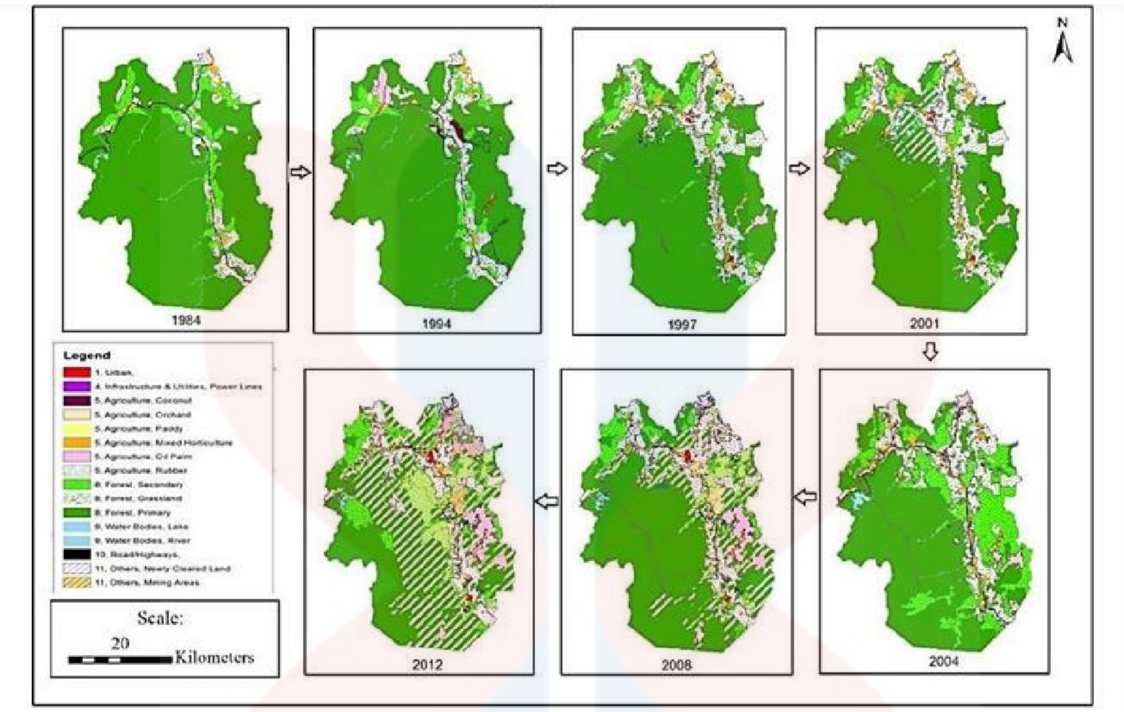


Figure 1.4: Image classification for land use changes of Jeli (1984 - 2004) (Sources: Muhammad Firdaus Abdul Karim et al., 2020).

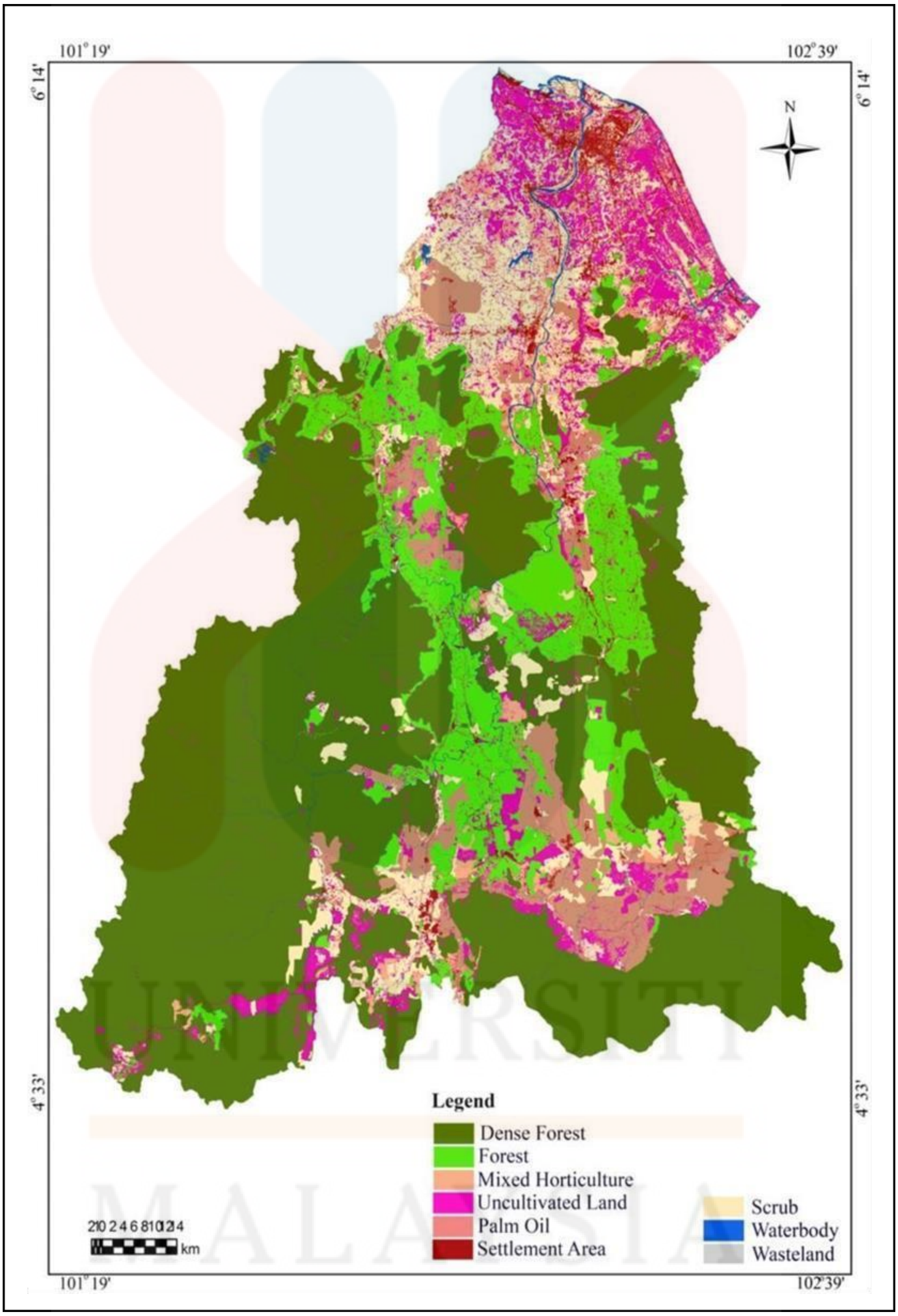


Figure 1.5: Map of land use and land change in Jeli,Kelantan. (Source: Muhammad Firdaus Abdul Karim et al.2020)

1.1.5 Social economy

Jeli is undergoing a phase of quick expansion and development. Both locals and outsiders now have employment options because to the district of Jeli's good effects of urbanisation. The majority of the social economy in the researched location is accounted for by the plantation sector and small and medium-sized companies in the surrounding residential neighbourhoods. In addition, logging activity was seen in various regions of the research zone, indicating the availability of new breakthroughs and possibilities in the area. The varied species of trees that exist in the research area allow for differentiation between oil palm and rubber plantations. Agriculture serves as the district of Jeli's main source of income for social and economic growth (Muhammad Firdaus Abdul Karim et al., 2020). The growth of the plantation created job opportunities to the people, whether they worked on the estate or in a factory environment. In many locations, the plantations are well established. Furthermore, Lata Keding is being evaluated as a potential site for future ecotourism development, as seen by the construction of Lalang's resort and several tiny kiosks along the road to that resort.

1.2 Problem statements

The geological maps of the research region may be acquired by consulting the relevant literature. However, these maps are out of date, have a poor resolution, and do not constitute a comprehensive geological map. The Department of Minerals and Geoscience Malaysia created a comprehensive geological map in 2003, which is the most latest geological map that has been made. The map is not very precise in its depiction of the terrain. As a consequence of this, it is essential to collect fresh geological data and information that may be of use to any organisations in the study of geology. This will allow for a more in-depth comprehension of the dynamic geological processes and history presents in the location of study. In term of geology, geoheritage sites are areas that have unique relief and long-term geomorphological features. These locations are the remains of dynamic processes that happened during whole history of the earth. A lack of geoheritage assessment in this study area, as well as a lack of knowledge among local community about the natural resources that have to be safeguarded, contributed to the bad outcomes. For the purposes of this investigation, Lata Keding is an ideal choice because it possesses a number of distinctive characteristics. Among these characteristics are delicate panoramas that are required by law to be preserved, as well as a strong emphasis on conservation, education, and environmentally responsible development. In addition, given that the Earth is in a constant state of flux as a result of dynamic processes that may influence the topography of the site under investigation, it is essential to bring the prior research up to date. As a consequence of this, the study is now being conducted in the Lata Keding area to collect as many data as is reasonably possible in order to establish how much the geoheritage potential is worth.

1.3 Objective

1. To update a latest geological map at research area with scale of 1:25000.
2. To analyze the geoheritage assessment in the research area for geotourism.

1.4 Scope of study

The purpose of carrying out this research is to produce a detailed geological map of the area under investigation at a scale of 1:25 000. The research of structural geology, lithostratigraphy, and geomorphology of this study area is the goal of both the geological map and the geological surveys that was conducted in this area. Following this step, the interpretation is used inside the ArcGIS programme in order to generate the geological map. By doing a literature study that is based on the results of previous research, the historical geology of the place that is the subject of the inquiry may be identified.

Another purpose of this study is to evaluate whether or not Lata Keding have the potential to become a geoheritage site that need to be protected, publicised, and handed down to following generations. The assessment of Lata Keding will be the primaryobjective of this study's scope. The site of the study will be investigated in order to ascertain whether or not it has a certain attribute that will be useful in determining its worth. The evaluation method for certain features will make use of a variety of factors, such as conservation, scientific value, economic value, educational value, and value added. This inquiry was carried out using a variety of methodologies, including the preliminary investigation, mapping, and some quantitative analysis of the findings will be conduct.

This inquiry was carried out using a variety of methodologies, including the preliminary investigation, mapping, and some quantitative analysis of the findings will be conduct. This study also focused with valuing and maintaining the natural or geomorphological characteristics that are found in Lata Keding, which is located in the district of Jeli in the state of Kelantan. In addition, the results of this research will be beneficial to educational pursuits, and it also has the potential to be of use to a very large number of different categories of individuals. Aside from that, the benefits that are most often linked with natural beauty and landscape are those that are connected with leisure and tourism. This is because natural beauty and landscape are both attractive features. The idea that the Earth is a dynamic system is useful information for geologists to have when trying to gain an understanding of geologic formations, the occurrence of those structures, and the historical context of those structures.

1.5 Significant of study

This study is significant because it gives detailed geological information about the study area as a result of a geological map. This will helps geologists to better understand the historical events and processes that have happened in the study area. The information which included data like lithostratigraphy, structural geology, weathering, and geomorphology, was used as a guide by the right authorities, agencies, or governments to manage and develop the area being looked into in the best way possible. Also, the landscapes at the research site are important from a scientific, cultural, social, and economic point of view and should be kept.

Since this area has some features that can be looked at to figure out if it can be used as a geomorphosite or not, it is a good idea to do the quantitative evaluation here. The assessment of geomorphosites in the study area is important not just to geologists but also to the government and the people who live there because it shows where and how important geological elements are found in the study area. This makes people more aware of how important it is to secure and keep geological resources in the study area and gives them more guidance to do so. It is just as important to keep important geological resources as to keep biodiversity, because these helps create a stable regional ecology and a stable geodiversity.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The research body is typically referred to as the literature review. It can be obtained from a select variety of sources, including books, journals, papers, the internet, and many other scientific resources connected to and pertinent to certain subjects. The objective of the literature review is to achieve a greater comprehension of the paper by locating specific examples of theoretical and scientific knowledge.

The study of geology is concerned with the study of changes that have occurred from the past to the present. In the field of geology, most researches are conducted using a method known as desktop research, which involves collecting data from earlier studies, journals, and scientific papers. Every type of information is gathered and analysed in order to achieve a comprehensive understanding of the geology of Kelantan, particularly in the area under researching.

The material for the specification element of the research is focused on the geological heritage of the area. In order to locate the question at the research site, a detailed analysis of the prior research was performed, during which the geoheritage element, the background of geoheritage, the prior methods that had been invented by the previous researcher, and the case study concerning the specification part were highlighted.

2.2 Regional Geology and Tectonic Setting

As can be seen in Figure 2.1, Peninsular Malaysia is divided into three belts: the Western Belt, the Central Belt, and the Eastern Belt. According to research conducted by Hutchinson, C. (1989), all of these belts has its own unique geology and tectonic history. According to Metcalfe, I., and Azhar, H. (1994), the deep marine formation represent peninsular Malaysia from the Permian to Triassic period. Deep-sea sediments are known as being present in the Semantan and Semanggol Formations, which date back to the Triassic period and based on sedimentology and palaeontology data. In general, Malaysia is considered to be a section of eastern Malaysia and a part of the tectono-stratigraphic terrain of Sibumasu.

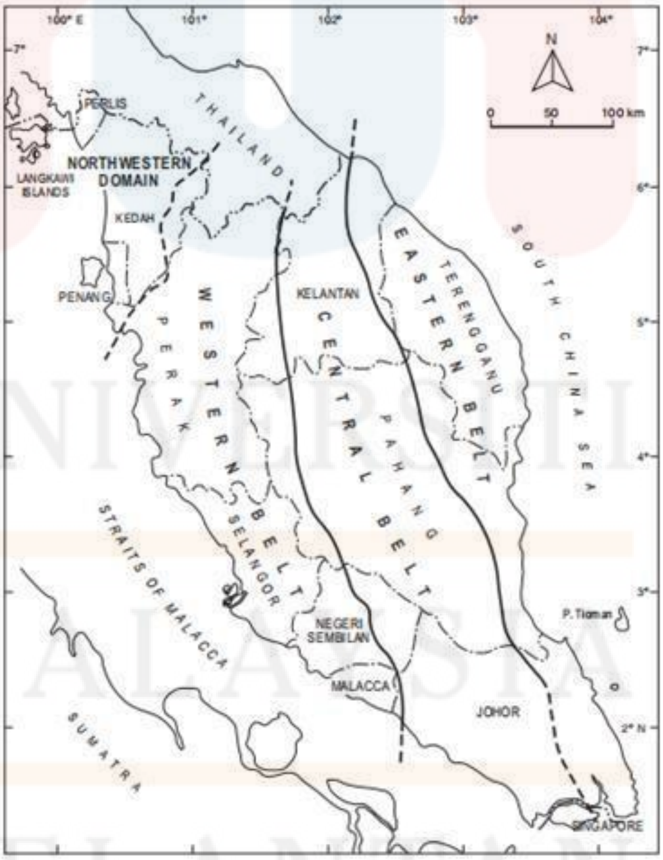


Figure 2.1: Map of Peninsular Malaysia showing Western, Central and Eastern Belts (Source: Hutchison & Tan, 2009).

