Geology and Hydrological Potential of Kampung Wakaf Raja, Pasir Puteh, Kelantan

By

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DEDICATION

TO MY BELOVED MOTHER AND FATHER

THANK YOU

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LIST OF SYMBOLS

% - Percentage

'– Seconds

"– Minutes

o – Degree

Ω m – Ohm meters

LIST OF ABBREVIATION

2D – 2 Dimensional

3D – 3 Dimensional

Bt. – Bukit

cm – Centimeters

E – East

ERI – Electrical Resistivity Imaging

km – Kilometers

m – Meters

mm – Millimeters

N – North

NE – North East

NNW – North North-West

NW – North West

S – South

SE – South East

SSE – South South-East

W – West

Geology and Hydrological Potential at Kg. Wakaf Raja, Pasir Puteh, Kelantan

ABSTRACT

Geological research includes geological structure, geomorphology, lithology and petrography in Kg. Wakaf Raja, Pasir Puteh, Kelantan located at the coordinate of N 05˚ 44' to N 05˚ 47' and E 102˚ 23' to E 102˚ 26'. The objectives for this research are to update the current geological map of the area and to determine the hydrological potential of the study area using electrical resistivity survey. The hydrological potential sources at an accurate location and depth can be determine the geology condition of that area and can be interpreted by using data obtained from resistivity survey. The analysis begins with the chosen horizontal line for collecting the resistivity data from ABEM Terrameter LS and LUND cable with electrodes. The data then was analyzed by using the RES2DINV software and the results of the analysis was represented in 2 – dimensional image. Schlumberger and Wenner array was used to identify the subsurface condition that is potential groundwater sources with the resistivity values ranging from 1 Ω meters to 95 Ω meters for Schlumberger array and the resistivity values ranging from 1 Ω meters to 75 Ω meters for Wenner array with depth of 22 meters to 40 meters. After this research was carried out, all objectives have been achieved. The geological map has is updated based on the geological information collected. The hydrological potential at Kg. Wakaf Raja, Pasir Puteh is identified.

Geologi Am dan Potensi Hidrologi di Kg. Wakaf Raja, Pasir Puteh, Kelantan

ABSTRAK

Kajian geologi termasuk struktur geologi, geomorfologi, lithologi dan petrografi terhadap batuan di Kg. Wakaf Raja, Pasir Puteh, Kelantan yang berkedudukan di koordinat dari N 05˚ 44’ hingga ke N 05˚ 47’ dan E 102˚ 23’ hingga ke E 102˚ 26’. Objektif kajian ini dilakukan adalah untuk melakukan penambahbaikan peta geologi di kawasan kajian dan untuk mengenalpasti potensi hidrologi di kawasan kajian dengan menggunakan kaedah geofizikal. Potensi hidrologi yang dapat dikenalpasti pada punca yang tepat boleh menentukan keadaan geologi kawasan tersebut dan bole ditafsirkan dengan menggunakan data yang telah diperolehi daripada survei keberintngan. Kajian bermula dengan pemilihan garisan lintang keberintangan elektrik bagi mengumpul data keberintangan daripada ABEM Terrameter Ls bersama kabel LUND serta elektrod digunakan. Data kemudian akan di analisis oleh program RES2DINV dan keputusan dari analisis akan ditunjukkan dalam bentuk gambaran 2 – dimensi. Susun atur Schlumberger dan Wenner telah digunakan untuk menunjukkan bahawa kawasan ini mempunyai sumber air bawah tanah yang berpotensi dengan bacaan keberintangan 1 Ω meter hingga 95 Ω meter untuk susun atur Schlumberger dan bacaan keberintangan 1 Ω meter hingga 75 Ω meter untuk Susun atur Wenner dengan kedua – duanya mempunyai kedalam daripada 22 meter hingga 40 meter. Setelah kajian dijalankan, kesemua objektif kajian telah dapat dicapai. Peta geologi bagi kawasan kajian telah dihasilkan berdasarkan maklumat geologi yang telah diperolehi. Potensi hidrologi di Kg. Wakaf Raja, Pasir Puteh telah berjaya dikenalpasti.

CHAPTER 1

INTRODUCTION

1.1 General Background

A base map and a geological map is essential on geological study as it contains numerous geological data for guidance. The importance features of geological map include the tectonic structures, fossil and mineral resources. Typically, a geological map shows the structure crossway of a section and also a smaller scale illustration of the desire study area.

Geological studies over a wide range of studies and parameter that include the distribution of rocks or outcrops. It should be categorized on the collected data which include the thickness and structure. The title of this research is Geology and Hydrological Potential of Kg. Wakaf Raja at Pasir Puteh, Kelantan. Kg. Wakaf Raja is the study area.

Two – dimensional (2D) imaging surveys are now widely used in engineering and environmental surveys to map moderately complex subsurface structures. Nonetheless, it also contributes in groundwater exploration due to its compatibility in detecting subsurface elements. Electrical resistivity imaging (ERI) survey comes with the purpose to determine the subsurface resistivity distribution by making measurement on the ground surface.

The focus of this research is on the hydrological potential of the study area within three type of rock that is metamorphic rock, igneous rock and sedimentary rock. Hydrological potential in this matter is whether the study area can become the next source of water supply. The usage of geophysical method which is resistivity method is used and applied in order to gather the information on this case study, which is the hydrological potential area for the study area.

1.2 Problem Statements

This study area does not have a proper and updated geological map. Geological map is required for the traversing process of the study area. The data for that area has not been updated recently. Also, there is no research that has been done to study the hydrological potential using resistivity method at study area. Thus, this study has to achieve detail information on the hydrological potential also geological and update the new information for that area.

1.3 Research Objectives

1. To produce an updated geological map of Kg. Wakaf Raja, Pasir Puteh
2. To determine the hydrological potential location in using geophysical method

1.4 Study Area

The study area is located at Kg. Wakaf Raja, Pasir Puteh, Kelantan as shown in Figure 1.1. Kg. Wakaf Raja is a residential area with development in progress. The size of the study area is 5 km x 5 km which is approximately 25 km^2. The main river that flows through the study area is Sungai Semarak. The coordinate for Kg. Wakaf Raja, Pasir Puteh is bound from 5º 44' 50" N to 5º 47" 30' N and from 102º 26' 15" E to 102º 23' 15" E.

1.4.1 Geography

I. Demography

According to the District Council of Pasir Puteh, the total amount of people distribution in the district are 122400. The result is from the census of population in the year 2006. The latest census of population in the year 2010 (Table 1.1), have showed the reduction in the population from 122400 to 113 191. This reduction might have been from the migration of the community.

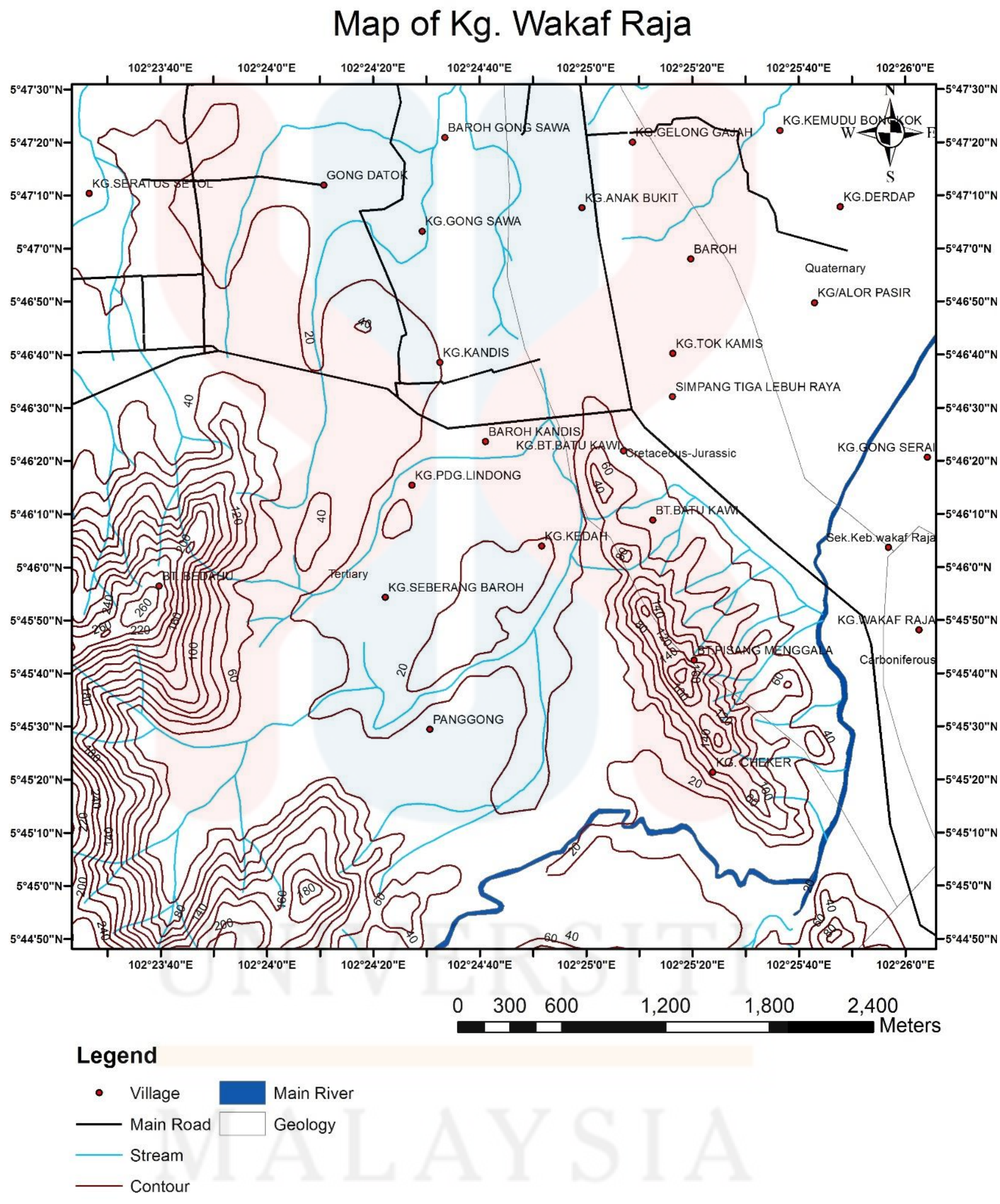


Figure 1.1: Map of Study Area

Table 1.1: The census of Population in 2010

Authority Area	Total	Malaysians Citizen							Non - Malaysian Citizen
		Total	Bumiputra			Chinese	Indian	Others	
			Total	Malay	Others				
PASIR PUTEH									
M.D. Pasir Puteh	113,191	112,337	110,642	110,597	45	808	17	870	854
Cherang Ruku	2,212	2,195	2,136	2,132	4	53	-	6	17
Pasir Puteh	2,115	2,085	1,829	1,826	3	243	-	12	31
Selising	129	128	60	59	1	62	-	6	1
The remains of M.D.	108,735	107,930	106,617	106,580	37	450	17	846	805

(Source: District Council of Pasir Puteh)

II. Rainfall

Most frequent rainfall occurs starting from August and end in January. Hot season occur in the interval of February to June or July. The other days are the transition of both seasons. Rainfall data in Pasir Puteh is acquired from the station at Kota Bharu, because the number and amount of rainfall are recorded in that station and the data are gathered.

The monthly amount of rainfalls for selected years in Pasir Puteh shown in Figure 1.2 and Figure 1.3. The highest amount of rainfall recorded is 612.7 mm in November 2015. While in the years 2016, in January is recorded 317.9 mm. In

2015, the amount of rainfall increase steadily from February to July which started to increase rapidly from August 2005.

In 2016, the amount of rainfall decrease from January to March, where March recorded the lowest rainfall with 4.5 mm only. The total amount of rainfall at the highest appears during August to November 2015. This is due to the Northern Monsoon period. Overall, the heavy rainfall occurs in the season of the Northeast Monsoon form August until the beginning of January.

In December 2015, the rainfall occurs in short duration but they were very heavy and sometimes the rain falls continuously for several days or more than one week. The full impact of monsoon season happens in the end of November until the beginning of January. The rainfalls during this period are more frequent. Duration time of rainfall within this period is longer compared to the other period within the year. Sometimes the impact of heavy poured and more frequent rainfall causes flooding for several days.

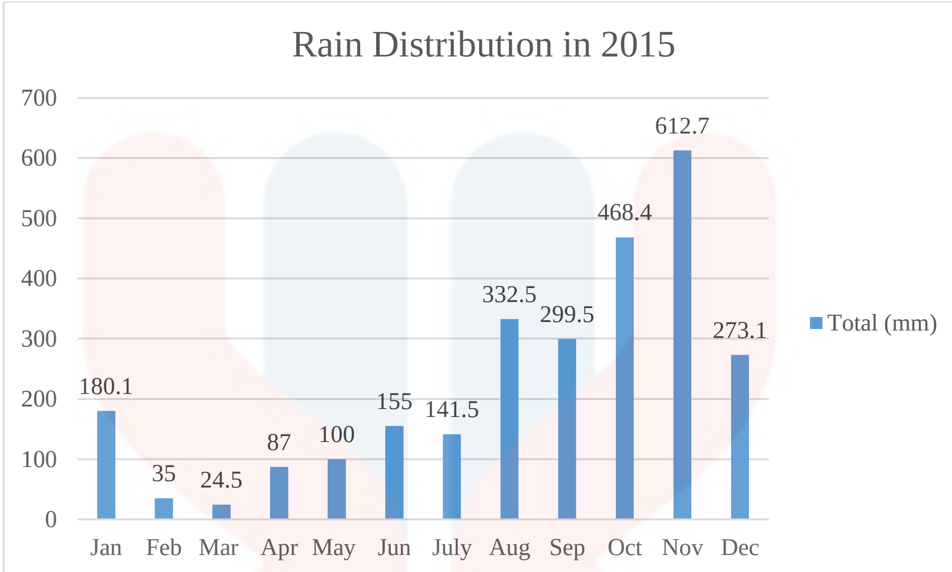


Figure 1.2: Rain Distribution in 2015

Source: Jabatan Pengairan & Saliran Kelantan (2016)

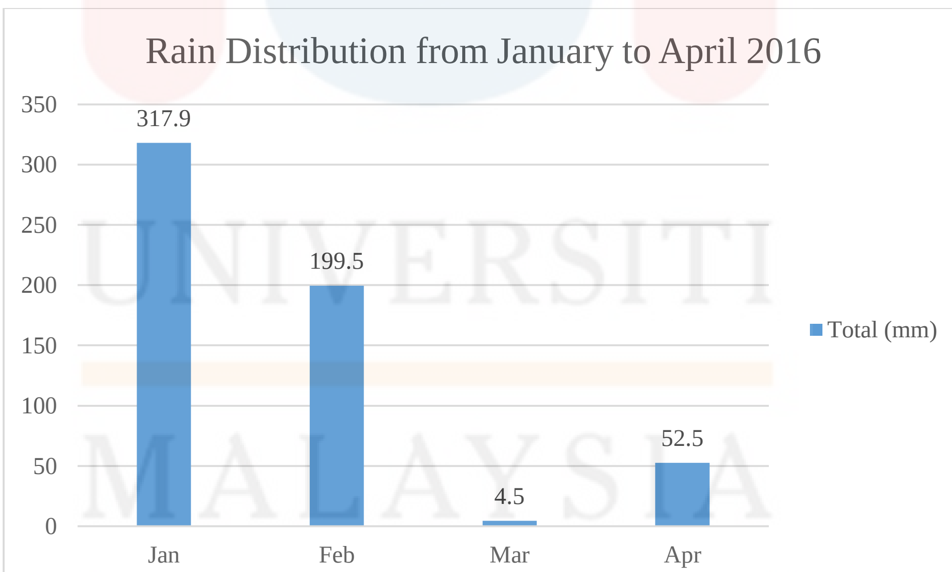


Figure 1.3: Rain Distribution from January to April 2016

Source: Jabatan Pengairan & Saliran Kelantan (2016)

III. Land Use

The land use in the district of Pasir Puteh is dominated by plantation. The major type of plantation in the area are paddy plantation with 81.79%. Beside than plantation, another dominant land use area is commonly for the commercial area. The minor land use area is commonly for the commerce purpose with percentage of 0.02%. The percentage of the land use can be seen in Table 1.2. Figure 1.4 and Figure 1.5 shows some of the land use in the study area.

