



Universiti Malaysia
KELANTAN

**GEOLOGY AND LANDSLIDE INVESTIGATION
USING ELECTRICAL RESISTIVITY IMAGING
(ERI) AT KG. CHUCHUH PUTERI, KUALA
KRAI, KELANTAN**

by

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

**FACULTY OF EARTH SCIENCE
UNIVERSITY MALAYSIA KELANTAN**

2023

APPROVAL

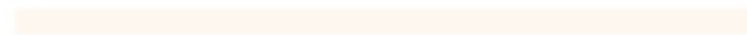
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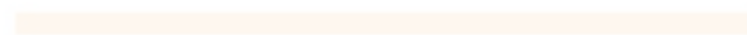
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ACKNOWLEDGEMENT

First and foremost, I would like to show my gratitude and all praises to Allah the Almighty that gives me strength to finish my final year project (FYPII). I also would like to thank my supervisor, Dr. Noorzamzarina Sulaiman in guiding me while finishing this research. Without his support, guidance and advices throughout this research then I won't get any better.

Not to forget my family especially my parents, Mr. Badros bin Abd Basir and Pn. Azlin binti Ayub and my siblings for their endless support in terms of moral, financial and love. Also, not to forget for those who has been my pillar of strength while I'm completing my research.

Besides that, I'm grateful for all the help that I got from geoscience lecturers and lab assistants especially Mr. Mohd Syakir bin Sulaiman, Mr. Khairul Aizuddin and Mr. Faathrio Hudaya for guiding us during geophysical survey. Not to forget, all my teammates for ERI survey: Syafira, Hidayah, Asikin, Ammar, Alif and Ridwan for helping me conducting my research.

Last but not least, my classmates, circle of friends Syafira, Hidayah, Asikin, Husna, Hamdani, Shawn, Azri, Abbas and Ibrahim whom together with me while solving the problems together. A lot of thank you for all my friends who always give me strength while I'm stuck in doing this research.

**GEOLOGY AND LANDSLIDE INVESTIGATION USING
ELECTRICAL RESISTIVITY IMAGING (ERI) AT KG.
CHUCHUH PUTERI, KUALA KRAI, KELANTAN**

Alya Syakirah binti Badros¹ & Dr. Noorzamzarina binti Sulaiman²

Abstract: Kg. Chuchuh Puteri is located at Kuala Krai, Kelantan which been chosen as the location in this final year project with along latitude 05° 24' 12.15" N to 05° 21' 31.88" N and longitude 102° 18' 44.50" E to 102° 18' 56.99" E. The objectives of this project are to update geological map at a scale of 25 km² and to identify potential landslide risk using electrical resistivity imaging (ERI) in the study area. Electrical resistivity imaging (ERI) has been used as the methodology of this study. Several types of study included in this project which are petrography, stratigraphy, geomorphology and structural geology. In order to gather all the information in completing this study, the geological mapping has been done and the samples must go through the petrography examination. Rocks composed of clay and metamorphic rock as well been found in the study area. Six survey lines were established during the geophysical survey at six different locations. For location 1, 2, 4 and 5 follows Pole-dipole electrode configuration array while location 3 and 6 follow Schlumberger electrode configuration arrays and all the data from all locations were recorded using ABEM Terrameter LS 1, then the data is processed by using RES2DINV software. The result show that potential landslide risk area may existing in the line survey 6. As for the result in minerals that discovered in this study are quartz, feldspar and biotite. Types of rock that can be found in the location is metamorphic rock which are sandstone, gneiss and quartzite through the geological mapping. Sample of the rocks in this area are mostly in medium fine-grained texture of rocks. Geological features that been found in the study area such as minor vein and fold. A substantial amount of study on the area has been advocated, with an emphasis on the structural geology of the area.

Keywords - Dabong, geological mapping, structural geology, quartz, feldspar, biotite, sandstone, gneiss, quartzite

**PENYIASATAN GEOLOGI DAN TANAH RUNTUH
MENGUNAKAN KESELAMATAN ELEKTRIK (ERI) DI KG.
CHUCHUH PUTERI, KUALA KRAI, KELANTAN**

Alya Syakirah binti Badros¹ & Dr. Noorzamzarina binti Sulaiman²

Abstrak: Kg. Chuchuh Puteri terletak di Kuala Krai, Kelantan yang dipilih sebagai lokasi dalam projek tahun akhir ini dengan garis lintang $05^{\circ} 24' 12.15''$ N hingga $05^{\circ} 21' 31.88''$ N dan garis bujur $102^{\circ} 18' 102^{\circ} 18' 56.99''$ E. Objektif projek ini adalah untuk mengemas kini peta geologi pada skala 25 km² dan untuk mengenal pasti potensi risiko tanah runtuh menggunakan pengimejan resistiviti elektrik (ERI) di kawasan kajian. Pengimejan resistiviti elektrik (EERI) telah digunakan sebagai metodologi kajian ini. Beberapa jenis kajian termasuk dalam projek ini iaitu petrografi, stratigrafi, geomorfologi dan geologi struktur. Untuk mengumpulkan semua maklumat dalam menyelesaikan kajian ini, pemetaan geologi telah dilakukan dan sampel mesti melalui pemeriksaan petrografi. Batu yang terdiri daripada tanah liat dan batuan metamorf juga dijumpai di kawasan kajian. Enam garis tinjauan dibuat semasa tinjauan geofizik di enam lokasi yang berbeza. Untuk lokasi 1, 2, 4 dan 5 mengikuti susunan konfigurasi elektrod poli-dipol sementara lokasi 3 dan 6 mengikuti susunan konfigurasi elektrod Schlumberger dan semua data dari semua lokasi direkodkan menggunakan ABEM Terrameter LS 1, maka data diproses dengan menggunakan perisian RES2DINV. Hasilnya menunjukkan bahawa kawasan risiko tanah runtuh yang berpotensi ada dalam tinjauan garis 6. Hasil mineral yang ditemui dalam kajian ini adalah kuarza, feldspar dan biotit. Jenis batu yang dapat dijumpai di lokasi adalah batu metamorf yang merupakan batu pasir, gneiss dan kuarzit melalui pemetaan geologi. Contoh batu di kawasan ini kebanyakannya terdapat tekstur batu halus sederhana. Ciri-ciri geologi yang terdapat di kawasan kajian seperti urat dan lipatan kecil. Sejumlah besar kajian di kawasan ini telah disokong, dengan penekanan pada geologi struktur kawasan tersebut.

Kata kunci: Dabong, pemetaan geologi, geologi struktur, kuarza, feldspar, biotit, batu pasir, gneiss, kuarzit.

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LIST OF SYMBOLS

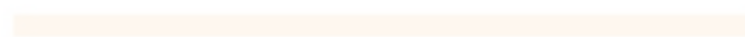
%	Percent
°	Degree



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LIST OF ABBREVIATIONS

CL	Crossline
GIS	Geospatial Information System
GPS	Global Positioning System
HCL	Hydrochloric acid
PPL	Plane Polarized Light
UMK	Universiti Malaysia Kelantan
XPL	Cross Polarized Light
ERI	Electrical Resistivity Imaging



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CHAPTER 1

INTRODUCTION

1.1 Research Background

Both Kuala Krai and Machang share a border on the territory's northern edge, while Gua Musang and Kuala Krai share a border on the territory's southern edge. The geography of Kuala Krai is lowland, and it is drained by the confluence of two rivers, the Kelantan (which flows into the Sungai Lebir) and the Galas. The Kelantan flows into the Sungai Lebir (which originates from the Sungai Lebir). After beginning its voyage in the direction of the north, the Kelantan River system eventually makes its way through Kuala Krai, which is one of the cities in Kelantan, and empties into the South China Sea. The topography is rather flat, making it a perfect location for plantations of rubber trees and oil palms, which are the principal sources of revenue for the local inhabitants.

There was a devastating flood known as the "Bah Kuning" that ravaged the east coast of Peninsular Malaysia towards the end of December 2014. Nearly eighty-five percent of Kuala Krai was flooded as a consequence, particularly the villages of Kampung Manik Urai, Kampung Manjor, Kampung Karangan, Kampung Laloh, and Dabong. There has been a big flood in the Kuala Krai region, and many people have lost their homes and possessions as a result. Accordingly, there is no specifically study occurred in Kg. Chuchuh Puteri, Kuala Krai, Kelantan. Landslide appraisal and hazard zonation are both necessary steps in the management and prevention of landslides in a systematic manner. During the course of the last several decades, many approaches that are capable of being used for landslide assessment and zonation have been created claim, Xing Min Meng (2022). Both qualitative and quantitative methods may be used to accomplish the same goals, however qualitative methods tend to be more in-depth. Methods such as geomorphological analysis and heuristic procedures are examples of qualitative approaches, while techniques such as statistical analysis, artificial intelligence, and deterministic methods are examples of quantitative approaches. The prediction of the susceptibility of landslides using quantitative methodologies is based on the actual factual facts as well as interpretations of such data. In addition to this, the objective nature of quantitative methods eliminates the subjectivity inherent in qualitative approaches. Each of these methods may take into account a unique combination of causal factors and makes use of a distinct set of tools for causal factor assessment and investigation stated Leulalem Shano, (2020).

Electrical resistivity imaging, often known as ERI, is a technology that does not destroy the subsurface being investigated. The purpose of ERI is to explore

variations in electrical resistance by passing an electrical current across the subsurface via cables attached to the ground. By using electrical surveying, researcher can be provided by the measurements on the ground surface for estimate the resistivity of the subsurface. (Loke, 2013)

1.2 Study Area

1.2.1 Location

The study area is inside Kg. Chuchuh Puteri, Kuala Krai, Kelantan. Kota Bharu known as the capital city of Kelantan which the state is in the north-eastern part of the Peninsula Malaysia. This area is located in the area of the villagers' house, rubber plantation, school, stall and mosque. It quite have a long pathway before arrived Kg. Chuchuh Puteri. Figure 1.1 shows the basemap of Kg. Chuchuh Puteri, Kuala Krai, Kelantan.

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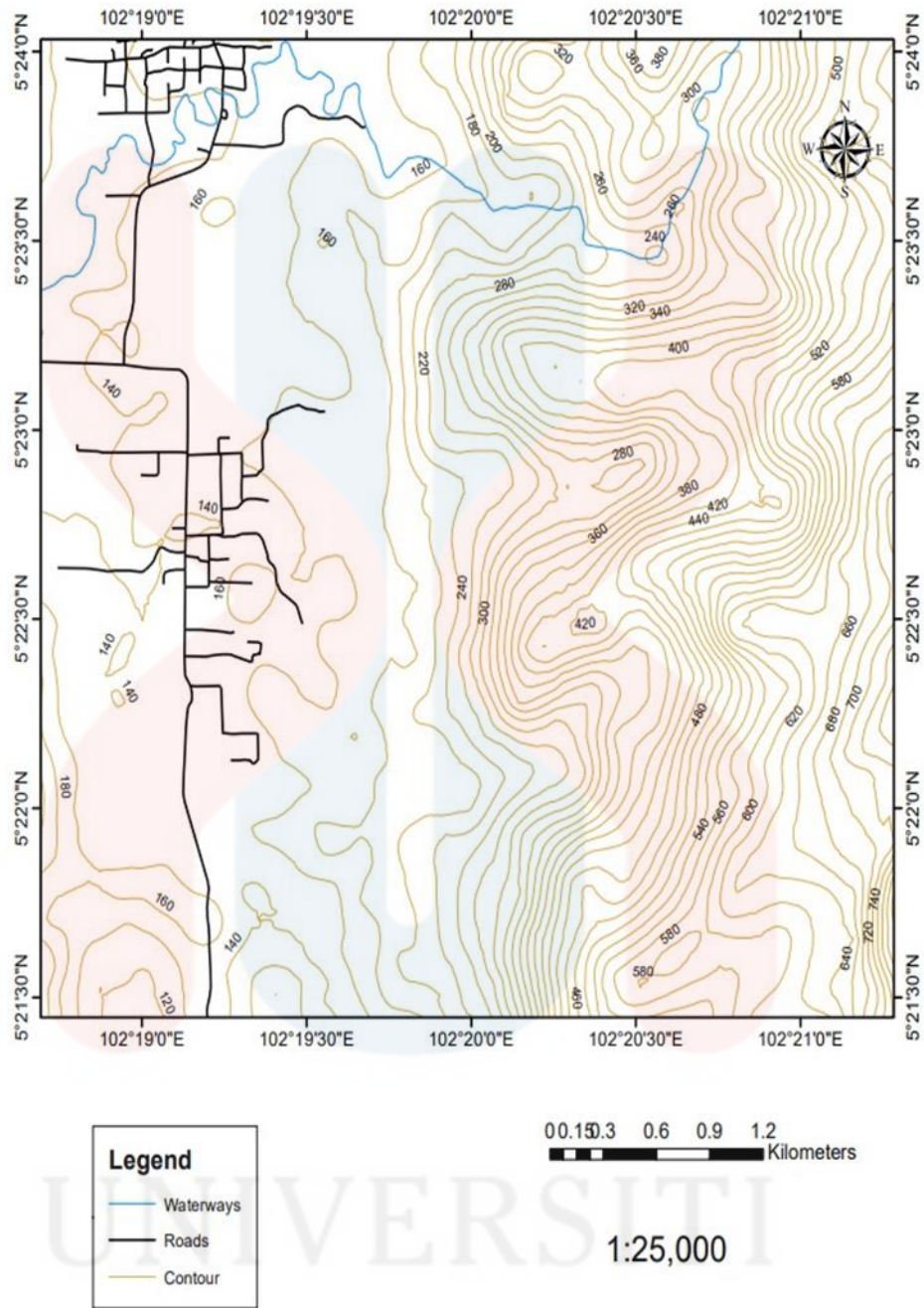


Figure 1.1: Basemap of Kg. Chuchuh Puteri, Kuala Krai, Kelantan using Google Earth Pro Application

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1.2.2 Accessibility

People moved into the areas to take advantage of the limitless land that was available for cultivation as transportation connections improved during the 20th century. In order to connect Kelantan State with the main population centres on the west drift, a railroad was built through Malaysia's undeveloped interior in the 1920s. Settlements were eventually constructed along this line, which passed through the Kuala Krai domain.

The study area can be accessed from Universiti Malaysia Kelantan as your first pathway through the Tanah Merah. And proceed with the Machang pathway by using car from UMK Campus Jeli that takes around 1 hour 56 minutes to arrive. The distance of this path from UMK Campus Jeli is 107km. Figure 1.2 show the pathways to the study area.

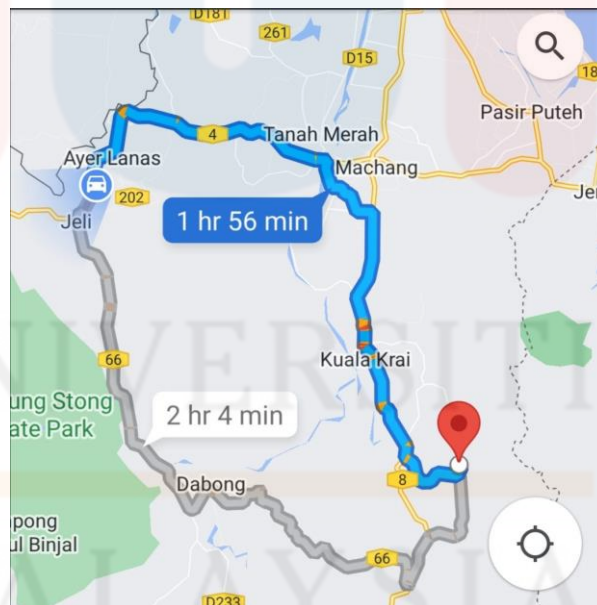


Figure 1.2: Pathways to the study area (Google Map, 2022)

1.2.3 Demography

At 2010, the overall population of Malaysia was 28,334,135, placing it in the 42nd place on the list of most populous countries in the world. Individuals in Malaysia's population come from a wide variety of cultural and religious traditions, making the country's population one of the most diversified in the world. Other ethnic groups, like as the Bumiputera, also consider the nation to be their home, despite the fact that the Malay population makes up just 50.4% of the total. In 2012, Malaysia had a life expectancy of 75 years, and there were around 15 infant deaths for every thousand others. The improvement in the population's health care came at a cost of around five percent of total government expenditure. The majority of Peninsular Malaysia's residents live in the region's urban areas; more than 25 million people call Kuala Lumpur their home. This is also where the majority of the nation's commercial and financial activity takes place.

The study of the human population of a particular region is referred to as demography. In this line of study, human migration, emigration, and death rates are all taken into consideration. Through the lens of demography, one may get a very helpful perspective on the social and economic challenges that are present. Changes in population characteristics have made it feasible for people to take the initiative in solving certain social problems, and these alterations have also provided individuals with the agency required to do so successfully. According to projections from the Malaysian Department of Statistics, the population of Kelantan will reach 1,792,501 by the year 2020, with a density of 118.70 persons per square kilometre. The data was extrapolated from future scenarios to the year 2020. There were 105,007 people living in the Permaisuri district, which spanned an area of 2,287

km². Between 2010 to 2020, experts predict annual population growth of 0.70 percent.

1.2.4 Land Use

The term "land use planning" is used to describe the process of organising, directing, and regulating the many uses that land and its resources may have. At the planning stage of land use, the aims of socioeconomic progress of the country and the necessities of the people are taken into account to deliver the most effective and ecologically responsible conclusion. The document depicts a desired future state for a certain area, whether it a neighbourhood, city, or other specified planning territory. The quiet town will undergo a thorough set of infrastructure changes in the year 2020, as detailed in the plan known as Rancangan Tempatan Jajahan Kuala Krai, in an attempt to increase the town's commercial and industrial production. As an extra perk, rather of looking for relief elsewhere, it may supply it on its own.