The major part of Kelantan is contained inside what is known as the Central Belt. Kuala Betis, Gua Musang, Aring, and Gunung Gagau form up the four districts that make up Southern Kelantan which is one of the parts that make up the Central Belt. There are 2 formations in the Gua Musang district: the Gua Musang Formation and the Gunung Rabong Formation. The Gua Musang Formation is the larger of the two. Besides, granite covers nearly one-third of Peninsular Malaysia and may be categorised into three distinct belts: the Western Belt, the Central Belt, and the Eastern Belt (Hutchison and Tan, 2009) that show in Figure 2.2.

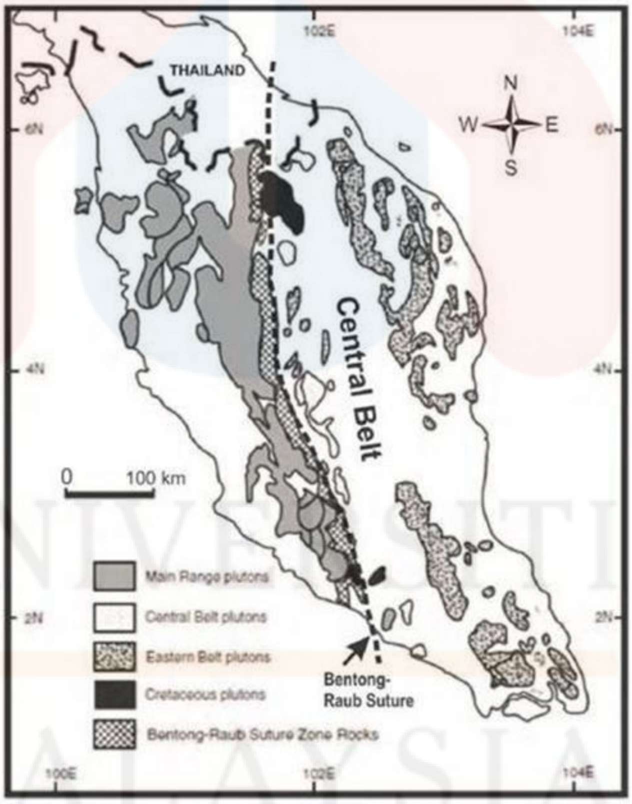


Figure 2.2: The Bentong-Raub Suture line in Peninsular Malaysia (Sources: Ariffin, 2012).

The Malay Peninsula has been subdivided into two provinces when it comes to granite: the Main Range Province and the Eastern Province. These two provinces are separated by the Bentong- Raub Suture line (Hutchison & Tan, 2009). First type granite predominates in the composition of the Eastern Province granite, which is found predominantly in the form of minor batholiths and unzoned plutons (Hutchison & Tan, 2009). These plutons evolved and intruded a series of mudstone, siltstone, sandstone, and limestone including a thick range of moderate to acid volcanic and volcaniclastic rocks between the Permian and Triassic time periods (Hutchison and Tan, 2009). Granites from the eastern province are characterised by a textural range that ranges from equigranularity to weakly porphyritic and are made up of a variety of minerals ranging from gabbro to monzogranite (Ghani, 2008).

Besides, Hutchison (1973) proposed that the Bentong-Raub line acted as the principal tectonic boundary between the western and central belts of Peninsular Malaysia. This serves as an extra point of reference. The term "Bentong-Raub row of the ophiolite" was used by Hutchison (1975) to refer toit. It is known as the Bentong – Raub Suture Zone (Metcalfe, 2000), and it stretches from the area in southern Thailand's southall the way down to Melaka in Malaysia via Bentong and Raub (Tjia, 1989). It is a continuation of the Nan-Uttaradit suture that may be found all the way through Thailand.In the south, the suture zone extends to Lancangjian, Changning – Menglian, which is located in the Yunnan Province in Southwest China. In the north, the suture zone extendsto Chiangmai, which is located in the northernmost part of Thailand (Metcalfe, 2000). Thesuture zones known as Lancangjian,Changning – Menglian, Chiangmai, and Bentong- Raub are all excellent examples of the central sea ofPalaeo-Tethys. The suture zones known as Lancangjian, Changning – Menglian, Chiangmai, and Bentong-Raub are all good examples of the secondary sea that existed in Palaeo-Tethys.

2.3 Stratigraphy

Peninsular Malaysia's central basin is made up of Triassic, Jurassic, and Cretaceous rocks that demonstrate axial-plane cleavage, folding, structural style, and faulting. In aspects of geological formations, Peninsular Malaysia's central basin is related to the Philippines' central basin in certain ways (Harbury et al., 1990). During the Triassic period, rocks could be bent and split in many different ways, but axial planar cleavage was the most common. The Tembeling and Gagau Group is made up of layers that are from the Upper Jurassic and Lower Cretaceous.

At Jeli Area, might find Triassic sedimentary rocks like the Gunung Rabong Formation and Permian sedimentary rocks like the Gua Musang Formation, which had been made by acid intrusions (Nazaruddin, 2015).The Main Range is mostly made up of granitic rocks, with several sedimentary and metasedimentary rocks mixed in. The Triassic rocks are in the central and southern parts of Kelantan. This sedimentary form is mostly made up of argillo-arenaceous sediments with layers of volcanic rock and limestone. There are plenty Permianintrusions that stick out of the Triassic sedimentary layer (MacDonald, 1967).

The metapelites, which comprise most of the material, have pieces of both abrasive and calcareous content in. Geologists have just recently found the minerals amphibolite and serpentinite that were very rare (MacDonald, 1967). Most of the east half of south-western Kelantan is made up of volcanic-sedimentary rocks that were laid down in the west of the island during the early permian. Almost all of the central and northern parts of Kelantan are made up of Taku Schist, the earliest form of rock on the island, whose age is still up for debate but is definitely before the Triassic.

Ghani et al. (2000) say that Kelantan is one of the Jeli granite formation. The Jeli Igneous Complex is 1 km north of Jeli. These granites, called Jeli Granite, is found in India. Some of the granitic parts that form Jeli Igneous Complex in the area are Noring Granite, Kenerong Leucogranite, and Berangkat Tonalite (Ghani et al,. 2000).

2.4 Structural Geology

The state of Kelantan is located in the most north-eastern part of the Malaysian peninsula. Basedon previous occurrence, the tectonic processes that took place inside Peninsular Malaysia throughout the Paleozoic and Mesozoic periods had an effect on the land mass, which resulted in the formation of folding and faulting (Nursufiah Sulaiman et al., 2020). Folding, jointing, and faulting are some of the localised features which were found in sedimentary and granitic rocks. These structures have been recognised (Nursufiah Sulaiman et al., 2020). In Kelantan, the pattern of local structures that predominated along the ways of north to south and from the northwest to the southeast was dominant, whereas in Jeli, the pattern of local structures that predominated along the ways of northwest to southeast and northeast to southwest predominated (Dony Adriansyah Nazaruddin, 2015).

According to Hamblin, W.K. (1994), a joint is created as a result of the strain that is produced whenever rock is uplifted, folded, or fractured as a direct result of tectonic activity. A joint is a fracture which divides two parts of rock that are moving apart from each other. This concept originates from the field of geology. When the tensile pressure in a material surpasses its threshold, a joint will develop even if the shear stress is not removed first. According to Tija (1986), the Gemas and Semantan Formations are the primary locations where the dominating strike and fold axis of Peninsular Malaysia can be found.

In addition, because Kelantan is located in the middle belt of Peninsular Malaysia, large structural zones have emerged, one of which is known as the Bentong-Raub Suture Zone. Along the Gua Musang-Cameron Highland Road, the Karak Highway, and the Bentong-Raub Road, there are a total of 24 road cuttings that serve as a barrier to safeguard the Bentong-Raub Suture Zone. The suture is a zone of deformed rocks that is approximately 13 kilometres broad and is composed of schist, phyllite, sandstone, cherts, and other metasedimentary rocks.

2.5 Historical Geology

The formation of the Main Range Granite took place between 200 and 230 million years ago, during the latter half of the Triassic era, as stated by the Malaysian Department of Minerals and Geoscience (2003). On a geological scale, the rock units that make up Kelantan can be categorised as unconsolidated sediments, extrusive rocks like granite and volcanic rocks, sedimentary or metasedimentary rocks, and sedimentary rocks. The granite that can be found in Kelantan is split up into two different masses, which are known as the Main Range and the Boundary Range.

The unconsolidated sediments make up the coastal section of this area, which encroaches on the portion of the state of Kelantan that is located farther north. They reach from the boundary with Thailand to the border with Terengganu. The Quaternary silt that covers the granite bedrock and contributes to the formation of the alluvial plain is located on top of this bedrock.

Besides, the extrusive rocks created an enormous size extending north to south in the centre zone and along the eastern boundary of the state with Boundary Range granite.

According to Kelantan's Geology and Mineral Distribution Map from the year 2000, they came into existence during the Permian age. The Geology and Mineral Distribution Map of Kelantan indicates that sedimentary and metasedimentary rocks ranging in age from the Ordovician to the Cretaceous represent 51percent of the state's land area. These rocks may be dated back as far as the state's history goes. These rocks blanketed the area that runs north to south in the middle of the state of Kelantan.

Following earlier research (Dony Adriansyah Nazaruddin et al.2018), the small river or stream, which is the major attraction in the region, drains along the flat alluvial plain to the south of the hill. Because of this, the terrain in the study area is influenced, and it becomes more stunning and distinctive as a result. As a direct consequence of this, Lata Keding has come to represent Jeli's tourism industry. Visitors have the opportunity to take in the natural beauty of the place (Dony Adriansyah Nazaruddinet al., 2018).

2.6 Geoheritage site

Geology is an important part of the natural world, and the geological record is an indispensable part of the natural history of the entire planet (ProGEO, 2011). Regarding rocks, minerals, fossils and landsforms, there are geological events including earthquakes and volcanoes that will be used to characterise the earth's history. These geological occurrences can be utilised to reconstruct the evolution of the planet. Knowledge about geoheritage can gain from in-situ (at geosites) and ex-situ (at excavations) (museums). A geoheritage is a scientific method that focusing on geological sites that are one-of-a-kind, exceptional, and representative while promoting the study of geology and its role in society today. A geoheritage is being known as a geopark (ProGEO, 2011).

Geoheritage sites that are considerable academically and scientifically provide with books of geologic features and landscapes, unique rock or mineral component, special or rare fossils or other geologic aspects relevant for learning and research. The places of geologic features or landscapes that have played an important role in major historical or cultural processes are the types of geoheritage sites that are considered to have cultural value. The spiritual value of geological qualities, folklore associated with the genesis of rock formations or landforms, and linkages among rock formations and archaeology are all factors that might lead to the creation of cultural values (Gray, 2005).

Many of the sites that make up geoheritage have the chance to grow into tourist destinations, which would be beneficial to the economy of the surrounding areas. The public benefit is served by the expansion of information that geoheritage sites provide regarding natural catastrophes, groundwater supplies, soil processes, and other elements of the nature and history of Earth. Locations such as these hold a lot of potential for the advancement of scientific study, the establishment of outdoor classrooms, the broadening of the general public's scientific knowledge, the development of recreational opportunities, and the provision of economic support to the surrounding communities (Aspect, 2011)

Geologists provide actual monetary values to the many geological locations and characteristics that we have. If these variables are considered, it will be much simpler to find potential geo-heritage treasures. Because of this, the values will help to provide people a deeper understanding of the significance of geology. This will be of great assistance in ensuring that geology will continue to be relevant in the years to come. There is a direct correlation between the values of geoheritage and the values of geodiversity (Ibrahim Komoo, 2002).

a) Scientific Value

It is generally accepted that geological structures and landscapes, certain kinds of rock or mineral, one-of-a-kind or extremely rare fossils, and other sorts of geological characteristics that are relevant to the investigation all have scientific value. It is essential for the protection of geological records and for gaining a knowledge of the history of Earth. Karst landforms, hot springs, and formations that allow for the identification of fossils are all types of geological formations (Ibrahim Komoo, 2002).

b) Educational Value

In accordance with the values that are associated with science, this value is closely tied to those values. On the other hand, it focuses mostly on education, like teaching people to appreciate geological areas and characteristics, which is nothing more than a value. In terms of its value to the scientific community, it is both more comprehensive and methodical. Such of this include knowing how to swimming in rivers and other sources of water, and knowing how to climb rock structures (Ibrahim Komoo, 2002)

c) Aesthetic value

Aesthetically significant geological heritage sites are those that have landscapes that are visually appealing as a result of their geological characteristics or processes. These types of landscapes are shown in the category of geological heritage sites. Karst landscapes and river landforms, for instance, are two examples of the kinds of features that might be discovered that are appealing to tourists (Ibrahim Komoo, 2002).

d) Recreational Value

The number of different kinds of tourism and recreational pursuits that may be carried out in a location is one factor that determines the recreational value of the location. Some examples of fun things to do outdoors include spelunking, climbing rocks, soaking in hot springs, and swimming (Ibrahim Komoo, 2002). This value is more focused on activities related to geotourism.

e) Cultural Value

Cultural Value geological heritage sites are places which have a geological or landscape feature and has a part in historical or cultural events. These places may be found all over the world (Ibrahim Komoo, 2002)

CHAPTER 3

MATERIALS AND METHODES

3.1 Introduction

There were a few materials and methods that needed to be used in order to finish the process of gathering data and the essential particulars for geological mapping and the potential worth of geoheritage in the Jeli area, which had helped with the research. The necessary resources and methodologies had made the study simple and more enjoyable.

