GEOLOGY AND IDENTIFICATION OF POTENTIAL GROUNDWATER LOCATION USING ERI OF DABONG, KELANTAN

by

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

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APPROVAL

“I hereby declare that I have read this thesis and in our opinion this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Applied Science (Geoscience) with Honors”

Signature : …………………………........

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DECLARATION

I declare that this thesis entitled "Geology and Identification of Potential Groundwater Location using ERI of Dabong, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Abstract: The study area is located in Dabong that belong to Kuala Krai district which is developing and increasing in population day by day. As the growth population increases, problems such as depletion of water resources and lack of clean water could be arises in time. In future, groundwater is important as an alternate source for backup plan to overcome the problem of decreasing sources of clean surface water. Keep in view, the present study focus on update the geological map on 1: 25,000 scale and to identify the potential groundwater location using Electrical Resistivity Imaging (ERI) method. Geological mapping and geophysical survey were conducted and rock samples were collected from lithology, and also structural data, were collected during the fieldwork. Three survey lines were established during the geophysical survey at three different locations. For location 1, the survey line follows Pole-dipole electrode configuration array while another two locations follow Schlumberger electrode configuration arrays and all the data from all locations were recorded using ABEM Terrameter LS 1, then the data is processed by using RES2DINV software. The results show that potential groundwater location existing in the alluvium for survey line 2 and fracture zones for survey line 1 and 3. The geological mapping and geophysical survey is a good combination to identify the potentially groundwater locations in the study area.

Keywords: Dabong, geophysical investigation, potential groundwater, geological map, ERI method

GEOLOGI DAN IDENTIFIKASI LOKASI POTENSI AIR BAWAH TANAH MENGGUNAKAN KAEDAH ERI DI DABONG, KELANTAN

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Abstrak: Kawasan kajian terletak di Dabong, merupakan sebuah daerah di Kuala Krai yang semakin berkembang dan mengalami pertambahan penduduk seiring dengan masa. Apabila pertumbuhan penduduk semakin meningkat, masalah-masalah seperti kekurangan sumber air bersih akan timbul. Air bawah tanah digunakan secara meluas di kawasan Kelantan, dimana mereka mempunyai Jabatan Air Kelantan sendiri yang mengurus sumber air. Pada masa akan datang, air bawah tanah menjadi sumber alternatif yang penting sebagai pelan sandaran untuk menampung masalah pengurangan sumber air. Kajian ini bertujuan untuk mengemas kini peta geologi pada skala 1: 25,000 dan untuk mengenal pasti potensi lokasi air tanah menggunakan kaedah Pengimejan Ketahanan Electrik (ERI). Penyelidikan geologi dan geofizik dilakukan melalui kerja lapangan di mana sampel dikumpulkan sepanjang perjalanan di lapangan. Tiga garis kaji selidik telah digunakan di tiga lokasi yang berbeza. Susunan elektrod Pole-dipole digunakan untuk satu garis selidik, manakala susunan elektrod Schlumberger digunakan untuk dua garis selidik dimana data direkodkan menggunakan ABEM Terrameter LS, kemudian diproses menggunakan perisian ABEM LS Toolbox dan RES2DINV. Keputusan menunjukkan bahawa potensi lokasi air bawah tanah terdapat dalam kawasan alluvium dan rekahan batuan. Gabungan peta geologi dan kaji selidik geofizik memberikan cara yang dipercayai untuk mengenal pasti potensi lokasi air bawah tanah di kawasan kajian.

Kata kunci: Dabong, kaji selidik geofizik, potensi air bawah tanah, peta geologi, kaedah ERI

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CHAPTER 1

INTRODUCTION

1.1 General Background

Our entire life needs water in order to continue with daily lives, including plants, animals and also human. For generations, human depends on water for food production, drinking, sustenance of generation and diversion. 33% of the water used in daily life comes from groundwater which is the same all around the world. In the countryside or rural area, the uses rate of groundwater is higher where some rely on the groundwater as their main source of water, especially for drinking purposes. Groundwater is more conventional and cheaper compared to surface water. This is due to its less variability of getting polluted than surface water where it is pumped from the sub-surface of the earth (Harter, 2003).

Upon entering the soils the first water that replaces the water will undergo evaporation or transpiration by the plants during the dry period. Hydrologists identify an unsaturated zone in between the land surface and the aquifer water. Usually, in this zone, the presence of water is low which they have smaller openings in the rock while the larger openings carry out air compared to water. When the rain falls within the significant amount, it will turn to almost saturated and the same goes when it undergoes dry climate. Saturated zone underlies the unsaturated zone where that contain pores and rocks that are filled with water. On the top of the openings in saturated zone is known as water table (Doc et al, 2002).

The aim of this research is to update the geological map of the study area. Apart from that, this research is held to identify the possible groundwater locations in the study area. The updated geological map can be useful for the future studies and also for the safety of the located study area. This is due to the geological changes that might occur throughout the year. The identification of the groundwater locations is to provide the possible area of groundwater locations to the villagers and other organizations. This study will use the Electrical Resistivity Imaging (ERI) method in finding the locations of groundwater.

1.2 Study Area

This research is based in Kelantan state, one of the states that locates in the eastern belt of peninsula Malaysia. Including Kuala Krai, Kelantan has 13 districts such as Tanah Merah, Pasir Puteh, Kuala Krai, Gua Musang and more. The study area is located in Dabong, a small town in Kuala Krai district. One of the famous attraction in Dabong, Gua Ikan is located near to Sungai Galas. In Kuala Krai constituency, there are four state seats which Dabong is one of it.

The study area is located in the coordinates (102° 00' 06" E, 05° 23' 57" N), (102° 02' 50" E, 05° 23' 57" N), (102° 02' 50" E, 05° 21' 16" N) and (102° 00' 06" E, 05° 21' 16" N) with the overall total area is $25km^2$. The highest elevation that can be found in the study area is 340m which situated at the southeast and the lowest elevation is 20m. The contour lines of the study area can be seen closely with each other except the ones in the upper area. This indicates the hilly area that covers almost 75% of the study area. We can conclude that the geomorphological feature at the study area is hilly and low-laying area which can be seen in the base map shown below in Figure 1.1.

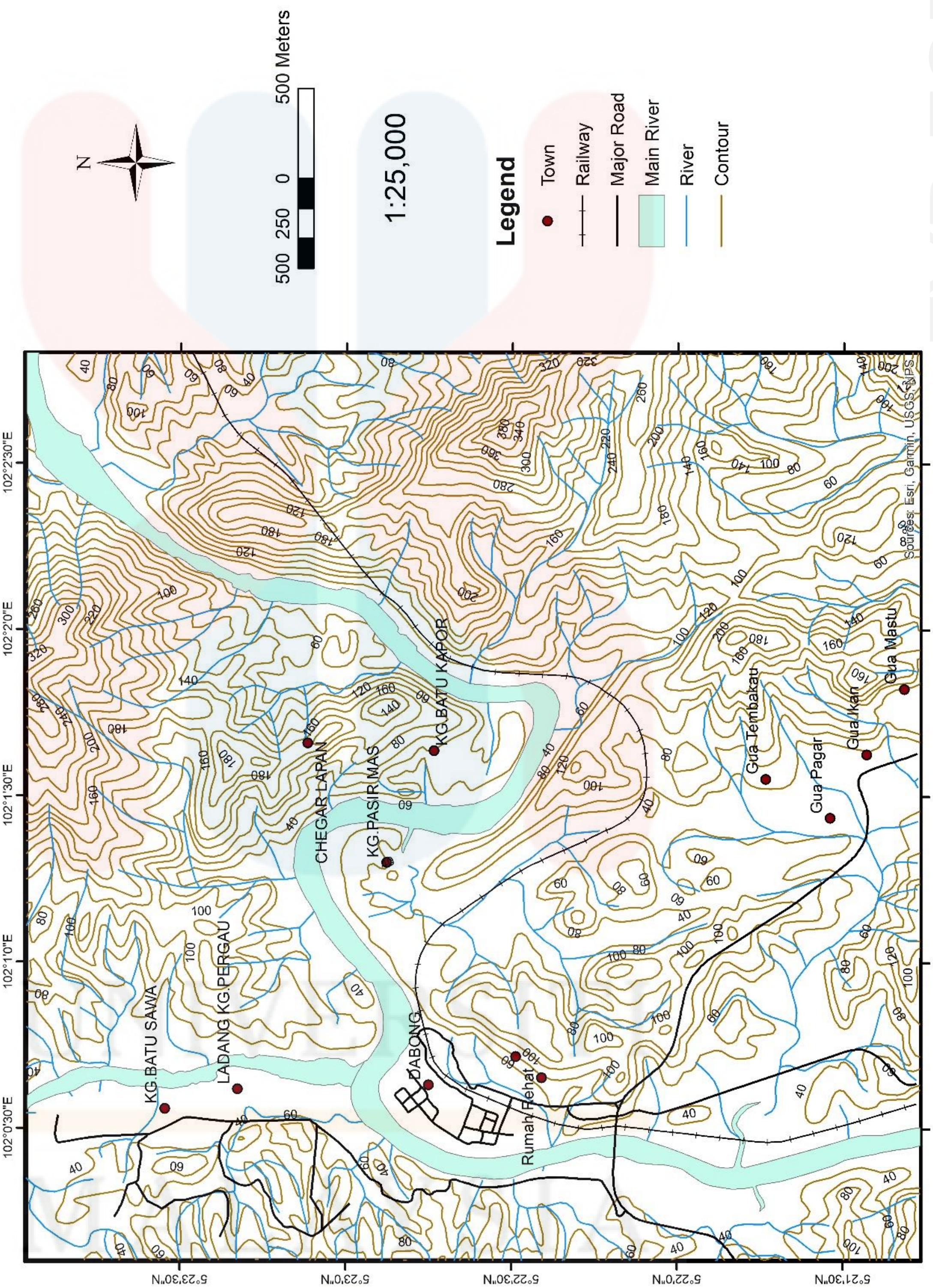


Figure 1.1: Base map of study area

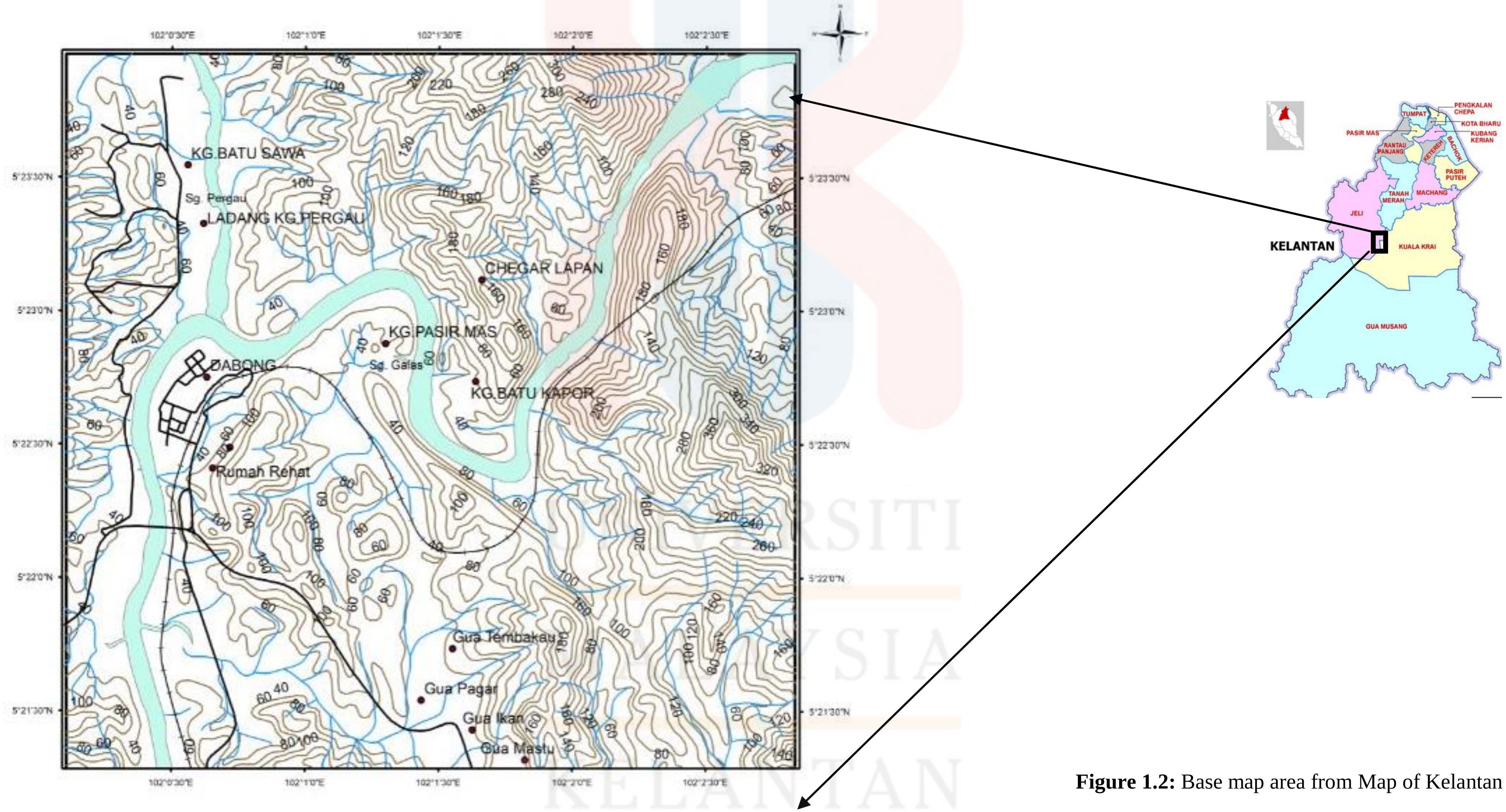


Figure 1.2: Base map area from Map of Kelantan

1.2.1 Location

Kuala Krai is an inland district acts as the focal point States of Kelantan in the north east of Malaysia which dominated with the hills and the entire area denotes as tropical rain forest before 20th century. The area retains the intersection of two noteworthy rivers, Sungai Lebir and Sungai Galas to shape Kelantan River which at that point streams somewhere in the range of 70km northwards through a standout amongst the most thickly populated flood plains on Peninsula Malaysia to its estuary in South China Sea close to the State capital of Kelantan. Dabong is located in between Jeli and Kuala Krai which it connects the two district where mostly people use the main road to get to Gua Musang also.

1.2.2 Road Connection and Accessibility

As transport joins enhanced amid the 20th century, individuals moved into the places to exploit the bottomless land accessible for cultivating purposes. A railroad was developed in the 1920s through the undeveloped interior of Malaysia to interface Kelantan State with the principle focuses of populace on the west drift. This line went through Kuala Krai domain, and settlements ended up built up along the course. Street linkage (Figure 1.3 and Figure 1.4) took after, the towns and surrounding village developed to provide food for the fundamentally horticultural populace. Within the study area, there are places that need water transportation to reach such as at the SW area where Kampung Chegar Lapan is located. According to the head village, back then there are people live at the village. As the time passes, they no longer lived there as the only access that connect the village and Dabong is the river. Other than that, we also can go to Dabong using train as it has their own railway station (Figure 1.5) which is used in daily life especially for the student that went to the school. Figure 1.6 shows one of the railway track in Dabong where it located under Dabong's bridge.

Figure 1.3: Main road accessibility

Figure 1.4: Dabong's gateway

Figure 1.5: Dabong's railway station

Figure 1.6: Railway track in Dabong

1.2.3 Demography

In 2010, Malaysia populations is at 28,334,135 where it is 42nd high in population. Different people with their religions and cultures can be found in Malaysia where Malay made up 50.4% of it and the other are other ethnic groups such as Bumiputera. Around 15 infants could not make it compared to another 1000 for the rate of mortality in 2012 and the oldest expectancy to live is at 75 in Malaysia. Government spent about 5% for the people in order to live with better health care. Peninsular Malaysia is made up of 75% population of urban where approximately 25 million of Malaysians were in Kuala Lumpur where most of commercial and financial activities exist.

Kuala Krai located in the centre of Kelantan with direction of north-east of Malaysia where it is covered with hills and tropical rainforest before the 20th century. Two major rivers, Galas and Lebir made up this territory which it forms the presence of Kelantan River flowing 70 km towards the estuary in South China Sea. With area of 2329 km^2, Kuala Krai comprises of three sub-districts: 757.6 km^2 taken by Daerah Olak Jeram (67 villages), 726.9 km^2 by Daerah Batu Mengkebang (122 villages) and 844.5 km^2 covered by Daerah Dabong (27 villages). Some of the famous and known villages and towns are Kemubu, Dabong, Kampung Laloh and Manek Urai. As in 2010, total people lives in Dabong, Kuala Krai is 40,659 with 21,026 males and 19,633 females. Table 1 below shows the distribution of people according to their age in particular area.

Table 1.1: People distribution total in Dabong (Source: Local Authority and State Malaysia, 2010)

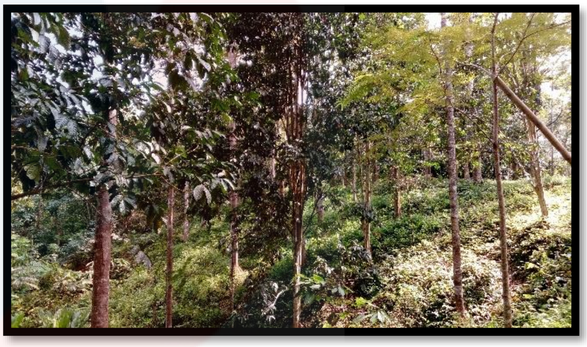
Local Authority Area	Total	Age Grouping							
		0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
Dabong District	40,659	4,418	4,581	5,573	5,010	3,929	2,688	2,251	2,161
Dabong	1,356	132	143	175	155	93	96	75	66
Kemubu	1,133	123	133	161	136	58	48	53	55
Manek Urai	1,638	133	195	241	228	111	94	63	75
Others	36,532	3,760	4,110	4,996	4,491	3,030	2,450	2,060	1,965

Local Authority Area	Total	Age Grouping							
		40-44	45-49	50-54	55-59	60-64	65-69	70-74	75
Dabong District	2,045	2,018	1,982	1,454	1,235	900	900	705	616
Dabong	65	58	75	75	43	34	59	47	40
Kemubu	59	57	55	55	50	28	38	53	26
Manek Urai	96	79	94	94	55	47	39	3,961	37
Others	1,825	1.824	1,758	1,758	1,293	791	569	1,293	565

1.2.4 Land Use

The process of organizing, managing and regulating the uses of lands and their resources is what mean by land use planning. Land use planning is created to meet the socio-economic development of the country and to meet the people's needs in the most efficient and sustainable way. It provides a vision for the future possibilities of development in neighbourhoods, districts, cities or any defined planning area.

Referring to Rancangan Tempatan Jajahan Kuala Krai 2020, all the basic facilities will be provided to the small town in order to increase the economic and industrial activity. Also, it can help people to have an easier life instead of going to other places. As for now, Dabong is divided into certain areas according to the interest and needs such as residential area, plantation area, utility and urbanization area. Middle part of Dabong is dominated by residential area where most of the villager lives there with almost all the facility locates nearby such as health centre, post office and public transport. The other part of Dabong is dominated with plantation area as shown in Figure 1.7 which most of them are palm oil plantation and rubber plantation. Not to mention, the villager's orchards which can be seen in Figure 1.8 (B). The study area has shown its improvement in facility aspect due to the good road connection from Jeli-Gua Musang.



A

B

Figure 1.7: Plantation area

A

B

Figure 1.8: Residential area

1.2.5 Social Economic

Socioeconomics is the social science that studies how economic activity affects and is shaped by social processes. In general, it analyses how societies progress, stagnate, or regress because of their local or regional economy, or the global economy. In other word it may refer to refer broadly to the "use of economics in the study of society". More narrowly, contemporary practice considers behavioural interactions of individuals and groups through social capital and social "markets" (not excluding, for example, sorting by marriage) and the formation of social norms. Basically, the residents in Dabong area work as rubber tappers or work in oil palm plantation. There are also those work who work as fishermen and boat makers. It can be seen almost in every house, they are drying tamarind for sale and fro their daily needs.