Located in southern Thailand, Kuala Krai District Council spans a total of 129.49 square kilometres of territory. Daerah Batu Mengkebang includes a large chunk of the surrounding area, including the villages of Kg. Keroh, Kg. Bukit Sireh, Kg. Batu Jong, Kg. Batu Lada, Kg. Kenor, Kg. Batu Balai, Kg. Gatal, Kg. Tualang, Kg. Bekok, Kg. Pahi, Kg. Telekong, Kg. Kuala Na Kuala Krai, Guchil, Kg Bukit Sireh, Pahi, and Tualang all fall within the 50 square kilometres under the jurisdiction of the Kuala Krai District Council. Kuala Krai, a city, is also located within this area.

The Kuala Krai District Council area grew by 2% yearly over 6 years, from 47,009 in 1980 to 53,041 in 1986. After 1986, the city's population grew by 3%,

reaching 63,331 by 1991. The Council's domains had 103,294 residents in 2005, a 4% annual growth rate.

1.2.5 Social Economic

Socioeconomics focuses on the ways in which economics and society interact with one another. It investigates the relationship between economic expansion, contraction, and social advancement on a national, regional, and international scale. Maybe what it implies is "looking at social issues through the prism of economics." The establishment of social norms, as well as social capital and social "markets" (such as marriage), are at the core of contemporary practise, which places equal emphasis on both individual and collective behaviour. Basically, the residents in Kg Chuchoh Puteri area work as rubber tappers or work in their own plantation.

There are almost 20 primary school in Kuala Krai which are SK Sungai Pas, SK Telkong, SK Manek Urai Baru, SK Banggol Guchil, SK Lata Rek, SK Ladang Taku, SK Kampong Tengah, SK Sungai Mengkuang and more. Kuala Krai also has boarding school which is Maktab Rendah Sains Mara (MRSM) Kuala Krai.

1.3 Problem Statement

The purpose of this study been applied because of the less geological data and information about the study area provided. Back in year of 2017, a case study of flood aftermath impact been conducted in Kuala Krai town, Kelantan located in Batu Mengkebang. From this study, the author mentioned that Sungai Kelantan and

its tributaries, Sungai Galas and Sungai Lebir, experienced flooding as a consequence of the river overflowing its banks after receiving above-average rainfall for many days in a row. Because the river could not hold the volume of water that was flowing into it, it overflowed onto the surrounding region of Bandar Kuala Krai, causing widespread damage to the city's people, buildings, and infrastructure, as well as causing economic havoc. Gap as needed in updating the geological map is between 6 to 7 years. Data and information for some investigation that required the geological characteristics is from geological survey that carried out by the researcher. Using GIS, a full geological map may be created based on the data and information obtained.

Malaysia, as a tropical country, has regularly experienced landslides. Natural causes of landslides, such as rainstorms, floods, and earthquakes, can result in significant human deaths and property destruction. It is one of the most significant barriers standing in the way of development efforts in the highlands of the nation. Most of these landslides occur as shallow rainfall-induced landslides in steep mountainous terrain and highlands, frequently because of severe rainfall. As a result, the goal of this study is to propose integrated methodologies for mapping and landslide investigation employing electrical resistivity imaging (ERI). This is because most of the past research study using electrical resistivity imaging (ERI) did not assess in the study area, Kuala Krai.

Natural occurrences such as landslides are notoriously difficult to predict and mimic. There is no laboratory that can forecast natural disasters. Assuming a landslide, no corporation or laboratory can now monitor crucial factors, enhance methodologies, and apply the results. Thus, identifying landslide risk areas is critical for future strategic planning in a region. It is also critical for

carrying out faster, safer, and more effective mitigation activities during an emergency.

1.4 Objectives

The objectives of this research are:

- I. To update geological map of Kg. Chuchuh Puteri with the scale 1:25000
- II. To determine potential landslide risk using electrical resistivity imaging (ERI) in the study area.

1.5 Methodologies and Scope of Study

This research covers the standard production of the geological map. The research covered in the study area only which is about 5×5 km around the Kg. Chuchoh Puteri. As researcher needed for the tools will be used such as GPS, compass, hammer and others. The collected samples during the fieldwork will undergo thin section if needed. Electrical resistivity imaging (ERI) been conducted as some of the location in the study area shown up the minor condition of the possibility landslide may be happened. ERI is the method chosen rather than other geophysical methods as this method help the researcher in determine the earth subsurface condition such as the subsurface thickness, rock structure.

This research also focused on the technique of the electrical resistivity imaging (ERI) assessment where the data collected are integrated in producing a landslide risk area map. Works by Nagai et al., (2008) have shown that two lines of ERI were utilising the ABEM Terrameter LS set of equipment based on the Schlumberger array. Furthermore, electrical resistivity anomalies were used to determine the existence of geological structure, namely fault and rock discontinuities associated with low resistivity anomalies. ERI helps in giving the

data of diverse subsurface material and borehole data permitted forensic examination of the landslide. Failure on the slope can be detected when happened the excessive rainfall and geological structure that shown in a weakness zone.

1.6 Significance of Study

In order to create a geological map, researchers in the field of geology must first collect and catalogue relevant geological data and information about the area under study. Those in charge of public works in Kelantan, Malaysia, might put this study's findings to good use (JKR). In order to minimise their negative effects on the natural world, buildings, water systems, and other forms of infrastructure need meticulous planning and design. Land and District Office controls municipal and regional planning. To get over obstacles and plan for the future, a geological map is vital. Soil quality, geomorphology, the presence of naturally valuable geological formations, and the availability of natural resources will all be evaluated with the use of this data. JKR Kelantan may potentially use the findings to create systematic, cost-effective road networks in the study region. Lastly, this study may be useful to another researcher in the same field.

On the other hand, the standard technique has been shown to have a number of drawbacks, including a high cost, an extended amount of time required, and a restricted amount of data coverage. Furthermore, the conventional method was based on the drilling data, which represent only single point information (1-D) at the actual drilling location. This enables a certain degree of uncertainty due to the boring interpolation, which is considered critical in an area with a complex geological environment. It was necessary to conduct a large number of drilling

points in order to improve the accuracy of the information obtained from the subsurface, which resulted in an increase in both the cost and the amount of time needed for the project. In addition, the traditional technique relied on the drilling procedure, which was capable of increasing the site's damageability because to the destructive approach it took to field exploration. Therefore, in order to find answers to these problems, we will need to do research that spans several disciplines, including the social sciences, the physical sciences, and engineering. As a result, the geophysical approach provides the opportunity to circumvent some of the challenges that are inherent in more traditional ground research procedures. The use of geophysical methods offers a number of benefits, including the fact that they may be carried out quickly and at a cheap cost and that they have the capacity to cover a larger region in a more comprehensive manner.

All of the data collected from the updated geological map and the potential landslide information can give benefits to other agencies such as JKR, JMG, JPBD, Economic Planning Unit (EPU). This is because the agencies could provide prevention especially for the area that has the possibility in landslide risk might happened in the future. As for the geological map that provide of the location or coordinate of the potential landslide risk location helps in giving awareness to the villagers from the agencies.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, three major field will be discuss focusing on the geology of Kg. Chuchuh Puteri, landslide and Electrical Resistivity Imaging (ERI). The tectonic environment, structural geology, stratigraphy, and sedimentology of Kuala Krai are discussed in this chapter. The use of electrical resistivity imaging (ERI) technologies in potentially landslide-prone locations is discussed in this chapter.

The systematic management and prevention of landslides requires many processes, two of which are hazard zonation and landslide evaluation. According to Xing Min Meng, several techniques that are applicable for landslide evaluation and zonation have been developed over the course of the last few decades (2022). Although qualitative and quantitative approaches may both be employed to achieve the same results, qualitative approaches are often more in-depth than quantitative approaches. Examples of qualitative approaches include geomorphological analysis and heuristic procedures; examples of quantitative approaches include statistical analysis, artificial intelligence, and deterministic methods. Methods such as geomorphological analysis and heuristic procedures are examples of qualitative approaches. The use of quantitative approaches allows for the forecast of the likelihood of landslides, and this prediction is based not only on the actual factual data but also on interpretations of that data. In addition to this, the subjectivity that is present in qualitative techniques may be eliminated by using quantitative

methods due to the objective nature of quantitative research. According to Leulalem Shano, (2020), each of these approaches may take into consideration a different mix of the causative factors, and each makes use of a different set of tools in order to conduct causal factor evaluation and inquiry.

ERI, which stands for electrical resistivity imaging, is a method of subsurface investigation that does not involve the destruction of the researched area. The Electrical Resistance Investigation (ERI) is designed to investigate differences in electrical resistance by transmitting an electrical current through the subsurface in the form of cables that are connected to the ground. Electrical surveys include collecting measurements on the ground's surface in order to arrive at an estimate of the subsurface resistivity distribution. The findings may be used to the process of calculating the true resistivity of the subsoil. (Loke, 2013).

According to the research carried out by Nagai et al. (2008), two lines of ERI were using the ABEM Terrameter LS set of equipment, which was based on the Schlumberger array. In addition, electrical resistivity anomalies were utilised to assess the presence of geological structure, namely faults and rock discontinuities associated with low resistivity anomalies. This was accomplished by using the data gathered from the electrical resistivity anomalies. An in-depth forensic investigation of the landslide was made possible thanks to the data obtained from boreholes and provided by ERI, which aids in providing data on a variety of subsurface materials. The failure of the slope may be identified when there has been an unusually high amount of rainfall combined with a geological structure that is located in an area of geological vulnerability.

Geoelectrical resistivity is a method that may be used in the measurement of both the depth of the earth's surface as well as the kind of rock strata that operate

as a sliding plane. This can be accomplished via the use of a technique referred to as geoelectrical resistivity. The discipline of geophysics is where this approach was developed. The two-dimensional resistivity geoelectrical technique has the potential to produce images of rock layers that are situated below the surface of the earth in two dimensions. These pictures are generated based on the rock resistivity value of the different component layers. This method, which also answers the topic of how to find the surface of the planet, is based on the measurement of the flow of electricity on the inner surface of the globe. The cornerstone of this approach is the measuring of the flow of electricity. This method involves the measurement of voltage and electric current that is produced by the injection of electric current into the ground through a pair of current electrodes. The voltage and current are formed when an electric current is passed through the earth. Through the process of injecting electric current into the ground, the voltage and current data may be collected. Mohd Hazreek Zainal Abidin, (2017) stated by comparing the potential of two electrodes allows one to calculate the voltage between them. In the course of our inquiry, we make use of the Wenner-Schlumberger arrangement, which is one of their publications. The Wenner-Schlumberger electrode array design allows for some degree of sensitivity to be felt in both horizontal and vertical constructions.

In order to make sense of the geoelectrical data, a two-dimensional resistivity technique that employs a Wenner-Schlumberger setup with a variation in spread is used. Based on the findings of the research carried out by Bintang Ramadhan (2015), we anticipate making use of the n factor in our calculations up to a value of 4. After that, you might use an electrode spacing of up to 5 metres for a 'a' electrode. In order to get an accurate reading using this method, draw three

lines that are parallel to each other. In order to conduct an analysis of the data collected from the field surveys, the Res2Dinv application is used. After the data has been analysed, it is interpreted by making links between the findings of the research and the underlying permeability and geological conditions of the area that is being investigated.

The first stages in landslide research include the collection of data from the field visit and/or the analysis of images obtained via remote sensing. The method that is used to gather data relevant to landslide studies is mostly contingent upon the scope of the research, the reason for conducting the study, and the level of accessibility to the study region. Studies on landslide susceptibility and hazard zonation need data on a variety of topics, but the most important ones are landslide inventories, environmental conditions, and the mechanisms that set off slides (Sreedevi and Yarrakula 2016; Metternicht et al. 2005; Soeters and Van Westen 1996). The environmental factors mainly consist of the slope angle, the slope aspect, the flow accumulation, the lithology, the geological structures or proximity to faults, the soil type, the soil depth or thickness, the slope hydrology, the geomorphology, the proximity to streams, road cuts, land use types and changes, and other things like that. Rainfall on a daily basis, the intensity and length of rainfall, earthquakes, and volcanic eruptions are the conditions that set off this phenomenon. It is not feasible, in general, to construct a unified list of such causative components that would be necessary for the research on landslides. The scope of the analysis, the features of the research region, the kind of landslide, and the failure may all have an impact on the identification of such causative elements. For landslide hazard zonation, spatial and temporal landslide data from archive, image analysis, and other sources are required, whereas for landslide susceptibility,

only spatial data is sufficient. The primary difference between the two approaches to the collection of data for landslide susceptibility and hazard zonation is in the collection of data for landslide inventory.

A human action that has the potential to inflict physical harm, such as death or injury, as well as damage to property, society, and the economy, as well as the environment, is referred to as a hazard. This event has a specific likelihood of occurring at a certain time period and in particular locations, as well as a certain degree of severity (Van Westen et al, 2009). According to Coppola (2007), a hazard is "anything that provides a danger to the health, safety, or welfare of a community's residents, companies, or natural resources.". According to these definitions, a hazard is something that poses a risk to the lives of people or the value of their possessions (property, infrastructure, facilities etc). According to the findings of this research, highways are considered to be a kind of infrastructure, and the possibility of landslides poses a danger to the survival of roadways. In this particular instance, the possibility of a landslide is brought about by human activity, namely the cutting of the contour of the ground in order to construct roadways. This action can cause the slope's stability to worsen, which might have negative consequences. The three aspects that make up a hazard are its temporal probability, its spatial probability, and its intensity. Temporal probability refers to the likelihood of an event occurring within a certain time period. spatial probability considers the likelihood of an event occurring inside (magnitude). In another definition of the term "hazard," (Chakraborty, 2008) the term "hazard" encompasses factors such as location, which is associated to the question "where," time, which is related to the question "when," and magnitude, which is related to the question "how." The definition states that the "where" issue may be answered

by considering the likelihood of an event's location, "when" can be answered by considering the event's timing, and "how" can be answered by considering the event's magnitude. Varnes (1984) states that there are two main aspects to landslide hazard: the spatial probability of slides and the temporal likelihood of slides, which is related to the amplitude, return duration of the triggering event, and frequency of slides.

In the event of a landslide, the stability of the slope might be affected by a wide variety of variables, including geological and hydrological conditions, geography, climate, and changes in the weather. Because of this one and only factor, landslides are rather uncommon.

2.2 Regional Geology and Tectonic Setting

Kota Bharu, the capital of Kelantan, is located in northeastern Peninsular Malaysia. Kelantan's longitude runs from E 101° 20' to E 102° 41'. While N 4° 33' to N 6° 14' in latitude are included. A total of four distinct varieties of rock may be found over all of Kelantan's 15,022 square kilometres. The state of Kelantan is likely home to four distinct kinds of rocks: unconsolidated sediments, extrusive rocks, granitic rocks, and sedimentary/metasedimentary rocks (Department of Mineral and Geoscience Malaysia, 2003). Figure 2.1 shows the general geology map of Kelantan.

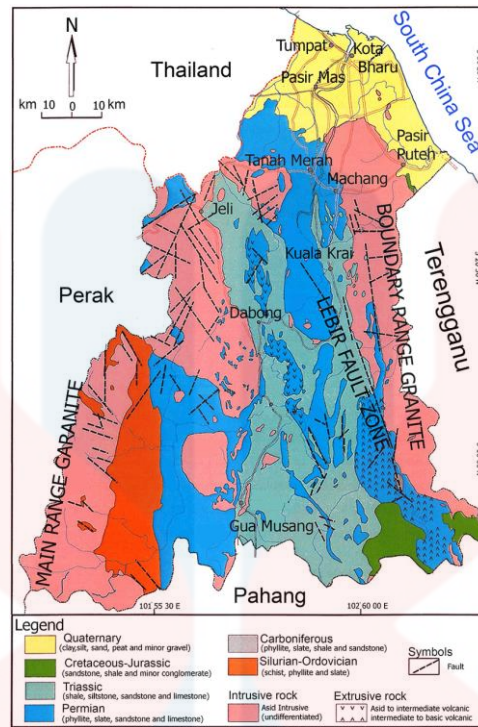


Figure 2.1: General geology map of Kelantan.

(Modified from Department of Minerals and 812 Geoscience Malaysia, 2003)

According to an article published in The Star, the number of landslides in Malaysia grew practically every year, peaking at 33 in 2014. Malaysia has seen around 18.5 landslides each year during the last ten years. Malaysia was in fifth place among nations with a geographical area more than 100,000 square kilometres for the highest number of landslides per square kilometre.

Extreme weather or earthquakes are often the factors that set off landslides. After performing extensive cutting and excavation on slopes for a road, construction, or mining operation, incorrect waste management has the potential to set off landslides.

2.3 Stratigraphy

The rocks in this area may be subdivided into three separate strata. Recent rock formations were placed higher in the stratigraphic column. Most of the soil in the study region is alluvium, the youngest rock layer. The Cretaceous period marks the first known appearance of alluvium soil. The sandstone used to make the second layer. This rock first began to take shape during the Paleozoic. Quartzite rock, which forms the third layer, was initially deposited during the Cretaceous period. The foundation is made out of gneiss. Similar to sandstone, the Paleozoic period was the time of this rock's formation. About 20% of Peninsular Malaysia is made up of Quaternary period sediments that overlie the Cenozoic era. Peninsular Malaysia, which is located over the Cenozoic, is not experiencing any significant fault movement or tilting and elevating at the present time. Researchers in the Malay Basin have estimated an average thickness of 10,000 metres for the sediments there, although the thickness of other known Cenozoic deposits varies (DuBois, 1980). We have also accounted for the offshore reserves in this debate and connection because of their crucial economic importance.

