GENERAL GEOLOGY AND GROUNDWATER PROSPECTING AT KAMPUNG RAHMAT, KUALA KRAI, KELANTAN

by

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

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DECLARATION

I declare that this thesis entitled General Geology and Groundwater Prospecting at Kampung Rahmat, Kuala Krai is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : _____

Name : NOR HATIKA BINTI ABD HALIM

Date : 8th JANUARY 2017

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GENERAL GEOLOGY AND GROUNDWATER PROSPECTING AT KAMPUNG RAHMAT, KUALA KRAI

ABSTRACT

Groundwater is used for domestic purposes by the people in the northern part of Kelantan. Normally, they get the water supply from the shallow aquifer through traditionally hand-dug wells as well as from the surrounding rivers. Therefore, this research is important to determine the existence of groundwater especially in the subsurface using the electrical resistivity method. This research was conducted in Kampung Rahmat, Kuala Krai, Kelantan with the title of general geology and the groundwater prospecting at Kg. Rahmat. The study area covers an area of 25 km². The objectives of this study are to produce the geological map of Kg. Rahmat, to identify the aquifer using resistivity method and to determine the physical characteristics of groundwater. Field observation and mapping reveals three types of lithologies present in the study area. It includes granite, shale and andesite porphyry. The groundwater potential at the study area was done by using electrical resistivity method (ERI). The potential aquifer area at the study area was determined. Result from the research is firstly, the geological map is updated to the latest information on the scale of 1:25000. The groundwater potential area and the physical characteristics of groundwater were determined. The further investigation like drilling purpose should be continues as it benefits the community.

Keywords : groundwater, electrical resistivity, potential area, physical characteristics

GEOLOGI DAN PROSPEK AIR BAWAH TANAH DI KAMPUNG RAHMAT, KUALA KRAI, KELANTAN

ABSTRAK

Air bawah tanah digunakan untuk tujuan domestik oleh orang di bahagian utara Kelantan. Kebiasanya, mereka mendapatkan bekalan air dari akuifer cetek melalui telaga tradisional yang digali dan juga dari sungai-sungai di sekitarnya. Oleh itu, kajian ini adalah penting untuk menentukan kewujudan air bawah tanah terutama di bawah permukaan menggunakan kaedah kerintangan elektrik. Kajian ini dijalankan di Kampung Rahmat, Kuala Krai, Kelantan dengan tajuk geologi dan mencari air gali bawah tanah di Kg. Rahmat. Kawasan kajian meliputi kawasan seluas 25 km². Objektif kajian ini adalah untuk menghasilkan peta geologi Kg. Rahmat, untuk mengenal pasti akuifer menggunakan kaedah kerintangan dan untuk mengetahui ciri-ciri fizikal air bawah tanah. Pemerhatian di lapangan dan pemetaan mendedahkan tiga jenis batuan hadir di kawasan kajian. Ia termasuk granit, syal dan andesit. Potensi air bawah tanah di kawasan kajian telah dilakukan dengan menggunakan kaedah kerintangan elektrik (ERI). Kawasan akuifer yang berpotensi di kawasan kajian ditentukan. Keputusan dari kajian ini adalah pertama, peta geologi dikemaskini untuk maklumat terkini dengan skala 1: 25,000. Kawasan potensi air bawah tanah dan ciri-ciri fizikal air bawah tanah ditentukan. Penyiasatan lanjut seperti tujuan penggerudian harus diteruskan kerana ia memberi manfaat kepada masyarakat.

Kata kunci : Air bawah tanah, kerintangan elektrik, kawasan potensi, ciri-ciri fizikal air bawah tanah

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LIST OF SYMBOLS

Km	kilometres
M	metres
Kg	kampung
Ωm	Ohm meter
>	Greater than
<	Less than
°C	Temperature (degree Celsius)

LIST OF ABBREVIATIONS

NO		
1	GIS	Geographic Information System
2	GPS	Global Positioning System
3	ER	Electrical Resistivity
4	TDS	Total Dissolve Solid
5	Min.	Minimum
6	Max.	Maximum

CHAPTER 1

INTRODUCTION

1.1 General Background

The study area was located at Kampung Rahmat, Kuala Krai. Kuala Krai was located in the center of the State of the Kelantan in the north east of Malaysia. The aim for this study was to produce geological map at the study area and to determine the groundwater potential using resistivity method in Kampung Rahmat, Kuala Krai. The general geology included determining and analyzing the rock structures and structural geology, stratigraphy, petrography analysis and geomorphology of the study area.

Groundwater is used for domestic purpose by the people in the northern part of Kelantan. They normally get their water supply from the shallow aquifer through traditionally hand-dug wells as well as from the surrounding rivers. In the late of twenties, a conventional groundwater supply distribution system came into existence with the establishment of Kota Bharu Waterworks Department which takes groundwater from deeper aquifers (Rahim et. al, 1997).

Less than 10% of the present water use in Malaysia is developed from the groundwater resources; the use of groundwater for domestic purposes is mainly confined to rural areas, where there is no piped water supply (Abdullah, 2010). In Kelantan, groundwater supplies more than 70% of the public water supply of the state (Abdullah, 2010).

For this research, basically use resistivity method (ER) because it provides detailed information about the subsurface. Besides that, by using resistivity method

the cost is lower than other geophysical methods. The specific study area was chosen to further exploit of the groundwater prospecting on Kampung Rahmat, Kuala Krai, Kelantan. This research is important to determine the existence of groundwater especially in the subsurface to the community.

1.2 Problem statements and justifications

At the study area, not many studies have been done. Hence, the study area contains no geological data that was not been updated. Besides that, there was no research has been done to study about the groundwater prospecting using Electrical resistivity method on the study area. The exploration of groundwater was much easier with the help of geophysical method that is resistivity method. Thus, this study had obtained detailed information on the groundwater potential at the area.

1.3 Research objectives

The main objective of this research are :

a) To produce a geological map in the study area at scale of 1:25000.

b) To identify the aquifer using resistivity method.

c) To determine the physical characteristics of the groundwater.

1.4 Study area

Kelantan is located on the northeastern corner of Peninsular Malaysia and shares a common border with Thailand in the north. The study area was located in

Kampung Rahmat in Kuala Krai district which is in the northern part of Kelantan. Kuala Krai territory contains two major rivers, that is Lebir and Galas, that form the Kelantan River. Before the 20th century, the entire area was tropical rain forest. The area is a border between Gua Musang and Dabong. The study area is a rural region with undeveloped infrastructure and services. That area also had been affected by flood on 2014.

The study area was surrounded by hill and alluvium area. This town is located about 155 km from Kota Bharu, the capital of Kelantan. This research was done within the study area that comprises of 5 x 5 km with a total of 25km^2. The coordinate ranges of the study area for latitude from N 05° 29’ 10’’ to N 05° 31’ 40’’ and for longitude from E 102° 12’ 20’’ to E 102° 14’ 40’’. The location of base map is shown in Figure 1.1.

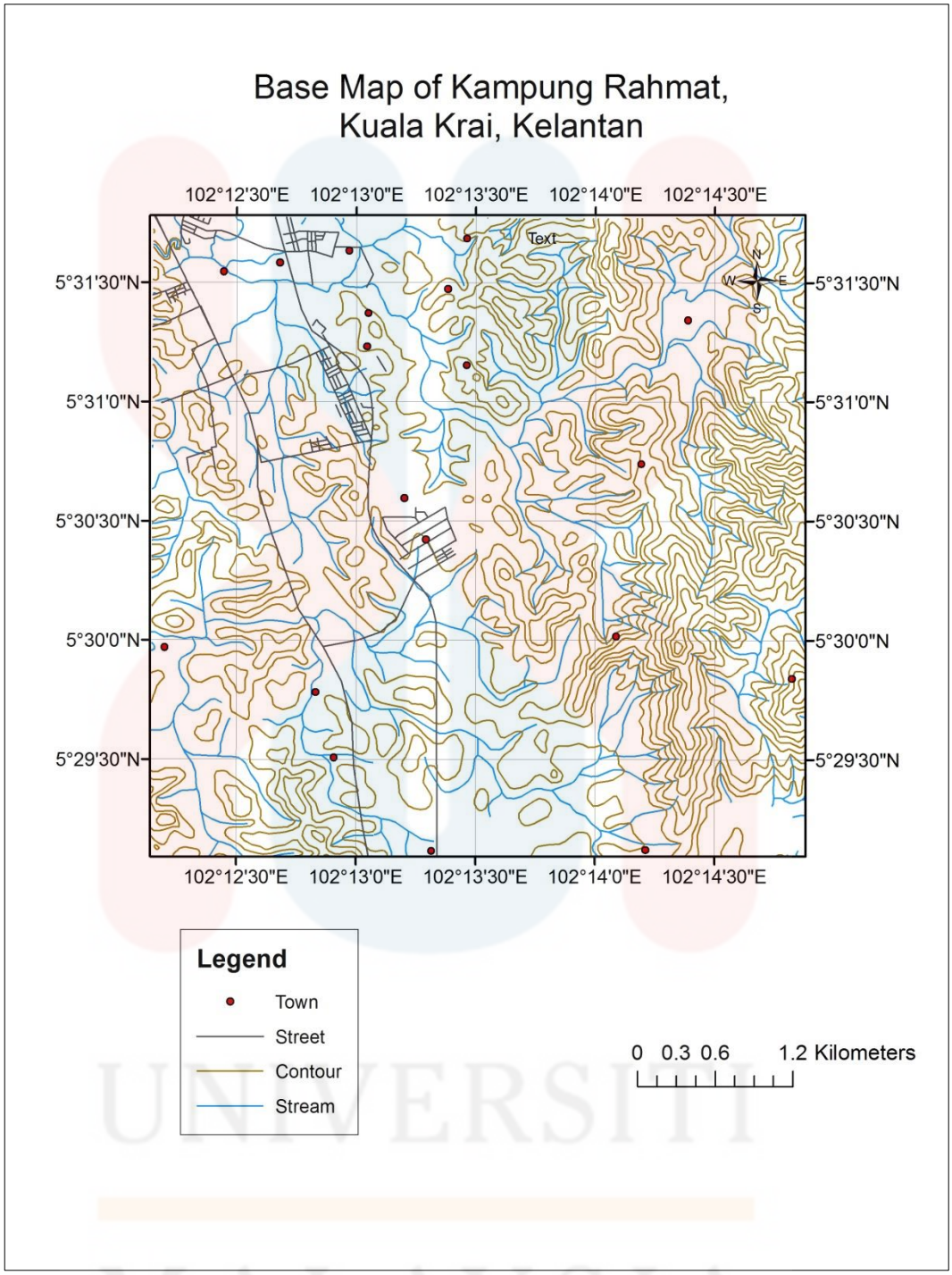


Figure 1.1 shows the base map of the study area

1.5 Geography

1.5.1 People distribution

People distribution usually refers to the population of people in an area. There are few factors that affect people distribution that are relief, resources and climate. Kelantan have 13 sub-district which is Kubang Kerian, Pengkalan Chepa, Pasir Mas, Gua Musang, Jeli, Kuala Krai, Rantau Panjang, Ketereh, Bachok, Tumpat, Pasir Puteh and Machang. Kuala Krai is the second largest colony in Kelantan after Gua Musang. The population of people in Kuala Krai is about 63, 575 people in 2010. Table 1.1 shows the number of population that comes from different races.

Table 1.1: Total population at Kuala Krai, Kelantan

(Source: Department of Statistics, Malaysia, 2010)

Jajahan/ Local Authority Area	Total	Malaysian citizens							Non-Malaysian citizens
		Total	Bumiputera			Chinese	Indians	Others	
			Total	Malay	Other Bumiputera				
M.D. KUALA KRAI	63575	61069	56164	56113	51	3952	847	106	2506
Kuala Krai & Guchil	15503	15147	12077	12063	14	2784	232	54	356
Kuala Pahi	377	376	366	366	-	10	-	-	1
Remainder of M.D	47695	45546	43721	43684	37	1158	615	52	2149

From the table, the population of people in Kuala Krai was dominated with Malay people with the number of population is 56113 person while for minority was only 51 person that comes from the other bumiputera. The bar chart about the number of population in Kuala Krai is shown in the Figure 1.2 and the pie chart about the percentage of population in Kuala Krai is shown in Figure 1.3

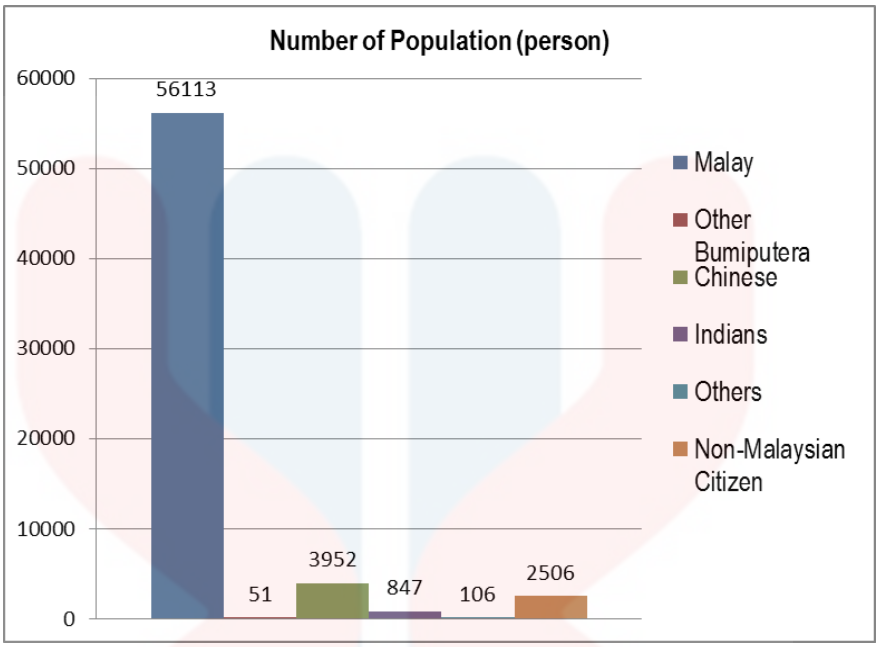


Figure 1.2: Number of population at Kuala Krai

(Source: Department of Statistics, Malaysia, 2010)

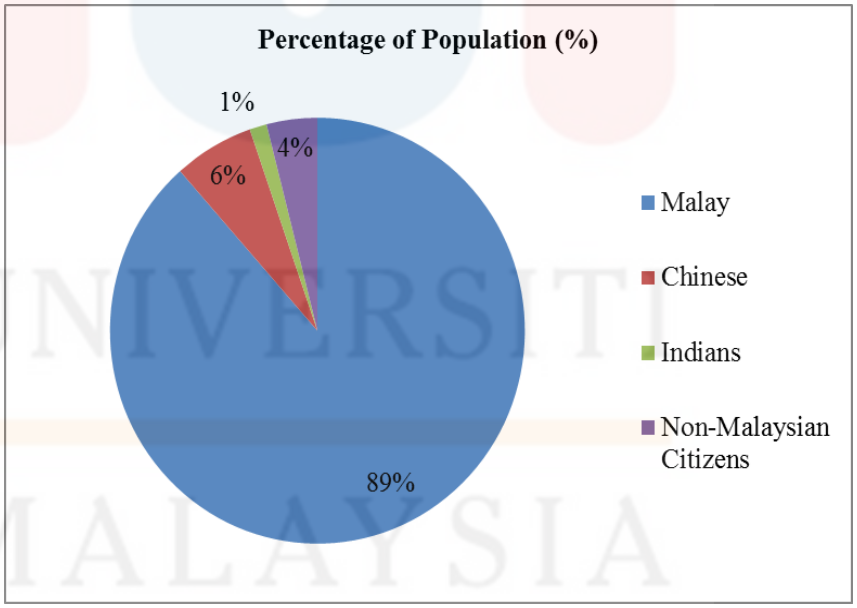


Figure 1.3: Percentage of population at Kuala Krai

(Source: Department of Statistics, Malaysia, 2010)

1.5.2 Rain distribution

Malaysia had uniform temperatures throughout the year of 25.5° to 32° C. Normally, the annual rainfall amount is between 2000 mm and 4000 mm while the annual number of wet days ranges from 150 to 200 days. The climate of Kuala Krai is same to Peninsular Malaysia that is tropical monsoon. Table 1.2 shows the record of total rainfall at Kuala Krai from 2008 to 2012.

Table 1.2: Data of rainfall distribution at Kuala Krai

(Source: Malaysian Meteorological Department, 2013)

State/Selected meteorological station (high above mean sea level in meters)	**Year**	**Mean temperature (°C)**		**Rainfall**		**Mean relative humidity (%)**
		Min.	**Max.**	**Total (mm)**	**No. of days**	
KELANTAN						
Kuala Krai (68.0 m)	2008	22.7	31.6	3132.3	205	86.0
	2009	22.8	32.0	3306.5	182	86.9
	2010	23.0	32.8	2356.6	166	85.4
	2011	22.7	31.5	3266.2	210	85.8
	2012	23.3	32.5	2454.8	193	84.5

Figure 1.4 shows the total rainfall for each year from 2008 to 2012 at Kuala Krai by the bar chart.

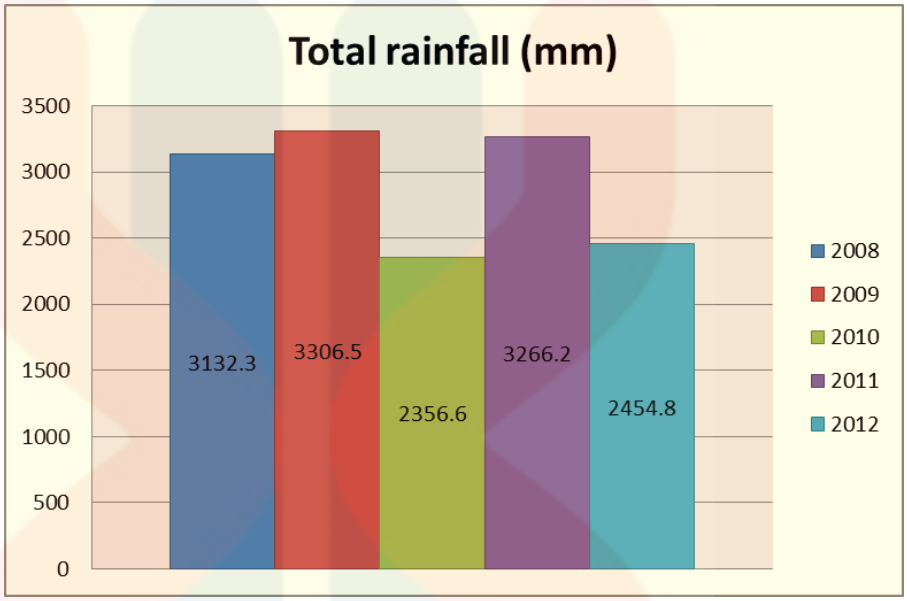


Figure 1.4: Annual rainfall data at Kuala Krai

(Source : Department of Irrigation and Drainage Kelantan, 2013)

According to Figure 1.4, the highest total rainfall recorded at Kuala Krai is on 2009 and the lowest total rainfall is on 2010. The changes of total rainfall are due to the East-Coast monsoon season.

1.5.3 Landuse

Most of Kg. Rahmat area, the most of the areas have been opened up for agriculture and reforestration. Besides that, Kg. Rahmat is complemented by infrastructure facilities for the local populations such as paved road, school and others.

1.5.4 Social economic

This study area was located at alluvium-rich area. Hence, the study area was suitable for agriculture. The people in Kg. Rahmat, were mainly self-employed. Their social economic status are from low to middle considering their income. The types of vegetation that were mainly seen in the study area are palm plantations. The palm plantation at study area are shown in figure 1.5. Another than that, while for business, local people here open small stall selling fruits and foods near the road.

Figure 1.5 shows the palm plantation at Kg. Rahmat at N 05°29' 30'' E 102°13' 0''

Figure 1.6 shows the Fish pond in the village

Figure 1.7 shows the rubber plantation at the study area

1.5.5 Accessibility

The main connection system in Kg. Rahmat is by roads. The main road connects from Kuala Krai to Gua Musang. In this area, there are two types of road that are paved road and unpaved road. Local people and outsiders use road as a main connection. The road accessibility can be seen in figure 1.11. For the mapping area, in order to find the outcrop, alternative way is needed. For example is by making a way through the rubber plantation and palm plantation. Figure 1.9 and 1.10 show the road at the study area. The field work for geological mapping were done about two month.

