Geology and geochemical exploration of Kampung Pahi, Kuala Krai

by

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THESIS DECLARATION

I hereby declare that the work embodied in this report is the result of the original research and has not been submitted for a higher degree to any universities or institutions.

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Date:

I certify that the report of this final year project entitled “Geology and Geochemical Exploration of Kampung Pahi, Kuala Krai”. Matric number E12A045 has been examined and all of the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Geoscience), Faculty of Earth Science, University Malaysia of Kelantan.

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Supervisor

Name:

Date:

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ABSTRACT

Geological mapping and geochemical exploration had been done widely by geologists for chemical or mineral prospecting and it's relation with earth system. Geological mapping and geochemical exploration are site investigations and technique to identify geological information and the correlation with chemistry. The study area is located at Kampung Pahi, a village which is approximately 9 kilometers from Kuala Krai town. The objectives of this study are to create a geological map and geochemical anomaly map of Kampung Pahi. The geomorphology, stratigraphy, structural geology and historical geology of the study area is determined via geological mapping which involves field observation, rock sampling, measuring parameter and studio work which is ArcMap 10.3. The concentration of iron (Fe), lead (Pb) and copper (Cu) is determined via geochemical mapping which is stream sediment sampling and laboratory analysis which is ICP-OES. The lithology of the study area consisting of siltstone, andesite porphyry, andesite tuff, lapilli tuff, and alluvium in which all of them are aged range of Permian until Recent. The ICP-OES shows the highest concentration out of three chemical element stated is iron (Fe) while the lowest is copper (Cu.)

ABSTRAK

Pemetaan geologi dan eksplorasi geokimia telah dilaksanakan secara meluas oleh ahli geologi untuk mencari bahan kimia atau mineral serta mengkaitkannya dengan sistem bumi. Pemetaan geologi dan eksplorasi geokimia adalah satu kerja lapangan dan sesuatu teknik untuk mengenal pasti maklumat geologi dan hubung kaitnya dengan kimia. Kawasan kajian terletak di Kampung Pahi, iaitu sebuah kampung yang terletak kira-kira 9 kilometer dari bandar Kuala Krai. Objektif kajian ini adalah untuk membuat peta geologi dan peta anomali kimia untuk Kampung Pahi. Geomorfologi, stratigrafi, struktur geologi dan sejarah geologi kawasan kajian ini ditentukan melalui kaedah pemetaan geologi yang melibatkan pemerhatian lapangan, persampelan batu, pengukuran parameter dan kerja-kerja studio seperti ArcMap 10.3. Kepekatan besi (Fe), plumbum (Pb) dan tembaga (Cu) ditentukan melalui pemetaan geokimia iaitu persampelan aliran sedimen dan analisis makmal iaitu ICP-OES. Litologi kawasan kajian ini terdiri daripada batu lodak, andesit porphyry, tuff andesit, tuff lapilli, dan aluvium di mana semua daripada mereka adalah daripada pelbagai umur iaitu dari Permian sehingga Terkini. ICP-OES menunjukkan bahawa kepekatan tertinggi daripada tiga unsur kimia tersebut adalah besi (Fe) manakala yang terendah adalah tembaga (Cu).

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CHAPTER 1

INTRODUCTION

1.1 General Background

Malaysia compromises broad range of rock types. Limestone is famously known sedimentary rock which could be found in southern part of Kelantan, and granite, an igneous rock type which could be found abundantly at the Main Range of Malaysia Peninsular. Throughout decades, many researches had been conducted, and many fieldworks, data analysis, reports and papers had been written regarding the geological information of Malaysia.

According to the previous studies; Malaysia Peninsular is one part of Sundaland aside of Sumatra, Java and Borneo (Hutchison *et al.*, 2009). The Peninsular is made up of Sibumasu Block at western part; which extends from Myanmar and Thailand through western part of Peninsular Malaysia which includes Langkawi, Perlis, Penang, Western Kedah and Western Perak, trending South-East to the Eastern part of Sumatra. Meanwhile, the eastern part of Peninsular Malaysia is made up of East Malaya Block that covers Kelantan, Terengganu, Pahang, Johor, Singapore and various island of Indonesia; trending southward alongside Bentong-Raub suture from the Gulf of Thailand.

In this thesis, a detail study about geological information of a selected and specified area is conducted. Kelantan alone as well has various types of rock; such as Kenerong Leucogranite the igneous rock at Stong Migmatite Complex; limestone and marble which are sedimentary rock and metamorphic rock respectively can be both found at Mountain Reng, Jeli. This study targets Kampung Pahi, Kuala Krai.

Geochemical exploration is applied for various purposes; in which one of the typical examples is hydrocarbon exploration. Petroleum and gas industry is major industry just about anywhere around the world, continuously and actively explored due to high demand worldwide. In Malaysia Peninsular, commonly the hydrocarbon exploration is typically targets oil and gas where the oil and gas fields are located offshore in the Malay Basin (Hutchison *et al.*, 2009). However, not only geochemical exploration techniques required for petroleum and gas exploration but also geophysics techniques and the geology knowledge itself as well.

Besides, geochemical exploration also applied for mineral exploration. The details about iron ore deposits are located at Bukit Besi as described by Bean (1969), Hosking (1973), and Hutchison (1983), and also at Bukit Ibam as described by Taylor (1971), and Eugster and Choi (1979). Geochemical exploration is required to explore these deposits.

However, this study is not intended to target any specific mineral ore or hydrocarbon for geochemical exploration but rather to determine the concentration of specified heavy elements by providing the anomaly map for these elements; specifically iron, lead and copper.

1.2 Problem statements

It is easier to find the geological information of the area in regional scale than finding geological information in much specific and smaller scale. The geology of Kampung Pahi is one example of this case. Probably during previous years, Kampung Pahi was mapped together with other neighbouring places but in large scale, not in a small scale and detail. This is the main reason this study is proposed; to reveal the detail about the geological information available in Kampung Pahi. Aside of that, probably nobody had known if there is potential valuable mineral resource available at Kampung Pahi. This study is conducted to reveal that.

1.3 Research objectives

There are two objectives for this research. Firstly, to produce the geological map of Kampung Pahi, Kuala Krai with scale of 1:25,000. Another objective is to create the anomaly maps of heavy elements (iron, lead, and copper) of Kampung Pahi, Kuala Krai.

1.4 Study area

1.4.1 Geography

Kuala Krai is located at the central part of Kelantan as shown in figure below.

Figure 1.1: Location of Kuala Krai, Kelantan.

(Source: The New Alfa, 2007)

As the whole country lies at the Equator line, Kuala Krai is hot and humid in climate; Kuala Krai will be having rainfall depending on monsoon change. The study area is located in Kampung Pahi, approximately 9 km south of Kuala Krai town in Kuala Krai district, Kelantan.

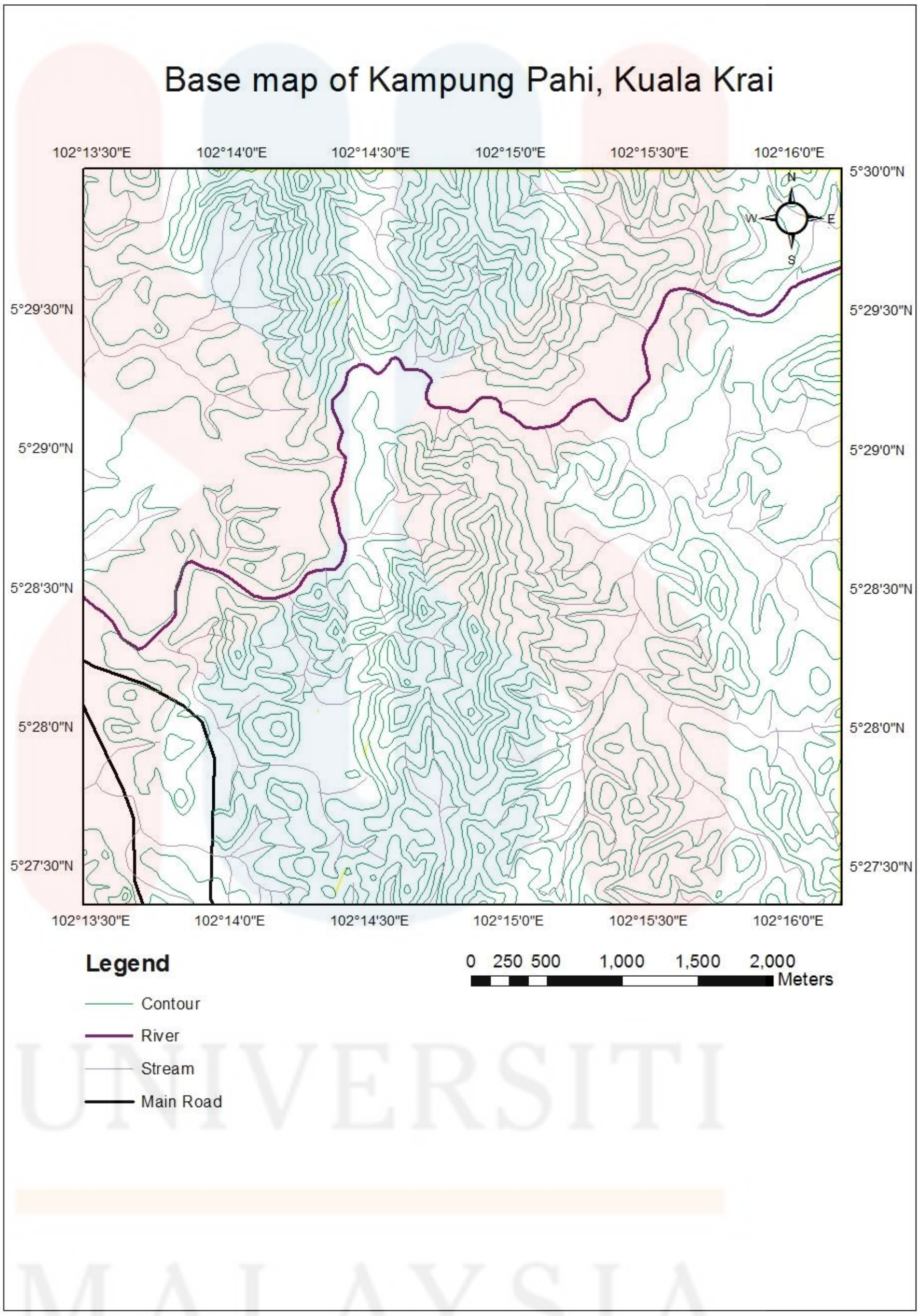

Figure 1.2: The base map of Kampung Pahi, Kuala Krai, Kelantan.

The study area is accessible via the main road through the south west of the base map. The study area is of 25 kilometres square large, mainly dominated by the vegetation with the tributaries widely distributed around the map that come from the main river, namely Pahi River (which is also a tributary of major river the Lebir River) that is trending from west to the north east of the map. Hill is the landform that compromise northern part, central part and southern part of the study area with the highest peak of 220 metre at the north. In particular, Kampung Pahi is located at the apparent road side as shown in Figure 1.2.

1.4.2 Demography

According to UPEN Kelantan (2004), Kuala Krai was populated by the total of 163,952 people in which 149,018 people are Malays, 9,862 are Chinese, 4,545 are Indians, and 527 are the others. This makes up Malay, Chinese, Indian and others are 90.8%, 6%, 2.7%, and 0.5% of total population, respectively. Estimated population at Kampung Pahi is not more than 100 people, or not more than 500 people combined with other villages at the whole of study area.

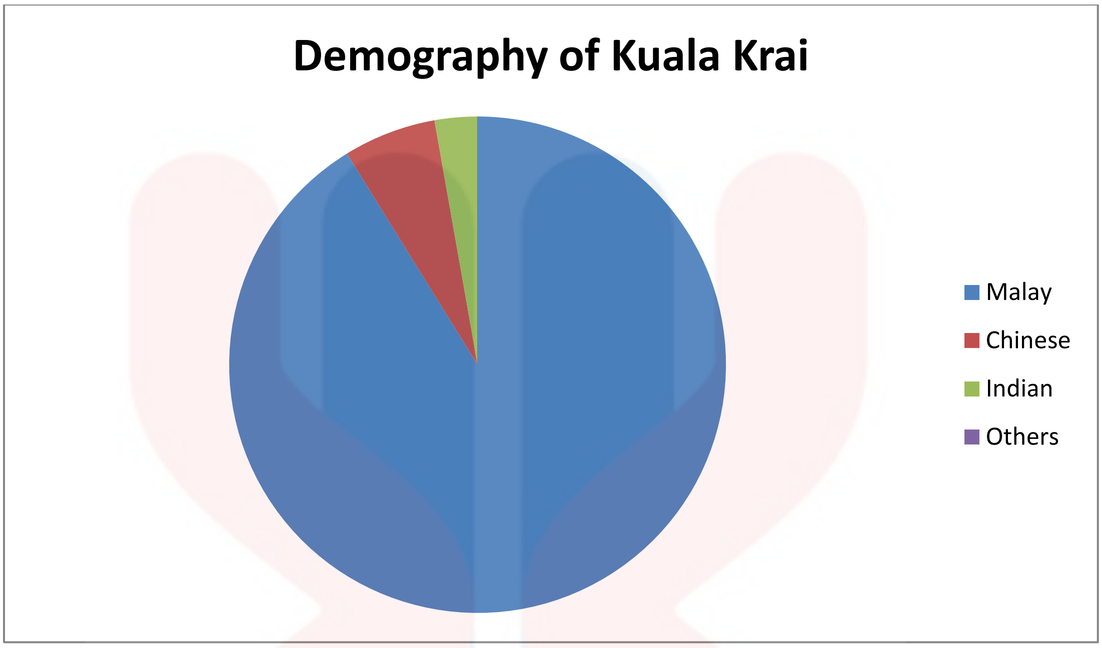

Figure 1.3: Demography of Kuala Krai in 2004

(Source: UPEN Kelantan)

1.4.3 Rainfall

Kuala Krai's climate is categorized as tropical, similarly as other part in the country. Kuala Krai as well is a city with a significant rainfall. According to World Weather Online, as the data taken is from 2000 to 2012, Kuala Krai received rainfall highest in November and lowest at February.

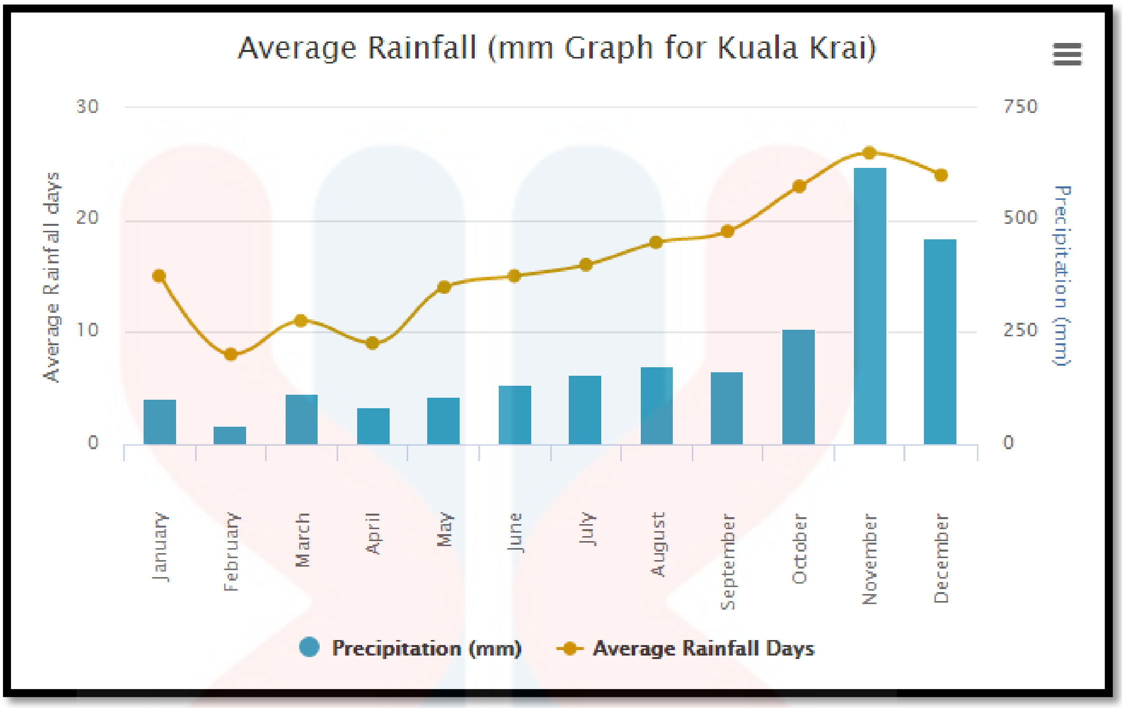

Figure 1.4: Average rainfall of Kuala Krai from year 2000 to 2012.

(Source: World Weather Online)

1.4.4 Landuse

The land uses in Kuala Krai are used for rural and urban developments. Today, the infrastructures available in Kuala Krai are a general hospital, public library, two primary schools, 8 secondary schools, 2 colleges, and 7 shopping places. There is also railway station linking to Tanah Merah and Gua Musang in Kuala Krai. Aside of these developments, the land uses in Kuala Krai also used for agricultural activities.

At Kampung Pahi, agricultural activities are palm plantation which covers approximately 20% of study area, and rubber plantation which covers 60% of the study area. The remaining 20% is covered by residential area.

