GEOLOGICAL MAPPING IN AREA LOJING AND INVESTIGATION OF SEAWATER INTRUSION OF SUNGAI PINANG AQUIFERS AT TUMPAT BY GEOPHYSICAL AND HYDROCHEMISTRY

by

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DECLARATION

I hereby declare that the work embodied in this report entitled "Geological Mapping in Area Lojing and Investigation of Seawater Intrusion of Sungai Pinang Aquifers at Tumpat by Geophysical and Hydrochemistry" is the original research and has not been submitted for a higher degree to any universities or institutions.

Signature: ……..

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APPROVAL

I certify that the report of this final year project entitled "Geological Mapping In Area Lojing and Investigation of Seawater Intrusion of Sungai Pinang Aquifers at Tumpat by Geophysical And Hydrochemistry" by Thilageswaran A/L M.Velu, E16A0294 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Geoscience) with Honours, Faculty of Earth Science, Universiti Malaysia Kelantan.

Approved by:

Signature: ……

Date:

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GEOLOGICAL MAPPING IN AREA LOJING AND INVESTIGATION OF SEAWATER INTRUSION OF SUNGAI PINANG AQUIFER AT TUMPAT BY GEOPHYSICAL AND HYDROCHEMISTRY

ABSTRACT

The present research is focused on geological mapping and seawater intrusion studies in parts of Lojing and Tumpat area respectively. The main objective of this research is to update geological rock units and produce map on scale of 1:25000 and investigate sea water intrusion in Sungai Pinang coastal aquifers in Tumpat. The methodology was applied for geological mapping based on fieldwork inputs including collection of samples from outcrop, recording structural trends in rocks and other field observation such as geomorphological features, drainage pattern etc. All these field related data processed in GIS based platform including the petrographic studies to generate geological and other thematic maps. For seawater intrusion studies Electrical Resistivity Imaging (ERI) survey were conducted and resistivity data processed using RESD2DINV software to obtain two- dimensional 2D resistivity profile and as well as geochemical method were also applied to investigate seawater intrusion. Insitu chemical parameter includes pH, turbidity, total dissolved solid (TDS), salinity, total suspended (TSS), electrical conductivity (EC). In addition few chemical parameters includes chloride, sodium, manganese, potassium, copper and iron were also analysed from selected shallow groundwater wells. Geologically the study area mainly consist schist and mudstone rock units. Based on the resistivity data which provided clear view as seawater intruded zoned into groundwater in all the lines approximately 50 to 70m. In addition the hydrochemical results shows that sample T5 contain sea water intrusion at shallow level. It is recommended to overcome this problem could be regular quality monitoring as well as control the pumping of groundwater.

Keyword: Geological mapping, seawater intrusion, aquifer

PEMETAAN GEOLOGI DI LOJING DAN PENILAIAN RESAPAN AIR LAUT KE DALAM AKUIFER MENGGUNAKAN GEOFIZIK DAN SAINS KIMIA AIR DI SUNGAI PINANG TUMPAT

ABSTRAK

Kajian ini memperihalkan geologi di Lojing dan penilaian resapan air laut ke dalam akuifer cetek menggunakan geofizik dan sains kimia air di Tumpat, Objektif utama penyelidikan ini adalah untuk mengemas kini batuan geologi dan menghasilkan peta pada skala 1: 25000 dan menyiasat resapan air laut di akuifer pantai Sungai Pinang di Tumpat, Kelantan. Metodologi ini digunakan untuk pemetaan geologi berasaskan masukan kerja lapangan termasuk pengumpulan sampel dari singkapan, merekam arah aliran struktur dalam batuan dan pemerhatian lapangan lain seperti ciri-ciri geomorfologi, corak saliran dan lain-lain. Semua data berkaitan bidang ini diproses dalam platform berasaskan GIS termasuk kajian petrografi untuk menghasilkan peta tematik geologi dan lain-lain. Kajian keberintangan elektrik (ERI) telah dijalankan dan data resistivitas yang diproses menggunakan perisian RESD2DINV untuk mendapatkan profil resistensi dua dimensi 2D dan juga kaedah geokimia juga digunakan untuk menyiasat resapan air laut. Parameter kimia insitu termasuk pH, kekeruhan, jumlah pepejal terlarut (TDS), saliniti, jumlah digantung (TSS), kekonduksian elektrik (EC). Di samping itu, beberapa parameter kimia termasuk klorida, sodium, mangan, potasium, tembaga dan besi juga dianalisis dari telaga air bawah tanah yang terpilih. Secara geologi, kawasan kajiannya terutamanya terdiri daripada unit-unit skis dan batu lapis. Berdasarkan data rintangan yang memberikan pandangan yang jelas seperti air laut resapan zon ke dalam air bawah tanah di semua garis kira-kira 50 hingga 70m. Di samping itu, hasil hidrokimia menunjukkan bahawa sampel T5 mengandungi resapan air laut pada tahap cetek. Adalah disyorkan untuk mengatasi masalah ini boleh menjadi pemantauan kualiti yang tetap serta mengawal pam air bawah tanah.

Kata kunci: Pemetaan geologi, resapan air laut, akuifer

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CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of study

This research entitled "Geological Mapping in Area Lojing and Investigation of Seawater Intrusion of Sungai Pinang Aquifers in Tumpat by Geophysical and Hydrochemistry". This study mainly focuses on two different aspects which are geological mapping and identify the seawater intrusion. The geology aspect explains about the geological mapping include of geomorphological features, regional geology, lithostratigraphy and structural geology. Seawater intrusion is the movement of saline water into freshwater. Seawater contain high mineral content than freshwater and it is denser. In this study, the area divided into two place which geological mapping at Lojing and the investigation of seawater intrusion at Tumpat.

Groundwater refers to water that inhabits all the pores, voids or cracks in geological formations comes from rain water catchment, rivers and lakes (Mohd Zin et al., 2017). Approximately one-third of the world's population depend on groundwater for drinking purpose (Tawnie et al., 2015). For the most part, water particularly groundwater is utilized for local use, farming purposes and industrial activities the world over. In Malaysia especially in Kelantan the source of water supply mainly from groundwater. Tumpat district is seaside zone which especially known as the region that experiences changes throughout the century with urbanization, population development and expanding industrialisation. Fast populace

development, broad industrialisation and farming can cause the expansion request of water and contamination to the aquifer (Nur Diyana, 2017).

The seawater moves and mix with groundwater in the shallow aquifer which leads to occur seawater intrusion. Study area mainly consist of alluvium near to coastal. In the aquifer, uncontrolled combine of seawater into groundwater can cause chemical and physical properties of freshwater become more salinity (Mohd Kamal et al., 2015).

There are be use many types of methods in the study of groundwater. In previous researchers, geophysical and hydrochemical methods are most commonly used in this study. There are many type of instruments can be used for identify seawater intrusion such as multi-parameter, turbidity meter, pH meter and more.

1.2 Study area and geological mapping

1.2.1 Location

The study area of geological mapping located a Gua Musang, Kelantan. The study area placed near to Cameron Highland, Pahang named Lojing. The study area comes on about 25km square and it lies between coordinate at 101°40'29.87"E to 101°43'15.42"E and until 4°40'35.22"N to 4°37'53.94"N in Figure 1.1.

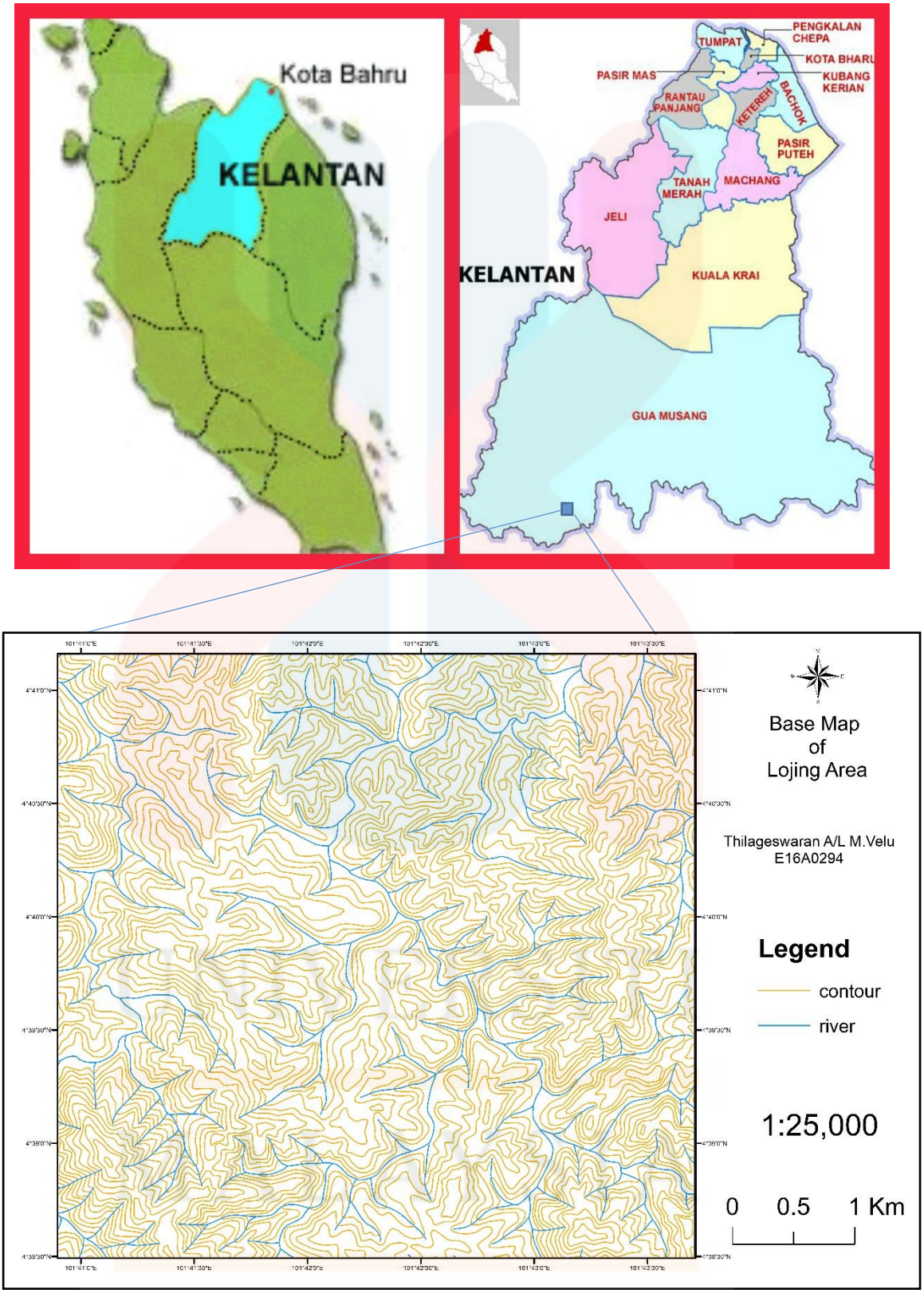

Figure 1.1 The base map of study area at Lojing

In addition, the study area of investigation of seawater intrusion located at Sungai Pinang, Tumpat near to coastal area. Sungai Pinang is a hill village and small area located at Tumpat. The study area given about 44km square and it lies between coordinates at 102°11'10"E, to 102°14'25"E and until 6°12’10"N to 6°08'55"N in Figure 1.2.

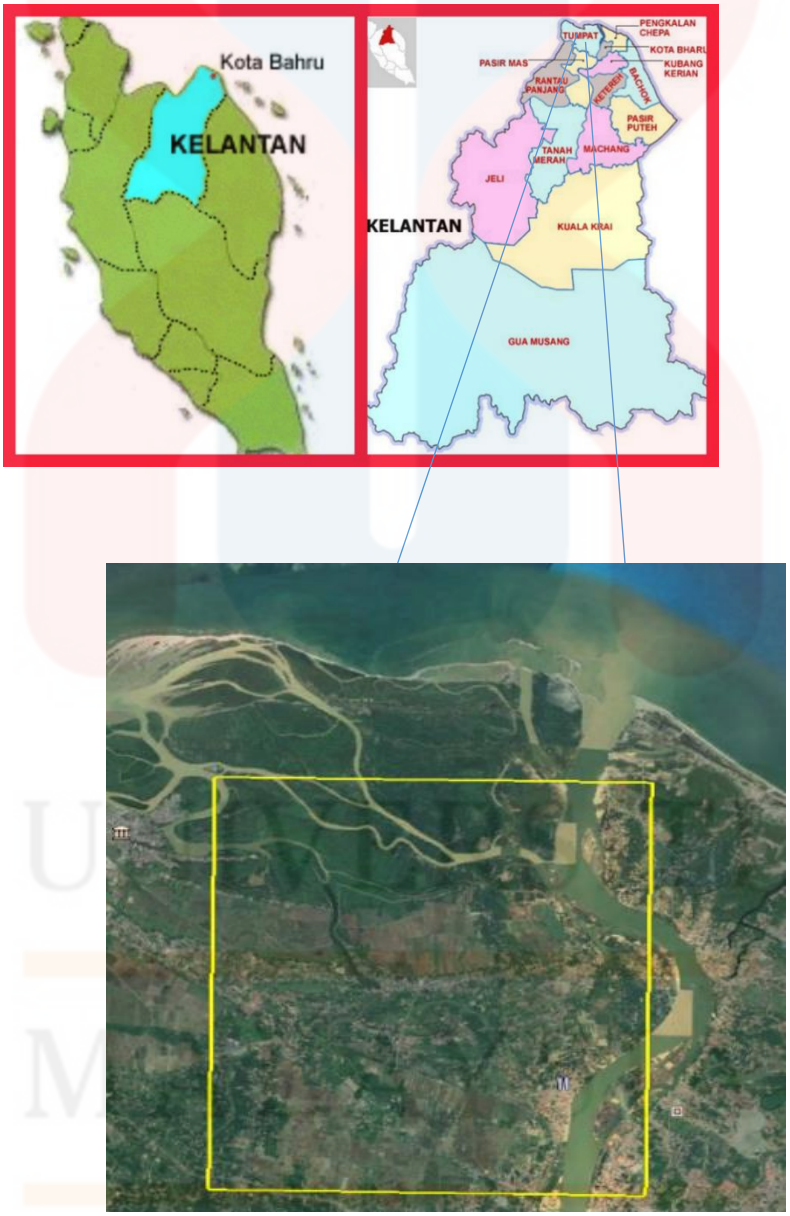

Figure 1.2: The base map of study area at Sungai Pinang

1.2.2 Road connection/Accessibility

Approximately 30 kilometres from Lojing main road to access the study area. The study area consists of fully forest ad only one paved road. The north part of the study are is the way to enter the field through the paved road. Figure 1.3 shows the paved road.

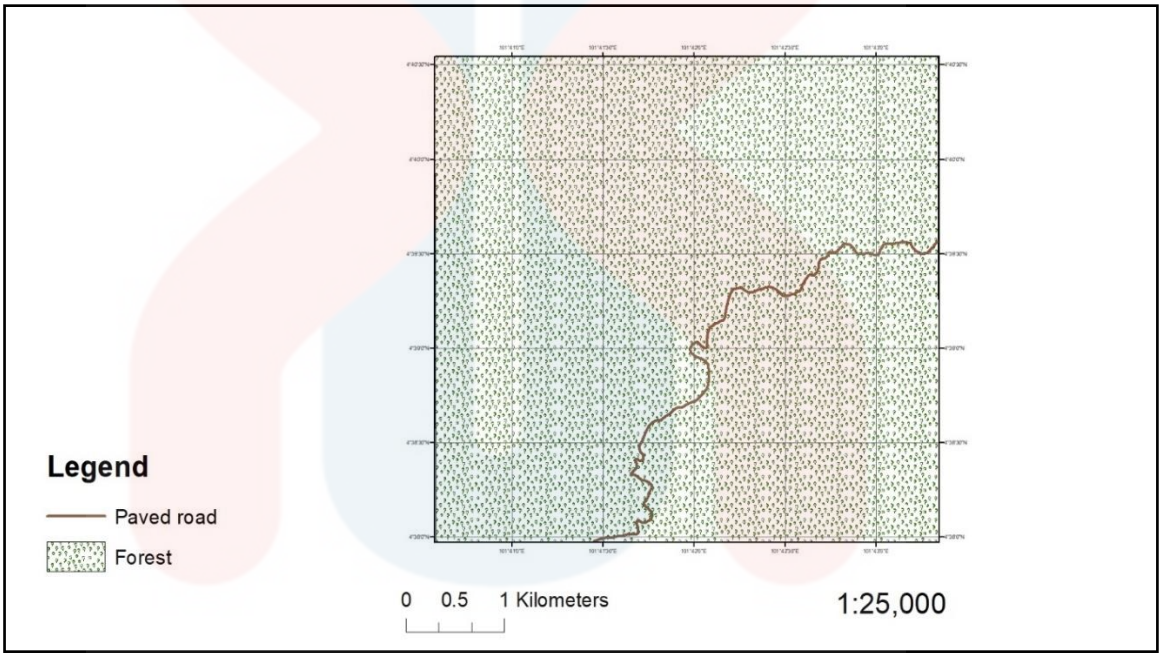

Figure 1.3: The accessibility of study area at Lojing

The study area at Sunagi Pinang locates around 15 kilometres from Kota Bharu. Moreover there are many well-developed roads around the study area which can easy to access. Federal road, main road and village road are the type of roads found in Sungai Pinang. This roads helps the residents in that area to travel one place to another place on time. The people who beside the river will use boats for their daily activities. Figure 1.4 shows the road connections in Sungai Pinang, Tumpat.

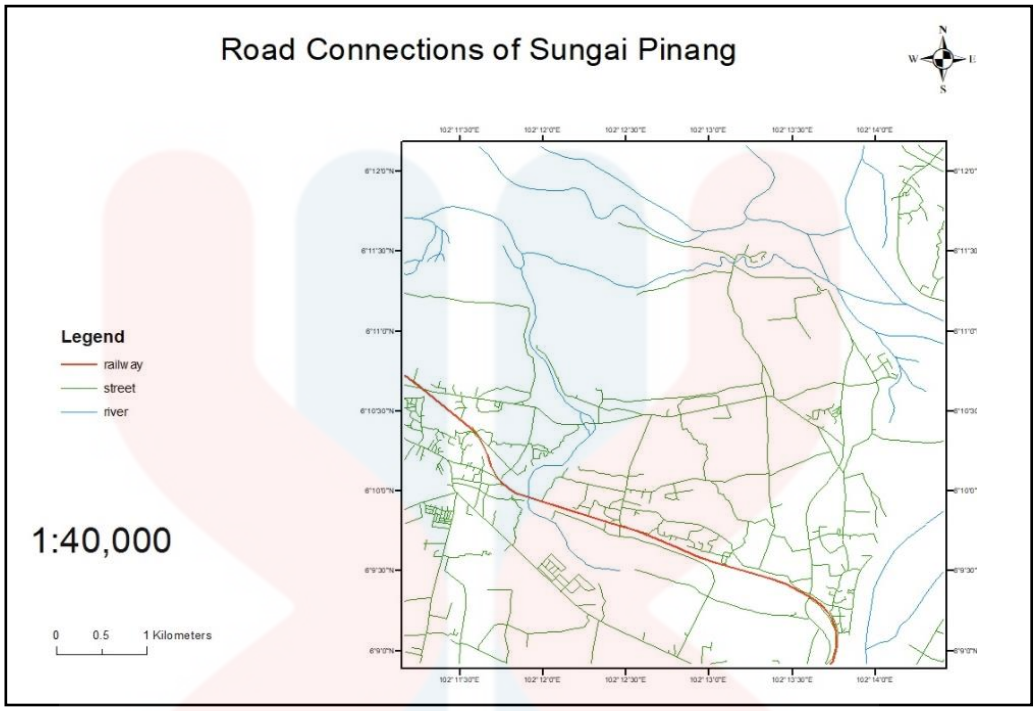

Figure 1.4: The road connections of study area at Sungai Pinang, Tumpat

1.2.3 Demography

According to the data from Majlis Daerah Gua Musang, the Table 1.1 shows the total population of residents at Gua Musang in year 2010, 2013 and 2014. In 2013, the total population of residents at Gua Musang was 111,700. However, there was an increase in the population number to 114,500. The dominant race in Gua Musang are the Malays with 96% followed by Chinese with 3%, Indians 0.6% and others with 0.4%. Figure 1.5 shows the percentage of ethnic group of Gua Musang.

