GEOLOGICAL MAPPING IN KPF BLAU PLANTATION, LOJING AND IDENTIFY SEA WATER INTRUSION OF COASTAL AQUIFER IN TUMPAT AREA USING ELECTRICAL RESISTIVITY IMAGING AND GEOCHEMISTRY

By

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DECLARATION

I declare that this thesis entitled "Geological Mapping in KPF Blau Plantation and Identify Sea Water Intrusion of Coastal Aquifer in Tumpat area Using Electrical Resistivity Imaging and Geochemistry" is the result of my own research expected as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in any candidature of any other degree.

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Date : January 2020

APPROVAL

"I hereby declare that I have read this thesis and in my/our opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Applied Science (Geoscience) with Honours"

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Geological Mapping In Kpf Blau Plantation And Identify Sea Water Intrusion Of Coastal Aquifer Tumpat Area Using Electrical Resistivity Imaging And Geochemistry

ABSTRACT

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Lojing Highland is located in SouthWest of Gua Musang part and mainly composed by high land use of agricultural activity while Tumpat is to be known as city near to the shore line and famous of coastal product. The present research focus on geological mapping and seawater intrusion into groundwater in parts of Lojing, Gua Musang and Tumpat respectively. Geological map produced is 1:25000 scale by traversing, field observation and petrographic study. Lithology mainly composed by mudstone, quartzite, limestone and schist unit in the study area. For seawater intrusion study, integrated approach is applied using ERI and chemical laboratory test using AAS and titration method. Total five survey line is done by using pole dipole and wenner configuration. The data collected of 200 meter using ABEM Terrameter LS, 42 electrode with spacing 5 meter and process using RES2DINV. Based on profile, all five location of survey line showing seawater intrusion. In addition, in situ analysis of physical parameter (TDS, TSS, Turbidity and etc) is done in selected well location and also chemical parameter is examined to analyze (Cl, Mn, Fe and etc). From the in situ chemical result, location 1 shows high salinity value as the location has shortest distance to the shore line. Based on ERI and chemistry result indicated the most intrusion shows in the depth of 30 meter below.

Keyword: Seawater intrusion, ERI, AAS, chemical parameter, physical parameter, salinity.

Pemetaan Geologi Di Ladang KPF Blau Dan Mengenalpasti Resapan Air Laut Di Akuifer Kawasan Pantai Tumpat Menggunakan Pengimejan Keberintangan Elektrik Dan Geokimia

ABSTRAK

Tanah Tinggi Lojing terletak dikawasan Selatan-Barat daerah Gua Musang dan terdapat banyak tanah tebus guna dijadikan kawasan aktiviti pertanian manakala Tumpat pula terkenal dengan bandar pesisir pantai kerana jaraknya yang paling hampir dengan garis pantai. Tumpat juga terkenal dengan produk dan hasil lautnya. Kajian terkini yang dilakukan berfokus kepada pemetaan geologi dan kajian resapan air laut terhadap air bawah tanah di kawasan Lojing, Gua Musang dan Tumpat. Peta geologi dengan skala 1:25000 dihasilkan dengan menjelajahi semua kawasan kajian, pemerhatian aspek geologi di lapangan dan kajian petrografik. Unit batuan dan litologi dikawasan kajian adalah batu lumpur, kuarzit, batu kapur dan syis. Kaedah integrasi diantara ERI dan ujikaji kimia di makmal dijalankan bagi kajian resapan air laut dengan menggunakan kaedah AAS dan titisan. Sebanyak lima survei dilakukan menggunakan konfigurasi pole dipole dan wenner. Sebanyak 200 meter data dikumpulkan menggunakan ABEM Terramater LS, 42 elektrod dengan jarak setiapnya 5 meter dan diproses menggunakan RES2DINV. Berdasarkan profil, kesemua lima survey dijalankan menunjukkan terdapat resapan air laut di kawasan tersebut. Tambahan pula, analisis parameter fizik turut dijalankan di kawasan tersebut (TSS, TDS, Turbidity dan sebagainya) di kawasan telaga terpilih dan parameter kimia turut diuji bagi menganalisis (Cl, Mn, Fe dan sebagainya). Lokasi 1 menunjukkan kemasinan yang paling tinggi berdasarkan keputusan dan data parameter kimia in situ kerana jarak yang terlalu dekat dengan garis pantai. Berdasarkan keputusan ERI dan kajian ujikaji kimia menentukan kebanyakan kawasan resapan air laut di kawasan rendah 30 meter kebawah.

Kata kunci: Resapan air laut, ERI, AAS, parameter kimia, parameter fizik, kemasinan

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LIST OF SYMBOL

Symbol	Name
%	Percentage
°	Degree
Ca_+	Calsium
Mg_+	Magnesium
K_+	Potassium
SO_{4-}	Sulphate
Cl_-	Chloride
HCO_{3-}	Bicarbonate

LIST OF ABBREVIATIONS

Abbreviation	Name
ERI	Electrical Resistivity Imaging
SME	Small Medium Enterprise
Mg/l	Milligram per litre
MLD	Million Litre per Day
AKSB	Air Kelantan Sendirian Berhad
TSS	Total Suspended Solid
TDS	Total Dissolved Solid
pH	Percentage Hydrogen
EC	Electrical Conductivity
GPS	Global Positioning System
KPF	Koperasi Permodalan Felda
WHO	World Health Organisation
MOH	Ministry of Health
N	North
E	East
S	South
W	West
AAS	Atomic Absorption Spectrometry
XPL	Cross Polarized
PPL	Plane Polarized
PPT	Part Per Thousand
S/m	Siemen/meter
M	Meter
KM	Kilometre
μScm^{-1}	Micro Siemen per centimeter

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CHAPTER 1

INTRODUCTION

1.1 General Background

The final year research project was focussed on geological mapping in Kampung Lojing, Gua Musang and sea water intrusion in Tumpat area. Kampung Lojing also known as Lojing Highland because of elevation was almost and equivalent to Cameron Highland and distance between them also not quite far. Topography of Kampung Lojing dominated by hilly and mountainous area resulting of the tectonic activity of the area in previous million years ago. Geological mapping was implemented to produce geological map in Kampung Lojing and KPF Blau Plantation. Geological map show topography, lithology, watershed and rock distribution (Richard, 2004). Geological mapping was conducted to know and study about prehistory and geology of Kampung lojing. From the map, all data will be sum up and able to interpret about condition of study area. The information like age of rock, depositional environmental and geological structure were the main core of this study.

Kampung Lojing and KPF Blau Plantaion situated near Cameron Highland and full fill with many plantation and agriculture. Area of Kundasang and Lojing produce temperate vegetable and flower as per elevation mora than 1000 meter above sea level (Asahari, 2015). That mean, main part of Lojing area in Gua Musang covered by forest.

Kampung Lojing also consist of Permanent Forest Reserved Sungai Brok with code of HSK KT026 and in district of South Kelantan (Shahrulnizam et al., 2012).

Tumpat area was located in Northern part of Kelantan. The research location cover Tumpat town along some villages for identify of sea water intrusion. Northern part of Kelantan consist of mainly coastal area include Tumpat, Kota Bharu and Bachok. As one of the last district before crossing national border between Malaysia and Thailand, Tumpat coastal area also have own beautiful beaches along the coastal line. The famous one is Pantai Sri Tujuh located in right before Pantai Geting that near to Tak Bai, Thailand. There also many coastal landform and morphology could be identified along the shore line. Coastal geomorphology concern about landform along the coast and process happen make them change also deal with beach outcrop, rock formation, cliff and sediment deposited there. The project on sea water intrusion was done along coastal area of Tumpat.

The present study for identify seawater intrusion was done by both geochemical test and geophysical survey. The salinity sources and water intrusion easily identify by using geophysical and geochemical. Geophysical test implemented by set three to five line of forty one electrode within the coastal part of Tumpat. Other than that, in situ test of hydrochemistry tested to obtain result of water sample in Tumpat. While result of geophysical test shows reading of rock and soil layer properties beneath earth. Electrical Resistivity Imaging (ERI) was used to identify type of rock underground by using resistivity concept. Resistivity was a mechanism when current flow through differences perspective of earth material. Sea water intruded coastal aquifer and contaminated the domestic well of people living near the shore. Villagers of people who is living in Northern part of Kelantan totally depend on groundwater for daily uses (Samsudin et al., 1997).

In addition many transformation process along with urbanization program implemented by Federal and state government changed and upgrade Tumpat area become a well develop town in Kelantan. A lot of company also offered to drill many wells so that their customer able to use groundwater as a primary sources. The phenomenon increase demand of using the groundwater as the population of people increase along with salt water contamination into aquifer. As the industrialization and urbanization rise up, over drilling borehole by industry also affected give the highest chances of sea water intrusion into groundwater aquifer (Omona et al., 2014). Sea water intrusion become major problem of the people living in Tumpat area.

1.2 STUDY AREA

1.2

a) KPF Blau Plantation

KPF Blau Plantation was located at sub district Lojing in Southern region of Kelantan. Border with district of Gua Musang and Cameron Highland, Pahang. The study area was in between two main district and also along highway of Gua Musang – Lojing – Kuala Betis – Cameron Highland. Main area of Lojing undergo deforestation as rich with forest resources. There were many new deforestation roads to access study area as deforestation still in progress. There were preserved forest near study area which is Hutan Rizab Ulu Berok. The permission from Kelantan Forestry Department needed to get accessed into preserved forest. About 90 % of study area in Kampung Lojing and KPF Blau Plantation was under deforestation while remaining 10 % preserved under Hutan Rizab Ulu Berok as a preserved forest. Figure 1.1 shows the base map of study area in KPF Blau Plantation and Figure 1.2 shows location of KPF Blau Plantation in Kelantan and Peninsular of Malaysia map.

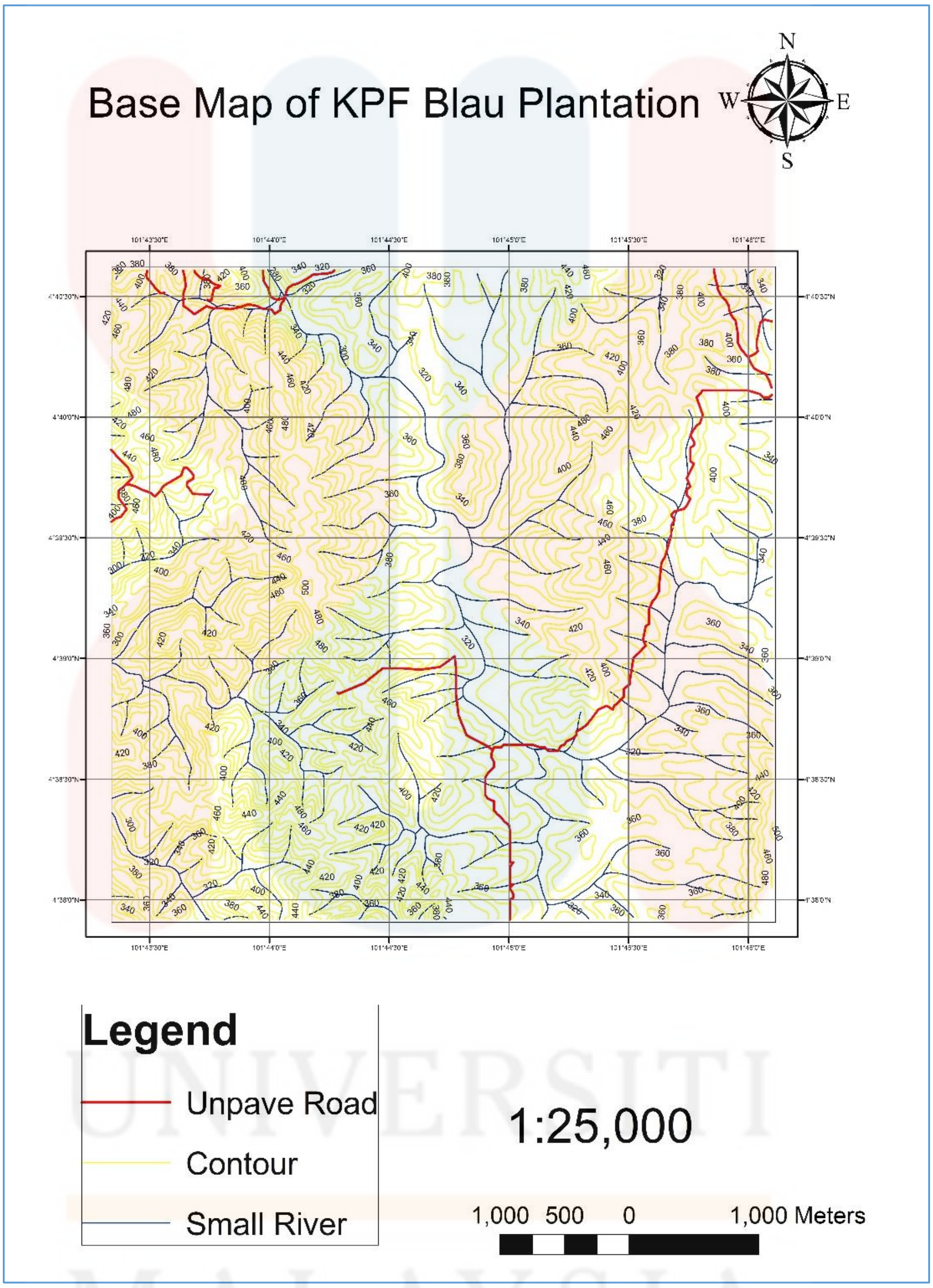

Figure 1.1 : Base map of KPF Blau Plantation

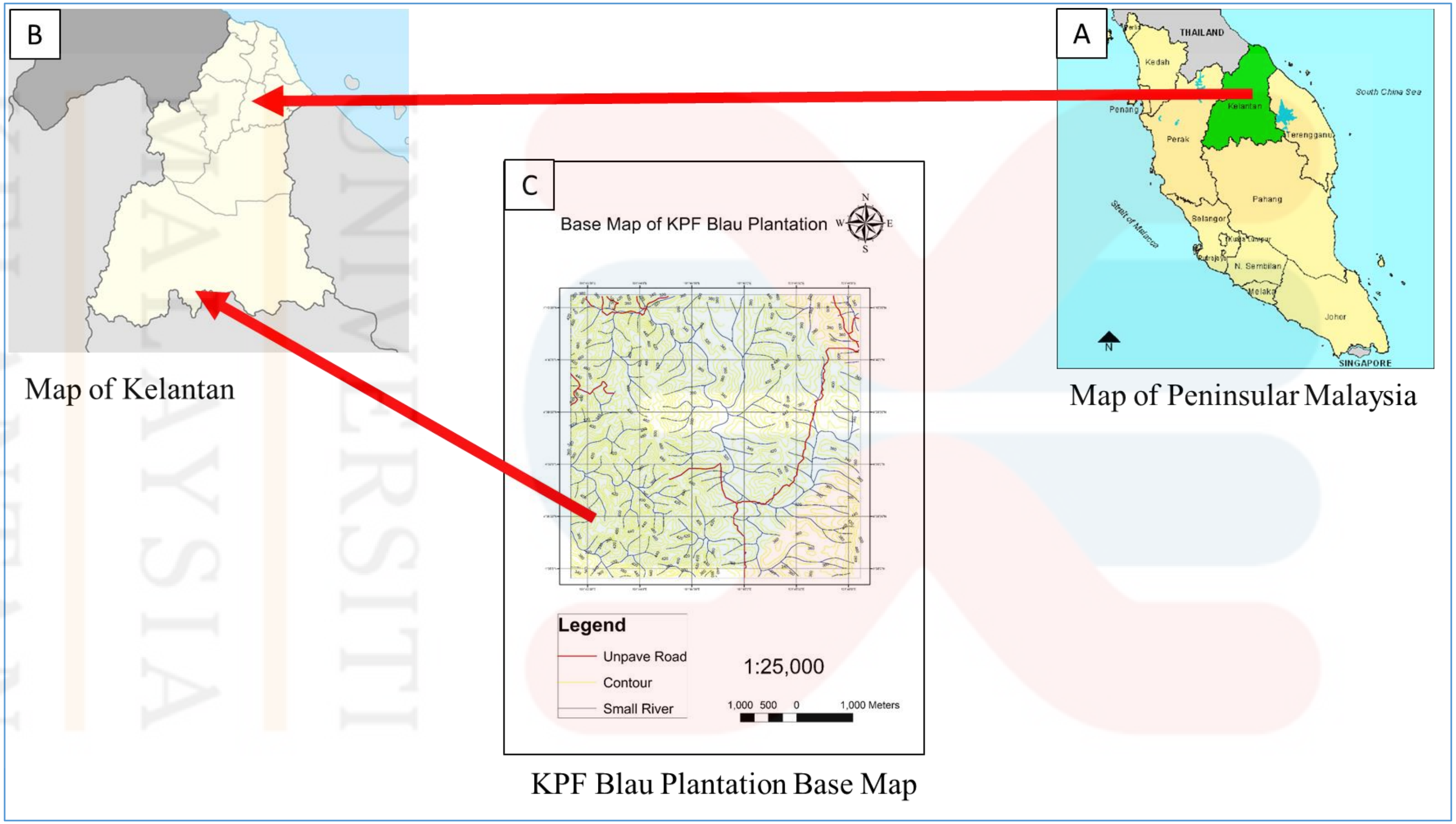

Figure 1.2 : Base map of KPF Blau Plantation in state of Kelantan and Malaysia

b) TUMPAT

Geophysical and hydrochemistry method were implemented in Tumpat coastal area. Tumpat was one of well develop town in Kelantan. Tumpat town located very near to seashore. Tumpat also considered as Malaysia national entrance as situated near the border of Tak Bai, Thailand. People may travel to Thailand via own car and ferry when they were passing through Tumpat. Tumpat also provide train and Railway station as an alternative public transport for the people. The train was well design to deliver either people or any parcel and act as one of the courier service. The last railway station in Tumpat provide service to entire Kelantan, Pahang, Selangor and lastly end in Gemas Railway Station, Negeri Sembilan. The near last city is capital city of Kelantan which was Kota Bharu. The journey take place in Tumpat as it was first district in Kelantan. Figure 1.3 shows Base map of Tumpat area while Figure 1.4 shows map with large image.

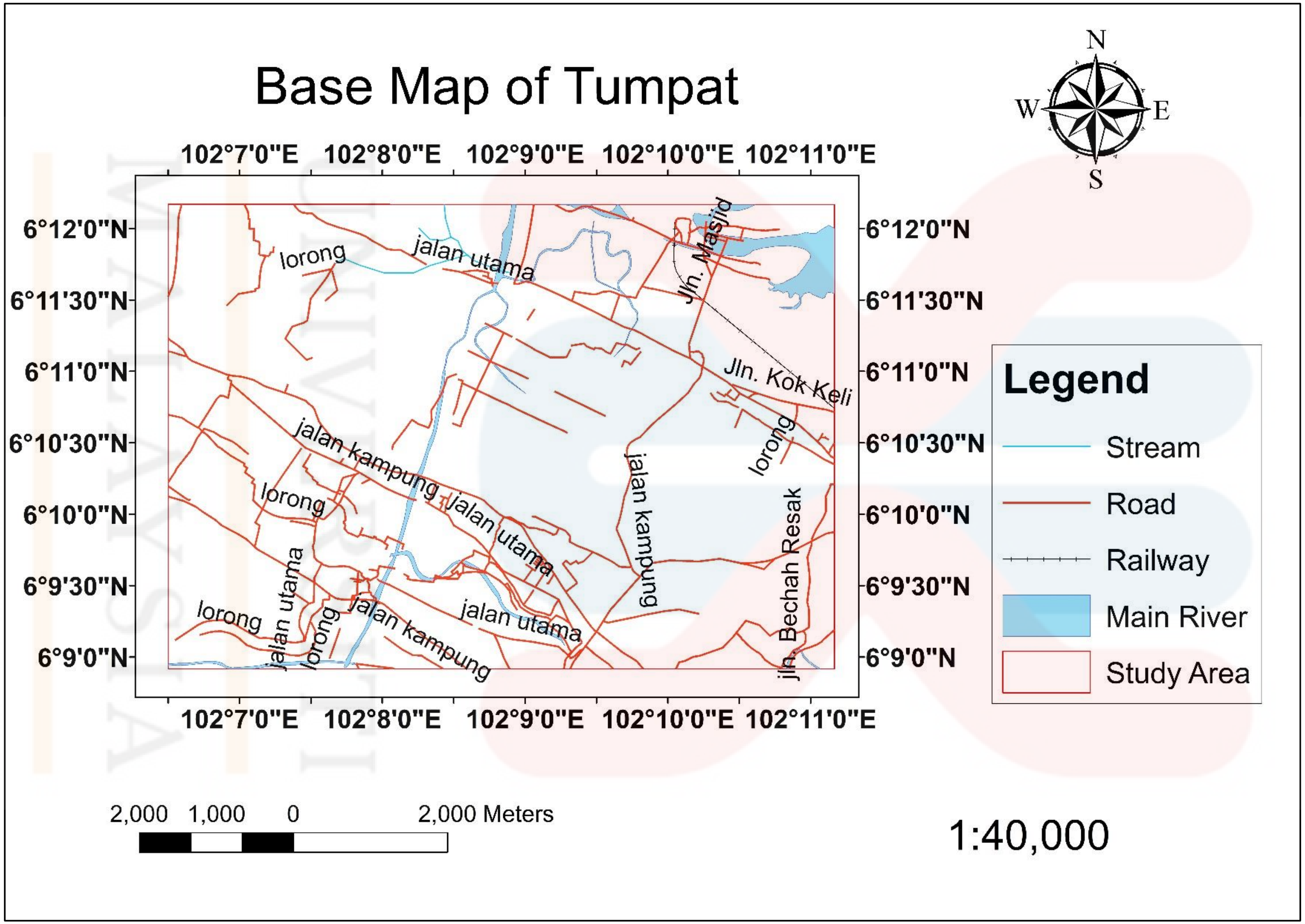

Figure 1.3: Base Map of Tumpat

Figure 1.1.4 location of study area in Tumpat town near the coastal and shore line from Kelantan and Peninsular Map.

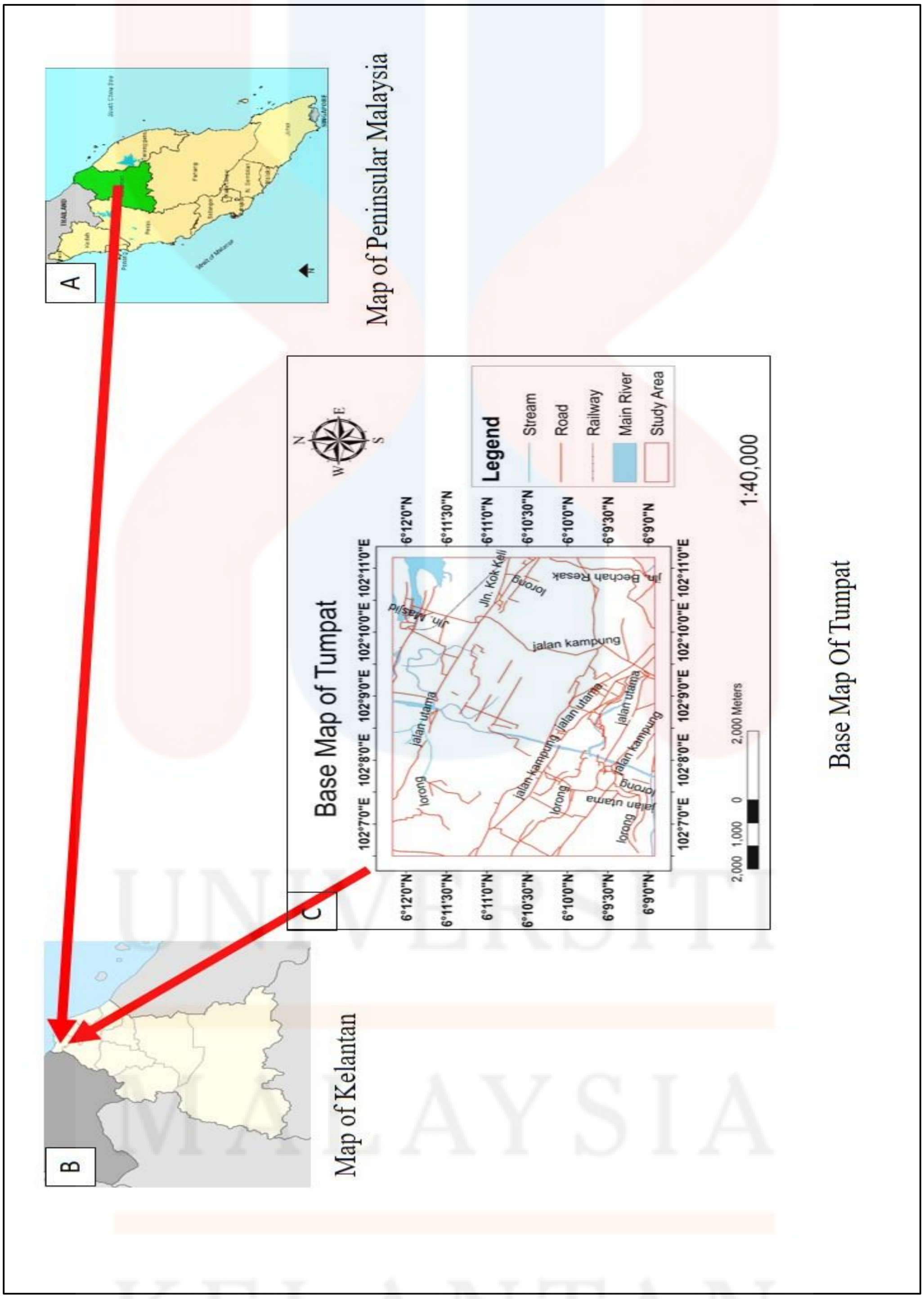

Figure 1.4 : Location of Tumpat in state of Kelantan and Malaysia

1.2.1 Road Connection / Accessibility

There was only small road or deforestation road exist in KPF Blau Plantation. Unpavement road that only can be accessed by motor cycle or four wheel drive car. Unless just walked to go in or out of the area. Distance on straight line in about 5 to 10 kilo meters. However, there was one highway and federal road that connect the area as the location was between Cameron Highland and Gua Musang which is Jalan Gua Musang – Cameron Highland. Distance between entrance of KPF Blau Plantation to Gua Musang city in about 40 kilo meter.

Another option was by using river road. Use boat to travel along Sungai Berok until reach the study area in Kampung Lojing. This method is quite dangerous as there was no proper jetty or any proper boat provided in this area. Figure 1.5 show accessibility map in KPF Blau Plantation.

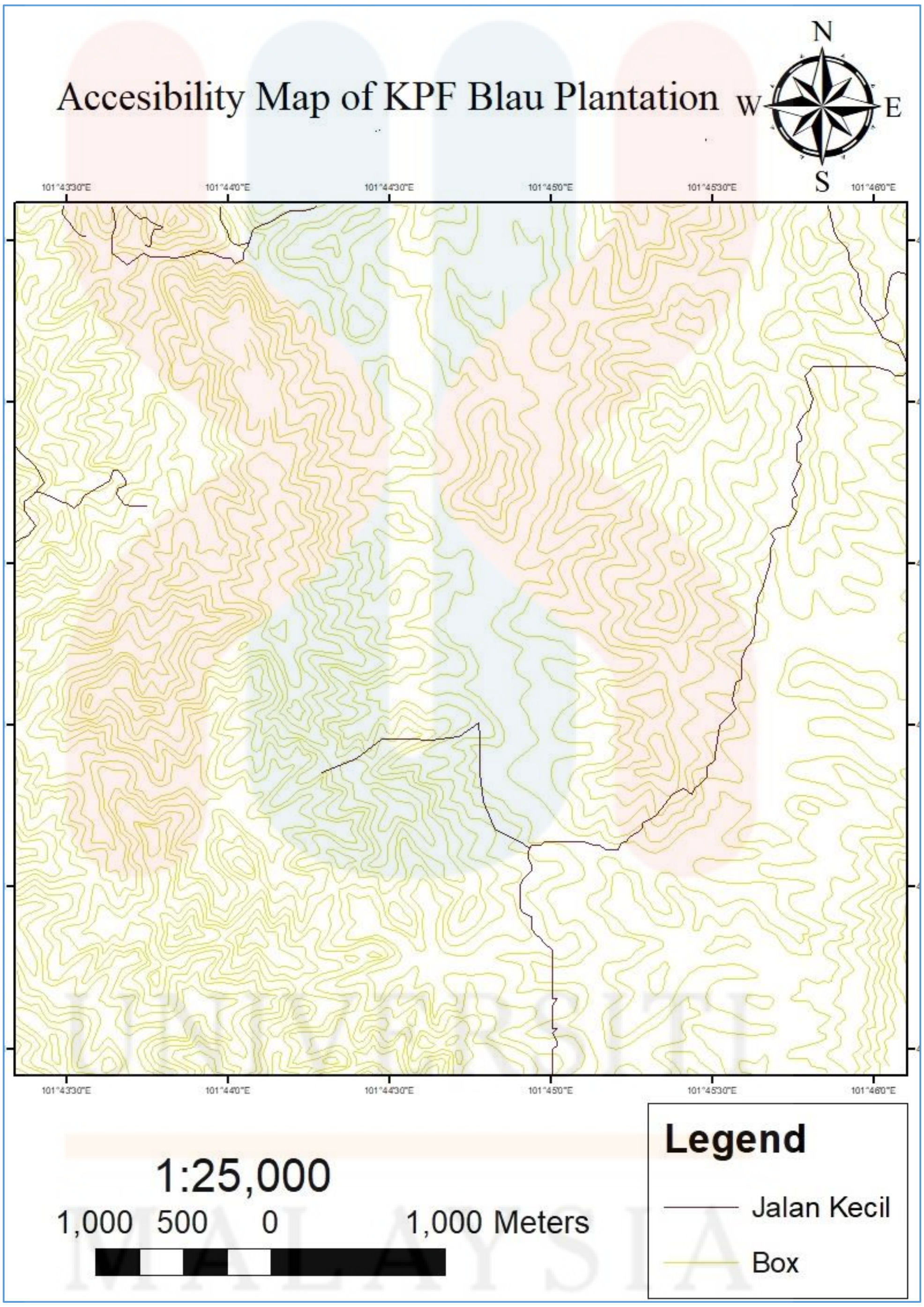

Figure 1.5 : Accessibility Map of KPF Blau Plantation

There are many road connection and accessibility in Tumpat area and Tumpat town. Generally, people inside and outside of Tumpat may travel by using their own vehicles otherwise use public transport. The state government provided public transport service such as bus, taxi and train. People also may use their own car to in and go out from Kelantan. There was main road or connect Tumpat with Kota Bharu, Pasir Mas and Rantau Panjang. Dictance from Kota Bharu is about 18 kilo meter. Distance from Pasir Mas is about 23 kilometer and from Rantau Panjang is about 35.7 kilometre.

People may travel until Johor by using train as the last station stop at Gemas, Negeri Sembilan. However, people who lived at the island use boat and fisherman ship to get to main land. For example, people who lived in Pulau Beluru and Pulau Suri will take boat or ship from Kok Majid Jetty to get to their village.

There also current project which was proposed by Federal Government to build Lebuh Raya Pantai Timur Third Phase in Tumpat. The project was located in Pengkalan Kubor. The highway will connect Kuala Nerus, Terengganu directly to Tumpat, Kelantan. Figure 1.6 shows road connection and accessibility in Tumpat town and the area around.

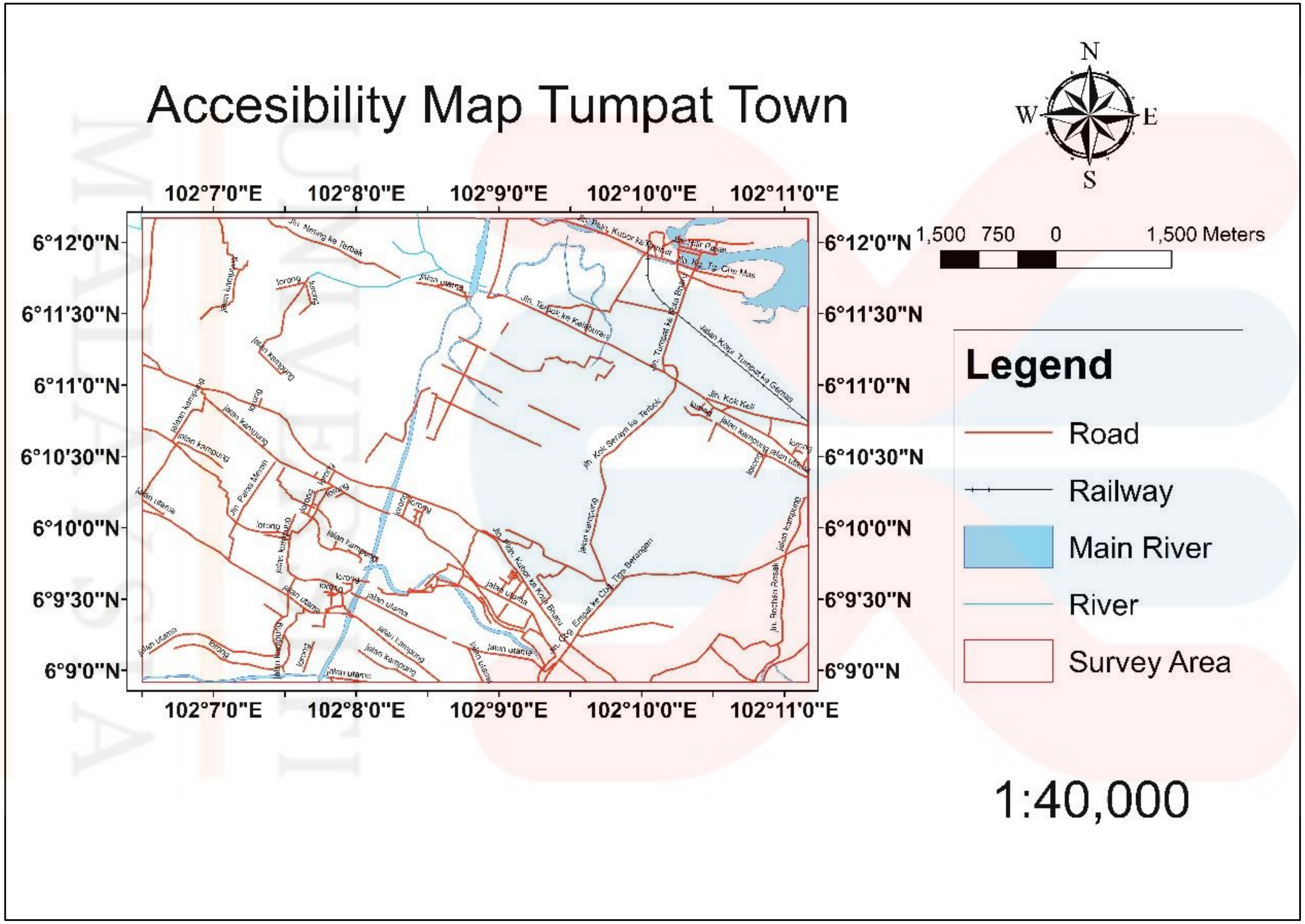

Figure 1.6 : Accessibility Map of Tumpat town

1.2.3 Demography

There were varieties of people live in Gua Musang especially Lojing and also Tumpat. The people are characterized by sub district, citizen and noncitizen. Based on Local Authority Area and State, Malaysia, 2010, there are 86 189 people live in Gua Musang include Lojing area and 147 179 people are live in Tumpat area. Table 1.1shows distribution of people in the two study area while Figure 1.7 and Figure1.8 shows bar chart of total population in Gua Musang and Tumpat area.

Table 1.1 : Distribution table of people in Gua Musang include Lojing and Tumpat

District / Sub District	**Citizenship**				**Non citizen**	**Total**
	Bumiputera	Chinese	Indian	Others		
Gua Musang	76 823	3 870	350	161	4 985	86 189
Tumpat	134 329	6230	121	4 784	1715	147 179

Source : Local Authority Area and State Malaysia, 2010

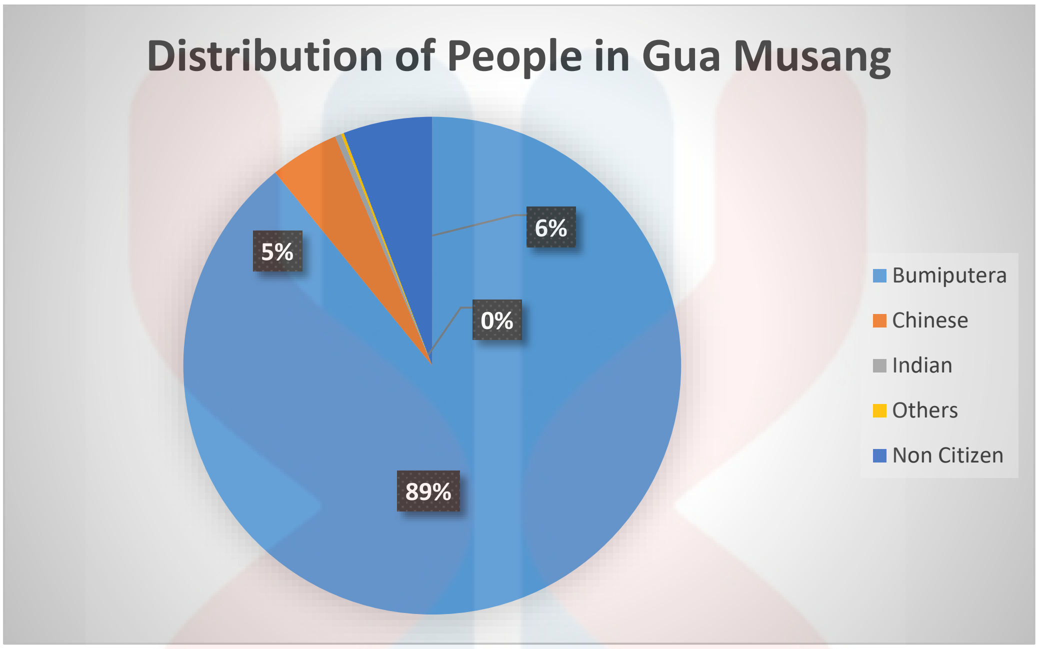

Figure 1.7 : Chart of population people in Gua Musang

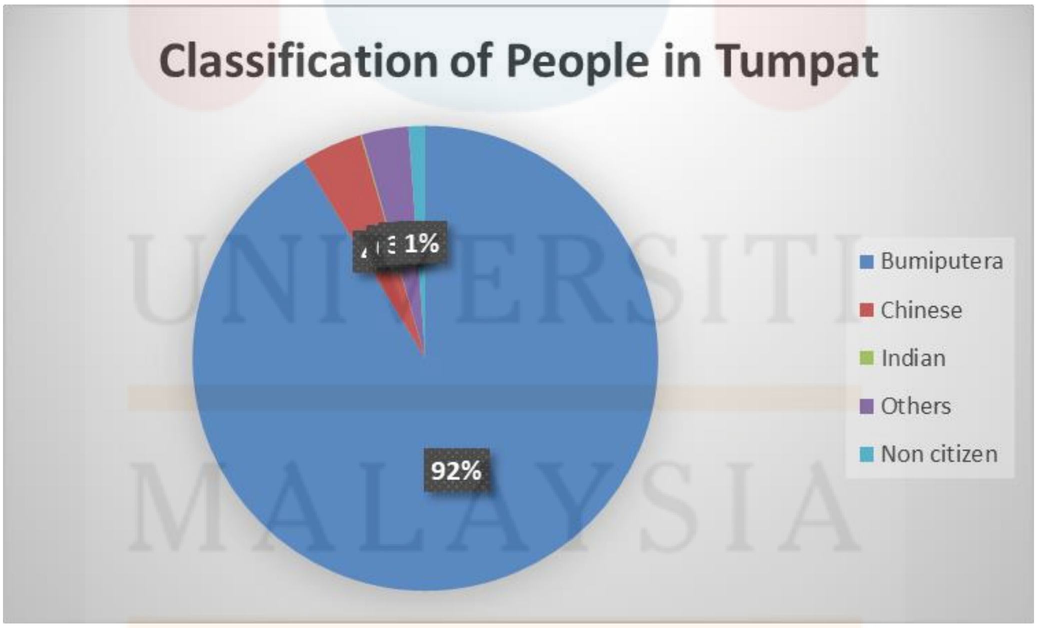

Figure 1.8: Chart of population people in Tumpat

Source : Local Authority Area and State Malaysia, 2010

1.2.4 LAND USE

Lojing area located in Gua Musang and currently undergo massive deforestation. Other than that, excessive logging normally happen in that area. Therefore, Kelantan Forestry Department establish remaining of the forest to become a preserved forest. One of preserved forest is Hutan Simpan Kekal Ulu Berok. About 65 % of Kampung Lojing become deforestation zone and balance is preserved as Hutan Simpan Kekal Ulu Berok. Figure 1.9 show Land use map in KPF Blau Plantation. Table 1.2 show land used classification and Figure 1.10 show land use chart in Gua Musang in 2018.