Figure 1.9 shows the road that access to Kg. Rahmat

(Coordinate N 05°30’ 0’’ E 102°13’0’’)

Figure 1.10 shows the unpaved road at the study area

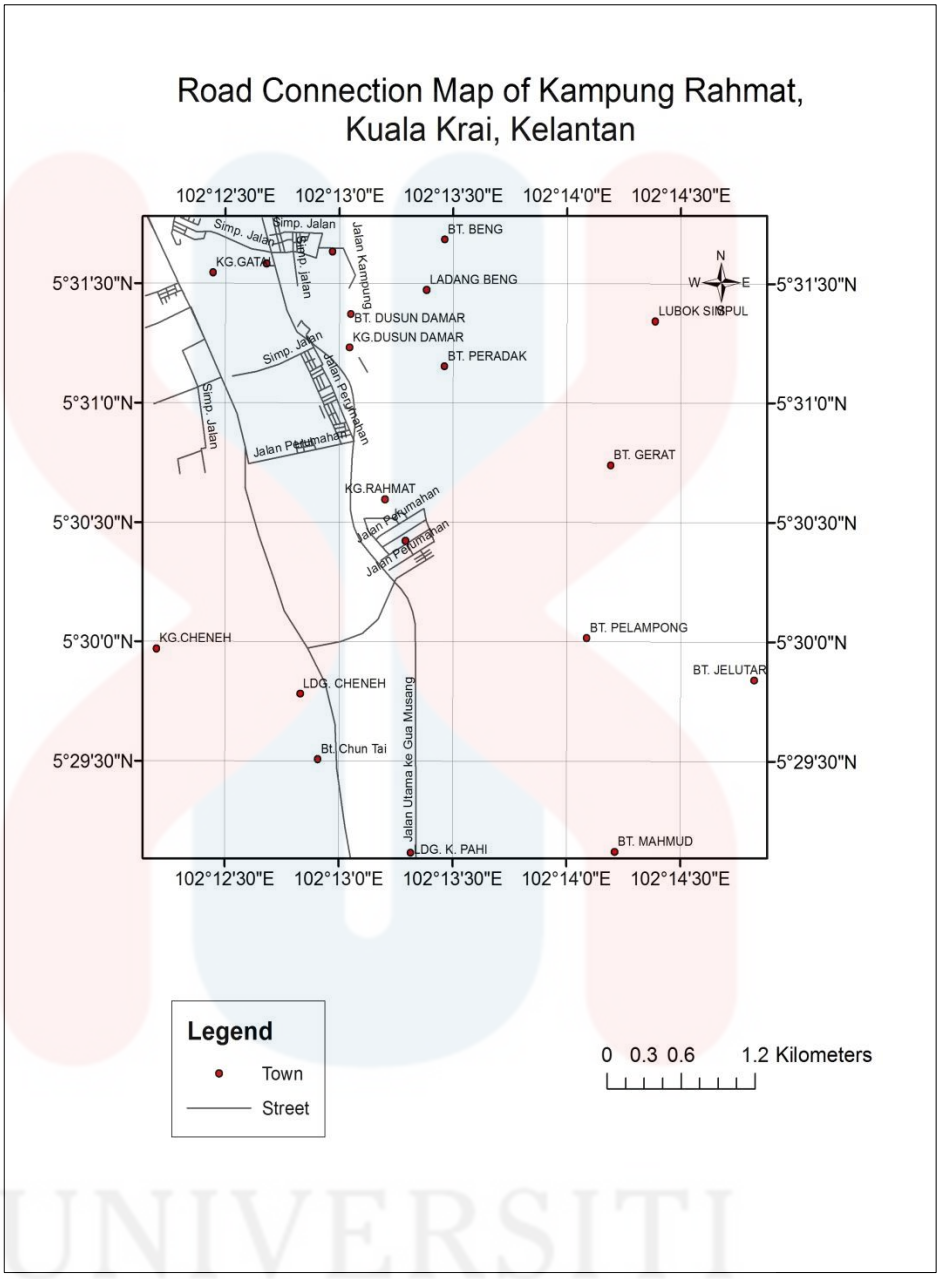


Figure 1.11 shows the map connection of Kampung Rahmat, Kuala Krai

1.6 Research Importance

The importance of groundwater cannot be deny as the demand for water is increasing every day. Hence, it was important to know that the study area have the potential groundwater or not. The resistivity method was used to carry the survey.

Nowadays, groundwater is important as it the natural resource for the community. This research was important as the information on the general geology that involves the lithology, morphology, drainage pattern, and many others general geology were update on that area. The existence of the groundwater on Kampung Rahmat, Kuala Krai was detect by using resistivity method.

The distribution of groundwater resources are confined to certain geological formation and structures. The proper investigation of groundwater resources need to be studied. This study is also give benefit for the future researches as it could serve as a reference for them.

1.7 Chapter's summary

The brief about the research had been discussed in Chapter 1. The aim and objectives on why this research was significant also has been discussed in this chapter. Besides that, the brief explanation about the study area, geography and base map also has been included. In conclusion, this chapter was focusing to gather information about the geology of the study area that results in the production of geological map.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In this chapter, the general geology about the study area was elaborated based on the previous researchers. This section also will describe the general geology of Kuala Krai and also the nearby area.

2.2 Regional Geology and Tectonic Setting

Kelantan is considerably extended the pre-Tertiary stratighraphic range in West Malaysia and shares a common border with Thailand in the north. Figure 2.1 shows the geological map of Kelantan and its neighboring states. The regional geology of Kelantan consists of a central zone of sedimentary and metasedimentary rocks bounded on the west and east by granites of the Main Range and Boundary Range respectively. In central Kelantan between the Sungai Lebir and Sungai Galas, the shales quartzites, limestones, and interbedded volcanic rocks form fairly low undulating land in which limestone hills are striking features (MacDonald,1968). Majority of Kelantan and Terengganu area composed of fine-grained argillite to arenite. Based on fossil that found in Kuala Krai, the age of sedimentary rock is Carboniferous to Triassic age (Hamizah, 2010).

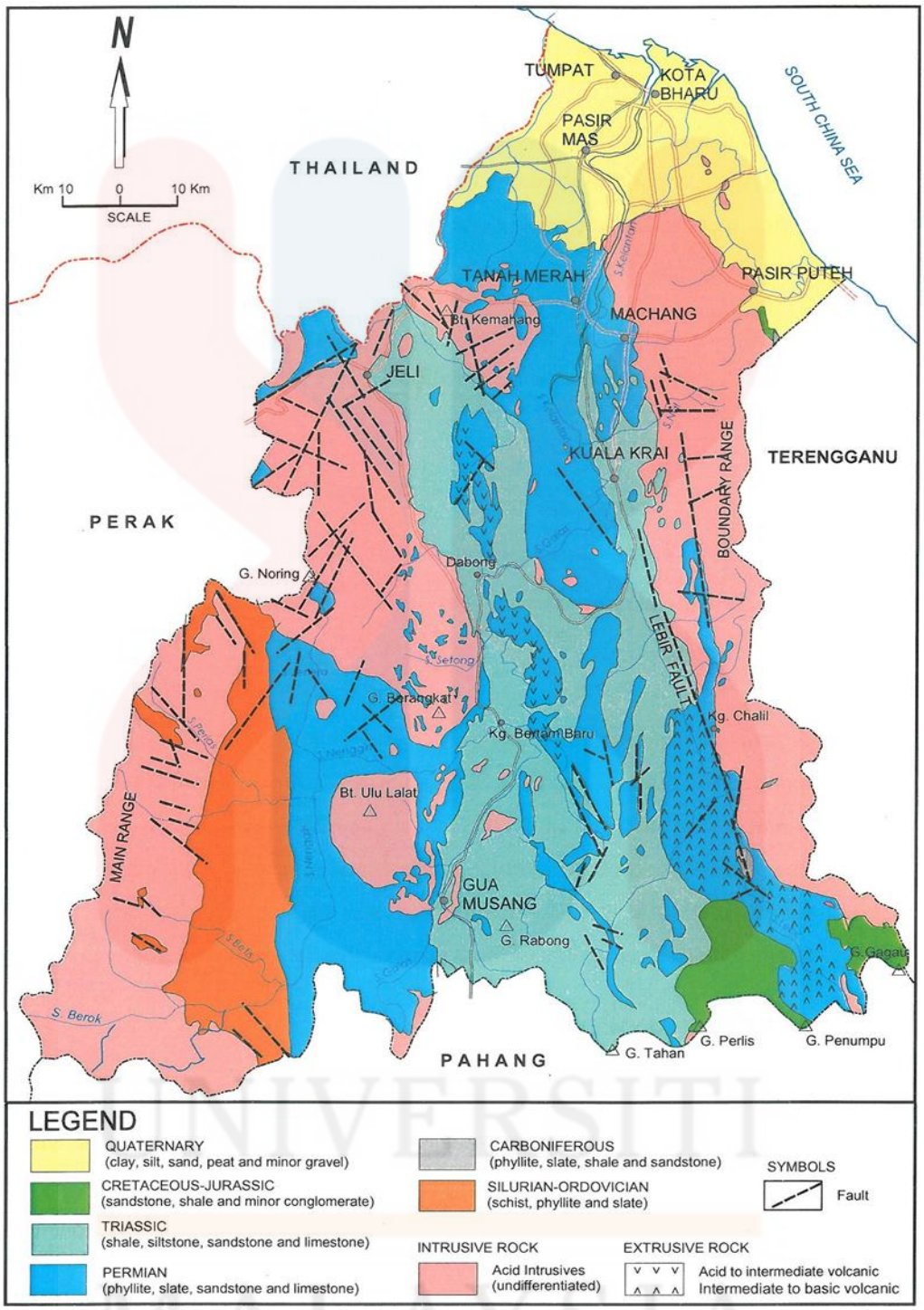


Figure 2.1: Geological map of Kelantan (Source : Khoo, 1983)

2.3 Stratigraphy

Hutchinson (2009), divided the geology of malay peninsular into three belts which are West, Central and Eastern Malaya belt. Carboniferous and Permian clastics and carbonates are dominated at the Eastern belt. Permian and Mesozoic age sediments was dominated at the central belt.

Batu Jong is under Gua Musang formation because the area of this formation is extended to the North Kelantan. The lower boundaries of this formation is not identified but in upper boundaries is overlained by Koh formation (Lee *et. al*, 2004).

The majority sedimentary rocks and associated volcanic range from Carboniferous to Permian in Kelantan. The age of the sedimentary rock based on fossil that found in Kuala Krai is from Carboniferous to Triassic age (Hamizah, 2010).

The lithology of Gua Musang formation based on Lee *et. al* (2004) is argillaceous and calcareous rocks interbedded with volcanic and arenaceous rock. Gua Musang formation is in Mesozoic age at the southern axial region belts (Khoo, 1983). Gua Musang formation does not stand by its lithology. The formation is interfingering with Telong formation, Semantan formation and Gunung Rabong formation at the upper part of Gua Musang formation.

2.4 Structural Geology

In Peninsular Malaysia most of the major fault zones experienced multiple of deformation that generated a diverse variety of fault rocks. As indicators for the condition and mechanism of deformation, the microstructure and texture of the fault

rocks can be used (Mustaffa Kamal Shuib,2000a). The land mass in Peninsular Malaysia has been subjected to four tectonic activities which occurs in Paleozoic and Mesozoic era and most dominant during Triassic period (Minerals and Geoscience Department Malaysia, 2003). During this land mass, the main forces that acting are folding and faulting.

2.5 Sedimentology

The sedimentary strata range from predominantly shale beds to predominantly quartzite beds with all degree of interbedding, and rarely is it possible to draw a sharp line between these main types (MacDonald, 1968). The majority of the associated volcanic and the sedimentary rocks that appear in Kelantan is from Carboniferous to Permian range but the rocks of Triassic age may occur (MacDonald, 1968).

In Kelantan, it is dominantly with limestones particularly between the Sungai Lebir and Sungai Galas. Gua Musang formation consists of argillaceous lithofacies, majority formed by massive shales, mudstone and interbedded with small amount of tuffaceous siltstone and sandstones (Shafeea, 1994). Graphitic shales have been noted at a large number of localities, and a bituminious shale that contain poorly preserved plant remains has been recorded by Slater in vicinity of Ulu Temiang Halt, on the railway line between Manek Urai and Dabong (MacDonald, 1968).

2.6 Petrography

A more detailed study on the geology and mineral resources of Kelantan and Northern Terengganu on the scale of 1:250000 is carried out by MacDonald in (1968). In the early eighties, Ab. Halim Hamzah and Mustafar Hamzah remapped the Tanah Merah area that previously covered by MacDonald. Ignimbrite at Temangan dyke is named based on the characteristic present and called the volcanic rocks as pyroxene basalt. Rhyolites are most extensively developed in Central Kelantan. They are variable in color from grey to green with rare red varieties and occur as narrow bands interbedded with shale and tuff, as a thick, massive, well jointed beds (MacDonald, 1968). Next, schist are best exposed in the Sungei Taku and its tributaries, but good exposures are also found in the Sungei Sokor and the Sungei Bertam (MacDonald, 1968). In Malaysia, the largest dyke found is in a distance of fifteen miles between Temangan and the Sungai Lebir which is a quartz-porphyry dyke.

2.7 Hydrogeology

The study of water in the broadest sense in called hydrogeology. Water is a natural resource unique to the planet Earth. Water is life to us and all living things. After discounting the volumes represented by oceans and polar ice, groundwater is the next most significant source (Willis, 2001).

Groundwater is functioning as a formidable poverty-alleviation tool, which can be delivered direct to poor community far more cheaply, quickly and easily than canal water (IWMI, 2001). Of the 37 Mkm^3 of freshwater to be present on the earth, about 22% exists as groundwater, which constitutes about 97% of all liquid

freshwater potentially available for human use (Foster, 1998). Groundwater makes up only 0.61 % of the total distribution of world water supply and is approximately 50 to 70 times more plentiful than surface water (Fetter, 1980). In order to archieve a large scale development of groundwater, it must have reliable estimates of groundwater potential (Singh, 1988).

Next is aquifer. Aquifer is a formation, part of a formation or group of formations that contain sufficient saturated permeable material to yield a significant quantities of water to wells or spring (Wills, 2001). It is a layer of porous substrate or layer that contains and transmit groundwater. Aquifer can be divided into two that is confined and unconfined aquifer. A confined aquifer is an aquifer that is overlain by impermeable layer of rock or substrate such as aquiclude or aquitard (Fetter, 2001). Generally, the more productive aquifers occur in sedimentary geologic formations; weathered and fractured crystalline rocks yield smaller quantities of groundwater in many environments (Fetter, 2001).

2.8 Resistivity Method

There are four main types of arrays used in two-dimensional resistivity surveying. They are the dipole dipole, pole-dipole, Wenner-Schlumberger, and Wenner arrays (Telford *et. al*, 1990). They differ in the relative positions and spacing of the current and potential electrodes. Each array type has its own advantages and disadvantages. The configuration can be shown in figure 2.2. For Wenner Array, the advantage is the penetration depth is approximately about 60 meter. Hence, it is good in order to achieve the objective that was to determine the depth of aquifer.

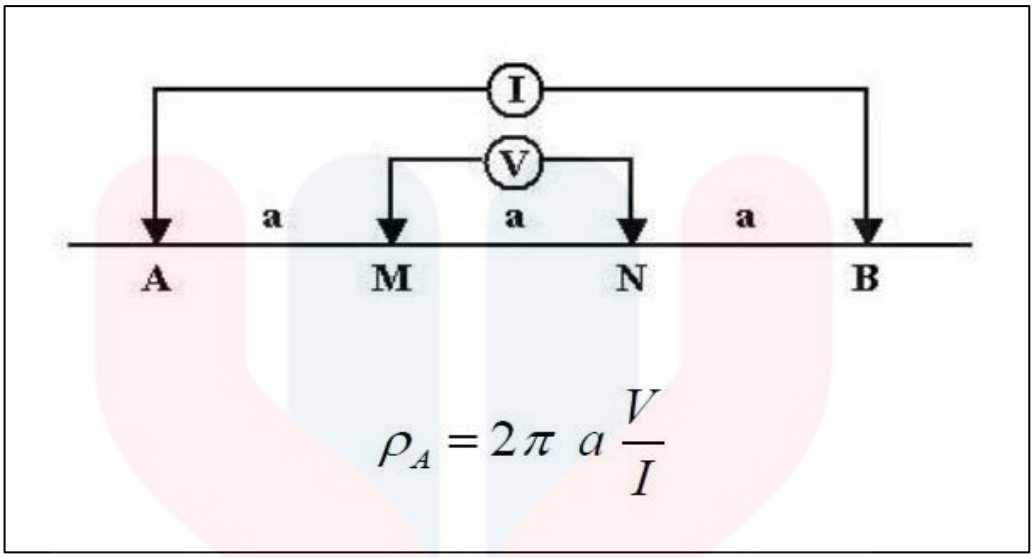


Figure 2.2 shows the Wenner array configuration (Telford et. al, 1990)

2.8.1 Resistivity method for Groundwater

The electrical resistivity techniques are based on the response of the earth to the flow of electric current (VenkataRao *et. al***,** 2014). Reynolds (1997) had classified geophysical techniques into two groups that were passive methods and active methods. The examples of passive method are gravitational or magnetic, that detect the variations in the natural earth fields while active method is artificial signal that are recorded after passing through and being modified by earth materials**.** The electrical resistivity have been much used in groundwater geophysical investigation due to the correlation that often exist between electrical properties, geologic formations and their fluid content (Zohdy, 1964). The resistivity of the ground is measured by sending current into the ground at the current electrodes and the corresponding potential difference is measured at the potential electrodes, then converted to apparent resistivity value by multiplying with an appropriate geometrical factor (Telford *et. al*, 1990).

The electrical sounding provides the information about vertical changes in subsurface electrical properties and thus, it is useful in the determination of hydrogeologic conditions such as depth to water table, depth to bedrock, and the thickness of the soil (Zohdy, 1964). Different types of water will produce different range of resistivity values. Figure 2.3 shows the electrical resistivity of the common earth materials.

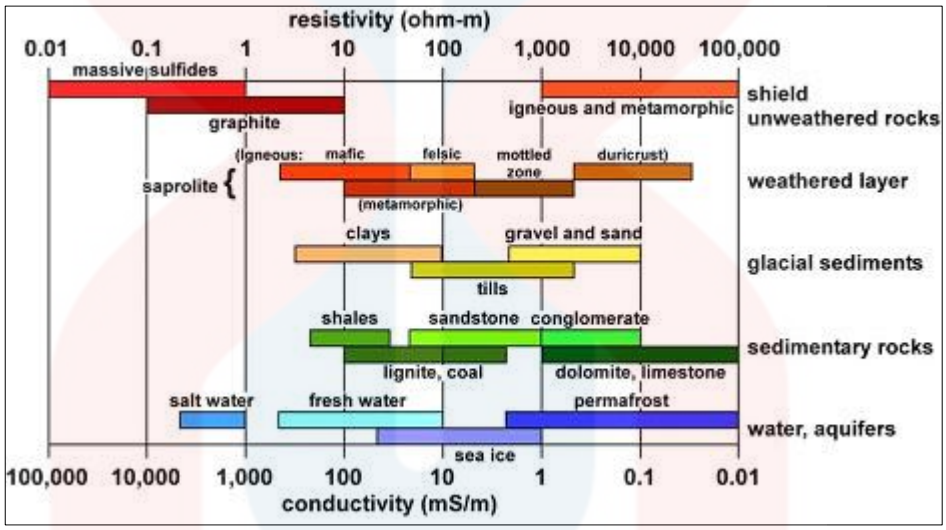


Figure 2.3 shows the representative electrical resistivities of rocks, minerals and soils.

2.8.2 Potential of Groundwater

The presence of groundwater through resistivity measurements is investigate using Archie law. The different types of water will produce different ranges of resistivity values. The table 2.1 below shows the different resistivity values obtain from various types of water.

Table 2.1 shows the Resistivity values obtain from various types of water.

Type of water	Resistivity (Ω-m)
Precipitation	30-1000
Surface water, in areas of igneous rock	30-500
Surface water, in areas of sedimentary rock	10-100
Groundwater, in areas of igneous rock	30-150
Groundwater, in areas of sedimentary rocks	>1
Sea water	Approx. 0.2

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

In this chapter, the detail research methodology was discussed to ensure that the study carried out in systematic and effective ways. Materials are the list of software and hardware that used in the project while methods are the steps in conducting the project. The flow chart for the research which were covered the preliminary studies, field work, laboratory analysis, software application, data gathering and interpretation and report writing. The research flow chart can be seen in Figure 3.1. All the workflows are followed by the flowchart.

