Geology Geology and Fault Analysis of Kampung Tualang, Kuala Krai, Kelantan

By

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ABSTRACT

This research is done in Kampung Tualang in Kuala Krai district, Kelantan. Study area is located at coordinate latitude of 102°10' 20''E to 102°13' 00''E while 05° 31' 30''N to 05° 28' 20''N. it is conducted to generate a geological map of area Kampung Tualang, Kuala Krai with a specific given area of 25km^2 and also to make a detail observation and analysing the study of general geology and fault analysis by studying the lineament, foliation, joint and fault analysis. The method used is geological mapping identifying the type of rocks, geological structure, contacts of rock layers and taking the reading of strike and dip. Then, the raw data taken from the site shall use the method GIS software, rose diagram software and stereonet. There are four type of rocks which are schist, mudstone, ignimbrite and breccia. Only two are interbedded which are schist interbedded with mudstone. From the result, there are two major fault that's been identified which are Tualang fault and Lebir fault. The first deformation major fault line is North (N) to South (S) and the second deformation is North West (NW) to South East (SE).

Geologi Umum dan Analisis Sesaran Kampung Tualang, Kuala Krai, Kelantan

ABSTRAK

Kajian ini dijalankan di Kampung Tualang di daerah Kuala Krai, Kelantan. Kawasan kajian terletak pada koordinat latitud 102 ° 10 '20"E hingga 102 ° 13' 00"E dan 05 ° 31 '30 "N hingga 05 ° 28' 20" N. Ia dijalankan untuk mengeluarkan peta geologi kawasan Kampung Tualang, Kuala Krai dengan kawasan yang diberikan khusus 25km2 dan juga untuk membuat pemerhatian terperinci dan menganalisis kajian geologi umum dan analisisi dengan mengkaji linamen, foliation, kekar dan sesar. Kaedah yang digunakan adalah pemetaan geologi mengenal pasti jenis batuan, struktur geologi, mengenal lapisan batu dan mengambil bacaan mogok dan berenang. Kemudian, data dari lapangan akan berlakunya satu proses dengan menggunakan perisian kaedah GIS, meningkat perisian gambarajah dan stereonet. Terdapat empat jenis batu-batu yang syis, batu lumpur, ignimbrite dan breksia. Hanya dua adalah interbedded yang interbedded schist dengan batu lumpur. Dari hasil kajian itu, terdapat dua sesaran besar yang sudah dikenal pasti iaitu kesalahan Tualang dan kesalahan Lebir. Arah sesaran major Utara (N) ke Selatan (S) dan arah sesaran yang kedua ialah Utara Barat (NW) ke Tenggara (SE).

CHAPTER 1

INTRODUCTION

1.1 General Background

Geology is the study of earth's behaviour that covers the movement, age and dynamic. Many fields explaining the Earth under geology which includes stratigraphy, structural, hydrogeology, petrography, lithology and much more.

This study focuses on structural geology where plate tectonics is the major part of the motion and is done in three ways; convergent motion because of stress, divergent motion due to the stress put separate ways and transform motion because of sheering stress. When stress is being applied, deformation of rocks happens. Geological structures are divided into three parts which are a fault, fold and joint.

Fault are fracture zones in the crust of the earth along which gives a distance of blocks about each other, usually are long and linear. Fault is the movement of crack in earth's crust, to be called a fault it has to be two surface rubs each other by one-sided or sometimes two sided. A fault can occur from a few centimetres to hundreds of kilometres. At the kilometre scale, field mapping and seismic reflection profiles provide fault images consisting of sub-parallel fault segments (Morley and Wonganan, 2000; Iacopini and Butler, 2011; Long and Imber, 2012) and/or multi-cored faults (Faulkner et al.,2003; Agosta and Aydin, 2006). Surface exposures of carbonate-bearing faults have been used to reconstruct a picture of a fault zone structure where much of the deformation is accommodated along a fault core, tens of centimetres to metres thick, surrounded by a damage zone of fractured host rock (Agosta and Kirschner, 2003; Billi et al., 2003). Principal slip surfaces are pervasive slip surfaces that accommodate the majority of slip across the fault zone, and may be < 5 cm-thick and in some cases mm's wide (Chester and Logan, 1986). The study of the geological structure of selected region most likely for the identification and configuration of the faults, has an important roll for geohazards and other geological studies. Though faults comprise a small volume of the crust which gives influence for the fluid flow and mechanical properties of the earth's crust and is mechanism accommodating most of the elastic strain in the crust through a variety of slip behaviours (Ward, 1998; Lockner and Beeler, 2002). In this study area, Lebir fault shows a large area which can be seen through the contour lines and is being split by the main river. This Lebir fault occurred due stressed applied to a spatially heterogeneous slip fault that can be explain using through kinematic (displacement) and dynamic (stress).

1.2 Problem Statement and Justification

Not many databases on geological aspect of Kg. Tualang, Kuala Krai can be assesses and be referred in the target study area. Mostly are not updated, and this will not bring good news for future reference if something to occur. No comprehensive of data sources to generate a geological map in smaller scale is not produced only being covered in bigger scale.

1.3 Research Objective

i. To update geological map of Kampung Tualang, Kuala Krai, Kelantan (Scale 1: 25,000).

ii. To identify the fault characteristics in the study area.

iii. To determine the fault mechanism in the study area.

1.4 Study Area

The peninsular of Malaysia with a total land area of 130,268 km² in the direction of North West to South East along being controlled by the regional structures. The North East to South East structural general does influence from the main range Granite that distributes it, the backbone of the Peninsula which extends from Malaysia-Thailand border to the southern state of Negeri Sembilan. The eastern and western parts separated effectively act as the central spine of the Peninsula.