1.2.6 Rain Distribution

Table 1.2 shows the total of rain distribution of year 2018. The data show increasing rain from May to December but in the start of the year it starts declining. The highest amount of the total rain distribution was on December 2018 which is 880 mm. The rainfall can cause the weathering process. Then, the weathering process will lead to the erosion, transportation and sedimentary process (Hady Ismail, 2007). The changes of the rainfall pattern are influenced by the changes in weather pattern where makes it difficult to estimate the rainfall. The global warming is a one of the factors that leads to the pattern of rainfall changes. The environment has become wetter because of the high temperature can melt the snows, falls as rain and these extremely has high chances of floods and allow the social disrupt. Also as we know, rainfall is one of the recharge source for groundwater as the water cycle keeps repeating its process. All the precipitation that resulted from rainfall, hail and also snow went through condensation process which lead the way to continue the cycle of water to the Earth from atmosphere.

Table 1.2: Rain Distribution Total in Dabong (Source: Water Resources and Hydrology, JPS Negeri Kelantan)

Rain Distribution Total in Dabong (mm) 2018													
Station	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
Dabong	304	99	43	68	35	163	115	142	170	250	539	880	2,808

1.3 Problem Statement

The previous map used in the past research is bigger in scale, so there is need to update the map with smaller scale and recorded all small unit of lithologies. The study area every day undergoes development which leads to high demand for clean water sources. Presently the area depends on surface water and in future, surface water is not sufficient to cater for everyday use where alternate sources need to be sought. In this regards, the present research aims to identify the potential groundwater location within the study area to help the community. The previous research that has been done at the study area based on other specification where the information regarding groundwater is nowhere to be found.

1.4 Research Objectives

The objectives of this research study are:

1. To produce geological map of the study area at scale 1:25,000.
2. To identify potential groundwater location using ERI method.

1.5 Scope of Study

The main outlook for this research is to conduct geological study and identify the groundwater locations using ERI survey. Geological mapping is essential in this research where we confirm the data collection of the study area. During the mapping, we ought to observe the geological features of the surrounding while traversing. Outcrop sample is collected throughout the field work for future step in the laboratory. During the geological mapping, information that related with geology of the area has been identified base on its lithology, geomorphology, drainage pattern, structural geology and others. The journey in completing the field work is not easy where unexpected things occurred such as the weathered outcrop, hidden structure and inaccessible.

The specification of this research is the identification of groundwater locations using Electrical Resistivity Imaging (ERI) method in Dabong area. The equipment that is used in this research is ABEM Terrameter along with the electrodes and cables. From the survey, we can locate the groundwater distribution of the study area which the data is stored in the ABEM Terrameter. This research is focused on the identification of groundwater locations of the study area. Limitation that can affect the study is the detection of electrode source from the data transmitted from the subsurface. Usually, it will detect only three to five lines and also the electrode of ABEM Terrameter cannot go too deep under the ground.

1.6 Significance of Study

The significance of the study is to produce an updated geological map of Dabong area. This is to ensure the future researcher for the study area got updated data for the future study. Furthermore, in order to keep up with the demand of clean water in the future, this research is important to locate the groundwater locations. Also, the new location can be huge of help to the future research of groundwater in the possible area. Hence, the information regarding possible locations of the groundwater can be a helpful guide to the community that needs the source of clean water. Other than that, with the information gathered at the end of this study, we can explain the important of geological survey to the surrounding people in order to increase their knowledge about their places.

1.7 Chapter's Summary

Briefly we have discussed in this chapter about the aim, objectives and the significance of the research to others and community. Other than that, we also identify the particular study area that are focused throughout the research. We can say that this chapter is important in order to complete the research study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter basically explains about the data collected from past research regarding the general geology and specification starts from Malaysia narrow down to the study area of the research. Literature review gives other information that the researcher needs to know. From past research, we can identify the problems, significance and future research that can be made regarding the selected title. This particular chapter also explain about the peninsula Malaysia which it locates the study area (Figure 1.2).

2.2 Regional Geology and Tectonic Setting

Regional geology of Kelantan is made up of a central zone of sedimentary and metasedimentary rocks in the west meanwhile granites of the Main Range and Boundary Range takes up the east respectively. The granite can be seen intrudes the central zone with its windows presence that is more prominent in the Dlu Lalat (Seting) batholith, Stong Igneous Complex and Kemahang pluton (Swee Hengl G *et al*., 2006). Granite and country rock belts has been trending in north-south direction that continuing the Pahang northern regional geology. It continues to flow into Kelantan in central and west part until it arrives in south Thailand, but Sungai Kelantan has overlain the granite boundary range with its coastal alluvial.

Lower Paleozoic age of rock belt is trending northerly at the foorhills of the Main Range which causes it to extend up to Sungai Neggiri in east ward position. It is noted as the oldest rocks in the state where the composition is mainly metapelites with lesser volcanic fragments and minor arenaceous and calcareous intercalations. It is recorded the occurrences of amphibolite and serpentinite which is rarely can be found (MacDonald, 1967).

Jeli district locates at the foot of the Main Range which is known as the backbone of peninsula Malaysia that mostly consist of granitic rocks. Several enclaves of sedimentary/metasedimentary rocks can be found in the range. The Main Range granite located in west of Kelantan that stretched along the western part of Kelantan until the boundary of Perak and Pahang (Dony Adriansyah *et al.,* 2015).

Regional geology of the area is dominated by medium-coarse grained, grey color and large feldspar phenocrysts. Predominantly grey, medium to coarse-grained of megacrsytic biotite-hornblende granite to granodiorite where the lineation of the feldspar phenocrysts can be seen with intense shearing at the west side. They are known as Kemahang Granite which is abundant with biotite composition. Gneiss is the product of shear with a schistose texture that deformed and bends feldspar, shattered quartz, strained polarization and mylonization. Abdullah has stated in 2007, the age Kemahang is Triassic which it is distributed along Bukit Jeli, Bukit Kemahang, Bukit Kusial and other smaller hills.

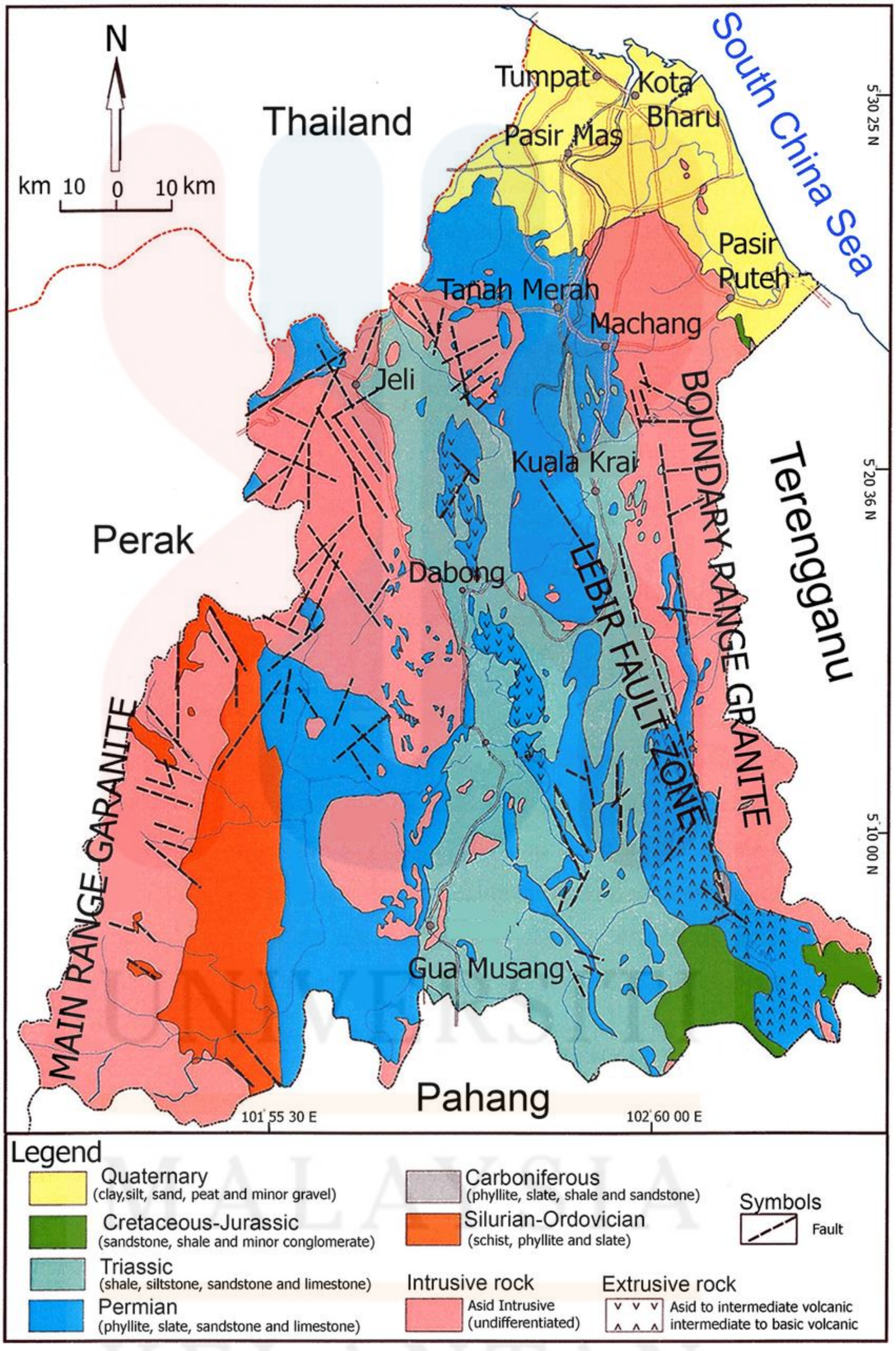


Figure 2.1: Geological Map of Kelantan (Source: Department of Minerals and Geoscience Malaysia, 2003)

2.3 Stratigraphy

Approximately 20% of Peninsular Malaysia is made up of Quaternary age of sediments that underlies with Cenozoic. Peninsular Malaysia that underlies over Cenozoic are in stable condition for its tectonic activity related with movement of fault or tilting and uplifting. The known Cenozoic deposits vary in thickness but an average thickness of 10,000 m has been noted for sediments in the Malay Basin (DuBois, 1980). The offshore deposits are also included for discussion and correlation in view of their economic importance.

Geology of peninsula Malaysia has divided into three belts which known as West, Central and Eastern belt by Hutchinson (2009). Eastern belt is made up of clastics and carbonates originate from Carboniferous and Permian, meanwhile Central belt is dominated by sediments belong to Permian and Mesozoic age. North Kelantan is classified under Gua Musang formation which it is overlained by Koh formation in the upper boundaries (Lee *et. al,* 2004).

Based on the fossils that were found at Kuala Krai area, it is denote that the sedimentary rock belongs to Carboniferous to Triassic age where majority of the associated volcanic and sedimentary rocks belongs to Carboniferous to Permian in age. Refer to Lee et. al (2004), Gua Musang formation is made up from the interbedded of calcareous and argillaceous rocks unit with arenaceous and volcanic rocks unit which belongs to Mesozoic age.

2.4 Structural Geology

Along Sungai Lebir traced of Lebir Fault Zone can be found with the direction of North-North-West to South-South-East curving into linear lineaments nearby to Manek Urai. Before it intersects at Pahang with Lepar Fault, the lineaments flow to south direction. (Mustafa Kamal Shuib, 2009).

According to Tjia (1996), based on the tension and drag fractures, fault that form is sinistral slip. It indicated by the cutting of road where the slickensides and sinistral movement can be identified on the fault structure surfaces. In between the fault zones, the parents rock has deformed into other rock units such as brecciated metasediment, flasered granite and mylonites. The identified lineament can be seen tracing in south direction that passes the granite batholiths located at the east part of Sungai Lebir, western part of Gagau Formation and continued to eastern part of Koh Formation. The observed zone of fault is approximately 10km in wide where it lies in between Taku Schist area near Kala Krai and Sungai Lebir. In Sungai Aring area, we can found the movement of sinistral slip around the faulting zoning (Aw 1990). This fault is known as Lebir Fault Zone where it passes along the basins of Jurassic-Createaceous that contain the formation of Koh, Tembeling and Gagau. The faulting happen has affected the present Triassic to Jurassic-Createaceous basin where it went through deformation process due to the movement of strike slip at the faulting zone (Mustaffa 2000).

2.5 Historical Geology

During 1922 until 1925, Savage has carried out basic work for regional geology which started with nature reconnaissance with the help of small scale topographical maps that is inaccurate. Later from 1951 until 1960, more work of this nature were carried out by MacDonald in 1951, Slater in 1957 and Santokh Singh in 1960. Hutchison & Tan (2009) has compiled the successful complete data with geological in the form of books and published later which is known as Geology of Peninsular Malaysia. Paleozoic, Mesozoic and Cenozoic are three major chronology of Kelantan geological formation that varies from Lower Paleozoic up till Quaternary.

The Cenozoic formation is mainly represented by Quaternary sedimentary deposits. The Quaternary sediment covering part of north Kelantan consist extensively of unconsolidated to semi-consolidated boulders, gravel, sand, silt and clay that underlie the coastal and inland plain (Rahim *et. al,* 1997).

Kelantan state can be divided into four types of landscape according to its geomorphological features which is mountainous, hilly, plain and coastal areas. Coastal areas only exist in the northern part of Kelantan meanwhile all three landforms can be found throughout the district of Jeli (Tanot *et al*., 2001). In the west and east of the district, mountainous areas can be seen.

During the Paleozoic and Mesozoic eras, land mass has been affected by the tectonic activities that resulted in the formation of faulting and folding where it has been observed as regional local structures. Local structures include folding, jointing, and faulting in the sedimentary rocks, and jointing and faulting in the granitic rocks (Department of Minerals and Geoscience Malaysia, 2003). Dominantly the structural pattern can be found along north-south to the northwest-southeast direction of

Kelantan. In Jeli district we can identify the dominant local structures takes part in northwest-southeast and northeast-southwest directions.

As for the lithology of the study area, we can classify it into two types which are an igneous unit (granite) and sediment unit (shale). Cooling and crystallization of magma in the subsurface that forms the igneous rocks which are divided into two types of rock; intrusive and extrusive rock. Coarse-grained igneous rock is referred to the intrusive rocks which form under slow cooling of magma processes such as granite and diorite. Extrusive rock has a fine-grained igneous rock which undergoes fast cooling of magma process such as andesite and basalt (Husin Mohamad, 1993).

Granite is a felsic igneous rock that rich quartz mineral with coarse-grained texture. It usually in light color due to the presence of high silica content. Mostly granite consist of feldspar, quartz and mica minerals which sometimes additionally amphibole or pyroxene. Granites also can be divided into three major types which are alkaline, peraluminous and calc-alkaline (Shah Othman A *et al*., 2000). Shale is a sedimentary rock which composed of silt and clay mineral with tiny fragment usually in silt sizes particle, especially quartz and calcite. Shale is characterized by breaks along thin laminae or parallel layering or bedding with less than one centimeter in thickness called fissility.

2.6 Hydrogeology

Underground water or subsurface water is the water that is stored underneath the layer of earth. The various geological formation can be a source of the groundwater occurrence. Almost all the rocks type beneath the land which locates in the upper part of the crust, regardless of their origin or age have the openings fractures or the pores of the water to seeps in. In unconsolidated rock texture, the sedimentary deposit is well sorted and it is high in porosity. This is due to the compaction of the grains by cementation that fills the voids. Hence, consolidated rock texture is due to the solution that rendered the rock by enlarging the fractures of the voids (Thomas Harter, 2003).

It occurs in two different zones, saturated and unsaturated zone as we can see in Figure 2.2. Unsaturated is the most upper layer of the underground water, located under the land surface and have both the water and air. Under the saturated zone is the capillary fringe where it separates the saturated zone and the unsaturated zone (Heath, 1983). The voids between this two-zone are full of water which water table is also located near under the capillary fringe is born. The water that located in the saturated one is the only water that will be extracted that becomes groundwater (Foster and Chilton, 2004).

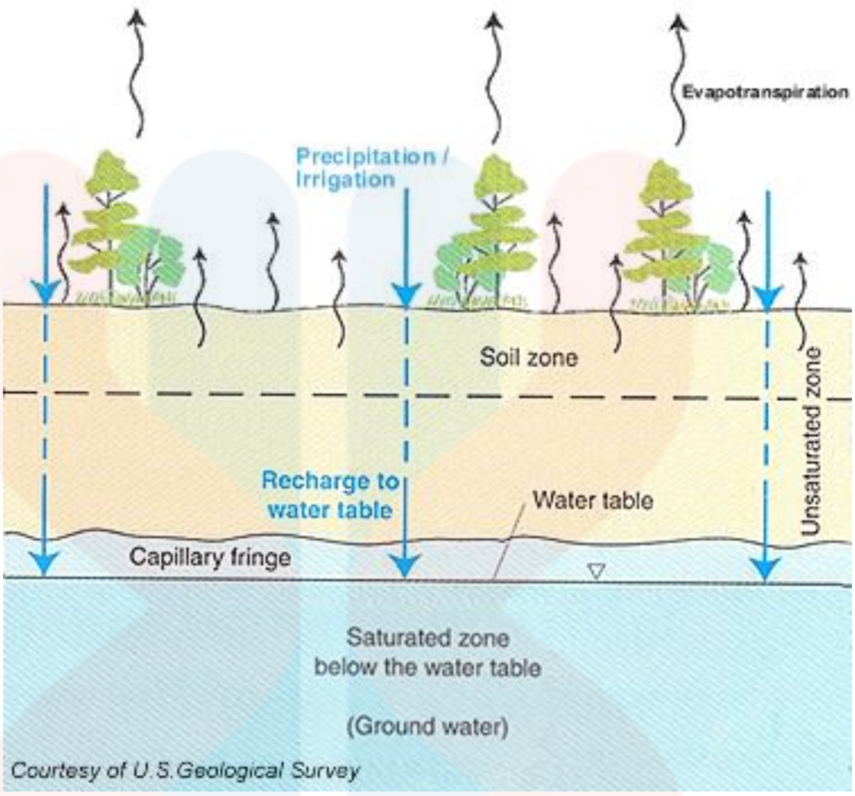


Figure 2.2: Groundwater Zones (Source: US Geological Survey)

Hydrology is a subdivision of science that incorporates the event cycle, development and characteristics of the water and their association with the surrounding during the period of the hydrologic cycle as shown in Figure 2.3. The hydrologic cycle is a constant and repeated step which the water traveled from the atmosphere. The water may have several pathways to complete its hydrologic cycle such as the melting of snowfall and rain falling is then infiltrate as runoff. The runoff goes into the river or stream before the soil and plants that consume it. From the plant, evaporation process occurs and the water which exists in vapor form is absorbed by the atmosphere (Heath, 2004).