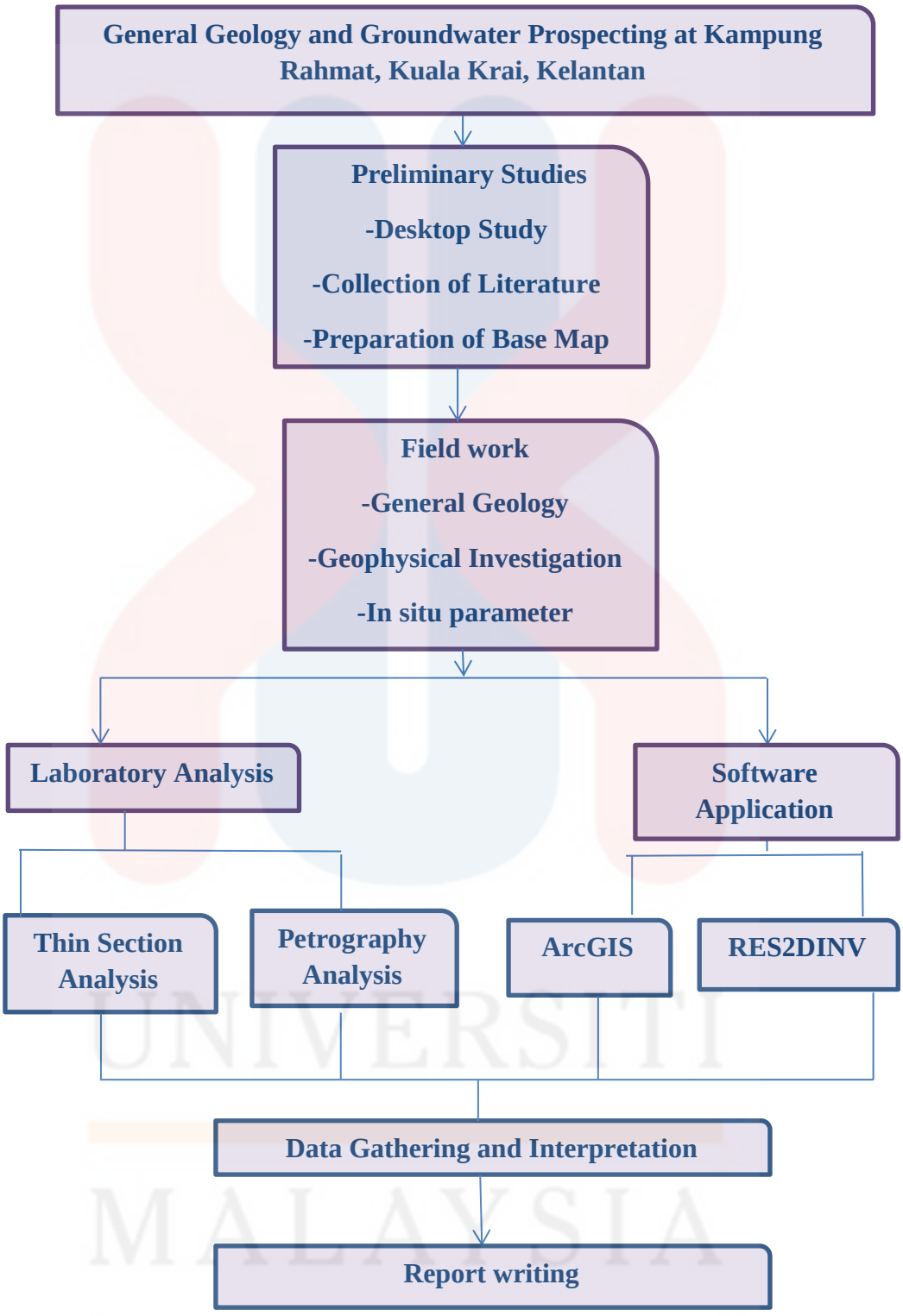


Figure 3.1 shows the Research Flow Chart

3.2 Preliminary Researches

Preliminary studies was the early stage of the study to gain information so that research can be conducted effectively. With the preliminary studies it had helped researchers to understand better about the topic. There are many sources like journal, related books, previous thesis and online search engines. This research was conducted according to the flowchart. Firstly started from the literature review, then the data collection from geological mapping and general geology of the study area. The next step was according to figure 3.1.

3.3 Materials

There are few materials that are needed to complete this study. The tools that had been used such as Global Positioning System (GPS), chisel hammer with rock pick, Brunton compass, topographical map, hand lens, measuring tape, sample bags, note book, pencil, water level indicator, YSI-556 Multi-Parameter and digital camera. GPS is used by recording the track in the field area. The device is also used to mark the point of intersect in term of longitude, latitude and elevation of the map.

Besides that, compass is an important tool in mapping. It is used to get directional degree measurements (azimuth) through use of the Earth's magnetic field. Another tool that is important in geology is hammer. Without a hammer, geologist cannot take rock sample from the outcrop.

Hand lenses also play important role in geologist life. It is used to observe the mineral grain of the rock in the field. Measuring tape is used to measure size of exposed outcrop in the field. It is also useful in taking measurement of bed thickness or other geology information Acid bottle that containing hydrochloric acid which is used to test on limestone rock. Limestone rock will produce gas bubble if hydrochloric acid is applied to it.

Next is water level indicator. The purpose is to determine the bottom of the well. It also can take static level readings and then switch to drawdown mode. The YSI-556 Multi-Parameter is use to measures dissolved oxygen, pH, conductivity, temperature, and Oxidation Reduction Potential or simply purchase to cable to measure electrical conductivity, and temperature if needed.

Last but not least is the Electrical resistivity (ER). It is portable and easy to handle. These methods are usually time-consuming but it provides sufficient data (Robinson, 1998). Figure 3.2 shows the image of the resistivity equipment. The instrument that will used for ER was shown in table 3.1

Table 3.1: The instrument that will be used:

NO.	TYPE OF EQUIPMENT
1.	ABEM Terrameter SAS 4000
2.	Electrode selector (ES464)
3.	Lund Imaging cable 5 m (spacing) 100 m
4.	Electrode jumpers
5.	Steel electrodes

6.	Cable connector
7.	Multifunction cable
8.	Battery (25-70^{7} Ah)
9.	Atomic Absorption Spectrometer (AAS) probe

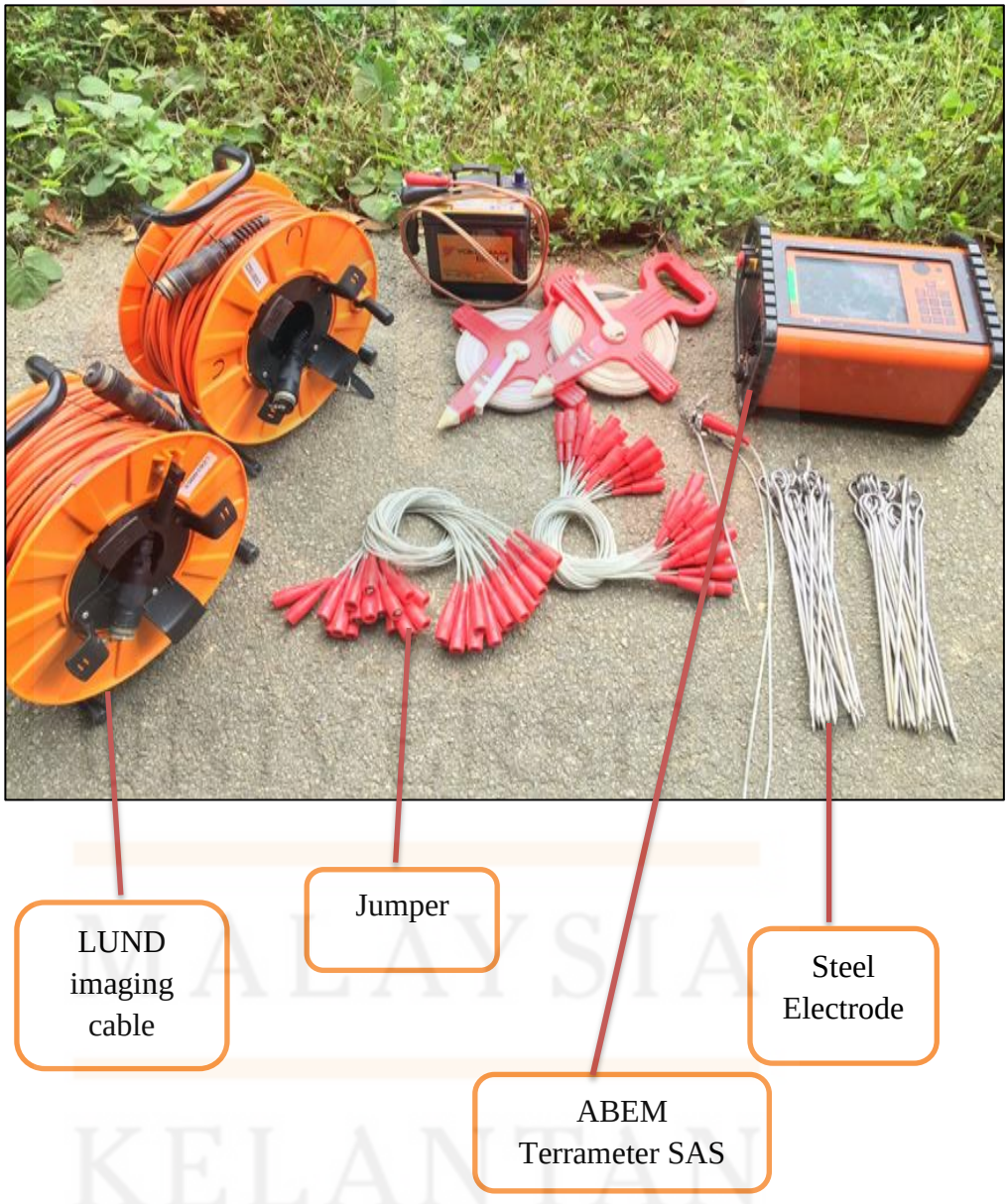


Figure 3.2 shows the image of resistivity equipment

3.3.1 Methodology for the geophysical investigation

a) Arrangement for the ABEM Lund System

The total needed electrodes are 41 electrodes. Then, the electrodes are planted into the ground at depth around 100 mm with 5 meters spacing along the horizontal line.

The Lund Imaging Cables are connected to the electrode selector which is ES464. The electrode selector then is connected to Terrameter SAS 4000. ABEM Terrameter 4000 is connected to the battery.

b) Method of Taking Data from ABEM Terrameter SAS 4000

The resistivity data from geophysical analysis is recorded by the ABEM Terrameter SAS 4000. There are few procedures need to be note before started the reading process. First and foremost, the battery need to be charge before the measurements start. Besides that, 41 metal electrodes need to be planted into the surface of the ground in order to measure the subsurface resistivity.

There are four main types of arrays used in two-dimensional resistivity surveying. They are the dipole dipole, pole-dipole, Wenner-Schlumberger, and Wenner arrays (Telford et al., 1990). They differ in the relative positions and spacing of the current and potential electrodes. Each array type has its own advantages and disadvantages. A Wenner array using 24 electrodes was implemented for this investigation.

3.4 Field studies

Field study or field work is the most important method in a geological study. As the field work is done, data can be gathered and direct observation can be done. Without geological mapping, all the data and samples cannot be obtained. Other than that, the field work also more accurate than desk studies which only guided by theories and not the real things compared to field work.

Field studies are also important in achieving the main objective of this study which is to produce the geological map of the study area. Mapping was done to get the overall data or information about the study area in general. This also includes measuring strike and dip, sketching, identifying beddings, foliations, joints, fractures, the geomorphology of the area and other measurable geological structures.

Traversing is a more specific way of mapping where position of outcrops and sampling locations are identified more precisely by marking the locations with GPS. Once the positions have been identified, sampling is done. Sampling is the method of obtaining rock or soil samples for the next step which is laboratory investigations. The type of sampling that had done is random mapping. During the mapping, only fresh samples are collected by using hammer and are put in the sample plastic.

3.4.1 Resistivity Characteristic of Different Rock Types

Each rock type do not have easily definable resistance or resistivity. For example limestone and granite, they are many types with varying resistivity. Table 3.2 is the

compilation from various standard references, shows the expectation range of resistivity for different rock types.

Table 3.2 shows the range of resistivity of different rock

Type of Rocks	**Resistivity (Ω-m)**
Clay	1-100
Marl	30-70
Sand (unconsolidated)	10-800
Sandstone	35-4000
Siltstone	10-800
Limestone	120-400
Marble	100- $1x10^6$
Granite	300-$1x10^6$
Basalt lava	10-$1.3x10^7$

3.5 Laboratory Investigation

Laboratory investigation was done after samples that obtained in the field brought back to the laboratory for further analysis. For the petrographic analysis, it is the method to determine the mineral composition in rock samples that leads to determining exactly the name of the obtained rock sample. The tool used for this analysis was electronic microscope with different magnifications.

The hand specimens that had been obtained at the sites during traversing are brought back for thin sections. The detailed analysis of minerals also known in the form of thin section to understanding the origin of the rock.

3.5.1 Thin Section

According to Buehler 2006, there are six procedure are required to prepare the thin section which is sectioning, impregnation, precision sectioning, bonding, re-sectioning and the last step is grinding and polishing.

Firstly, is the sectioning process. Sectioning process is the process of manage the size of specimen that to be cut. The Diamond Slab Saw machine was used for cutting the rocks. For the second step is the impregnation process. The machine that had been used was SampIKups machine. Vacuum impregnation is used to remove gases from pores or cracks in friable specimens and allows infiltration of a suitable bonding material from retard sample fracturing and plucking (Buehler, 2006).

Then, precision sectioning or trimming process is low deformation cutting and IsoMet are the machine for precision sectioning of petrographic specimens. Next, is re-sectioning process. The excess material was removed quickly and efficiently with PetroThin Thin Sectioning System. This machine consisting of a diamond cutting, a diamond grinding wheels and vacuum chuck. Last process is grinding and polishing. Grinding is to remove deformation induces in sectioning and remove excess material while polishing is to remove the final deformation induces by grinding process. That

involves upgrading the surface with fine abrasive, decreasing to sub-micrometer size (Buehler, 2006).

After all the stages of thin section are followed and completed, thin section will be examined under light microscope. The thin section was observed under microscope to determine the characteristics of mineral composition.

Figure 3.3 shows the cutting of rocks using The Diamond Slab Saw machine

Figure 3.4 shows the trimming process using IsoMet machine.

3.6 Data Analyses and Interpretations

3.6.1 Mapping

In order to achieve the first objective that was to produce the latest geological map, Geospatial Information System (GIS) application was used. All the data that had

been collected in the field, need to be analyze and digitized in GIS application. GIS have many advantages such as give a great accuracy and better view of map.

3.6.2 Data Analysis for Resistivity

The value of the resistivity that been obtained from the instrument will be compared to the standard resistivity value. This analysis is important to determine the thickness of the layer of structure and to detect the below surface of the structure.

3.6.3 Groundwater Analysis

Most of the groundwater is within 100 meters of the surface of the Earth. To find groundwater, geophysical techniques are the key. A number of geophysical standard methods such as geo-electric, transient electromagnetics and airborne electromagnetics are applied for groundwater exploration. A detailed knowledge on groundwater resources enable its sustainable use, where the regional distribution of resources, the hydraulic characteristics of the aquifer as well as the regional and temporal variations of the water quality are important factors.

ERI is a geophysical technique for imaging sub-surface structures from electrical resistivity measurements made at the surface, or by electrodes in one or more boreholes. If the electrodes are suspended in the boreholes, deeper sections can be investigated. It is the impendence of electrical flow through the subsurface material.

There are few advantages using the ERI method. First, it is flexible and can be used for various purposes and depths of investigation. Secondly, the qualitative interpretation of the data is rapid and straightforward and the equipment is light, portable

and inexpensive. For the in-situ parameter, it was applied to measure the physical properties. The physical properties was done through pH, electric conductivity (EC), total dissolved solvent (TDS), turbidity and temperature.

3.6.4 Software Applications

There are three software application that will be used in this research. First is ArcGIS software, RES2DINV and Rose diagram software.

ArcGIS software is a geographic information system (GIS) that used for creating and using maps, analyzing the mapped information and managing geographic information in a database.

For the RES2DINV software, it a software to analyze the resistivity data that obtained from ABEM Terrameter SAS 4000. This software will display the data in the form of image. Then, the image is used for the interpretation of the potential groundwater in Kg. Rahmat area and also can determine the depth of the potential groundwater. This is important in order to achieve the objective.

Rose diagram software is to generate diagram of strike, dip and dip direction and to calculate strike from dip direction. The software benefits us because it helps us to draw to diagram using software rather than draw it manually. We just have to insert the value of strike and dip on this software. Then, it will give us the rose diagram.

Microsoft Excel is for drawing table and charts. Data analyses and interpretations holds a very important postion in every research on order to achieve the mentioned objectives.

3.7 Report Writing

Report writing was the final step in completing this task. All data and results that have been collected, analyzed and tabulated after laboratory investigations and field works are written down in the form of a report to be presented to examiners. This report has six chapter including introduction, literature review, materials and methods, general geology, groundwater potential using ERI method and conclusion.

Chapter 4

GENERAL GEOLOGY

4.1 Introduction

This chapter of general geology mainly discusses on the findings of research based on geological mapping and field observations done. General geology comprises of geomorphology, lithostratigraphy, petrographic analysis, structural geology and historical geology**.** The observations and descriptions have been recorded throughout the entire geological mapping.

4.1.1 Survey Traverse

The traversing method was done to survey the study area. It was the most recommended method in order to survey the study area. During this traversing, a geographic information system (GPS) was used to track the movements at the study area. Figure 4.1 shows the traverse map of the study area.

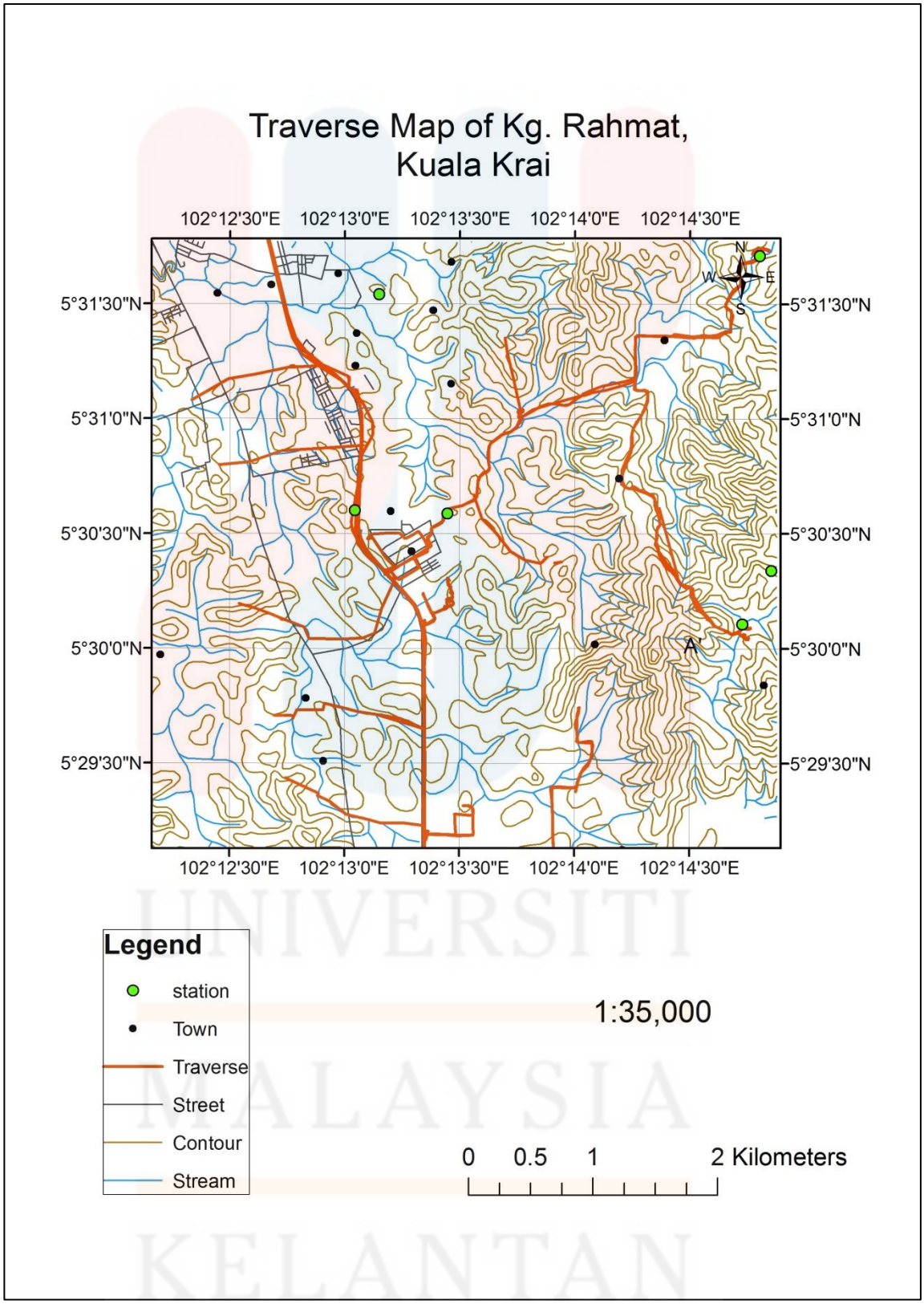


Figure 4.1 : Traverse map of the study area

4.2 Geomorphology

Geomorphology is the study of landform and its processes related to the origin and evolution. The earth landforms is influenced by endogenic and exogenic processes. Studying geomorphology of an area also helps us in predicting its past environment and the processes that might have taken place. On this study area, it was mainly a rural area consisting of several obvious geomorphological features.

Table 4.1 shows the major landforms with prominent relief expression according (Bacco, 2001)

Unit Name	Relief Amplitude (m)	Slope Steepness	Dominant Lithology
Very low hills	<250	3-8°	volcanic
Low hills	250-500	6-20°	volcanic
High hills	500-1000	20-45°	various
Sierras	1000-4000	>30°	various

Based on table above, there are two groups of major landforms, with and without important relief expression. For the first group include four geomorphologic regions that are very low hills, low hills, high hills and sierras. Then, for the second group, it was formed by four other regions, valleys, plains, highplains and piedmonts.

In the study area, it consist of two major landform that were hilly and alluvium landform. This was shown on figure 4.2. The hilly landform show the high elevation of relief while alluvium landform show the low elevation.