Table 1.1: Amount of population by the year

Year	2010	2013	2014
Total populations	90,057	111,700	114,500

(Source: Majlis Daerah Gua Musang,2014)

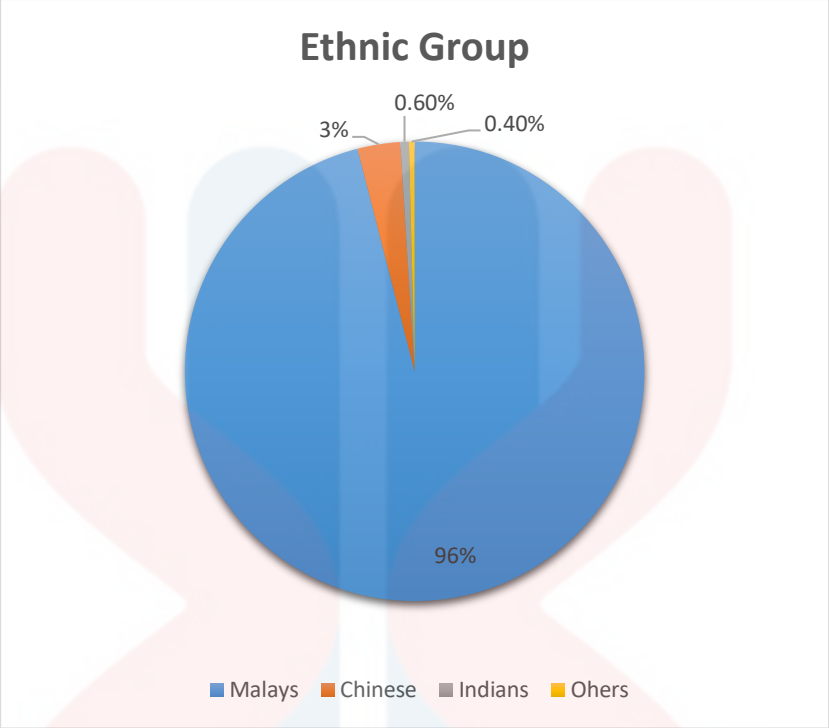

Figure 1.5: The ethnic group of Gua Musang

Table 1.2: The population of ethnic group in Gua Musang

Race	Population
Malay	1,378,352
Chinese	48,787
Indian	8,843
Others	3,658

The total population in Tumpat is 8916 peoples according to the data from Local Authority Area and State of Malaysia, (Table 1.3). The dominant ethnic groups in Tumpat are Malay community with roughly around 96, followed by the Chinese, Indian and others about 4% which shoes in Figure 1.6.

Table 1.3: Total population by ethnic group

Sub - district	Malaysian citizens				Non-Malaysian citizens	Total
	Malay	Chinese	Indian	Others		
Tumpat	8554	276	23	18	45	8916

(Source: Local Authority Area and State of Malaysia, 2010)

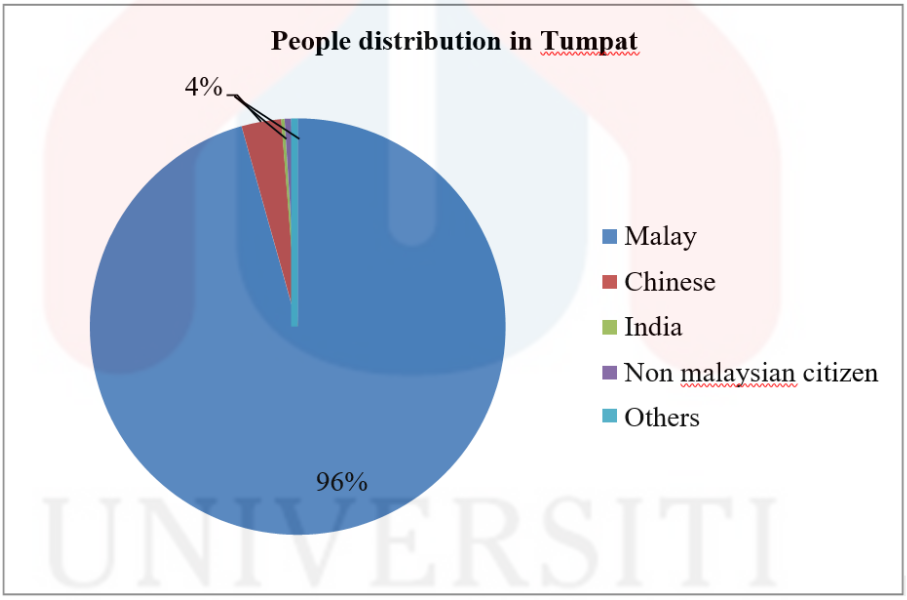

Figure 1.6: Total population by ethnic group in Tumpat

1.2.4 Rainfall

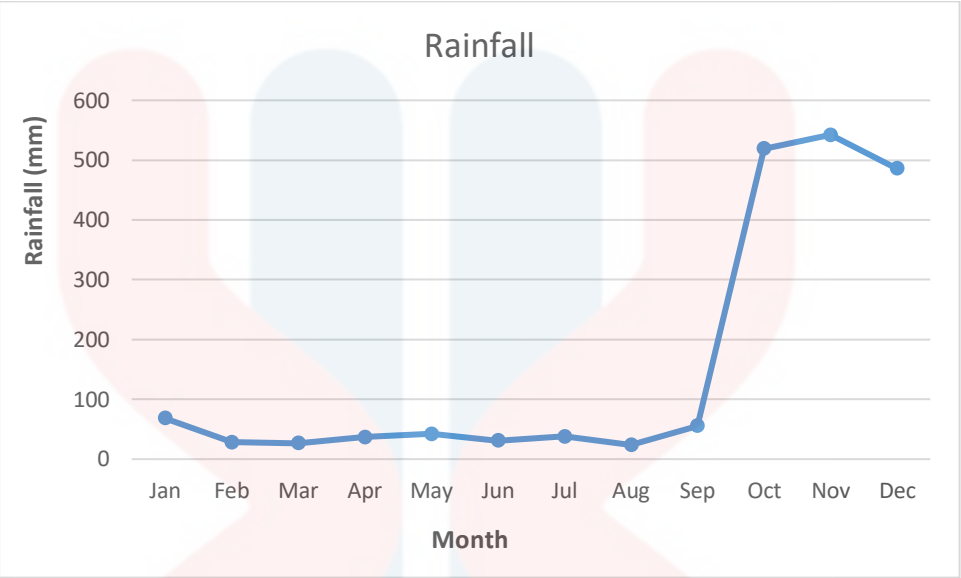

Figure 1.7: Rainfall in year 2018 around Gua Musang, Kelantan

Table 1.4: Annual rainfall at Gua Musang

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total amount (mm)
68.28	28.09	26.83	36.75	42.06	30.93	37.74	23.69	557.7	519.3	542.3	485.8	1897.54

(Source: worldweatheronline, 2018)

Figure 1.7 illustrated the distribution of rainfall or precipitation in Gua Musang. The highest precipitation is in November which is 542.3mm and the lowest precipitation is in August which is 23.69 mm. Generally, Kelantan has monsoon season starting from October until December. Thus, precipitation in October, November and December shows high amount of precipitation.

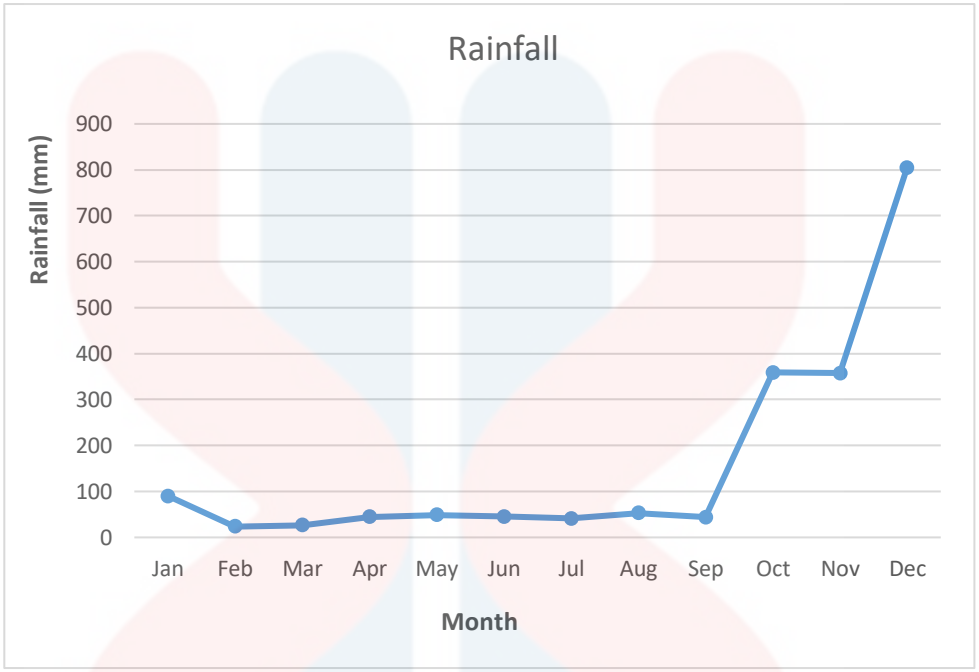

Figure 1.8: Rainfall in year 2018 around Tumpat, Kelantan

Table 1.5: Annual rainfall at Tumpat

Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total amount (mm)
89.54	23.35	26.53	44.67	48.58	45.41	41.14	52.86	43.58	359.08	357.4	805.1	1937.24

(Source: worldweatheronline, 2018)

Figure 1.8 shows the distribution of rainfall or precipitation in Tumpat. The highest precipitation is in December which is 805.1mm and the lowest precipitation is in February which is 23.35mm. Generally, Kelantan has monsoon season starting from October until December. Thus, precipitation in October, November and December shows high amount of precipitation. Rainfall is very important to form groundwater because rainfall is essential to recharge groundwater in aquifers. Hence, water demand can be fulfilled when groundwater content rise.

1.2.5 Land Use

Gua Musang is an area consist of total 8104 km^2 which is the largest district in Negeri Kelantan. Table 1.6 shows the type land uses area ruling the Gua Musang in 2018. The number of population of the area cause the changes of the land uses in the area.

Table 1.6: Land uses in Gua Musang

Land Uses	Area (hectares)	Percentage (%)
Water body	4,940.227	0.608
Forest	695,450.733	85.564
Industry	155.166	0.019
Institution and facility	693.714	0.085
Infrastructures and utility	23.493	0.003
Recreation	193.475	0.024
Transportation	2,468.969	0.304
Commercial	93.683	0.012
Mixed development	647.418	0.080
Residential	1,220.591	0.150
Agricultural	106,540.677	13.108
Empty land	353.284	0.043
TOTAL	812,781.430	100

(Source: Jabatan Perancangan Bandar dan Desa Malaysia 2018)

In 2018, the total land use dominates by forest area in Gua Musang, Kelantan which is area of 695,450.733 hectare with total 85.564%. This data shows there is a huge amount of area still classified as non-built up area in Gua Musang. Moreover, the transportation area covers around 106,540.677 hectares with 13.108% and followed by water body area of 4,940.227 with 0.608%.

Tumpat is a district consist of total around 22,852 hectares in Negeri Kelantan. Table 1.7 shows the type land uses area dominated the Tumpat in 2018. The number of population of the area cause the changes of the land uses in the area.

Table 1.7: Land uses in Tumpat

Land Uses	Area (hectares)	Percentage (%)
Water body	1,643.330	7.191
Forest	7.964	0.035
Industry	105.874	0.463
Institution and facility	666.149	2.915
Infrastructures and utility	336.083	1.471
Recreation	54.104	0.237
Transportation	915.859	4.008
Commercial	273.638	1.197
Mixed development	9.362	0.041
Beach	18.385	0.080
Residential	4,638.972	20.299
Agricultural	12,497.404	54.687
Empty land	1,685.536	7.376
Total	22,852.661	100

(Source: Jabatan Perancangan Bandar dan Desa Malaysia 2018)

In 2018, the total land use dominates in Tumpat is agricultural area which covers around 12,497.404 hectares with 54.687%. This shows half of the area covered by plants which gives the residents agricultural works. Moreover, the empty land area covers around 1,685.536 hectares with 7.376% and followed by water body area of 1,643.330 with 7.191%. Figure 1.9 shows the land use at Sungai Pinang, Tumpat, Kelantan.

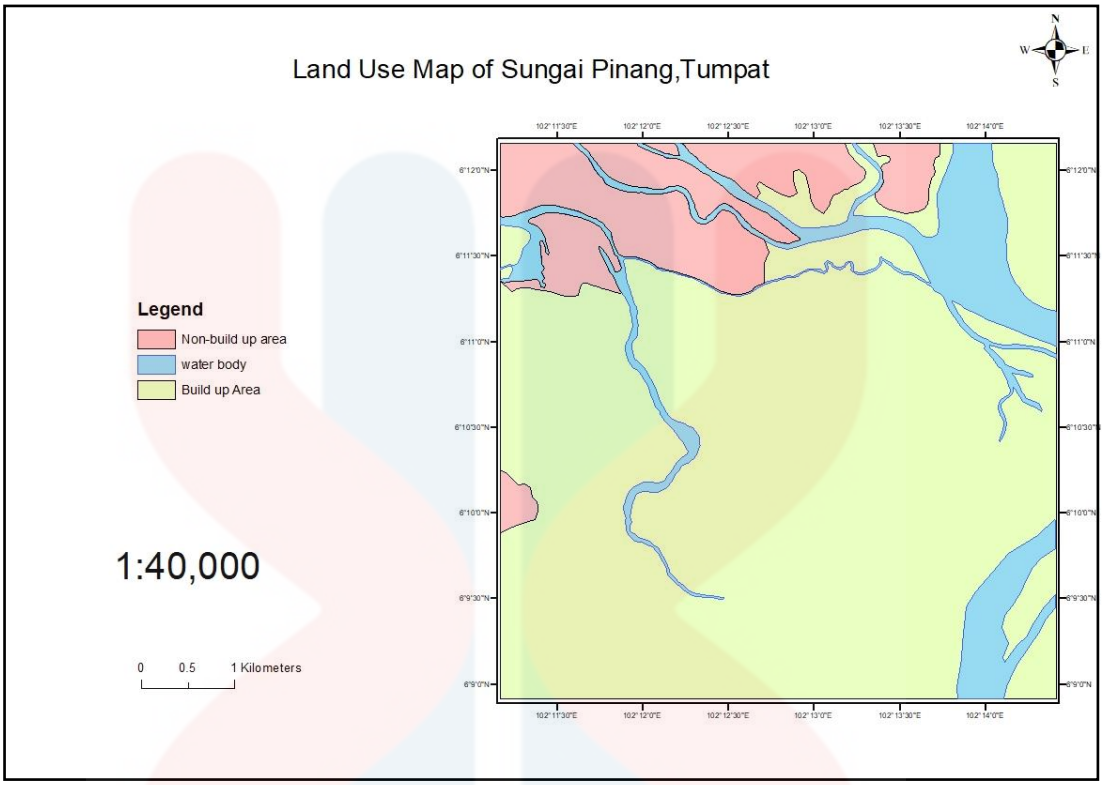

Figure 1.9: Land Use in Study Area

1.2.6 Social Economic

The people in Lojing find their income by mostly work as plantation activities and logging activities. This is because Lojing area mostly covered by vegetation area. Social economic means the actions or activities conducted by the society according to their local economic. Business and agriculture are the two main sectors involved by the local people in Tumpat area. Production of raw materials and local specialty affects the business sector in Tumpat. Normally business activities are categorized as small and medium scale or also known as Small and Medium Entrepreneurs (SME) business. SME business varied from silverware manufacture, fishery product, batik, food product and woodcraft product. Sometimes, each product will become as iconic signature in their respective location.

Besides that, the agro-based sector and agriculture is further divided into certain sectors like aquaculture, fishery and poultry. Since Tumpat consists fertile soil because of the presence of Kelantan deltas, varieties of crops had been planted such as maize plant, paddy, tapioca, sugarcane and rubber.

Next apart from Tok Bali in Pasir Puteh, Tumpat is also a very well-known centre for fishery sector since there are many types of seafood. Furthermore, freshwater species such as “keli” or “patin” are mainly found in Tumpat. The number of breeders for freshwater species is high because of the availability of the little and large scaled of ditches or irrigation channels that creates a suitable environment.

1.3 Problem statement

Compared to other states Kelantan is the state that using groundwater for various purpose. The presence of excess salinity causing the groundwater supplied to the Tumpat residents to be unhealthy. Besides that, the excess of seawater in groundwater also can give a bad impact to agriculture activities. This can affect the growth of plants and also the residents can get unhealthy food such as vegetables.

Moreover, there are many geological data in large scale. The present map from the Jabatan Mineral Geoscience scale of 1:50000 and no map in 1:25000. This scale covered more detailed lithological units. According to previous research, the geological data given at the particular area have been conducted long time ago. This research conducted to give new updates on geologic details of study area and the information and findings will helpful for the residents.

1.4 Research Objective

i. To produce geological map of Lojing area at 1:25,000 scale
ii. To evaluate seawater intrusion of Tumpat area by using ERI and hydrochemistry

1.5 Scope of study

Discovering the geological structure, producing the geological map of study area and also identify the seawater intrusion of groundwater at Kota Bharu are the main scopes of the study in this research. Geological mapping, geophysical and hydrochemical analysis are the methodologies used in this research.

Geological mapping conducted to produce of geomorphological features, regional geology, lithostratigraphy and structural geology of the study area of Gua Musang. In geophysical aspect, resistivity method uses to obtain two-dimensional (2D) resistivity profile of groundwater coastal especially shallow well of study area. Moreover, hydrochemical analysis will be conducted to identify the presence of elements in freshwater. These methods use to investigate the seawater intrusion at Kota Bharu area.

