GEOLOGY AND DEMARCATION OF THE GROUNDWATER POTENTIAL ZONES USING ELECTRICAL RESISTIVITY IMAGING (ERI) IN KUALA BALAH, 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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DECLARATION

I declare that this thesis entitled Geology and Demarcation of the groundwater potential zones using Electrical Resistivity Imaging (ERI) in Kuala Balah is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name :

Date :

APPROVAL

"I hereby declare that I have read this thesis and in my 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	:	…….....
Name of Supervisor	:	
Date	:	……..

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Abstracts: A study entitled Geology and Demarcation of the groundwater potential zones using Electrical Resistivity Imaging (ERI) in Kuala Balah has been conducted. The research area is located in Kuala Balah which is part of sub district of Jeli Kelantan, Malaysia. Presently the area is totally depending on surface water which cannot be promise regular supply during drought time and also easy to contaminate by the surface activities. Keeping in this view, the present research provides an update geological map on a scale of 1: 25,000 and demarcate groundwater potential zone in Kuala Balah, Kelantan. The methodology of this research involve preliminary studies, field studies, laboratory work, data processing, and data interpretation. For first location, the Pole dipole electrode arrangement is used while second and third location, the Schlumberger is used. Each survey line spread 200 meters with 5 meters spacing. The resistivity and induced polarization data were collected by using ABEM Terrameter LS. After data acquisition, the procedure continues to the data processing and inversion using RES2DINV software. The processed data interpreted by overlapping the resistivity value and the IP value on 2 D profile which shows the occurrence of the bedrock, coarse grain sand, clay lenses, and geological structure like fault and fracture. Further this results show that groundwater potential zone in the form confined aquifer and fractured zone. Geological mapping and geophysical survey has been proved as an effective way to find the groundwater potential zones. This research project represents a major step toward new development of water supply.

Keywords: Geological map; groundwater potential; electrical resistivity imaging; aquifer; water supply.

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Abstrak: Satu kajian bertajuk Geologi dan Kajian Zon Potensi Air Bawah Tanah dengan menggunakan kaedah Pengimejan Keberintangan Elektrik di Kuala Balah telah dijalankan. Kawasan kajian terletak di Kuala Balah di mana ianya ialah sebahagian daripada daerah Jeli Kelantan, Malaysia. Pada ketika ini kawasan tersebut bergantung sepenuhnya kepada air permukaan yang tidak dapat menjanjikan bekalan tetap semasa masa kemarau dan mudah dicemari oleh aktiviti permukaan. Merujuk kepada hal ini, kajian ini menyediakan peta geologi yang dikemaskini pada skala 1: 25,000 dan menjelaskan zon potensi air bawah tanah di Kuala Balah, Kelantan. Metodologi kajian ini melibatkan kajian awal, kajian lapangan, kerja makmal, pemprosesan data, dan analisis data dan tafsiran.Bagi lokasi pertama, susunan elektrod Pole Dipole telah digunakan, manakala lokasi kedua dan ketiga, Schlumberger telah digunakan. Penyebarannya adalah 200 meter dengan jarak elektrod sepanjang 5 meter. Data keberintangan dan induksi polarisasi telah dikumpulkan dengan menggunakan ABEM Terrameter Lund. Selepas pengambilalihan data, prosedur diteruskan dengan memproses data dan proses penyongsangan menggunakan perisian RES2DINV. Dalam seksyen pseudo ini, ia menunjukkan kewujudan batuan dasar, batuan pasir , kanta tanah liat, zon potensi air bawah tanah dan juga struktur kebiasaan seperti zon sesar dan zon kekar dapat ditafsirkan. Hasil kajian menunjukkan bahawa kawasan kajian mempunyai potensi sumber air bawah tanah yang terdapat di pasir sebagai akuifer perch, dan akuifer patah yang wujud di dasar batuan. Pemetaan geologi dan survei geofizik telah dibuktikan sebagai cara yang berkesan untuk mencari zon potensi air bawah tanah. Projek penyelidikan ini merupakan langkah utama ke arah pembangunan baru bekalan air.

Kata kunci: Peta geologi; potensi air bawah tanah; pengimejan keberintangan elektrik; akuifer; bekalan air

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CHAPTER 1

INTRODUCTION

1.1 Background study

Ground water is one of the natural resource which is essential for living organism, therefore it is important for most people to know about the ground water and it potential sources. (Interior, 2016). As the increase in the number of population and highly domestic usage, the demand for freshwater also slightly increase. This situation might lead to the new extraction of the source of freshwater. (Liu Changming, 2010) .

Groundwater is widely in Kelantan, which provides more than 50% of the potable water supply. Groundwater is important because groundwater supplies cost cheaper than developing surface water supplies. Other than use the groundwater for a daily purpose, groundwater also helps in stabilizing hydrological cycle. The water that store inside limestone caves maintain cavity pressure and prevent sink hole to happen. (Actforlibraries.org, 2017) .

For the general geology, the aim of the study is to provide the geological map and identify the evidence of event take place by interpreting the lithology, geological

structure, hydrology aspect. By conducting mapping session, the lithology observed is useful to relate with the potential aquifer of the study area. The geophysical methods are chosen as the method to identify the groundwater resources in the study area.

1.2 Study Area

1.2.1 Location

The research has been conducted at the Kuala Balah. Kuala Balah is one of the sub districts in Jajahan Jeli, Kelantan. The total area of Jajahan Jeli is 128,020.56 hectares or 1,280.21 km2 which one of the largest colony in the State of Kelantan. (Jeli, 2014). Kuala Balah is bounded in the north by Jeli and in the south by Dabong. Kuala Balah dominates the area by 62,159.76 hectares. The given study area that should be covered is 25km^2. The coordinate is N 5^{o}25'21", E 101^{o}55'43", the next coordinate is N 5^{o}25'19", E 101^{o}58'26", the third point is N 5^{o}22'40, E 101^{o}55'42". The last point is N 5^{o}22'43", E 101^{o}58'27".

1.2.2 Road

Before conducting geological mapping, reconnaissance visit of study area has been done. It is important process before continuing mapping project in order just to have preliminary look at the area. It slightly gave the student such a picture of type of geological features, geological setting and also the accessibility toward the area. The study area is accessed main road which is Jalan Sungai Sam- Dabong- Jeli.

For the better accessibility, the students used unpaved road which connected between plantation and the villagers. If there is no unpaved road can be accessed, the

problem can be overcome by taking the initiative on clearing the bushes. A new discovery of road has been made.

In this study area, there is a main river which known as Sungai Pergau. The villagers can access the river safely by using boat. Some small village with road connection also exists in this study area named Kampung Biak B.

Figure 1.1 Unpaved road (left) and the main road (right) of my study area.

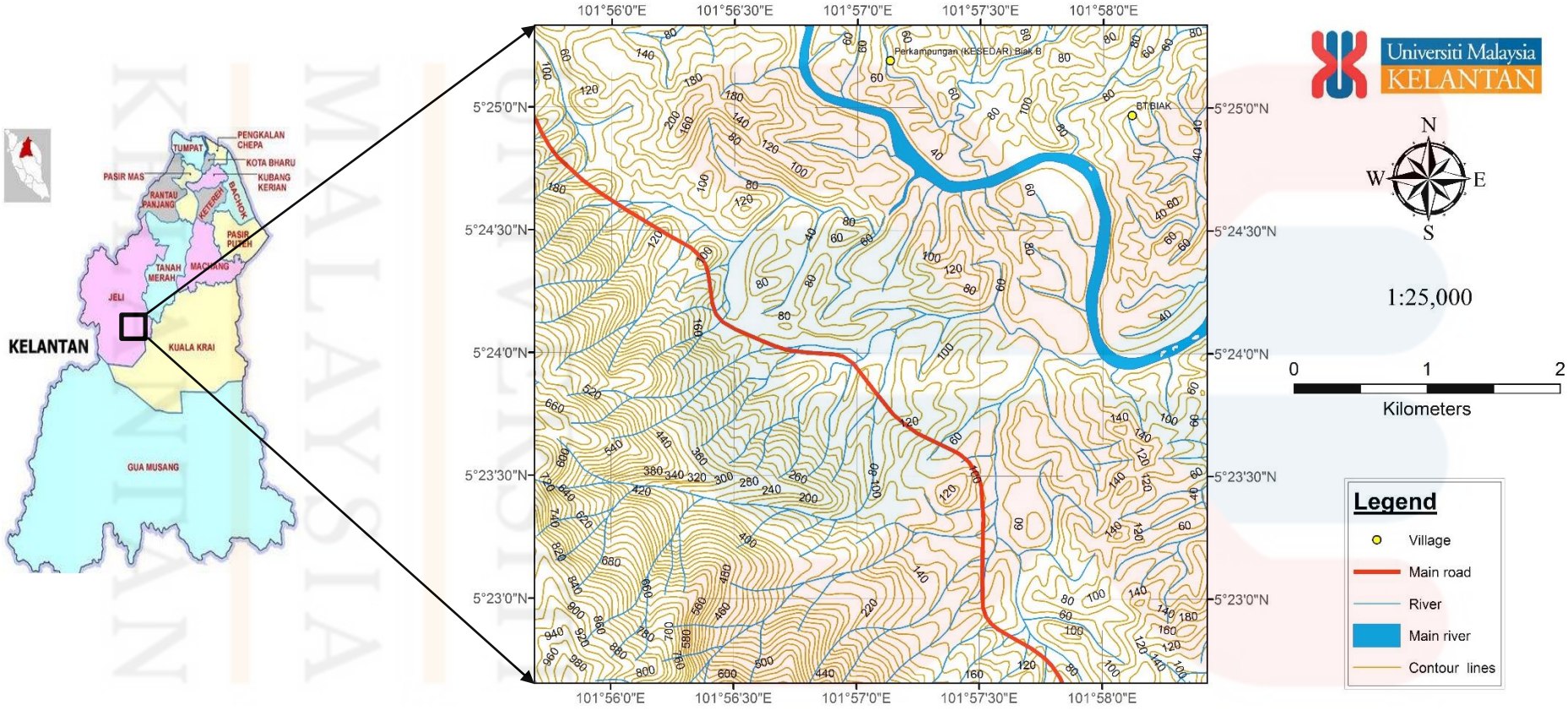


Figure 1.2 Base map of the study area

1.2.3 Demography

For the demography aspect, according to a study by the Kelantan State Statistics Department, 42,872 people in Jajahan Jeli has been recorded in a year of 2014. The population number consists of 21,764 males and 21,108 females. Kuala balah population is the second largest among the three sub district.

Table 1.1 The total people composition in Jajahan Jeli. (Jeli, 2014)

District	**Male**	**Female**	**Total**
Batu Melintang	4,826	4,864	9,690
Jeli	10,820	10,300	21,120
Kuala Balah	6,118	5,944	12,062
			42,872

The population in this study limited to the only Malay and Orang Asli. There is no other race recorded like Chinese or Indian who currently stay in Jajahan Jeli. The race distribution can be seen in table below.

Table 1.2 Population by race in Jajahan Jeli. Source: (Jeli, 2014)

Race	**Jumlah**
Melayu	42,400
Orang Asli	472
Cina	-
India	-
Others	-
Jumlah	**42,872**

1.2.4 Rain distribution

The rain distribution also affected the study area. Malaysia's climate is categorised as equatorial, as it being hot and humid throughout the year. The average temperature is 27 °C (80.6 °F) where the rain fall that has been recorded within a year 250 centimetres (98 inches). The main range of Peninsular Malaysia has affect the climate differs between the eastern and western. It is also because the western part of Malaysia has experience Monsoon season.

The El Niño also effect in decreasing in rainfall during dry season. The highest rainfall recorded in a day was 608 mm (23.9 in) in Kota Bharu, Kelantan on 6 January 1967. Kuala Balah is a city with a significant rainfall. Even in the driest month there is a lot of rain. The average annual temperature in Kuala Balah is 26.8 °C. In a year, the average rainfall is 2482 mm.

There is 87 mm of precipitation in February as it becomes the driest month. With an average of 27.6 °C, May is the warmest month. January is the coldest month,with temperatures averaging 25.5 °C. Refer the temperature graph below.

Most of the precipitation here falls in December, averaging 343 mm. The table below summarize the average climate of Kuala Balah. The precipitation varies 256 mm between the driest month and the wettest month. The variation has been recorded 2.1 °C within a year.

1.2.5 Land use

Human use the land for a lot of different function. The study of land use is the study of how way in managing land, including how the natural world is adapted to human needs. There are several important why land use is important in our life cycle. The study in landsuse will tells a great deal about the governments making the decisions for land use and the priorities.

It also gives better understanding in community's life pattern, their needs and eventually able to predict the future trends. By knowing the future trends, the government can prepare for negative impacts. In Jeli district and Kuala Balah, the land is use for the recreational, transport, agricultural, residential & commercial. As we can see, Kuala Balah is a developing town which a lot activity is been doing.

1.2.6 Socio economic

Based on data recorded by Pejabat Tanah dan Jajahan Jeli in 2014, the early human activity of Jeli residents mostly involved in rubber tapping and other forms of plantations for a living, recently the new generations have managed to find their way up to a much better profession. Other than that, they also have been doing some business and small industrial. (Council, 2016)

1.3 Problem Statement

Kuala Balah is one of the developing areas which require clean and continuous water supply to full fill the requirements. Presently the area totally depends on surface water which cannot be insuring regular supply during drought time and also easy to contaminate by surface activities.

Geologically the study area mainly covered by hard rocks and due to hard rocks no development of groundwater in the area. Keeping in this view, the present study is focused to identify the new groundwater sources as one of the alternative sources of water for different uses.

1.4 Research Objectives

1. To provide the geological map of the study area with a scale of 1:25000.

2. To determine the potential zones of groundwater using electronic resistivity imaging.

1.5 Scope of study

This study was carried out at the Kuala Balah area to conduct the geological mapping in the area of 25km^2. The geological mapping has covered the lithology aspect, structural geology, geomorphology aspect, traversing and also sampling. The sampling made was by following its requirement. The research specification will require student to have several geophysical materials like ABEM Terrameter LS, ABEM Multi Core Cable, electrodes, battery and clips, and the accessories such as cable remote if needed. The selection of Electrical Resistivity survey lines is based on the structural geology, lithology and topography of the study area. In this research, three resistivity lines were measured.

1.6 Significance of study

This research project represents a major step toward new development of water supply. It also helps to keep awareness as it gave a better understanding among the communities about the groundwater. This study will be useful to the community as in agriculture activities and drinking purpose.

The updated map will provide sufficient information for any exploration in the future. Furthermore, this research also useful for any development of the new well as it can reduce the water supply issues. Finally, this study can generate money by selling the data to the interested company or authority.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In chapter 2, the research is proceeding to the desk study where the student has to do the study on previous research or discussion. This process will include the preliminary study based on research articles, journals, newspaper, and bulletin and also the books.