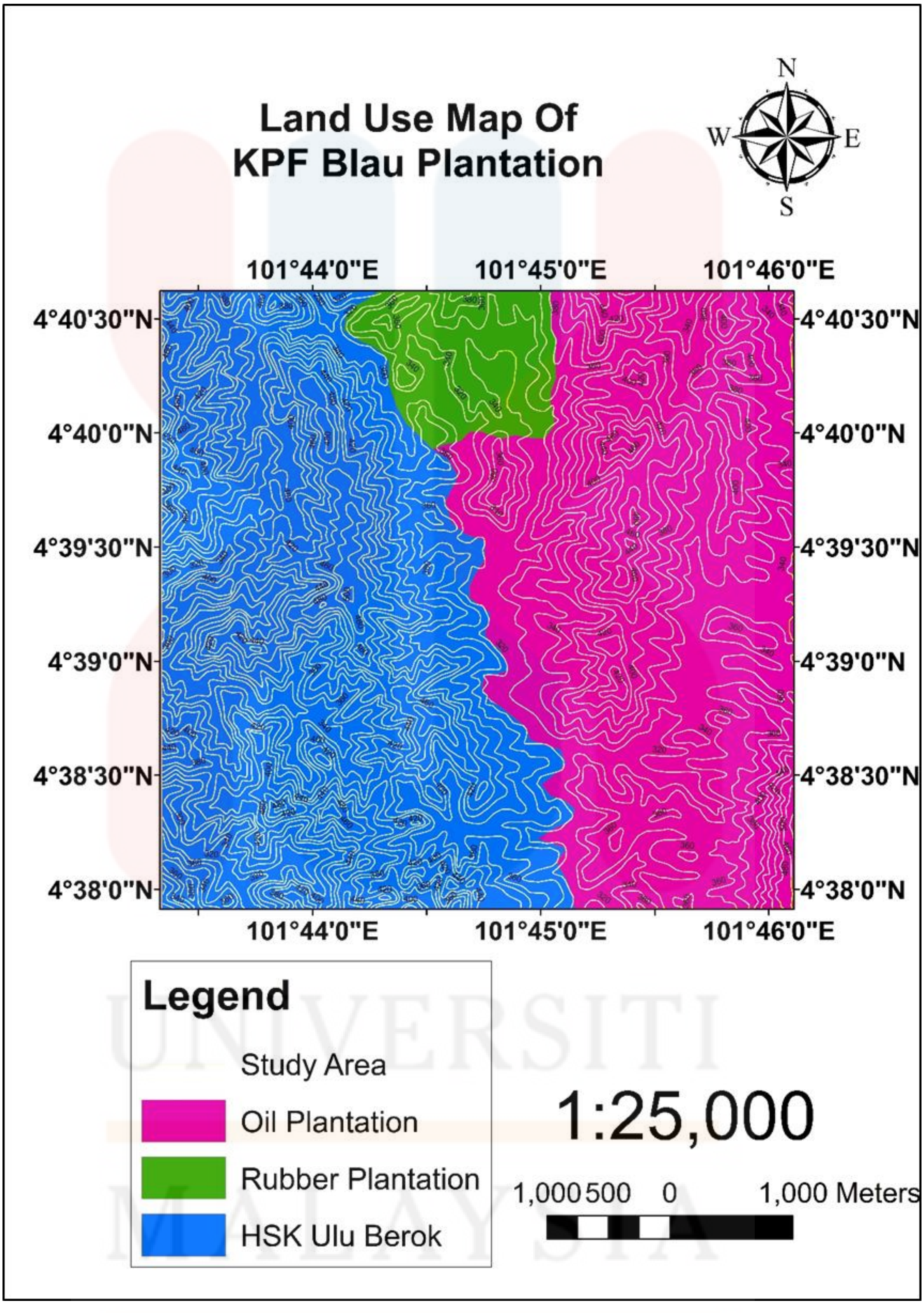

Figure 1.9 : Map of land use in Kampung Lojing 2018

Table 1.2 : Classification of Land use of Gua Musang in 2018

Type of land use	Percentage (%)
Forest (include deforestation zone)	82
Agriculture	18
Total	**100**

Source : Department of Planning Rural and City, 2018

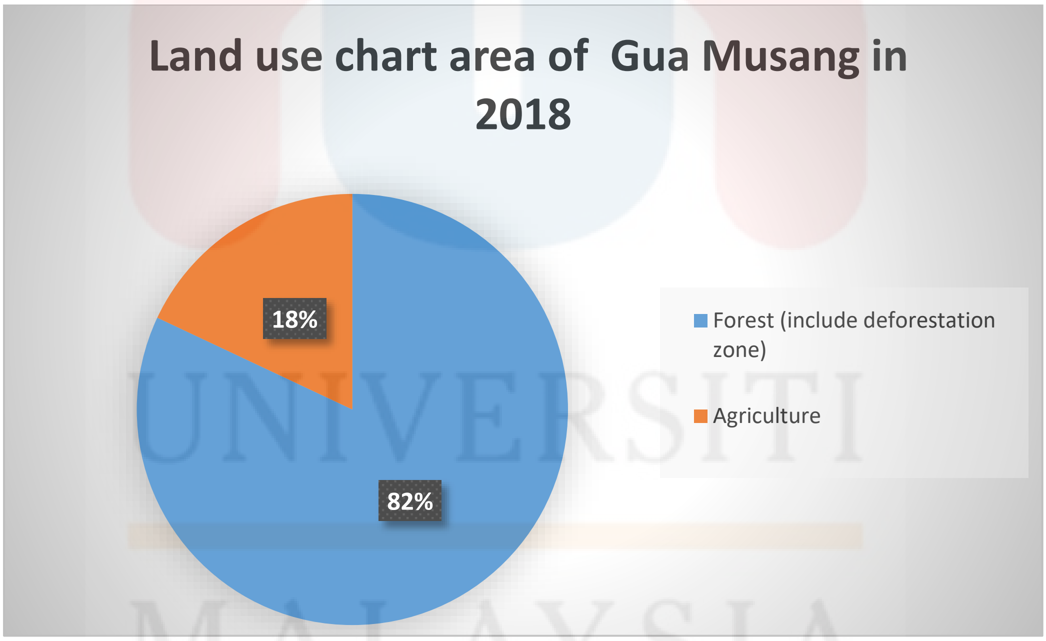

Figure 1.10 : Land use distribution of Gua Musang in 2018

Tumpat located in the corner of Negeri Kelantan and head of the town was situated near the shore line. As one of the well develop city in Kelantan, Tumpat area covered by more than half non build up area and remaining was water body and build up area. Figure 1.11 shows land use map in Tumpat area.

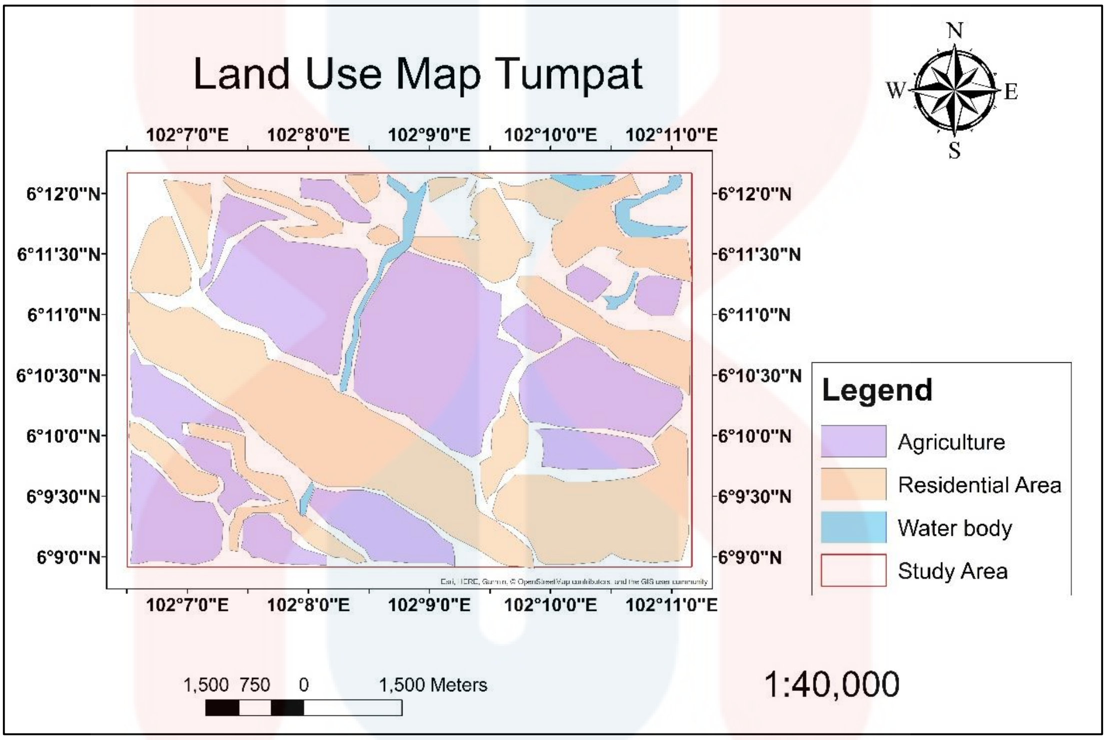

Figure 1.11 : Land use map Tumpat town in 2018

Based on Table 1.3 shows built up zone and non build up zone of Tumpat district in 2018. In general, build up zone contribute 30.74 % or in other words cover 6 995 hectares area while non build up zone contribute 69.26 or in other words cover 15 858 hectares area in Tumpat. Figure 1.12 shows classification chart of area and zone of Tumpat in 2018.

Table 1.3 : Land use zone of Tumpat in 2018

No.		Land use	Area (Hectares)	Percentage (%)
1.	Build up zone	Residential	4 634	20.3
2.		Transportation	916	4
3.		Institution and society welfare	666	3
4.		Infrastructure and utility	336.1	1.5
5.		Commercial	274	1.2
6.		Industry	106	0.5
7.		Recreation	54	0.2
8.		Mix development	9.4	0.04

9.	**Non build up zone**	Agriculture	12 497	55
10.		Unclaimed land	1 686	7.4
11.		Water body	1 643	7.2
12.		Beach	18.4	0.08
13.		Forest	8	0.04
14			**22 853**	**100.0**

Source : Department of Planning Rural and City, 2018

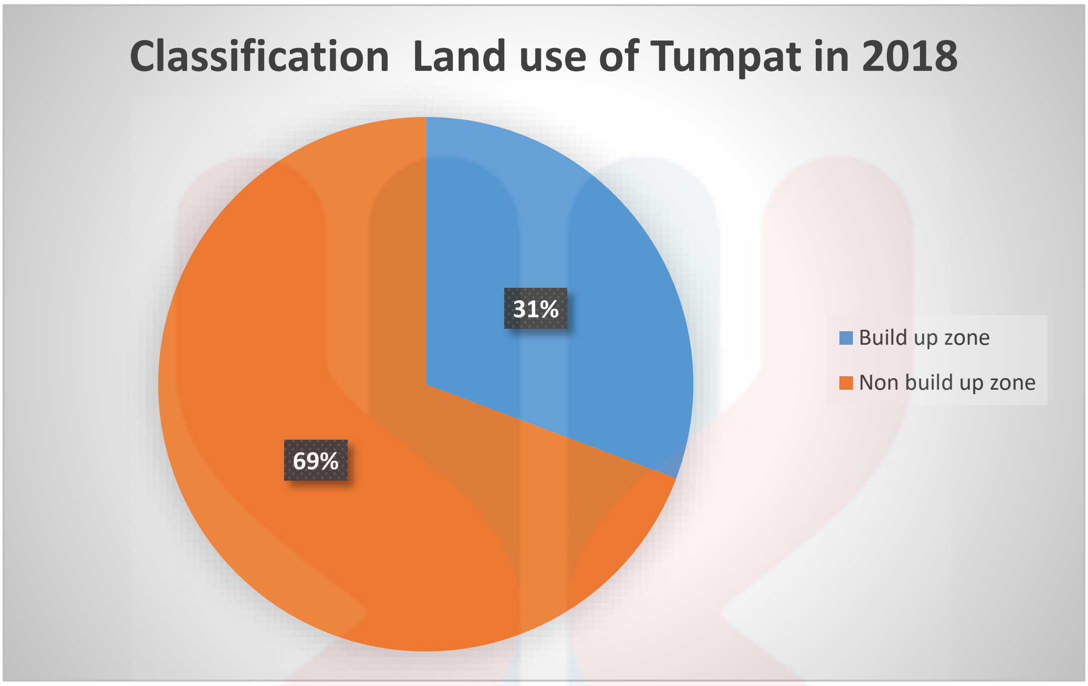

Figure 1.12 : Land use classification of Tumpat town in 2018

1.2.5 Social Economic

Various type of occupations and works done by people to survive in this world. People in Kelantan also work to gain money and use it in their daily live. In, Kelantan there were many type of works and jobs which contribute to social economic of those people. It can be divided into two such as government employee and self-employee. People in Gua Musang mostly in Kampung Lojing dominantly were self-employee. They were working by themselves either in city or village. The economic in Kampung Lojing was dominated by agriculture. This is because their village situated very deep inside and too far from Gua Musang city. They need to do self-farming and manage the farm themselves in order to improve their life style and social status. Farming become a solution to increase their income as Lojing also one of the highland and had cool temperature which was suitable for many kind of vegetables and fruits such as strawberries.

However massived deforestation and excessive logging in that area destroyed suitable condition and habitat for vegetables and fruits to grow healthy. Deforestation from logging company also use similar land they use to do farming. This issues become major problem of the people who is living in this remote area. Other than that, the villagers and farmer in Lojing have Kelantan Agriculture Development Authority (KADA) on their back. KADA always help and support their economic program so that may increase their income. KADA also provided prior business capital and also loan for their survival in farming. Other than that, KADA also help them to promote and do marketing service for their product. These kind of work and occupation done by people in Kampung Lojing to increase their social economic.

In contrast, these quite different for people who are living in Tumpat. This is due to different landform also affect social economic in that area. Tumpat consist of coastal area that provide different condition from Lojing which was remote area and full fill with hilly and mountainous area. Social economic dominated by several aspect such as agriculture, fisheries and Small Medium Enterprise (SME).

Agriculture cover more than half of land use in Tumpat which was 55 %. People often do farming such as paddy, vegetables, fruits, maize and other in commodity industries. The alluvium soil become major factor as suitable for grow plants especially paddy. The farmer sell their crop and product in local market around Tumpat. Sometime, they will export the product to large or retailer premises.

Next was Small Medium Enterprise (SME). Kelantan state government always enhance people to take part in this sector. There were a few products come from SME programme such as keropok lekor or rebus, ikan kering or dried fish, budu or anchovies sauce and others food based product. Other than that creative industry like batik and sutera, martial arts weapon like keris and badik, traditional game accessories such as Wau bulan and gasing and others in the SME program.

Lastly was fisheries. Fisheries also contribute a lot in people economic as the location was very near to the coastal area. Fisherman catch fish either use their boat or ship. There were many types of seafood sold by fisherman such as fish, crab, prawn and others. Seafood restaurant can be found along the shore line in Pantai Sri Tujuh and Pantai Getting. The fish also will be dried to become dried fish. There also small fisherman harbour in this area show that Tumpat has high chance and potential to become a domestic and international port in the future.

1.3 PROBLEM STATEMENT

Geological map of Kelantan had already been produces by Department of Mineral and Geoscience Kelantan. However, the existed map produced in Kampung Lojing was large in scale and not too focus in specific area and this research focus in KPF Blau Plantation. The geological map with small scale must be produced to obtain appropriate data of study area. The complete geological map able to interpret the geology in KPF Blau Plantation.

Ground water contamination always occur in near coastal area. This become threat for people especially villagers that depends on groundwater as primary sources. Industry boring water means pumped out water from underground become an alternative method rather than drill a whole to get fresh water. By using set of pump, they were able to collect ad use fresh water of aquifer straight forward. However, local worker generally just know the drilling only as it also become an industry for certain people. They do not know much about water pollution include chemistry and hydrogeology of that area. This matter become urgent issues as involved with human health because their customer use the water for domestic purpose.

1.4 RESEARCH OBJECTIVE

1. To produce geological map of KPF Blau Plantation, Gua Musang on scale 1 : 25 000.
2. To identify sea water intrusion in of coastal aquifer Tumpat area by using ERI.
3. To analyze the groundwater quality of domestic wells.

1.5 Scope Study

Scope of study focus on geology, hydrogeology, geophysical and hydrochemistry of study area in KPF Blau Plantation and Tumpat. Study of geology in KPF Blau Plantation include stratigraphy, sedimentology, structural geology, petrology, geomorphology and others geological features. At the end, a complete geological map of KPF Blau Plantation with small scale and accurate data will be produced. The map will show pre historic moment of ancient life and time in Lojing area.

Other than that, the study also include geophysical survey in Tumpat. Geophysical method used in coastal area of Tumpat to determine sea water intrusion into shallow aquifer of selected location. The result of geophysics survey were in form of pseudo section and show aquifer contaminated in that aquifer.

In addition, the study also involve geochemistry of the selected well in Tumpat. Physical parameter of hydrochemistry become important subject to monitor and analysis. Example of physical parameter such Total Dissolved Solid (TDS), Total Suspended Solid (TSS), Salinity,Turbidity, Temperature, Electrical Conductivity (EC) and pH of water sample in Tumpat area. Major cation and anion also analyse.

1.6 Significance of Study

This study and research will important for future planning regarding terrain mapping in Lojing, Gua Musang. All data include geomorphology, stratigraphy, sedimentology, structural geology and petrology. All the data used from field investigation projected and illustrated the geology of the study area. Important for engineer or consultant company basically used for construct new road or measure slope stability in the area in KPF Blau Pantation. Other than that, the data also essential for mining, planning and urbanization.

The collected data of seawater intrusion become useful sources for user or agency that manage groundwater resources. High demand of groundwater use in Tumpat cause these research were very crucial. These study become a new plan for designing and developing future groundwater well also for groundwater modelling.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review related to the purpose, previous research and also contain research gap from the researcher. In the literature review, many aspect included regional geology and tectonic setting, stratigraphy of Paleozoic, Mesozoic and Cenozoic of Negeri Kelantan.

Other than that, literature review also covers about hydrogeology, sea water intrusion, and information regarding research of identification sea water intrusion by using electrical resistivity imaging and hydrochemistry or geochemistry.

2.2 Regional Geology and Tectonic Setting

Negeri Kelantan is located in Eastern Coast of Peninsular Malaysia. History of Peninsular Malaysia starts when collision between two continental plate called Indochina and Sibumasu. Therefore, the collision resulting current geological condition. Bentong Raub Suture Paleo Tehtys characterized Peninsular Malaysia into West or Indochina and East for Sibumasu also called as East Malaya. Bentong-Raub suture zone explained Paleo Tethys of Peninsular Malaysia (Metcalfe, 1997). Geological age and rock formation of Kelantan distribute since Lower Paleozoic until Quartenary deposit (Hutchison and Tan, 2009). The granitic body of Eastern belt distribute and extend from lower part of Peninsular Malaysia to the Northern part of

Kelantan (Rajah et al., 1977). Sub district Lojing is one of Main Range and located in southern part in Kelantan, the most wellknown mountain range in Malaysia (Adriansyah et. al., 2014). Other than that, Lojing area located in Central Belt that cover from Johor to Kelantan in the Main Range and between eastern foothill (Hutchinson & Tan, 2009).

2.3 Stratigraphy

Stratigraphy of Kelantan may be divided into three classes which are Paleozoic, Mesozoic and Cenozoic. In General Gua Musang and Lojing area consist of geological age from Paleozoic until Triassic and Tumpar area consist of geological age in Cenezoic time frame.

2.3.1 Paleozoic

Upper Paleozoic rock in central belt consist of Taku Schist in East of Kelantan while in south consist of Gua Musang and Aring Formation (Hutchinson & Tan 2009). The Gua Musang formation measured and thickness is about 650 meter while the rock unit consist of crystalline limestone, interbedded with thin bed of shale, chert nodules, tuff and subordinate volcanic and sandstone. Calcitic limestone with dark grey in colour is splintery, nonporous, brittle and hard (Hutchinson & Tan 2009). The argillite unit of outcrop more appear than limestone and become a series of limestone from Gua Musang to Merapoh area. Other than that was volcanic rock. The series formed from rhyolite to andesite include agglomerate, tuff and lava flow (Hutchinson & Tan 2009).

Aring Formation obtain name from Sungai Aring near Aring in South of Kelantan. The formation was dominated with pyroclastic rock with with a little amount of lava, argillite and dolomitic marble also the outcrop thickness is about 3000 meter (Aw, 1990). The basal section of dolomitic marble overlain by calcerous argillitic and tuff with thickness of 270 meter (Aw, 1990). Paloh member consist of 1000 meter thick and located in the top of the formation with facies of argillo-tuffaceous.

2.3.2 Mesozoic

Lojing area in Gua Musang also become a part of Mesozoic stratigraphy. Gua Musang was located in central belt of Mesozoic age that lies in Bentong-Raub suture (Hutchinson & Tan, 2009). Yin (1965) study about rock unit appear calcerous and argilliceous rock with subordinate pyroclastic, lava flow and arenite. Kamal and Mohd Shafeaa (1994) suggest Gua Musang Formation become a group status of all existing calcerous and argillaceous Permian Lower-Middle Triassic formation that exposed northern half of the central belt. The tuffaceous rock, argillaceous, and calcerous rock represent lithology within Gua Musang Group, Nilam Marble, Aring Formation and outcrop limestone near Gua Sai, Merapoh.

The lower boundary and upper part are not exposed but Yin (1965) proposed that overlapping the boundary by Gunung Rabong Formation without range. Conglomerate conformably overlie with sandstone in Kuala Betis area in the Gua Musang Formation (Aw, 1974). Basal conglomerate also known as Gunong Ayam represent oldest rock unit in Gua Musang Formatin in the east. Foo (1983) proposed that Gua Musang formation is correlatable with Telong formation. Nilam Marble and Telong formation is similar rock with Gua Musang formation.

2.3.3 Cenezoic

Cenezoic stratigraphy facies develop at onshore along West Coast and offshore in Straits of Malacca and South China Sea. Quartenary deposit remark as layering of unconsolidated to semi consolidated boulders, gravels, sands, silts and clays that underlie inland plain and coastal part like infilled valleys. Beach ridges and river terraces formed and known as permatang and be called as alluvium. Scrivenor (1913) state that first quaternary sediments in peninsular Malaysia is sandy clay deposit with distributed many clast at at the base of unconsolidated sediments in Kinta Valley and the sediments called Gopeng Bed. There are three unit of lithology observed based on lithology, deposition environment and age (Suntharalingham 1983). Simpang Formation is the oldest age in range of Pleistocene and the other two is Beruas and Gula formation in Holocene age.

Coastal plain at Tumpat, Kelantan consist of alluvium deposit from Quaternary age. The silt, clay, peat, gravel, sandy clay, was described by Suntharaligam (1987) to identify fluviatile-estuarine-lacustrine deposit in Beruas Formation. Maximum thickness of Beruas Formation is in 10 meter and in Holocene age that contemporaneous with Gula Formation.

Gula Formation proposed by Suntharalingam (1985) for facies grey to green grey marine to estuarine clay in Taiping with subordinate sand. Thickness of the formation is said about 20 meter. Gula Formation contain sand with minor amount of gravel, shell, silt, clay, shell and coral deposit in a marine environment (Bosch, 1988). The formation also from Holocene age as the sample of peats is 3.1 meter depth below sea level. Quaternary stratigraphy and age of Kelantan can be characterized into two which are Pleistocene and Holocene (Bosch, 1986).

2.3.4 North Kelantan

Hutchinson and Tan (2009) stated that arrangement of the sediment from medium coarse gravel to poorly sorted very fine and silty sand at the beach ridges of sand. Greyish white continental clay fill the swales in south of Kelantan (Bosch, 1988). Delta of Sungai Kelantan contain wide valley also and include in Simpang Formation. From Selising to Bachok-Kubang Kerian exist low ridges in 2 – 3 meter high along 5 kilometer and continue until 20 kilometer to the north (Hutchinson & Tan, 2009). The thickness of unconsolidated sediment increase in Eastwards and achieve 150 meter of the deepest bedrock in the delta of Kelantan (Bosch, 1986). The depth of thin clay beds widely range from coarse gravel sand is at 50 – 60 meter even though in 130 meter depth consist of 10 meter thick clay (Hutchinson & Tan, 2009).

2.4 Structural Geology

Structural geology of Gua Musang may be divided into three period since Paleozoic, Mesozoic and Cenozoic. All of the record already been recorded in the Geology of Peninsular Malaysia and edited by Hutchinson and Tan (2009). For sure, indicator of structural geology may be classified through exposed outcrop along the way of Gua Musang. Dominant structure consist of folding, faulting, mineralization and others. Along the way of Lojing – Cameron Highland, there are many structure could be identified. The slicken line and slicken side of one massive normal fault exposed in about 1 kilometer of the road. Next, alternating many type of folding such as anticline and syncline with chevron fold at the mudstone outcrop. This process associated due to the tectonic process near the area such as suture zone between Indochina and Sibumasu plate. This also may result of paleo-tethys structure happen million years ago.

Yin (1965) conducted structural geological mapping in Provisional Draft to Gua Musang. The result is folding like recumbent, assymetrical, tight concentric and overfold.

2.5 Historical Geology

Thick volcanic and argillite deposited next to volcanic arc of Indochina in the early Permian age become current, Telong and Aring Formation. Kubang Pasu Formation with argillite unit deposit with mudstone of Singa Formation in the west. The complex of accrenation form subduction of paleo-tethys ocean (Mohamed et al., 2016).

The shallow marine of Gua Musang platform formed by thick and argillite volcanic rock unit which develop benthic fauna and carbonate rock. The east region develop Gua Musang formation in age of middle to late Permian. Subsidence of forearc basin during peak of volcanism. Chert facies develop in deep of Semanggol basin while limestone of Kodiang and Chuping develop in shallow basin of the west region ocean (Mohamed et al., 2016).

Gua Musang platform often subsided and increase suitable place for deposition of argillite, carbonate and volcanic rock. When Sibumasu get close into Indochina plate, the paleo-tethys ocean completely subducted in early Triassic ocean (Mohamed et al., 2016).

Deep marine Gemas-Semantan basin developed when subduction on oblique of Sibumasu help basin segmentation subsidence process. The shallow marine platform of this basin can be seen in figure 2.1 below. The presence of clast deposition of slumping is from faulting in Pos Balu, Raub, Kurau and Kota Gelanggi. Arenite-rudite deposit in the west region at the submarine fan of Semanggol deep basin ocean (Mohamed et al., 2016).

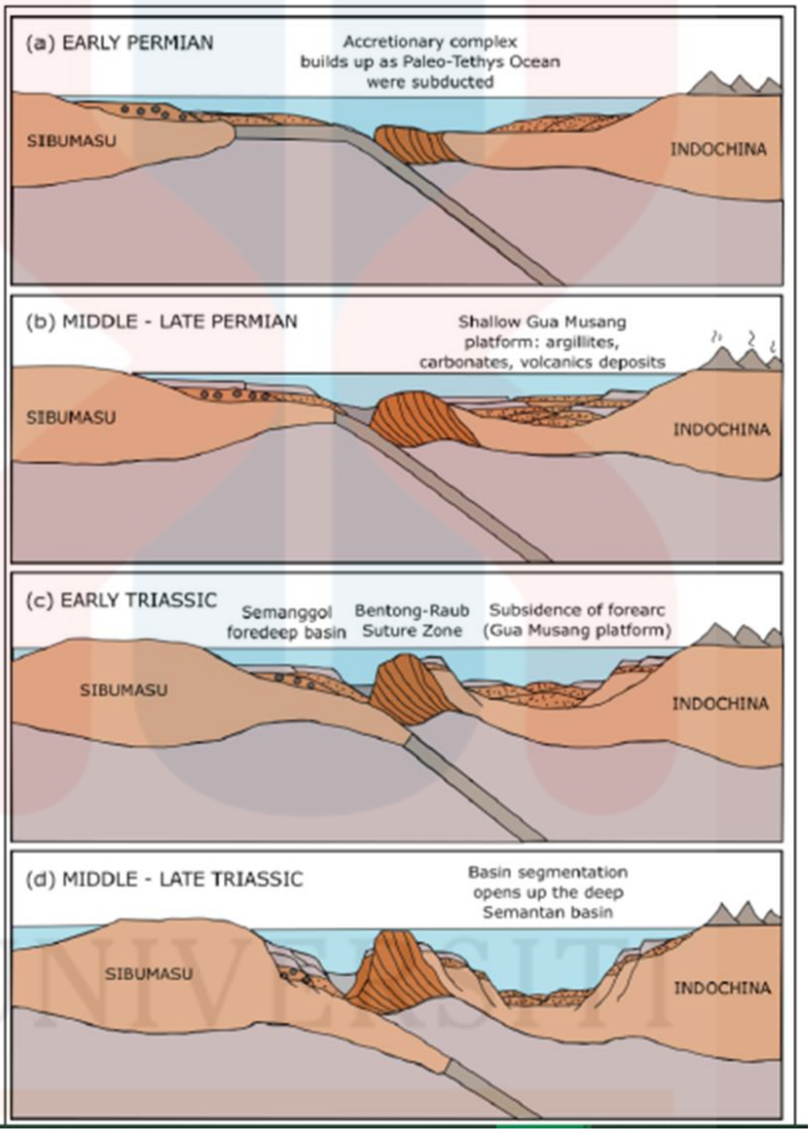

Figure 2.1 : Paleo-Tethys structure

Source : (Mohamed et al., 2016)

2.6 Hydrogeology

Hydrogeology may defined as the science of the occurrence, distribution, movement and chemistry of water below the surface of the earth (Fetter, 1988). While Hydrology cover the study of surface water. Some other relation term known as geohydrology which give similar meaning to hydrogeology. All of this study become essential and importance for advanced study in drainage basin, topography, vegetation, physiography, surficial geology, relationship between draining of water with drainage basin. The mountain range and topographic features affect distribution of precipitation in that area (Fetter, 1988).

Hydrogeology may be observed and analyse either qualitative or quantitative. Mathematical calculation prove that 97.2 % from saline water. 2.8 % for land area. 2.14 % for ice caps and glaciers. Groundwater in depth 4000 meter have 0.61 %, soil moisture for 0.005 %, river for 0.0001 % and saline lakes for 0.008 % (Fetter, 1988).

2.7 Groundwater

Groundwater hydrology defined as movement of water below the surface along with occurrence and distribution . Groundwater means the association of geology strata with void and particle of underground moving water. The saturated zone that contain under groundwater important for water supply, engineering and study. Mostly, above saturated zone usually unsaturated zone and place for root zone of soil moisture and extent upward. Supply of water from groundwater become favour in years (Fetter, 1988).

In Kelantan Lower Basin, groundwater become primary source where 100 % industrial usage and water supply come from groundwater (Tawnie et al., 2016). The main concern of the more than 75 % user here such as maintaining, protecting groundwater resources and sustainable management. From Tanjung Mas well, about 9.875 MLD or 6.8 % abstracted. The clean water become demand and estimated increase in 2.5 % per year.

Air Kelantan Sendirian Berhad (AKSB) become one company which supply treat water for the people who was living in the north of Kelantan (Islami et al., 2015). So, extraction of groundwater by using pumping method aggressively implemented in that area. Shallow aquifer used to take out fresh water for daily uses of people living in that community. To overcome the problems, a 30 meter conventional well was developed however, sea water intrusion become a threat since location of village near the coastal line. The old brackish water trapped and high frequency of extraction at the subsurface in long time ago (Islami et al., 2015). Groundwater will flow through porosity of rock and soil and filter many pollutants in the flowing water (Hamzah et al., 2014).

2.8 Aquifer

Water storage beneath our earth called aquifer. There are many types and classifications of aquifer (Fetter, 1988). Aquifer may become aquiclude, aquifuge and aquitard. Aquifer may be defined as a saturated permeable material and condition to flow some water to springs and wells and come from many formations. While aquifer, availability to transmit at fast rate also enough to so supply water to well corresponding to the geologic unit and lithology. Unconsolidated material such as limestone, sandstone, sand, dolomite, gravel, plutonic fracture, flow of basalt and metamorphic rock were example of aquifer based on their rock units (Fetter, 1988).

Confining layer has no intrinsic permeability. The flow limit are based on current surrounding and environment. Clay consist of 10x-4 intrinsic permeability while, silt 10x-2. Confining layer provide flow for groundwater although slow rate of interflow within it (Fetter, 1988).

There are two type of aquifer which unconfined and confined aquifer. Unconfined aquifer and often called as water table aquifer because close to land surface (Fetter, 1988). The process of recharge occur to unsaturated zone via downward seepage from aquifer. Other than that, recharge also may from upward. Lateral groundwater flow and seepage. Unconfined aquifer also called artesian aquifer as overlain by many confining layer. The water is known under a great pressure. Figure 2.2 below shows Kelantan Hydrogeology Map

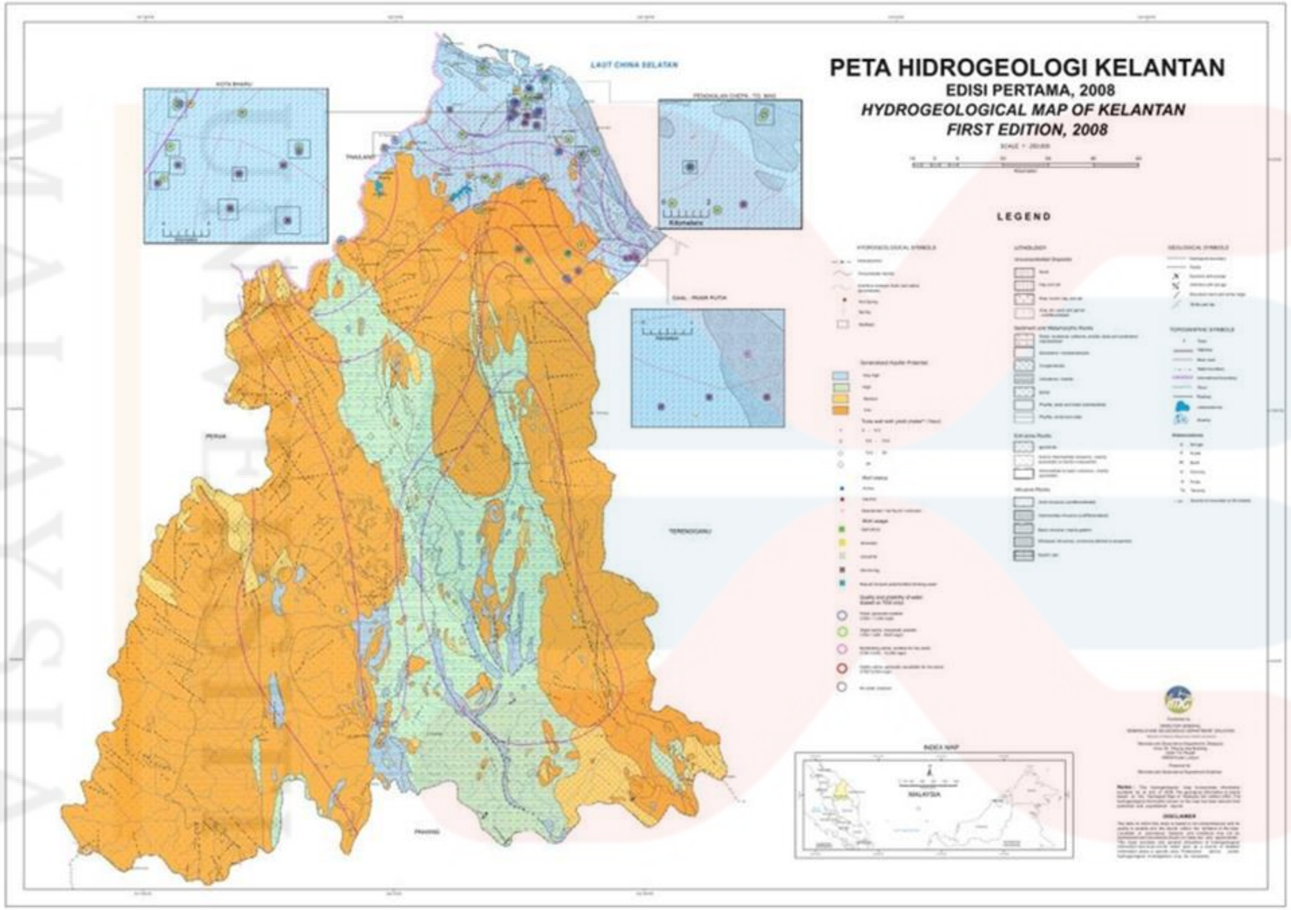

Figure 2.2 : Kelantan Hydrogeologic Map

Source : JMG Kelantan, 2008

2.9 Hydrochemistry

Hydrogeochemical process very essential for changes in chemistry of groundwater and help evaluate groundwater. Hydrochemistry mainly defined as hydrogeology and geochemistry. Chemistry of water can be identified by applying the concept of hydrochemistry to groundwater.

There are two parameter unit used to test water sample in the study area such as physical and chemical test (Islami, 2015). The physio-chemical test are important to determine contamination of water and compare with normal standard (Patil et al., 2012). The influence of sea water intrusion may be determined by using physical and chemical parameter into the aquifer of groundwater (Atea et al,. 2018)

2.91 Physical Parameter

Physical parameter often called as in situ parameter. Data collecting will be conducted live in the location. The data collection include Electrical Conductivity (EC), Temperature, pH, Salinity, Total Dissolved Solid (TDS) and Total Suspended Solid (TSS) (Samsudin et al., 2016).