3.2 Materials

The materials that were used for this study were field tools such as maps, cameras, geological hammers, global positioning systems (GPS), notebooks, plastic samples, and books about geoheritage and the area being studied. During this investigation, many different methods were used, such as geological mapping and site surveying done by "traversing." The rock samples were taken at different points along the traverse that was conducted in the area being studied. In addition to going to each location in the area of study, tasks such as identifying, mapping, observing, and describing the geological features were also completed. In table 3.1 can see a list of the tools that were used in this evaluation

Table 3.1: **Function of equipments**

No.	Equipment	Function
1.	Base map	Prior to entering the field, statistics and information on the research area are obtained using a base map.
2.	Global Positioning System(GPS)	The GPS will record both the coordinates and the track, as well as any outcrops that occur at the site.
3.	Geologic Hammer	Use to get rock samples and as tools to measure the size of the rock samples.
4.	Brunton Compass	The Brunton Compass is utilised for the purpose of determining the strike and dip of geographical formations such as bedding.
5.	Hand Lens	The hand lens is utilised to do a detailed examination of the rock sample, which may include the examination of fossils, minerals and other materials of a quite tiny size.
6.	Sample Bags	The sample of rocks is then placed in the Sample Bag, which is then labelled with the coordinates of the area from which the samples were gathered.
7.	Measuring Tape	At the field, measurements of both the length and width of the outcrops are taken.
8.	Field Notebook	To write and record all the data.
9.	Camera	Serves as a tool for taking photos of outcrops and providing a geomorphology perspective.

3.3 Methodology

For the methodology, there were a total of four stages to carry out this investigation. The preliminary research was the initial way that was looked into for this research. The preliminary research was carried out so that we could get some understanding regarding the geology in general as well as for the specific parts. The field studies were the next one that was covered in this investigation. In this section of the research, some data was collected through the use of geological mapping and geoheritage mapping. The third phase consisted of data processing and quantitative analysis, both of which were carried out at Lata Keding. This was done by conducting a survey for the potential of a geoheritage site, which was then evaluated in accordance with the geoheritage values, which included scientific value, educational value, aesthetic value, recreational value, and cultural value. The final stage in the methodology used in this investigation was the processing and analysis of the collected data. The final score for Lata Keding was calculated at this point in order to establish whether or not it was feasible for this location to be marked as a geoheritage site in the future.

3.3.1 Preliminary Studies

Studying literature papers, coming up with research questions, and gathering secondary data from literature journals and also other materials were all ways to do preliminary studies. Moreover, having read resources from books and websites were used to get more information, and a base map was made and analyzed before the 12 days of fieldwork.

3.3.2 Field Studies

Geological mapping was used most of the time in field studies to mark geological data for geomorphology, stratigraphy, structural geology, sedimentology, mineralogy, and petrology. Among these things were taking readings on strike and dip, joint systems, drafting outcrops, and collecting rock samples. Fieldwork studies were scheduled to start in August 2022 and last for 12 days.

3.3.3 Laboratory work

The work in the lab included petrographic analysis. A few samples were sent to a lab for research to identify what kind of rocks they were. This was done by looking at hand specimens and thin sections. As for figuring out the types of magma and the tectonic setting of the area of the study.

1) Hand specimen analysis

The analysis of hand specimens involved looking at rock samples with the naked eye to see how they felt and what minerals were in them. A hand lens was used to see things more clearly.

2) Analysis of a thin section

Sample thin sections were broken and thinned before being placed on a glass slide and polished until they reached a thickness of 30m. A petrographic microscope was used to make observations of thin sections of minerals to determine their texture and makeup procedures for thin section.

To prepare a glass slide for a rock sample, the first step was to ensure that the glass was frosted. This helped to create a plain, even surface with the same diameter throughout. Once the glass slide was prepared, the next step was to determine where on the rock sample to make the thin section. This depended on the specific characteristics of the rock and the information that was being studied. To create the thin section, a slab saw was used to split the rock sample into a manageable size. Then, a diamond saw was used to carefully cut and grind the rock sample to create a smooth, even surface. After the rock sample was prepared, glue was made by mixing epoxy with a hardener. Just a few drops of this glue were placed on the surface of the polished glass slide and allowed to sit for at least 5 minutes before applying more epoxy. Once the glue was applied, the frosted side of the glass slide was placed down and moved around to remove any excess glue or air bubbles. The glue was allowed to fix for 20 to 30 minutes. Finally, a grinding wheel was used to carefully grind the rock sample down to the desired diameter, which was typically around 30 micrometers. This allowed for the creation of a thin section that was thin enough to study the rock's structure and properties in detail.

3.3.4 Data Processing

The global positioning system (GPS) had geological data taken from it, such as coordinates and traverse data, and then that information was imported into ArcGIS software that was obtained from the fieldwork investigations. After being entered into an Excel sheet, the petrological data generated from the petrographic analyses was then imported into GCD kit for the purpose of data processing during the whole-rock analysis.

This study applied the qualitative and quantitative assesment by (Dony 2017), that heritage site for the section of the study pertaining to the specification. These ideals included scientific value, educational value, aesthetic value, recreational value, and cultural value.

In addition, the survey approach was used to determine the kinds of activities that could be carried out in the region under investigation, with a particular emphasis on the five geoheritage values. The residents in the nearby area received this survey after it had been completed. In addition to testing their knowledge, the survey also included a list of prospective activities and interesting things that could be found there. The questions focused on the term of geoheritage, which refers to knowledge about geoheritage values. Not only that, but the respondents were also asked about the geological structures and features in the study area.

3.3.5 Data Analysis and Interpretation

1) Geoheritage Values Classification

There were five kinds of geological value: scientific, educational, recreational, aesthetic, and cultural. In terms of their scientific value, geological features, landscapes, types of rocks or minerals, rare fossils, and other geological things were more important than anything else. Recreational value was focused on the kinds of fun things that could be done there. The aesthetic value referred to geological features and landscapes that were beautiful because of how they were formed. Geological features that had been important in cultural or historical events gave a place its cultural value. The numerical assessment analysis (quantitative method) of the study area was assessed using Table 3.2 (Nazaruddin, 2013).

Table 3.2: Numerical assessment value

VALUES	DESCRIPTION
1	Very poor
2	Poor
3	Average
4	Good
5	Very good

1) Geoheritage Survey Analysis

The focus of this survey was on the residents of the Jeli district, as well as tourists, students, and geologists. The goal was to gather information from a total of 100 respondents, which would include students, geologists, lecturers, locals, and tourists. The survey asked participants about the kinds of activities that could be done at different locations and what the major attractions were that interested them. The data collected from the survey was analyzed and organized using Microsoft Excel software. The purpose of the survey was to study potential geological heritage locations and identify appropriate activities for these sites, with a particular focus on five geological values. It was also intended to gauge the level of conservation awareness among the local population.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

General geology is a field that involves the collection and interpretation of data from previous research and agencies. It aims to understand the details and processes that shape the earth and its various features. One important aspect of general geology is geomorphology, which is the study of landforms and the processes that shape them. This includes the origin and evolution of the earth and how it has changed over time. Understanding the mechanisms that contribute to these changes can provide valuable insights into the earth's history and help to better understand its current state.

Another key aspect of general geology is stratigraphy, which involves the analysis of rock layers and their ages. This includes understanding the relationships between different layers of rock and how they relate to one another. Lithostratigraphy is a technique that is often used in this research to classify the association between different rock layers.

Structural geology is also an important part of general geology. It focuses on the structure of the earth and the geometry of rocks in order to understand the history of deformation and how it has shaped the earth over time. This knowledge is crucial for interpreting historical events and understanding the processes that have shaped the earth as we know it today.

By combining these different areas of study, we can gain a comprehensive understanding of the earth and its history. Geomorphology, stratigraphy, and structural geology all play important roles in exposing past occurrences and helping us understand the earth's past, present, and future.

4.1.1 Accessibility

There were several ways to get to the study area located in the southern region of Kelantan known as Jeli. One option was to take the Jeli-Gerik highway, which provided a direct connection to the area. Alternatively, you could also reach Jeli by taking the Tanah Merah-Jeli or Jeli-Gerik highway. In addition to these major roadways, there were also a number of unpaved roads that could be used to access the study area, which may have been useful for reaching more remote or isolated areas within the research region. Finally, it was possible to explore the study area on foot, allowing for a more hands on and immersive field analysis experience.

4.1.2 Settlement

The focus of the settlement in the study area was on Lata Keding, Jeli, and the surrounding villages like Kampung Gemang and Kampung Lakota. These areas were inhabited by residents. While much of the study area had been developed and contained numerous plantations, there were still some settlements scattered throughout the region.

4.1.3 Forestry and vegetation

The study site was located in a region where land use was dominated by forestry, rubber, and oil palm plantations. In the Jeli plantation, which was situated with in the study area, rubber and oil palm cultivation was the primary land use and economic activity. Within the study field, rubber plantations were particularly prevalent. The forests in the study site had undergone significant changes in recent years, with some being transformed into oil palm or rubber plantations and others being irrigated. Overall, the land use in the study area was shaped by the dominance of rubber and oil palm operations, particularly in the Jeli plantation.

4.2 Geomorphology

Geomorphology was a field that involved the study of the various processes that had shaped the earth's surface over time, as well as the physical characteristics of the various landforms that existed on the planet. Landforms such as mountains, valleys, and lakes were all shaped by a variety of forces, including erosion, weathering, tectonic activity, and human intervention. To study these processes and landforms, geomorphologists used a range of tools and techniques, including field observations, mapping, and geospatial analysis. By using these tools, geomorphologists were able to gain a better understanding of how landforms were formed and how they evolved over time, and to make predictions about how the earth's surface may have changed in the future. Geomorphologists often worked in fields such as physical geography, geology, engineering geology, archaeology, and geotechnical engineering, and their work had important implications for a wide range of applications, including natural resource management, land use planning, and environmental protection.

4.2.1 Geomorphological classification

The geomorphology of the research area was thoroughly analyzed using a variety of methods, including field observation, topographic map analysis, and satellite imagery. The topography, drainage patterns, river structure, and vegetation of the study area were all taken into consideration when discussing the geomorphology of the region. According to Tanot et al. (2001), there were four main types of geomorphological landscapes present in the Kelantan state: mountainous areas, hilly areas, plain areas, and coastal areas. However, it is important to note that the geomorphology of any given area can be influenced by a wide range of factors, including climatic conditions, geological history, and human activities. As such, it was essential to thoroughly assess all of these factors in order to gain a comprehensive understanding of the geomorphology of a particular region.

4.2.2 Topography

Topography is the study of the natural features and landforms on the surface of the earth. These features can include hills, valleys, mountains, and other natural features that are formed by the physical processes that shape the earth's surface. The contour pattern, or the arrangement of the different landforms, can be used to describe the topography of an area. For example, an area with a contour pattern that features hills and steep slopes may be described as hilly, while an area with a contour pattern that features two hills with a dip in between may be described as having a valley. The figure 4.1 (from the State of New South Wales, Department of Education and Training, 2009) illustrates how the contour pattern can be used to describe the topography of an area.

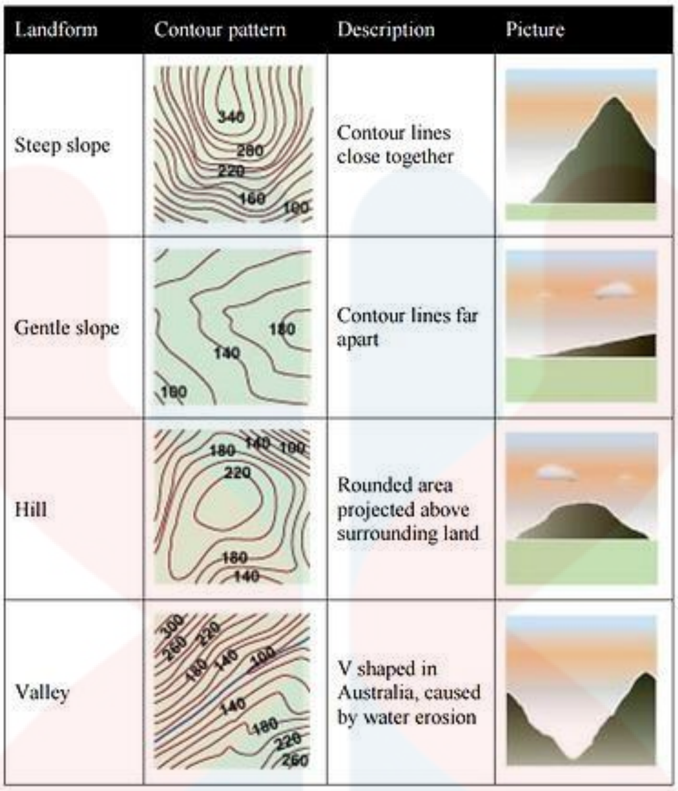


Figure 4.1: Landform based on contour pattern (State of New Wales, Department of Education and Training, 2009)

The lowest contour value in the research area was found in the northwest section, where the presence of a river, combined with corrosive water characteristics and heavy precipitation, often led to impacts on the surrounding area. This region was also characterized by the presence of limestone outcrops located near the river. In contrast, the north-east section of the research area was located on a steep slope and hill, with a peak elevation of 440m. A 3-D topography map, depicted in Figure 4.2, further illustrated the variations in elevation and terrain within the study area.

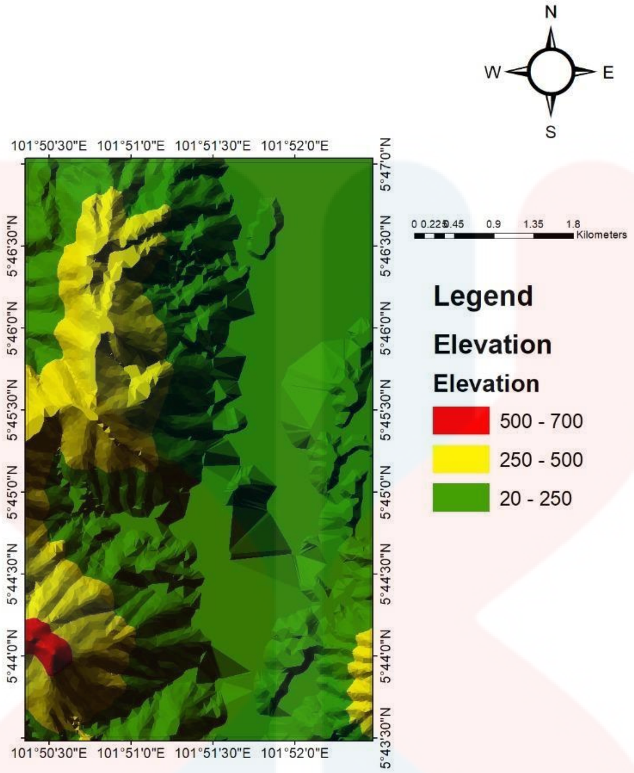


Figure 4.2: The 3D geomorphology map in study area

4.2.3 Drainage pattern

The patterns of streams, rivers, and lakes in a particular area, known as a drainage basin, were referred to as the drainage pattern. These drainage basins were separated from one another by topographical barriers called watersheds. There were several different types of drainage patterns, including dendritic, radial, rectangular, trellis, parallel, annular, and meandering. Dendritic drainage patterns, which are the most common and often found in areas with flat terrain and uniform rock and soil types, resembled trees with branching tributaries and a main stream. Radial drainage patterns, on the other hand, featured streams that radiated outward from a central hill, dome, or volcanic cone.