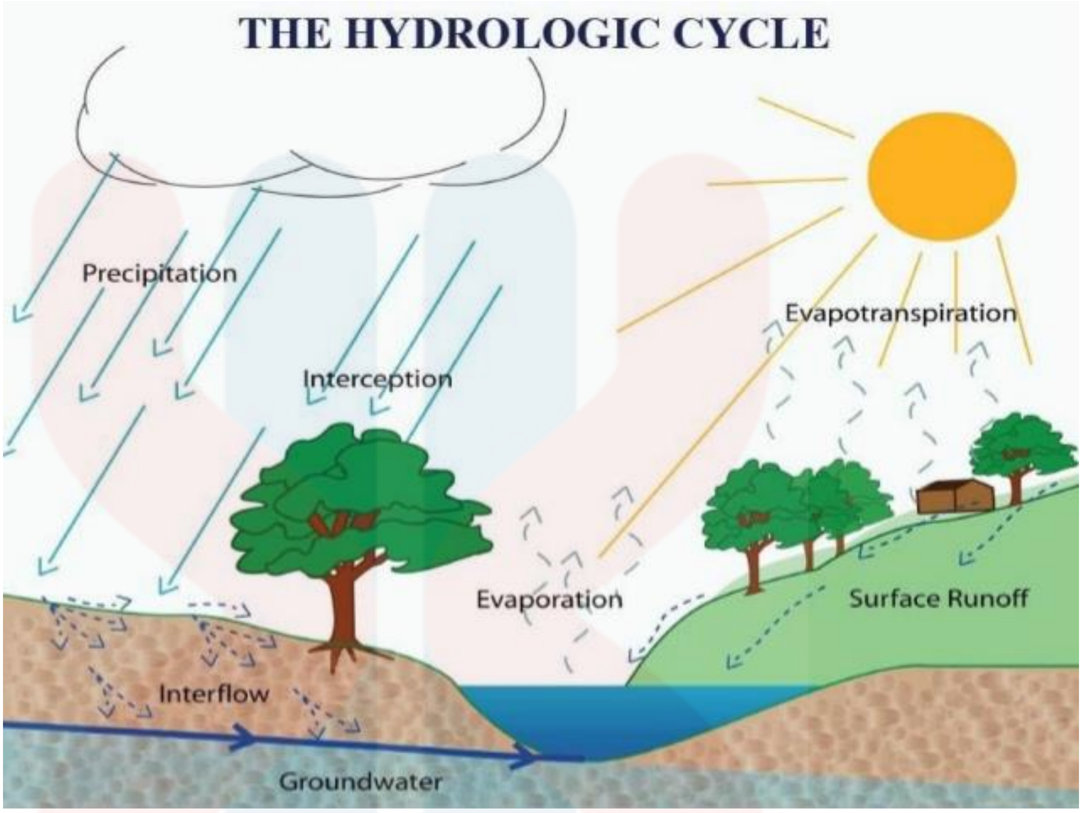


Figure 2.3: Hydrologic Cycle (Source: Dathan CS.)

The volume of water stored underground is measured by the hydrologist from their water levels of the wells that have been built. Apart from that, the geologic records of the well-drilling are examined in order to identify the depth and thickness of the sediments that carried out the water such as sedimentary rocks. The various test has been conducted on the completed hole where all the data is recorded from the accurate logs and test results (Foster and Chilton, 2004).

2.7 Research Specification

2.7.1 Electrical Resistivity Imaging

One of the popular geophysical method applied by the engineers in civil engineering field is Electrical Resistivity Imaging (ERI) that offer attractive technique for subsurface profile characterization in large area. Applicable alternative technique in groundwater exploration such as ERI which complement with existing conventional method may produce comprehensive and convincing output thus effective in terms of cost, time, data coverage and sustainable. ERI has been applied by various application in groundwater exploration. Over the years, conventional method such as excavation and test boring are the tools used to obtain information of earth layer especially during site investigation. There are several problems regarding the application of conventional technique as it only provides information at actual drilling point only. Results from ERM could be additional information to respective expert for their problem solving such as the information on groundwater pollution, leachate, underground and source of water supply. The method as such has not developed much in the last two decades (Barker, 1981).

Electrical resistivity is a fundamental physical property of any material. It is the impedance of electrical current flow through that material. Electrical resistivity of sediments or rock is a function of porosity, saturation, resistivity of the pore fluids and the solid phase, and the material texture. Because tills, fluvial and lacustrine sediments, bedrock, and structural features such as faults, are expected to exhibit large contrasts in such properties, electrical resistivity should be well suited to resolving structural features and intruded bedrock in unconsolidated sediments. According to Telford et al. (1976), resistivity methods can be used to investigate the boundary between crystalline and sedimentary rocks, compact quartzite rocks with schist or phyllite, and etc. The resistivity differentiation of rocks can be anticipated in the horizontal direction; (1) in the maximum resistivity changes occur in the vertical direction; (2) in areas with approximately horizontally deposited layers and vertical electric sounding is used.

Many geophysical methods such as magnetic, gravity, seismic and electrical methods have been used to locate and delineate subsurface water resources (Telford et al., 1976). The resistivity measurements are normally carried out with four electrodes set equidistant along a line. The arrangement of the four electrodes, known as an array, will affect the depth of investigation, sensitivity, resolution and the incorporation of noise into each apparent resistivity measurement (Smith, 2006; Loke, 2001). The sensitivity plot for the Wenner array has almost horizontal contours beneath the centre of the array. The Wenner array is relatively sensitive to vertical changes in the subsurface resistivity below the centre of the array. However, it is less sensitive to horizontal changes in the subsurface resistivity.

During ERI survey we will use the resistivity and IP technique that is famous for groundwater exploration in alluvium area. This technique is often used as it provides more detail that is needed to map the subsurface geology effectively. Most current feature in resistivity instruments permits a 4/8/12 channels input in which will provide a better acquisition of data where the equipment offers 2D resistivity imaging survey coupled with minimum of 56 electrodes configuration. Table 2.1 below shows the different resistivity of common rock, minerals and chemicals used in the interpretation of the readings in resistivity meters at the site (Loke M H, 1999).

Table 2.1*:* Resistivity of Common Rocks, Minerals and Chemicals (Loke, 1999)

Material	Resistivity (Ω•m)	Conductivity (Siemen/m)
Igneous and Metamorphic Rocks		
Granite	$5x10^{3} - 10^{6}$	$10^{-6} - 2x10^{-4}$
Basalt	$10^{3} - 10^{6}$	$10^{-6} - 10^{-3}$
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	$50 - 4x10^{2}$	$2.5x10^{-3} - 0.02$
Soils and waters		
Clay	1 - 100	0.01 - 1
Alluvium	10 - 800	$1.25 x10^{-3} - 0.1$
Groundwater (fresh)	10 - 100	0.01 - 0.1
Sea water	0.2	5
Chemicals		
Iron	$9.074x10^{-8}$	$1.102x10^{7}$
0.01 M Potassium chloride	0.708	1.413
0.01 M Sodium chloride	0.843	1.185
0.01 M acetic acid	6.13	0.163
Xylene	$6.998x10^{16}$	$1.429x10^{-17}$

Commonly 2-dimensional electrical resistivity (ERI) method is used in determining the resistivity of the ground subsurface in geotechnical and environmental surveys. Resistivity values depends on the rock materials, pore shape and size, porosity, temperature and other various geological parameters (Fetter, 2001). The ERI method basically is the response between the electric current flows of the Earth which can be used for geological and groundwater identification base on their resistivity values emitted. Barker (2002) stated that one of the famous technique that is widely used for geological surveying is electrical imaging which involves the resistivity sounding and is compatible in providing information even in limited area. This geophysical method requires the centre electrode point to remains immovable, instead increase the spacing in between two terminals to reach deeper subsurface sections. The ERI survey is carried out using multi-electrode system with the electrodes number varies from 25 to 100 that is lined up in a straight line and constant spacing usually 5 meters and connected with multicore cable. Resistivity method is famous with the researcher that study about groundwater exploration where it shows the Earth's cross section in 2-dimensional represents with colours.

2.7.2 Resistivity Array

Resistivity array is the arrangement of the electrode along the straight line in respect with the geological information of the study area. A basic setup of the electrode arrangement for resistivity survey involving the uses of resistivity meter and four electrodes. The relative positions of the electrode with one another is related to the geometric factors (Figure 2.4) and numerical multipliers in a resistivity survey which it affects the depth of the survey, resolution, sensitivity and noise intensity in response to the measurement of the apparent resistivity, referring to Loke (2006). In resistivity method, there are about five types of electrode arrangement used; (1) pole-dipole array, (2) pole-pole array, (3) dipole-dipole array, (4) Wenner array and (5) Schlumberger array, where each types have their own advantages and limitations. In terms of depth, pole-dipole array is in the lead with its signal amplitude meanwhile the best choices for set-up are Wenner and Schlumberger arrays.

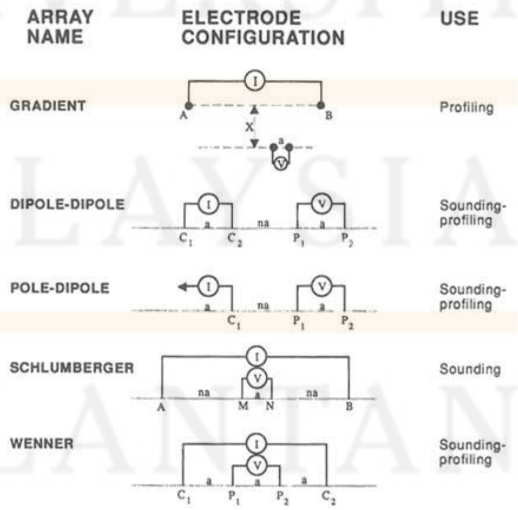


Figure 2.4: Arrays used and their geometric factors (Loke, 2006)

2.7.3 Previous Study

Based on the present knowledge of the hydrogeology of peninsula Malaysia, the groundwater occurrence and potential are more conveniently discussed in terms of rock types. The groundwater prospects can be broadly grouped into four main categories. The most promising aquifers can be found within the Quaternary alluvium. In general, the yield from wells in these areas exceeds $25m^3$/hr if sandy or gravelly horizons are present. However, in Kelantan and Terengganu, the yield from the well can exceed 100m3/hr. this is due to the alluvial aquifers on the East Coast generally more extensive both laterally and vertically (F.S. Chong and Dennis N.K. Tan, 1986).

Fariz Mohamed (2009) study the vulnerability of soil and groundwater located in Ulu Langat Basin, Melaka. Groundwater and soil potential source of pollution were determined through secondary data analysis with the same method in determining groundwater supply potential. As a remark, groundwater and soil in the Langat Basin ecosystem is an important resource which can be a huge help for high demand of water and soil for various uses.

In the south-western region of peninsula Malaysia, an assessment of groundwater resources has been held by using integrated geophysical techniques. It combined geophysical techniques such as multi-electrode resistivity, induced polarization and borehole geophysical techniques which were tested on volcano-sedimentary rocks in the northern part of Gemas (Geosci, A, 2012). Five main lithologies were identified based on the integrated geophysical techniques use; tuffaceoous mudstone, tuff, tuff with quartzite, sandstone and shale. Also, the type of aquifers can be classified by using the techniques. As a conclusion, along Kuala Balah area there is no past research using geophysical methods. Thus, this research is important for the future information of the study area.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

This particular chapter explains the procedures that we need to go through while doing this research and the materials that are needed to complete the study which the validity of the research are being judged. All the materials and equipment mentioned is used in method section that disclose all the research protocol including the measurement and calculations throughout the process. All the process was organized and planned chronologically that helps in achieving the ending result. The information must be in organized framework to avoid any slip-up. For instance, the presented result was arranged according to sub-heading of the chapters or the materials in each section should be organized by the least important topic. All the process involved in this research are followed as written in the flowchart that can be seen in Figure 3.1.

RESEARCH FLOWCHART

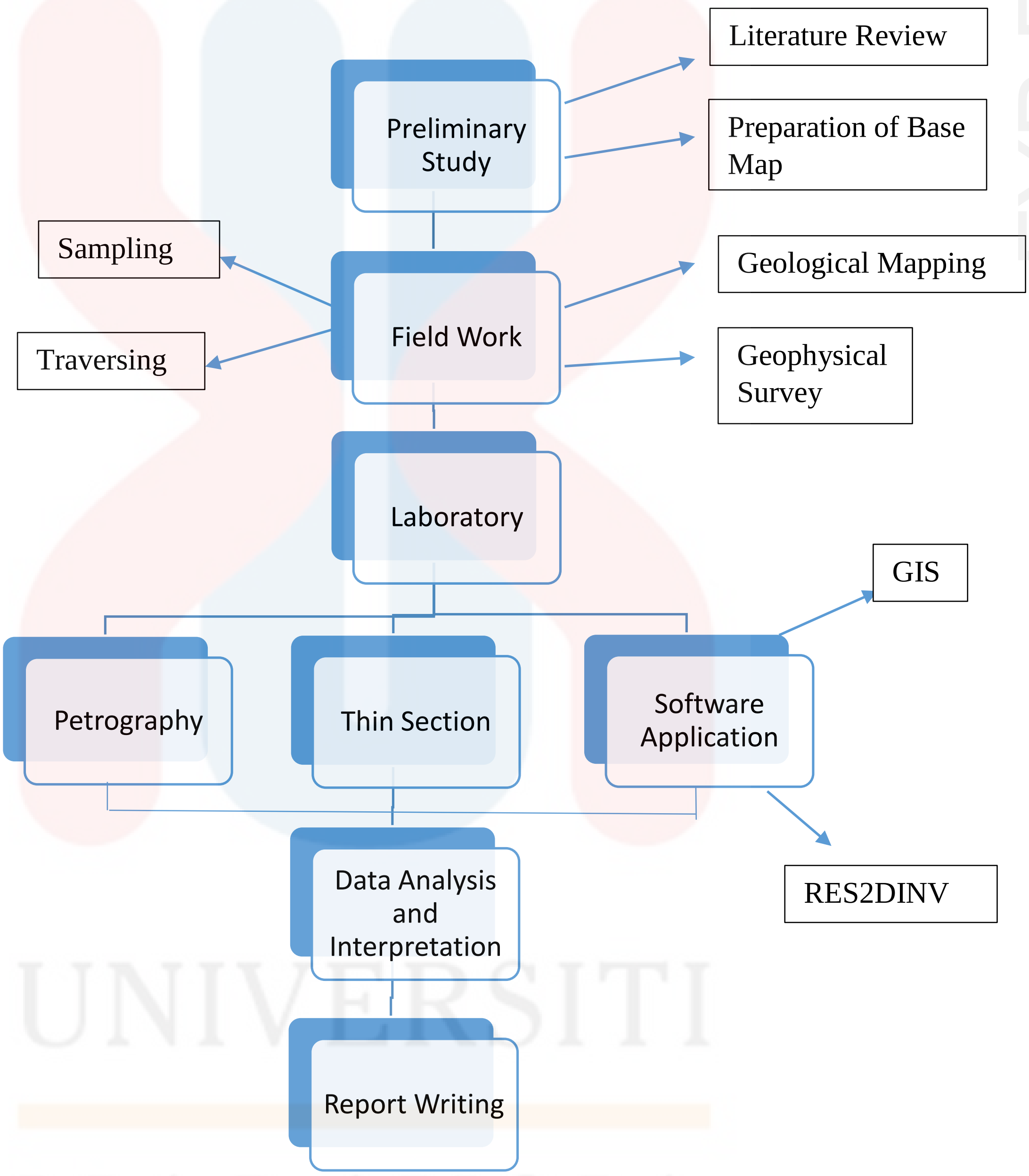
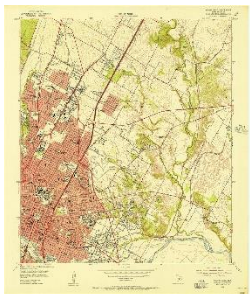


Figure 3.1: Research flowchart

3.2 Materials/Equipment

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

Table 3.1: List of Materials and Equipment

NO.	MATERIALS/ EQUIPMENT	USES	PICTURE
1.	Global Positioning System (GPS)	A GPS is based on the radio navigation system that will show the user their exact position on land or sea along with the velocity, time for 24 hours a day anywhere in the world.	
2.	Topographic Map	A topographic map is used to identify the landforms of the study area based on the contour lines with variety scale details.	
3.	Compass/Clino meter	A compass is used for orientation that will guide the pathway using the diagram called a compass rose with the directions of north, south, west, and east.	
4.	Geological Hammer	A geological hammer is needed in gathering the outcrop sample, as the rocks are strong. The common hammer used by the students is chisel and tip-point.	

5.	Hand Lens	A hand lens is used to analyze the hand specimen. The small details on the sample can be seen with the aid of a hand lens while at the site, although a further study needs to be done in the lab.	
6.	Measuring Tape	The measuring tape is used to make a measurement of the outcrop dimension. The dimension of the outcrop is important in doing the lithology part.	
7.	Camera	The camera is needed to take pictures of the information around the outcrop that we cannot bring back. It is one of the clear evidence that we can use for future studies.	
8.	Sampling Tools	The sampling tools that are used are sample bags. It is used to keep the outcrop sample and the rock material from the site of the study area. Labeling is needed when we take a sample.	
9.	ABEM Terrameter LS 1	ABEM Terrameter is used for the surveying of the groundwater locations.	
10.	Dilute HCl	Used in the field to test the presence of carbonate ion in the outcrop and sample that we found.	

11.	Field Notebook	In order to keep down the note and data is safe, notebook is essential to write down all the information gathered at the field.	
12.	Stationary	Stationary like pen or pencil is needed to write down the data. The ruler also is needed for sketching of the outcrop and the sample that is collected.	
13.	Multi-Electrode Cables	The passive electrode cables are designed to be hard-wearing and are designed with molded stainless steel (or graphite) electrode takeout encapsulated in molding material that is chemically bonded to the outer and inner cable jacket.	
14.	Microscope	The microscope is used to determine the nature of the rocks and its composition of the mineral.	
15.	Thin Section Machine	Used for the grinding of rock and for fast and precise material removal of Petrographic thin sections.	

3.3 Methodology

The research is conducted using certain methodology and procedures which are divided into several phases. All the phases include the preliminary study, field study, laboratory work, data interpretation and completion of the report.

3.3.1 Preliminary Study

The first phase is where the preliminary study of the research starts with the problem identifying from past research of the selected title. Preliminary study is an initial exploration of issues related to a proposed quality review or evaluation. During this phase, a lot of literature review will take parts where we collect data from past journals, reports and research study. This phase needs to be taken before doing the field study in order to prepare ourselves for the possibility and the unexpected outcome of the study. Hence, preparation of base map also during the first phase.

3.3.2 Field Study

Next phase is field study. In a field study, it includes all the activities that we do during the field work such as traversing, sampling, and observations of the geological traits at the study area. Traversing is compulsory to mark the pathway during the field work and as an evidence that we do the research by undergoes field study. Sampling is a method to take a sample from the chosen outcrop which we only use fresh rock and not to be confused with a weathered rock. Observations are written in the notebook regarding the geological features and related information.

3.3.3 Laboratory Work

After the field work is done, laboratory work needs to be done. This works as extra information collecting that involves the laboratory equipment and apparatus. Laboratory work are made after identifiable samples from the field has been brought back for further inspection and analysis which include thin section, petrography analysis and software application. In order to determine the composition of mineral for rock samples, petrographic analysis need to be done which we determine the minerals type. Electronic microscope is used during this step which we observe the samples with different magnifications. All the hand specimens that were collected during site traversing undergone thin section before we analyse the minerals under microscope in order to understand the rocks origin.

3.4.2.1 Thin Section

There are six procedures needed in order to complete the thin section of the collected specimen known as sectioning, impregnation, precision sectioning, bonding, re-sectioning and grinding and polishing (Buehler 2006). The first step is sectioning which we cut the specimen into smaller pieces throughout the process. For this process, we used Diamond Slab Saw machine for cutting the specimen. Secondly, SamplKups machine is used during impregnation which we remove the gases that form in the rock cracks. According to Buehler 2006, this allow infiltration to occur between the rock materials and fractures of the sample through vacuum impregnation. Third step is precision section also known as trimming process that involve a small cutting deformation of rocks. The equipment used for this process is IsoMet.

After the precision process, the specimen need to undergone re-sectioning where all the unwanted and excess materials such as air bubble was removed efficiently using Petro Thin Sectioning System. A grinding wheel consist of diamond cutting and vacuum chuck that made up this machine. The final step is grinding and polishing. The deformation induces during sectioning is removed during grinding and all the unwanted excess materials were removed during polishing that is done after grinding processes. This step will make the surface of the specimen occur in small sub-micrometer with fine abrasive size. After all the procedure is completed, the thin section slide will be brought and examined under polarized microscope. This is for the details of mineral composition of the rocks.