According to Hutchinson (2009), the geology of the peninsula of Malaysia may be separated into three main zones: the Western Belt, the Central Belt, and the Eastern Belt. The Eastern Belt is composed of clastics and carbonates that date back to the Carboniferous and Permian periods, while the Central Belt is mostly composed of sediments that date from the Mesozoic and Permian eras. The Koh formation, which can be found just above the Gua Musang formation, is what distinguishes the most northern region of Kelantan (Lee et. al, 2004).

Fossil evidence suggests that the sedimentary rock in the Kuala Krai region dates from the Carboniferous to the Triassic. However, most of the volcanic and

sedimentary rocks found nearby are millions of years older, from the Carboniferous to the Permian. The Gua Musang formation, as described by Lee et al. (2004), is made up of alternating layers of calcareous and argillaceous rocks, arenaceous, and volcanic. The Mesozoic epoch is responsible for this geological formation.

2.4 General Structural Geology

The study describes the regional tectonic history of NE Peninsular Malaysia by using field and microstructural observations to illustrate how the Taku Schist has evolved over time, with an emphasis on the kinematics of shear deformation. This research shows how the Taku Schist has changed over time. During the Paleozoic epoch, the Taku schist was a sedimentary series; however, as a result of the Indosinian Orogeny, it underwent metamorphism and is now classified as an amphibolite facies. There was an episode of burying and metamorphism (D1), then there was flattening in a top-WSW direction (D2), and ultimately there was upright folding (D3) in this direction (D3). The evolution of continental subduction and the collision of Sibumasu and Indochina throughout the Permo-Triassic period are congruent with the overall orogenic structure, which was created by East-West directed contraction. The top-southeast directed shear deformation, also known as D4, was seen and published for the first time. This deformation was responsible for the construction of a core complex as well as a large-scale extensional separation. Later strike-slip and normal faulting accommodated the observed low-angle mylonitic detachment shearing, which resulted in the formation of a broad fault zone that trended from northwest to southeast. At the same time as the Taku Schist and other footwall units were being excavated to a great extent, they went through

a process of retrograde metamorphism that turned them into a greenschist-facies. A top-SE separation method was used in a manner similar to that which was used to separate the Stong Complex, Kemahang Granite, and the Tiang Schist from the Gua Musang hanging-wall. Post-orogenic extension and concurrent exhumation may have occurred between the Late Cretaceous and the early Eocene, as shown by the formation of young sedimentary basins in the hanging-wall and syn-kinematic intrusion of the high temperature Strong Complex during top-SE shearing.

2.5 Historical Geology

Between the years 1922 and 1925, Savage laid the groundwork for regional geology. Natural reconnaissance was performed first using inaccurate small-scale topography maps. The groundwork for regional geology was laid in part by Savage's research. Between 1951 and 1960, other work of a similar kind was done by MacDonald (1951), Slater (1957), and Santokh Singh (1960). Hutchison and Tan (2009) have completed the Geology of Peninsular Malaysia, a comprehensive compilation of geological data that will be published in book form. The Paleozoic, Mesozoic, and Cenozoic eras are the three basic chronologies that make up Kelantan's geological formations, which stretch from the Lower Paleozoic to the Quaternary epochs.

When most people think of rocks from the Cenozoic period, they think of sedimentary rocks that date back to the Quaternary Period. The majority of the Quaternary sediment covering a section of north Kelantan is comprised of unconsolidated to semi-consolidated boulders, gravel, sand, silt, and clay. These

materials also serve as the bedrock for the region's coastal and interior plains (Rahim et. al, 1997).

Kelantan is a state in Malaysia that may be divided into four distinct landscape types based on its geomorphological characteristics: mountainous, hilly, plain, and coastal. You may classify these four landscapes as follows: Kelantan is a state in Malaysia, and the only part of the state that has any coastline is in the north. The tectonic activity that occurred throughout the Paleozoic and Mesozoic eras resulted in the development of two regional local landform features: faulting and folding. Sedimentary rock joints, faults, and folds, as well as granitic rock joints and faults, make up the regional structures (Department of Minerals and Geoscience Malaysia, 2003). Kelantan is mostly organised along north-south and northwest-southeast axes.

2.6 Research Specification

2.6.1 Electrical Resistivity Imaging

Electrical Resistivity Imaging (ERI), one of the geophysical technologies employed by civil engineers, stands out as a particularly enticing tool for characterising subsurface profiles over vast territories. This is because ERI can measure variations in subsurface resistivity across large areas. Using ERI in conjunction with the present conventional method of groundwater exploration has the potential to provide results that are comprehensive and convincing while also being cost-effective, taking less time, providing more data coverage, and being more sustainable. ERI has been used by a number of different firms in their hunt for subsurface water. Digging is one of the classic procedures that has been used for a significant amount of time in order to gather information about the different strata of the earth, especially during the process of site research. Using conventional

techniques creates a number of issues due to the fact that these methods only give data at the point where the actual drilling is taking place. Information on contaminated groundwater, leachate, the underground, and prospective sources of water supply might all be valuable findings from ERM to the appropriate expert in order to assist in the development of solutions to the problem. There has been very little advancement made on the method itself over the course of the last twenty years (Barker, 1981)

The resistance of a material to electrical current is a crucial physical property. It's a measurement of how difficult it is for an electrical current to go through a certain material. Porosity, saturation, pore fluid and solid phase resistivity, and material roughness affect sediment or rock electrical resistivity. Tills, fluvial and lacustrine sediments, bedrock, and structural features like faults all have varying electrical resistivities; hence, electrical resistivity should be well-suited to resolving structural structures and intruded bedrock in unconsolidated sediments. According to Telford (1976), resistivity methods may be used to analyse crystalline and sedimentary rock types, as well as compact quartzite and schist or phyllite. Vertical electric sounding may predict horizontal rock resistivity if you know where the highest resistivity variations are (usually deep) and where layers were deposited horizontally.

Utilizing a broad range of geophysical methods, such as magnetic, gravity, seismic, and electrical approaches, subsurface water resources have been discovered and defined (Telford et al., 1976). For a standard measurement of resistivity, four electrodes are placed in a line and are uniformly spaced apart. The arrangement of the four electrodes in the array is what affects the amount of information that can be gathered from each apparent resistivity value as well as the

amount of background noise that is included (Smith, 2006; Loke, 2001). The sensitivity map of the Wenner array is almost horizontal under the array's core. The Wenner array is capable of identifying with a high degree of sensitivity any subsurface resistivity oscillations that occur below its centre. On the other hand, it is less prone to vertical and horizontal subsoil resistivity fluctuations.

The electrical resistivity (ERI) method is widely used in geotechnical and environmental investigations to measure the subsurface resistance of the ground. Rock materials, pore shape and size, porosity, temperature, and a number of other geological variables all contribute to resistivity readings (Fetter, 2001). To identify geological structures and groundwater using the resistivity values emitted by such features, the ERI method may be used, which is simply a response between the electric current flows of the Earth. Electrical imaging is one of the most widely used and well-known techniques for geological surveying, as stated by Barker (2002). Resistivity sounding is used in this procedure, and it can provide data even in restricted locations. Plus, it's one of the most used methods. To use this geophysical method, it is necessary to maintain a constant distance between the two terminals rather than moving the centre electrode. Multiple electrodes are used to conduct the ERI survey. Depending on the size of the survey, anything from 25 to 100 electrodes may be employed, with a typical electrode spacing of 5 m and connections made using multicore wire. Because it shows the cross section of the earth as a two-dimensional representation with distinct colours, the resistivity method is well-known among researchers who are interested in groundwater investigation.

2.6.2 Resistivity Array

The geological data of the area being investigated directs the placement of electrodes in a resistivity array, also known as a grid. In order to carry out a basic

survey of the resistivity, you will need four electrodes and a resistivity metre. The relative positions of the electrodes in a resistivity survey are related to geometric parameters (Figure 2.2) and numerical multipliers that impact the survey depth, resolution, sensitivity, and noise intensity in response to the measurement of the apparent resistivity. Moreover, the survey's depth is affected by the electrodes' relative placements (Loke, 2006). Furthermore, relative electrode locations have an effect on the perceived resistance. There is a wide variety of electrode designs that may be used to perform the resistivity method, each with its own advantages and disadvantages. Examples of arrays that fit this description include the pole-dipole array, the pole-pole array, the dipole-dipole array, the Wenner array, and the Schlumberger array. Even though the pole-dipole array has the highest signal amplitude, the Wenner and Schlumberger arrays provide the greatest installation flexibility. The signal amplitude is greatest with the pole-dipole array. Advantages of the arrays selected is pole-dipole could be used at sites where the great horizontal resolution is needed.

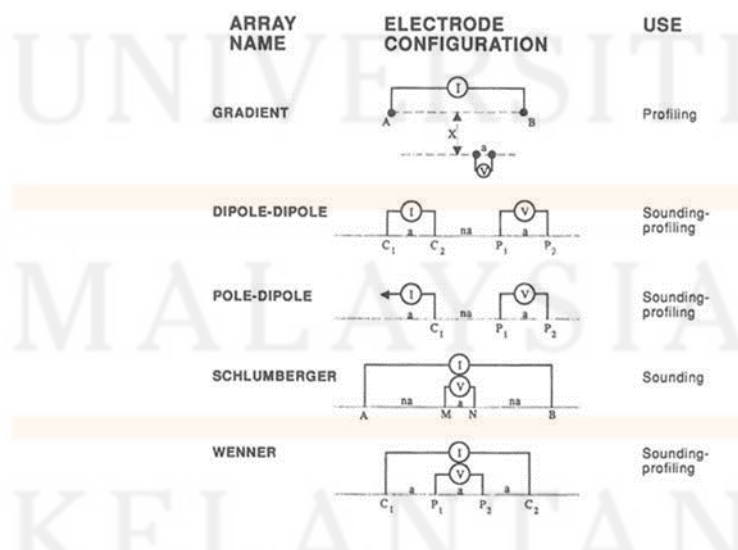


Figure 2.2: Arrays used and their geometric factors (Loke, 2006)

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter details the procedures we must follow and the resources we must gather to complete the study that will be utilised to establish the reliability of our findings. All the materials and tools on the list are used in the method section, which details the whole research protocol and all of the associated measurements and computations. The entire thing was well organised and thought out, which helped us get the results we wanted. The data has to be organised in a systematic framework to eliminate room for mistake. The presented findings, for instance, may have been arranged according to the chapter headers' subheadings, or the contents in each section may have been arranged from least significant to most serious problem. Figure 3.1 is a flowchart used to guarantee that all of the study's procedures are carried out as intended.

RESEARCH FLOW CHART

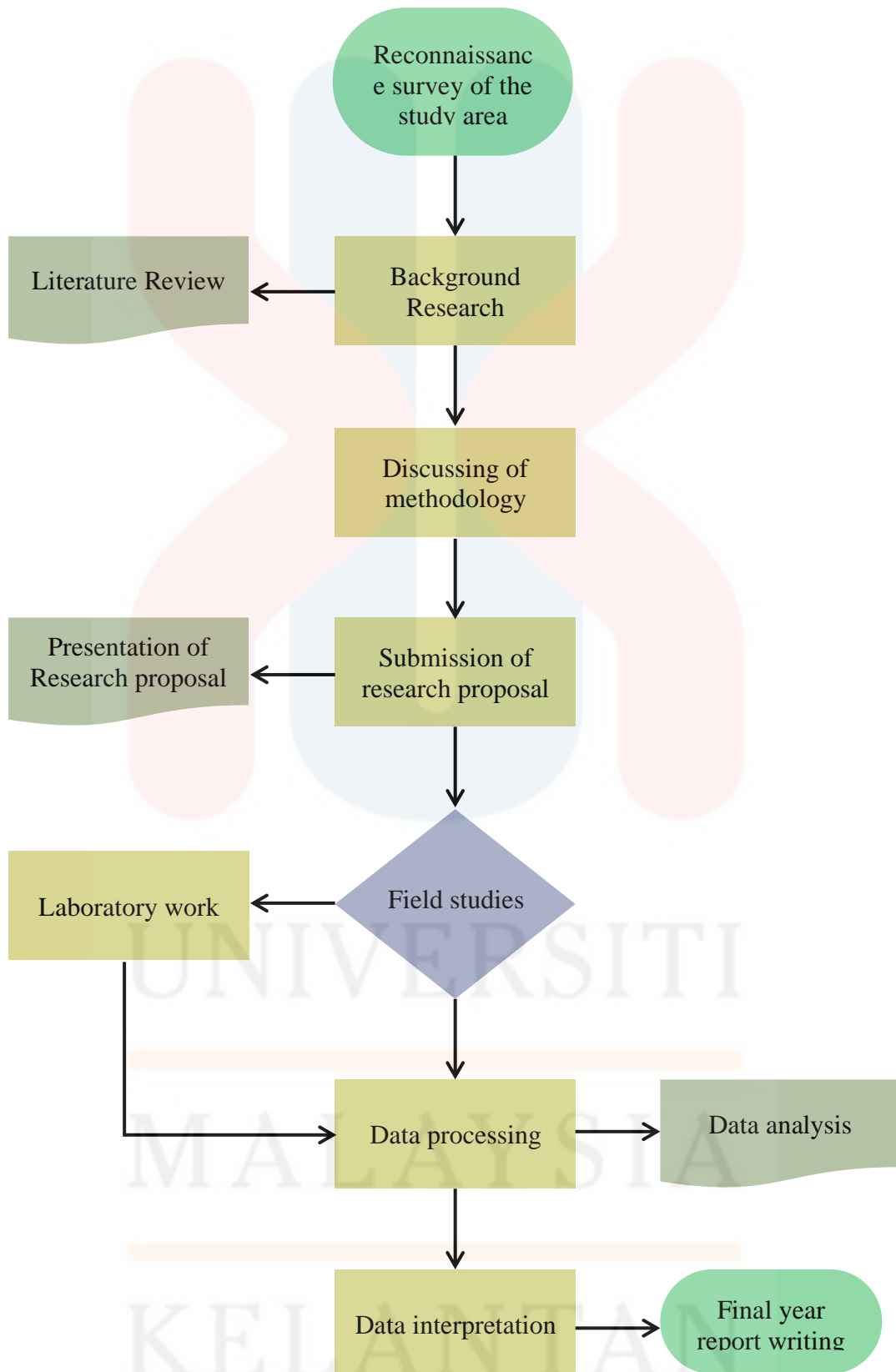


Figure 3.1: Research flow chart






3.2 Materials





3.2.1 Geological Mapping

The materials and equipment that needed for this research consist of mainly the laboratory apparatus and geological mapping apparatus. Table 3.1 below shows the list of needed equipment and apparatus.

Table 3.1: List of Materials and Equipment

NO.	MATERIALS/ EQUIPMENT	USES	PICTURE
1.	Global Positioning System (GPS)	A GPS is based on the radio navigation system that will show the user their exact position on land or sea along with the velocity, time for 24 hours a day anywhere in the world.	
2.	Topographic Map	A topographic map is used to identify the landforms of the study area based on the contour lines with variety scale details.	
3.	Compass/Clinometer	A compass is used for orientation that will guide the pathway using the diagram called a compass rose with the directions of north, south, west, and east.	

4.	Geological Hammer	A geological hammer is needed in gathering the outcrop sample, as the rocks are strong. The common hammer used by the students is chisel and tip-point.	
5.	Measuring Tape	The measuring tape is used to make a measurement of the outcrop dimension. The dimension of the outcrop is important in doing the lithology part.	
6.	Sampling Tools	The sampling tools that are used are sample is needed for keeping bags. It is used to keep the outcrop sample and the rock material from the site of the study area. All information needed such as the coordinate, type of rocks also been labelled on it Labelling is needed when we take a sample.	
7.	ABEM Terrameter LS	ABEM Terrameter is used for the surveying of the potential landslide locations.	
8.	Dilute HCL	Utilized in the field to determine whether the outcrop and sample we collected had detectable levels of carbonate ion. Used in the field to test the presence of carbonate ion in the outcrop and sample that we found.	

9.	Field notebook	Having a notebook to record all of field notes and data in is crucial for their security. In order to keep down the note and data is safe, notebook is essential to write down all the information gathered at the field.	
10.	Stationary	To record the information, stationary such as a pen or pencil is required. The ruler is Stationary like pen or pencil is needed to write down the data. The ruler also useful is needed for drawing and sketching of the outcrop and the sample that is collected specimen.	
11.	Multi-Electrode Cables	The passive electrode cables are designed to be hard-wearing and are designed with molded stainless steel (or graphite) electrode takeout in the passive electrode cables is encased in a moulding encapsulated in molding material that is chemically attached to the outsidebonded to the outer and inner cable jacket, making the cables very durable.	
12.	Microscope	Rocks and mineral composition are identified with the use of a microscope. The microscope is used to determine the nature of the rocks and its composition of the mineral.	

3.3 Methodology

In methodology section, the steps to conduct the research are discussed. This section contains preliminary study, field studies, laboratory work, data processing, data analysis and interpretation and final report writing. This section provides a description of a range of activities that occur during the technique phase. Some of these activities include pre-field and field research, sampling, laboratory work, petrology analysis and interpretation, and seismic analysis and interpretation. Separate aspects of geology, namely general geology and seismic interpretation, are investigated in this study.

