GEOLOGY AND HEAVY METALS ANALYSIS IN STREAM SEDIMENTS OF PERGAU RIVER, JELI, KELANTAN

by

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DECLARATION

I declare that this thesis entitled “Geology and Heavy Metals Analysis in Stream Sediments of Pergau River, Jeli, Kelantan” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ______________________________

Name : ______________________________

Date : ______________________________

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This research study impossible to finish up without the help and support from everyone I know including parents, family, supervisor, lecturers and friends.

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Geology and Heavy Metals Analysis in Stream Sediments of Pergau River, Jeli, Kelantan

ABSTRACT

The study area is located in Kampung Relak, Jeli, kelantan. The objective of this research is to update the geological map in the study area with scale 1:25000. The lithology that found in the study area was meta sediment, phyllite, biotite granite porphyry, coarse grained foliated granite and micrograpnite. Biotite granite porphyry, coarse grained foliated granite and microgranite were classified these granite as Noring Granite (Aman, 2000). Kampong Relak was underlain by meta sediment and phyllite. These two lithologies were originated from Gua Musang formation at the age of Permian to Triassic. The meta sediment has sharp contact with Noring Granite. The age of Noring Granite was Createaceous. The other objectives of this research is about heavy metal analysis which is to determine heavy metal content in stream sediment of Pergau River and to develop spatial distribution map of heavy metal in study area. The sample of stream sediment was collected 5 checkpoints randomly along Pergau River. The heavy metals that contain in Pergau River were Iron (Fe), Zircon (Zr), Manganese (Mn), Titanium (Ti), Thorium (Th) and Lead (Pb). The conclusion showed that the highest of heavy metals content in Pergau River was Iron (Fe) while for Lead (Pb) and Thorium (Th) only concentrated at checkpoint 1. Checkpoint 4 has the lowest heavy metal content because it does not contain Zircon (Zr), Thorium (Th) and Lead (Pb).

Geologi dan Analisis Logam Berat dalam Pasir Sungai di Sungai Pergau, Jeli, Kelantan

ABSTRAK

Kawasan kajian yang dijalankan terletak di Kampung Relak, Jeli, Kelantan. Objektif kajian ini adalah untuk mengemaskini peta geologi di kawasan kajian dengan skala 1:25000. Jenis batuan yang terdapat di kawasan kajian adalah sedimen separa meta, filit, biotit granit porfir, granit pemendapan yang berbutir kasar, dan mikrogranit. Biotit granit porfir, granit pemendapan berbutir kasar dan mikrogranit di klasifikasikan sebagai Noring Granit oleh Aman et al., (2000). Kampung Relak asalan daripada sedimen separa meta dan filit. Kedua dua jenis batuan ini berasal dari pembentukan Gua Musang pada usia Perm ke Trias. Sedimen separa meta ini mempunyai sentuhan yang sekata dengan Noring Granit. Noring Granit berusia Kapur. Antara objektif lain dalam kajian ini adalah mengenai analisis logam iaitu untuk menentukan kandungan logam berat dalam pasir sungai di Sungai Pergau dan juga untuk menghasilkan peta taburan kandungan logam berat di kawasan kajian. Sampel pasir sungai ini di ambil di 5 tempat yang berbeza secara rawak sepanjang Sungai Pergau. Sungai Pergau mengandungi 6 jenis logam berat iaitu Besi (Fe), Zirkon (Zr), Manganese (Mn), Titanium (Ti), Thorium (Th) dan Plumbum (Pb). Kesimpulannya, kandungan logam berat yang paling tinggi dalam Sungai Pergau ialah Besi (Fe), manakala Plumbum (Pb) dan Thorium (Th) hanya tertumpu di lokasi pertama. Lokasi keempat mempunyai kandungan logam berat yang paling rendah kerana tidak mempunyai Zirkon (Zr), Thorium (Th) dan Plumbum (Pb).

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LIST OF ABBREVIATIONS

NW	northwest
N	North
E	East
km^2	kilometer square
mm	millimeter
Zn	Zinc
Pb	Plumbum (Lead)
Hg	Hydragyrum (Mercury)
Cd	Cadmium
Ni	Nickel
Cu	Copper
V	Vanadium
Cr	Chromium
P	Phosphorus
Fe	Iron
Zr	Zircon
Mn	Manganese
Ti	Titanium
Th	Thorium
XRF	X-Ray Fluorescence
AAS	Atomic Absorption Spectroscopy
ICP-MS	Inductively Coupled Plasma-Mass Spectrometry

LIST OF SYMBOLS

%	percentage
°C	degree Celsius
°	Degree
’	Minute
”	Second

CHAPTER 1

INTRODUCTION

1.1 General Background

Jeli is district of Kelantan where Jeli is located near the Malaysia – Thailand international border. 82% of the earth surface in Jeli area is forest and river. The main rivers that have in Jeli district is Pergau River, Suda River, Renyok River and Balah River (Majlis Daerah Jeli, 2013).

Sungai Pergau is the main and largest river in district of Jeli that is flowing from the south of hill. This site was found as a good potential in economic (Heng & Singh, 1986). According to Teh et al., (1998) the gold used for economic is more concentrated and larger with 1.1mm length and 0.7 widths in Sungai Pergau. The dominant rock of Pergau Lake which is man-made dam for use as hydroelectric power generation is granitic rocks. Sungai Pergau composed the outcrop of andesite dyke (intrusion) and white marble (Dony Adriansyah et al., 2015).

The stream sediment from the source of rock fragment is called as disintegration of rock of the Earth's crust. The erosion of unconsolidated particle to become stream sediment is sheet erosion and channel erosion. Sheet erosion is the roughly removal of sediment from land surface. It is rarely occur because of the runoff tend to flow over the land surface. Channel erosion is happen when the runoff from land surface make the erosion of channel bank or bed. Besides that, the aeolian sediment also may become stream sediment when it falls on water surface as loose particle (Colby, 1963)

According to Sany et al., (2011), the main sources for heavy metals accumulated in the environment are lithogenic and arthopogenic. Lithogenic is cause from the natural occurring that may cause the enrichment of heavy metals while arthopogenic is because of the transportation of pollutant to the water by human activity. The organic complex in the stream may cause the difficulties in heavy metals reaction due to oxidation of dithizone. Normally, the water that contain heavy mental will seem cloudy due to precipitation of dissolved sulphate and carbonate (Robert et al., 1955).

The geological map is the map that records the distribution of rock according to different formation. It have different scale that can be used depends on the type of geological map that need to be produced. This map can be used to solve the problem in earth resources exploration, civil engineering, environmental geosciences, and hazards. Therefore, for a geologists, this is a fundamental skill that should they have. This geological map must been accurate in the form of the basis geological field work and also laboratory works (Richard et al., 2011).

1.2 Problem Statements

The geological map in Jeli area that has been used is not updated. Mapping should be done to update the geological map. Besides that, there is no research yet about the heavy metal content in stream sediment of Pergau River. This is the problem need to be faced according to lack of research in the study area.

1.3 Research Objectives

i. To produce an updated geological map with the scale 1:25000 at the study area.

ii. To determine the heavy metal content in stream sediment of Pergau River.

iii. To develop spatial distribution map of heavy metal in study area.

1.4 Study Area

The study area is located in Jeli district on the NW of Kelantan (Figure 1.1) that is located near the international border of Thailand-Malaysia. The study area (Figure 1.2) lies approximately within the latitude and longitude which are 5°28’30”N to 5°30’30”N and 101°52’0”E to 101°54’30”E respectively. This study area is covered 5x5 km^2 including the main river which is Pergau River, river which is Terang River and Suda River. Besides that, there are also several villages that have in the study area. The geological mapping had covered all of 5x5 km^2 of study area while the sample for the heavy metal analysis had been done along the stream.

1.4.1 Location (Topography)

Topography in the study area is hilly area and flat area. Hilly area is covered by forest with 540 meter elevation. Hilly area can be seen in Figure 1.3 while flat area showed 0-40 meter elevation. This flat area represents flood plain where it has high possibility of flooding. Normally, villagers planted their agriculture in flat area to generate their economic

Figure 1.1: Map of Kelantan

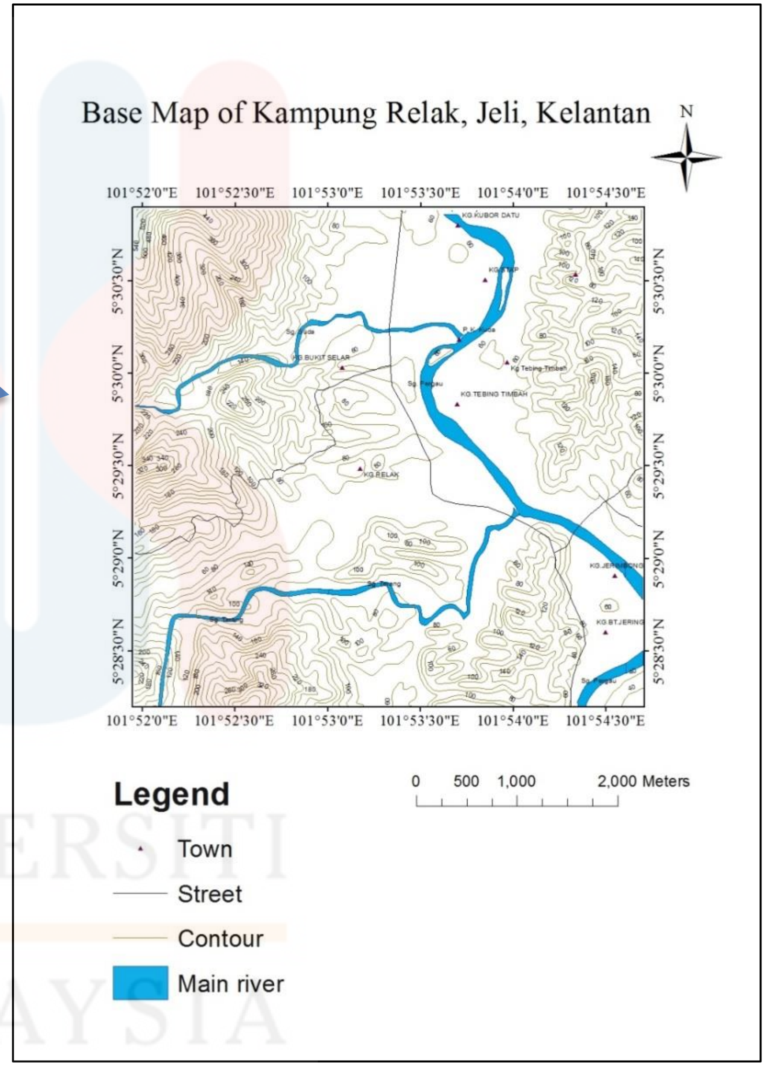

Figure 1.2: Base map of Kampung Relak, Jeli, Kelantan

Figure 1.3: Hilly area in Kampung Relak, Jeli

1.4.2 Demography

According to State Department of Statistics, the population of Jeli development is estimated at 42872 which is increased 11% from 2000. This amount consists of 21764 male and 21108 female that can be seen in the Table a in Appendix B while the total amount of population based on race is shown in Table 1.1. Figure 1.4 is the pie chart that shows the percentage of the total population in each Jeli district (Pejabat Tanah Jajahan Jeli, 2014).

Table 1.1: The total of population based on race

Race	Total
Malay	42400
Orang Asli	472
Chinese	-
Indian	-
Others	-
Total (overall)	42872

(Source: Pejabat Tanah Jajahan Jeli, 2014)

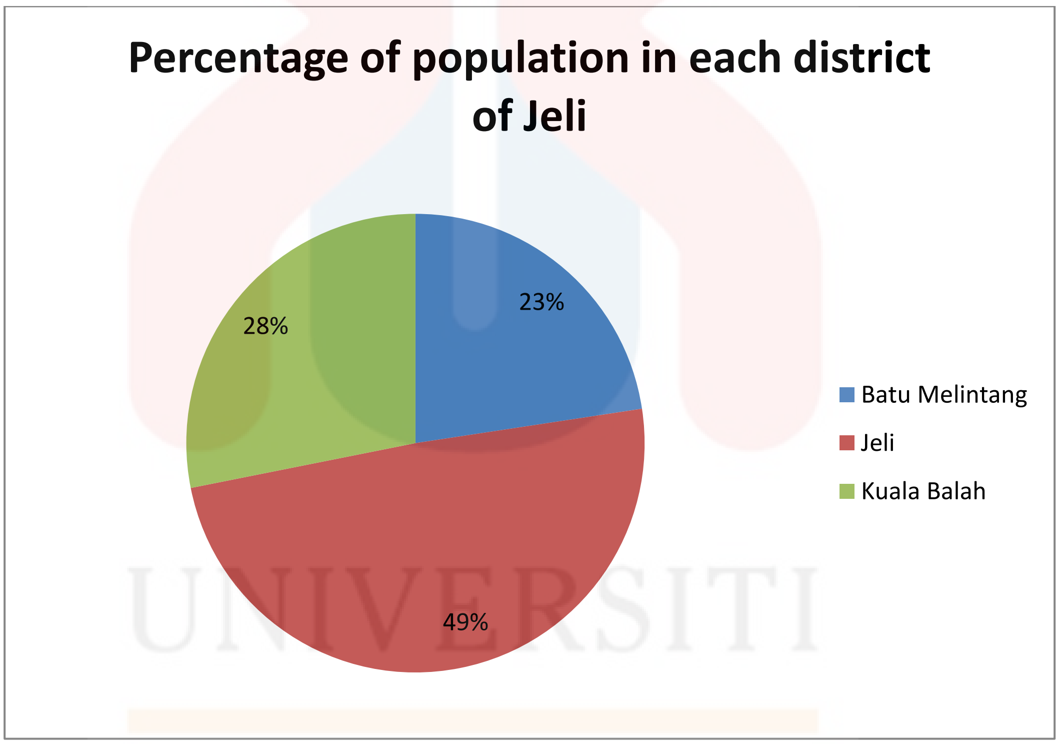

Figure 1.4: Percentage of population in each district of Jeli (source: Pejabat Tanah Jajahan Jeli, 2014)

1.4.3 Rainfall

The tropical climate can be found in Jeli which has a major amount of rainfall in Year 2014. 26.7°C is the average for the annual temperature in Jeli which is about 4907.0 mm of precipitation falls annually. Table b in Appendix B showed the total amount of precipitation falls monthly in Jeli. The least amount of rainfall occur in February which is 6.0mm while the most precipitation in December which is 1542.0 mm. The high precipitation during December is because of monsoon. The data of the total amount of precipitation falls monthly in Jeli is converted into line graph as shown in Figure 1.5 (Department of Mineral and Geoscience, 2014).

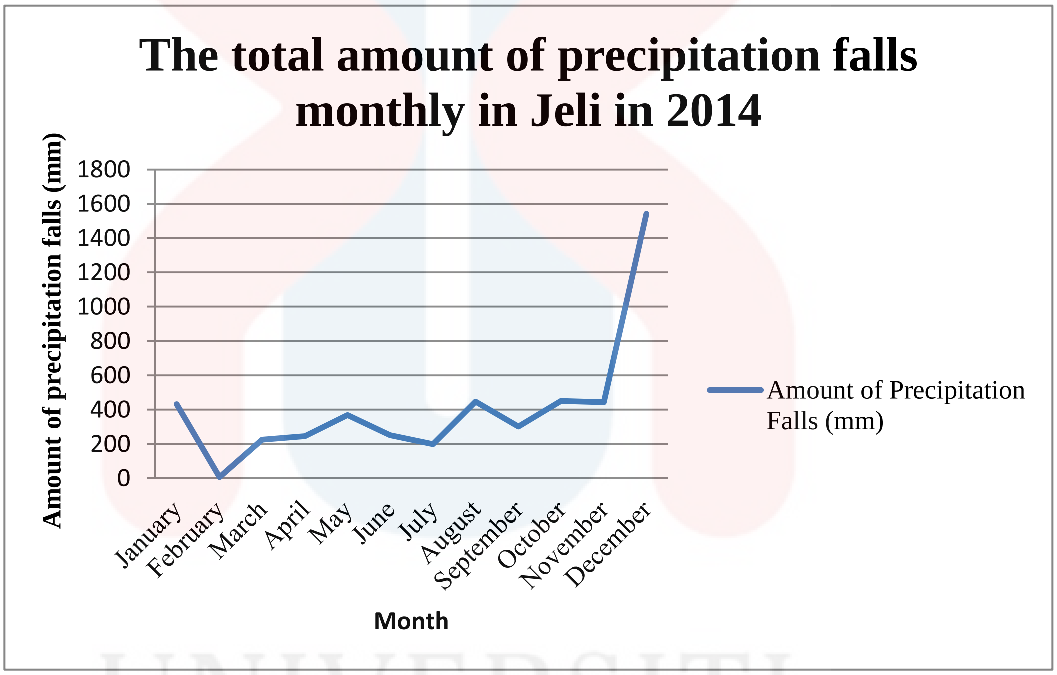

Figure 1.5: The total amount of precipitation falls monthly in Jeli in 2014 (Source: Department of Mineral and geoscience, 2014)

1.4.4 Landuse

The land of Jeli has 129,680.26 hectares which is 8.58% of Kelantan State. Jeli District Council had managed the 3 sub-districts which are Jeli, Batu Melintang and Kuala Balah. The study area is located in Kuala Balah sub district which is consist of Lubok Bongor, Kubor Datu, Selar Hill, Jering Hill, Jerimbong and Kuala Balah. The land use map of the study area showed in

Figure 1.6. For the development of building in Jeli, 1.63% of land had been used. 65.04% of the land is not allowed to be used because of the paddy field, water bodies and reserved forest. The remains of the land which is 33.33% can be used for the upcoming development of Jeli district (Draf Rancangan Tempatan Jajahan Jeli, 2010).