3.3.4 Data Processing

After the collection of data, it has to be prepared for analysis. The raw collected data must be converted in the form that is suitable for any required analysis. The form of the data will affect the analysis result. A proper data preparation must be taken care for a reliable result. This section associated with software and some even relates with laboratory equipment for processing. Data obtained during the field surveying and observation is known as geological data, is then processed by using software according to its important. Some of the software that is used in this research is GeoRose, ArcGIS, RES2DINV software (Figure 3.2) and Terrameter LS Toolbox (Figure 3.3). GeoRose software is used for joint analysis with using the strike and dip data by plotting them to determine the direction of force acting on the particular area. Software that is used for producing geological map is known as ArcGIS. In order to obtain the result for specification, we used Terrameter LS Toolbox and RES2DINV where it displays the pseudosection with the reading of resistivity and chargeability for the specific study area.

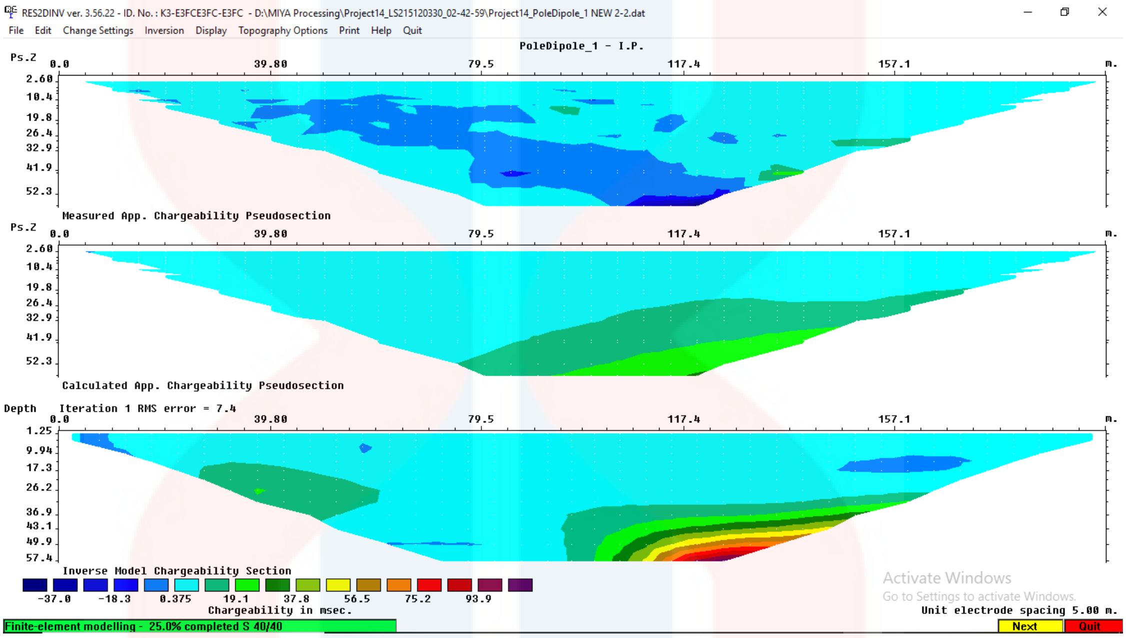


Figure 3.2: Inversion step in RES2DINV software

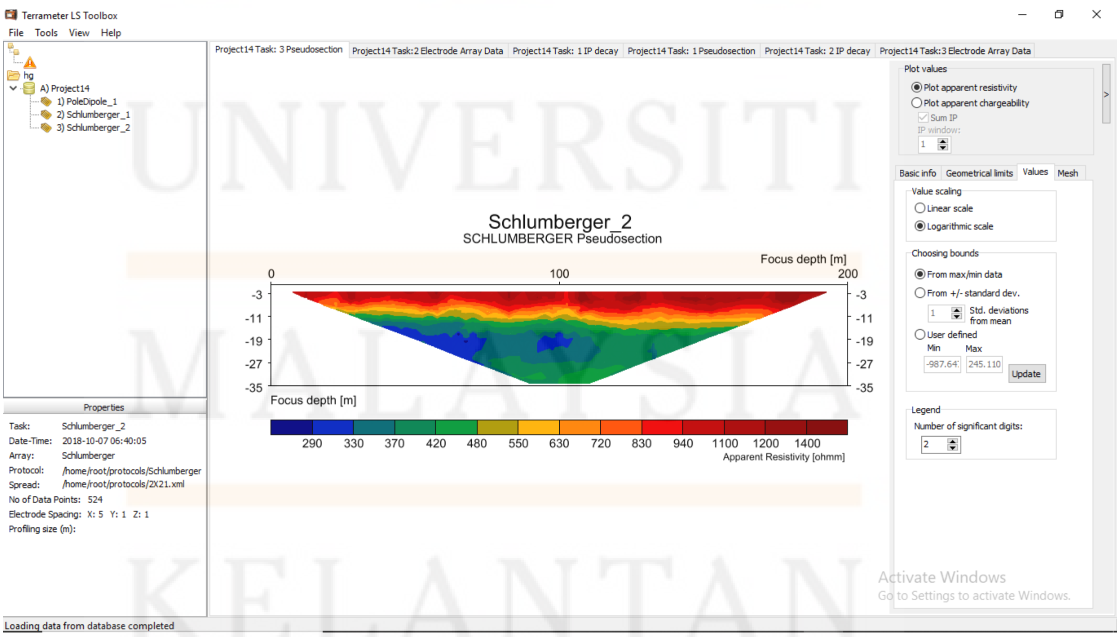


Figure 3.3: Reading data from Terrameter LS Toolbox

3.3.5 Data Analysis and Interpretation

Results from laboratory work is used for data analysis and interpretation. Data analysis is the final write up of the research which it determined the reliability of the research and all the objectives were proven. After we obtained the result from data processing, for example the rose diagram produced by GeoRose software. We can identify and understand the forces that acted on the area. As the area may experience deformation throughout the time passing, we can reconstruct the history and explained further the related details in the research report. The composition of minerals in rock specimen were described during petrography analysis where it includes all the textural content of the rocks. The petrographic analysis is then relating with the hand notes that were collected during field observation. This can give another better understanding by relating all the information gathered and can give a strong prove to the existence.

Due to some error or mistake, the interpretation might be wrong where the research needs to be redo from the start. Using the data and information that we interpreted, we complete the stage with a full report writing of the research.

3.3.6 ERI Analysis

After the field survey, the resistance measurements are reduced to apparent resistivity values. Practically all commercial multi electrode systems come with computer software to carry out this conversion. To interpret the data from a 2-D imaging survey, a 2-D model for the subsurface consisting of a large number of rectangular blocks is usually used. A computer program is then used to determine the resistivity of the blocks so that the calculated apparent resistivity values agree with the measured values from the field survey.

Here the computer program RES2DINV provided will automatically subdivide the subsurface into a number of blocks, and then it uses an inversion scheme to determine the appropriate values that must be entered into a text file which can be read by the RES2DINV program (Geotomo software, 2006; Loke & Barker, 1995). The use of the RES2DINV essentially involves the reading of the field data, inversion of the data using least square inversion procedure to get the true resistivity and the true depth of the field resistivity image. Topographic corrections to account for variations in the surface elevation are also included in RES2DINV. Basically, the data from these surveys are commonly arranged and contoured in the form of a pseudosection which gives an appropriate picture of the subsurface resistivity (Loke et al., 2003).

3.4 Methodology for geophysical investigation

3.4.1 ABEM Lund System Arrangement

Overall, 41 electrodes are needed for electrical resistivity investigation (ERI) method. They are then planted on the ground with the spacing between the electrodes are 5meters along the horizontal line. The electrodes are planted for about 100mm or half of the electrode length. The model of the Lund Imaging Cables used for this survey is ES464 that acts as connecter with the electrode selector. It is then connected to Abem Terrameter LS 1, which it connects to the battery.

3.4.2 Taking Data from ABEM Terrameter LS 1

All the data collected from the ground is recorded and save by ABEM Terrameter LS 1 which it read all the resistivity value resulted from the geophysical contact underneath the ground. Before we start with the survey, we need to follow a few procedures in order not to mess up the result later on. First thing first, we need to make sure the battery is in full as the ABEM Terrameter LS 1 used a large amount of power. Next, we must make sure that all 41 electrodes planted nicely on the designated area, into the ground as it can affect the measurement of the subsurface resistivity. In resistivity survey, there are five type of arrays that is used in two-dimensional surveying (Figure 3.4). According to Telford et al. 1990, the main array types used in two-dimensional survey are dipole-dipole, pole-dipole, Wenner and Schlumberger array. The relative position and spacing for the electrodes arrangement is differ according to the array type where they have their own pros and cons.

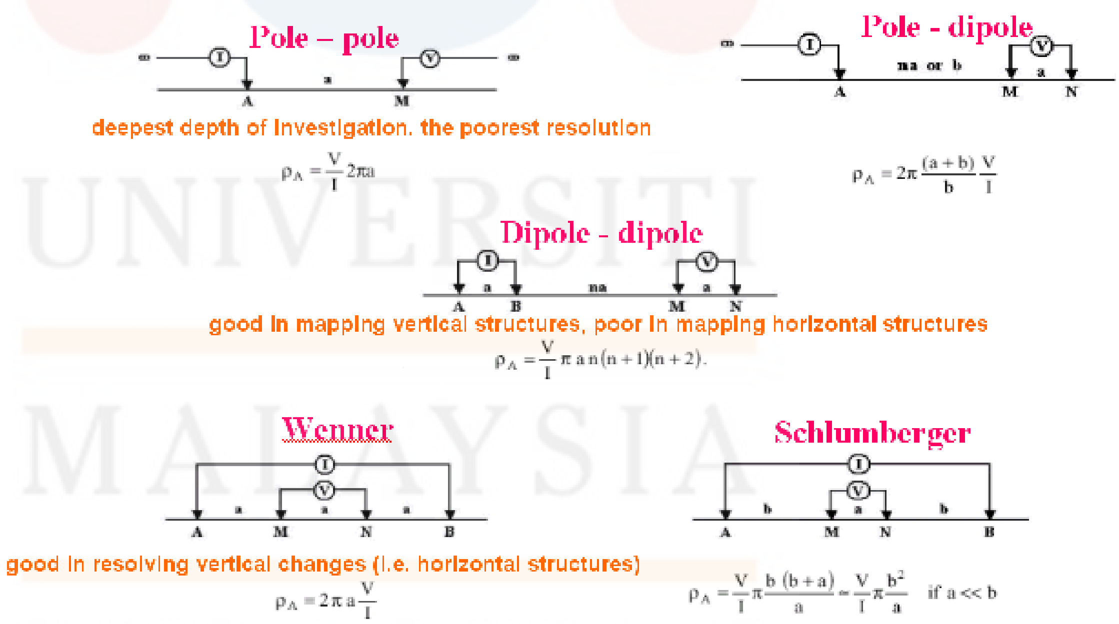


Figure 3.4: Electrode arrays arrangement

3.5 Software Applications

While conducting this research, software application is used in order to get the result of the research. One of the software application used is ArcGIS software where we produced map using the geographic information (GIS). The mapped information was analyzed and managed by the geographic information that is saved in the database. Next is the RES2DINV software that help us in analyzing the resistivity data gathered and collected by the ABEM Terrameter LS 1. It will show the pseudosection of the study area in image form (Figure 3.5). The pseudosection image is then used for interpretation referring to the resistivity values and chargeability values. The depth of the groundwater location can be determined from the interpretation and the borehole location can be proposed. This software is important as well as ArcGIS software (Figure 3.6) as it connects with the objectives of this research.

Other than the two software, GeoRose software is used to determine the force direction that acted on the area. This software produced a rose diagram that consist the data of strike and dip collected at the field. Other than GeoRose, we can also do it manually but with the help of technology and software it makes the result more precise and easier. All the related information and data, strike and dip in this case was written in the software and the diagram is ready. For further explanation, the data are recorded in Microsoft Excel for table drawing and related charts. Software applications is as important as other methods as it is needed in order to continue with data analyzing and interpretations for objectives achievement.

Figure 3.5: Raw data from ABEM Terrameter LS 1 at site

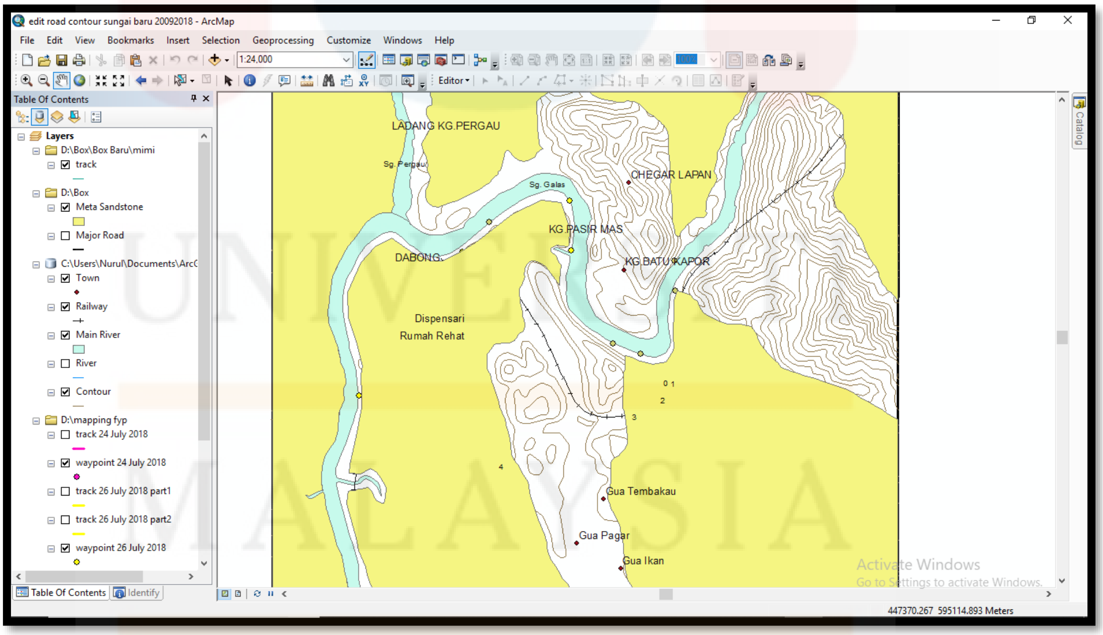


Figure 3.6: Map processing using ArcGIS

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

For this chapter, we will focus on the general geology that are related to the research such as geomorphological aspect, stratigraphy, petrographic analysis, structural analysis and the historical geology. All the related maps are presented in this chapter according to its importance. All the collected geological information was gathered in this chapter that help in working out the research. Mainly, Dabong is made up of sedimentary rock unit which consist of interbedded sandstone, meta-sedimentary and conglomerate.

4.1.1 Traversing of the Study Area

4.1.1.1 Traverse Survey

Traverse survey is an important step for the research to continue to another part. During mapping, traverse is important as it act as an evidence and certainty of the information and data provided. As we can see from Figure 4.1, almost all the accessible area has been travelled during the survey. One of the product from traverse survey is map where all the data gathered is used in producing sampling maps, drainage pattern map, lineament map and traverse map. We obtain all the coordinate from the marked place by using GPS.

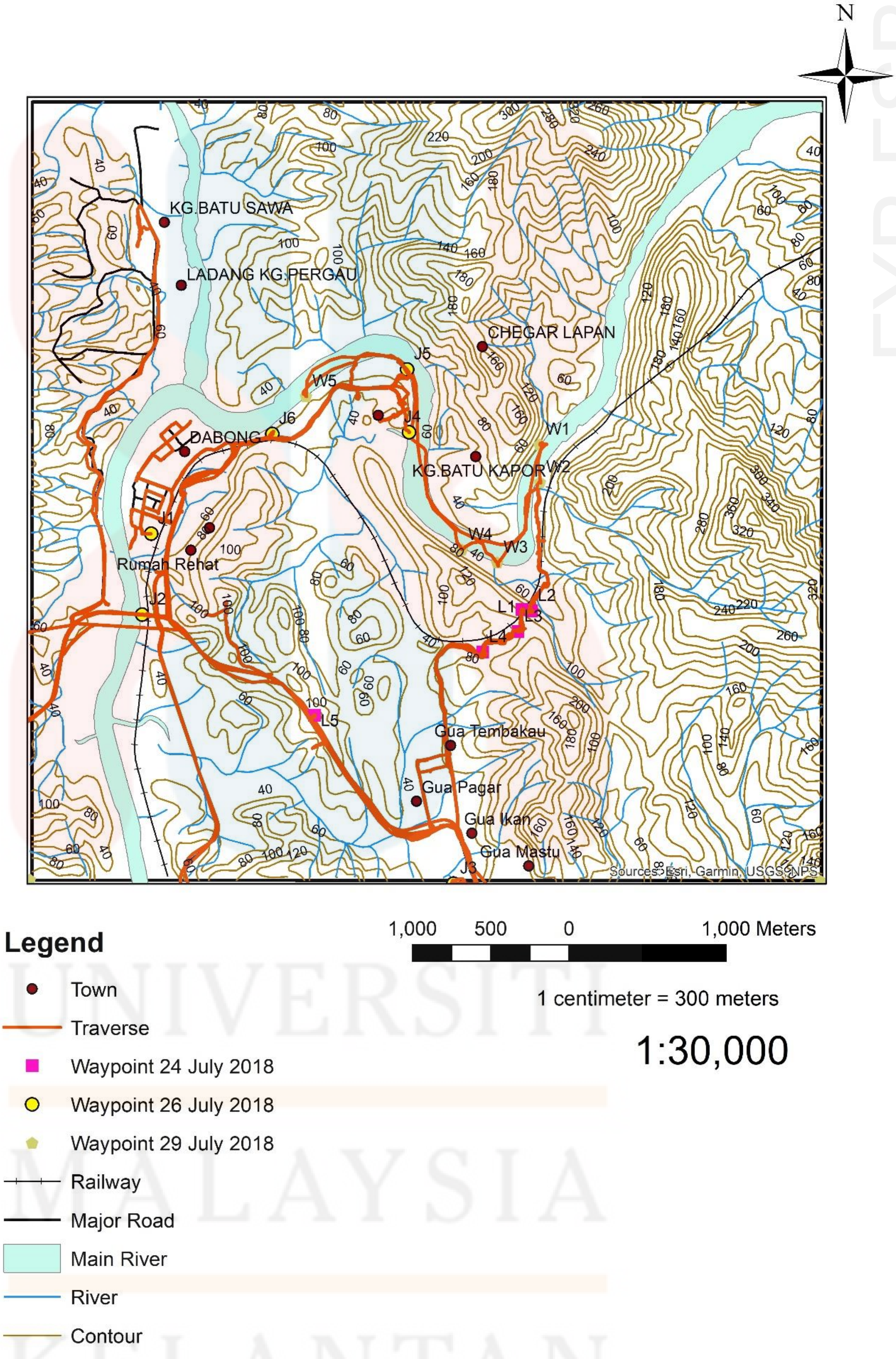


Figure 4.1: Traverse Map of Study Area

4.1.1.2 Accessibility

At the study area, there is one major road that connects it with other area. The major road act as connected road between Jeli, Dabong and Gua Musang. In order to reach to Dabong, we need to pass along Dabong's bridge (Figure 4.2). Referring to connection map in Appendix D, the study area can be reached from Jeli, Gua Musang and Kemubu. Even though main road is easily access, in order to reach the mapping area alternative road is needed. One of the easiest way is passing through rubber plantation tracks Figure 4.3. The tracks left by the lorry that carry out the palm out can be found out at the plantations area. Other than that, the tracks left by animal also being used in order to reach to the outcrop area. Most of the time, walking is the most plausible way to reach to the other part aside from main road. Within the study area, there are places that need water transportation to reach such as at the SW area where Kampung Chegar Lapan is located. According to the head village, back then there are people live at the village. As the time passes, they no longer lived there as the only access that connect the village and Dabong is the river. As for now, the villagers and people use the area for their farming purposes and place where they keep their animals such as cows.