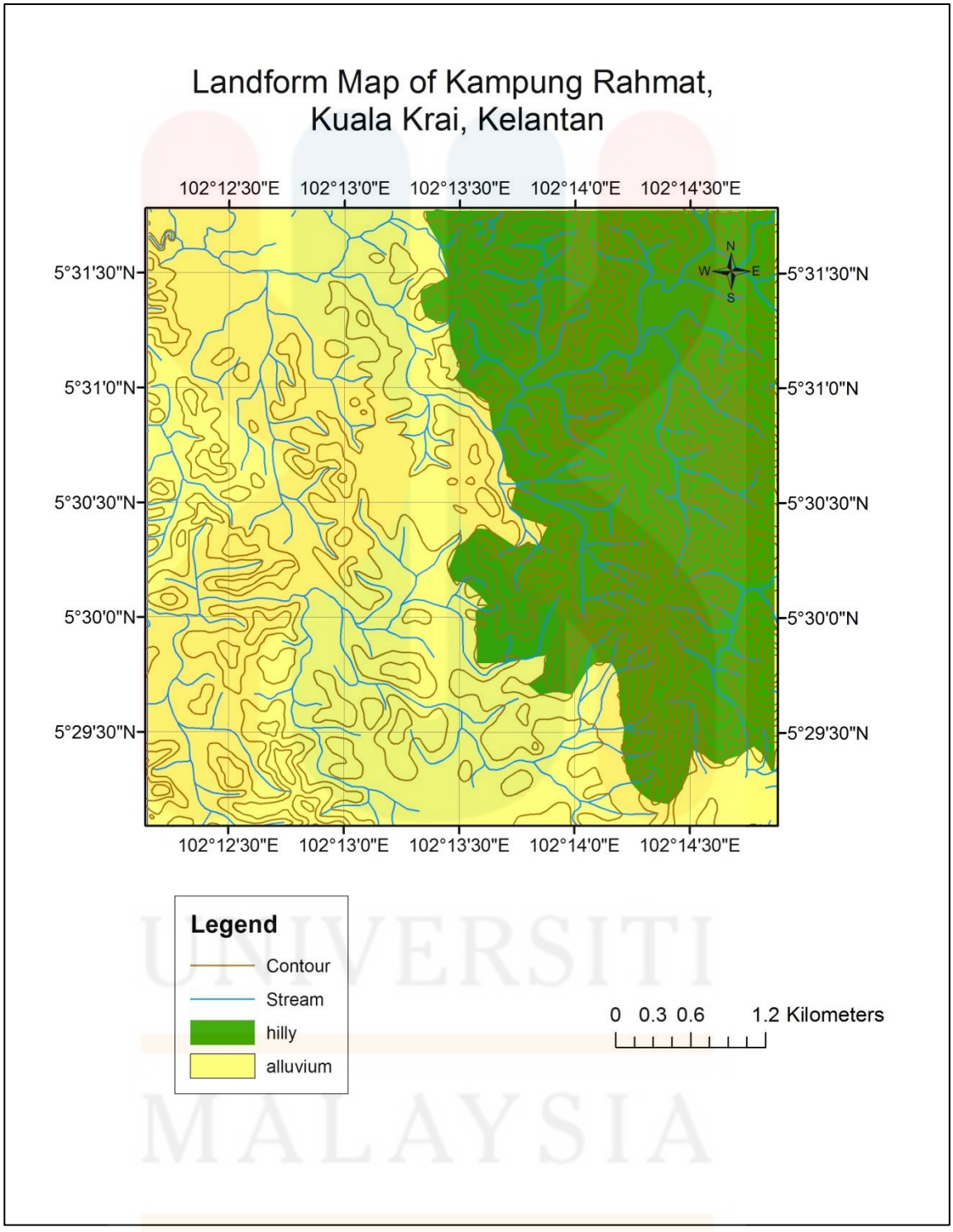


Figure 4.2 : Landform map at the study area

Figure 4.3 shows the geomorphology of the area

Figure 4.4 : The mountain view of the study area

Figure 4.5 : The landscape view of the area

Figure 4.6 : The plantation at the study area

4.2.1 Topography

Topography is a measurement of elevation and describe the shape and relief of the land. Topography also includes a variety of different features known as landforms. There are five main categories of the topographic features of Peninsular Malaysia. The different categories are shown in the table 4.2.

Table 4.2 : The classification of topographic unit in Peninsular Malaysia (Hutchison and Tan, 2009)

Class	Topographic Unit	Mean elevation (m above sea level)
1	Low lying	< 15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	> 301

By means of elevation as shown in Figure 4.7, the lowest recorded elevation in the study area is 40m while the highest recorded elevation is 220m. The area that is low land was shown clearly by the low values of elevation. The highest elevation indicates the opposite which is an area of highland. Based on table 4.2, the topography unit at the study area was from undulating to hilly unit.

The topographic map of the study area is shown in 2D map as shown in figure 4.8. From the map, the study area had elevation of flat to gently and gently sloping. Other than that, the study area was classified to high resistance and low resistance area. The high resistance area mainly the hilly area while the low resistance area show the alluvium area.

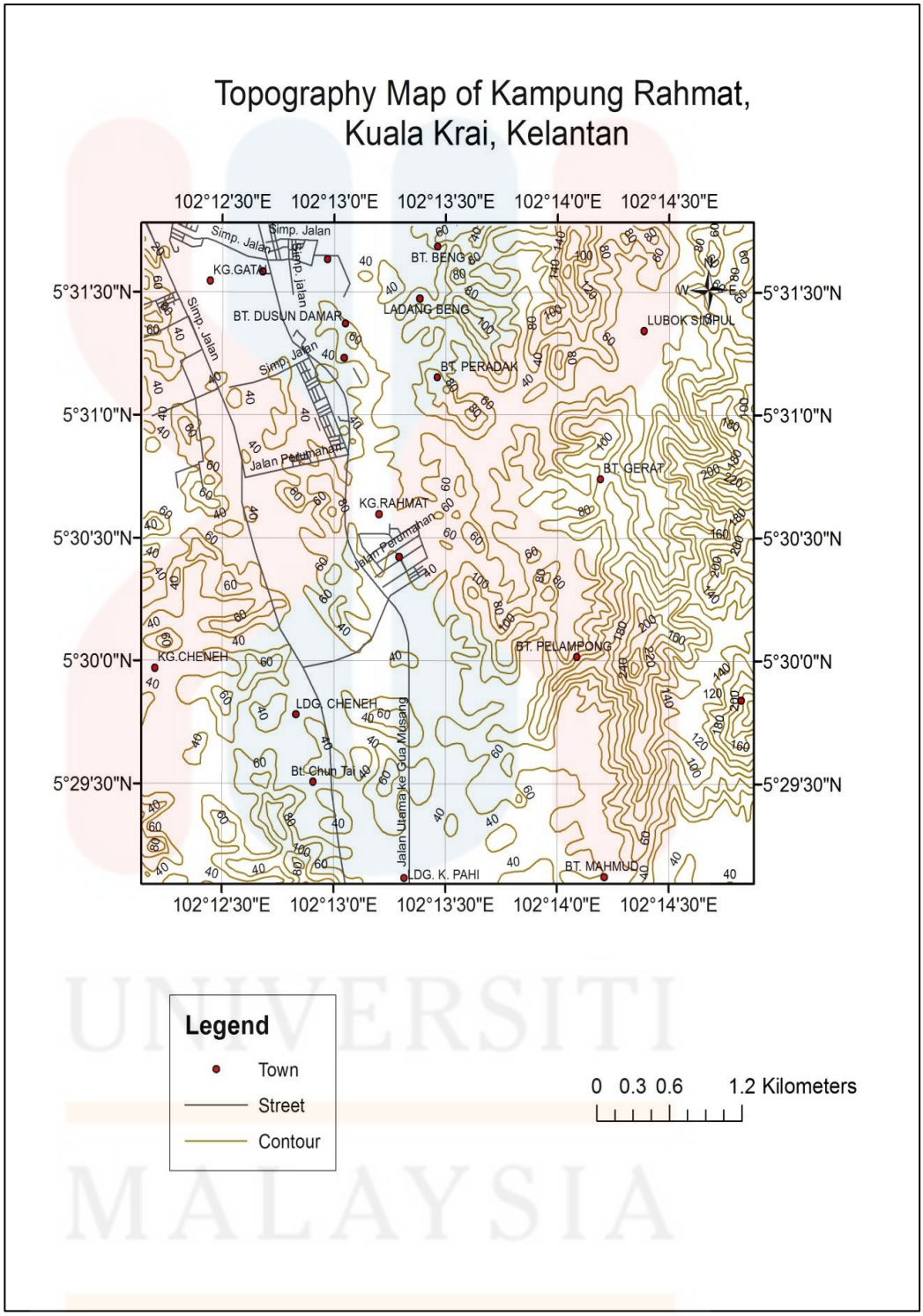


Figure 4.7 : Topography Map of the study area

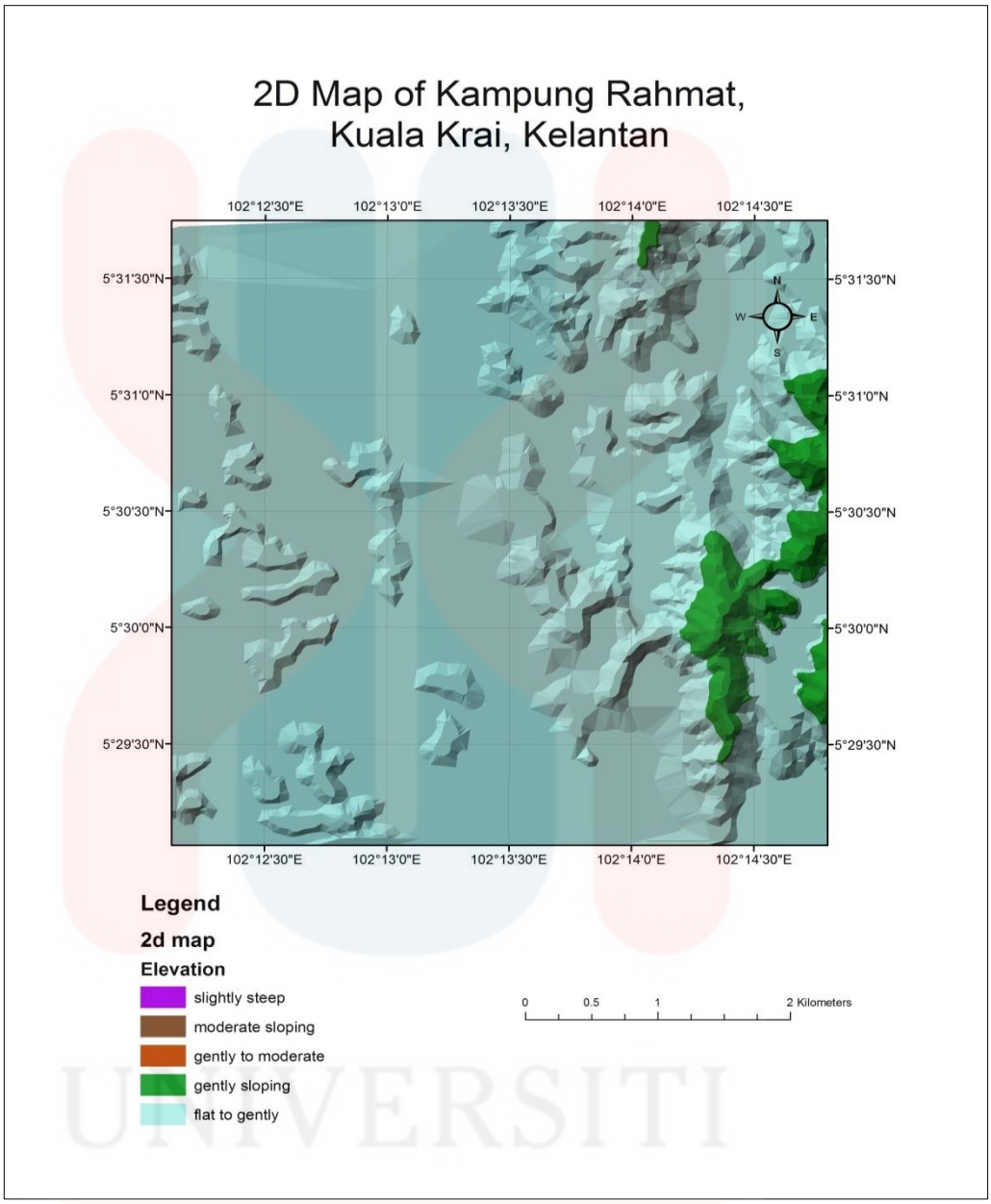


Figure 4.8 : 2D map of the study area

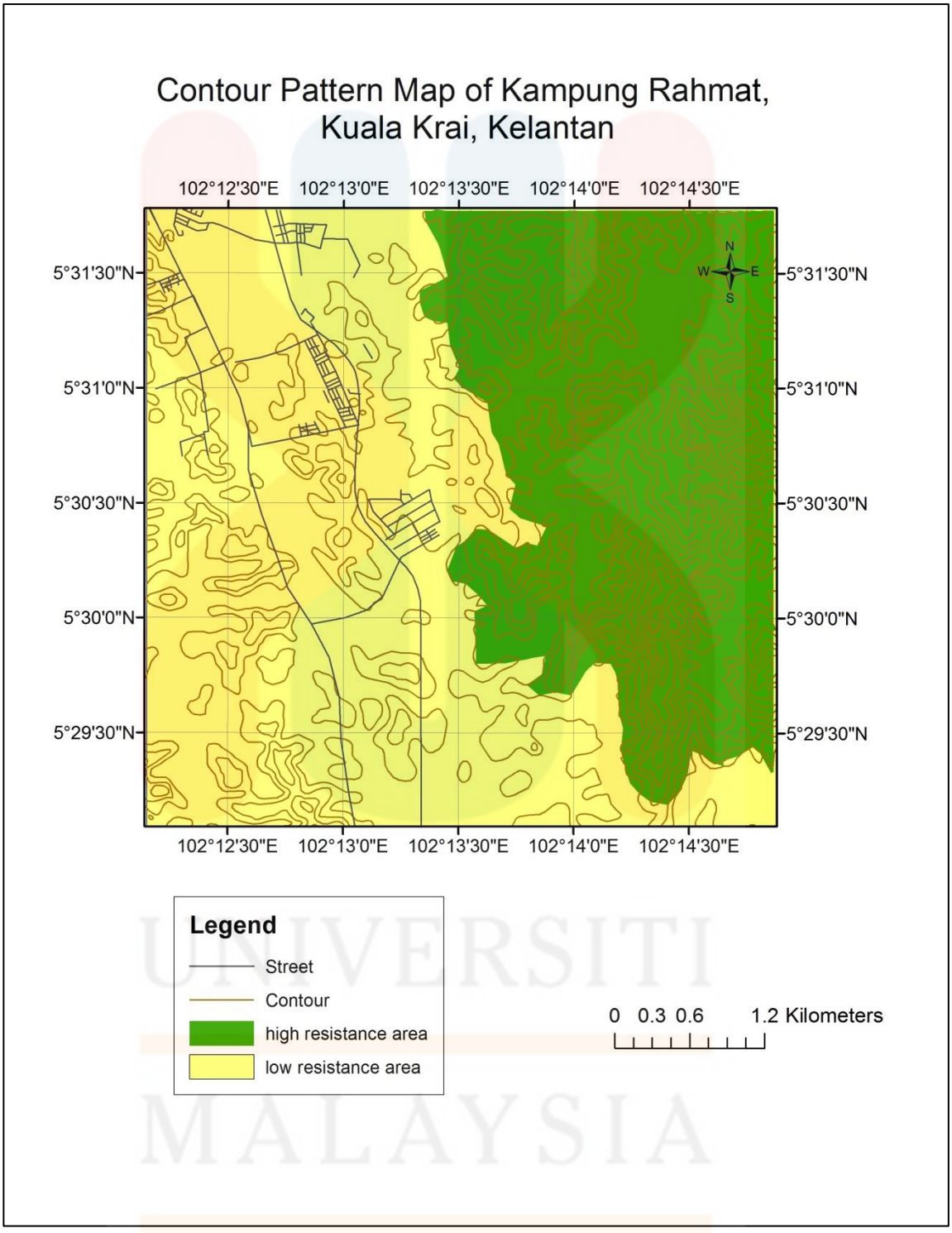


Figure 4.9 : Contour pattern map at the study area

4.2.2 Drainage system

A drainage system is the pattern that is formed by the streams, rivers, and lakes in a perticular drainage basin. Usually the drainage pattern will indicate different geomorphology. The drainage pattern formation is controlled by a few factors such as rock type, rock distribution and location of rock at the surface. There are 5 types of drainage pattern show in Figure 4.10 that are dentritic, parallel, trellis, rectangular and reticulate.

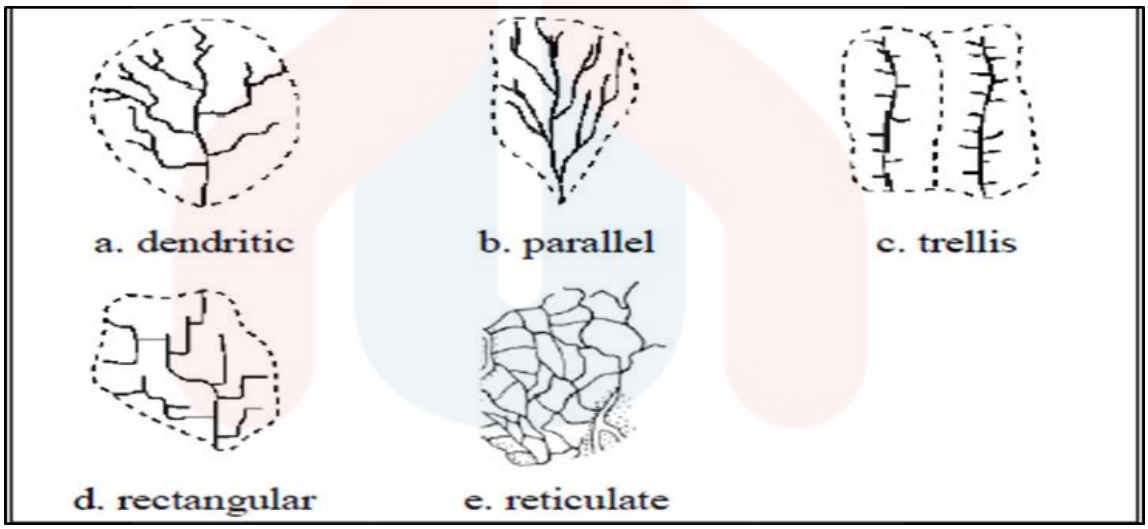


Figure 4.10 shows the types of drainage pattern (Ling and Guilbert, 2012)

At this study area, it was filled with drainage systems. Usually in river system, dendritic pattern is the most common form. In a dendritic river system, the shape of this drainage is tree like pattern with an irregular branching of tributaries in many direction. According to Twindale, 2004, the mostly found in region of very slight slope which had a little or no influence from structural factors and was common at mud flats regions was the denritic pattern. In the study area, it was mainly consist of dendritic pattern. This can be seen on figure 4.11. Dentritic drainage pattern was recognized by its branching

pattern similar of tree roots. Another than that, this type pattern is most common form and it shows the geology has a similar resistance to weathering.

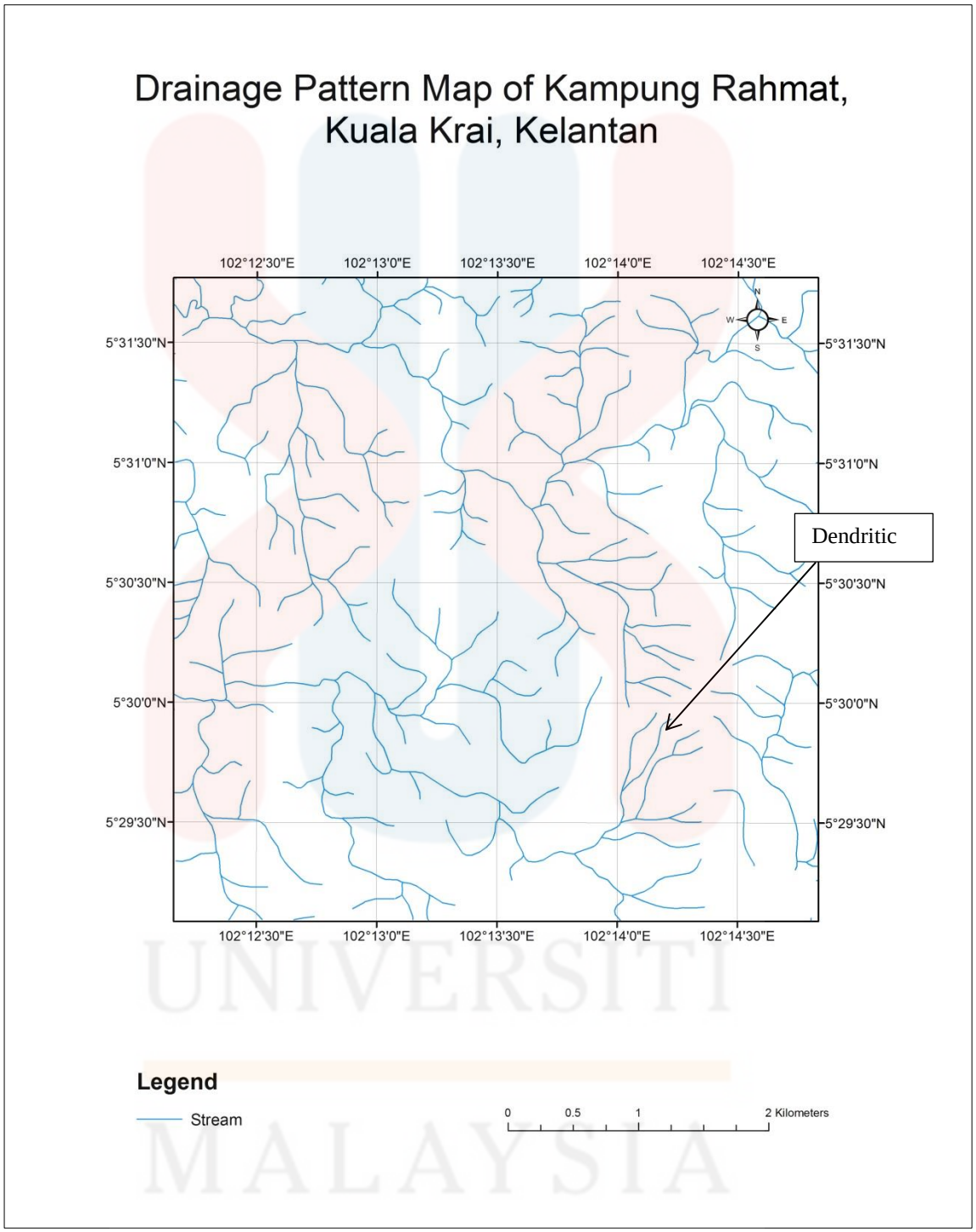


Figure 4.11 shows the drainage pattern map at the study area

4.2.3 Weathering Process

Accoding to Bland and Rolls (1998), weathering is a natural process and the alteration by chemical, mechanical, and biological processes of rocks and minerals at or near the Earth's surface in response to environmental conditions. This process occurred gradually within time. The agents of weathering are rain, snow, temperature, wind and atmospheric pollutants.