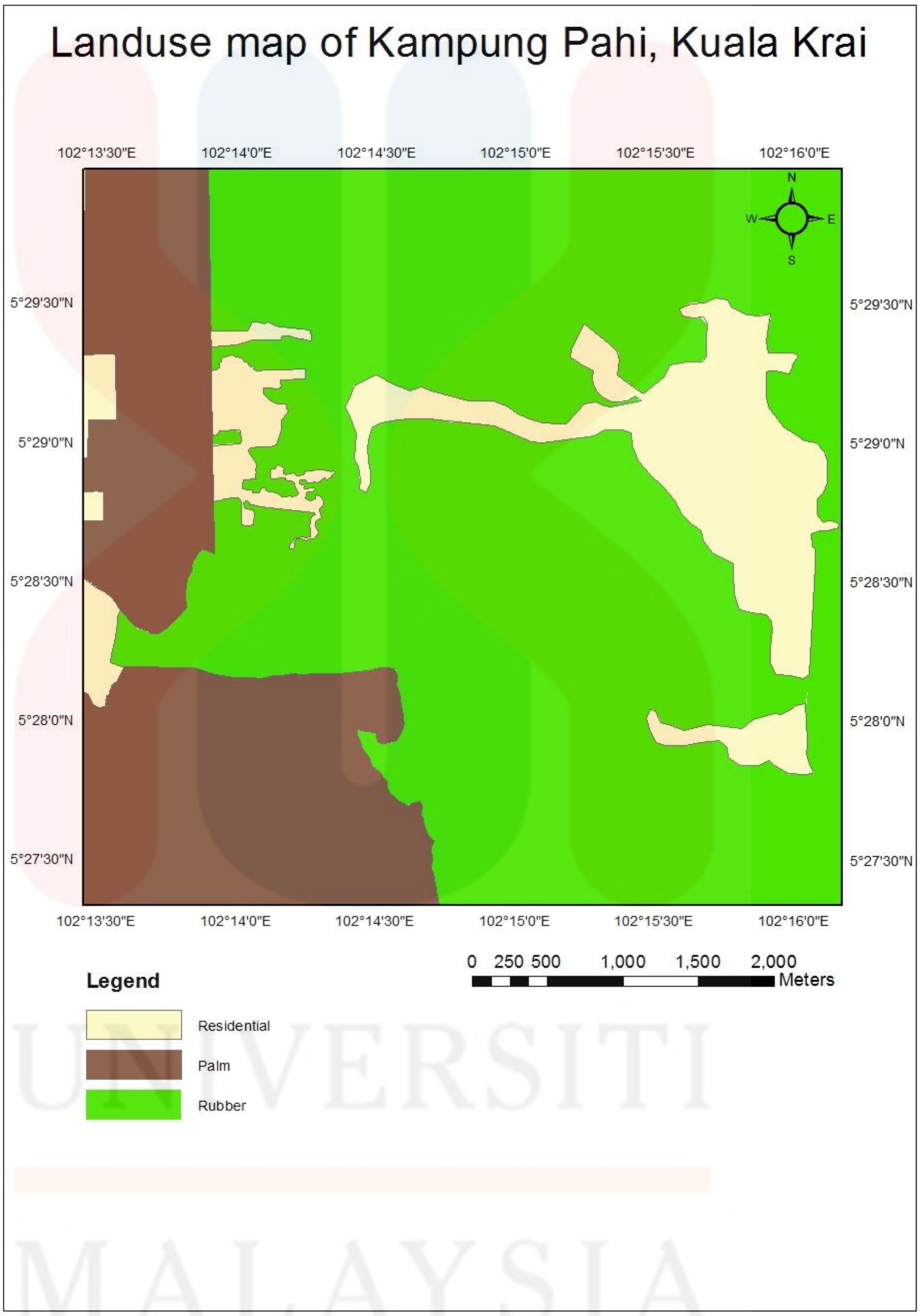

Figure 1.5: Landuse map of Kampung Pahi, Kuala Krai.

1.4.5 Social economic

Most local people of Kampung Pahi are working in agricultural sector which are palm plantation and rubber plantation. Some of them, however, are working in educational sector, and some other public sector such as banking, business and many more. These activities are mainly done by local Malay people.

Figure 1.6: Palm plantation.

Figure 1.7: Rubber plantation.

1.4.6 Accessibility

Based on Figure 1.2, the study area apparently can only be accessed via the main road in the southwestern part of the base map by small to medium sized vehicle. However, the road junction leading to the accessibility of this area is discovered during fieldwork which is located western part outside of the map, extending across the map until the eastern part of the map. This study area also can be assessed from Batu Mengkebang at the north eastern part of the map and from Kampung Peria at the south eastern part of the map using similar method. Some part of the map is only accessible by walking through the unpaved road.

1.5 Scope of the study

For the general geology investigation, this study focuses on the lithology and structural geology of the area. For the identification of lithology, the rock sample is only taken anywhere along the main river and any other observable fresh outcrop anywhere in the study area. For the geochemical exploration part, the investigation is only focus on the determination of concentration of heavy elements; particularly iron, lead and copper. The stream sediment sampling will be done around one or two for each grid of the map; depending on the availability of the river or tributary. For laboratory investigation, the concentration of heavy elements is determined by XRF method.

1.6 Research importance

The eventual result of this study will reveal the detail geological information and the distribution of heavy elements of Kampung Pahi, Kuala Krai. This information will be a useful knowledge for future researchers, either geologist or other science fields researchers, even to the resident of the area and to the government. The past geological information about Kampung Pahi may be inadequate; hence this paper is proposed to add extra information about it.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Literature review is a preliminary research before the study is conducted. It is important to review past writings or reports in order to know what are the geological information of the selected study area and the records of previous researches.

2.2 Regional geology and tectonic setting

Malaysia Peninsular is an integral part of Eurasian plate, South-East Asian part of which is known as Sundaland (Hutchison *et al*., 1989a) that also includes Borneo, Java and Sumatra. There is no stratigraphic correlation between Malaysia Peninsular and Sarawak despite the attempt made to compare the Triassic volcanic rock of Pahang Series and Serian Volcanic Formation (Pimm, 1967). Rather, the western part of Malaysia Peninsular is more closely stratigraphically correlated with some part of Thailand via Sibumasu block which also includes some parts of Sumatra. While the eastern part of Malaysia Peninsular, which is of East Malaya Block has no major stratgraphic difference with Indochina Block of eastern Thailand (Hutchison *et al*., 2009). Between Malaysia Peninsular and

Sumatra, geological features of Malaysia Peninsular disappeared in Sumatra beneath the large Tertiary oil basin of North, Central, and South Sumatra. Bentong-Raub suture extends southwards from beneath the Gulf of Thailand, along the eastern part of Pattani Basin, and through the central part of Malaysia Peninsular.

2.2.1 Stratigraphy

Kuala Krai lies between Taku Schist at the west and Boundary Range Granite at the East; meanwhile Kuala Krai at the middle is mainly andesite and tuff with some sedimentary rocks. It is unknown which formation this sedimentary rocks are belong to, but in this study sedimentary rocks are assumed to be originated with Gua Musang Formation. Andesite and tuff are assumed to be originated from Pahang Volcanic Series.

Gua Musang Formation consists of tuffaceous and argillaceous with pyroclastics and lava flow, aged Middle Permian to Lower Triassic (Yin, 1965). Shale is aged Triassic (Tamura 1968). Taku Schist is reported to mainly pelitic consisting of quartz-mica schist, quartz-mica-garnet schist and garnet-mica schist (Macdonald, 1968). The narrow band of amphibolite schist, quart schist and serpentinite also presents. The age of non-fossiliferous Taku-Schist is believed to be Permo Triassic and maybe older in the core of schist outcrop. Boundary Range Granite which lithology is granite is aged Triassic (Darbyshire, 1988). Pahang Volcanic Series; which lithology consisting andesitic tuff and rhyolitic tuff is aged Permian to Late Triassic (Metcalfe *et al*., 1982).

2.2.2 Structural geology

Lebir Fault Zone is one of major faults in Malaysia Peninsular that named according to the name of Sungai Lebir near Manek Urai, Kelantan. Lebir Fault Zone lineament can be traced on the RADARSAT imagery (Hutchison *et al*., 2009). Lebir Fault Zone passes through the granite batholith east of Sungai Lebir, western margin of the Gagau Formation, the eastern margin of Koh Formation, eastern margin of Tembeling Group until it terminates at the intersection with Lepar Fault in Pahang. The fault zone is at least 10 km wide. The Lebir Fault Zone is initially thought as a dextral strike-slip fault based on the characteristics of the other major faults of Malaysia Peninsular (Hutchison *et al.*, 2009), the evidence from the slickensides on the fault surfaces exposed along road-cuts however shows otherwise. From the investigations by Tjia (1969) and Aw (1990) proved that Lebir Fault Zone is a sinistral strike-slip fault.

2.2.3 Historical geology

Gua Musang Formation and Pahang Volcanic Series may had been occurred at the same event as they are generally aged Permian to Triassic (Yin, 1965; Tamura, 1968; and Metcalfe *et al*., 1982). The volcanic eruptions may had been occurred leading to the formation of various types of pyroclastic rocks at from Pahang until central of Kelantan (Willbourn, 1917). The intrusion of Boundary Range Granite (Darbyshire, 1988) may had caused the uplifting of the adjancent area, while at the same time pyroclastic flow caused by the volcanic eruption was then leading to metamorphism at

Kuala Balah, Kemubu and Dabong (Alexander, 1965). This might had been followed by post-Triassic major faulting of Lebir Fault (Singh, 1985) and the follow up series of minor faultings in Kuala Krai, and eventually forming the present day landform of this place.

2.3 Geochemical exploration

The exploration of the earth materials beneath the ground below us begin with specified geological mapping, which is called as geochemical mapping. Geochemical mapping would deal with geochemical variables and thus needs mathematical and mapping techniques (Zhang *et al*., 2008). In wider term, there are quite a lot of things to be explored or investigated in geochemical exploration; 1) the mineral distribution in the rock around the area of investigation, 2) the chemical contents in soils, rocks, and even water bodies, 3) to find the economical mineral ore (gold, tin, bauxite, etc.) using specific method such as till geochemistry in Finland (Sarala *et al.*, 2009) and geochemical anomaly method (Cameron *et al*., 2010) or energy resource (petroleum, gas, and coal). The most common data could be obtained anywhere in the world is the geochemical anomaly.

Mineral distribution occurs naturally and depends on what type of rocks and found in the area. For example, quartz, feldspar, and biotite could be found anywhere in the area consists of mainly granite. While the chemical content of the area may be either occurs naturally, or affected by the human activities or even the natural disaster itself. The chemical content that occurs naturally in Ireland according to the proposed work in Ireland (Arnand *et al*.,

2001) stated that higher SOC (Soil Organic Carbon) and low pH are due to occurrence of peat or organic soils, while vice versa due to intensive grassland agriculture of the country. The chemical content of that occurs by human activities, for example, heavy metals (e.g. lead, zinc, and copper) in the area may be due to mining activities and urban sprawl; available nutrient (e.g. Magnesium and Potassium) may be due to agricultural activities. The chemical content that influenced by the natural disaster for example there was a significant change in chemical content of the Poring Hotspring in Ranau, Sabah after the earthquake occurred in the mid of 2015.

Different purpose of different geochemical exploration would require different types of method. Sometimes the name of geochemistry method would derived from the type of soil where the place was investigated, for example, gold exploration in Finland was conducted by using till geochemistry (Sarala *et al*., 2009), laterite geochemistry (Cornelius *et al*., 2008) and geochemical anomaly method of buried copper deposits in Northern Chile (Cameron *et al*., 2010).

Typical geochemical exploration method is stream sediment sampling. During sampling, one sample is taken as the representative of geochemical anomaly of the surrounding area (Salminen *et al*., 2008). The selection of sampling density is based on geological information, geomorphological information, or soil type of the targeted area. The grain size must be smaller than 0.018 mm to be brought into analysis technique; let say ICP-OES as in this study.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

This chapter discusses about the materials and methodology carried out throughout this study. The materials and equipment discussed are for the usage of both geological mapping and geochemical exploration; in which including Geographic Information System, topographic map, portable Global Positioning System, Brunton compass, geological hammer, geological hand lens, hydrochloric acid, camera and stationaries. The methodology includes preliminary research, data collection, laboratory work and fieldwork analysis, interpretation and evaluation, and report writing is discussed in detail in following sections.

3.2 Materials and equipment

a) Geographical Information System

Geographic Information System (GIS) is a system commonly used by geologist to digitize the new map or the pre-existing map of the study area. Every map produced in this thesis is produced using GIS. The researcher utilizes this system to produce maps based on data obtained from geological mapping and geochemical exploration.

b) Topographic map

One of the most essential materials in geological mapping is topographic map. Topographic map is common geological map used by geologist, which basically represents the elevation and contour of the study area. Usually, the scale of 1:10000 or 1:25000 is used.

c) Portable Global Positioning System (GPS)

GPS is very important equipment during geological mapping and geochemical exploration. GPS is used to traverse, marking the waypoints, locating, and coordinating. These data are used for the re-digitization of the map from GIS. During traversing, the tracks are recorded and presented in traverse map. The waypoint is marked to show where rock sampling, stream sediment sampling and field observation are done.

d) Brunton compass

Unlike ordinary compass, Brunton compass is designed specialized in measuring the strike and dip of an outcrop, and to determine the azimuth of an outcrop.

e) Geological hammer

Geological hammer also called as geologist pick hammer, used for splitting and breaking the rocks for rock sampling. Geological hammer also may be used to clear the vegetation on an outcrop or to pry open a fracture. Sometimes geological hammer is used as scale for outcrop photograph.

f) Geological hand lens

Geological hand lens is a specialised lens for the determination of mineral composition, the texture or the grain size of the rock. This lens also can be used to determine possible pre-existing fossil in the rock. This tool may be used in varying magnifications.

g) Sample bag

Sample bag is essential for rock and stream sediment sampling for laboratory works and fieldwork analysis. During fieldwork, rock sample and stream sediment sample are stored inside the sample bag.

h) Hydrochloric acid (HCL)

In identifying a type of rock, as HCL gives reaction to calcium, HCL is used to determine the occurrence of calcium in the rock, in which geologist typically used to differentiate between marble and limestone.

g) Camera

In geological mapping and geochemical exploration, camera is used to photograph the rock and stream sediment samples and the outcrops or site where those samples are taken.

i) Stationaries

Including pen, permanent marker, notebook, and other stationaries; to record any important data or information.

3.3 Methodology

The overall research flow chart is as shown in Figure 3.1.

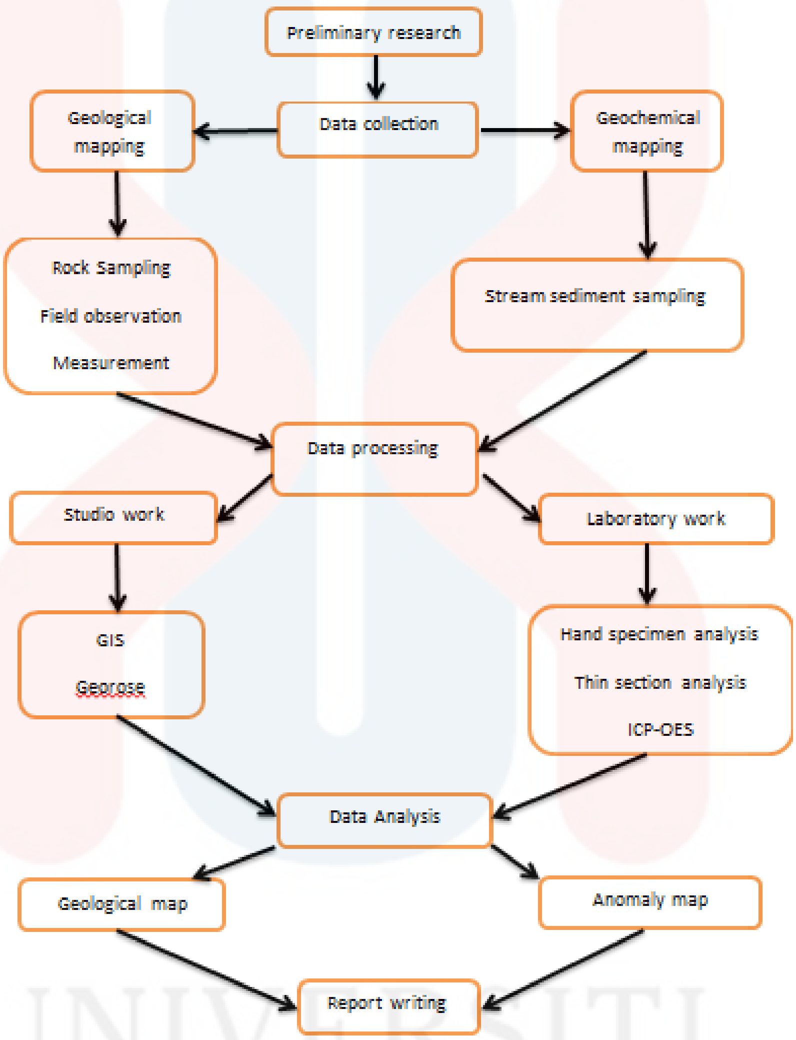

Figure 3.1: The methodology flow chart.

3.3.1 Preliminary research

In order to determine what method is needed to conduct this study and what are the materials needed to be carried along, preliminary research or desk study is the first thing to be done. This is done by referring to the reports written by previous researchers, understanding and documenting the source as reference for this writing. By conducting a preliminary research, the researcher can find ideas and eventually finalizing the topic by stating the hypothesis of the study.

3.3.2 Field studies

3.3.2.1 Geological mapping

Geological mapping is the most basic and essential method for a site investigation. This is done by conducting fieldtrip to the chosen site of investigation or the study area. During geological mapping, field observation, hand specimen analysis, and parameter measurement are done.

3.3.2.1.1Field observation

During geological mapping, geologists are required to observe any observable outcrops. Outcrops tell structural geology available in the area, lithology, and stratigraphy. Aside of observing outcrops, geologists also required observing every feature around such as buildings, roads, vegetation and any water bodies.