1.6 Significant of study

Firstly, the geological mapping conducted in Lojing, Gua Musang to give new update about the geological data and details of the study area. Furthermore, the hydrochemical and resistivity method conducted at Tumpat to determine the salinity of water. Besides that, this information will be helpful to residents about the quality of groundwater at the study area. It also improve social economic condition of the area.

CHAPTER 2

Literature Review

2.1 Introduction

This chapter includes the former studies that related to this research studies. This chapter included regional geology and tectonic setting, stratigraphic, structural geology, historical geology and research specification.

2.2 Regional Geology and Tectonic Setting

Kelantan state consist of 14 922km square area with 10 districts which is located in north-east Peninsular Malaysia. Gua Musang is the largest district in it which is around 8104km square area in Kelantan. The Lojing sub-district only forms about 22.42% from the district of Gua Musang. It has an altitude of 610 - 1500 m above sea level. Whereas, temperature of the highlands ranges from 18˚C - 25˚C. It has 3 main areas and they are Betis Area, Hau Area and Sigar Area. Total of 5613 people are recorded as residents at Lojing, and 4,113 of them are the indigenous race, Temiars. The name Lojing was believed by the Temiars that it has been long used before 1900 and it came from the name of the head of a Temiar family, called “Ajing”, the first pioneer at Sungai Belatop. The area was named after him, which then became Lojing we(Nazaruddin et al., 2015). Lojing Highlands, which is a part of the Main Range. This range contains mostly a few enclaves of metasedimentary rocks and mostly granite. The Main Range Granite in Kelantan is located somewhere in the west of the

state stretching along western Kelantan up to the state boundary of Perak and Pahang, and the international boundary of Malaysia (Nazaruddin et al., 2015).

The Upper Paleozoic formation in Kelantan was comprised of Gua Musang Formation and Aring Formation in the south of Kelantan while the Taku Schist is in eastern of Kelantan. The Upper Paleozoic formation is dominated by argillaceous and volcanic facies while the rest belong to calcareous and arenaceous facies (Hutchison & Tan,2009). The Mesozoic formation is dominant in the central belt that form continuous north – south trending belt extending beyond the international boundaries with Thailand (Gua Musang Formation) in the north and Singapore (Jurong Formation) in the south. The Gua Musang, Aring and Gunong Rabong formations, aged Permian – Triassic is dominated by shallow marine clastics and carbonates with volcanic interbeds (Hutchison & Tan,2009).

In Kelantan, Cenozoic formation is primarily represented by the Quaternary sedimentary deposits. This Quaternary sedimentary deposits generally cover the northern part of Kelantan and it is comprised of unconsolidated and semiconsolidated of boulders, gravel, sand, silt and clay. These sediments underlie the coastal area, inland plain as well as infilled valleys (Hutchison & Tan,2009).

2.3 Stratigraphy

Stratigraphy of Lojing explained that the state of Kelantan has a wide variety of rocks. This includes igneous, sedimentary and metamorphic rocks. Distribution of rocks in Kelantan are in a north-south trend. Distribution of igneous rocks in Kelantan is in the west and east borders of the state the Main Range Granite and the Boundary Range Granite. It also occurs in the centre of the state. The granitic rocks in Kelantan can be divided into two main bodies which are the Main Range and the Boundary Range. This is also stated by the Department of Minerals and Geoscience themselves. The Main Range Granite is generally of a Late Triassic age, between 200 and 230 million years ago (Nazaruddin et al., 2015).

The Northern part of Kelantan map consists of districts such as Tumpat, Pasir Mas, Kota Bharu and Pasir Puteh. Based on researches and field findings done by previous geologists, these parts of Kelantan Map contain rock types from the Quaternary Period. The most common examples of the rocks found in these locations are clay, silt, sand, peat and minor gravel. Since all these rocks were formed during the Quaternary and recent period, they are all considered as young rocks in geological rock strata.

The southern part of Kelantan map comprises another study area involved in this project which is Gua Musang. Based on the earlier research and evidences, geologists have classified the rock types at Gua Musang area according to the geological time scale chronology. So therefore, it can be concluded that rocks from Permian and Triassic were the majority at Gua Musang and its surrounding. Besides that, the igneous rocks found here were dominantly of acid intrusive (undifferentiated) type. Apart from that, there were also some major and minor noticeable faults that had occur last time at Gua Musang and its neighbouring districts.

The Permian is a geologic period which extends from 299 to 252 million years ago. It is the last period of the Palaeozoic Era after the Carboniferous Period and occurred before the Triassic period of the Mesozoic era in geochronology. During that time our world was dominated by a single supercontinent which was called as Pangaea, and surrounded by a global ocean that was named as Panthalassa. The vast tropical rainforests of the Carboniferous period had all disappeared, leaving behind major regions of dry desert surrounding the interior continent. The ocean depth during the Permian remained mostly low, and near-shore environments were restricted by the collection of all the dominant landmasses into one continent which was the Pangaea. This could have been the reason for the major marine species extinctions during the final time of the period by critically decreasing shallow coastal areas that contained varieties of marine organisms. The rocks formed during Permian period were stained red because of iron oxides as the result of severe heating by the sun since there was lack of vegetation and the land was bare (Permian Period, 2014) .

The Triassic Period was the very first period of the Mesozoic Era and it occurred between 251 million and 199 million years ago. It was followed by the great mass extinction called the Permian-Triassic extinction at the final stage of the Permian Period. This was when apart from marine species began to form and diversify (Triassic Period Facts and Information, 2019.). By the end of the Triassic period which was about 199 million years ago, the earth's supercontinent began to split into two major parts because of the tectonic forces and plate movements. The first continent was called as Laurasia which is situated in the north meanwhile the second continent was named as Gondwana which is located in the southern part.

The types of rocks found at Gua Musang and its surrounding were phyllite, shale, slate, siltstone, sandstone and dominantly limestone. The mass extinctions caused

during the Permian and Triassic period had contributed into many valuable fossils and since we all know that limestone is mainly composed of skeletal fragments of marine fossils it is therefore proved that majority of the rock types are from Permian and triassic period found at Gua Musang and its surrounding areas.

Quaternary period is the most recent time of Geological time scale and it began 2.6 million years ago and continues till present. Climate change and developments caused by this period are stated in Earth's history. At the beginning of the Quaternary period, all the continents were almost about the similar location they are in today, but little by little moving here and there because of the forces of plate tectonics that are pushing and tugging them about ("Quaternary Period Information and Facts | National Geographic,").

Normally the Quaternary period is one of the best-studied parts compared to other time scale in the geological record. The is because it was proven that majority of the parts were very well preserved and undisturbed when comparing to the other geological time scale. For instance, significantly a very little amount had been lost due to natural disasters such as erosion. Furthermore, rock forming processes did not alter the sediments present. Quaternary rocks and sediments which are categorised as the most recently laid in geologic strata, can still be found till this day in areas such as Tumpat. The rocks and sediments found in the study area are really important to unravel the geologic history in Kelantan. The geologic processes and environments found during the early times in the Quaternary period are approximately similar to those of today. Besides that, The relation of living organisms today is hugely associated to the Quaternary fossils. A variety of dating methods can be used to tell the exact time of geological events and rates of changes (F.Belknap Daniel, 2018).

2.4 Structural Geology

Structural geology is the study of the any geological features that formed during the rock formation. Many factors actually ccontributes to the formation of structural geology like tectonic process, deposition of sediment, force of energy and others. There are many possibilities for the structural geology to form. It may form either before the formation of the rock, during or after the formation of the rock. There are many geological formations found in Kelantan. The formations have different faults. A fracture or a zone of fractures between two blocks of rock are called as a fault. The blocks are able to move relative to each other when there is a fault. There are two types of movements regarding to fault. Earthquake occurs when the movement is really rapid where as if it occurs slowly then fault will happen in the form of creep. Furthermore, faults can be ranged in length from a thousands of kilometers to a few millimeters. Most of the faults will normally produce repeated displacements over geological time. The rock on one side of the fault slips with respect to the other side all of a sudden when an earthquake strikes. The surface of the fault can either be vertical or horizontal or even some arbitrary angle in between. The angle of the fault with respect to the surface which is known as the dip and the direction of slip along the fault are used by earth scientists to classify the types of faults ("What is a fault and what are the different types?,".). Diagram 2.1 show the general geology of Kelantan.

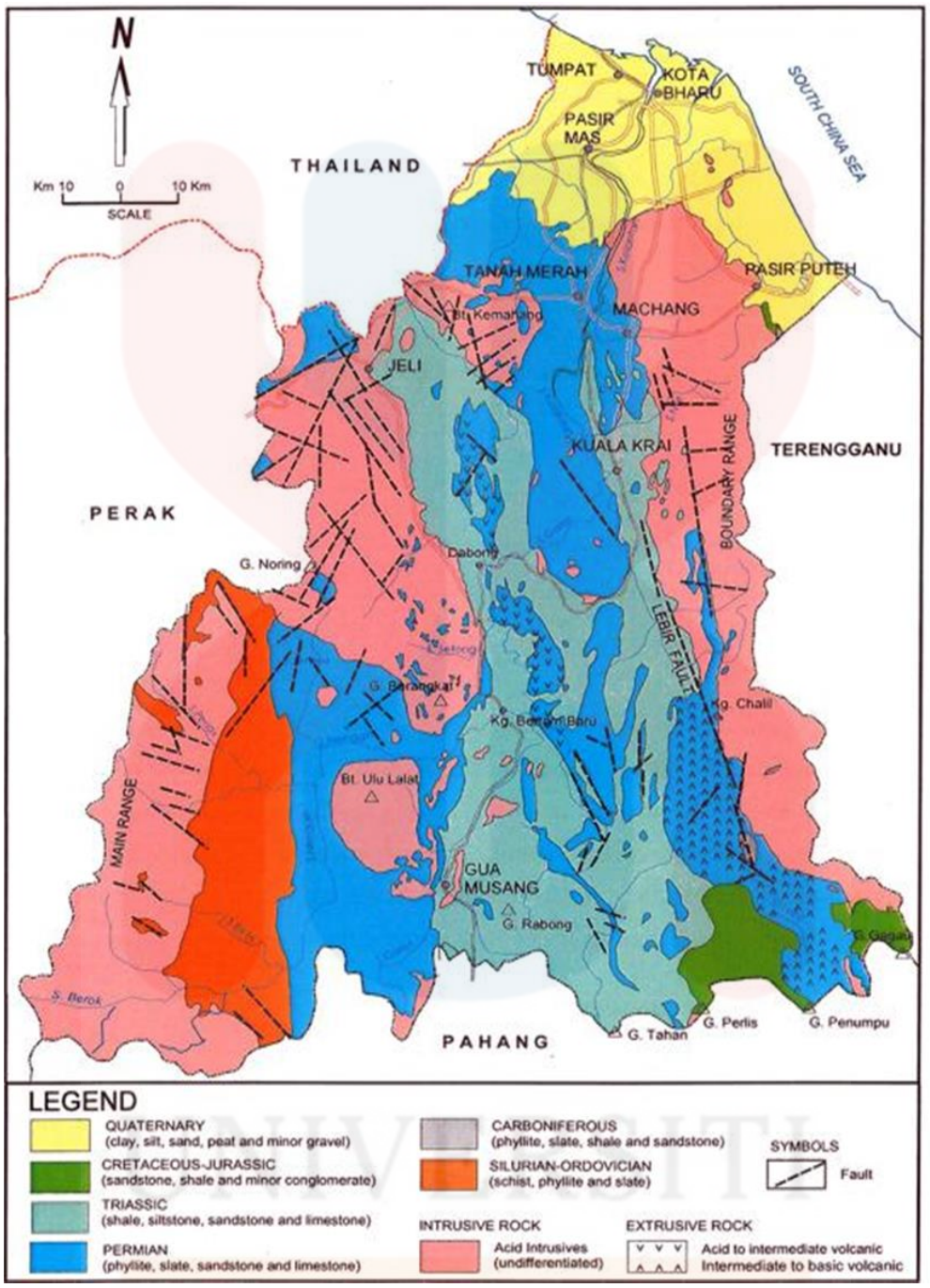

Figure 2.1 shows the general geology of Kelantan.

(Source: Department of Minerals and Geoscience Malaysia 2003)

2.5 Historical Geology

The Gua Musang formation in South Kelantan – North Pahang was mapped to describe Middle Permian to Late Triassic argillite, carbonate, and pyroclastic/volcanic facies within Gua Musang area. Now, the term has been often used for nearly all Permo-Triassic carbonate-argillite-volcanic sequences in the northern part of Central Belt Peninsular Malaysia. Widespread distribution of argillite-carbonate-volcanic across northern Central Belt has triggered issue regarding current names assigned. For an example, similar lithologies to the Gua Musang formation in Felda Aring is called as Aring Formation, where as those at Sungai Telong is named as Telong formation. These lateral facies changes could be gathered within the same group as long as these sediments were deposited in shallow marine environment of the Gua Musang platform during the Permo-Triassic period. The relevance of grouping these formations is based in terms of paleontological and sedimentological aspects. The researches find the need to reassess the usage of the informal 'Gua Musang formation' for future rank elevation, formalization, and clearer understanding on the geology of the northern Central Belt, particularly with regards to deposition of various lithostratigraphic units within the Gua Musang platform (Roslan et al., 2016).

The word Tumpat has a few meanings in Malay language. One of the definition simply means that it is either the final or conclusion of any certain thing. Apart from this, one more famous saying of the word Tumpat is that it refers to any empty space which had been filled up until full. Moreover, some old legends mention that the district of Tumpat had been in Kelantan for the past 190 over years. Last time, all the basic things used for daily purposes had to be transported from the state capital of Kota Bharu. However, the roads were not in good condition and there was a lack of proper

transportation channels. Therefore, the goods and things needed were always transported in and out of Tumpat through little boats named sampan in the local language. When Malaya was ruled by British, Tumpat underwent many more interesting activities when new British rules allowed bigger transportations to pass through the district. During the older days, transportations between 300 to 400 tonnes only were allowed to enter the shore. Since new rules and regulations were created by the Kelantan law, some other transportations stop by when passing Tumpat before heading to our neighbouring country, Singapore.

The very first head of the harbour was Mr. William Kerr, who was an English officer working for the Siam Public Services department from Thailand. He was positioned in Kelantan before the year of 1909. Until now a picture of him can be found hanging on the Tumpat Club's wall. The district of Tumpat have five little islands on the western region of the confluence of the Kelantan River. The five islands are situated quite closely to each other and are named Tanjong Dato, Tanjong Pak Jah, Tanjong Che Mas, Tanjung Che Tahir and Tanjung Rulah. ("Tumpat - Kelantan,".)

2.6 Research Specification

2.6.1 Groundwater

Generally, groundwater can be stored in two types of aquifers and they are alluvial aquifers and hard rock aquifers(Nazaruddin et al., 2015). In Kelantan, 70% of the residents depend on the groundwater, whereas in Malaysia it's just 10 percent needed. The clean water resources are important to the people of Tumpat and this is due to the population increasing.

2.6.2 Seawater intrusion

Saltwater intrusion which is the movement of saline water in freshwater aquifers, can lead to contamination of drinking sources and also can give other negative effects to the consumers. In most coastal aquifers, saltwater intrusion occurs naturally to certain degree. This owes to the hydraulic connection between groundwater and seawater. As mentioned initially, saltwater has a higher mineral content than freshwater, and therefore it is denser and has a higher water pressure. Some human activities, especially groundwater pumping which comes from coastal freshwater wells, caused the rise in saltwater intrusion at many coastal areas. Furthermore, water pressure is reduced because of the drop of fresh groundwater level caused by water extraction. This will allow saltwater to flow further inland. Ghyben-Herzberg principle can explain the relation between fresh groundwater and sea water in this phenomenon (Kumar et al., 2015). Figure 2.2 shows the sketch of fresh and seawater.

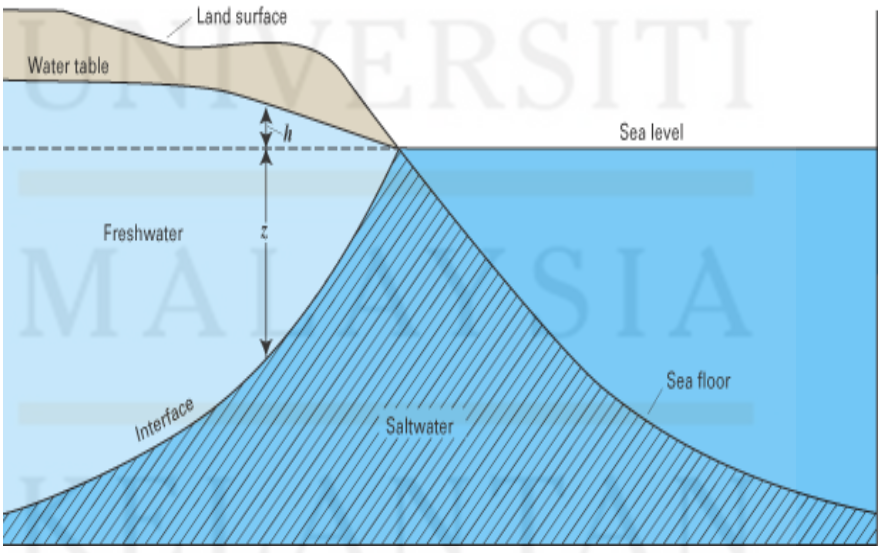

Figure 2.2: The idealized sketch of fresh and sea water groundwater in unconfined coastal

The equation Ghyben-Herzberg principle : $Z=\rho_f /(\rho_s - \rho_f) \bullet h$

where, ρf = Fresh water density

ρs= Sea water density

h = Elevation of the water table above sea level

Z = Depth to the fresh – sea water interface below sea level

2.6.3 Geophysical Method

Resistivity survey is the one of the method used for identification of groundwater under surface because the results are same to the soil in subsurface and groundwater. Electrical resistivity survey is the current injected to the ground by using two electrodes. There are two different values will be recorded for these two electrodes. The resistivity value will be converted from the value of two electrodes. This strategy is exceptionally useful in investigation of minerals, groundwater, in designing based examinations and some more (Zafirah Sakinah Amiruzan, 2015).

2.6.4 Hydrochemistry

Hydrochemistry is defined as the knowledge of water's chemical composition and allthe laws which affects its changes in the composition because of the biological, physical and chemical phenomena that occurs in the nearby environment around us. Moreover, hydrochemistry can also be said as a combination of the hydrology and geochemistry. (Hydrochemistry n.d.). Based on the groundwater and its chemistry, hydrochemistry plays an essential role in evaluating the hydrogeochemical processes which is capable of creating a significant impact for spatial and temporal differences in the groundwater's chemistry. Information and ideology regarding the differences in chemistry of groundwater and hydrogeochemical processes can be found in literature.