Weathering can be divided into three different types which are physical, chemical and biological weathering. Physical weathering is also known as mechanical weathering is caused by the effects of changing temperature on rocks, causing the rock to break apart without changing chemical properties. The result of physical weathering at the study area can be seen on figure 4.13. The physical weathering at the study area was depend on the force that act on the rock mass.

Next is chemical weathering. Chemical weathering is the breakdown of rock by chemical mechanisms. It does not break rocks into smaller fragments through wind, water and ice, instead, it changes the chemical composition of the rock, usually through carbonation, hydration, hydrolysis or oxidation.

Then is biological weathering. Biological weathering is the weakening and subsequent disintegration of rock by plants, animals and microbes. It is caused by the presence of vegetation including root wedging that form on the rock crack and fracture. In the study area, the biological weathering shown in figure 4.14.

Figure 4.12 :The result of physical weathering where some of the rocks were broken into smaller size

Figure 4.13 : The biological weathering of granite

4.2.4 Mass wasting

Mass wasting is the downslope movement of material under the influence of gravity and mass wasting phenomena can be linked to weathering processes. It is the geomorphic process by which soil, sand, regolith, and rock move downslope typically as a mass, largely under the force of gravity, but frequently affected by water and water content as in submarine environments and mudflows. In the study area, the mass wasting can be clearly seen on figure 4.14.

Figure 4.14 shows the example of mass wasting of rock at the study area

4.3 Stratighraphy

4.3.1 Lithology

The definition of lithology is the study of rocks and its physical properties. The lithologies found at the study area consist of all two types of rocks which are igneous, and sedimentary rocks.

Outcrop 1

Outcrop 1 is located at N 05° 30’ 04.8” E 102° 14’ 43.4” and elevation of 107 m. This outcrop is situated at the hilly landform. The outcrop was weathered as the fresh rock was difficult to be taken. This outcrop is about 500 metre from the road. Figure 4. 15 shows the outcrop taken with the scale.

Figure 4.15 : Outcrop at station 1

The hand specimen taken had characteristic of coarse grained that is phaneritic and rough surface. The color is brownish-blsck as weathering effect. The rock is hard when touch. The rock is identified as granite. From the hand specimen that had taken, the rock had composed of quartz,feldspar and biotite mineral. Biotite is in shiny black color while quartz shows shiny milky white in color and feldspar is in light grey in color. Figure 4.16 shows the hand specimen of rock at station 1.

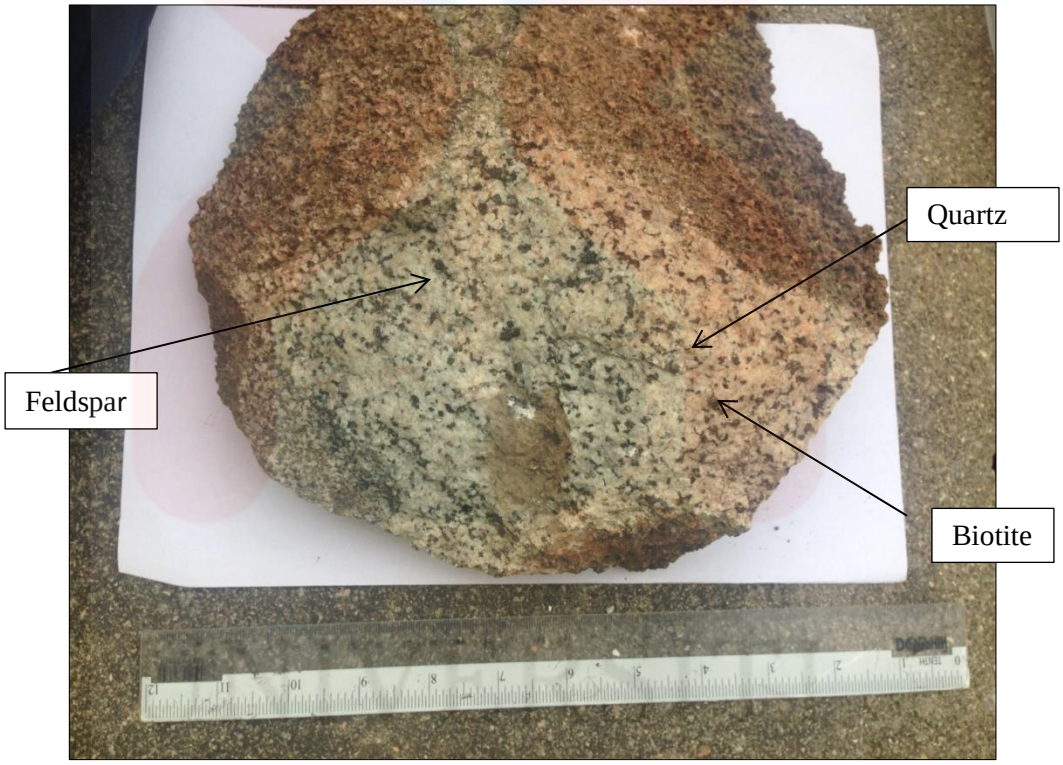


Figure 4.16 : The hand specimen of granite at station 1

The rock sample then was identified under the microscope. Under the microscope, a few mineral was identified. The minerals that can be identified under microscope were quartz, alkali feldspar, plagioclase and biotite. Figure 4.17 shows the image of mineral under microscope.

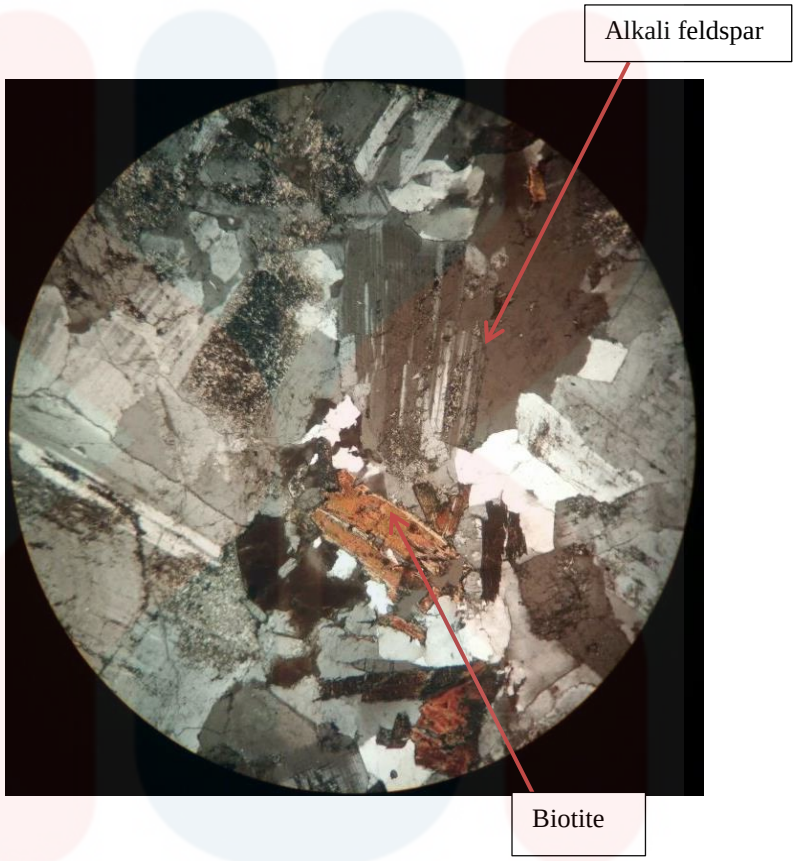


Figure 4.17 shows the granite under microscope 4 x 10 magnification in cross polarised

Outcrop 2

Outcrop 2 was located at N 05° 30’ 35.8” E 102° 13’ 26.0” at elevation of 60 metre. This outcrop was about 5m width and 2m height. The outcrop shows the existence of bedding. The measurements of bedding were taken to proceed with Rose diagram for bedding analysis. The outcrop was a natural outcrop.

Figure 4.18 :The outcrop of shale at the study area with coordinate N 05° 30’ 35.8” E 102° 13’ 26.0”

The hand specimen shows the color of blackish. From hand specimen, shale is a highly fissile rock, by it breaks up the rock into sheets. It has very fine grained and not visible to be seen by naked eyes. The rock is identified as shale. Figure 4.19 shows the hand specimen of the rock at station 2.

Figure 4.19 :The hand specimen of shale at station 2

From the microscope, the shale shows the clay mineral. It also shows some foliation on the shale. Figure 4.20 shows the image of shale under microscope.

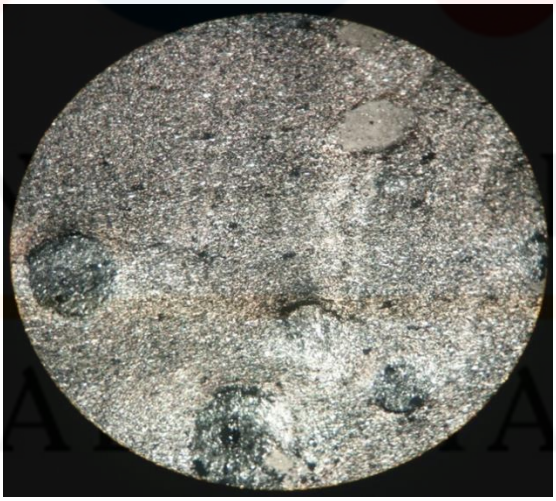


Figure 4.20 shows the shale under microscope 4 x 10 magnification

Station 3

Station 3 was located at N 05° 31’ 14.4” E 102° 13’ 01.7”. The elevation of this outcrop is 50 metre. The outcrop’s width was 15m and height of 5m. It is hill cutting outcrop. The outcrop is about 1 metre from the road. The outcrop shows the existence of joint. The measurements of joint were taken to proceed with the joint analysis. Another than that, this outcrop also shows some physical weathering.

Figure 4.21: The outcrop at station 3

The hand specimen that had taken shows the characteristics of very coarse grained and the color is greyish-black. The rock is hard to touch. The texture is classified as porphyritic. From the hand specimen, it was classified as andesite. Figure 4.22 shows the hand specimen of andesite at station 3.

Figure 4.22 shows the hand specimen at station 3

From the microscope, some of minerals that can identified were olivine and alkali feldspar. Not only that, heavy metal also were clearly seen under the microscope. Figure 4.23 shows the minerals under microscope.

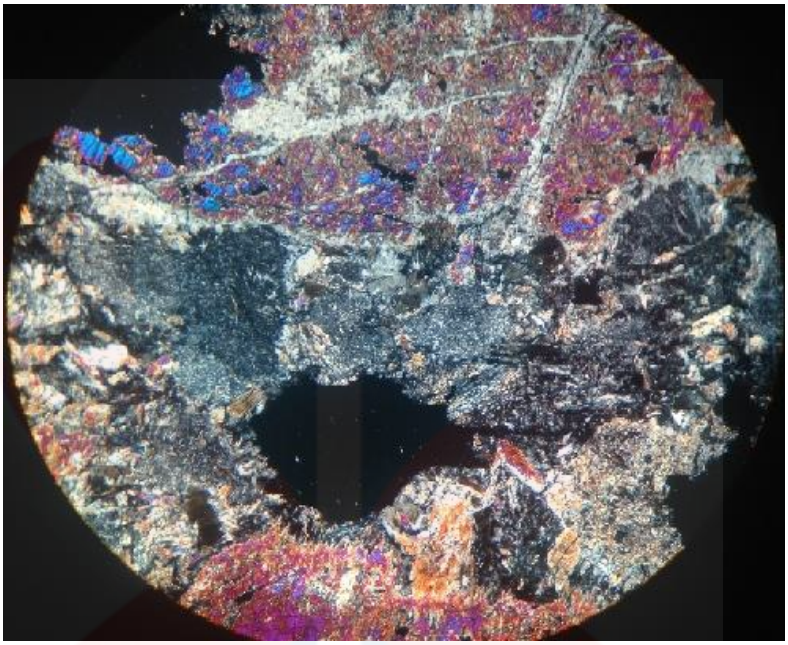


Figure 4.23: The mineral under microscope in 4 x 10 magnification

Station 4

Station 4 was located at N 05° 31’ 42.6” E102° 14’ 48.2”. It was located along the small river. The outcrop shows some physical weathering. It was known as granite outcrop. The image can be seen on figure 4.24. Morphology of the outcrop at low-lying plain.

Figure 4.24 : Outcrop at station 4

The hand specimen taken had characteristics of . The color is light brownish with black as weathering effect. The rock is hard to touch. The rock was identified as granite. It has coarse grained that can be seen by naked eyes. The hand specimen can be seen on figure 4.25.

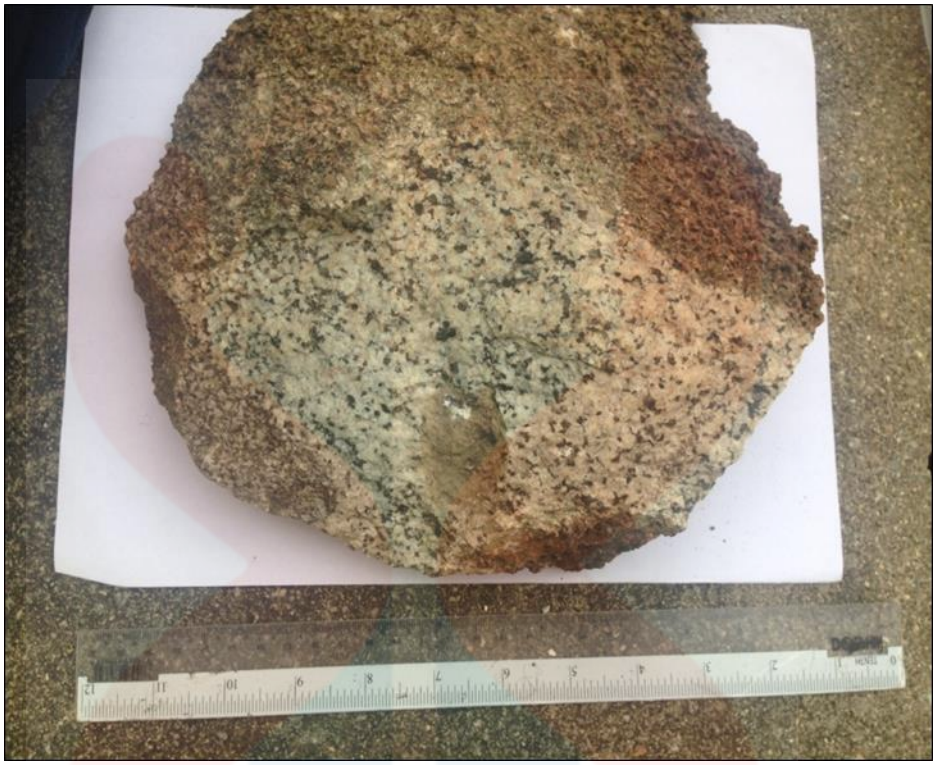


Figure 4.25 : The hand specimen of granite at station 4

Station 5

This outcrop was located at N 05° 30’ 22.0” E 102° 14’ 51.2” at elevation of 137 m. This outcrop is about 5 m width and 1 m height. It was hill cutting outcrop. Figure 4.26 shows the outcrop of the study area. It was shale outcrop and weathered.

Figure 4.26 : Outcrop at the study area with human scale

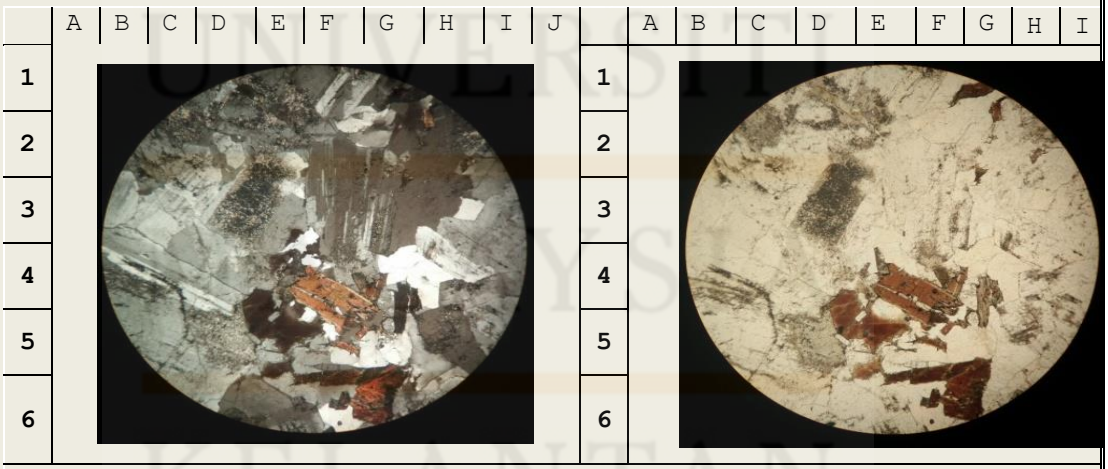
4.4 Petrographic analysis

Petrographic analysis was done on rock samples collected from the study area. This analysis is important in identifying the mineral composition of the rocks. The rock sample is made into thin section and was observed in cross polarized light (XPL) and plane polarized light (PPL).