3.3.2.1.2Hand specimen analysis

During the outcrop observation, some obtainable rock samples may be hammered for hand specimen analysis. Hand specimen analysis can be done either in the field by observing the mineral composition of the rock by using geological hand lens and the hydrochloric acid (to determine the presence of calcium content in the rock or to differentiate almost lookalike different rocks like limestone and marble) or can be done in the laboratory for thin section analysis.

3.3.2.1.3Measuring parameters

Parameters can be done in the field are measuring the dip and strike of an outcrop (usually minimum 50 readings) and measuring the height and width of the outcrop (by approximation or by the measuring tape measurement).

3.3.2.1.4Traversing

The geologist would carry the portable GPS to track any single path (tarred or untarred road), mark the waypoint for any available important features either natural or manmade, such as small pond, small hut and road junction. These data are then brought for studio analysis.

3.3.2.2 Geochemical mapping

Geochemical mapping may be done at the same time geological mapping is done, but emphasized more on geochemical exploration. During geochemical mapping, stream sediment sampling and sample preparation are done.

3.3.2.2.1Stream sediment sampling

For geochemical exploration part, geochemical mapping may be done together with geological mapping or done separately. This is done by taking silt sample from the river and the tributaries. Silt sampling will be started from any point of the river from the map. Each silt sample will be taken in the range of 500 metres between each other; taken at the tributary ranging from first order to third order. Very fine silt is taken from an active tributary with low energy. Pre-sieve is done for the sample that has lack of fine silt. Each sample must be carefully recorded to avoid the confusion from which locality each sample was taken. These samples are then taken for laboratory analysis.

3.3.2.2.1Sample preparation

The purpose of sample preparation is to ensure that the samples are remained fresh and unpolluted when it is send to the laboratory, as well as avoiding the labelling mistakes.

1. Drying

Silt sample can be dried under the sunlight with supervision or inside the laboratory oven of the temperature of 50 – 55 degree Celsius, if the weather is unfavourable.

2. Sieving

After fully dried, the sample is slowly sieved using some available laboratory apparatus such as stainless steel standard sieve and mortar porcelain. The purpose of sieving is to get the desired silt size; usually lesser than 125 micrometre in geochemical exploration.

3.3.3 Laboratory work

Laboratory work in this study is the data analysis for both geology and geochemical exploration. This includes thin section analysis and ICP-OES.

3.3.3.1 Thin section analysis

The rock sample taken from the measured out crop is cut into an extremely thin section, to be observed under the polarized microscope to determine the mineral composition of the rock. There following are the procedures for the preparation for thin section analysis:

1. The rock sample is cut using the petro cut machine into a suitable size for trimming.

2. The rock sample is cut using the petro trim machine into a desired size to be glued into the thin section glass.

3. The sample is glued into the thin section glass without leaving the air bubble. The sample is left for a day before the next procedure.

4. The sample is cut further inside the petro thin machine into a suitable size for grinding.

5. The sample is grinded inside the petro thin machine until thin section size.

6. The sample is polished using silicon carbide powder mixed with water.

3.3.3.2 ICP-OES

Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) in an analytical technique that can show the concentration values of the targeted elements. After the samples are dried and sieved, and before the samples are analysed with ICP-OES, the procedures for the preparation of sample is as discussed in detail in Chapter 5.

3.3.4 Data processing

There are two data processed in this study; which are geological map and anomaly map, for the later interpretation.

3.3.4.1 Geological map

The map digitized during data processing will produce a new and more accurate geological map of study area with current state. This newly produced geological map is interpreted further to determine the structural geology, hydrogeology, and stratigraphy of the study area.

3.3.4.2 Anomaly map

The anomaly map is digitized specifically for geochemical part of this study. The anomaly map represents local variation of chemical distribution and concentration at study area. This study specifies on creating anomaly map of distribution and concentration of iron, lead, and copper. Therefore, there would be three separate anomaly map of iron, lead, and copper, respectively, in the end of this study.

3.3.5 Data analysis and interpretation

The final step in any scientific research is report writing. Starting from preliminary research, the report is written in literature review. Next, the report of every method of data collection, data analysis, and then data interpretation is written. The purpose of report writing is that to help readers review and understand what this research is all about and to think of suggestion of better ways in handling research of the same field.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter discusses about the geomorphology, stratigraphy, structural geology and historical geology of Kampung Pahi. During the site investigation, the area is traversed and several fieldworks done which are rock and sediment sampling, and field observation. The site investigation is done as shown in figure 4.1.

The study area is generally low lying and gently sloping. High relief features are found at the central north to north east and central to south of the map. This high relief features are surrounded by nearly flat area across the map. Drainage pattern of the area found to be dendritic where the streams flow from these high relief features towards Sungai Pahi. Most outcrops at study area also are heavily weathered. Therefore, it is difficult to locate the fresh rock sample.

The lithology of the study area is siltstone which is probably as the indicator of shallow marine origin of the study area. If based on previous writings, this rock probably associated with Gua Musang Formation far from the south and if it is true, the age of this rock was probably Permian to Triassic. There is very little evidence of sandstone found in the study area however. The study area lies between Taku Schist at the west and Boundary Range Granite at the west.

Beside, there are pyroclastic rocks found at the north western and south eastern of the map. Lapili tuff is found to be well deposited at the south eastern part, probably indicating the pyroclastic flow during Late Triassic. Andesitic tuff is found deposited at north western of the map. These pyroclastic rocks also were probably one part of Pahang Volcanic Series. Alluvium is deposited during Quarternary until Recent.

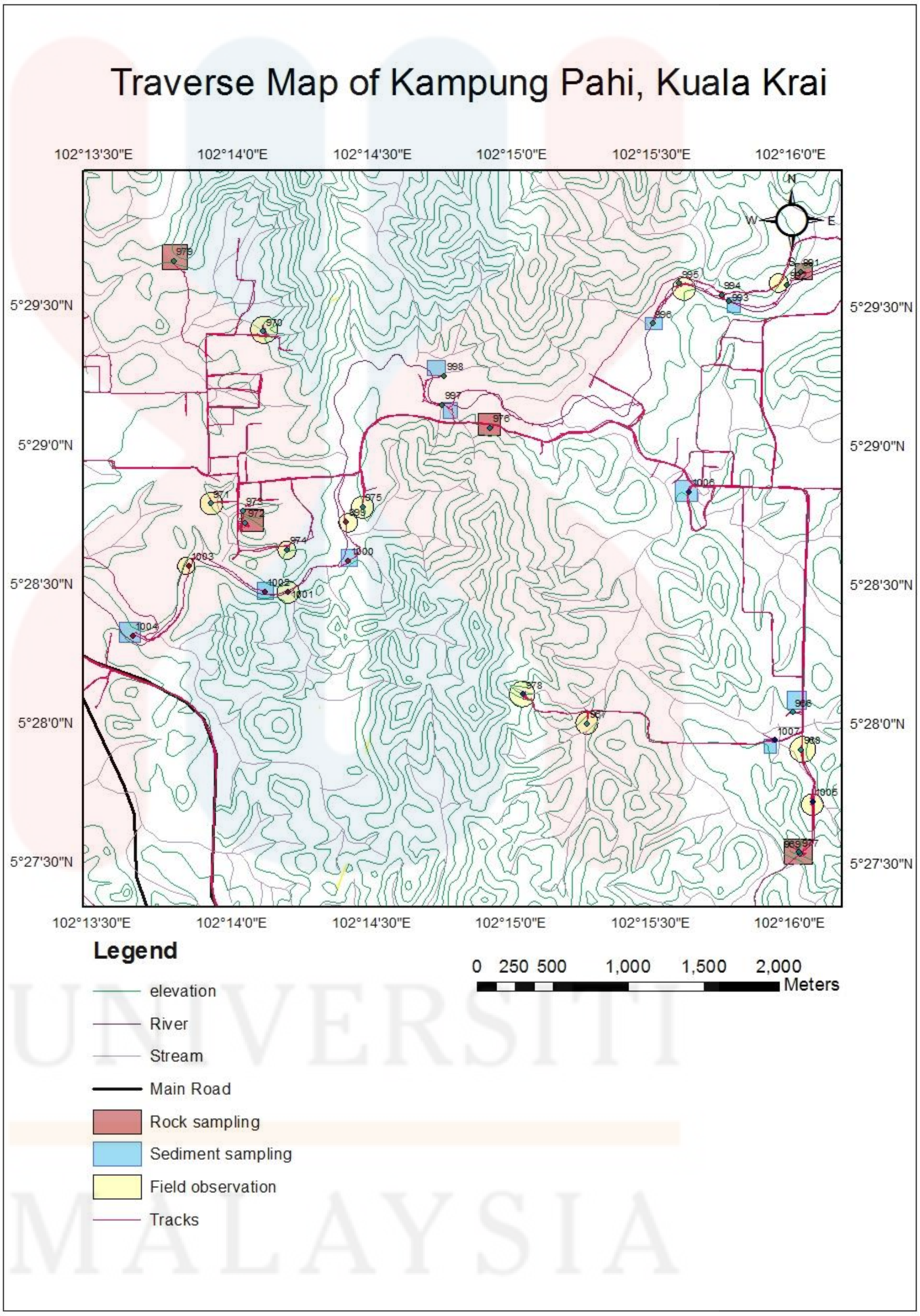

Figure 4.1: Traverse map of Kampung Pahi, Kuala Krai.

4.2 Geomorphology

4.2.1 Geomorphology classification

The elevation in Kelantan varies along Central and Eastern Belt, generally decreasing from the west to the east. The western part to central part of Kelantan bounded by the Main Range where high relief features are located at. While at the north eastern part of Kelantan, the elevation is lower and closer to sea level.

At the study area, as shown by Figure 4.2, the elevation varies from 60 metres to 200 meters. The study area is located in the middle betweeen Central Belt where Taku Schist lies at the west and Boundary Range Granite which is also one part of Eastern Belt, at the east. Lebir Fault might be the dividing factor between high relief features at Taku Schist and low lying and moderately high relief features at the study area. These factors therefore give the formation of overall landform of the study area. The study area also generally gently sloping which compromises most part at the west and southwestern part of the map as well as aluvium along Pahi River. Moderate slopes are generally found at high relief area at this map. The detail of the slope types in study area is as shown in Figure 4.3.

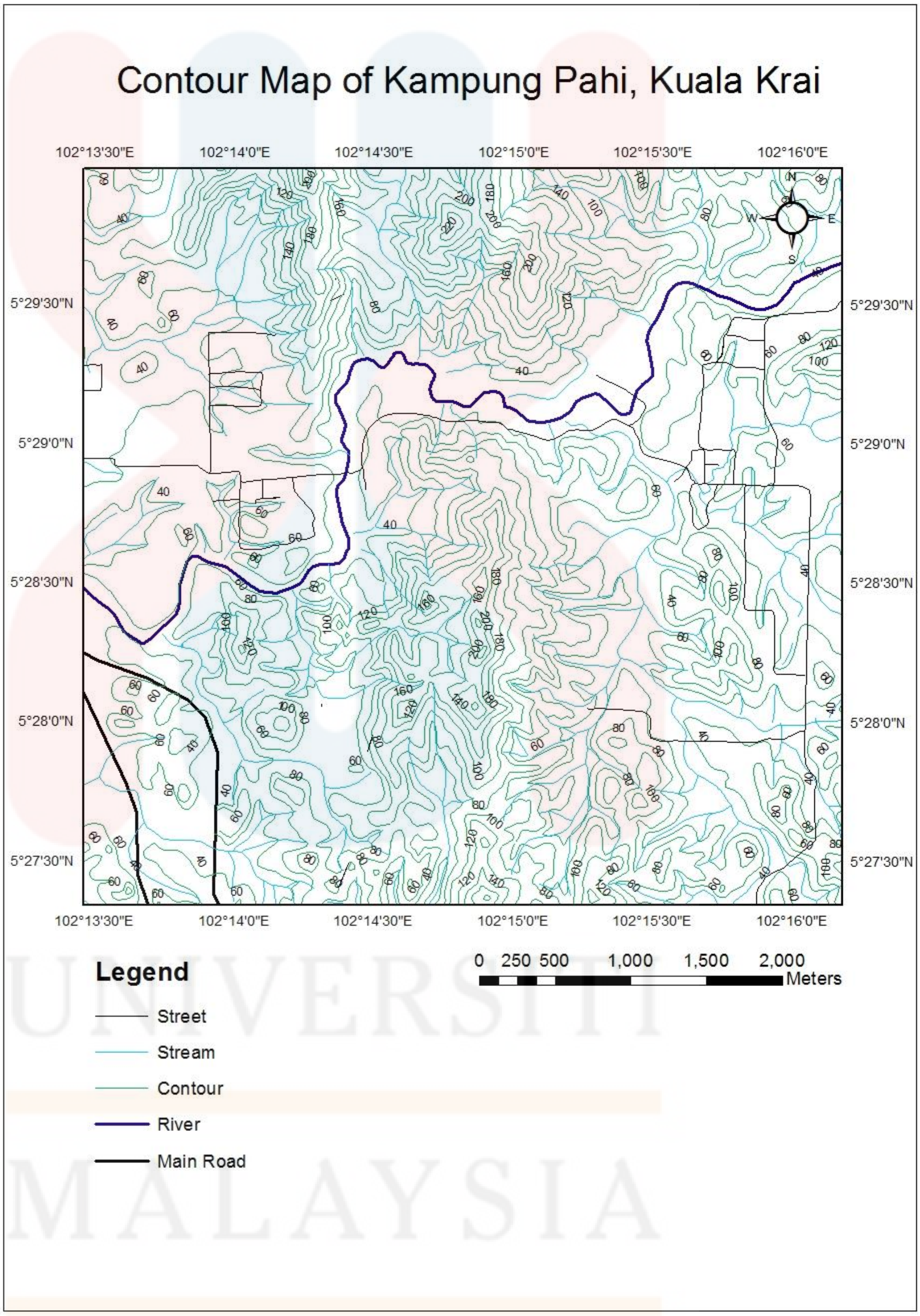

Figure 4.2: Contour map of Kampung Pahi, Kuala Krai.

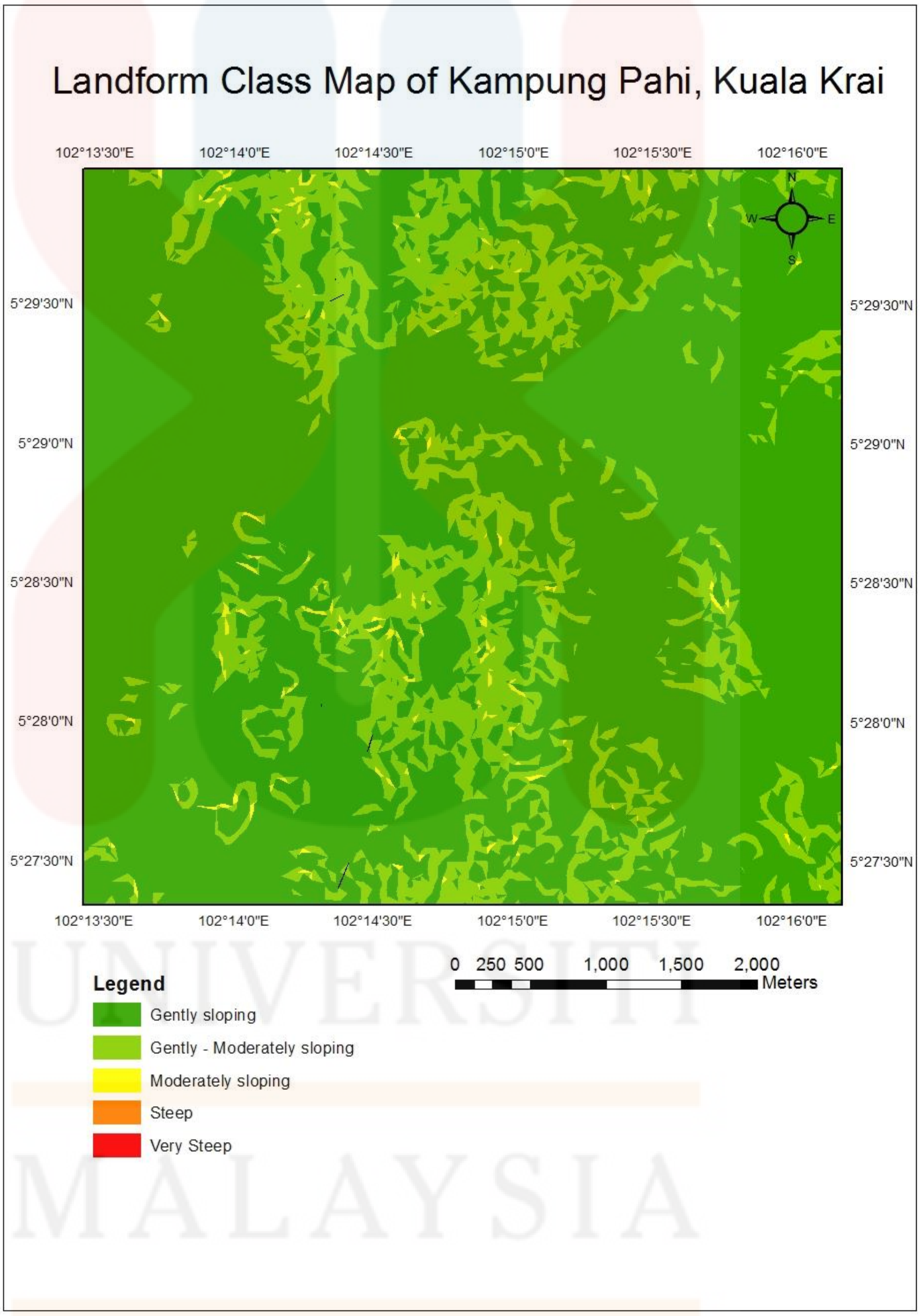

Figure 4.3: Landform classification map of Kampung Pahi, Kuala Krai.