This study area covers to 5x5km which is on the scale of 1:25,000. The coordinates are from N 102° 10' 26" to N 102° 13' 02" and N 102° 11' 3" and E 05° 28' 45" to E 5° 31' 28". The mapped that generates the Lebir Fault clearly exposed in the centre of the base-map around 70 m of high along the Lebir fault and covers more than 5 km of the base map study area and approximately more than 20 km long.

The topography clearly divided the area into two parts. In the study area on the left is high latitudes around 80-120 m and on the right has low latitudes from 40-60 m. This shows that the geomorphology gives a clear evidence for the fault that occurs at different latitudes. Eastern China including craton margins, the Dabie and Yanshan orogenic belt separates two topographically, tectonically and seismically different regions (Ye *et al*., 1987). Secondly for the rainfall, it pours down from the hills to the river creating a lineament which provides an expression for a structure as this Lebir Fault.

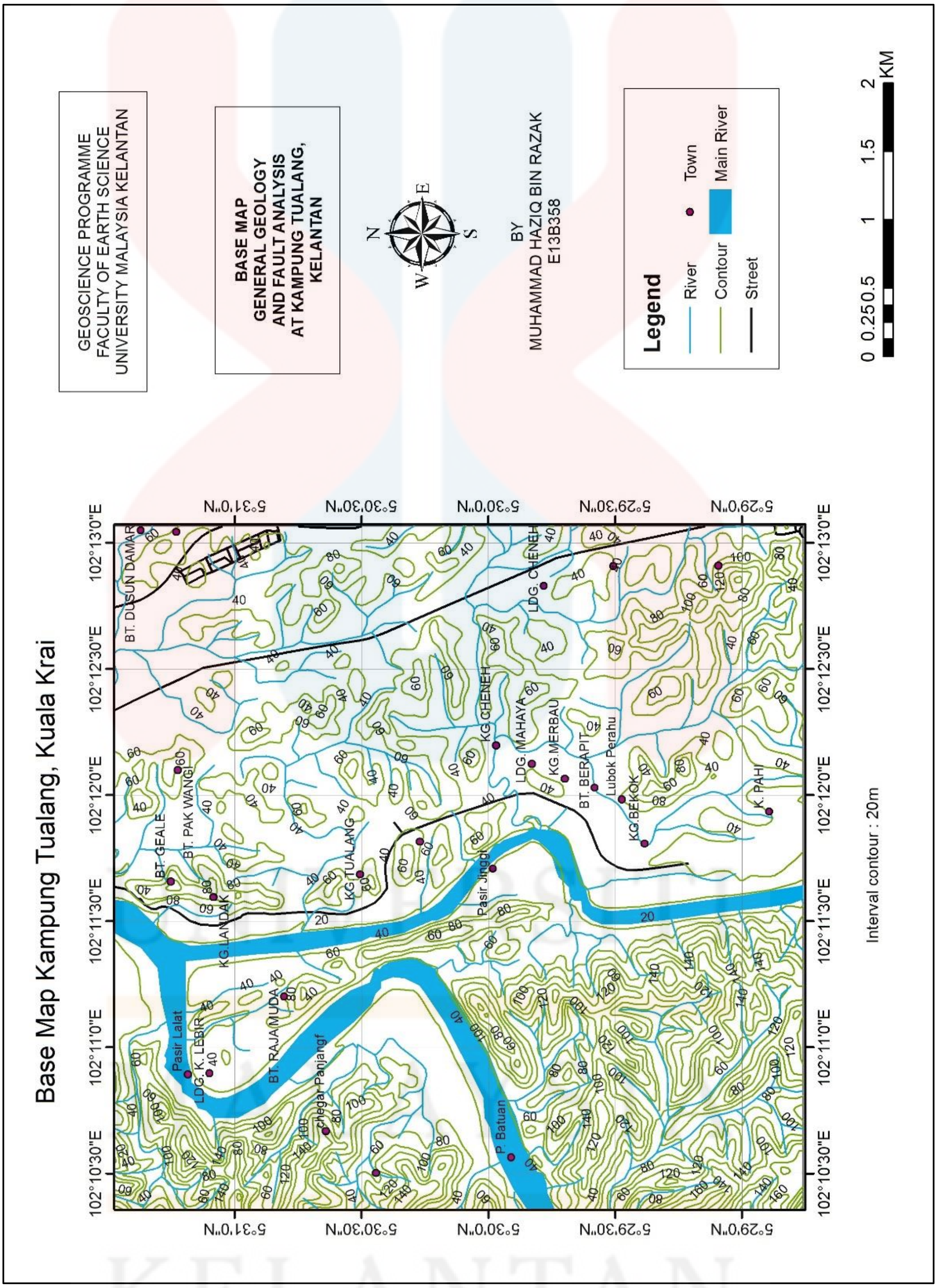


Figure 1.1: Base Map Kampung Tualang, Kuala Krai, Kelantan

1.4.1 Geography

The study of geography is essential in covering all the aspect of information regarding for the needs of the study area to get into more details and specifically.

a) People distribution

People distribution is the pattern or arrangement of how people live in a particular area. It is a measurement of the number of individuals in an area averagely. Population density is calculated by dividing the number of people by area. Population density is usually shown as the number of people by area. Population density is usually shown as the number of people by area. Population density is usually shown as the number of people per km. The below table shows the statistic of Kuala Krai, Kelantan.

Kuala Krai population according to the census of 2004 was of 163.952 people and a breakdown by race and projections are mention in Table 1.1. The population in the study area is dominated by Malay's followed by Chinese, Indian and others.