Chemistry of groundwater is mostly influenced from various factors which are artificial or natural discharge and recharge, irrigation practices being recycled and the movement throughout rocks. Water presumes an eccentric chemical composition as it flows because of the interaction between stratigraphical and lithological frameworks. The word hydro chemical facies means to discuss the spatial variations found in quality variations of aquifer groundwater. The facies includes the kinetic solutions, lithology functions and the aquifer's flow patterns. Besides that, results of hydro chemical are capable of providing a platform for the classification of groundwater within each of the units of hydrogeology. Based on this information, inferences regarding the processes that can take place in the aquifers, the host rock, use of ground water and its suitability and finally the impact of abstraction of groundwater on the aquifer is possible to be drawn. Furthermore, in the subsurface many mechanical, hydrochemical and solution activity can be triggered. Therefore, as an outcome for these mentioned processes, spatial and temporal changes that occurs in their chemical composition, hydraulic conductivity, porosity, fluid pressure of pores, fractures, solution cavities and fissures. (Şen 2015).

Next, the classification of parameters is divided into two distinct types such as chemical and physical parameters while conducting the geochemical analysis. (Kura, Ramli, Sulaiman, Ibrahim, & Aris, 2018). The mentioned parameters are essential for the groundwater classification process and also to distinguish the chemistry of ground water. (Jeevanandam et al., 2007). Based on the research done by Kura et al. (2015), hydrochemistry of certain areas was understood by using these parameters. As the end process, the groundwater quality can be fully assessed and obtained for agriculture, drinking, industrial functions and also domestic purposes based on all the data collected from geochemical analysis.

2.6.5 In-situ Parameters

In situ chemical analysis parameters which are pH value, TDS, TSS, salinity, turbidity and electrical conductivity.

2.6.4 Previous Study

` Kelantan is comprised of Quaternary sediments which is lined up by clay,silt, sand and gravel. According to the Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia, it is known that groundwater around Kota Bharu, Kelantan is safe and suitable for usage of all purposes in daily life.

Previously a research had been conducted to study the level of salinity of groundwater aquifers. It was conducted across the shore area of northern part of Kelantan. This case study was done successfully by using the geophysical and integrated hydrogeochemical methods. Major contents of the groundwater ion were analysed for the hydro chemical experiment. Besides that, some other chemical parameters like totally dissolved solid and pH values were also identified. Next, surveys of reflection seismic and geoelectrical resistivity soundings were done to identify the subsurface properties and groundwater present in the aquifers based on the geophysical study method (Samsudin et al., 2008).

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CHAPTER 3

Materials and Methods

3.1 Introduction

This chapter will explain about materials and method to achieve the objectives. The methodology describes the preliminary studies, field studies, laboratory work, data processing, data analysis and interpretation. Figure 3.1 show overall flowchart of this research.

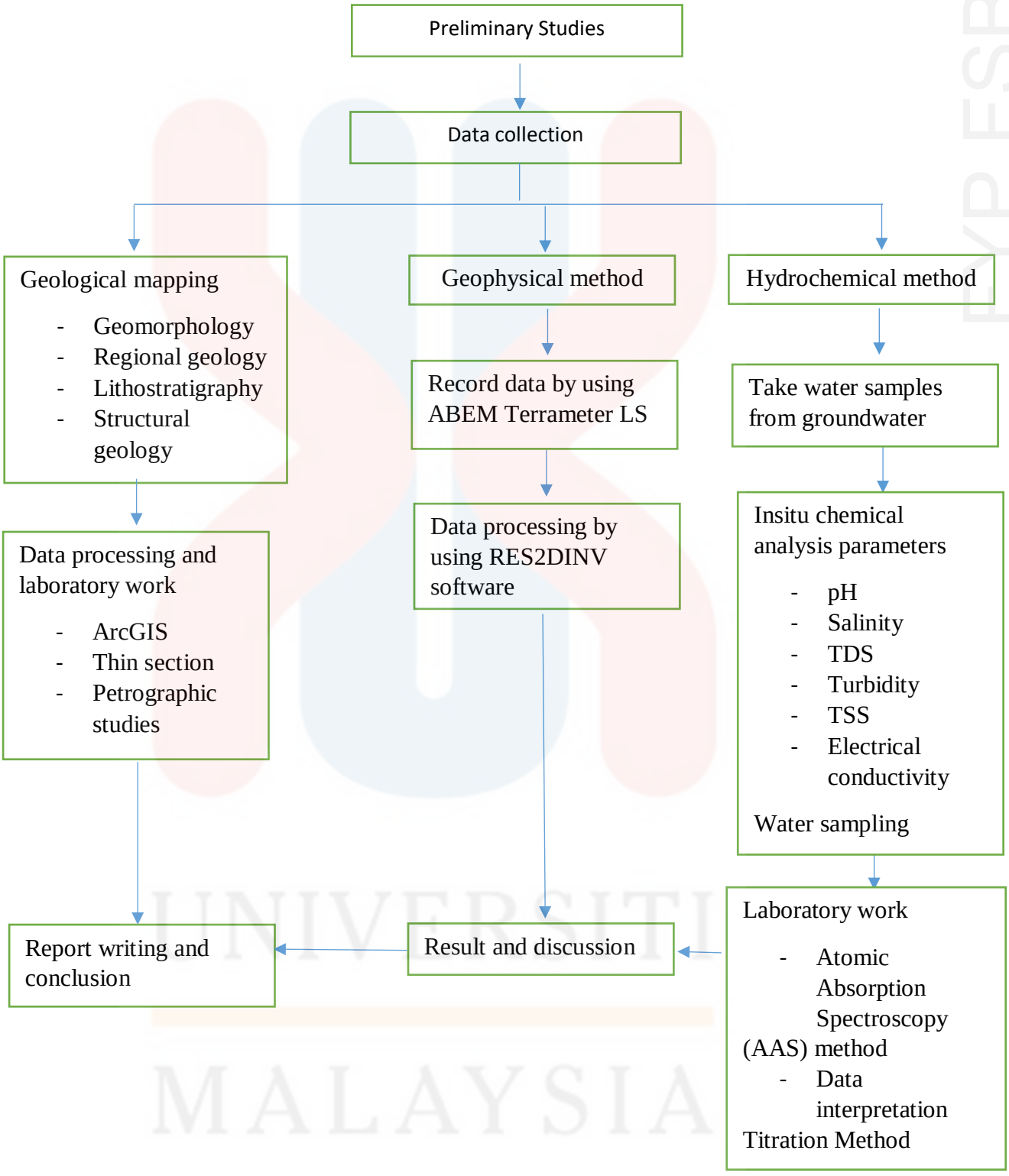


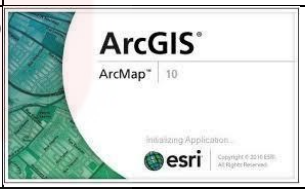
Figure 3.1: Overall Flowchart

3.2 Materials/ Equipment

There were different types of equipment used for two study areas which were at Lojing and Tumpat. Table 3.1 shows the materials/equipment used for this study.

Table 3.1: shows the materials/equipment

Material	Functions	Picture
Hammer	Outcrops were broken down using the hammer.	
Global Positioning System(GPS)	GPS helped to detect the elevation of the location and was also used to identify the coordinates of location using satellites and to track the travelled journey.	
ABEM Terrameter LS	This helped to conduct the electrical resistivity imaging survey of the study area	
Atomic absorption spectroscopy (AAS)	Major cations and major anions in water sample will be determined by using AAS	
Multi parameter	In situ parameters of water like pH value, temperature and electrical conductivity were measured using multi parameter.	

Turbidity meter	Turbidity meter used for determining the turbidity of water sample.	
Portable TSS meter	Portable TSS meter used to identify total suspended solid in water.	
Total Dissolved Solids (TDS) meter	A TDS meter was used to determine the total dissolved solids (TDS) of a solution, such as the concentration of dissolved solid particles	
Sampling bottle and bag	Sampling bottle and bag were used to store water sample and rock sample	 
ArcGIS software	ArcGIS software was used to produce maps.	

3.3 Methodology

3.3.1 Preliminary studies

Preliminary studies are an underlying investigation of issues identified with a proposed quality survey or assessment. This study helped us a lot in order to collect all basic literatures and preparation of base map of study area. For example, article journal, books, and data reports and senior's thesis were the basic literatures that helped to generate new ideas and gave us a clear clarification about this study which was an important aspect. The drainage pattern, land use, watershed, landform, lithology and vegetation were identified with the aid of the topographic map. Furthermore, the base map was used during the fieldwork.

3.3.2 Field studies

a) Geological mapping

Field work inputs including collection of samples from fresh outcrops, recording structural trends in rocks, and other field observations such as geomorphological features, regional geology, lithostratigraphy and structural geology were mainly focused regarding the Geological mapping aspect of the current project. All these field related data will be processed in GIS based platform to generate geological and other thematic maps.

b) Resistivity survey

Electrical resistivity method aids so well in knowing the seawater intrusion of groundwater in the study area. To do so, pole dipole array was used. It must be made sure that it is used on a flat and straight surface in order to attain a good result. The data was then transferred to a software for further analysis. By doing so, a clear picture of the contamination will be visible. This experiment should be conducted at least three times and the average result from those experiments was used to obtain an optimum result. Those experiments must be conducted in a closed area to ensure the groundwater are from the same source.

Good results were produced when data from various results were combined together. Remote sensing and ArcGIS software also were used for this research and it added more information with great details to this study. Both the software produced a map of 2D and also 3D which left us with a better understanding about the topic. A geologist can interpret the data from this software and solve the mystery of resistivity image very easily. Apart from identifying the seawater intrusion of groundwater, this resistivity method also helped on to figure out the depth of the subsurface.

c) Water sampling

Water sample of groundwater from wells at different location with minimum ten samples were taken. In situ chemical analysis parameters which are ph value, pH, TDS, TSS, salinity, turbidity and electrical conductivity were measured immediately at the location of sampling. The apparatus used for in situ chemical analysis parameters were the multi parameter, turbidity meter and portable TDS meter. All data was then recorded and the water samples were brought to the laboratory.

3.3.3 Laboratory work

a) Petrology studies

The rock samples from the field were used for petrographic studies to identify its mineral, texture, matrix, clast and classification the rocks. The rock samples underwent thin section process to get clear image under microscope. This is important and should be borne in mind.

b) Atomic Absorption Spectroscopy (AAS) method and titration method

The concentration of metals in water samples were determined by the atomic absorption. The collected water samples from field were used in this atomic absorption and titration method. Copper, Cu^{2+}, sodium, Na^{+}, iron, Fe^{2+}, potassium, K^{+}, manganese, Mn^{2+} were used for AAS method and chlorine, Cl^{-} used for titration method. Later on the presence of elements in the liquid from the AAS and titration was recorded.

3.3.4 Data processing

The data from geological mapping was used in software ArcGIS to produce several type of map such as traverse map, topography map and geological map. Moreover, the data from the resistivity method, process in RES2DINV software to produce 2-D to obtain two-dimensional (2D) resistivity profiles helped in providing a clear view of the distribution of basement rock, as well as seawater intruded zones into groundwater. Then, several graph and diagram constructed for interpretation for understandings of the readings.

3.3.5 Data analysis and interpretation

The geological data from field mapping were used to produce several maps. Some of the examples of maps produced were the geological map, drainage pattern map, traverse map and topography map. These maps were obtained using Software ArcGIS.

CHAPTER 4

GEOLOGY OF THE STUDY AREA

4.1 INTRODUCTION

a) Brief content of chapter 4

This chapter discusses about the general geology based on the data collected during the mapping process. The geology of the study area is discussed in detail based on the geomorphology, lithostratigraphy, structural geology and historical geology. The accessibility, vegetation and traverse map of the study area will be discussed first before discussing about the subtopics.

b) Accessibility in study area

The study area was quite difficult to access as there were only two unpaved roads which were very far from the main road Jalan Gua Musang- Cameron Highland. Only vehicle such as four wheel drives could pass through those routes. This is because the study area was surrounded by thick forest and vegetation.

c) Vegetation

The study area consisted majority of thick forest which was impossible to surpass. Certain parts of the forest that was accessible had traces of logging activity which might have been done in the past. Besides that, the middle of the study area comprised of rubber plantation which was roughly around 20% of the study area.

e) Traverses and observations

The total duration taken to observe and traverse the study area was eight days. Many checkpoints were marked and observed for rocks but only some samples were collected as the rocks were of the same type. The attained samples were then used for petrographic analysis. The samples taken for petrographic analysis were from checkpoints TD1C1, TD1C2, TD2C2, TD3C6, and TD5C11. The Figure 4.1 shows the checkpoints that were mentioned earlier.

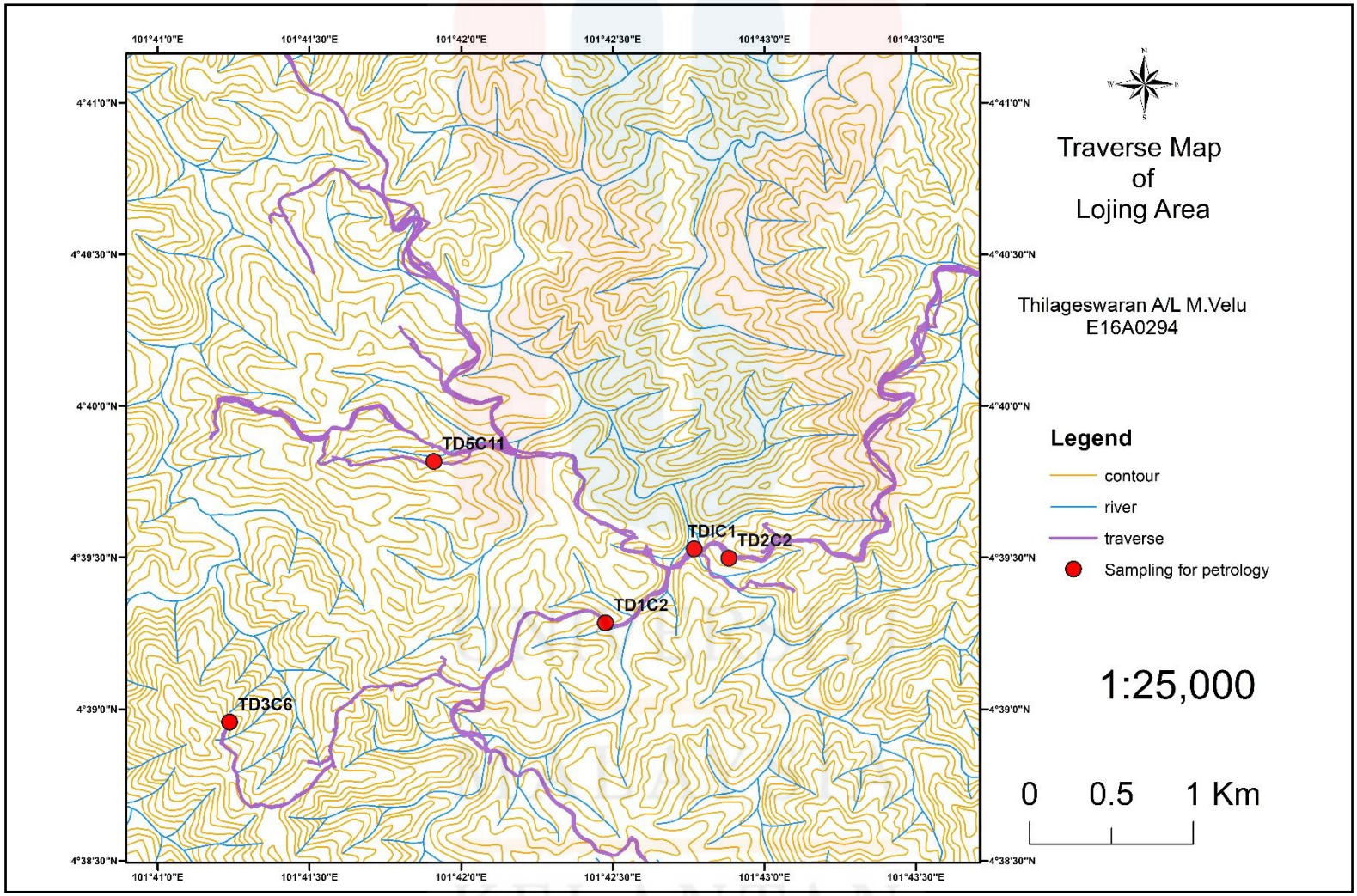


Figure 4.1: The traverse map of Lojing area

4.2 Geomorphology

The study of landform, description of evolution, origin and also the types of physical landscape is commonly known as geomorphology. The geomorphology of a certain location can be said as the change or formation because of weathering, depositional or erosional processes that widely influence our planet's surface. Some of the geomorphological changes underwent by earth can affect living things by causing tremendous jeopardy. Examples of such events are volcanic eruptions, landslides, massive earthquakes, tsunamis and floods. By studying geomorphology, one can predict the geohazards and also interpret the previous changes and processes involved in climate. That can be done by analysing the remaining sediments and landforms present. The three categories of geomorphology are weathering process, topography, drainage pattern, weathering, landform and mass wasting in the study area.

a) Geomorphology Classification

(i) Topography

Topography is the study of the shape and features on earth surface. The classification of topography is categorised into five classes according to the elevation of contour and seven classes based on its slope of the hills. The study area consists of the low lands, low hills and hilly topographic unit with flat and gently sloping hills.

ii) Landforms

Landforms can be categorised into two major parts of our planet's terrain whereby the first one is large landform and the second one is small landform. Examples of large landforms are mountains, plains and hills. The small landforms consist of valleys, basins and so on. The reason for these landforms to form is because of the plate tectonic movement, erosion deposition and weathering processes. Any type of landform needs a very long time to be formed (Nazaruddin et al., 2015).

The first landform identified in the study area was conical hill in Figure 4.2. Conical hill is a hill in the shape of cone. Conical hills are distinctive from other hills as they are often separated rises above from surrounding foothills. Most of the conical hills were formed because of volcanic activities (Scott et al., 1978).

The next type of landform found in the study area was fluvial landform in Figure 4.3. There were a river and many streams found in many locations of the mapping box. The streams were meandering and straight channel streams. Flood plain was found around the meandering river in the study area. Flood plain which can also be addressed as alluvial plain consists of unconsolidated deposits of sediments such as alluvium and is subjected to interval overabundance by the stream. Besides that, flood plain is a land which is usually flat and adjoining to a stream. When a stream moves laterally and deposition process occur in overbank, this will produce flood plains. When down cutting happens dominantly there can't be floodplain in that area("Floodplain | geology | Britannica,"). Furthermore, many little streams in the study area were dried up because of the dry season in Kelantan.

Other than conical hill and fluvial landforms, the rest were just random hilly area and forest found in the study area. Figure 4.2, Figure 4.3 and Figure 4.4 shows the geomorphology of study area.

Figure 4.2: Conical hill

Figure 4.3: River in the study area

Figure 4.4: Forest area in the study area

b) Weathering

Weathering is defined as the changes from rocks to sediment because of certain factors such as temperature, surface area, climate and composition of rocks itself. Mainly there are three weathering types which are biological weathering, chemical weathering and physical weathering. Chemical weathering has the capability of changing a rock's chemical composition and it is driven by the actions of carbon dioxide, acid rain, oxygen and water. Only two types of these weathering were observed in the study area which were physical and biological weathering (Regmi et al., 2012).