The land use of Jeli district can be classified into two categories which is develop land use and non develop land use and the uses can be seen in the Table 1.2. The examples that have in develop land use are for the residential, business, industries, institution, recreation, transportation and infrastructure while for the non develop land use are vacant land, agriculture, water bodies and forest.

a. Social Economic

Most people in Jeli worked as rubber tapper. Thus it contributes as one of the main economy sources. Commonly, families own a small rubber plantation. Besides that, they also have their agriculture business and sell it to the community of the villages. For example, they sell watermelon, vegetables, honeydew, corn, etc. Furthermore, in the study area, the villagers also opened a grocery shop as their side income. Basically, the villagers do not have to go to either Jeli town or Tanah Merah to get their daily necessity.

Table 1.2: The land used of Jeli district

SOIL USE	Existing (hectare)	Percentage (%)
A. DEVELOP LAND USE		
Residence		
Planned	45.80	0.04
Non planned	553.28	0.43
Business and Services	58.96	0.05
Industry	37.68	0.03
Institution and community services		
Education	270.19	0.21
Health	11.34	0.01
Religious	14.92	0.01
Cemetery	20.27	0.02
Safety	39.43	0.03
Welfare home	0.80	0.01
Government use	35.77	0.03
Another facilities for community	6.02	0.01
Open space and recreation	33.33	0.03
Transportation		
Road	965.69	0.74
Transportation facilities	2.11	0.01
Infrastructure and utility		
Electric supply	4.58	0.01
Water supply	6.73	0.01
Landfill	1.51	0.01
Telecommunication	2.29	0.01
Sub total	2,110.70	1.63
B. NON DEVELOP LAND USE		
Vacant land	405.85	0.31
Agriculture		
Agriculture	46,921.03	36.18
Abandoned land	570.22	0.44
Husbandry and aquaculture	15.81	0.01
Water bodies	2,097.78	1.62
Forest	77,558.37	59.81
Sub total	127,569.56	98.37
TOTAL	129,680.26	100.0

(Source: Draf Rancangan Tempatan Jajahan Jeli, 2010)

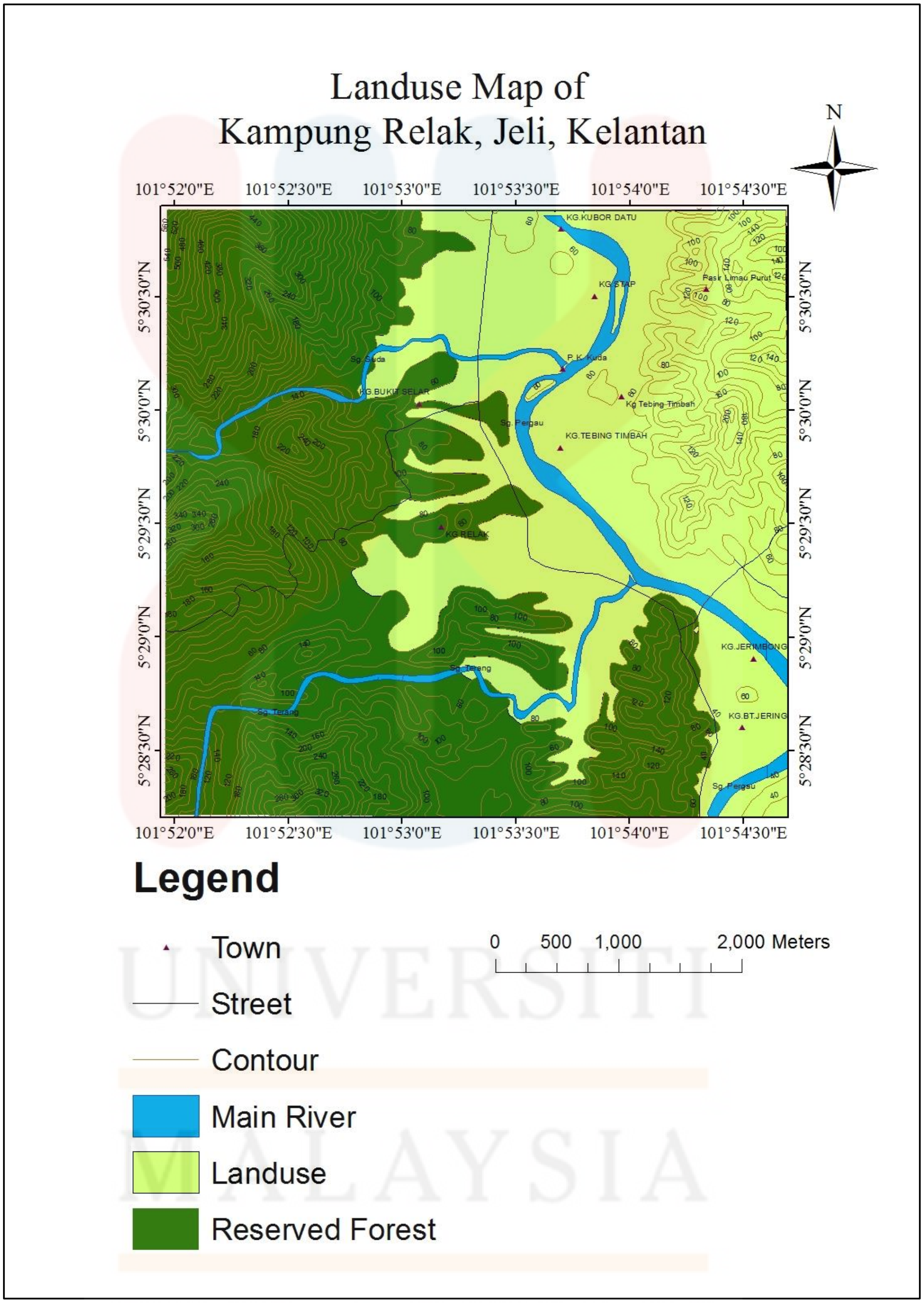

Figure 1.6: Landuse map of Kampung Relak, Jeli

b. Accessibility

The main road connected to the study area is East – West Highway and then from the main road toward the study area is along Jalan Sungai Sam – Dabong - Jeli. It can be seen in the map of road connection in the Figure 1.7. There is small road that connect the entire village. Most of the road is paved road that built for the user's pleasure.

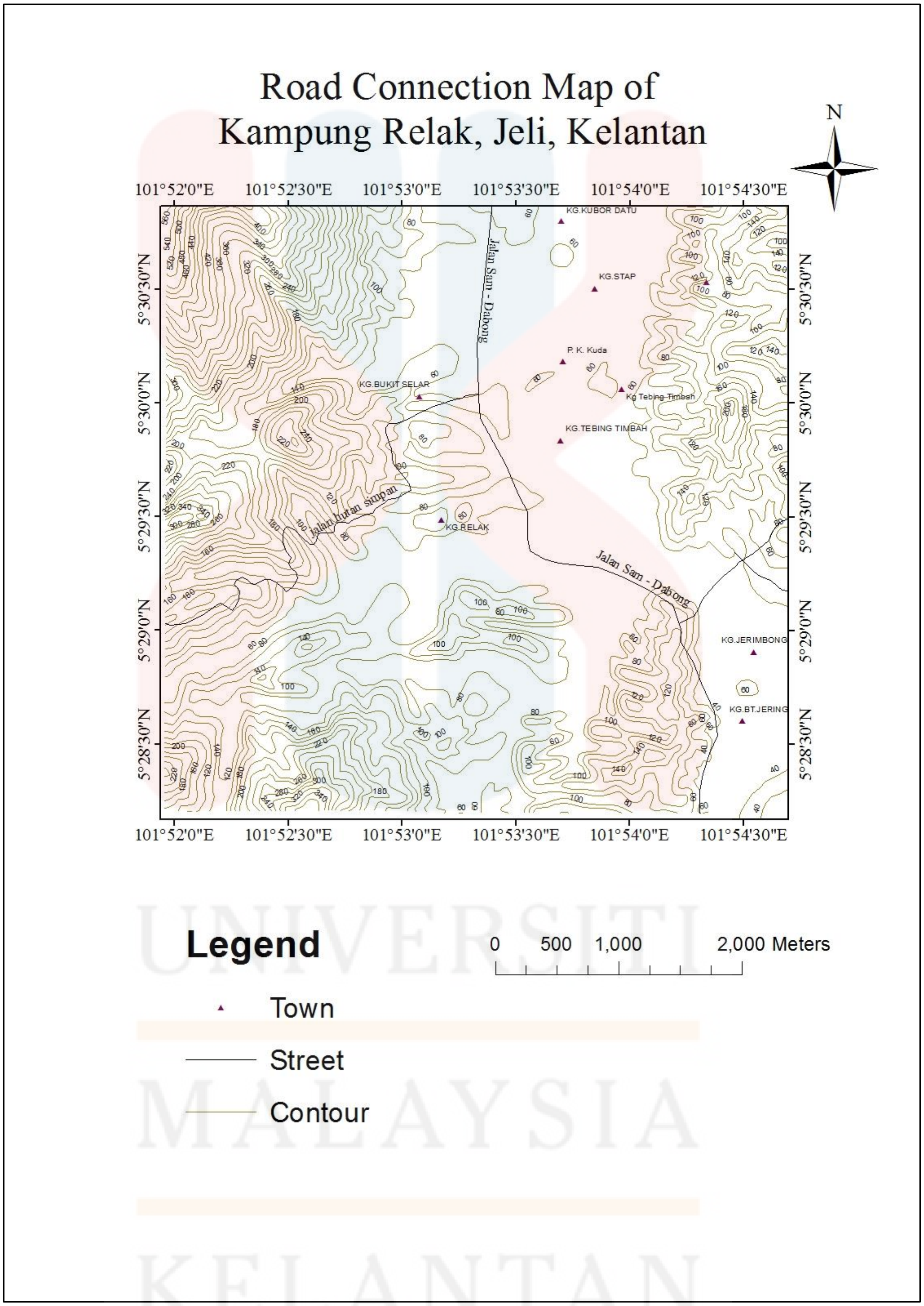

Figure 1.7: Road Connection Map of Kampung Relak, Jeli, Kelantan

1.5 Scope of the Study

This study focuses on study of geology which is mapping at the study area to obtain or to observe the geomorphology, rock distribution and also the data of heavy metal content at the study area. Besides that, the laboratory work that has been done was X-Ray Fluorescence to determine the heavy metal content in stream sediment of Pergau River. Software ArcGIS also has been used to make the geological map of the study area and also to make the spatial distribution of heavy metal content in the study area. The study area is covered 5x5 km^2 which lies approximately within the latitude are 5°28’30”N to 5°30’30”N and longitude are 101°52’0”E to 101°54’30”E.

1.6 Research Importance

The updating of geological map is important to give the details information about the study area. It is significant for the other researchers to conduct their research when the scale of geological map is small. Besides that, this research may give the information about the heavy metals at the study area which is Pergau River. This can be the awareness for the villagers near the Pergau River and the community that used Pergau River as water source or place for recreation about the heavy metals.

CHAPTER 2

LITERATURE REVIEWS

2.1 Introduction

This chapter is discussed about the overview of past research which is regional geology and tectonic setting, historical geology, regional stratigraphy, structural geology, sedimentology, petrography and heavy metals at river.

2.2 Regional Geology and Tectonic Setting

2.2.1 Stratigraphy

General geology of Jeli district composed two formations and one acid intrusive. They are Gunung Rabong Formation, Gua Musang Formation and Granitic rocks. Besides that, the landscape in Jeli area that have isolated hill which is low lying area such Gunung Reng and elongated hill which is ridge but lower than mountain (Dony Adriansyah et al., 2015).

Tanot et al., (2002) had said that Lata Renyok which is located near Jeli-Dabong Road is a part of Stong Magmatite Complex that is consists of leucogranite with enclave of metasedimentary rock.

The outcrop along area of East-west Highway west of Kampung Batu Melintang was interpreted by Tjia & Syed (1996) as olistostrome. The olistostrome encompass the variety of clast that range from bedded chert, sandstone, limestone, volcanic and volcanoclastic rocks, mudstone and conglomerate (Hutchinson & Tan, 2009). However, Wong (1974) described in this area have the metamorphic rock that the range of grades is from upper greenshist to lower amphibolite facies. The rocks are schists and gneisses. Mohd Raji (1990), had done the detailed mapping in the area stated that the rocks are muscovite-quartz schist, garnet-muscovite schist, sillimanite-muscovite schist, biotite-hornblende schist, hornblende-epidote schist, and biotite-hornblende gneiss. Besides that, he also stated the country rocks at the granite contact are slate, meta-tuff, meta-anglomerate, phyllite, marble and biotite-hornfels. Limestone along the Sungai Pergau had been metamorphosed into marble and this indicates the age of the site as Permian (Wong, 1974).

Yin (1965) stated Gua Musang Formation is the Middle Permian to Upper Triassic. The formation is composed of crystalline limestone, interbedded with thin bedded of shale, tuff, chert nodules and subordinate sandstone and volcanic. The environment of deposition of Gua Musang Formation is shallow marine shelf deposit with active volcanic activity (Lee et al., 2004).

Aring Formatin is correlated with Gua Musang Formation and Pahang Volcanic series. The age of Aring Formation is Upper Carboniferous to Lower Triassic. This formation mostly has pyroclastic with minor lava, dolomitic marble and argillite (Lee et al., 2004).

Sungai Rual area composed of granitic rock that surrounded by hilly area. Gunung Reng composed of limestone, marble that is sitting on granitic rock and surrounded by alluvial deposit (Dony Adriansyah et al., 2015).

Petrology is the study of the modes of occurrence, theories of origin and classification of rocks. It is emphasis of mineralogical and geochemistry of rocks. Petrologic have two categories which is i) identification and classification of rocks, ii) interpretation of the data and generation of origin of the rocks (Anthony & Jay, 2009).

Research by Azman (2000) stated that Stong complex is granite that formed from Noring Pluton. The age of Stong complex is dated as Cretaceous. Granite in Stong complex is made up of plagioclase, pinkish K-feldspar megacryst, quartz, hornblende, biotite, apatite, sphene, allanite, epidote and magnetite. This shows that the Noring magma is from different magma type possibly of andesite in composition. Because of Noring Granite is consist of coarse grained granite and distinct phenocryst of alkali feldspar, it is named as biotite granite porphyry (Haziq, 2013).

2.2.2 Structural Geology

According to Khoo and Tan (1983) during the late Triassic, the Taku Schist and adjacent area had been suffered to uplifting and recumbent style folding and regional metamorphism. Continental deposition began soon after the terminated marine sedimentation of the rest of the Central Belt that continued up to early Creteceous. At the late Cretaceous, the continental deposits were uplifted and gently folded. During Permian to Triassic, there is significant acid to andesite volcanism occurred.

Dony Adriansyah et al., (2015) stated that Kampung Kalai in Jeli is underlain by metasedimentary rocks that near to granite intrusion. This gold mineralization affected by Kalai fault which is trending north-south direction. Besides that, Sungai Rual is one of the river that flow and entering the Sungai Pergau. The geological feature along Sungai Rual is fault, joint and magma mixing. In Lata Renyok the fracture is trending the west-east direction that is flow the river direction (Tanot et al., 2002).

2.2.3 Historical Geology

According to Khoo & Tan (1983) the main Range of Granite is formed from pre-early Devonion deposition of coarse clastic, argillaceous sediment chert and other rock type. The whole belt is regionally metamorphosed during Devonion and the foothills belt is emplaced by ultramafic bodies. Taku Schists is occupied in the northern part of central belt that consist of schist, amphibolite and phyllites. Because of the rock in Taku Schist is similar to those in Permian-Triassic outside, so it may be represent pre-Permian rocks.

The oldest rock in central belt is the main Range Granite that is bordering with the eastern part. It is known as Bentong Group that is consisting of schists, amphibolite, conglomerate, clastic and small body of serpentinite that is associated with schists. The greater part of the belt is covered up by marine Permian and Triassic rocks which are consist of shale, mudstone, fine grain sandstone, limestone and volcanic (Khoo & Tan, 1983). Goh et al., (2006) stated that the youngest rock in Kelantan is in the age of Jurassic to Cretaceous which is overlying the main Range Granite and Triassic sediment in Gunung Gagau. The lithology in the area is sandstone with sporadic volcanic intercalations underlain the conglomerate.