Table 1.1: People distribution

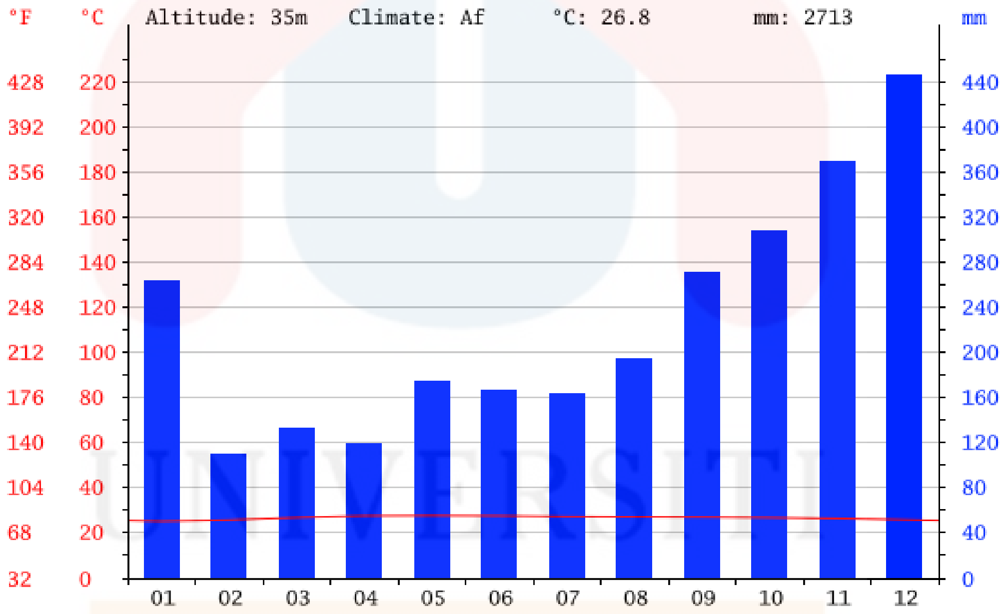
Race	**1990**	**%**	**1995**	**%**	**2000**	**%**	**2004**	**%**
Malay	92,916	91.4	110,246	90.9	130,810	90.9	149,018	90.8
Chinese	5,685	5.6	7,282	6	8,657	6	9,862	6
Indian	2,650	2.6	3,364	2.7	3,990	2.8	4,545	2.7
Others	354	0.4	121,339	0.4	463	0.3	527	0.3
Total:	101,605		121,339		143,920		163,952	

(Source: Forecasts for annual growth rate of 3.48% Information from Kelantan)

b) Rain distribution

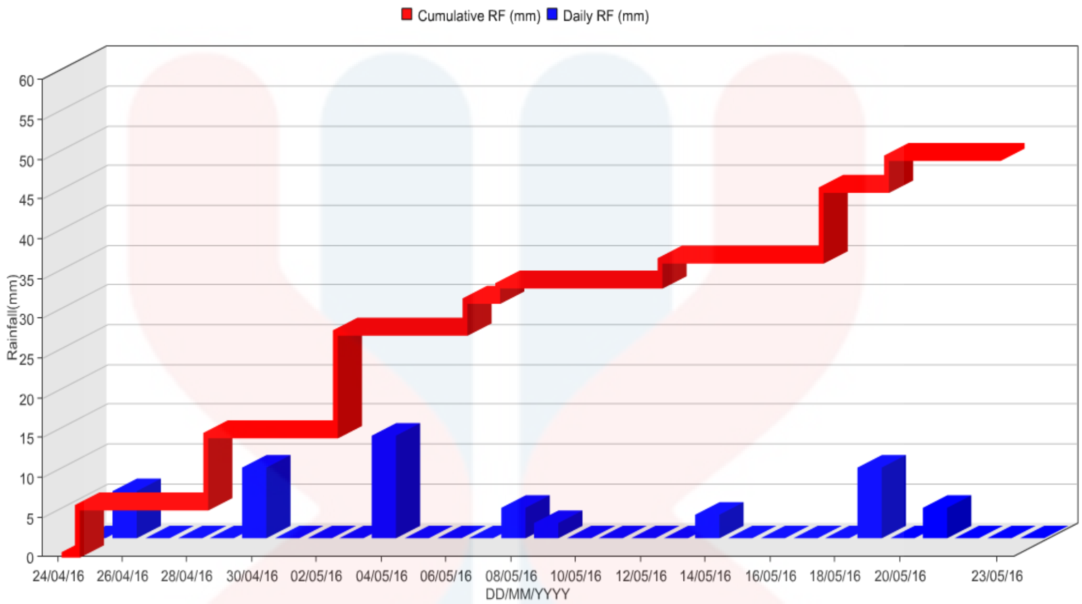
Kuala Krai's climate is relegated as tropical. Kuala Krai is a city with a consequential rainfall. Even in the driest month there is a plethora of rain.. The average annual temperature in Kuala Krai is 26.8 °C. The average annual rainfall is 2713 mm. Precipitation is the lowest in February, with an average of 109mm. Most of the precipitation here falls in December, averaging 446 mm.

Figure 1.2: Climate graph of Kuala Krai, Kelantan.



(Source: Data for the cities is based on data from the Open Street Map project)

Figure 1.3: Hydrological data for Kg. Tualang Kuala Krai, Kelantan



(Source: Department of Irrigation and Drainage Malaysia)

c) Land use

Based on the data in Department of Mineralogy and Geoscience Kelantan, in Kelantan's land, under state land status, there are about 45%, under reserved land there are 33%, under alienated there are 21% and the other status is 1%. The soil use in Kelantan under forest cover, mainly within the reserved land and verbalise land is about 60%, located in Southern Kelantan of Kuala Krai, Jeli and Gua Musang district. Within alienated land, mostly agriculture accounts for another 22% of land use. Meanwhile, by only covering less than 1% of the Kelantan, are the insignificant urban and mining lands.