Geological mapping of the study area located at Kg. Chuchoh Puteri, Kuala Krai, Kelantan is essential in order to understand geology in general. The kit includes a hand lens, a measuring tape, a geological hammer with a tip point and chisel, a compass, geological sample bags, hydrochloric acid, and a measuring tape. Additionally, a field notebook and a global positioning system (GPS) are included. The Faculty of Earth Science at the University of Malaysia Kelantan will have laboratory materials available for its students (UMK). In addition, the process of carrying out this mapping will be aided by a number of books, journals, and official references derived from government bodies. This research will make use of a geological mapping approach, which calls for a minimum of two weeks' worth of observations of the region being investigated. It is necessary to cover the research area's breadth, which is 25 km², along with its surface area. The research approach absolutely cannot function without the inclusion of field research. The information gathered from the geological mapping is now being sent to the laboratory so that it may be analysed using thin sections. During this stage of the process, the researchers are tasked with selecting a new sample to be thin sectioned. Researchers have benefited from this tool's assistance with sample analysis.

The apparent electrical resistivity of the subsurface materials is measured as part of the ERI procedure. During an ERI survey, a pair of current electrodes are used to inject an electrical current into the ground, and a pair of potential electrodes are used to detect the difference in potential between the two sets of electrodes. In most cases, a linear array serves as the organisational principle for both the current and potential electrodes. The bulk average resistivity of any and all subsurface materials that have an effect on the flow of current is what is referred to as the apparent resistivity. Multiple such measurements of apparent resistivity are required during a normal ERI survey, and these measurements are performed using a variety of electrode placement configurations. After the data has been collected, as in Figure 3.2 below, it is analysed, and resistivity contour maps are created to highlight differences in resistivity along depth and horizontal locations. Because the composition and amount of water in subsurface materials affect the electrical resistivity of those materials, the resistivity contour maps may be used to get a broad understanding of the state of the subsurface or to locate specific objects of interest. For instance, because to the fact that soils and bedrocks often have differing resistivities, ERI may be used to designate where soil and bedrock interfaces are located (Utility Survey Corp, 2017).

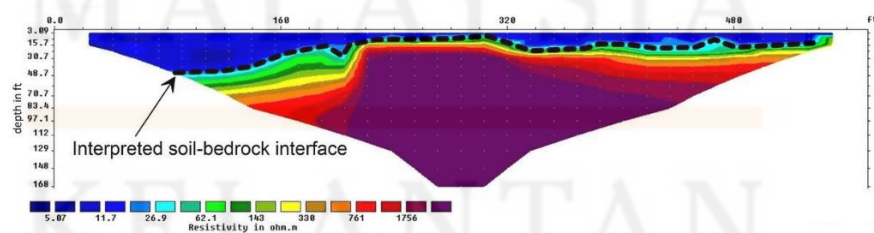


Figure 3.2: 2-D electrical resistivity lines.

The technique of measuring electrical resistivity is an example of an active geophysical method. It uses an artificial source that is implanted into the ground by means of a pair of electrodes. In order to complete the technique, you will need to measure the potential difference that exists between the other two electrodes in the area of the flow of current. Calculating apparent resistivity involves utilising the potential difference as the interpretation for the calculation. The electrodes that allow current to be put into the ground are referred to as current electrodes, while the electrodes that are used to detect the potential difference between two points are referred to as potential electrodes.

Steps for conducting the electrical resistivity survey are by determine where is the location to do the research. Next, make a decision on the distance between each of electrodes. Put out the tape measure and place the hammer in the stakes. Then, establish a connection between the SuperSting, the stakes, the electrode cable, and the switch box.

Conduct a test of the contact resistance to determine whether or not everything is connected correctly. Start the survey's resistivity scan right away and visualize the data scan in real time. Lastly, transform the collected data into a model that can accurately describe the subsurface.

The levels of danger, vulnerability, and direct effect all need to be classified before classification can take place. This study made use of a technique called Equal Intervals. This approach makes the value ranges in each category the same size by setting them all to the same value. This approach is the one that can be calculated with the least amount of effort and is suitable for displaying data that fluctuates linearly. The full range of possible data values, from their maximum to

their minimum, was evenly split up into many different groups. In order to get the detail classes, it was necessary to employ 5 different class criteria, which are as follows: extremely low, low, moderate, and high. This approach was used to classify the hazards, as well as the vulnerabilities and the direct impacts. In order to maintain consistency in the reference, the class interval that is used for classifying hazards and direct impacts is the class interval for a return period of one year. The following equation may be used to determine the class of an interval:

$$\text{Interval class} = (\text{max value} - \text{min value}) / 5$$

Combining past landslide events with mapping units allowed for constructing a spatial probability model. Utilizing a number of different parameter mappings is required in order to generate a mapping unit. In this particular instance, the author constructed the landslide danger maps by using the usage of two different parameter maps, namely the slope map and the landuse map. The chance of landslides occurring inside each mapping unit was used to derive the spatial probability that was achieved. The method used to approach it consisted of calculating the density of landslides per unit of mapping, which displays the geographic likelihood. The following equation may be used to figure out the spatial probability of an event: (Nayak, 2010).

Moreover, the preparation and pre-field activities include the collection of literature reviews, which may include journals, papers, books, and the results of prior research linked to the data that is required as well as information on analytical methodologies. At this point in the process, data pertinent to the study have been gathered.

Secondary and primary data also included in the field work of this study. Two data that contributes are secondary sources of information and primary data. Data on the occurrence of landslides, the classification of road networks, the typical costs associated with dealing with roads (repairs, construction, and maintenance), the number of days that roads are blocked, the volume of debris slides, and other types of data are examples of secondary information. Other than that, primary data is the primary method of data gathering consisted of conducting interviews and observing the incidence of landslides to the road. In order for the author to get information on historical landslide incidents, he or she must first watch a landslide and then discuss the topic with members of the local community who have experience dealing with previous landslide disasters. In addition to this, data was obtained via interviews with prominent members of the community and other important informants. The identification of the kind of landslide and the measurement of its morphometry (length, breadth, run out, and soon) using a lacer ace are both included in the process of landslide observation. Road tracking is something that has to be done in order for the author to be able to guarantee and measure the real road network in the field. Suunto is a device that may be used to measure slope data, both in terms of the upper and lower road that was utilised to construct the micro slope. At this point in the process, the main statistics that deal with the number of vehicles of a given kind were utilised to determine the indirect effect on the road. The basic data of community perception linked with the route alternative and fuel usage may be gathered via the use of the tool quisionere.

3.3.1 Preliminary Study

In the first step of the process, you will do research into the background of your selected topic to assess the nature of the problem at hand based on what has previously been learned about that subject. When referring to an in-depth investigation of possible issues with a subsequent evaluation of quality, the phrase "preliminary study" is often used. At this point, we will perform a comprehensive literature study, during which we will search through various published works such as articles and reports to locate material that is pertinent to the topic at hand. Before we can begin the study in the field, we need to complete this stage in order to ensure that we are prepared for any unanticipated challenges. As a result, the first phase need to also include the creation of the fundamental map.

3.3.2 Field Study

The next stage will be the field research. In the context of a geological research, this encompasses everything we do when we're out in the field, from navigating to collecting samples to observing the geological features of the region. Indicating the path that will be taken during fieldwork and providing evidence that we actually perform field study by walking it are both reasons to traverse. In this sense, "sampling" means collecting rock from an outcrop; the word "weathered rock" should not be used interchangeably with it. Geological features and associated data are noted in the notebook.

3.3.3 Laboratory Work

The fieldwork is followed by the work in the laboratory. The apparatus and gear from the laboratory may be used in this manner in order to perform the job of collecting supplemental data. After undergoing preliminary inspection and analysis, recognisable samples that have been gathered in the field are processed in

the laboratory using techniques such as thin section, petrography analysis, and software application. A greater understanding of the composition of a rock may be gained via the use of petrographic analysis, which identifies the different mineral kinds that are present in a given rock sample. At this point in the process, we analyse the samples using an electronic microscope at a variety of magnification levels. We took thin pieces of each of the rock samples that we collected by hand while we were wandering over the site, and we will examine the minerals in these sections using a microscope in order to figure out where these rocks originated.

3.3.4 Thin Section

In order to finish the thin section of the collected specimen, there are six steps that must be taken, and they are as follows: sectioning, impregnation, precision sectioning, bonding, re-sectioning, grinding, and polishing (Buehler 2006). The first stage of the procedure is called sectioning, and it consists of cutting the specimen into increasingly smaller pieces as the procedure progresses. During this stage of the procedure, we made use of a Diamond Slab Saw machine to cut the specimen. Second, during the impregnation process, a machine called a SamplKup is used to evacuate the gases that have accumulated in the crevices of the rock. According to Buehler's (2006), this makes it possible for vacuum impregnation to take place between the rock components and the cracks in the sample. The third stage is the precision section process, which is also known as the trimming process. This stage involves the rocks being deformed slightly by a little incision. IsoMet is the piece of machinery responsible for carrying out this procedure.

The Petro Thin Sectioning System was utilised to efficiently eliminate any unwanted and unnecessary materials, like as air bubbles, from the specimen once

the exact procedure was completed. The grinding wheel of this machine is made using diamond cutting and a vacuum chuck. The remaining processes are grinding and polishing. Grinding takes rid of the distortion caused by sectioning, while polishing gets rid of the extra material that forms during grinding. This is followed by polishing, which occurs after the sectioning process has been completed. The result of this procedure is a sub-micron abrasive finish on the specimen's surface. The method is finished when a slide containing the thin slice is supplied and examined under a polarised microscope. This is for the details of the mineral composition of the rock, as mentioned above.

3.3.5 Data Processing

The data must be cleaned and formatted before it can be analysed. In order to use the acquired data for analysis, it must first be transformed from its raw format. The analysis outcome is sensitive on the data's format. For accurate results, careful attention must be paid to the data preparation process. Information processing software and hardware are discussed here. Geological data, which consists of information gathered by surveying and observing geological features in the field, is processed by software to prioritise the data. In this study, we make use of a number of different programmes, including: GeoRose, ArcGIS, RES2DINV (Figure 3.2), and Terrameter LS Toolbox (Figure 3.3). In order to calculate the force operating on a given location, the strike and dip data are plotted in GeoRose software for combined analysis. ArcGIS is the name of the programme used to make geological maps. We utilised Terrameter LS Toolbox and RES2DINV, which shows a pseudosection reading of resistivity and chargeability for the region of interest, to acquire the result for specification.

3.3.6 Data Analysis and Interpretation

The outcomes of the tests are used as a basis for doing data analysis and interpretation. An analysis of the information that was gathered allows one to determine whether or not the objectives of the study were accomplished, hence establishing the research's credibility. After receiving the results of the data processing, such as the rose diagram that was built by GeoRose. It is now abundantly evident to us the causes that contributed to the formation of the area. In spite of the possibility that the topography would shift as more time passes, we were nevertheless able to put together its past and give further context for our investigation via this research. During the petrography study, the whole textural content of the rocks was analysed in great depth. This analysis included the composition of the minerals that were found in the rock specimen. The results of the petrographic investigation and the handwritten field notes are compared and correlated with one another. By piecing together the pieces of the puzzle, one can get a more in-depth understanding, and robust evidence of the existence might be offered.

It is possible that the interpretation is incorrect due to some kind of inaccuracy or mistake, in which case the study will need to be redone from the very beginning. We put the finishing touches on the stage by creating a comprehensive report on the study, making use of the data and information that we interpreted.

3.3.7 ERI Analysis

Following the completion of the field survey, the resistance data will be converted into apparent resistivity values. Virtually every commercial multi-

electrode system now comes pre-packaged with the necessary computer software to do this conversion. In order to correctly understand the results of a two-dimensional imaging survey, it is usually necessary to use a two-dimensional model of the subsurface that is composed of a significant number of rectangular blocks. After that, a computer programme is used to estimate the resistivity of the blocks in order to ensure that the calculated apparent resistivity values are in agreement with the observed values obtained from the field survey.

In this scenario, the subsurface will be automatically divided into a specified number of blocks using RES2DINV. Next, it uses an inversion approach to identify the proper numbers, which you must then enter into a text file that the programme can read (Geotomo software, 2006; Loke & Barker, 1995). RES2DINV reads field data and inverts it using the least square inversion algorithm to acquire the real resistivity and depth of the field resistivity picture. Once you do so, you'll get a clear view of the real resistivity and depth of the field resistivity. RES2DINV incorporates topographic changes to accommodate for height disparities. Pseudosections are utilised to present and contour the findings of these surveys owing to the precise image of subsurface resistivity they offer (Loke et al., 2003).

3.4 Methodology for geophysical investigation

3.4.1 ABEM Lund System Arrangement

The ERI method of measuring electrical resistivity requires a total of 41 electrodes. After that, a horizontal line of electrodes is dug and buried at five-meter intervals. The electrodes have been implanted for around 100 mm, or almost half of their overall length. In this investigation, we used a Lund Imaging Cables ES464 type as a connector for the electrode selector. Those wires were put to use. Next,

the Abem Terrameter LS 1 is connected, and it is this instrument that is wired to the power source.

3.4.2 Taking Data from ABEM Terrameter LS 1

The resistivity value gleaned from geophysical contact below the earth is read by the ABEM Terrameter LS 1, which then stores all the data gathered from the ground. In order to ensure the integrity of the final result, we must adhere to a few protocols before we begin the survey. The ABEM Terrameter LS 1 used a lot of power, therefore the first order of business is to make sure the battery is fully charged. When measuring subsurface resistivity, it is important to ensure that all 41 electrodes are firmly planted in the earth at the predetermined location. There are five distinct array types used for two-dimensional resistivity surveys (Figure 3.3). Dipole-dipole arrays, pole-dipole arrays, Wenner arrays, and Schlumberger arrays are the most common kinds of arrays used in two-dimensional surveys (Telford et al., 1990). When it comes to electrodes, the relative location and spacing might vary depending on the array type, each of which has its own advantages and disadvantages.

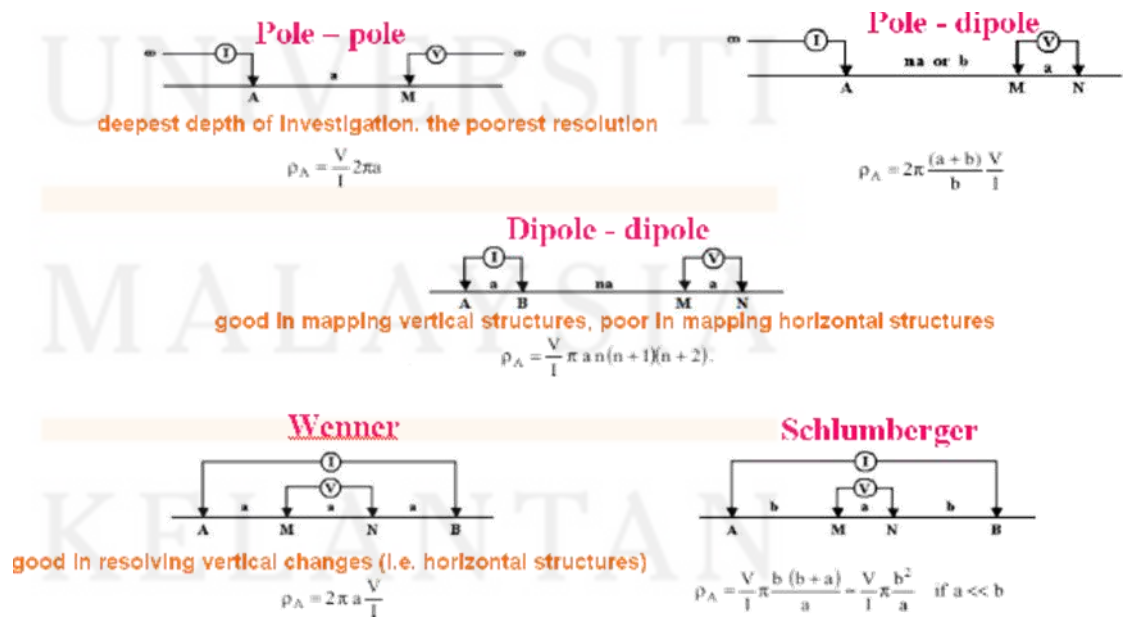


Figure 3.3: Electrode arrays arrangement

3.5 Software Applications

The collection of data for analysis is aided by software designed specifically for research. One of the programmes that assisted us in generating the maps that displayed the geographical data that we collected was called ArcGIS (GIS). It was possible to analyse and handle the mapped data thanks to the geographic data that was saved in the repository. After then, the RES2DINV application offers its assistance to us so that we may evaluate the resistivity data that the ABEM Terrameter LS 1 has gathered. The graphic will depict a "pseudosection" that traverses the area that is the subject of the inquiry. After that, the values of the material's resistivity and chargeability are used so that the pseudosection image may be comprehended. We may be able to recommend a drilling site and estimate the depth to groundwater via the process of interpretation. Due to the fact that its primary focus is similar to that of ArcGIS, this software is as important to the accomplishment of the objectives of the current investigation as is ArcGIS.