Firstly, the reason for intense physical weathering to take place in the study area depend on contributing factors like water, wind and continuous change in climate. The most common and clear physical weathering was observed near the river and streams in the study area. The rocks by the river were found to be broken into smaller sediments without altering their chemical composition. The reason for the rocks to break into little places is also influenced by transportation process. Since the rocks and boulders collided with each other the smaller broken rocks were deposited at the river beds and by the river bank (Skinner B.J. 1966).

Moreover, the study area also consisted of biological weathering. Biological weathering usually takes place because of microbes, plants or animal activities. Plants grow in the cracks and also joints found in the rocks for water. Weathering occurs when the pressure exerted by plants on the rocks when the roots started growing. Besides that, even animals can also cause weathering of rocks to sediments. For an example, burrowing animals such as rabbits can burrow a rock and cause it to crack and split. Figure 4.5 and 4.6 shows highly weathered outcrop (Murakami, 2003).

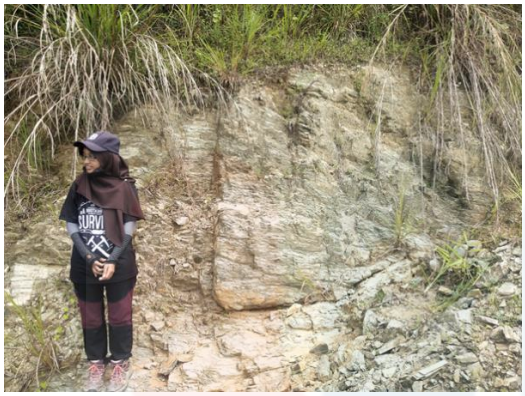


Figure 4.5: Highly weathered schist

Figure 4.6: Weathered mudstone

c) Drainage Pattern

Drainage pattern is a pattern caused by erosion of streams that shows the characteristics of rocks and structures in geology over time. Drainage pattern usually is formed by rivers, streams and also lakes in a certain drainage basin(“Types of Drainage Patterns,” n.d.). Drainage pattern is varied based on the hardness of rocks, structural conditions and elevation in the study area. Figure 4.7 shows the drainage pattern of the study area. There were two drainage patterns observed in the mapping box which were rectangular dendrites and radial patterns.

The rectangular dendrites pattern was found in almost three quarter of the study area. This drainage pattern usually will be formed in places with less topography and also fractures, faulting and bedding planes with rectangular design. One of the reason for this rectangular drainage pattern to occur is because of the rock that has similar resistance when it comes to erosion.

The radial pattern whereby consequent streams will radiate facing outwards from the center. The radial drainage pattern in the study area was observed at the east and west corner of the box (“Types of Drainage Patterns,” n.d.).

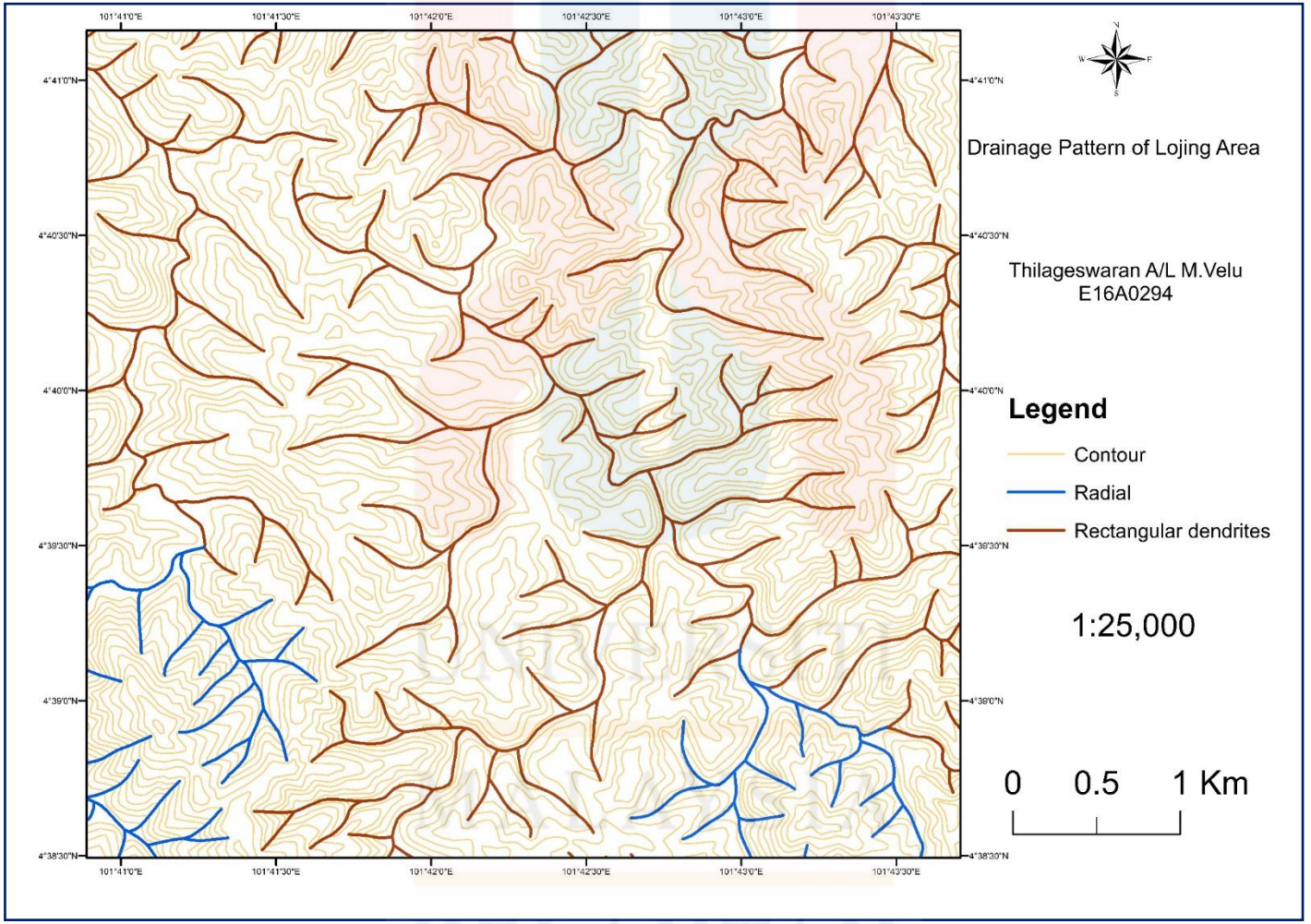


Figure 4.7: Drainage pattern of study area

4.3 Lithostratigraphy

Lithostratigraphy is the studies about layers of rock which is used to relate the formation of rock based on their stratigraphic position and also lithic properties. Besides that, the relationship between the igneous, sedimentary and metamorphic rocks are also described based on this study. Furthermore, the age differentiation can also be identified based on the rock layer's vertical position and rock layering.

There were two types of rocks which are sedimentary and metamorphic rocks found in the study area based on the lithostratigraphic unit. The sedimentary rock consisted of mudstone while the metamorphic rock was identified was schist. The lithological unit were all recorded and plotted in the geological map.

a) Stratigraphic Position

The stratigraphic position can be used to determine and explain the vertical column of rock's age. According to the law of superposition, the youngest rock layer lies at the top of the strata whereas the oldest rock will be located at bottom part of the rock strata sequence. But anyways, the position of rocks can be altered due to several other reasons based on different stratigraphic laws. Figure 4.8 show the geological map of the study area. Figure 4.9 shows the stratigraphic column of study area (Tjia, 1996)

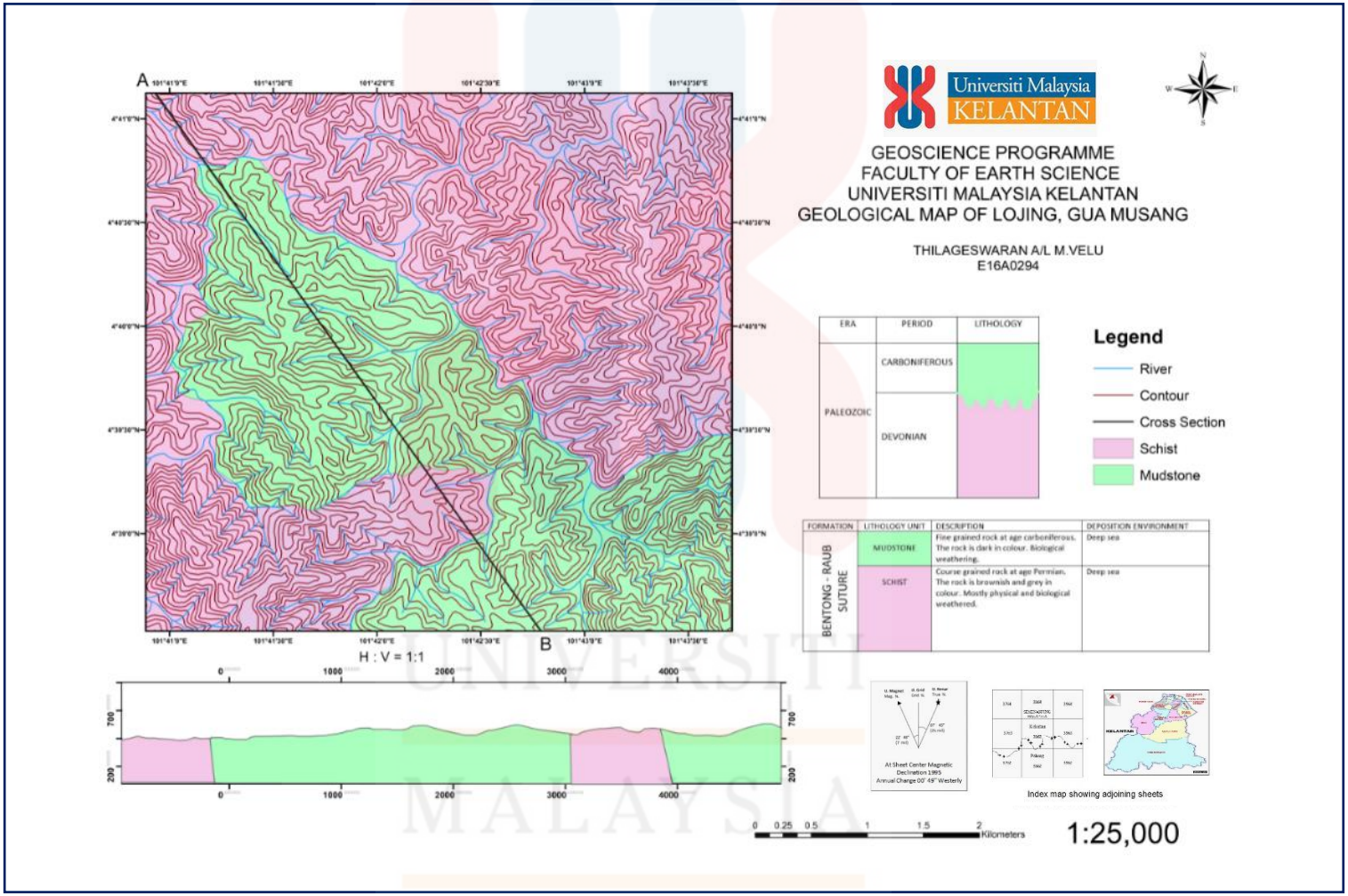


Figure 4.8: Geological map of study Lojing area

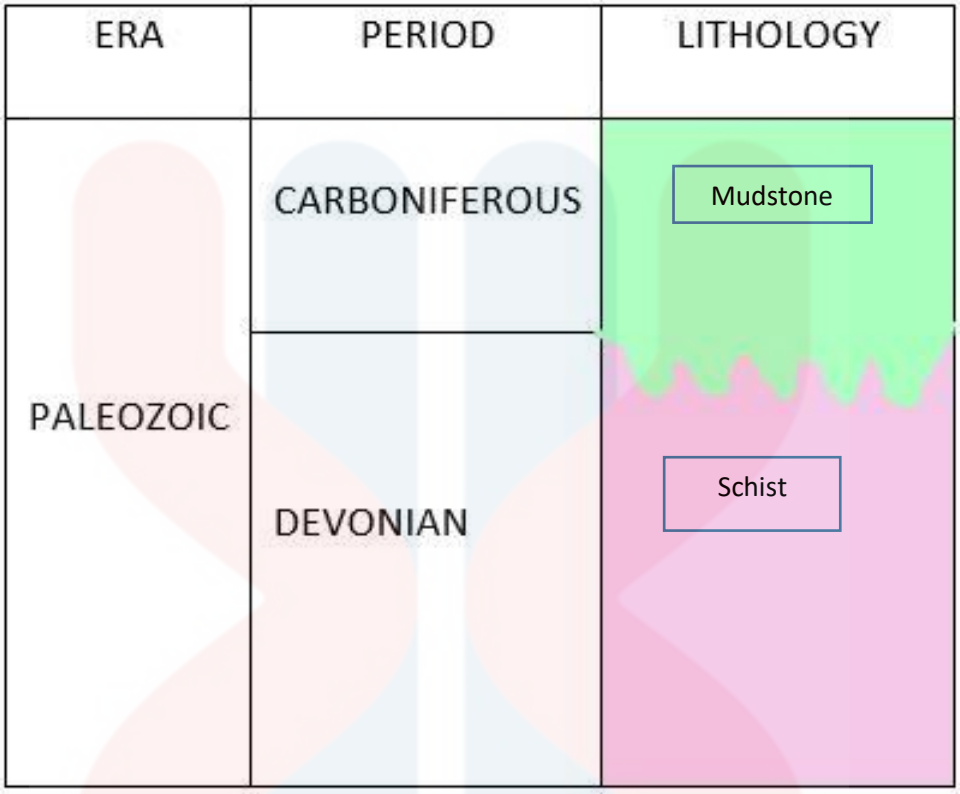


Figure 4.9: Stratigraphy column of study area (Tjia, 1996) .

b) Unit Explanation

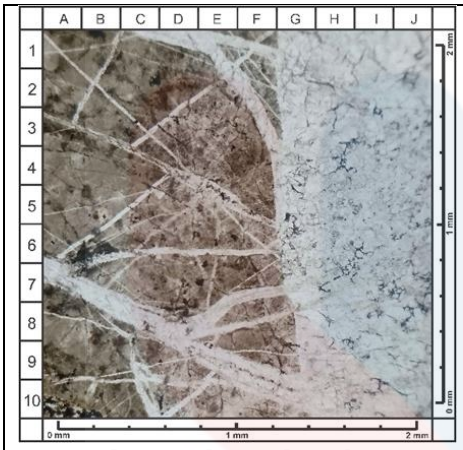
The lithology unit describes the rocks from oldest to youngest based on their horizontal and vertical distribution. The rock unit describes about the thickness of rock, the relationship and their distribution area.

i) Mudstone

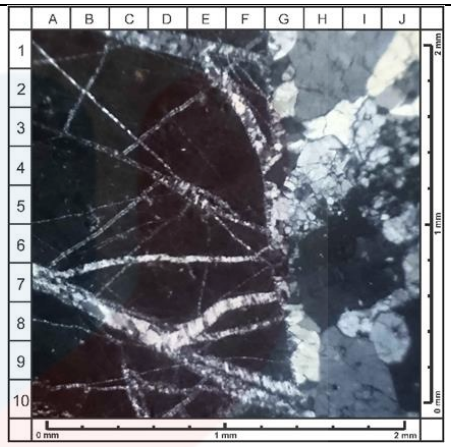
The mudstone unit covered around 25% of study area located at the middle part of the area. It is youngest rock found in study area. The Figure 4.10 shows the sample taken at station TD5C11. The coordinate of the rock sample is N 4º66'60.9", E 101º69.85". The mudstone deposited at age of carboniferous. The colour of the sample grey and it's also weathered. The table 4.1 shows the mineral composition of mudstone.

Figure 4.10: Station TD5C1 and sample of mudstone

Table 4.1: Mineral Composition of Mudstone



PPL (Plane Polarized Light)



XPL (Cross Polarized Light)

The observations were carried out at 10x ocular magnification and 5x objective magnification and the observations were known of massive structure, texture including grain size <1/256 - 0.8 mm, good sorting, closed packing. Began to appear mineral alignment.

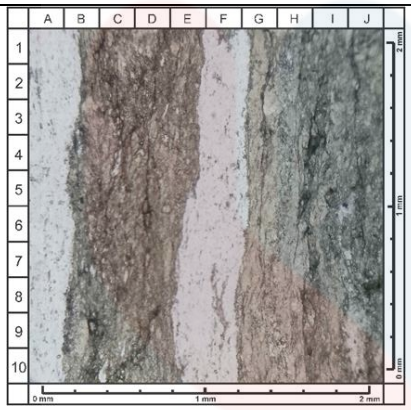
Mineral composition	**Description**
Vein Quartz	In the observation of white PPL, white XPL - gray - black, low relief without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. 52%
Mineral Clay - Oxide Clay	In the case of brown PPL, in XPL the grayish-brownish-blackish color, relief-pleochroism-crystalline form and invisible cleavage are present in the incision. 45% abundance
Opaque Mineral	In observations PPL and XPL look dark, present in the incision spread. 3% abundance

ii) Schist

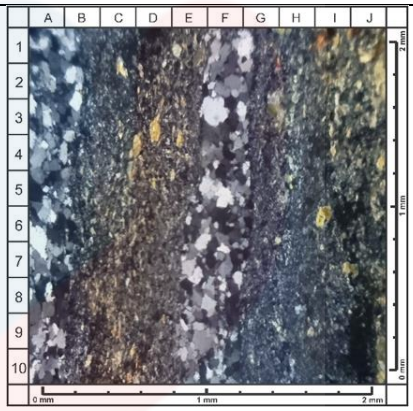
The schist unit covered around 75% of study area. It is the oldest rock found in study area. The figure 4.11 shows the sample taken at station TD1C2. The coordinate of the rock sample is N 4º65'47.4", E 101º70.79.4". The schist deposited at age of devonian. The colour of the sample greyish green and it's also weathered. The Table 4.2 shows the mineral composition of schist.

Figure 4.11: Station TD1C2 and sample of schist

Table 4.2: Mineral composition of Schist



PPL (Plane Polarized Light)



XPL (Cross Polarized Light)

The observations were carried out at 10x ocular magnification and 5x objective magnification and on observations of the foliation structure (schistose), palimset texture (blastopsamit) including grain size <1/256 - 1/6 mm, good sorting.

Mineral composition	**Description**
Quartz	In the observation of white PPL, white XPL - gray - black, low relief without cleavage, low pleocroism, anhedral crystalline form, present spread in the incision. 30% abundance
Pyroxene	In observations of light brown PPL, XPL yellow-gray-brown-orange-orange, low relief, 2-way hemisphere, weak pleocroism, spotted present in the incision. 15% abundance
Mineral Clays - Silica Clays	In the case of white-gray PPL, in XPL the gray-black color, relief-pleokroisme-shape crystals and parts are not visible, present spread in the incision. 54% abundance
Opaque Mineral	In observations PPL and XPL look dark, present in the incision spread. 1% abundance

4.4 Structural Geology

In the study area, there are difficult to find geological structure. This is because the study area fully covered by forest and all the outcrops are highly weathered by biologically and physically.

a) Fold

Fold is one of the structure found in study area. The type of fold in found in study area is chevron fold. Chevron fold is looks like v-shaped beds. It's found at coordinate $4^0$65'92"N with $101^0$71'92.2"E. Figure 4.12 Shows the v-shaped chevron fold.