Table 1.2: Category of Land Use

Category	Area (Hectare)	Percentage
Forest reserve	894,271	59.5%
Agriculture	335,660	22.3%
Urban	4,967	0.3%
Mining	3,737	0.3%
Others - grazing areas - cleared areas - river, water ways and dam reservoir areas - mangrove areas secondary jungle	263,565	17.6%
Total	1,502,200	100%

(Source: Department of Mineral and Geoscience, 2009)

d) Social economic

Social economics is about social norms, ethics and another convivial aspect that influence consumer department shapes an economy, and uses history, politics, and other gregarious sciences to examine potential results from changes to society or the economy. Kelantan's main economy are mainly from rice, rubber, paddy and fruits to be the source of them. Kuala Krai district, the people are mainly involving in the agriculture activities such as rubber tapping.

e) Road connection

The main connection system in the study area of Kg. Tualang, Kuala Krai is by roads. The highway of Kuala Krai-Machang is the main road to Kuala Krai. There is a street road that connects from Kuala Krai town to Kg. Tualang and ends at a palm oil plantation. Then it continues with a small village road for the villagers to the rubber estates for their living income.

1.5 Scope of the study

The structural geology is consisting of several parts such as fold, joint, fractures and fault which is the main analysis of this thesis. The study will be identified by using GIS software to produce a geological map. By a conducting a geological map will have a better understanding and exactly where the potential study area.

1.6 Research Importance

This study will be useful for the body knowledge for future references and other similar or related to this study context. The fault which generates earthquakes revealed how the earth deformed over time, affect sedimentation and play a major role in the transport of fluid in the earth’s crust. Moreover, by conducting this study, a geological map will be produced through the collecting of scientific information and is expected to contribute to the safety of the villagers. Also, fault zones are a weakness to engineering projects. This study is for observation and analysing for the many faults in peninsular Malaysia. An additional information faults being added and may be a reference to future guidance. The discovering and changes in these remote sensing images will clearly show the natural boundaries in regions and act as a valuable solution for the various type of applications, including geological mapping analysing of images on the earth’s surface.

1.7 Chapter’s Summary

This research will investigate about structural geology that forms at Kampung Tualang, Kuala Krai, Kelantan during the collision of two tectonic plates. This study is shown towards the structural geology, and it focuses more to fault analysis. Based on the investigation, the data that have been collected in this chapter is people distribution, rain distribution, land used, social, economic and road connection to complete this final year project. Finally, this chapter also introduces the study area that will be conducted using geological map.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The purpose of the literature review is to convey the readers the knowledge and information gathered all together that have been established on the topic and what their strengths and weakness are. A body of text to support this investigation by having researchers that have been studied in the similar field. Besides that, to conduct a survey study in a historical perspective and evaluate promising research methods. Lastly, to relate this finding to previous knowledge and gives a suggestion to further research.

2.2 Geological Review

Geological review consists the aspects of regional geology, stratigraphy, structural geology and petrography. By combining all of these, a geological information of the study area is examined and analyse in detail for further research from the past history of the earth's surface and the rocks identification on the specific study area.

2.2.1 Regional Geology and Tectonic Setting

The study area is the Lebir Fault that can be traced the zone of curvilinear lineaments along the Sungai Lebir near Manek Urai in Kelantan. The lineaments can be continuously marked and traced along the direction of south, passing the straight boundary region of the granite batholiths east of Sungai Lebir until it ends at the intersection with the Lepar Fault. The fault region area is, at least, 10 km wide, covers between Sungai Lebir and the eastern margin of the Taku Schist near Kuala Krai.

2.2.2 Stratigraphy

The relationships between rock strata, regional and local can determine the potential fault study area. By studying the age of rocks, we can understand more and better about the future or past Earth structural. Thus, the strata of growth are used commonly for deformation as well as to infer folding mechanisms to define the ages and rates. (Medwedeff, 1989; Shaw and Suppe, 1994 and 1996; Hardy et al., 1996). By demonstrate the role of stratigraphy in controlling fault related patterns of deformation, note stratigraphic variability of the complicated structure at one structural position on a map-scale. Fractures and cleavages in a stratigraphic reveal the characteristic deformation of fault processes. When complex fault patterns occur, the recognition of phases of faulting has been used as a tool to reconstruct the history of the faulting. (Angelier, 1994).