2.2 Regional geology and tectonic setting

2.2.1 Regional geology of Malaysia

Peninsular Malaysia is the product of the two plate converging. The two plate known as Sibumasu and East Malaya block. As results of the clash between these two, the main range of Granite has formed. The range has become Malaysia's backbone which elongated from Malaysia-Thailand border to the southern state of Negeri Sembilan. (Shuib, 2009)

2.2.2 Regional Geology of Kelantan

Kelantan is include in the central belt and also eastern belt. Some part is exposed to the eastern belt. In Kelantan, there are three type of major formation which is Gua Musang Formtion, Aring Formation and Taku Schist. (Hutchison, 2009)

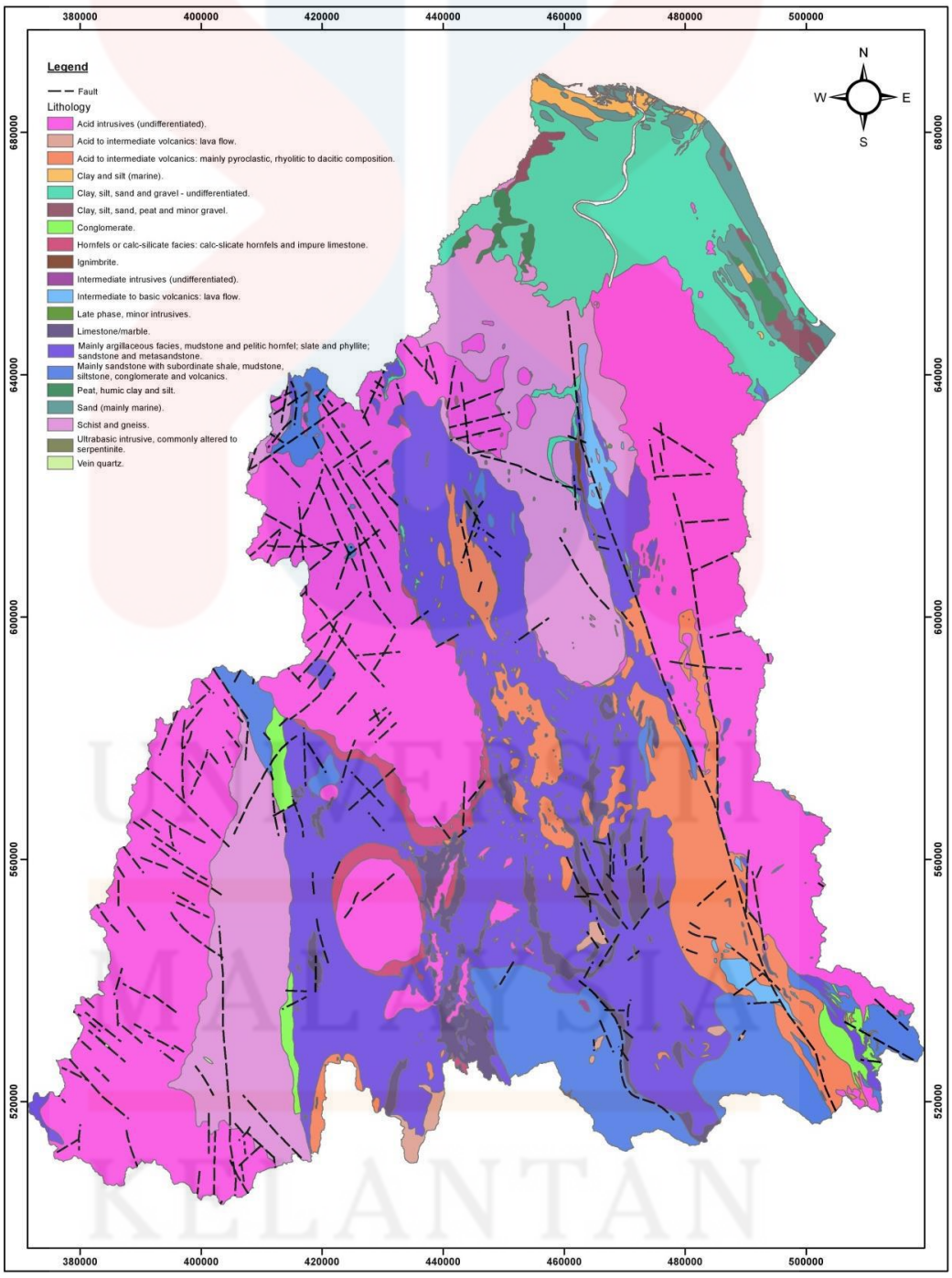


Figure 2.1 Geological map of Kelantan state

(JMG ,2010)

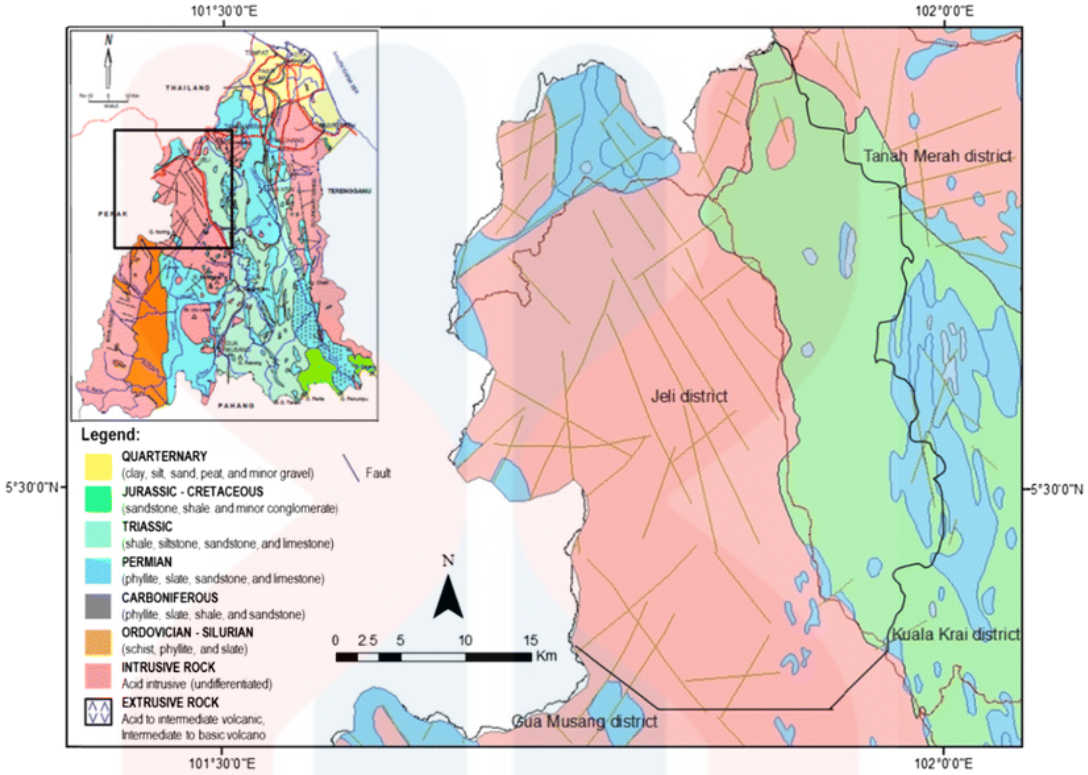


Figure 2.2: Geological map of Jeli district (Nazaruddin, 2017)

2.2.3 Geology of Kuala Balah

Peninsula Malaysia is believed has been uplifted and the north part is highly eroded and tilted down to the north. Due to this event, the northern part of Peninsula has obtained high grade metamorphism complex. The stong migmatite complex has been believed occur at the Kemubu and Dabong as it consists of various plutonic and metamorphic rocks. This complex can be identified because it appears as a spine like and have Gunung Stong as it summits. Stong Migmatite Complex is divided into three plutons the main in the old age to the young is the Tonalit Departure, Kenerong Leukogranite and Granite Noring. Research thorough to this rock has been done for example by (Hutchison, 2009) in the field of rock geochemistry.

The road links Dabong with Jeli and some 17 km north of Kuala Balah. The major rock component occurs in Kuala Balah generally is Norong granite, phyllite which interfoliated with tuff and Kenerong Lucogranite. (Hutchison, 2009)

2.3 Stratigraphy

According to Lee Chai Peng, the stratigraphy of Malaysia started in Paleozoic age. Peninsular Malaysia can be classified into three group of different stratigraphy. There are Western belt, central belt and Eastern belt. The complete sequence of stratigraphy starts in age from Upper Cambrian to the Upper Permian. The Northwestern Domain consists of shallow marine shelf or can be known as a part of Gondawanaland as in Langkawi. It shows that the stratigraphy starts in early Paleozoic. As a time flies, a newly-formed landmass has been uplifted in Mesozoic era. (Abdullah, 2009). Based on the previous reading, the Cenozoic sedimentary has occur along West Coast and offshore in the Straits of Malacca.(J.K Raj, 2009).

2.4 Structural Geology

As stated in the book of Geology of Peninsular Malaysia, the dominant structure that strike along Peninsular Malaysia can be seen in the central basin. (Hutchison, 2009). The fold axis trends of central basin which consist of Carnian-Norian Semantan and Gemas Formation has become the indicator for the shape of the Peninsula. (D.J. Gobbett, 1973) In Kelantan, the field work is conducted at the several place such as in Kuala Krai, Manik Urai and Temangan the stretched lineament that is occupied along Sg. Lebir was found. (Tjia, 1969) The lineament is assumed such wrench fault is occur here even though it cannot be proof totally.

2.5 Historical geology

There are three types of plutonic components which are the earliest is Berangkat Tonalite and Kenerong Leucogranite and the final granite appearance which is pink Noring Granite is deformed.

Berangkat Tonalite contains course grey K-feldspar megacrystic biotite-hornblende tonalite that is highly deformed. It is estimated deformed in Permo-Triassic age (Cobbling et al, 1992). The Kenerong Leucogranite started to expose during Cretaceous age and the Kenerong Leucomicrogranite cuts the Tonalite. The pink Noring granite intrudes the Kenerong Leucogranite.

2.6 Petrography

The research has recorded that 90% of Southeast Asian is granitic. Granitoids in Malaysia and other Southeast Asia country have petrogical and geochronolical character that allow them to be in the same belt.

Central plutonic province consists of plutonic rocks from both Central and Eastern Belts. (Cobbing, 1992) put the granite from Central and Eastern Belt together because of it has same structure.

The Peninsular Malaysian granites have been grouped into two granite provinces namely Western and Eastern Belt granites. The Western Belt has been considered as constituting an exclusively. The 'S' type granite features in the granites are, high initial isotope ratio, low sodium content and narrow range of felsic rock, usually ilmenite bearing and contain pelitic or quartzose metasedimentary xenoliths. However, detailed study of published and unpublished

field and geochemical reports reveal that the Western Belt granite shows mixed 'I' and 'S' type features and thus the batholiths cannot be designated as exclusively 'S' type.

The 'I' type features are being AI-rich minerals such as sillimanite and cordierite are absent, occurrence of primary wedge sphene and pale green amphibole especially in the northern part ofthe batholith, occurrence of pinkish K-feldspar crystals (usually as phenocrysts), occurrence of mafic, hornblende bearing enclaves, showing a similar trend to the 'I' type granite in Implication of this study indicates that the Western Belt granite is not solely derived from metasediments. The study has mixed origin of crustal material such as metapelites, greywackes and metaigneous rocks. (Azman, 2001)

As in Stong Complex, there are three components which are Berangkat tonalite, Kenerong microgranite and Noring granite. The first two components is known as highly foliated granite and the only Noring granite is not foliated. The age of it is said to be Cretaceous and being substituted to the metasedimentary rocks that composed of sillimanite and calc-silicate gneisses.

2.7 Hydrogeology

Hydrogeology is a branch of geology, the study of the water and how it interacts with geological systems. It is because water is widely used by the human and continuously generate from the sources. Water also known as an essential natural resource worldwide. The water circulates naturally as in hydrologic cycle. By understanding where the source is and how it can be exploit is important to sustain this valuable sources.

The hydrogeology of Peninsular Malaysia shows that the groundwater occurrence and potential are mostly viewed from the rock type. The groundwater occurrence can be classified in four type of rock condition. Quaternary alluvium become the most promising aquifer which have potential of yielding 25m^3/hr. In some cases, the yield of the alluvium aquifer in Terengganu and Kelantan can be 100m^3/hr. East Coast area have extensive alluvial aquifer which is said to have promising potential of groundwater. Meanwhile, in West Coast the Quaternary alluvium consist of high percentage of clay where the good aquifer should consist of sand and gravel.

Aquifer can be contaminated by saline water in the West Quaternary alluvium. The karst aquifer which consist of carbonate rocks also helps in becoming water resources and helps in hydrogeological cycle. The production well that is situated in carbonate rocks (Permian limestone) have water yield more than 65m^3/hr.

The rest of the Peninsular, which are layered by volcanic rocks, have limited groundwater potential which can be use in domestic purpose only. The granitic rock can store groundwater in the form of fractured aquifer and weathered zones.(F.S. Chong, 1986)

2.8 Groundwater potential and occurrences

2.8.1 Groundwater

Groundwater is known as one of the important natural resource and the trusted potable water supply used in the city and also in the countryside. Besides benefiting human, groundwater also gives positive impact to the large scale ecosystem. The percentage of total insufficient annual water supply which is from fresh water resource has been recorded around 76% in this recent time. Thus, the appraisals in sustainable

management of ground water resources are very important (PrinceSoundranayagam, 2012).

Based on Department of Statistic of Malaysia, Malaysia population growth is recorded in the year of 2010 is approximately 28.6 million. In the 22 years in the future, the total number of population is estimated to increase to 38.6 million. The other aspect to focus on is the estimated water use in Malaysia, which is in 2010. 13,200 Million Liters per Day (MLD) has been used. The usage is estimated to increase to approximately 16,500 MLD in the next 10 years after 2010.

Ground water usually defined as subsurface water that has been stored below the water table in the saturated zone. (Dixon, 2012) The author also mentions that, the porosity and the permeability is the main factor that affects the ability of an aquifer in storing and transmitting the water. As in Figure 2.0 below, it shows the illustrative groundwater system. Based on previous studies, from a journal written by (Singh, 2006), in order to ascertain the groundwater potential, it is necessary to have knowledge in aquifer parameter and assess the impact of pumping activities. The picture below shows the cross section of the sub surface which contains aquifer.

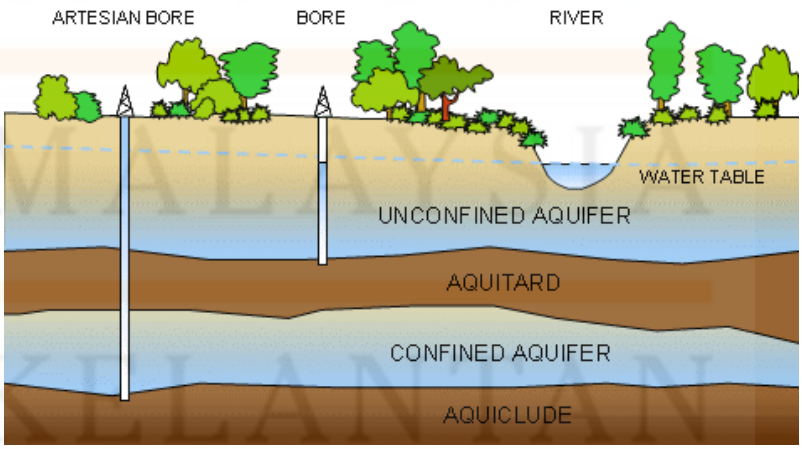


Figure 2.3 Groundwater system (Dean, 2017)

Malaysia should not be involved in the crisis of water supply because the country has approximately 63.5 billion meters of groundwater. The groundwater storage should be used by government in order to control clean water supply problems, usually when there is a contamination in the main water supply.