Table 1.2: The percentage of the land use

Land use	Percentage (%)
Plantation	81.79
Residential area	0.40
Commerce area	0.02
Industrial area	0.30

(Sources: *http://www.mdpputeh.gov.my/*, last accessed 20th April 2016)

Figure 1.4: Paddy plantation at Kg. Wakaf Raja

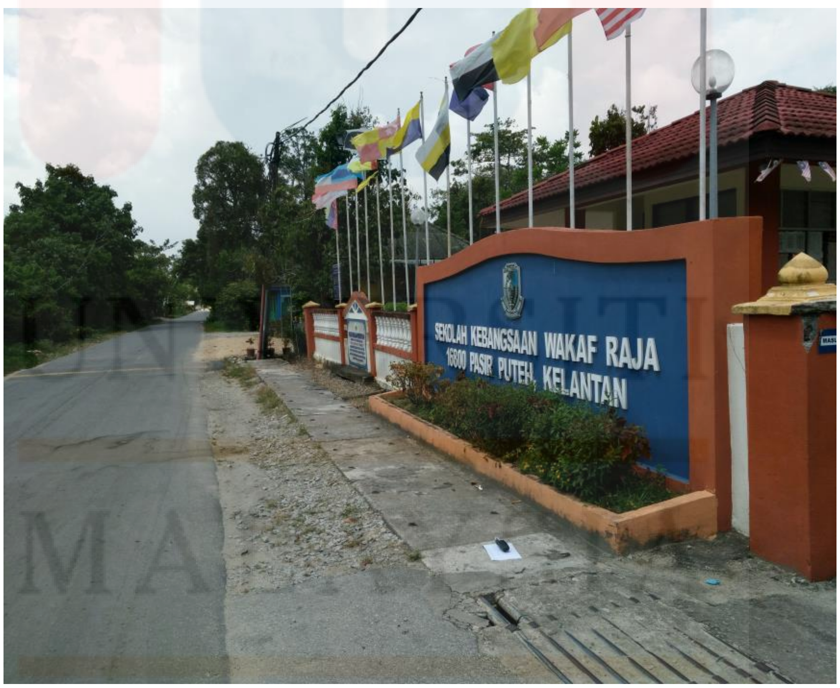


Figure 1.5: Middle school located at Kg. Wakaf Raja

IV. Social Economic

The main social economic that generate the major income for the community in the district of Pasir Puteh are from the plantation activity. Usually the plantation activity is done by the villagers. For the rural area community, paddy plantation and rubber plantation are the main activity to generate income (Figure 1.6) and the rural area community including a school shown in Figure 1.5.

Figure 1.6: Paddy plantation at the study area

V. Road Connection

The road at the study area are mostly paved road (Figure 1.7). Some of the road are unpaved due to the plantation area like the rubber plant and some of the fruit plant (Figure 1.8). For the roads that connecting the residential area and the plantation area are which paddy fields are also unpaved roads. This is mostly due to the transportation that is used most likely tractor, and some of it was traditional tools like the ox plow which can damage the road that connect the areas.

Figure 1.7: Paved road that connect with the villager house

Figure 1.8: Unpaved road that connect the paved road with the plantation area

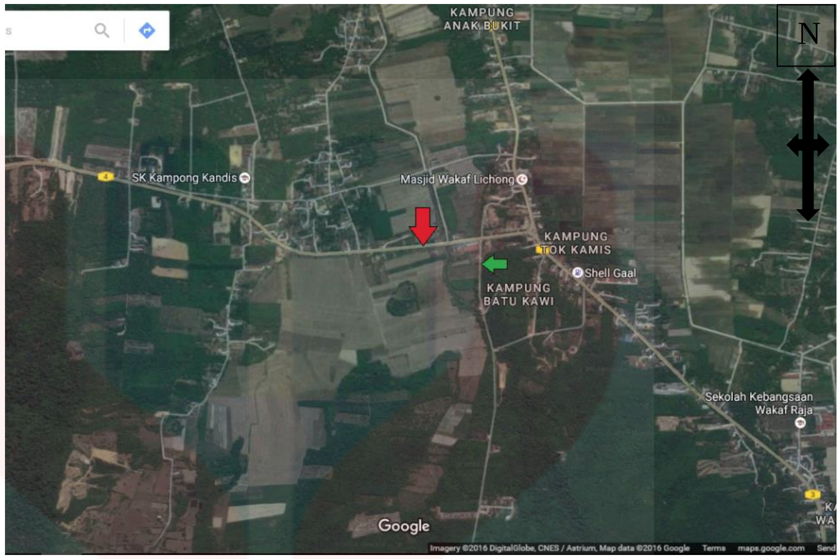


Figure 1.9: Road connection map of Kg. Wakaf Raja; red arrow show main road access and green arrow show smaller road; Source: Google Maps (2016)

Figure 1.9 shows the road connection in the study area based on the satellite imagery obtained from Google Maps. The red arrow indicates the main road that connect with the smaller road which point by the green arrow. The smaller road is used mostly by the villager.

1.5 Scope of Study

The study area is located at the Kg. Wakaf Raja, Pasir Puteh. Most of the area is plantation area and some of it is residential area and others. The area is originally flat surface area that mostly covered by alluvium. The general information about the area is that, the rock presence is mostly igneous rock.

This can be confirmed by the presence of quarry mine in that area of the place. There are many space or targeted area in the study area that the electrical resistivity imaging surveys can be done. This research also included the geological mapping process of the area in order to obtained the general geology of the place and completing the geological map. By mapping, hard evidence and conformation can be made to clarified about the study area.

1.6 Research Importance

The importance of this study is that it provides an update for the existing geology map of the study area. Other than that, the study of hydrological potential can give an insight for the people whether their place have the potential in becoming the source of fresh water that can be used in the times of needs. It as well can be a reference for understanding the situation around the area and can helped in avoiding disaster that may or may not happen. This is the reason that the study is important, not only that it served as guidance but also a proper reference for the future studies.

1.7 Chapter's Summary

This research shows the investigation about the general geology and the hydrological potential at Kg. Wakaf Raja, Pasir Puteh, Kelantan. This research is shown towards hydrological potential, whether the study area can provide source of water for that specific area. Based on the investigation also, the data that have been collected in this beginning chapter is people distribution, rain distribution, land use, social economic and road connection.

This chapter also introduced the study area that will conducted using geological map in order to complete the general geology and the acknowledgement about the research objectives that need to be achieved. Beside the study area and objectives, this chapter explain about the importance of this research in which generally to educate the people to become more aware about their surrounding and helping in giving knowledge about the study area.

Moreover, the problem statement that need to overcome in this research are also being mentioned in order to manage the outcome and ways to overcome the problem that have to face.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss on the general geology and electrical resistivity survey be used in hydrological detection. The general geology will be including the regional and tectonic setting, historical geology, stratigraphy and structural geology. There is also subtopic that will be focusing on that are petrography, hydrogeology and geophysics.

2.2 Regional Geology and Tectonic Settings

The total land area of 130,268 km^2 is the Peninsular Malaysia, from the part of Sundaland that include Borneo, Java and Sumatra, as well as the intervening shallow seas from which emerge a number of smaller islands (Bemmelen, 1949). Maximum length of 750 km and breadth of 330 km, the Peninsular is elongated in a general NNW-SSE direction. Separated from the Singapore Island by the narrow Johor Strait whilst is to the South, while to the West that is separated from the Sumatra Island by the Strait of Malacca. For the South-East and East of the South China seas separates the Peninsular from the Borneo Island. According to Hutchison (1989, 1996), the South-East Asia part is known as Sundaland while the Peninsular Malaysia is an integral part of the Eurasian plate.

Malaysia is tectonically inactive due to its location on the Sunda shelf. Dated from 540 million years ago is the oldest rocks in the country and it is mostly sedimentary rocks. Formed during the Paleozoic Era is the limestone, which is the most common form of rock. Limestone have already existed during the tertiary period has since eroded and resulted in the formation of basin of sedimentary rocks which is oil and natural gas. Throughout the orogenesis process that begins in the Mesozoic Era, the mountain ranges in Malaysia were formed.

The Peninsular Malaysia is subdivided into three types of belt, which is the Western belt, Central belt and Eastern belt. Each have its own distinctive in their stratigraphy. The Kelantan state is located in the Central belt and Eastern belt. Stretches from Kelantan to Johor, the western part of the Central belt are upper Paleozoic rocks of the Gua Musang and Aring Formation in South of Kelantan and also Taku Schist in East of Kelantan (Hutchison and Tan, 2009).

There are several major fault zones occurred in some part of the state in Peninsular Malaysia. As in for Kelantan, there is Bentong-Raub Suture zone which can be seen along the Gua Musang to Cameron Highlands, Galas fault zone that striking from the NNW-SSE cutting the Stong Complex, Lebir fault zone along Sg. Lebir near the Manek Urai in Kelantan and one other major fault zone that occurred are Kemahang Granite and the Tahan Range (Hutchison and Tan, 2009).

2.3 Stratigraphy

Stretches from Kelantan to Johor between the eastern foothills of Main Range, forming its western boundary, to its eastern boundary marked by the Lebir Fault in the north down to the western boundary of the Dohol Formation in the south, is the Central Belt. Consists largely of Permian clastics are the Paleozoic rocks with the sporadic outcrops of Carboniferous limestone that occur as linear belts flanking Mesozoic sediments on both edge of the belt. In the western part of the Central Belt is Upper Paleozoic rocks of the Gua Musang and Aring Formation in south Kelantan and Taku Schist in east Kelantan, and further south are the Raub Group in west Pahang and Kepis Beds in Negeri Sembilan.

These Upper Palaeozoic rock are predominantly of argillaceous strata and volcanic rocks, with subordinate arenaceous and calcareous sediments deposited in a shallow-marine environment, with intermittent submarine volcanism, starting from the Upper Carboniferous and peaking in the Permian to Triassic. Marking a change from submarine to sub-aerial volcanism in the south is the Lower Triassic lava unconformably overlies Permian phyllite in south Pahang and Johor (Foo, 1983). Figure 2.1 show the schematic classification and correlation of Paleozoic formations of Peninsular Malaysia (after Foo, 1983)

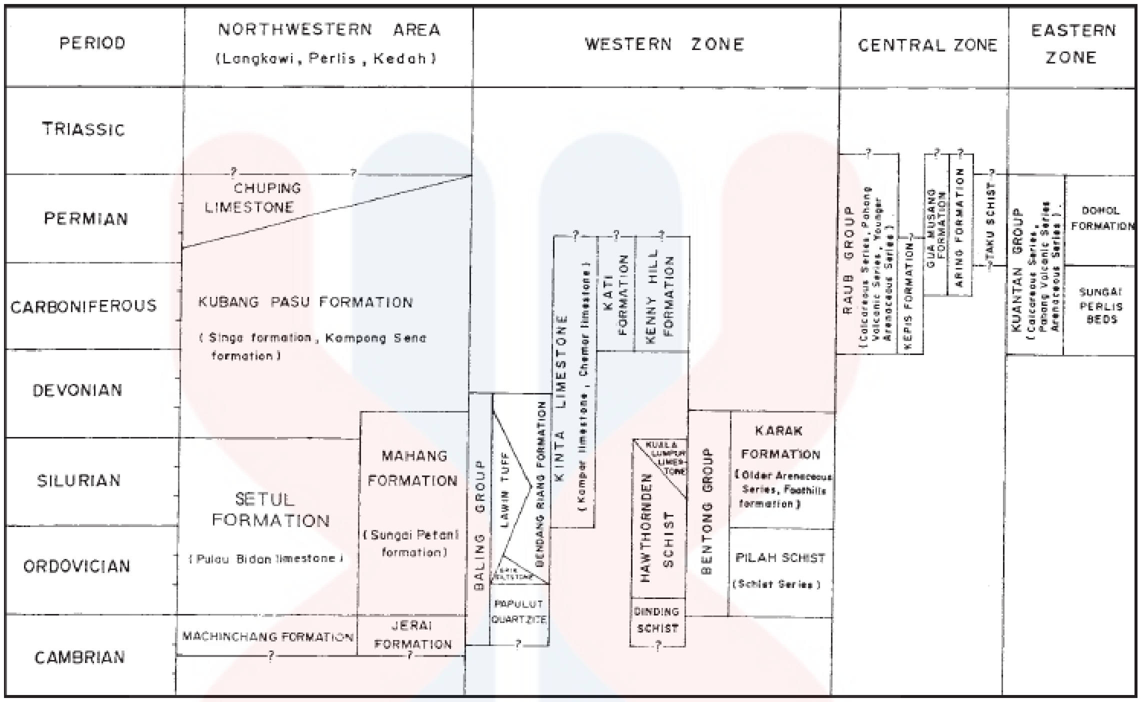


Figure 2.1: Schematic classification and correlation of Palaeozoic formations of Peninsular Malaysia (after Foo, 1983).

2.4 Structural Geology

Belong in an integral part of the Eurasian Plate is the Peninsular Malaysia, which the South-East Asian part of Sundaland (Hutchison, 1989, 1996). Due to the collision between Sinoburmalaya to the West and Eastmal-Indonesia blocks to the East, Peninsular Malaysia was formed. Bentong-Raub Suture represented the collision zone which can be traced northward into Thailand and southward into Banka and Billition Islands. Resulted in rock deformation in the Malay-Thai peninsular, the collision was accompanied by the major tectonic event during Late Triassic.

South to SSE, the dominant strike and fold axis trends of Peninsular Malaysia, especially of the mainly Carnian-Norian Semantan and Gemas Formations of the Central

Basin which controlling the shape of the peninsula (Tjia, 1989). Pre-orogeny sedimentary successions in the Transect area are generally folded into a series of synclines and anticlines. Controlling the shape of the island is the dominant strike and folds axes direction of Sumatra is NW-SE. Tight, asymmetric and open folds is the characteristic of folding which cause the repeated and overturn sequence in the older sedimentary rock. Sub-parallel to the long axis of the Malay Peninsula is the NW-SE and N-S trending fold axes and with various dip angles which mostly the bedding planes dip towards the east.

The geology of Peninsular Malaysia continues into Sumatra and the shallow Straits of Malacca is no tectonic significance. The highly oblique convergence at the Sumatran Trench (Sunda Trench) has resulted in Sumatra Island being dominated by a right-lateral fault system. Faulting is widespread throughout the Transect area. Due to the thick soil and deep tropical weathering, more than a few places fault zones are seldom exposed along with their traces. Generally, varies in width characterized by fractured, sheared or even mylonitised rocks are faults.

Lebir fault zone is at least 10km wide, spanning the gap between Sungai Lebir and the eastern margin of the Taku Schist near Kuala Krai. According to Singh, 1985, on the geological map, Triassic rock boundaries are shown displaced sinistrally for about 20km along the Lebir Fault. Slicken-sides on the fault surfaces, exposed along road-cuts, indicate sinistral slip. Being deformed into brecciate metasediments, flasered granite and mylonite were the rocks within fault zone. Tjia (1969) showed that, based on tension fracture and drag fracture, the fault zone has a sinistral slip. Evidence for the sinistral movement along the fault zone in Sungai Aring area was found, (Aw 1990).

2.5 Petrography

Petrography is a branch of petrology that focuses on detailed description of rocks. The mineral content and the textural relationships within the rock are described in details. The petrography analysis is done after the thin section process, where the mineral of the rock can be observed and identify through the microscope. Through this process, the name of the rock can be identified and the study area can be classified into which of the dominant rock take place.

The petrographic description started with the field notes at the outcrop and include macroscopic description of hand specimens. The most important tool for the petrographer is the petrographic microscope. The detailed analysis of minerals by optical mineralogy in thin section and the micro-texture and the structure are critical to understanding the origin of the rock.