One of the most common drainage patterns was the dendritic pattern, in which a main stream was joined by tributaries at roughly the same angles. Another variation of this pattern was the trellis pattern, which occurred when the main stream and its tributaries flowed in parallel and produced a distinctive fold in the underlying rock strata. Another type of drainage pattern was the annular pattern, which occurred when a primary stream formed in a concentric, circular pattern around an uplifted dome of sedimentary rocks. All of these patterns were influenced by the topography and geology of the landscape, as well as the flow of water through the area. The dendritic pattern of the study area had shown in the Figure 4.3.

a. Dendritic

The dominant drainage pattern in the study region is dendritic. In the southeast and northwest of the study field, two major dendritic patterns were identified, with water flowing southward. This type of pattern is typically found in areas where the rock or unconsolidated material under the stream has no specific shape or fabric and can be easily eroded in both directions.

b. Parallel

In contrast, the parallel drainage pattern is characterized by rivers with some relief caused by steep slopes. These streams are typically fast and straight, with only a few tributaries, and all flow in the same direction. This type of pattern is often found in regions with pronounced slopes or elongated landforms such as outcropping resistant rock bands. In the study area, the parallel pattern was mostly located at the center.

c. Radial

The radial pattern is marked by rivers flowing out from a central point, like the spokes of a wheel. It tends to develop on the flanks of a dome or volcanic cone. In the study area, it was observed that this pattern exists at the northeast.

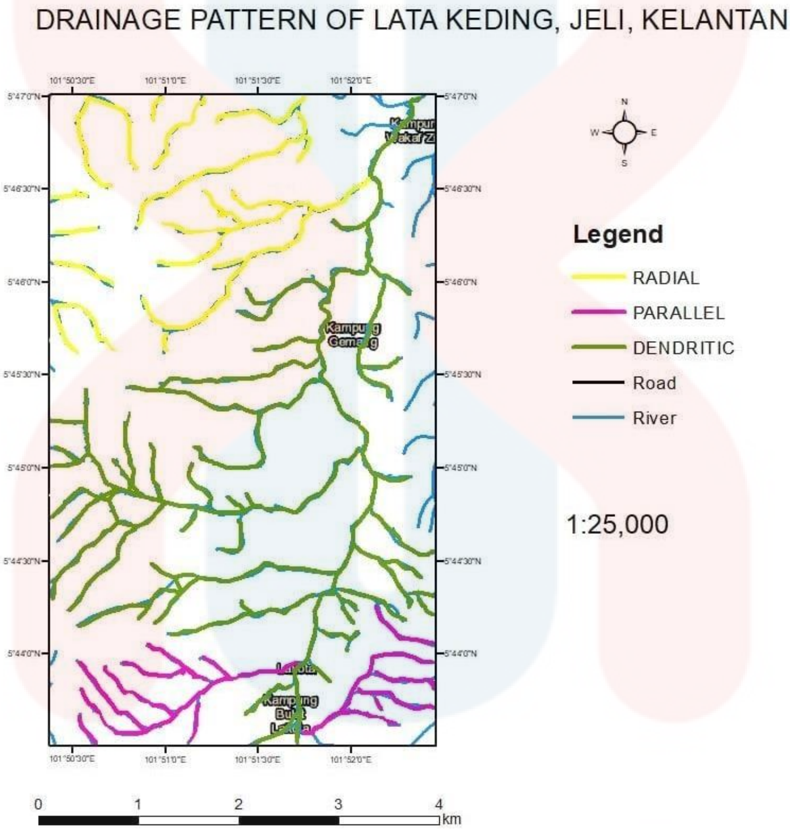


Figure 4.3: Drainage pattern map of study area

4.3 lithostratigraphy

Lithostratigraphy was a branch of geology that focused on the description and classification of rock bodies based on their lithological (physical and chemical) characteristics and stratigraphic relationships. These rock bodies, known as lithostratigraphic units, served as the fundamental units of geological mapping and provided important information about the geology of a particular area. In order to understand the distribution of rock types in a given study area, it was necessary to gather and interpret both primary and secondary data, including previous research and mapping efforts. In the course of my own research, I had identified several lithostratigraphic units in the study area, including units of granitoid, granite, shist, hornfell, and rhyolite gneiss. These units were depicted on the geological map of the study area shown in Figure 4.4.

The geological map provides valuable information about the rock lithology, structural geology, and stratigraphy of the study area. By examining the stratigraphy column, we can see that the rocks in the study area belong to the Jeli Formation, which has been the subject of previous research. In order to accurately describe the different categories of lithology, it is necessary to have a clear understanding of how rocks are defined and classified.

4.3.1 Unit explanation

a) Meta quartz rich Granitoid

Granitoids are a group of rocks that include granites and similar rocks such as tonalites, monzonites, and diorites. These rock has medium to coarse grain size and are composed mainly of quartz, feldspar, and mica minerals. Meta-quartz rich granitoid rocks are a subtype of granitoids that have a particularly high content of quartz. These rock is light in color and have a granular or crystalline texture. They also contain other minerals, such as feldspars, micas, and amphiboles. Meta-quartz rich granitoid rocks are formed through the solidification of magma beneath the Earth's surface, a process known as magmatism.

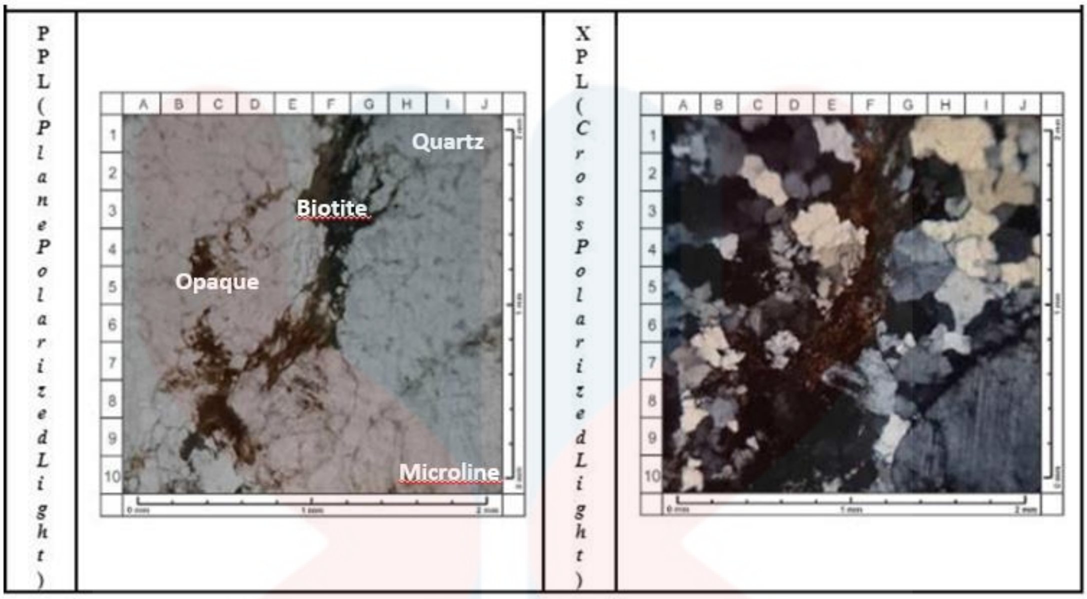


Figure 4.4: The thin section of meta quartz rich granitoid sample from study area

In the observation, it was carried out at 10x ocular magnification and 5x objective magnification and in the observation of massive structure, faneriktexture - weak foliation, coarse mineral size - medium. It is a metamorphic rock, characterized by the appearance of parallel mineral arrangements that have not yet formed foliation but have not yet shown mineral flattening.

<u>Mineral composition:</u>

Quartz (J1) - 75%, In PPL, the colour is colourless, the relief is low, there is no pleochroism, the crystal shape is anhedral, there are no fractures. In XPL, the interference colour is gray-white order 1, the birefringence angle is wavy, there are no twins. Microclin (J10) - 15%, In PPL, the colour is colourless, the relief is low, there is no pleochroism, the crystal shape is subhedral-anhedral, the fractures are in one direction. In XPL, the interference colour is gray-white order 1, the birefringence angle is sloping, the twins are polysynthetic Biotite (F3) - 8%, In PPL, the colour is brown-greenish, the relief is medium, the pleochroism is strong, the crystal shape is subhedral-euhedral, the fractures are in one direction. In XPL, the interference colour is green-orange order 3, the birefringence angle is parallel, there are no twins. Opaque Mineral (C5) - 2%, In PPL, the colour is black, the relief is low, there is no pleochroism, the crystal shape is euhedral-anhedral. In XPL, the interference colour is black order 1, there are no twins.

b) Meta alkali feldspar Granite

Meta-alkali feldspar granite is a type of granite that contains a high proportion of meta-alkali feldspar, a mineral rich in sodium and potassium. This type of granite is known for its hard and durable qualities, making it a popular choice for construction projects and decorative applications. Meta-alkali feldspar granite can come in a variety of colors, including pink, red, grey, white, and black, and it is formed through high-grade metamorphism in convergent plate boundary settings.

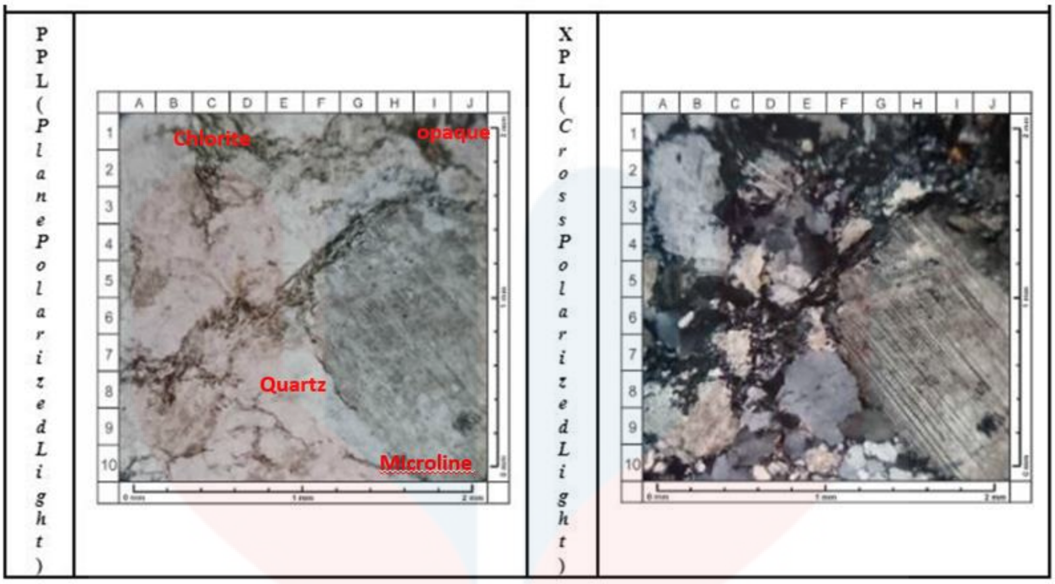


Figure 4.5: The thin section of meta alkali feldspar granite sample from study area

Microscopic Observation:

In this observation, magnification with the eyepiece was 10x and the objective magnification was 5x, and in the observation of massive structure, the texture is phaneritic - weak foliation, the size of the minerals is coarse - medium. It is a metamorphic rock, characterized by the apparent parallel arrangement of minerals that have not yet formed a foliation structure but have not yet shown mineral flattening.

Mineral Composition:

Microclin (J10) - 47% Partly transformed into sericite. In PPL, the color is colorless, the relief is low, there is no pleochroism, the crystal shape is subhedral - anhedral, cleavage in 1 direction. In XPL, the interference color is gray-white order 1, the angle of extinction is oblique, the twin is polysynthetic. Quartz (E8) - 40% In PPL, the color is colorless, the relief is low, there is no pleochroism, the crystal shape is anhedral, there is no cleavage. In XPL, the interference color is gray-white order 1, the angle of extinction is wavy, there is no twin. Chlorite (C1) - 12% In PPL, the color is green, the relief is low - medium, the pleochroism is weak - medium, the crystal shape is anhedral - subhedral, cleavage in 1 direction - none. In XPL, the interference color is dark gray - dark green order 1 - order 2, the angle of extinction is oblique, there is no twin. Opaque minerals (J1) - 1% In PPL, the color is black, the relief is low, there is no pleochroism, the crystal shape is euhedral - anhedral. In XPL, the interference color is black order 1, there is no twins.

C) Schist

Schist is a metamorphic rock that forms from the metamorphism of shale or mudstone and is characterized by its distinct foliation and ability to be split into thin sheets or flakes. It is composed of mica minerals such as biotite, muscovite, and chlorite, as well as quartz and feldspar, and is often found in areas that have experienced tectonic activity. Schist is known for its high degree of metamorphism and is a hard, durable rock that is commonly used in construction and as a decorative stone. It found in green, gray, black, and brown colour.