Head director of Malaysian National Hydraulic Investigation Institute (NAHRIM), Dr. Azuhan Mohamed, said NAHRIM's study found that groundwater quality is cleaner than surface water because it is filtered by various types of rocks before it stores in the aquifer. He state that the qualities of groundwater is equivalent to the bottled mineral water. The groundwater is rich in minerals such as calcium, sodium, chloride, and potassium. (Lisut, 2017). Groundwater development in Peninsular Malaysia started since the early 1900s in Kelantan. At present about 65% of the groundwater exploited is for domestic supply, 35% for industrial supply and 5% for agricultural use. (S.SURATMAN, 2009)

2.7.1 Rock properties affects groundwater

a) Aquifer

Groundwater is the water that percolated underground through the cracks and spaces in the soil. The groundwater will flow beneath the soil through the geologic features called aquifer. Aquifers generally consist of gravel, sand, sandstone, or fractured rock, such as limestone. The large interconnected spaces between them which results in making them permeable will allow the water from moving through these materials. Groundwater can be found almost everywhere. The water table may be deep underground or nearby the surface. It can rise or fall due to many factors. (Wemhoff, 2000)

In the hydrogeological classification of rock uses it follows in this terminology. There are few components such as aquifer, aquitard, aquiclude and aquifuge. According to the Samuel Dixon, there are two types of aquifer which are confines and unconfined aquifer. The unconfined aquifer defined by Johannes C. Nonner in the book Introduction to Hydrogeology is groundwater storage that is directly contact with atmosphere and the confined aquifer is an aquifer that is not directly contact with atmosphere. This aquifer usually situated beneath the aquiclude. (Nonner, 2010)

Aquitard is a geological feature with a low permeability, where it only transmits less amount of groundwater. Next, Aquiclude is a rock in which is very less permeable but it can be porous as it may contain high amount of groundwater. Even though the water content is high in aquiclude but the water is hardly being transmit due to its permeability. Aquifuge is defined as geological feature that does not tranmit water nor contain groundwater. It refers to any type of rocks that does not have porosity and permeability. (Nonner, 2010)

b) **Porosity**

Groundwater can have occupied the portion of a soil and rock that is not filled by solid matter. The spaces that being mention before is the pore space or voids. All of the spaces are characterized by several characters such as according to their size, shape, irregularities and distribution.

There are three types of porosity which is primary porosity, secondary porosity and tertiary porosity. The primary porosity is the porosity that is created during the geologic process of rock formation. The pore spaces are developed in rock matrix, mostly in sedimentary rocks or any soft rocks. The secondary porosity is the porosity which

available after the rock was formed. When there are joints, fracture, or openings on the rocks, the secondary porosity is already developed. (D.K Todd, 2005)

Table 2.1 Representative value of porosity (after Morris & Johnson)

Material	Porosity, percent	Material	Porosity, percent
Gravel, coarse	28[a]	Loess	49
Gravel, medium	32[a]	Peat	92
Gravel, fine	34[a]	Schist	38
Sand, coarse	39	Siltstone	35
Sand, medium	39	Claystone	43
Sand, fine	43	Shale	6
Silt	46	Till, predominantly silt	34
Clay	42	Till, predominantly sand	31
Sandstone, fine grained	33	Tuff	41
Sandstone, medium grained	37	Basalt	17
Limestone	30	Gabbro, weathered	43
Dolomite	26	Granite, weathered	45
Dune sand	45		

2.8 Electrical Resistivity Imaging

It is called as electrical resistivity imaging because the electrical resistivity in the rock formation can be changed when the electrical potential is applied. The measurement of electrical resistivity is also known as resistivity survey. This method emitted the reading of resistivity of the tested area in the form of 2D image which known as pseudo section. The resistivity of the rock is depending on the material, density, porosity, water content and quality and the temperature. The reading is also not having a fixed limit as it can be varies based on the type of rock formations and condition. (D.K Todd, 2005)

The resistivity is measure based on the current and potential differences between pairs of electrodes that been placed in the ground. It is measured over an unspecified depth. In resistivity, there are several processes that must be done. To avoid

any common error during collecting data from resistivity survey, students must use correct technique in conducting this survey. (D.K Todd, 2005)

There are several electrode arrangements which are Wenner Arrays, Schlumberger Arrays, Dipole-Dipole Array and Pole Dipole Array. (D.Barker, 2006).

The most common used array is Wenner and Schlumberger arrangement. The Wenner arrangement has the potential electrode is placed in between the currents electrodes. The selection of the electrode array is according to the noise of the area, and also the depth of the area.

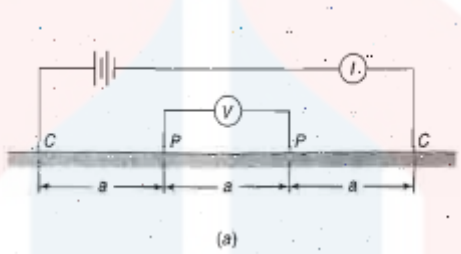


Figure 3.2: The arrangement of electrode in Wenner Array for the resistivity determination.

The apparent resistivity formula of the Wenner :

$$\rho_a = 2\pi a \frac{V}{I}$$

a: distance between adjacent electrodes

V: voltage difference between the potentials electrode

I: Applied current

The Schlumberger arrangement has a potential electrode that is located close to each other. The apparent resistivity is

$$\rho_a = \pi \frac{\left(\frac{L}{2}\right)^2 - \left(\frac{b}{2}\right)^2}{b} \frac{V}{I}$$

a: distance between adjacent electrodes

V: voltage difference between the potentials electrode

I: Applied current

b = distance between potential electrode spacing

L = distance between current electrode spacing

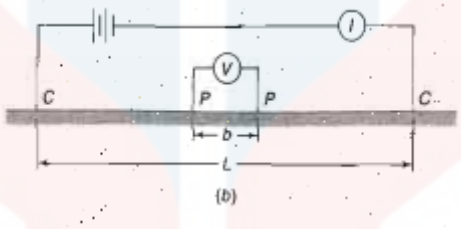


Figure 3.3 The arrangement of electrode in Schlumberger Array for the resistivity determination

CHAPTER 3

MATERIAL AND METHODOLOGY

3.1 Introduction

Before doing the research, the materials and methodologies are needed to be list. The methodologies include several important stages in completing this research. In this research, several steps have been listed. Figure 3.1 is the research flow chart that will be used in the research.

3.1 Materials and Equipment

There are few basic mapping tools that we brought along in order to complete the geological mapping and the geophysical survey. These are the few list of material and equipment that we used.

Table 3.1 Material use in both geological survey and geophysical survey

Materials	Function	Picture
Hammer	To obtain rock specimen	
Brunton or Suunto Compass	To show direction for strike and dip data	
Global Positioning System (GPS)	To do traversing	
Hand lens	To observe and identify mineral grains	

Hydrochloric Acid (HCL)	To identify calcite	
Polarized microscope	To identify mineral's thin section	
Protective goggle	To protect eyes during sampling	
Camera	To take picture of the sample and outcrop	
Electrical Resistivity Imaging (ERI) a) ABEM Multi Core Cable	To conduct geophysical survey	

b) Electrodes c) Battery d) Clips e) ABEM Terrameter SAS4000		

3.3 Methodology

In methodology, the section was focused on each process throughout this research. The process of the research is starting from the preliminary studies, field studies, laboratory work, data processing, and data analysis and interpretation.

3.3.1 Preliminary studies

Preliminary studies involved primary data collection. Study area review and the other information are gained from this preliminary research. In order to study for the background of study area, this method is done using previous geological reports, journals, and books related to hydrogeological system and the groundwater.

3.3.2 Field studies

Field studies are mappings or doing any land survey at the study area. At the field work, some geological information will be collected. The assessment is depending on what survey are conducting. For the field assessment, it requires tools preparation, topographic maps, physical and also mental preparation.

a) Geological survey

This survey is usually known as mapping. It involves study about the lithology, and the structure at the selected study area. There are several materials that should be brought along the field work as shown on the table (Table Figure 5.0). Besides, observation towards the samples collects in the study area will be carried out and the finding in the field will be analyzed. Since outdoor activities are involved, preparation must be done before going to the site.

Geophysical Investigation

In order to determine the characteristic of the subsurface, the geophysical surveys have been applied from beginning of the site investigations in previous year. Geophysics method can be used to identify rock structures which cannot be seen by naked eyes. For the better understanding, it plays roll as an x-rays or magnetic imaging in medical examination.

Electronic Resistivity Imaging (ERI)

A survey has been conducted in the selected study area. Before conducting the survey, we have asked permission from the community of the selected study area to avoid any misunderstanding and in order to get some information. The survey will be conducted using the geophysical method named electronic resistivity imaging where the ground of study area has been injected with an electrical current which it able the subsurface resistivity to be mapped.

There are few components in this electrical survey such as the electrode, multi core cable and the apparent resistivity. The electrode is a conductor planted into the ground through which current passed, or which is used to measure the voltage caused

by the current. The multi-core cable is a cable with a number of independent wires. The apparent resistivity is the resistivity of an equivalent homogeneous earth model that will give the same potential value as the true earth model for the same current and electrodes arrangement.

The data of resistivity will be collected at the end of the survey. Flow chart below shows the step using ABEM

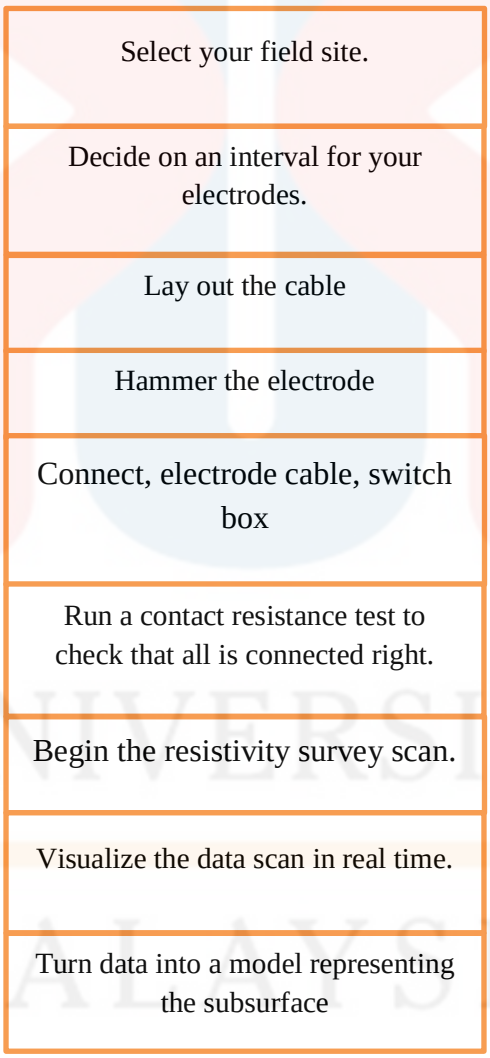


Figure 3.1 Steps on conducting Electronic Resistivity Imaging

Electrode configuration.

Before the ERI is conducted, the suitable electrode configuration which also known as the protocol used has been selected. There are several type of electrode configuration such as Wenner, Schlumberger, Pole-Dipole, and Pole-pole. The selection of the protocol is based on suitable objective. Some protocol requires an accessory such as Pole-Dipole which require particular length of remote to run the survey.

Different electrode configuration shows different result in depth. Wenner covers less depth other than Schlumberger whereas Pole-Dipole protocol covers the greatest depth. Wenner arrangement is suitable for the structure trace whereas Pole-Dipole protocol is suitable in finding the groundwater potential as groundwater always occur at the certain great depth.

3.3.3 Laboratory investigation

In this laboratory investigation, the process involves petrographic analysis which is used in analyzing the mineral composition of the samples. In this laboratory work, it is important for student to know about the mineral identification. This process will cover some crystallography. In crystallography there are few types of crystal system such as cubic, isometric, tetragonal, hexagonal, trigonal, orthorhombic, monoclinic and triclinic.

a) Thin section Analysis

The rock samples are gathered and made into thin section. The thin section analysis may include several steps which is preparing the glass slide, frost the glass slide, marking the sample, cutting and cleaning the slab, cut the chip, glue the slide to

the chip, cutting the chip from the slide and grind the slide to the correct thickness. The thin section then can be observed under petrographic microscope.

b) Petrography Analysis

In this type of analysis, microscope is the tool that is needed. Microscope is use to identify the type of rock based on its morphology. A petrology study is important in carrying out this analysis.

3.3.4 Data processing

Data processing includes the process of making geological map, sedimentology log, stereonet and also correcting the pseudo section by removing the error from the raw data. This method basically using the software that been installed to the computer.

a) ArcGIS Software

ArcGIS software is one of an application which is using Geographical Information System technique. It has ability to store, retrieve, classify, manipulate, analyze and present a huge spatial data and information. This software helps student's research in constructing base map of the study area. The base map should be done before going to field work. From the base map, the lineament can be recognizing. The transverse that has been done in the study area is transfer to the ArcGIS software. Other than that, the application of GIS has been used in identifying groundwater potential.

b) **Terrameter LS Toolbox software**

Terrameter LS Toolbox is a state-of-the-art data acquisition system for self-potential (SP), resistivity, and time-domain induced polarization (IP). It helps in transferring data file to PC, viewing, culling and export of data file contents via table, export of data files in different formats and etc.

c) RES2DINV Software

In order to see the result of the geophysical survey, the RES2DINV software is used to interpret the resistivity and conductivity of the electric survey. The RES2DINV shows the 2 dimensional image of the psuedosection with a raw data. After the raw data is obtained, the data will be process in order to remove the bad data. This process took several time to be done. The removal of bad data will decrease the number of datum. This process is continuing until the root mean square error is reduced at range 10% - 15%. This software is important because the image will be used in the data analysis and interpretation.

By using this image, the aquifer and other geologic features can be determined based on the resistivity and conductivity value. Other than showing the resistivity and induced polarization result been shown, the topography also can be include by using this software.

d) GeoRose Software

After collecting structural data of the study area, the next process is constructing the stereographic projection. Other than using by using tracing paper and

Schmidt net to plot the stereographic projection, GeoRose software also able to be used.

By using a GeoRose, the students are able to plot stereonet diagram with plane data and lineation data for both equal area and equal angle projections. The student also can fully control the style of the diagram as in rose diagram plotting mode.

e) SedLog Software

As usual, students will construct the lithology using analog method. The student will sketch the sedimentology log in order to obtain the lithostratigraphy information. The sediment logs are done to do the rock correlation. SedLog is for creating graphic sediment logs which is designed by geologists for geologists. It makes it very easy for anyone to use with minimum effort. The graphic sediment logs produced by SedLog can be exported as PDF, SVG, or JPEG for use by other drawing applications or for publications.