2.6 Hydrogeology

Hydrogeology is the study of water in the broadest sense. Water is life to us and all living things and also a unique natural resources to the planet Earth. Groundwater is the next most significant source after discounting the volumes that represented by the ocean and polar ice (Willis, 2001).

Groundwater makes up only 0.61% of the total distribution of the world water supply and is approximately 50 to 70 times more plentiful than the surface water (Fetter, 1980). To achieve a large scale development of groundwater, it must have a reliable estimates of groundwater potential (Singh, 1985).

Aquifer is a formation, part of a formation or a group of formation that contain sufficient saturated permeable material to yield a significant quantities of water to wells or spring (Wills, 2001). A layer that contains and transmit groundwater and it can be divided into two, that is confined and unconfined aquifer. Confined aquifer, overlain by impermeable layer of rock such as aquiclude or aquitard (Fetter, 1980). The more productive aquifers occur in sedimentary geologic formation rather than the weathered and fractured crystalline rocks yield smaller quantities of groundwater in many environments.

2.6.1 Groundwater

According to Singh. C. L. 1984, estimation of groundwater potential is essential to have in order to pursue large scale development of groundwater. Rain fall to the ground does not stop moving but it flows along the surface in stream or lakes, some of it is use by plants to grow, some of it evaporates and returns to the atmosphere and some seeps into the ground. Like pouring a glass of water into a pile of sand, the water moves into the spaces between the particles of the sand. Groundwater is the types of water that is found in crack and spaces in soil, sand, and rocks. Saturated zones of geologic formation are called for the area where the water fills this spaces. On the top of this zones are called the water table which may be only a meter below the ground's surface or even be hundreds of meters down.

Depending on many factors, the water table may be shallow or may be deep and may be rise or fall. Groundwater can be found almost everywhere. Heavy rains or melting of the snow can cause the water to rise or during the dry weather, may cause the water table to fall. Groundwater is stored in and move slowly through the layer of soil, sand and rocks called aquifers. Depending on the size of the spaces in soils or rocks and how well the space is connected is the speed for the groundwater. The groundwater can be replenished or recharged by the rain and snow melt and in some areas of the world, people face serious water shortage due to the groundwater that is used faster than it is naturally recharge.

In the areas where material above the aquifers is permeable, pollutant can sink and get into the groundwater. Some of the pollution that can affects the groundwater are landfills, septic tanks, leaky underground gas tanks and overuse of fertilizers and pesticides. The groundwater will no longer become safe to drink when it is polluted and it is important to protect and conserve the groundwater.

2.7 Geophysics

The main use of geophysics in the geosciences is for hydrocarbon exploration typically at depth greater than 1000 meters. Significant technological advances have been made in this industry over the last thirty years especially with seismic reflection techniques. Groundwater application of near-surface geophysics include mapping the depth and thickness of aquifers, mapping aquitards or confining units, locating preferential fluid migration paths such as fracture and fault zones and mapping contamination to the groundwater such as that from saltwater intrusion (Reynold, 1997).

Near-surface geophysics for groundwater investigation is usually restricted to depth less than 250 meters below the surface and developments have not concentrated on one specific geophysical technique.

The successful of each geophysical technique depend on the consideration of key geological and cultural factors together with geophysical data. The factors include; depth of the burial of the target, target size, measurement of the station interval and calibration of the data. Electrical Resistivity Imaging (ERI) is the measurement of ground resistivity involves passing an electrical current into ground using a pair of copper or steel electrodes and measuring the resulting potential difference within the subsurface using a second pair of electrodes. Electrical Resistivity Imaging (ERI) is a fully automated technique that uses a linear array of up to 40 electrodes connected by multicore cable. Using a laptop and control module that connected to a ground resistivity (that provides the output current), the current and potential electrode pairs are switched automatically. Along the survey line a profile of resistivity against depth ('pseudosection') is built up.

Data is collected by automatically profiling along the line at different electrode separations. The spacing between the electrodes was fixed initially by the computer and moves the pairs along the line until the last electrode reached. The spacing is then increase by the minimum electrode separation and the process repeated in order to provide an increased depth of investigation.

The spacing between the electrodes and the number of electrodes in the array can determined the maximum depth of the investigation. For a 64 electrodes array with an electrodes spacing of 2 meters this depth is approximately 20 meters. Fewer and fewer points are collected at each 'depth level' as the spacing between the active electrodes increase, it is until on the final level only 1 reading is acquired. For overcoming this, the array is 'rolled-along' the line of investigation in order to build up a longer pseudosection.

Many Electrical Resistivity Imaging (ERI) surveys are carried out using the Wenner Array. The data is initially converted to apparent resistivity values using a geometric factor that is determined by the type of electrode configuration used. The converted data is used for modelling using finite element and least squares inversion methods in order to calculate a true resistivity versus depth pseudosection. Each of the materials has its own resistivity values and it is summarizing in Table 2.1

Table 2.1: Resistivity range of rocks, chemicals and minerals (Loke, 1997)

Materials	Resistivity (ohm.m)	Conductivity $(ohm.m)^{-1}$
Igneous and Metamorphic Rocks		
Granite	$5x10^3 – 10^6$	$10^{-6} – 2x10^{-4}$
Basalt	$10^3x – 10^6$	$10^{-6} – 10^{-3}$
Slate	$6x10^2 – 4x10^7$	$2.5x10^{-8} – 1.7x10^{-3}$
Marble	$10^2 – 2.5x10^8$	$4x10^{-9} – 10^{-2}$
Quartzite	$10^2 – 2x10^8$	$5x10^{-9} – 10^{-2}$
Sedimentary Rocks		
Sandstone	$8 – 4x10^3$	$2.5x10^{-4} – 0.125$
Shale	$20 – 2x10^3$	$5x10^{-4} – 0.05$
Limestone	$50 – 4x10^2$	$2.5x10^{-3} – 0.02$
Soil and Water		
Clay	1 – 100	0.01 – 1
Alluvium	1 – 800	$1.25x10^{-3} – 0.1$
Underground Water (Fresh)	10 – 100	0.01 – 0.1
Sea Water	0.15	6.7
Chemicals		
Iron	$9.071x10^{-8}$	$1.102x10^7$
0.01M KCl	0.708	1.413
0.01M NaCl	0.843	1.185
0.01M Acetic Acid	6.13	0.163
Xylene	$6.998x10^{16}$	$1.429x10^{-17}$

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

The important part of doing research is the methodology. All the methods that have been conduct during the research will be describe in details. Within this research, the resistivity method from geophysics analysis is used in approach for solving the matter. Figure 3.1 shows the flow chart of the research.

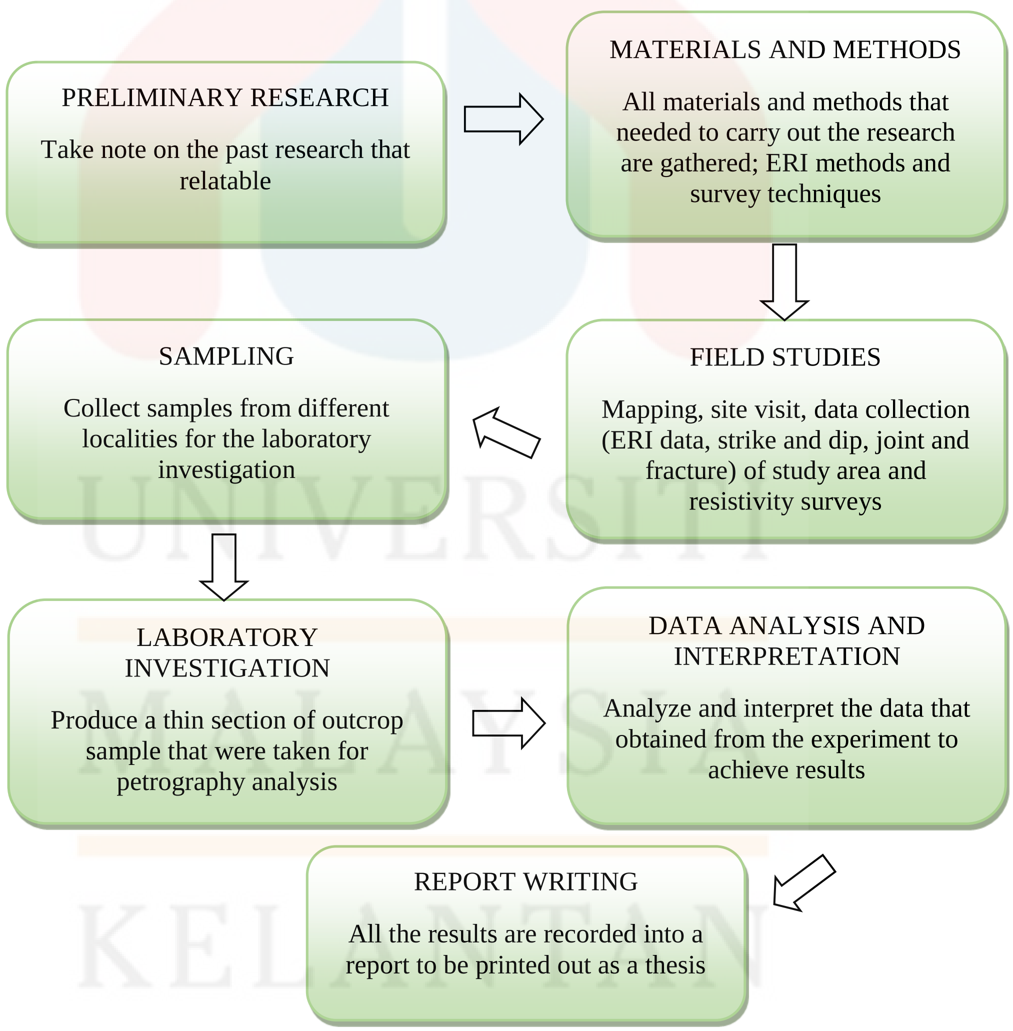


Figure 3.1: Flow chart of the research

3.2 Materials

For the purpose of geological mapping, several equipment will be used to help indicate the parameters of the study, the equipment needed are:

Table 3.1: List of materials that required for the research

Equipment	Uses
1. Garmin Geographical Information System (GPS)	The purpose of obtaining coordinate of specific places in real time
2. Geological Hammer	Use for splitting and breaking rocks into small pieces for sampling purpose
3. Burton Compass	To measure the directional degree measurements (azimuth) through use of Earth's magnetic field and taking strike and dip measurements
4. Measuring tape and sample bag	Usage of measuring the outcrop at the field and keeping the sample save.
5. Magnifier	For a closer look at the mineral composition that contain in the rocks sample
6. Hydrochloric acid (HCl)	For the purpose of testing on carbonate minerals and rocks during laboratory and in the field.
7. Resistivity measurement equipment	This equipment is used to measure the resistivity measurement below the surface of the ground as shown in Figure 3.2. In Table 3.2 shows the list of the instrument that can be used to measure the resistivity.

Table 3.2: Type and quantity of equipment that will be use

Bill.	Type of Equipment	Quantity
1	ABEM Terrameter LS	1
2	Electrode selector	1
3	Lund Imaging cable 5 m (spacing) 100 m	2
4	Electrode jumper	42
5	Steel electrode	41
6	Cable connector	1
7	Battery (25 – 70^7 Ah)	1
8	Measuring tape	2
9	Hammer	2

Figure 3.2: Image of resistivity measurement equipment

3.3 Methodologies

3.3.1 Preliminary Research

This is an initial study for gathering general information about the research and study area. The material that are used such as articles, journals and other publications are collected in order to determine the level of research and development that was done in Malaysia and around the globe. The sources of this material are from the library and from the Geology of Mineral and Geosciences Department, Kelantan and also from the website. The purpose of this research is to obtain the initial overview about the geological setting, morphology and topography of the study area, including the knowledge about topographic map within the scale of 1:25000. In order to help in the production of the base map, observation from the satellite imagery was also been done.

3.3.2 Field Studies

I. Mapping

Traversing is the first steps to be done in mapping. Method that will be carry out by the travers along the road and river. Observation will be done during the traversing and all of the info about the study area will be recorded in the field notes. During the travers, ground photo will also take all over the study area. This method is necessary in order to get the overall view and exact information about the study area so that the next mapping in detail can be done and geological map can be complete.

The coordinates of the outcrop are recorded and any sedimentary and tectonic structures such as bedding, faulting, folding, fracture and joint, the dip and strike reading of all these structure is taken by using the compass. By using the fracture and joint reading, the rose diagram can be produce.

Furthermore, it can help in the study of land use, topography, drainage pattern and can also help in order to plot the hydrological potential location such that aquifers location.

II. Sampling

The rock sample must be fresh because if the rock sample is weathered, then it is not suitable for petrography analysis due to the sample that already decomposed and disintegrated from rock to soil. For this process, samples are collected from the field for microscopic analysis. The samples are processed in thin section form and it is examined under the microscope.

III. Resistivity survey

After the determination of the place of study, resistivity survey is done in order to obtain the various geological parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock. Basically, practice in the field is to apply an electrical direct current between two electrodes that is implanted in the ground and to measure the difference between two additional electrodes that do not carry current at the time. The resulting voltage differences at the potential electrodes are measured by the instrument and the apparent resistivity is the being calculated. The potential electrodes are usually in between the current electrodes but they can be located anywhere in the principle. Electrical resistivity survey can either using direct current, commutated direct current or alternating current of low frequency (typically about 20 Hertz). All interpretation and analysis are done to the basis of direct current.

$$Pa = kV/I \quad (1)$$

Pa = Apparent Resistivity

k = Geometric factor which depends on the arrangement of the electrodes

V = Voltage

I = Current

The calculated values of resistivity are not exactly the true resistivity of the sub – surface, it is only the apparent values of the sub – surface as shown in (1). Inversion of the calculated apparent resistivity values can determine the true resistivity values by using the RES2DINV program. The RES2DINV program will presented the data in the form of image after it have been processed.