2.3 Research Specification

2.3.1 Heavy Metals Definition

Heavy metal is a dense alloy that used for radiation transmission and balancing purpose (John, 2002). The biochemical and geochemical cycle of some heavy metals is altered drastically by human activities. Therefore, the assessment of environmental risk is important for the agriculture and non-agriculture area due to soil pollution that can cause the human health (Grzebisz et al., 2002). The urban development as continuously and large amount of solid waste pose can cause major environmental risk because of the difficulties in removal. The major target pollution may occur is in landfill and solid waste disposal because rainfall and groundwater leaches these highly contaminated substances into rivers, streams and waterways which used by residence (Asonye et al., 2007)

2.3.2 Type of Heavy Metal

The major heavy metals and may give the serious effect for human health is Hg, Cd and Pb because they are the most toxic heavy metals. Lead is the one of the example that had change significantly in anthropogenic atmospheric emission. The combustion of fuel in particular coal is the anthropogenic source for the atmospheric level of mercury. Furthermore, the other anthropogenic sources are cement production, waste incineration and chlor-alkali production. The cadmium in the atmosphere has multiple sources which are various process of combustion based on fossil fuel and also in non-ferous metal industries (Ilia Ilyin et al., n.d).

According to Ziemacki et al., (1989), arsenic may appear in the form of sulphides when it is in natural state. It exhibits metallic and non-metallic properties. For the chromium (Cr), it is used in the manufacturing chromic acid, as a pigment in leather tanning and corrosion control. Besides that, manganese is not naturally occurring but has the minerals which is oxides, silicates and carbonates.

2.3.3 Heavy Metals in Stream Sediment

Requirement in strong acid condition for chromium removal cause the poor associated with carbonate and exchangeable phase (Idris & Ahmad, 2013). According to Sunday et al., (2013) natural sources and industrial activities is the main result of metal contamination of the environment. The soil and surface water of industrial areas in Southern Nigerian is affected by these activities (Olijire et al., 2003). The industrial effluent is the cause of containing the heavy metal in the river. Because of the heavy metal released to the river, it is eventually bound with the particulate matter and become incorporated into sediment (Idris & Ahmad, 2013).

Physical effect of heavy metal in sediment may cause the decreasing of light penetration and this make the organic matter uses up the oxygen and this cause the lack of oxygen for aquatic life. Presence of hazardous substances also may alter the water quality, and interruptions of economic activities (Asonye et al., 2007). Idris & Ahmad (2013) stated that based on analysis of pH and percentage of organic matter, the correlation of nickel and chromium at oxidation fraction is not strongly in Juru, Penang. The nickel is distributed largely in sedimentary matrix especially in the harsh condition while it less for remobilization into the water column for the normal condition.

Based on the previous research that is located in Klang, heavy metals such as Zn, Pb, Hg, Cd, and Ni is concentrated during the day monsoon. This is maybe because of the dilution that occurs in the aquatic area (Sany et al., 2011). The field laboratory that had been done by Robert et al., (1955) stated that the heavy metal that is present in the most stream and spring water is zinc. Besides, the normal sample of the stream water had detected the cation which is zinc and rarely Fe while the anion that is easily detected is sulphate.

The gold-base metals zone (volcanic exhalative) shows the high anomalies of heavy metal in stream sediment. This zone is located in northern part of central Kelantan towards the south (Goh et al., 2006). In the research by Gale et al., (2004) at the Big River and Flat River Creek, the extensive benthic alteration and contamination of Pb, Zn, Cu and Cd are potentially toxic if it is taken up by living organism in excessive amount. The organic matter that contained in soil and sediments will bind with heavy metals and it may exchange reaction with living organism depending on ionic strength, temperature and ambient pH.

Urbanization may cause soil contamination because of manufacturing activity. Geochemical mapping with high density had been done to get the detailed spatial distribution. In Beijing region, some elements such as Ni, As, V and Cr have the enrichment factor value that is between 0.95 to 1.08. These elements distribution in topsoil is relatively homogenous since they have low coefficient of variation. The coefficient of variation of other element is higher so that it suggests that their distribution is heterogeneous. Besides, these other elements which are Cu, Pb, Cd, Zn and Hg have higher value of enrichment factor than 1.3 (Yuan et al., 2013). Meanwhile in the research by Krupadam et al., (2006) at Tapi estuary, Zn and Pb have highest contamination because the index value is around 5 to 6 (6 is very strong contamination). The enrichment factor is used to determine the metal concentration or elemental concentration either lithogenic or anthropogenic origin. Zn, P and Cr in this research shows that they are have high enrichment factor and not correlated with bottom layer so it is representing that it is influences by anthropogenic activities.

2.3.4 Effect of Heavy Metals

The heavy metal give the badness for human when lead can accumulate in the liver and kidney and Pb is absorbed in bone where it replace the calcium (Steoppler, 1997). Besides that, the heavy metal also passes going into plant and fish to man through the food chain when the metal is accumulated in the body of flora and fauna and it is found as a toxic (Sunday et al., 2013).

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

The geological study is involved a detailed mapping about the type of rocks which is igneous rock, sedimentary rock and metamorphic rock that have exposure in the study area. The rock samples have been collected for the detailed observation for example for petrographic analysis, mainly use for the determination of rock type (Omosanya et al., 2012). The structural analysis also can be study by doing the detailed mapping. The forces direction can be known by taking strike and dip of the joint and fracture, which can be done by using Georose software.

The geochemical mapping is used for investigate the heavy metal in stream sediment around the source of pollution of anthropogenic origin. The investigation of microelement composition need to be done by laboratory works (Dumcius et al., 2011). There is a few of machine that can detect the element of heavy metal for example X-Ray Fluorescence (XRF), Atomic Absorption Spectroscopy (AAS) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS). The detail research flow is show in Figure 3.1

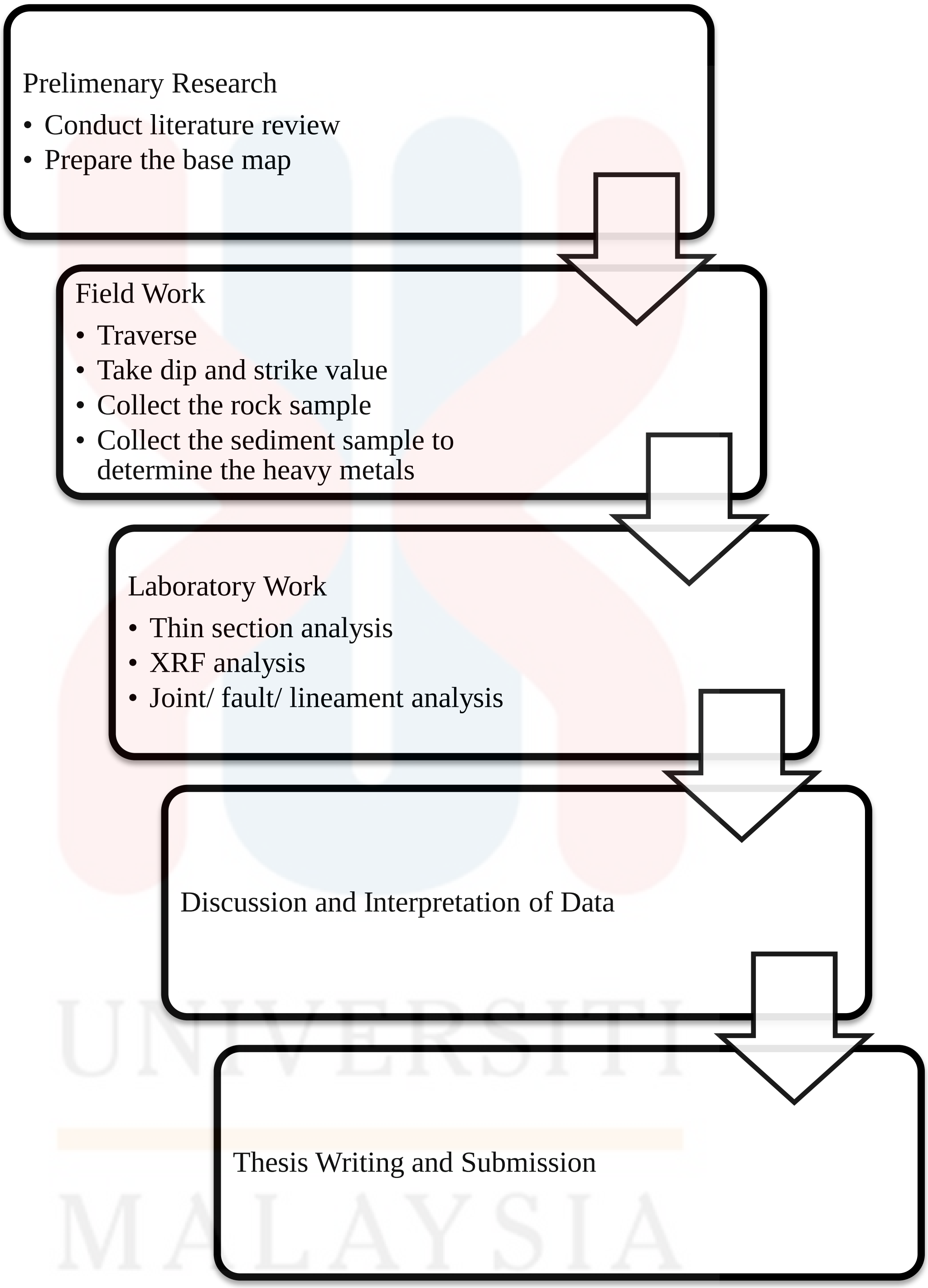

Figure 3.1: Research flow chart

3.2 Materials

There are a few tools and equipment that has been used to support the methods during field works and laboratory work in order to collect the data. There is also the software that has been used to analyse the data.

The tools that were used at the field can be seen in the Table 3.1 while the equipment that was used in laboratory is shown in Table 3.2.

Table 3.1: List of tools that use at the field

Tools	Functions
	1) Brunton or Suunto compass Used for determining direction, measuring inclination and measuring strike and dip in the field.
	2) Hammer The tool used for collecting samples or for look clearly the texture of rock
	3) Geographic Positioning System (GPS) Used in geological field mapping for finding the position, traversing, measuring elevation.
	4) Hydrochloric Acid (HCl) It helps in determination of carbonate minerals in the field. The bubble will produce when it react with HCl.

	5) Hand lens It is used to see the micro minerals or fossils at the field before further investigation in the laboratory.
	6) Measuring tape It is used for measure the thickness of the beds.
	7) Digital camera Photographs are important for description purposes
	8) Field notebook and stationary Important observation must be written down in a concise, orderly and legible manner for better understanding
	9) Sample bag It is used to keep sample from the field.

Table 3.2: List of equipment that use in laboratory

	10) Polarized microscope To determine the mineralogy of the thin section.
	11) X-ray Fluorescence (XRF) To determine the element of the sample.

The software that will has been used to analyse the data are as follows:

1) ArcGIS software
2) Georose software
3) DnR GPS

3.3 Methodology

3.3.1 Preliminary Research

All the information was obtained by doing the literature review. The literature review has given slight information about the past research that had been done in Jeli and it can be obtained from journals, books, reports, and also online web page. Besides, the base map was done to know about the study area. This base map can be derived from the ArcGIS software.

3.3.2 Field Studies

A geological mapping has been conducted according to base map. The geological mapping was been conducted to study about the geological structure, geomorphology, stratigraphy and lithology data by doing the traverse method in Pergau River, Jeli. The sample was taken from the outcrop in the study area by using the hammer. The standard size for the sample is hand size. This sample should be fresh for easy to determine the minerals of the rock. Sample was kept in the sample bag with the labelled of coordinate and type of rock. For the geochemical analysis of heavy metals, the samples have been taken from the stream sediments along Pergau River. Normally, the parameter that is set up to collect the samples for heavy metals is one meter depth.

3.3.3 Laboratory Work

a. Thin section

The thin sections were conducted to determine the mineralogy and the texture of the rock samples. These thin sections processes have been carried out in the laboratory in Universiti Malaysia Kelantan. The thin sections were observed by using the petrography polarized microscope.

According to Dave (n.d.) the tools that will be used to make the thin section are the slab saw, the trim saw, the grinder, the cut-off saw and the lap wheels. The steps in the making of the thin sections are by followed:

i. The slide was rubbed using carbon to frosted the slide surface. This step was showed in Figure a in Appendix A.

ii. The rock was cut by using the slab saw. In this step, the rock will be clamped by the holder. The cover was closed then the cut will begin. The cut should be in plane which is about 8 to 10 mm (Figure b in Appendix A).

iii. The trim saw was used in order to reduce the size into a smaller size than the slide size.

iv. The chip was glued at the frosted side of the slide. The ratio that have been used to make a glue is 2 : 1 which is 2 grams of epoxy and 1 gram of hardener. These materials were mixed well before glue it on the chip with the slide. The trapping bubbles while doing this step need to avoid. After that, the glued chip was let to be dry about 24 hours.

v. The chip was cut off after it has being dried by using the cut-off saw. Once, it finished, the slide was rinsed to remove any particles.

vi. The slide was grinded to get the correct thickness so that the minerals can be identified. The grinding was been done slowly to avoid the minerals in the thin section cracked.

vii. The cover slip was added to protect the chip from damage.

b. X-Ray Fluorescence (XRF)

XRF was used to determine the element of the sample. This XRF method can provide the precision and accuracy for determination of major element or trace element in rock and mineral sample. The sample that using this machine can be in the solid, powder, paste, liquid or gas formed (Taggart et al., 1982).

The stream sediments were collected in Pergau River. Then it was crushed and grinded by using grinding machine. The stream sediments were grinded less than 70 microns to avoid analytical problem. The stream sediment's powders were sent to x-ray laboratory to determine the element in stream sediments using X-ray fluorescence.

3.3.4 Data Analysis and Interpretations

The data was obtained by doing the field work and also laboratory work. In this part, the geology of the study area was analyzed to determine the correct lithology, drainage pattern and also dip and strike value that should be in the geological map. Furthermore, the data of heavy metals that were obtained from the XRF also been analyzed. All the data obtained were interpreted to know the heavy metals content in the study area.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The mapping part was covered by traversing the study area according to base map. In this chapter, it will discuss about the output of geological mapping such as topography of the area, drainage pattern in study area, weathering process that had done in certain part of the area. Besides that, it also discuss about lithostratigraphy which is what type of rock that had in the study area with their thin section for naming the rock and stratigraphic column to show the age of the formation. Furthermore, the structural analysis also had been discussed in this chapter to know the direction of the force.

The mapping was conducted by traversing the study area to find lithology, stratigraphy and structural geology. The traverse map in Figure 4.1 was showed the area that had been covered.

Based on the Figure 4.1, the point of sampling was the checkpoint that sample of lithology and stream sediment were been taken. The pink point showed the checkpoint for observation. The point at the SE of the map was the place of residual soil. The weathering process of this area will be explained in sub topic 4.2.3 which is weathering process. For the ob2 which is stand for observation 2 at east of the map in Figure 4.1, the area showed the rubber plantation. There is no outcrop in this area however, based on literature review, it stated that area had same lithology with checkpoint 5 which is phyllite.

Point C1, C2, C3, C4 and C5 showed the point of sampling for lithology. Some of the areas were traverse by river to find the lithology while some area can be traverse by car because of the lithology was located beside the road. All of the checkpoint for sampling were also been observed to discover the geomorphology of the area. C1, C2 and C4 have the same geomorphological landform which is river, vegetation area and hilly area since they were located at upstream. While geomorphology at checkpoint 3 are beside the road and has vegetation that cover some part of lithology.

Point ss1, ss2, ss3, ss4 and ss5 showed the location of sampling for stream sediment. These stream sediments were collected to determine the heavy metals content in stream sediment of Pergau River. The stream sediments were sampled randomly. The range of each location sampled was about 0.5 kilometer to 1 kilometer. The route that was used to reach the location was by plantation area.