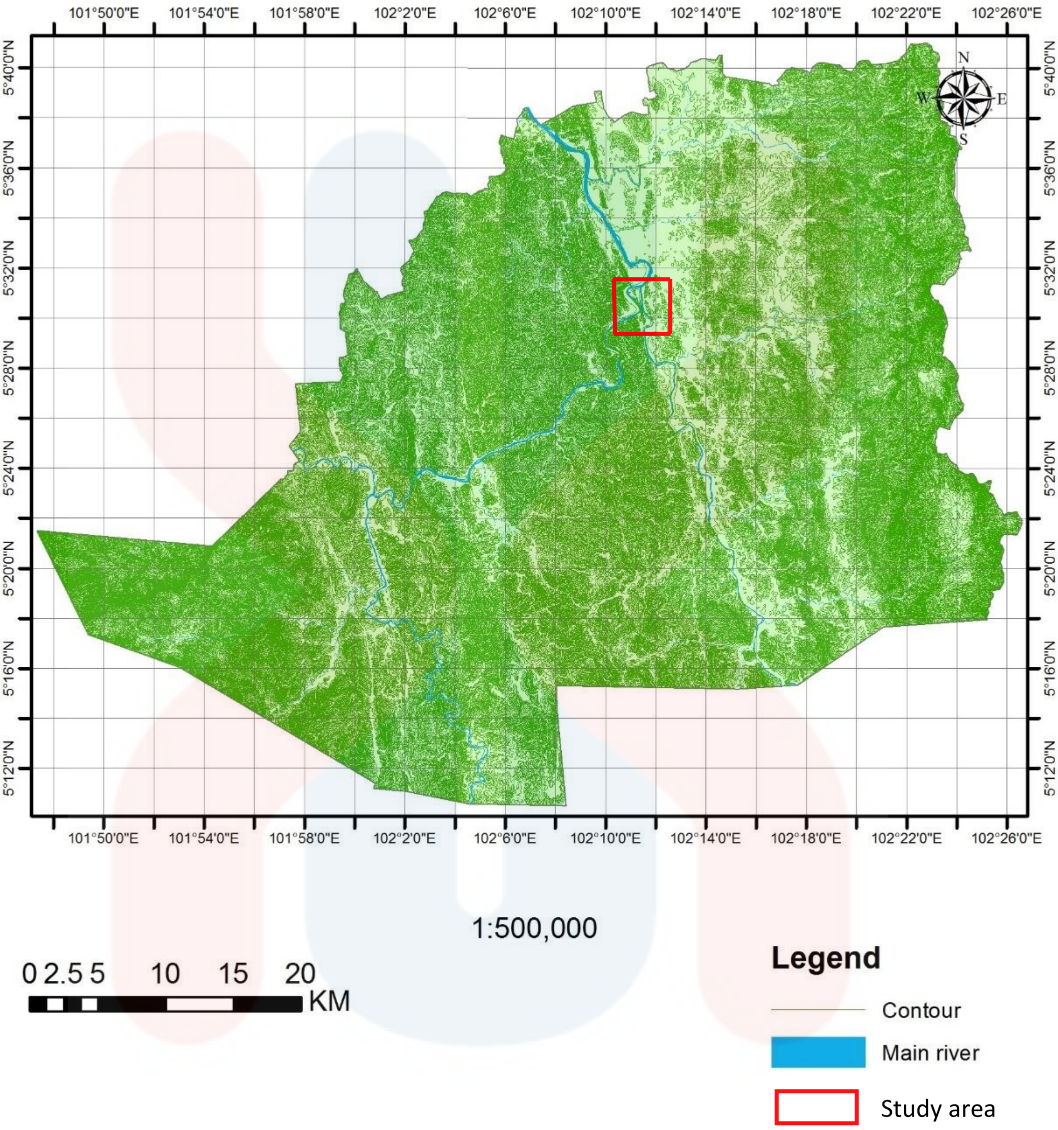


Figure 2.1: Map of Kuala Krai

2.2.3 Structural Geology

Our understanding of the physical and mechanical properties depends on the knowledge of their internal structure for fault zones. (Sibson, 1977) and of the active deformation processes occurring at seismogenic depths (Sibson, 1977). Though faults comprise a small volume of the crust, they influence the mechanical and fluid flow properties of the crust and are mechanisms for accommodating most of the elastic strain in the crust through a variety of slip-behaviors (Ward, 1998; Lockner and Beeler, 2002; Kanamori and Brodsky, 2004). This study of the distribution of the three-dimensional rock to achieve a target to enquire about the information in the rocks of the history of deformation up to present day, strain.

To understand the stress applied must observed strain and geometries. Significant events in the geologic time scale can be discovered by understanding the dynamics of stress. Over the last several years a number of inverse methods have been devised for determining regional stresses from populations of fault-slip data to (Angelier, 1979; Etchecopaer et al., 1981).

This structural geology is crucial to understand the physical and mechanical properties of rock's natural structures behaviour. The strike ridges show for the discovering of the lineament line and the geological map. It is defined by the strike of bedding and lithological regions, axial traces of folds and strike of axial planes. Because faults are the principal structures that accommodate strain during seismicity in the brittle portion of the crust, are long-lived, preserve a clear elastic deformation history and earthquakes are common, it is reasonable to conclude that exhumed fault zones preserve evidence for ancient seismicity (Sibson, 1975, 2003).

2.2.4 Petrography

Petrology is the study of origin, distribution, composition and structure of rocks. Lithology and petrography are like the same but different when handling the sample; lithology focuses on the analysing hand sample with naked eyes and when petrography is more into microscopic details. Other than that, petrography describes the mineral content and the textural relationships within the rock. The rock can be classified by gathering information during analysis when dealing with unknown types of rocks due to the fine-grained that their minerals content cannot be observe using a hand lens, the microscope is being used instead.

Determining and understanding the origin of the rock is the most important roll by analysing in thin section. This observation and analysing using thin section under microscopic will tell the same rock types, origin, structure and distribution when displacement occurs caused by the fault. The distance can be identified and can make a similarity or differentiate by comparison between two samples. Studies from meso- to microscales provide significant for exhumed fault zones insights into the deformation associated with rupture of the earthquake and the seismic cycle from the total energy budget. (Chester et al., 1993; Wibberley and Shimamoto, 2003), that contributed a more adequate understanding of structural geology. Microstructural data collected from excavated carbonate-bearing structures suggest that the bulk of seismic displacement during earthquake slip is accommodated within highly localised slip zones less than a few millimetres thick (Smith et al., 2011).

2.3 Fault Analysis

In structural geology, it studies the present rocks to discover the information about the deformational changes histories. The understanding of fault related to other structural geology by observing several patterns in the deformation (strain), and total of stress act upon the rocks. The analysing of fault is based on two aspects which are dynamic and descriptive analysis. For dynamic analysis, stress data are being collected at the site by taking strike and dip of the outcrops. For descriptive analysis, methods such as using stereonet or rose diagram is the resourceful way of extracting stress information.