2.9.2 Chemical Parameter

Chemical parameter also called as experimental parameter. The major purpose of chemical parameter to detect major and trace element in the water. The element include calcium (Ca_{+}), magnesium (Mg_{+}), sodium (Na_{+}), potassium (K_{+}),sulphate (SO_{4-}), chloride (Cl_{-}) and bicarbonate (HCO_{3-}) (Kura et al., 2015).

2.10 Resistivity Method For Groundwater Exploration

Resistivity method is one of the geophysical ways to study groundwater exploration. Geophysical method consist of resistivity, gravity and seismic. Resistivity method may be Electrical Resistivity Imaging (ERI) or Electrical Resistivity Tomography (ERT). Electrical imaging use resistivity to detect subsurface geology beneath earth to obtain information of underground (Samsudin et al,. 2012). There are 2 variation of study and may be projected to 2 dimensional or 3 dimensional imaging. 2-D and 3-D ERI while using Wenner array use for geophysical survey (Samsudin et al., 2016).

The resistivity give different value and measure different range of depth with colour between the subsurface layer (Desa et al., 2014). Some of related problem regarding groundwater issues lithology boundary alluvium depth and aquifer location.

Similar to groundwater exploration, different level of aquifer give different type of lithology. Resistivity of different material provide different value resistivity of the rock unit. Hidden part of water lies underground give different resistivity value (Riwayat et al., 2018).

2.11 Electrical Resistivity Imaging (ERI)

Subsurface of and underground rock layer may be understood by using electrical resistivity as the medium of the layer may have resistivity itself. The earth layer must be assumed in horizontal state. Measure of resistivity concern about how the material react when exposed to the electrical current. Figure 2.3 shows idea of resistivity beneath the earth.

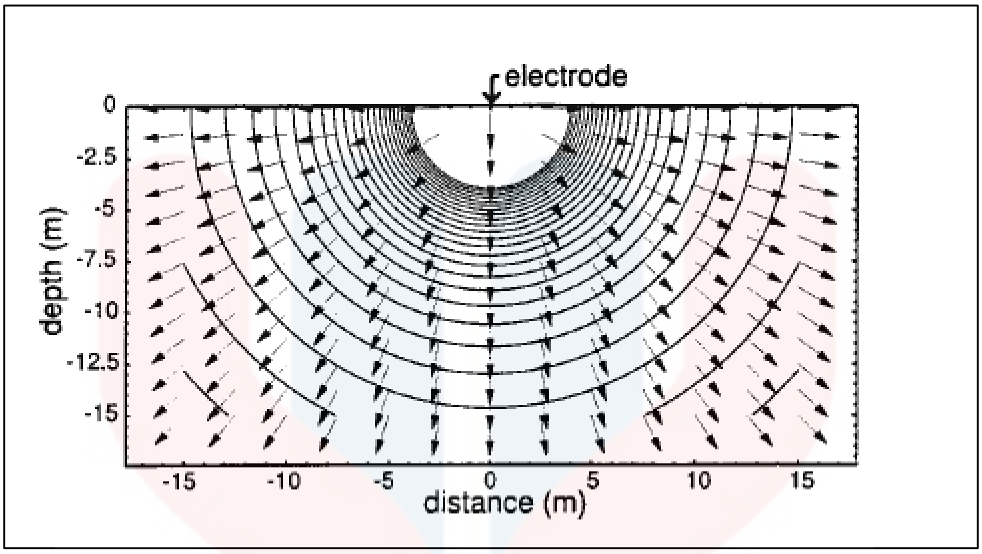

Figure 2.3 : Resistivity beneath Earth

Source : Herman, (2001)

The underground layer need to combined with geologic line to find the resistivity of certain material. Resistance may be defined as resistance in certain length per unit area due to the density of material. The figure 2.4 shows equation of resistance.

$$R = \rho \frac{L}{A}.$$

Figure 2.4 : Equation of resistance

Source : Herman, (2001)

By using electrode as main detector, the resistivity of the material wil be read by machine. Other than that, layout of plan become major factor and affect result of ERI reading. There are many lay out plan such as Schlumberger array, Wenner array, Pole-dipole and lastly dipole-dipole. Figure 2.5 show all the arrays.

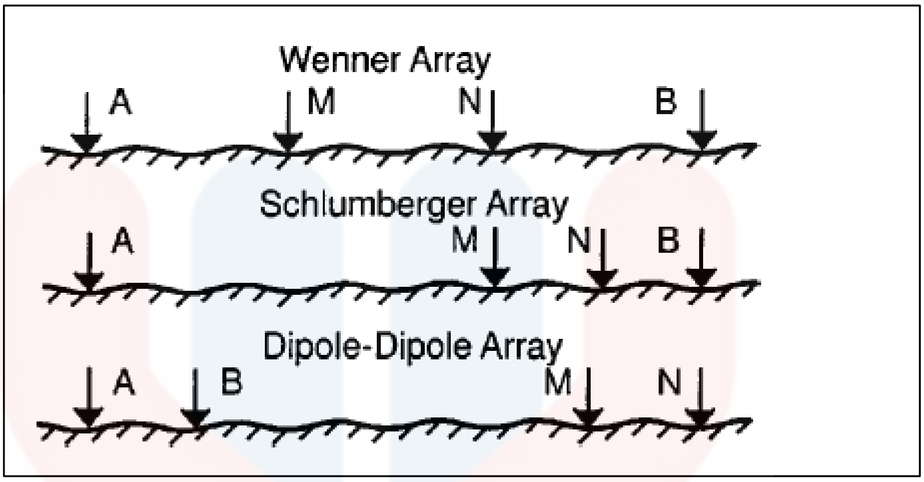

Figure 2.5 : List of arrays

Source : Herman, (2001)

2.13 Resistivity of material and rock

Every material have different type of resistivity value include rock. The conductivity and resistivity of rock depends on the order of magnitude. Figure 2.6 shows the resistivity for rock type.

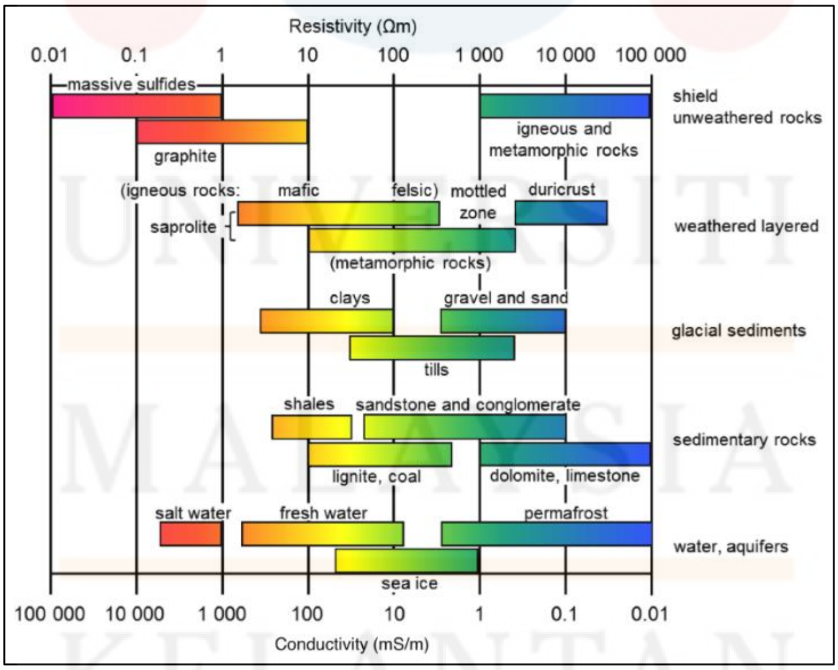

Figure 2.6 : Resistivity on different type of rock

Source : Loke, (2000)

CHAPTER 3

3.0 Introduction

All the methods, procedure and precaution of all work related to the research been discussed here. The material and method used under supervision of lab assistance.

3.1 Material and Equipment

All the material and equiment used for geological mapping and identification of seawater intrusion was shown in Table 3.1 shows all material and apparatus used.

Table 3.1 : Material and apparatus

Material	**Function**	**Picture**
Hammer	Hammer was used to break any outcrop. Commonly had two type which were chissel and point tip.	
Global Positioning System (GPS)	Gps use for locate any position and earth elevation for earth. Basically used latitude and longitude.	

Brunton Compass	Used to measure bearing, strike and dip.	
Measuring tape	Use for measure exposed outcrop.	
Set of Abem Terrametter LS	Use for detect resistivity of the underground aquifer.	
Multiparameter	Used to detect conductivity. pH, temperature, salinity and total dissoved solid	
Portable TSS Meter	Used to examine amount of suspended solid in the sample.	

Turbidity Meter	Use to determine the cloudness of water.	

3.3 Methodology

3.3.1 Preliminary Study

Before conducting the real method and practical, previous study or research need to be apply and master very well. This is because, all the general ideas and methods have already state and explained very well. Data like rock type igneous, sedimentary or metamorphic, lithology unit, stratigraphy unit, sedimentology, structural geology and others.

The data can be collected from pioneer research paper from many institutions and universities. Other than that, the research gap and research question which already state before also could become pioneer idea to start the mapping procedure. The revision is needed to obtain clear idea and data collection of the study area.

3.3.2 Field Study

a) Geological Study

To produce a complete geological map, all set of data need to be combined altogether. All the data collection must be included in the geological map. Raw data like traverse. In traversing, it is important to fulfill the data of bearing, coordinate, slope, waypoint and any massive symbol need to be pointed in map. The details of mapping characteristic like strike and dip, and plot all the geological features like geology structure, outcrop, sedimentary structure and others. All of the data is collected and noted by GPS and plot on the base map or topographic map. Other than that, rock description like size, color, weathering, grain size, location, structural analysis like rose diagram for joint and stereo net also need to collected during field.

Other than that, the data must be inserted into Arc GIS. Arc GIS is one of mapping software. Next is report writing in form of thesis. The most important is stratigraphy analysis and map of selected of seawater intrusion in both study area.

b) Geophysical Method

It is important to use geophysical method when conducting experiment about groundwater. Schlumburger array will be used to perform this test. Abem Terrameter LS is a device that will help to show the result of selected aquifer which have been intruded by sea water. For electrical resistivity imaging survey, Schlumburger array with forty one electrode of 200 metres will be choosen and spread three to five line. The apparatus and machine that will be used to record data is ABEM Terrameter LS. After that, the raw data from ABEM will be processed by using a software, RES2DINV and able to obtain 2 dimensional resistivity profile of distribution in basement rock and also intrusion of seawater into groundwater.

c) In situ test

In situ test will be performed at the site near the coastal area. YSI Multi parameter, Turbidity Meter and TSS Meter will be used to examine about pH, Total Dissolved Solid, Salinity, Total Suspended Solid, Electrical Conductivity, Temperature and Turbidity.

d) Water Sampling

There were 10 sample collected in different area. The reason was to identify each well about their contamination and mineral content inside. Also to differentiate the water sample in each of location.

3.3.3 Laboratory Work

a) Petrology analysis

The lab test are include method in performing thin section and analysis of thin section under electron petrographic microscope. The thin section method will be done before starting analyse the sample. The sample will be analysed by referring to the petrology and mineral analysis of rock and thin section sample.

Thin section of the sample is important so that, identification of mineral can be easily recognized and drawn. The thin sample of rock slice must be taken properly by using diamond saw and on flat shape. Then, the sample will be mounted on a glass slide and ground smooth with fine abrasive grit until the sample 30 micrometer. By using polarizing petrographic electron microscope, the thin section sample will be examined through two method which is cross polarized, xpl and plane polarized, ppl with the correct orientation.

The mineral that can be seen below the cross polarisation (xpl) or plane polarization) ppl must be adjust to correct lens so that it can show actual mineral properties. All this lab work will lesser work on petrographic mineral analysis. Rock mineral petrographic analysis may be classified by three type of rock which are igneous, sedimentary and metamorphic. All the data is important in determination of rock type, depositional environment and rock grade type.

b) Atomic Absorption Spectometer (AAS)

All sample will be tested by using AAS method. Before using AAS machine dilution must be done. Concentration of cation and anion will be evaluated from AAS result in unit of mg/L.

3.3.4 Data Processing

Data processing was done after obtained all data in the field. ERI data were processed by using application RES2DINV. The process was long s need to put all the coordinate into the software. Other than that, process gps data. All the data were put into the ARC GIS software include coordinate of all locations.

3.3.5 Data Analyse

All the data were analyse based on their method and technique. The geological data was analyse to produce geological map. All data include stratigraphy, sedimentology, petrology, structural geology, geomorphology and hydrogeology.

Data of geochemical were analyse by using Multi parameter, Turbidity Meter and Total Suspended Solid (TSS) Meter. The collected data such as Electrical Conductivity (EC), Temperature, pH, Salinity, Total Dissolved Solid (TDS) and Total Suspended Solid (TSS). Analysis of major cation and anion also could be seen from AAS result in form of concentration.

3.4 Research Flow Chart

Figure 3.1 below shows flow chart and process of conducting geological mapping and specification study.

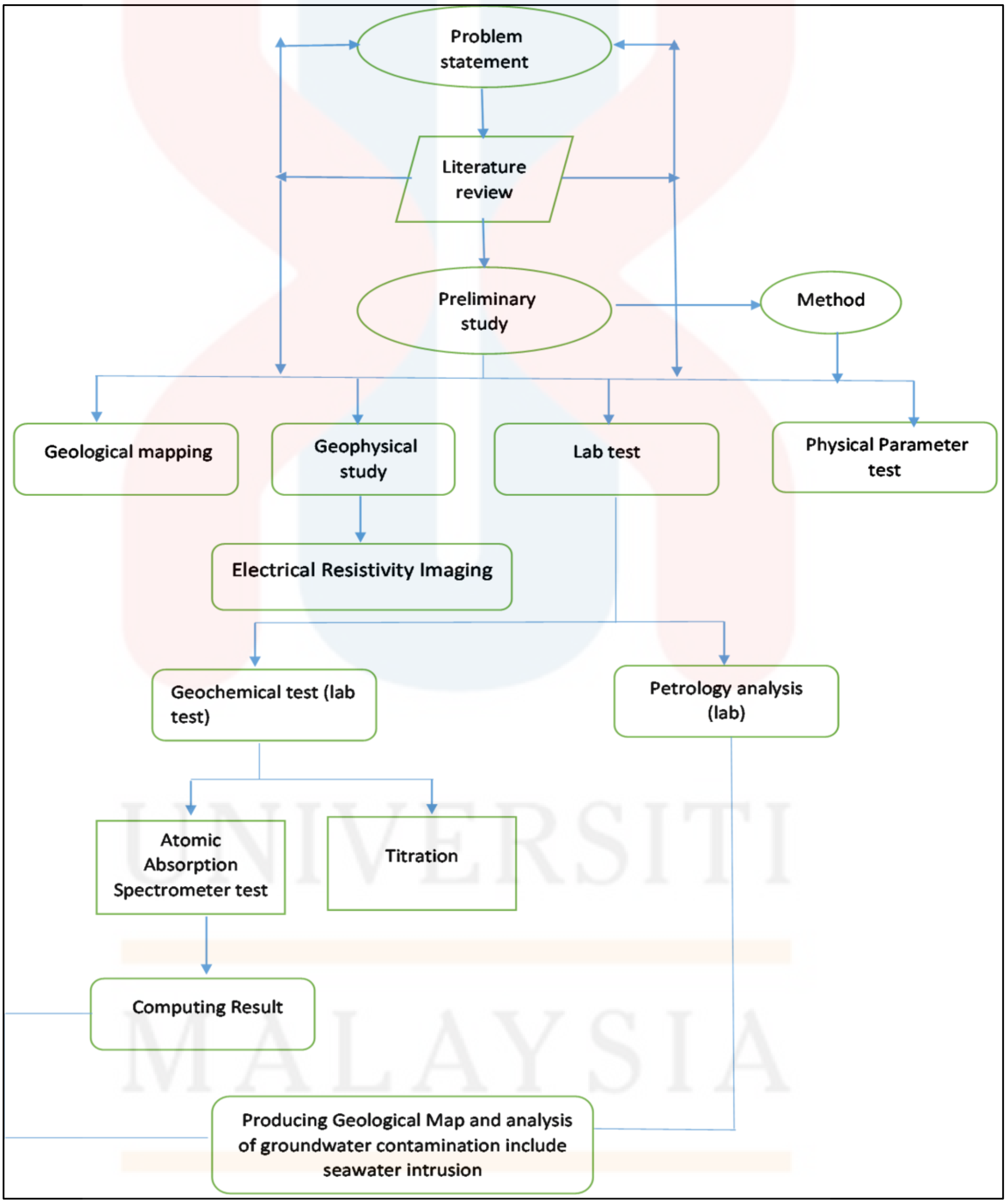

Figure 3.1 : Flowchart of geological mapping and specification

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter will be cover about general geology of study area which is in KPF Blau Plantation. There are many items in general geology will be explained such as accessibility, settlement, vegetation, traverse and observation map, geomorphology with their classification, weathering, drainage pattern, lithostratigraphy with stratigraphic position, unit explanation, structural geology with cleavage, vein, joint, fault and folding, mechanism of structure and historical geology.

4.1.1 Accessibility

There are only one highway and one main road to access Kg. Lojing and KPF Blau Plantation. Figure 4.1 below shows road connection in KPF Blau Plantation

Figure 4.1 : Road Connection (A) Main Entrance (B) Unpaved Road

4.1.2 Settlement

There are not many settlement or housing area inside study area and KPF Blau Plantation. From the survey when mapping was done, there were only a few building which can be identified. All the buildings belong to KPF Blau Plantation. The complex include hostel, general office, warehouse, storage and others. KPF Blau Plantation is one of the branch which is located in Gua Musang Town. Other facilities exist here such as unpaved road, oil palm plantation, surau, toilet and others. Figure 4.2 shows settlement in KPF Blau Plantation.

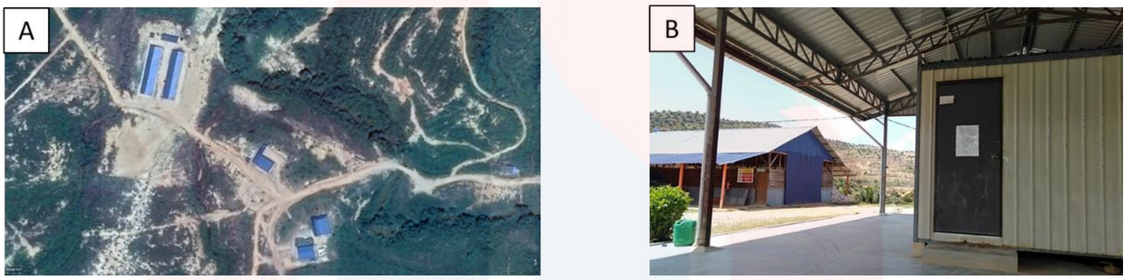

Figure 4.2 : Settlement area (A) Office by satellite imagery (B) Office

4.1.3 Forestry and Vegetation

Based on traversing and observation data, almost 75 % is dominated with oil palm and rubber plantation. Only 25 % cover by forestry. Oil palm plantation is belong to KPF Blau Plantation and rubber plantaion belong to private company. Figure 4.3 below show vegetation and and Hutan Simpan Kekal Ulu Berok in KPF Blau Plantation.

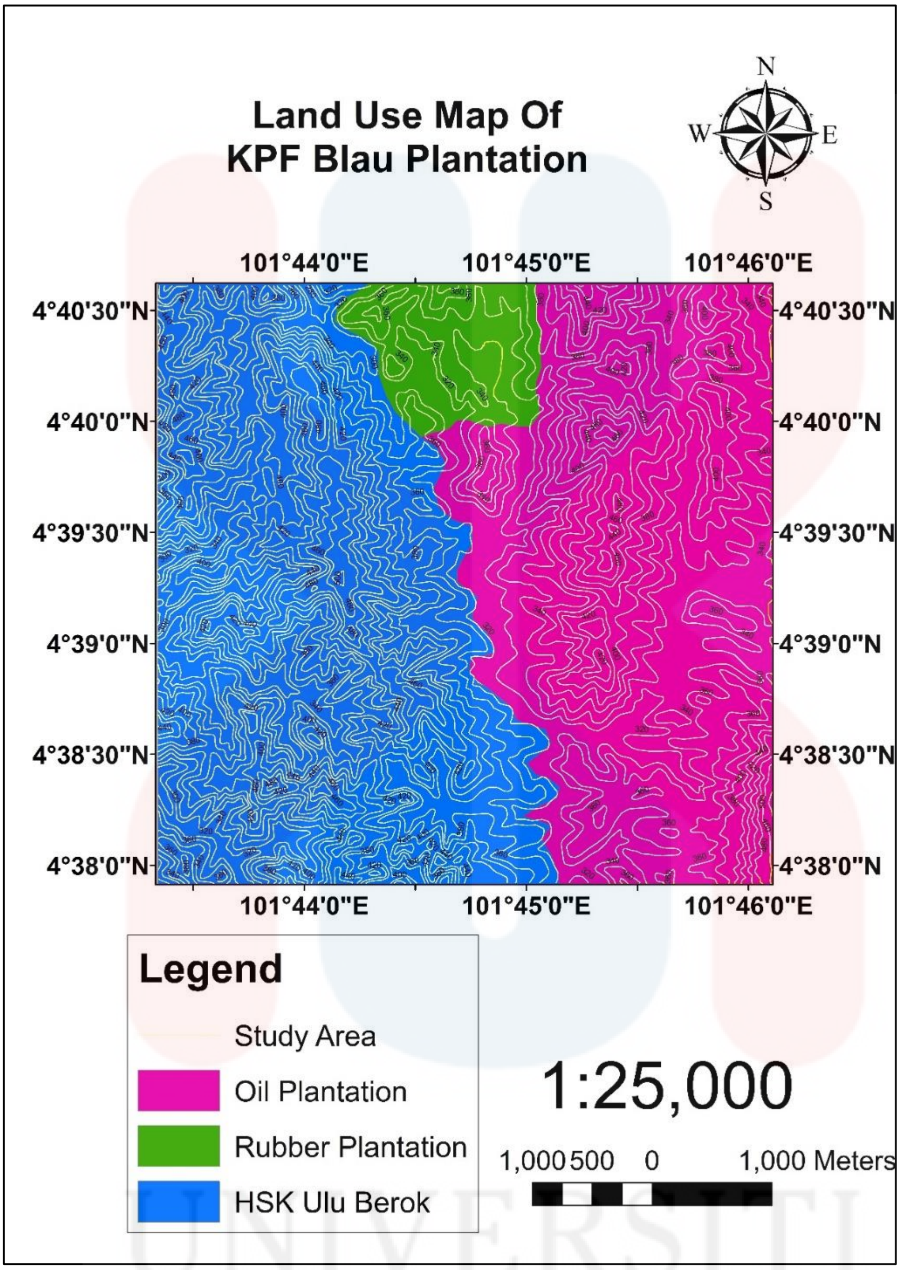

Figure 4.3 : Vegetation and Forestry Map in KPF Blau Plantation and Kg. Lojing

Figure below 4.3 show forestry area and vegetation area in Kg. Lojing and KPF Blau Plantation.. Figure 4.4 shows vegetation in study area

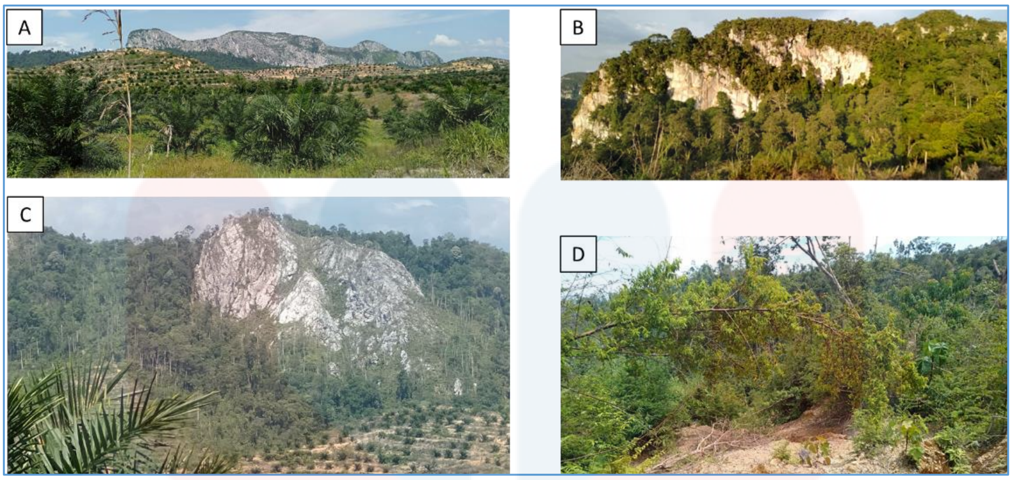

Figure 4.4 : Vegetation (A) Vegetation on limestone (B) Vegetation in Limestone (C) Vegetation on Quartzite (D) Hutan Simpan Kekal Ulu Berok

4.1.4 Traverse and Observation

Traverse is one of the method when conducting geological mapping. Usually, traversing is done by using certain devices and tools such as base map, global positioning system (GPS), geological compass and many others thing. When doing mapping, all the important data will be remark and noted in GPS. Later, data from GPS will be transferred to ArcGis software. All geological data such as lithology, structural geology, vegetation, land use, slope, fossil and new finding are recorded in GPS and projected in the mapping software. Hence, a complete traverse map with the selected legend will be produced and show all characteristics and information depend on individual specification.

Complete traversing can be done after ensuring all accessibilities and roads in the study area such as in KPF Blau Plantation. All the unpaved road must be explored to obtain a lot of information in the study area.

Traverse map in Figure 4.5 show all the traversing data such as traverse line, settlement, river and bridge. All the important data is recorded through GPS when mapping is conducted in KPF Blau Plantation and Kg. Lojing.

Other than that, observation map is a map that show all location when sampling and observation site. Usually, sampling data and observation data will be distinguished. Rock sampling is done at the most important and rare outcrop whereas observation is done when finding similar lithology or outcrop. Not all similar findings will be recorded and sampled. But, just marking in GPS to ensure lithological boundary of rock. Figure 4.6 show observation map in KPF Blau Plantation.

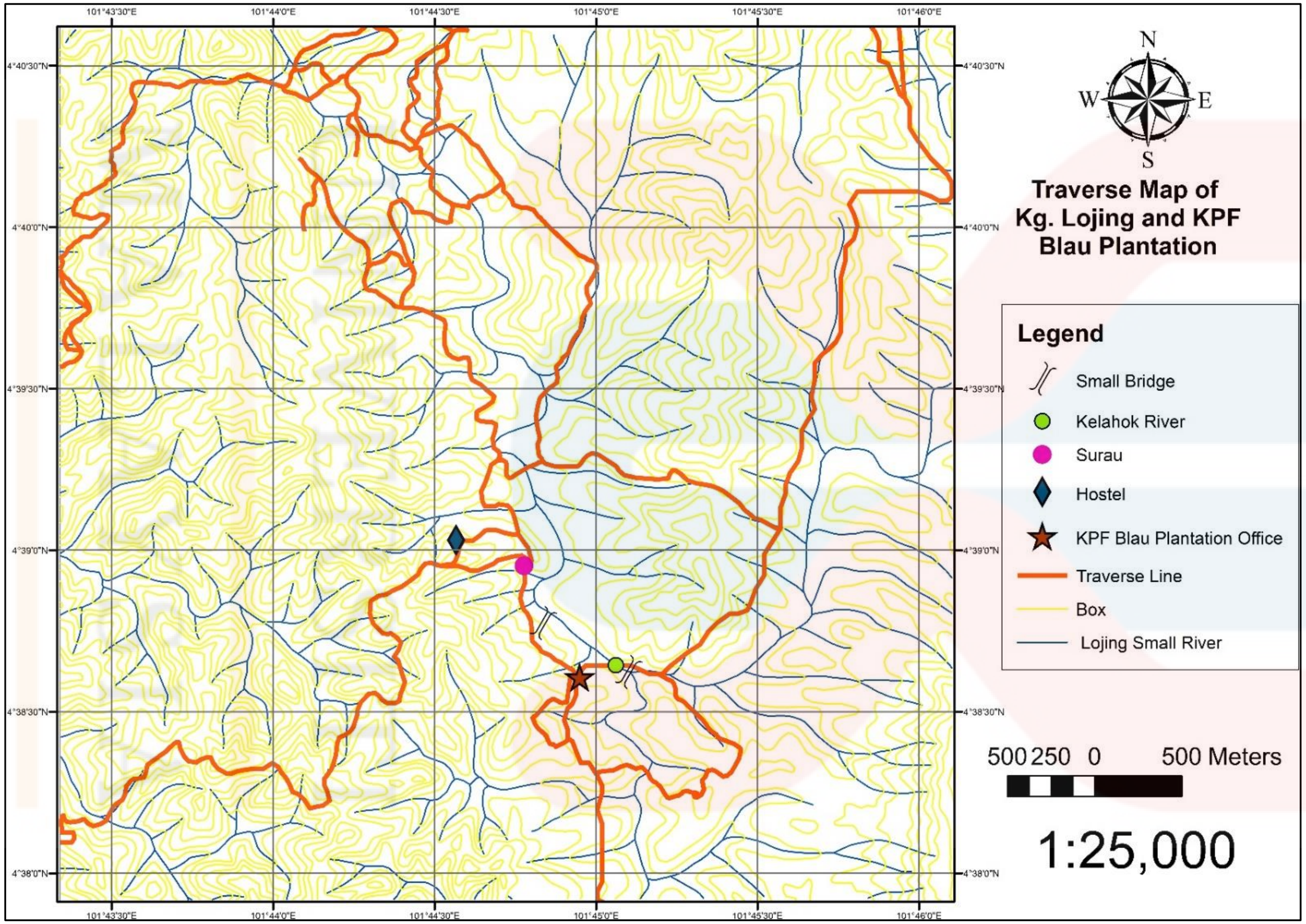

Figure 4.5 : Traverse Map of KPF Blau Plantation and Kg. Lojing

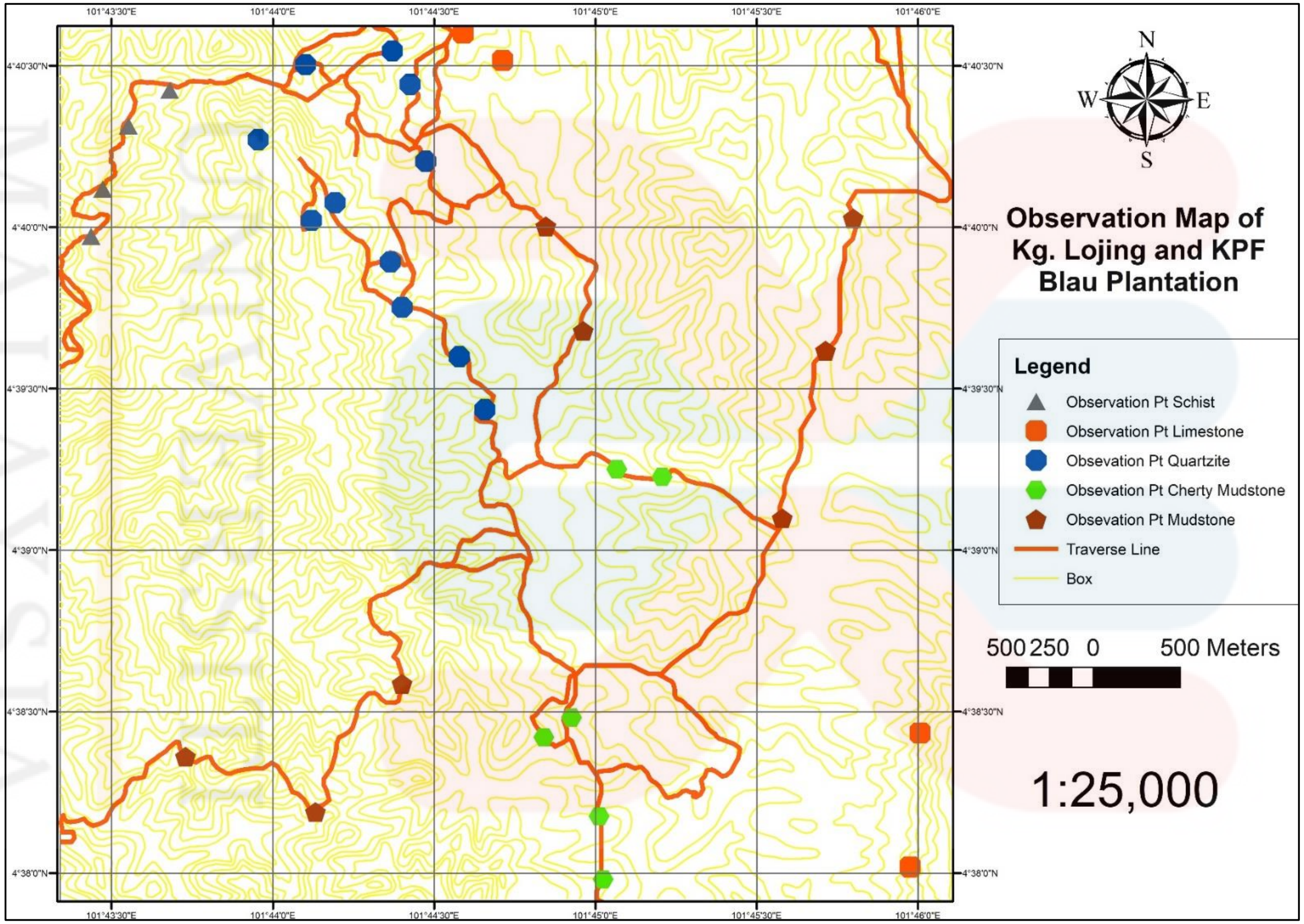

Figure 4.6 : Observation Map of KPF Blau Plantation and Kg. Lojing

4.2 Geomorphology

Geomorphology is a scientific research and study which concern about evolution of earth physical landscape that distributed across the earth. Literal meaning of geomorphology, Geo mean earth, morph mean form and logy meaning process. Geomorphology also discuss about earth landform and process associated with them.

4.2.1 Geomorphologic Classification

Geomorphological classification is a method to classify and identify landform of certain location with their characteristic. There are many landform can be classified in KPF Blau Plantation and Kg. Lojing. Classification of landform normally follow Hutchison (2009) and Van Zuidam (1985). Table 4.1 shows topographic classification by Hutchison in Geological of Peninsular Malaysia, 2009. Table 4.2 shows topographic classification by Van Zuidam (1985).

Table 4.1 : Topographic classification based on mean elevation unit

Topographic unit	Mean Elevation (m above sea level)
Low lying	Less than 15 m
Rolling	16 to 30 m
Undulating	31 to 75 m
Hilly	76 to 300 m
Mountainous	More than 301 m

Source : Hutchison, (2009)

Hutchison (2009) already classified into five topographic unit with respected to their mean elevation above sea level. Low laying is less than 15 meter. Rolling from 16 meter to 30 meter. Undulating from 31 meter to 75 meter. Hilly from 76 meter 300 meter and mountainous is more than 301 meter. However, Van Zuidam (1985) also proposed elevation-relative height with slope.

Table 4.2 : Topographic classification by Van Zuidam (1985)

Class	Elevation-relative height (m)		Slope (%)	Characteristic
1	Less than 50 m	Low lands	0-2	Flat or almost flat
2	50 m to 200 m	Low hills	3-7	Gentle slope
3	200 m to 500 m	Hills	8-13	Sloping
4	500 m to 1000 m	High hills	14-20	Moderately steep
5	More than 1000 m	Mountains	21-55	Steep
6			56-140	Very steep
7			More than 140	Extremely steep

Source : Van Zuidam, (1985)

Classification of topographic unit is well explained by Hutchison (2009) and Van Zuidam (1985) also explain about slope. There are different classes as the characteristics of every classes is differentiated by their own elevation and slope. KPF Blau Plantation is located at Lojing Highland which indicate most of the area consist of high elevation. The lowest elevation in KPF Blau Plantation is 275 meter from sea level and the highest elevation is 503 meter from sea level. Hutchison (2009) already classified range of elevation from 76 meter from sea level until 300 meter from sea level as hilly topographic unit and 301 meter from sea level and above as mountainous topographic unit. However, Van Zuidam (1985) also categorized topographic unit with slope. Elevation from 50 meter from sea level until 200 meter from sea level as low hill topographic unit with slope range 3°-7° as gentle slope. 200 meter from sea level until 500 meter from sea level as hills topographic unit with slope range 8°-13° as sloping and 500 meter from sea level until 1000 meter from sea level as mountains with slope range 14°-20° as moderately steep. Slope in KPF Blau Plantation start from range 0° until 43° with classification flat to steep. Figure 4.7 shows topographic classification in KPF Blau Plantation. Figure 4.8 shows Slope Map with classification in KPF Blau Plantation. Figure 4.9 shows 2 dimensional map of KPF Blau Plantation. Figure 4.10 shows 3 dimensional map of KPF Blau Plantation.