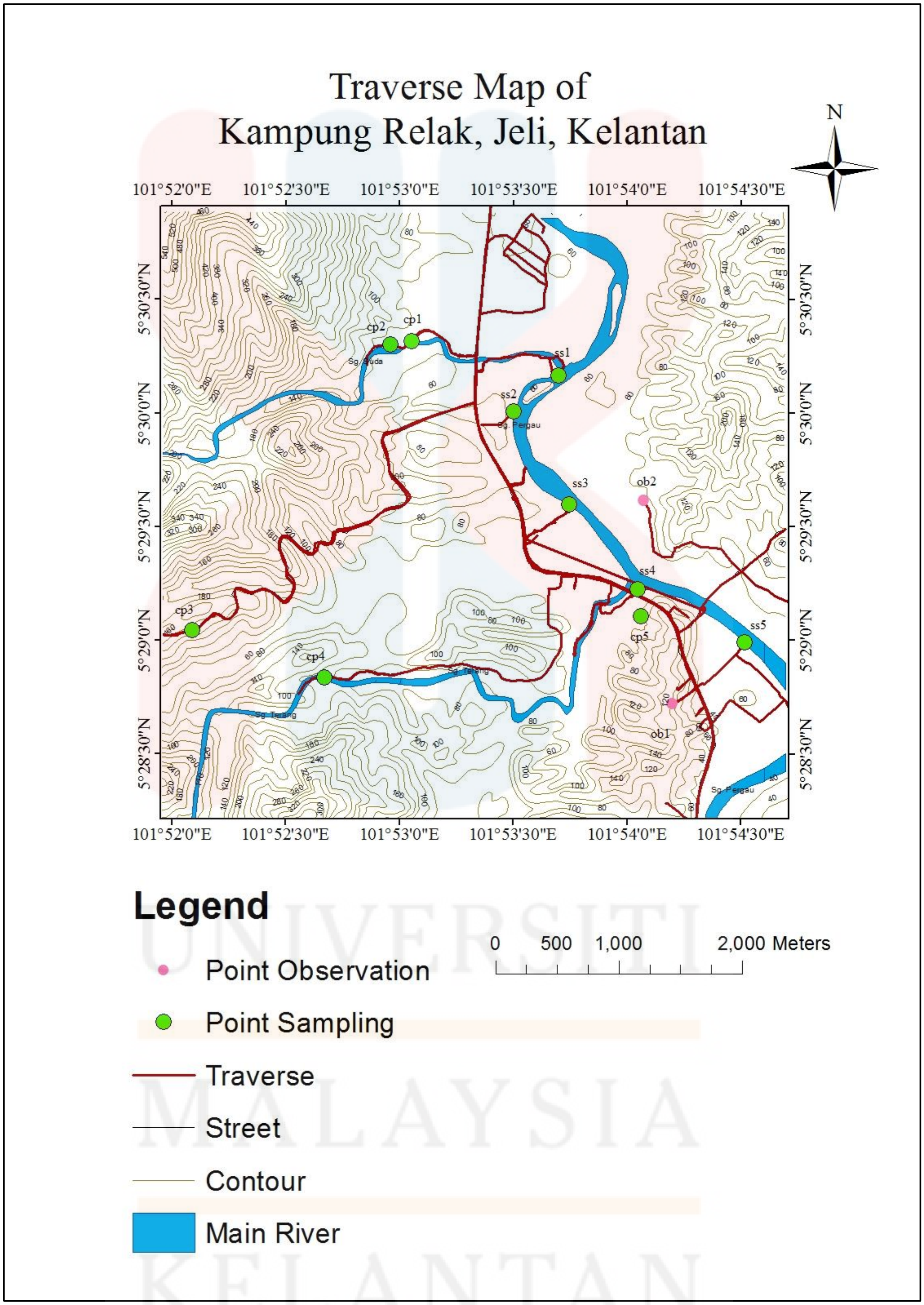

Figure 4.1: Traverse map that showed the area which had been covered

4.2 Geomorphology

Geomorphology is the landform and its process that related to its origin and evolution. The variables that control the formation of landform are the climate which is temperature and precipitation, plate tectonic and history. These variables are also known as geomorphological processes. There are three types of geomorphological process which is exogenic process, endogenic process and extraterrestrial process. Exogenic process includes weathering and erosion process that related to climate while for endogenic process includes the plate tectonic movement that may cause the uplifting, faulting or folding.

4.2.1 Geomorphological Classification

Hill may formed by erosion of larger landform or by the deposited of sediment that was brought by geomorphological agent such as wind. Faulting also may create the hill. Based on the geomorphological classification map in Figure 4.4, hilly area with 540 of elevation showed the high resistant. The high elevation was located in west of the map (Figure 4.4)The hill area at North West is covered by forest and it caused the difficulty to traverse however the river that flow from western part of hill showed the type of rock is meta sediment while in the hill at south west area is biotite granite porphyry.

Rainfall and runoff may cause the gradual lowering the topography by erosion. Flowing water at the high topography has the ability to breakdown the earth material by hydraulic action then transport the leftover material to the deposition area. Deposition may occur at the area of low flow of water. Normally, the rock at the upstream area was angular while the rock at the downstream area was rounded. This is because of the distance of the rock was transported.

The flat area alongside the river is known as floodplain. This floodplain area has the high possibility of flooding. During flood, the pebble or sediment may deposit on the surface of this area. In my study area, the villagers usually planted on the floodplain area due to fertile area for planting. Figure 4.2 also showed the alluvial landform that has the lowest elevation.

4.2.2 Drainage Pattern

Drainage system is the pattern of the river that shows the connection between the streams. The geographical factors that may cause different pattern are such as topography, bedrock type, transport of sediment and water and soil type (Ling & Eric, 2012). Based on Summerfield (1991) there are 8 types of drainage patterns which are dendritic, radial, rectangular, annular, parallel, trellis, centripetal and deranged. All of this type of pattern was influenced by structural control and topography of the area.

In the study area based on Figure 4.5, the drainage patterns in the study area were mainly composed of dendritic pattern and a few of parallel pattern. Dendritic pattern is common drainage pattern that showed the tributaries of the stream at low angle that look similar to tree-like. Normally, in the area that have dendritic pattern there is lack of structural control which are the rock was in uniform resistance without having major fault or fold. Besides that, in the area of dendritic pattern, the underlying rock was in horizontal layers.

A part from that there is also parallel pattern on North-West area of the map that flow from hill to Suda River. This pattern generally makes the stream flowing straight from slope to the low elevation. In the area of parallel pattern, there are non-cohesive sediments.

4.2.3 Weathering Process

Weathering is the process that breaking down or dissolving the rocks or minerals of Earth surface by altered the physical, chemical and biological properties. For the physical weathering, the rocks or minerals just breaking down without chemical change while for chemical weathering, it is the chemical reaction that may cause the rocks or minerals to dissolve and forming a new substance. Biological weathering is the disintegration of rock due to action of plant and animal.

There is 6 class of weathering grade classification; (i) fresh rock, (ii) slightly weathered rock, (iii) moderately weathered rock, (iv) highly weathered rock, (v) completely weathered rock and (vi) residual and colluvial soils. However, slope angle, relief contour and land uses are the main elements that used for weathering classification that were obtained through interpretation of aerial photo (Borelli et al., 2007)

Figure 4.2 showed the rock was highly weathered of granite that turn into residual soil. However, there was a slight part of the outcrop that still has mineral which is quartz at edge of the picture. Mineral was high resistant to weathering because it has high hardness in Mohs scale which is 7. Besides that, quartz is lack of cleavage and last mineral that crystallize in Bowen Reaction Series. Figure 4.3 showed the quartz mineral that found in this area.

Figure 4.2: Residual soil at coordinate N 05°28’44.2” E 101°54’11.3”

Figure 4.3: Quartz that found in the residual soil

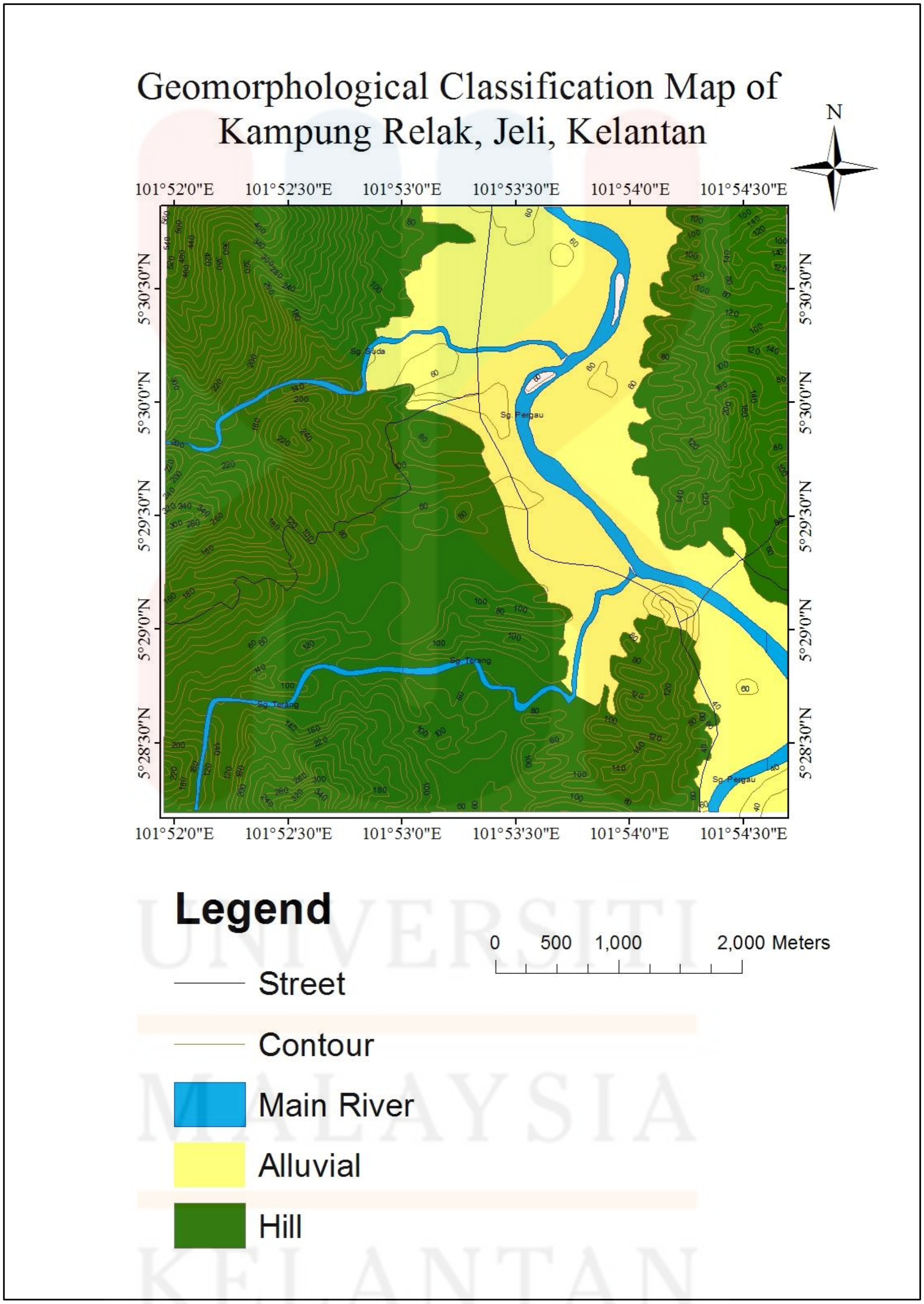

Figure 4.4: Geomorphological classification map that showed hilly area and alluvial landform

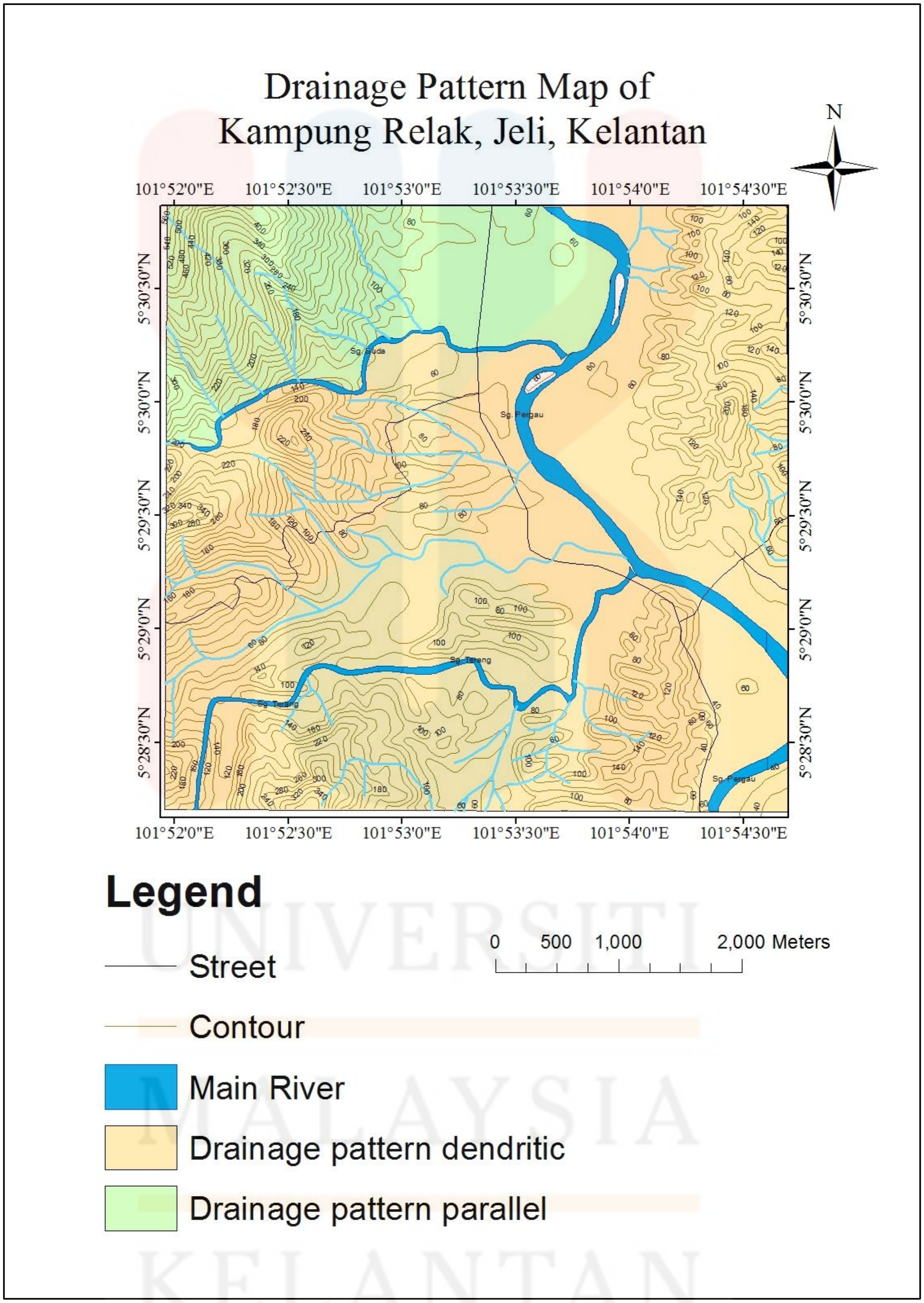

Figure 4.5: Drainage pattern of Kampung Relak which is composed of dendritic and parallel pattern.

Formation of pothole in the bedrock is common and spectacular by flowing of water rapidly. Potholes require hundreds to thousands years to form due to considerable resistance to erosion of the bedrock (Vishwas & Veena, 2004). In the study area that can be seen the potholes is located at upstream of Terang River (N 05°28’50.1”, E 101°52’40.1”) which can be access by using the car. Jon et. al., (2014) said that the size and shape of pothole is controlled by water flow velocities, erosion rates and sediment transport rates. Besides that, during the low flow may be less efficient for the pothole to trap the sediment thus it showed that formation of pothole is mobilized during the high flow. This may triggered the optimal growth rate of pothole become higher.

The potholes in the study area that showed in Figure 4.6 and Figure 4.7 showed the difference size of potholes that represent the erosion process occur by flowing water. High energy of flowing water was eroded the bed surface and created in situ water circulating motion. Figure 4.6 showed the length of pothole was 0.3meter with 0.5meter depth while for Figure 4.7, 1.25meter for length and 1.5meter depth.

Figure 4.6: Pothole in the study area with chisel hammer as a scale

Figure 4.7: Large pothole with chisel hammer as a scale

4.3 Stratigraphy

4.3.1 Lithostratigraphy

There are five main type of lithology that have in my study area. They are granite, intrusion of microgranite, meta sediment and phyllite. 70% of the lithology that found in the study area was igneous rock while for intrusion of microgranite and phyllite was 10% each. Another 10% of lithology in the study area was meta sediment.

Based on the past research by Tulot and Umor (2001), they had said the igneous rock in Kampung Relak was from Noring Granite part of Stong Magmatic Complex. Besides that, they also had said that in this area has meta sediment that originated from Gua Musang Formation. The type of igneous rock in the study area was porphyritic granite. Porphyritic means that it has two cooling stage which first is slow cooling then continue with rapid cooling. So, we may see the two different size of mineral which are large crystal and small crystal. Aman et al., (2000) had stated in their journal that the rock in Jeli area was undergone both magmatic and high temperature solid state deformation. One of the igneous rocks that found in the study area was coarse grained foliated biotite granite.

4.3.2 Lithologic Unit

a. Phyllite

Phyllite was found near the Terang River bridge which is at N 05°29’11.5”, E 101°54’00.8” (Figure 4.8). The colours of the rock were brown, black and green. These colours indicated mineral composition of the rock. This rock has very fine grain with a smooth texture. The rock name as phyllite because the foliation was developed well. Phyllite is low degree of metamorphism. It developed after slate and before schist. The hand sample of this rock was showed in Figure 4.9.

b. Meta sediment

Meta sediment in the study area was located in Suda River with coordinate N 05°30’19.0”, E 101°53’03.2”. Tulot and Umor (2001) had identified this meta sediment as schist quartzite mica. However, the outcrop that had found was highly weathered (Figure 4.10) but the foliation still clearly can be seen. The hand sample of this meta sediment showed in Figure 4.11. For the detailed of minerals in the rock, thin section had be done (Figure 4.12(a) and 4.12(b)).