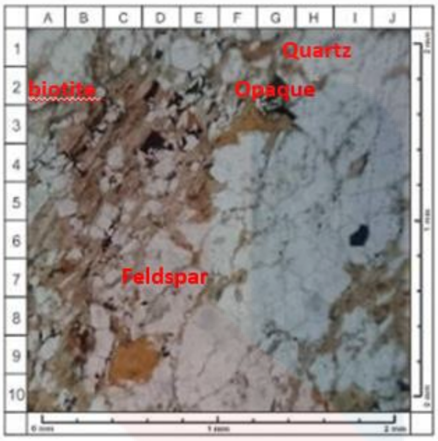
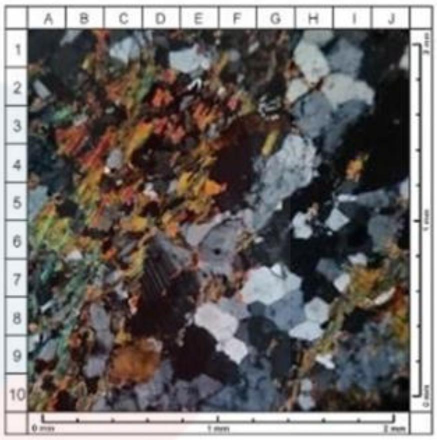
PPL (Plane Polarized Light)		XPL (Cross Polarized Light)	

Figure 4.6: The thin section of schist sample from study area

<u>Microscopic Observation</u>

In this observation, the magnification used was 10x for the eyepiece and 5x for the objective. The observation focused on the foliation structure (schistose) and the crystaloblastic texture (nematoblastik). The grain size was <1/256 - 1/2 mm and the sorting was good.

<u>Mineral Composition</u>

The minerals present in the sample were quartz (H1), biotite (A2), feldspar (D7), and an opaque mineral (G2). Quartz made up 65% of the sample. In plane polarized light (PPL), it had a colourless absorption, low relief, no pleochroism, anhedral crystal shape, and no cleavage. In cross polarized light (XPL), it had a gray-white interference colour (order 1), a wavy angle of extinction, and no twinning. Biotite made up 30% of the sample. In PPL, it had a brown-green absorption colour, moderate relief, strong pleochroism, a subhedral-euhedral crystal shape, and cleavage in one direction. In XPL, it had a green-orange interference colour (order 3), a parallel angle of extinction, and no twinning. Feldspar made up 3% of the sample. In PPL, it had a colourless absorption colour, low relief, no pleochroism, an euhedral-anhedral crystal shape, and cleavage in one direction. In XPL, it had a gray-white interference colour (order 1), a parallel angle of extinction, and twinning of albite-orthoclase-orthoclase-albite-polysynthetic. The opaque mineral made up 2% of the sample. In PPL, it had a black absorption colour, low relief, no pleochroism, and an euhedral-anhedral crystal shape. In XPL, it had a black interference colour (order 1) and no twinning.

d) Hornfels

Hornfels are metamorphic rocks that form through the process of contact metamorphism. This occurs when rocks are subjected to high temperatures and pressures, typically as a result of being in close proximity to an igneous intrusion or a fault zone. The minerals in the rock undergo changes in their structure and chemistry, resulting in a new rock type with distinct physical and chemical properties. Hornfels are typically fine-grained and have a smooth, even texture, due to the intense heat and pressure that they have been subjected to. They may be composed of a variety of minerals, including quartz, feldspar, mica, and hornblende, and are often used as building materials due to their durability and resistance to weathering.

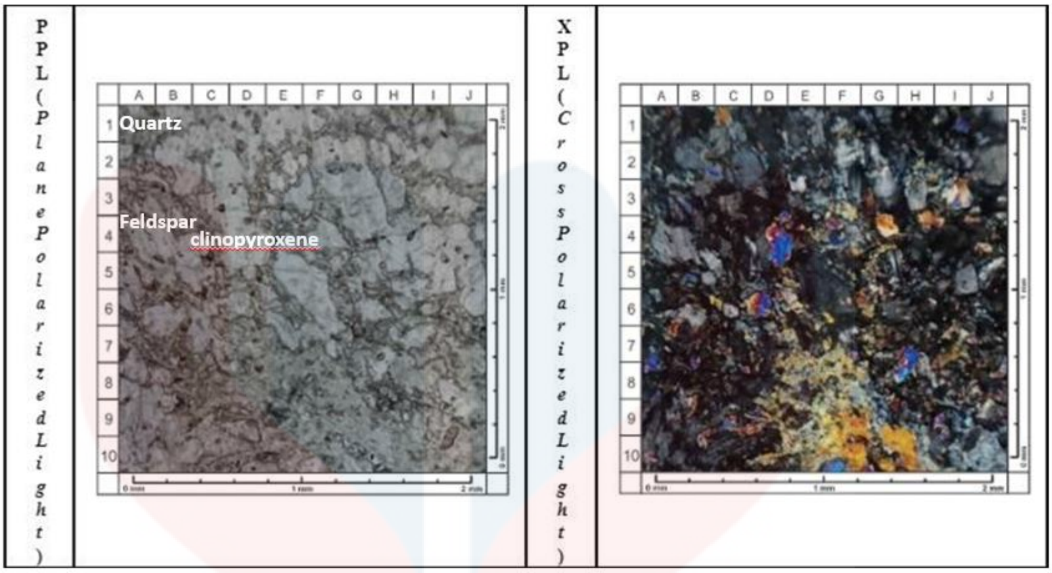


Figure 4.7: The thin section of hornfel sample from study area

Microscopic Observation:

In this observation, the magnification used was 10x for the eyepiece and 5x for the objective. The observation focused on the non-foliated structure (granulose) and the crystaloblastic texture (granoblastik). The grain size was <1/256 - 1/2 mm and the sorting was good.

Mineral Composition:

The minerals present in the sample were quartz (A1), feldspar (A4), clinopyroxene (D4), talk (F8), and the base mass (a3). Quartz made up 10% of the sample. In plane polarized light (PPL), it appeared colourless with low relief and no pleochroism. Its crystal shape was anhedral and it had no cleavage. In cross polarized light (XPL), it had a gray-white interference color (order 1), a wavy angle of extinction, and no twinning. Feldspar made up 35% of the sample. In

PPL, it appeared colourless with low relief and no pleochroism. Its crystal shape was euhedral-anhedral and it had cleavage in one direction. In XPL, it had a gray-white interference colour (order 1), a parallel angle of extinction, and twinning of albite-orthoclase-orthoclase-albite-polysynthetic. Clinopyroxene made up 6% of the sample. In PPL, it had a light brown-light green absorption colour, high relief, weak pleochroism, an euhedral-subhedral crystal shape, and cleavage in two directions. In XPL, it had a yellow-bluish green interference colour (order 2), a slanted angle of extinction, and twinning of monoclinic parallel. Talk made up 20% of the sample. In PPL, it appeared colourless with low relief and weak pleochroism. Its crystal shape was anhedral and it had no cleavage. In XPL, it had a blue-yellow interference colour (order 3), a slanted angle of extinction, and no twinning. The base mass made up 28% of the sample. In PPL, its colour varied from colourless to light gray to light brown and it had high relief. In XPL, its colour ranged from dark gray to black to brown. It consisted of quartz microlites, feldspar microlites, and silica mud.

e) Gneiss

Gneiss is a metamorphic rock that forms under high temperature and pressure conditions. It is characterized by a banded or layered appearance, with alternating bands of light and dark minerals. The minerals in gneiss are typically quartz, feldspar, and mica, and the rock may also contain other minerals such as amphiboles and pyroxenes. Gneiss is often more resistant to weathering and erosion than other metamorphic rocks, and it is also typically more resistant to deformation than sedimentary rocks. Gneiss can be found in a variety of environments, including mountain ranges and orogenic belts, and it is often used as a building and construction material due to its durability and strength.

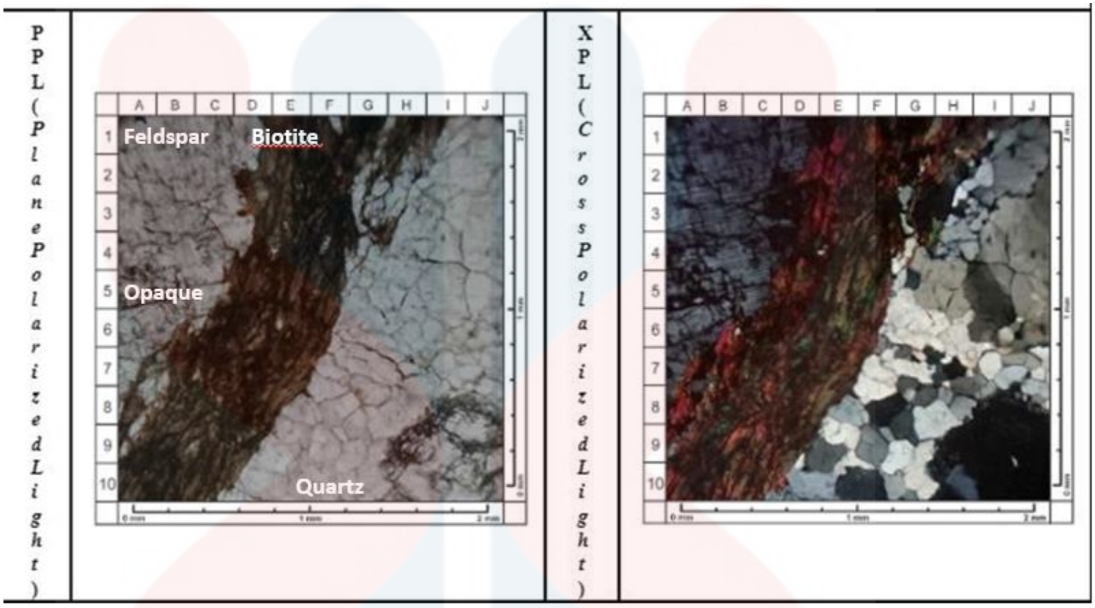


Figure 4.8: The thin section of gneiss sample from study area

Microscopic Observation:

During the observation, the magnification of the eyepiece was 10x and the magnification of the objective was 5x. The observation included the foliation structure (gneissic) and the crystaloblastic texture (porfiroblastik). The grain sizes were <1/256 - >2 mm and the sorting was poor.

Mineral Composition:

Feldspar (A1) - 25% In PPL, the color of absorption is colorless, the relief is low, and there is no pleochroism. The crystal shape is euhedral - anhedral and the cleavage is in one direction. In XPL, the colour of interference is gray-white order 1. The angle of extinction is parallel and the twin is albite - plagioclase - plagioclase-albite - polysynthetic. Quartz (F10) - 44% In PPL, the color of absorption is colourless, the relief is low, and there is no pleochroism. The crystal shape is anhedral and there is no cleavage. In XPL, the color of interference is gray-white order 1. The angle of extinction is wavy and there is no twin. Biotite (E1) - 30% In PPL, the color of absorption is brown-greenish, the relief is moderate, and the pleochroism is strong. The crystal shape is subhedral - euhedral and the cleavage is in one direction. In XPL, the colour of interference is green-orange order 3. The angle of extinction is parallel and there is no twin. Opaque Mineral (A5) - 1% In PPL, the color of absorption is black, the relief is low, and there is no pleochroism. The crystal shape is euhedral - anhedral. In XPL, the colour of interference is black order 1 and there is no twin.

4.3.2 Stratigraphy column

Based on the analysis of secondary data and previous research, it appeared that the research area was composed of five different types of lithology: granitoid, granite, schist, hornfels, and gneiss. As shown in Table 4.1, the stratigraphy column of the study area revealed that meta quartz rich granitoid and meta alkali feldspar granite were the youngest rock that had been discovered in the research area, with schist, gneiss and hornfels being progressively older. Specifically, the ganitoid and granite were from the Stong Complex formation in the era late cretaceous. Schist, gneiss and hornfels were from Telong Formation which were in Permian era.

Formation	Era	Lithology
Stong complex	Late cretacious	Meta quartz rich granitoid
		Meta alkali feldspar granite
Telong formation	Permian	Schist
		Gneiss
		Hornfels

Table 4.1: stratigraphy column of study area

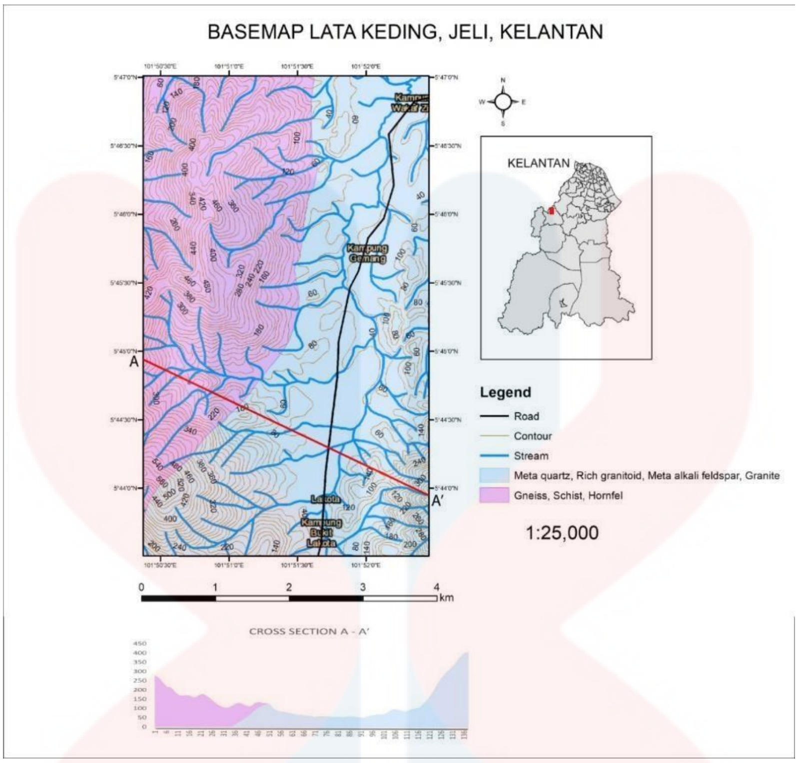


Figure 4.9: Geological map of the study area

4.4 Structural Geology

Structural geology was the branch of geology that investigated the processes and mechanisms responsible for the formation of geological structures and how these structures affected the properties of rocks. Structural features such as lineaments, folds, faults, and fractures were often the result of strong tectonic forces, such as those caused by plate tectonics or earthquakes, which could cause rocks to fold and crack, creating faults and raising mountains. The study of these forces and their effects, known as force of lineament fault analysis, was a subfield of structural geology that sought to interpret the history and impacts of these forces on the Earth's crust.

4.4.1 Fault

Separations between blocks of rock in which displacement had occurred were called faults. There were three types of faults: normal, reversing, and thrust. The type of fault was determined by the type of stress acting on the earth's crust and its orientation. In the field, it could be difficult to identify faults, so lineament analysis was often used to understand them. Lineament referred to linear and semi-linear features in the landscape, such as slopes and valleys. It was used in structural landform studies to indicate the underlying rock properties. The lineament interpretation in the research area was shown in Figure 4.10 on the lineament map.