CHAPTER 3

MATERIALS AND METHODOLOGY

3.1 Introduction

The materials and methods is important in conducting this study to be fully completed. With the right tools and ways of usage, the data that needs to be collected in the field studies will be fulfil. The data that being collected when conducting geological mapping is more accurate with the correct equipment and the correct method.

3.2 Preliminary Researches

This study focuses on a structural fault that occurs by collecting samples in the field, a detail observation, analysing and resulting a geological mapping using GIS software. This will help and guide to see a clear path on the going of this study.

3.3 Materials and Equipment

For materials and equipment that being use to get raw data from fieldwork are sample bag to contain sample from being exposed, compass to navigate direction on the field, a handheld Global Positioning System (GPS) to determine the coordinate of the location, a camera to capture evidence of sample and place, HCl acid, a geology hammer and a hand lens. After collecting raw data on the field comes the studio work which is placing all the raw data information into the GIS software to create a geological map.

3.4 Final Studies

Observation and analysing the outcrops behaviour and gaining the latest information. Data collection at the site is very important to ensure and determine the potential existing of this research. When gathering information which being done by conducting a geological mapping needs to observe in several cases which are geomorphology, stratigraphy, and structure. For geomorphology is an understanding to seek landscapes landform by a combined field of observations. Usually, an observation from a high latitude such as a hill is suggested to analyse the vegetation area, drainage pattern, road connection and hills/mountain.

Secondly for stratigraphy, it provides a geological history by concerning description sequences and its understanding in general time scale for this case study by observing and analysing rock layers.

Thirdly for structure, deformation which are caused by stress to make changes on the surface of the earth is being analysed and to be used in the descriptive analysis for the data to be use in this research. When doing this field studies, transverse/exposure is to be used as an assuming prediction of the total area covered. The outcrop that taking should be solid and not being considered to be transported. By using this method, it needs to be done carefully by following each contact until no trace being discovered. Every point needs to take it coordinates and measure its length also its height of outcrop and taking a sample bigger than a fist.

After obtaining all the data in the field comes the data processing, it is consisting of two which are laboratory work and studio work. Laboratory work is where sample needs to research under microscopic for optical mineralogy. Then, studio work which brings into the processing of geological map using GIS software by plotting every data and methods which relate in this study case. After, data are being analysed to avoid error and mistake for a better result. Lastly, when all the flow of this research is being done correctly, writing a report about all these discoveries is a must for future reference.

3.4.1 Geological Mapping

Geomorphology: observation and measurement of the offset rock bodies and topographic features from high latitude.

Lithology: samples are taken bigger than a hand fist, analyse rock type and take measurement of the outcrop that discovered. Get the differences of the rock bodies.

Transverse method: mark target points and take coordinates to extend to make a region area types by using remote sensing (satellite imaginary)

Stratigraphy: take measurements and analyse different layers of each rock type.

Structural: observe and analyse the affects internal fault and structure behaviour, internal structure; the pattern of the fracture, looking into the faults paralleled by other fractures by the assumption that the fault causes fault-parallel fractures to form.

Geometry method: planar features; bedding planes, foliation plane, fold axial planes, fault planes and linear features.

3.5 Laboratory Investigations (Data Processing)

In this part of the study, the data collected will be divided into two parts which are studio work and laboratory work.

3.51 Studio work

This studio work is being done by software which being called ArcGIS. This software is a geographic information system (GIS) for the use of working related to maps with geographical information. The main purpose of this software is to create and generate a map at the end by analysing and discovering new information to plot into the database. The things that including are streets, rivers, villages and contour line. Thus, the base map and geological information for the site can be generated in this section. Furthermore, rose diagram and stereonet also being used from the collection of data for this studio work.

3.52 Laboratory work

The optical mineralogy is shown in this laboratory work by cutting a small piece from the rock sample to be observed under a microscopic. This thin section is being arranged to examine the minerals in the rock sample for its optical properties. The work of this part is to show the evolution and origin of the parent rock.

3.6 Data Analyses and Interpretations

Basically fault has many classifications which is dip-slip fault; net slip parallel to dip direction of fault plane, strike-slip fault; net slip parallel to strike direction of fault plane, oblique-slip fault; net slip at some acute angle to strike and dip of fault plane, normal fault; dip-slip fault in which hanging wall moves up relative to footwall, reverse fault; high angle and dip-slip fault which hanging wall moves up relative to footwall, thrust fault; low-angle, dip-slip fault which hanging wall moves up, strike-slip fault; hanging wall and footwall offset along strike of fault plane and oblique-slip fault.

Recognition of fault has three characteristic to be evidence to be pointed at. Firstly by intrinsic features, there are three things to look into which are cataclasis; mechanical crushing/grinding of rocks along a shear zone which uses the name of fault "breccia", broken clasts. Other than that, mylonites; foliated shear zone and is common in deep fault structures, associated with metamorphism. Moreover, slickensides; smooth offset along fault plane due to hear the polishing action. Furthermore, secondary mineralization in rock fracture turns to fluid flow such as quartz, calcite vein fillings.

Secondly, effects on stratigraphy which comes into four parts which are vertical repetition or strata; usually thrust and reverse faulting will tectonically thicken the stratigraphic sequence, error of strata; normal faults basically removes a part of the stratigraphic section which resulting unusual relations, drag folds; which gives a secondary folding in the area of the fault to secondary stress and rollover anticlines;

structures of anticline found in the normal faults where a great spot of area for oil and gas.

Lastly, tectonic of geomorphology and faulting movement; disturbing nearby environment such as erosional phenomena happen and quite narrow of crustal deformation that being boost by physical and chemical weathering, scarps of landforms; slops long fault zone result from direct offset of land surface by fault movement and is usually results in V-shaped valleys cut through the fault scarp. The landform involves drainage disruption, spring development and surfaces uplift/marine terracing.