4.2.2 Drainage pattern

Drainage pattern is a system formed by streams, rivers and lakes in a drainage basins. The formation of drainage pattern also influenced by the landform and topography, regardless of lithology and slope gradient. As shown in Figure 4.4, the study area seems to have two types of drainage pattern; dendritic system and parallel system. Dendritic system indicates that the lithology is non porous and impermeable. Parallel system indicates how steep is the landform is. The streams in parallel system supposed to be the flowing straight before meeting at bigger stream. The drainage pattern at south western and north eastern part (Figure 4.4) are identified as parallel system because they have lack of contibuting streams as characterized in dendritic system. The landform from which this parallel systems flow is also steep. Regardless, the stream flow through both of these patterns notably meet at Sungai Pahi.

The streams were formed due to the surface run off of the rain water. When the precipitation occur at hilly area, the rain water flows downward the gravitu from higher ground to lower ground. Due to the influence of topograhy, landform, or lithology, this stream would meet another stream at one point, and the newly formed bigger stream would meet another stream and forming the new one bigger again, until they meet at the tributary. This is the leading cause of the occurrence of dendritic system and parallel system in this study area. Sungai Pahi act as the tributary in this study area. However, human activity may interrupt these system causing another new system to form, or totally diminished.

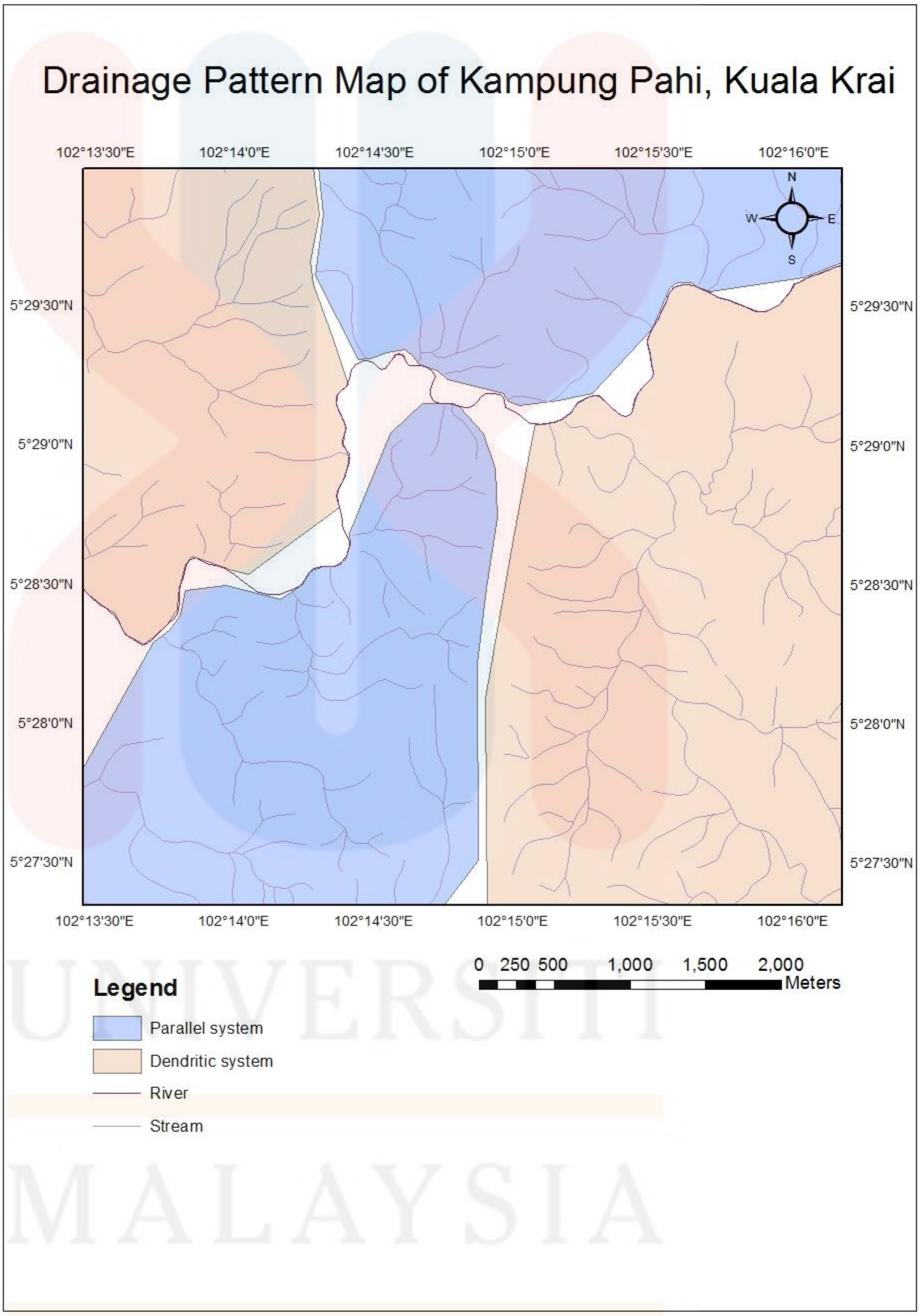

Figure 4.4: Drainage pattern of Kampung Pahi, Kuala Krai

4.2.3 Weathering Process

Weathering is a process of where the rock or mineral is broken down into smaller pieces by either physical or chemical process. Weathering process occurs due to influence of water, temperature, chemical or any physical forces. As the process occur, the hardness of the rock will decreases gradually and eventually weak enough for it to be eroded. The eroded part of this rock is then deposited into a coarse to very fine soil. As the study area share similar climate as the other parts of the country, the activity of weathering happens actively at the study area. Most outcrops of study area is heavily weathered.

There are three types of weathering found in study area. The first one is physical weathering. Physical weathering is a type of weathering that caused by mechanical disruption. Physical weathering may be affected by temperature, water, wind, or many more.

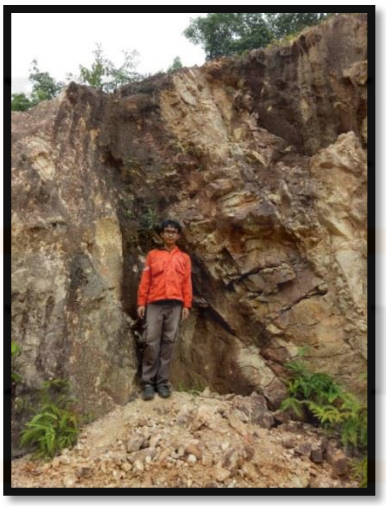

Figure 4.5: Physical weathering

Chemical weathering is the decay of rock caused by the chemical reaction. Figure 4.6 below shows feldspar intruded the shale outcrop. Feldspar in this figure had undergone chemical weathering. As the result, white color clay mineral is formed.

Figure 4.6: Chemical weathering.

Biological weathering is the type of weathering that caused by the vegetation or animal activity. Figure 4.5 shows moderately weathered shale weathered by the vegetation of plant nearby.

Figure 4.7: Biological weathering

As mentioned earlier, most of the outcrops in study area is heavily weathered. However, based on Figure 4.8 below, the grade of weathering of the study area ranges from moderately weathered to completely weathered.

Class	Term	Description
VI	Residual and colluvial soils	All rock material is converted to soil. The original rock structure is completely destroyed. The point of geological pick easily indents in depth. When the rock material is struck by the hammer don't emits sound.
V	Completely slightly weathered rock	All rock material is completely discolored and converted to soil, but the original mass structure is still visible. The point of geological pick not easily indents. When the rock material is struck by hammer emits a dull sound.
IV	Highly slightly weathered rock	All rock material is discolored. The original mass structure is still present and largely intact. The point of geological pick not easily indents. The rock material makes a dull sound when is struck by a hammer.
III	Moderately slightly weathered rock	The rock material is discolored, but locally the original color is present. The original mass structure is well preserved. The point of geological pick produces a scratch on the surface. The rock material makes an intermediate sound when is struck by a hammer.
II	Slightly weathered rock	Discoloration is present only near joint surface. The original mass structure is perfectly preserved. The point of geological pick scratches the surface with difficulty. The rock material makes a ringing sound when is struck by a hammer.
I	Fresh rock	The rock material isn't discolored and has its original aspect. The point of geological pick scratches the surface with many difficulties. The rock material makes a ringing sound when is struck by a hammer.

Figure 4.8: The grade of weathering

(Source: Eldin, 2013)

Figure 4.9: Moderately weathered outcrop.

Figure 4.10: Highly slightly weathered outcrop.

Figure 4.11: Completely slightly weathered outcrop.

Figure 4.12: Residue soil.

4.3 Stratigraphy

4.3.1 Lithology

1. Siltstone

Siltstone outcrop is found at Kampung Belanga (N 28º 28’ 42.94”, E 102º 14’ 2.77”). The size of outcrop is approximately 50 metres wide and and 20 metres high. The outcrop is moderately weathered, but fresh rock sample is obtainable. Weathering of feldspar is found as shown earlier in Figure 4.6.

Siltstone is found laminated with shale along this outcrop. As shown in Figure 4.13, the vegetation of this outcrop is found to be rubber plantation which is also found surrounding this area.

Figure 4.13: Siltstone outcrop.

Besides, siltstone is also found at several other localities. The outcrop of these localities are heavily weathered. Despite this condition, clayish soil at these outcrops shows similar characteristic as soil in outcrop as Figure 4.13 above. In addition, some of these localities are not entirely weathered, making it easy to compare the weathered rock with the rock in Figure 4.13 above. Siltstone covers approximately 40% of study area.

Figure 4.14: Heavily weathered siltstone

(N 5º 29’ 24.18”, E 102º 14’ 6.54”)

The grain size of siltstone hand specimen is very fine, with the grain size of between 1/256 and 1/16. Aside of that, the hand specimen shows that the grain of the rock is clastic, or in other word it is a clastic sedimentary rock. The rock can be crushed or splited by hand and it is broken into blocks or layers. Due to this factor and also the weathering condition, siltstone cannot be brought to thin section analysis.

Figure 4.15: Siltstone hand specimen

2. Andesitic tuff

Andesitic tuff is only found at N 5º 29 39.39", E 102º 13' 47.24" at Kampung Belanga. The size of outcrop is very small; approximately 10 metres wide and 2 metres high. This is also the only outcrop where Andesitic tuff is found in comparison to surrounding area. The outcrop is moderately weathered. The vegetation of this area is grassy with just re-plantation of palm plantation. Andesitic tuff covers only 10% of study area, approximately.

Figure 4.16: The outcrop of andesitic tuff.

The texture of andesitic tuff is porphyritic; with approximately 40% of the mineral composition is composed of quartz with the other rock fragments and probably some metals.

Figure 4.17: Andesitic tuff hand specimen.

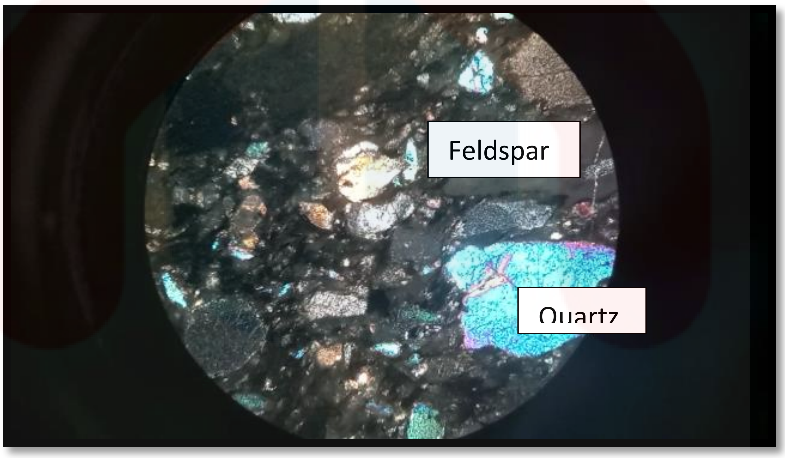

Figure 4.18: Andesitic tuff under thin section.

3. Lapili tuff

Lapili tuff is found at the road side outcrop of Kampung Belanga at N 5º 27’ 32.11”, E 102º 16’ 1.93”. The size of outcrop is approximately 40 metres wide and 15 metres high. The outcrop is also moderately weathered. As shown in Figure 4.18, the bushes is found growing on this outcrop; as well as a trees on the top. The rock is believed to be lapili tuff because of lapili sized and shaped on it’s texture. It is very difficult to locate the exact fresh sample for this rock, therefore the hand specimen of this rock also cannot be brought into thin section. Lapili tuff covers approximately 7% of study area.

Figure 4.19: Lapili tuff outcrop.

Lapili tuff hand specimen is coarse grained in texture. It is named as lapili tuff due to it's origin from volcanic ash of lapili size (2 milimeters to 64 milimeters.

Figure 4.20: Lapili tuff hand specimen.

4. Andesite porphyry

During geological mapping, andesite porphyry is found at two localities which are at Sungai Pahi (N 5º 29’ 37.18”, E 102º 16’ 2.10”) and Kampung Belanga (N 5º 29’ 3.46”, E 102º 14’ 44.41”). Andesite porphyry outcrop is found deposited and eroded at Sungai Pahi which covers approximately 10 metres square of the outcrop area, while andesite outcrop at Kampung Belanga is approximately 20 metres long and 2 metres high. Andesite porphyry outcrop at Kampung Belanga also vegetated by rubber plantation. Andesite porphyry covers approximately 40% of study area.

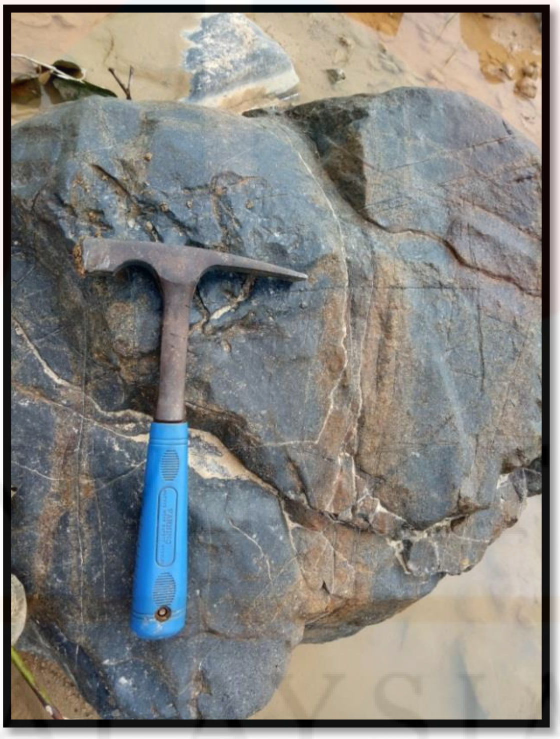

Figure 4.21: Andesite porphyry outcrop at Sungai Pahi.

Figure 4.22: Andesite porphyry outcrop at Kampung Belanga.

Andesite is fine grained with porphyritic texture. The mineral composition of andesite based on hand specimen below is mainly quartz and feldspar.

Figure 4.23: Andesite porphyry (Sungai Pahi) hand specimen.

Figure 4.24: Andesite porphyry (Kampung Belanga) hand specimen.

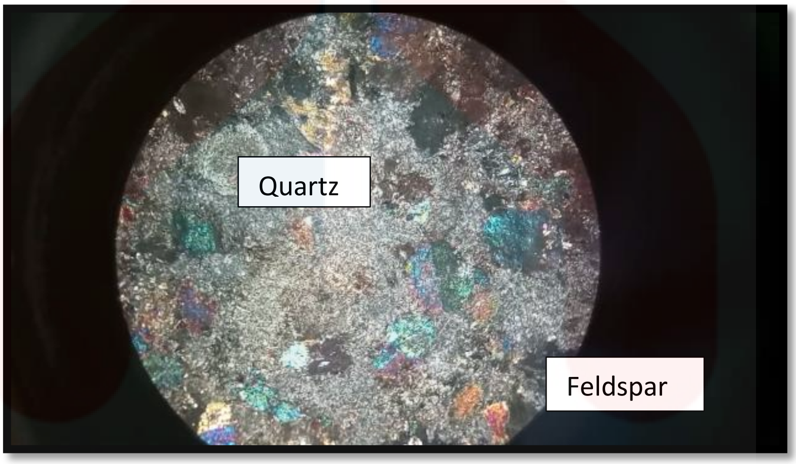

Figure 4.25: Andesite porphyry (Sungai Pahi) under thin section.

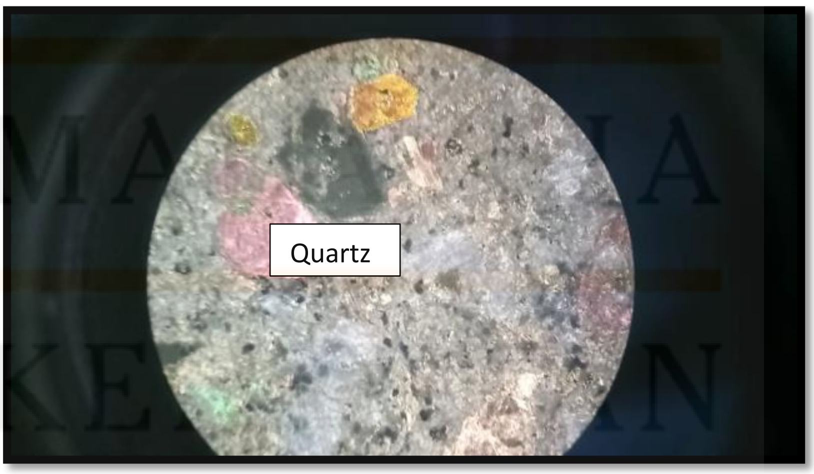

Figure 4.26: Andesite porphyry (Kampung Belanga) under thin section.

5. Alluvium

Alluvium is located alongside Sungai Pahi where stream sediment sampling is done. The sediments are mainly rounded and subrounded, with the size ranges from gravel to fine silt.