Figure 4.12 : Chevron fold

4.5 Historical Geology

Historical geology is important in order to understand the previous events under geology that caused changes in the study area. It focusses on the tectonic process and settings that contributed to the mineral growths surrounding the regional area.

The location of this study area is exactly on the Bentong-Raub Suture Zone. During Upper Permian a collision between the Indochina Plate and Sibumasu Plate occurred and the collision was ended by Upper Triassic. In the ancient time, peninsular Malaysia together with the regional south East Asian countries like Vietnam and Thailand were placed in the bottom of the Paleo-Tethys Ocean. With the aid of the stratigraphic column, three types of formation were identified in the study area which are the Karak Formation, Semanggol Formation and lastly the Gua Musang Formation. It had been proved that the Semanggol formation was located at deep marine environment according to the chert lithology. Meanwhile, the environment for Karak and Gua musang Formation were shallow marine.

Based on, (Basir, 2013) during collision the oceanic plate of Sibumasu which represents the Semanggol Formation had previously undergone subduction below the Indochina Plate which represents the Gua Musang Formation and Karak Formation. Because of the collision, compressional reverse faulting in imbricated structures, extensional fault in large scale and lateral fault movements were all produced.

CHAPTER 5

INVESTIGATION OF SEAWATER INTRUSION OF SUNGAI PINANG AQUIFERS

5.1 INTRODUCTION

There are two methods were used which are geophysical and hydrochemistry to identify the sea water intrusion. All the result of resistivity and insitu analysis around Sungai Pinang, Tumpat, Generally, groundwater can be stored in two types of aquifers and they are alluvial aquifers and hard rock aquifers (Nazaruddin et al., 2015). In Kelantan, 70% of the residents depend on the groundwater, whereas in Malaysia it's just 10 percent needed. The clean water resources are important to the people of Tumpat and this is due to the population increasing. Saltwater intrusion which is the movement of saline water in freshwater aquifers, can lead to contamination of drinking sources and also can give other negative effects to the consumers. In most coastal aquifers, saltwater intrusion occurs naturally to certain degree. This owes to the hydraulic connection between groundwater and seawater. As mentioned initially, saltwater has a higher mineral content than freshwater, and therefore it is denser and has a higher water pressure.

5.2 Hydrogeology of north Kelantan

Kelantan is comprised of Quaternary sediments which is lined up by clay,silt, sand and gravel. According to the Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia, it is known that groundwater around Kota Bharu, Kelantan is safe and suitable for usage of all purposes in daily life. Previously a

research had been conducted to study the level of salinity of groundwater aquifers. It was conducted across the shore area of northern part of Kelantan. This case study was done successfully by using the geophysical and integrated hydrogeochemical methods. Major contents of the groundwater ion were analysed for the hydro chemical experiment. Besides that, some other chemical parameters like totally dissolved solid and pH values were also identified. Next, surveys of reflection seismic and geoelectrical resistivity soundings were done to identify the subsurface properties and groundwater present in the aquifers based on the geophysical study method (Samsudin et al., 2008)

5.3 Study Area

The study area located at north part of Kelantan at Tumpat district. There are three line of resistivity survey conducted in study area. For the in situ analysis there are totally ten samples taken in the study area named as T1, T2, T3, T4, T5, T6, T7, T8, T9 and T10. Figure 5.1 shows the location of resistivity survey line and the water samples.

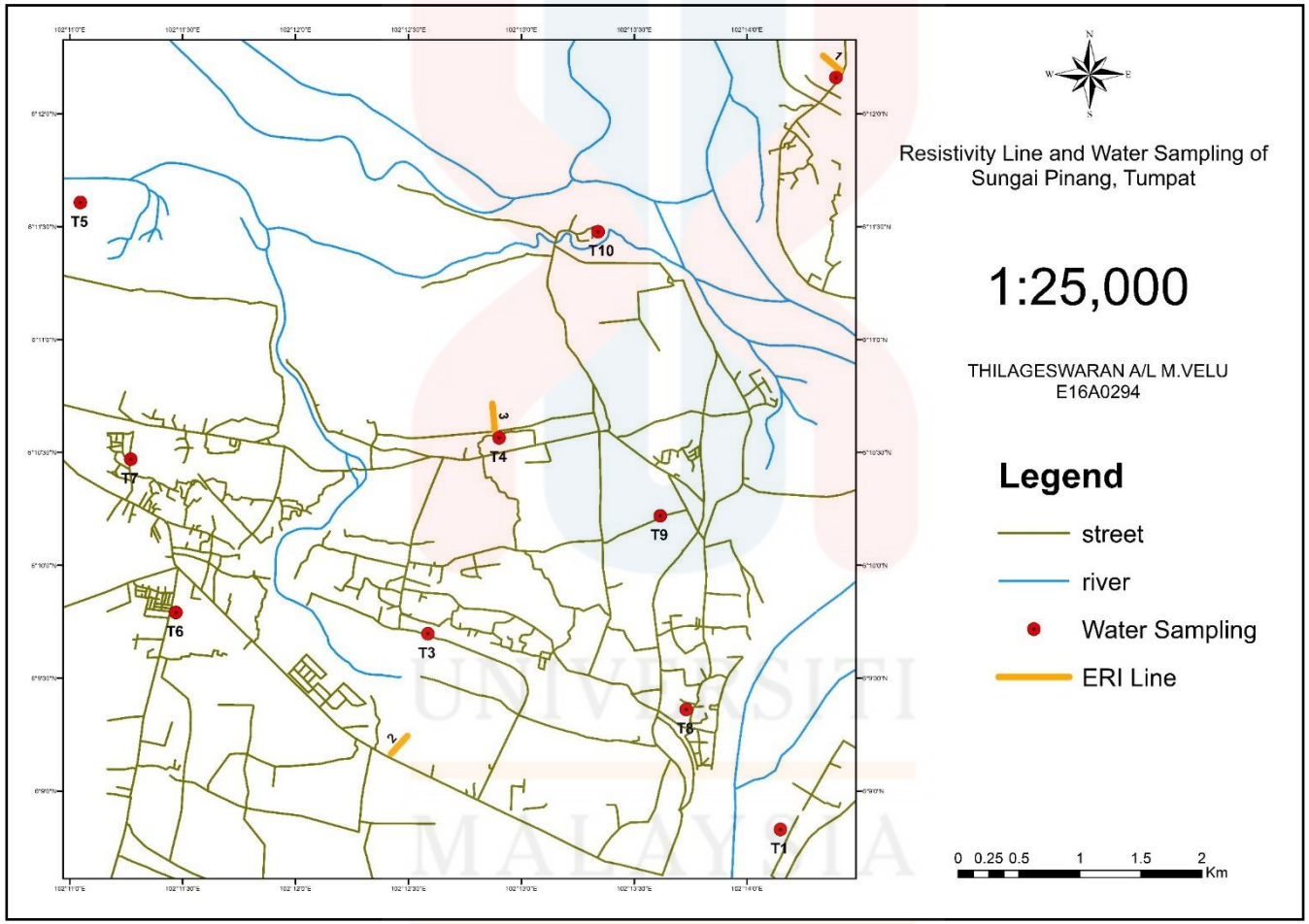


Figure 5.1: The location of resistivity survey line and the water sample

5.4 Result and Discussions

Basically, the result of water samples mostly groundwater samples shows different values and concentration for each location. The factors which contribute to differences in values and concentration of water samples also discussed in this chapter. At the end, these result then compared with National Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia. This standards used as the benchmark to determine the groundwater quality status around Tumpat, Kelantan.

5.4.1 Resistivity Survey Line

The resistivity survey line conducted at three places and all the details of the survey line are given in table 5.1. The interpretation of each line based on the table 5.2 given by (Loke, 2000).

Table 5.1: Details of Resistivity Survey Line

No of survey line	Location	Coordinates	Elevation	Array	Distance to shoreline
Line 1	Kampung Teluk Katak	6º20’37.1”N 102^{0}23’95.4”E	8m	Pole dipole	2 Km
Line 2	Kampung Kepulau	6º15’33.6”N 102º23’95.9”E	10m	Pole dipole	5 Km
Line 3	Kampun Kok Keli	6º17’48.4”N 102º21’45.4”E	5m	Pole dipole	2 Km

Table 5.2: Resistivity of some common rock minerals and chemicals

Material	Resistivity (Ω•m)
Igneous and Metamorphic Rock	
Granite	$5x10^3 – 10^6$
Basalt	$10^3 – 10^6$
Slate	$6x10^2 – 4x10^7$
Marble	$10^2 – 2.5x10^{-2}$
Quartzite	$10^2 – 2x10^8$
Sedimentary Rocks	
Sandstone	$8 – 4x10^3$
Shale	$20 – 2x10^3$
Limestone	$50 – 4x10^2$
Soils and waters	
Clay	1 – 100
Alluvium	10 – 800
Groundwater	10 – 100
Sea water	0.2

(Source Loke, 2000)

a) Resistivity Survey Line 1

Resistivity survey Line 1 is located in a wide open field at 6º20’37.1”N and 102^{0}23’95.4”E with a length of 200 m in the N-S direction (Figure 5.2). Based on the resistivity image of Line 1, the resistivity values are from 0.28 Ωm to more than 4725Ωm (i.e. color ranges from darkblue to dark purple in Figure 5.3). The result shows there is high quantity of water under the ground. Based on the result, its shows the unsaturated top soil material from 4 to10 Ωm. Based on the value the upper part dominant by alluvium. The lowest resistivity part shows there is groundwater potential. Based on resistivity value by (Loke, 2000) the 0.2 Ωm to 10Ωm will be seawater intrusion. The figure 5.2 shows the resistivity profile of line 1.

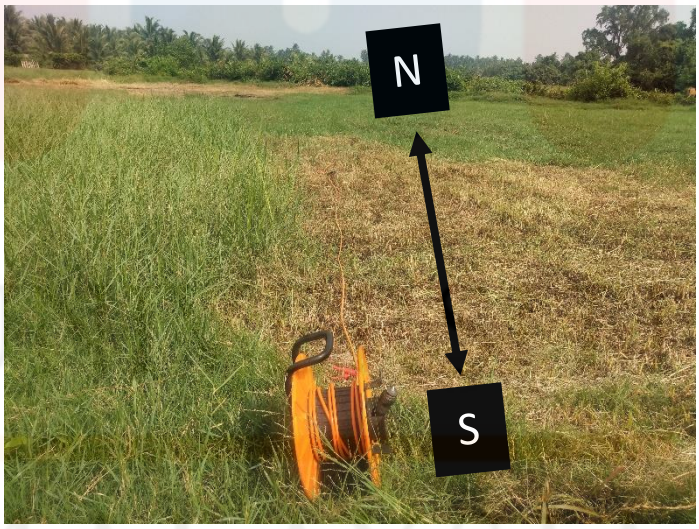


Figure 5.2: Location of the resistivity survey Line 1.

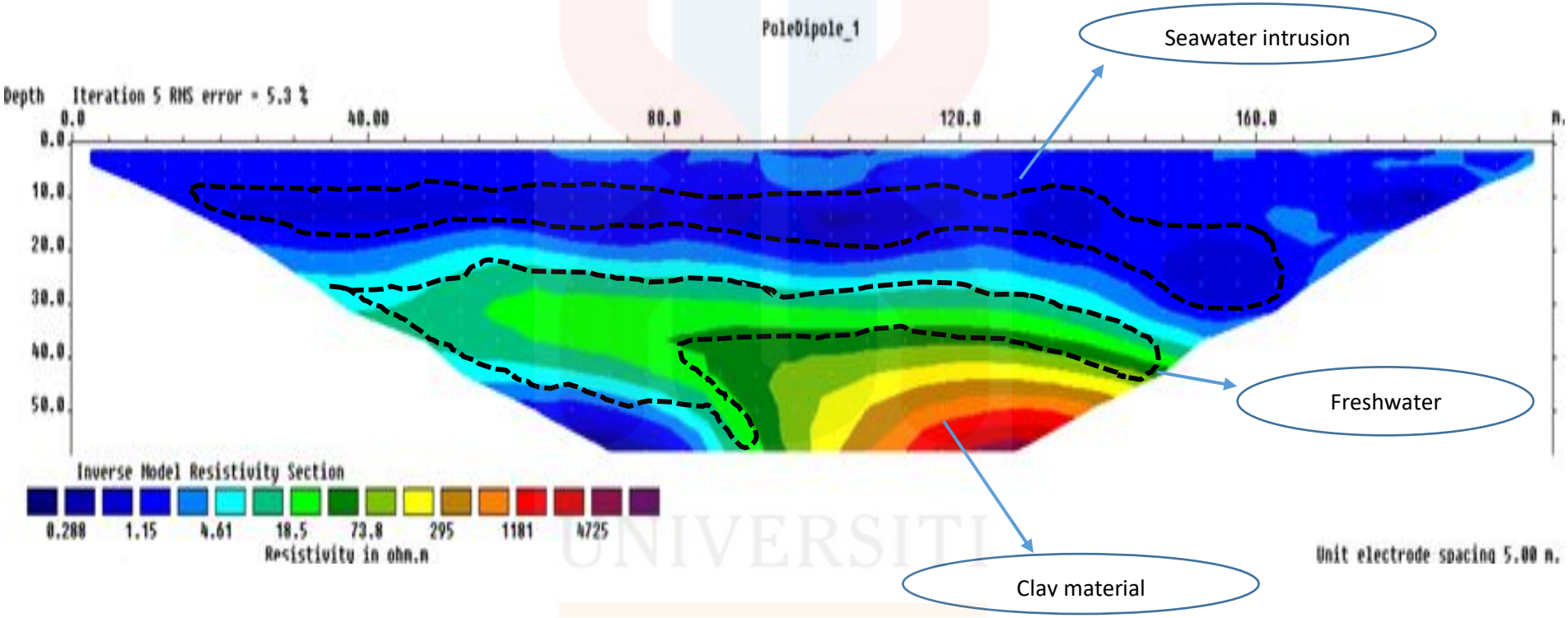


Figure 5.3: The resistivity profile of line 1

b) Resistivity Survey Line 2

Resistivity survey Line 2 is located in a wide open paddy field at 6º15’33.6”N and 102º23’95.9”E with a length of 200 m in the N-S direction (Figure 5.4).The highest resistivity value is 125 Ωm and the lowest value is 0.975 Ωm. The result shows there is low amount water under the ground. Based on the result, its shows the unsaturated soil material from 10 to 130 Ωm. Based on the value the upper part dominant by clay and alluvium. The middle part show high resistivity whisch clay material. The lowest resistivity part shows there is groundwater potential. Based on resistivity value by (Loke, 2000) the 0.9 Ωm to 10Ωm will be seawater intrusion which at depth of 10m and 60m. The figure 5.5 shows the resistivity profile of line 2.

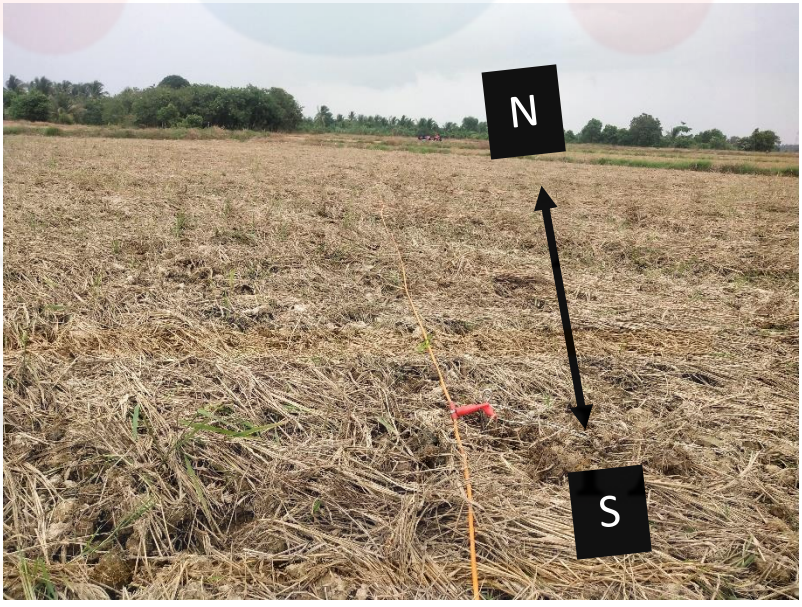


Figure 5.4: The location of the resistivity survey Line 2

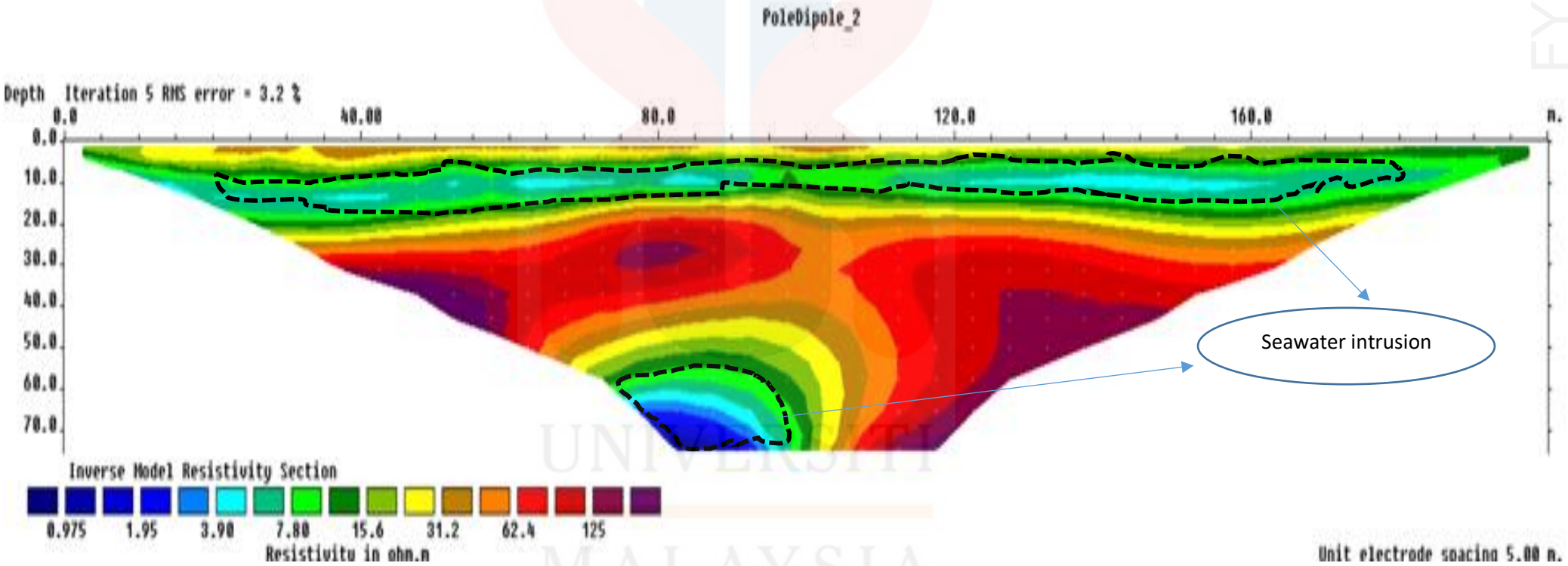


Figure 5.5: Resistivity profile of Line 2

c) Resistivity Survey Line 3

Resistivity survey Line 1 is located in a wide open field at 6°17’48.4”N and 102°21’45.4”E with a length of 200 m in the N-S direction (Figure 5.6). The highest resistivity value is 69.9 Ωm and the lowest value is 0.546 Ωm. Based on the result, its shows the unsaturated top soil material from 10 to 70 Ωm. Based on the value the upper part dominant by clay and alluvium with suface water. The lowest resistivity part shows there is groundwater potential. Based on table 5.2 it must be sea water intrusion. The figure 5.7 shows the resistivity profile of line 3.