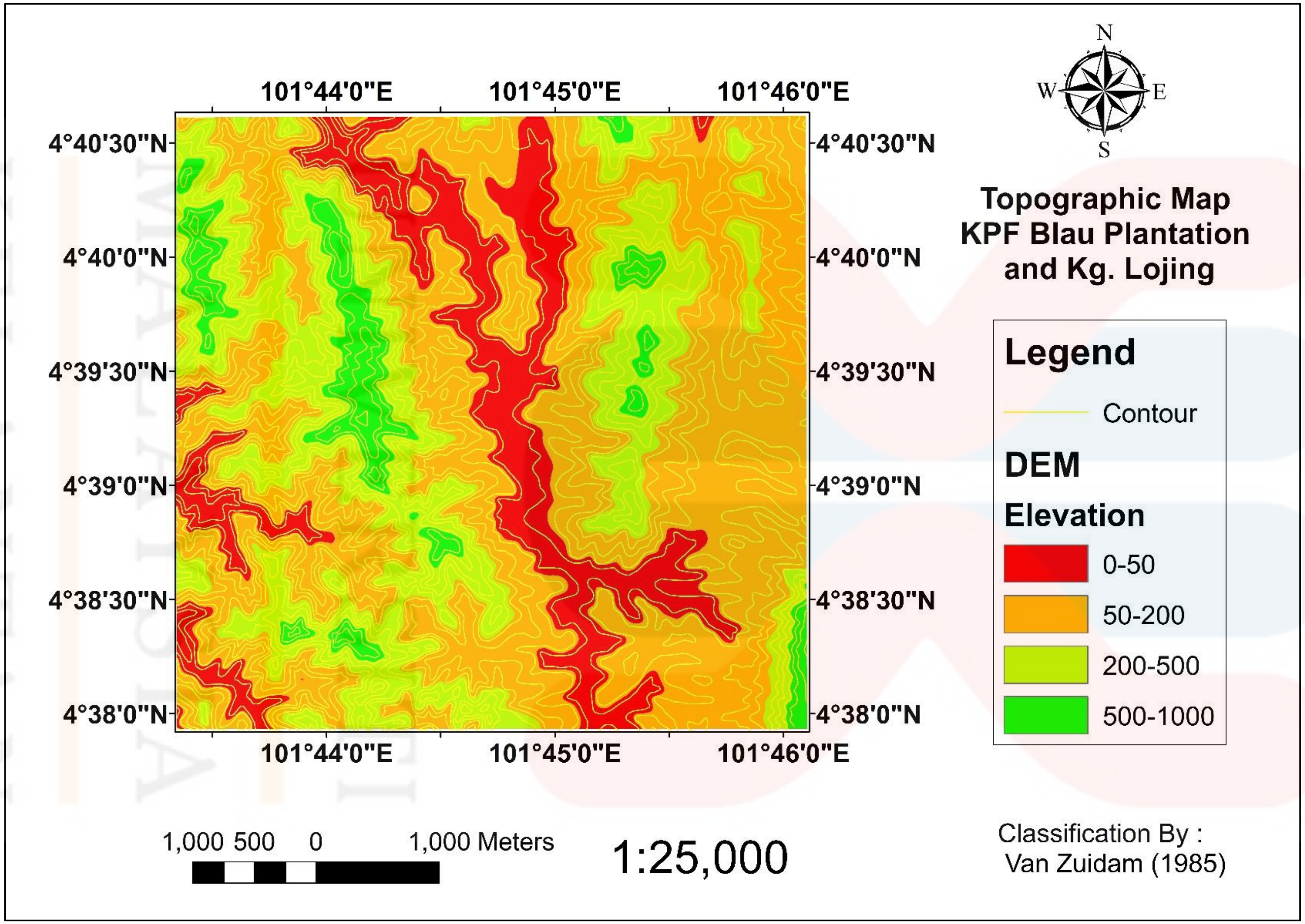

Figure 4.7: Topographic classification in KPF Blau Plantation

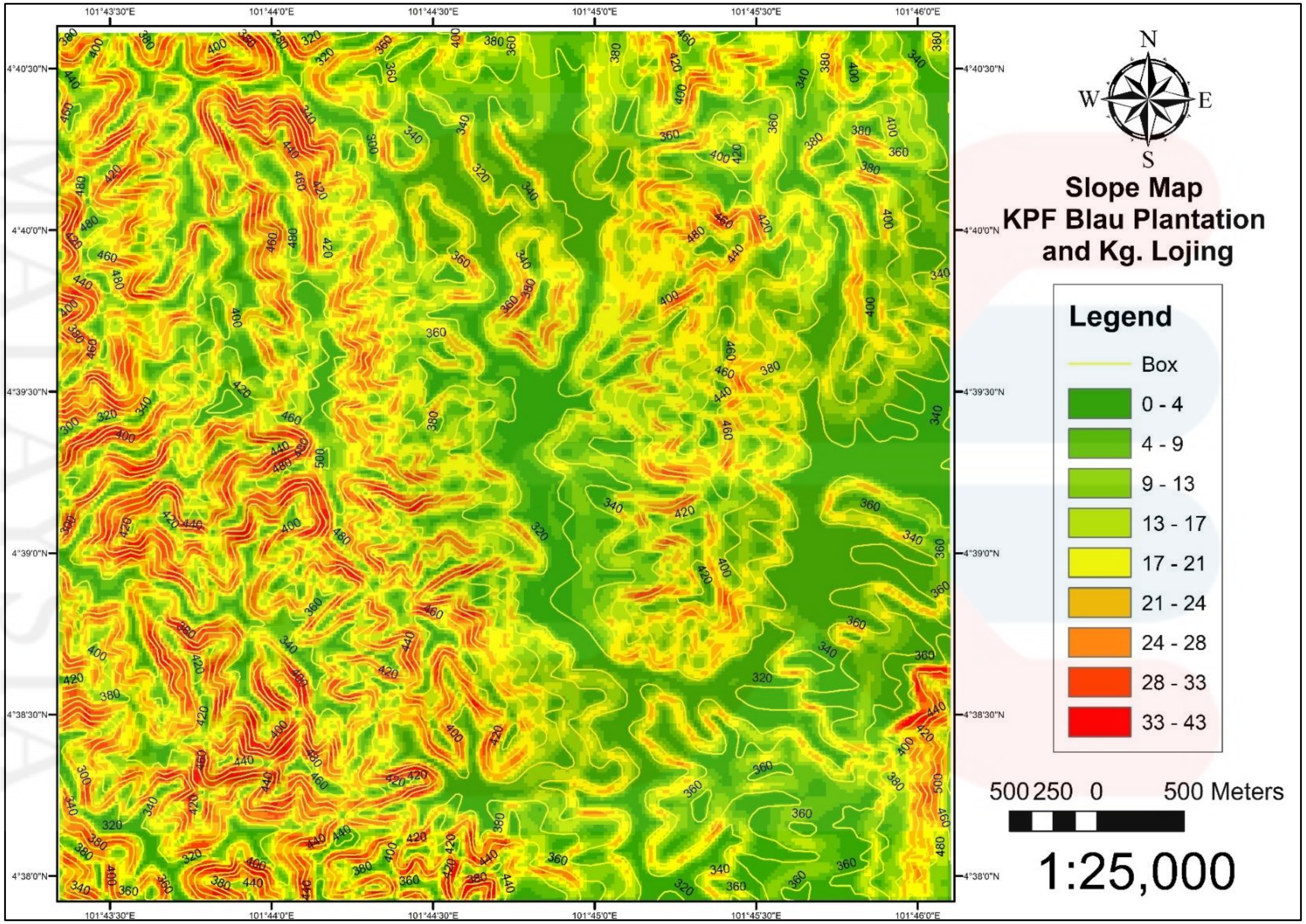

Figure 4.8 : Slope map of KPF Blau Plantation

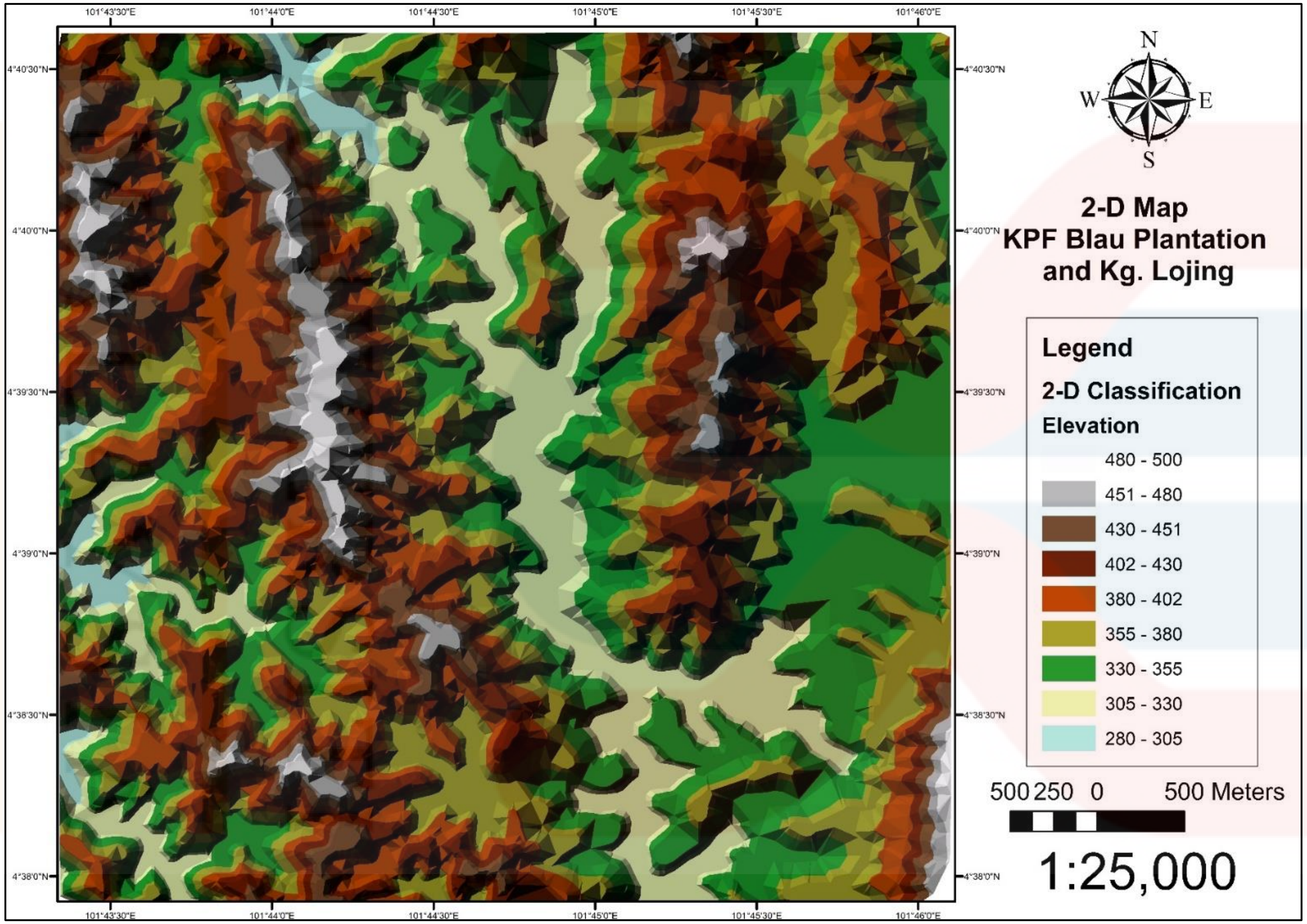

Figure 4.9 : 2-D map of KPF Blau Plantation

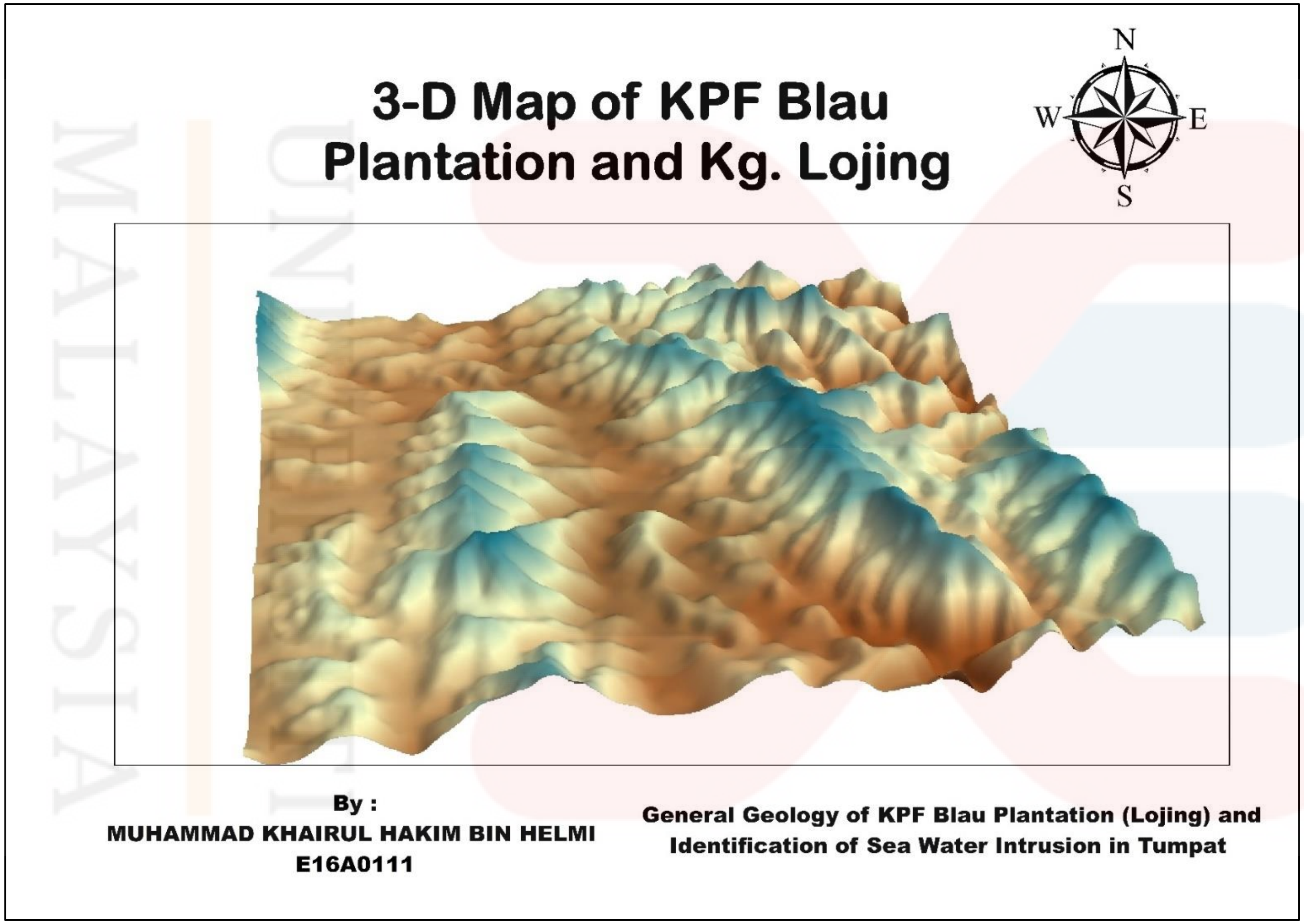

Figure 4.10 : 3-D map of KPF Blau Plantation

There are several classification of landform in KPF Blau Plantation. There are based on elevation, lithology, valley and hill slope unit. Mountainous area can be found in KPF Blau Plantation with large slope and steep in elevation. Figure 4.11 shows series of hilly-mountainous region in study area

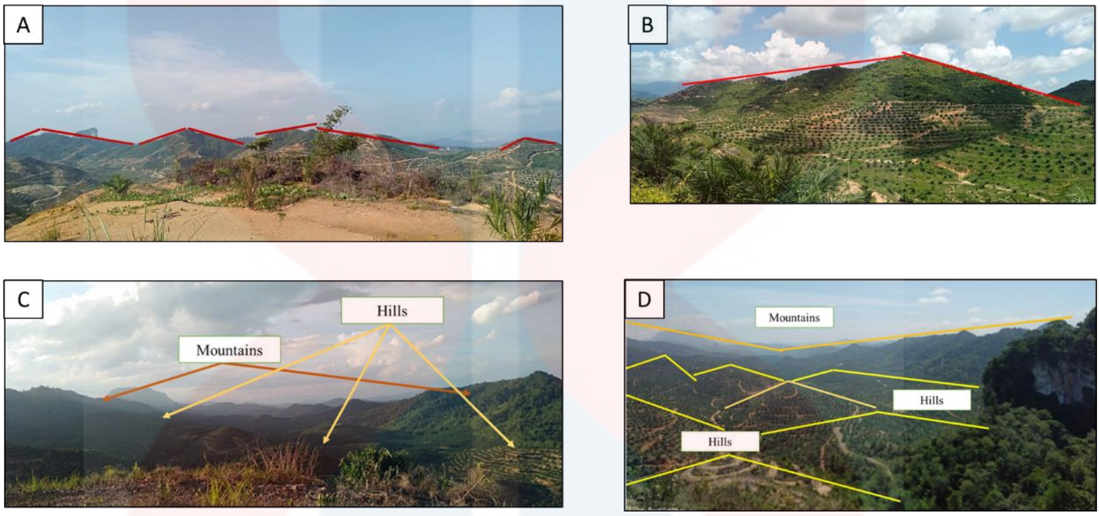

Table 4.11 : Series of hilly-mountainous (A) Mountainous (B) Hilly (C) Hilly—Mountainous (D) Hilly-Mountainous

Other than that, there also sedimentary and metamorphic lithology that form different landscape in KPF Blau Plantation. Quartzite landform usually consist of high and steep contour level with sharp peak or blunt peak at the top. However, there are two type of quartzite landscape in study area which are in high elevation and low elevation above sea level. Figure 4.12 shows quartzite landform with high elevation in KPF Blau Plantation

Table 4.12 : High elevation of quartzite (A) Far view (B) Close view (C) Panoramic view

Second landscape of quartzite formation in KPF Blau Plantation with low elevation. The long contour indicates quartzite ridge in KPF Blau Plantation. Therefore, owner of plantation are unable to plant within quartzite are as it composed of hard rock. Figure 4.13 shows quartzite with low elevation.

Figure 4.13 : Formation of low hill quartzite in KPF Blau Plantation

Other than quartzite formation is limestone or karst formation. Karst hill also can be identified in KPF Blau Plantation. Limestone is one of the sedimentary rock made from calcium carbonate in the form of mineral calcite. Generally form in warm, clear and shallow marines environment. Formation is due to process accumulation of coral and shell. However, karst is a landscape and topography that formed from dissolution of soluble limestone. Figure 4.14 shows karst landscape in study area.

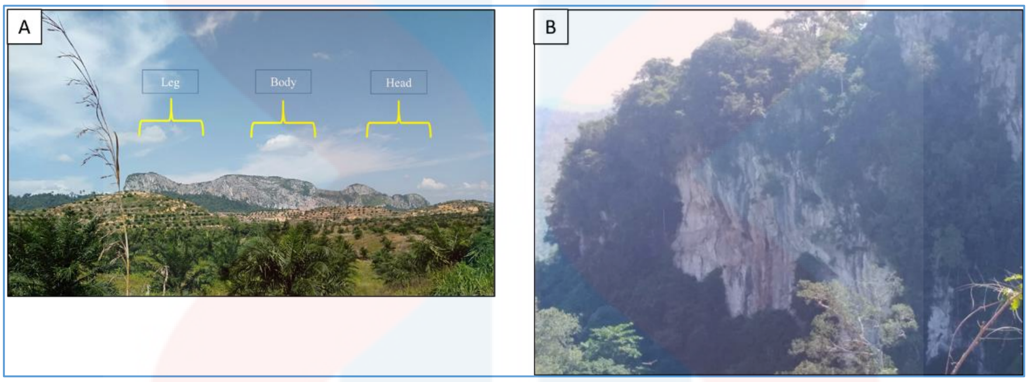

Figure 4.14 : Karst landscape (A) Gua Tidur (B) Karst Hill

Karst hill give different landscape and contour arrangement than other rock formation. Usually, limestone consist of high hill but sometime moderately high with high slope and extremely steep. However, very flat and plateau at the peak due to weathering process.

Other than that are hill slope environment. Hill slope environment are range from flat to steep. There are different classification of hill slope environment which are soil mantle hill slope and bedrock hill slope. Soil mantle hill slope are hill slope with regolith of soil. Sometime the soil mantled with a little exposure of bedrock. Bedrock hill slope are hill slope that form of bare of rock. Figure 4.15 shows hill slope environment in study area.

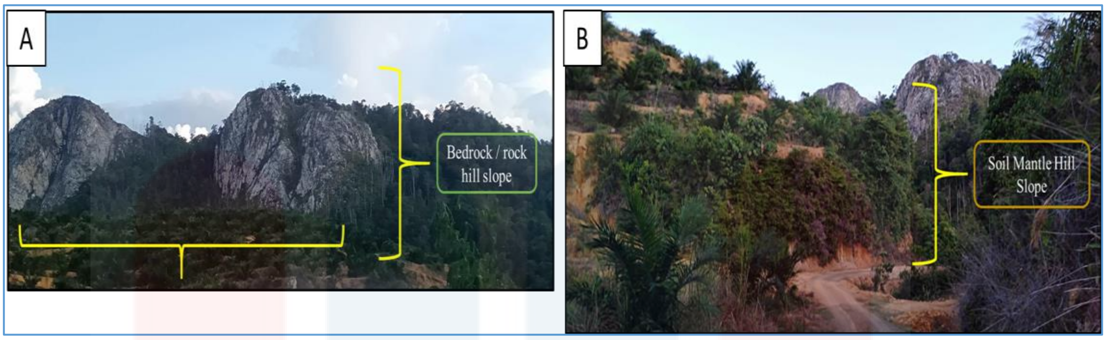

Figure 4.15 : Hill slope environment (A) Bedrock Hill slope (B) Soil Mantle Hill slope

Hill slope form and unit also can be observed in KPF Blau Plantation. Figure 4.16 shows hill slope form and unit in KPF Blau Plantation.Generally, top of the hill or mountain consist of convex upper slope unit which is gradient increase with length. Straight middle slope unit consist of constant gradient and concave lower slope unit has gradient decrease with length.

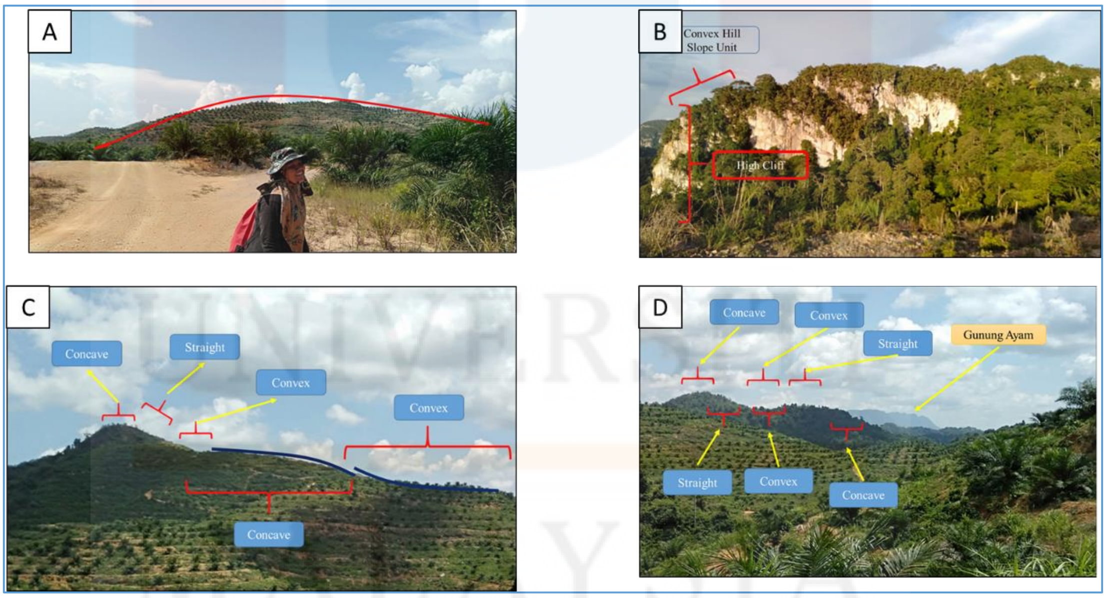

Figure 4.16 : Hill slope Unit (A) Concave unit (B) Concave unit at Limestone (C) Concave-Straight-Convex (D) Concave-Straight-Convex

Other than that, valley also can be seen easily from top of view in KPF Blau Plantation. Valley is defined as alley of space between two adjacent hills or mountain wall or slope in similar area. Usually there are two type of hills which are u-shaped valley and v-shaped valley. Figure 4.17 shows type of valley in study area.

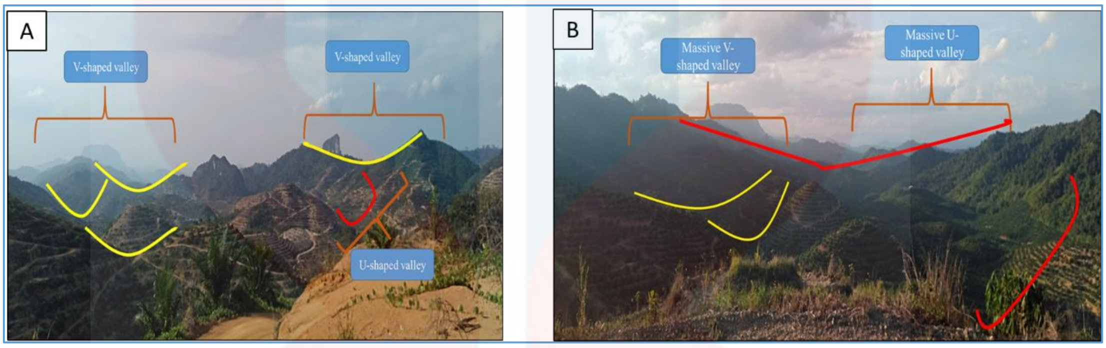

Figure 4.17 : Type of valley (A) V and U-Shaped valley (B) Massive V and U-Shaped valley

4.2.2 Weathering

Weathering is disintegration and decomposition of rock either in situ which is not involved transportation process and also produce regolith. Other than that, weathering also been carried out by action of extreme temperature, rain water or biological activity. In details, weathering process involve mechanical or physical, chemical and biological weathering. Physical weathering or mechanical are the process of disintegration and decay of rocks through weather element, high temperature and others. However, there is no changes in chemical composition of rocks. Example of physical weathering are exfoliation due to thermal expansion or contraction with release of pressure when buried rock is are uplift and exposed. Figure 4.18 below shows example of physical weathering in study area. There are joint sample are taken from quartzite outcrop.

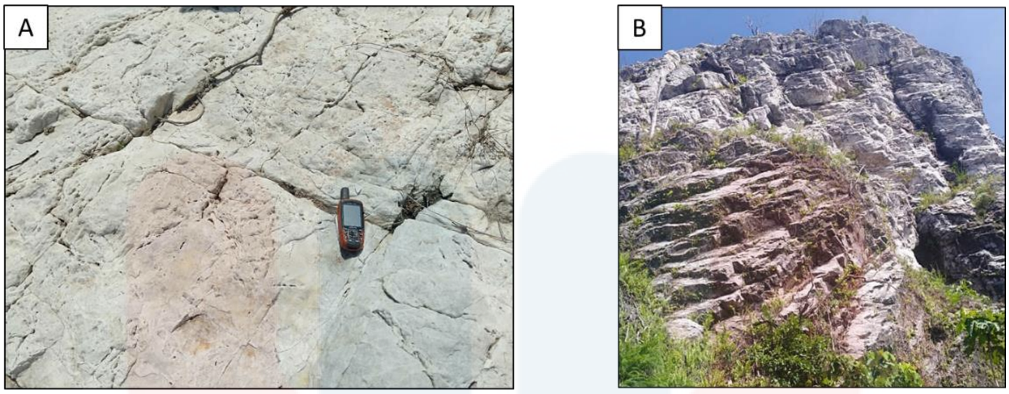

Figure 4.18 : Physical weathering (A) Physical weathering on quartzite outcrop (B) Effect of physical weathering

Other than that is chemical weathering. Common problems of chemical weathering are decomposes of rock through chemical change and its mineral. Example of chemical weathering are oxidation, hydrolysis and carbonation or solution. Oxidation normally related to iron rich mineral outcrop. Often become reddish colour like rust. Hydrolysis generally occur at igneous rock that have high amount of silica that already combine with water. Carbonation and solution is the process when carbon dioxide dissolves in water and reacts with carbonate rock to create a soluble product as calcium bicarbonate. Figure 4.19 shows dissolution of carbonate rock and biological weathering in the study area. As the result, many hole are formed from erosion process of chemical weathering.

Next is biological weathering. Biological weathering is a process that decaying of rock by pressure, stress, animal or plants associated with subsequent and weakening disintegrations by microbes, plants and animal. Example are roots which are physically break or wedge rock. Burrowing animal sometimes may increase biological weathering.

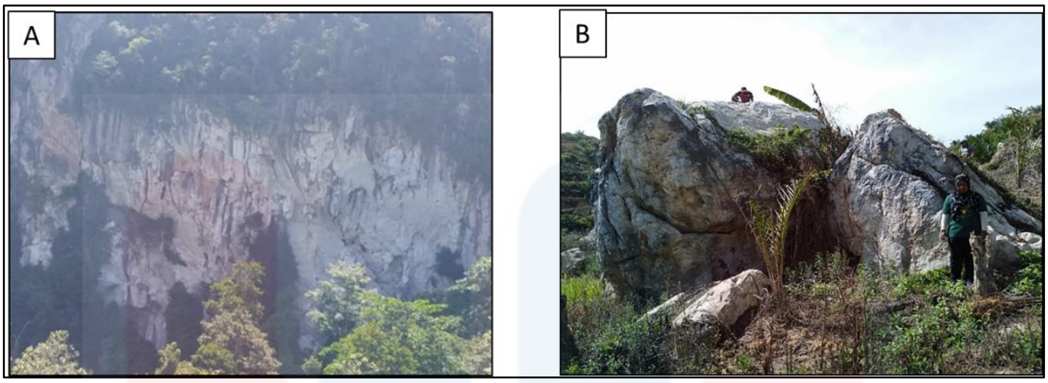

Figure 4.19 : Effect of weathering (A) Chemical weathering (B) Biological weathering

Table 4.3 : Weathering grade of rock mass

Term	**Symbol**	**Description**	**Grade**
Fresh	F	No visible sign of rock material weathering and slightly discolouration on major discontinuity surface.	I
Slightly weathered	SW	Discolouration indicates weathering of rock material and discontinuity maybe somewhat weaker extremely than their fresh condition.	II
Moderately Weathered	MW	Less than half of the rock is decomposed and disintegrated into soil. Fresh or discoloured rock is present either as a continuous framework or as a corestones.	III

Highly Weathered	HW	More than half of the rock material is decomposed and half disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as a corestones.	IV
Completely Weathered	CW	All the rock material is decomposed and disintegrated to a soil. The original mass structure is still largely intact	V
Residual Soil	RS	All the rock is converted to a soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has been significantly transported.	VI

Source : Ferrer, (2011)

4.2.3 Drainage Pattern

Drainage pattern or river system is are formed of aggregation of natural drainage ways (Argialas et al., 1988). Pattern of each drainage generally follow earth landform and topography either composed of hard rock or soft rock. Different topography and lithology give different drainage pattern and river system.

Flow patterns are easily recognized from topographic maps or aerial photographs, especially on a large scale. Branches - small branches and erosion on the surface of the earth will be clearly visible, while on a medium scale will show a comprehensive pattern as a reflection of rock types, geological structures and erosion. The pattern of drainage on layered rocks is very dependent on the type, distribution, thickness and area of rock layers and the geology of structures such as faults, burs, direction and shape of the folding.

There are many types of drainage systems. Commonly are dendritic, parallel rectangular, pinnate, trellis, radial and annular. Figure 4.20 below shows example of the most common drainage system.

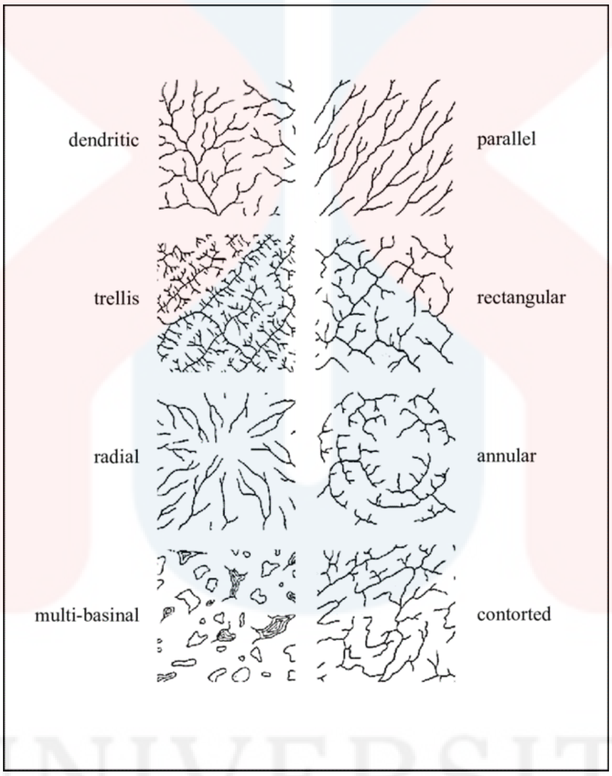

Figure 4.20 : Variety of drainage pattern

Source : Zhang, (2012)

In KPF Blau Plantation, dendritic drainage pattern can be observed. Figure 4.19 below shows drainage pattern map in the study area.

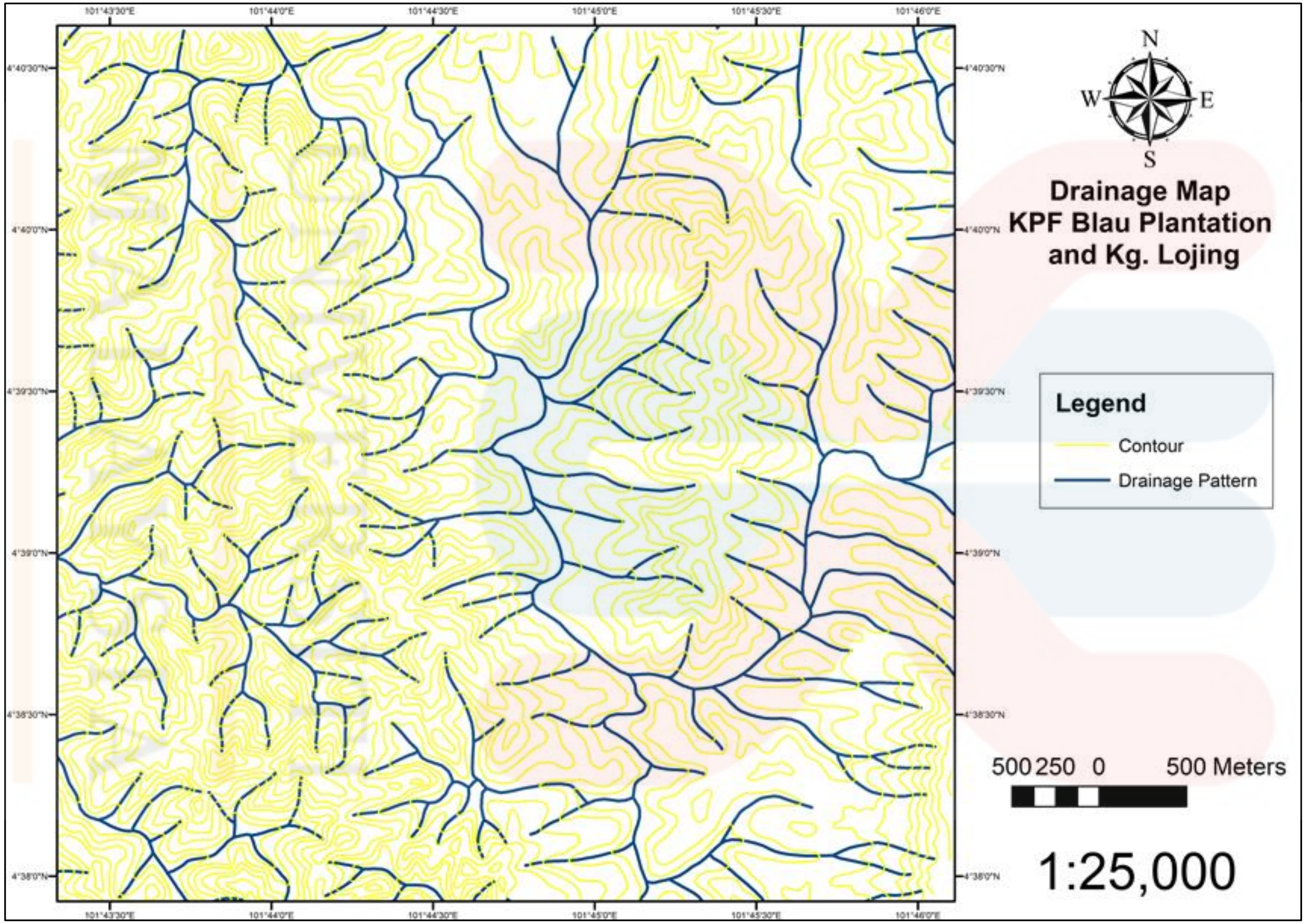

Figure 4.21 : Dendritic drainage system in KPF Blau Plantation

4.3 Lithostratigraphy

Lithostratigraphy is a study about physical relationship between rock unit. All physical properties and stratigraphic position are related to other lithostratigraphic position. No time connotation other than superposition. The rock are characterised into their own classes. There are many type of lithology are classified with several condition of certain stratigraphy at certain area. Different type of rock may be classified and become one group, member, unit or formation.

There are various type of rock in KPF Blau Plantation. There are mainly sedimentary rock and metamorphic rock. Sedimentary rock mainly composed of mudstone unit and limestone unit while metamorphic rock are composed of schist unit and quartzite unit. All of these rock unit are from Gua Musang Formation.

Gua Musang formation mainly consist of calcerous-argillaceous sequence of crystalline limestone with interbedded argillites and subordinate sandstone with volcanic. Usually, shale are grey in colour but change to black when carbonaceous (Yin, 1965). The sandstone include greywacke, protoquartzite and orthoquartzite. But metaquartzite are the most common (Yee, 1983). Volcanic rock also can be found in rhyolite and andesite include tuff, lava and agglomerate. The present fossil indicate geologic age of Gua Musang Formation in range of Late Carboniferous to Triassic (Yee, 1983).

4.3.1 Stratigraphic Position

Stratigraphic position is a layer of rock that show their position respected to their age era, epoch and lithology. Figure 4.22 shows stratigraphic position of all lithology in KPF Blau Plantation. Generally, position of rock unit are arranged by their age. Younger rock unit lies above older rock unit. Figure 4.23 shows geological map of study area in KPF Blau Plantation. There are metamorphic rock and sedimentary rock can be found in the study area.