3.7 Report Writing

A quality of a result comes from a raw data collection in the field. From chapter one; giving a general idea of this research and a clear objective also its importance of doing so, proceeding to chapter two; providing support and enhanced of confirmation evidence that being done for this study by some complete researcher’s studies and lastly producing a thesis for a documentation and statement for the body of knowledge.

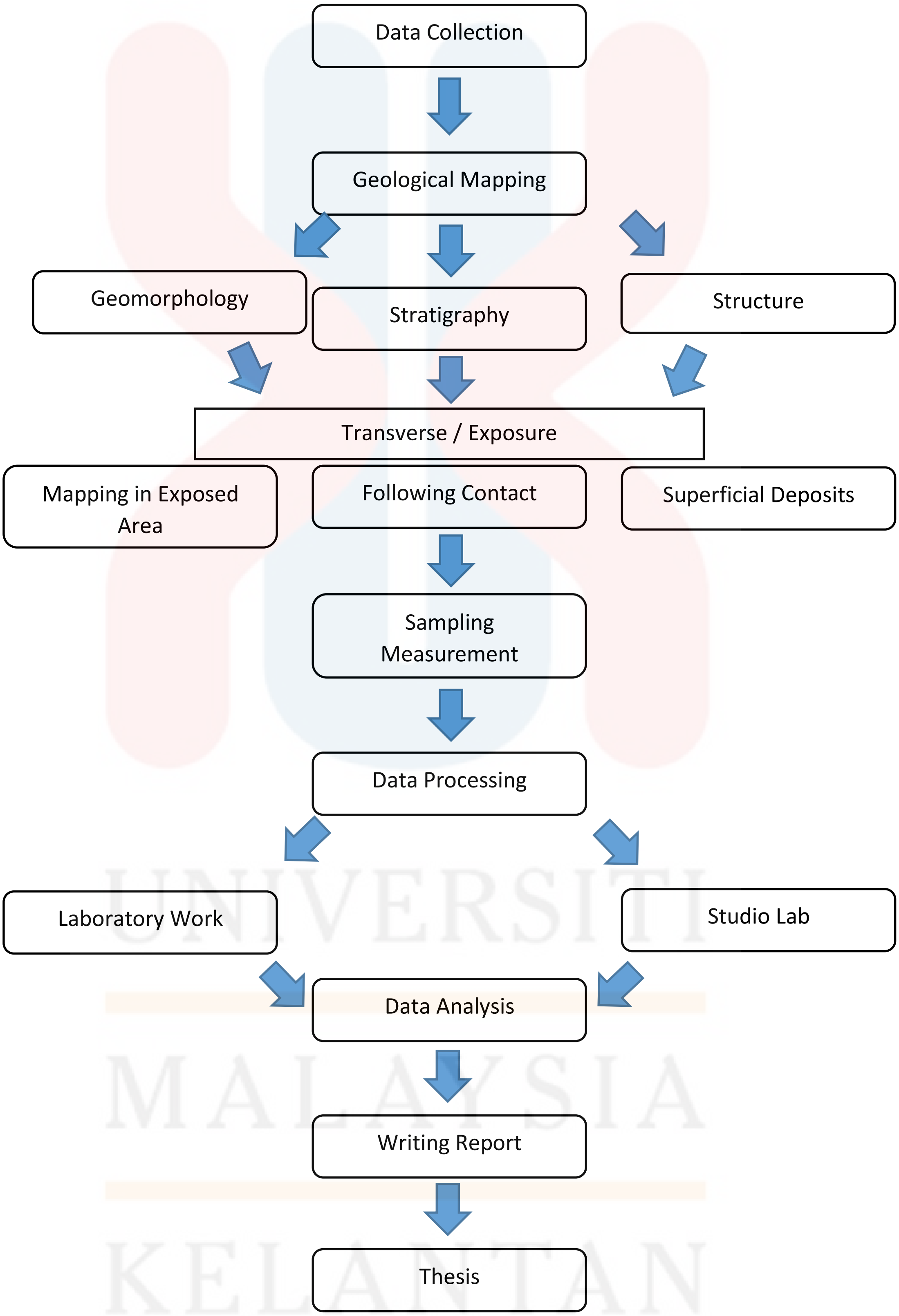


Figure 3.1: Flowchart of the research

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

The total area state of Kelantan 15,022 km² and is divided into ten districts which are Kota Bharu, Pasir Mas, Bachok, Tanah Merah, Machang, Tumpat, Gua Musang, Jeli, Pasir Puteh and Kuala Krai. Kuala Krai is located at the center to the East of the State of Kelantan. In this chapter, will study into the geological condition of the study area such as topography, drainage pattern, landform, alluvial, petrography analysis and weathering process.

4.1.1 Traverse

Traverse is important activity for geological mapping. Observation and analysing is being done in detail at the study area by identifying the locality, lithostratigraphy and structural geology. Lithology mapping by boundaries is done to determine differences between the type of rocks. Traversing is being done by walking to observe the site in detail to prevent errors of missed sight-seeing. The traverse map for this research study is shown in figure 4.1. In the study area, a total of six rock samples are taken across the study area which includes the area of rivers, plantation and also residential area. At the coordinates of N 05° 31' 08" and E 102° 12' 20.7" with the elevation of 37 meters is the rubber plantation area and the palm oil plantation is located at the coordinates of N 05° 30' 42.1" and E 102° 12' 08.7" with the elevation of 34m as shown in figure 4.2 and 4.3. Meanwhile at the area coordinate of N 05° 31' 11.3" and E 102° 12' 19.6" at the elevation of 33 meters occurs deforestation as shown in figure 4.4.