IV. Types of Resistivity Survey

There are four type of array for the resistivity survey, which are the Schlumberger array, Wenner array, Dipole – Dipole array and the Pole – Dipole array.

a) Schlumberger Array

The Schlumberger array consists of four collinear electrodes (Figure 3.3), where the outer electrodes are known as the current or the source electrodes and the inner two electrodes are known as the potential or receiver electrodes. Typically, less than one fifth of the spacing between the current electrodes is where the potential electrodes are installed at the center of the electrodes array with a small separation. During the survey, while the potential electrodes are still remaining in the same spot, the current electrodes are increased to a greater separation then until the observed voltage becoming too small to measure.

$$\rho_A = \frac{V}{I}\pi\frac{b\left(b+a\right)}{a} \approx \frac{V}{I}\pi\frac{b^2}{a} \quad \text{if } a << b$$

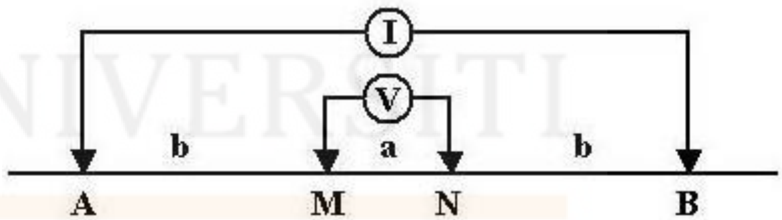
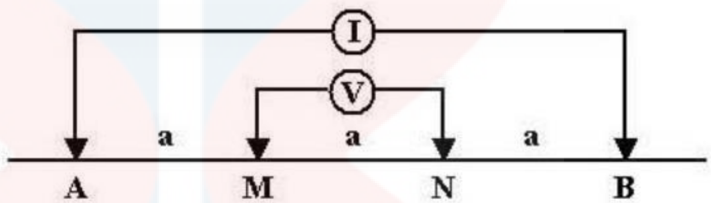


Figure 3.3: Schlumberger array and apparent resistivity; Source: (Morrison and Gasperikova, 202)

b) Wenner Array

The Wenner array consists of four collinear and equally spaced electrodes. Same as the Schlumberger array (Figure 3.4), it has two outer electrodes known as the current or the source and two inner electrodes known as the potential or the receiver. While maintaining an equivalent spacing between each electrode, the array spacing expands about the midpoint of the array.



$$\rho_A = 2\pi \; a \frac{V}{I}$$

Figure 3.4: Wenner electrode array geometry and apparent resistivity; Source: (Morrison and Gasperikova, 2012)

c) Dipole – Dipole Array

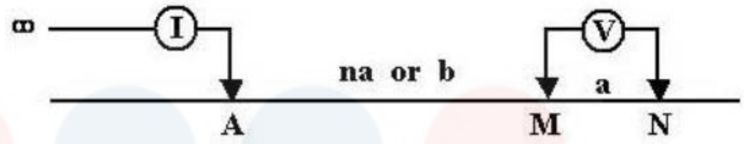
This type of array consists of two sets of electrodes which are the current or the source and the potential or the receiver (Figure 3.5). A dipole is a paired electrode set with the electrodes located relatively close to one another and if the space between the pair is wide, it is referred as a bipole. The array needed to maintain an equal distance for the both pair of electrodes which are the source and potential (spacing = a), with the distance between both as an integer multiple of a.

$$\rho_A = \frac{V}{I}\pi a n(n+1)(n+2)$$

Figure 3.5: Dipole - Dipole configuration and apparent resistivity; Source: (Morrison and Gasperikova, 2012)

d) Pole – Dipole Array

Figure 3.6 show the pole – dipole array. Consists of four collinear electrodes. One of the current electrodes which is the source is installed at an "effective infinity" distance, which is approximately five to ten times the survey depth. The other current electrodes are place in the vicinity of the two receiver or the potential electrodes. This geometry is used due to effectiveness in reducing the distortion of equipotential surfaces.



$$\rho_A = 2\pi \frac{b\,(a+b)}{a}\frac{V}{I}$$

Figure 3.6: Pole - Dipole electrode array and apparent resistivity (Morrison and Gasperikova, 2012)

3.3.3 Laboratory Investigations

Laboratory investigation for this research project was divided into two parts which are general geology which include the thin section and the identification of mineral under the microscope. Thin section process is needed in order to identify the types of rocks for the samples taken in the field based on its mineral content.

I. ArcGIS software

In the steps of producing a complete and details geological map of the study area, all information obtained from mapping is inserted in ArcGIS software. Thus, all the information about the geological features will be plotted on this new map. The software also has a complete tool that can help researchers to insert any geological data to represent the map. In addition, the potential map for the hydrological potential location will be produce based on the map produce.

II. Thin Section

Using the rock sample that have been taken from the field, thin section slide is done for analyzed and interpreted under the microscope in order to proceed the next step. The process of making thin section is explained in the next section.

a. Prepare the glass slide

The rock sample will be glued to the glass slide to be flatten in order for the rock section to end up with a constant thickness. To achieve this, the slide must be 'frost' which two goals can be accomplished, that are: remove the thick spot on the slide and the face slide is adjusted to be parallel to the grinding whell's face.

b. Frost the glass slide

'Frost' or grind the glass slide is for the purpose to flatten out and roughen the surface so that the epoxy can bind well together. The slide is place on the grinder in the same orientation to achieve the flat and rough surface.

c. Mark the sample

For rocks that have fabrics, decision must be made on where to cut the rock sample. Usually, the rock sample is cut on the perpendicular plane for any planar fabric. However, for particular purpose, other orientation might be preferable. A line should be mark on the rock for guide line.

d. Cutting and cleaning the slab

Slab saw is used in this process, which slab is cut from the rock sample along the line that was marked.

e. Cut the chip

The size of the slab need to be reduced slightly smaller to a thin section. The thin section saw is used to cut the slab. Carefully decide from which part of the slab that is needed to cut the section.

f. Glue the slide to the chip

The frosted side of the slide is glued to the side of the chip that was ground down. Constant thickness of epoxy is needed to be ensure across the section.

g. Cutting the chip from the slide

Most of the chip is cut off and leaving only a thin slice attached. With the thin slice, the grinding process for making a thin section can be easier and not time consuming which is crucial to carefully when doing this step.

h. Grind the slice to the correct thickness

Grind the remains of the rock on the slice which must be done carefully because it is the step where mostly thin section can easily break.

3.3.4 Data Analyses and Interpretation

I. RES2DINV

This software is designed to interpolate and interpret field data of electrical geophysical prospecting (2D sounding) of electrical resistivity (conductivity) and induced polarization. The inversion of the resistivity and IP data is conducted by least-square method involving finite-element and finite-difference methods. The software can handle data from any electrode array, including Wenner, dipole-dipole, inline pole-dipole, pole-pole, Wenner – Schlumberger, equatorial pole-dipole and non-conventional arrays. Interpolate data from land, under water, and cross-borehole surveys. Easy data conversion from the most popular geophysical instruments including ABEM Lund, Syskal, AGI, PASI, IRIS, SCITREX, and others.

II. Petrography Analysis

From the process thin section that have been done in laboratory investigation process, the finished thin section is interpreted. This process is crucial to determine the type of rock, the minerals content that made up the rock mineral is at the study area to naming the rock, what its parent rock and others. By observing igneous rock under the petrographic microscope, a specific interlocking texture with slow crystallization from a melt can be seen. Without knowing how to recognize, describe, organize and analyze the textures, the origin of the rocks cannot be study. Petrography analysis is important in order to identify the type of rocks accurately.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The study area is located near the border of Kelantan and Terengganu. The 5x5 km area includes the T – junction road to Pasir Puteh, Kelantan and Jerteh, Terengganu. In this chapter, the study area will be described according to its geomorphology, stratigraphy, structural geology and historical geology. This chapter will mainly conclude the general geology part of research which it will then be discussed. Traverse map of the study area are shown in Figure 4.1.

4.2 Geomorphology

Geomorphology is the scientific study of landforms and the processes that shape them such as by erosion of the wind, water, ice or depositional process of the laying down material that have been eroded. The understanding of the geomorphology and its processes is essential to the understanding of physical geology. The geomorphology will be discussed in this research are related to the topography, drainage system and weathering processes.

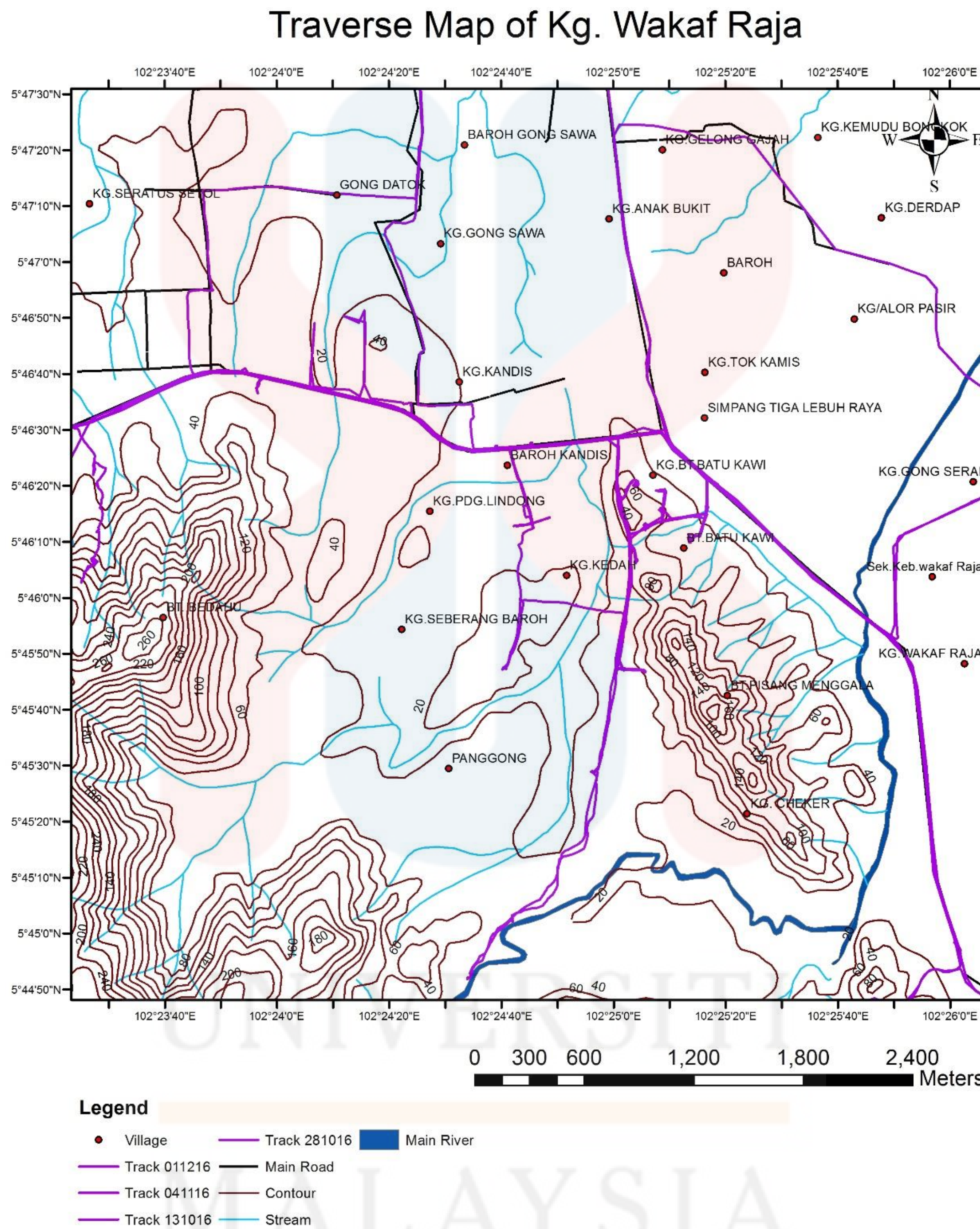


Figure 4.1: Traverse Map of Kg. Wakaf Raja

4.2.1 Topography

Topography is the physical features of a surface area including relative elevations and the position of natural man-made features. It is the field of earth science comprising the study of surface and features of the Earth and other observable astronomical objects including the planets, moons and asteroids. It involves recording of relief of terrain, three-dimensional (3D) quality of the surface and the identification of specific landforms.

The physical features of the study area include small hills named as Bt. Bedahu and Bt. Pisang Menggala that can be located on the western part and the eastern part of the study area, with their elevations respectively of 280 meters and 140 meters.

Most of the residential areas are concentrated to the north-west, northern and the north-east of the study area. The houses mostly are built along the roads for an easier connection. The main roads extend from the west to the north and east that connecting the two district that is Kelantan and Terengganu. Topography map of the study area are provided in Figure 4.2. Geomorphology map is displayed in Figure 4.3. The geomorphology map describes the elevations of the hills in the study area.