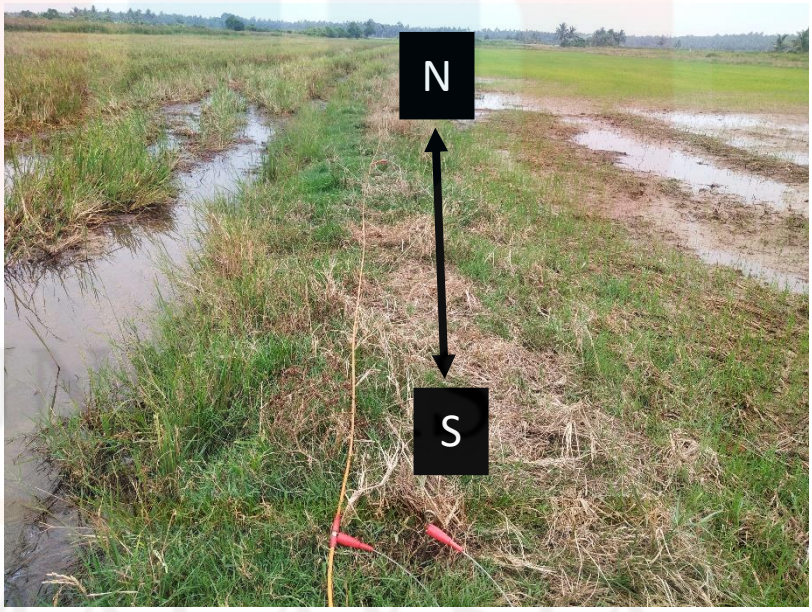


Figure 5.6 : The location of resistivity survey line 3

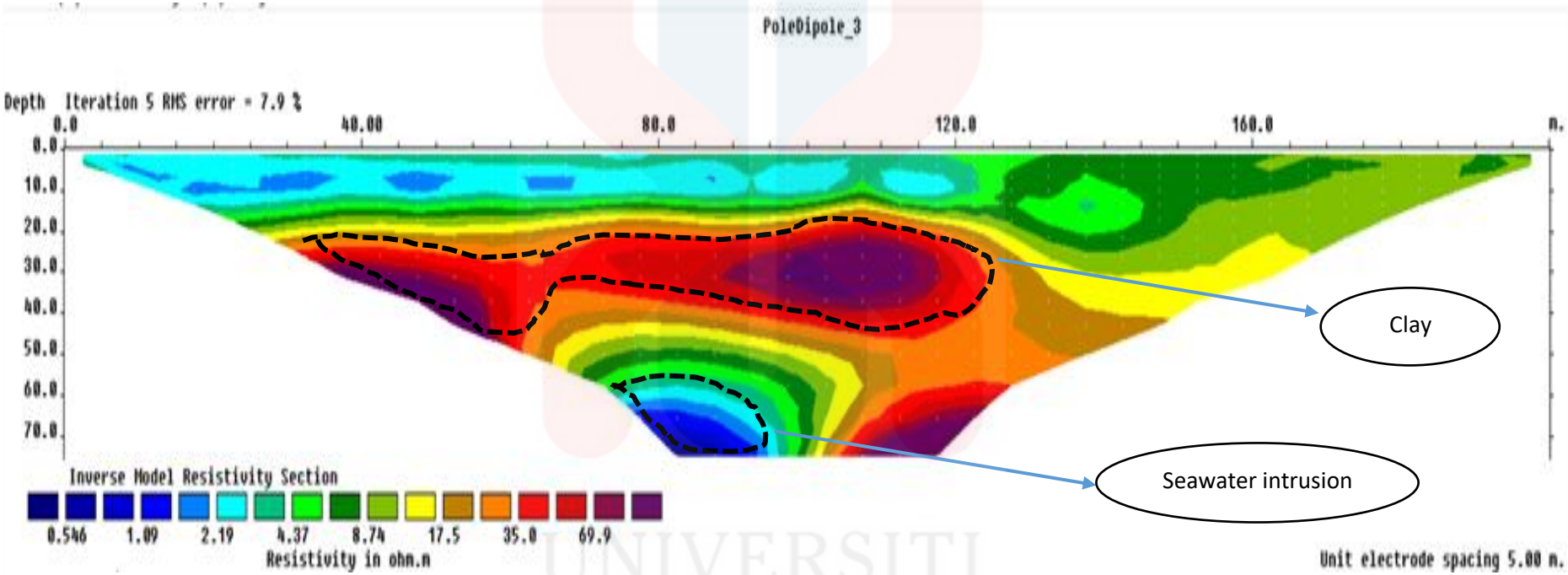


Figure 5.7: Resistivity profile of line

5.4.2 Insitu Parameter of Groundwater

The water sample for insitu analysis conducted at ten places and all the details of the samples are given in table 5.3 and table 5.4.

Table 5.3: Sampling details

No of sample	Type of water sample	Location	Coordinates	Elevation (metre)	Distance to shoreline (kilometre)
T1	Groundwater	Kampung Penambang	6º14’71.78” 102º23’58”	13.85	8.33
T2	Groundwater	Kampung Teluk Katak	6^0 20’26.8” $102^0$23’99.1”	10.24	1.50
T3	Groundwater	Kampung Kok Pasir	$6^0$16’16.233” 102º20’97.7”	8.95	6.50
T4	Groundwater	Kampung Kok keli	6º17’60.87” 102º21’50.3”	11.19	4.90
T5	Groundwater	Kampung Besut	6º19’34.6” 102º18’41.1”	11.30	3.00
T6	Groundwater	Badang Kerian	6º16’31.94” 102º19’11.6”	16.81	7.00
T7	Groundwater	Kampung Belukar	6º17’45.09” 102º18’78.3”	11.37	5.81
T8	Groundwater	Kampung Dalam Pandan	6º15’60.32” 102º22’88.4”	16.27	7.25
T9	Groundwater	Kampung Gerong	6º17’03.24” 102º22’69.3”	13.40	5.72
T10	Groundwater	Kampung Pulau Gorek	6º19’13.08” 102º22’23.44”	7.16	3.16

Table 5.4: Physical Parameter of groundwater samples around study area

Sample	pH	Salinity (ppt)	Total Dissolved Solid (TDS) mg/L	Turbidity (NTU)	Total Suspended Solids (TSS) mg/L	Electrical conductivity µs/cm
Permissible limit in MOH 2000	5.5 – 9.0	0.5	1000	5	-	200-800
T1	5.96	0.1	172.7	0.15	99	291.9
T2	6.79	4.1	581.0	9.99	320	989.9
T3	6.20	0.1	174.7	0.68	121	290.3
T4	6.18	0.1	107.8	0.31	278	181.6
T5	6.48	6.0	1061	2.14	116	1979
T6	5.55	0.1	82.38	7.12	110	140.3
T7	6.28	0.1	126.8	4.79	101	212.1
T8	6.22	0.1	134.8	2.09	168	230.7
T9	6.17	0.1	148.2	2.32	112	250.3
T10	6.37	0.2	225.8	3.15	118	379.3

a) pH

pH esteem is significant parameter to portray nature of groundwater in light of the fact that pH worth can controls the sum and substance type of solutes in groundwater (Fisher, Goodmann, & Webb, 2002). pH value generally show whether water samples is acidic or alkaline. Based on Table 5.3, the values for pH ranged from 5.55 to 6.79. T6 showed lowest pH value which is 5.55 whereas T2 showed highest value of pH value which is 6.79. The average of pH value for all water samples was 6.22. Low pH value of T6 may cause by cultivation activities as the location where sample was taken near with paddy cultivation. Cultivation in agricultural over long period may cause soil to be more acidic by nutrient uptake of bases (Knutsson, 1994).As water pass through the acidic soil, the water become acidic as well before the water infiltrate into groundwater. The range of pH value from 5.55 to 6.79 is acceptable according to National Guidelines of Raw Water Quality Standard from Ministry of Malaysia (MOH) as shown in table 5.4.

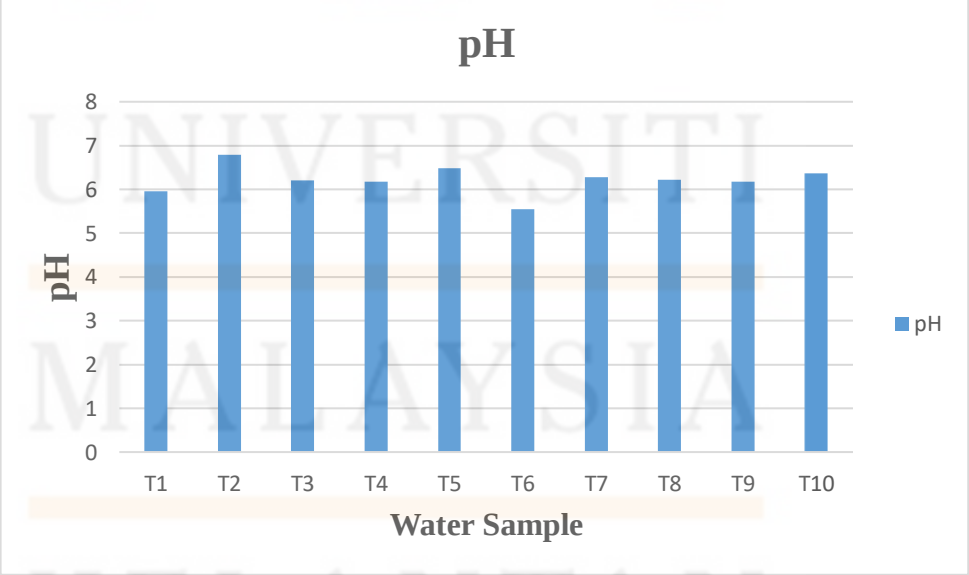


Figure 5.8: pH value of water samples around Tumpat, Kelantan

b) Total Dissolved Solid (TDS)

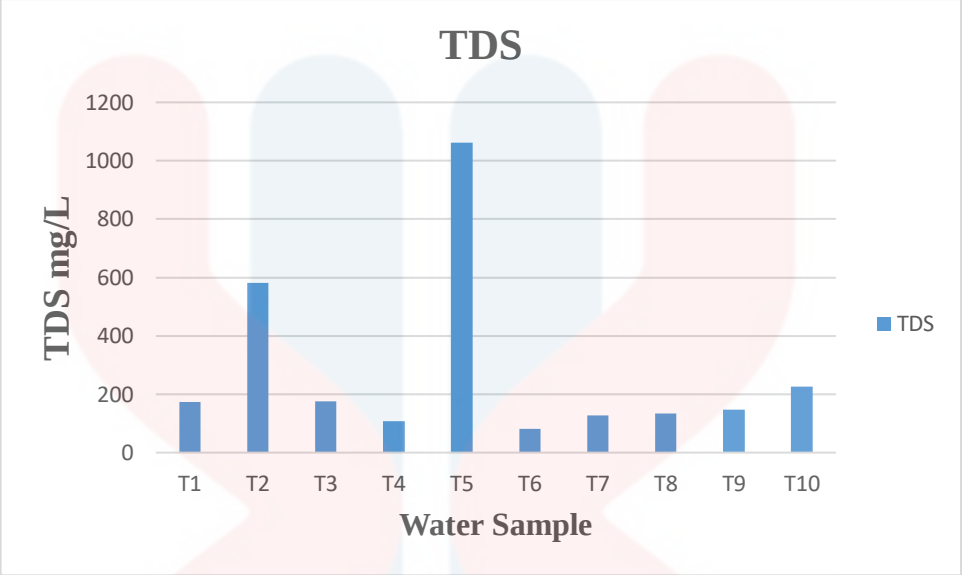


Figure 5.9: TDS of water samples around Tumpat, Kelantan

Table 5.5: Classification of TDS (Total dissolved solids in Drinking-water Background document for development of WHO Guidelines for Drinking-water Quality, 2003)

TDS level	TDS mg/L	Classification
Excellent	< 300	T1, T3, T4, T6, T7, T8, T9, T10
Good	300-600	T2
Fair	600- 900	-
Poor	900-1200	T5
Unacceptable	>1200	-

The range of TDS around the study area is 82.38mg/L to 1061mg/L with the average value 281.52mg/L. These all water samples are allowable to the limit of standard of MOH. The water sample in T5 has the highest value which is 1061mg/L. May be the water sample contain high concentration of Sodium, Copper, Iron, Potassium, Manganese (Ojo, Otieno, & Ochieng, 2012).

c) Turbidity

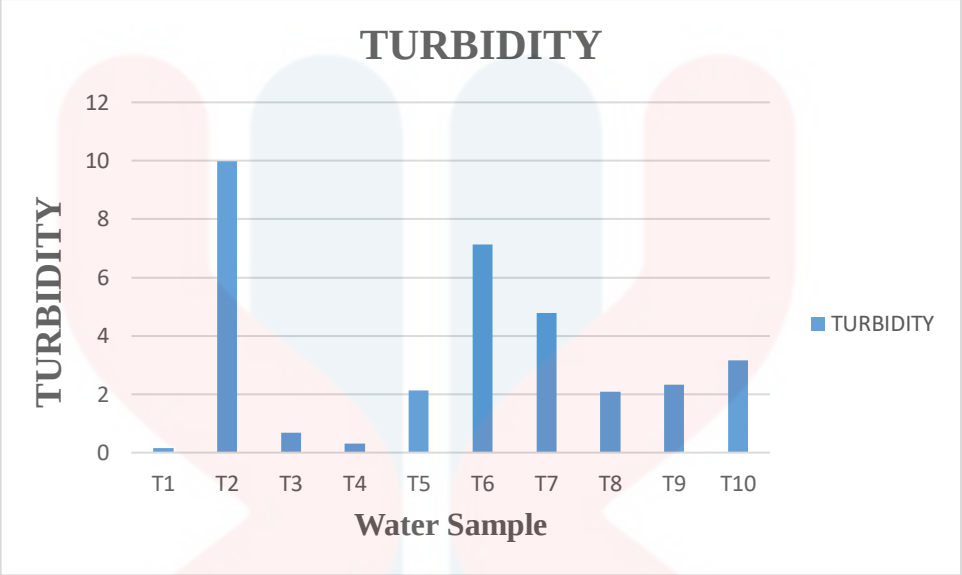


Figure 5.10: The turbidity of water samples around Tumpat, Kelantan

The range of turbidity at study area is 0.15 to 9.99 NTU with average value of 3.27 NTU. According to the MOH standard for drinking water T2, T6 are not acceptable samples because these two samples are more 5 Turbidity is a parameter to gauge the shadiness the water. In other and, turbidity of water tests may brought about by the nearness of suspended material, measured from colloidal to coarse scattering.

d) Salinity

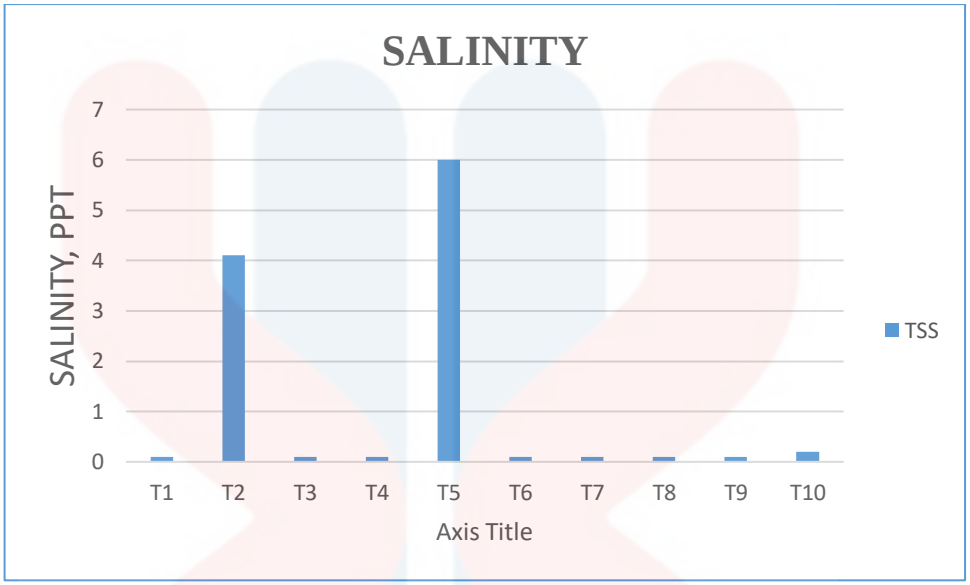


Figure 5.11: The salinity of water samples around Tumpat, Kelantan

0.1 to 6 was the range of salinity values in water samples collected around Tumpat, Kelantan. T5 recorded high value of salinity with 6.0 while T1, T3, T4, T6, T7, T8, T9 recorded low value of salinity with the 0.1(Figure 5.12). The average value is 0.98. T2 and T5 recorded high salinity which contain high amount of sodium chloride.