In addition to these two programmes, the GeoRose software may be used to determine the thrust that was exerted in a given area. This programme used strike and dip data collected on the ground to generate a rose diagram. Using GeoRose isn't the only option; we can also do it manually, but the results obtained with the use of technology and software are more precise and easier to attain. In this case, the diagram is complete when all necessary information and data, such as strike and dip, have been input into the computer. The information has been put into Microsoft Excel in preparation for the creation of tables and graphs that will give more background. Data analysis and interpretations for the purpose of attaining objectives are impossible without the use of software programmes, which are just as important as other ways.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

Utilizing the map that was shown in the prior part, this section covers the area with regard to its accessibility, residents, forestry and vegetation, traverses, and observations. Following that, this chapter delved into the subject of the geomorphology of the region. Geomorphology is the study of the processes of weathering, the patterns of drainage, and the categorization of landscape features by utilising maps of geomorphologic units. These are all characteristics of the landscape that are investigated by geomorphology. The findings of a lithostratigraphic research that was carried out in the region under investigation are presented below. A geological map and cross section are used in order to illustrate the results of a lithostratigraphic investigation. Following the presentation of each unit of stratigraphic information comes a thorough dissection and definition of that unit.

Structural geology is also covered to a lesser extent in this chapter. In this section, we record the structural geology of the whole study region. Veins, joints, and fractures are all the same thing in structural geology. The study of historical geology has the potential to provide light on the mechanisms responsible for the production of the region's unique rocks, structures, and landforms.

4.2 Accessibility

Kampung Chuchoh Puteri is located in Kuala Krai, Kelantan, which makes it easier access by the main road from Jeli and Tanah Merah in Figure 4.1. Next, a significant proportion of the roads in the villages have surfaces made of dirt, and these roads often lead to private residences. These pathways are used by both construction equipment and locals. Getting to the location of the study is often a straightforward endeavour whether one chooses to drive their vehicle or ride a motorbike there. On the great majority of roadways, the situation is exactly the same. Its accessibility is useful for the cars, motorcycles or even lorry to use the pathway.

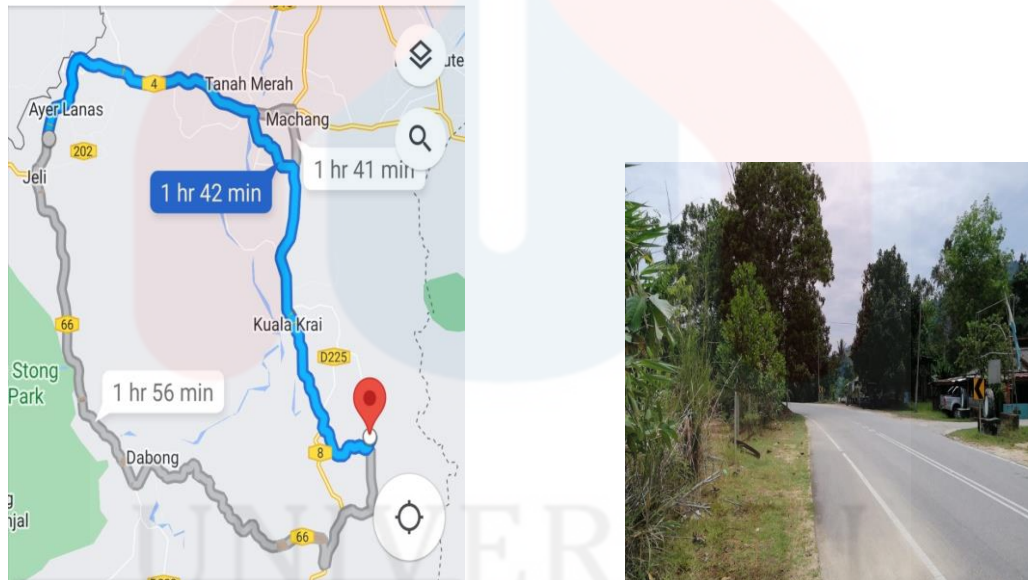


Figure 4.2 shows the distance from university based on waze and road to access to the study area.

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4.3 Settlement

Kampung Chuchoh Puteri is mostly dominated by the village area. Kampung Chuchoh Puteri also has resident areas, schools, rubber palm plantation, a forestry department,. The residential area consists of the villages and modern houses. Modern houses are newly and currently developed in the study area. As a result of meeting the demands of the locals, the region under investigation might be considered a prime spot for settling.

Located in Kuala Krai, Kelantan, Kampung Chuchoh Puteri is one of the city's less-developed neighbourhoods. In spite of this, the research area still has a somewhat wooded region. The people of Kampung Chuchoh Puteri, however, own the rubber plantations privately.

4.4 Forestry/Vegetation

In the study area, 1/3 of it is covered with forestry area while the other 2/3 is cover by plantation area, villages and others. Most of the plantation found in the study area are rubber plantation. To create, manage, plant, use, conserve, and restore forests, woodlands, and related resources for human and environmental benefit is the science and art of forestry. Plantations and wild forests are where forestry work is done.

4.5 Traverse and Observation

Traverses are a kind of method used in surveying, and they are also used in geodesy for setting up control networks. Building a traverse network involves setting up a series of survey nodes at regular intervals along a path or corridor, and then using the information gathered at those nodes to guide the observations made

at following nodes. Making geological maps in the field may include a number of different approaches, one of which is traversing. The traverse was created so that researchers could keep track of their whereabouts in the region of investigation while they conducted their study. Geologists will be there during the whole excursion to take field notes and images that may be incorporated into a detailed map of the area. This will have the immediate effect of simplifying the process of locating relevant resources within the study's domain. Both the traverse and observation maps display the path taken by the cartographers throughout the mapping process.

Geological field mapping was carried out across an area of 25 km² to indicate the location of field data, geologic features, and their subsequent placement in a base map. Several methods were used to guarantee the success of a traverse activity. As a first step, the Global Positioning System (GPS) is used due to its rapid adaptability for surveying and its capacity to instantly offer a position containing latitude, longitude, and height without the need to estimate angles and distances between intermediate locations. Using a global positioning system (GPS), every move throughout each traverse route been recorded.

Gpx, or GPS Exchange Format, is a file format that is extensively used for storing GPS data and is supported by a broad variety of GPS devices and software applications. Google Earth Pro was used to display the traverse area based on the imported data from the tracks and waypoints. To better educate the public about the survey area, it was decided to revise the existing waypoint placemarks and track routes.



Figure 4.2: shows the rubber plantation in the study area.

4.6 Geomorphology

Landscape and landforms are the focus of geomorphology. A look at how processes at Earth's surface shape our mental images of its topography was undertaken. Water, wind, and ice are all examples of processes that occur on Earth's surface. Both erosion and deposition have a role in shaping landscapes. Sediment is produced when rock is weathered and then moved and deposited elsewhere by natural transport forces including water, wind, and gravity. The local climate has a significant impact on the types of landforms that may emerge. When compared to the glacial and periglacial structure typical of sub-polar and polar regions, desert landforms like sand dunes and ergs stand out as a stark contrast.

Earth's surface processes now shape existing landforms. In most situations, the process alters the landscape in a very short period of time. In general, geomorphic processes are rather gradual. It is not uncommon for the ecosystem to undergo drastic alteration after a large-scale disaster, such a landslide or a flood. If this kind of fast environmental change happens in a populated location, those living there might be in danger.

4.6.1 Geomorphologic Classification

a) Landform

Simply put, every physical feature on Earth's surface may be classified as a landform. A landscape is the collection of various landforms. Topography refers to the pattern of landforms over a terrain. Mountains, hills, canyons, valleys, and plateaus are the most common types of topographical features on Earth.

Fluvial landforms are another typical landform. The peninsula, bays, and oceans are all examples of fluvial landforms. Volcanoes, ocean basins, and mid-ocean ridges are just a few of the underwater structures that are considered part of the fluvial landform.

There are two main categories of landforms considered in this research: ground landforms and hydrothermal landforms. Surface landforms in the study region include mountains and hills, while hydrothermal landforms include rivers. Figure 4.3 shows the mountain landforms found in the study area.



Figure 4.3: Mountains landform.



Figure 4.4: River with the view of hills and trees.

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b) Topography

Topography is detailed physical feature of the study area. For example, hills, valleys, and rivers. Topography study also include the representation of the physical features on maps (Figure 4.5). Topographic unit could be classified into five units based on the mean elevation. Majority of the study area covered by the hilly area with 60% estimated.

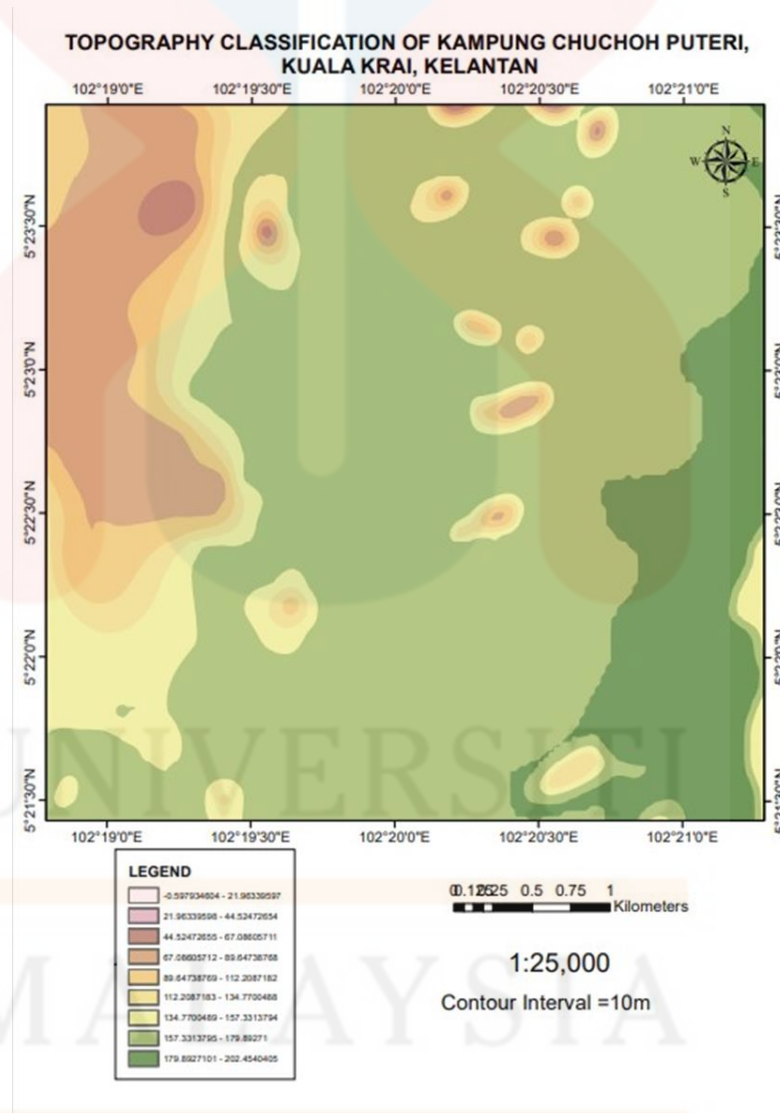


Figure 4.5: Topography map

4.6.2 Weathering

Through the process of weathering, rock minerals and rock masses are transformed when exposed to the elements. When rocks are weathered in-situ, they seldom, if ever, shift. All fresh, hard rocks are more easily eroded as a result of weathering.

Weathering has three different types. First, weather impact. Rocks undergo physical weathering, often called mechanical weathering, which breaks down their physical properties without changing their chemical makeup. Pressure, temperature, wind, and frost all cause degradation. Physical weathering causes rock degradation symptoms such surface fractures. Chemical activity speeds up item disintegration by breaking down more of it.

Substances that cause corrosion when they interact with the environment. The process of chemical weathering causes changes to occur in the composition of rocks. The reaction that takes place when water and exposed minerals come into contact with one another is known as the chemical weathering process. Rock minerals undergo a process that is referred to as chemical weathering, in which they progressively and persistently adapt to their immediate environment. In the rock, a secondary mineral will develop in the surrounding area of the main mineral.

Finally, the biological process of weathering. Biological weathering may be started or sped up by living things like plants and animals. Root wedging and the creation of organic acid are both effects of vegetation, but rock fissures and soil gaps are expanded as a result of animal burrowing.

In most instances, weathering was governed by regional climate. Dry and cold climates dominate physical deterioration. Due to favourable circumstances for plant and animal life, a humid and warm environment is dominated by chemical

and biological weathering. Physical and biological weathering are most common in the studied area (Figure 4.6 and Figure 4.7). Because the research region is mostly covered by trees and vegetation.



Figure 4.6: shows the physical weathering in the study area.



Figure 4.7: shows biological weathering occur in the study area.



Figure 4.8: shows the chemical weathering in the study area.

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4.6.3 Drainage pattern

Rivers, streams, and lakes in a catchment region create a drainage pattern. Topography shapes streams. Designing tributaries in a catchment region relies on geology and structures. Streams, rivers, and lakes in a given drainage basin all work together to form a unique pattern known as the drainage pattern of that basin. Erosion patterns produced by streams throughout time provide information about the underlying geology and rock types of a given region. The drainage pattern in a specific area is determined by the terrain, the gradient, and the predominant rocks in that area.

Because to erosion, the river has carved a path below ground. Because of the force of gravity, every river starts its voyage at a higher elevation (such as the top of a hill, mountain, or plateau) and flows down to lower land. A river may be little when it initially starts its course, but it often swells as it moves further and farther downriver. The potential patterns generated by the system of streams and rivers that compose a specific drainage basin are dependent on a number of factors, including the topography, the presence or lack of bedrock structure, and the kind of rock that predominates in the area. Trellis, dendritic, parallel, angular, distorted, and radial are only a few of the numerous possible drainage patterns. These examples represent the many categories. To consult the literature review, not only just use the topographical map to organize the data.

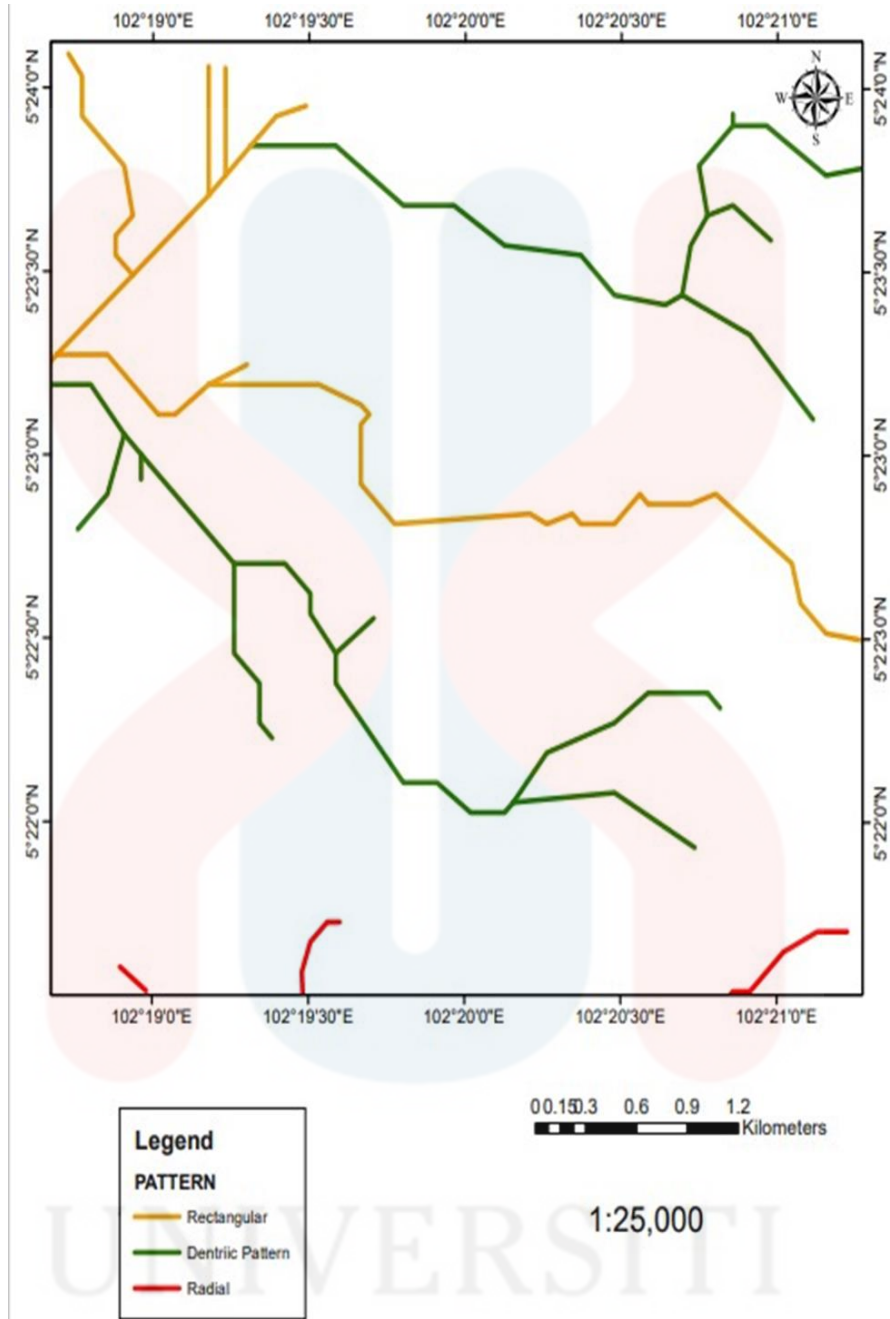


Figure 4.9: Drainage Map

4.7 Lithostratigraphy

The geological map depicts the lithostratigraphy of the area, outlining the distribution of lithological units, the geological structure, the strike-dip of beds, and the foliation. The study of rock layers, or strata, is the field of stratigraphy in geology. Lithostratigraphy is a sub-discipline of stratigraphy. Some of the most important subfields are geochronology, comparative geology, and petrology. The Law of Superposition governs the arrangement of sedimentary and igneous rocks into lithostratigraphic units. Lithostratigraphy is the study of the relationships between geological units, including their description, crystallization, and nomenclature.