3.6 Data Analysis and Interpretation

The data that has been collected will be analyzed by discussing it with the supervisor and a lecturer that are majoring in this field of study and correlated with the lithology after observing the study area. Analysis of the data will be performed in the specific resistivity table through particular software.

CHAPTER 4

GEOLOGY

4.1 Introduction

The content of this chapter is basically about geomorphology, stratigraphy, structural geology and some of historical geology of the study area. After field observation is conducted through the geological mapping, all the data is gathered to earn the knowledge and the geological evidence of the study area.

Kuala Balah is one of the sub districts in Jajahan Jeli, Kelantan. In this study area, there is a main river which known as Sungai Pergau. The main road connection is Dabong—Jeli highway. The highest elevation is 980 meter above sea level and the lowest elevation is 40 meter above sea level. The difference in elevation is quiet high because of the different type of lithology. Kuala Balah has a moderate climate with a significant rainfall. Even in the driest month there is a lot of rain. Kuala Balah is one of the potential place to be listed as tourism place due to its beautiful landform.

4.1.1 Traversing of the study area

The traverses started at the first day of mapping until the final day. The student should be covered all the lithology observation in the study area. The traversing process is important for the data collection. It is also help the student to know which part of the study area that already being observed.

Along with the traversing processing, the sampling location were selected and the sample is collected. The sample is collected in several different places at the different lithology. The sample were collected in granitic area which is at the west direction of the study area and at the east part of the study area. Figure 4.1 showed the traverse map in study area.

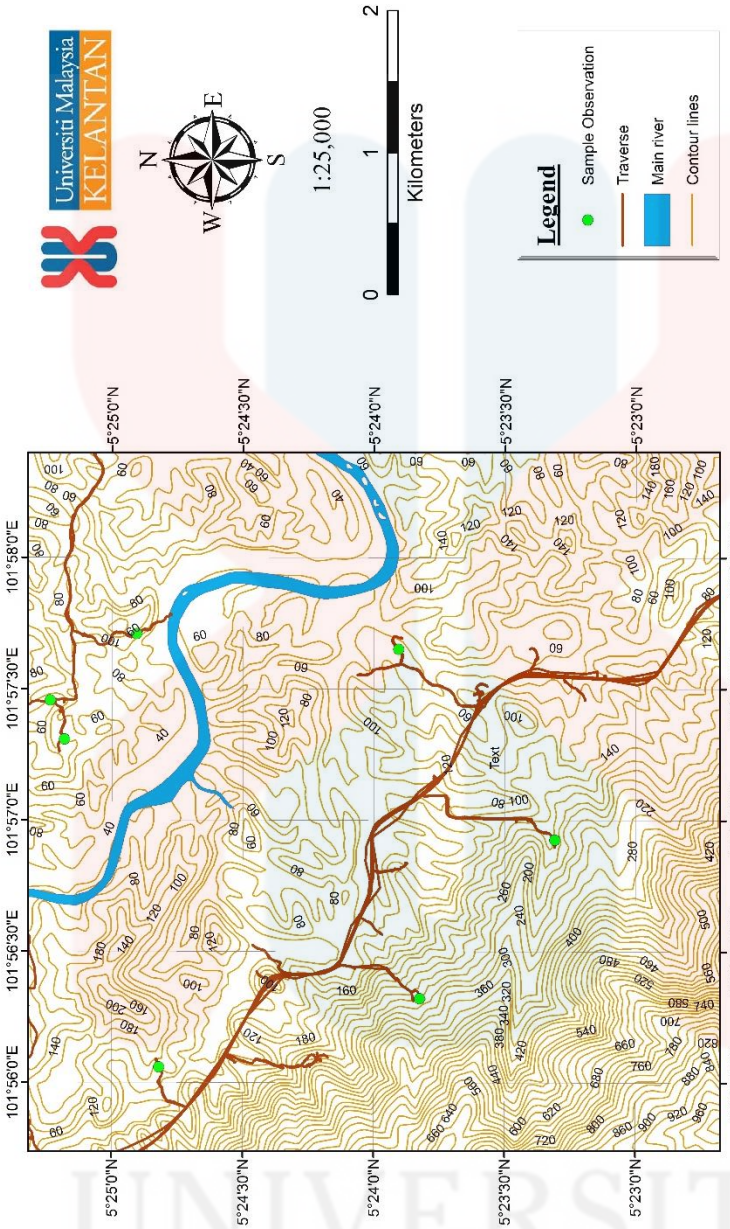


Figure 4.1 Traverse map of the study area.

4.1.2 Landuse

The settlement in this study area is quiet less. This study area is not completely discovered by the human. There is no town in here as the forest and vegetation covered approximately 70% of this study area. There is small village which is Kampung Biak B and a small mosque. There are four types of forestry or vegetation in our study area which are rubber estate, palm tree plantation, orchard and the forest. The highest percentage of vegetation is forest, followed by rubber plantation and orchard. The

smallest part of vegetation is palm plantation. The rubber plantation, palm trees and orchard grew on the sediment because this type of rock has high porosity and suitable for plant growth. The forest lies on the sediment that is overlaying the igneous bedrock. The orchard area is owned by the villagers in Kuala Balah,

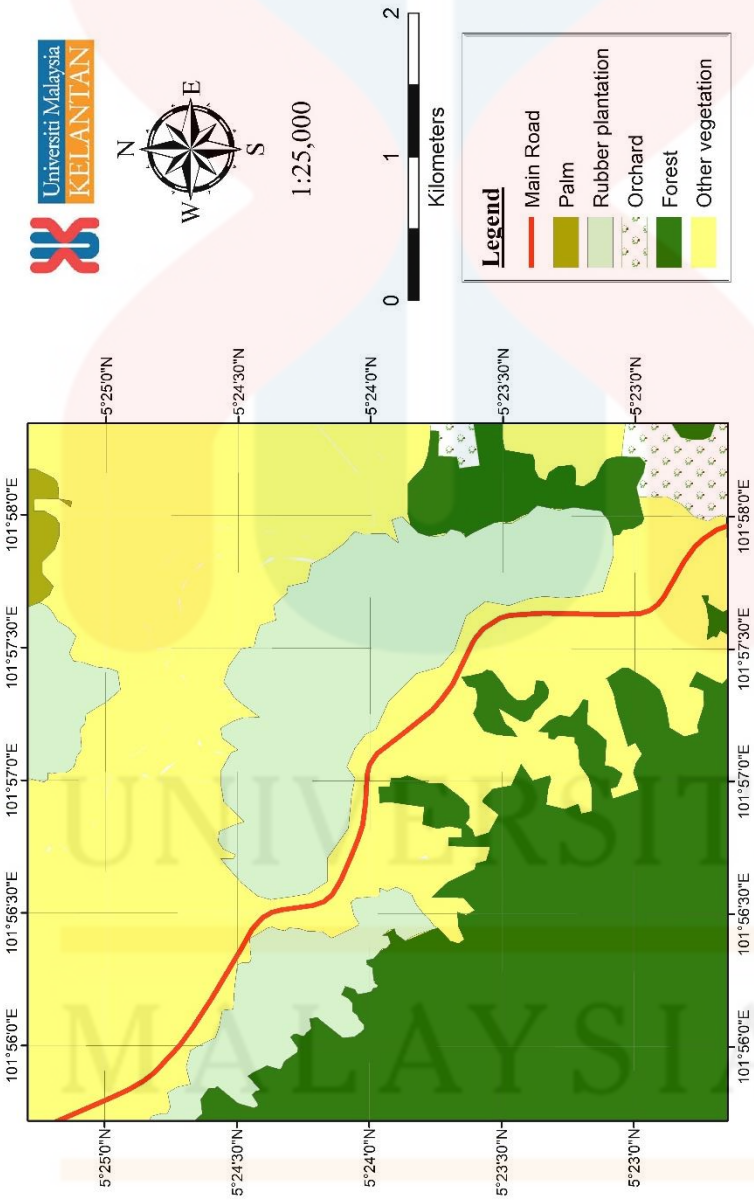


Figure 4.2 Land use map

4.2 Geomorphology

Geomorphology defined the landform and its origin and evolutions related to its geological structures that present in the study area. From here, we understood the origin and evolutions of study area that have been occurred in the past. It often included the topographic study and features created by physical, chemical or biological processes that operated on the surface. The geomorphology is classified into several types such as mountainous, hilly, plain and alluvial.

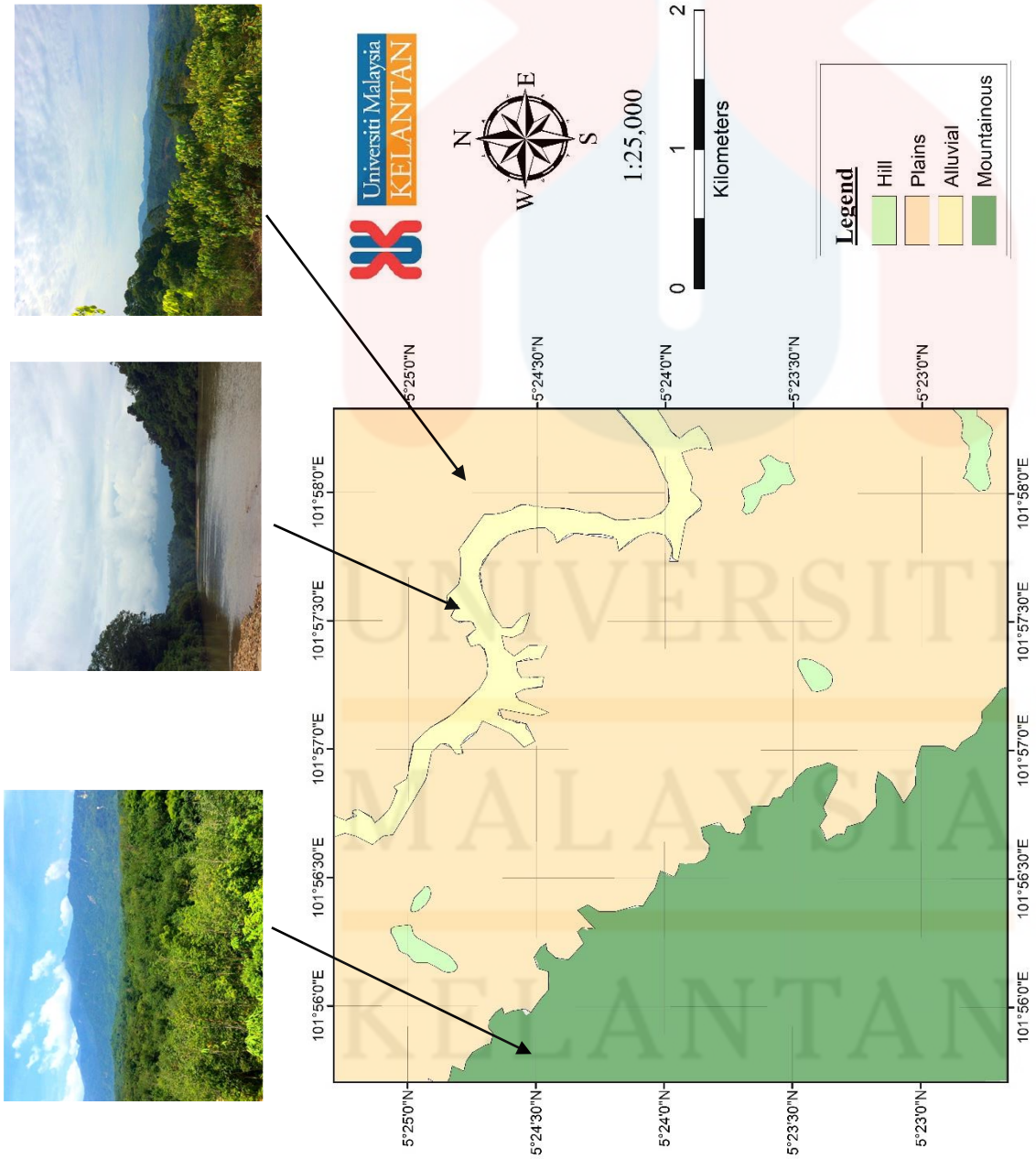


Figure 4.3 Geomorphological map of Kuala Balah

4.2.1 Topography

Based on the observation, the topography of the study area consists of high hill, foot slope, low plain, flood plain and also lower hill.

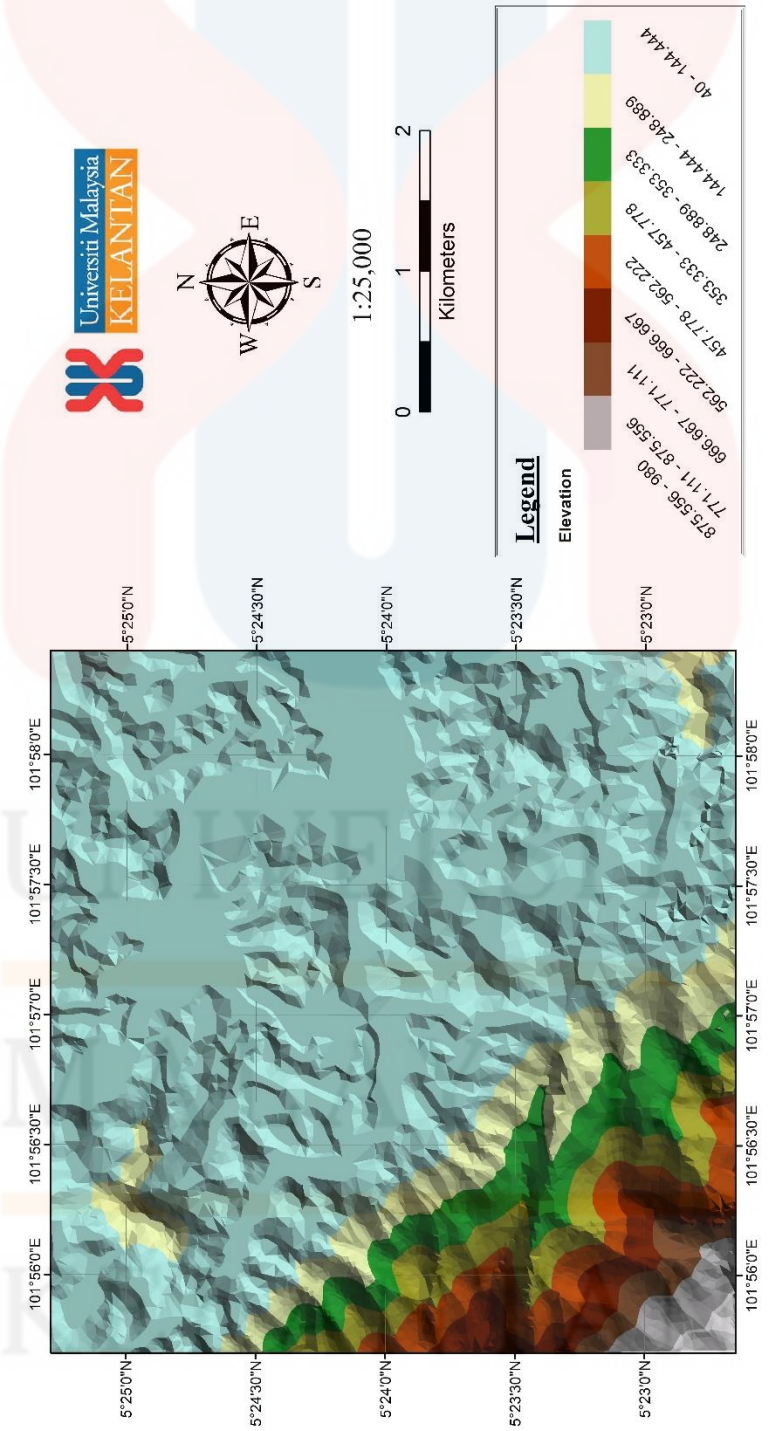


Figure 4.4 3D topographic map of Kuala Balah

4.2.2 Drainage pattern

The drainage is in dendritic pattern and it was common in the study area which is the characteristics of many natural rivers. This pattern branching like a tree. Parallel drainage patterns were also identified in river system. A parallel drainage system is a pattern of rivers caused by steep slopes. There is a main river in this study area called Sg. Pergau.