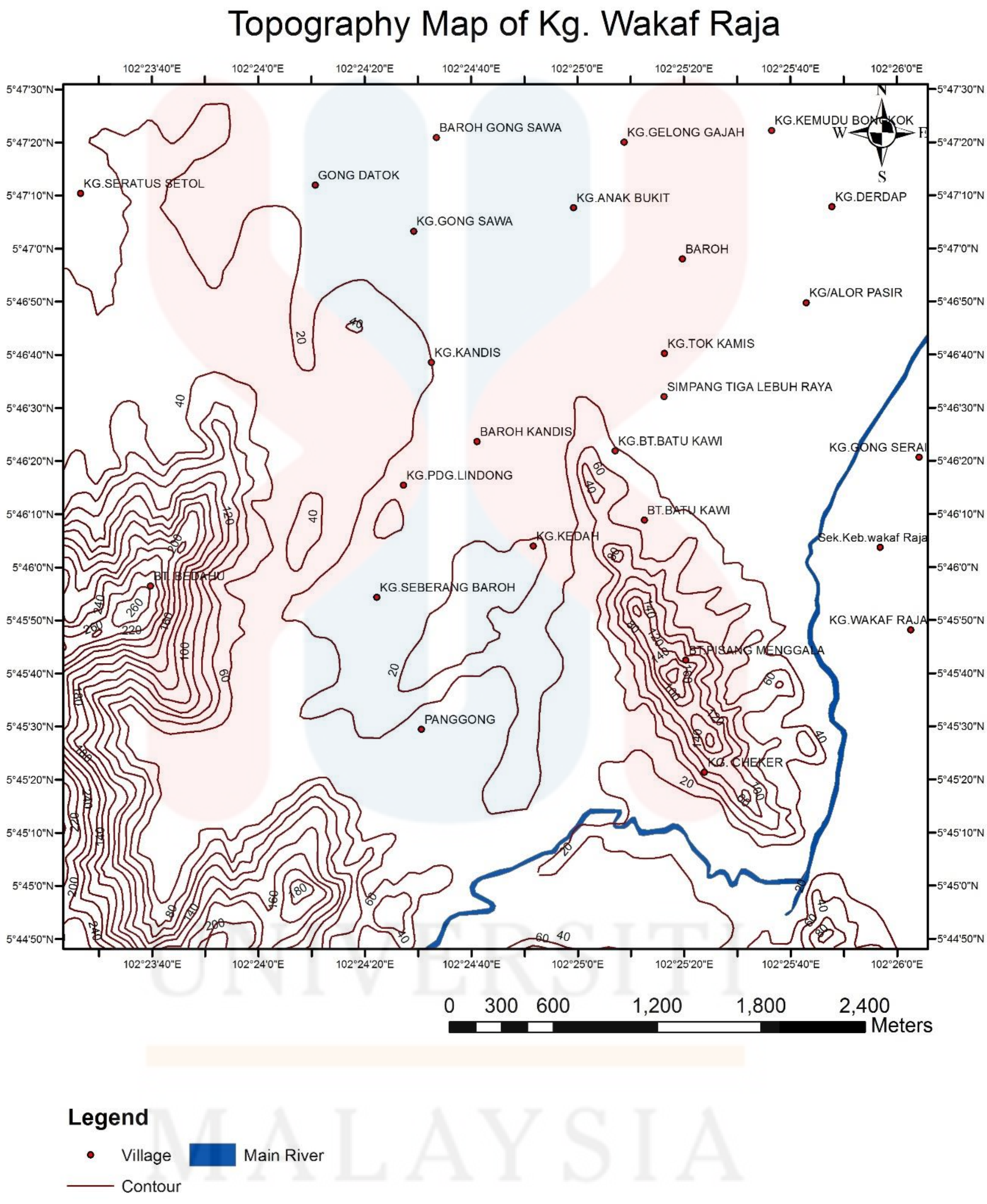


Figure 4.2: 2–Dimensional topography map of Kg. Wakaf Raja

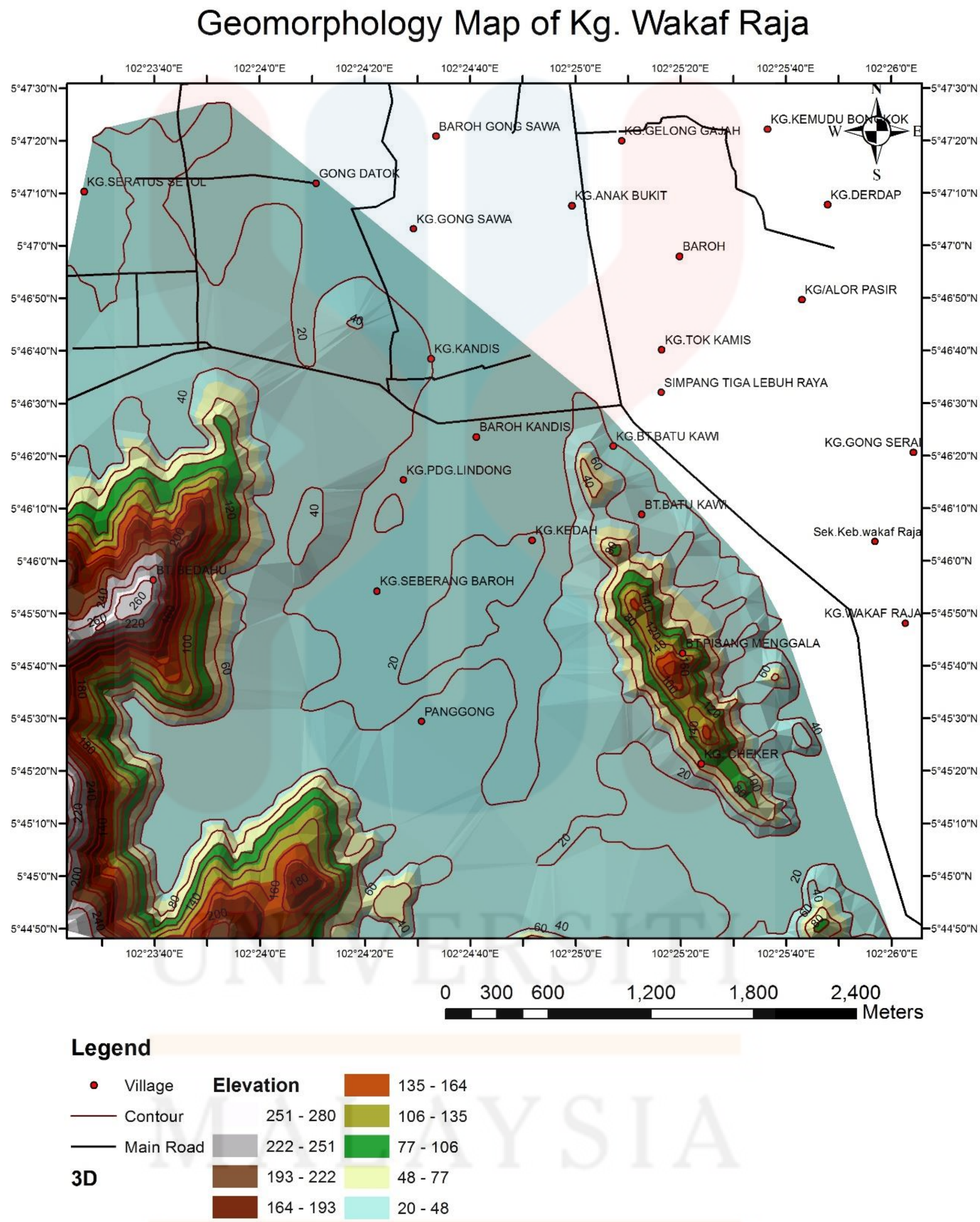


Figure 4.3: Geomorphology map of Kg. Wakaf Raja

The highest relief marked at the study area is 260 meters which is located at the western part of the study area. The highest elevation indicates the small hills known as Bt. Bedahu. The next hills found in the study area has the elevation of 140 meters, located at the eastern part of the study area and it is known as Bt. Pisang Menggala.

The lowest part of the study area, marked at the study area around 0 – 48 meters as shown in Figure 4.3 indicate the residential area or the urbanization area which is flat landform indicates that the area is not hilly.

4.2.2 Drainage Pattern

Drainage pattern is included in the geomorphology. Drainage system is the pattern formed by the streams, rivers and lakes in a particular drainage basin. They are governed by the topography of the land, whereas a particular region is dominated by hard or soft rocks and the gradient of the land. A drainage basin is the topographic region from which a stream receives runoff through flow and groundwater flow. According to the configuration of channels, drainage systems can fall into one of several categories known as drainage patterns or systems.

There are several types of drainage system according to their patterns. Drainage system can be classified into several types which includes dendritic, parallel, trellis, rectangular, radial, centripetal, deranged, annular and discordant depending on the topography and the geology of the land. Different pattern can indicate different geomorphology.

Figure 4.4: Dendritic drainage patterns

Most of the drainage patterns that can be found inside the study are dendritic drainage pattern (Figure 4.4). This pattern is the most common form of drainage system in the world. In a dendritic system, there are many contributing streams, which are then joined together into the main river. They develop where the river channel follows the slope of the terrain.

Parallel drainage system is a pattern of rivers caused by the steep slopes with some relief (Figure 4.5). Due to the steep slopes, the streams are swift and straight with very few streams flowing into the main river and all of them are in the same direction. The study area consists of sub – parallel drainage system due to the steep slopes of the Bukit Bedahu.

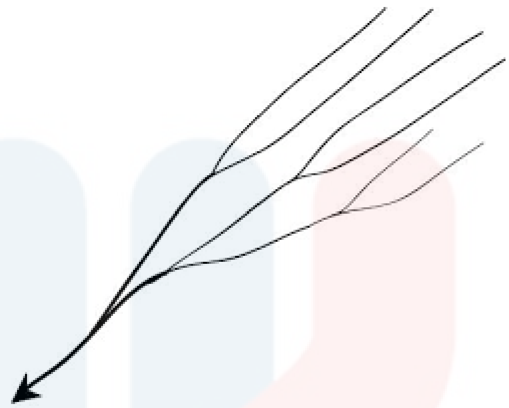


Figure 4.5: Parallel drainage patterns

There are two types of rivers that could be classified based on the drainage map of the study area (Figure 4.6). Both are recognized as river and stream which goes by the name Sungai Kandis and Sungai Semerak. The flow of the river is from the South towards the North of the study area where water in a river will flow from the higher elevations towards the lower elevations area. These state that why does the water flow in such direction as lower elevations are found in the Northern part of the study area and the higher elevations are found in the Southern part of the study area. There are many stream can also be found in the study area which located on the left side, at the South – West of the study area and begin its flowing from higher elevations to lower elevations into the main river. Most of the drainage patterns are shown by the streams.

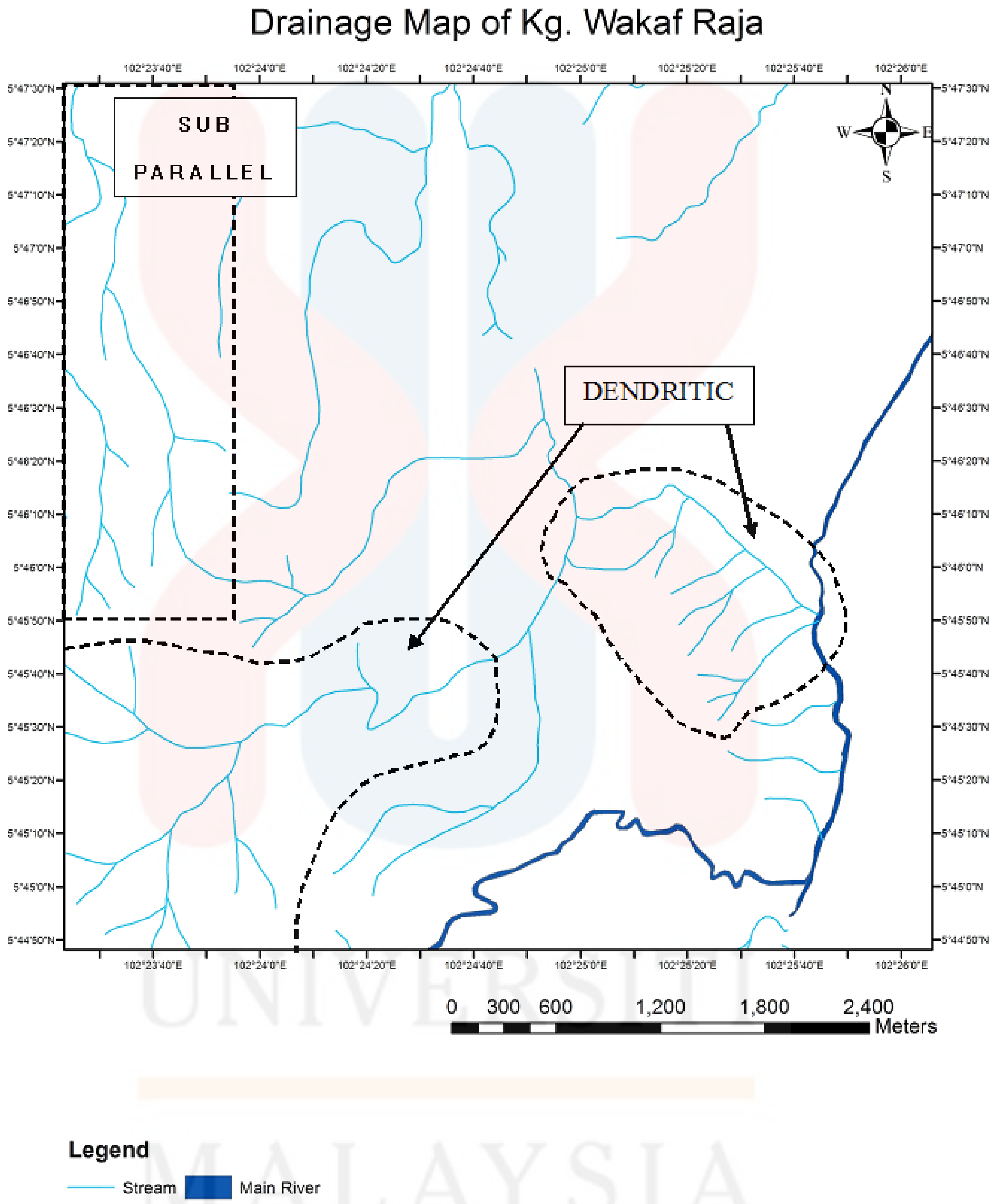


Figure 4.6: Drainage patterns in Kg. Wakaf Raja Area

The dendritic pattern in the study area occurs when the tributary system become divided such as the tree branches. This pattern is due to the rocks mass which is reasonably homogeneous and usually form in horizontal sedimentary or in intrusive igneous rocks such that in the study area, granite rocks. The dendritic pattern drainage tends to become subparallel and join at an acute angle. This type of drainage pattern will be disturbed or interfered when there is any marked structure such as joints or faulting.

4.2.3 Weathering Process

Weathering is the breaking down of rocks, soils and minerals as well as artificial materials through contact with the Earth's atmosphere and waters. The breaking down of material can be by mechanical or physical, chemical and biological weathering. Weathering can occur in situ or with no movement, and should not be confused with erosion process which involved the movement of rocks and minerals by the help of their agent, such as water, wind, ice, snow, waves and even gravity. Weathering can change the state of the rock from a hard state to a much weaker and softer state, making it easier to erode.

Physical weathering is a process where the breaking of solid rock into smaller pieces and may separate the different minerals without involving any chemical reactions (Figure 4.7). It is caused by the effect of changing temperature on rocks, causing the rocks to break apart. This process sometimes assists by water whether from rain or from the streams nearby its location.

Figure 4.7: Physical weathering that is caused by the change of temperature

Other than that, biological weathering is a form of weathering caused by the growth of trees, roots and burrowing of animals. Plants roots are the most efficient agents of the biological weathering as they give off acids that contributes in breaking the rocks apart as shown in Figure 4.8 and Figure 4.9.

Figure 4.8: Biological weathering that is caused by plant's root

Figure 4.9: Another biological weathering that is caused by plant's roots

Figure 4.8 and Figure 4.9 shows the biological weathering found in the study area. From the photograph, it can be seen that the roots had penetrate into the rock causing the soil to be disintegrated. The roots are moving downwards as it is looking for water and minerals. As the times goes by, this action will cause the soil to falls and causing soil flows or landslide.

4.3 Structural Geology

Structural geology is the study of the three dimensional distribution of rocks units with the respect to their deformational histories. The purpose of structural geology is that to uncover information about the history of deformation or strain in the rocks and to understand the stress field that resulted in the observed strain and geometries. This understanding can be linked with the important events in the regional geologic past. With the respect to the regionally widespread patterns of rock deformation due to plate tectonics, understanding the structural evolution of a particular area is the common goal.

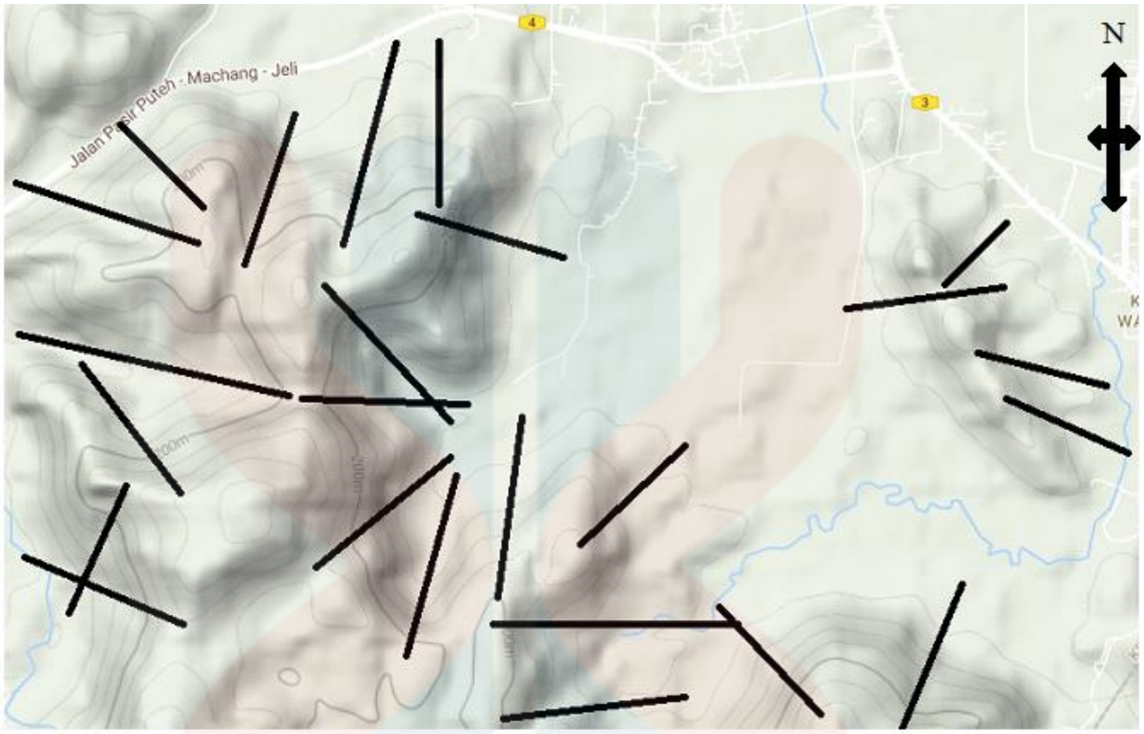
4.3.1 Lineament Analysis

Lineament is a linear fracture in a landscape which is an expression of an underlying geological structure such as fault. Fracture zones, shear zones and igneous intrusion such as dyke can also give rise to lineaments. These lineaments can be appearing obvious on aerial or satellite photographs while in geological maps or topographic maps, lineament are often seeming apparent. Based on the Table 5.1, the strike data that have been obtained from the lineament analysis is used in the GeoRose software in order to obtain the Rose diagram for the purpose of lineament analysis.

Table 5.1: Reading of lineament data analysis

Lineament Data (Strike, ^{o})			
35^{o}	79^{o}	104^{o}	106^{o}
25^{o}	144^{o}	42^{o}	90^{o}
89^{o}	08^{o}	104^{o}	93^{o}
82^{o}	14^{o}	128^{o}	02^{o}
16^{o}	18^{o}	126^{o}	103^{o}
98^{o}	145^{o}	35^{o}	110^{o}

The lineaments are interpreted from the ridges in the topography of the study area and from all the drainage (Figure 4.10). Using the Rosenet application, a Rose diagram can be plotted in order to obtain the direction of forces, tension and shear (Figure 4.11). The result shown that the major force that is σ^1 comes from the direction of North West (NW) while the tension or minor force, σ^3 being taken from the North East (NE), directly proportional to the major force.



Legend

Lineament line

Figure 4.10: Regional lineament of Kg. Wakaf Raja and its vicinity.