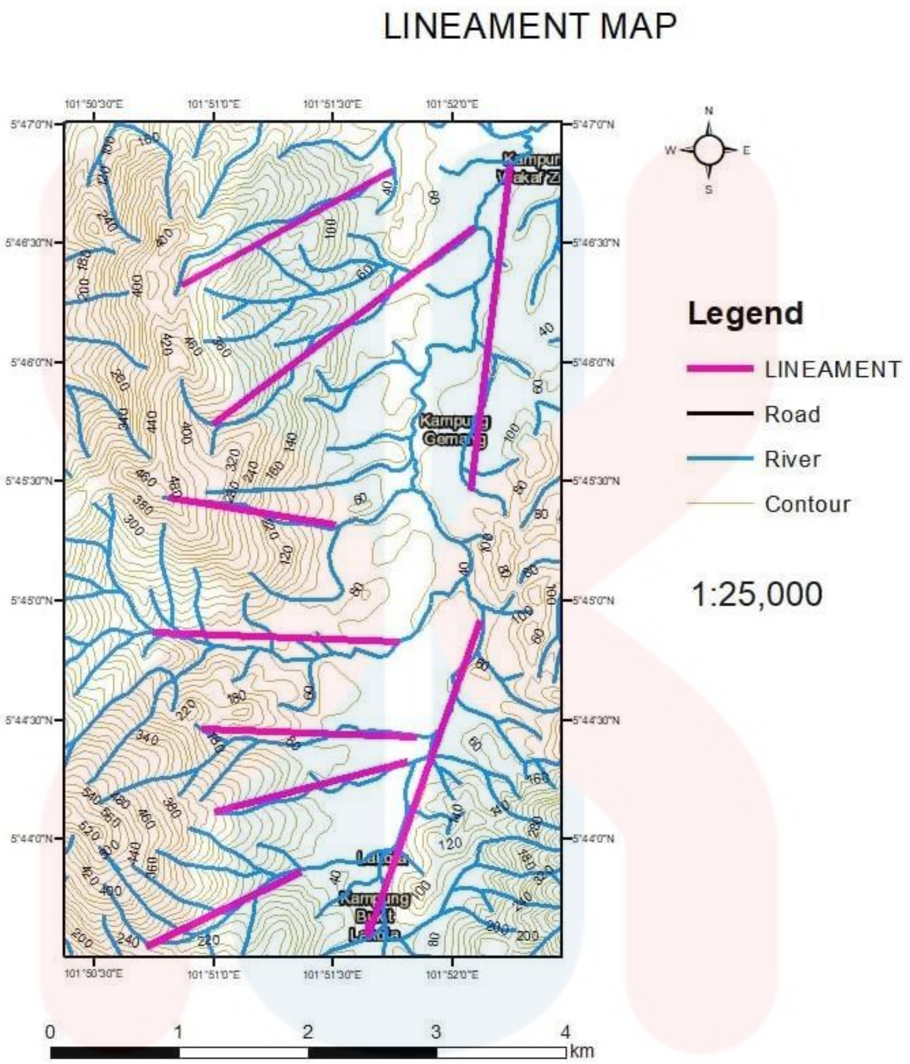


Figure 4.10: Lineament map of study area

4.4.2 Mechanism of structure

In the study area, the structural mechanism of uplifting during tectonic movement had been identified as the main cause of the hilly terrain. This process occurred when tectonic forces were exerted on the earth's crust, causing it to be lifted upwards. As a result, the surface of the ground was elevated, creating ridges and valleys. Lineament analysis was often used in the study area to help locate potential fault lines that may have formed due to this tectonic activity. By careful examining the topographic features of the area, geologists could identify patterns that may suggest the presence of faults, which could provide valuable insights into the underlying geological processes at play.

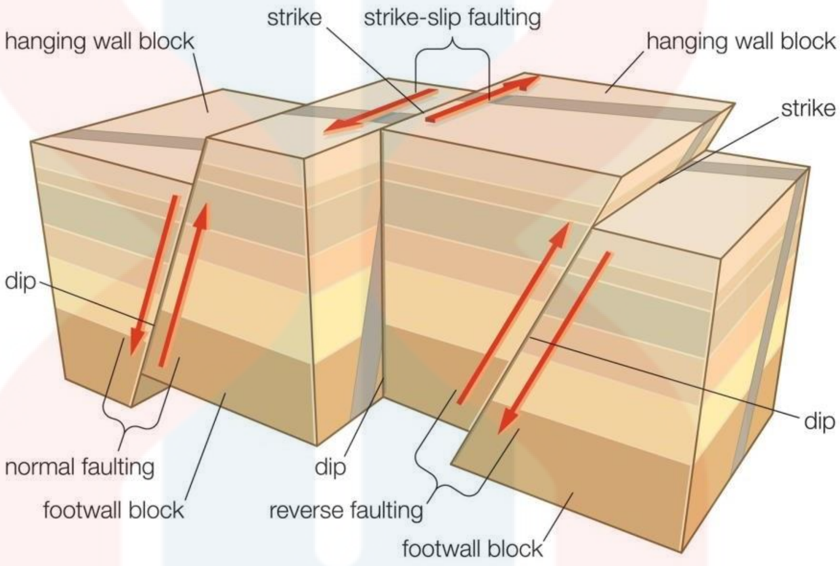


Figure 4.11: Fault mechanism (Source: Britannica, 2015)

There was a significant change in the shape of the land surface in the study area due to a fault displacement, which resulted in the formation of a fault known as a thrust fault. A thrust fault is a type of dip-slip fault, in which the upper block of rock or earth moves upwards and over the lower block, above the plane of the fault. This type of faulting is common in areas where the Earth's crust is subjected to compression and forces that push the land upwards.

Joint analysis

Strike	Dip°
177	48
180	57
168	36
210	58
155	45
162	52
129	42
218	85
183	71
146	68

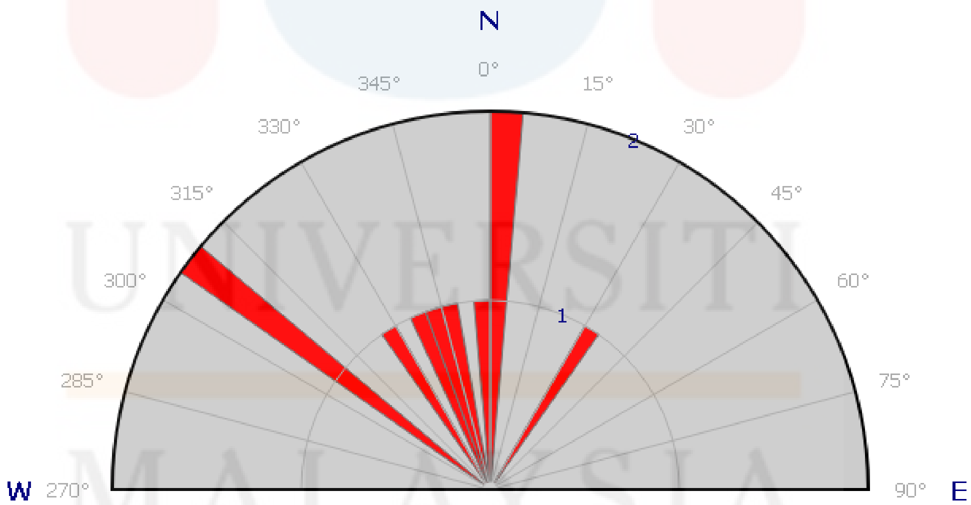


Figure 4.12: Rose diagram for the orientation of discontinuity collected from study area

During fieldwork, the orientation of geological features such as joints has been recorded on a Rose diagram (see Figure 4.4). Based on the diagram, it was found that the majority of the discontinuities observed had a trend in the direction of 285°. This suggests that the primary stress, σ1, likely originated from the NW-SE direction, which caused the rocks to become compressed and brittle deformation to occur, resulting in the development of discontinuities.

4.5 Historical geology

The Jeli area in Kelantan, Malaysia was known for its diverse and complex geological history. The region had a wide range of rock types that formed during different time periods, reflecting the various tectonic events and processes that had shaped the area. The oldest rocks in Jeli were metamorphic and sedimentary rocks that formed during the Paleozoic Era, a time period lasting from approximately 541 to 252 million years ago. These rocks were subjected to high pressures and temperatures, and contained minerals such as quartz, feldspar, and mica. In the Mesozoic Era, which lasted from about 252 to 66 million years ago, the Jeli area experienced mountain building and faulting, leading to the formation of additional rock types such as granites and gneisses. More recently, during the Cenozoic Era, which began about 66 million years ago and continued to the present day, the region had undergone volcanic activity, resulting in the formation of volcanic rocks like basalt and andesite. Overall, the geology of Jeli was rich and varied, and provided valuable insights into the earth's history and the processes that had shaped our planet.

CHAPTER 5

GEOLOGY AND GEOHERITAGE ASSESMENTS OF LATA KEDING, JELI, KELANTAN

5.1 Introduction

The purpose of this chapter was to examine the geoheritage value of Lata Keding, a location in the Kelantan province of Jeli. In order to fully understand and appreciate the geological significance of this area, it was necessary to delve into the unique and special characteristics and elements that made it stand out. Through careful analysis and interpretation, we could determine the potential value of this site for geological heritage site, as well as its worth in terms of the earth's geological resources. In order to do this, we needed to identify the specific geological features and elements that occurred at Lata Keding, such as distinctiveness, rarity, and representativeness. The geological characteristics, elements, and composition of the area all played a role in determining its potential value and significance. By studying these factors, we could better understand and appreciate the rich geological heritage of Lata Keding, and the ways in which it contributed to the larger geological landscape of the region.

5.2 Geoheritage

Geological heritage referred to the natural features of the Earth .that had scientific, educational, aesthetic, or intrinsic value, and that provided insight into the geological processes that had shaped the planet over time. These features, known as geosites, were considered to be important resources for understanding the Earth's geological past and for promoting socio-economic growth. According to ProGEO (2011), it was important to study, survey, protect, and develop geosites in order to preserve them for future generations and to ensure that they could be appreciated for their natural beauty. Bruno (2015) also emphasized the importance of geosites as geo-heritage resources that should be carefully managed in order to promote their long-term conservation and to ensure their continued value for both scientific research and public enjoyment. Overall, the concept of geological heritage was essential for promoting the understanding and appreciation of the Earth's unique geological history and for protecting and preserving the natural features that were integral to this history.

5.3 Assessments (qualitative and quantitative method)

There are two approaches that can be taken when evaluating the geoheritage resources in a study area. The first is a qualitative method, which involves examining the various values and significance of the resources. This includes considering their scientific, educational, and cultural importance, as well as any aesthetic, recreational, and functional value they may have. In addition to this, the qualitative approach involves assigning levels of importance to the resources, such as global, national, regional, and local significance. An example of this approach can be seen in Table 5.1, which presents a qualitative assessment of the study area.

Table 5.1: Qualitative assessment of the study area (Lata Keding)

Geosite	Scientific Value	Aesthetic Value	Recreational value	Educational value	Level of significance
Lata Keding	Quartz veins intrusive and Granite, granitoid , hornfel, schist and gneiss (rocks)	Unique waterfall, river and the rock structures	Swimming, picnicking and photography session	The geologist can come to learn more about the waterfall and cascade geomorphology of the study area.	State

Figure 5.1: The intrusion of quartz vein in hornfels outcrop

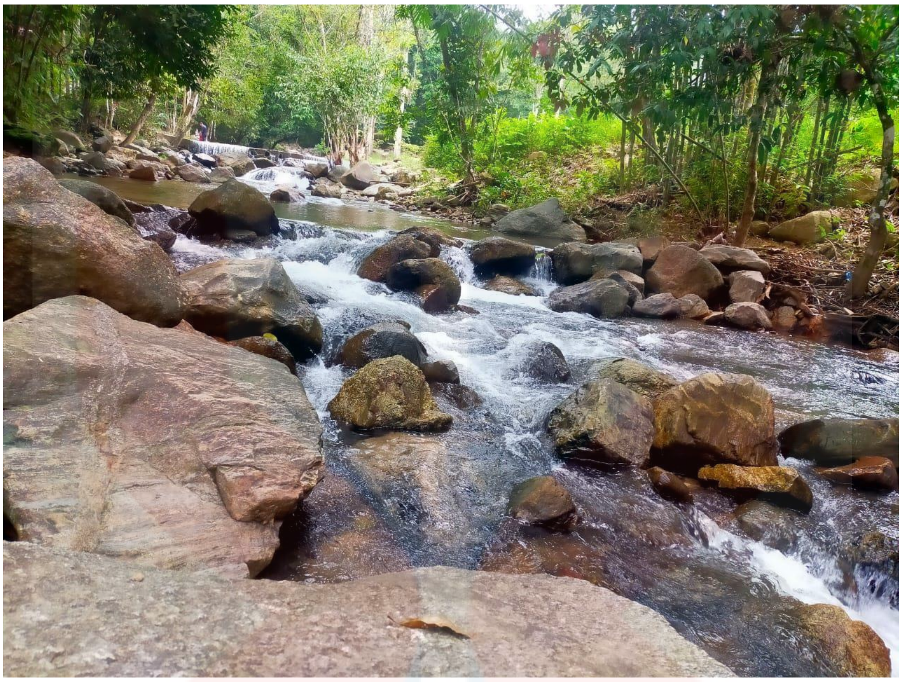


Figure 5.2: The beautiful waterfall at Lata Keding

Figure 5.3: One of the scenery of cascade at Lata Keding

5.3.1 Geoheritage survey at Lata Keding

This research project was designed to gather data from a diverse group of individuals, including those from various educational backgrounds and both local and non-local residents of the Jeli region. A total of 102 people participated in the survey, exceeding the initial target of 100 respondents. The focus of the survey was on five systematic studies and the geoharitage values present in the area. In addition to these topics, the survey also included questions about the types of activities that can be enjoyed at these sites and the main attractions that draw people to visit. This information is valuable for understanding the potential of the geoharitage values of the region and for assessing the level of awareness among local residents about the importance of conserving these sites. Additionally, the results of the survey may help to shift attitudes towards preserving these geosites and encourage a greater appreciation for nature.