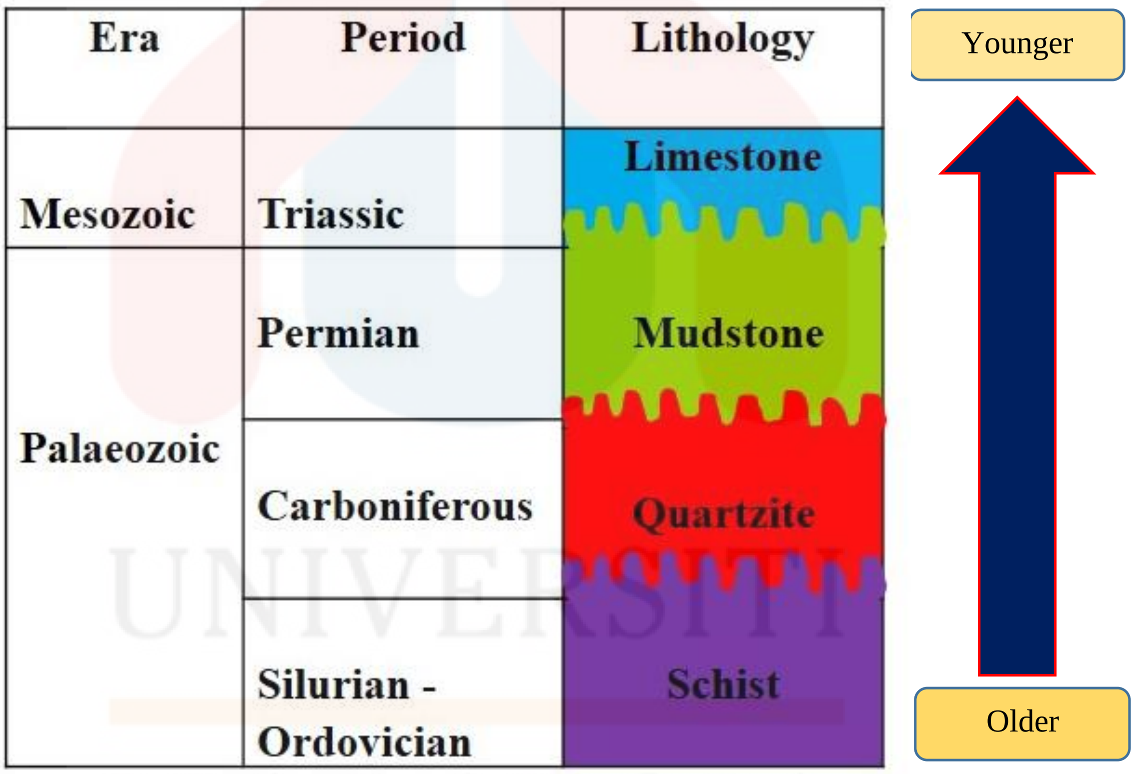

Figure 4.22 : Stratigraphic position of all rock unit in KPF Blau Plantation

Source : Lee et al. , (2004) and Department Of Mineral and Geoscience, (2003)

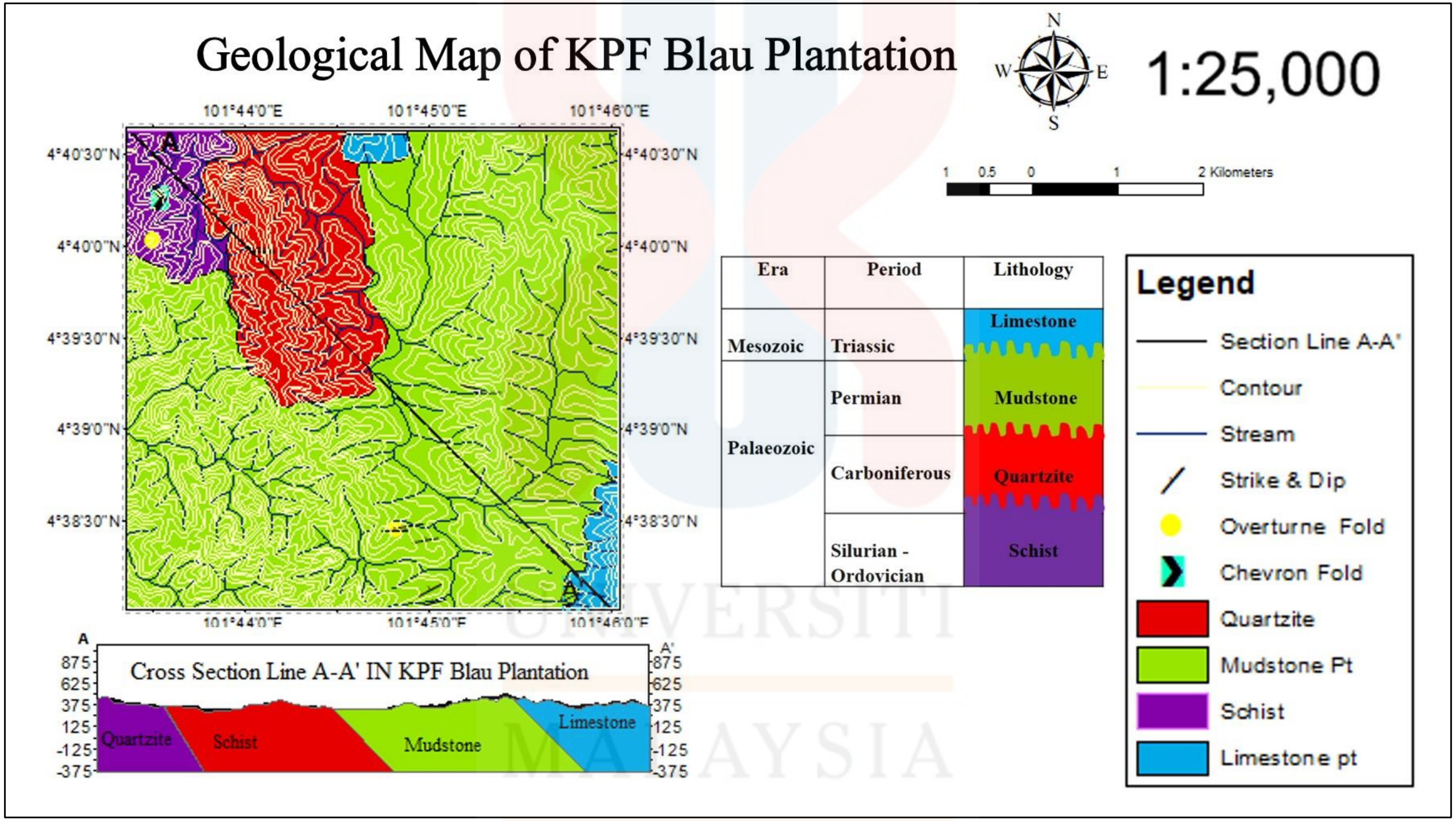

Figure 4.23 : Geological Map of Kpf Blau Plantation

Figure 4.23 above shows geological map of KPF Blau Plantation. Geological map size A1 shown in Appendix A. Generally, there are two main type of rock unit in KPF Blau Plantation which are sedimentary rock and metamorphic rock. Sedimentary rock unit consist of marbelised limestone and mudstone while metamorphic rock unit consist of quartzite and schist. All of the rock unit are well distributed in the study area.

Limestone can be easily found in North and South East of KPF Blau Plantation. Mudstone is the major component of all rock units in study area. Mudstone is well distributes in North East – South West of KPF Blau Plantation. However, schist and Quartzite rock unit can be found in North West of KPF Blau Plantation.

All the rock unit can be said overlies unconformable from the others. Mudstone overlies unconformable quartzite and schist. Limestone overlies unconformable mudstone in stratigraphic column. This is because, there is no contact sign of all the rock unit when geological mapping is conducted.

4.3.2 Unit Explanation

Lithology and rock unit in KPF Blau Plantation are distinguished by their own type which are sedimentary or metamorphic rock. From oldest to youngest, the distribution of rock as follow the stratigraphic position which are limestone, mudstone and quartzite and schist.

a) Limestone unit

Limestone found in KPF Blau Plantation are classified into to class based on Dunham classification. The grain size of limestone is very fine and cannot be seen by naked eyes. The colour is blackish grey with small calcite vein. According to Dunham classification, these kind of limestone categorised as mud supported which has less than 10 % grain. The original components are not bind together during deposition. There are no sign of bedding the outcrop being classified as massive sedimentary rock. Limestone also already being test by Hydrochloric acid hence the result is bubble of colourless gas is released. Figure 4.24 shows hand specimen and image thin section of limestone. Limestone also dissolved in water as a result of dissolution and chemical weathering. Table 4.4 below show mineral properties of limestone.

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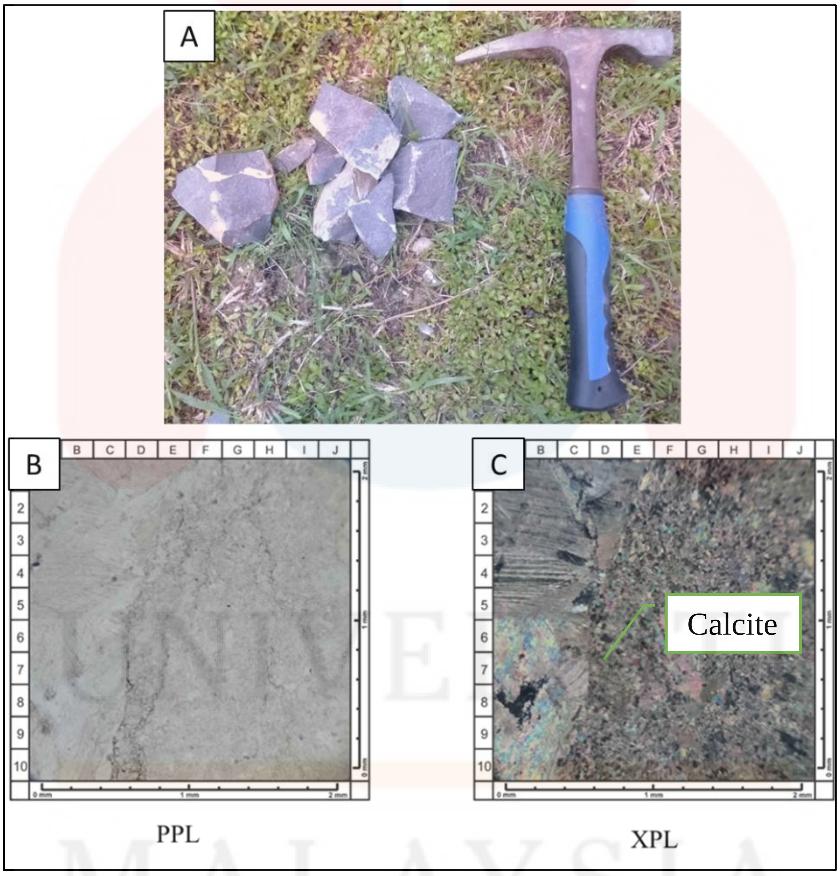

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Figure 4.24 : (A) Hand Specimen (B) Thin section limestone under ppl (C) Thin section limestone under xpl

Table 4.4: Properties of limestone under xpl and ppl

Name	**Limestone**
Colour	Calcite white bright in PPL Pink greenish in XPL
Pleochroism	Strong
Percentage	69%
Calcite vein	30 % Dark in PPL and xpl Strong pleochroism
Opaque mineral	1 %

Age of limestone in KPF Blau Plantation is Middle Permian to Late Triassic (Mohamed et al., 2016). Depositional environment of limestone usually in shallow marine (Mohamed et al., 2016). These stratigraphy unit is from Gua Musang Formation.

b) Quartzite unit:

Quartzite is an unfoliated metamorphic rock. The protolith of quartzite is sandstone unit. When sandstone exerted by heat and pressure it transform to quartzite rock unit. The process recrystallize grain size of sand and silicate mineral that bind together. Quartzite may be found at mound building system in convergent plate boundaries. Folding and faulting due to tectonic event produce compressional force which resulting formation of quartzite. Composition of rock dominated by sand grain size. The colour observe is greyish white. Quartzite undergo regional and contact metamorphism. Since there is no layering and banding found at the hand specimen, it considered as contact metamorphism. In Gua Musang, quartzite is categorised as arenaceous rock or quartz arenite (Lee et al., 2004). Table 4.5 shows properties of quartzite.

Table 4.5: Properties of quartzite

Quartzite		
Quartz	Colour	White in PPL and XPL
	Relief	Low with no cleavage
	Pleochroism	Low
	Shape	Anhedral
	Percentage	88%
Clay mineral and clay silicate	Colour	White grey PPL Grey-black XPL
	Shape	Crystal
	Percentage	10 %
Opaque mineral	Colour	Dark in PPL and XPL
	Percentage	2%

The geologic age of outcrop quartzite is in Middle Permian – Late Triassic in Gua Musang. Formation (Lee et al., 2004). Since the hardness of the quartzite is very high and mohr's scale is 7, quartzite been classified as high resistance rock unit with low weathering. Figure 4.25 shows outcrop, hand specimen and thin section of quartzite outcrop.

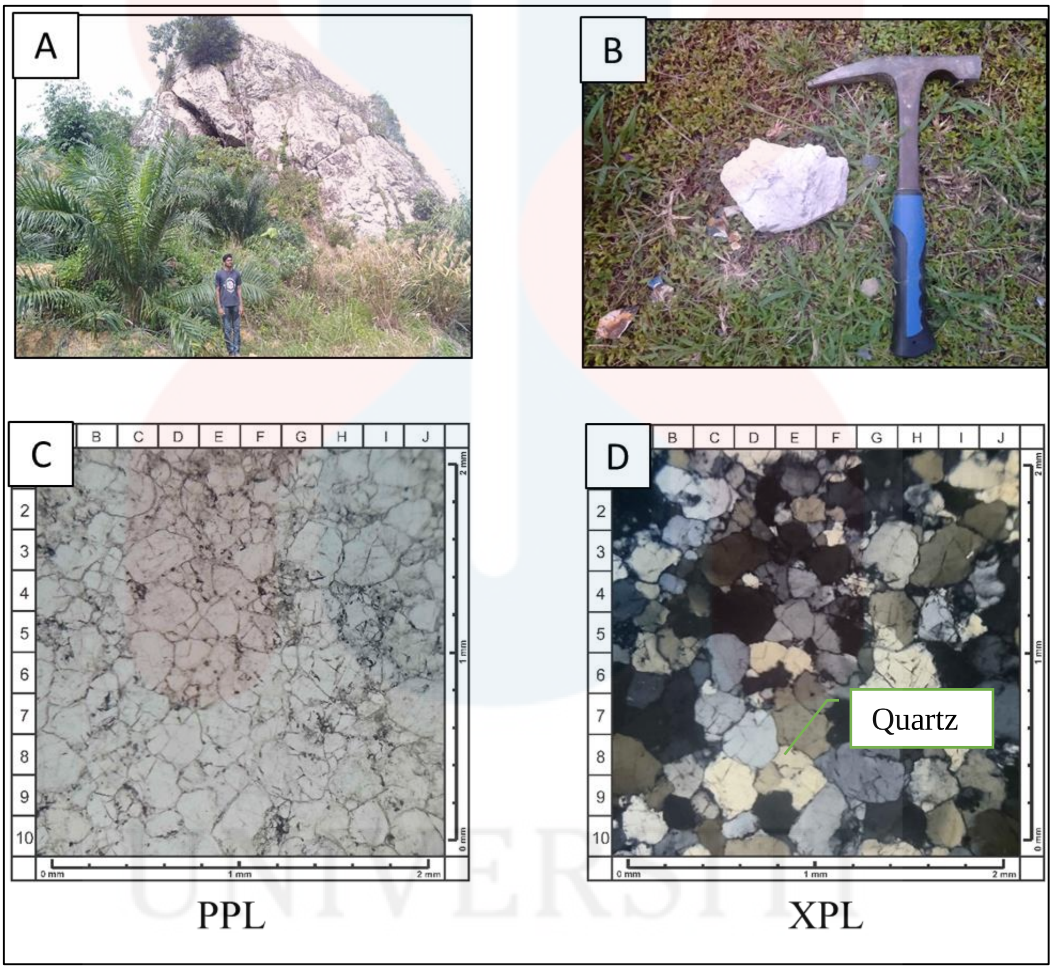


Figure 4.25 : (A) Quartzite outcrop (B) Hand specimen of quartzite (C) Thin section quartzite under ppl (D) Thin section quartzite under xpl

c) Schist unit:

Schist is medium grade foliated metamorphic rock formed after phylite. The previous rock is phylite. When phylite exterted by high temperature and pressure it will recrystallize current crystal mineral composition of the rock. When high pressure, the force exerted is perpendicular to the alignment of mineral and resulting trend of mineral assemblation. This is called shistocity texture. Schist is generally formed at continental side of convergent plate boundary. Figure 4.26 shows schist outcrop, hand specimen and thin section image. Table 4.6 below shows properties of schist.

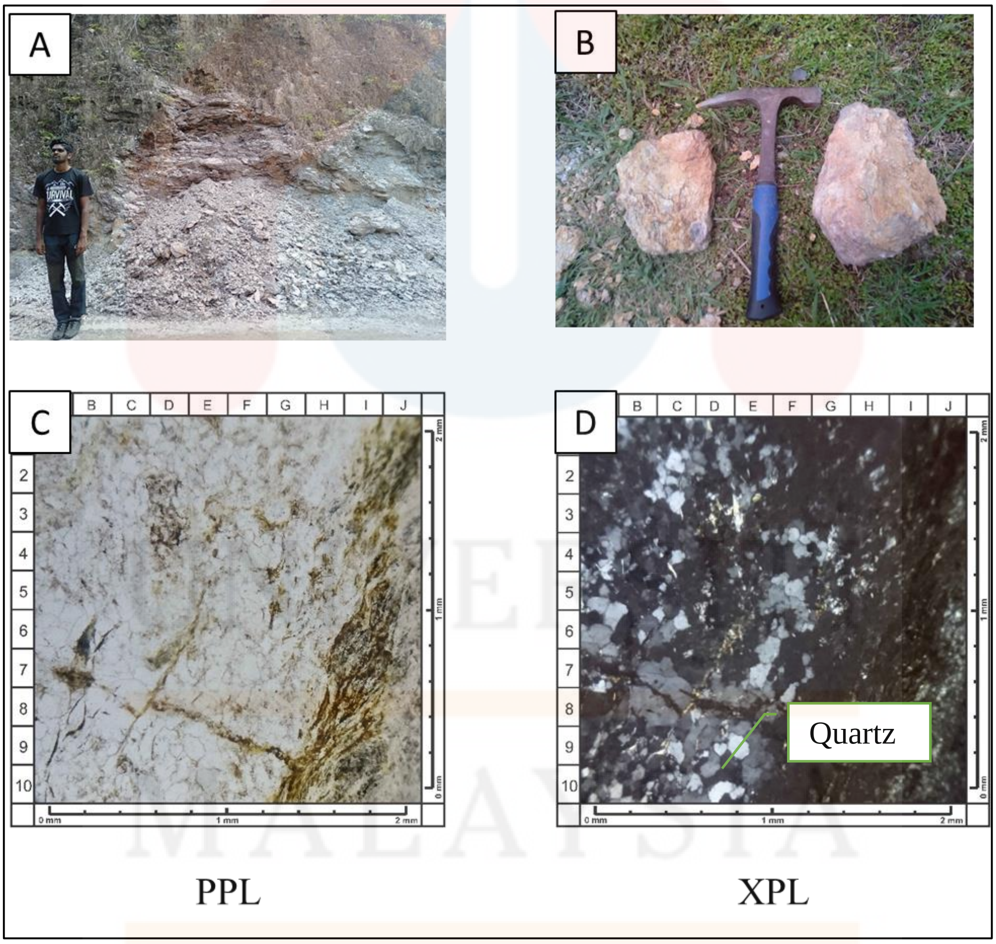


Figure 4.26 : (A) Schist outcrop (B) Hand specimen of schist
(C) Thin section schist under ppl (D) Thin section schist under xpl

Table 4.7: Properties of schist under xpl and ppl

Schist		
Quartz	Colour	White in PPL and grey-black XPL
	Relief	Low with no cleavage
	Pleochroism	Low
	Shape	Anhedral
	Percentage	47%
Clay oxide and clay mineral	Colour	Brown PPL Grey, brownish, balckish XPL
	Percentage	15 %
Opaque mineral	Colour	Dark in PPL and XPL
	Percentage	3%
Structure	Schistocity	

The geologic age of schist is Ordovician – Silurian (Department of Mineral and Geoscience Malaysia, 2003).

d) Mudstone Unit:

Mudstone is categorized as clastic sedimentary rock sedimentary rock unit. The grain size of mudstone is based on percentage of clay, silt and sand grain size. Grain size of mudstone is very fine grain associated with clay grain size which is 1/256 milimeter..

However, mudstone is classified as meta-sediment rock through petrographic analysis. There is trend and pattern of flatty in mineral arrangement indicate mudstone in undergo metamorphism process. Figure 4.27 shows outcrop mudstone, hand specimen and thin section image. Table 4.8 shows properties of mudstone.

Table 4.8: Properties of mudstone under xpl and ppl

	Mudstone	
Quartz	Colour	White in PPL and grey-black XPL
	Relief	Low with no cleavage
	Pleochroism	Low
	Shape	Anhedral
	Percentage	4%
Silicate mineral and clay mineral	Colour	White-grey PPL Grey-black XPL
	Percentage	73 %
	Colour	Brown in PPL XPL grey, brownish, blackish

Clay mineral and oxide mineral	Percentage	20 %
Opaque mineral	Colour	Dark in PPL and XPL
	Percentage	3%
Notes	Mudstone show undergo metamorphism process as per their hardness however, there are no any sign of it in petrology analysis. Therefore the rock can be classified as meta mudstone	

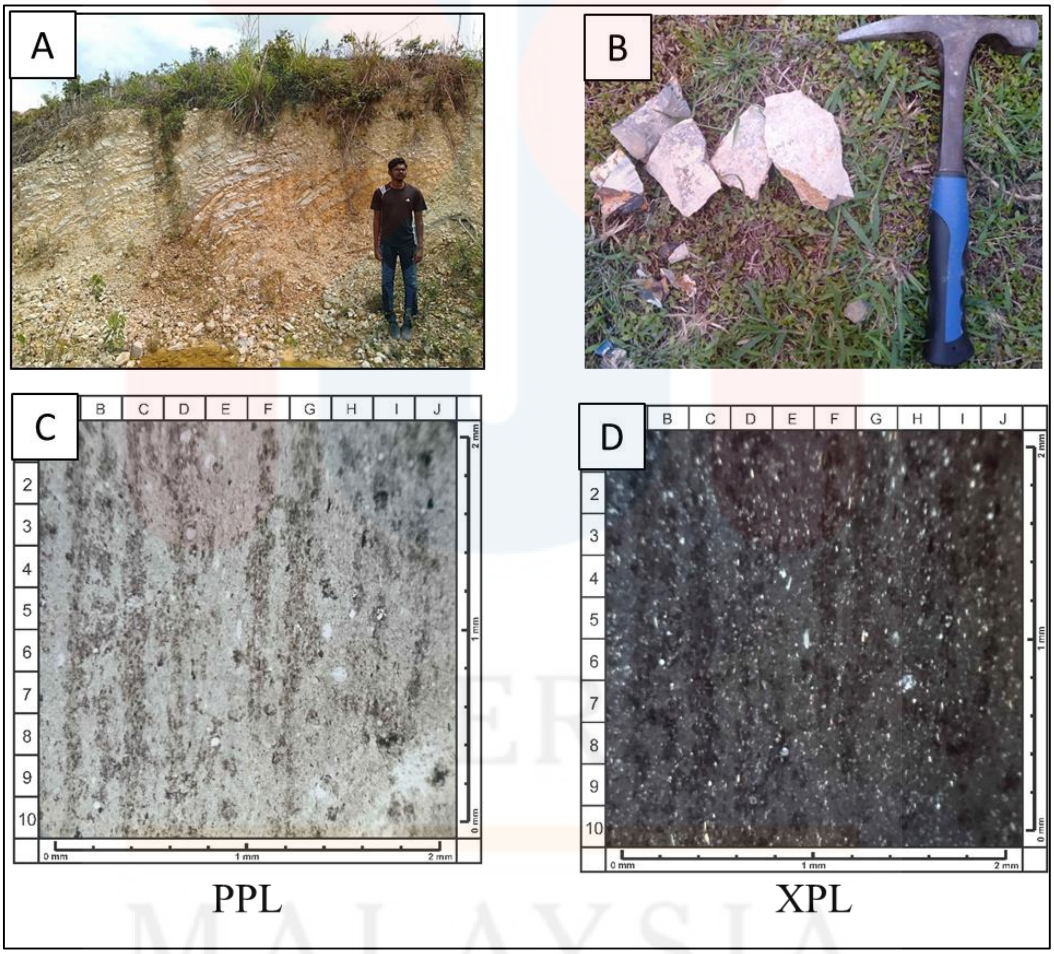


Figure 4.27 : (A) Mudstone outcrop (B) Hand specimen of mudstone (C) Thin section mudstone under ppl (D) Thin section mudstone under xpl

The age of mudstone rock is Middle Permian to Late Triassic (Lee, 2004) as similar in Gua Musang Formation.

4.4 Structural Geology

Structural geology is a study of earth process after going through deformation process. In addition, all the geological structures and formations of the rock such as fold, fault, vein and joint. The rock strain and stress are the process involving structural geology process.

4.4.1 Lineament Analysis

Lineament is a linear feature in a topography that showing and indicate geological structure and structural geology in a certain area. Generally, a lineament will form as fault-alligned valley or series of fold and fault in that particular area.

Generally, weak zone is located in drainage valley and may consist of fault, fold, joint and vein that across them. Figure 4.68 shows lineament map of KPF Blau Plantation.

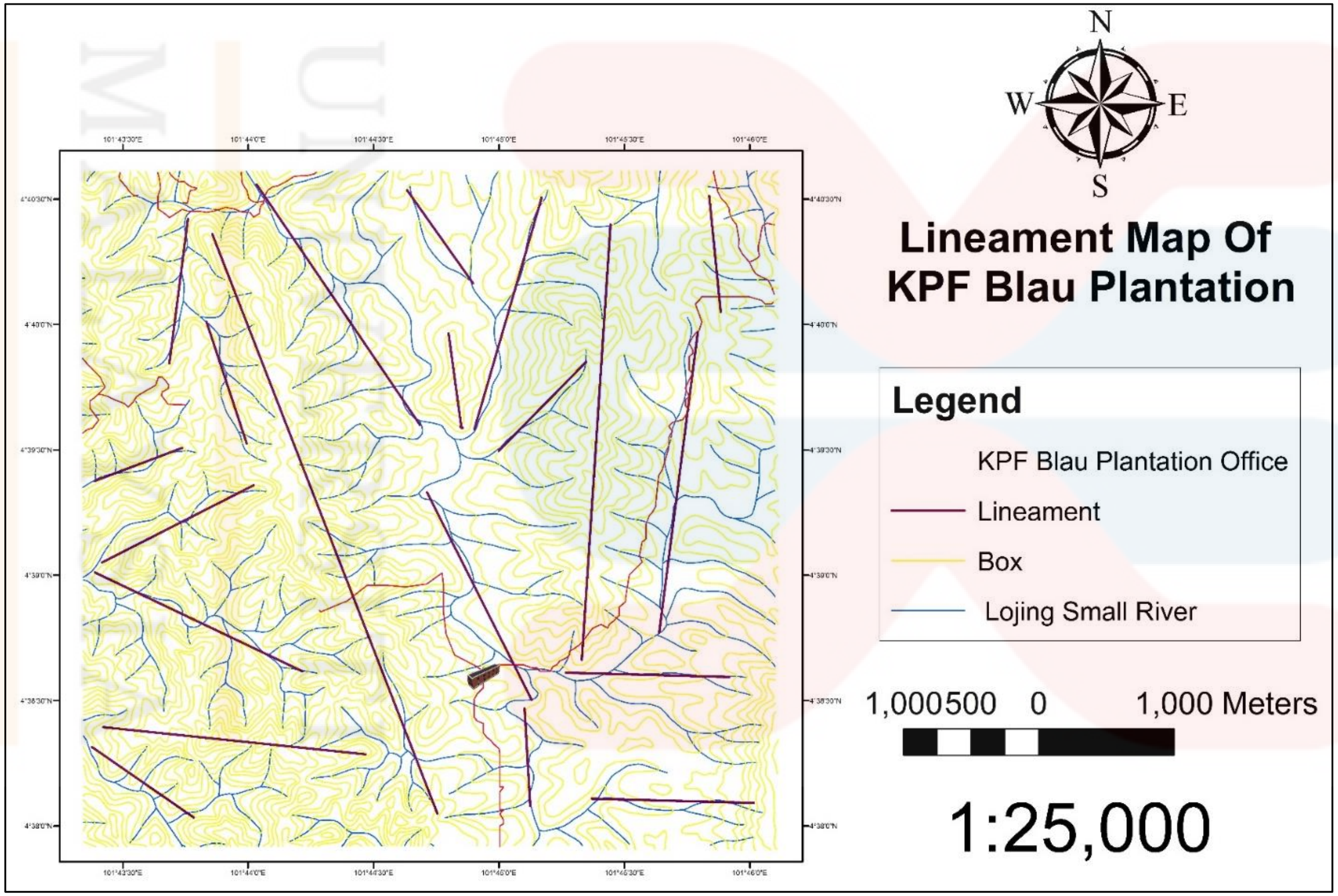


Figure 4.28 : Lineament map of KPF Blau Plantation

4.4.2 Vein

Vein can easily defined as fracture of rock that associate with mineral intrusion and precipitation within the space. Usually, mineral calcite and quartz be filled inside the fracture. Generally vein is formed when an aqoues solution carry constituent mineral between rock mass and precipitated. The vein generated at planar surface of the rock mass and wall. Process of generate vein involving shearing process and their development. There are three mode of shear which are mode 1 is extension fracture, mode 2 is tension fracture and mode 3 is shear fracture. Figure 4.29 shows classification mode of shear in fracture mechanism.

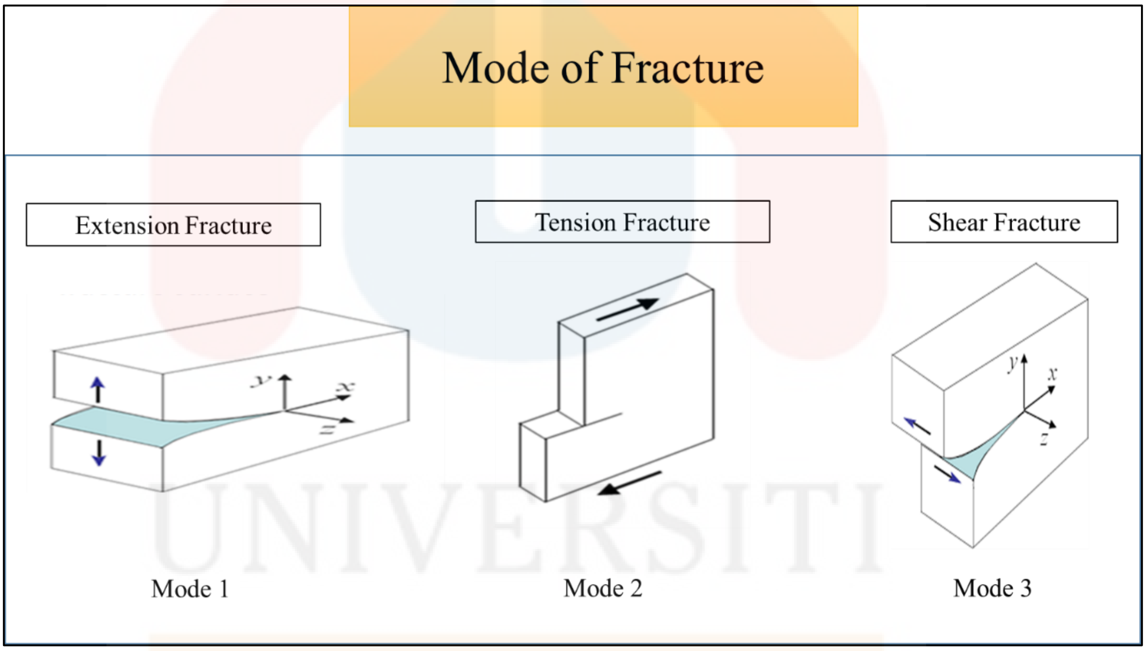


Figure 4.29 : Mode of fracture mechanism

Source : Lauren, (2015)

Minerall filling and rock fracturing in vein obey mode 1 of facture mechanism. In mode 1, extension fracture form positive and compressive stress. The fracture plane is perpendicular to lowest principal of sigma which is 3. There is no displacement across the extension plane but only extension normal to fracture surface.

There are plenty of quartz vein intuded mica schist quartzite in KPF Blau Plantation. Quartz vein is a new mineral which is intrude to the older host rock unit such as mica schist. Coordinate of the location is 4°40'10.19"N, 101°43'30.30". Orientation of the quartz vein is 225°/40°. And the coordinate is 4°40'26.74"N, 101°43'43.99"E. Figure 4.30 shows vein in KPF Blau Plantation.

Figure 4.30 : Quartz vein in KPF Blau Plantation

4.4.3 Joint

Joint defined as fracture formed inside rock mass when displacement of fracture is greater than displacement of lateral movement in the plane of fracture such as move up, side or down of one side relative to the other. Generally joint form with their sets and group altogether. Joint also one of the fracture. Usually, formation of joint is associated with extension of the hard rock which is brittle and exceed their strength. Fracture of rock across parallel plane to the most dominant principle stress also perpendicular with the less dominant of principal stress.

Continuous deformation process resulting development of one or more additional joint sets. There are many type of joint such as sheet join, tectonic joint, unloading joint, exfoliation joint, cooling joint and master joint. There are cross joint and extension joint at outcrop quartzite at coordinate 4°40'2.06"N, 101°44'11.09"E. Figure 4.31 below shows parallel with cross joint, extension joint and rose diagram of joint at Station 1.

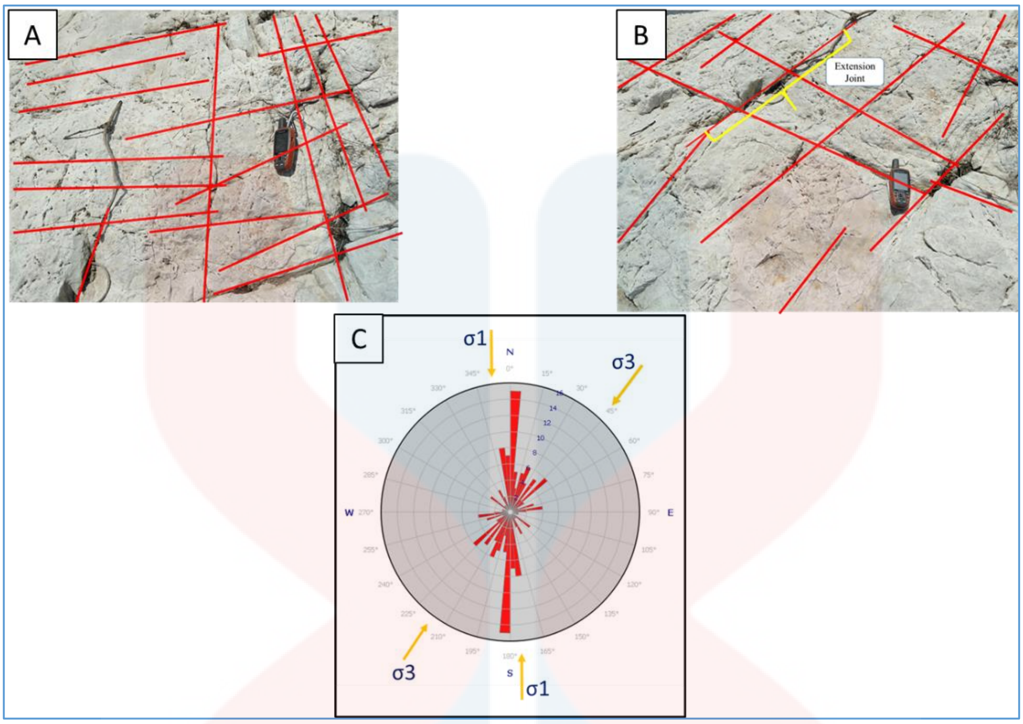


Figure 4.31 : (A) Parallel and cross joint (B) Extension joint (C) Rose diagram of the Station 1

Based on the joint analysis of the quartzite outcrop above, principal stress 1 or σ1 is from N 10° W or 350° and S 5° E or 175°. However, principal stress 3 or σ3 is from N 45° E and S 40° W or 230°. Figure 4.68 below shows rose diagram of the outcrop quartzite at Station 1.

Other than that there also joint reading and analysis in Station 2 at KPF Blau Plantation near quartzite hill. The coordinate of Station 2 is 4°39'59.44"N, 101°44'5.86"E. Figure 4.32 shows extensional joint, cross joint and rose diagram at Station 2.

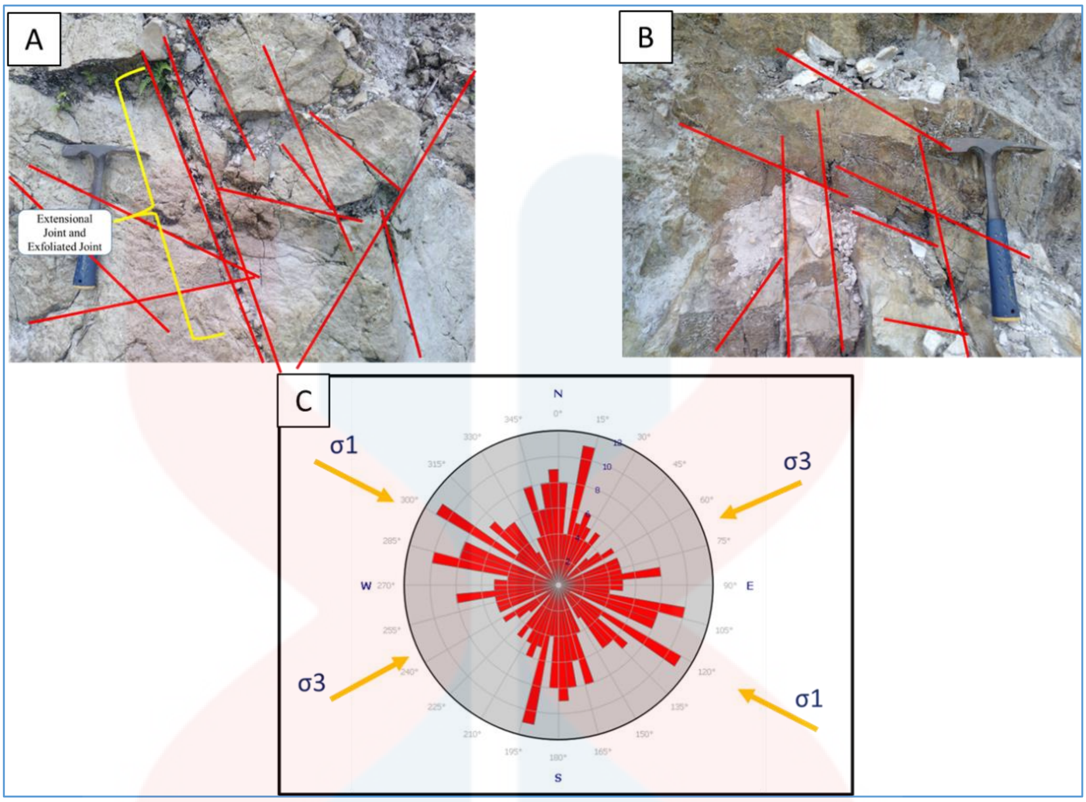


Figure 4.32 : (A) Extensional joint (B) Cross joint (C) Rose diagram at the Station 2

From the joint analysis above, principal stress 1 or σ1is from N 60° W or 300° and S 60° E or 120°. However, principal stress 3 or σ3 is from N 68 E σ1 or S 25° W or 245°.

Both of the join are analyzed from quartzite outcrop. There are exfoliation weathering that from sheet layer due to high temperature and pressure. Other than that there also has parallel joint which shows systematic joint system of the rock mass. Next, there also have cross joint perpendicular to each other which give different joint set reading after analysis is done. There also have extensional joint that stretched out from their fracture plane. Hence other mineral are intruded and growth inside. There also no mineral growth and precipitation inside the other extensional joint in similar outcrop.

4.4.4 Fold

Folding is one of secondary structure of structural geology. Normally folding occur when the rock layer undergo ductile deformation. When the rock layer is achieve high limit of deformation and it stop resulting folding structure. There are many type of fold such as anticline and syncline. There also others type of fold in KPF Blau Plantation. Figure 4.33 overturned fold. Figure 4.34 shows chevron folding unsymmetrical wavy bedding of the schist outcrop.