Figure 4.12(a) showed the meta sediment under cross polarized light while Figure 4.12 (b) showed meta sediment under plane polarized light. The texture of the quartz (Q) in this thin section was anhedaral and does have neither cleavage nor twinning. The colour of quartz under plane polarized was colourless and its pleochroism does not present. Quartz has first order for interference colour order.

While for mica (M) characteristics, it has laminar textural features, the colour of mica under plane polarized was colourless and the pleochroism does not present. The relief of this type of mineral was medium. It was second order or third order for interference colours order. As can be seen in the Figure, mica showed the straight arrangement of the minerals. This indicated that rock has foliation.

Figure 4.8: Outcrop of phyllite

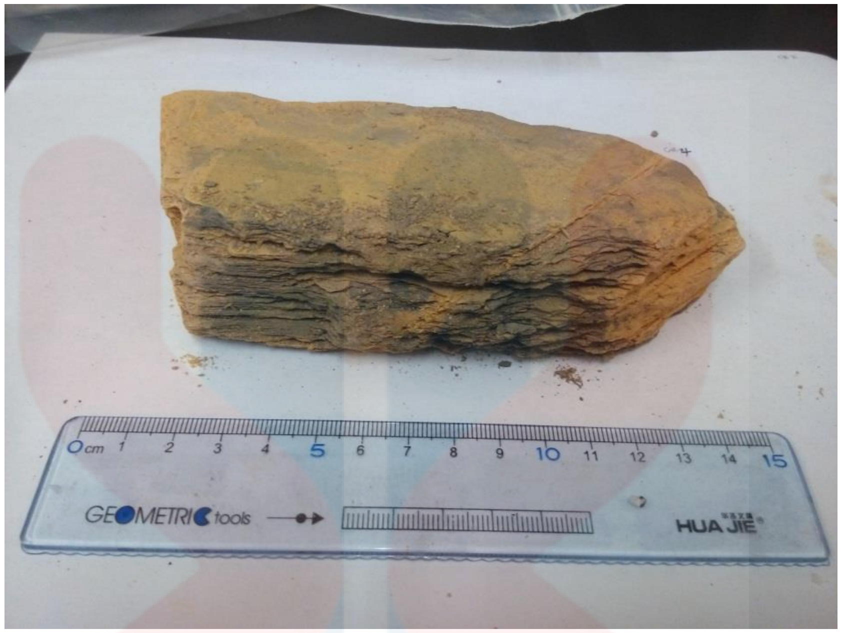

Figure 4.9: Phyllite

Figure 4.10: Outcrop of meta sediment

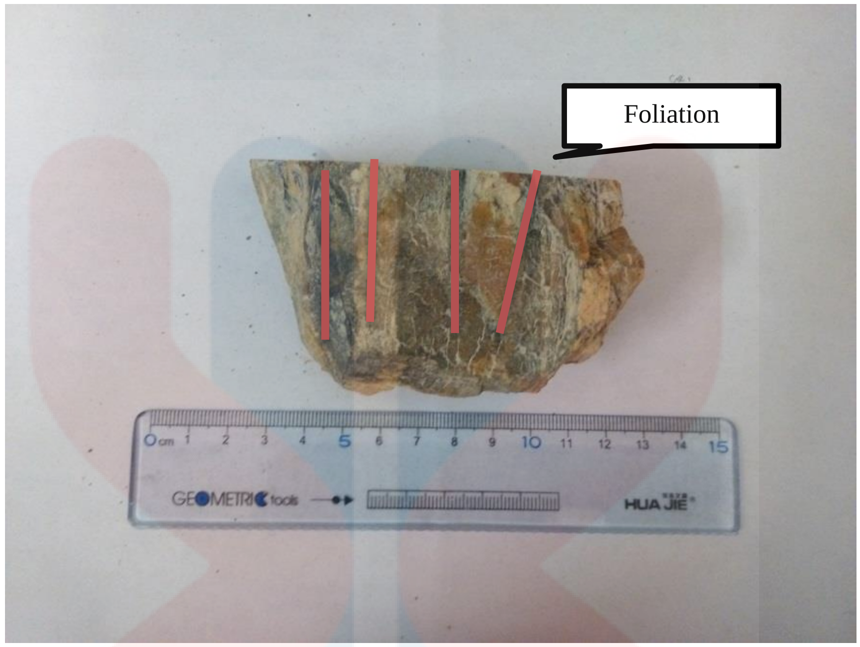

Figure 4.11: Meta sediment with foliation

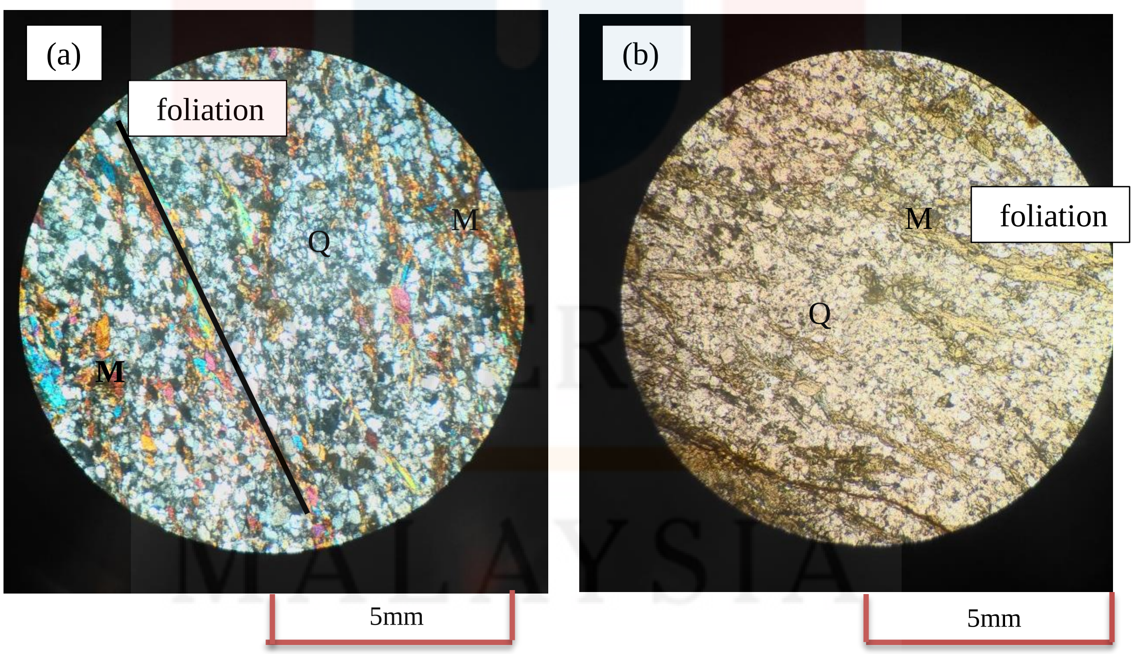

Figure 4.12 (a): meta sediment under cross polarized **(b)**: meta sediment under plane polarized

c. Granite

Outcrop of biotite granite porphyry can be seen in the Figure 4.13 which is located at N 05°29'02.6", E 101°52'05.3". The hand sample of rock (Figure 4.14) has a rough texture with coarse grain size. The minerals that can be seen on hand sample of this rock are quartz, biotite, plagioclase, and alkali feldspar. The name of this rock as biotite granite porphyry since it has a dominant of biotite with porphyritic texture. For the detailed mineral and naming of the sample, the thin section of this rock had been done.

Figure 4.15(a) showed the biotite granite porphyry under cross polarized light while Figure 4.15(b) showed the same rock which is biotite granite porphyry under plane polarized light. Q in the Figure represents quartz with anhedral shape and colourless under plane polarized light. Besides that, the pleochroism does not present and does have neither twinning nor cleavage. B in the Figure showed the biotite mineral with perfect cleavage. It can be seen as brown to tan colour. It exhibits high interference colour in cross polarized light. Normally it is surrounded by quartz and feldspar. AF was stand for alkali feldspar. It has low birefringence which is grey under cross polarized light but colourless in plane polarized light. It does not have pleochroism. The large mineral showed in the Figure was plagioclase (P). This mineral easily identified because of lamellar twinning (zebra line) that can be seen obviously under cross polarized light. However, it was colourless under plane polarized. This twinning showed the differences between alkali feldspar and plagioclase. The shape of this mineral that can be seen under microscope was either anhedral or euhedral.

Figure 4.13: Outcrop of biotite granite porphyry

Figure 4.14: Hand sample of biotite granite porphyry

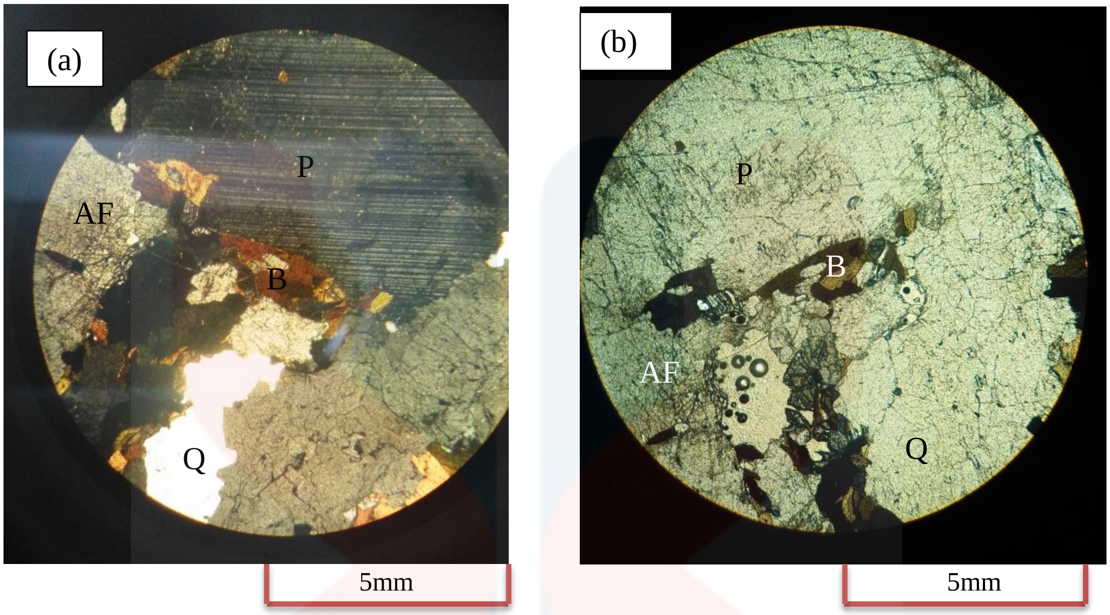

Figure 4.15(a): biotite granite porphyry under cross polarized light **(b):** biotite granite porphyry under plane polarized light.

At the upstream of Terang River (N 05°28’50.1”, E 101°52’40.1”), there was intrusion of microgranite intruded coarse grained foliated granite (Appendix A in Figure c). The outcrop was showed in Figure 4.16 while hand sample for coarse grained foliated granite and microgranite showed in Figure 4.17 and 4.18 respectively. The intrusion of microgranite has a smaller grain than granite. This indicate that the parent magma of microgranite undergone rapid cooling and occurred in smaller intrusion. The granite in this cascade area was also from Noring Granite. The mineral that can be seen clearly on hand sample of coarse grained foliated granite were quartz, biotite and alkali feldspar. The grain size of minerals on coarse grained foliated granite was 0.2-2cm. While the minerals that can be seen on hand sample of microgranite was quartz, alkali feldspar and biotite with the size was 0.1-0.3cm.

All of this mineral has showed in Figure 4.19 (a) for cross polarized light and (b) for plane polarized light for coarse grained foliated granite and Figure 4.20 (a) and (b) for microgranite. The characteristics of quartz (Q) that showed in Figure 4.19 and 4.20 were in anhedral shape with colourless under plane polarized. Alkali feldspar (AF) on Figure 4.20(a) clearly can see the twinning however is was not same with the twinning that present on plagioclase. Biotite mineral has a perfect cleavage with 001. The colour of biotite that can be seen under microscope was brown to tan. It exhibits high interference colour in cross polarized light.

Figure 4.16: Outcrop of intrusion microgranite intruded coarse grained foliated granite

Figure 4.17: Hand sample of coarse grained foliated granite

Figure 4.18: Hand sample of microgranite

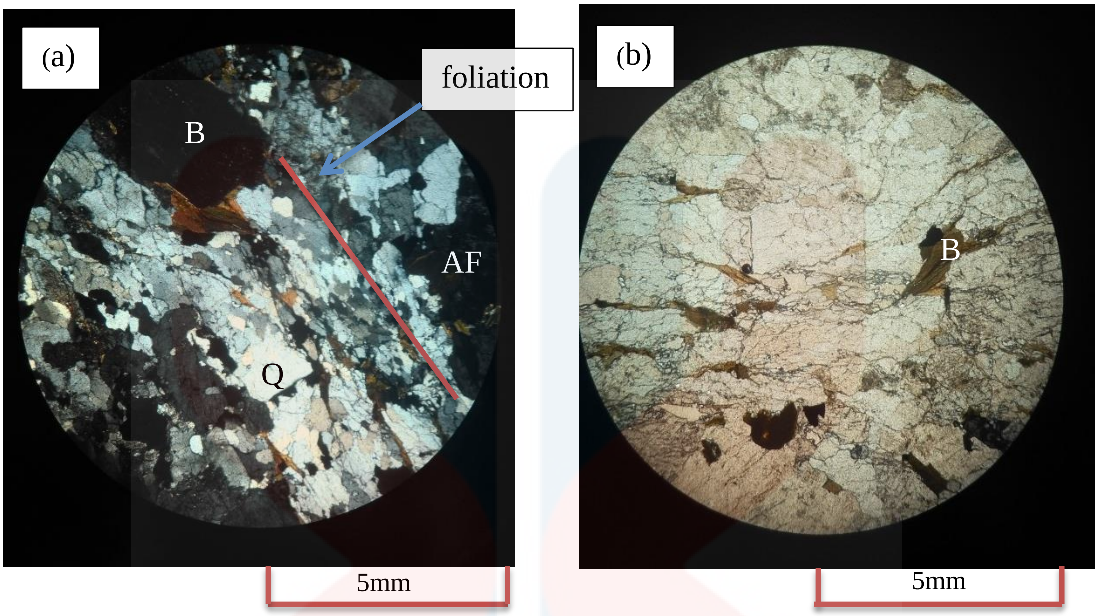

Figure 4.19 (a): Coarse grained foliated granite under cross polarized **(b):** coarse grained foliated granite under plane polarized.

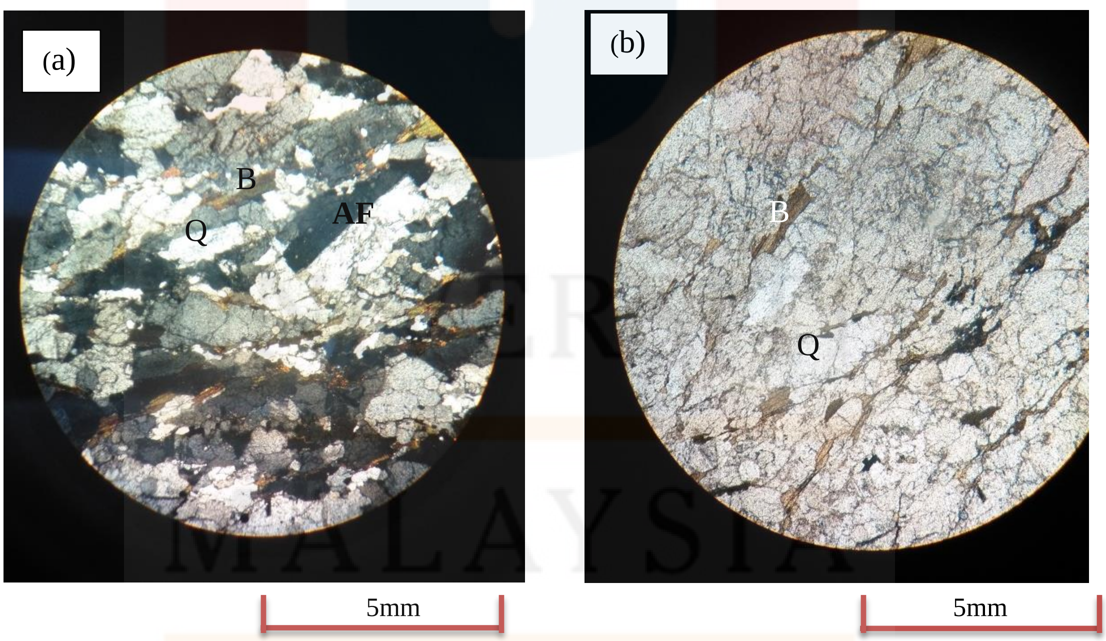

Figure 4.20 (a): Microgranite under cross polarized, **(b):** microgranite under plane polarized

d. Quaternary sediment

Quaternary sediment can be found along the downstream of Suda River and Terang River. This quaternary sediment was formed from the weathering and erosion of Noring Granite at the upstream of both Suda and Terang River. Physical and chemical weathering happened due to climate and temperature that made changes to the rock. The physical weathering caused the rock break down into smaller pieces such as lithic fragment, clay and quartz since quartz has high resistant compared to other mineral. This made the erosion easily occur with the help of rapid flowing water. At the downstream of Suda River and Terang River, quaternary sediment and pebbles can be found (Figure 4.21). For chemical weathering, it cause the rock has a mineral changes due to chemical reaction. There are three types of chemical weathering which is hydrolysis, oxidation and dissolution. In the study area, possibility to have oxidation process was high because a lot of iron (Fe) had found in the Pergau River. This Fe can found in stream sediment of Pergau River by using XRF.