Source: Google Maps (2016)

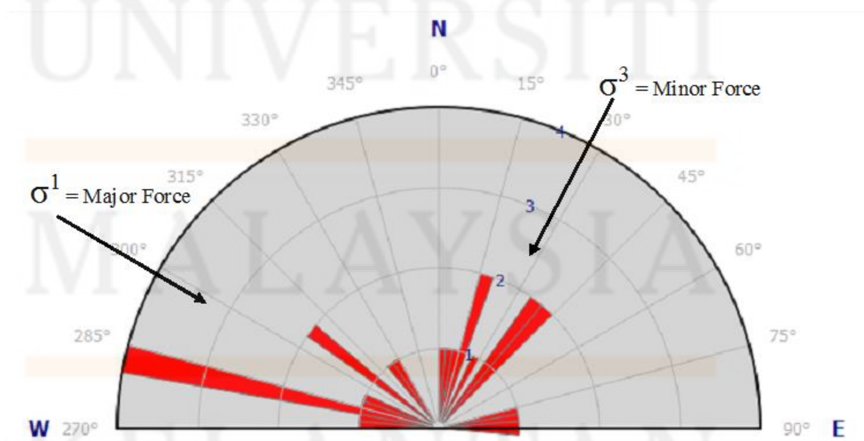


Figure 4.11: GeoRose data of lineament

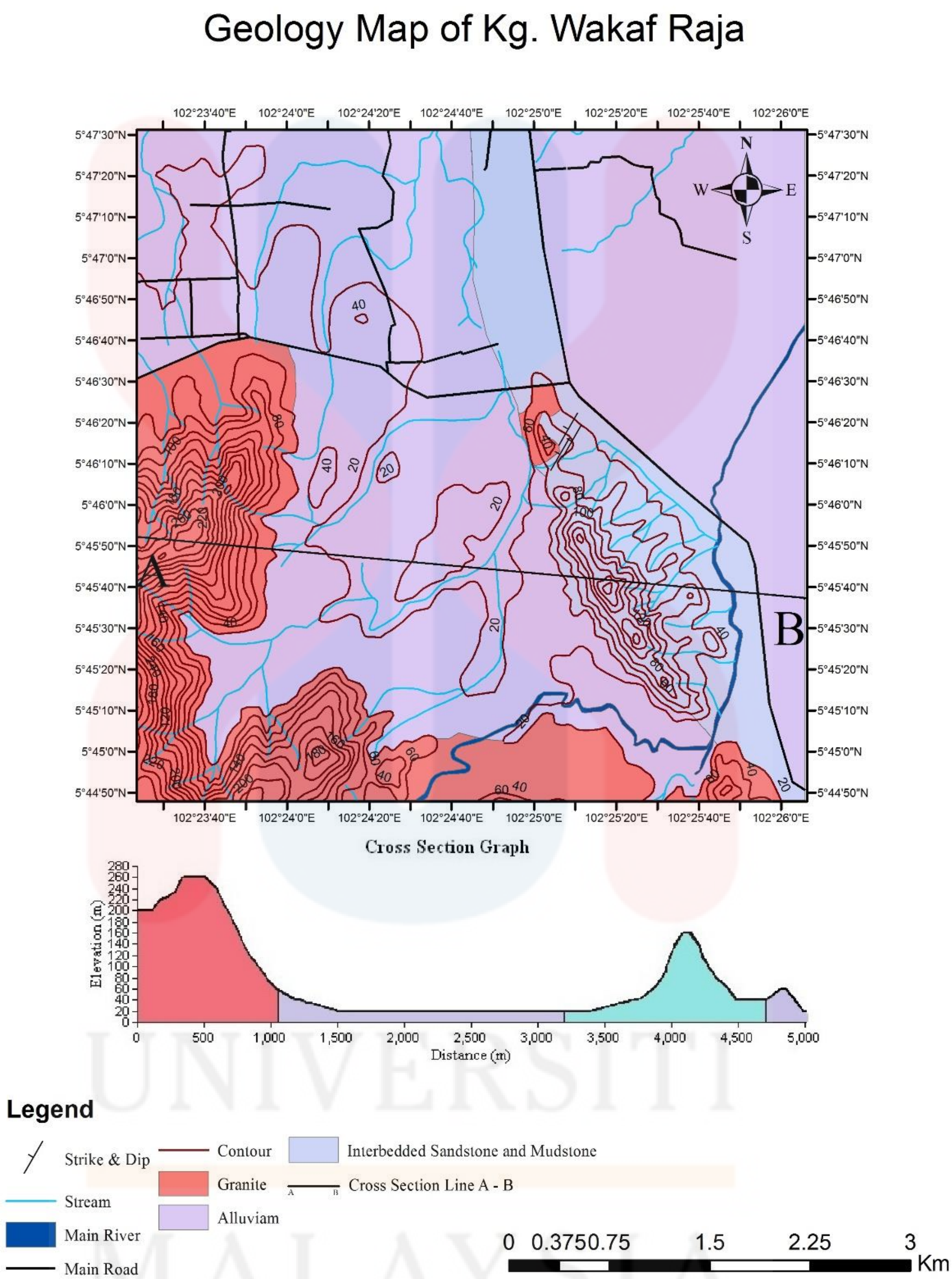


Figure 4.12: Geology map of Kg. Wakaf Raja

4.4 Stratigraphy

In the study area, there are two main types of rock that are present which are igneous rocks and sedimentary rocks. The igneous rocks that are present is granite that are majorly found in the study area while the sedimentary rocks that are present in the study area are sandstone and mudstone (Figure 4.12).

Sample 1

Figure 4.13: Hand specimen of Granite

Figure 4.13 shows the hand specimen of granite where the color on the surface ae yellowish brown due to the weathering process. It is difficult to obtain a fresh rock sample because most of the exposed outcrop already gone through weathering process for a long period of time. The texture is coarse. The outcrop basically in the Earth surface and exposed probably by the soil erosion and human activities (Figure 4.14). The thin section of the specimens is shown in Figure 4.15 for plain polarized and Figure 4.16 for cross polarized.

Figure 4.14: Granite Outcrop

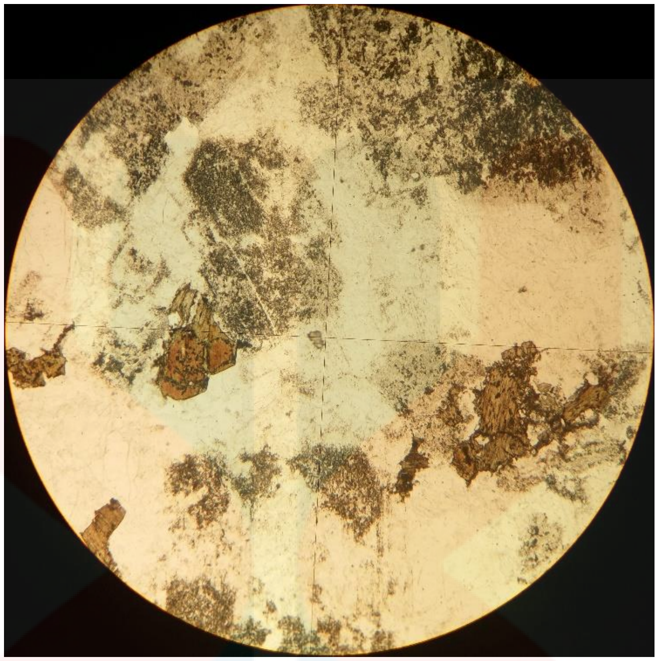


Figure 4.15: Plane Polarized of Granite (4X)

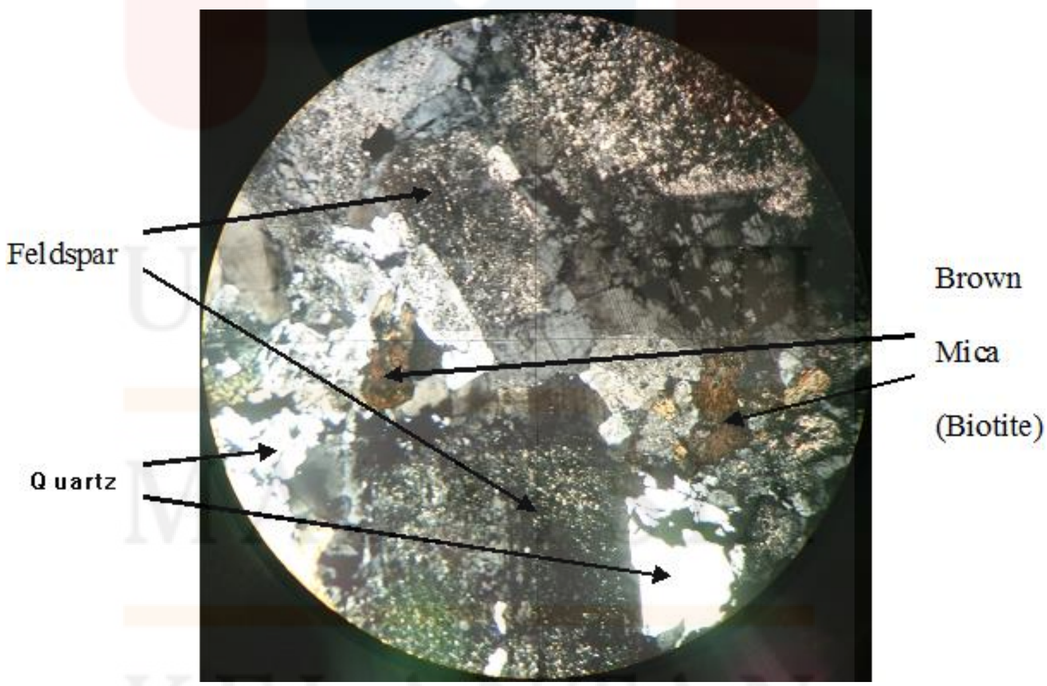


Figure 4.16: Cross polarized of Granite (4X)

Throughout the analysis under the light microscope with the lenses of 4 x 10, the results showed in Figure 4.16 is made up of interlocking rectangular feldspars and irregular clear quartz, all in shades of dark gray to white. The crystal showing brownish in color is known as brown mica (biotite).

Sample 2

Figure 4.17: Hand specimen of Granite

The specimen Figure 4.17 is located at N 05˚ 44’ 52” E 102˚ 24’ 34”, this specimen is collected. The color of this hand specimen from the surface is greenish brown due to the biological weathering that is algae. The texture is coarse and the mineral can be seen by the naked eyes. The outcrop is well exposed due to its location on the riverbed. It is hard to obtain a fresh specimen due to the physical weathering that is caused by the flow of the water in the river as shown as Figure 4.18.

Figure 4.18: Outcrop of Granite near the riverbed

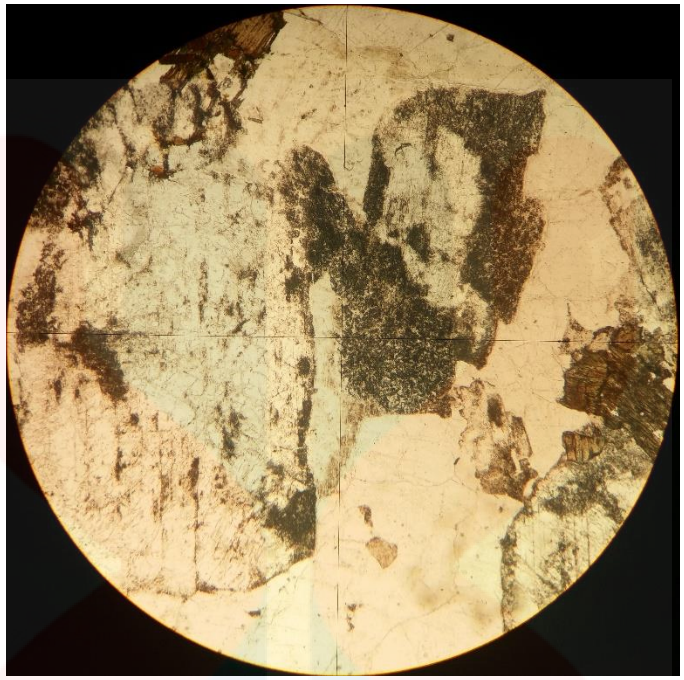


Figure 4.19: Plain polarized of Granite (4X)

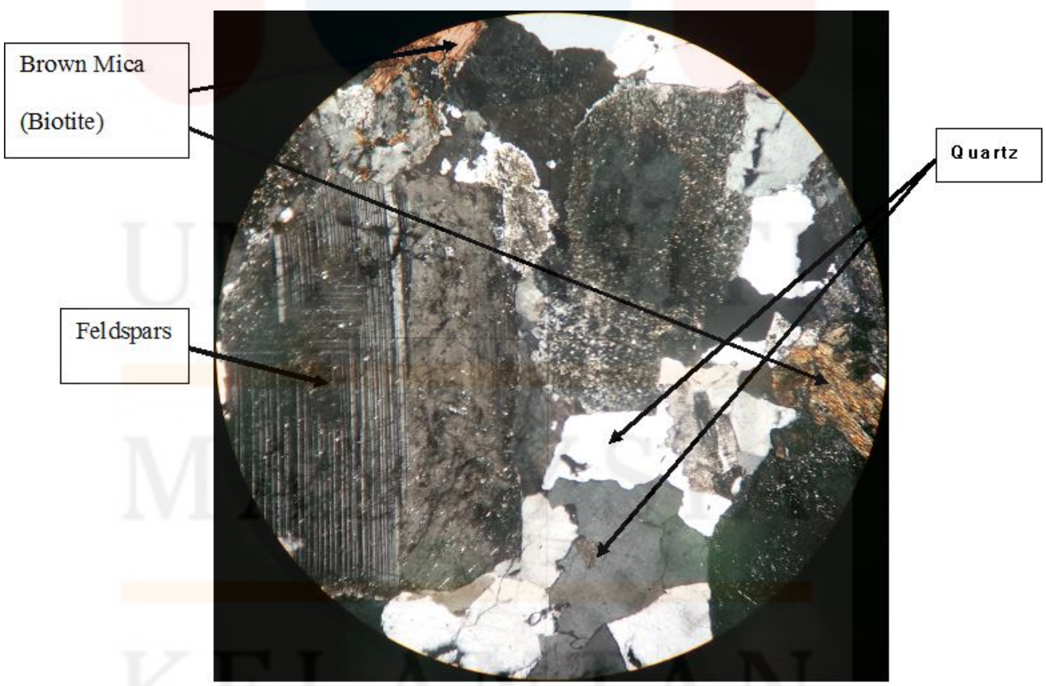


Figure 4.20: Cross polarized of Granite (4X)

The Figure 4.19 showing thin section of the hand specimen under the microscope with plain polarized while in Figure 4.20 show the thin section of the specimen under cross polarized lens.

Sample 3

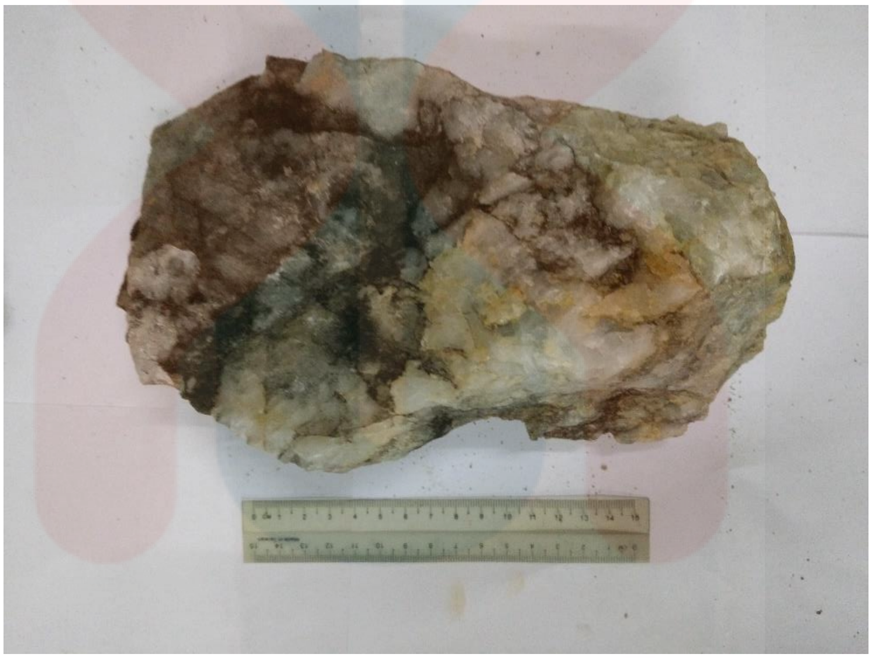


Figure 4.21: Hand specimen of Quartzite

Figure 4.21 shows sample 3 from the study area which is quartzite. This samples were taken at the same place as sample 1 from Figure 4.14. The outcrop of this hand specimen was not clearly exposed but can be seen clearly from the surface. The sample was taken near the outcrop which have been broken down due to weathering process.