Table 4.3 shows the description of the minerals (Travis, 1975)

Reference No. : Station 1 Location : Kampung Rahmat		Name of Rock: *Granite*
Rock Type **:** Plutonic Igneous Rock		
Classification **: Travis (1975)**		
Microscopic **:** The thin section showing greyish black color in cross polarized and brown color in plane polarized. Mineral shape is euhedral, grain size is mm with mineral composition of quartz, plagioclase		
Description of Mineralogy		
Composition of Mineral	***Amount (%)***	***Description of Optical Mineralogy***
Quartz 3H	**50**	Interference color is grey to white , absorption color is brownish-white, shape is prism, it shows medium relief, medium intensity, no pleochroism and grain size is about 0.1 – 1.5 mm.
Plagioclase 5F	**20**	Interference color is grey slightly lower than quartz, shape is subhedral
Biotite 4F	**15**	Interference color is brown ,Show single cleavage, have pleochroism, shape is euhedral degree of crystalline
Alkali feldspar 2G	**15**	Interference color is colourless, shape euhedral, low to moderate relief

Foto



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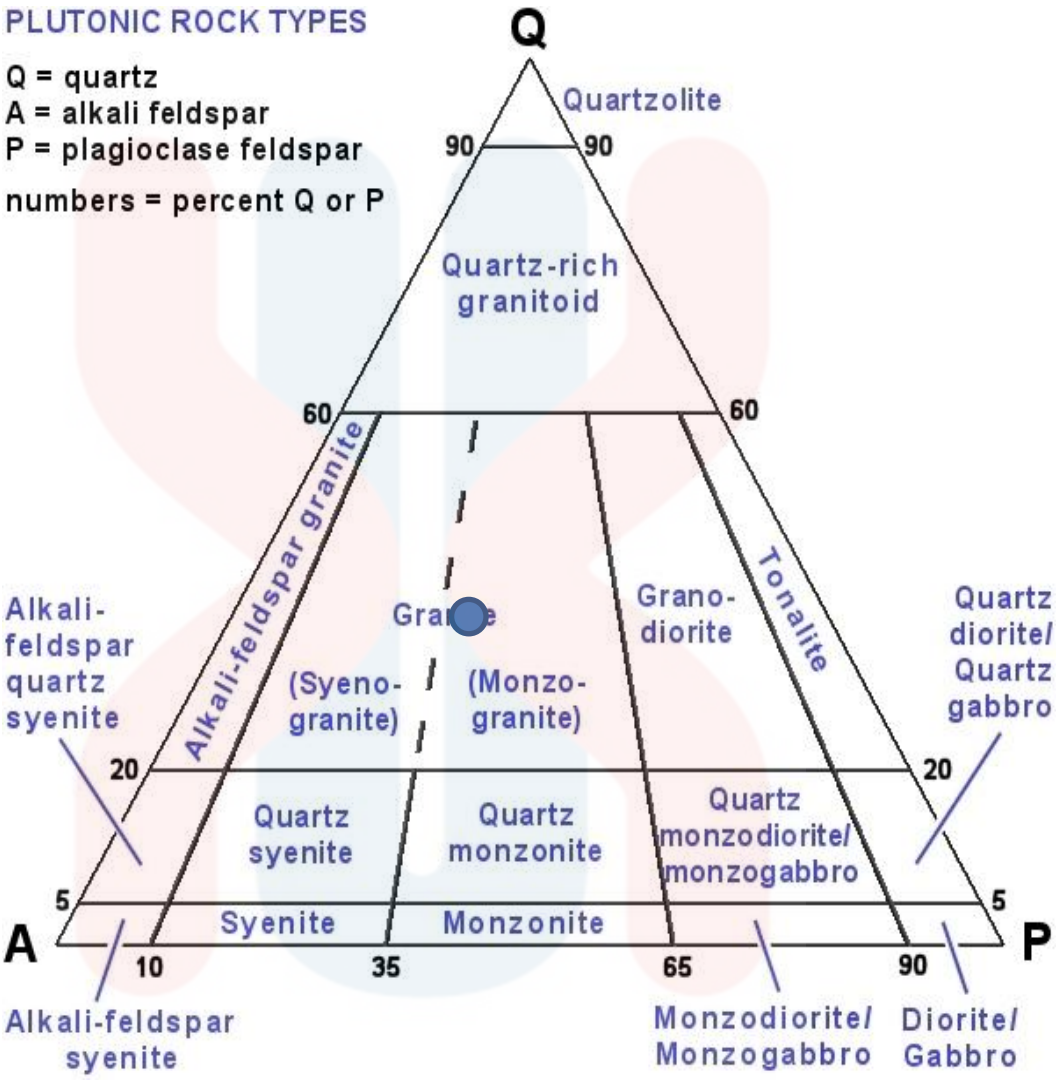


Figure 4.27 shows the QAP Triangle (Travis, 1955)

Reference No. : **Station 3**
Location : Kampung Rahmat Name of Rock: *Andesite porpyry*

Rock Type **:** Igneous Rock

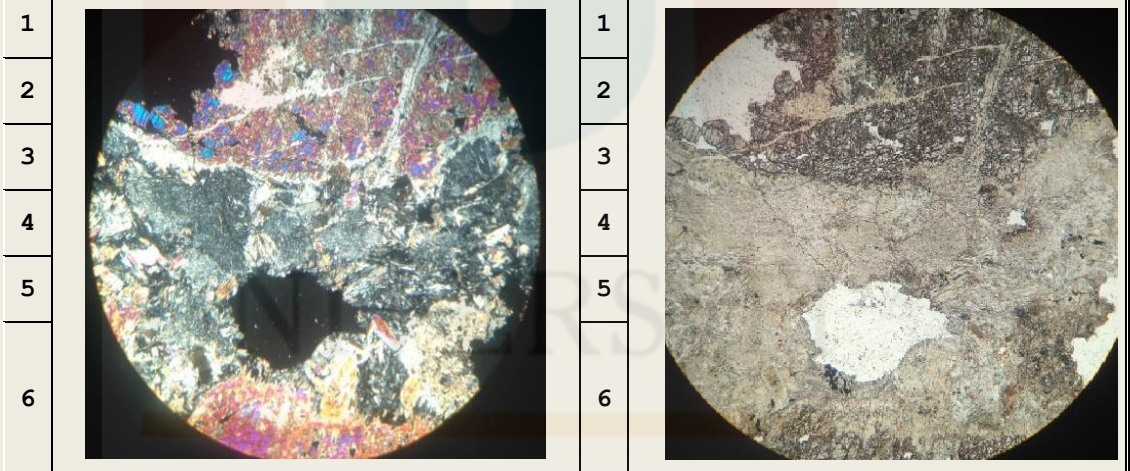
Classification **: Pettijohn (1975)**

Microscopic **:**
The mineral is believe in porphyry texture. It have heavy metal in the thin section.

Description of Mineralogy

Composition of Mineral	***Amount (%)***	***Description of Optical Mineralogy***
Olivine	**60**	Absorption color is brown, Interference color is pinkish, Subhedral-anhedral shape, high relief, high pleochroism, Grain size is about 0.2-3.125 mm.
Alkali feldspar	**20**	Absorption color is brown. Interference color is grey, euhedral
Heavy metal	**20**	Absorption color is white, Interference color is black, euhedral shape

Foto



//– Nikol *X – Nikol*

Next thin section is shale. Figure 4.28 is a photograph showing a petrographic thin section view of a finely shale. It can be seen lamination in this sample. The size is mostly clay sized.

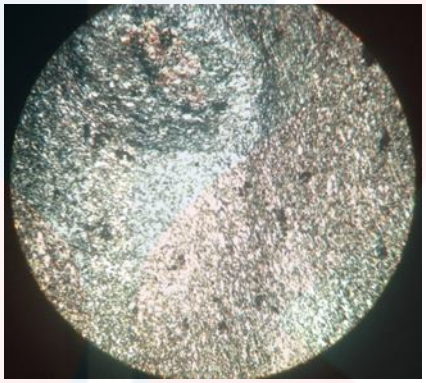


Figure 4.28: Thin section of shale

4.5 Structural Analysis

Structural analysis is the analysis done to further analyze and discuss about any deformation or changes brought about due to forces acting on continental blocks. Structural analysis that are usually observed and analysed include faults, folds, beddings, joints and fractures, foliations as well as lineament analysis (Christopher et al., 1981). In this study, structural analysis is confined to lineament, fracture, bedding analysis and joint analysis only due to absence of other observable structure at the study area.

4.5.1 Lineament Analysis

Lineament is the straight linear or clear features that are observed on the surface of the earth with measurable azimuth, width and end points. The lineament analysis is about the study of straight lines or study of lineament on map, aeriel photos or model of the earth's surface. Lineaments are controlled by few factors such as geologic trends and structure of the Earth.

Apart from that, lineaments usually reflects few structures such as faults, fractures and folds. Lineaments was drawn on the screen of a computer. This measurements were taken to identify the compression and extension force. According to Christopher et., al, 1981, the GeoRose v. 7.1 is a software to plot the rose diagrams.

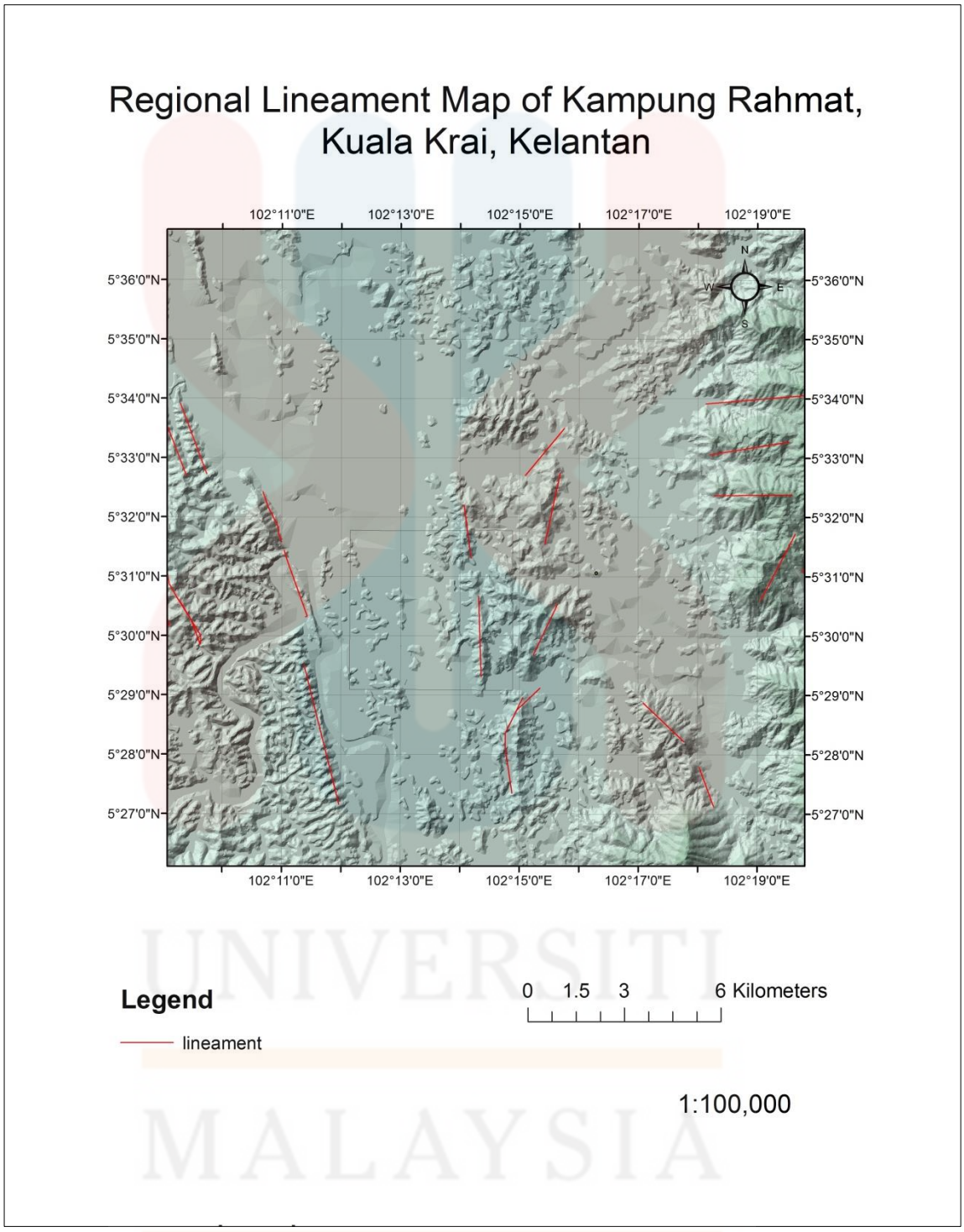


Figure 4.29 : Regional Lineament Map of the study area

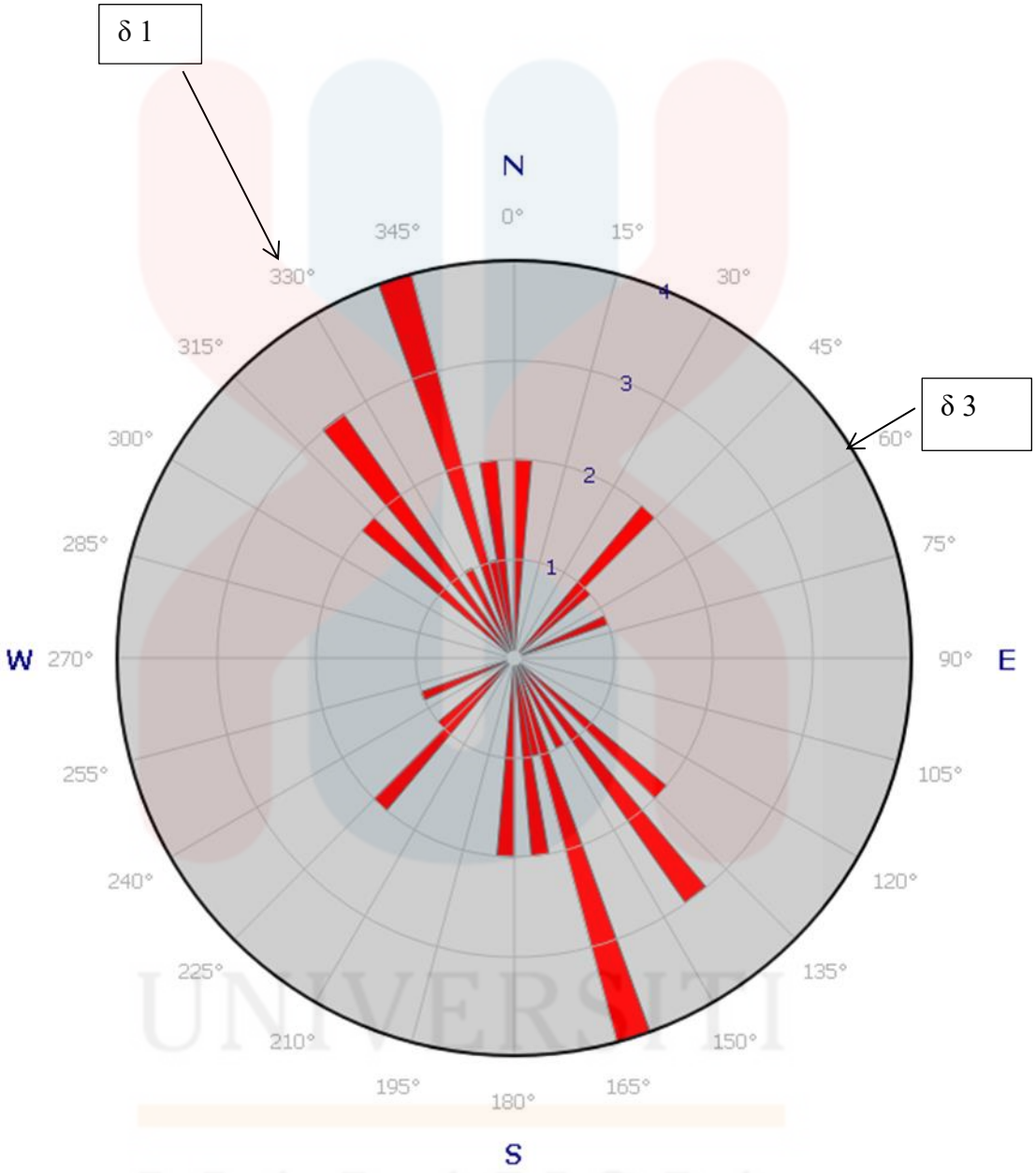


Figure 4.30 shows the rose diagram of the lineament

From the above rose diagram, the maximum force was applied from the North-West direction.

4.5.2 Joint Analysis

Joints is a fracture in rock and is similar to a fault, except that in a joint rocks on either side of the fracture have not moved. Joints develop during the exhumation of rocks following erosion of the overburden. Joints result from contraction and expansion due to cooling and decompression respectively (Christopher *et* al., 1981). A group of joint is known as joint set. Joint is important in structural geology because joint can lead the pathway of water flow. Joint analysis is done on the major outcrops found at the study area. The direction of force is represented by the arrows. The rose diagram was analyzed at figure 4.31. Figure 4.32 shows the joint at the outcrop. From the rose diagram, the maximum force was applied from West East direction.

Table 4.4 : Strike measurements at study area 1

Bearing	**Frequency**
0-90°	2
91-180°	14
181-270°	14
271-360°	20

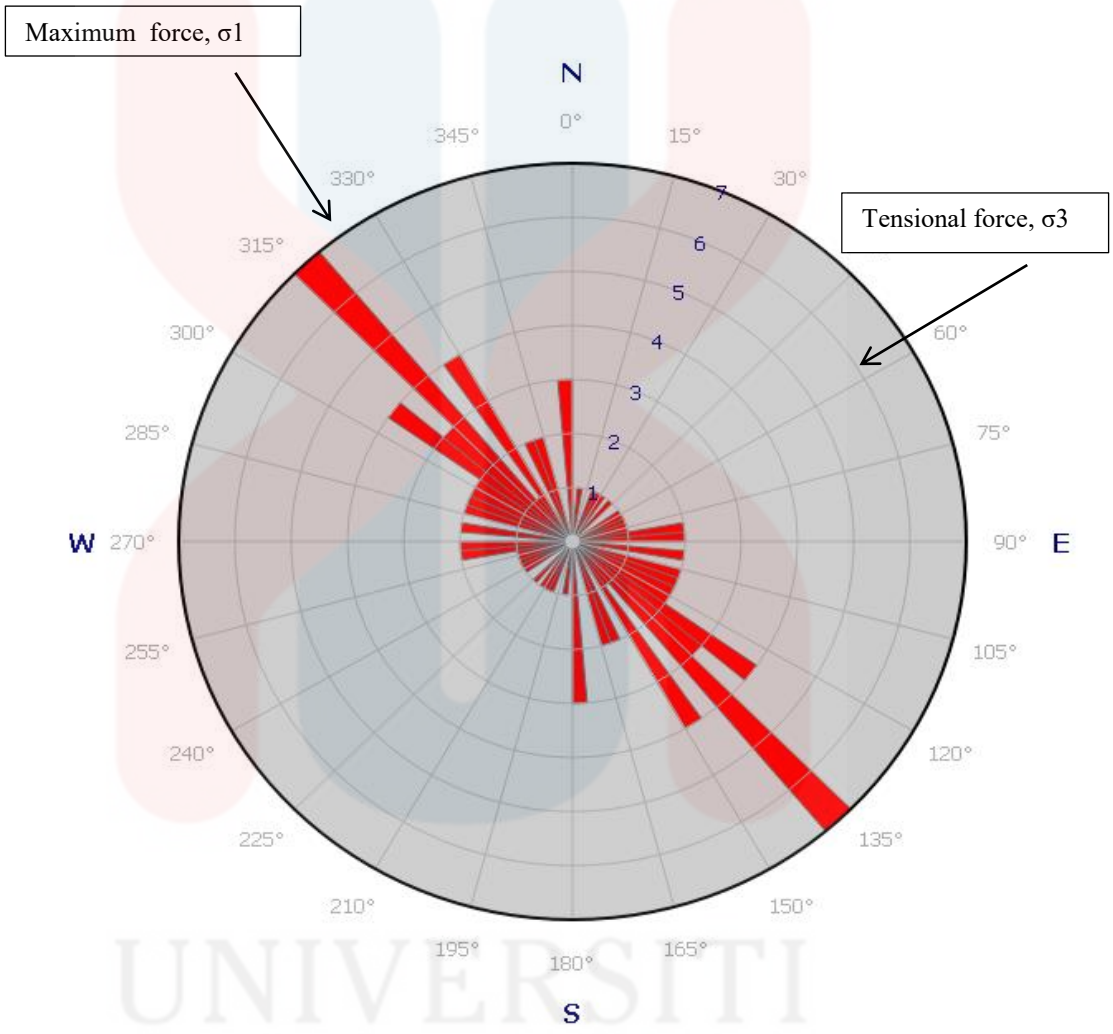


Figure 4.31 shows the joint analysis in the form of rose diagram of outcrop arrows show the direction of force.

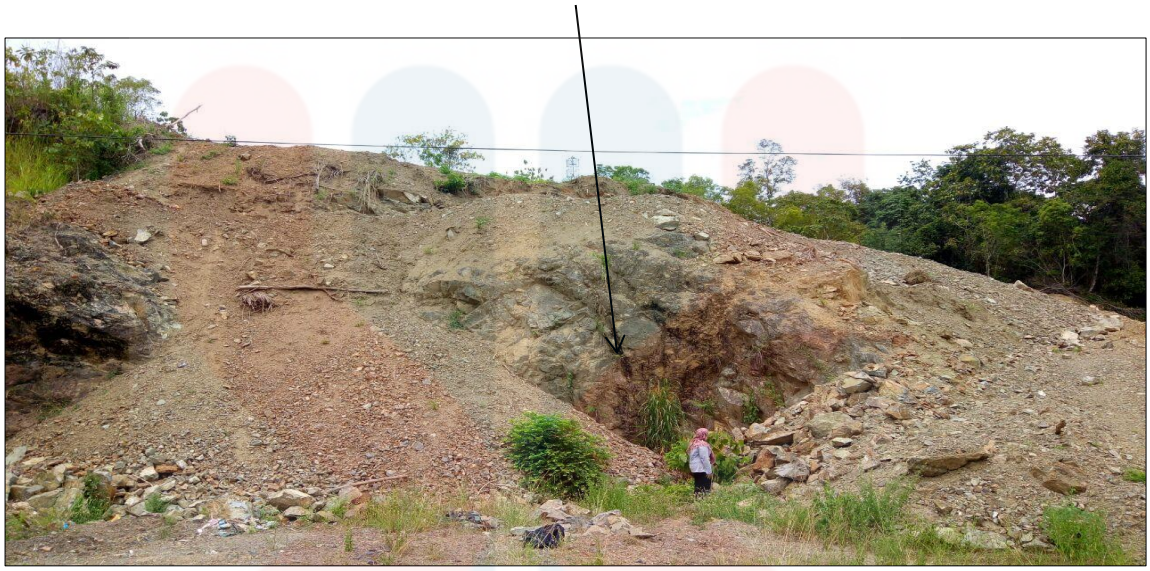


Figure 4.32: The joint on the rock of the andesite

b) Bedding analysis

The surface of the bed is usually in parallel or horizontal plane when the sediments starts to deposit. This surface then created a boundary between tha layers, or different bedded sediments from each other in the form of texture and composition. The rock that was deposited first is older than the rock that was newly deposited. Figure 4.34 shows the bedding of shale. The orientation is from West East direction.