For the purpose of explaining the stratum's existence, a few guiding principles are used. The hard rock that caused the cutting is younger than the rock formation it sliced through, and this may be deduced by comparing the age of the two. Information on the composition, texture, and structure of the rock, as well as other features of geological mapping, gleaned through fieldwork has allowed geologists to better understand events on Earth's history.

4.7.1 Stratigraphy Position

The law of superposition is met by a stratigraphic position. The law of superposition states that in every undisturbed and unflipped sequence of strata, the youngest rocks will always be on top. According to the idea of lateral continuity, a bed spreads out across a wide region and may be traced back to its origin. Stratigraphic units are classified according to their shared geological features. As the name implies, facies are a visual classification of strata. Lithic properties define stratigraphic units. Strata are age-crystallized into discrete layers.

The rocks in the region under investigation may be broken down into three distinct layers. When constructing the stratigraphic column, the most recent rock formation was put at the top. Alluvium soil is the youngest rock layer in the research area. Alluvium dirt has been around since the Cretaceous era. Layer 2 is composed of sandstone. The Paleozoic era saw the formation of this rock. The third stratum is made up of quartzite rock, which first appeared during the Cretaceous epoch. Gneiss constitutes the bottom layer. Like sandstone, this rock originated during the Paleozoic era.

Table 4.1: Stratigraphy column of the study area

ERA	PERIOD	FORMATION	LITHOLOGY
Mesozoic	Cretaceous	Gua Musang Formation	Coarse-grained Rock Sub-Unit: Sandstone, Quartzite
Mesozoic	Triassic	Gua Musang Formation	Gneiss

4.8 Unit Explanation

a) Sandstone Unit

Upper left of the research area is a sandstone rock unit. It covers 10% of the whole area. Sandstone, the newest rock in the area, is in the second layer of the geologic column. Sedimentary rocks like sandstone are formed of microscopic rock and biological bits. It may comprise silt- or clay-sized particles to fill spaces between sand grains and a cementing agent to bond the grains together.

All across the globe, in sedimentary basins, you may find sandstone, a common sedimentary rock. It is likely that rivers are responsible for transporting the sand deposits that will become sandstone to the basin, however waves and winds also play a role. It's possible that some of the sand grains are really organic material from the basin, such broken shells.

Crushed sandstone might be utilized in building if it is hard enough. Crushed quartz with a high enough silica concentration might be utilized in the production of glass. Aquifers for groundwater and oil and natural gas reservoirs are both possible uses for the layers of sandstone that lie under the Earth's surface.



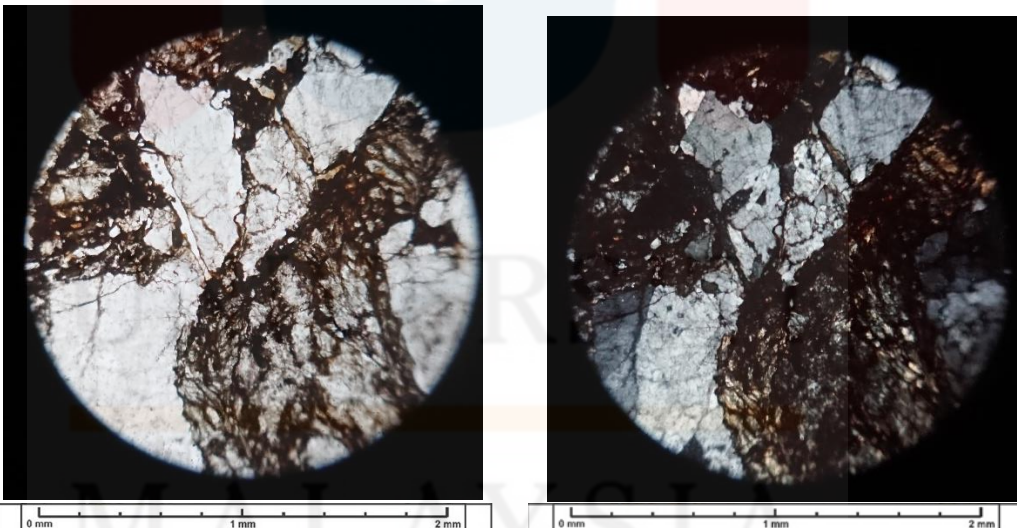
Figure 4.10: Sandstone hand specimen



Figure 4.11: Sandstone outcrop

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Table 4.2: Petrographic analysis of sandstone

Reference No. : 001	
Name of Rock : Sandstone	
Rock Type : Metamorphic Rock	
Description of Mineralogy	
Composition of Mineral	Description of Optical Mineralogy (Magnification 4X)
Quartz	Colourless under PPL, white to grey colour interference under XPL
Oxide Clay	Brownish under PPL, Darker brown colour interference under XPL
	

b) Quartzite unit

Almost completely made of quartz, quartzite is a non-foliated metamorphic rock. It is the result of the metamorphic transformation of a sandstone rich in quartz by high temperatures, pressures, and chemical reactions.

Once the sand has undergone metamorphism, the silica cement that holds the grains together also recrystallizes. This process produces a super-strong network of interlocking quartz grains.

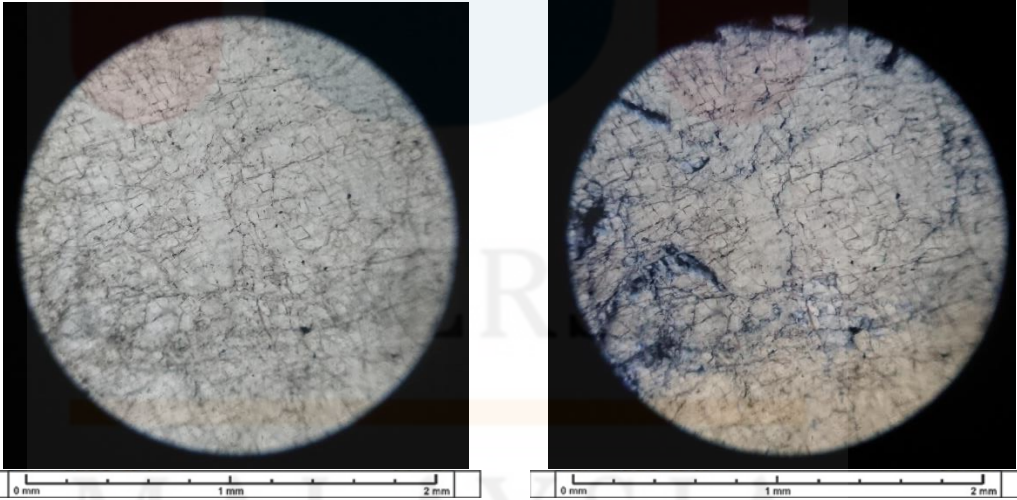


Figure 4.12: Quartzite hand specimen



Figure 4.13: Quartzite outcrop

Table 4.3: Petrographic analysis of quartzite

Reference No. : 002	
Name of Rock : Quartzite	
Rock Type : Metamorphic Rock	
Description of Mineralogy	
Composition of Mineral	Description of Optical Mineralogy (Magnification 4X)
Quartz	Colourless under PPL, white to grey colour interference under XPL
Graphite	Appear in black colour for both under XPL and PPL
	

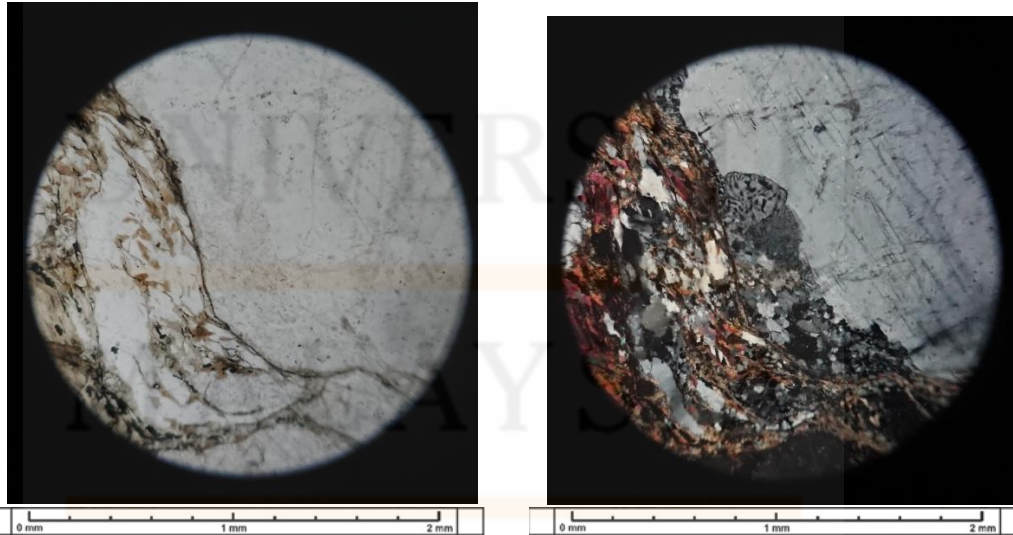
c) Gneiss Unit

The sericite mica plates that are so prevalent in phyllite make it a foliated metamorphic rock. There is a noticeable change in metamorphism level between slate and mica schist. The hue ranges from black, grey, and a bluish-green. At a greater degree of regional metamorphism than slate, phyllite occurs from pelitic deposits (shale and mudstone). The fine-grained tuffs and clayey tuffite from which it may have originated are additional possible sources. Thanks to its high mica and chlorite concentration, phyllites exhibit a remarkable fissility, with thin schistosity in their tiniest sheets. The fissility of a rock is its propensity to crack along parallel fracture surfaces. Mica flakes give the schistosity surfaces a dazzling silvery sheen. Microcrystalline quartz, fine-grained micas (sericite, muscovite), and chlorite are the main mineral components of phyllites. Within the sheets, which are mostly composed of fine-grained mica and chlorite, the quartz often occurs as elongated thin lenses or veins. Unlike slate, the phyllites have undergone more metamorphism and have totally recrystallized into fine-grained mica and chlorite, eliminating the clay minerals.



Figure 4.14: Gneiss hand specimen

Table 4.4: Petrographic analysis of gneiss

Reference No. : 003	
Name of Rock : Gneiss	
Rock Type : Metamorphic Rock	
Description of Mineralogy	
Composition of Mineral	Description of Optical Mineralogy (Magnification 4X)
Feldspar	Colourless under PPL, White colour interference under XPL
Quartz	Colourless under PPL, white to grey colour interference under XPL
Biotite	Colourless under PPL, Light brown to white colour interference under XPL
	

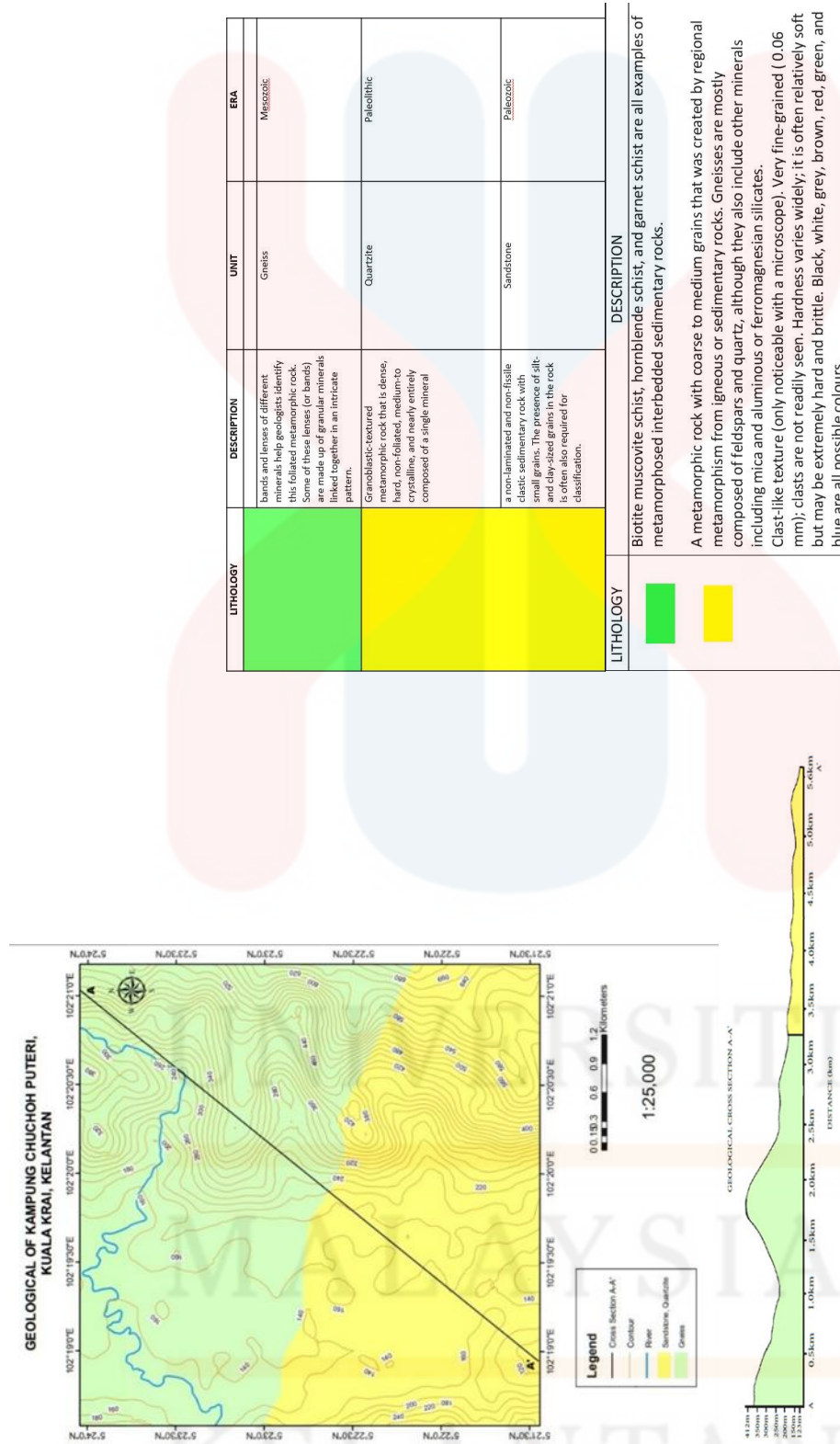


Figure 4.15: Geological map of the study area

4.9 Structural geology

Geologists that specialise in structural geology analyse the relationships between geological processes and the spatial organisation, external appearance, and internal make-up of rock units across several dimensions. The primary purpose of structural geology is to determine the mechanism or process that created the strain and geometries found in present-day rocks, therefore revealing historical information about rock deformation. Geological occurrences may be related to the dynamics of stress fields. Geological occurrences may be related to the dynamics of stress fields.

Veins, joints, fractures, folds, and incursion are all examples of geological structures that may be seen in the research region. The investigation of the structure itself may be used to glean previously hidden details. For instance, analyses such as joint analysis and fold analysis were performed to learn more about joint and fold structure, respectively.

4.9.1 Veins

Veins are the crystalline byproduct of crystallization from hydrothermal fluids. Their chemical composition may vary significantly depending on the fluid used to create them. Sizes may range from millimetres to kilometres. Because of cracks in the host rock, hydrothermal fluids may seep in and form these deposits. Sometimes the rock breaks through again, letting in a fresh supply of hot, mineral-rich water. This process is known as “crack-sealing” since the vein is responsible for sealing the fracture in the rock. Over time, when pressures on the

rock shift the veins' orientation, you'll see more instances of veins crossing and lying atop one another. Veins may be seen in both the first outcrop and the second outcrop.

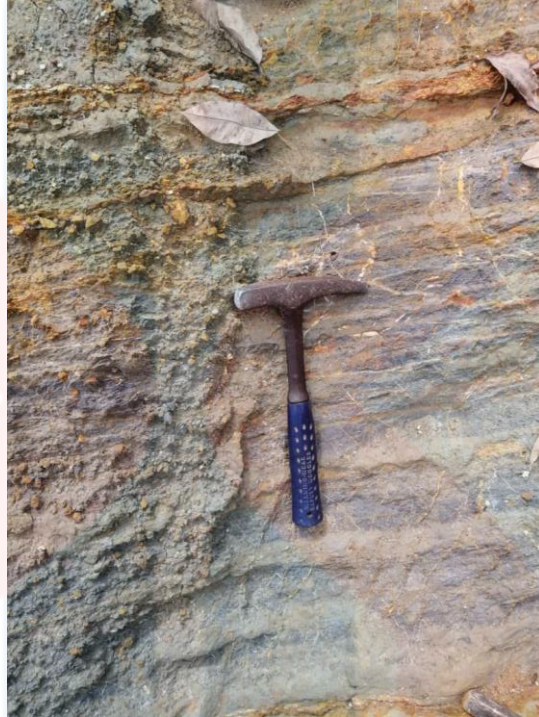


Figure 4.16: shows the minor veins in the study area.

4.9.2 Faults

A fault is a break or zone of breaks between two geologically distinct areas. Because of the defects, the blocks might slide in respect to one another. This shifting might occur abruptly, as during an earthquake, or gradually, like during a creep. Faults may range in size from just a few millimetres to hundreds of kilometres. Most faults cause periodic displacements that occur over long periods of time in the geologic past. At the time of an earthquake, rock on one side of a fault slides abruptly with respect to rock on the opposite side of the fault, causing the quake. It's possible for the fault's surface to be horizontal, vertical, or at any angle in between. Normal faults, strike slip faults, and reverse faults are all different

kinds of faults.