Figure 4.21: Quaternary sediment in Suda River

4.3.3 Stratigraphic Column

Based on the lithologic description, the aged of each lithologic can be synthesized into Stratigraphic Column that showed in Table 4.1. The table showed the oldest rock was meta sediment and interbedded of shale and siltstone that was originated from Gua Musang Formation followed by Noring Granite in the period of Cretaceous. Microgranite was formed during late Cretaceous and the youngest was Quaternary sediment. On the other hand, Figure 4.22 showed the geological map of the study area with cross section.

Table 4.1: Stratigraphic column of lithology in the study area.

Era	Period	Epoch	Lithostratigraphy	Lithology
Cenozioc	Quaternary	Holocene	Quaternary sediment	Lithic fragment, pebbles, sand, clay and quartz.
		Pleistocene		
			unconformity	
Mesozioc	Cretaceous	Late	Microgranite	Grey colour of microgranite with fine grain mineral.
		Early	Noring Granite (part of Stong Magmatic Complex)	Biotite granite porphyry and coarse grained foliated granite. Pinkish in colour with coarse grain mineral.
	Triassic	Late	Meta sediment and interbedded shale and siltstone (originated from Gua Musang Formation)	Meta sediment schist quartzite mica. Phyllite
		Middle		
		Early		
Paleozioc	Permian	Late		

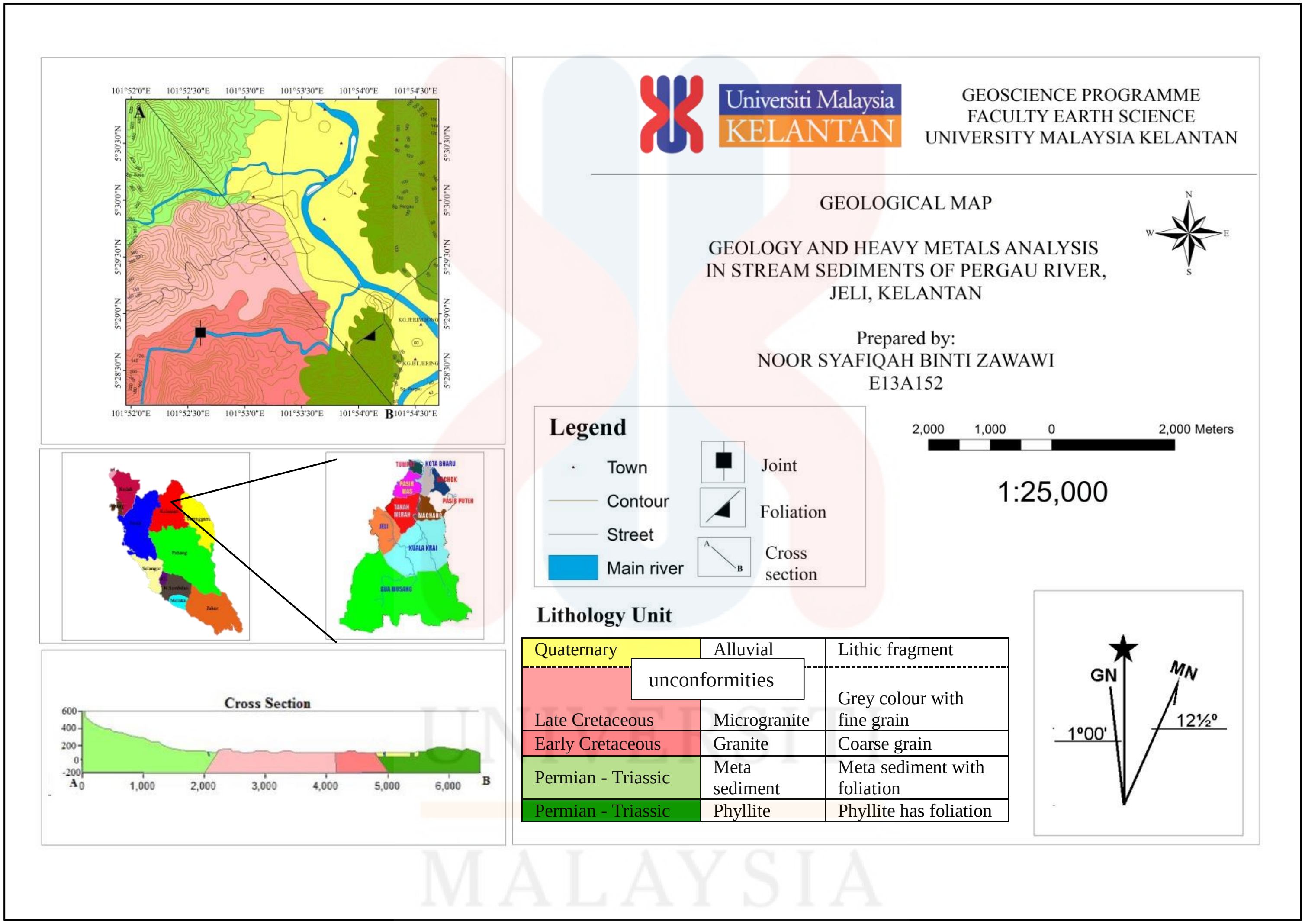

Figure 4.22: Geological map of Kampung Relak, Jeli, Kelantan

4.4 Structural Geology

4.4.1 Lineament Analysis

Lineament is a linear line that interpreted one dimensional line which is show the terrain form. This study of lineament is based on aerial photo with the type of structures. By knowing the lineament in the study area, the continuous feature on smaller scale can be known (Latterman, 1958)

Figure 4.23 showed the lineament map that presence in the study area based on high ridge. The bearing of the lineament was taken by using protector to determine the main force of formation of lineament. 60 readings was been taken that showed in Table c in Appendix B to use for forming the georose diagram (Figure 4.24).

Figure 4.23: Lineament map of the regional area of Jeli

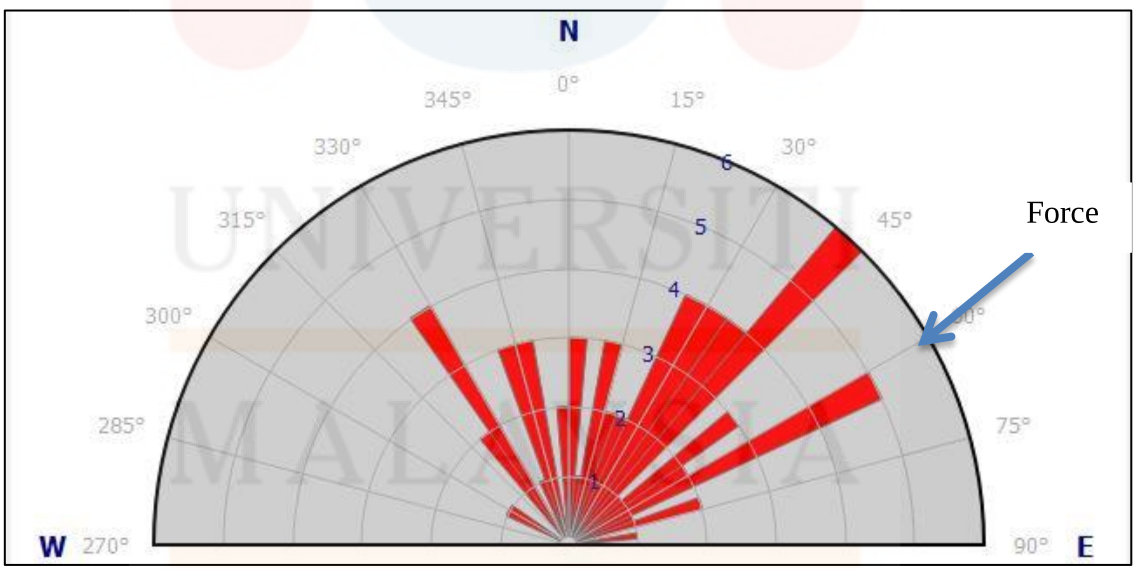

Figure 4.24: Georose diagram of lineament with the main force at NE

4.4.2 Structural Analysis

Structural analysis is to determine the main force of the structural by taking the data of joints and fractures. The data was taken at coordinate N 05°28’50.1”, E 101°52’40.1” with 100 readings showed in Table d (Appendix A). The data was analyzed by using Georose Software. Georose diagram is showed in Figure 4.25.

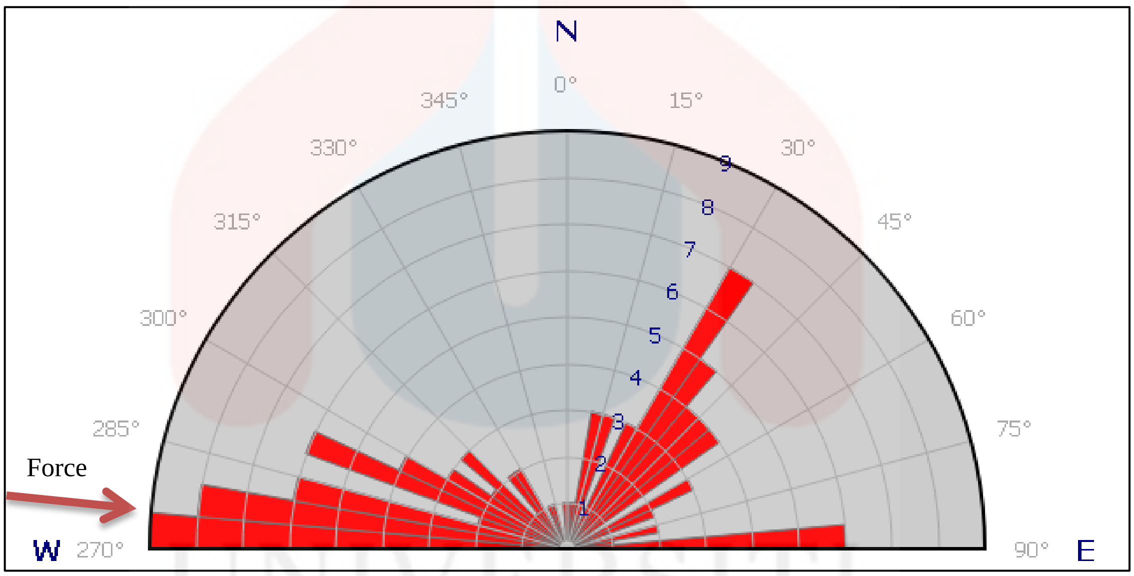

Figure 4.25: Georose diagram with the main force on NW.

Based on the Figure 4.25, between the highest rose petals showed the main force that created the joint and fracture. The main force was come from the north-west. This georose diagram was showed in geological map (Figure 4.26) where the data of fracture and joint were obtained.

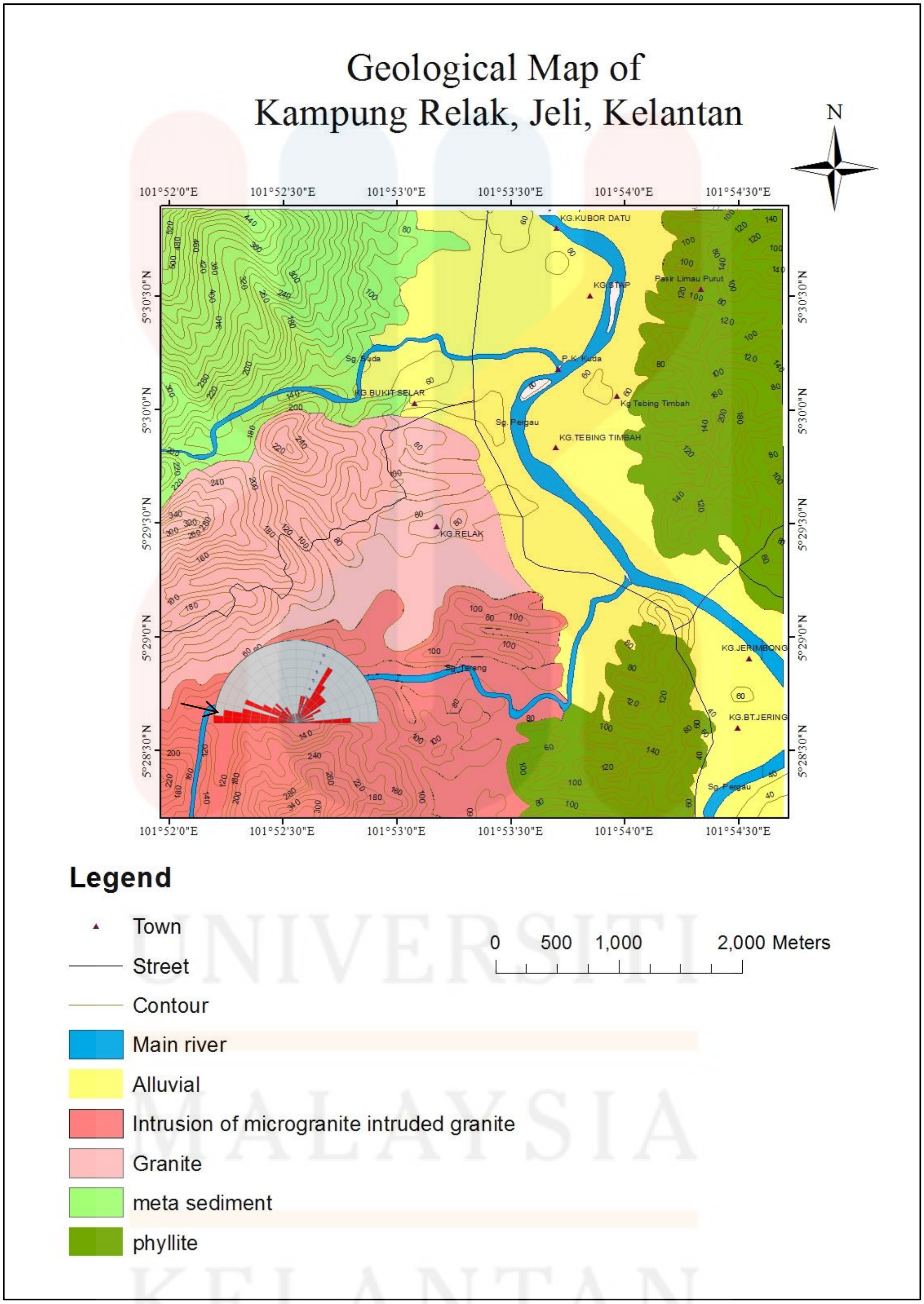

Figure 4.26: The geological map of Kampung Relak, Jeli, Kelantan

4.5 Historical Geology

The oldest rock in study area was meta sediment. This meta sediment was originated by Gua Musang Formation based on Tulot and Umor (2001). The age of meta sediment was Permian to Triassic. Based on Ibrahim and Jamitka (2003) said that meta sediment in jeli was enclave that found from leucogranite due to deformation. This meta sediment was overlying by Noring Granite at the age of Cretaceous with the sharp contact. Noring Granite has three types of granite that can be found in the study area which is biotite granite porphyry, coarse grained foliated granite and microgranite. Coarse grained foliated granite was intruded by microgranite at the same age but different epoch. The intrusion of microgranite with coarse grained foliated granite can be seen in Figure 4.27. Figure 4.28 showed the xenolith of coarse grained foliated granite. This proves that coarse grained foliated granite older than microgranite.

Quaternary sediment was the youngest lithology that had in the study area in era of Cenozoic. Quaternary sediment was the alluvium such as lithic fragment, pebbles, sand and quartz that transported by flowing water and deposited in area of floodplain.

Figure 4.27: Intrusion of microgranite with coarse grained foliated granite

Figure 4.28: Xenolith of coarse grained foliated granite

CHAPTER 5

HEAVY METALS ANALYSIS OF STREAM SEDIMENT IN PERGAU RIVER, JELI, KELANTAN

5.1 Introduction

This study was to determine heavy metal content in stream sediment. The stream sediment samples were collected five checkpoints randomly at Pergau River in study area. The samples were collected 100g of stream sediments for each checkpoint by using non metal shovel. The samples were analyzed by using X-ray Fluorescence to determine heavy metal contents.

5.2 Result and Discussion

Based on Table 5.1, the heavy metal that contain in stream sediment of Pergau River were Iron (Fe), Zircon (Zr), Manganese (Mn), Titanium (Ti), Torium (Th) and Lead (Pb). Figure 5.1 showed the graph of concentration of heavy metal for each checkpoint.