<u>Questionnaire (Geoheritage survey)</u>

- Section 1

Section 1 of the survey focuses on obtaining information related to the biodata of the respondents. The first question pertains to the gender of the respondents. The results indicate that a majority of those who participated in the survey and work in the field of server maintenance are female, comprising 52% of the total respondents, while males comprise 48%.

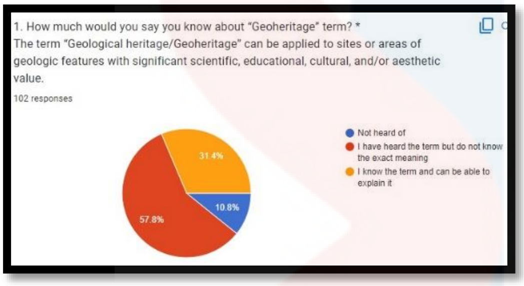
The second question in Section 1 explores the age of the respondents. The data reveals that the highest percentage of respondents fall within the age range of 30 and above, representing 53.9% of total participants. The second highest age group represented in the survey is those between the ages of 22-25, comprising 29.4% of the respondents, followed by those between the ages of 17-21 at 12.7%. The lowest percentage of respondents fell within the age range of 26-29, representing just 4% of the total participants.

The third question in Section 1 relates to the educational level of the respondents. The results indicate that the majority of the respondents have a degree background, comprising 88.2% of the total participants, followed by those with diplomas, pre-university and school education. The lowest percentage of respondents hold a doctorate degree.

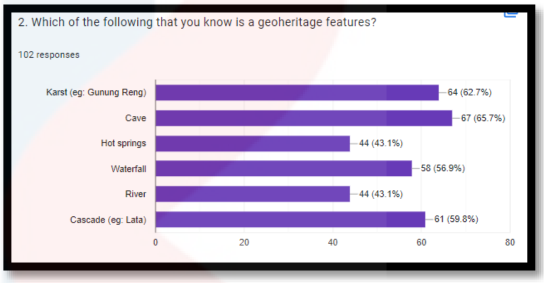
The final question in Section 1 pertains to the origin of the respondents, specifically whether they are local Jeli or non-local Jeli. The results indicate that a vast majority of the respondents are non-local Jeli, comprising 84.3% of the total participants, while only 15.7% of the respondents are local Jeli. All of the questions for section 1 had been display at the appendix part.

- Section 2 (the questions focusing on the term and meaning of Geoheritage)

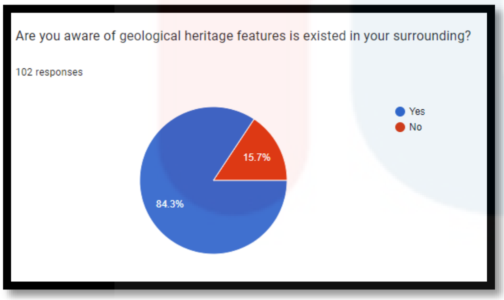
1. Geoheritage term



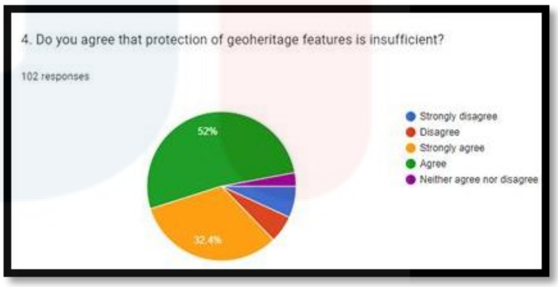
2. Example of geoheritage features



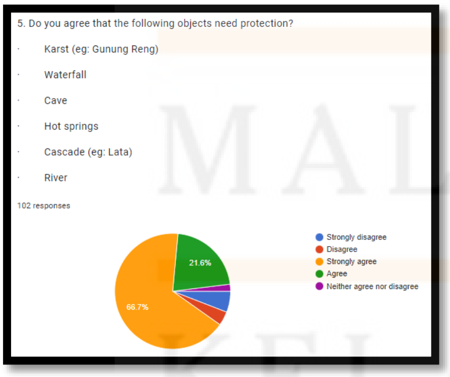
3. Awareness of existing geoheritage features



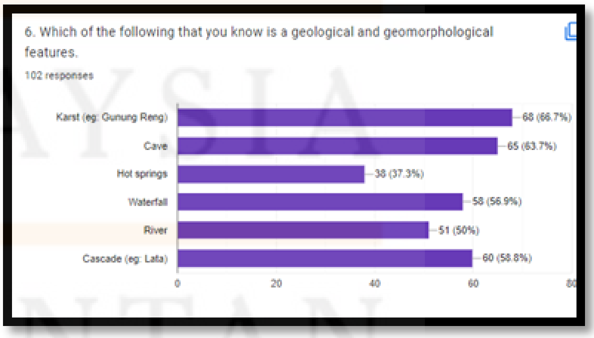
4. Awareness of geoheritage feature



5. Protection of geoheritage features

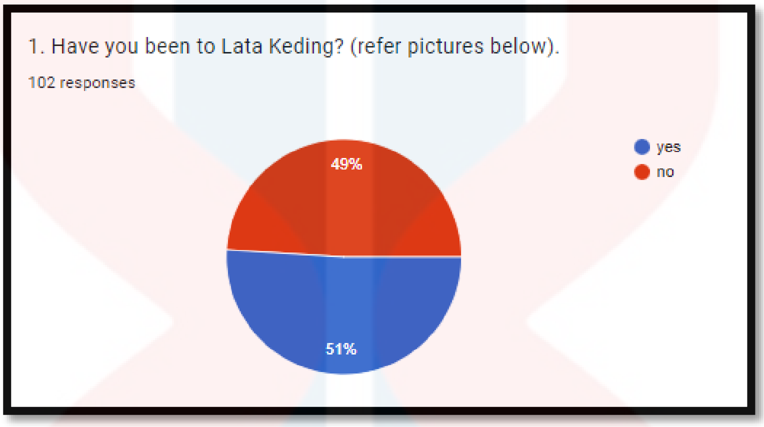


6. Example of geological features

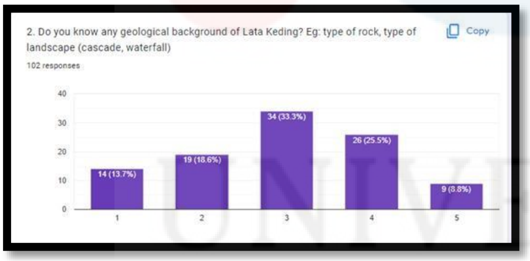


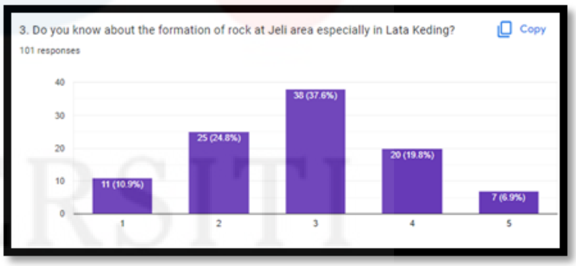
- Section three (focusing on geoheritage values)

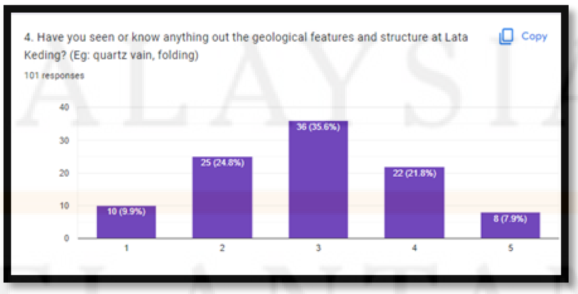
1. Visit study area



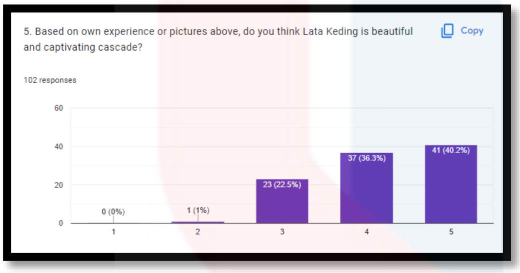
2. Questions based on Scientific value



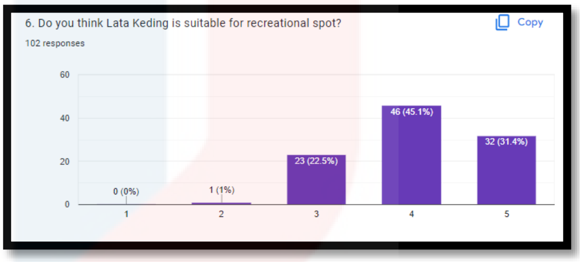




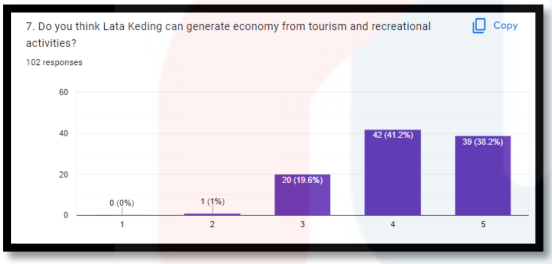
3. Question based on Aesthetic Value



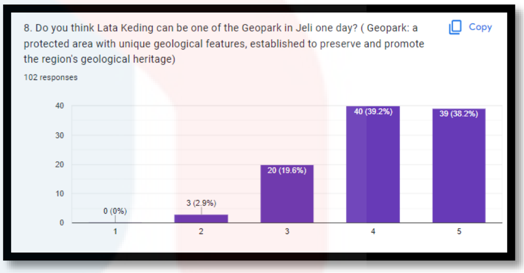
4. Question based on Recreational Value



5. Question based on Economic Value



6. Question about the suggestion



5.3.2 Quantitative method

On the other hand, the quantitative method involves a more statistical approach to evaluating and ranking the geological features based on their geoheritage values. This approach involves the use of a rating system, where a score of 1 represents very poor, 2 is poor, 3 is average, 4 is good, and 5 is very good. The results of the quantitative method are used to determine the overall significance of the resources and are presented in Table 5.2, which presents a quantitative assessment of the study area. This approach is particularly useful for making comparisons between different geoheritage resources and for determining their relative importance.

Table 5.2: Quantitative assessment of the study area based on questionnaire

Geosite	Scientific/ Educational value	Aesthetic value	Recreational value	Economic value
Lata Keding	3	5	4	4

Table 5.3: Quantitative assessment of the study area based on my interpretation

Geosite	Scientific/ Educational value	Aesthetic value	Recreational value	Economic value
Lata Keding	5	5	5	4

Based on the survey that has been conducted and the mapping of the study area, it can be concluded that there are geoheritage values present in Lata Keding. The survey, which was designed to gather information on the topic of geoheritage, focused on all types of society regardless of their educational background and was conducted in order to gain insight into the public's understanding and awareness of the topic. The results of the survey indicated that most of the respondents, approximately half of those who participated, had an average level of knowledge related to the term "geoheritage." This suggests that while some people may have a general understanding of the concept, there is still a significant portion of the population that is not fully informed on the topic. However, it is important to note that among the respondents were also individuals who were studying geology and some lecturers who could be considered experts in the field, and these individuals had very good knowledge about the term "geoheritage."

Additionally, it was found that most of the respondents were not from Jeli, which indicates that Lata Keding has become well-known throughout Malaysia. This is an important finding as it suggests that the geoheritage site is not only of local significance, but also holds national importance. The survey also aimed to gather information on geoheritage features, awareness about geoheritage, and the protection of geoheritage sites. The results of this aspect of the survey will provide valuable information for the implementation of conservation and preservation efforts for Lata Keding and other geoheritage sites in the future.

Based on the survey conducted to assess the geoheritage value of Lata Keding, it can be classified as possessing a number of different types of geoheritage values, including scientific and educational value, aesthetic value, recreational value, and economic value. According to the survey results, most of the respondents demonstrated an average level of knowledge related to the scientific value of Lata Keding (in section three, no. 2), with a percentage ranging from 30% to 40%. Additionally, there were also respondents who possessed good and very good knowledge about the scientific value of Lata Keding, as indicated by ratings of 4 and 5, with a percentage ranging from 10% to 30%. Similarly, there were also respondents who had poor and very poor knowledge about the scientific value of Lata Keding, as indicated by ratings of 1 and 2, with a percentage ranging from 10% to 30%.

Based on questions of aesthetic value (in section three, no. 3), most of the respondents demonstrated very good knowledge related to aesthetic value, as evidenced by a score of 5 on a scale of 5, with a percentage of 40.2%. Additionally, on a scale of 4, which represents good knowledge about aesthetic value, the percentage of respondents was the second highest, amounting to 36.3%. Notably, one respondent gave a score of 2 on this question, indicating poor knowledge related to aesthetic value. Additionally, no respondents gave a rating of 1, which represents very poor knowledge. This data suggests that most respondents have some level of understanding and knowledge of aesthetic value, and may have likely visited Lata Keding and observed the features that are considered to possess aesthetic value.

Regarding to the question of recreational value (in section three, no 4), the highest percentage of respondents scored 4 on a scale of 5, indicating good knowledge about recreational value, with a percentage of 45.1%. The second highest rating was on scale 5, which had a percentage of 31.4%. Additionally, there were also respondents who gave a rating of 2, which represents poor knowledge about recreational value, with a percentage of 1%. These results suggest that most respondents possess knowledge and are able to comprehend the concept of recreational value.

Lastly, in regards to the question of economic value (in section three, no. 5), the highest percentage of respondents scored 4 on a scale of 5, representing good knowledge about economic value, with a percentage of 41.2%. This was followed by the second highest rating of 5, which had a percentage of 38.2%. This data demonstrates that respondents possess good and very good knowledge and awareness about economic value in Lata Keding. However, it should be noted that there were also respondents who gave a rating of 2, indicating poor knowledge about economic value, with a percentage of 1%.

A thorough and comprehensive evaluation of the geoheritage value of Lata Keding was conducted, with results presented in Table 5.2. To determine the significance of the findings, a rating system was established and is detailed in the table. The scientific value was determined to be average, with a rating of 3, as a majority of respondents had not yet had the opportunity to visit Lata Keding and witness the natural beauty of its geological features firsthand. This rating system was developed using data gathered from a comprehensive survey aimed at determining the level of public awareness and understanding of the geoheritage features in the area that are important for preservation for future generations.