Figure 4.2: Dabong's bridge main road

Figure 4.3: Unpaved road within the study area

4.1.2 Land Use

From base map show in Figure 1.1, we can identify the existence of some village such as Kampung Chegar Lapan and Kampung Batu Kapor. As we know, data that we get to digitize and processing map is not up to date. It provided some old information that did not exist nowadays. Field observation and traversing is important in order to prove the existence of some place and location around the study area which can help in processing result. As for Dabong area, there are still few villages that exist and people still lives there. As per we observed during the traversing, Kampung Chegar Lapan is not available for people to live as the only way to go to the village is through water ways by boats. It is quite dangerous for daily use and more of the young people migrates from the village. It is due to lack of occupation and no proper accessibility. Most of people live in the Dabong town because of the facility that helps their everyday life. Malays or Kelantanese dominates this area which most of them are related to each other even by distant. School, police station, post office and hospital is the main facility that people decide to be near as it can prevent them from any unwanted event when they are away from other people. As we dugs further during the observation, we conclude that Dabong's people mostly work by themselves, government workers or plantations worker.

From map (Figure 4.4), Dabong consist of plantation and forest area. West to North part of the study area is covered with palm plantation that is known as Ladang Kampung Pergau. Northern part of the study area is where Kampung Chegar Lapan located which consist of forest. Meanwhile at lower part of the study area, rubber plantation (Figure 4.5) and villagers' orchard were located around the area. Basically, the study area is covered with plantation and forest (Figure 4.6).

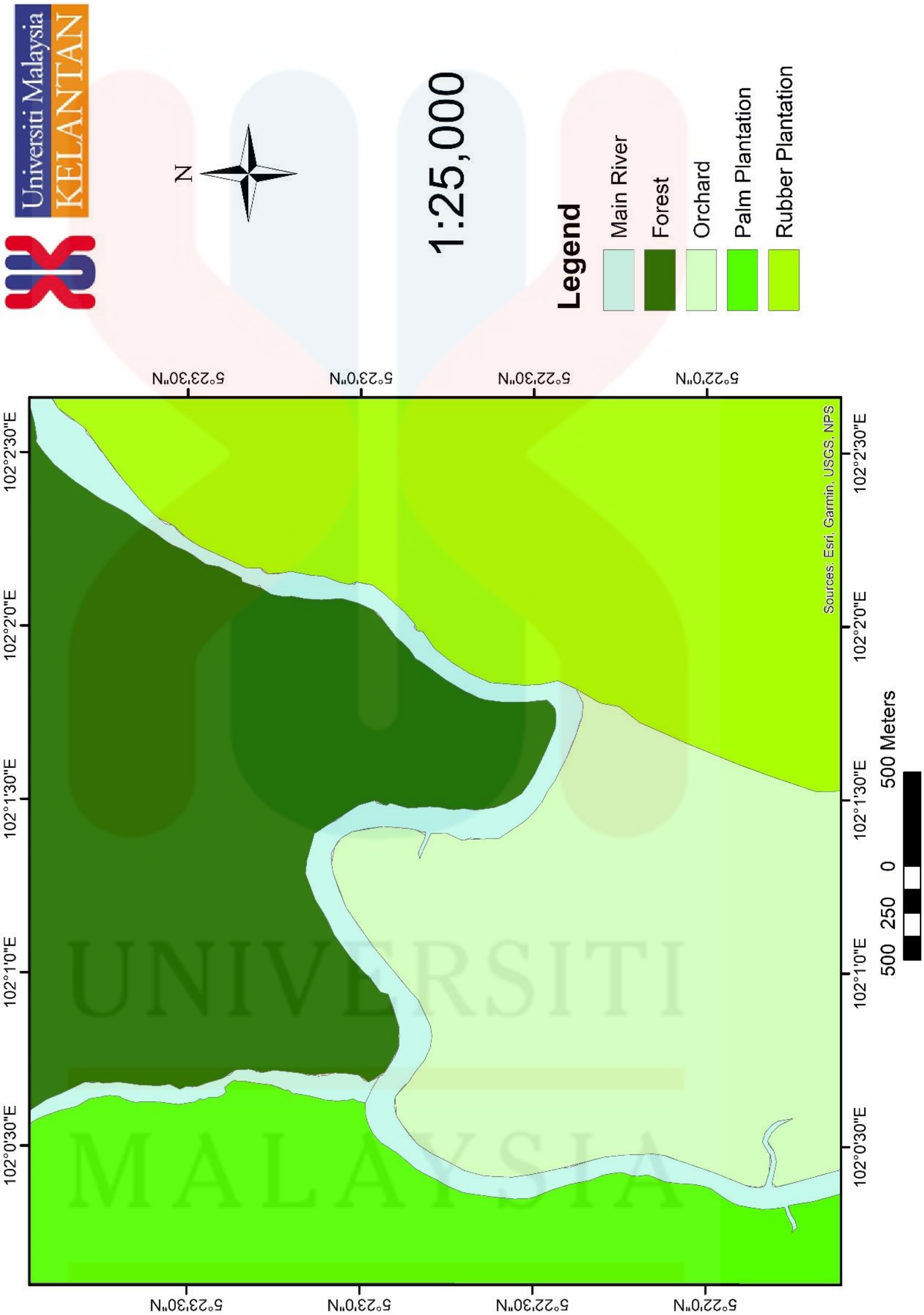


Figure 4.4: Land use map of study area

Figure 4.5: Rubber plantation area

Figure 4.5: Bushes towards the forest area

4.2 Geomorphology

Geomorphology covers the landform parts of information within the study area and surrounding area. It is a study regarding the existing landform and the earth form and the related process that affect the landforms. Geomorphology is an aspect that can be an evidence to the changing and testify the relationship between landform changes. Also we can identify the factors and process related from the existing geomorphology.

One of the recognized process is weathering process where it can be seen anywhere. Other than that, erosion process also gives effect on the earth landform along with the equilibrium and different in climate. Different processes give different influence on the landform. Figure 4.7 below shows two different places of geomorphological view from elevation 120 meters (A) and elevation 360 meters (B).

Figure 4.7: Geomorphology of study area

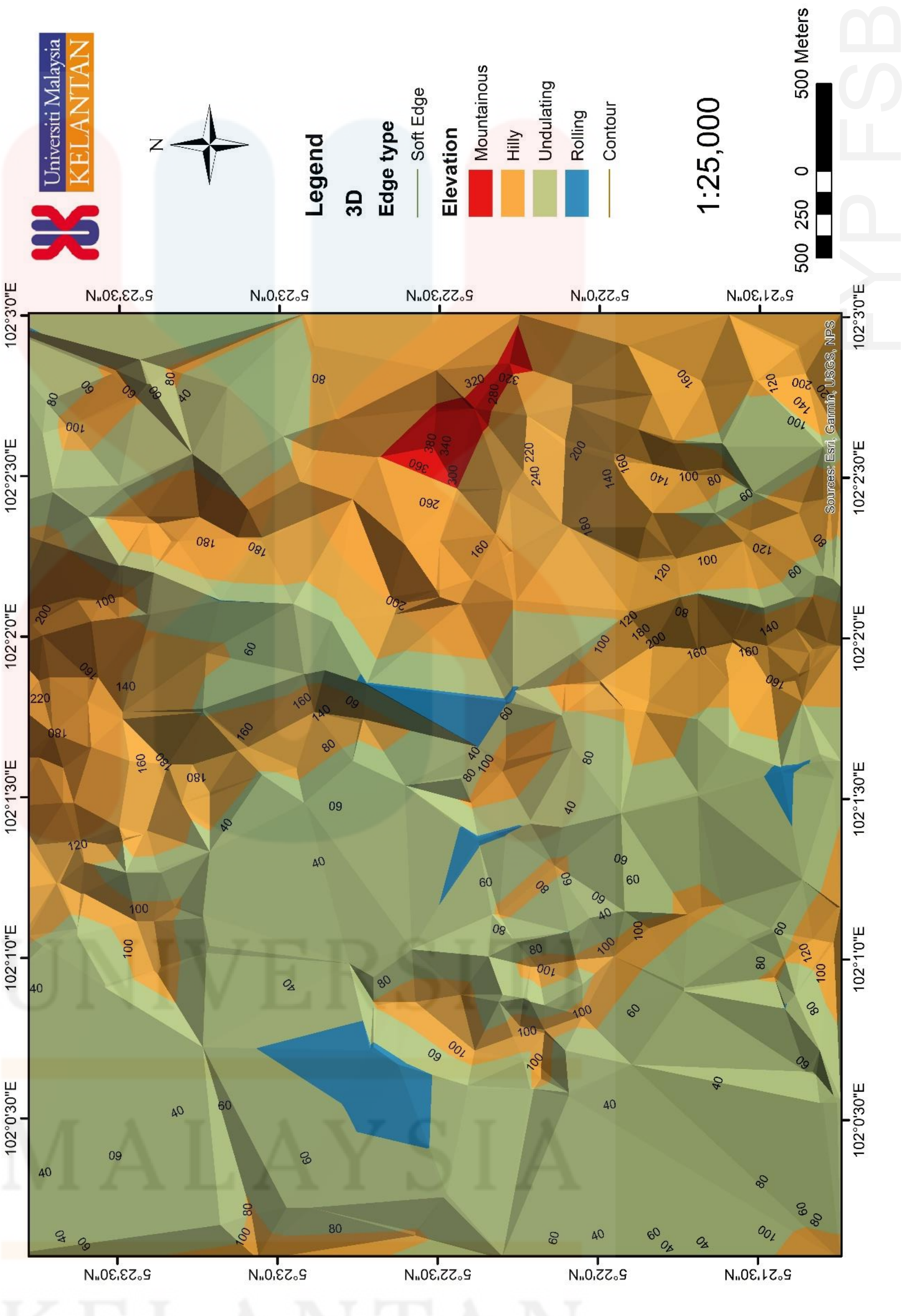


Figure 4.8: 3D map of the study area

4.2.2 Topography

Topography shows us the measurement of the landforms in terms of their elevation. From the elevation of the landforms, we can identify their shape and the land relief. Basically in Malaysia we classify the topography into five features as shown below in table 4.1. The features are based on their class and elevation.

Table 4.1: Topographic unit classification of Peninsular Malaysia (Hutchison and Tan, 2009)

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

Based on the topography map (Figure 4.9) of the study area, the lowest elevation is 20 meters meanwhile the highest recorded elevation is 340 meters. We can see from the map that there was clearly some free area without contour line which is the low land. Opposition to the lowest area, the highest elevation is believed to be a high land. From the topographic unit classification, we can say that the study area is covered from mountainous to rolling unit. We can classify from the map that the mountainous area is high resistance while the rolling area is low resistance.

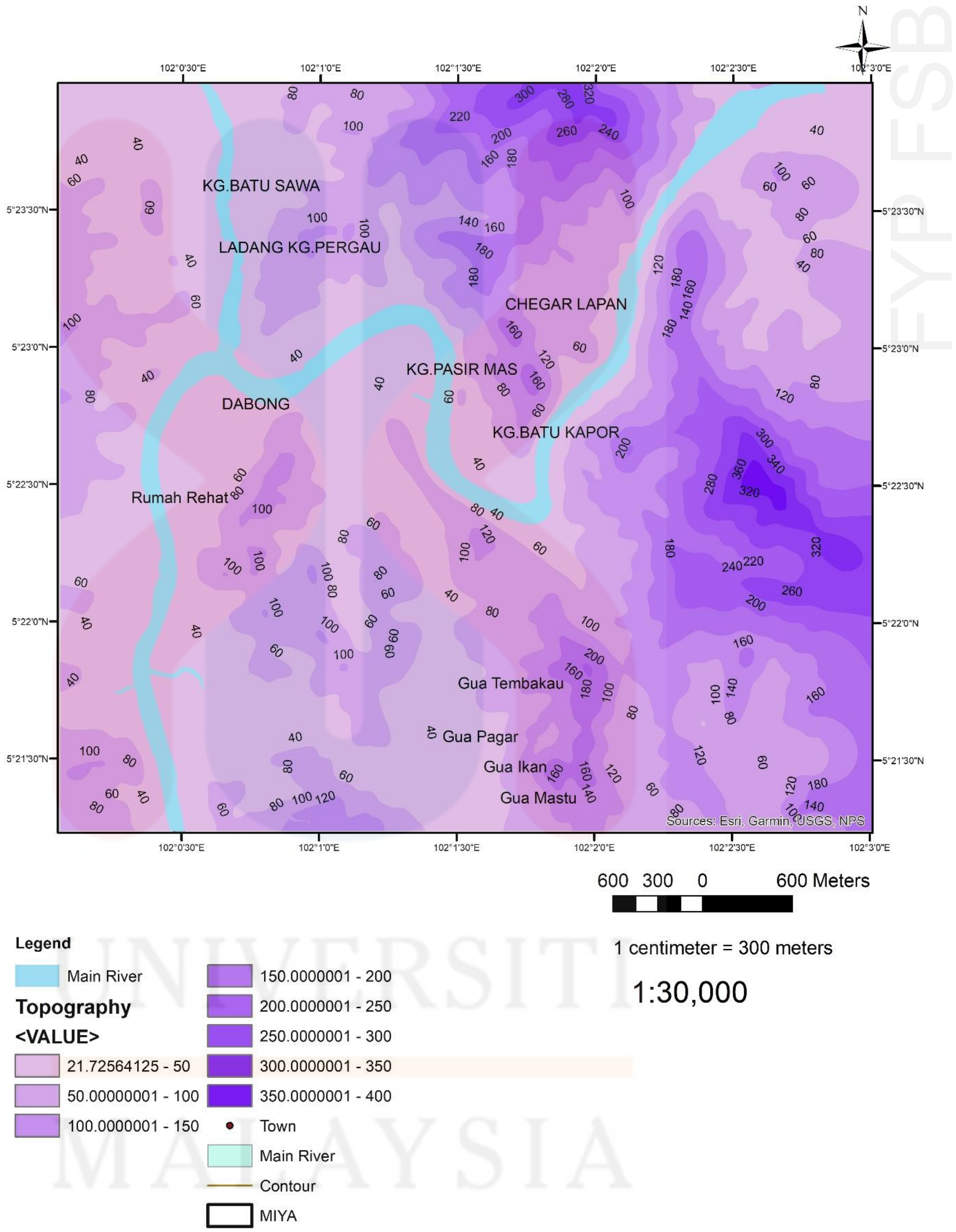


Figure 4.9: Topography map of the study area

4.2.3 Weathering Process

The break down or colour changing of a rock is known as weathering where it started to decompose and change into other form of physical usually. For example, sandstone change into residual soil after being exposed to the air, and other weathering agents. Weathering have it certain grades which associates with its type of weathering. As per everyone know, three major weathering types are physical, biological and chemical weathering. Usually it happens in situ, which it can happen naturally without any movement but it also can happen due to movement of earth material related to erosion. Mobility of the rock material affected the erosion or mass movement to happen in some area with the help of weathering agents such as gravity.

Changed in rock mineral usually is due to effect from chemical weathering that often affect rock unit of mafic. There are several steps for weathering to occur and change the rock which involves process of oxidation, hydrolysis and also reduction. We take limestone for example in referring to Figure 4.10, which it forms holes and shape on the outcrop when water dropped on it. It also can indicate the presence of calcite minerals which we know it is weak to acid. As for some rock, we cannot identify the effect of chemical weathering on them as chemically mineral changes cannot be determine using naked eyes.

Figure 4.10: Chemical weathering

Rock decayed matter is the prove that the rock has undergone some weathering falls under bilogical category. It is related closely with the activity of organism that lives in between the rocks or near the rock. Growing roots often shows a good example of biological weathering effect as it can be seen from naked eyes. Other than plants, animals such as mice also can affect the rocks structure. As shown in the below Figure 4.11, the disintegration and decaying rock is due to biological process weathering.

Figure 4.11: Biological weathering from plants

Overall form the observation, the study area was highly weathered where weathered rock and outcrop can be found easily. Hardly can be seen during traversing fresh and coloured rock which disintegration and rock has already decomposed into other rock unit.

4.2.4 Drainage System

Small streams, lakes and rivers that are connected to each other will form a drainage system and there are different patterns according to its framework in a particular basin. The pattern of the drainage system usually shows different geomorphology forms. The shape of the drainage pattern is controlled by the rock type, rock distribution and location of the rock on the surface. Based on the drainage map (Figure 4.12), we can say that the study area is made up of dendritic drainage pattern. This pattern is similar to tree branches which commonly are not straight in the drainage pattern. The small streams near to tributaries of Sungai Galas and Sungai Pergau joined together which lead to its current state. Also denotes in the map, there are three watershed area in the study area. V-shaped valleys can be found in the study area which is the effect of reaction between the water flows and the rock types which mainly impervious and non-porous.