Table 5.1: Heavy metal content in stream sediment with its concentration for each checkpoint

Element	Concentration Checkpoint1 (ppm)	Concentration Checkpoint2 (ppm)	Concentration Checkpoint3 (ppm)	Concentration Checkpoint4 (ppm)	Concentration Checkpoint5 (ppm)
Fe	24.5	5.94	5.31	5.56	5.86
Zr	0	0.462	0.242	0.301	0.446
Mn	0.138	0.249	0.206	0	0.244
Ti	1.04	0.487	0.192	0.774	0.68
Th	0.271	0	0	0	0
Pb	0.256	0	0	0	0

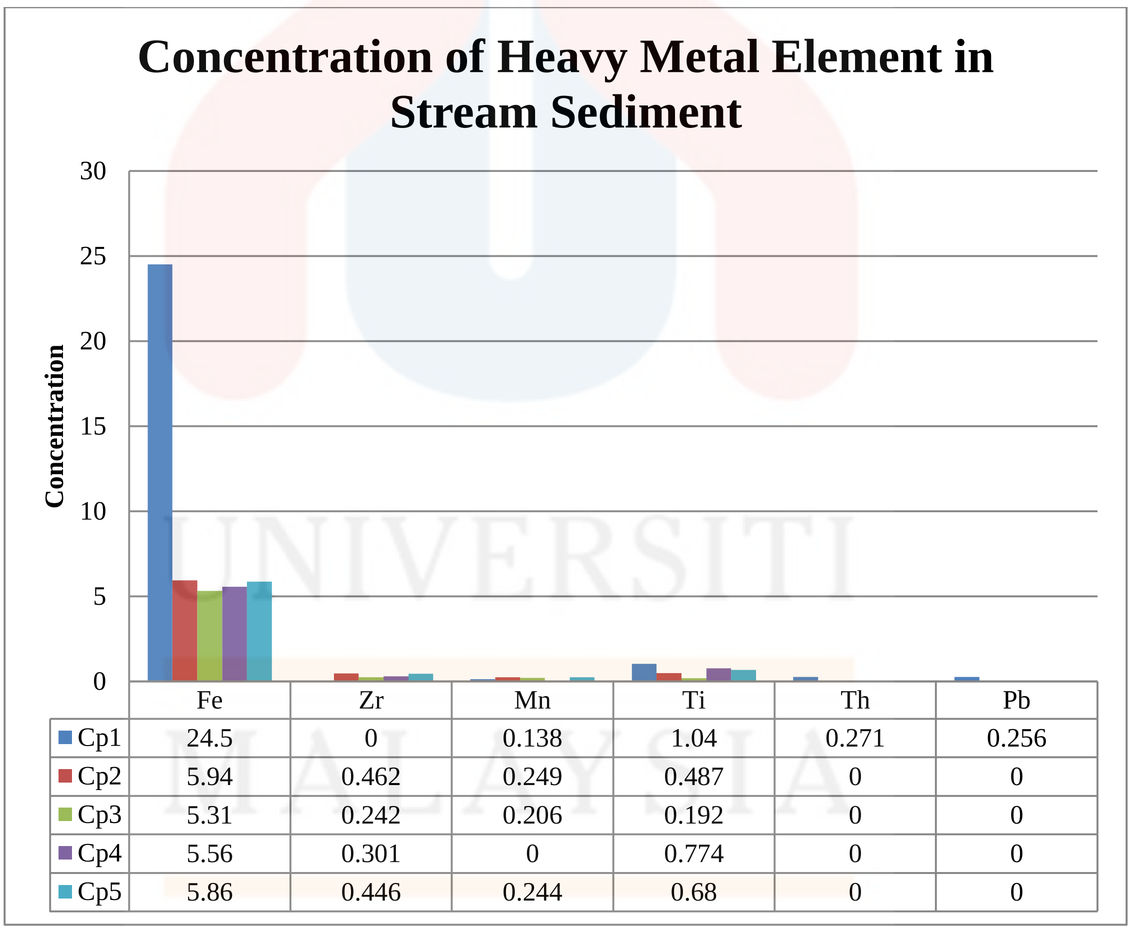

Figure 5.1: Concentration of heavy metals element for each checkpoint

Based on the Figure 5.1, checkpoint 1 has the highest Fe with 24.5 ppm while the second highest was checkpoint 2 with 5.94 ppm. There was a huge difference between checkpoint 1 and 2 which is 18.56 ppm. The lowest concentration of Fe was checkpoint 3 with 5.31 ppm.

Checkpoint 1 and 4 does not have any concentration of Zr and Mn respectively. However, heavy metal element for Th and Pb only concentrated at checkpoint 1 with the value of concentration were 0.271 ppm and 0.256 ppm respectively.

The highest concentration for Zr was checkpoint 2 which is 0.462 while the lowest concentration was 0.242 ppm at checkpoint 3. The second highest concentration of Zr was at checkpoint 5 with 0.446 ppm.

Ti has the highest concentration at checkpoint 1 which is 1.04 ppm with the difference between second highest was 0.266. The lowest concentration of Ti was 0.192 at checkpoint 3. This graph also showed that checkpoint 3 always had the lowest concentration of heavy metal elements while checkpoint 1 has the highest content of heavy metal elements.

High amount of heavy metal was released by human activities such as industrial production, agriculture and transportation into biosphere (Ruqia et al., 2015). In the study area, there is a lot of agriculture area that had be done by villagers as their social economic located beside the Pergau River. The heavy metal normally will accumulate in crop plant through soil root interface. When the rain comes, this heavy metal may carry away by rain into stream sediment. In addition, the soil that contaminated by heavy metal may give the risk for human health and wildlife.

The iron (Fe) concentration for each location has showed in the interpolation map (Figure 5.2). Blue colour in the Figure 5.2 showed the highest concentration area which is 22.581 – 24.5 ppm while yellow colour showed the lowest concentration area which is 5.31 – 7.229 ppm. On the other hand, this figure also showed the highest concentration of heavy metals content for each location. The highest concentration of heavy metals for each location was iron (Fe).

The reason for the extremely in value for iron (Fe) might be due to weathering process that occur in the river. The type of weathering process was chemical weathering which is oxidation. This process is the combination and addition of oxygen to mineral. The oxidation process be more active when the presence of moisture and resulted the hydrated oxide such as iron. Besides that, another process of chemical weathering was reduction which is the process of removal oxygen. This type of process may convert the ferric iron to ferrous iron compounds.

Another heavy metals concentration that had been found in stream sediment of Pergau River were Zircon (Zr) (Figure 5.3), Manganese (Mn) (Figure 5.4), Thorium (Th) (Figure 5.5), Titanium (Ti) (Figure 5.6) and Lead (Pb) (Figure 5.7). For each interpolation map, the darkest colour which is dark blue showed the highest concentration area while the lightest colour which is light yellow showed the lowest concentration area.

The concentration of heavy metals such as iron and manganese may relate with the rock that have in the study area. The rock that has near Pergau River was phyllite. Phyllite is the metamorphic rock that metamorphosed from sedimentary rock. Based on Penrose Jr. (1893), they stated that iron and manganese may form from decay of preexisting rock. It was compaction and cemented in geologic horizon before a present rock was resting on it. Mechanical sediment may deposit with heavy metals that precipitated chemically. It may produce the deposit in pure iron and manganese ore. However, in the study area the ore either of iron or manganese were not found.

Lead is non essential heavy metal that has an association with gold (Wasiu, 2016). This heavy metal only has a concentration in checkpoint 1 maybe because of the nearest place to gold mining since there is a gold mining at the area of Lata Renyok. Lead may cause dangerous disease for human such as brain and nerve cells damage. If lead bioaccumulation in pregnant mother, it may give a negative impact for the baby that mother carry (Reis et al., 2013).

Besides that, Wasiu et al., (2016) said that the presence of landfill near the river may give the responsible for the presence of heavy metal in stream sediment. This is because of leaching from incineration point.