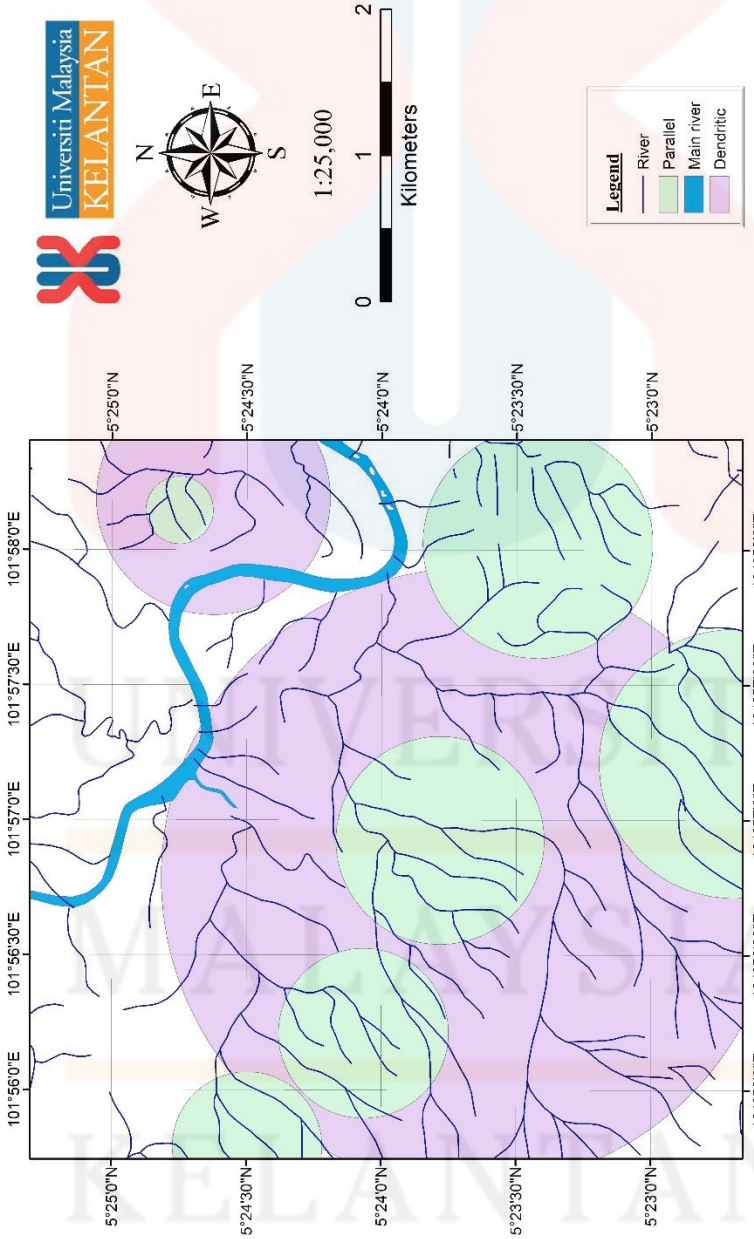


Figure 4.5 Drainage pattern classification map

4.2.3 Weathering

There are three types of weathering that occur in my study area. First, the physical weathering. Physical weathering is the geological process that breaks the rock without changing its composition. These can be seen along the granitic landform as in the river, there are high amount of boulders, cobbles, gravels and also pebbles.

Figure 4.6 Granite boulders along the river.

Figure 4.7 Biological weathering happened in igneous rock

Other than that, there are also chemical weathering and biological weathering. Biological weathering happens because of the pressure that stressed on the rock by the growing plants.

4.3 Stratigraphy

A mountainous landform is basically the remaining of the Stong migmatite complex. There are three type of plutonic component which intruded into the sedimentary rock. It is Berangkat Tonalite, Kenerong Leucogranite and Noring granite. Kenerong Leucogranite cut Tonalite which resulted a complex network of small intrusive and vein system that can be found in metasedimentary rock. These intrusive rock are defined as an Upper Cretaceous. These rock are believing experience metamorphism process forming migmatite (mixture of igneous and metamorphic rock).

For the metasedimentary rock which are slowly change to phyllite is believed resulted from the intrusion of the granite batholith. A change in temperature and pressure may resulted in alteration of the mineral of sedimentary rock.

4.3.1 Stratigraphic position

The oldest stratigraphic units in the study area are the Mesozoic rocks such as phyllite, The Paleozoic and Mesozoic rocks were deposited nearly horizontal beds in the previous era. On the west side of the study area, the recent clastic sedimentary rock is keep increasing in thickness as the weathering process is actively occurred. The thick sedimentary rock is said to be a weathering product of the granite landform. This interpretation might be right. The youngest unit consist primarily of intrusive igneous

rock in age of Cretaceous that on top of the Late-Triassic rocks such as phyllite, metasandstone, siltstone, shale with subordinate sandstone.

4.3.2 Unit Explanation

a) Granite unit

The sample of granite unit is taken at the coordinate of N 05° 24’ 29.0” E 101° 56’ 0”. The granite unit has been proven to be occurred at the west part of the study area. The rate of weathering of granite rock is highly weathered. The surrounding vegetation of this outcrop is rubber plantation. The granite unit that has been found is observed and classified as intrusive igneous rock.

The physical properties that has been observed is the granite has coarse grain, composed of common mineral like biotite, mica, quartz and feldspar. The colour of the rock is light which represent rich in silica. Type of contact is by intrusion. The percentage of the rock distribution is only 30% of my study area.

Figure 4.8 Granite outcrop

Figure 4.9 Granite sample 1

Figure 4.10 Granite sample 2

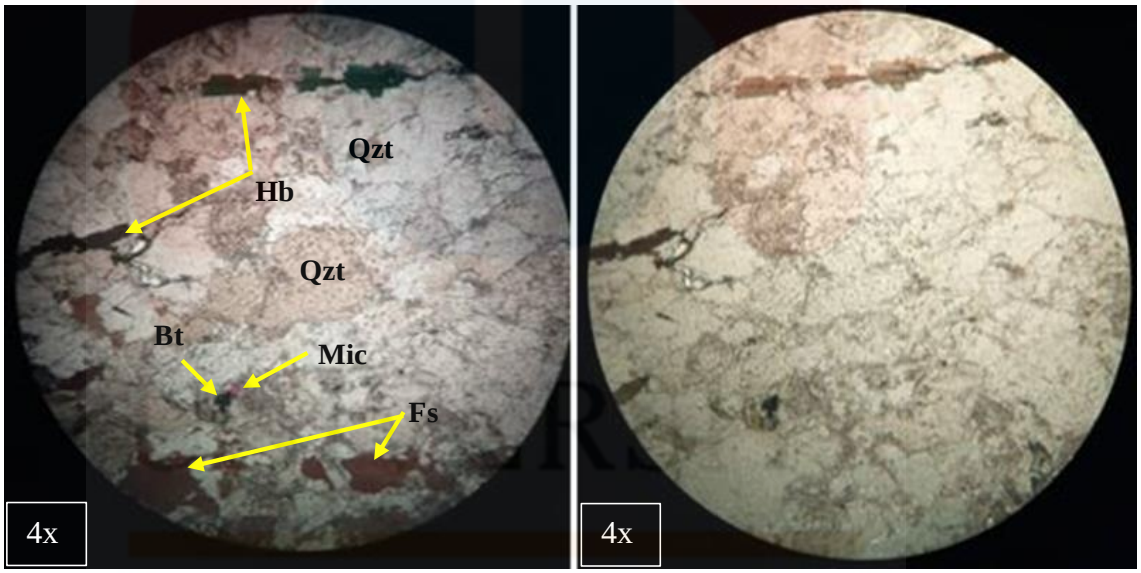


Figure 4.11 The photomicrograph of granite code E1 under cross polarize light (XPL) on the left and plain polarize light (PPL) on the right. Quartz = Qtz, Plagioclase = Pl,

Biotite = Bt, Mica = Mic

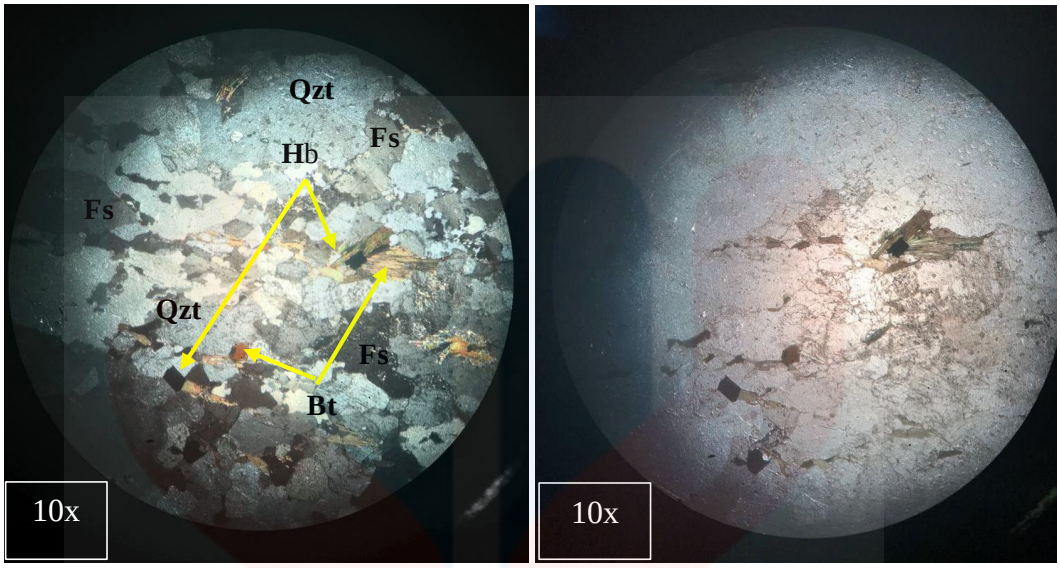


Figure 4.12 The photomicrograph of second point granite code E1 under cross polarize light (XPL) on the left and plain polarize light (PPL) on the right. Quartz = Qtz, Plagioclase = Pl, Hornblende, Hb

These are some of photographs of a thin section of Granite with magnification 4X and 10X. Figure 4.3 is the photograph of first point of the thin section followed by figure 4.4 which is the photograph of second point of the thin section. By comparing the crossed polarizer (Right) and plane polarized light (Left) and images, four types of mineral can be identified in this thin section.

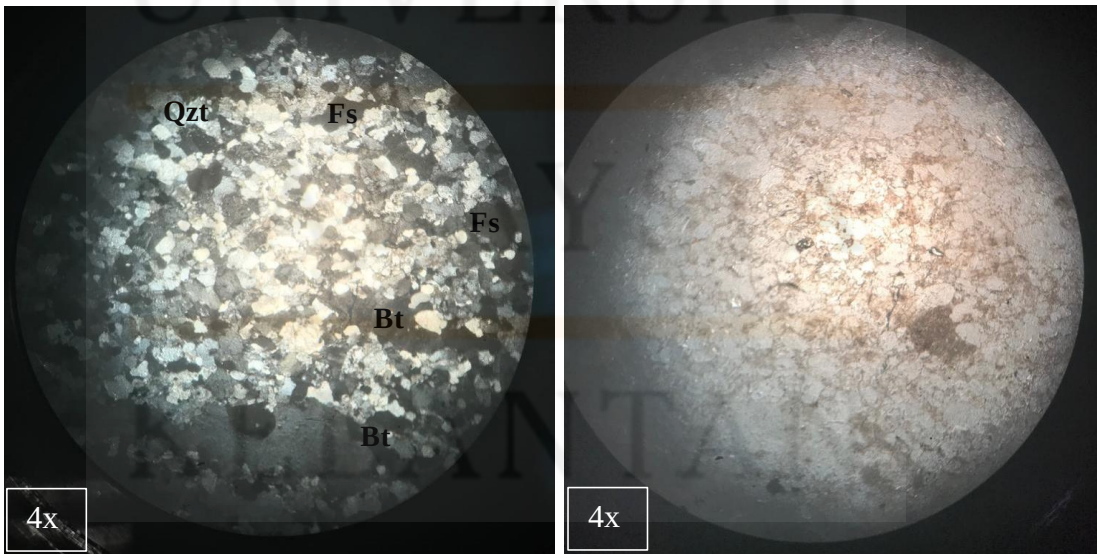


Figure 4.13 The photomicrograph of second granite sample with code E2 under cross polarize light (XPL) on the left and plain polarize light (PPL) on the right. Quartz = Qtz, Feldspar = Fs, Biotite = Bt

Table 4.1 The Description of minerals under thin section of both granite sample.

Composition of mineral	Description of optical Mineralogy	
	Cross polarize light (XPL)	Plain polarize light (PPL)
Biotite	**Colour** • Brown to black • Usually happen in mineral that rich in iron **Birefringes** • High **Extinction** • Parallel **Twinning** • No twinning	**Colour** • Brown grains in plain light **Paleochroism** **Relief** • Medium relief

Quartz	**Colour** • Light brown **Birefringes** • Moderate **Extinction** • Degree **Twinning** • No twinning	**Colour** • Colourless **Relief** • Low relief
Plagioclase	**Colour** • darker grey interference colours **Birefringes** • Low	**Colour** Dark colour **Relief** Low relief
Mica	**Colour** Colourful mostly pinkish	**Colour** Grey to white **Relief** High relief
Hornblende	**Colour** • Greenish brown	**Colour** • Black

b) Phyllite

Phyllite can be found at the east part of the map. The sample of phyllite is taken at the location of N 05° 24' 21" E 101° 57' 20.7" at Kg. Biak B. The rate of weathering of phyllite is very high. The colour of the phyllite rock is no longer fresh as it occurs in brownish. The surrounding area of the outcrop is within the rubber plantation. The type of contact of this rock is by stratigraphy. Phyllite is categorised as metamorphic rock with a physical property which is fine grain, platy texture, has cleavage, and also brittle. The distribution of phyllite in this study area are approximately 70%. The picture of phyllite sample is shown below.