Figure 4.27: Alluvium sand.

4.3.2 Lithostratigraphy

The pyroclastic rocks, which are identified as andesitic tuff and lapili tuff found at north western and south eastern part of the map, respectively, are assumed to be deposited at the same age during Late Triassic. Andesite Porphyry may had been deposited later at early Cretaceous. As mentioned earlier, there is two types of lithologies found in study area which are sedimentary rock and pyroclastic rocks. As the previous writing suggests and if these sedimentary rocks are associated with Gua Musang Formation, they were probably deposited first from Permian to Triassic. Therefore, the stratigraphic column for all of the lithologies of study area is as follow:

Erathem	System	Lithology	Strata
Cenozoic	Quarternary	Alluvium	
Mesozoic	Cretaceous	Andesite Porphyry	
	Late Triassic	Andesitic tuff Lapili tuff	
	Middle Triassic		
	Early Triassic	Siltstone	
Paleozoic	Permian		

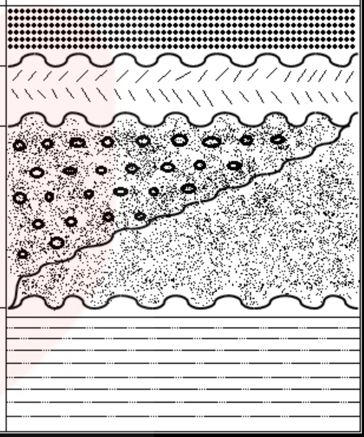

Figure 4.28: Stratigraphic column of Kampung Pahi, Kuala Krai.

4.4 Structural geology

4.4.1 Lineament Analysis

Lineament is the line feature that is mapped on a surface where the line align the topography of the map. When the topograhic map is viewed under 3D, the lines are observable whether they are straight or slightly curved. The purpose of lineament analysis is to identify the structure beneath the surface. As shown in Figure 4.29, the strike of total of 71 lineament is measured and producing the result as in Figure 4.30.

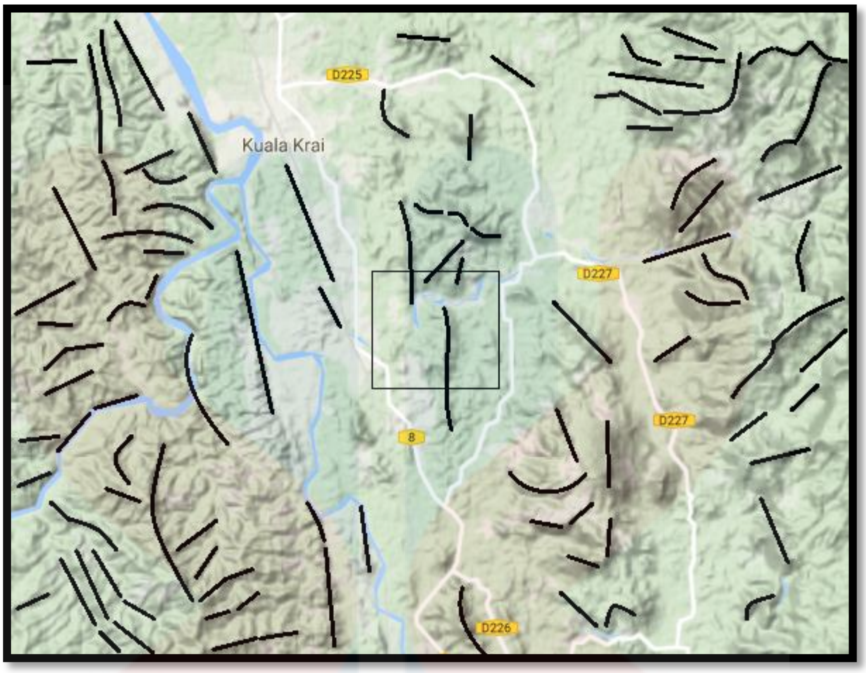

Figure 4.29: Lineaments of Kuala Krai.

Figure 4.30 shows that the major force trending at NNW and SSE. This force may actually associated with Lebir Fault and followed up by the various secondary faultings at surrounding area.

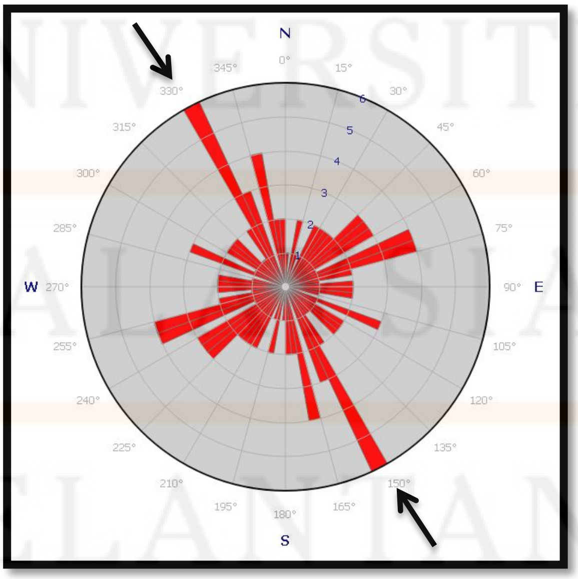

Figure 4.30: Rose diagram of lineament of Kuala Krai.

4.4.2 Crack Analysis

During geological mapping, 50 readings of strike was taken at three localities, in which the readings taken was specifically at extensional joint of the outcrop of each locality.

1. First Locality (N 5º 29’ 34.72”, E 102º 15’ 35.92”)

The first locality where strike and dip measured is located at Sungai Pahi. Strike and dip value are taken at extensional joints of the deposited lapili tuff outcrop.

Figure 4.31: First locality.

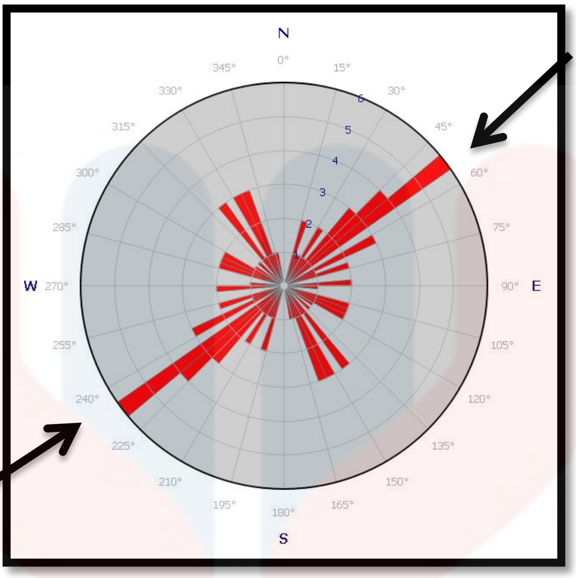

Figure 4.32: Rose diagram of first locality.

Figure 4.32 shows that the major forces come trending NNE and SSW.

2. Second Locality (N 5º 27’ 31.83”, E 102º 16’ 2.09”)

The next locality where 50 strike and value is taken is at the extensional joints of lapili tuff outcrop at Kampung Belanga as shown in Figure 4.33 below.

Figure 4.33: Second locality.

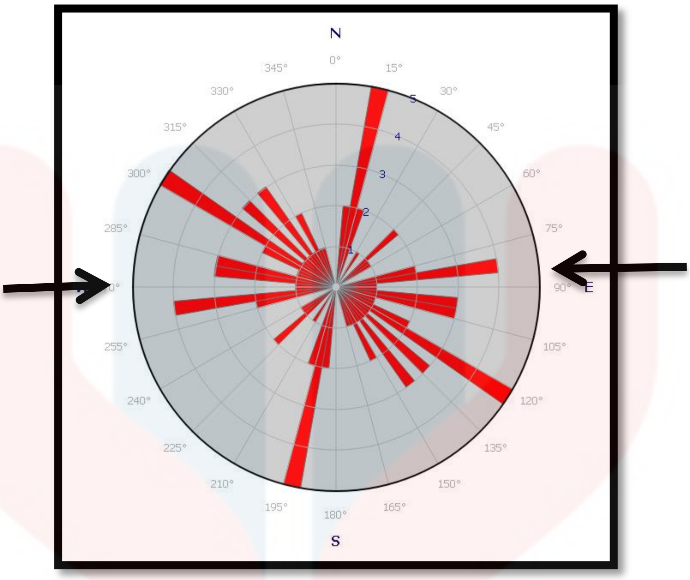

Figure 4.34: Rose diagram of second locality.

Figure 4.34 shows that the major forces come trending west and east.

3. Third locality (N 5º 28’ 47.94”, E 102º 14’ 2.77”)

The third locality where 50 readings of strike and dip taken is at the extensional joint of siltstone outcrop at Kampung Belanga as shown in Figure 4.35 below.

Figure 4.35: Third locality.

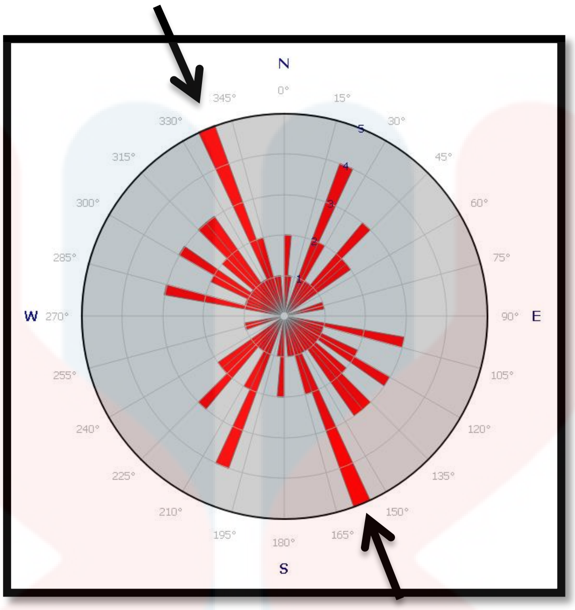

Figure 4.36: Rose diagram of third locality.

Figure 4.36 shows that the major forces come trending NNW and SSE.

4. All localities

The sum up of strike and dip taken from all localities mentioned is as shown in Figure 4.37 below. This hence varify that the major force comes from NNW and SSE, as confirmed earlier in Figure 4.30.

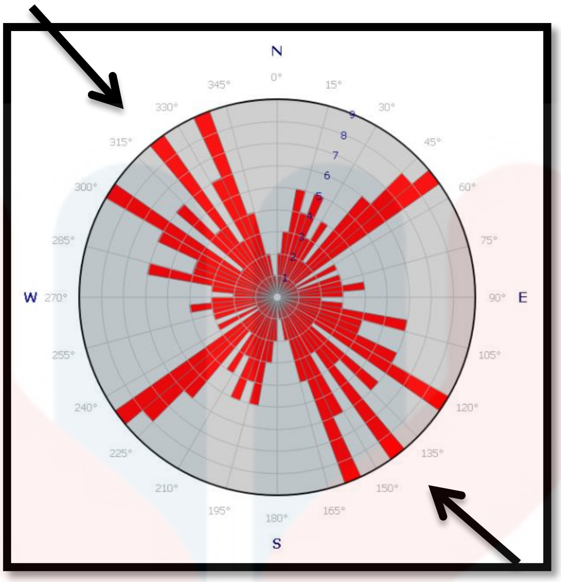

Figure 4.37: Rose diagram of all localities.

4.4.3 Geology map

Throughout the site investigations or geological mapping, there are five main lithologies found at study area as discussed earlier which are siltstone, andesitic tuff, lapili tuff, alluvium and andelite. During geological mapping, there is no apparent structural contacts or fault evidence found anywhere at the study area. Therefore, the structural is determined based on the whole chapter 4 discussions

.As shown in Figure 4.38, there are two secondary faults identified. One of them is Belanga Fault, named after Kampung Belanga, trending NNW to east. Another one is Pahi Fault, named after Kampung Pahi, trending NNE and SSW. Belanga Fault seems to had been faulted by a probably younger Pahi Fault as the displacement between andesitic tuff at the north east and andesite porphyry at central to north east of the map is noticable.

Pahi Fault is constructed on the map based on the lithology boundary between andesite porphyry and siltstone at the central north of the map.

Belanga Fault is constructed on the map based on the drainage pattern along Sungai Pahi but trending NNW after that due to the lithology boundary between andesitic tuff and siltstone at the north western part of the map.

Interpolate line is constructed across all the lithologies as shown in Figure 4.38, producing the cross section map.

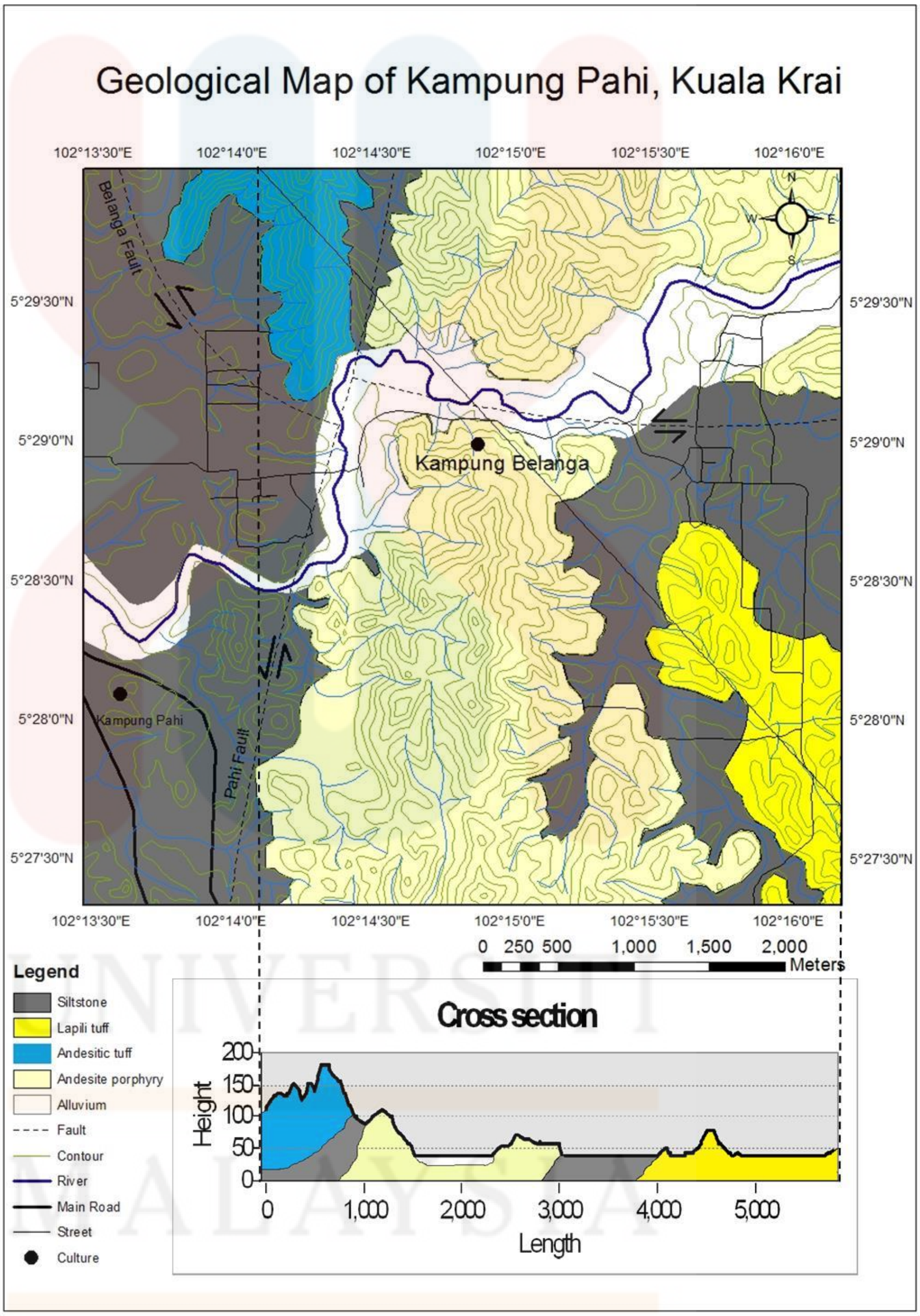

Figure 4.38: Geology map of Kampung Pahi, Kuala Krai.

4.5 Historical geology

Throughout all of the discussions in Chapter 4 and based on Figure 4.28, siltstone is deposited first during Permian in shallow marine environment and ended with erosion until Early Triassic. By Middle Triassic, massive volcanic eruptions might had been occurred from several places; resulting of the deposition of volcanic tephra of various size overlying the siltstone. Andesitic tuff and lapili tuff may had been deposited at the same age but from different place because of the difference of grain size. Andesitic tuff which is of porphyritic texture may had been originated from place closer than lapili tuff was from. This is followed up by another volcanic eruption leading to the genesis of andesite porphyry which is also from another place probably different with andesitic tuff and lapili tuff. Andesite porphyry overlain the eroded andesitic tuff and lapili tuff. Probably by post-Triassic, Lebir Fault formed by the major faulting event and followed up by secondary faultings of the study area. Finally, the study area is deposited with alluvium especially at Belanga Fault.

CHAPTER 5

GEOCHEMICAL EXPLORATION

5.1 Introduction

Geochemical exploration is a process of identifying the chemical element contents on an area. This chapter discusses about the geochemical exploration at Kampung Pahi via stream sediment sampling and specifically targets iron (Fe), lead (Pb), and copper (Cu). The process of geochemical exploration is begin geochemical survey in which the drainage system as in Figure 4.4 and as well the relation with other geomorphological information as discussed in Chapter 4 is analysed. The stream sediments were randomly sampled as shown in Figure. The samples were then taken to laboratory for laboratory analysis.

5.2 Geochemical survey

Preliminary research is also done for geochemical exploration similarly as preliminary research done for geological mapping.