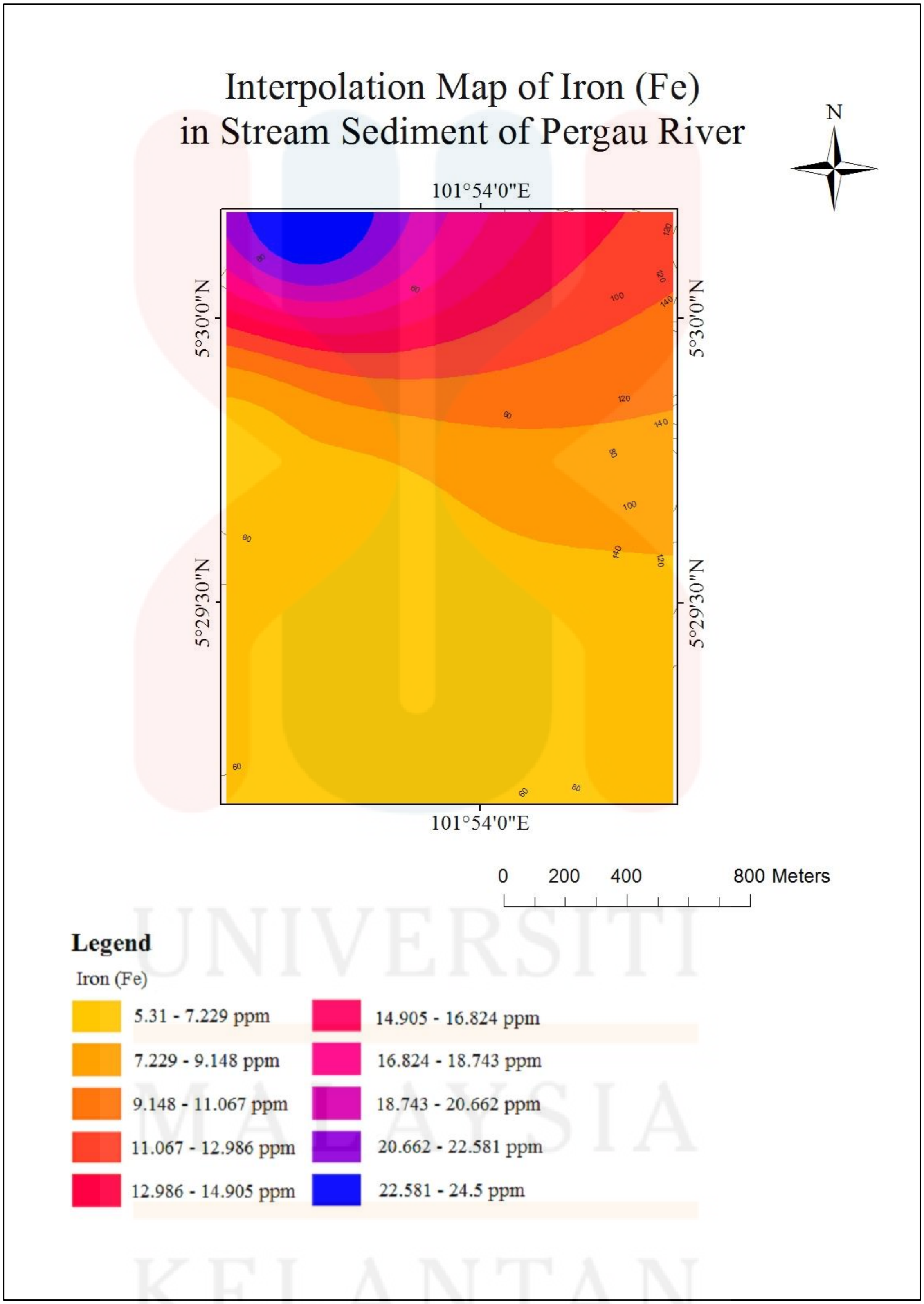

Figure 5.2: Distribution of Fe concentration for each location

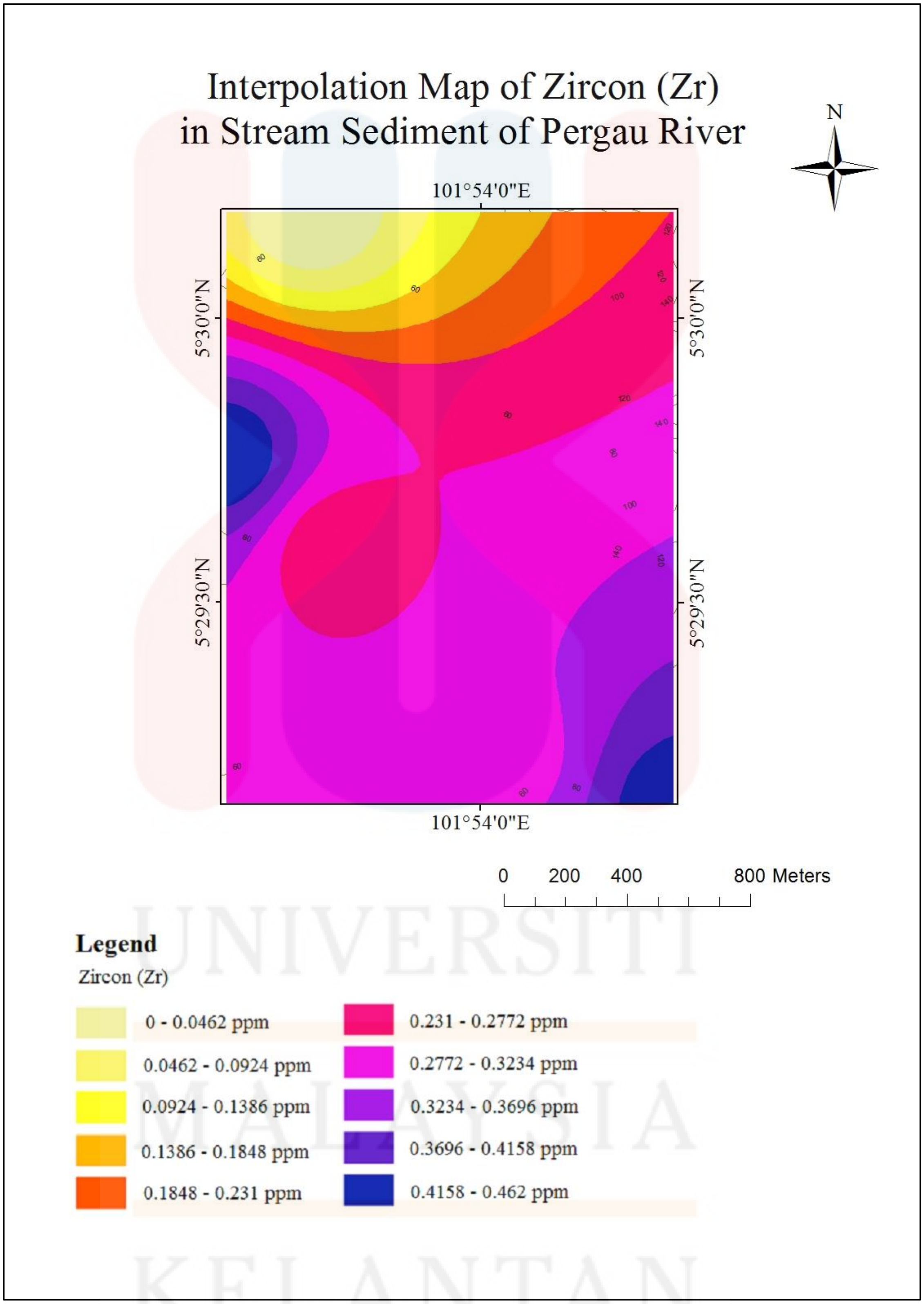

Figure 5.3: Distribution of Zr concentration for each location

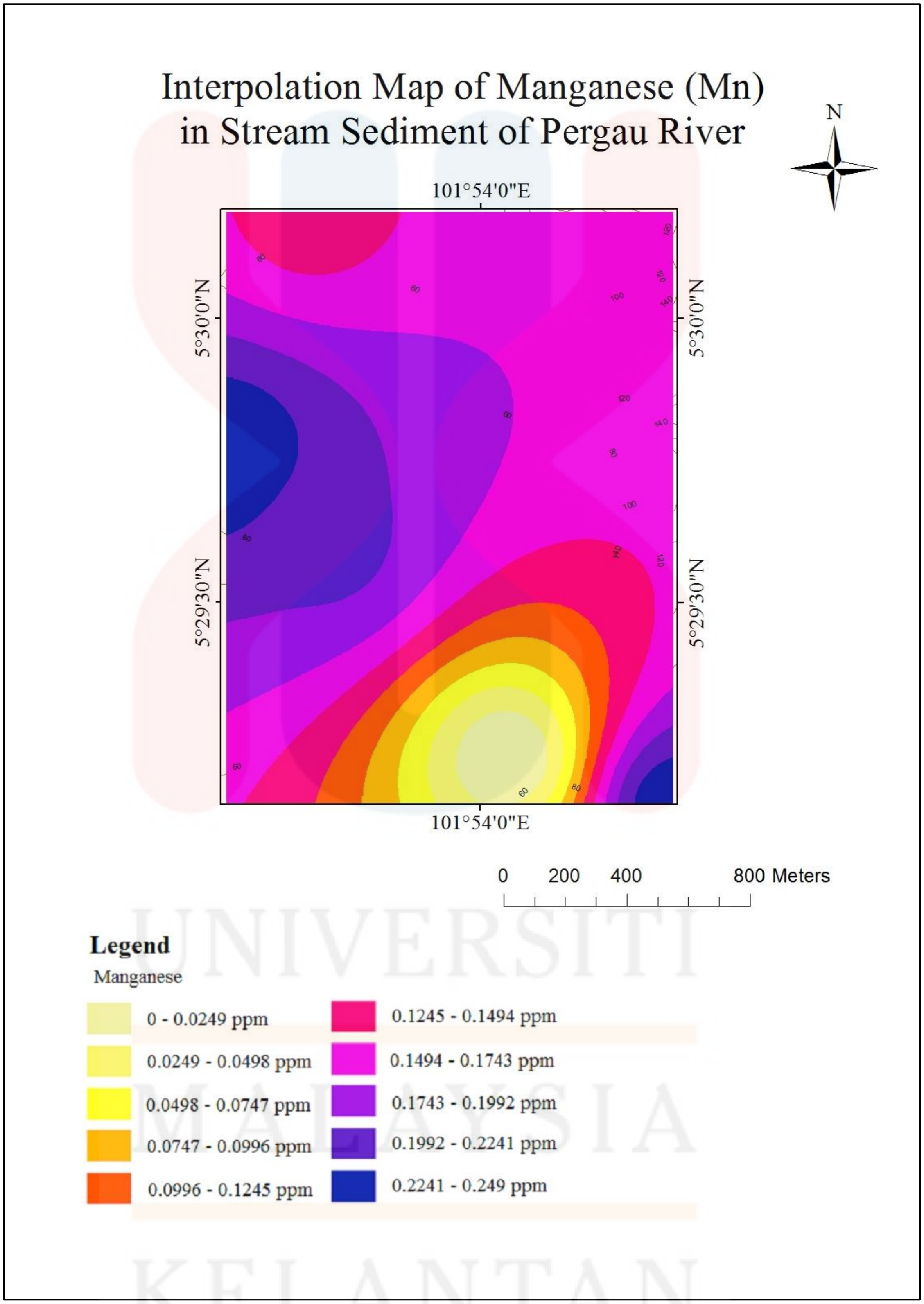

Figure 5.4: Distribution of Mn concentration for each location

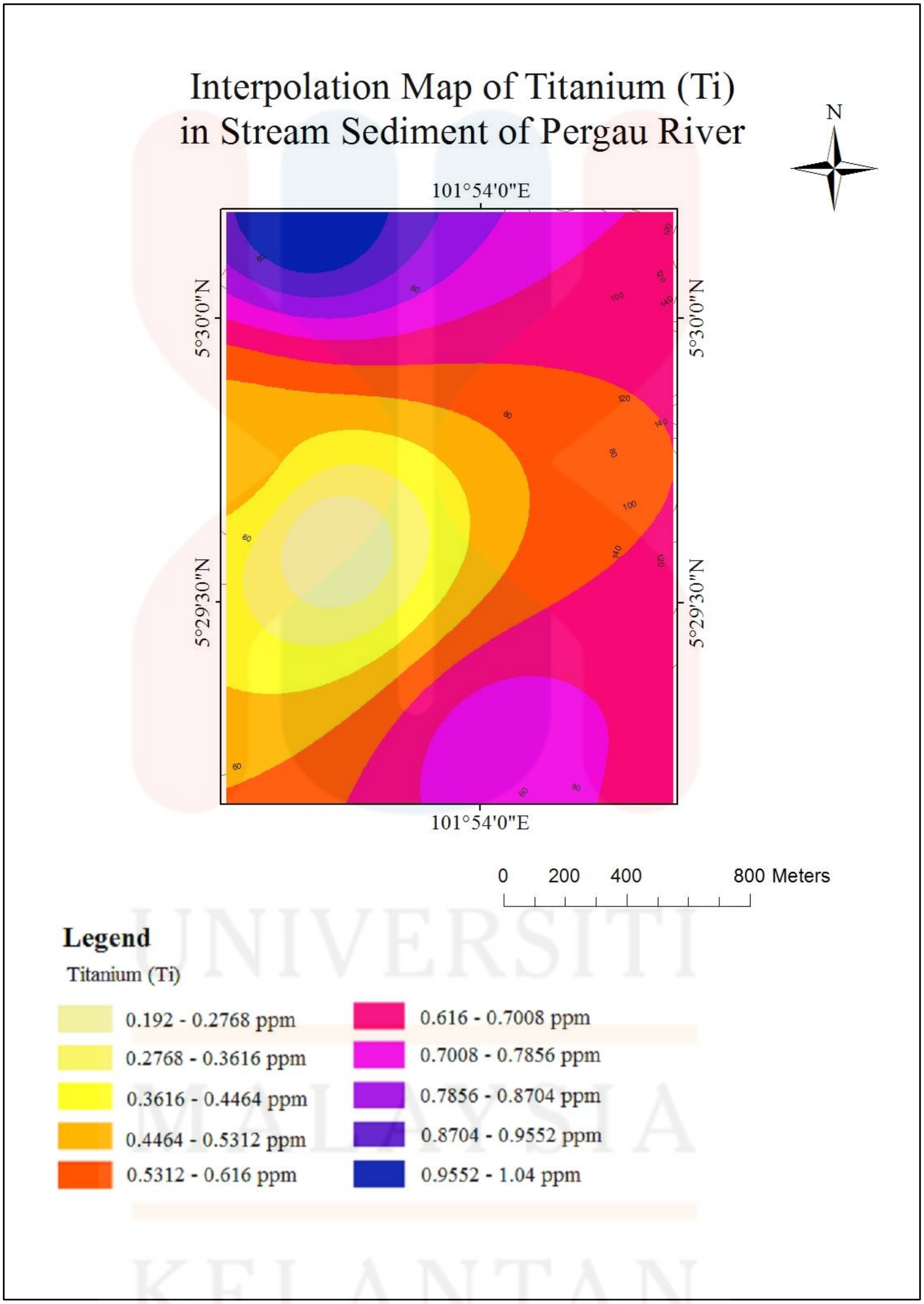

Figure 5.5: Distribution of Ti concentration for each location

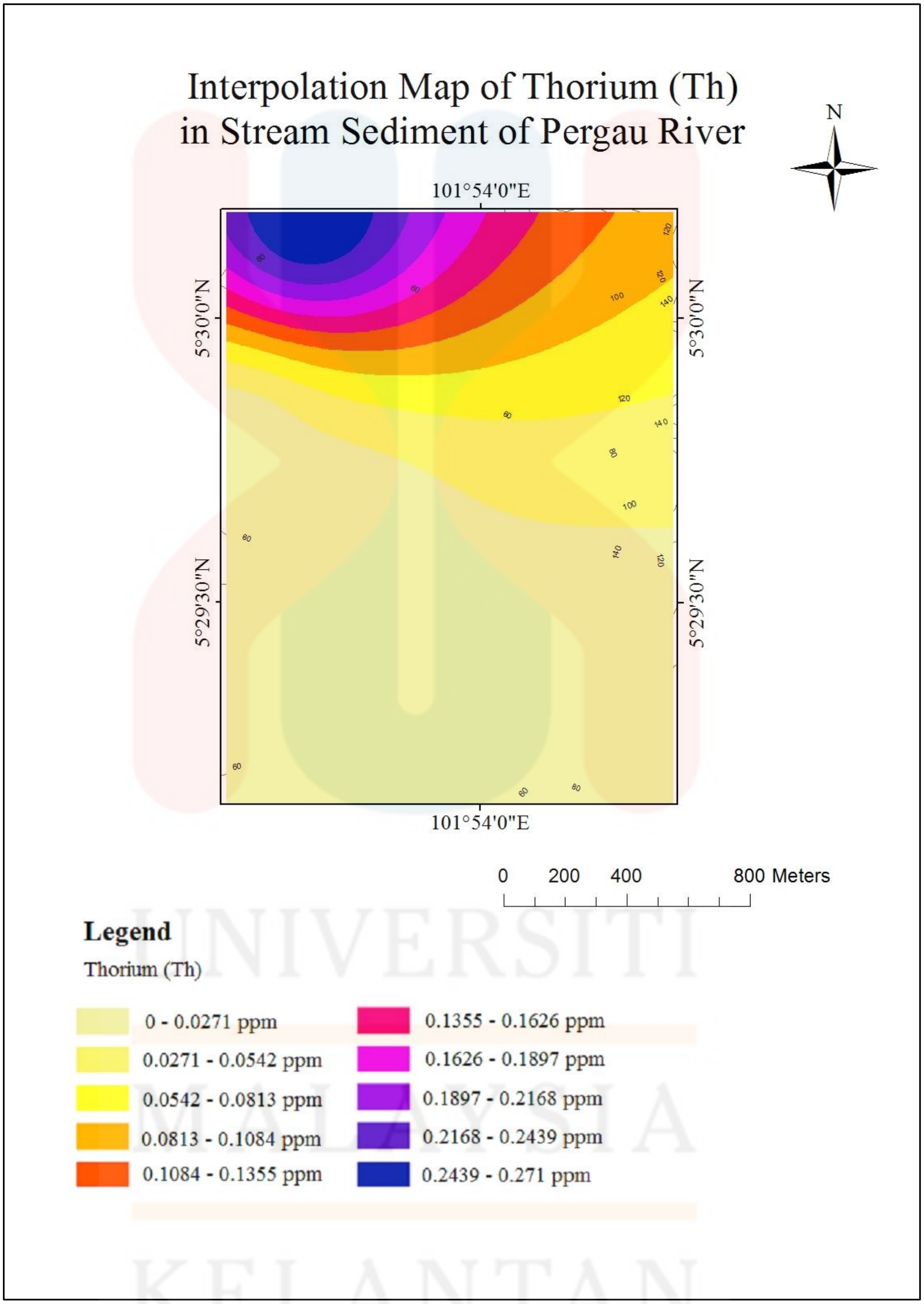

Figure 5.6: Distribution of Th concentration for each location

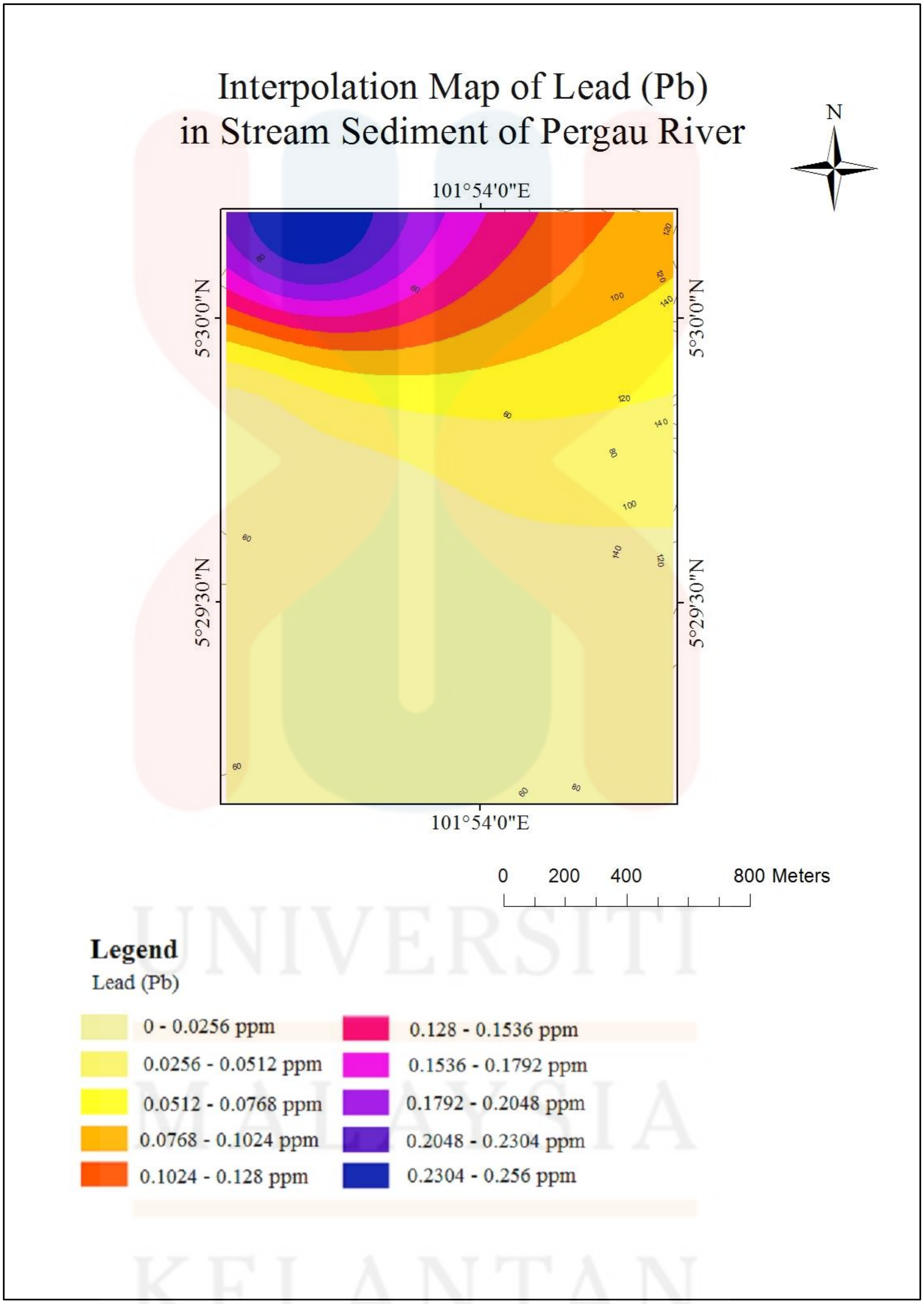

Figure 5.7: Distribution of Pb concentration for each location

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Geology in the study area had been identified including the geomorphology, stratigraphy, lithology, structural geology and historical geology. Based on the data collected in the study area, the lithology that had been found in the study area were meta sediment, phyllite, biotite granite porphyry, coarse grained foliated granite and microgranite. Meta sediment and phyllite have a same age which is Permian to Triassic. While for biotite granite porphyry and coarse grained foliated granite was early Cretaceous and microgranite that intruded coarse grained foliated granite was late Cretaceous. All of this granite was classified as Noring granite.

The result for heavy metal content in Pergau River was determined. There were Iron (Fe), Zircon (Zr), Manganese (Mn), Thorium (Th), Titanium (Ti) and Lead (Pb). The dominant major element that contain in Pergau River was iron (Fe) while Thorium (Th) and lead (Pb) only concentrated in checkpoint 1.

The spatial distributions of heavy metals content were showed in the interpolation map. The map showed that every checkpoint contain high value of iron with range 5.30ppm – 24.20ppm.

6.2 Recommendation

For recommendation, field observation and mapping in the study area to find the contact between meta sediment with granite should be carried out. The meta sediment enclaved that had be mention in literature review need to find by larger the box of the study area. Besides that, for structural analysis in the study area can be considered because of a lot of joint can be found.

For heavy metal analysis in Pergau River should be carried out. This may give the awareness to villagers and society about heavy metal content in Pergau River since that was the main source of water in study area. High value of contamination in stream sediment may give the negative impact to villagers that live in that area.

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APPENDIX A

Figure a: The slide was rubbed using carbon to frost the slide surface

Figure b: The rock was cut by using the slab saw

Figure c: Microgranite intruded granite

Figure d: Quartz vein

APPENDIX B

Table a: Amount of male and female for each district in Jeli

District	Male (no.)	Female (no.)	Total (overall)
Batu Melintang	4826	4864	9690
Jeli	10820	10300	21120
Kuala Balah	6118	5944	12062
Total	21764	21108	42872

(Source: Pejabat Tanah Jajahan Jeli, 2014)

Table b: The total amount of precipitation falls monthly in Jeli in 2014

Month	Amount of Precipitation Falls (mm)
January	432.0
February	6.0
March	225.0
April	245.0
May	368.0
June	251.0
July	198.0
August	446.0
September	301.0
October	451.0
November	442.0
December	1542.0
TOTAL	4907.0

(Source: Department of Mineral and geoscience, 2014)

Table c: 60 readings of lineament

19	34	340	34	206	32
22	3	38	61	20	50
342	2	123	53	44	117
27	27	66	328	40	345
355	347	44	325	58	52
10	11	37	62	44	37
325	4	74	208	80	11
336	37	61	73	322	57
6	33	343	61	40	46
348	323	327	177	240	41

Table d: 100 readings of joint at N 05°28’50.1”, E 101°52’40.1”

335	33	278	86	44	75	219	8
197	30	312	125	50	64	123	36
216	323	277	214	134	60	52	272
279	36	214	310	137	67	44	328
274	327	195	277	163	110	42	297
210	264	274	285	77	275	298	12
92	95	176	209	26	40	34	242
225	89	86	300	113	140	296	193
267	265	94	120	66	234	10	94
232	99	96	127	114	227	283	103
93	113	180	118	19	47	205	101
87	103	92	102	100	112	105	49
216	212	114	94				