Figure 4.14 Highly weathered phyllite outcrop

Figure 4.15 Phyllite sample (Highly weathered)

4.3.3 Stratigraphy Column

Lithology	Lithostratigraphy unit	Description	Age
	Alluvium	Consist of gravel, pebbles. No boulder appear	Recent
	Phyllite	Contain phyllite and other metasediment such as sandstone, metasandstone, siltstone.	Late Triassic
	Granite	Consist of intrusive rock type which known as plutonic igneous rock. Occur as migmatite due to the metamorphism contact.	Cretaceous

4.4 Structural Geology

In structural geology, the student discussed about the three dimensional distribution of large bodies of rock, their surfaces, and the composition of their inside in order to learn about their tectonic history, past geological environments and events that could have changed or deformed them. There are many ways and method to study the structural geology such as lineament analysis and the forces that exerted on rocks. There are few types of structural geology that can be found in this study area which is primary structure and secondary structure.

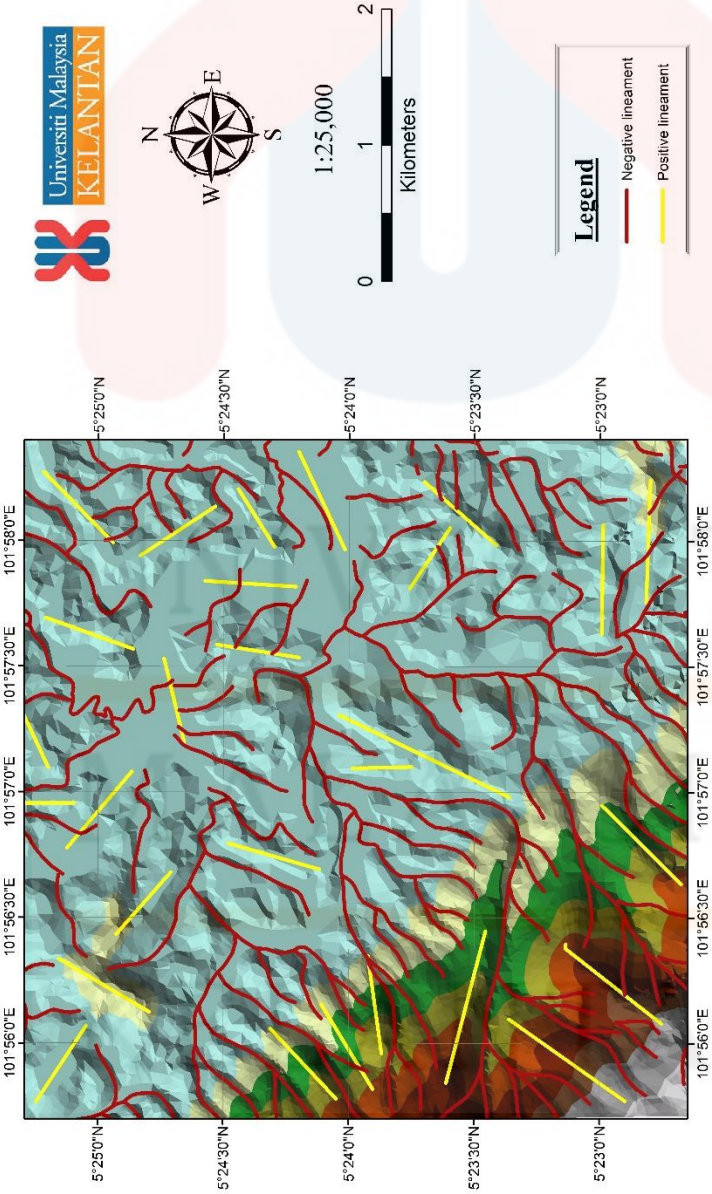


Figure 4.16 Lineament of the study area

4.4.1 Joint analysis

There are lack of geological structure that can be found in my study area. However, at the granitic landform the joints are appear. The joint consist of two type which are shear joints and extensional joints. The shear joint reading is taken at the site.

Figure 4.17 Great amount of shear joint

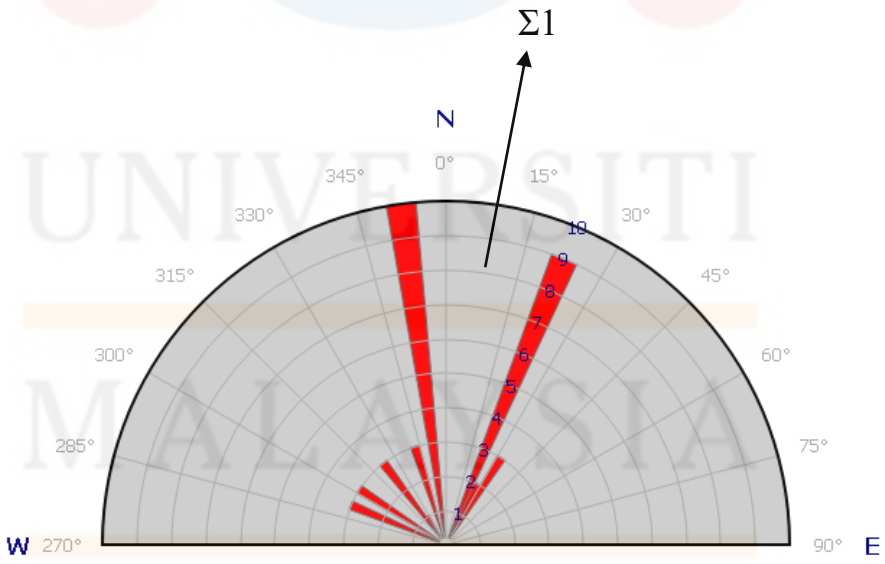


Figure 4.18 Rose Diagram of the granite outcrop

The rose diagram shows that the principal pressure is said to be at Σ1. The joint reading has shown the frequency of the force exerted by the rock at the certain

bearings. Figure 4.17 shows the most frequently force act at bearing range from 345 to 360. Table 4.2 shows the shear joint data in order to know the principal force that being exert by the granite rock in the study area. The bearing of the joint is taken out along with its frequency.

Table 4.2 Granite outcrop shear joint data

BEARING (^{o})	FREQUENCY
0-1	0
11-20	17
21-30	7
191-200	1
201-210	1
281-290	1
291-300	1
321- 330	2
331-340	1
341-350	3

4.4.2 Mineralization

The other structure that can be found is secondary structure which is mineralization. Mineralization occur when the fracture has a displacement and the space is occupied by the other minerals. The quartz mineral assemble in the fracture and become abundant over the time. The example of mineralization is quartz vein.

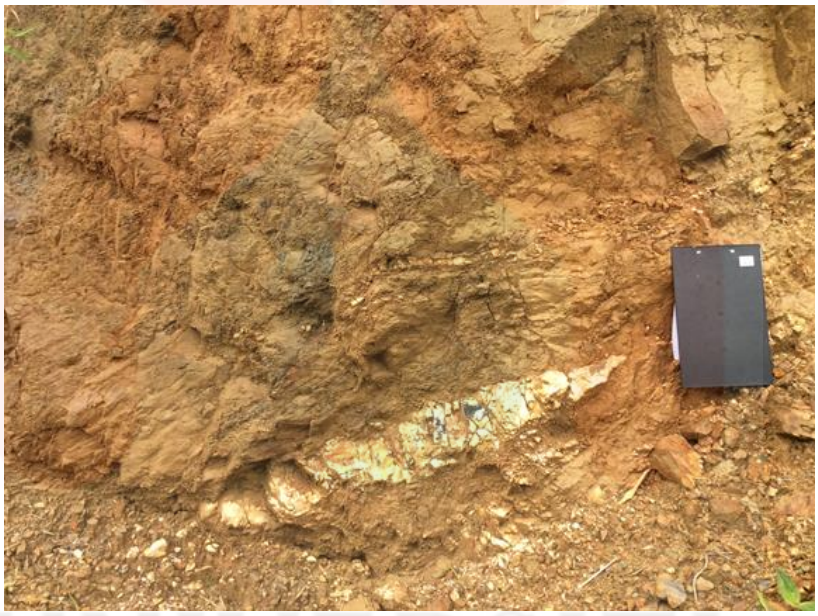


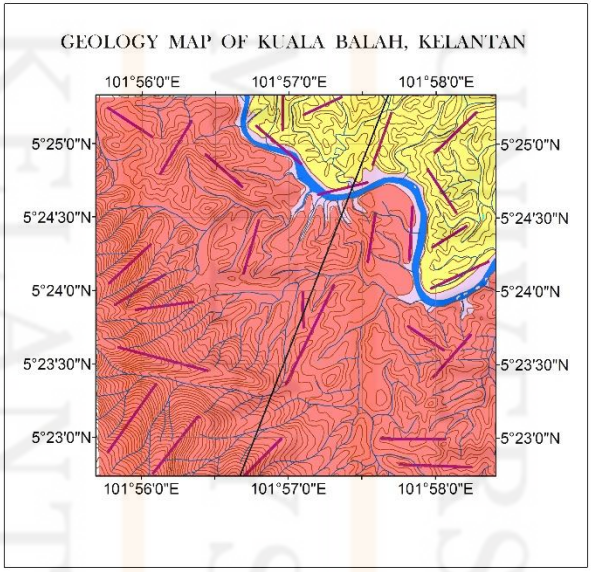
Figure 4.19 Quartz vein in sedimentary rock

Figure 4.20 Quartz vein in igneous rock

4.5 Historical Geology

The sedimentary rocks which overlay above the granitic rock started to form metasedimentary rock which resulted from metamorphism process. Metamorphic rock which is phyllite and other metasedimentary rock such as metasandstone is found in this study area which is appear since Late Triassic.In the age Cretaceous, the study area consists of intrusive rock type which known as plutonic igneous rock.

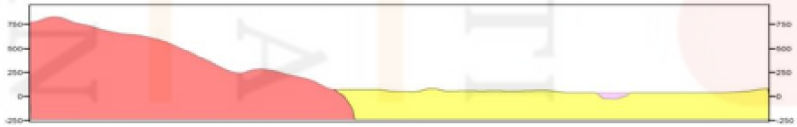
It occurs as migmatite due to the metamorphism contact. The intrusive igneous rock intruded in sedimentary rock in the later stage. As the time passes, the granitic rock which exposed to the weathering process will produce residual soil and sedimentary deposited as alluvium.

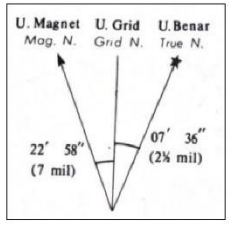


Legend

- Phyllite
- Granite
- Alluvium
- River
- Contour
- Main River
- Strike and dip
- Cross section A-B
- Postive lineament

Cross section A-B





Universiti Malaysia KELANTAN

Department of Geoscience
Faculty of Earth Science
University Malaysia Kelantan

GEOLOGY AND DEMARCATION OF GROUNDWATER POTENTIAL ZONES USING ELECTRICAL RESISTIVITY IMAGING (ERI) IN KUALA BALAH, KELANTAN

ENALINA SUHAIMI

1:25,000

0 0.75 1.5 2.25 3

Kilometers

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CHAPTER 5

RESEARCH SPECIFICATION

5.1 Introduction

In this chapter, the research explains more detail on the geophysical survey of groundwater potential which is electrical resistivity imaging. The interpretation and further discussion of the result is done here.

Basically, geophysical method that has been used while conducting this research is Electrical resistivity imaging (ERI). It is used to detect the subsurface resistivity through the electrode that been injected to the ground surface. The mathematical inversion of resistivity is known as conductivity. The Electrical Resistivity Imaging profile shown 2D cross-sectional model that is plotted with resistivity values and depth. The depth is depending on what electrode array is used. A raw data such as pseudo section can be seen during the data collection on ABEM Terrameter. The raw data then will be processed using RES2DINV software. The resistivity values scale of earth materials is used for comparison as it helps in interpretation.

5.2 Electrical Resistivity Imaging Survey Lines.

In this research, the total three survey lines has been chosen to predict the potential of groundwater in Kuala Balah. Every each of the lines is been selected due to the suitable condition. There are several factor that must be analyses first such as lineaments of the whole area. According to the hydrogeology studies, the discharge and recharge area can be obtained from the topography of the area. Recharge area located at the area with high elevation such as mountain and hill. Therefore, the discharge area is said to be at the low elevation area such as plain.

As we know, the water flow is restricted to the gravitational direction hence the flow of groundwater usually from high elevation area to the gentle area. The direction of line can be parallel or crossing the lineament in order to see the potential rock bodies that stored water. The three resistivity lines location is selected at the flat area and all the resistivity line data is measured using RES2DINV software.

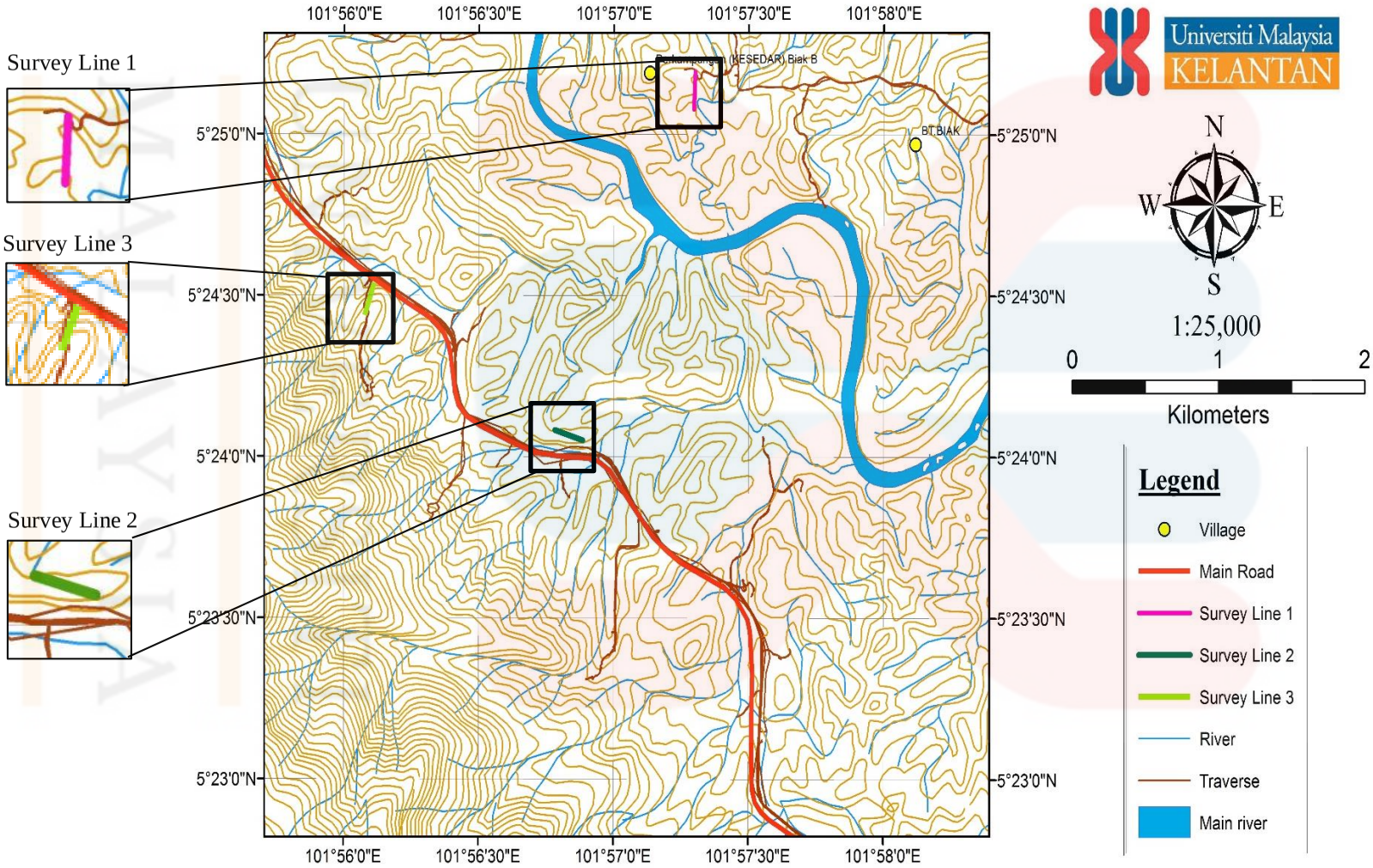

Figure 5.1 Electrical resistivity survey line map

5.3 Data processing and inversion

After the raw data is obtained, LS Terrameter Toolbox software is used to transfer measured data, spread and protocol files between the ABEM Terrameter to the personal computer. Thus, the project database files, export data files, location of the survey, edit the electrode coordinate and other things relate to the data can be view and export to the different format. Before exporting the data, the filtered data file can be choosing whether to remove the bad and negative data at first or include the bad and negative data. After the data format has been change to res2dinv (.dat) file type, then it can be used in RES2DINV software in order to continue the process.