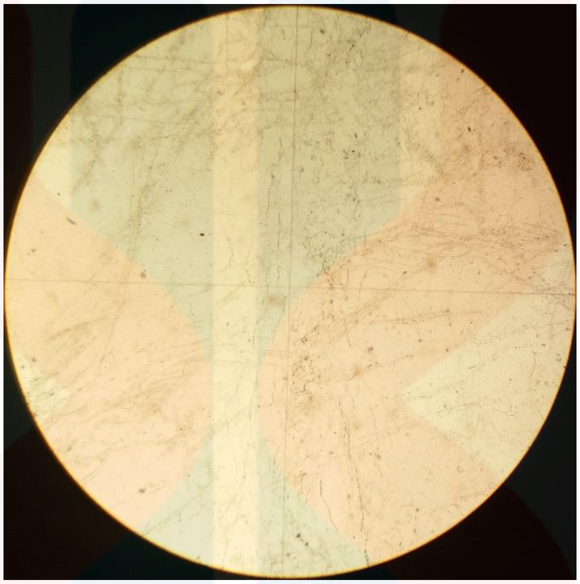


Figure 4.22: Plain polarized of Quartzite (4X)

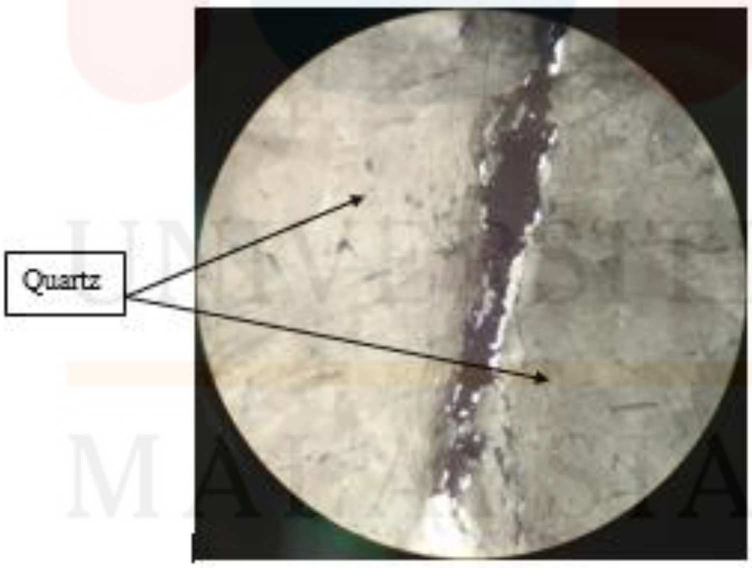


Figure 4.23: Cross polarized of Quartzite (4X)

From Figure 4.22 and Figure 4.23, it is clear that the only existing mineral in the specimen is quartz.

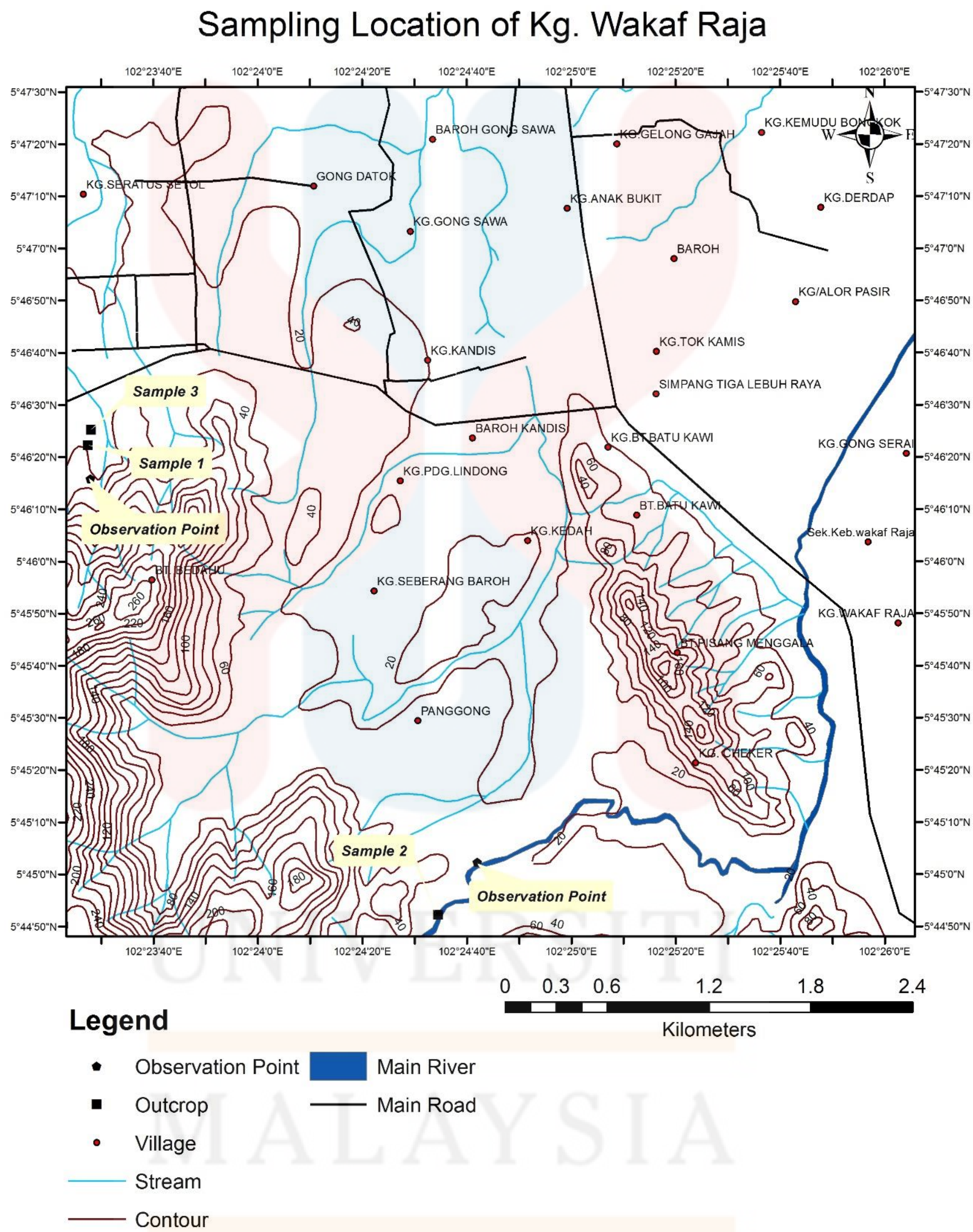


Figure 4.24: The map of location for sampling and observation point

Figure 4.25: Observation point at Bt. Bedahu

Figure 4.26: Observation point at Sungai Semarak

Figure 4.24 shows the location of sampling point and the observation point of the study area. Bt. Bedahu is the highest area throughout the research area and the study area is observable from the top of Bt. Bedahu in order to see the landform variety of the study area, while the other observation point is near the main river in the study area Sungai Semerak; located at the southeast of the study area. The observation point is shown in Figure 4.25 and Figure 4.26.

CHAPTER 5

HYDROLOGICAL POTENTIAL AT KG. WAKAF RAJA

5.1 Introduction

This chapter explains on the geophysical investigation using electrical resistivity method. The location and interpretation of the horizontal line are discussed in detail from the data which is obtained from the ABEM Terrameter LS. These include in determining the hydrological potential and identifying its depth from the surface.

The RES2DINV software will analyze the data by using the geoelectric resistivity method and gave the result in the unit of Ω – meter together with the profile form of modal image and 2D Lund Imaging Resistivity.

5.2 Location of Survey Line

The survey line is used for the electrical resistivity survey in this research and chosen in Kg. Wakaf Raja for the placement of the survey line. The survey line is placed nearly at the center of the study area and placed in a direction according to the Figure 5.1. It is carefully chosen based on the topography and placed on a valley, which according to Fetter (1980), generally, groundwater always move from a higher elevation area to the lower elevation area with its driving force is gravity. Valleys are an ideal area for exploration of hydrological potential due to its lower elevation and its high recharge rate. This is the concept that has been chosen for the location.

Location of Resistivity Survey Line

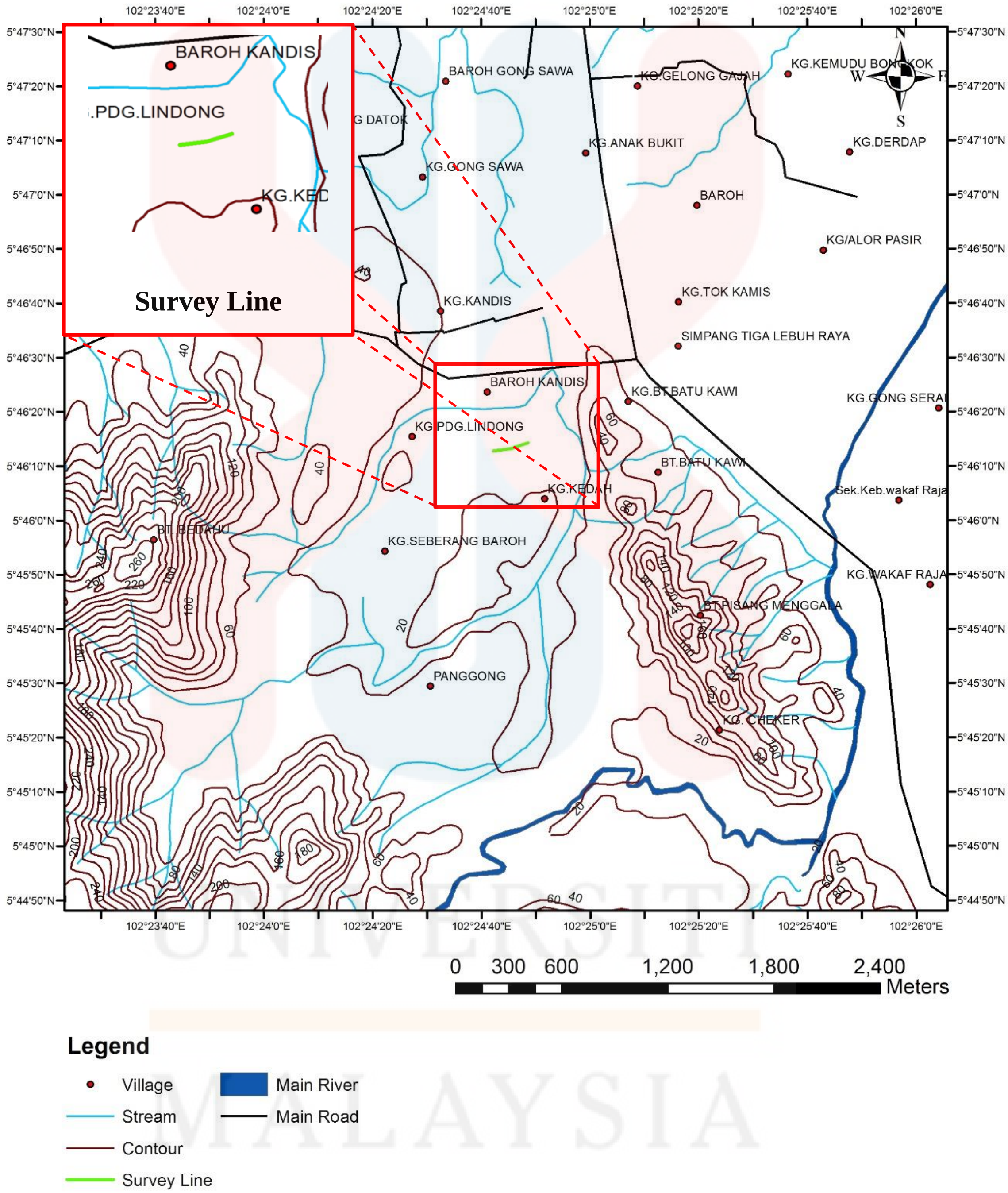


Figure 5.1: Location of the Resistivity Survey Line in Kg. Wakaf Raja

5.3 Interpretation of Sub – surface

The image that is produced by the RES2DINV software from the horizontal line are interpreted and discussed. The interpretations are made by referring to the resistivity values of materials from Loke, 2004. Each of rock or materials has their own resistivity values and this resistivity values are affected by several factors such as pores, structures and permeability. Figure 5.2 shows the resistivity values of rocks, soils and minerals based on Loke, 2004.

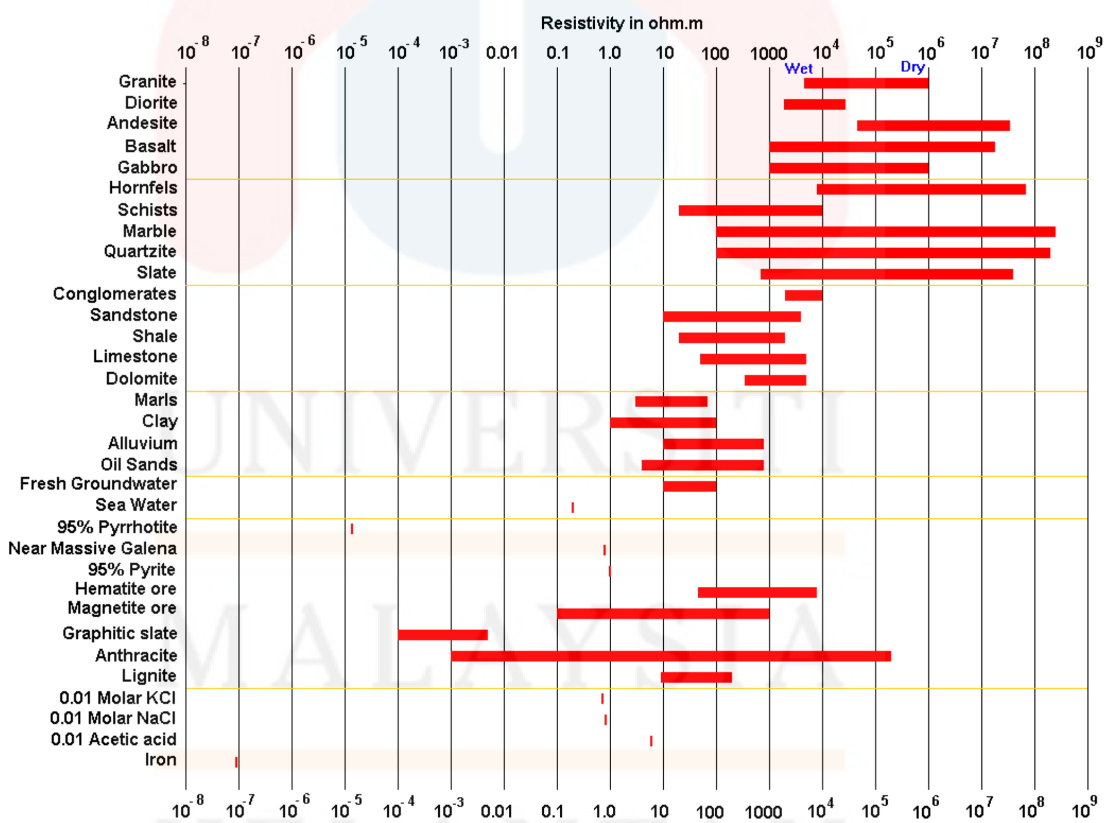


Figure 5.2: Resistivity values of rocks, soils and minerals (Loke, 2004)

5.4 Electrical Resistivity Survey Line

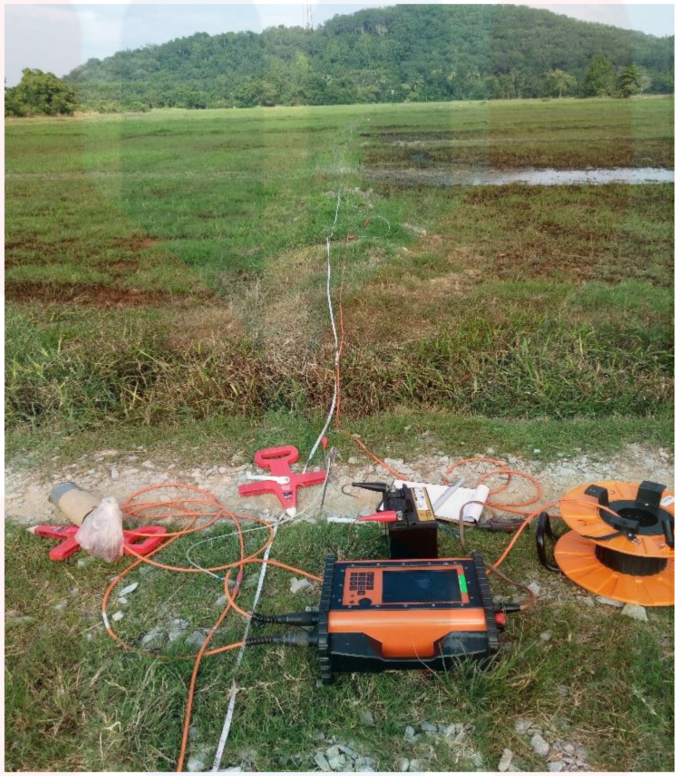


Figure 5.3: Location for survey line

The survey line is located along N 05˚ 46' 13.3" and E 102˚ 24' 45.4" with a length of 200 meters, 5 meters spacing between the electrodes using 40 electrodes. The survey line is located along a paddy field a flat wide paddy field as shown in Figure 5.3. The resistivity configuration used at the site are Schlumberger array and Wenner array and conducted at the study area, Kg. Wakaf Raja, Pasir Puteh. The location is nearly at the center of the study area and surrounded by Bt. Bedahu and Bt. Pisang Menggala.