In comparison to my own assessment, as presented in Table 5.3, I gave Lata Keding a rating of 5 for its scientific and educational value, aesthetic value, and recreational value, and a rating of 4 for its economic value. As a geology student, I was able to appreciate the unique and beautiful geological features present at Lata Keding, such as the formation and facies of the rocks, as well as the cascade flow. Additionally, Lata Keding offers many opportunities for activities such as swimming, picnicking, and jungle trekking, which could attract both local and non-local tourists. The area's beautiful outcrops also contribute to its scientific value and make it a desirable location for photography. While I believe that Lata Keding holds great economic value due to its potential to attract tourism, I determined that its location in a more remote area and lower rate of visitor traffic may make its economic potential less significant. For me, Lata Keding deserves to be classified as one of the Geosite projects in Kelantan.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, the geological map of Lata Keding is an essential tool for understanding the geology of the area and can be produced with a scale of 1:25,000. An updated geological map is not only valuable to geologists as a reference for conducting research and field surveys, but it is also extremely beneficial for future researchers who are looking to collect data and geological information about that specific location.

Furthermore, Lata Keding is an ideal location for a geoheritage site due to its unique geological features and landscapes that possess high scientific, cultural, aesthetic, and economic value as a result of human exploitation. Surveys have been conducted among individuals from diverse backgrounds to evaluate Lata Keding as a site of geoheritage value, utilizing both quantitative and qualitative assessment methods. According to the results of the assessment, the highest percentage of value attributed to Lata Keding was aesthetic value, indicating that the area boasts beautiful landscapes and geological features that are a direct result of geological activity. Specifically, this study area is characterized by its alluvial landform, which includes cascading formations, as well as advanced developments such as chalets nestled within lush forests, creating breathtaking views for tourists to enjoy.

6.2 Suggestion

Tourists flock to Lata Keding for its allure and ease of access. However, certain modifications can be implemented to enhance the experience for visitors. The local government must establish a thorough conservation and preservation plan specifically tailored to Lata Keding, which is particularly susceptible to damage and pollution caused by human activity. To ensure Lata Keding remains protected and safeguarded against any potential hazards, measures should be taken to preserve its natural beauty and recreational qualities for future generations.

Some areas within Lata Keding pose potential dangers and the authorities should take action to enhance safety, particularly regarding the risk of wild animal encounters. To make it easier for people to navigate to their desired destinations, the location should be marked on popular mapping applications such as Google Maps.

Effective marketing and public relations efforts are crucial in promoting and preserving Lata Keding, as well as drawing in more visitors. Additionally, highlighting the recreational activities available such as swimming and picnics as well as educational opportunities to learn about the cultural significance of Lata Keding to the Kelantanese people, can also be attractive to visitors.

REFERENCES

Adriansyah, D., Busu, I., Eva, H., & Muqtada, M. (2015). *Geoheritage as the basis of geotourism development: a case study in Jeli district, Kelantan, Malaysia. GeoJournal of Tourism and Geosites*, *15*(1), 25-43.

Adriansyah, D. (2015*). Systematic Studies of Geoheritage in Jeli District, Kelantan, Malaysia. Geoheritage*, 9 (1), 19-33.

Adriansyah, D., Muqtada, M., Rasheeqa, S., Zulkarnain, Z., & Raman, K. (2017). *Geological Assessment of Water-Based Tourism Sites in Jeli District,Kelantan, Malaysia. In Water Resources in Arid Areas: The Way Forward* (pp. 173-195). Springer, Cham.

Awang, M., Negash, B. M., Akhir, N. A. M., Lubis, L. A., & Rafek, A. G. M. (Eds.). (2017). *ICIPEG 2016: Proceedings of the International Conference on Integrated Petroleum Engineering and Geosciences*. Springer.

Basori, M. B. I., Zaw, K., Meffre, S., & Large, R. R. (2016). *Geochemistry, geochronology, and tectonic setting of early Permian (~ 290 Ma) volcanic-hosted massive sulphide deposits of the Tasik Chini district, Peninsular Malaysia. International Geology Review*, *58*(8), 929-948.

Bokovikova, E. (2013). *The impact of the transition economy on gender compositionin employment in the Russian heavy industry* (Doctoral dissertation, University of East Anglia).

Brocx, M., & Semeniuk, V. (2007). *Geoheritage and geoconservation-history, definition, scope and scale. Journal of the Royal Society of Western Australia*, *90*(2), 53-87.

Brocx, M., & Semeniuk, V. (2011). *The global geoheritage significance of the Kimberley Coast, Western Australia. Journal of the Royal Society of Western Australia*, *94*(2), 57-88.

Charlton, T. R. (2001). *Permo-Triassic evolution of Gondwanan eastern Indonesia,and the final Mesozoic separation of SE Asia from Australia. Journal of Asian Earth Sciences*, *19*(5), 595-617.

Department of Minerals and Geoscience. (2003). *Malaysia: Quarry Resource Planning for the State of Kelantan, Osborne and Chappel Sdn. Bhd.*

Dowling, R. K., & Newsome, D. (2005). *Geotourism: Sustainability–Impacts and Opportunities.*

Durbha, S. S., & King, R. L. (2005). *Semantics-enabled framework for knowledge discovery from Earth observation data archives. IEEE Transactions on geoscience and remote sensing*, *43*(11), 2563-2572.

Đurović, P., & Đurović, M. (2010). *Inventory of geoheritage sites: The base of geotourism development in Montenegro. Geographica Pannonica*, *14*(4),126-132.

Fontaine, H., Khoo, H. P., & Vachard, D. (1988). *Discovery of Triassic fossils at Bukit Chuping, in Gunung Sinyum area, and at Kota Jin, Peninsular Malaysia*. *Journal of Southeast Asian Earth Sciences*, *2*(3-4), 145-162.

Franjid, R., & Favro, S. *Natural and Cultural Resources in Tourism and ThematicRoutes. Collection of Papers*, 82.

Giardino, M., & Progeo Piemonte Research Team. (2011). *PROGEO-Piemonte: a* *multidisciplinary research project for developing a proactive management of geological heritage in the Piemonte Region. In Geoitalia 2011-VIII Forum italiano di Scienze della Terra* (Vol. 4, pp. 132-132).

Gray, M. (2005, January). *Geodiversity and geoconservation: what, why, and how?. In The George Wright Forum* (Vol. 22, No. 3, pp. 4-12). George Wright Society.

Gtg.webhost.uoradea.ro. (2021). Retrieved 22 June 2021, from http://gtg.webhost.uoradea.ro/PDF/GTG-1-2015/GTG-1-2015.pdf.

Hamblin, W. K. (1994). *Late Cenozoic lava dams in the western Grand Canyon* (Vol.183). Geological Society of America.

Hassim, R. (2020). *General geology and geoheritage investigation value of nglanggeran area in special region of Yogyakarta, Indonesia* (Doctoral dissertation, Universiti Malaysia Kelantan).

Harbury, N. A., Jones, M. E., Audley–Charles, M. G., Metcalfe, I., & Mohamed, K. R. (1990). *Structural evolution of Mesozoic peninsular Malaysia. Journal ofthe Geological Society*, *147*(1), 11-26.

Hutchison, C. S. (1975). *Ophiolite in southeast Asia. Geological Society of America Bulletin*, *86*(6), 797-806.

Hutchison, C. S. (2014). *Tectonic evolution of Southeast Asia.*

Howard, A. D. (1967). *Drainage analysis in geologic interpretation: asummation. AAPG bulletin*, *51*(11), 2246-2259.

Jasin, B. (2013). *Chert blocks in Bentong-Raub Suture Zone: A heritage of palaeo-tethys.*

Komoo, I., & Unjah, T. (2002). *Warisan geologi dan potensi geopelancongan Kepulauan Aman–Gedong, Pulau Pinang (IN MALAY), Geological heritage and geotourism* *potential of Aman–Gedong Islands, Pulau Pinang.*

Kubalíková, L. (2013). *Geomorphosite assessment for geotourism purposes. Czech Journal of Tourism, 2*(2), 80-104.

Malaysia, J. P. (2010). *Taburan penduduk dan ciri-ciri asas demografi. Laporan banci penduduk dan Perumahan Malaysia. Kuala Lumpur: Jabatan Perangkaan Malaysia.*

MacDonald, H. C., Brennan, P. A., & Dellwig, L. F. (1967). *Geologic evaluation by radar of NASA sedimentary test site. IEEE Transactions on Geoscience Electronics, 5*(3), 72-78.

Metcalfe, I. (2000). *The Bentong–Raub Suture Zone. Journal of Asian Earth Sciences, 18*(6), 691-712.

Mitchell, A. H. G. (1977). *Tectonic settings for emplacement of Southeast Asian tin granites.*

Muhammad, S. N. (2015). *Tahap keselamatan pejalan kaki dalam kalangan pelajar sekolah kajian kes di sekolah-sekolah terpilih di Wilayah Persekutuan Kuala Lumpur dan Kelantan* (Doctoral dissertation, Universiti Pendidikan Sultan Idris).

Mohd Sabari, N. S. (2020). *Geology and geoheritage potential value of KampungJeram Gajah, Lojing, Kelantan* (Doctoral dissertation, Universiti MalaysiaKelantan).

Newsome, D., & Dowling, R. (2006). *The scope and nature ofgeotourism. Geotourism, 3, 25.*

Othman, A. S., Ghani, A. A., & Roslee, K. H. (2000). *Field relations and petrochemistry of the Jeli igneous complex, north Kelantan: preliminary observations.*

Peng, K. H. (1983). *Mesozoic stratigraphy in Peninsula Malaysia.*

PERSATUAN GEOLOGI MALAYSIA - PDF Free Download. Docplayer.net. (2021). Retrieved 22 June 2021, from http://docplayer.net/48094027-Persatuan-geologi-malaysia.html.

Petro, Y. (2017). *Ambidexterity through Project Portfolio Management Resolving paradoxes in organizations* (Doctoral dissertation, The British University in Dubai (BUiD)).

Pinang, P. B. P. (2009). *Jabatan Perancangan Bandar dan Desa Semenanjung Malaysia. Kementerian Perumahan dan Kerajaan Tempatan*.

Ramli, M. A. (2017). *Geology and geoheritage of Bukit Marak, Bachok,Kelantan* (Doctoral dissertation, Faculty of Earth Science).

Singh, R. B. (2020). *Global Geographical Heritage, Geoparks and Geotourism: Geoconservation and Development*. Springer Nature.

Suradi, S. S. (2017). *General geology and geoheritage of Bantimurung, Kabupaten Maros, South Sulawesi Province, Indonesia* (Doctoral dissertation, Faculty of Earth Sciences).

Spiller, F. C., & Metcalfe, I. (1995). *Late Palaeozoic radiolarians from the Bentong-Raub suture zone, and the Semanggol formation of Peninsular Malaysia— initial results. Journal of Southeast Asian Earth Sciences*, *11*(3), 217-224.

Tjia, H. D. (1987). *Olistostrome in the Bentong area, Pahang.*

Tjia, H. D. (1986). *Geological transport directions in Peninsular Malaysia.*

Van Zuidam, R. A. (1985). *Aereal photo-interpretation in terrain analysis and geomorphologic mapping. Netherlands.*

Watson, P. H., Godwin, C. I., & Christopher, P. A. (1982). *General geology and genesis of silver and gold veins in the Beaverdell area, south-central British Columbia. Canadian Journal of Earth Sciences*, *19*(6), 1264-1274.

Appendix A

QUESTIONNAIRE

Title: Geology and Geoheritage Assessment of Lata Keding, Jeli, Kelantan.

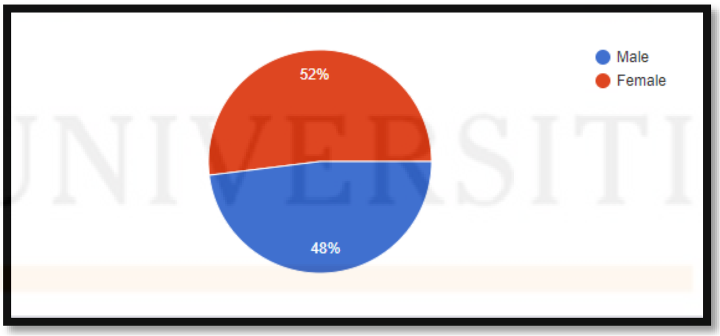
Questionnaire survey for a final year project conducted by GeoscienceProgramme, Faculty of Earth Sciences, Universiti Malaysia Kelantan.

Confidentially: All information gained from this survey is confidentialand will be only used for the research purpose.

Objective: To evaluate the important of main values and additionalvalues Lata Keding.

1. Gender

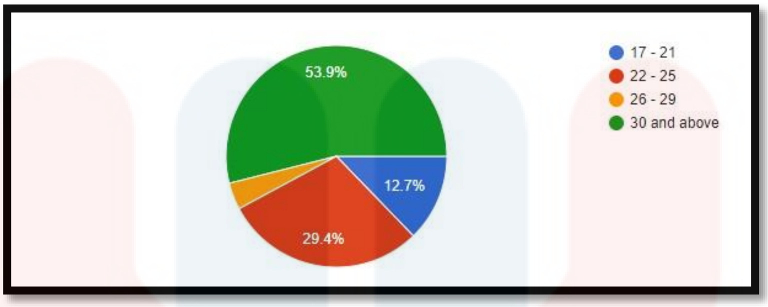
- Male
- female



2. Age

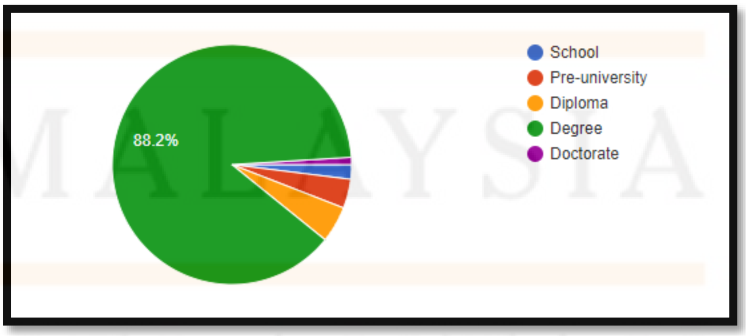
- 17-21
- 22-25
- 26-29

- 30 and above



3. Education Level

- School
- Pre University
- Diploma
- Digree
- Dectorate



4. Origin

- local Jeli
- Non Local Jeli