After the data acquisition process, the data processing and inversion is started. If the root mean square error of the data is high due to the noise and the problem of the electrode contact with the ground, the bad data has to be remove. Figure 5.2 shows the bad data removal process. The resistivity and induced polarization is used as parameters because from this proposed conceptual model, the student will picture the real condition that related to the other geological evidence**.** This also proved that it will increase the knowledge and the relationship can be seen clearly.

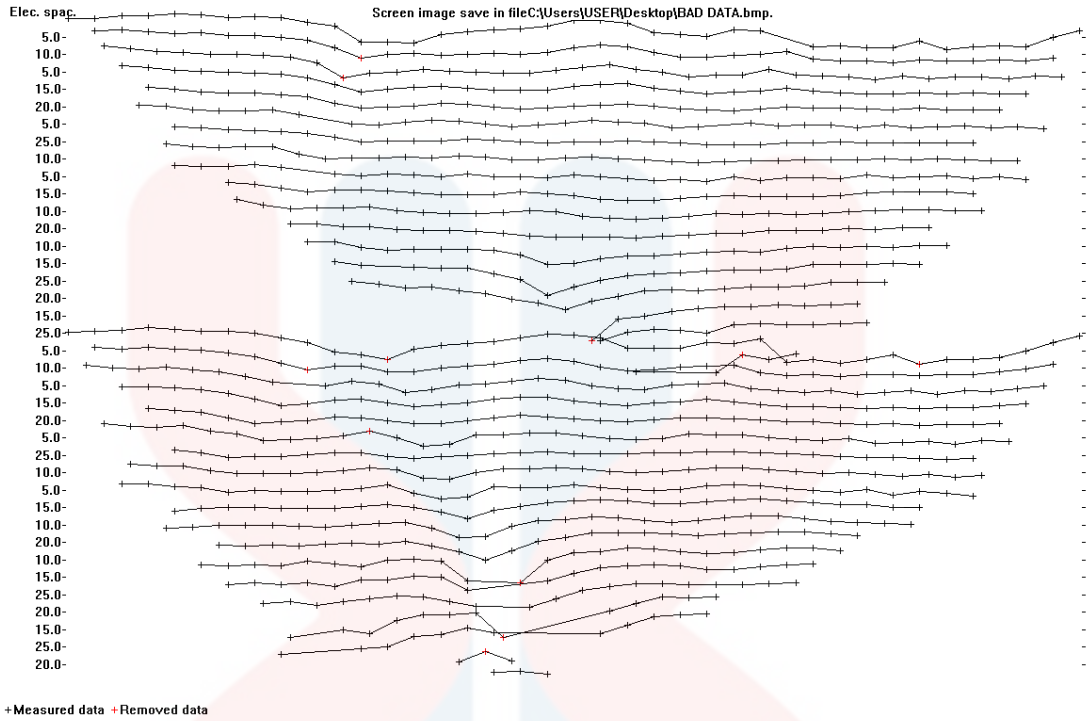

Figure 5.2 Exterminate bad data point

5.4 Data interpretation

5.4.1 Resistivity

The pseudo section is the model section that measured the apparent resistivity. The apparent resistivity is depending on the electrode's geometry, (M.H.Loke, 1999) therefore the apparent resistivity cannot be appearing at the real subsurface condition.The inversion is required to read the apparent resistivity in order to discover the subsurface. In model section there are inverse resistivity scale. The subsurface layer is interpret basically by the resistivity value as refer to the standard resistivity scale of earth material.

In term of pore fluid content, the resistivity value of rock will be recorded as high if the pore fluid is being displace. This is because the electric current is not being allowed to pass due to the compaction and clogged by deposition of minerals during lithification. The same condition happens when the salinity of pore fluid is low, the resistivity value will be increase. It is because the salinity content determines the amount of dissolve salt in the fluid. Great amount of salt precipitation may increase the activity of ions to conduct the electricity.

Table 5.1 Resistivity and conductivity of some rocks, waters and chemicals. (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	$8 - 4 \times 10^3$	$8 - 4 \times 10^3$

5.4.2 Chargeability

The chargeability value that appear in model section is the measured term related to the induced polarization. This value is used in order to know the difference between groundwater and clay soil because both generate same range of resistivity. (M.Azwan et al,2015). The chargeability value will be decrease as the increasing in the value of conductivity. (Juanah et al., 2012). The high amount of clay content should have low chargeability value than the high water content. The value of groundwater chargeability is interpreted at range 1 msec to 2 msec. Thus, chargeability value of clayed soil should be less than the groundwater.

Table 5.2 The values of 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

5.5 Survey Line 1

Survey line 1 has been made at the rubber plantation in Kg. Biak. The line has been selected near the recharge area such as a small river. The first line is measured with 200m length and 5 meters' electrode spacing. The Wenner array is used and Pole-Dipole array also been used for survey line 1. For Pole-dipole 200 meters' remote cable has been used as the accessories. Both arrays are used to in order to compare the result. Based on the picture of location, point A cable is stretched in the south direction whereas point B to the north direction. Table 5.1 showed the coordinate of three electrodes used. The weather of the data is recorded in sunny day

Figure 5.3 Location of the survey line 1

Table 5.1 Coordinate of the electrodes of survey line 1

Electrode No.	Latitude	Longitude	Elevation
1	N 05° 25’09.0”	E 101° 57’25.1”	82.0 m
21	N 05° 25’12.4”	E 101° 57’25.2”	81.0 m
41	N 05° 25’15.3”	E 101° 57’25.2”	74.0 m

Based on the resistivity survey line 1 of Pole – Dipole protocol, the minimum resistivity value that has been set is 1.0 ohms and the maximum resistivity value is 3000 ohms. The high resistivity value can be stated at range 3000-1000 ohms which represent red to dark purple color.

Based on the resistivity value that has been stated by M.H Loke, the bodies at the zone 1, can be interpret as bedrock. The bedrock is the hard layer of rock that has been lithified beneath the ground. It might be igneous bedrock, metamorphic bedrock or sedimentary bedrock. Since the survey line 1 was set up at the metasedimentary rock, the bedrock is considered as metamorphic bedrock. Other than that, the interpretation of fault zone has been made. As we focused on pseudo section, there is separation between zone 1 and zone 2 where zone 2 is the boulder blocks of metamorphic bedrock. This changes indicate the faulting that might happen.

The medium reading of resistivity value is at range 700 ohms to 100 ohms. At this range, the zone or layer is classified by two zones which is zone 3 and zone 4. The zone 3 and zone 4 shows the distribution of this resistivity value as referred in the pseudo section. Clayed sand appears at the zone 3 with a resistivity value range from 200 ohms to 100 ohms. According to the resistivity result, the clays appears as

lenses. Clay is not an aquifer because its characteristic which poorly permeable. Thus the water partially allows to move along its pore. For the zone 4, it indicates the resistivity value of course grain sand which is 300 ohm. At this range, there is a potential aquifer that can be interpret. The type of aquifer that might be obtain is unconfined aquifer. The reasons why it has been stated as confined aquifer is because the aquifer is not exposed to the atmosphere and have confining layer. Other than that, coarse grain sand has a high porosity and permeability. It allows the water to transmit along the interconnected spaces. This zone lies at the depth between of 70 – 50 meters above sea level.

The interpretation that has been used in this research is a combination between resistivity and induce polarization value. It is because when there is any confusion in determining the body using the resistivity, the chargeability value is used. The resistivity value at zone 3 is at range 80 ohms to 90 ohms meanwhile its chargeability value is below than 1. That is the reason why it is classified as clay.

Zone 5 is interpreted as groundwater potential from fractured zone. This is because the resistivity value at this zone is very low at range 1 ohms to 20 ohms. Based on the resistivity scale of earth material, this resistivity value shows the water occurrences. As further interpretation using chargeability value, the result shows that possibly have potential of groundwater in the fractured zone. The water seep through the fracture and accumulate in the empty space. The depth of groundwater occurrence is at between 30 to 20 meter above sea level.

Survey Line 1

Pole Dipole

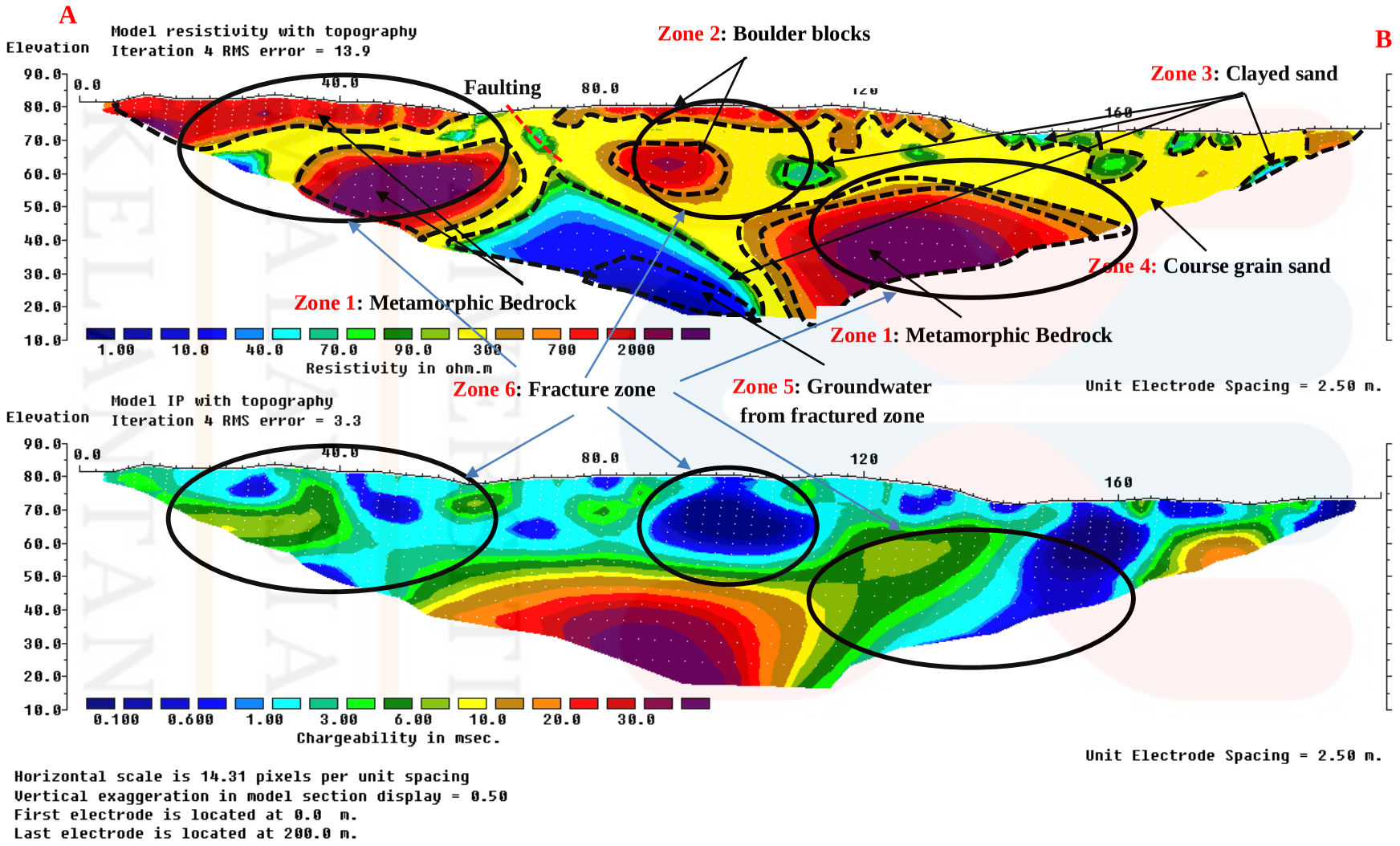

Figure 5.4 2D Inverse resistivity and chargeability model section of survey line 1

5.6 Survey Line 2

The survey line 2 has been made is with 200 meters in length and 5 meters' electrode spacing. Schlumberger array configuration is used for this survey line. The area of this line is set up at the rubber plantation nearby the main road. There is a small river there. Table 5.5 showed the coordinate of three electrodes used. The point A is being stretched to the direction of North-West and point be to the South-East.

Figure 5.5 The location of survey line 2

Table 5.2 Coordinate of the electrodes of survey line 2

Electrode No.	Latitude	Longitude	Elevation
1	N 05° 24'02.0"	E 101° 56'58.2"	63.0 m
21	N 05° 24'01.2"	E 101° 57'04.3"	62.0 m
41	N 05° 24'01.6"	E 101° 57'01.3"	65.0 m

The two dimensional image of resistivity and chargeability profile shows varies type of zones. Zone 1 can be interpreted as bedrock because of the high value of resistivity ranging at 1000-3000 ohms. The type of bedrock that has been interpreted is metamorphic bedrock. Meanwhile, zone 2 is which appear as boulder blocks are interpreted as compacted clayed sandstone. It lies near the surface in the

form of layer and blocks of compacted slayed stone with high value of resistivity at 800 to 1000 ohms. Further investigation using chargeability value shows that zone 2 has low chargeability value around 0.9 msec. This combination of resistivity value and chargeability value support the interpretation.