Table 4.5 : Strike measurement of the bedding

Bearing	Frequency
0-90°	3
91-180°	9
181-270°	10
271-360°	16

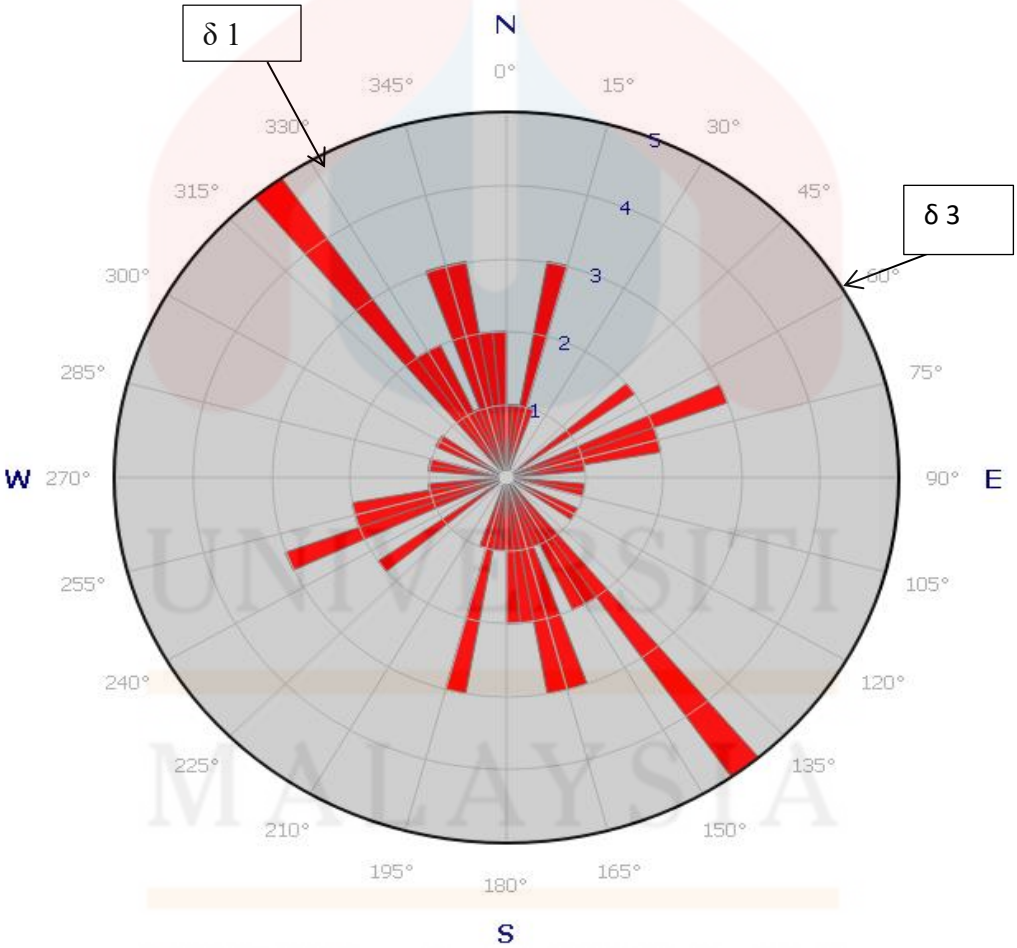


Figure 4.33 : The rose diagram shows the major orientation of the bedding at WE direction

Figure 4.34 : Bedding occur on the outcrop

c) Fracture analysis

Fractures are discontinuities in displacement and mechanical properties where rocks or minerals are broken, and reduction or loss of cohesion. Table 4.6 shows the strike measurements of the fracture at the study area. From the rose digram at figure 4.35 that had plotted, the maximum force was on North West direction. Figure 4.36 shown the image of fracture at the study area.

Table 4.6 : Strike measurements at the study area 2

Bearing	Frequency
0-90°	40
91-180°	14
181-270°	21
271-360°	5

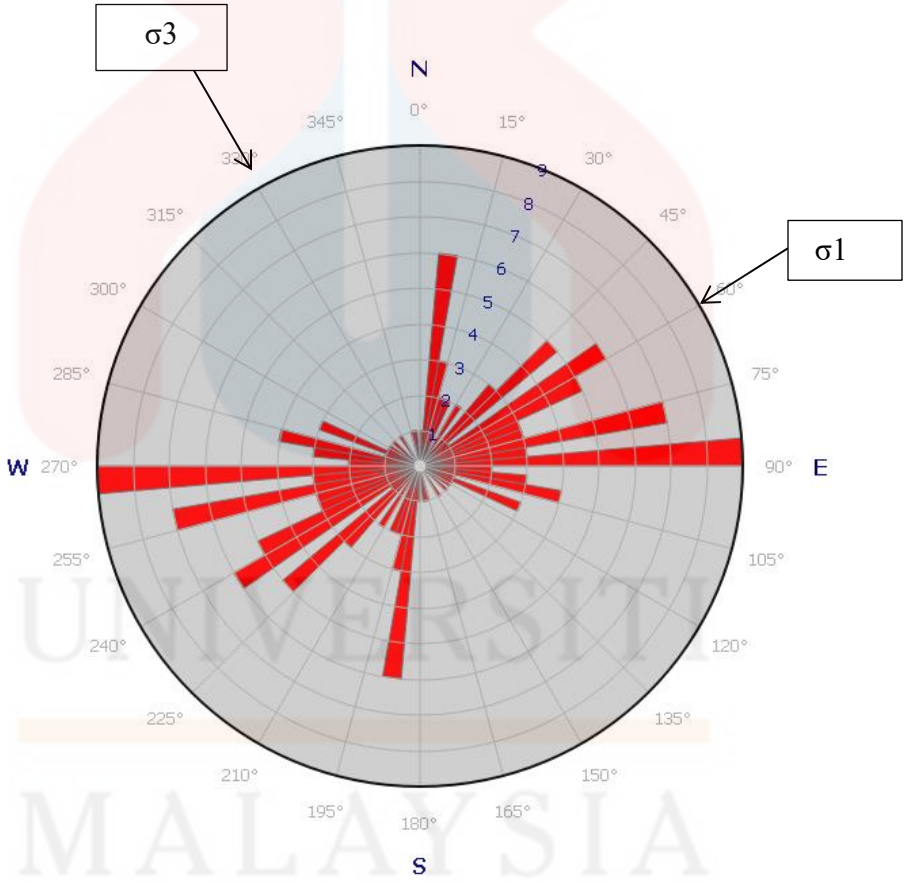


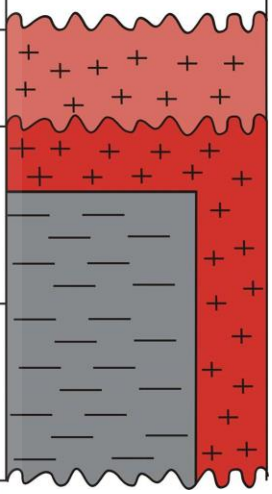
Figure 4.35 shows the rose diagram for the fracture

Figure 4.36 : The fracture found on the outcrop of the study area

4.6 Historical Geology

In the study area comprise of three periods which are from Permian, Triassic, Cretaceous and Quartenary. Table 4.7 shows the stratigraphic column of the study area. From the study area, it have three different lithologies that are andesite, granite and shale. According to the lithology that had found, the older rock was shale, then followed by granite. The eldest rock was andesite porphyry. Figure 4.37 shows the geological map that had been update.

Table 4.7: Stratigraphic Column of Kampung Rahmat, Kuala Krai, Kelantan

ERATHERN	SYSTEM	LITHOLOGY	STRATA
CENOZOIC	QUATERNARY	ALLUVIUM	
MESOZOIC	CRETACEOUS	ANDESITE PORPHYRY	
	TRIASSIC	GRANITE	
PALEOZOIC	PERMIAN	SHALE	

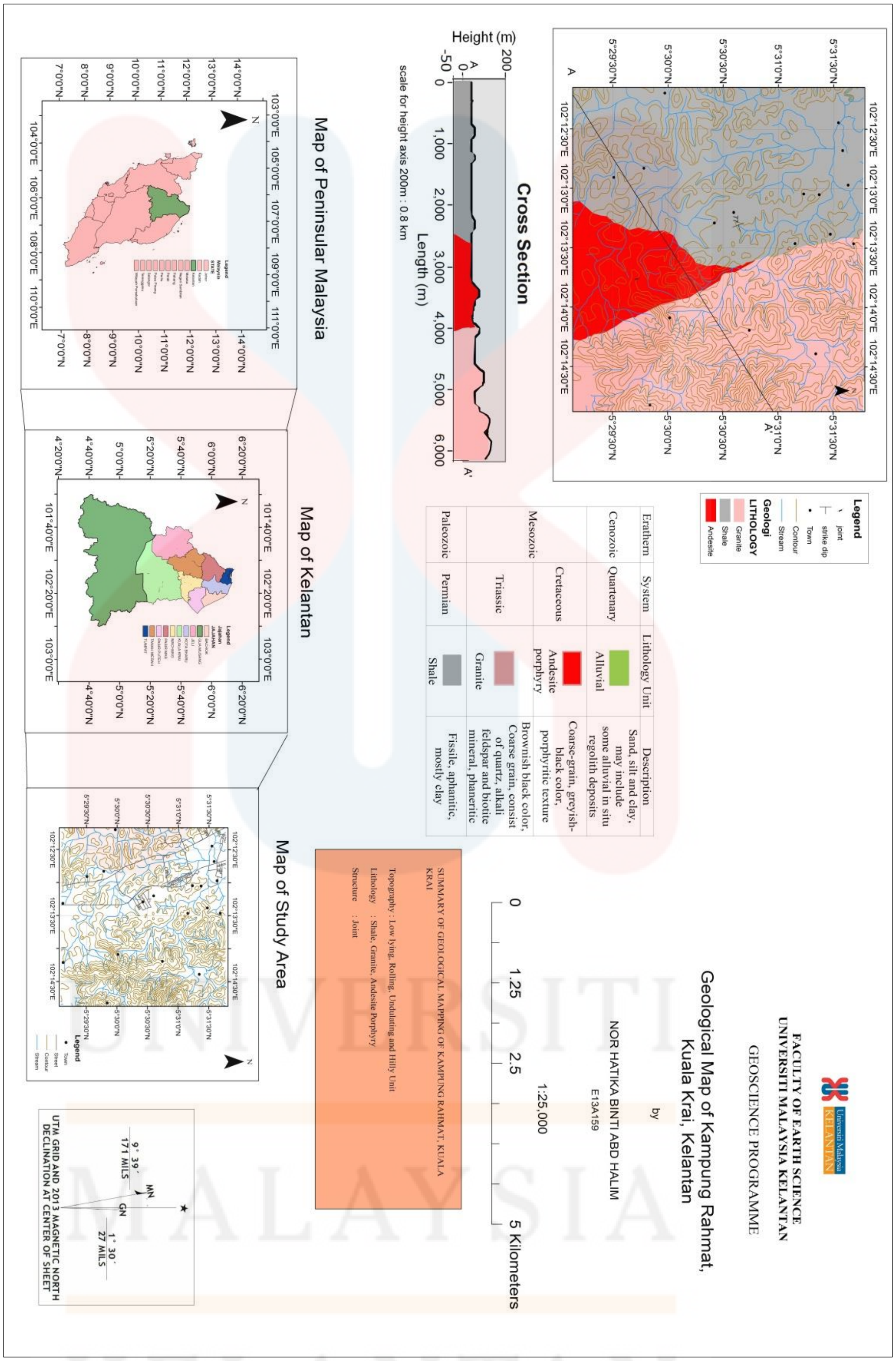


Figure 4.37 : Geological Map of the study area

CHAPTER 5

GEOPHYSICAL INVESTIGATION OF POTENTIAL GROUNDWATER

5.1 Introduction

In this chapter explains on the geophysical investigation using the electrical resistivity method (ERI). The locations and interpretations of each horizontal line was discussed in detail. Other than that, these also include the determining of the existence of potential groundwater and identifying its depth from surface. The physical properties of groundwater was identified.

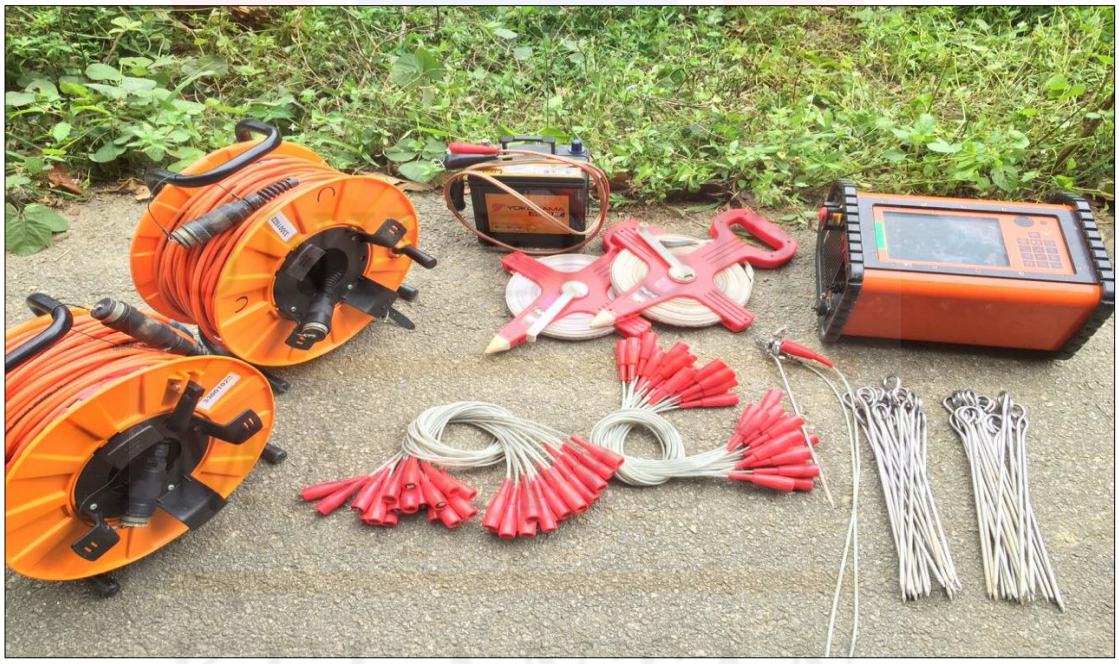


Figure 5.1 : The instruments of the electrical resistivity method

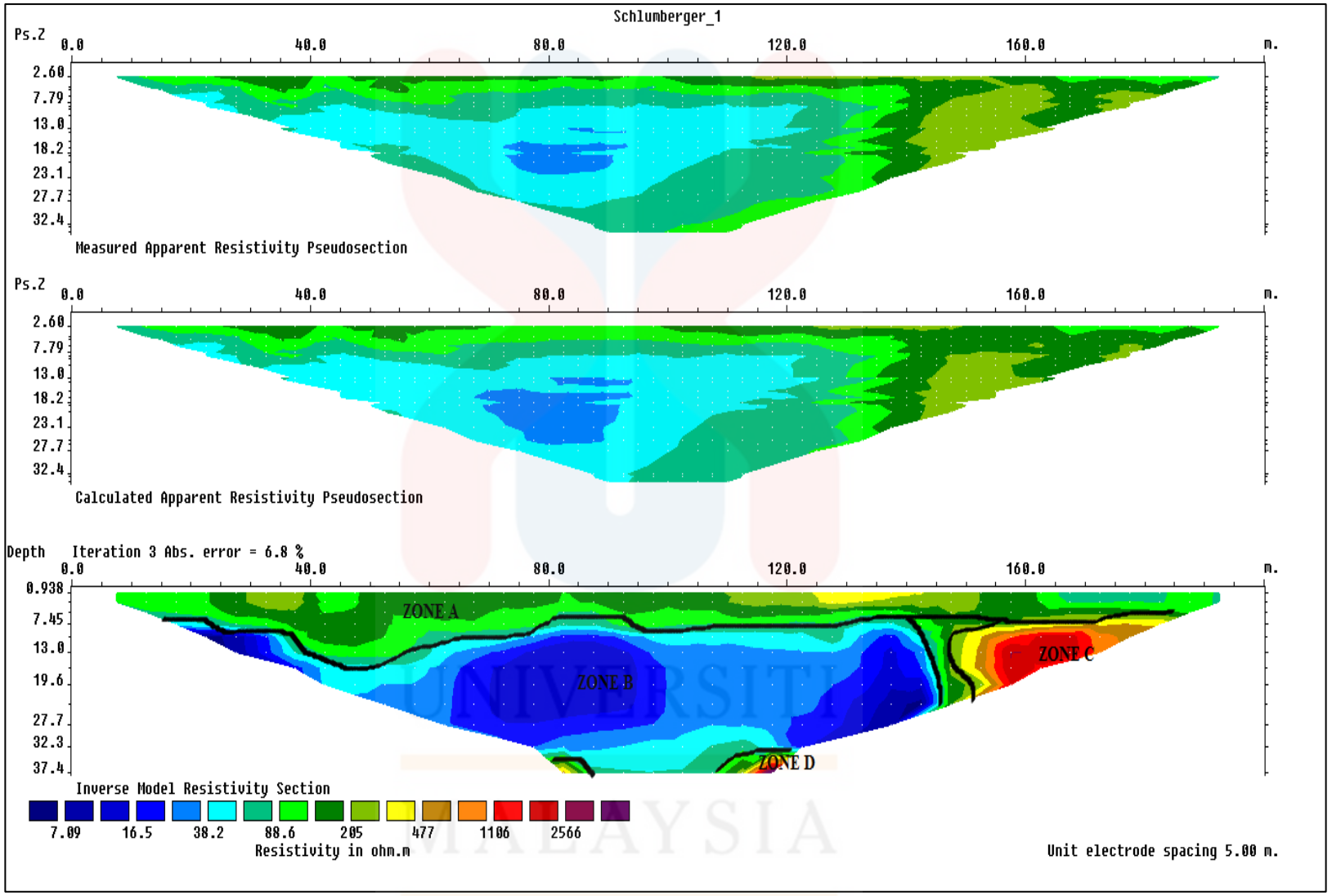
5.2 Location of Horizontal Line.

For the electrical survey in this research, only one line of horizontal line was used. This is because during this research, the instrument was broken. The location of the chosen line was chosen based on the type of rock that had found and the well that found on the nearby area. The best time of conducting the resistivity method is around in the morning.

The horizontal line-1 is located at N 05° 31’ 03.4” and E 102° 14’ 18.7” with elevation at 61m. Figure 5.2 shows the resistivity configuration at the site while figure 5.3 shows the instrument at the centre of the line.

Figure 5.2: Resistivity Configuration Used at Site (Schlumberger Array)

Figure 5.3 : The instrument at the centre of the line



5.3 Interpretation of Subsurface

Survey Line 1.

The image that produced by RES2DINV software from the lines was interpreted and discussed. The resistivity values that obtained was compared from the resistivity values of previously established researchers. For survey line 1, total length of 200 metre was done at location N 05° 31' 03.4" E 102° 14' 18.7". The electrode spacing for survey line was 44m. From the survey line 1, there were four zones were identified for the interpretation. Zone A has the resistivity value of 88.6 to 205 Ω m with depth of 0-13 metre. Zone A can be interpreted as metamorphic rocks / weathered layer.

For the zone B, the resistivity range was from 7 to 38.2 Ω m with depth of 7 to 35 metre. Zone B was interpreted as sandstone. Zone C has the resistivity range from 477 to 2566 Ω m. The depth of zone C was from 13 to 19 metre. Zone D was the igneous bedrock. Hence, zone D have the highest resistivity range that was from 477 to 2566 Ω m.

5.4 Well water depth parameter

There is some additional parameter was taken due to the electrical resistivity (ER) was broken during the survey. Hence, the reading of well depth was taken in order to know the underground potential of water. The help of the well depth reading can give the peziometric level. The reading of well depth parameter as shown in table 5.1.

Table 5.1: Measurement of well depth

	Reading of well water depth parameter				
Well no.	W1	W2	W3	W4	W5
Coordinate	N 05° 31’ 04.3” E 102° 14’ 19.2”	N 05° 30’ 55.3” E 102° 14’ 14.6”	N 05° 30’ 55.8” E 102° 14’ 15.3	N 05° 31’ 02.5” E 102° 13’ 56.4”	N 05° 30’ 57.9” E 102° 13’ 52.2”
Elevation (meter)	26	53	54	43	45
Water Level (meter)	1.44	0.60	0.50	2.2	1.13
Water Depth (meter)	4.65	3.84	1.52	5	4.77
Well Height (meter)	0.79	0.20	0.20	0.70	0.60

There are five wells with different coordinates were taken at the study area. At well 1, the coordinate is N 05° 31’ 04.3” E 102° 14’ 19.2” and the elevation is 26 m. The water level is 1.44 m. For the measurement of well water depth in well 1 is 4.65 m and the well height is 0.79 m.

For the well 2, the coordinate is N 05° 30’ 55.3” E 102° 14’ 14.6” and the elevation is 53 m. From the measurement at the field, the water level of well is 0.60 m. The well water depth that had taken in well 2 is 3.84 m while the well height is 0.20 m.

Next, for the well 3, the coordinate is N 05° 30’ 55.8” E 102° 14’ 15.3 and the elevation is 54 m. In well 3, the well water level is 0.50 m and the well water depth is 1.52 m. Then, the well height for well 3 is 0.20 m.

For the well 4, the coordinate is N 05° 31’ 02.5” E 102° 13’ 56.4” and the elevation is 43 m. The well water level reading is 2.2 m while the well water depth is 5 m. Then, the well height that had taken is 0.70 m.

Lastly, for the well 5, the coordinate is N 05° 30’ 57.9” E 102° 13’ 52.2” and the elevation is 45 m. For the well water level, the reading from the water depth meter is 1.13 m. The well water depth is 4.77 m. Then, the well height is 0.60 m.