5.3 Stream sediment sampling

Stream sediment is done in first-order, second-order, and third-order streams. Stream sediment cannot be taken at fourth-order or higher stream because the energy is high and most of the desired sediment size is lost due to transportation or dilution. Besides, sampling at location near any contaminated area is avoided such as agricultural area, construction area, road side and bridge because this will give the false result of geochemical data. However, contaminated area due to agricultural activities is difficult to avoid because the effect of fertilizer used is more widespread. Therefore, the best way to avoid it is by taking sample as far as possible from the source of agricultural activities.

During stream sediment sampling, at least 1 kg for each sample was taken despite it is more than sufficient because to find desired size of fine sand to silt is difficult along the stream at the study area. Therefore, this step is to obtain fine sand to silt sized sediment as much as possible for later separation. The samples are slowly scooped by trowel and then placed inside the sample bag. The sample bag is then labeled with permanent marker. There were total of 10 stream sediment samples collected; in which 7 of them were collected at the Pahi River and another 3 is at smaller stream. The samples were numbered according to sequence from the first location until the last; as “C1” until “C10”.

Before the samples are brought into the laboratory work, the samples are dried under the sun. Some of the samples which are not completely dried (due to change of weather) are put inside the laboratory oven and left for a day. After drying, the samples are sieved using auto sieving machine in order to separate fine sand and silt from coarse rocks.

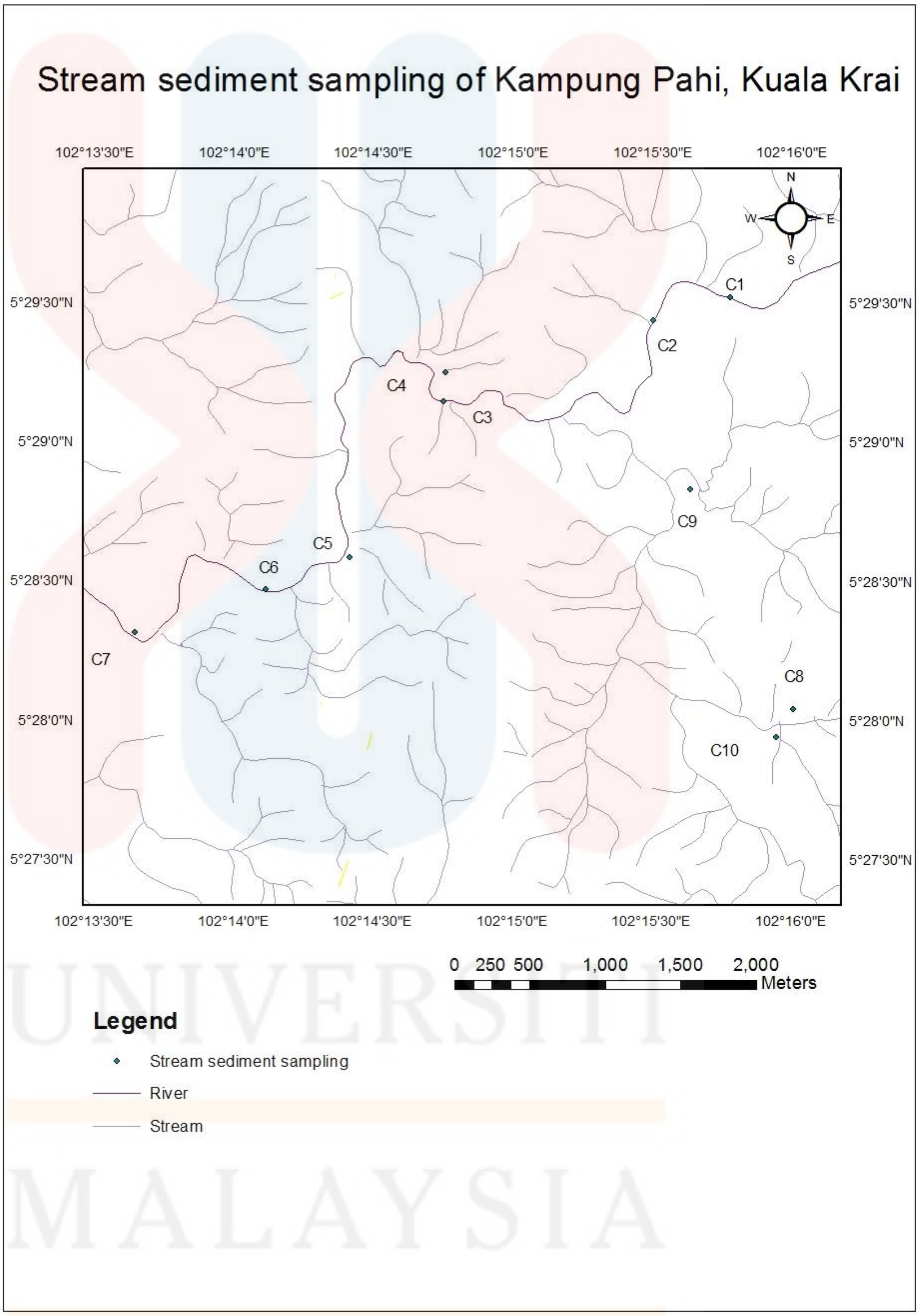

Figure 5.1: Stream sediment sampling of Kampung Pahi, Kuala Krai

5.4 Laboratory procedure

5.4.1 Apparatus

The apparatus included for sample preparation are 10 units of 50 ml beaker, a 100 ml measuring cylinder, an eye dropper, a weighing machine, a hot plate, a Whatman filtering paper, and 10 units of sampling bottle. The 50 ml beaker serves for mixing and heating the samples and each of these beakers are labeled according to sample labels which are C1 to C10. The 100 ml measuring cylinder is used to measure the volume of liquids or chemicals for use in reaction. The eye dropper is used to transfer small amount of liquids or chemicals. The hot plate is used for heating the mixed chemicals. Whatman filter is used to separate fine silt from the liquid during sample preparation. The 10 sampling bottles, which are also labeled from C1 to C10. serves as the storage of final product of the samples to be analysed by ICP-OES.

5.4.2 Materials

The materials included during sample preparation are the stream sediment samples, concentrated nitric acid (HNO_3), 30% of hydrogen peroxide (H_2O_2), and distilled water. Both concentrated nitric acid and hydrogen peroxide act as leaching agent where concentrated nitric acid removes metals and hydrogen peroxide removes organic matter from the stream sediment samples.

5.4.3 Procedures

Firstly, 1.0 g of each stream sediment sample is weighed in 50 ml beaker, and each of these samples is labelled according to sample label, which is from C1 until C10. 10 ml of concentrated HNO_3 is then added into each sample. Next, the samples are heated at 90ºC inside the fume chamber for 10 to 15 minutes. After the heating, the samples are allowed to cool and 5 ml of concentrated HNO_3 is added into each sample. The sample is then heated again for 30 minutes or until no brown fume inside the fume chamber, or in other word until the reaction is complete. The samples are ensured to evaporate not more than 5 ml.

After that, 0.5 ml of 30% H_2O_2 is added step by step until total of 3 ml of 30% H_2O_2 is added. The sample is allowed to cool. Another H_2O_2 is added (not more than 10 ml) if the organic content of the sample is still high. The sample is transferred into the centrifuge bottle. Distilled water is added until the total volume of sample is 30 ml. The sample is centrifuged for 15 minutes with 2000 rotation per minute. The sample is filtered into sampling bottle. Distilled water is added until the total volume of sample is 100 ml. The sample is ready for ICP-OES.

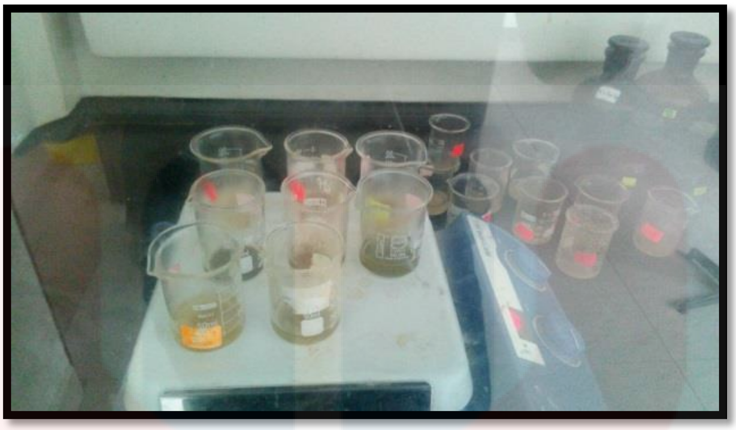

Figure 5.2: The samples are heated inside the fume chamber.

Figure 5.3: The samples are centrifuged.

5.4.4 ICP-OES

The samples prepared are brought to sample analysis by ICP-OES at Universiti Teknologi MARA (UiTM), Shah Alam. Before the data about the concentration of each element is analysed, several callibrations are done. The result is displayed in monitor as shown in Figure 5.4 below.

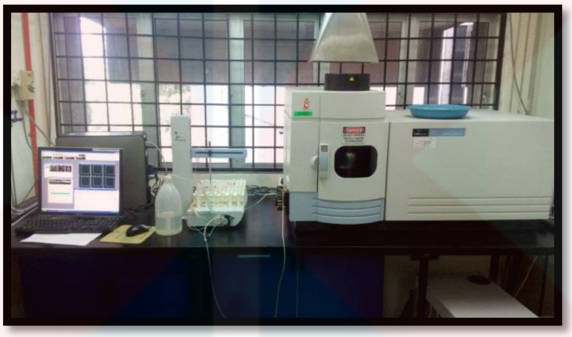

Figure 5.4: ICP-OES.

5.5 Results

Sample	Concentration (ppm)			Coordinate
	Iron (Fe)	Lead (Pb)	Copper (Cu)	
C1	4.834	0.198	0.050	N 5º 29’ 30.94” E 102º 15’ 46.72”
C2	10.35	0.255	0.053	N 5º 29’ 26.10” E 102º 15’ 30.92”
C3	11.14	0.275	0.067	N 5º 29’ 8.50” E 102º 14’ 45.03”
C4	29.84	0.347	0.058	N 5º 29’ 8.5”, E 102º 14’ 45.42”
C5	11.43	0.290	0.051	N 5º 28’ 34.8” E 102º 14’ 24.87”
C6	13.02	0.138	0.045	N 5º 28’ 28.05” E 102º 14’ 6.95”
C7	14.76	0.106	0.058	N 5º 28’ 18.58” E 102º 13’ 38.61”
C8	38.61	0.068	0.087	N 5º 28’ 2.34” E 102º 16’ 0.49”
C9	59.26	0.263	0.073	N 5º 28’ 49.74” E 102º 15’ 38.24”
C10	60.63	0.103	0.089	N 5º 27’ 56.30” E 102º 15’ 56.70”

Table 5.1: The result showing concentration of each element.

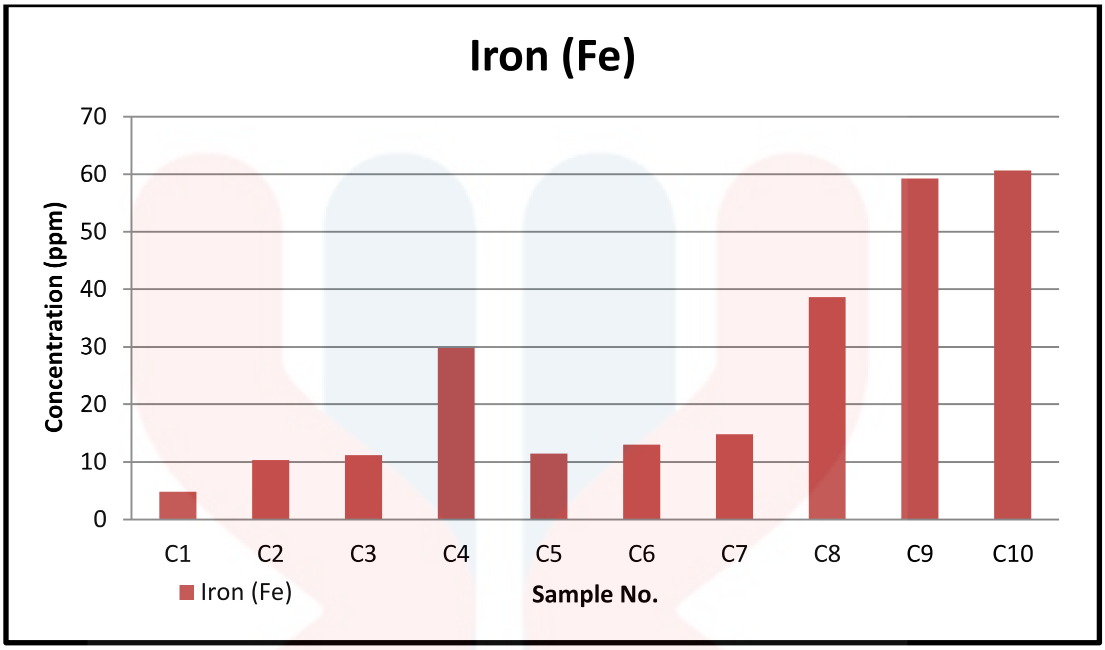

Figure 5.5: The graph of Sample No vs Concentrarion of Iron (Fe).

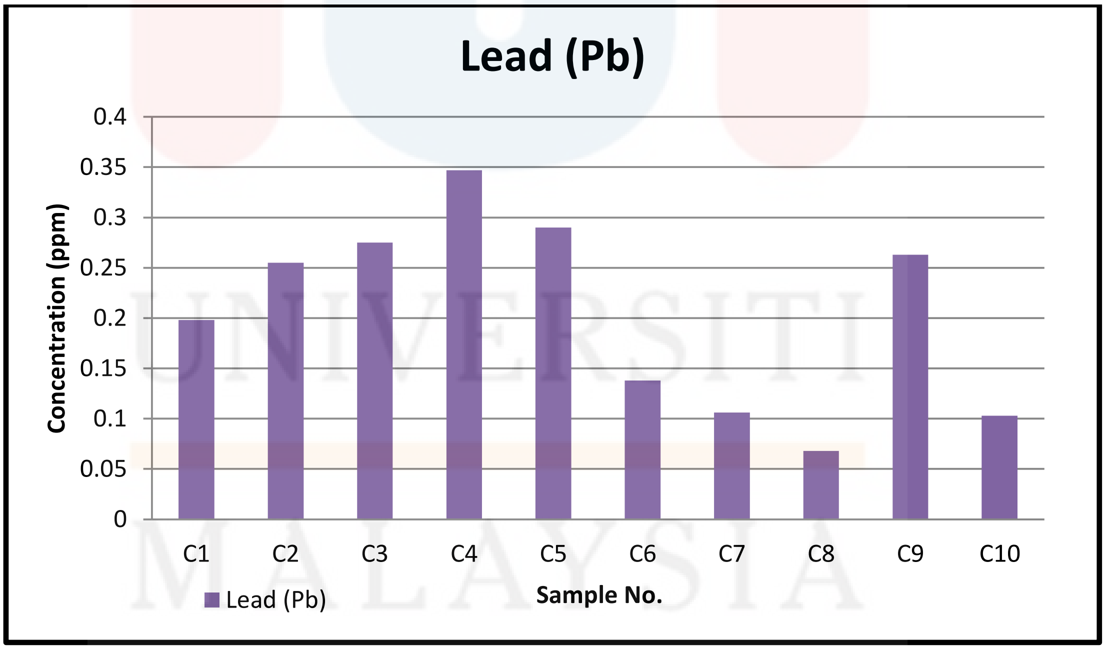

Figure 5.6: The graph of Sample No. vs Concentration of Lead (Pb).

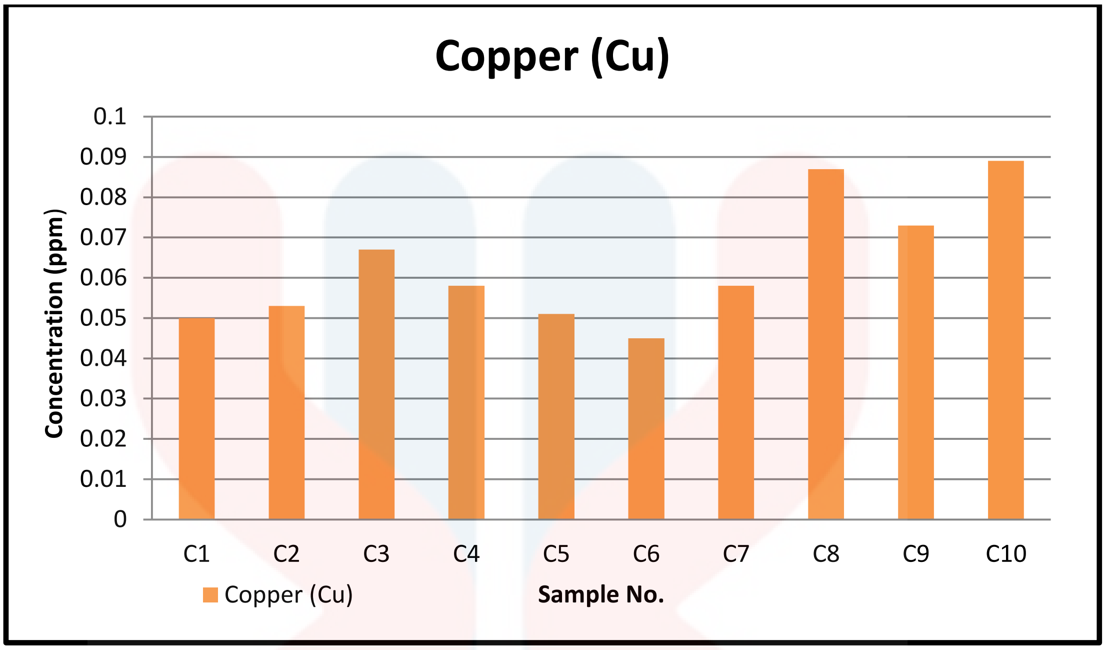

Figure 5.7: The graph of Sample No. vs Concentration of Copper (Cu).