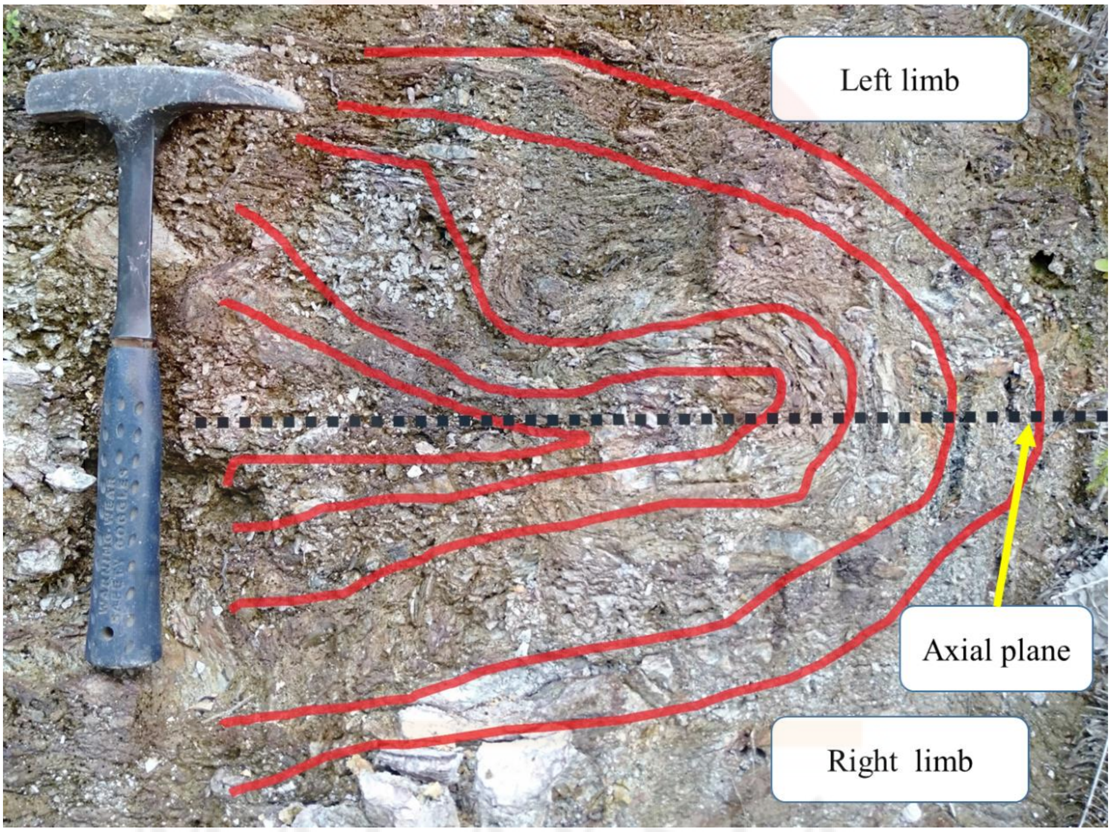


Figure 4.33 : Overturned fold on the outcrop mica schist

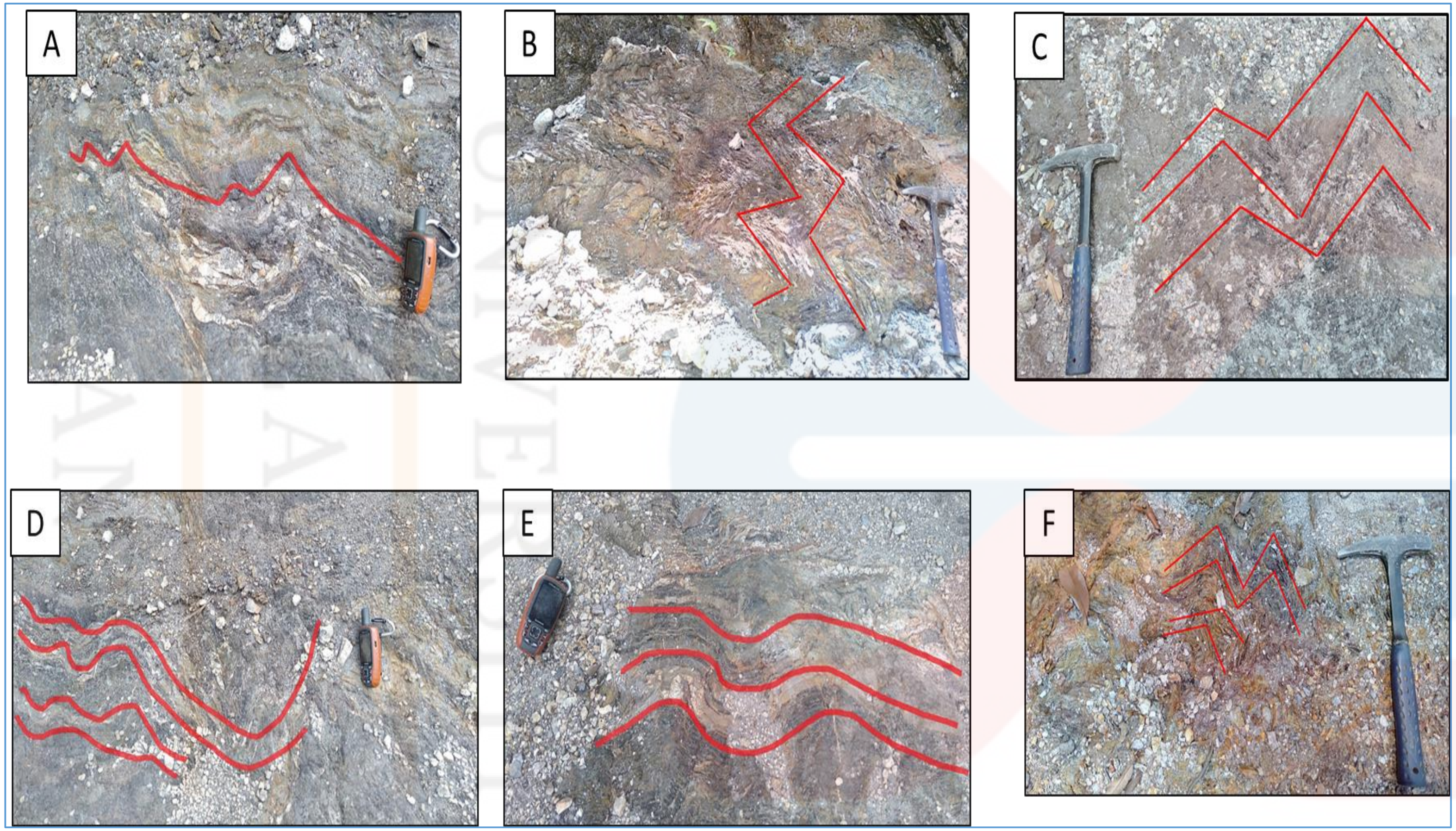


Figure 4.34: Folding (A) Unsymmterical wavy bedding (B) Chevron Fold (C) Chevron Fold (D) Unsymmterical wavy bedding (E) Banded of mineral in form of bedding (F) Chevron Fold

4.4.5 Mechanism of Structure

Based on joint analysis and reading at station 1, the greater force or principle stress 1 come from NNW-SSE. There are N 10 W and S 5. This reading almost as N-S. While principle stress 3 come from NNE-SSW. There are N 45 S and S 40 W. The high force of principle stress 1 contribute in strike slip fault that could not be seen and measure during field. Based on the Riedel theory (Fridolin, 2014) there is one small force perpendicular to principle stress 1 form folding structure which is from NNE-SSW. Principle stress 1 with greater force create compressional pressure acting on principle stress 3 with low forces create extensional pressure. Hence elastic deformation affected the rock behavior in study area. Figure 4.35 shows Riedel Theory.

When the elastic limit of rock is exceeded, alteration of rock take place and force to become folding structure.

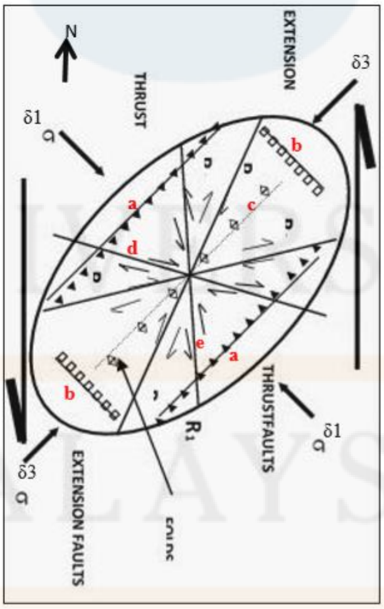


Figure 4.35: Riedel Theory

4.5 Historical Geology

KPF Blau Plantation is located at Lojing area near Gua Musang and Cameron Highland. Lojing area undergo many tectonic activity and also involve in Bentong-Raub Suture Zone. Along the highway of Gua Musang – Cameron Highland, Bentong-Raub Suture expose in about 20 kilometer wide through many deformed of rock. There are about seven facies of rock of Bentong-Raub Suture (Tjia, 1996).

There are complete series such as sequence of phyllite and schist, clastic intercalation with bedded chert and olistostrome. There also serpentinite lens within the schist. Imbricated structure is suggested due to the tectonic activity (Tjia, 1996). The suture zone western boundary consist of Upper Triassic – Jurassic granitoid injection complex (Tjia, 1996). Lower Middle Palaeozoic oceanic region is the origin Bentong-Raub Suture and closed by collision of Lower Triassic between Cathaysian plate and Gondwana land (Tjia, 1996). Bentong-Raub Suture undergo tectonic process and setting in Late Pemian with absence of deep ocean radiolaria. In Late Triassic all the tectonic activity settle down completely (Shuib, 1994).

Deformation of Schist series occur in Lojing area of Gua Musang. The schist show inclinal fold, foliation parallel to bedding and buckling (Alexander, 1968). In addition, there also faulting and folding. The folding is suggested undergo twice, show strong folding, micro folding and crenalution (Haile et al., 1977).

Multiple deformation of schist series associate with tectonic transport to the east then to the west (Tjia, 1984).

Chapter 5

IDENTIFICATION OF SALT WATER INTRUSION IN TUMPAT COASTAL AREA BY USING ELECTRICAL RESISTIVITY IMAGING AND GEOCHEMISTRY

5.1 Introduction of Seawater Intrusion

Salt water intrusion is the most common pollutant in fresh groundwater. Intrusion of saline water occurs where salt water replaced or combine with fresh water in particular aquifer. Saline intrusion also possible occur in deep aquifer due to advance of salt water of geologic origin. In shallow aquifer occur from surface water discharge. In coastal area, saline invasion is commonly happen and become major problem (Fetter, 1988).

Generally, human activities also become main factor of sea water intrusion. Usually, sources of fresh water near to the sea and to water body of saline water also effluent released by human activity. Typically, shallow groundwater overlies salt water because the flushing action during recent time. And also remove salt from previous marine deposits (Fetter, 1988).

Some sources of saline water is encroachment of seawater in coastal area. Next, seawater that entered aquifers during previous time. Other than that, salt originate from salt domes, thin bed or disseminated in geologic formation. In addition, water concentrated by evaporation in tidal lagoons, payas, or other enclosed area. Next, the water return flow to streams from irrigated land. Last, from human saline waste (Fetter, 1988).

5.2 Previous Study

5.2.1 Global Scenario

Saltwater intrusion become major problem across the world. A world case study related of saline intrusion in Adriatic Coast, Italy. Salt water intrusion affect growth of plan, density of plant, limited type of plant survival and dry the pine plant along Ravena pine forest (Felisa et al., 2013). The study approaches by using analytical model according to Strack theory. With consideration of groundwater withdrawal in phreatic zone. The extension of salt water intrusion is assumed by using Strack theory with modelling of Dupuit-Forchheimer in coastal phreatic aquifer (Felisa et al., 2013).

There also previous study case in Thiruvananthapuram district of Kerala. Coastal area in about 78 kilometer and elevation is 8m above mean sea level. The study approach on numerical modelling and seawater pattern intrusion of the well depth and distance from shoreline (Letha & Krishnan, 2008).

5.2.2 Previous study in Malaysia

There also few previous study about intrusion of sea water in Malaysia such as Terengganu. Saltwater intrusion along the coast area of Terengganu coast line (Hairoma et al., 2016) . The waste dumping material affect result of chemical analysis along the coast area. In situ test also done and focus on electrical conductivity, total dissolved solid and salinity.

5.2.3 Kelantan Case

Study of seawater intrusion was done in Bachok, Kelantan by using Regional Groundwater Model. Bachok area normally expose to groundwater contamination. Generally, people living in Bachok are farmer and planting tobacco. Hence resulting high amount of chloride concentration which affect health as exceed the standard limit (Hassan, 2001). The distribution of chloride concentration is measured and calculated in the Regional Groundwater Model.

The research conducted in Kota Bharu area in Pengkalan Chepa and Tanjung Mas (Kamal et al., 2015). Both location contain high content of chloride since the sample collected near the coastal area. National Water Quality Standard already standardised in 1983 that the only concentration of chloride content is about 250 mg/l. From observation, five from seven well show high reading of chloride content (Kamal et al., 2015)

5.3 Geology of Northern Kelantan

5.3.1 Quartenary Deposit

North Kelantan lithology and rock unit normally consist of quartenary deposit. There are Pleistocene and Holocene (Bosch, 1986). Other than that there also small formation under the age for example Simpang Formation in the Pleistocene and Gula and Beruas Formation under Holocene. Figure 5.1 shows Geological Map of Northern Kelantan. In general, Kelantan river valley and state are mainly composed of consolidated to unconsolidated gravel, silt, clay and sand.

Quartenary sediment deposit at the first 13 to 15 meter is a recent age and mainly consist of silt and clay or silty to clay. Alluvium rock unit can extend higher than 200 m towards coastal part. In the quartenary age, changes of sea level get affected by combination of nonmarine and marine sediment.

5.3.2 Gula Formation

Mainly composition for rock unit and sediment grain size in Gula Formation are clay, silt and gravel. There are obstacle that differ Gula Formation from Simpang Formation such as 40 meter of underlain bedrock. Organism present such as foraminifera, ostracod, gastropod and others. Depositional Environment is shallow marine to estuarine. Port Weld Member and Matang Gelugor Member characterized Gula Formation.

a) Matang Gelugor Member

Matang Gelugor Member generally consist of clayish sand with rare lenses of clay. Upper part of lithology composes of sand and lower part compose of clayish sand. Sediment thickness is about 4 meter associate with coastal marine deposition.

b) Port Weld Member

Clay sediment dominated lithology composition of Port Weld Member. Lithology are clay associated with medium to fine silt and sand. Generally, clayish sediment colour range from brownish-black or brownish grey to greenish grey. Clay sediment thickness is about 2 meter. Depositional environment is shallow marine or marine.

5.3.3 Simpang Formation

The lithology and rock unit consist of clay sand and silt associate with gravel. Simpang Formation can be found during Pleistocene age. The combination of sediment such as clay, sand, clay and silt and intercelation with each other. There also present of peaty clay and peat. Clayish thickness is about 3o meter and more than 30 meter associate with plant fossils. Depositional environment of Simpang Formation is fluvial.

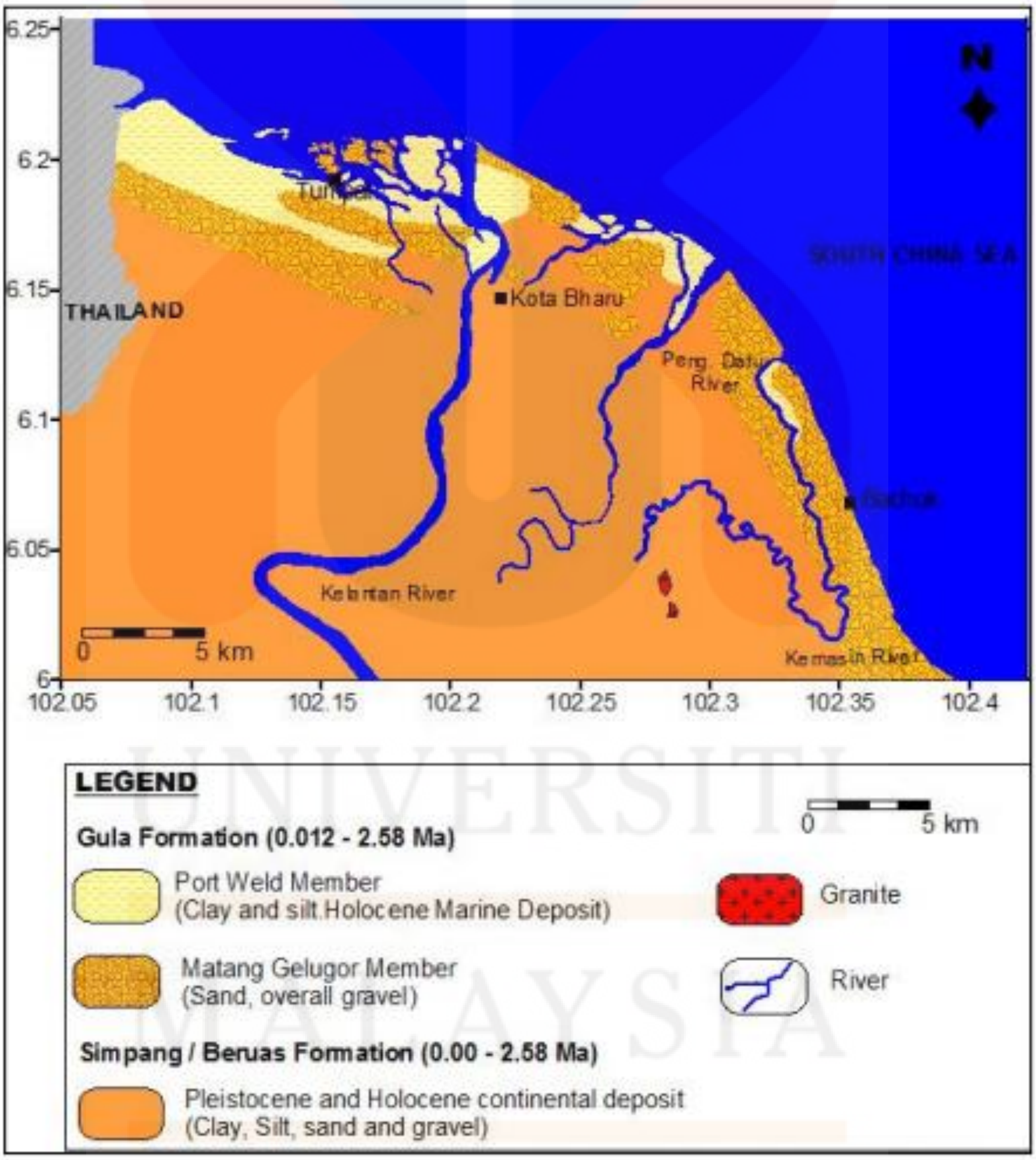


Figure 5.1 : Geology Map of Northern Kelantan

Source : Hussin et al., (2013)

5.4 Hydrogeology of Kelantan

Hydrogeology of Kelantan study is based on well drilling and profile of geo electric near Kelantan River Basin. The survey was done by measuring thickness sequence of Quaternary deposit which almost 200 m towards ocean. Study area was done in western and eastern part of Kelantan River. There are about 8 well drilled in Tumpat area and more than 240 of test well and observation build at the eastern part.

Quaternary alluvium of unconsolidated sediment underlain by granitic rock during Mesozoic age and associate with some other bedrock from metamorphic rock. Aquifer system form during deposition process take place in Kelantan River Basin. Different aquifer have different thickness of aquifer. Layer of aquifer get separated by impermeable clay and associate with soft, blue, grey, clay and shells. There also three in total of aquifer found. First layer consist of 20 m depth (Heng, 1989). Second layer consist depth from range 20 to 50 m (Heng, 1989). Third layer is more than 50 m depth (Heng, 1989).

Alluvium thick sequence can be seen in the eastern part of Kelantan River. Clay impermeable layer form aquiclude and aquitard. Shallow aquifer get recharge from precipitation, infiltration, river leakage and pipe consummation while deep aquifer get recharge from shallow aquifer and runoff surface at the foot hill.

5.5 Data Acquisition

5.5.1 Data Acquisition Orientation

The location of water sampling and parameter with ERI survey line. Figure 5.2 shows distance of ERI survey line toward shore line and Figure 5.3 shows distance of in situ test toward shore line. Figure 5.4 shows water sample map Figure 5.5 shows map of ERI line.

Figure 5.2 : Distance in situ test from shore line

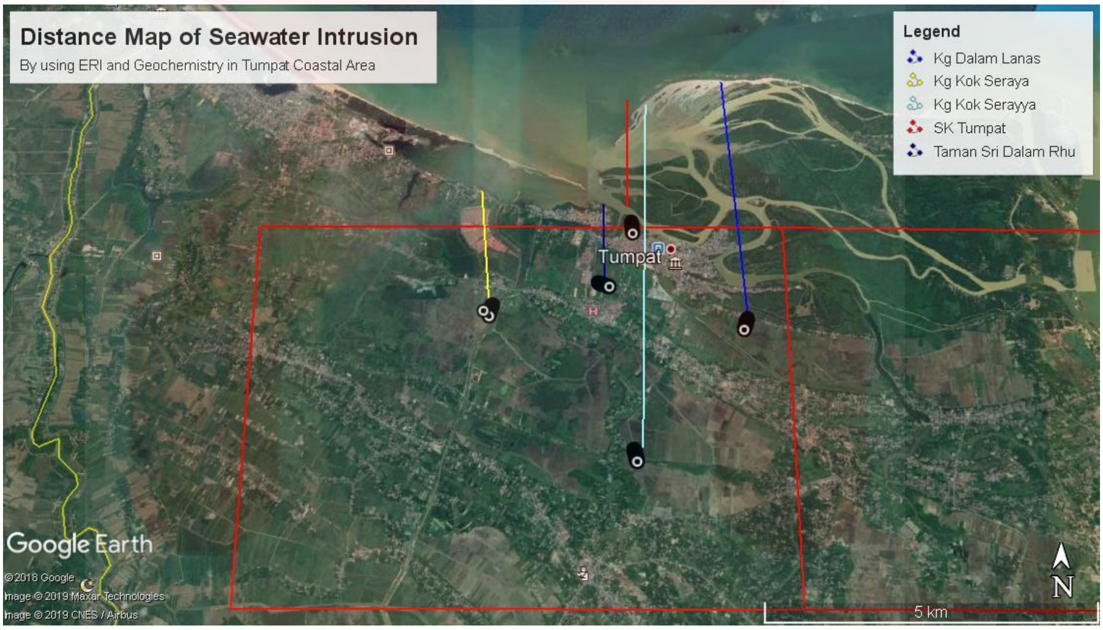
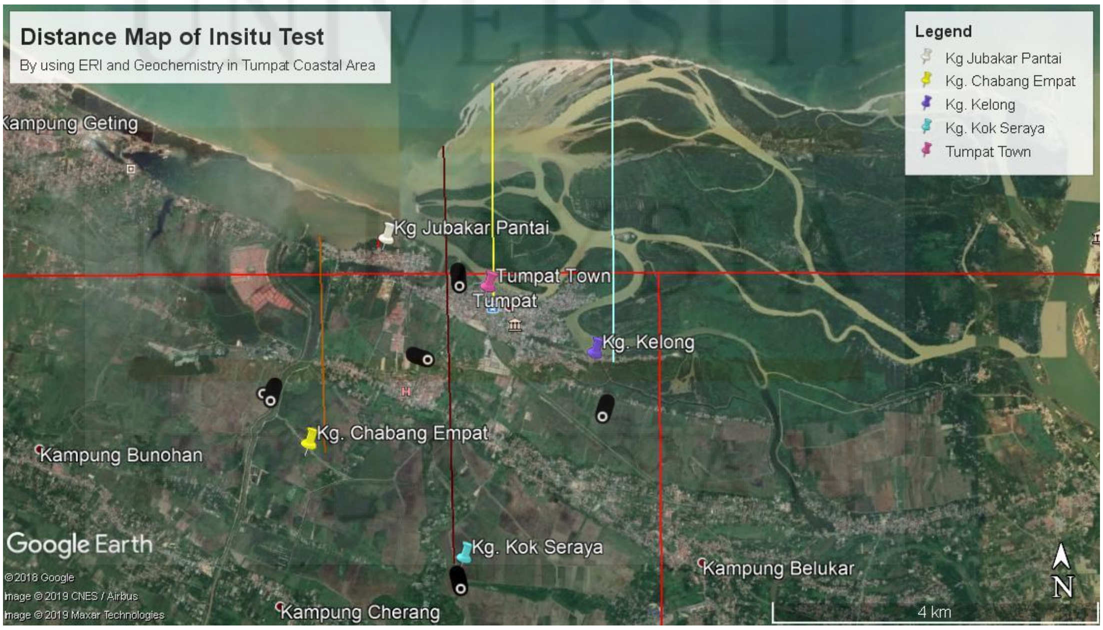


Figure 5.3 : Distance of ERI survey line from shore line



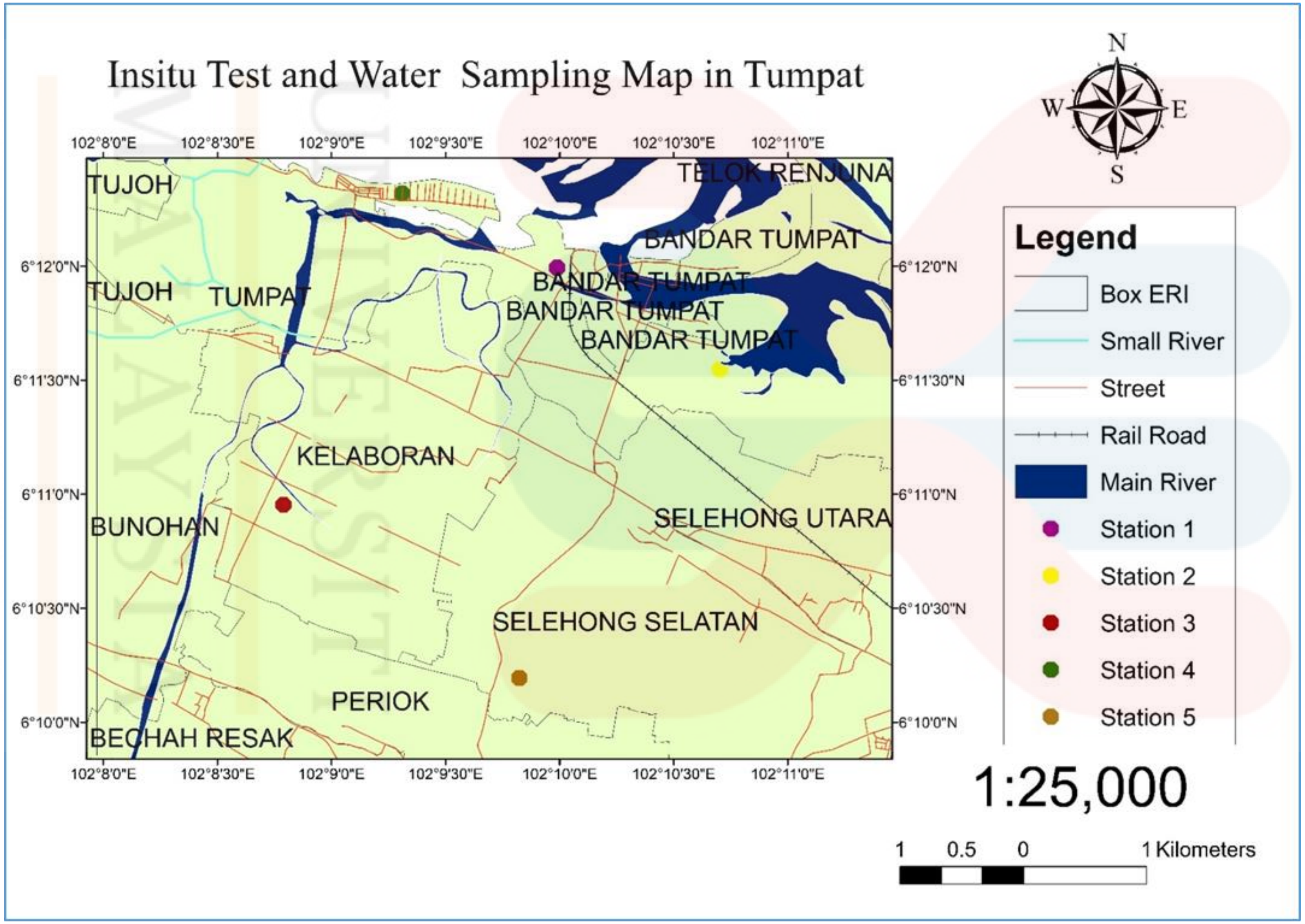


Figure 5.4 : In situ and water sampling map

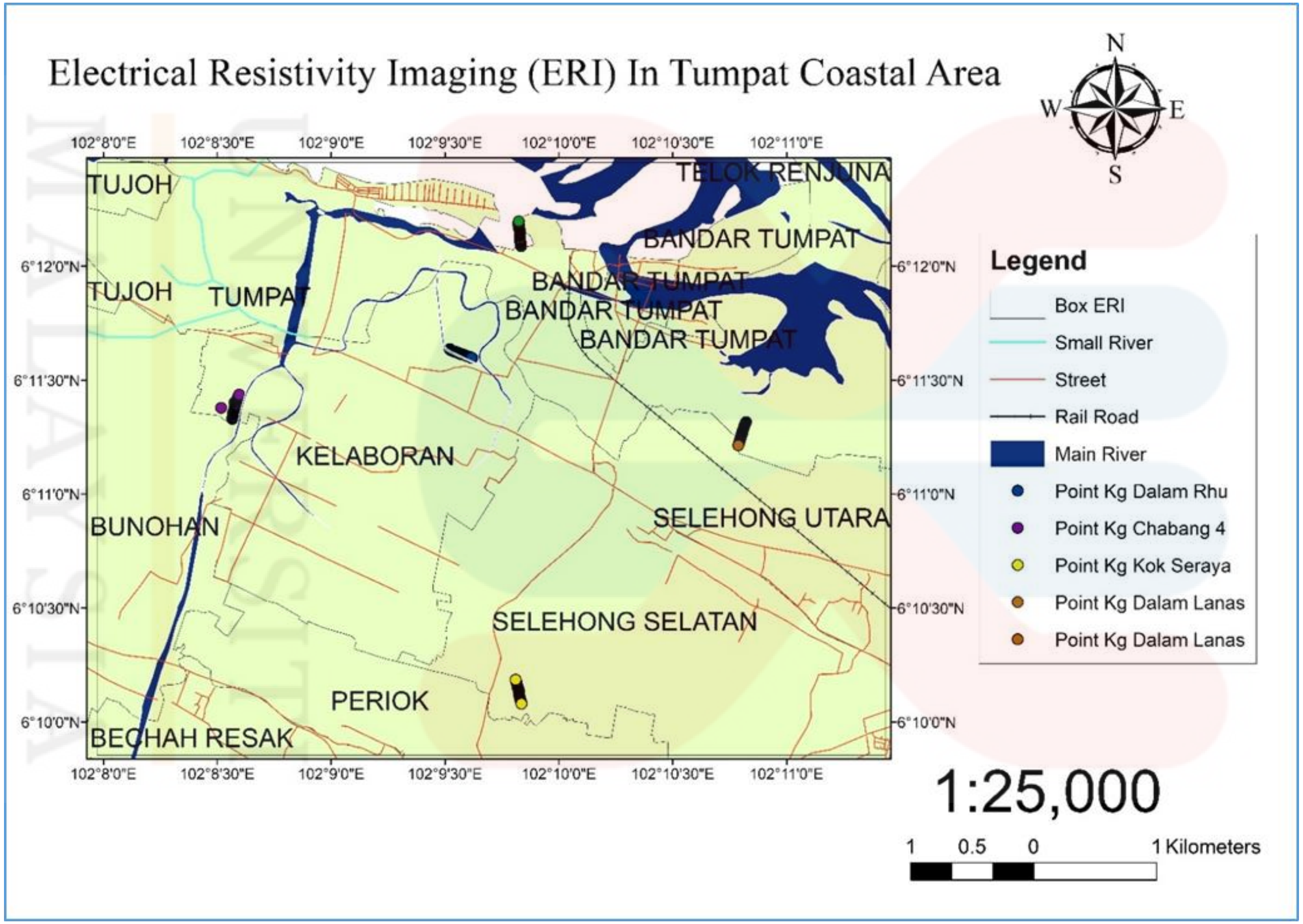


Figure 5.5: ERI map of Tumpat Coastal Area

There are difference distance of ERI survey line from shore line in five different location. Table 5.1 shows distance of ERI survey line towards shore line and table 5.2 shows distance of in situ test towards shore line.

No.	Location	Distance (km)
1.	Kampung Chabang Empat	5.78
2.	Taman Sri Dalam Rhu	1.37
3.	Kampung Kok Seraya	3.98
4.	Kampung Dalam Lanas	4.6
5.	Sekolah Kebangsaan Tumpat	0.92

Table 5.2 : Distance of in situ test toward shore line

No.	Location	Distance (km)
1.	Pekan Tumpat	2.64
2.	Kampung Kelong	3.76
3.	Kampung Chabang Empat	2.66
4.	Kampung Jubakar Pantai	0.13
5.	Kampung Kok Seraya	5.11

5.6 Result and Discussion

5.6.1 Result of Physiochemical Parameter of Groundwater

There are result of physiochemical test of fresh water from water sampling. In situ test consist of physical data and chemical test consist of chemical data. Table 5.3 below shows the information about sampling location. Other than that, summary of in situ test result is shown in Table 5.4 summary of chemical parameter and major cation is shown in Table 5.5. Figure 5.4 shows sampling map.

Table 5.3 : Sampling Location information

No.	Location Name	Coordinate	Sample type	Elevation (m) above sea level	Well depth (m)
1.	Kg. Jubakar Pantai	6°12'19.15"N 102° 9'18.56"E	Groundwater	4	2.7
2.	Bandar Tumpat	6°11'59.62"N 102° 9'59.33"	Groundwater	8	2.19
3.	Kg. Kelong	6°11'32.90"N 102°10'42.16"E	Groundwater	5	3
4.	Kg. Chabang Empat	6°10'57.26"N 102° 8'47.38"E	Groundwater	4	2.57
5.	Kg. Kok Seraya	6°10'11.69"N 102° 9'49.40"E	Groundwater	4	2.69

Table 5.4 : Summary of in situ test result

No.	Location	Electrical Conductivity (μScm^{-1}) (750-2000)	Temperature	pH (5.5-9.0)	Salinity (ppt) (1.0)	Total Suspended Solid (50) (mg/L)	Total Dissolved Solid (1500) (mg/L)	Turbidity (NTU) (50)
1.	Kg. Jubakar Pantai	887	22.5	7.18	0.4	12	350	7
2.	Pekan Tumpat	343	23.2	6.77	0.2	10	144	8
3.	Kg. Chabang Empat	446	23	6.61	0.2	6	94	11
4.	Kg. Kelong	159	22.8	6.84	0.1	19	66	18
5.	Kg. Kok Seraya	94	23	7.48	0.0	10	40	9

Table 5.5 : Chemical parameter of groundwater quality

No.	Location	Cu^{2+} (mg/L) (1.0)	K^{+} (mg/L) (30)	Mn^{2+} (mg/L)	Ca^{2+} (mg/L) (200)	Fe^{2+} (mg/L) (1.0)	Cl^{-} (mg/L) (250)
1.	Kg. Jubakar Pantai	2.919	15.05	0.604	98.68	2.919	79.946
2.	Pekan Tumpat	0.039	3.983	0.205	5.276	4.268	73.414
3.	Kg. Chabang Empat	0.052	5.645	0.047	27.01	0.599	85.2
4.	Kg. Kelong	0.035	3.477	0.655	7.763	1.032	49.7
5.	Kg. Kok Seraya	0.057	3.798	0.196	4.521	1.103	31.24

5.6.2 In situ Parameter

a) Electrical Conductivity

Electrical Conductivity is a parameter that show conductivity of certain solution. The higher value of electrical conductivity, the higher value of ion contain inside the solution. Figure 5.6 shows the graph of electrical conductivity of sampling water and in situ test..

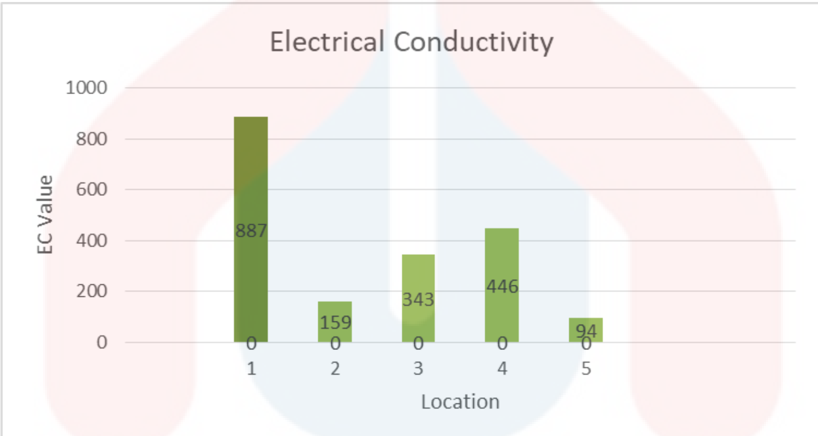


Figure 5.6 : Value of electrical conductivity in study area

From the above result, Kg. Jubakar has the most highest value of electrical conductivity which is 887 out of five sampling station. The value already categorised under permissible classification. The result showing indicator of saltwater intrusion due to high amount of conductivity value. The location of Kg Jubakar also very close to the sea. Next is Kg. Chabang Empat and Bandar Tumpat also show higher conductivity value which is 446 and 343 respectively. This value is consider under good category. Electrical conductivity measure ability of water to conduct electricity because presence of dissolved salt in water (Shahida & Ummatul, 2015)

b) Temperature

Temperature is measure wether heat or cold of certain solution. Figure 5.7 shows temperature of all the groundwater sample.