The water level map was produced. The water level map was to know water flow at the study area from the water well depth parameter. From the water level map in figure 5.4, its shows that the water flow from the high elevation to the low elevation. Figure 5.5 and 5.6 show the measurement of well water depth. The well distribution map can be see on figure 5.7.

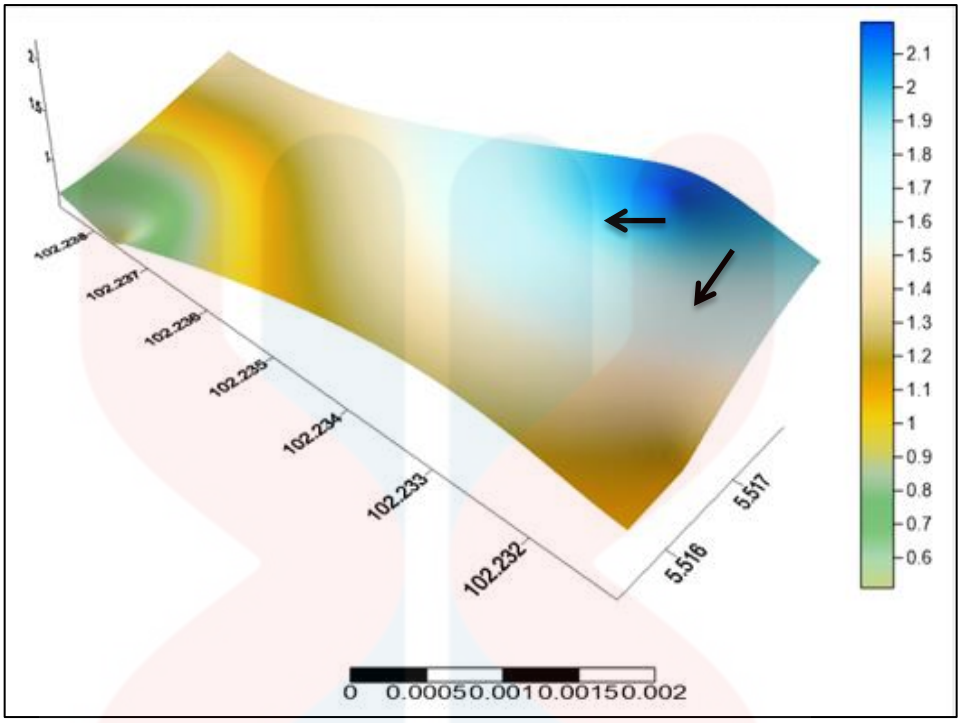


Figure 5.4 : Water Level Map

Figure 5.5 shows the measurement of water level depth using water depth meter

Figure 5.6 shows the measurement of well water depth

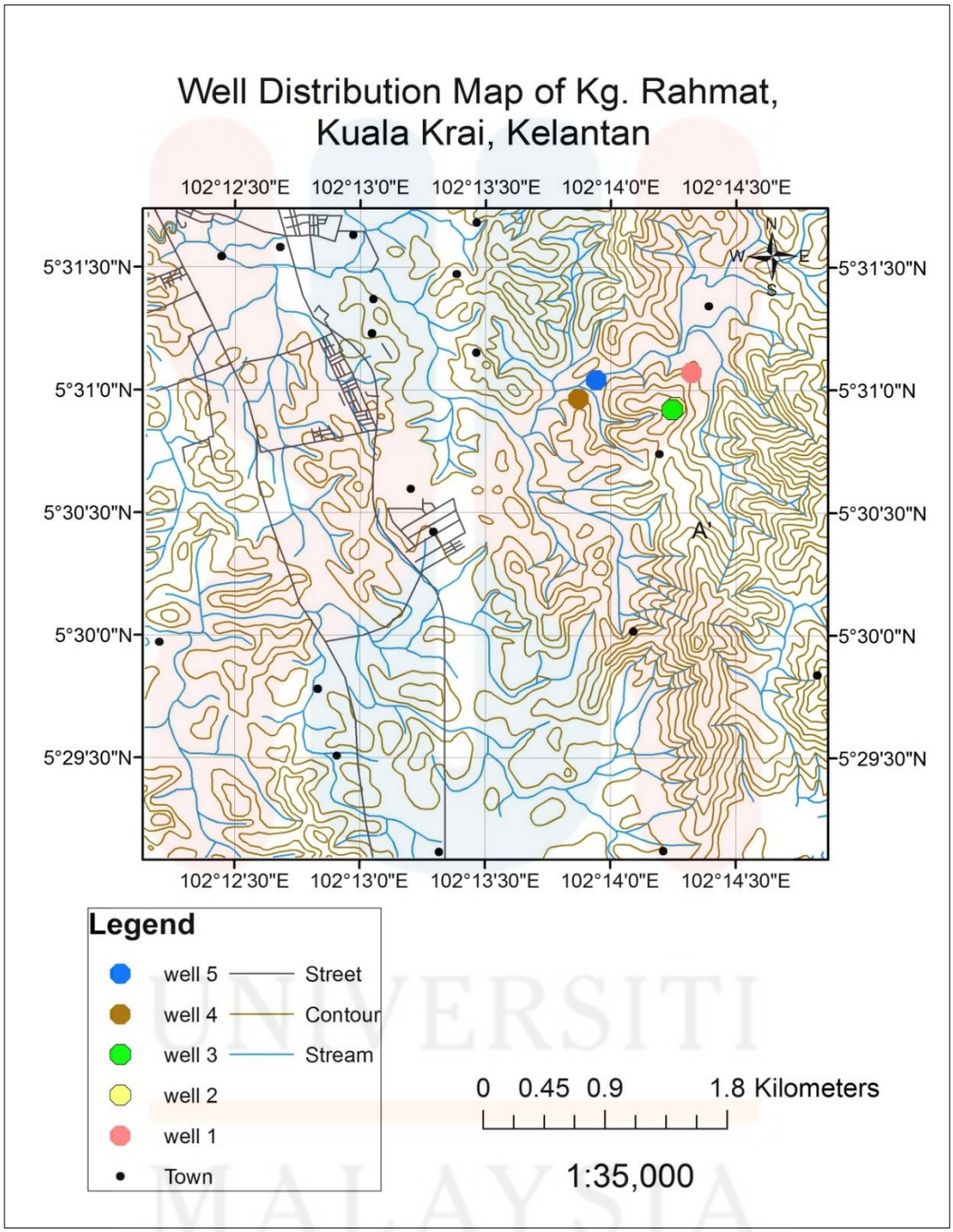


Figure 5.7 shows the Well Distribution Map at the study area.

5.5 Physical Properties of Groundwater

The physical properties of groundwater are measure in field by different parameters including pH, Electrical Conductivity, Total Dissolved Solids (TDS), Turbidity and Temperature. Table 5.2 shows all the values of in situ parameter in the study area.

Table 5.2 shows In-situ or Physical Parameter of Groundwater Samples.

Well No.	Temperature (°C)	pH	Electrical Conductivity (µS/cm)	TDS (mg/L)	Turbidity (NTU)
1	26.3	5.54	88	56	2.17
2	25.8	5.56	86	42	7.56
3	25.4	5.91	142	93	8.4
4	21.6	6.26	187	31	10.3
5	26.4	6.16	135	35	6.0

5.5.1 Physical Parameter

A) Temperature

The degree or intensity of heat that present in substances or objects is the definition of temperature. The highest temperature is 26.4 °C in well 5 while the lowest temperature is 21.6 °C that is in well 4. The temperature was measured in warmth or coldness of an objects or substances with the reference of standard value.

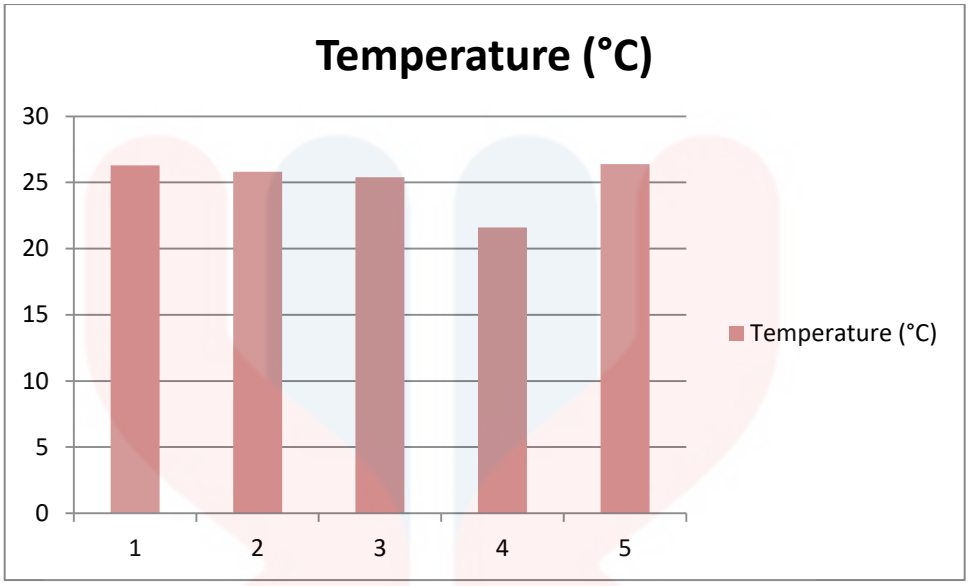


Figure 5.8 shows the value of Temperature (°C)

B) pH (Hydrogen Ion Concentration)

pH is known as Hydrogen Ion Concentration. The value of pH indicates the acidity of water samples. From the reading that had taken, well 4 give the high pH that is 6.26 while the lowest pH is from well 1 that is 5.54. The pH value can measure the acidity and alkalinity of the water. The measurements for the scale that is below than 7.0 are considered as acid while 7.0 to 14.0 are considered alkaline and 7.0 is neutral reading. From the water in the wells, the run scale shows the reading of acidic. The reaction of water in shallow aquifer will decrease the pH.

According to Timothy M.Kresse, 2012, the amount of plant growth and organic materials within the water body had affect the pH value. Another than that, the factors that affected the pH of body of water is the water moves through bedrock and soil composition, both in its beds and as groundwater. As an example, granite have no effect to pH while limestone can neutralize the acid.

Figure 5.9 shows the value of pH

C) Electrical Conductivity

Electrical conductivity is the ability of water pass through the electric flow. The factors that affect the ability of water to conduct electricity are concentration and types of disolved materials that presents. Based on table 5.2, the highest value of the electric conductivity is 187 µS/cm that is in well 4 while the lowest electric conductivity is 86 µS/cm that is in well 2. The value of electric conductivity that had obtained from the all wells indicates the low conductivity.

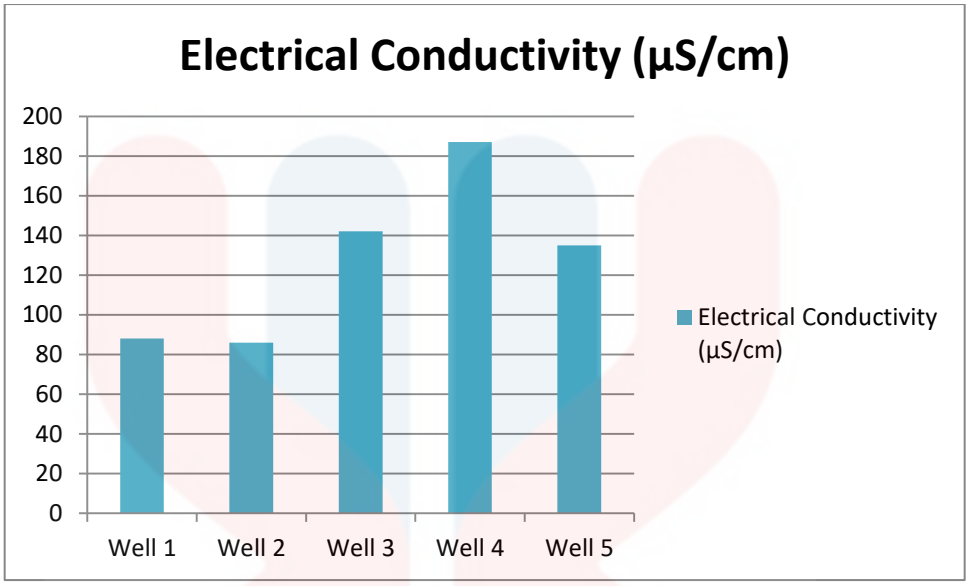


Figure 5.10 shows the value of Electrical Conductivity (µS/cm)

Table 5.3 shows the Classification of Electric Conductivity (Suzannah, 2007) and classification of groundwater based on drinking purpose.

Class	EC (µS/cm)	Sample
Low Conductivity	<500	All sample
Medium Conductivity, Class 1	500-1000	-
Medium Conductivity, Class 2	1000-3000	-
Medium Conductivity, Class 3	>3000	0

D) Total Dissolved Solid (TDS)

Total dissolved solid (TDS) is measure in milligrams per liter to measures the water quality. There are several factors that affect the TDS level at the study area which are the geology of the region, climate, weathering and geological features. According the World Health Organization, 2003, the geological features had affected the dissolved materials and transported to the water system. Calcium, magnesium, sodium, potassium cations, carbonate, hydrogen carbonate, chloride and sulfate anions are the solutes in TDS. From the table 5.2, the highest TDS value can be see in well 3 that is 93 mg/L while the lowest value is from well 4 that is 31 mg/L. Table 5.3 shows the TDS classification of groundwater samples by Suzannah, 2007. Based on the classification, all the water samples are classify as fresh water which is below 1000 mg/L.

Table 5.4 shows the TDS classification of groundwater samples (Suzannah, 2007).

Water Class	**TDS (mg/L)**	**Well**
Fresh	<1000	All wells
Brackish	1000-10000	0
Saline water	10000-100000	0
Brine water	>1000000	0

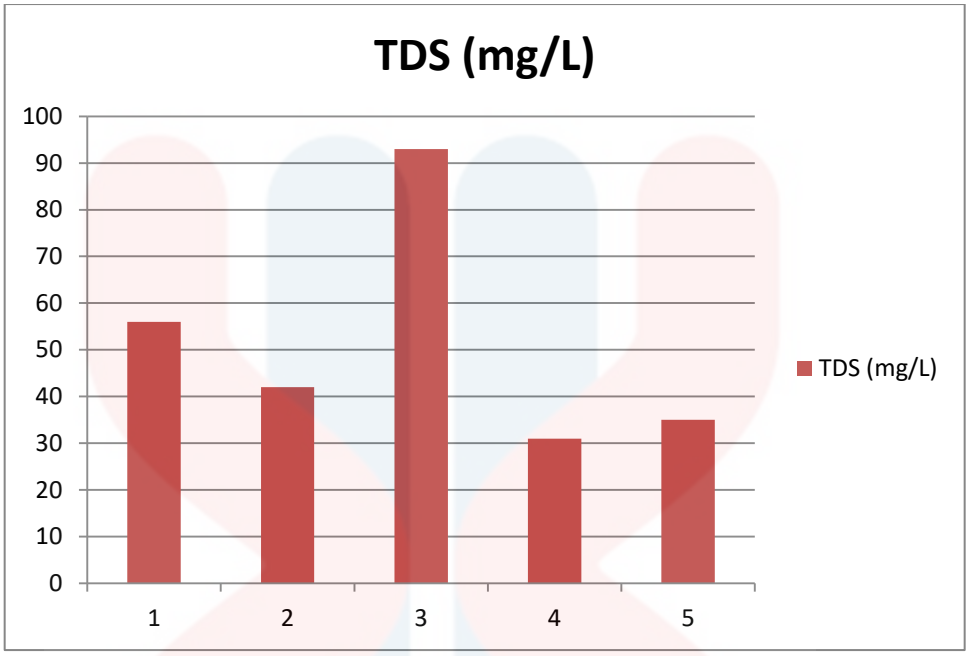


Figure 5.11 shows the value of Total Dissolved Solids (TDS)

E) Turbidity

Turbidity is the cloudiness of a fluid that caused by suspended solids and can be seen by naked eyes. The water that is cloudy shows the high turbidity while the water that is crystal clear and very suspended solid shows the low turbidity. Turbidity is measured for the water quality purpose in the units Nephelometric turbidity unit (NTU) because the measurements cannot in milligram per liter (mg/L). From the samples that had taken, well 4 shows the high turbidity that is 10.3 NTU while the lowest turbidity is in well 1 that is 2.17 NTU.

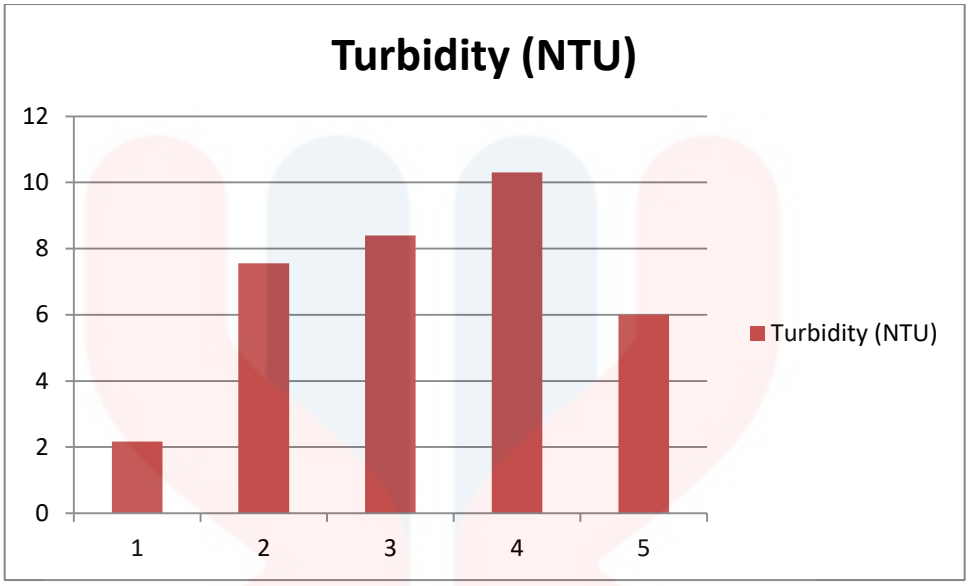


Figure 5.12 shows the value of turbidity

5.6 Discussion

Based on the interpretation of survey line 1, the zone B was identified to be the groundwater potential. The sedimentary rock which is in this site was shale, usually are more porous and have higher water content. Other than that, sedimentary rocks normally have lower resistivity values compared to igneous and metamorphic rocks. There were few factors that gave the resistivity value such as porosity of the rocks and the water contained. The resistivity value for unconsolidated sediments was from less than 10 Ωm to 1000 Ωm.

Next, for the igneous and metamorphic rocks, the resistivity values usually high. This is due to few factors such the degree of fracturing and the percentage of the fractures filled with groundwater. The resistivity value was from 1000 to 10 million

Ωm. These high values was depending on wet or dry rock type. In order to detect the fracture zone and other weathering features, this characteristics was very useful.

Normally groundwater is within 100 metres of the surface of the Earth. The potential of groundwater has low resistivity because it can highly conduct electricity. From the interpretation of the subsurface, the groundwater potential is found within depth of 7 to 37 metres. Groundwater can be in unconfined aquifer that is means does not have confining layer between it and surface.

The result from the interpretation of the subsurface was similar to groundwater potential as it does not have bedrock that have the high resistivity value on the lower and upper part. Besides that, the climate and weather also can give the influence during the electrical resistivity survey. During the survey at the study area, the weather was good. Hence, the results were good.

For the in-situ parameter, the physical properties was determined. The different parameters including Total Dissolved Solids (TDS), Turbidity, Electric Conductivity, pH and Temperature. The highest temperature in the well is at 26.4°C. For the TDS, the highest result is 93 mg/L and for the turbidity is 10.3 NTU. The highest value for Electric Conductivity is 187 μS/cm and for pH is 6.26.

CHAPTER 6

CONCLUSION AND SUGGESTIONS

6.1 Introduction

This chapter was the final chapter in this thesis writing. It mainly concludes all the methods, experiments, data and results obtained during the period this research was conducted. In this chapter, data, errors and recommendations for future research will be suggested and discussed.

6.2 Conclusion

As a conclusion for this Final Year Project studies, based on the mapping study at Kampung Rahmat, Kuala Krai, Kelantan, there were there different lithologies at the study area. The lithology that presence are igneous rock that are granite and andesite porphyry and sedimentary rock that is shale. The study area is filled with a lot of drainage system and possible to contribute for groundwater potential. The pattern of drainage is classified as dentritic. The electrical resistivity imaging in this study has been successfully used to detect the potential of groundwater at the study area. Besides that, the depth of aquifer also was determined that are 37 metre depth. Then, the reading of well water depth parameter was taken to know the detail about underground potential of water. The readings of well water depth parameters of five wells were taken as the

additional parameters. Another than that, the physical properties of groundwater was able to identify using the in-situ parameter. The different parameters was measured in the field including the Electric Conductivity, Total Dissolved Solids (TDS), Turbidity, Temperature and pH.

6.3 Suggestions

This research was able to investigate the groundwater potential in the subsurface and the depth of aquifer was determined. Besides that, more survey line resistivity need to be done to gain more detail about the area. The further investigation should be continue as it benefits the community of Kampung Rahmat. For example, the drilling purpose can be do here to further investigation. Another than that, the groundwater analysis should be done at the study area because aquifer tend easily to have contamination.

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