Based on Figure 5.5, the highest concentration of Fe is at C10 which is 60.63 ppm, while the lowest concentration of Fe is at C1 which is 4.834 ppm. Based on Figure 5.6, the highest concentration of Pb is at C4 which is 0.347 ppm, while the lowest concentration of Pb is highest at C8 which is 0.068 ppm. Based on Figure 5.7, the highest concentration of Cu is at C10 which is 0.089 ppm, while the lowest concentration of Cu is at C6 which is 0.045 ppm. All of these graphs show that the concentration of each element from each place are uneven.

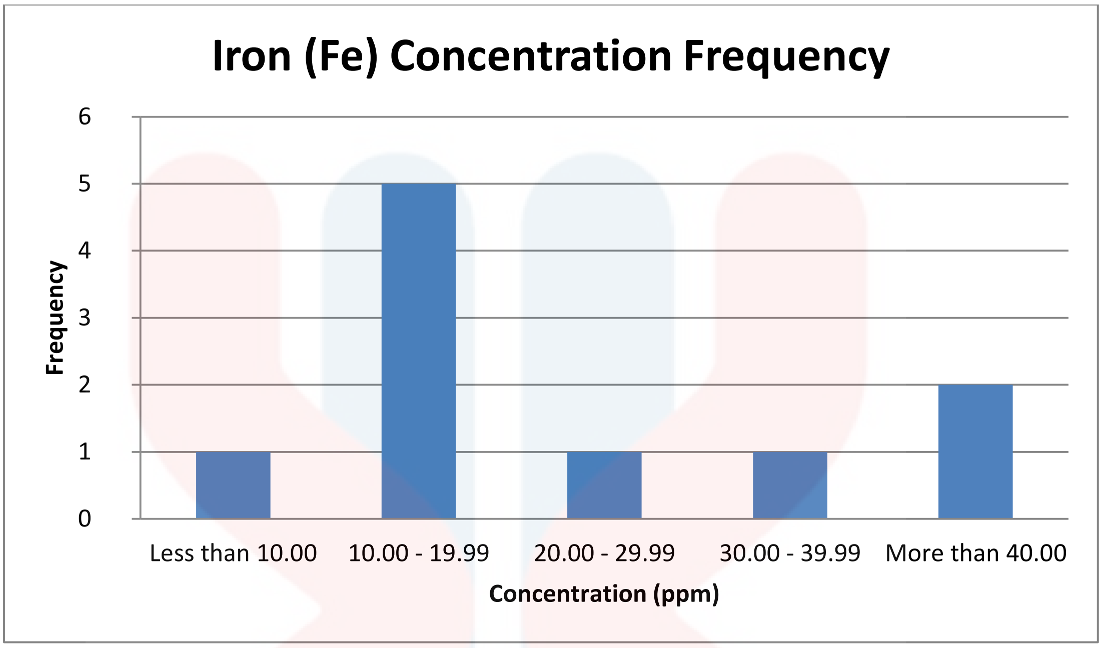

Figure 5.8: The graph of Concentration (ppm) vs Iron (Fe) Frequency

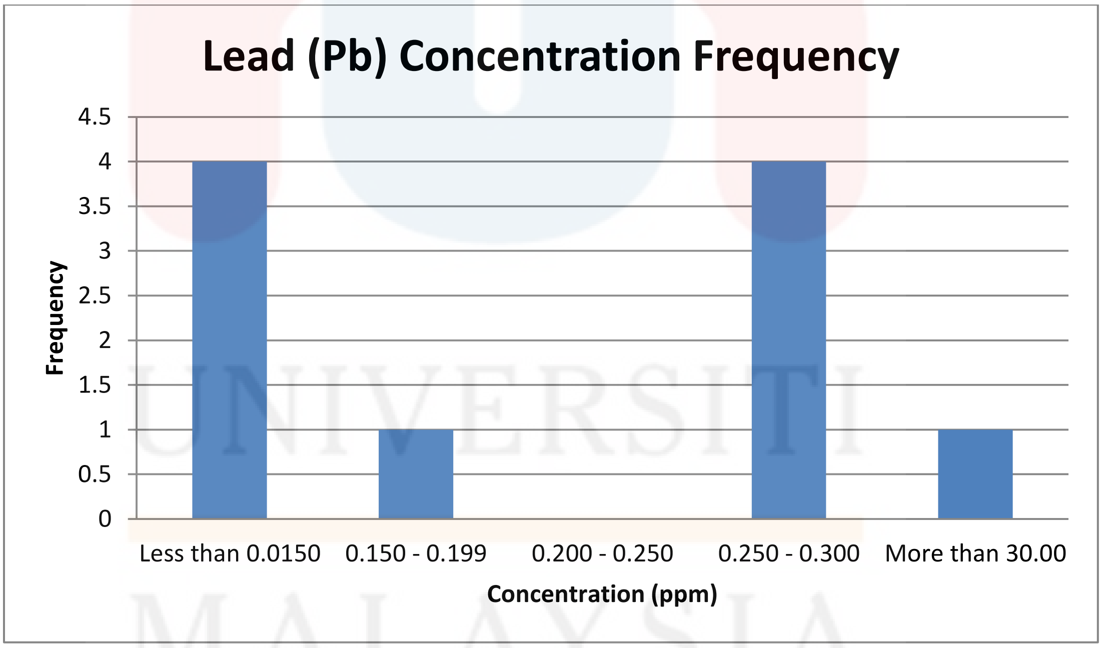

Figure 5.9: The graph of Concentration (ppm) vs Lead (Pb) Frequency.

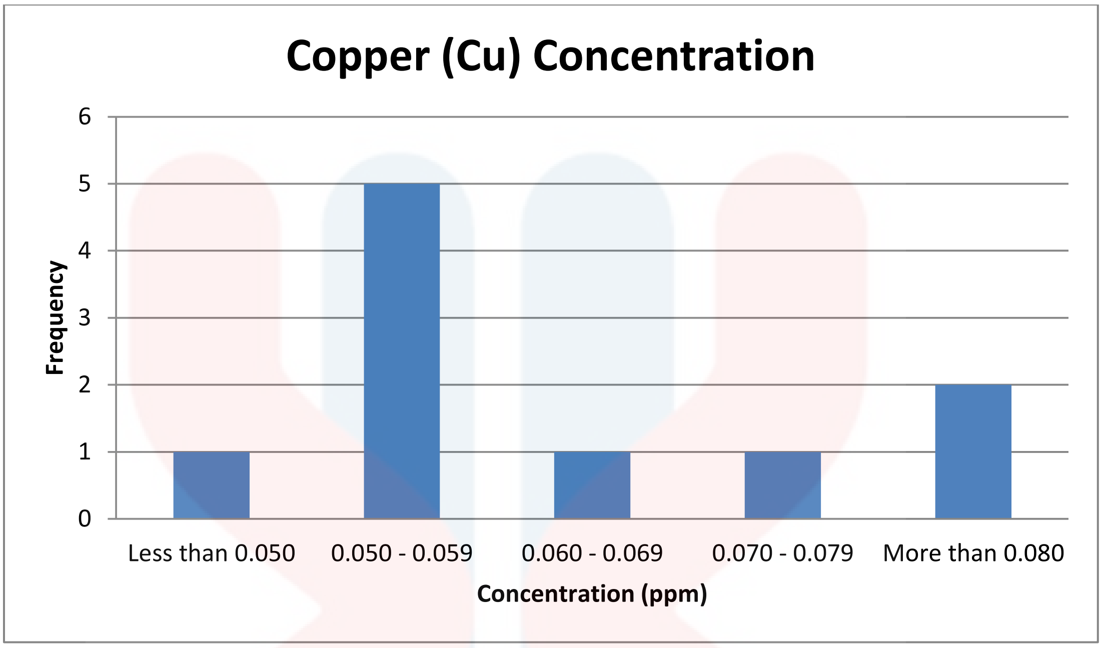

Figure 5.10: The graph of Concentration vs Copper (Cu) Frequency.

Figure 5.8 shows that iron (Fe) concentration with the highest frequency is in between 10.00 ppm and 19.99 ppm. The frequecy of iron (Fe) concentration in range of less than 10.00 ppm, 20.00 ppm to 29.99 ppm, and 30.00 ppm to 39.99 ppm are equally low and in addition, the lowest. Figure 5.9 shows that lead (Pb) concentration with highest frequency is in both range of less than 0.150 ppm and between 0.250 ppm and 0.300 ppm, while the lowest is in range between 0.200 ppm and 0.250 ppm. Figure 5.10 shows that copper (Cu) concentration with highest frequency is in range between 0.050 ppm and 0.059 ppm The frequency of copper (Cu) concentration in range of less than 0.050 ppm, 0.060 ppm to 0.069 ppm, and 0.070 ppm to 0.079 ppm are equally low and in addition, the lowest.

The purpose of these frequency graph is to show which concentration range of each element appear the most throughout the map of the study area.

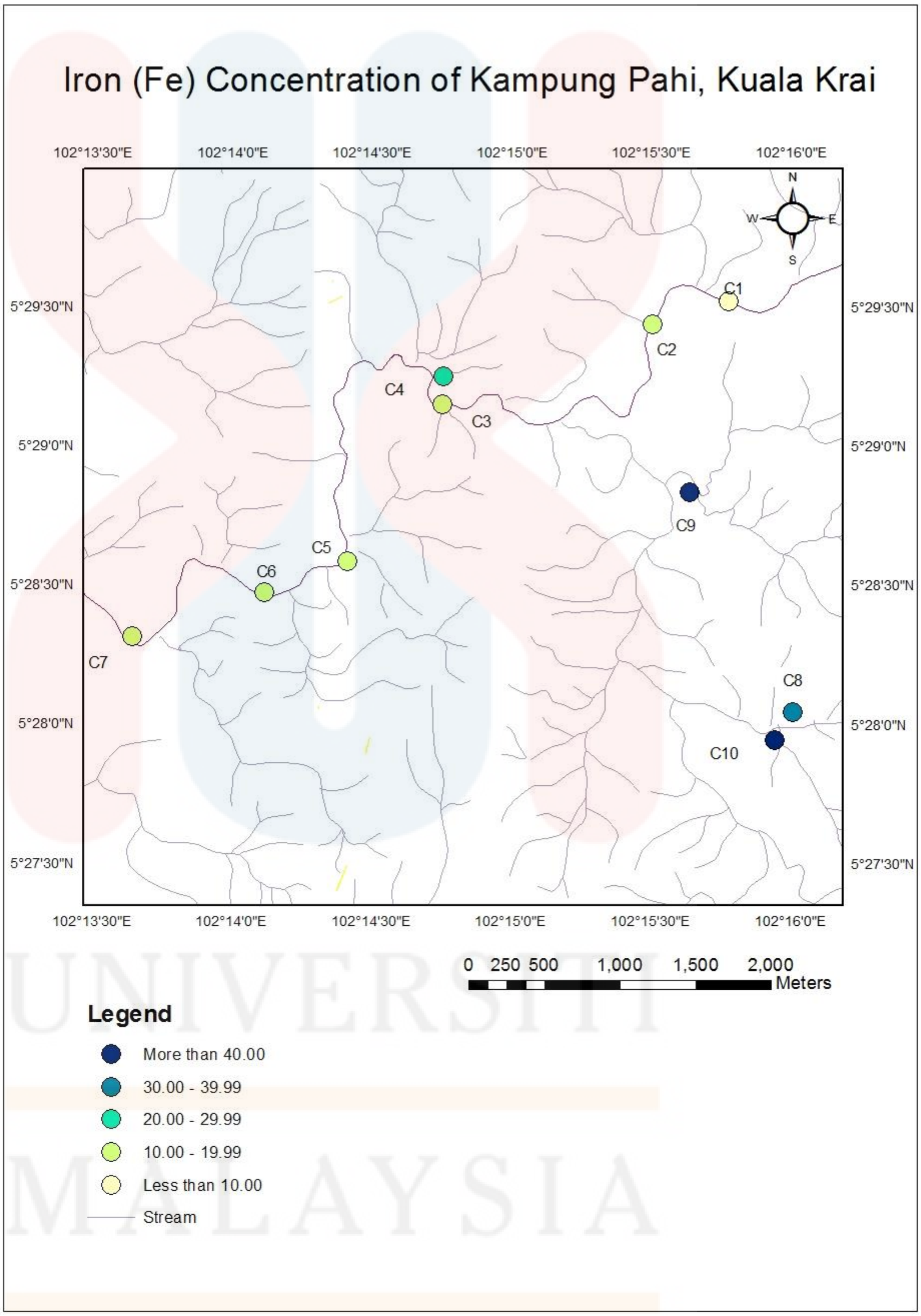

Figure 5.11: Iron (Fe) Concentration map of Kampung Pahi, Kuala Krai.

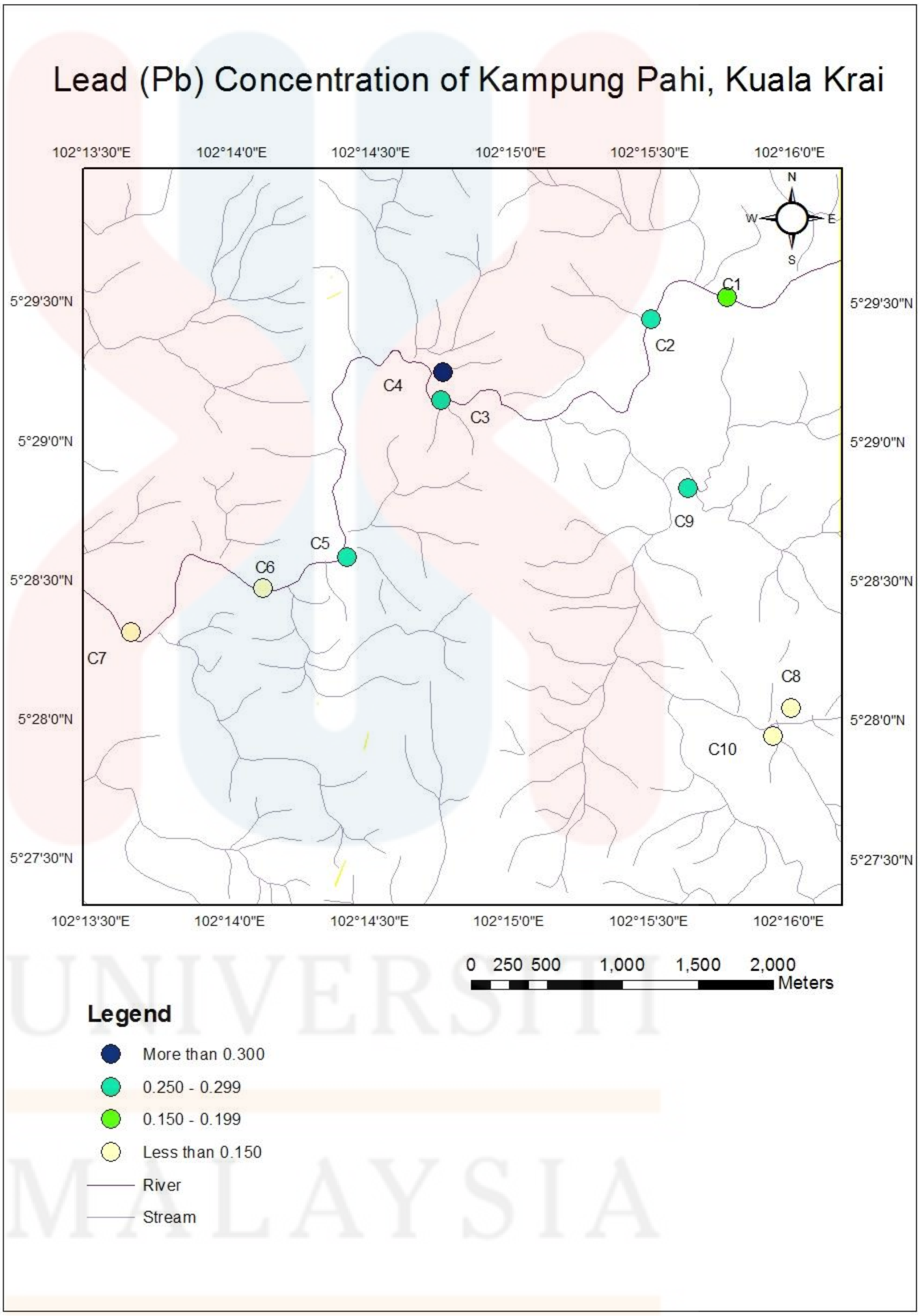

Figure 5.12: Lead (Cu) Concentration map of Kampung Pahi, Kuala Krai.