Next, zone 3 is said to be weathered rock due to its resistivity value at 500 to 700 ohms. The weathered rock is originated from the weathered metamorphic bedrock. The bedrock has contact with the rock that consist of porosity and wet therefore it became weathered. A small part that presented as zone 4 which look like lenses are known as sandy area. The resistivity stated at range from 80 to 100 ohms. It has been proving as sand because it's chargeability value is at 4 to 10 msec. Sand lenses has the potential of being perched aquifer as it has loose pore spaces that might allow the flow of water.

Compacted sand is said to be appeared at zone 5 with a resistivity value 100 to 300 and chargeability value at range of 5 to 8 msec. The sandstone is compacted hence; the water cannot be stored in the body. There is no potential groundwater found in this area but likely this area got fractured zone that eventually lead an accumulation of water. Zone 6 is recognized as potential fracture zone because it shows water chargeability value but the recorded resistivity is quiet high.

Survey Line 2

Schlumberger

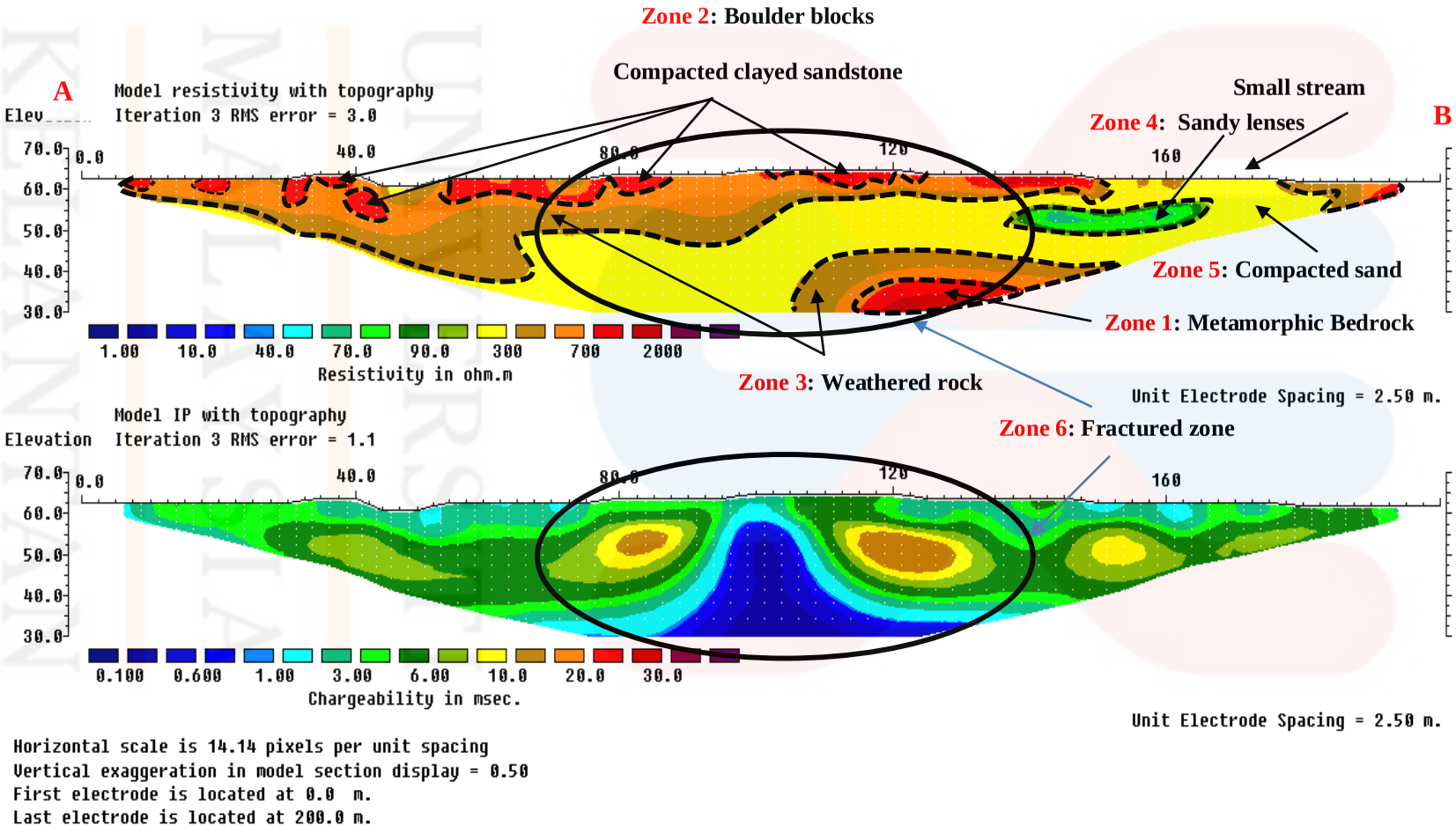

Figure 5.6 2 D Inverse resistivity and chargeability model section of survey line 2

5.7 Survey Line 3

This survey is conducted at the granitic area in Kuala Balah. The recharge area is small stream for the mountainous area. The survey line 3 used 200 meters' length cable and 5 meters' electrode spacing. Schlumberger array configuration is used for this survey line. Table 5.3 showed the coordinate of three electrodes used. The direction of the cable A is to the North and the direction of cable B is to the South.

Figure 5.7 The location of survey line 2

Table 5.3 Coordinate of the electrodes of survey line 3

Electrode No.	Latitude	Longitude	Elevation
1	N 05° 24'22.1"	E 101° 56'03.7"	101 m
21	N 05° 24'19.1"	E 101° 56'03.4"	100 m
41	N 05° 24'16.1"	E 101° 56'03.1"	117 m

Based on the model section of resistivity and chargeability, zone 1 can be predict as bedrock. The resistivity reading for igneous rock is between 1000 – 3000 ohms, the model section reading of resistivity has been proved lies at the same value. The type of the bedrock is igneous bedrock because this survey line lies near the

source of granitic area. The igneous outcrop also appears clearly at the surface. Zone 2 are known as igneous boulder blocks, other than high in resistivity value the interpretation is made according to the surrounding area. Its chargeability value at range of 0.9 to 2 msec also shows the potential of this layer has water accumulation. (M.A Mohamed Zawawi, 2015)Keeping remind that the rock is an igneous, there should probably have fractured zone resulting the water to seep through and stored. The third zone is interpreted as weathered rock zone. The igneous bedrock in contact with wet bodies and become weathered. Its resistivity value is moderately high which is ranging from 300 to 600 ohms. The interpretation continues to the other zone of rock bodies which is zone 4 representing the coarse grain sand.

Coarse grain sand in zone 4 is being predicted based on its resistivity value and also chargeability value. This combination resulted it to be stated as coarse grain sand. It is because the value of resistivity of this zone is 300 ohms with a chargeability value at 0.9 to 3 msec. Zone 4 can be interpreted as potential zone of being an aquifer. The type of aquifer that correspond to this condition is confined aquifer because it has confining layer. Finally, the zone 5 is interpret as fractured zone because there is a storage of water within the igneous rock.

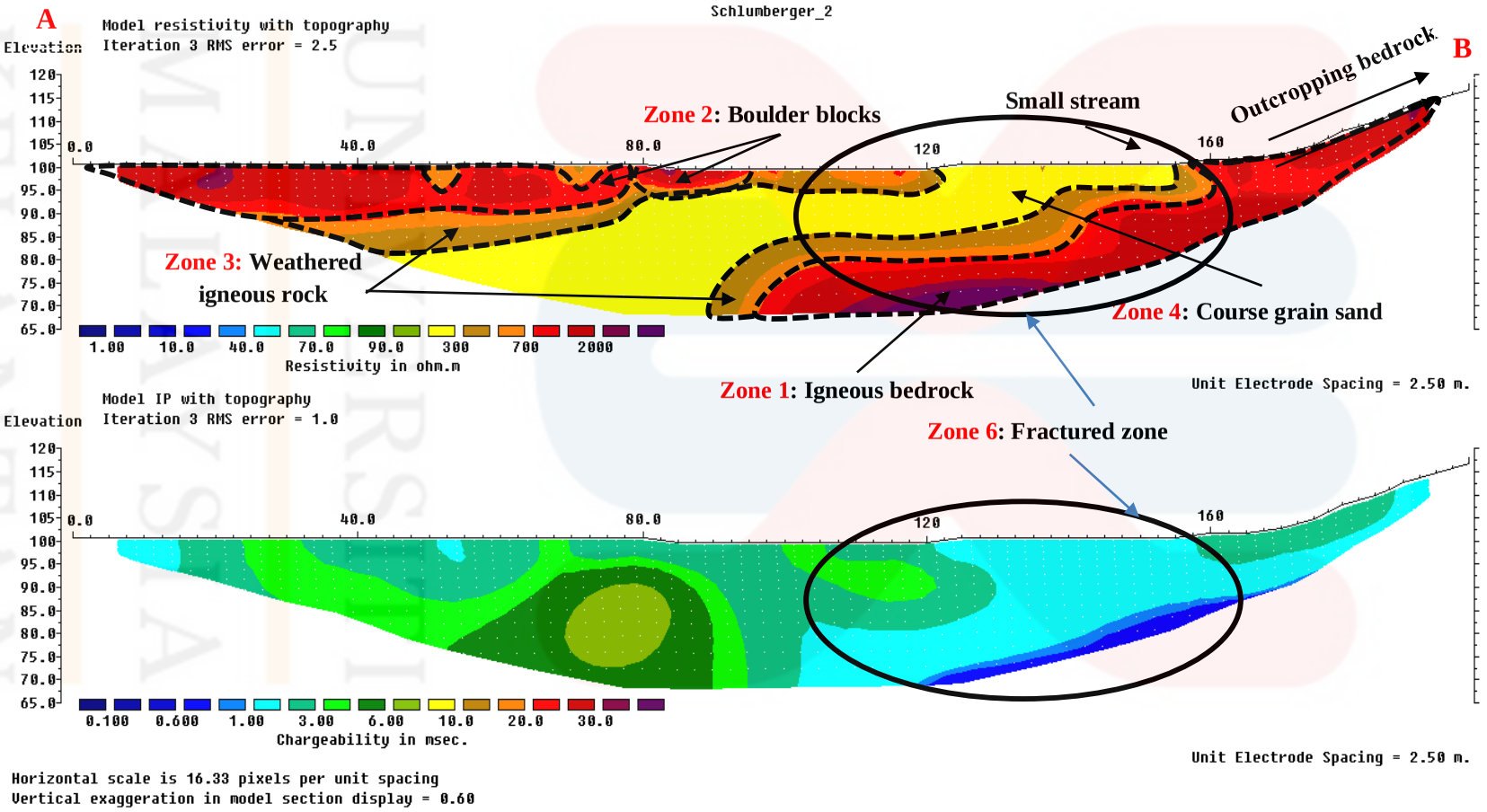

Figure 5.8 2 D Inverse resistivity and chargeability model section of survey line 3

5.8 Discussion

In this section, further discussion of the result is being stated. According to the results of three survey lines, it clearly shows that resistivity value is highly comparative with a conductivity value. The earth material which have high value of resistivity is usually have lower conductivity. The electrical charge may pass through the water that is why water content become a vital parameter to measure the conductivity. Whereas, the resistivity shows how resistant the earth materials towards the water.

As refer to the results, the resistivity of both bedrocks which is an igneous and metamorphic shows high resistivity value. This is because the bedrock itself is poorly have interconnecting space of it matrix. The porosity value also indicates conductivity and resistivity. Igneous and metamorphic bedrock consists of very poor porosity. This type of rock bodies can be called as aquitard. Meanwhile the coarse grain sand has high porosity and permeability. This type of rock bodies usually become a medium in transporting the water. The good aquifer always come from this type of rock bodies. As in survey line 1 and 3, shows unconfined aquifer are from coarse grain sand while in survey line 2, the aquifer exists in the term of sand lenses.

From the result that has been observed, every each of the line got a fractured zone. The fractured zone is important as it can be the second porosity. The water can pass through and flow within the cracks and fracture and also has storage of water. As in all survey lines, the present of fracture might be the factor of fractured aquifer existence. Therefore, the results can be concluded that other than having shallow groundwater potential zones, the deep groundwater potential zones also present in the form of fractured aquifer.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

In this chapter, the result of geological mapping and geophysical survey that has been carried out will be conclude. The general geology mapping allowed the student to determine the geological aspect present in the study area. The geological aspect might give the evidence of the history of the place in previous age. The lithogies that bounded each other probably exist in different condition. The granite lithology has been found in my study area. The percentage of the rock distribution is only 30%.

Meanwhile, the other lithology that has been discussed is the lithology at the east side of the study area. The lithology that present is dominantly metasedimentary rock. Phyllite had further undergo metamorphism processes by increasing pressure and temperature. As the time passes, the sedimentary rock layer has been developed due to the weathering process. The residual soil from weathered granite also contribute to the sediment deposition. There are several joint reading and strike and dip reading has been taken.

As mentioned specifically, the study area consists intrusive igneous rock, sandstone, siltstone, and phyllite subordinate with sandstone. The age of lithology covers the Late-Triassic to Cretaceous. In structural geology aspect, the positive lineament analysis by the contour pattern show that the principal force might be come from south-east and north-east direction. The negative lineament like rivers shows the inverse result. Tension direction is in the north and south direction of my study area. By conducting the geological mapping, an updated map of my study area has been achieved. Based on the observation and measurement that has been carried out, it allows the student to understanding the tectonics action towards the study area that may occurred in the previous age until today. The intrusion and alteration of rock bodies due to changes in temperature has been proved by the geological evidence that been found.

According to the specification topic, the results of the electrical resistivity imaging survey shows that shallow groundwater potential may be present in my study area. Combining the resistivity and chargeability value in interpretation process gives better understanding and better interpretation of the rock bodies within the subsurface. Based on the model section result of the survey line 1, the groundwater potential may occur at the depth between of 70 – 50 meters above sea level. For the survey line 2, there is a shallow groundwater potential as it covered by sand bodies. It appears as perched aquifer which estimate cover 20 meters' depth from the surface. The survey line 3 showing that course grain sand may contribute to the shallow groundwater potential.

6.2 Suggestion

In this subtopic, the data can be used as a guideline by the students or researcher in finding the potential of groundwater. This project also contributes to the groundwater exploration in Kelantan. Since the title of this project has limitation in only finding the groundwater potential zone, further step of groundwater exploration should be done in the future. Further studies on the groundwater direction and and proposed borehole location should be determined. Besides, extensional subsurface investigation of groundwater involves borehole logging, checking the groundwater quality, pumping test in order to calculate the transmissivity and storage of the aquifer has to be covered.

On the other hand, besides using the Electrical Resistivity Imaging method, another geophysical method should be proposed such as Vertical Electrical Sounding (VES). This method will give information of thickness of subsurface bodies and yield capacities of the water. This will bring a better picture in finding the groundwater potential zones.

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APPENDIX

Flow chart