Dissociation, bifurcation, convergence, and migration of faults across considerable distances may sometimes result in the development of intricate fracture systems. Relative defect mobility may be represented by the relationship between a foot wall and a hanging wall (from one side to the other). When a fault is located underneath a block, the fault plane of that block will slope downward, creating what is known as a foot wall. A hanging wall is a vertical slab of rock that protrudes from the top of a fault plane that dips downhill.



Figure 4.17: shows the minor fault found in the study area.

4.9.3 Folds

During lengthy periods of pressure, fragile rocks may fold instead of cracking under the weight, and this is exactly what happened to the rocks that make

up the Grand Canyon. It is organized as a series of waves that build upon one another. Anticline, syncline, monocline, symmetrical, asymmetrical, inclines, anti-form, chevron, slump, and dome are all examples of folding. Different types of folds, including anticline, syncline, symmetrical, and asymmetrical, may be discovered in the studied region.

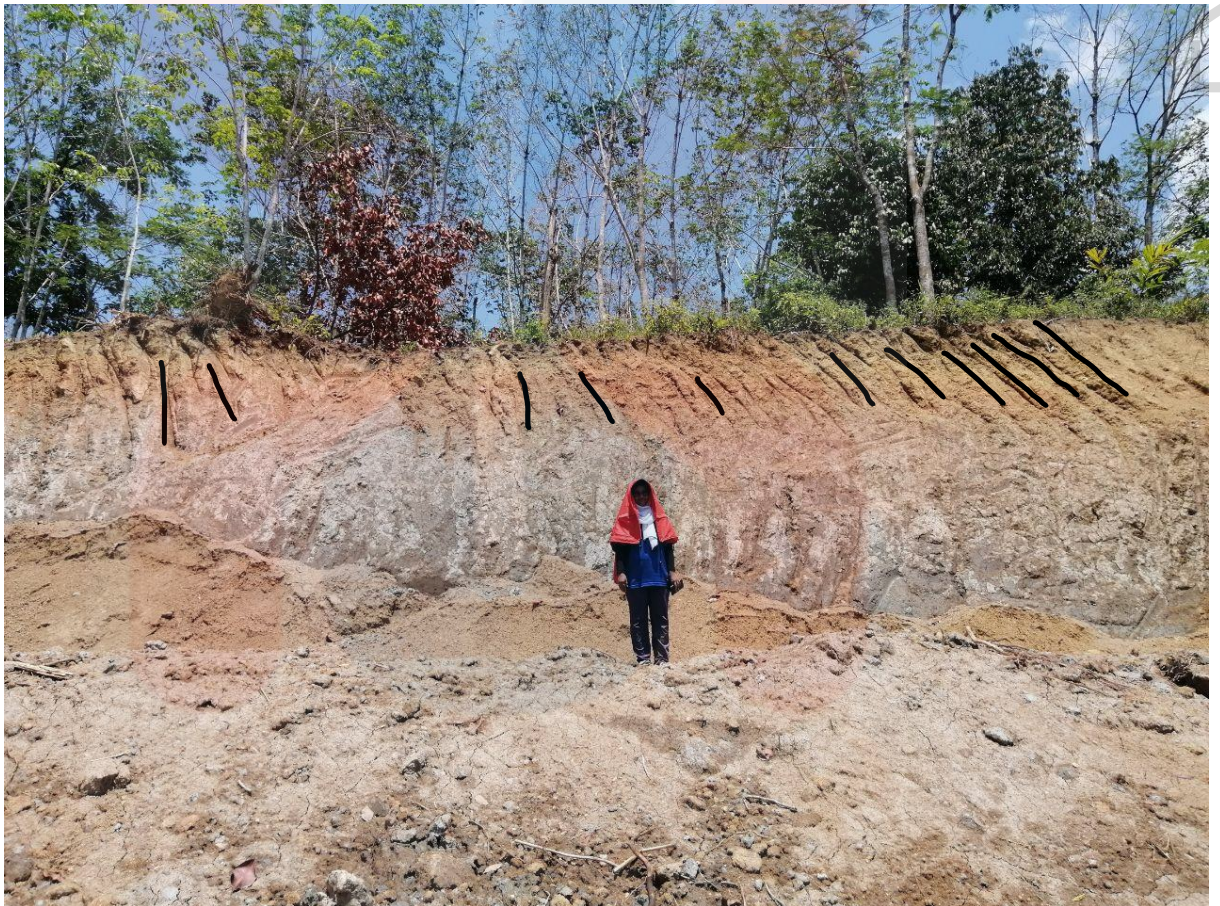
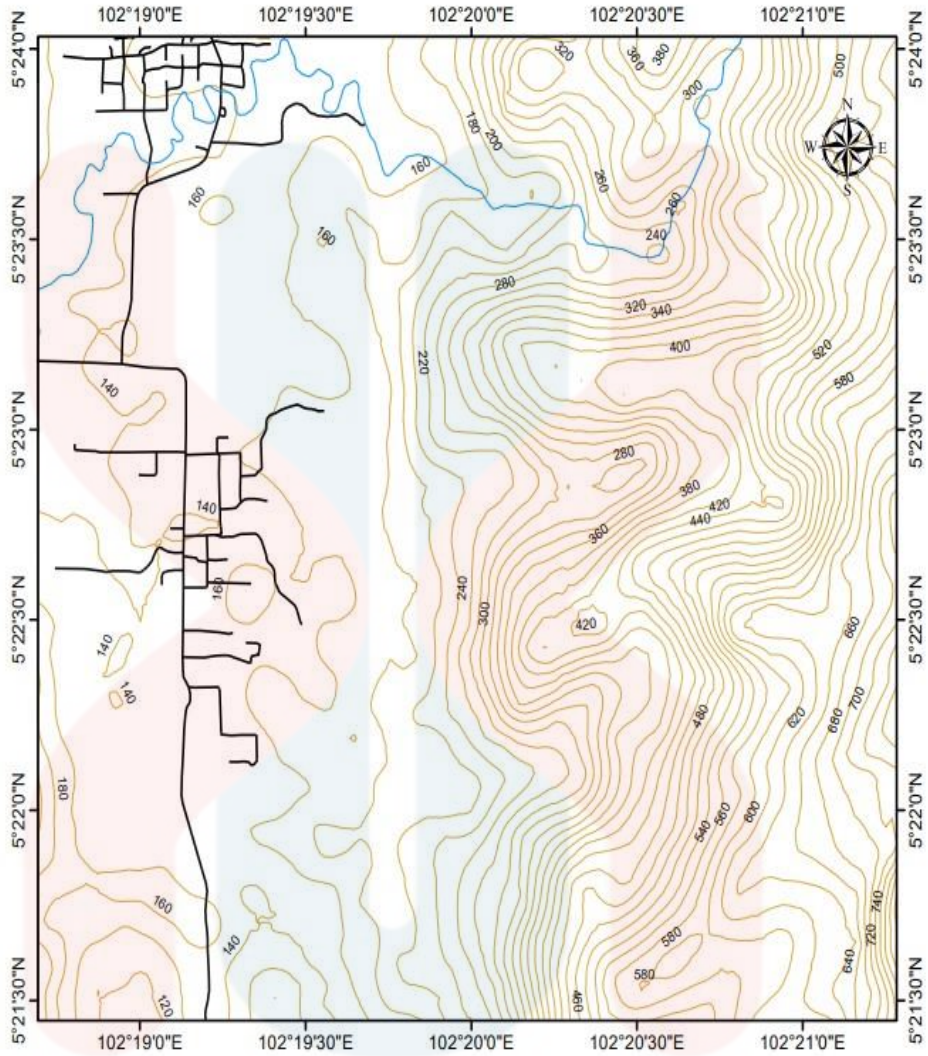


Figure 4.18: shows the folding in the study area.

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4.10 Mechanism of structure

a) Lineament Analysis

Lineament is a straight or nearly straight line of curvature that indicates geological structure. Ridges, fault-aligned valleys, fault- or fold-aligned hills, irregularity, and stratigraphic layer borders may be influential. Lineaments are connected with conspicuous structures. Lineaments appear on pictures and maps when a relief break or surface alignments match patterns in the underlying geology. Reflectance differences related with changes in plants, soils, and relief break are represented in the brain as a separate line of demarcation that humans can perceive. Long lineaments may indicate faults and other structures' persistence. Figure 4.19 shows the lineament in the study area.

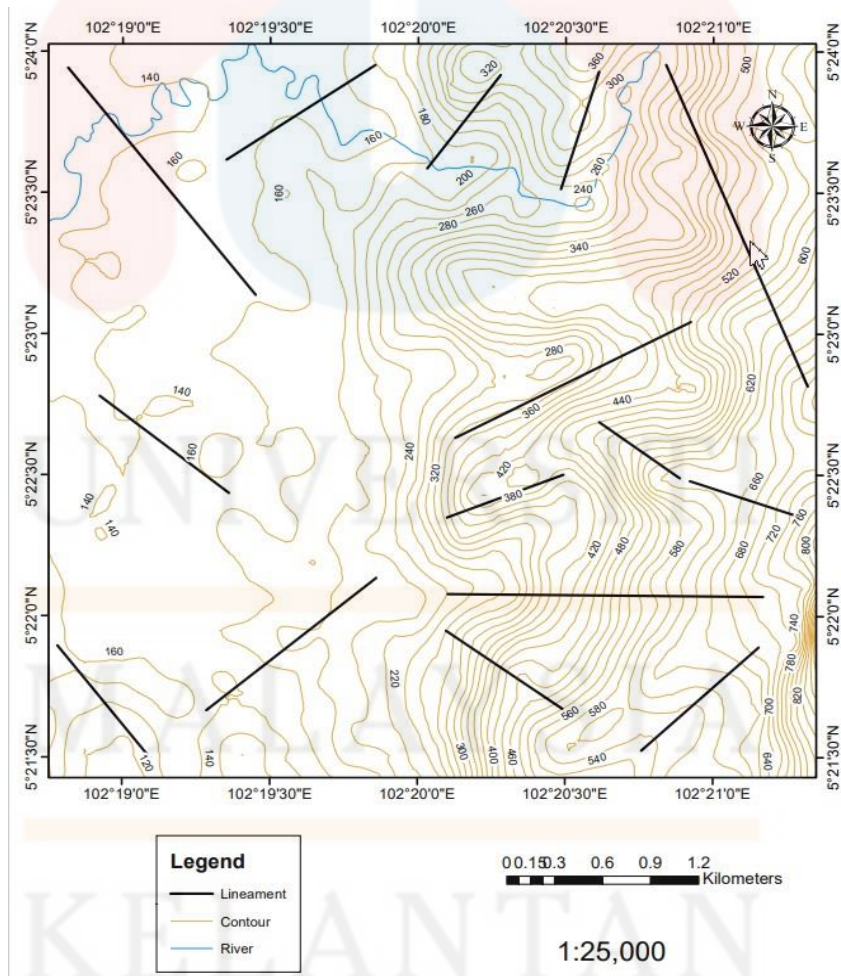


Figure 4.19: Lineament map

4.11 Historical Geology

The rocks of Kelantan date from the late Paleozoic through the Quaternary. North Kelantan is underlain by unconsolidated and consolidated boulders, which are part of a Cenozoic Quaternary sedimentary deposit. Faulting, folding, and other topographic characteristics developed as a result of the movement of rock layers over the Paleozoic and Mesozoic epochs. Gneiss, sandstone, and quartzite are all present in the area under study. It consists of Cretaceous sandstone and quartzite, and Triassic gneiss. Lineament and bedding are the observed structural geology during the study. In general, Kuala Krai is the study area that consist of the rocks in Late Permian- Middle Triassic age. This study shows that the granite Stong Complex can be found in the western portion of Kuala Krai, and the Gua Musang and Taku Schist rock formations can be found in the eastern portion of the island. The majority of the Taku Schist is made up of metamorphosed argillaceous and arenaceous rocks, with mafic components either interbedded within them or intruding into them. Despite the fact that most of the Taku Schist has undergone Barrovian Metamorphism, the existence of minor metamorphic minerals allows for the inference of even higher degrees of metamorphism. High-temperature metamorphism with varying degrees of shear stress, as described by Hutchinson (1973), produced the Taku Schist.

CHAPTER 5

GEOPHYSICAL INVESTIGATION

5.1 Introduction

In this section, we will talk about how the electrical resistivity technique is used in geophysical studies (ERI). From the ground's surface, where the horizontal line will be interpreted in more detail, we may calculate the potential of groundwater and its depth. The interpretation of the pseudosection we get after processing the data allows us to determine the groundwater's physical qualities. The three locations in red, yellow and blue shows in the Figure 5.2 of the inquiry inside the study area are shown by the horizontal lines. Each line survey was compared to the analysed findings from ABEM Terrameter LS 1. The region around the survey line has very different geology and lithology, accounting for these variations.



Figure 5.1: Equipment for electrical resistivity investigation.

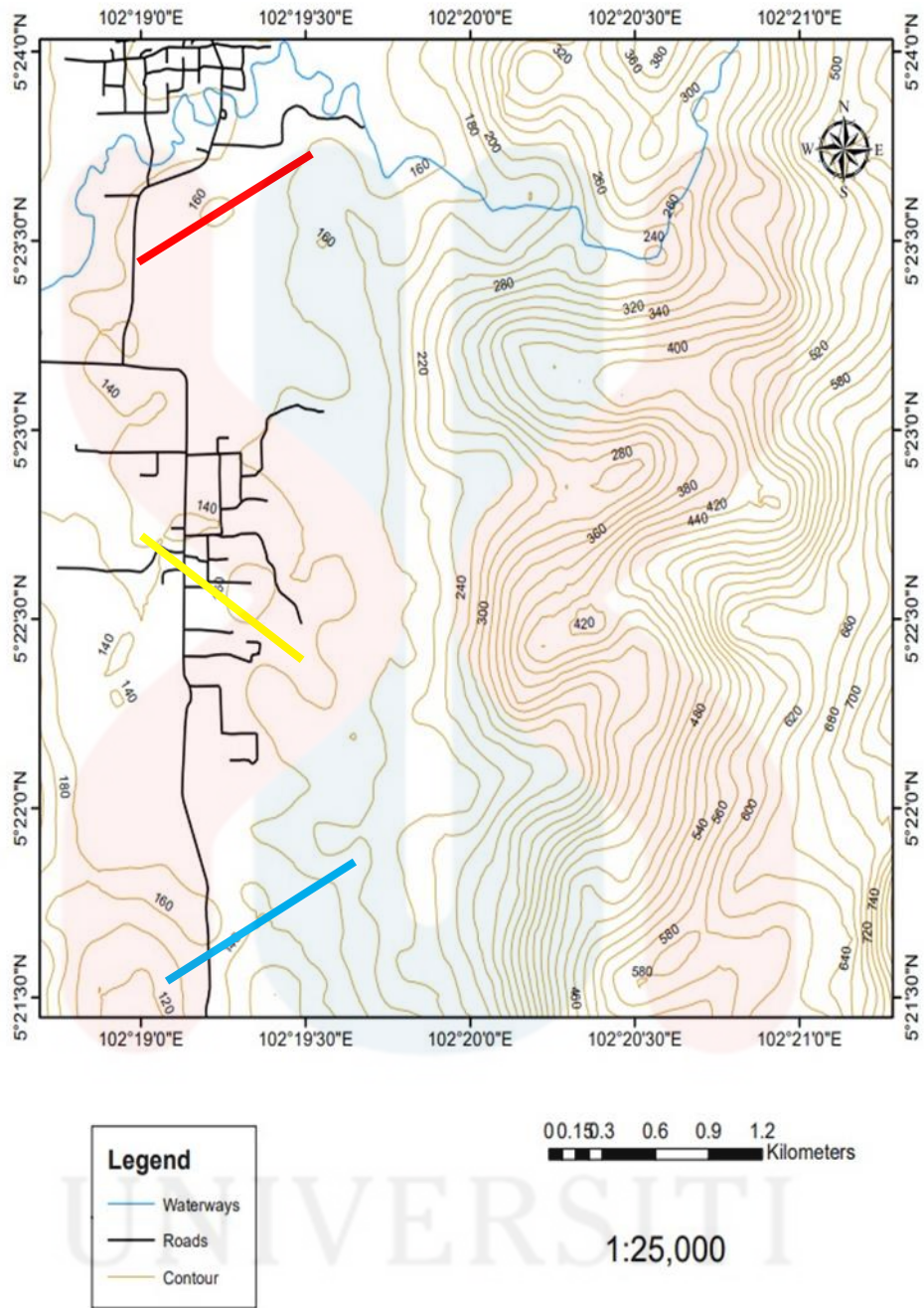


Figure 5.2: Location of the survey line

We began our investigation of the region of interest with a preliminary study, which consisted of collecting all of the data that are associated with the geophysical survey. We now go on to the field research phase, during which we gathered all of the pertinent information, such as the lithology of the particular location that was determined. This information serves as a reference for

determining whether or not additional exploration of the region would be beneficial.

5.2 Locations of Survey Line

During the field survey, we surveyed the terrain in four different directions to look for possible landslide sites. Based on the area's lithology and structural characteristics, we've chosen where to place our survey lines. Another factor considered when pinpointing possible landslide sites is the local silt or lithology.

i. Survey Line 1 and 2

After a thorough study, line survey 1 and 2 was chosen at rubber plantation area with coordinates of $102^{\circ}20'.283''$ E $5^{\circ}21'33''$ N and pole dipole configuration is used during the investigation. The investigation site is located in the rubber plantation and near to construction. Line survey one were set up in the rubber plantation towards North. As shown in the Figure 5.2, we can see that the centre electrode of survey line 1 is in the rubber plantation. For the electrode 1(A) also set up in the rubber plantation while electrode 41(B) is heading towards bushes in the area. For the line survey 2, electrode 41(B) is still along the rubber plantation that easily getting the reading on ABEM Terrameter LS without any difficulty. At field, we can make rough assumption from the pseudosection that is shown on ABEM Terrameter LS 1 after the reading has complete. From the raw data that we can see from the pseudosection, we can assume that the site might have the probability of landslide potential.