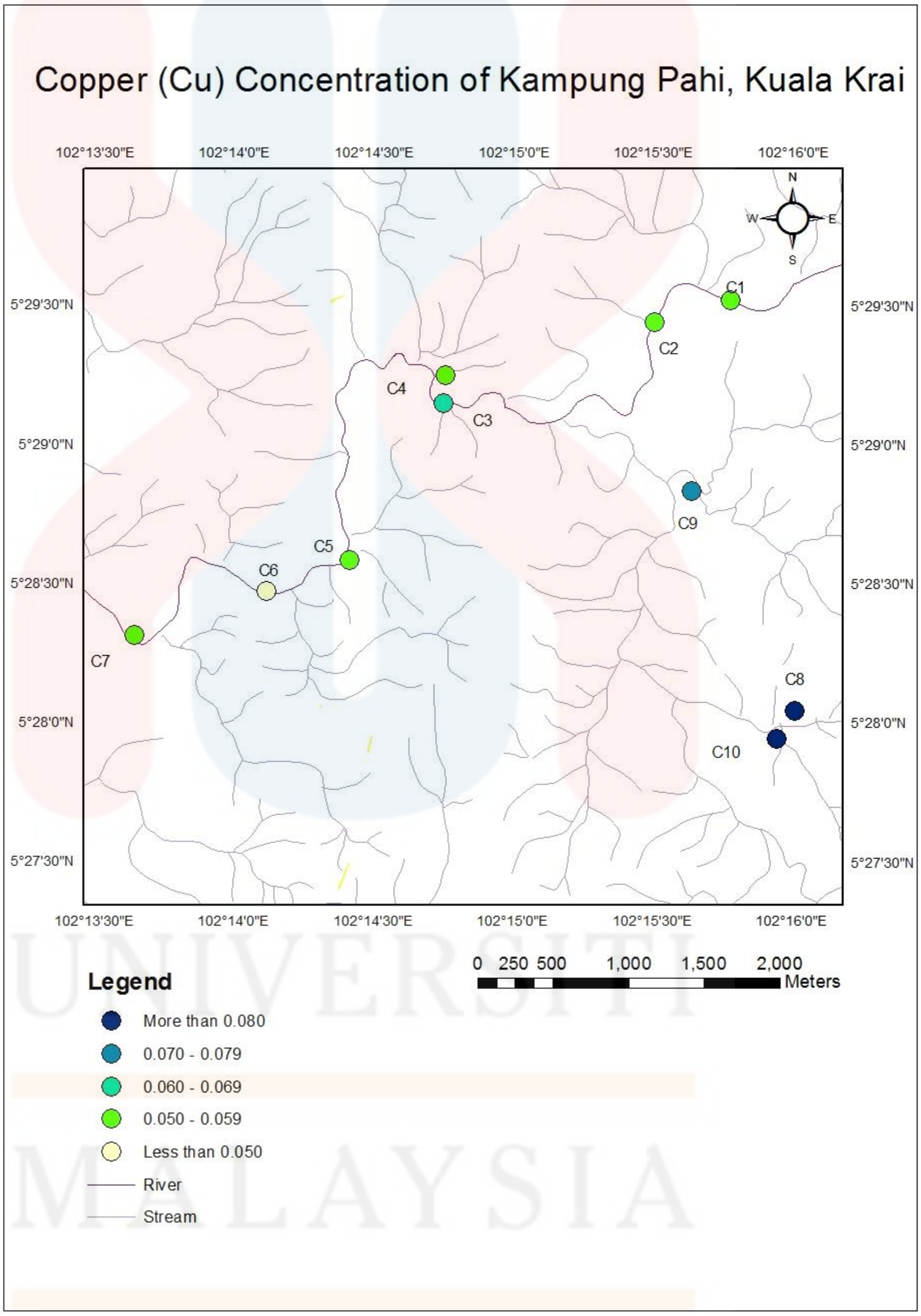

Figure 5.13: Copper (Cu) Concentration map of Kampung Pahi, Kuala Krai.

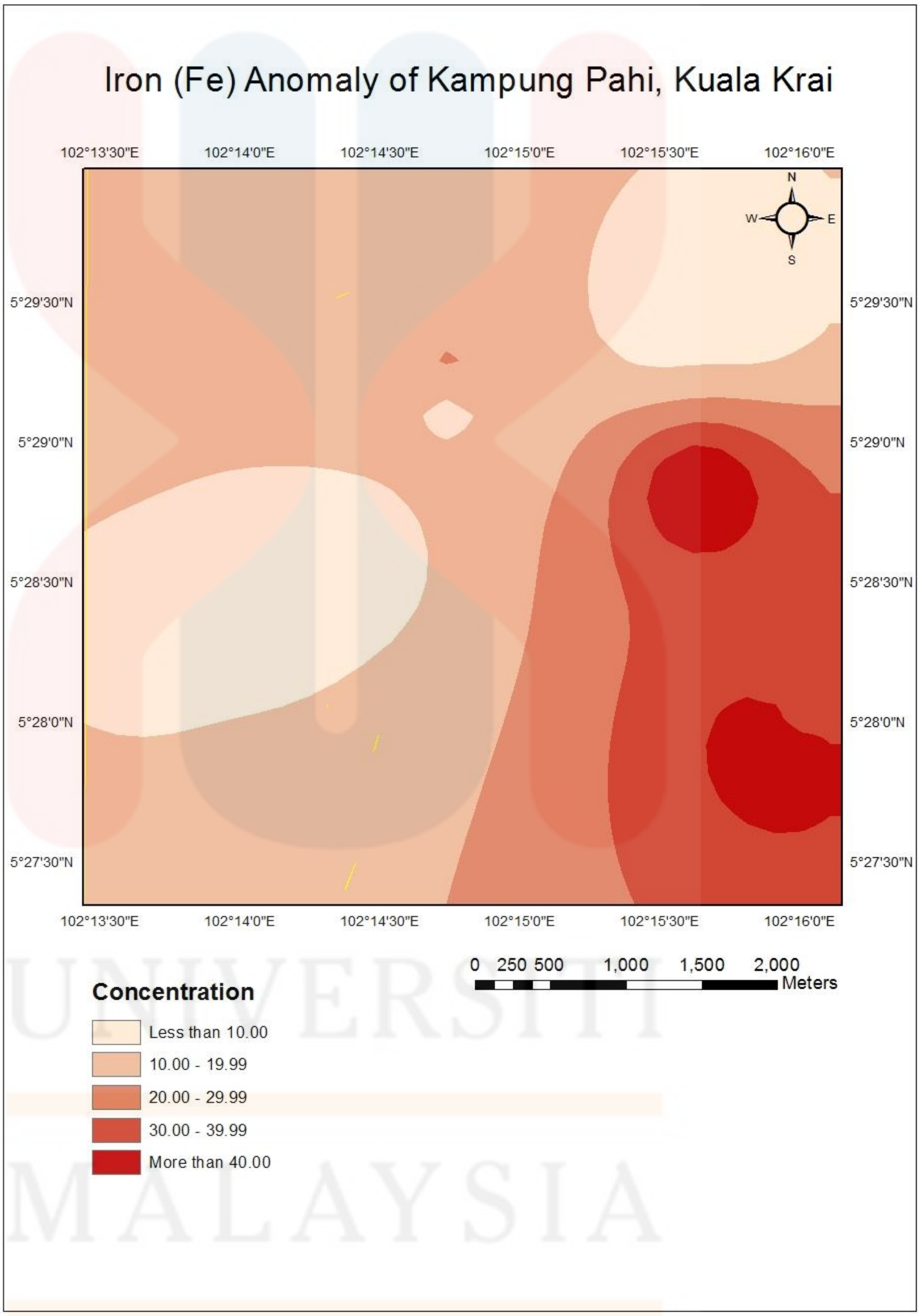

Figure 5.14: Iron (Fe) Anomaly map of Kampung Pahi, Kuala Krai.

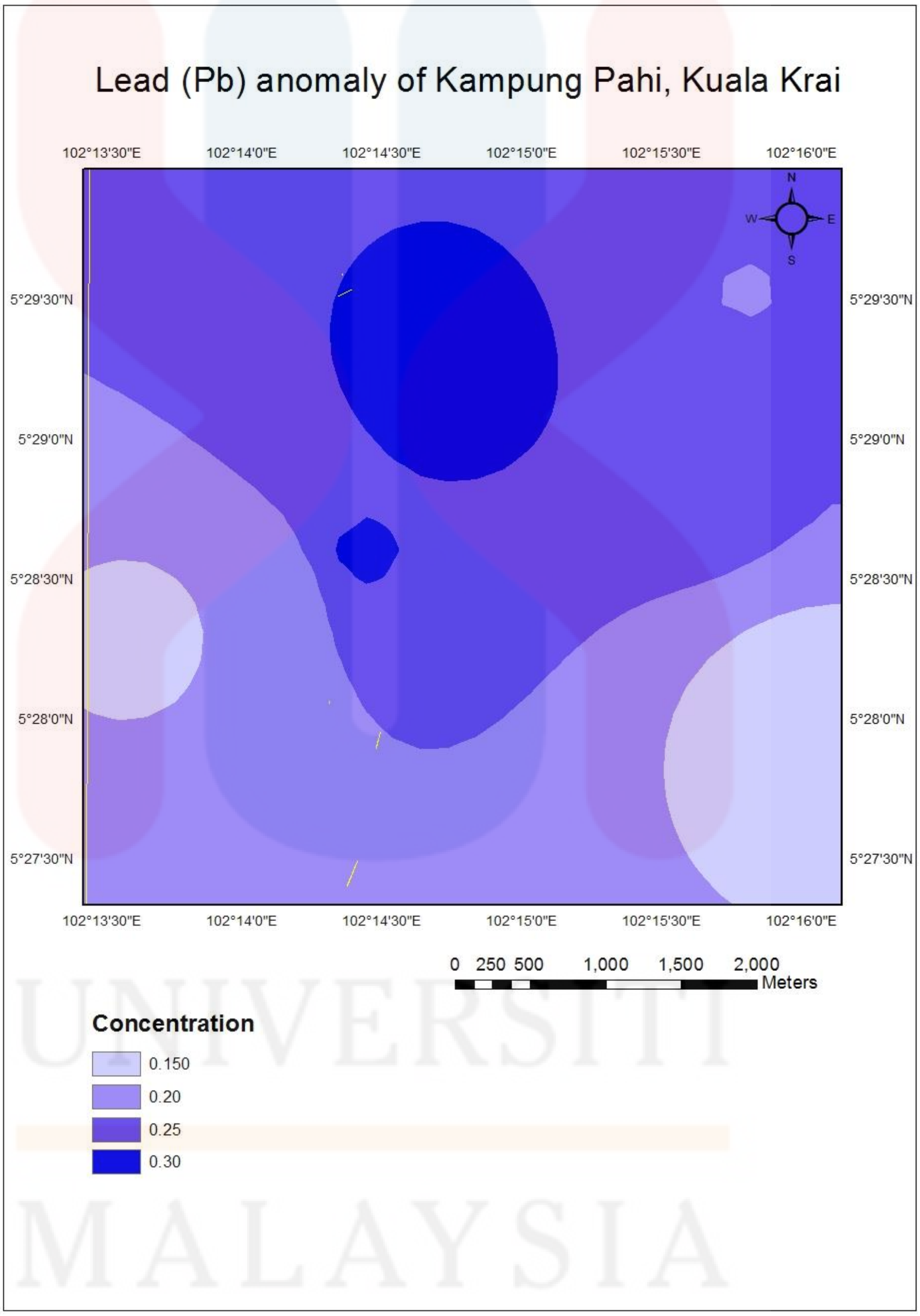

Figure 5.15: Lead (Pb) Anomaly map of Kampung Pahi, Kuala Krai.

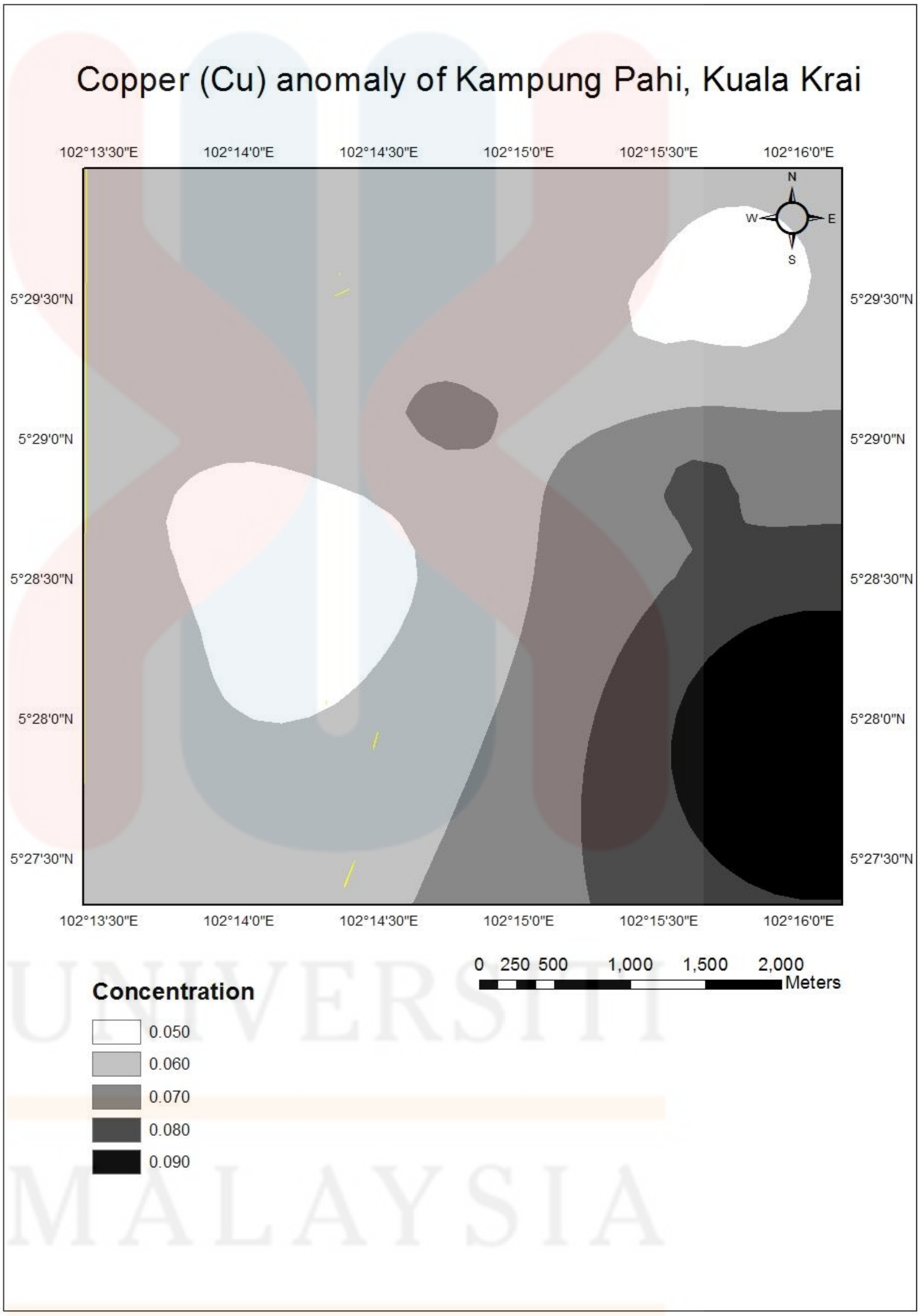

Figure 5.16: Copper (Cu) Anomaly map of Kampung Pahi, Kuala Krai.

5.6 Discussions

There were 10 sediment samples taken at random places. These samples were brought for laboratory analysis and finally the result is shown by ICP-OES. Then, the data is presented as graphs and maps. The overall result shows that iron (Fe) is generally highest in concentration out of three; in which the highest is located at sample C10 with the concentration of 60.63 ppm.

As noted in Figure 5.14 and Figure 5.16, both iron and copper are highly concentrated at south eastern of the study area. This is probably because of the presence of iron oxide in that area, although no iron ore source (example: magnetite) located. If iron ore does exist in this area, during ore genesis, iron always deposited together with some other trace elements which also including copper. This explains why the highest concentration of both iron and copper is found at the same place.

Meanwhile, lead is highly concentrated at the Central North part of the study area, in which may represent the existence of another mineral ore other than the one that of iron and copper. All of these elements seems to be deposited at the time when volcanism was occurred as discussed in Chapter 4, and then probably followed by fractional crystallization and several magmatic processes.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusions

Based on study made in Kampung Pahi, Kuala Krai, the lithology of the study area are siltstone, andesite porphyry, andesitic tuff, lapili tuff, and alluvium. Permian siltstone was first deposited in shallow marine environment and then eroded at the end of Early Triassic. By Middle to Late Triassic, volcanic eruptions occurred probably from different places at the same time, leading to the deposition of andesitic tuff and lapili tuff overlying siltstone strata. By Cretaceous, another volcanic eruption might had been occurred, leading to the formation of andesite porphyry; overlying eroded andesitic tuff and lapili tuff. Then, the study area is deformed by two secondary faults namely Belanga Fault and Pahi fault. Lastly by Quarternary, alluvium begin to deposited especially along Sungai Pahi. All of these interpretations are solely based on previous writings and studio work on GIS.

During geological mapping, almost all outcrops observed are heavily weathered. The study area is gently and moderately sloping. There was 50 strike and dip readings taken from three selected localities and analysed into Rose Diagram. Lineament of study area at the surrounding is also analysed into Rose Diagram. The concluding major force from each Rose Diagram is trending NNW and SSE.

During geochemical mapping, 10 samples were taken at random places. Iron (Fe), Lead (Pb), and Copper (Cu) do present in study area with different concentration. For Iron (Fe), the highest concentration is 60.63 ppm and the lowest is 4.834 ppm. For Lead (Pb), the highest concentrattion is 0.347 ppm and the lowest is 0.068 ppm. For Copper (Cu), the highest concentration is 0.089 pm and the lowest is 0.45 ppm.

6.2 Suggestions

There is no suggestion for geological mapping because data gained from geological mapping is quite adequate to present every geomorphology, lithology, and lithostratigraphy information about the area. Therefore, the suggestions would be highlighted on geochemical mapping part.

Despite the time limit and the availability of materials or apparatus, it is suggested that the stream sediment samples should be taken more than the one conducted in this study. This because the more stream sediment samples taken would represent more accurate geochemical anomaly data. Besides, the samples taken were mainly at the main river. To gain more accurate distribution of geochemical anomaly data, it is suggested that the samples taken at a more widespread places inside the study area. The samples also should taken more at the smaller streams.

Other than that, the samples may be taken from soil and water besides stream sediment, or for every sampling location, there must be secondary sample in order to reduce the chance of getting false results. It is also suggested the more than one method of geochemical analysis used. Maybe it is not enough for ICP-OES alone, the other analysis method also may be used such as AAS and XRF; in order to achieve more accurate geochemical data.

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