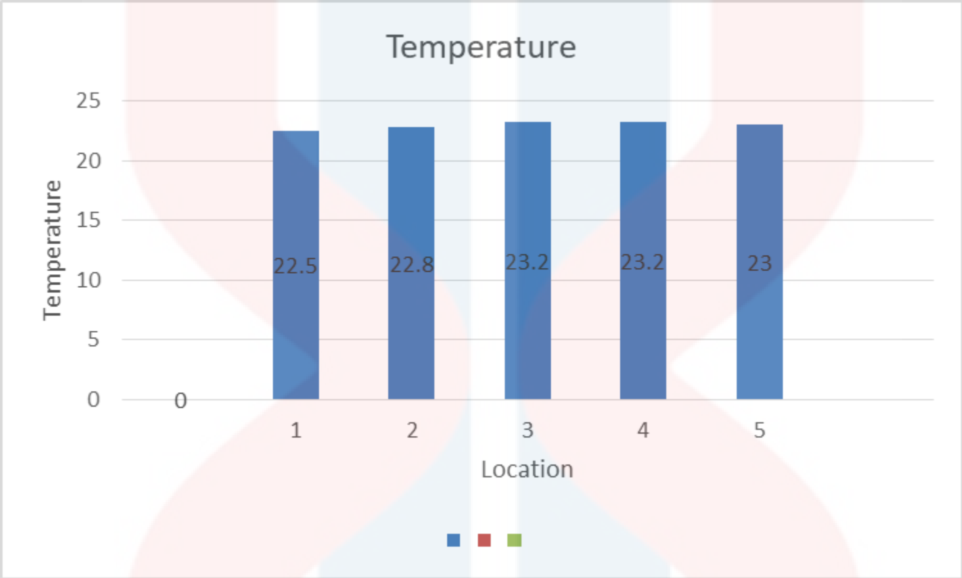


Figure 5.7 : Groundwater temperature

The temperature of groundwater is almost the same for five areas.

c) pH

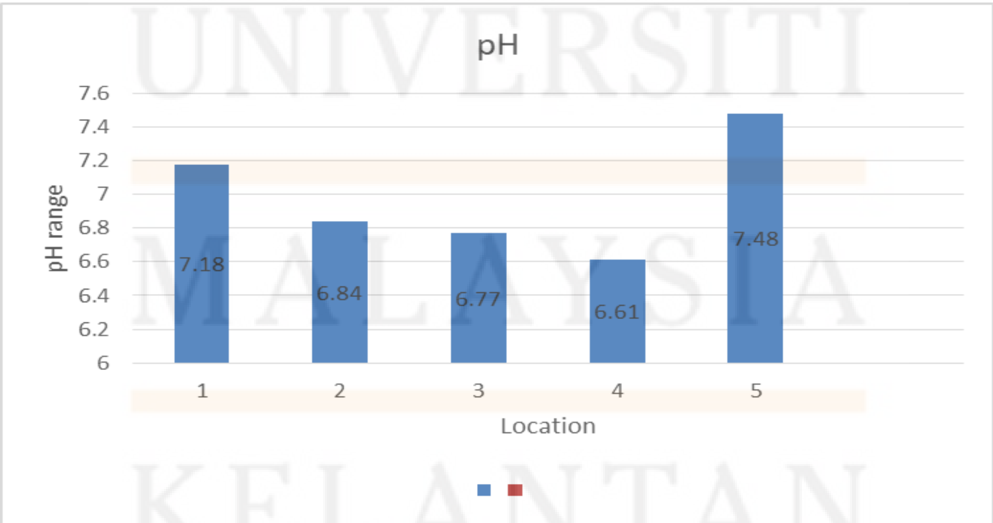


Figure 5.8 : pH of groundwater sample

pH measure acidity and basic of certain solution. Normally, pH consist of range from 1 until 14 reading. 1 until 6.9 usually acidic and 7.1 until 14 is basic. pH is one significant parameter to analyse water quality and environment. Table 5.6 shows National Guidelines of raw water quality standard (2000). Figure 5.8 shows pH values of all water sampling location.

From Figure 5.8 above, Kg. Kok Seraya has the highest pH which is 7.48 and the lowest pH is in Kg. Chabang 4 which is 6.61. Therefore, pH of groundwater in Kg. Jubakar, and Kg, Kok Seraya is basic and pH in Kg. Kelong, Kg. Chabang Empat and Bandar Tumpat is acidic as below than 7.

Kg Jubakar and Kg. Kok Seraya exhibit basic nature and Kg. Kelong, Kg, Chabang Empat and Bandar Tumpat exhibit acidic nature. The interaction of groundwater with human activities such as agriculture, waste product and others may affect the pH. High pH during precipitation and infiltration during raining season also affect the pH when the location is recharge.

However, range of pH value for groundwater allow by Ministry of Health is about 5.5 to 9.0. So all the sampling location is suitable for domestic use.

Table 5.6 : National Guideline of Raw Water Quality Standard, (2000)

Constituents	Permissible limit in MOH 2000
pH	5.5 – 9.0
Total Dissolved Solids (TDS)	1500
Turbidity	1000 NTU
Calcium	200
Magnesium	150
Sodium	200
Potassium	30
Iron	1.0
Chloride	250
Sulphate	250
Bicarbonate	500

d) Salinity

Salinity is a measure how much the groundwater affected by seawater. Figure 5.9 shows the salinity of all five sampling location.

Table 5.7 : National Water Quality Standard For Malaysia (2006)

National Water Quality Standards For Malaysia

PARAMETER	UNIT	CLASS					
		I	IIA	IIB	III	IV	V
Ammoniacal Nitrogen	mg/l	0.1	0.3	0.3	0.9	2.7	> 2.7
Biochemical Oxygen Demand	mg/l	1	3	3	6	12	> 12
Chemical Oxygen Demand	mg/l	10	25	25	50	100	> 100
Dissolved Oxygen	mg/l	7	5 - 7	5 - 7	3 - 5	< 3	< 1
pH	-	6.5 - 8.5	6 - 9	6 - 9	5 - 9	5 - 9	-
Colour	TCU	15	150	150	-	-	-
Electrical Conductivity*	µS/cm	1000	1000	-	-	6000	-
Floatables	-	N	N	N	-	-	-
Odour	-	N	N	N	-	-	-
Salinity	%	0.5	1	-	-	2	-
Taste	-	N	N	N	-	-	-
Total Dissolved Solid	mg/l	500	1000	-	-	4000	-
Total Suspended Solid	mg/l	25	50	50	150	300	300
Temperature	°C	-	Normal + 2 °C	-	Normal + 2 °C	-	-
Turbidity	NTU	5	50	50	-	-	-
Faecal Coliform**	count/100 ml	10	100	400	5000 (20000)a	5000 (20000)a	-
Total Coliform	count/100 ml	100	5000	5000	50000	50000	> 50000

Notes

* = At hardness 50 mg/l $CaCO_3$

= Maximum (unbracketed) and 24-hour average (bracketed) concentrations

N = Free from visible film sheen, discolouration and deposits

Sourse : EQR2006

National Water Quality Standard

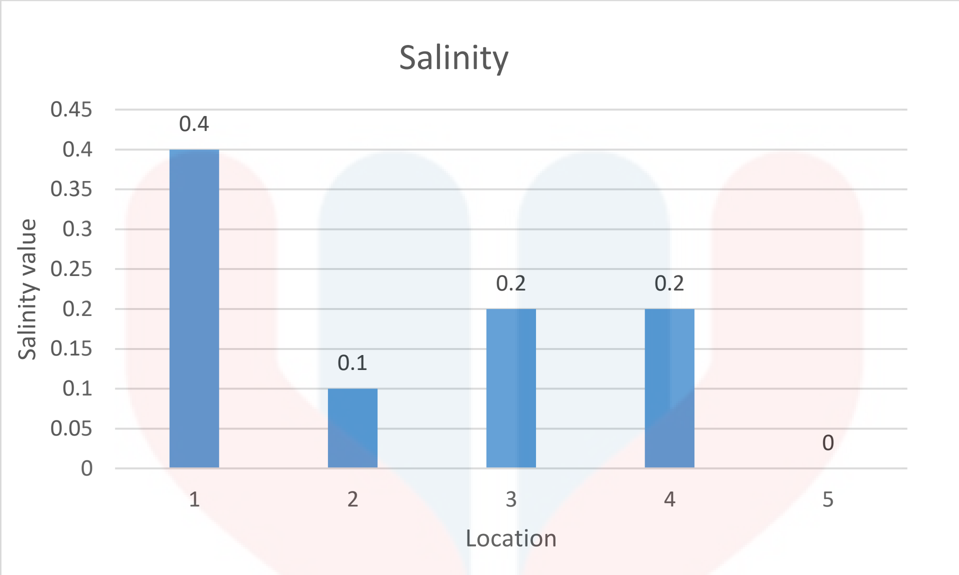


Figure 5.9 : Salinity of groundwater sample

There are various value of salinity in five different sampling location. The highest salinity recorded in Kg. Jubakar as the location is near the sea and shore line which is 0.4 mg/L. Bandar Tumpat also near to the shore line and have second highest reading of salinity. But share similar reading with Kg Chabang Empat which is 0.2 mg/L.

High amount of salinity affect growth rate of paddy production in that area irrigation of saline water damage crop yield to entire village. From the Table 5.7 above permissible limit for salinity is 1.0 mg/L. Salinity value in location 1 is consider approaching permissible limit and maybe contain saltwater intrusion. Salinity distribution map is shown in Appendix B.

e) Total Suspended Solid (TSS)

Total suspended solid is values of particle suspend in certain solution including organic and inorganic matter (Mohammad, 2013). All the TSS values are in range of 6-19 mg/L. Figure 5.10 below shows graph of TSS value in all five sampling area at Tumpat.

Figure 5.10: Total Suspended Solid of groundwater sample

Highest value of TSS is in Kg Kelong. The reason is may because of agriculture activity associate with groundwater movement. Table above shows permissible limit of TSS not more than 50 mg/L.

f) Total Dissolve Solid

Total Dissolve solid measure how many particle in solid form that dissolve in a solution. For example is dissolve solid in groundwater sample. Figure 5.11 below shows graph of Total Dissolve Solid in five different location of sampling area. Table 5.8 shows classification of TDS in groundwater.

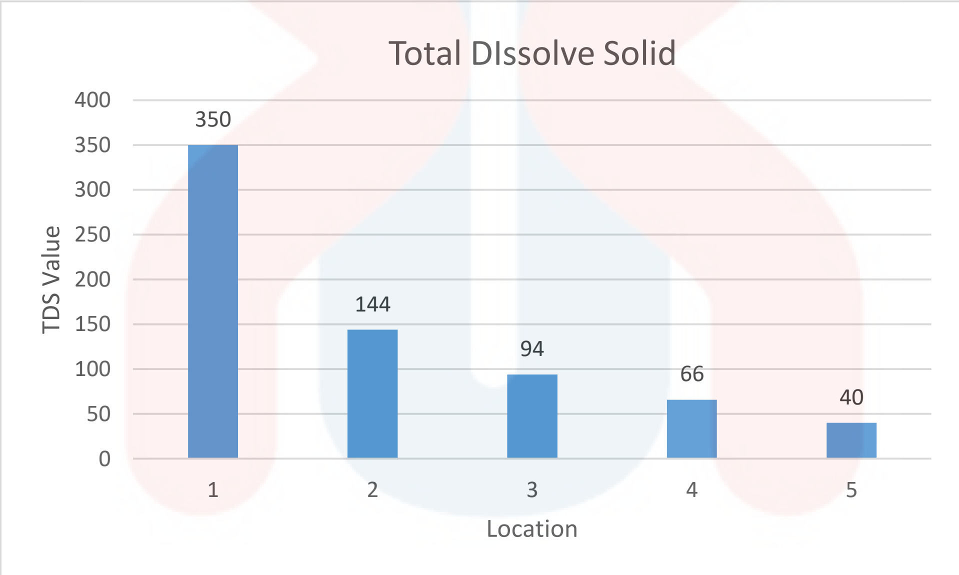


Figure 5.11: Total Dissolve Solid of groundwater sample

From the figure above, the range of TDS is from 40 to 350 mg/L. Kg. Jubakar has the highest value of TDS which is 350 mg/L the lowest value is Kg. Kok Seraya which is 40 mg/L. High content of Ca^{2+} ion may affect reading of TDS value. Distance of sampling area towards sea water also very close which is 0.13 in Kg Jubakar Pantai and may indicate the saltwater intrusion in that area. Salinity in that area also high which is about 0.4 ppt. TDS distribution map is shown in Appendix C.

Table 5.8 : Classification of TDS (Shahida, Ummatul, 2015).

Categorize	TDS in mg/L
Freshwater/Non-saline	< 1000
Slightly saline	1000 – 3000
Moderately saline	3000 – 10000
Very saline	>10000

From the classification above all the water sample is bellow than 1000 mg/L. Therefore all the water sample is not contaminate by saline intrusion in TDS aspect.

g) Turbidity

Turbidity is a measure cloudy of water. There are many factor turn clear water to cloudy. There are dissolved element like solid particle such as organic or inorganic matter. There also can be major cation and anion inside the water sample. Figure 5.12 shows turbidity of water sample in all five different sampling locations.

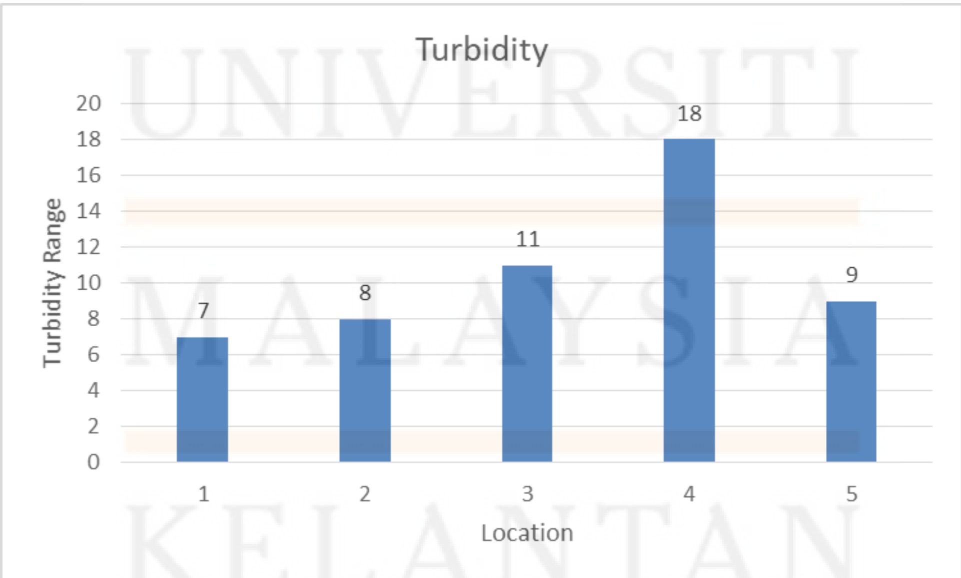


Figure 5.12: Turbidity value of groundwater sample

Other factor turn clear water to cloudy is presence of solute element such as clay, sand and silt in the fresh water. Turbidity is measured in unit NTU (Nephelometric Turbidity Unit). Contamination of fresh water can be determined from the result of turbidity. Range of turbidity is from 7-18 NTU. The reason of high turbidity value is because of open well. Many impurities come from outside and affect fresh water content.

From the figure above, Kg. Kelong has high amount of turbidity than other location which is 18 NTU. This indicate many dissolved and contaminant present on the well and groundwater sources. Lowest value of turbidity is in Kg Jubakar Pantai which is 7 NTU. Table 5.7 above shows permissible rate for Turbidity is 50 NTU. Hence, all the result is acceptable and can be used for domestic usage. Turbidity distribution map is shown in Appendix D.

5.6.3 Chemical Parameter and Analysis of anion and cation in fresh water of Tumpat area

a) Ca^{2+}

Concentration of major cat ion usually affect concentration of fresh water sample and degree contamination of water. Different location has different concentration of Ca^{2+}. Range concentration of Ca^{2+} is 4.521 to 98.68 mg/L. The highest value recorded from Kg. Jubakar is 98.68 mg/L. Kg. Chabang Empat, Kg. Kelong and Kg. Kok Seraya has almost the same concentration of Ca^{2+}. Figure 5.13 shows concentration of Ca^{2+} in five different location of water sampling.

Saline intrusion affect original concentration of the fresh water. Distance of location from seawater from sampling station influence reading of Ca^{2+} concentration. Far distance give lowest concentration of Ca^{2+}. Cat ion exchange process occur naturally also affect groundwater chemistry. Other than that permissible concentration of Ca^{2+} is not more than 200 mg/L.

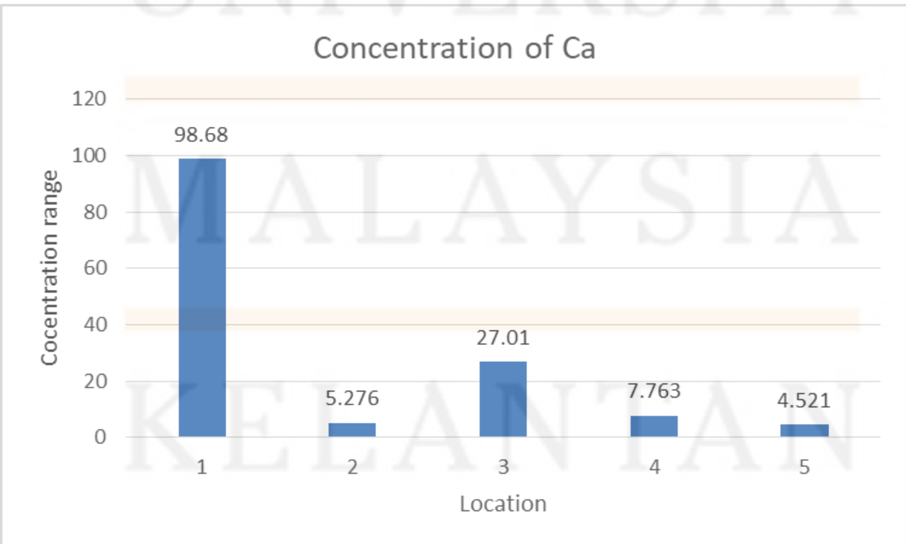


Figure 5.13: Concentration of Ca^{2+} of groundwater sample

b) Cu^{2+}

Concentration of Cu^{2+} also affect contamination of groundwater. Figure 5.45 below shows graph concentration of Cu^{2+} in all location of water sampling. Normally Cu^{2+} will leave trace at the bottom of sink in the kitchen. If the colour of bottom sink turn to brown, hence it indicate high concentration of Cu^{2+} of the water sources. Figure 5.14 shows graph of concentration of Cu^{2+} of all five different location in Tumpat area.

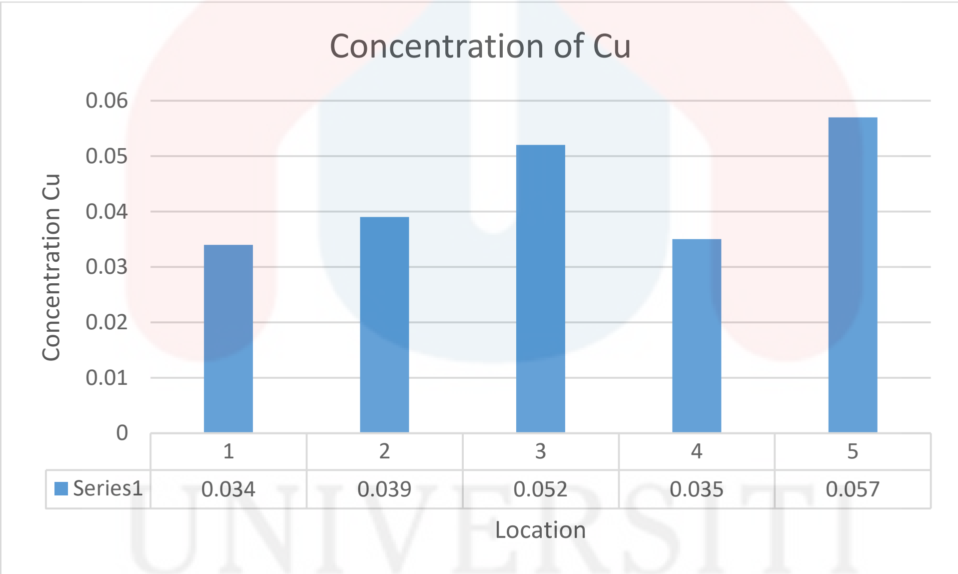


Figure 5.14: Concentration of Cu^{2+} of groundwater sample

Range concentration of Cu^{2+} in Tumpat area as well as sampling location is from 0.034 to 0.057 mg/L. Kok Seraya has high concentration of Cu^{2+} among of all the others 4 location which is 0.057 mg/L. The second higher concentration of Cu^{2+} is in Kg. Chabang Empat which is 0.052 mg/L. The others three location has similar amount of concentration which is 0.035 mg/L.

c) Fe^{2+}

Concentration of Fe^{2+} usually influence chemistry of groundwater in a certain area. Normally Fe^{2+} element also leave trace such as orange colour when the solution leave certain area. Fe^{2+} ion able to precipitate and affect cleanliness of the fresh water. Figure 5.15 shows graph concentration of Fe^{2+} of all the sampling location in Tumpat area.

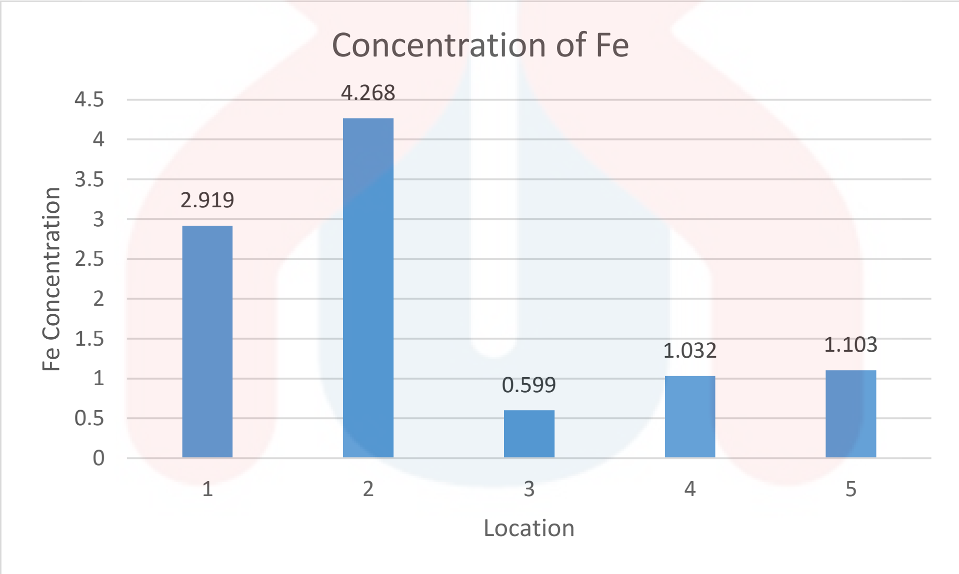


Figure 5.15: Concentration of Fe^{2+} of groundwater sample

Concentration of Fe^{2} is different in all locations. Range of concentration is from 0.599 to 4.268 mg/L. Concentration of Fe^{2+} in Pekan Tumpat is the highest which is 4.268 mg/L. This is indicate that the groundwater in the aquifer is highly contaminate with Fe^{2+}. Kg. Jubakar also has high value of Fe^{2+} which is 2.919 mg/L. The other three location has lower values of Fe^{2+} concentration but also considered as contaminate.

The sample of all location shows the value of Fe^{2+} exceed permissible limit of National Guideline of Raw Water Quality Standard (2000) which is 1.0 mg/L as shown in table 5.7 above.

d) Mn^{2+}

Manganese (ii) ion is one of the element that affect groundwater quality especially in Kelantan area. Manganese (ii) iron usually give pungent smell as their trace in certain water sample. Manganese (ii) ion and Iron (ii) become one of groundwater threat in North Kelantan as they give high concentration value. Figure 5.16 shows graph concentration of manganese (ii) ion in different location of water sampling.

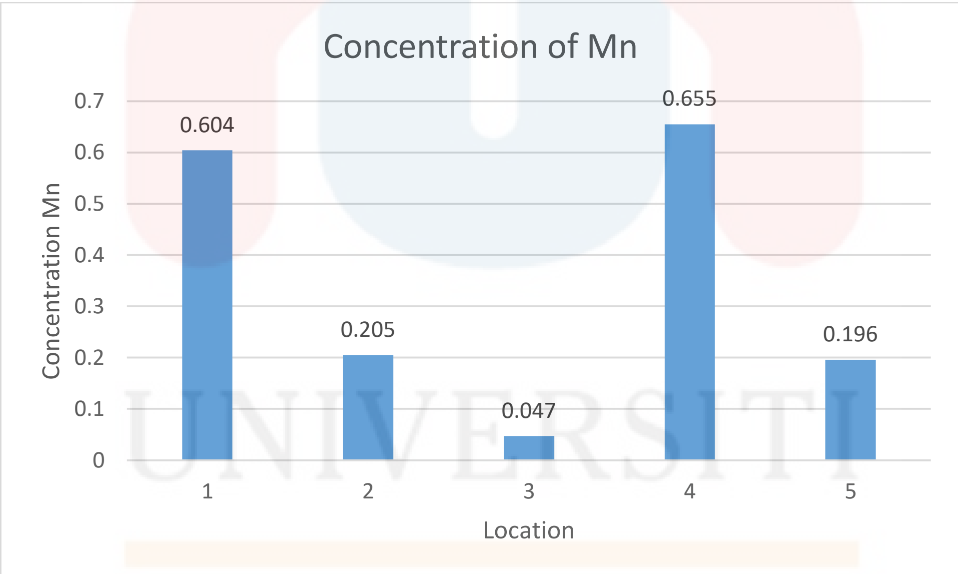


Figure 5.16: Concentration of Mn^{2+} of groundwater sample

From the figure above, range concentration of Mn^{2+} from 0.047 to 0.655 mg/L. The highest concentration is in Kg Kelong and the lowest concentration is in Kg. Chabang Empat. Concentration of Mn^{2+} difference in every location depend to their aquifer and groundwater sources.

e) K^+

Concentration of K^+ also is not similar from all five location. Potassium ion usually derived from dissolution process of clay and silicate mineral that from subsurface (Plummer et al., 2003). Figure 5.17 shows graph concentration of K^+ concentration in all different area of sampling location at Tumpat.

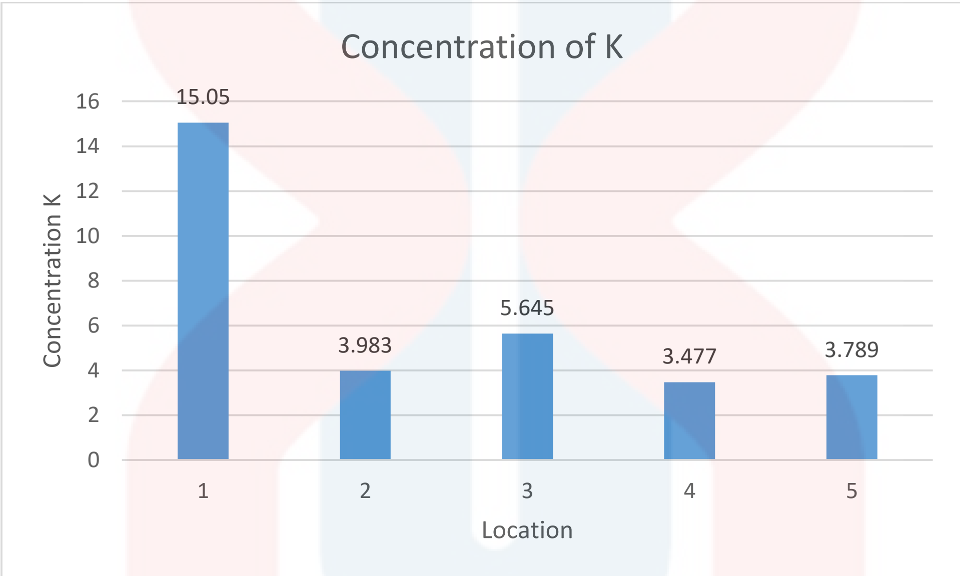


Figure 5.17: Concentration of K^+ of groundwater sample

Range concentration of K^+ in Tumpat as well as five study area start from 3.477 to 15.05 mg/L. Concentration of K^+ do not affect human body much. Kg. Jubakar has high amount of K^+ while Kg. Kelong has the lowest concentration of K^+. Kg. Kelng has high concentration due to close location toward shore line. The other three location shows similar concentration of K^+ which is equivalent to 3.5 mg/L.

All the concentration value is safe and suitable for domestic usage as not over the permissible limit from National Guideline of Raw Water Quality Standard (2000) which are 30 mg/L as shown in table 5.7 above.

f) Cl^-

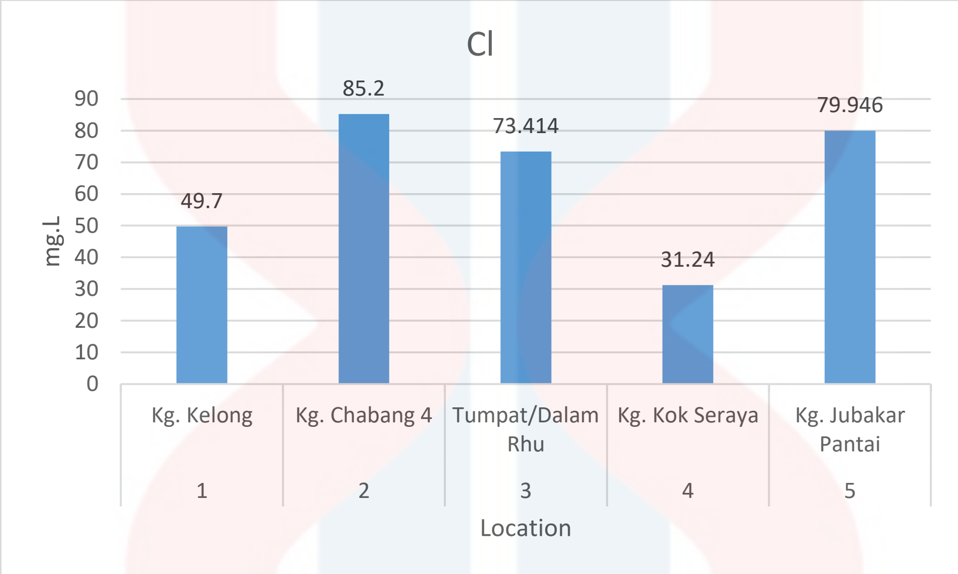


Figure 5.18: Concentration of Cl^- of groundwater sample

Figure 5.18 above shows concentration of chloride ion in all sampling location. From the result above, Kg. Jubakar Pantai and Kg. Dalam Rhu has the highest reading of chloride concentration. This is because, these two location is the nearest distance to the shore line. However, the other three location shows low concentration of chloride concentration as location far from ocean.

Even though the two location has high reading if chloride content, it still below the permissible limit was set by World Health Organisation which is 250 mg/L. Hence, fresh water from the well still can be used for domestic usage.

5.6.4 Result of Electrical Resistivity Imaging (ERI) of coastal area in Tumpat

Electrical Resistivity Imaging was done in five different line of coastal aquifer in Tumpat area. The line survey was done almost in alluvium area and consist of sand, silt and clay. Distance of line survey from shore line can be shown in table 5.1 and exact numerical value of distance from shore line is shown in table 5.2. However, location of ERI map is shows in figure 5.18 belowThere are relationship between geology and geophysical data associate with electrical resistivity imaging. Difference rock unit and different type of water give different resistivity value based on the resistance to electric. Sedimentary rock has low resistivity value due to high water content and more porous. Low resistivity value can be identify groundwater and wet soils (Loke, 2000).

Groundwater resistivity usually in range of 10 to 100 ohm meter and due to concentration of dissolved salt (Loke, 2000). Resistivity of salt water is low because of high amount of salt concentration. Table 5.9 shows resistivity value of rock units, minerals and chemicals (Loke, 2000).

Table 5.9 : Resistivity value in common rock, waters and chemiclas

Material	Resistivity (Ω•m)	Conductivity (Siemen/m)
Igneous and Metamorphic Rocks		
Granite	$5x10^{3} - 10^{6}$	$10^{-6} - 2x10^{-4}$
Basalt	$10^{3} - 10^{6}$	$10^{-6} - 10^{-3}$
Slate	$6x10^{2} - 4x10^{7}$	$2.5x10^{-8} - 1.7x10^{-3}$
Marble	$10^{2} - 2.5x10^{8}$	$4x10^{-9} - 10^{-2}$
Quartzite	$10^{2} - 2x10^{8}$	$5x10^{-9} - 10^{-2}$
Sedimentary Rocks		
Sandstone	$8 - 4x10^{3}$	$2.5x10^{-4} - 0.125$
Shale	$20 - 2x10^{3}$	$5x10^{-4} - 0.05$
Limestone	$50 - 4x10^{2}$	$2.5x10^{-3} - 0.02$
Soils and waters		
Clay	1 - 100	0.01 - 1
Alluvium	10 - 800	$1.25 x10^{-3} - 0.1$
Groundwater (fresh)	10 - 100	0.01 - 0.1
Sea water	0.2	5
Chemicals		
Iron	$9.074x10^{-8}$	$1.102x10^{7}$
0.01 M Potassium chloride	0.708	1.413
0.01 M Sodium chloride	0.843	1.185
0.01 M acetic acid	6.13	0.163
Xylene	$6.998x10^{16}$	$1.429x10^{-17}$

Source : Loke, (2000)

5.6.4.1 Line Survey 1

First line survey was done in Kampung Chabang Empat. Table 5.10 below show the details of the location. Figure 5.19 shows result of pseudosection of line 1 survey.

Table 5.10 : Location Information of survey line 1

Location	**Kampung Chabang Empat**
Date	30/10/2019
Elavation (m)	3
Coordinate	6°11'23.0"N 102°08'34.7"E
Orientation	NE - SW
Protocol	Pole Dipole
Distance from shore line (km)	5.78
Location Description	Paddy field near river

There are many interpretation can be made from the pseudosecction result. Range of resistivity value are from 0.190 to 24.3 ohm meter. Based on the Table 5.9 above all the values indicate of water and soils which is 1-100 ohm meter. 0.190-0.380 ohm meter shows result of saline water. 1.52 – 24.3 ohm meter also show the result of fresh groundwater as the range is 10 – 100 ohm meter (Loke, 2000). Resistivity of 1.52 – 24.3 ohm meter can be classified as sand or clay and alluvium sediment (Loke, 2000). Generally, saline intrusion is below 30 meter depth.

Resistivity values if fresh water in alluvium is about 50-150 ohm meter. And resistivity value for saline water in alluvium is about 0.2 until 20 ohm meter. It can be classified most of the area of survey has infected with seawater intrusion. Values resistivity of 1.52-24.3 ohm meter indicate clay or alluvium particle associate with saline intrusion. Saline water intrude into depth of 60 to 70 meter with resistivity range of 0.190 ohm meter until 20 ohm meter while clay and alluvium is in depth of 1until 50 meter.

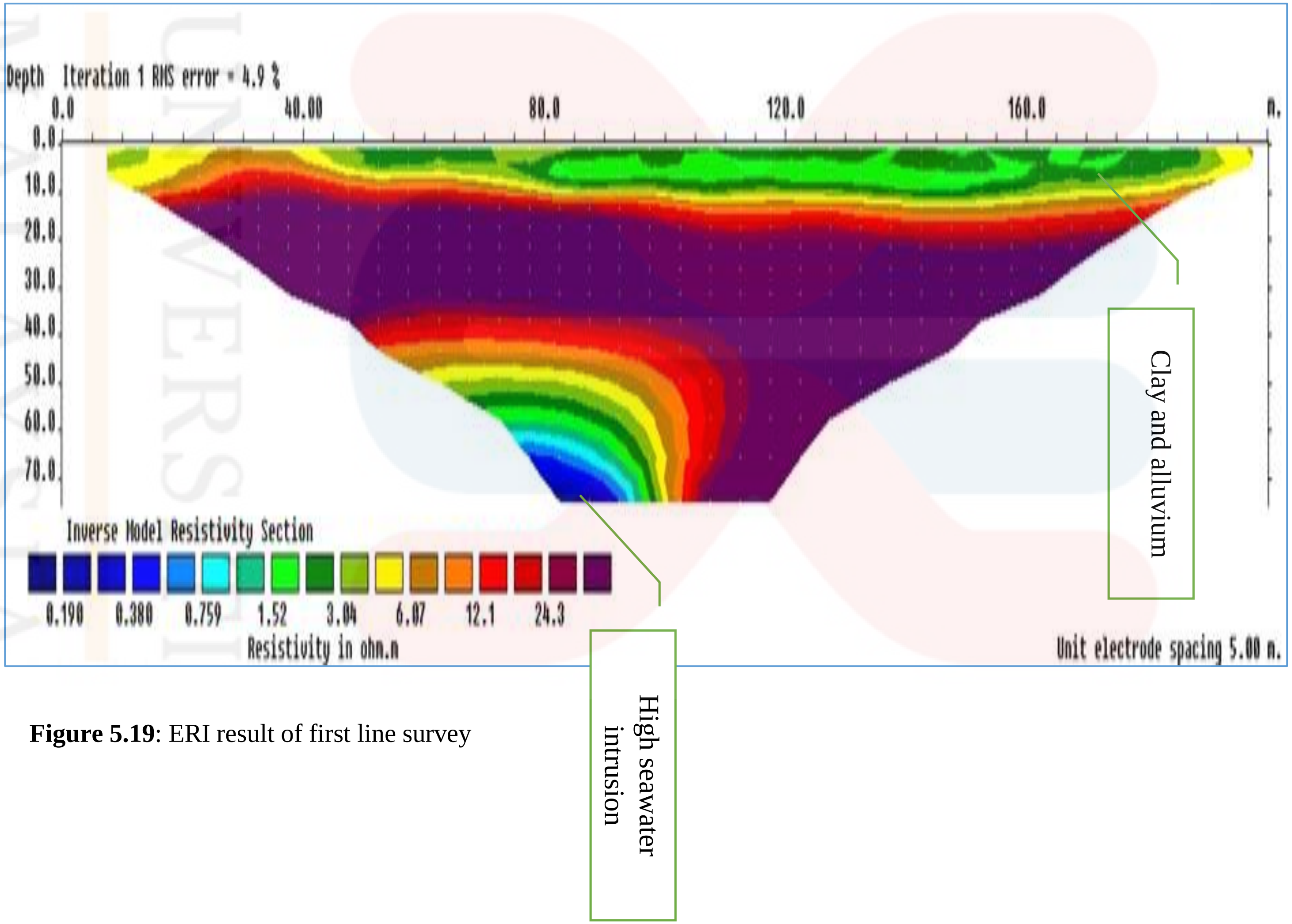


Figure 5.19: ERI result of first line survey

5.6.4.2 Line Survey 2

Table 5.11: Location information of survey line 2

Location	**Taman Sri Dalam Rhu**
Date	30/10/2019
Elavation (m)	3
Coordinate	6°11'37.0"N 102°09'34.1"E
Orientation	NW - SE
Protocol	Schlumberger
Distance from shore line (km)	1.37
Location description	Housing area, paddy field near main river

Table 5.11 above shows details about second line ERI survey. Figure 5.20 shows pseudo section of second line survey. Resistivity values in range of 0.846 until 21.5 ohm meter. From the result showing seawater intrusion. Salt. However, protocol used is Schlumberger which give depth until 35 meter. In contrast, seawater intrusion in second aquifer of North Kelantan.

From the profile, 0.846 until 5.37 ohm meter shows high to low saline intrusion with depth of 0-15 meter which is surface water. Resistivity value of 8.53 until 21.5 ohm meter shows clay particle associate with saline intrusion from low to very low intensity. From depth 15 to 35 meter, there shows sign of alluvium associate with saline intrusion and there no fresh water.

Geochemistry result showing no sign of seawater intrusion as Kg. Jubakar have high concentration of Ca^{2+} which is 98 mg/L. Concentration of K^{+} also high which is 15 mg/L and concentration of Fe^{2+} is also over the permissible values which is 2.919 mg/L. However another parameter reading shows the fresh water is contaminated.