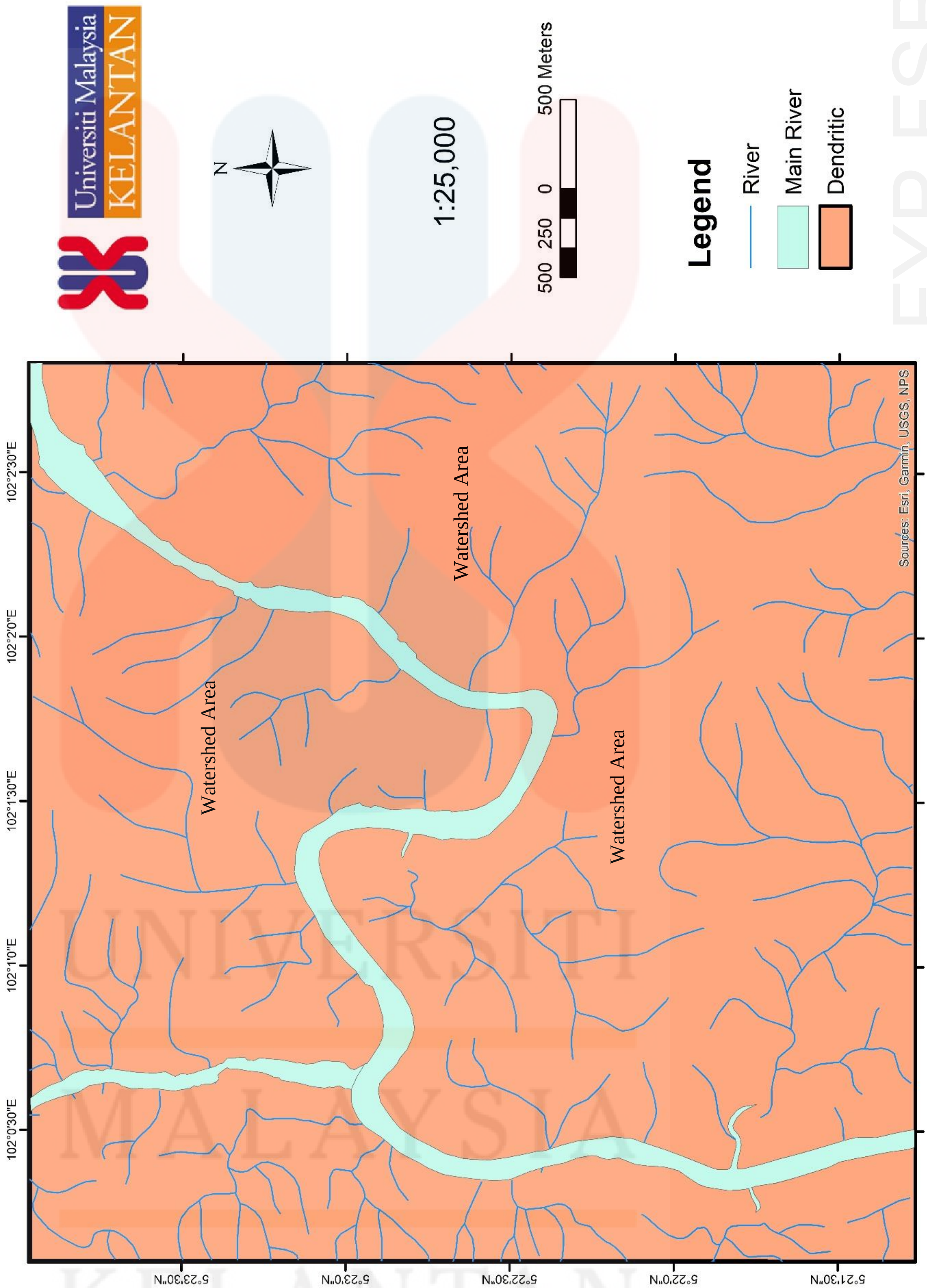


Figure 4.12: Drainage Map

4.3 Lithotratigraphy

4.3.1 Stratigraphic position

Table 4.2: Stratigraphic column

ERA	PERIOD	FORMATION UNIT	STRATIGRAPHIC COLUMN	LITHOLOGY
Cenozoic	Quarternary			**Alluvium** ▪ Sand, Silt, Clay and Gravel
Mesozoic	Triassic	Gua Musang Formation		**Limestone**
				Sandstone ▪ Interbedded with Conglomerate
Paleozoic	Carboniferous	Taku Schist		**Meta-Sedimentary** ▪ Schist, Laminated Sandstone

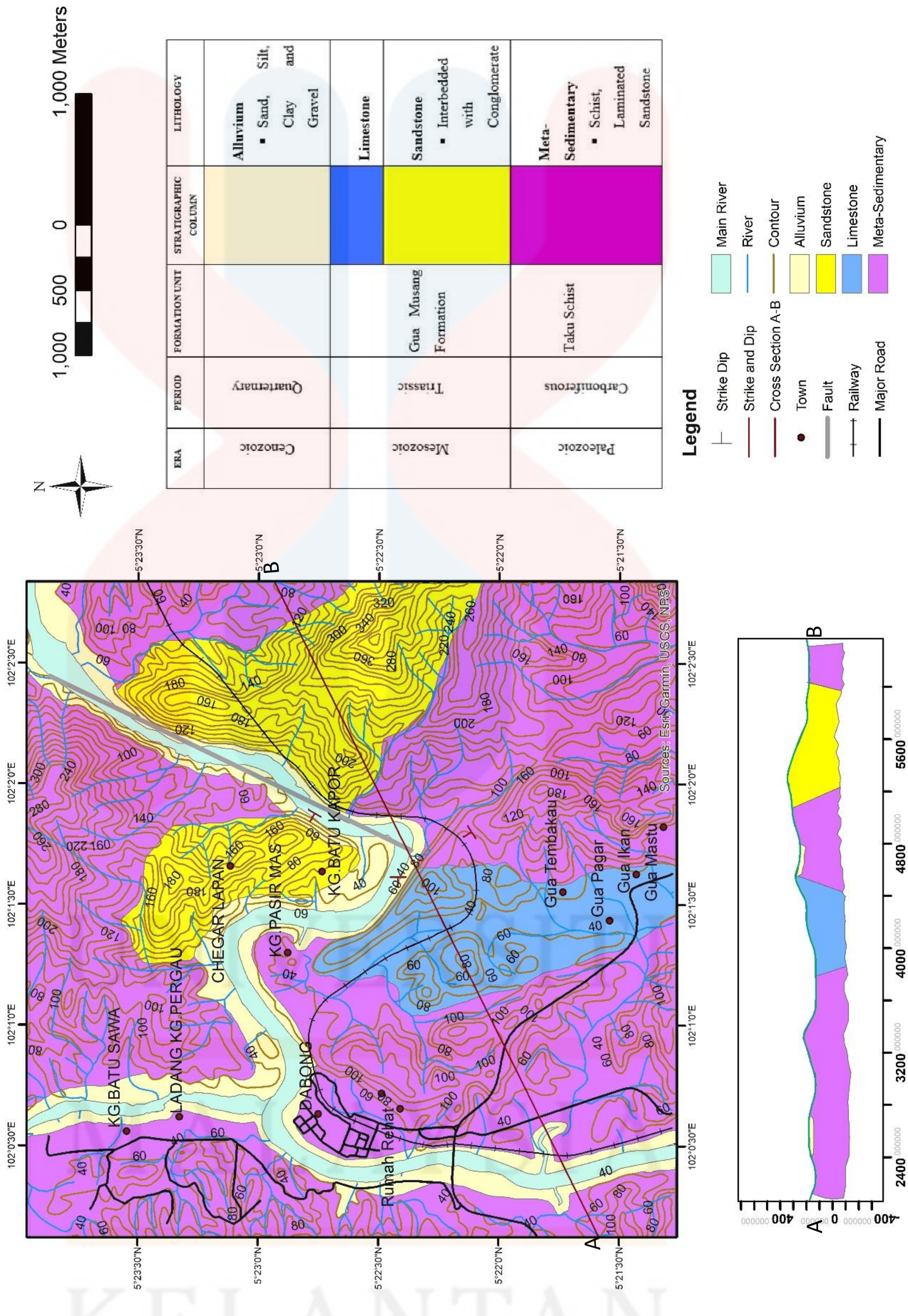


Figure 4.13: Geological Map of the study area

In refer to table 4.2, lithology unit of the study area are made up of three major units. First is limestone which believed come from Gua Musang Formation. The period for limestone was around Triassic and it originates from Mesozoic era. Next is sandstone that interbedded with conglomerate unit. This combination can be found at 102° 1' 51"E 5° 22' 46.6"N near the Sungai Galas. It is believed around this area fault has happened in the past. Other than those mentioned, meta-sedimentary unit also occur in the study area. This rock unit consist of laminated sandstone and schist which have undergone some metamorphic process. This data is compiled and geological map of the study area is processed (Figure 4.13) above.

4.3.2 Unit explanation

4.3.2.1 Alluvium Unit

Alluvium located around the river area which occur in form of cobble size to pebble size where it is considered as easily get involved with flood hazards. This unit is commonly used for vegetation purposes but rarely used for residential development. About 35% alluvium can be found within the study area due to the present of major river, Sungai Galas. Sand, silt and gravel dominates the unit of alluvium that has been carried out throughout the river where it stops at stream. Deposition occur first for heavier sediment.

Figure 4.14: Alluvium unit

4.3.2.2 Limestone Unit

In this study area, limestone dominates about 45% as more of the research area covered by caves. For example, Gua Tembakau which locates near to Gua Ikan and associates caves nearby. This has been an attraction for the traveller to come and visits the places. Near to Sungai Galas, karst landform can be spotted as it consists of limestone outcrop. Due to its grain is coarse, we identified it as sedimentary and has undergoes weathering process while being exposed to water and air. Some fractures and holes can be observed on the outcrop obviously.

Figure 4.15: Limestone outcrop

Figure 4.16: Hand sample of Limestone

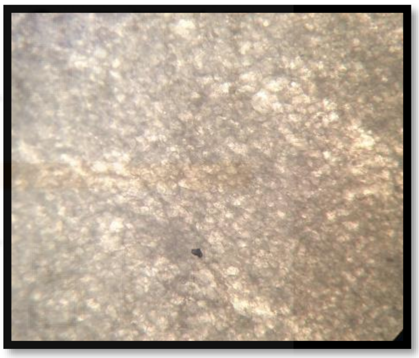


Figure 4.17: Thin section of limestone

4.3.2.3 Meta-sedimentary Unit

Meta-sedimentary rock unit refer to that kind of sedimentary rock that undergoes metamorphism process. Laminated fine-grained sandstone is the first rock unit that we classified into meta-sedimentary. This is due to its origin of sedimentary rock that have lamination on the surface. The laminated sandstone later will turn into siltstone and also shale or mudstone. With bigger diameter of grain size, it can change into conglomerate or brecciated rock.

Figure 4.18: Laminated fine-grained sandstone outcrop

Figure 4.19: Hand specimen

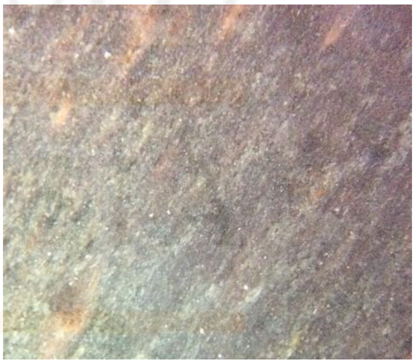


Figure 4.20: Thin section of the sample

4.4 Structural geology

4.4.2 Joint

Mostly the cracks or fracture that shattered around each other on the surface of the rock made up of joints. The highest element that can be seen on the Earth's crust is joint where it resulted from breaking of rock that are stretched but do not have big fracture. They occurred in two dimension of direction, vertical and horizontal. Usually the will come with a large number that is called as joint set which we can easily detected their presence on the Earth's crust surface. In this study, we found a set of joint on meta-sedimentary rock which have many foliation and joints. Not to be confuse with foliation which exist in small scale compared to joint. Usually the obvious joint set were the systematic joint that usually carried mineral in their crack. Reading of the joint is recorded in Appendix A.

Figure 4.21: Joints on outcrop

4.4.3 Bedding

We can determine the rock unit age based on its bedding structure that is formed on within sedimentary rock. Oldest rock unit usually located on the upper part where it overlies the younger rock unit. Depending on the structures that we observed, this order is not valid for all cases. The direction flows of paleocurrent indicated that the sediment has deposited and flow through the same direction. Strike and dip of the bedding act as the guidance of the origin of the beds. Graded bedding, cross bedding, mud cracks, and ripple marks are the famous bedding type. Range of bedding in this study area are around 10cm-30cm. mostly the bedding consists of meta-sedimentary unit and sandstone outcrop.

Figure 4.22: Bedding outcrop

4.4.4 Mechanism of structure

4.4.4.1 Joint Analysis

Joints flow direction and structure can be classified during the field survey. Any discontinuity of the rock that affect the appearance of joints can be brought to light. One set of data joint has been taken at one possible area. It is situated 102 0’ 45”E 5 22’ 2”N where it is near to main road. Joints orientation has been observed from naked eyes before we analysed it using GeoRose software. From the Figure 4.23 below, the highest compressional force comes from North-East area where σ1 is located. Meanwhile the opposite of North-East area is considered lower force acted on it.

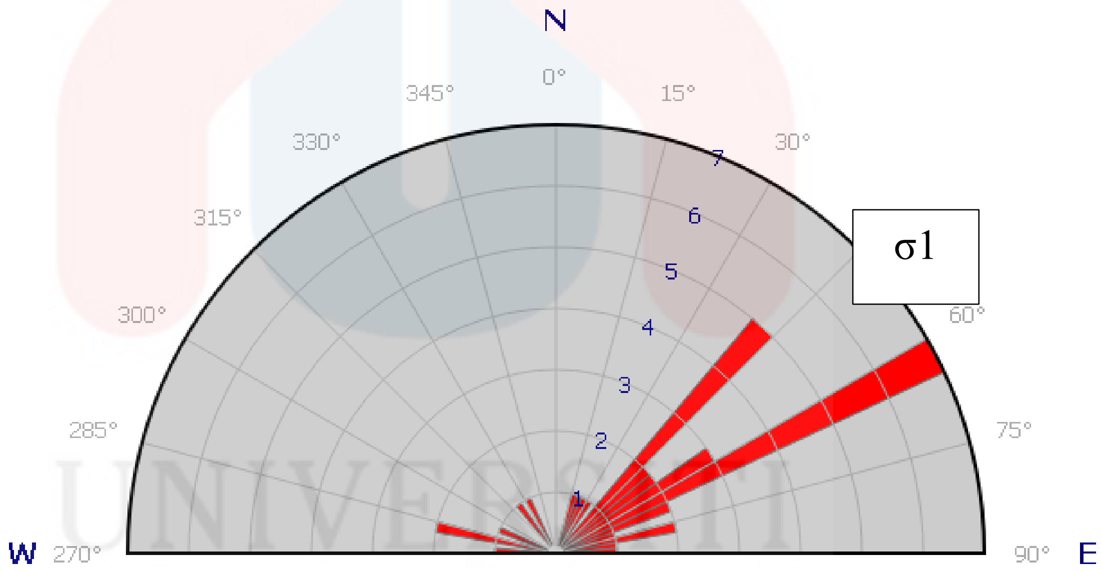


Figure 4.23: Joint analysis

4.4.4.2 Lineament

As we can see from the map in Figure 4.24, the lineaments are tracing towards North pole and during the geophysical survey we used this as the guidance during the arrangement of electrode configuration.

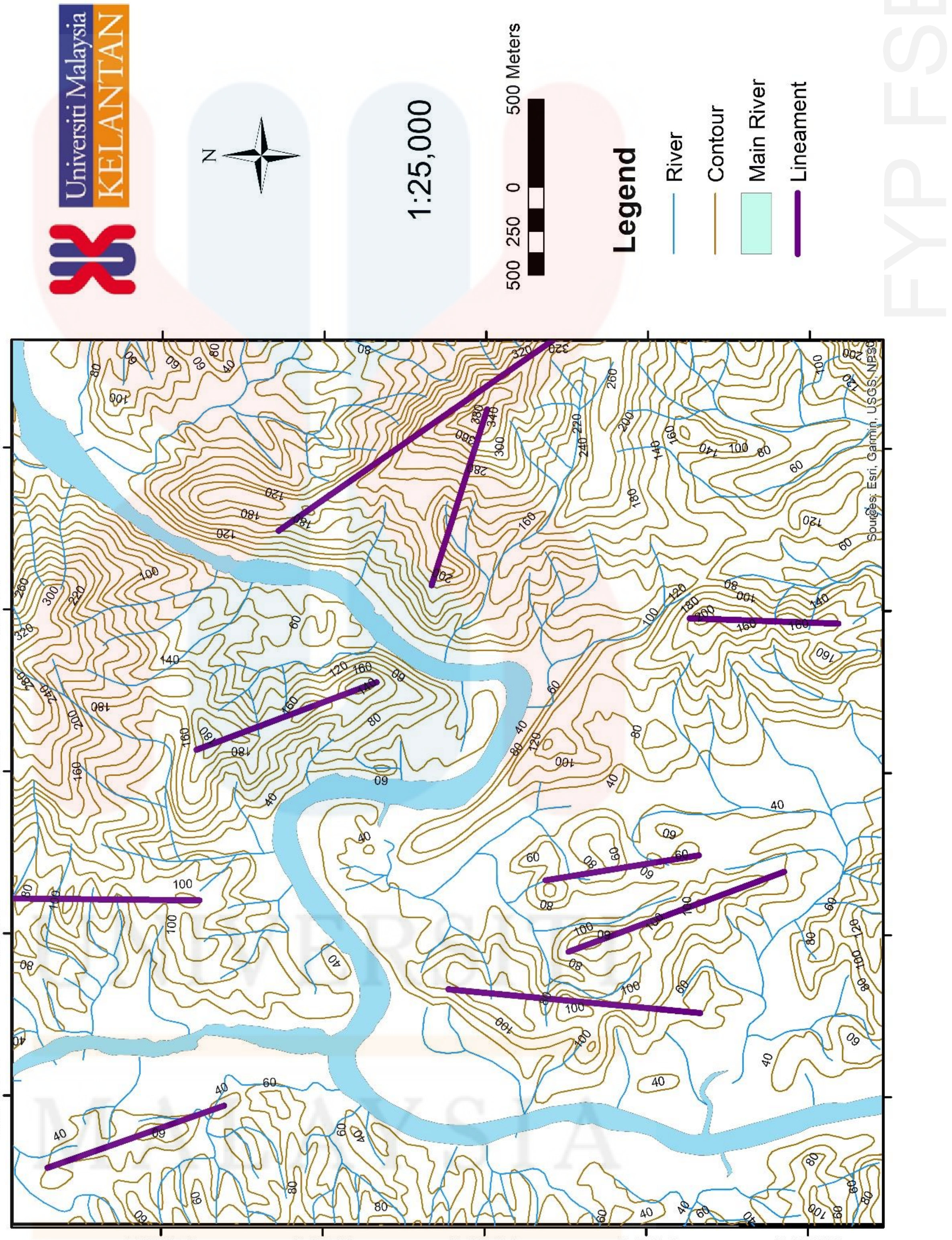


Figure 4.24: Lineament map

4.5 Historical Geology

Geological formation of Kelantan is made up of Lower Paleozoic until Quaternary. Quaternary sedimentary deposit belongs to Cenozoic formation in north Kelantan that consist of unconsolidated and consolidated boulders that underlies the coastal and inland plain. The land mass has been affected by tectonic activities during Paleozoic and Mesozoic eras due to the movement of the rock layers resulted to faulting, folding and other structures. Sedimentary rock units made up the central zone, metasedimentary rock units dominated the west zone and granite made up Main Range and the Boundary Range at the east zone.

In this study area, we have classified the lithology of the study area are alluvium, limestone, sandstone and meta-sedimentary units. The identified rock age for the unit area Quarternary for alluvium, Triassic for limestone and sandstone and Carboniferous for Meta-sedimentary. Joint, beddings and foliation are the observed structural geology during the study. From geological map, we identified the occurrence of sinistral fault as it can be seen from the trace of lineament of the study area.

CHAPTER 5

GEOPHYSICAL INVESTIGATION

5.1 Introduction

This chapter discusses geophysical investigations involving the electrical resistivity method (ERI). Using such a method, we can determine the potential of groundwater and its depth from the surface of the ground where we will interpret the horizontal line in more detail. We can identify physical properties of the groundwater with the interpretation of the pseudosection that we get from processing the data. Horizontal line indicates where the investigation takes place in three different places within the study area. The results that we analysed from ABEM Terrameter LS 1 were compared with each of the line survey. This is due to the difference of geological and lithology of the survey line area.

Figure 5.1: Equipment for electrical resistivity investigation

We started with preliminary study of the study area which gathering all the data that are related with geophysical survey. We proceed with field study, during this phase we collected all the related information such as lithology of the identified area. This information act as a reference for the suitability of the area for further investigation.

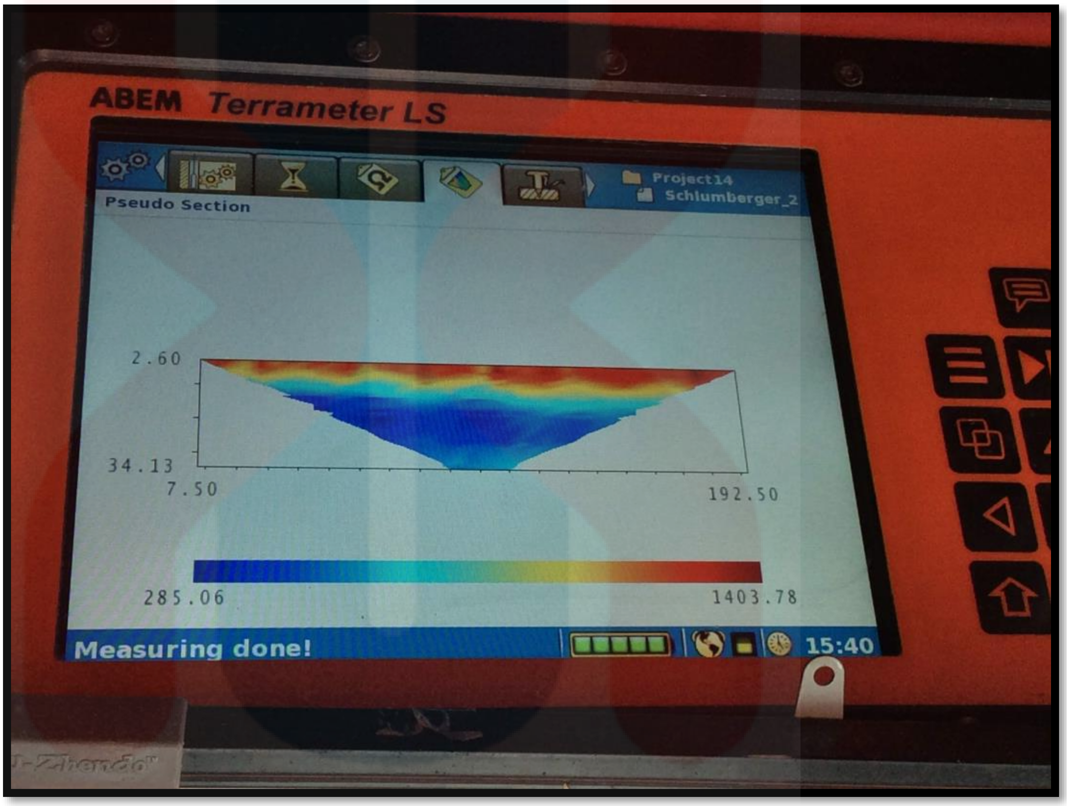


Figure 5.2: One of the pseudosection at location line III

5.2 Locations of Survey Line

During the field survey, we completed the investigation with three lines survey in finding the potential locations of groundwater within the study area. The survey lines located at the identified area which we decide with respect to its lithology and structural of the locations. Lineaments that were present and observed at the study area has been used as a guidance for choosing the best point of geophysical survey as the potential of groundwater travel to low laying place from higher places. Other than that, types of sediment or lithology of the area also taken into measure while deciding the locations where usually sandstone and limestone carries out water through them. Referring to Figure 5.3, the three survey lines are plotted on the map.