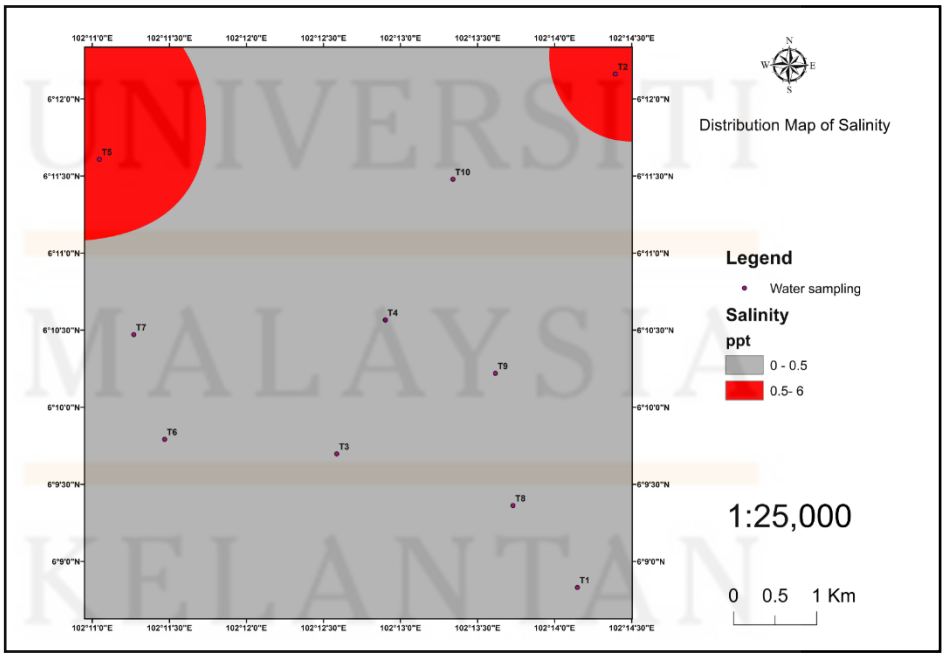


Figure 5.12: The distribution map of salinity

e) Electrical conductivity

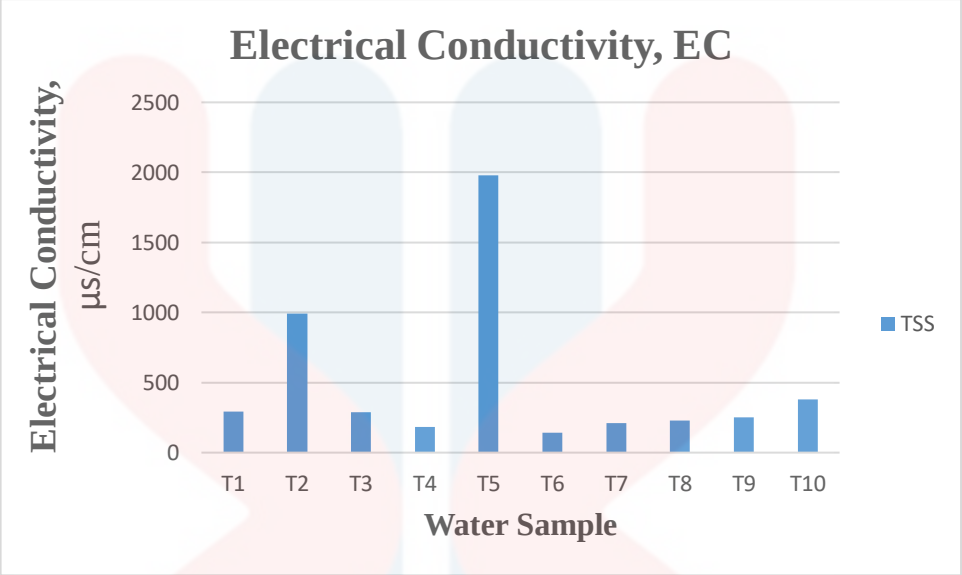


Figure 5.13: The EC of water samples around Tumpat, Kelantan

Electrical conductivity (EC) in study area recorded from 140.3 µS cm^{-1} to 1979 µS cm^{-1}, T5 had highest value of EC whereas T6 had lowest value of EC. EC is a measure of capacity and ability of water to conduct electric current due to presence of dissolved salt in water ("The Electrical Conductivity of Water," n.d.) Dissolved salts that capable to conduct electric current is sodium chloride (NaCl). Therefore, T2 and T5 may had high amount of NaCl because the sample exceed the standard value permissible limit in MOH 2000.

5.4.3 Chemical parameters of water samples

Result of chemical parameters of water samples around Tumpat, Kelantan was showed in Table 5.6. All the water samples tested by using Atomic Absorption Spectroscopy (AAS).

Table 5.6: Chemical parameters of water samples

Elements, mg/L	Water samples					Permissible limit in MOH 2000
	T4	T5	T6	T8	T10	
Cu	0.039	0.063	0.040	0.042	0.046	1.0
Na	7.127	605.4	7.426	6.199	19.93	200
Fe	0.114	0.765	1.072	0.402	0.747	1.0
K	6.303	27.51	2.491	3.547	5.776	30
Mn	0.041	0.064	0.029	0.052	0.148	0.2
Cl	30.29	1288.4	43.07	29.82	50.55	250

a) Copper, Cu^{2+}

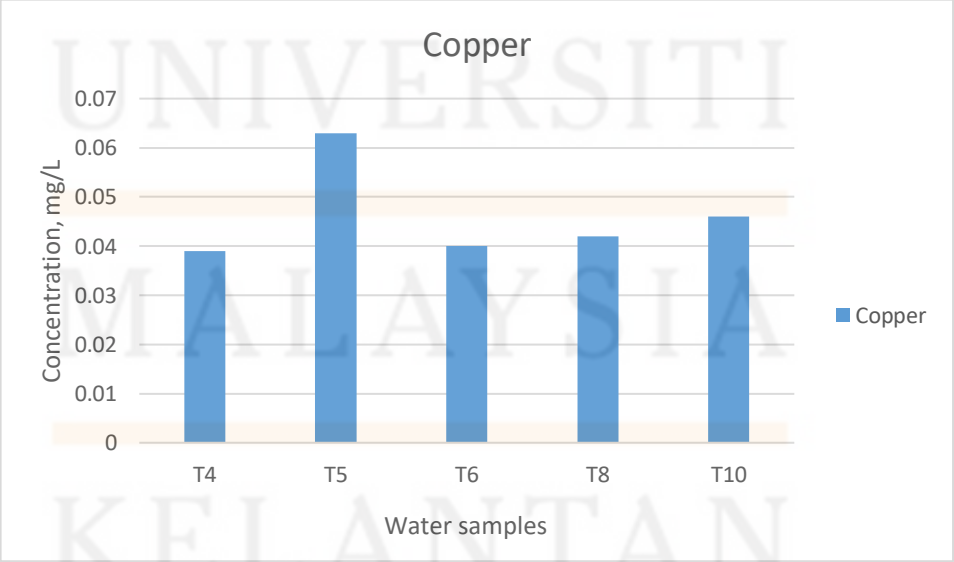


Figure 5.14: Copper ion concentration around Tumpat, Kelantan

Copper is one of essential alkaline-earth element for life forms. The concentration for calcium ions around Tumpat, Kelantan ranged from 0.039 mg/L to 0.063 mg/L. All the samples are acceptable because below the permissible limit.

b) Sodium, Na^+

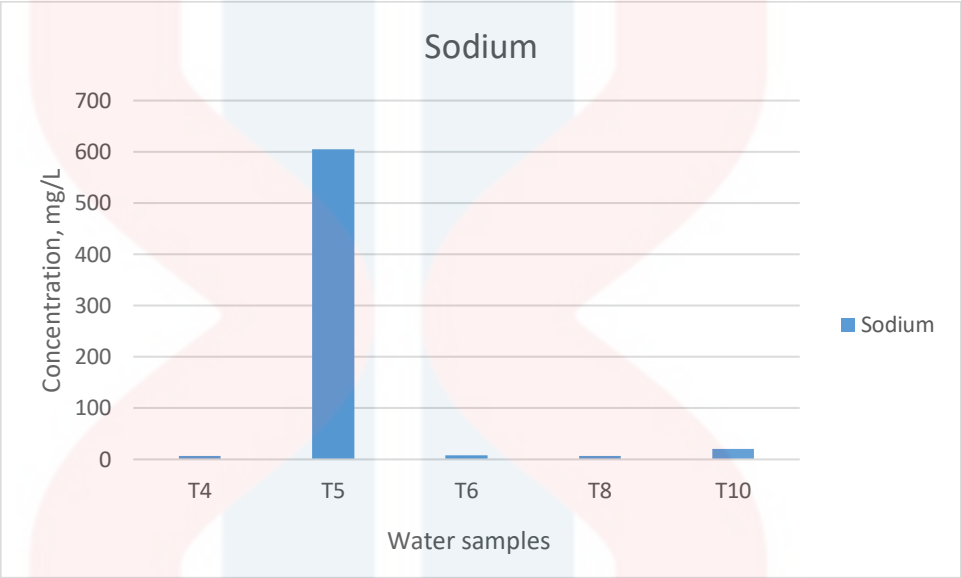


Figure 5.15: Sodium ion concentration around Tumpat, Kelantan

The range of sodium ions concentration of water samples around Tumpat, Kelantan start from 6.199 mg/L to 605.4 mg/L. As the result in the Table 5.6, T5 had 605.4 mg/L of sodium ions concentration which exceed the permissible limit. This can be explained by natural cation exchange, reaction of ion exchange on the surfaces of certain clay minerals meanwhile sodium is released to the water in exchange for calcium or magnesium. As water from precipitation had contact with soil contained sodium, water brought together the solutes enter into the groundwater. It may be seawater intrusion occurs in the groundwater.

c) Iron, Fe^{2+}

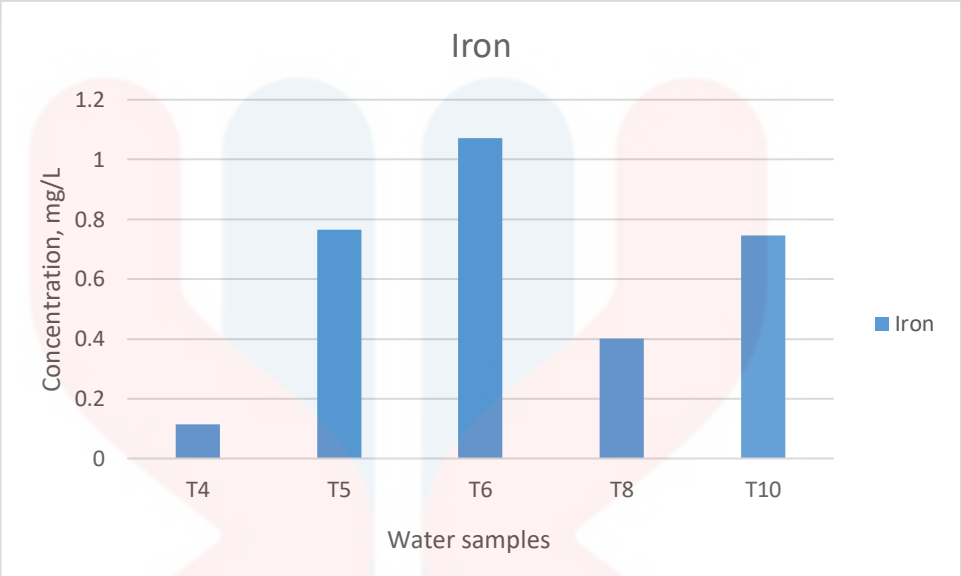


Figure 5.16: Iron ion concentration around Tumpat, Kelantan

Concentration of iron ions around Tumpat, Kelantan ranged from 0.114 mg/L to 1.072 mg/L. Table 5.6 clearly showed that T6 had 1.072 mg/L of iron ions concentration, which the highest value compared to others. Amount of iron ions concentration should not more than 1 mg/L in terms of suitability of water for daily purposes as excessive of iron in water can cause stains pipes, laundry and cooking appliances (Todds, 2005). Based on permissible limit T6 exceed the limit.

d) Potassium, K

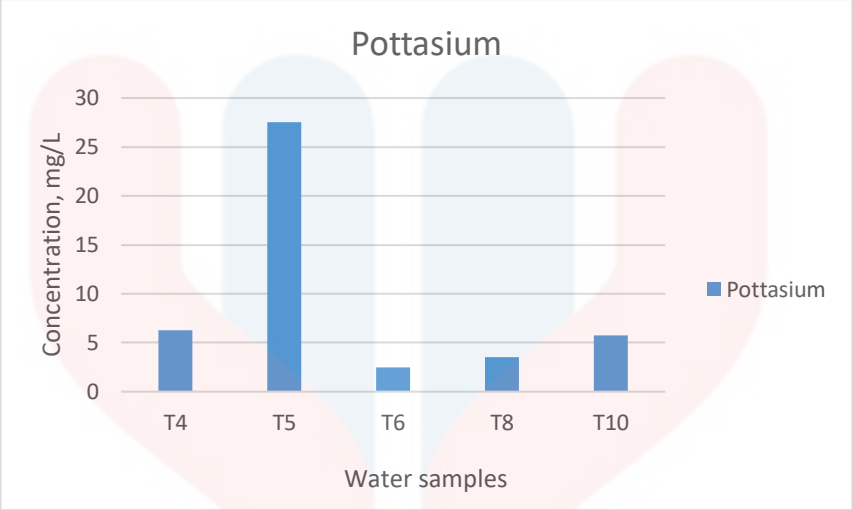


Figure 5.17: Potassium ion concentration around Tumpat, Kelantan

Analysis of geochemical data showed potassium ions concentration around Tumpat, Kelantan ranged from 2.491 mg/L to 27.51 mg/L. T2 recorded highest concentration of potassium ions which is 27.51 mg/L while T6 recorded lowest concentration of potassium ions which is 2.491 mg/L. Potassium ions originated from the dissolution process of several silicate minerals and clay minerals which present sub surface. This explains why T6 recorded high concentration of potassium ions. All water samples showed concentration of potassium ions below than 30 mg/L, indicates groundwater around Tumpat, Kelantan can be used for human activities, livestock and agriculture activities. This followed standard from MOH.

e) Manganese, Mn^{2+}

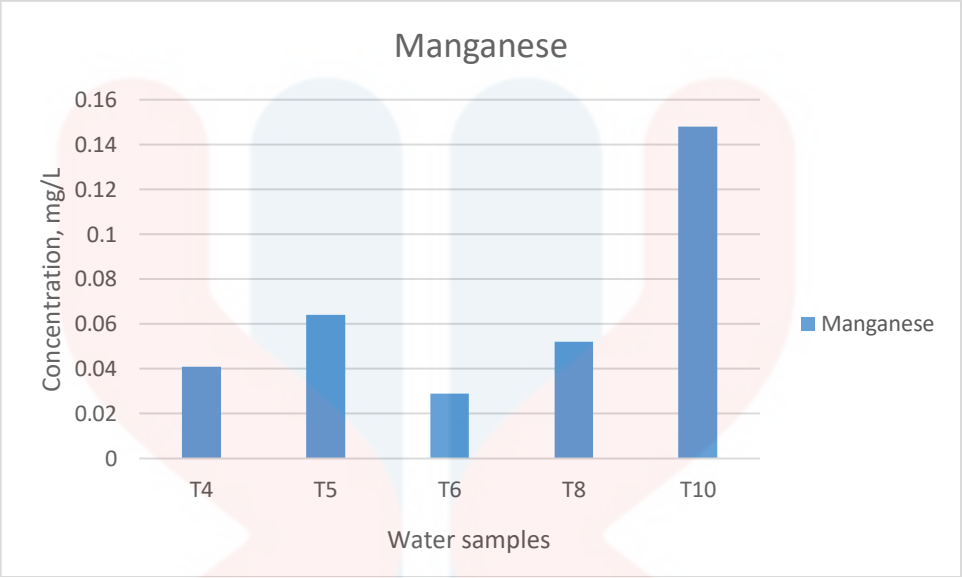


Figure 5.18: Manganese ion concentration around Tumpat, Kelantan

The concentration for manganese ions around Tumpat, Kelantan ranged from 0.029 mg/L to 0.148 mg/L. Manganese can cause discoloured water at concentrations that are still safe to drink. There are no known health concerns from hand washing, showering or bathing in water with high levels of manganese. All the samples are acceptable because below the permissible limit.

f) Chlorine, Cl^-

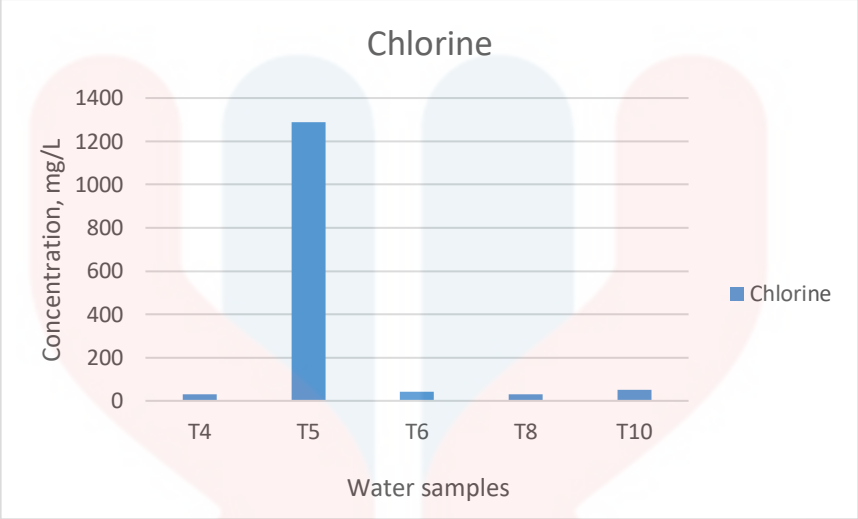


Figure 5.19: Chlorine ion concentration around Tumpat, Kelantan

As illustrated in Figure 5.13 above, around study area, range of chloride ions concentration initiated at 29.82 mg/L to 1288.4 mg/L. The average for chloride concentration is 288.4 mg/L. T8 was at low concentration which is 29.82 mg/L of chloride ions conversely with concentration of chloride ions for T5 soared up to 1288.4 mg/L, top the charts. As for chlorine ions, the limit is not more than 250 mg/L in water as excessive chlorine in water imparts a salty taste. Based on Figure 5.13, all the water samples were below than 250 mg/L except T5. T5 contain high level of salinity. Drinking highly concentrated sources of chlorine can lead to vomiting, coma, and even death. For this reason, many people fear that the chlorine in swimming pools and drinking water can be harmful for health, and cause cancer.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study to identify the geology of the study area is conducted at Lojing. The geological map produced in scale 1:25000 and the objective achieved. Mudstone and schist are the type of rocks deposited at the study area. The study to determine the sea water intrusion conducted at area Sungai Pinang, Tumpat . Kelantan was sheltered and appropriate for use of all reasons in day by day life as per the Guidelines of Raw Water Quality Standard from the Ministry of Health of Malaysia. The result of resistivity survey shows there is sea water intrusion in aquifer. Based on physical and chemical parameter test the sample T5 is not acceptable as drinking water. As conclusion, based on both geophysical and hydrochemistry, there was sea water intrusion into shallow aquifers happened around Tumpat, Kelantan.

6.2 Recommendation

For the clients of groundwater that contained high centralization of iron particles which above reasonable farthest point are prescribed to filtrate the water before use it for any reasons as abundance iron particles can influence the wellbeing. Future research must be direct again as this wonder can occur in only a couple of years as Tumpat is one of the regions that experience creating stage. The requests of groundwater will be increment and the overdraw of groundwater will interrupt the harmony among seawater and freshwater interface along beach front line and add to the sea water interruption in aquifers. In future, scientists are recommend to utilize increasingly modern research centre instruments to build the exactness and accuracy of the after effect of the investigation.

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APPENDICES

Figure 1.0: Resistivity survey

Figure 2.0: Groundwater wells for water sampling

Figure 3.0: Preparation for AAS method

Figure 4.0: Observing outcrop