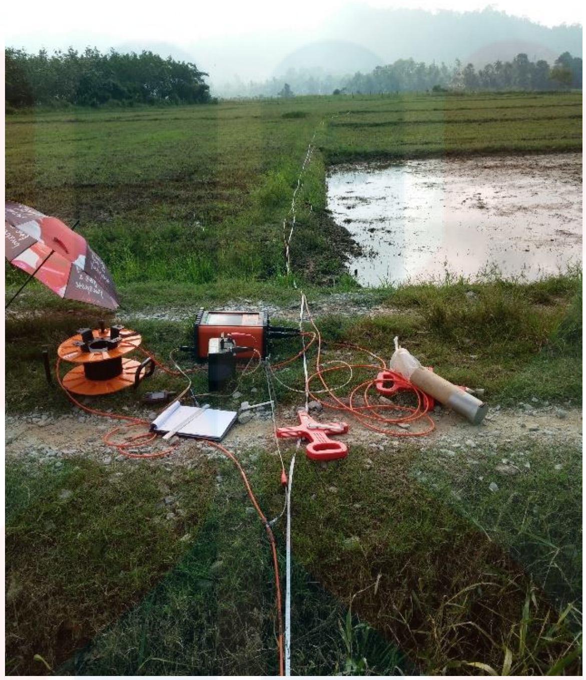


Figure 5.4: Hills can be seen clearly surround the area

Resistivity Survey Line

Model Resistivity Profile 1 (Schlumberger Array)

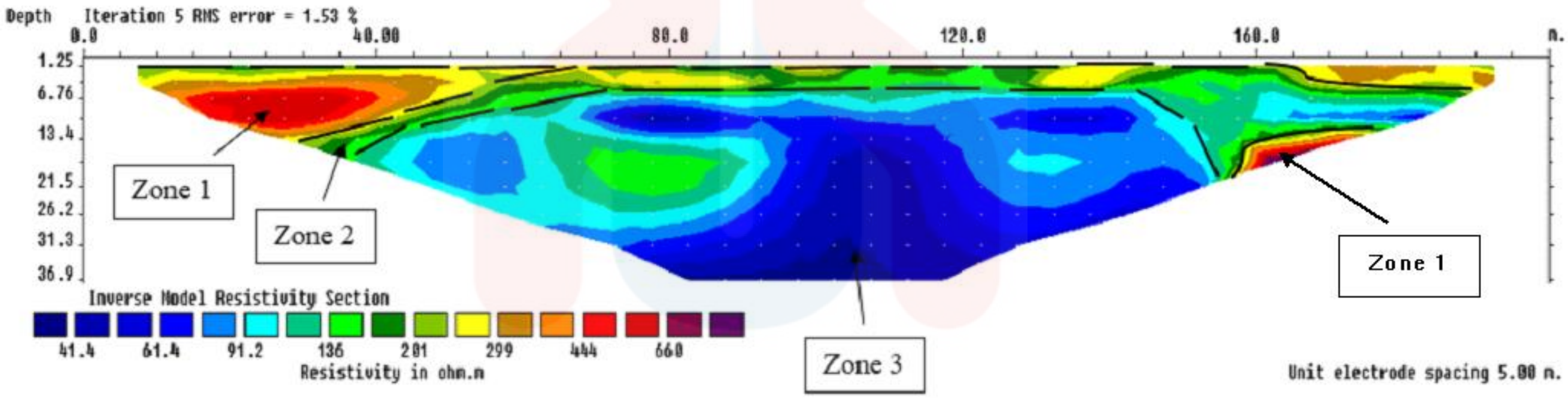


Figure 5.5: Model Resistivity Profile 1 (Schlumberger Array)

Resistivity Survey Line

Model Resistivity Profile 2 (Wenner Array)

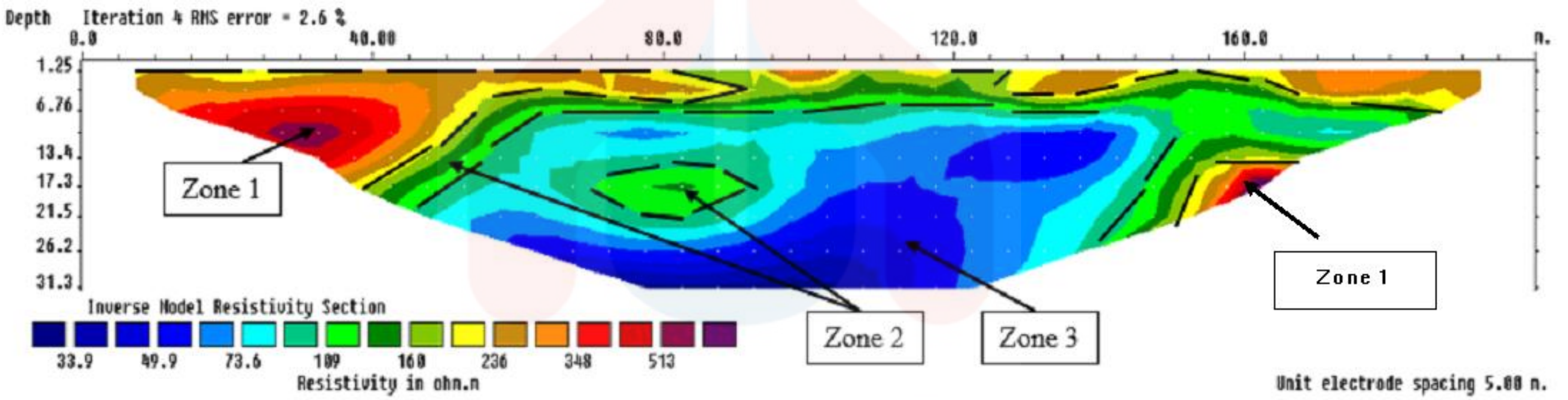


Figure 5.6: Model Resistivity Profile 2 (Wenner Array)

For the survey line, the total length of 200 meters is done at location N 05˚ E 102˚. The electrode spacing for the survey line is 5 meters each. The results are divided into 3 zones for interpretation. Figure 5.5 shows the subsurface resistivity results using Schlumberger array for zones 1 with the resistivity values ranging from 240 Ω meters to 650 Ω meters and 220 Ω meters to 500 Ω meters for Figure 5.6 that using Wenner array. This values can be interpreted as high resistivity values due to its character which has less ability to conduct electricity. In order words, electricity is unable to pass through easily. With its depth respectively in range from 0 meters to 15 meters for Figure 5.5 and range from 0 meters to 17.3 meters for Figure 5.6. According to the resistivity values in Figure 5.2, this reading indicates that it is most likely to be alluvium and fresh rock in the zone 1. Some of the high resistivity values are located at the upper part can be interpret that the rocks underneath may already undergoes weathering process, while the right part of the result, it shows in zone 1 with the reading ranging from 300 Ω meters to 700 Ω meters which indicates fresh rock, probably sandstones or mudstone. For Zone 2 with the depth respectively 21.5 meters which are most located in the upper section and surrounds the lower resistivity values. This medium resistivity reading is between 136 Ω meters to 240 Ω meters for Figure 5.5 and 109 Ω meters to 220 Ω meters for Figure 5.6. This zone most likely to be compact materials.

The lowest resistivity reading is between 1 Ω meters to 95 Ω meters for Figure 5.5 and between 1 Ω meters to 75 Ω meters for Figure 5.6 which is distributed mostly at the center of both of the figures. This low resistivity reading indicate as groundwater potential. Groundwater naturally has low resistivity value due to its characteristic as a highly electrical conductivity. This hydrological potential can also be classified as unconfined aquifers; this is due to the fact that the upper boundary of unconfined aquifers is water table. Unconfined aquifers also known as water table or phreatic aquifers. The name unconfined aquifers are because that it does not have a confining layer between it and the surface. Around 100 meters in width is the hydrological potential and the depth is around 22 meters to 40 meters.

5.5 Well Water Depth

This parameter helps in distinguish roughly the depth of the hydrological potential or the water table around the study area. Most of the well in the study area have been closed or buried due to the sources of water that have been provided by the government. Only few to none of the villagers that are still using the well, but only for the purpose of emergency supply if there will be a cutback from the government.

Table 5.1: Measurement of well depth

	Reading of well water depth parameter				
Well no.	W1	W2	W3	W4	W5
Coordinate	N 05˚ 46’ 35.9” E 102˚ 24’ 28.9”	N 05˚ 46’ 51.9” E 102˚ 24’ 17.1”	N 05˚ 46’ 38.5” E 102˚ 24’18.7”	N 05˚ 46’ 17.8” E 102˚ 25’ 0.62”	N 05˚ 47’ 23.5” E 102˚ 25’ 30.1”
Elevation (meters)	5	9	16	19	21
Water Level (meters)	2.5	0.39	0.53	2.15	0.6
Water Depth (meter)	6.49	3.9	0.8	5.23	3.2
Well Height (meters)	0.8	0.69	0.62	0.87	0.62

Table 5.1 shows the measurement reading some of the well that have been taken in the study area. It can safely be said that the water table can be reached at the range of 7 meters in depth and can be extracted. With this information data, the determination of the hydrological around the area can be determine to be high and can be extract for the purpose of domestic use as the source of emergency.

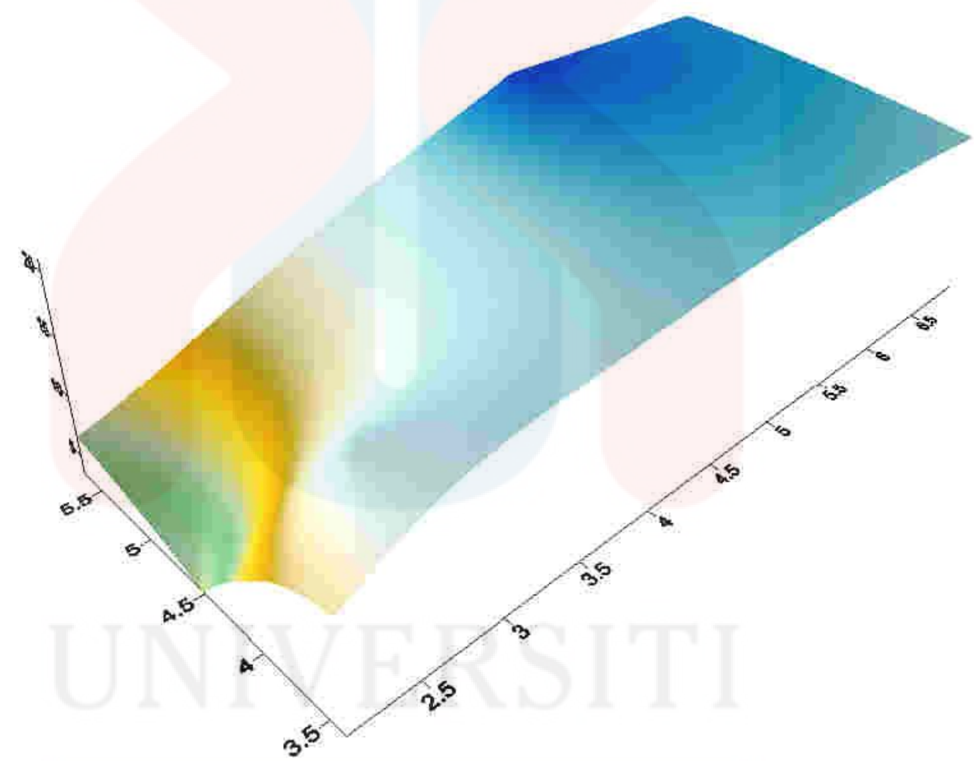


Figure 5.7: The model of water table

Figure 5.7 shows that the water table model from the data that have been collected from the well water depth.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

The purpose of this study is to identify the hydrological potential of Kg. Wakaf Raja, Pasir Puteh, Kelantan using the geophysical survey. The geophysical survey used was the electrical resistivity method. General geology of the study area was also conducted for the purpose of advancement of research in order to update the geological information. The geomorphology, structure, lithology and other characteristics were identified in this study. Based on the study that have been conducted, it was found that the study area consists of granitic rocks, sediment rocks and alluvial deposits. Structure was little to none in the study area which are lineaments and strike/dip in rocks. The drainage pattern in the study area were determined into two types; that are dendritic drainage patterns and sub – parallel drainage patterns. Basically, Kg. Wakaf Raja geomorphology is hilly area which to be found on the southwest of the study area with valley on its center and another one that is nearly at the center of the study area to the eastern part.

The second part of the research was the geophysical survey. Electrical resistivity method had been applied in the location of study area by using ABEM Terrameter LS with its other equipment. The program that helped in the process of interpreting and analyzing data is the RES2DINV program which had been helpful in this research. The geophysical survey by using the electrical resistivity method was successfully used in the purpose to identifying the hydrological potential in sub – surface of the chosen location. The hydrological potential that was found was interpreted to be in shallow to intermediate unconfined aquifer and also the depth of the hydrological potential can be identified with this method. The resistivity horizontal line contains an unconfined aquifers located at the center and the eastern part of Figure 5.5 and Figure 5.6 with its depth ranging from of 22 meters to 40 meters from the surface. This method is reliable and suitable to be used in this research due to its success in identifying and determining the hydrological potential of the study area.

6.2 Suggestion

This research should not end here and should be continued because of this research was able to investigate and identifying the hydrological potential in the sub – surface of the study area which also for the benefits of the community. Other investigation should be conduct to further the study such as determining the recharge rate of the groundwater and also the quality of the groundwater. These data can also be contributed to many purposes such as in the engineering factors in constructing and rehabilitation or even for the purpose of safety. Water quality test should also be used in the nearby well in order to identify the quality of the water whether it is safe for drinking and investigate for any sign of contamination at the water.

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