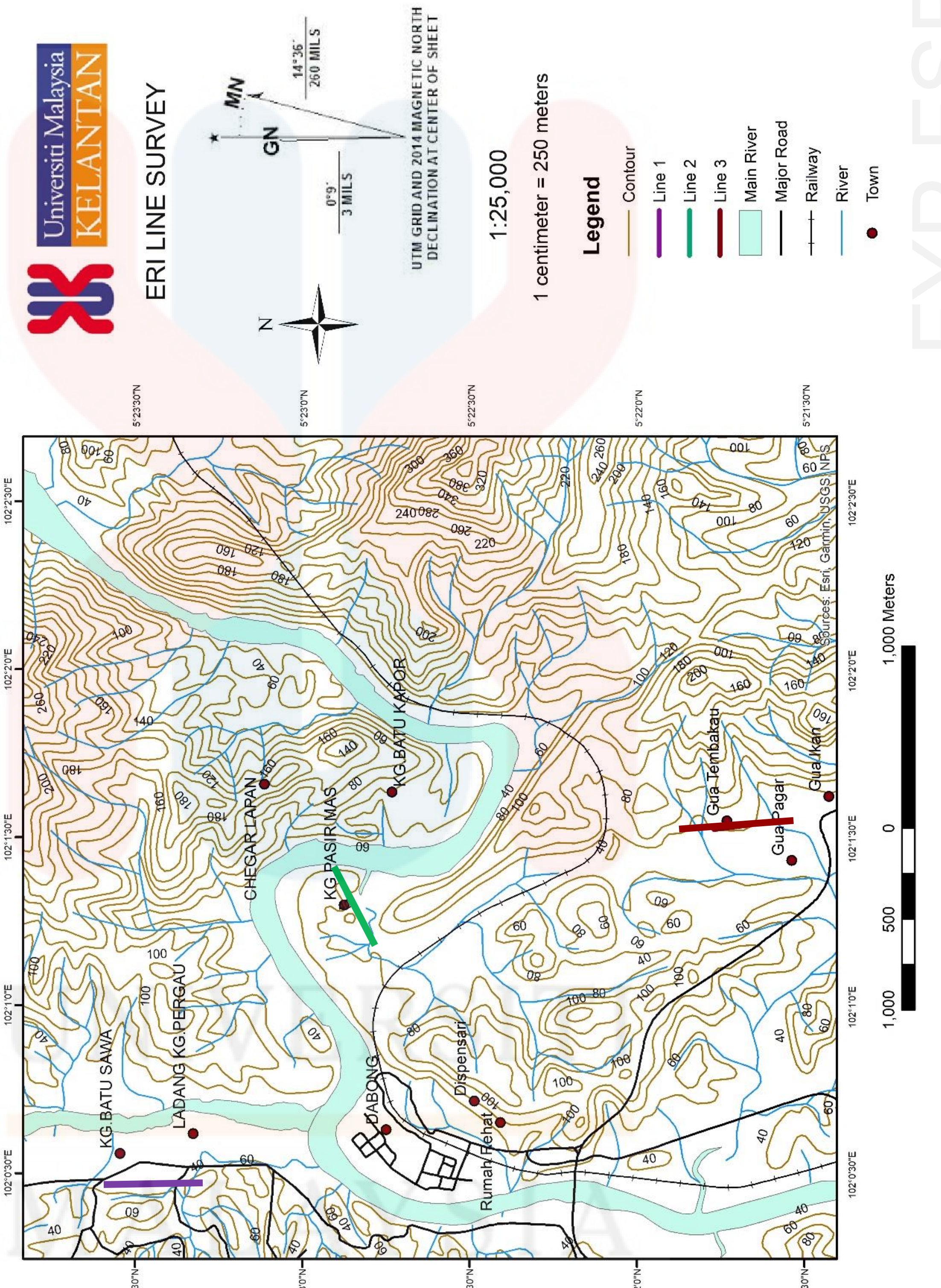


Figure 5.3: Location of three survey lines

i. Survey Line 1

After a thorough study, line survey 1 was chosen at palm plantation area with coordinates of 102°0'28.593"E 5°23'30.84"N (Table 5.1) and pole-dipole configuration is used during the investigation. The investigation site is located near to the palm plantation workers and near to hilly landform. About 50 meters from the back of the workers' house, line survey one were set up with the direction heading towards North. As the hilly landform can affect the depth reading due to mean elevation for this site is 45 meters, we used pole-dipole configuration in order to have more depth reading. Site 1 is made up of meta-sedimentary rock with the domination of schist rock unit. As we can see from Figure 5.4 A, the centre electrode of survey line 1 is situated in between the palm trees and the Figure 5.4 B show us the location of the last electrode location which also in between the palm trees. At field, we can make rough assumption from the pseudosection that is shown on ABEM Terrameter LS 1 after the reading has complete. From the raw data that we can see from the pseudosection, we can assume that the site has little probability potential of groundwater.

Table 5.1: Coordinates of electrode 1, Centre and 41 at site 1

Electrode	**Latitude**	**Longitude**	**Elevation (m)**
1 (A)	5°23'34.011"N	102°0'27.948"E	45.7
Centre	5°23'30.84"N	102°0'28.593"E	48.57
41 (B)	5°23'27.73"N	102°0'28.061"E	48.07

Figure 5.4: Shows the configuration setup for survey line 1

As for survey line 1, Pole-dipole arrangement has been used to find the location of groundwater. As we compare the pesudosection result for resistivity and chargeability value for the location, we can say there are 3 possible locations for groundwater. As for A, B and C, we identified that the water is located in the fractured rock meanwhile for D also come from fractured rock with the contact of weathered clay near to the surface. The chargeability for water occurrence is in between 1.2 msec to 2 msec as we can see from the image result.

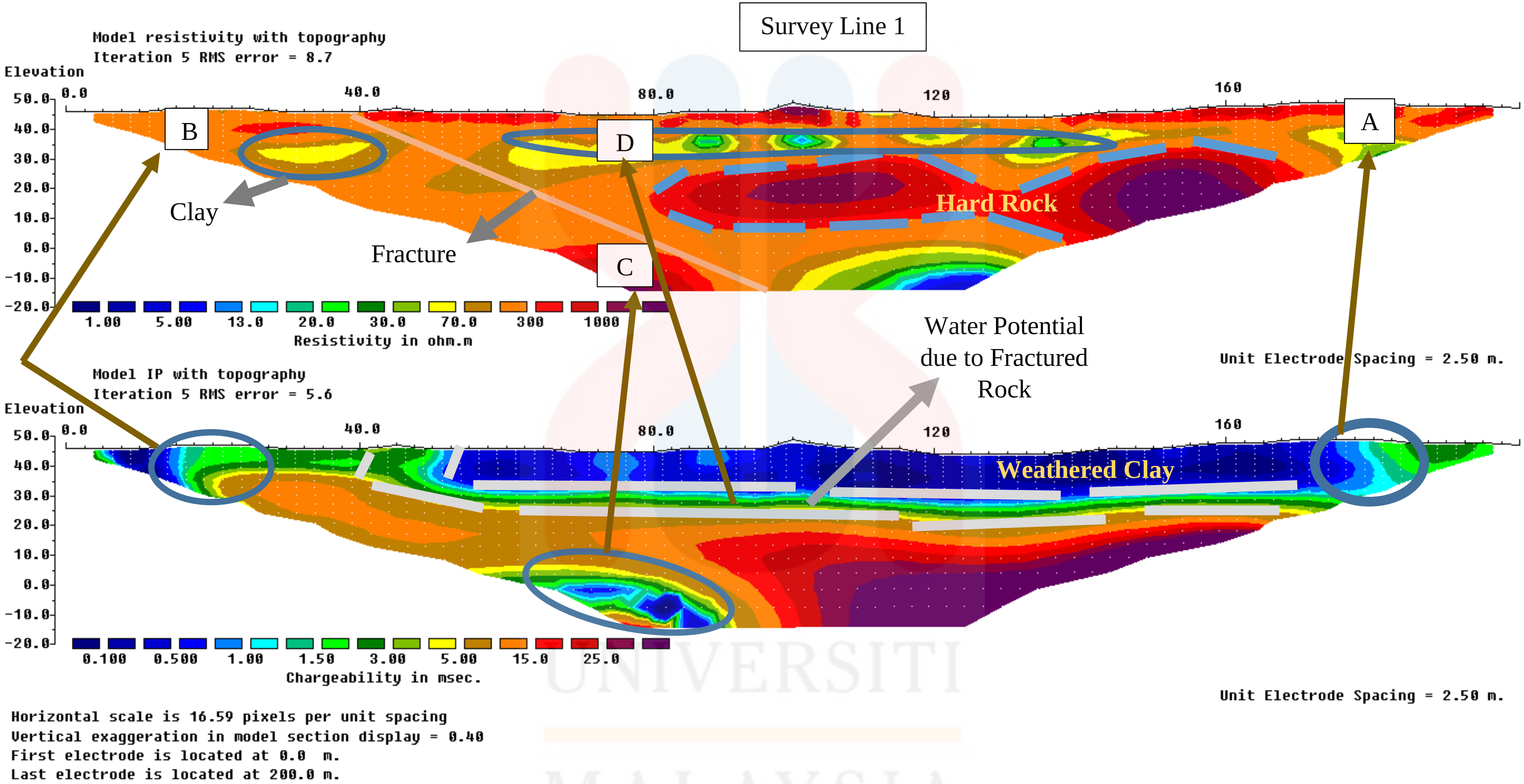


Figure 5.5: Pseudosection of Line 1 Pole-Dipole

ii. Survey Line 2

The next line survey is near the villagers' orchard and located in the alluvium area which is next to Sungai Galas. Before the electrode configuration of the survey begun, the area need has to be cleared of as it is covered with bushes and small tress. Around this site, there are no people lived but there was one abandoned small house of mushroom breeding. Other than that, the survey site was filled with fruit trees which belongs to the local villagers. With the existence of the orchard, we highly believe that the area need source of water in order to keep their trees alive. Identified lithology of this area is alluvium which composed of loose sediments such as sand and clay. Table 5.2 shows the coordinates of the electrode configuration at A side, centre and B side. As shown in Figure 5.6, configuration centre at this area surrounded by some bushes meanwhile Figure 5.7 A and B shows the direction of the survey line.

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

Electrode	Latitude	Longitude	Elevation (m)
1 (A)	5°22'51.44"N	102°1'18.36"E	53.38
Centre	5°22'52.542"N	102°1'21.549"E	58.24
41 (B)	5°22'53.943"N	102°1'24.176"E	56.03

Figure 5.6: Location of centre electrode at site 2

Figure 5.7: Site 2 cable configuration

Schlumberger arrangement is used for survey line 2 during the investigation. We identified from the result, the possibility of groundwater zone is in the alluvium area as we compared the value of resistivity and chargeability value. The recorded resistivity is 80 Ωm to 800 Ωm which is the value for alluvium meanwhile the recorded chargeability is 0 msec to 4 msec. While interpreting and referring to the resistivity and chargeability value in appendix E and F, we compared all the recorded value while relating it with the surrounding study area.

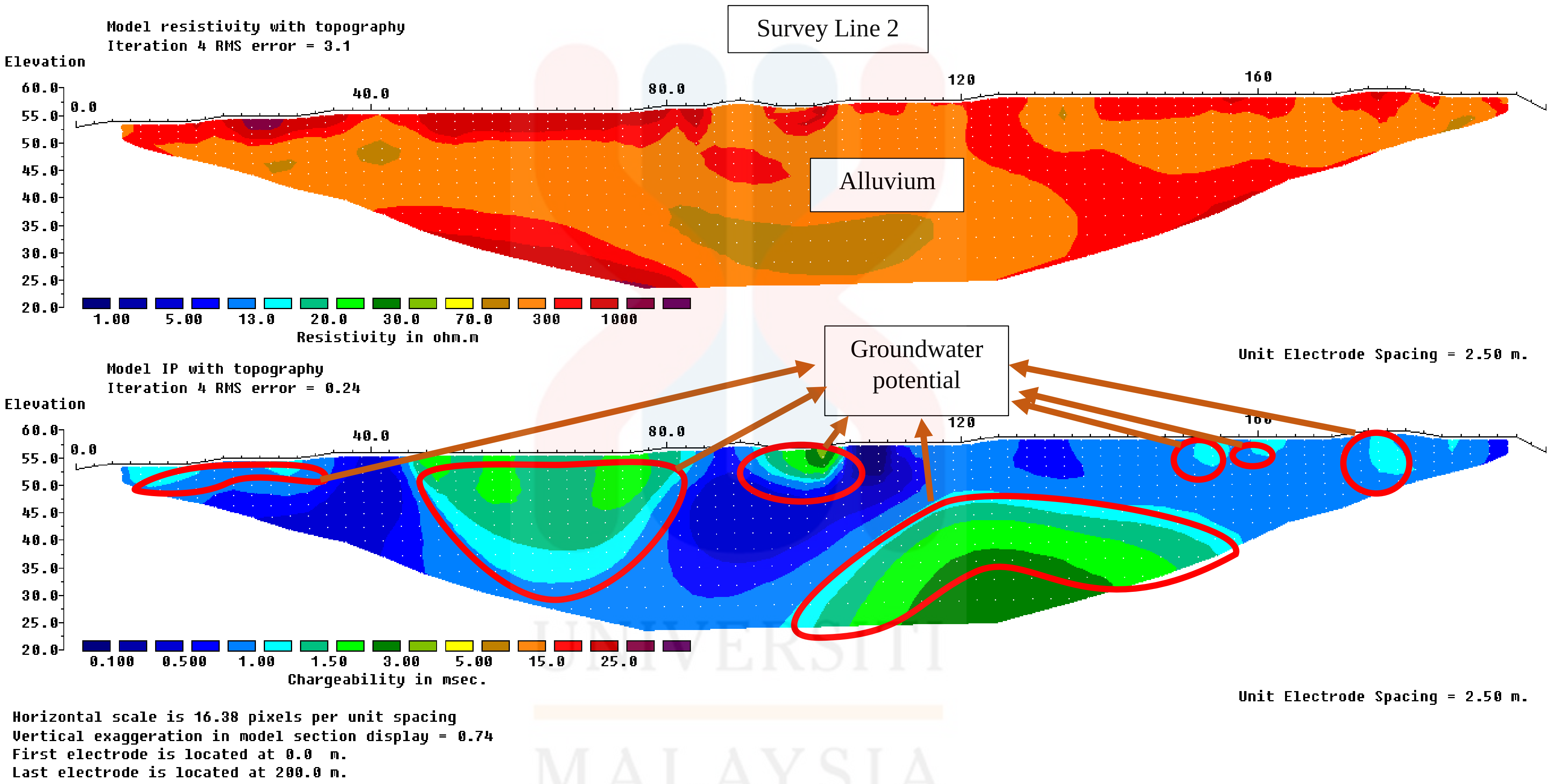


Figure 5.8: Pseudosection of Line 2 Schlumberger

iii. Survey Line 3

Configuration setup for the last line at 102°1'32.30"E 5°21'42.90"N with the elevation 61 meters were done in a short time as it locates at an open area. It is easily accessible as it has unpaved road that any kind of vehicles can pass through. Site survey 3 is near to Gua Ikan, Gua Tembakau and Gua Pagar which limestone made up most of the area. Electrode planting at this survey site is not easy as the ground was dry due to lack of rain and it requires the extra help by using hammer. Schlumberger array configuration is used in conducting this survey. Location of electrode for first, centre and last electrode can be found in Table 5.3 below. In refer to Figure 5.9, survey line 3 is situated at an open space.

Table 5.3: Coordinates of electrode 1, Centre and 41 at site 2

Electrode	Latitude	Longitude	Elevation (m)
1 (A)	5°21'46.356"N	102°1'31.584"E	61.12
Centre	5°21'42.893"N	102°1'32.303"E	61.79
41 (B)	5°21'39.853"N	102°1'32.449"E	64.00

Figure 5.9: Surrounding area of Site 3

Figure 5.10: Cable A for survey line 3

Figure 5.11: Cable B for survey line 3

For last survey line 3, the site is covered hard rock on the upper part of the pseudosection. A few clay lenses are detected underlying the hard rock part. This might be affected by surrounding area of the survey line where we can see from the arrangement of the electrode, the area have many electricity poles which can give disturbance towards the resistivity geophysical survey while it penetrates to the ground. Comparing from its chargeability and resistivity values, A and B are the identified location for groundwater potential that is stored in fractured hard rock.