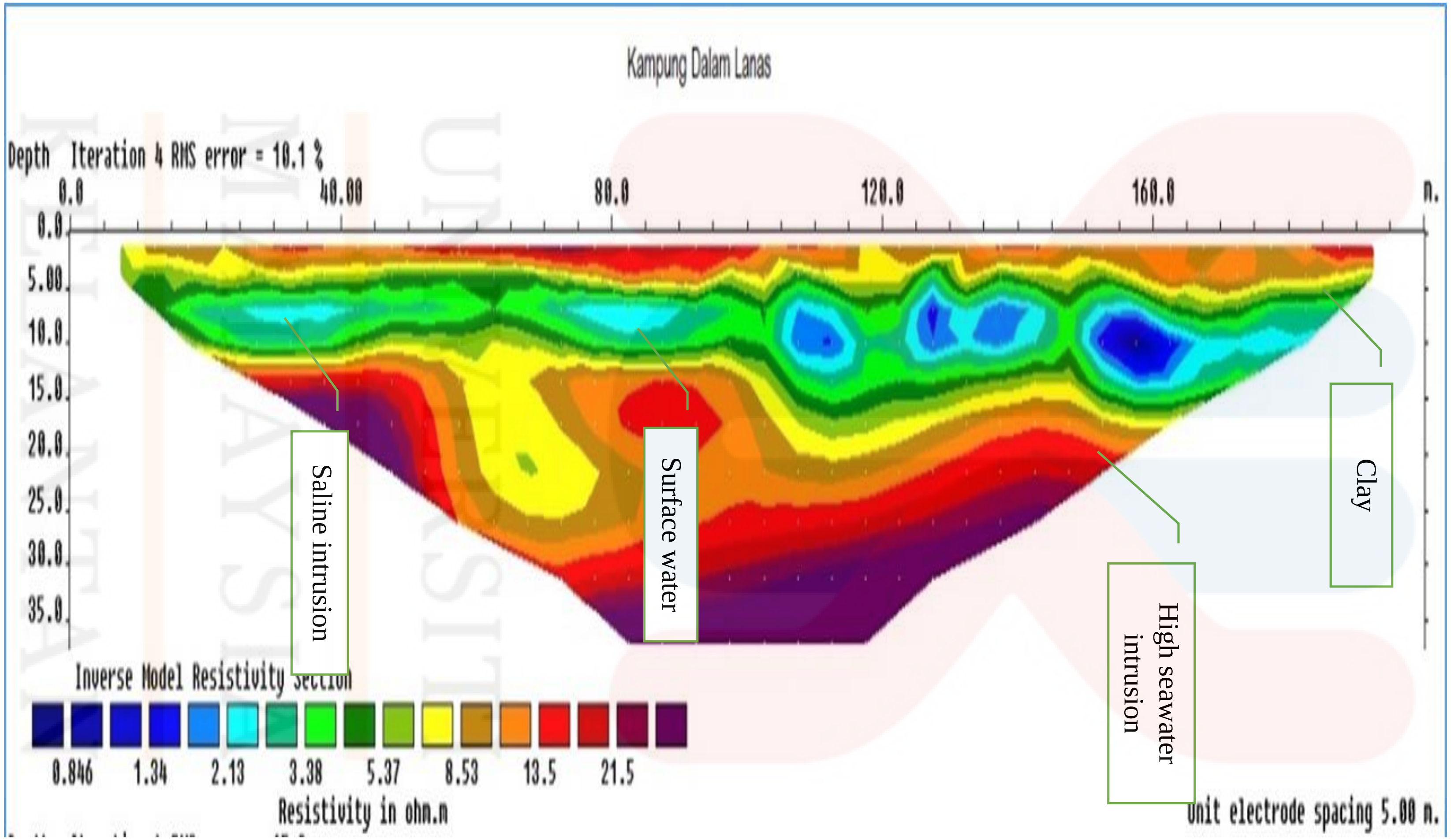


Figure 5.20: ERI result of second line survey

5.6.4.3 Line Survey 3

Table 5.12 : Location Information of survey line 3

Location	**Kampung Kok Seraya**
Date	31/10/2019
Elavation (m)	4
Coordinate	6°10'07.9"N 102°09'49.5"E
Orientation	NW - SE
Protocol	Pole Dipole
Distance from shore line (km)	3.98
Location description	Paddy field near main river

Table 5.12 show details about third line survey and Figure 5.21 shows result of ERI survey in third location. Based on the result, range values for third line survey is 0.668 until 85.5 ohm meter. Based on Loke (2000), the result shows resistivity reading of soils and waters. 0.668- 20 ohm meter is probably seawater intrusion from low intensity to high intensity with depth 0-20 meter. Clay particle associate with saline intrusion in depth 20 until 30 meter with resistivity value 5.34 until 21.4 ohm meter. 85.5 ohm meter and above shows fresh groundwater or maybe associate with clay sediment or alluvium from depth 30 to 70 meter,. Range of clay is 1-100 ohm meter and fresh water 10-800 ohm meter (Loke, 2000). Resistivity value of fresh water in alluvium is in range 50 to 150 ohm meter.

These evidence can correlate with geochemistry data which show lower concentration of Ca^{2+}, Mn^{2+}, K^{+} and Cu^{2+}. Only Fe^{2+} has high concentration which is over the permissible values which are 1.103 mg/L.

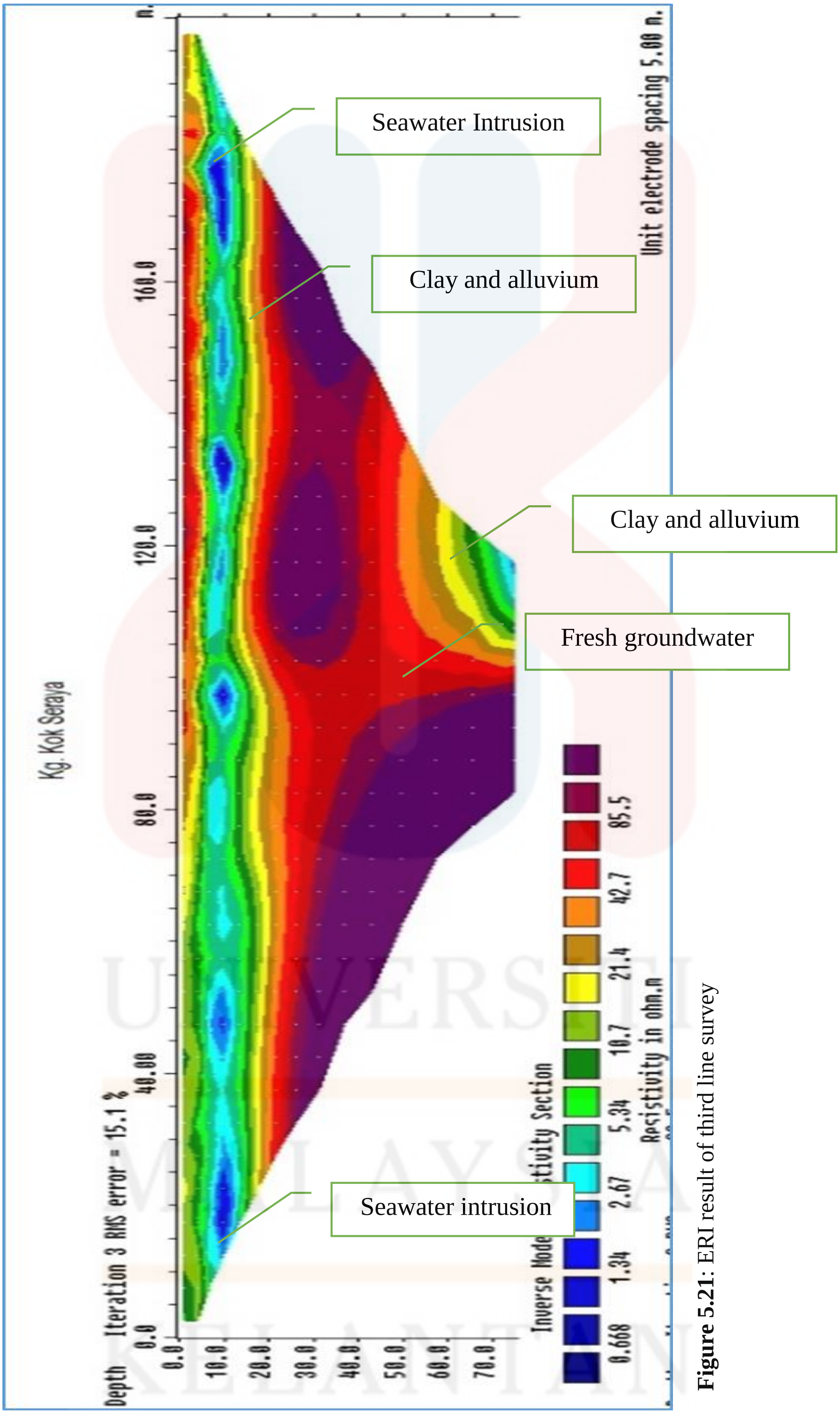


Figure 5.21: ERI result of third line survey

5.6.4.4 Line Survey 4

Table 5.13 : Location Information of survey line 4

Location	**Kampung Dalam Lanas**
Date	31/10/2019
Elavation (m)	3
Coordinate	6°11'15.9"N 102°10'48.3"E
Orientation	NE - SW
Protocol	Pole Dipole
Distance from shore line (km)	4.4
Location description	Paddy field, railway track

Table 5.13 above shows details about forth line survey in Kg Dalam Lanas

Figure 5.22 shows resistivity result of fourth line. The resistivity values of the forth line varies from 0.195-24.9 ohm meter. Based on the result there is saline intrusion between reading 0.195-20 ohm meter. 1.56-24.9 ohm meter may become sand or clay material associate with saline water. However, all the reading showing alluvium resistivity varies from 10-800 ohm meter (Loke, 2000). Depth of 0 until 70 meter shows all depth intruded by saltwater. There is no sign of fresh water until depth of 70 meter. Depth 20 until 70 meter showing clay and alluvium associate with saline intrusion.

Distance of survey from shore line quite far but exhibit saline intrusion for depth 0-20 meter. Also length from 20 until 160 meter survey exhibit saline intrusion. In contrast of geochemical data has lower concentration of cation. Only Fe^{2+} has high concentration which is 1.032 mg/L that over the permissible limit from Ministry of Health which is 1.0 mg/L in table 5.7.

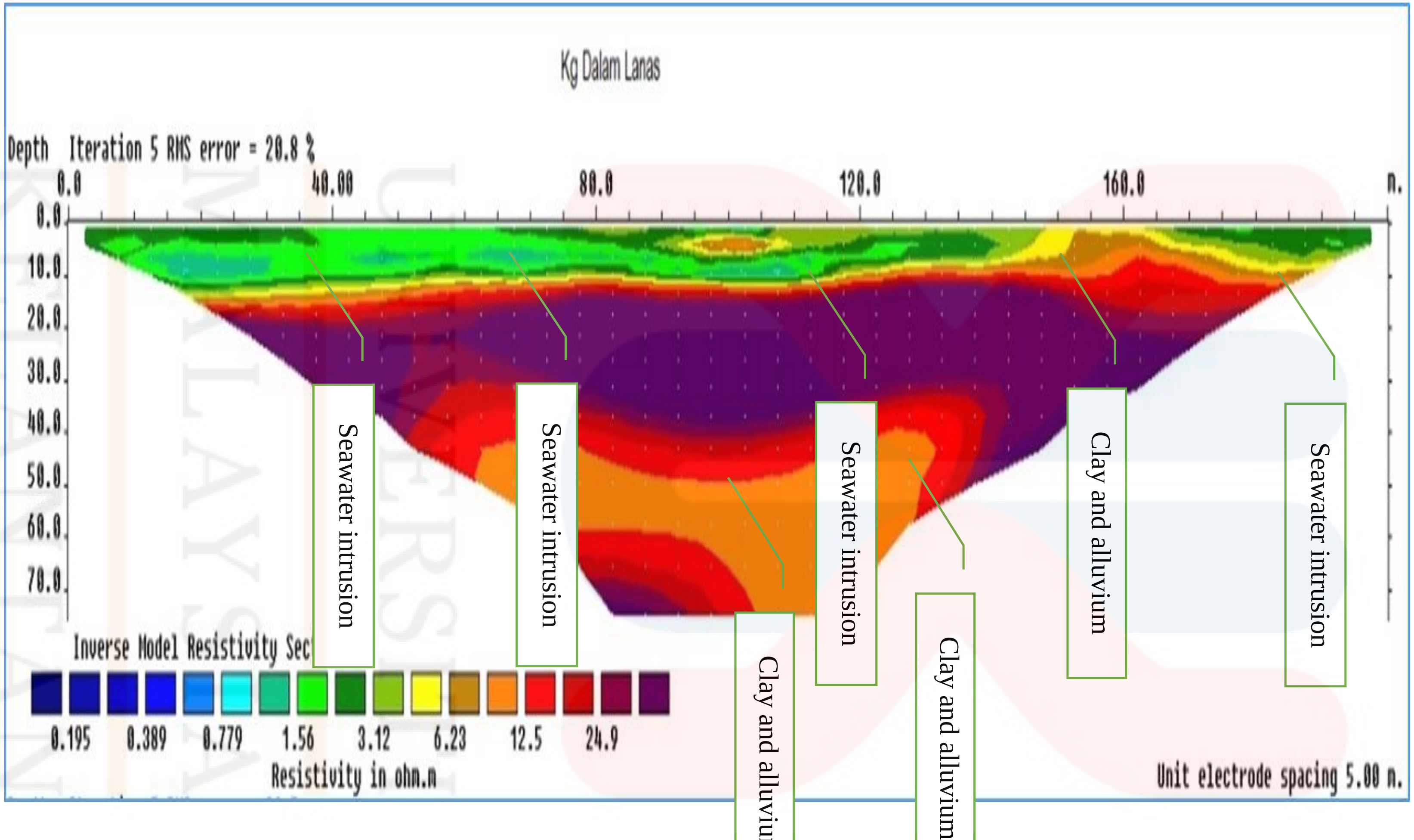


Figure 5.22: ERI result of forth line survey

5.6.5.5 Survey Line 5

Table 5.14 : Location Information of survey line 5

Location	**Sekolah Kebangsaan Tumpat**
Date	31/10/2019
Elevation (m)	3
Coordinate	6°12'08.5"N 102°09'49.7"E
Orientation	NW - SE
Protocol	Schlumberger
Distance from shore line (km)	0.39
Location description	Football field

Table 5.14 above shows details about fifth line survey near Sekolah Kebangsaan Tumpat. Figure 5.23 shows resistivity survey result of fifth line. Based on the result below there is no saltwater intrusion the groundwater aquifer. The resistivity value is 0.801-103 ohm meter. Seawater intrusion is detected in range of 0.801 until 20 ohm meter within depth of 0-20 meter. Clay particle maybe exhibit from depth 20 until 35 meter with resistivity value range of 25.6 until 103 ohm meter (Loke, 2000). And associate with saline intrusion. Fresh water associate with alluvium can be identified from depth 25 until 35meter in range 51.3 ohm meter until 103 meter.

However, result from geochemistry analysis also show low concentration of cation except Fe^{2+}. Fe^{2+} has high concentration which is 4.268 mg/L.

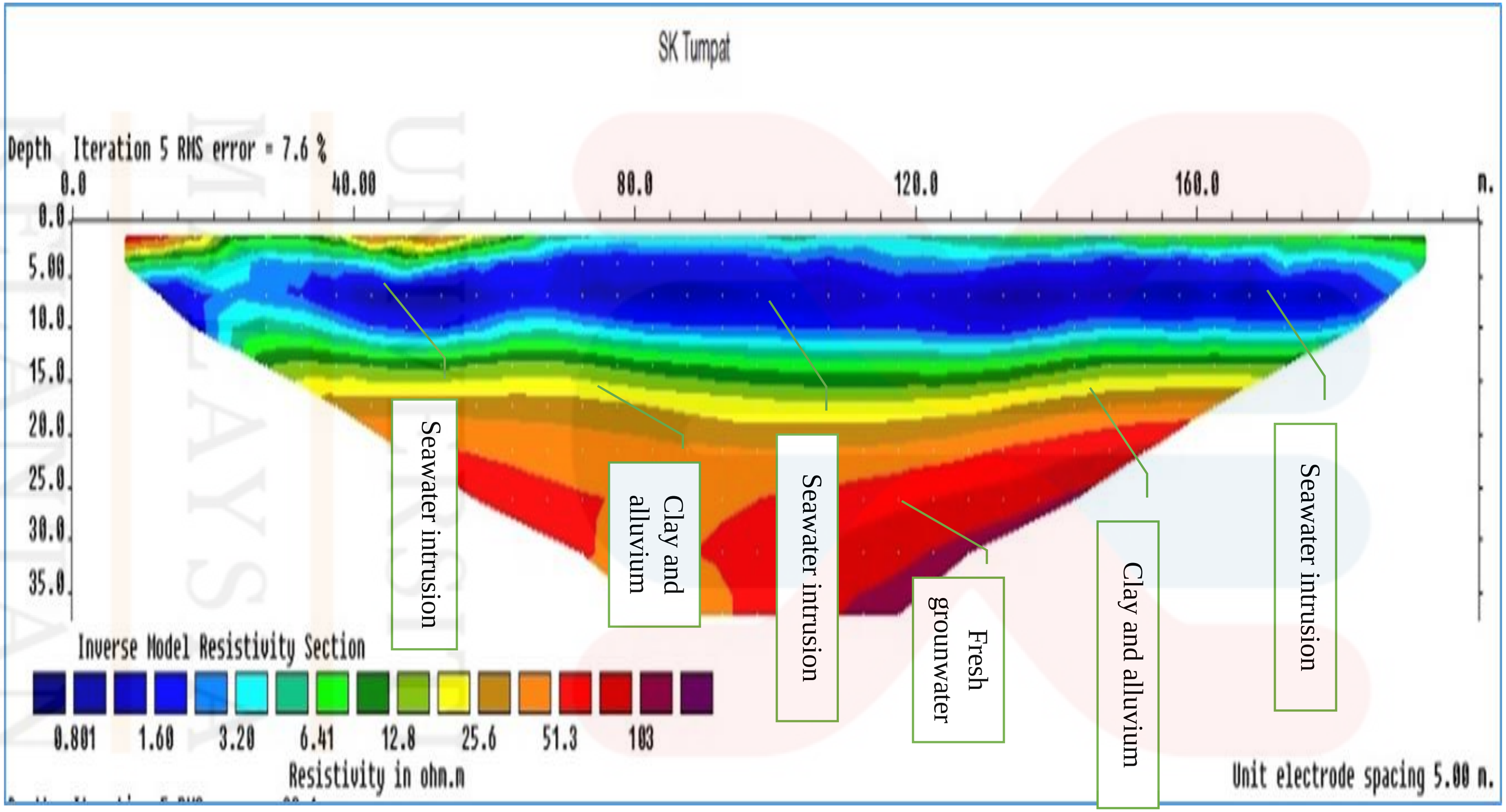


Figure 5.23 : Result of ERI fifth line survey

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

In conclusion, objective for final year thesis research is achieved. The geological map of Kg Lojing in scale of 1:25000. Second objective also accomplish by identifying salt water intrusion in Tumpat coastal area by using Electrical Resistivity Imaging and Geochemistry.

There are many aspect when doing geological mapping such as general geology, stratigraphy, petrology, structural geology, geomorphology, lithostratigraphy and others. Lithology of KPF Blau Plantation is dominated by limestone, mudstone, quartzite and schist. Stratigraphy of Kg. Lojing is based on Gua Musang Formation. Limestone rock unit overlies mudstone rock unit uncomformably. Mudstone rock unit overlies schist and quartzite rock unit uncomformably. The age of limestone is Triassic, mudstone is carboniferous and quartzite and schist is Ordovician – Silurian. Geomorphology is affected by limestone and quartzite topography. There also high slope and low slope in KPF Blau Plantation. Structural geology of geology in KPF Blau Plantation consist of vein, folding and joint. There are recumbent fold and minor chevron fold. There also sheet joint, extensional, exfoliation and parallel joint. Direction of principle stress one from join data is N 60 W and S 60 E. This indicate major forces are coming from NW-SE direction. Depositional environment of Kpf Blau formation is deep marine to shallow marine.

KPF Blau is located in Bentong-Raub Suture. Therefore, consist of Schist series such as mica schist, quartz-mica schist and meta quartzite.

North Kelantan and Tumpat area is dominated by alluvium and Quartenary deposit. Main lithology are sand, silt, clay and gravel. There also confined aquifer and unconfined aquifer which store fresh water. Usage of groundwater increase day by day. Therefore, groundwater exploitation get increase day by day. These activity affect groundwater contamination.

There also shallow aquifer and deep aquifer that affect with saline intrusion. All of five different location shows different resistivity value. From resistivity study, there are three deep aquifer and two of them are affected by saline intrusion. However the other two aquifer also may be affected by salt water intrusion in the deep aquifer as one of the location is very near to the coast. This is because protocol being used only measure shallow aquifer and not deep. Normally groundwater affected by saline intrusion has values in about 0.2 ohm meter. Low resistivity indicate present of saltwater intrusion. Low resistivity indicate high conductivity in the pseudo section result.

Other than that, salinity of Tumpat coastal area can be determined by implementing in situ test by using multi parametet. Kg. Jubakar has the highest values of salinity which is 0.4 ppt. this because the location just near to shore line. The location also shows highest value of Total Dissolve Solid which is 350 mg/L. Kg, Jubakar also has the highest value of Electrical Conductivity which is 887 m/S. Other location also have saline intrusion which are Pekan Tumpat and Kg. Chabang Empat and the salinity values is 0.2 ppt. it can be concluded that Tumpat is contaminated by saltwater intrusion.

In addition, geochemistry data also support in situ test and resistivity survey result. Atomic Absorption Spectrometer is used to measure concentration of cation in the fresh water sample. Difference cation have difference value of concentration of different location. High concentration of cation indicate many element exist in the solution. Turbidity of fresh water sample in all locations show low and high. This is because condition of open well or close well that prevent other particle coming inside the well.

All the parameter tested are iron, calcium, manganese, potassium, and copper. Location near the shore line have high volume of cation concentration while location far from shore line has lower concentration of cation. However, depth of well from groundwater sources also affect concentration of cation.

6.2 Recommendation

Implementation of preliminary study need to be done before starting geological mapping. Understand and find information about regional map and setting of the study area. Lineament analysis must be done before do geological mapping in order to help study and recognize geological structure. A raw geological map must be done with satellite imagery interpretation data so that, the field data acquire from field mapping can be correlated.

Accessibility of study area also need to be considered as it become a major problem if study area cannot easily access. Determination of study area must consider main road, phone coverage, base camp and must easy to access the area via barefoot walking and also transport especially hilux.

Other than that, people who are living near the shore line need to cure and filter the fresh water taken from well. This because most of them contaminated with salt water intrusion and others cation and anion such as calcium, chloride and iron. Filtration can also use conventional method or modern method based on their cost. These also important to prevent drinking fresh water from the well that contain high amount of total suspended solid, total dissolve solid, turbidity, electrical conductivity and salinity.

Usually, chlorine is put in the conventional well to clean the fresh water and kill tiny organism inside. Chlorine usually obtain from local hospital or clinic. Local Authorities must observe exploitation and pumping of groundwater activity to prevent saline intrusion. This is because most of people in Northern part of Kelantan depend on fresh water as domestic usage. Certain act need to be strained to preserve fresh water aquifer.

Researcher in local university and government agency must cooperate and do specific research to preserve quality of groundwater. Groundwater monitoring must be done continuously by using appropriate and sophisticated instruments to acquire specific and details data as well as result.

Saline water intrusion normally affect people economy of certain area. This because when sea level is high it may intrude fresh water aquifer in agriculture location such as paddy field. This may affect crop yield and growth rate of paddy. Government should help farmer by supplying them new seeds, fertilizer and some money. Hence, this may help farmer to overcome their problem regarding of sea water intrusion.

It is highly proposed to do specific research regarding seawater intrusion in Northern part of Kelantan with different method and procedure. Mitigation plan also must be planned and implemented to prevent saline intrusion into coastal aquifer in North Kelantan especially Tumpat area.

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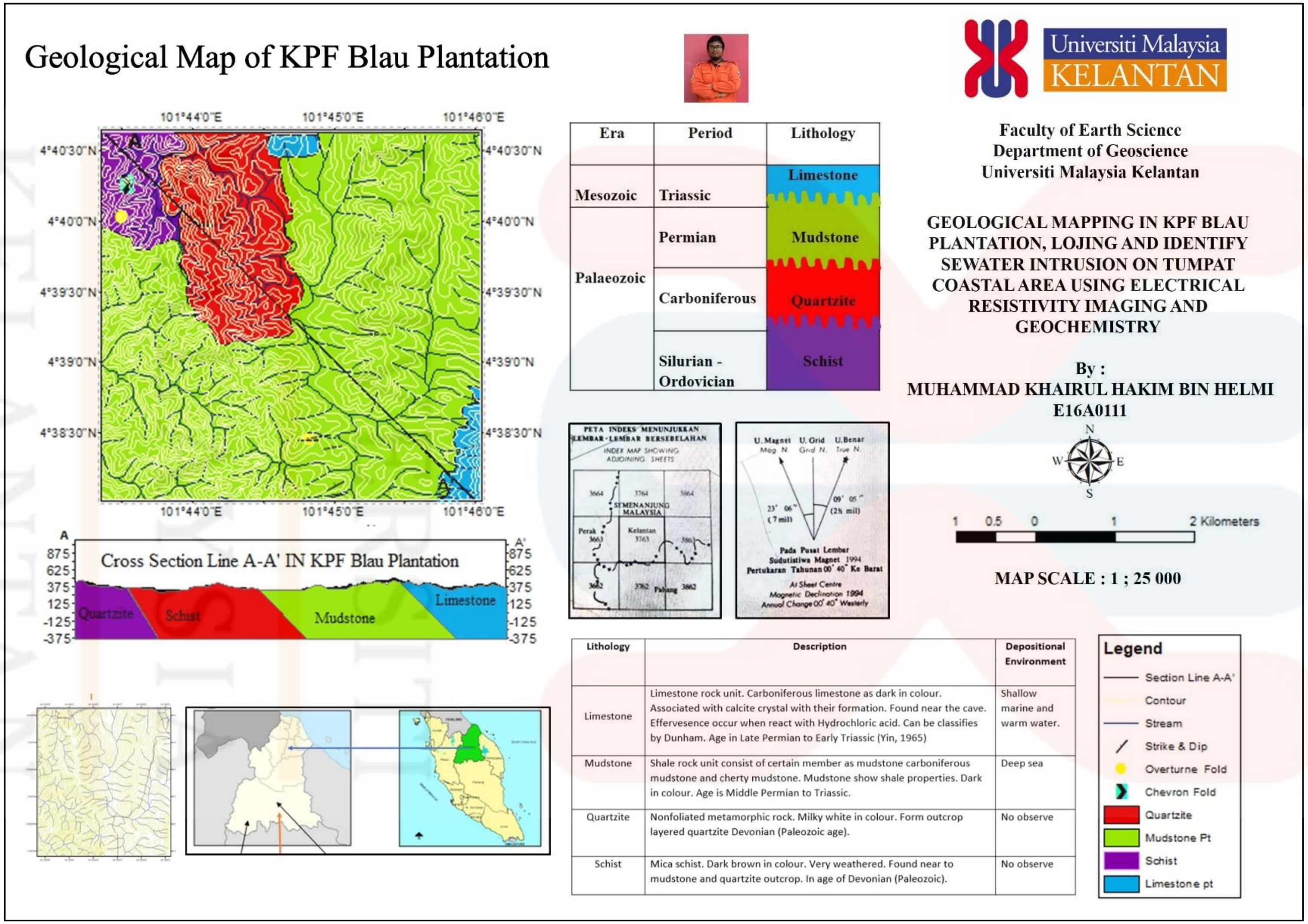
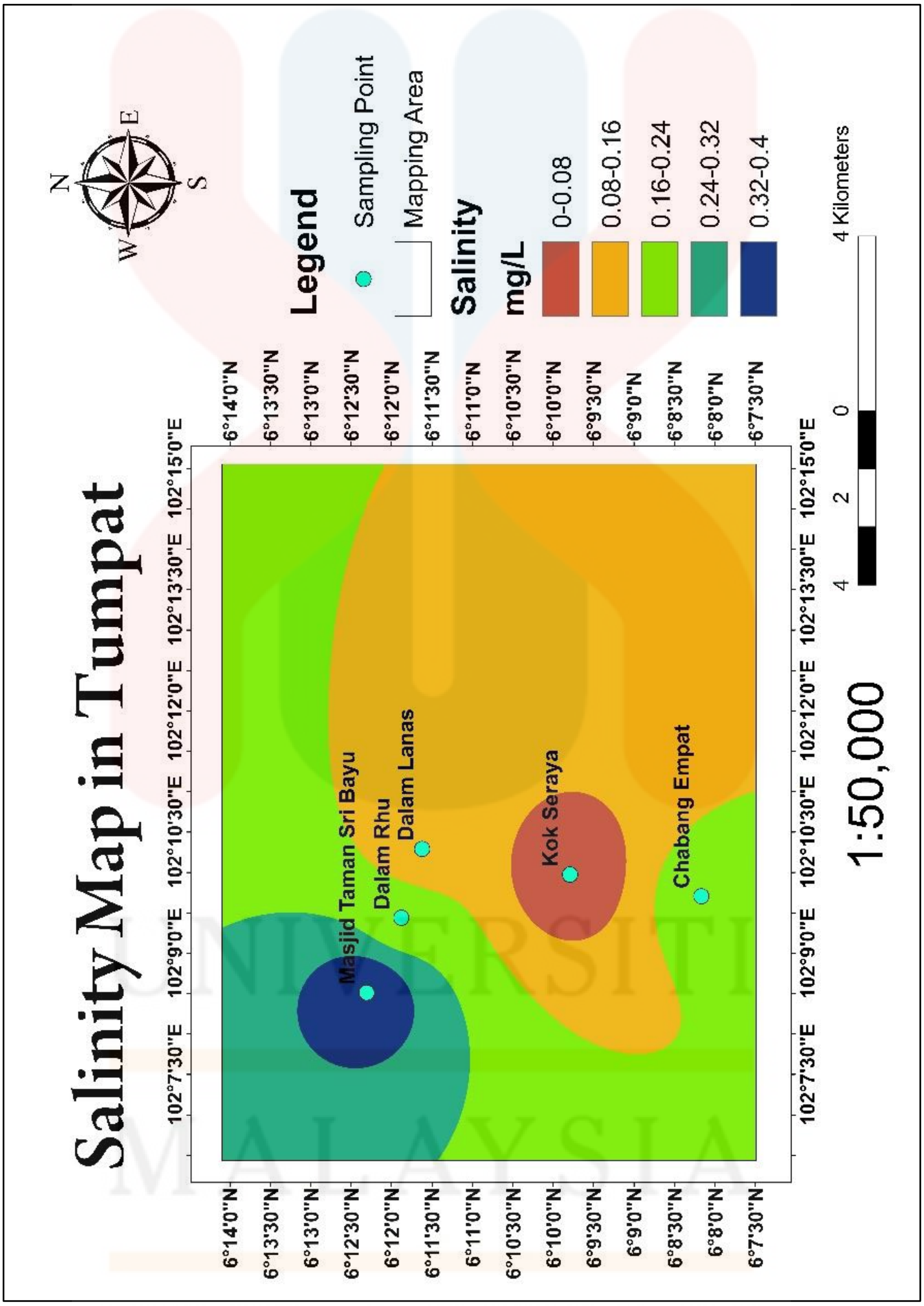
Appendix A



Lithology	Description	Depositional Environment
Limestone	Limestone rock unit. Carboniferous limestone as dark in colour. Associated with calcite crystal with their formation. Found near the cave. Effervesence occur when react with Hydrochloric acid. Can be classifies by Dunham. Age in Late Permian to Early Triassic (Yin, 1965)	Shallow marine and warm water.
Mudstone	Shale rock unit consist of certain member as mudstone carboniferous mudstone and cherty mudstone. Mudstone show shale properties. Dark in colour. Age is Middle Permian to Triassic.	Deep sea
Quartzite	Nonfoliated metamorphic rock. Milky white in colour. Form outcrop layered quartzite Devonian (Paleozoic age).	No observe
Schist	Mica schist. Dark brown in colour. Very weathered. Found near to mudstone and quartzite outcrop. In age of Devonian (Paleozoic).	No observe

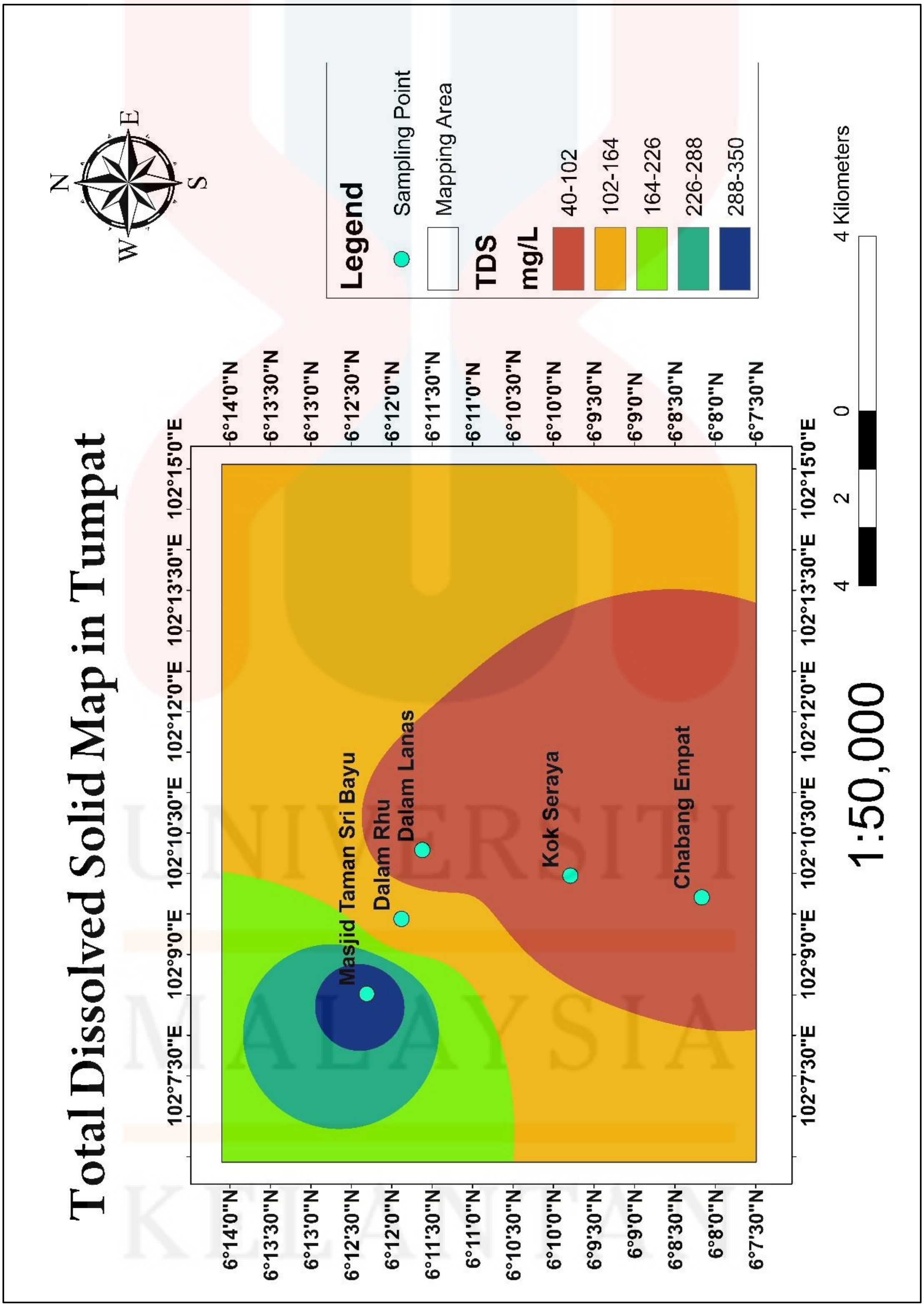
Appendix A: Full Geological Map in KPF Blau Plantation

Appendix B



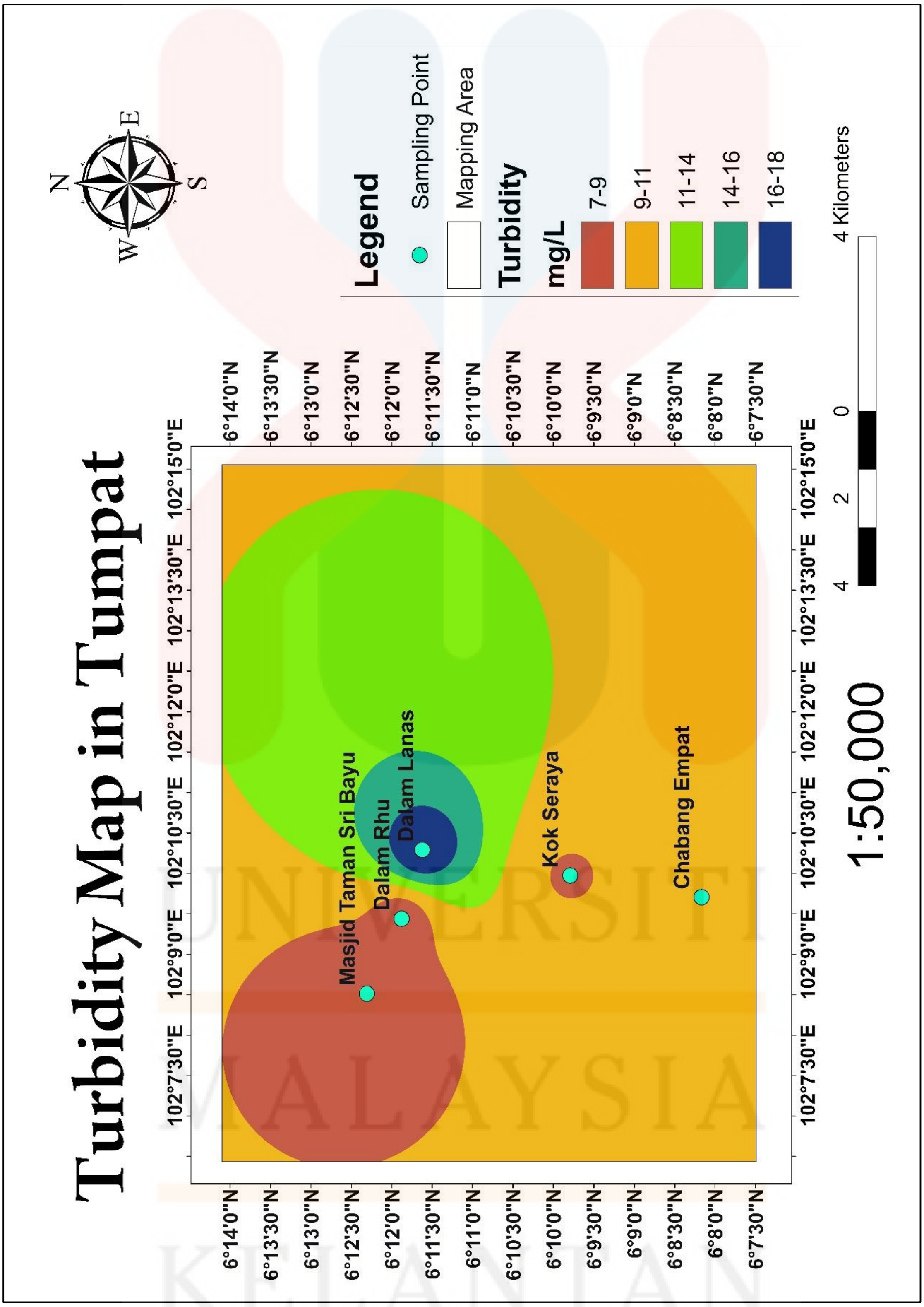
Appendix B: Salinity Map in Tumpat

Appendix C



Appendix C: Total Dissolved Solid Map in Tumpat

Appendix D



Appendix D: Turbidity Map in Tumpat