Table 5.1: Coordinate of electrode 1, Centre and 41(B) at site 1

Electrode	Latitude	Longitude	Elevation (m)
1(A)	5°20'31"N	102°20'.270" E	300
Centre	5°20'33"N	102°20'.283" E	170
41 (B)	5°20'34"N	102°20'.290" E	150
2 (A)	5°21'33.5"N	102°21'.270" E	140
Centre	5°21'34"N	102°21'.260" E	150
41(B)	5°21'34.7"N	102°21'.253" E	160



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Figure 5.3: Shows the configuration setup for survey line 1 and 2



Figure 5.4: Shows surrounding of the location of survey line 1 and 2

As for survey line 1 and 2, Pole-dipole arrangement has been used to find the location of the potential landslide. Through the observation for this location shows that the landslide would not be easily occur as the land in this location are not much higher than the other location. Plus, for survey line 1 was set up in the rubber plantation that shown as loamy soil type. Clayey soil is the type of soil that prone to having landslide.

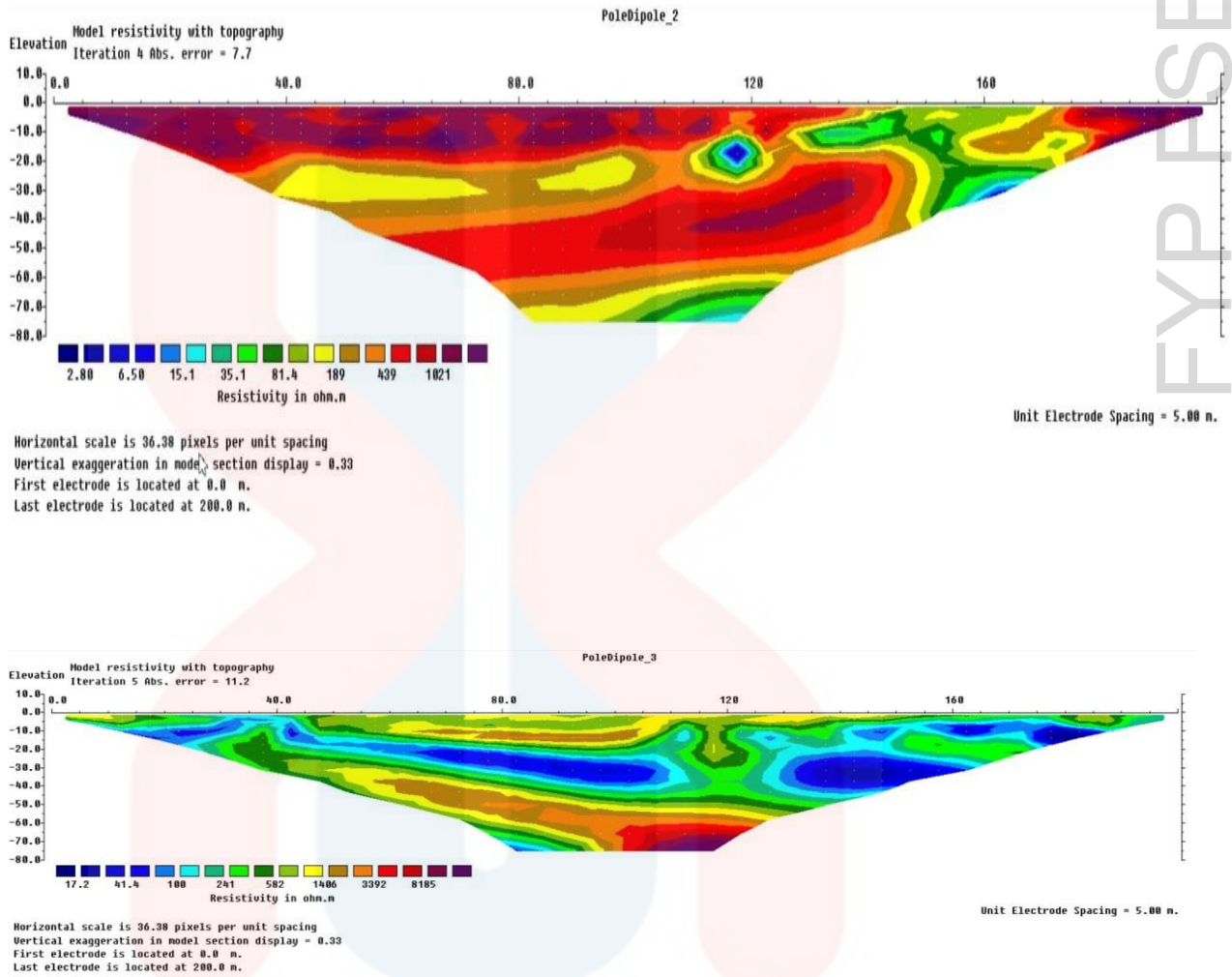


Figure 5.5: Pseudosection of Line 1 and 2 Pole-Dipole.

ii. Survey Line 3

The next line survey 3 is near the villagers' house area which also the centre of the electrode is on top land of the small river. Before the electrode configuration of the survey on 41(B) begun, the area need has to be cleared of as it is covered with bushes and small trees. There is also one abandoned small house on the right side along the 41(B) electrode set up. Electrode at the side B have to been adjusting due to the error reading appear on the ABEM Terrameter LS. For 1(A) electrode set up was along in front of the villagers' houses that shown in the Figure 5.4 with a small

road. Other than that, the survey site was filled with fruit trees which belongs to the local villagers. Table 5.2 shows the coordinates of the electrode configuration at A side, centre and B side. Schlumberger arrangement is used for survey line 3 during the investigation.

Table 5.2: Coordinates of electrode 1, Centre and 41 at site 2

Electrode	Latitude	Longitude	Elevation (m)
1(A)	5°22'20"N	102°20'.250" E	170
Centre	5°22'33"N	102°19'.265" E	160
41 (B)	5°22'37"N	102°20'.271" E	150



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Figure 5.6: Shows the configuration setup for survey line 3

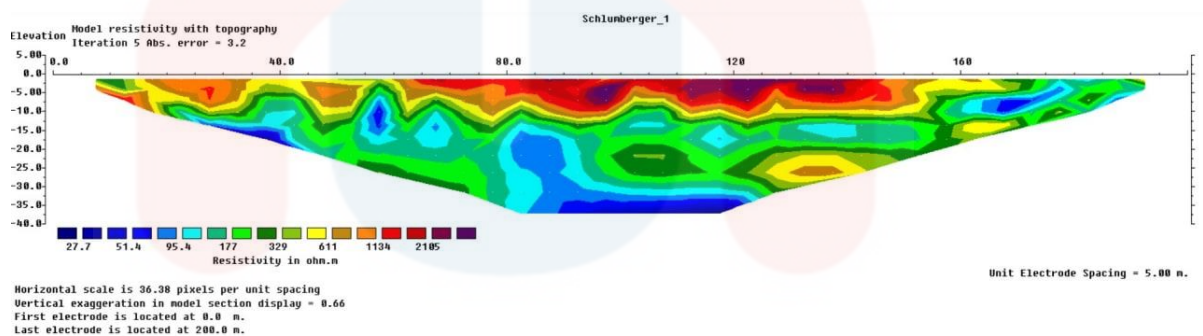


Figure 5.7: Pseudosection of Line 3 Schlumberger

iii. Survey Line 4 and 5

In this survey line 4 area was covered in the plantation. Configuration electrode of the centre was placed on land with some bushes. For the configuration electrode side A is along the rubber plantation while on the B side is through bushes in the plantation until plain land. As shown in the Figure 5.7 on the left side which was the view in front of the A side. Also in the Figure 5.7 shows road that been used either for the villagers or lorry went through the rubber plantation or construction

nearby. Pole-dipole configuration is used in conducting this survey. From the raw data that we can see from the pseudosection, we can assume that the site has little probability potential of landslide occur.



Figure 5.8: Shows the configuration setup of line survey 4 and 5



Figure 5.9: Shows surrounding of the location in survey line 4 and 5

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Table 5.3: Coordinates of electrode 1, Centre and 41 at site 3

Electrode	Latitude	Longitude	Elevation (m)
1(A)	5°21'33"N	102°20'.283" E	140
Centre	5°21'33"N	102°20'.283" E	150
41 (B)	5°21'33"N	102°20'.283" E	160
2 (A)	5°21'33"N	102°20'.283" E	150
Centre	5°21'33"N	102°20'.283" E	150
41(B)	5°21'33"N	102°20'.283" E	160

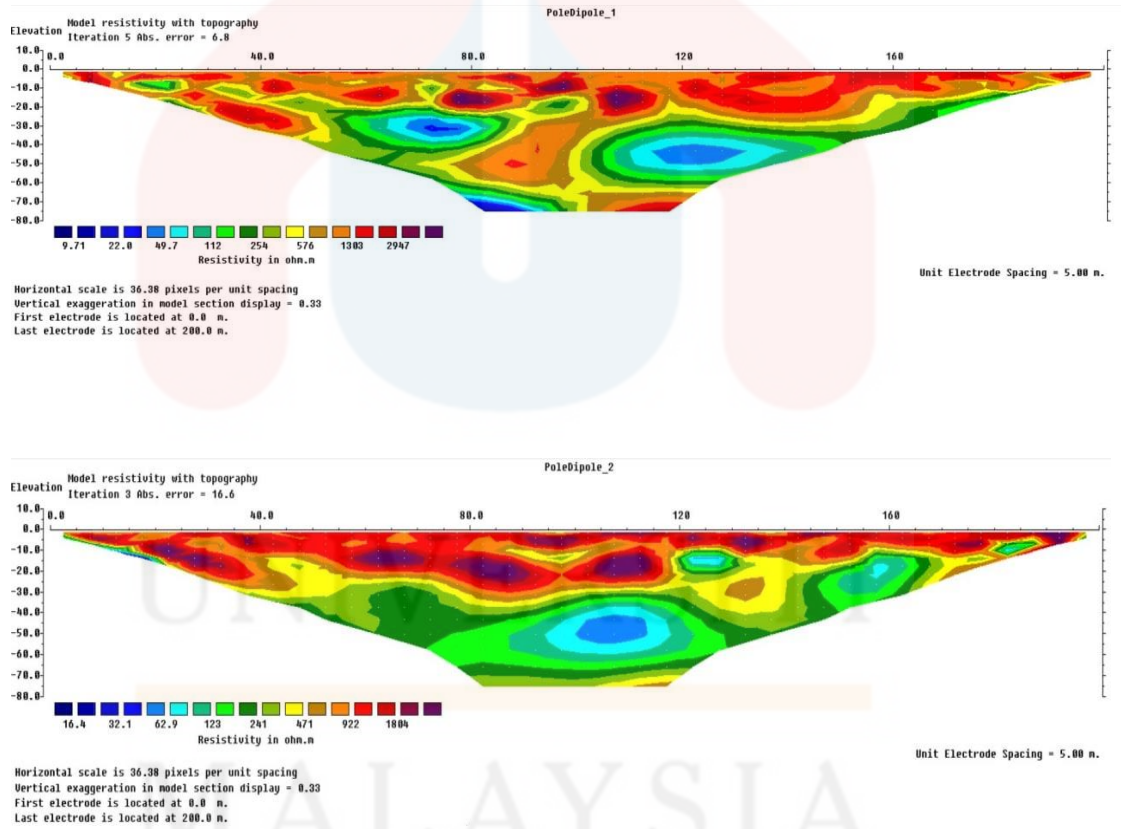


Figure 5.10: Pseudosection of line survey 4 and 5

iv. Survey Line 6

Configuration setup for the last line at $102^{\circ}19'.293''$ E $5^{\circ}23'33''$ N with the elevation 160 meters were done in a short time as it locates at an open area. It is easily accessible as it has paved road that any kind of vehicles can pass through. Site survey 4 is along the road of mosque and school. The opposite of the road also has stall. View in front of the configuration centre electrode was shown in the Figure 5.10 which was the villagers' plantation. For the configuration of A side was along in front of the school. Schlumberger array configuration was used for this investigation. Location of electrode for first, centre and last electrode can be found in Table 5.4. In refer Figure 5.10, survey line 6 is situated at an open space. For this survey area has the possibility of the potential landslide might be happened in the future.



Figure 5.11: Shows the configuration setup for line survey 6

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Figure 5.12: Surrounding view area of the survey line 6

Table 5.4: Coordinates of electrode 1, Centre and 41 at site 3

Electrode	Latitude	Longitude	Elevation (m)
1(A)	5°23'30"N	102°19'.253" E	150
Centre	5°23'33"N	102°19'.263" E	160
41 (B)	5°23'43"N	102°19'.273" E	140

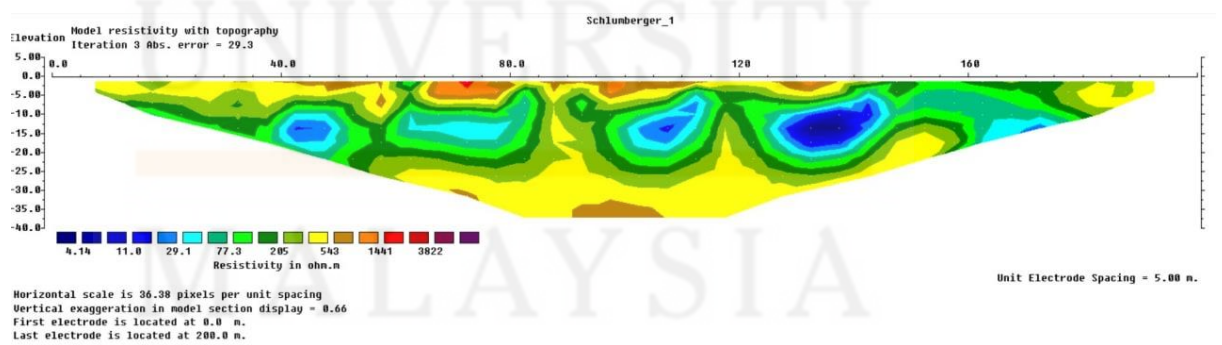


Figure 5.13: Pseudosection of Line 6 Schlumberger

5.3 Discussion

Relationship between resistivity and conductivity is reciprocal whilst doing the geophysical survey. Pole-dipole array configuration was used in the survey line 1, 2, 4 and 5 while schlumberger array configuration for the survey line 3 and 6. From the pseudosection processed from Res2DINV software, survey line 6 is identified mostly has the probability potential of landslide happened. Based on the pseudosection for survey line 1 and 2, that study area might not have potential of the landslide because of the type of soil in that area. For these two survey lines show that the rubber plantation has no any fault or slope as one of the factor in identify the potential landslide risk area. Following the gathering of information on the lithology, geomorphology, and geology of the region, survey lines were selected. All of the survey lines, as expected from the lineament of the study region, go in the direction of the north. In order to identify the most probable location of the landslide in the study region, a geophysical survey is carried out. The analysed and interpreted results offer the intended outcome, which is provided by the data and information acquired from the survey. End results of this study that can be concluded is that most probably landslide risk can be happened is at the survey line 6 that show us soil near the school area are little collapsed. Probability of the landslide might happened in the future is quite high.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The geomorphology of the examined area consists largely of hills and valleys. Because of its convenience, most people live in the metropolitan centre. Some residents of the study area work in the rubber and palm plantations that occupy over 65% of the land. Throughout our travels, metamorphic rocks have predominated as the dominant geological feature. The primary highway that joins Kuala Krai and Jeli serves as a shortcut to Gua Musang.

Our study area is comprised of sandstone, quartzite, and gneiss units, therefore it has a diverse lithology. The oldest kind of rock is quartzite, while the youngest is gneiss. There is no separation between the various rock groups or between the geology of the area. It's feasible that we might need to make a new geological map. Landslide hotspots are identified via geophysical studies. All locations along the surveys lines were determined to be in potential landslide zones, as mentioned in chapter 4. As mentioned in the objectives in determine the potential landslide risk area is in the survey line 6. This is because of some of the soil near the school area with elevation 160m has collapsed. Overall of the location area of the survey line been conducted, the study area might having some collapse of the soil but may having landslide risk that not could harm the villagers' life or

buildings.

6.2 Suggestion

If any other scientists are interested in employing Electrical Resistivity Imaging (ERI) to investigate landslides in the region, they may use this paper as a reference. Before continuing with any more landslide studies, it could be a good idea to carry out additional research in other regions that have geology that is comparable to the possible landslide zone. At a minimum, the following three physical criteria are required in order to conduct a landslide risk assessment: historical records, slope steepness, and bedrock. In order to take into consideration the fact that ground water is often a factor that contributes to landslides, it is also important to include a hydrologic component in the analysis. The people and towns in the vicinity might benefit from the study's investigators looking at other areas as well. It's possible that others might get benefits and take away something meaningful from the study's results.

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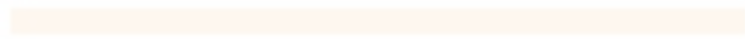
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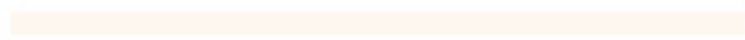
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