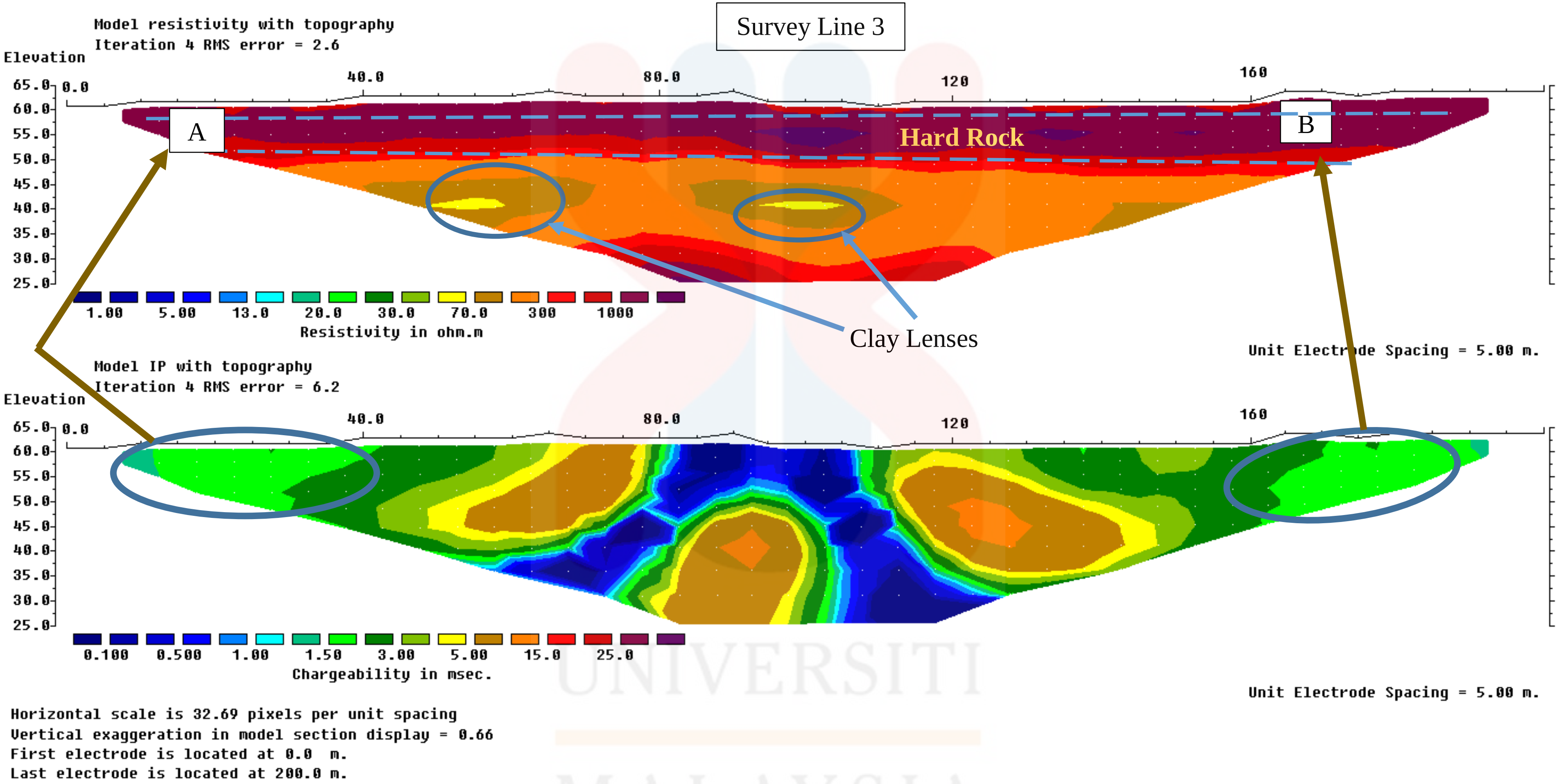


Figure 5.12: Pseudosection of Line 3 Schlumberger

5.3 Discussion

Relationship between resistivity and conductivity is reciprocal whilst doing the geophysical survey. The conductivity is the material ability to conduct electricity while resistivity is the ability of water to resist electrical current emitted. The conductivity value decreases when the resistivity value increase. If the resistivity value is high, it is likely that the electric current did not pass through the material well, vice versa with a low resistivity indicates that the flow of electric current cannot pass through. In survey line 1 and 3, clay lenses can be found in between rock layers with the resistivity value ranges between 55.00 Ωm to 80.00 Ωm. The clay lenses formed during the sedimentation process of the rock layers when it becomes intact with the surrounding water from the fractures. From the pseudosection processed from RES2DINV software, we identified that mostly groundwater located in fractured aquifer which is obvious can be seen in survey line 1. From the weathered rock also can denote as potential location of groundwater as we compare its resistivity and IP values.

All three survey lines were selected based on the lithology, geomorphology and geology information gathered of the study area. All the survey lines follow the direction of north based on the lineament of the study area. As we mentioned, geophysical survey is conducted in order to locate the potential groundwater in the study area. After the survey is done, the data and information gathered was analysed and interpretation occur in order to get the answer and achieve the objective. As we go deeper to the result interpretation, the groundwater potential location can be found mostly in the fractured rocks area. This is related to the lithology of the study area that is covered with hard rock underlying in the ground with the presence of clay.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Introduction

A final remark will be made throughout this chapter that include all the information for this research starting from geological data until the result of geophysical survey. A conclusion will be made according to the information, result and discussion that we obtained throughout the research.

6.2 Conclusion

As a conclusion, the study area is covered with hilly and low lying geomorphology. Most of the people lives in the town area as it has all the needed facility. Also, rubber and palm plantation dominates almost 65% of the study area where some of the people works at the plantations. Main morphology that we observed while traversing are alluvium and karst landform. Gua Ikan which is nearby the study area is famous with the traveller and they love to visit all the nearby caves. Main road that connected Kuala Krai and Jeli makes the town more accessible as people use the road as a shortcut to Gua Musang.

Other facility such as train station and public transport makes it easier to be reached other than going there by car or motorcycle. With the addition of police station, school area and hospital it is considered safe if anything happen and people can help us. As for the lithology, our study area is made up of sandstone, limestone and meta-sedimentary units. The youngest unit is alluvium and the oldest rock unit is the meta-sedimentary unit. All the rock unit are related with each other and we can relate with the surrounding area. An updated geological map is achievable. As for the geophysical survey, it is to locate the potential groundwater. As identified and mentioned in chapter 4, we manage to locates the potential groundwater zones mostly stored in the fractured rock for the three survey line site.

6.3 Suggestion

For future, this research can be useful for preliminary study regarding the study area. A future research regarding the possible groundwater zones may be proceeding using another method which can provide more data with a higher accuracy before groundwater exploration. One of the method can be use in future research is drilling which is a process to dug a hole with the desired length and depth in according to its uses. Other than that, logging, pumping test, quality study and remotes sensing survey can be done for future research. Another site can be explored while doing the survey and it can give benefit to the surrounding people and villagers. The result from the study can be used in a useful and meaningful way for others.

REFERENCE

Abdullah NT (2009) Geology of peninsular Malaysia (Mesozoic stratigraphy). In: Hutchison, CS, Denis NK Tan (ed). University of Malaya/Geol Soc Malaysia, Kuala Lumpur, Malaysia. p. 107–123.

Abdullah I & Setiawan J. (2003), The Kinematics of Deformation of the Kenerong Leucogranite and it and it enclaves at Renyok Waterfall at Jeli, Kelantan. Geological Society of Malaysia Bulletin, 46, 307-3012.

Aw P. (1990), Geological Survey of Malaysia District Memior Geological and Mineral Resources of Sungai Aring area, Kelantan Darul Naim, 21, 116 pp.

Buehler, LTD. (2006). Specimen Preparation Stages. In B. LTD, Guide to Petrography (pp. 2-5). USA: Buehler Ltd. USA.

Bugg, S.F. & Lloyd, J.W., 1976. A study of freshwater lenses configuration in the Cayman Islands using resistivity methods. The Quarterly Journal of Engineering Geology, 9, 291–302. Cazenave, A. & Cozannet, G.L., 2013. Earth's Future, 2, 33-36.

Doc, Noaa, & Nws. (2002, October 22). Description of the Hydrologic Cycle. Retrieved April 02, 2018, from https://www.nwrfc.noaa.gov/info/water_cycle/hydrology.cgi

Draf Rancangan Tempatan Jajahan Kuala Krai Jilid 1 2020, (2011), Majlis Daerah Kuala Kari & Majlis Daerah Dabong

DU BOIS, E. P., (1980) • Synoptic review of some hydrocarbon bearing and potentially hydrocarbon-bearing basins of Southeast Asia: United Nations - ESCAP, Proceedings of 17th Session CCOP (Document Ropea. - R. 093) p. 245-285.

Eagleson, P. (1991). Hydrologic Science: A Distinct Geoscience. *Hydrologic Science: A Distinct Geoscience*, *29*(2), 237-248.

Fariz Mohamed, A., Zuhairi Wan Yaacob, W., Raihan Taha, M., & Rahim Samsudin, A. (2009). Groundwater and Soil Vulnerability in the Langat Basin Malaysia. European Journal of Scientific Research, 27(4), 1450-216.

Ferguson, G. & Gleeson, T., (2012). Vulnerability of coastal aquifers to groundwater use and climate change. Nature Climate Change, 2, 342-345.

Fetter, C.W., (2001), Applied Hydrogeology. Prentice-Hall, Inc. Upper Saddle River, New Jersey, ISBN 0-13-088239-9

Foster, Stephen & J Chilton, P. (2004). Groundwater: the processes and global significance of aquifer degradation. Philosophical Transactions of The Royal Society B Biological Sciences. 358. 1957-72. 10.1098/rstb.2003.1380.

George NJ, Obianwu VI, Obot IB (2011) Estimation of groundwater reserve in unconfined frequently exploited depth of aquifer using a combined surficial geophysical and laboratory techniques in The Niger Delta, South–South, Nigeria. Advances in Applied Science Research 2(1):163–177

Geosci, A., E Juanah, M., Ibrahim, S., Nor Azmin Sulaiman, W., & Abdul Latif, P. (2012). Groundwater resources assessment using integrated geophysical techniques in the southwestern region of Peninsular Malaysia. Arabian Journal of Geosciences, 6-10.

Hady Ismail, H., Madon, M., & Affendi Abu Bakar, Z. (2007). Sedimentology of The Semantan Formation Along the Karak-Kuantan Highway, Central Pahang, *Sedimentology of the Semantan Formation (Middle -Upper Triassic) along the Karak -Kuantan Highway*, central Pahang. Geological Society of Malaysia Bulletin, 53, 27-34.

Harter, T. (2003). Groundwater Quality and Groundwater Pollution. Groundwater Quality and Groundwater Pollution, Publication 8083, 11.1th ser. doi:10.3733/ucanr.8084

Heath, Ralph C., (1983), Basic Ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, 86p.

Hutchison CST, Denis NK (ed) (2009) Geology of Peninsular Malaysia (Mesozoic stratigraphy): The University of Malaya and The Geological Society of Malaysia, Kuala Lumpur, Malaysia.

Jing, X., Geerts, B., & Friedrich, K. (n.d.). Dual-Polarization Radar Data Analysis of the Impact of Ground-Based Glaciogenic Seeding on Winter Orographic Clouds. Part I: Mostly Stratiform Clouds.

Lateh, H., Tay, L., Khan, Y., Kamil, A., Azizat, N., & Professor, A. (2013). Prediction of landslide using Rainfall Intensity - Duration Threshold along East - \ West Highway, Malaysia. Caspian Journal of Applied Sciences Research, 2, 124-133.

Lee C.P, Shafeea, L.,Kamaluddin, H., Bahari, N., Rashidah, K. (2004). Stratighraphic Lexicon of Malaysia . Geological Society of Malaysia. Kuala Lumpur.p.43-48.

Loke, M. H. (2011). A practical guide to 2-D and 3-D electrical imaging surveys. RES2DINV Manual, IRIS Instruments, Orleans, France

Macdonald S. (1967) The Geology and mineral resources of north Kelantan and North Terengganu. Mineral and Geological Survey Department West Malaysia, 202p.

Mohamad Husin Mohamad, 1993. Geologi kawasan Jeli, Kelantan dengan penekanan keatas petrologi dan geokimia batuan granit. Unpubl. BSc. thesis, Univ. of Malaya.

Mustaffa Kamal Shuib (2000). The Mesozoic Tectonics of Peninsular Malaysia – An overview. In: GSM Dynamic Stratigraphy & Tectonics of Peninsular Malaysia The Mesozoic of Peninsular Malaysia,Geological Society of Malaysia Warta Geologi,26,

Dony Nazaruddin, ZafirahSakinah & Hussin, Hamzah & Muqtada Ali Khan, Mohammad & Jafar, MohamadTaufiqMohd. (2016). Geological Mapping and Multi Electrode Resistivity Survey for Potential Groundwater Exploration in Ayer Lanas Village and Its Surroundings, Jeli District, Kelantan, Malaysia. Chiang Mai Journal of Science. 43. 1335-1345.

Rahim Samsudin, Haryono, U. Hamzah, A.G. Rafek, (1997), Salinity study of coastal groundwater aquifers in north Kelantan, Malaysia, Geological Society of Malaysia Bulletin 41, pp. 159-165.

Sander P. (2007). Lineament in groudwater exploration: a review of application and limitations. Hydrogeol.J 15 71-74.

Shah Othman, A., Ghani, A., & HAm RosLEE, K. (2000). Field Relations and Petrochemistry of the Jeli Igneous Complex, North Kelantan: Preliminary Observations. Geological Society of Malaysia Annual Geological Conference, 105-110.

Singh, C.L. (1985). "Role of Surface Geophysics (pp. 445-494). Canada: John Wiley&Sons, Inc.

Swee Hengl, G., Guan Hoe, T., & Fuad Wan Hassan, W. (2006). Gold Mineralization And Zonation In The State Of Kelantan. *Geological Society of Malaysia Bulletin*, *52*, 129-35.

Tjia, H.D (1996). Tectonic deformed and undeformed Jurassic Createaceous of Peninsula Malaysia. Geological Society of Peninsula Malaysia Bulletin, 39, 131-156.

Tracy J. Baker, Beth Cullen, Liza Debevec, Yenenesh Abebe. (August 2015). Applied Geography. *A socio-hydrological approach for incorporating gender into biophysical models and implications for water resources research*, 325-338.

Wightman, W. E., Jalinoos, F., Sirles, P., and Hanna, K. (2003). "Application of Geophysical Methods to Highway Related Problems." Federal Highway Administration, Central Federal Lands Highway Division, Lakewood, CO, Publication No. FHWA-IF-04-021, September 2003. http://www.cflhd.gov/resources/agm/

APPENDIX

Appendix A: Joint readings

Joint reading at L5
262
258
252
246
222
256
198
290
228
330
226
224
238
272
240
280
220
320
240
282
210
220
200
230
222
230
265
207
242
240
244
238
246
244
238
242

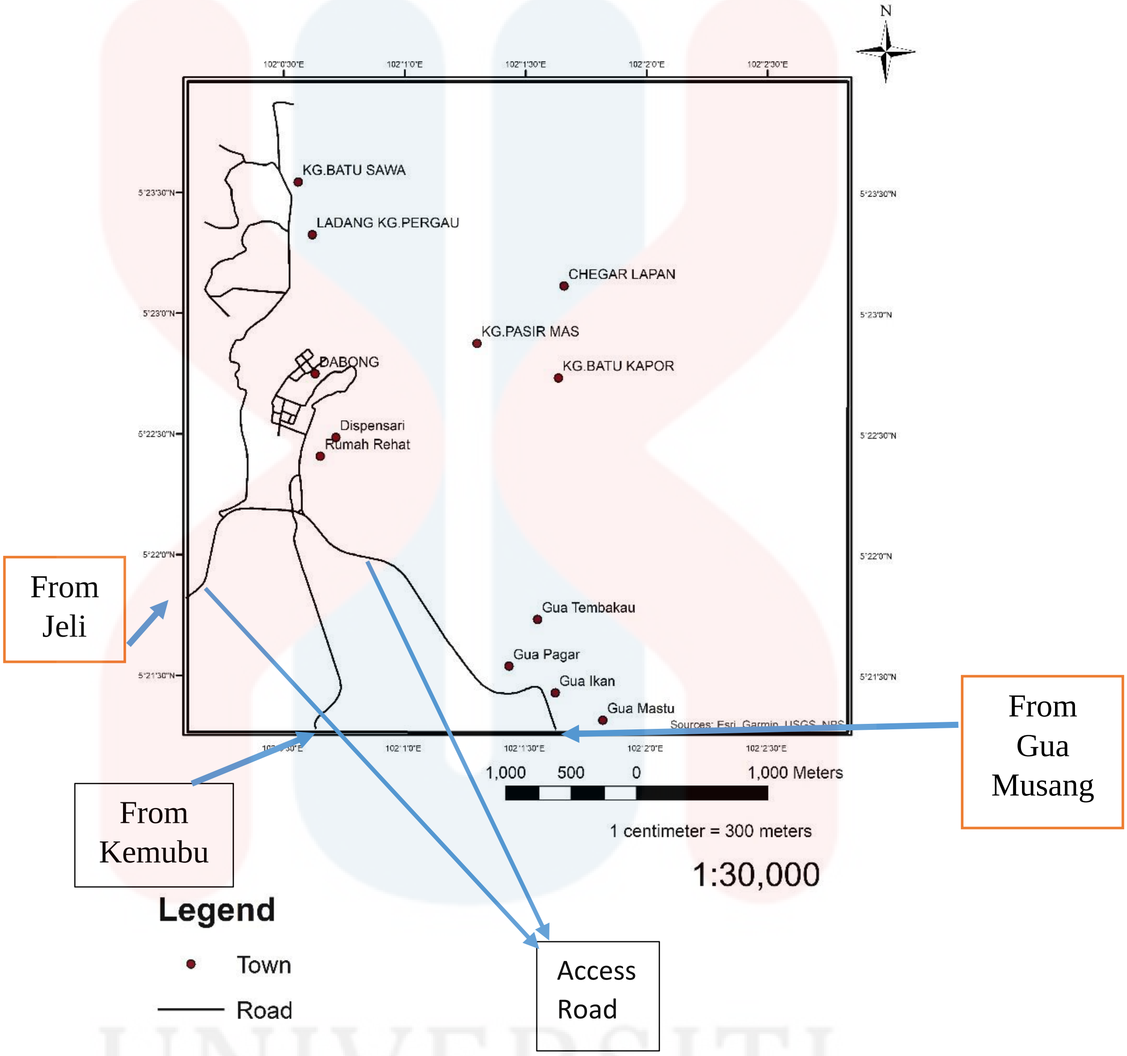
Appendix B: Reading of ERI survey for LS Terrameter Toolbox

Spacing	elevation LINE1	elevation LINE2	elevation LINE3
0	46	53	61
5	46	54	61
10	46	54	62
15	47	54	62
20	47	55	62
25	47	55	62
30	46	55	62
35	46	56	62
40	46	56	63
45	47	56	63
50	46	56	63
55	46	56	63
60	46	56	63
65	46	56	64
70	45	56	63
75	45	56	63
80	45	57	63
85	46	57	63
90	46	58	64
95	46	57	62
100	49	57	62
105	47	58	62
110	46	58	61
115	46	58	62
120	44	58	62
125	44	59	62
130	44	59	62
135	44	59	62
140	45	59	62
145	46	59	62
150	46	59	62
155	47	59	62
160	48	59	62
165	48	59	64
170	49	59	64
175	49	60	63
180	49	60	64
185	48	59	64
190	48	59	64
195	48	59	64
200	47	56	64

Appendix C: Reading of bedding plane

bedding			
L3	322	52	64
	356	86	36
	2	92	36
L4	26	116	28
	22	112	36
L5	356	266	54
	346	256	42

Appendix D: Connection Map of the Study Area



Appendix E: Resistivity value (Source: Loke, 1997)

Material	Resistivity (Ωm)	Conductivity (Siemen/m)
Igneous and Metamorphic Rocks		
Granite	5×10^3 - 10^6	$10^{-6} - 2 \times 10^{-6}$
Basalt	$10^3 - 10^6$	$10^{-6} - 10^{-3}$
Slate	$6 \times 10^2 - 4 \times 10^7$	$2.5 \times 10^{-8} - 1.7 \times 10^{-3}$
Marble	$10^2 - 2.5 \times 10^8$	$4 \times 10^{-9} - 10^{-2}$
Quartzite	$10^2 - \times 10^8$	$5 \times 10^{-9} - 10^{-2}$
Sedimentary Rocks		
Sandstone	$8 - 4 \times 10^3$	$2.5 \times 10^{-4} - 0.125$
Shale	$20 - 2 \times 10^3$	$5 \times 10^{-4} - 0.05$
Limestone	$50 - 4 \times 10^2$	$2.5 \times 10^{-3} - 0.02$
Soils and Waters		
Clay	1 - 100	0.01 – 1
Alluvium	10 - 800	$1.25 \times 10^{-3} - 0.1$
Groundwater (fresh)	10 – 100	0.01 – 0.1
Sea water	0.15	6.7
Chemicals		
Iron	9.074×10^{-8}	1.102×10^7
0.01M Potassium chloride	0.708	1.413
0.01M Sodium chloride	0.843	1.185
0.01M Asetic acid	6.13	0.163
0.02 Xylene	$8 - 4 \times 10^3$	$8 - 4 \times 10^3$

Appendix F: Chargeability of materials

Material type	Chargeability (ms)
Groundwater	0
Alluvium	1 – 4
Gravels	3 – 9
Precambrian volcanics	8 – 20
Precambrian gneisses	5 – 20
Schists	5 – 20
Sandstones	3 – 12
Argilites	3 – 10
Quartzites	5 – 12