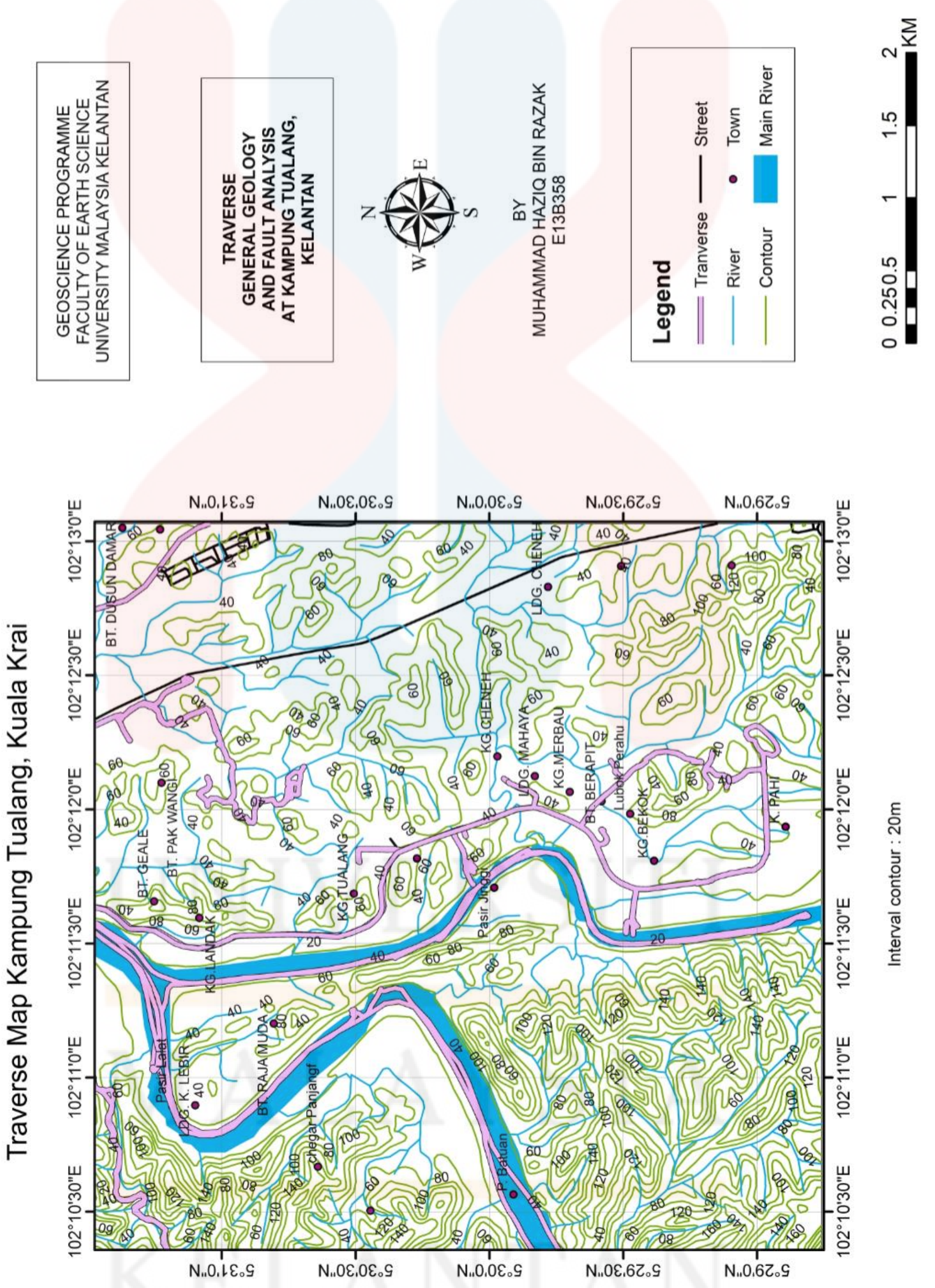


Figure 4.1: Traverse Map of Kampung Tualang, Kuala Krai

Figure 4.2: Rubber plantation area

Figure 4.3: Oil palm plantation

Figure 4.4: Deforestation

4.2 Geomorphology

Geomorphic process is influenced by tectonic, climate, ecology and human activity of an area. This chapter will discuss about topography, contour pattern, drainage pattern, landform, fluvial, hill slopes and weathering process. This chapter also describe on the general geology and geomorphology element of Kuala Krai in detail. Table 4.1 shows the relationship of absolute altitude with morphology element based on (Zuidam, 1985). The study area is in the category of lowland, lowland, lowland inland and low hills which is from below 50 meters up till 200 meters high as shown in figure 4.5, contour map.

Table 4.1: Relationship with absolute height morphology

ABSOLUTE ALTITUDE	MORPHOLOGY ELEMENT
< 50 meter	Lowland
50 meter – 100 meter	Lowland inland
100 meter – 200	Low hills
200 meter – 500 meter	Hills
500 meter – 1,500 meter	High hills
1,500 meter – 3,000 meter	Highlands
>3,000 meter	High mountains

(Source: Van Zuidam, 1985)

4.2.1 Topography

The mapped area is a rural area consisting of forest surface of land. The area is much undulated with sudden declination of steep slopes and high elevation localities of elevation pattern of contour. The lowest elevation in the study area marked of is 20 metres and the highest elevation is 160 metres above sea level. The lowest elevation area is located at the Eastern of the study area which covers more than 50% of the study area where urbanization and residential area are located. The highest elevation marked on top of the hill located at the Western part of the study area which indicates hilly areas. In the aspect of topography, a contour map and landform map was constructed as depicted in figure 4.5 and Figure 4.8.

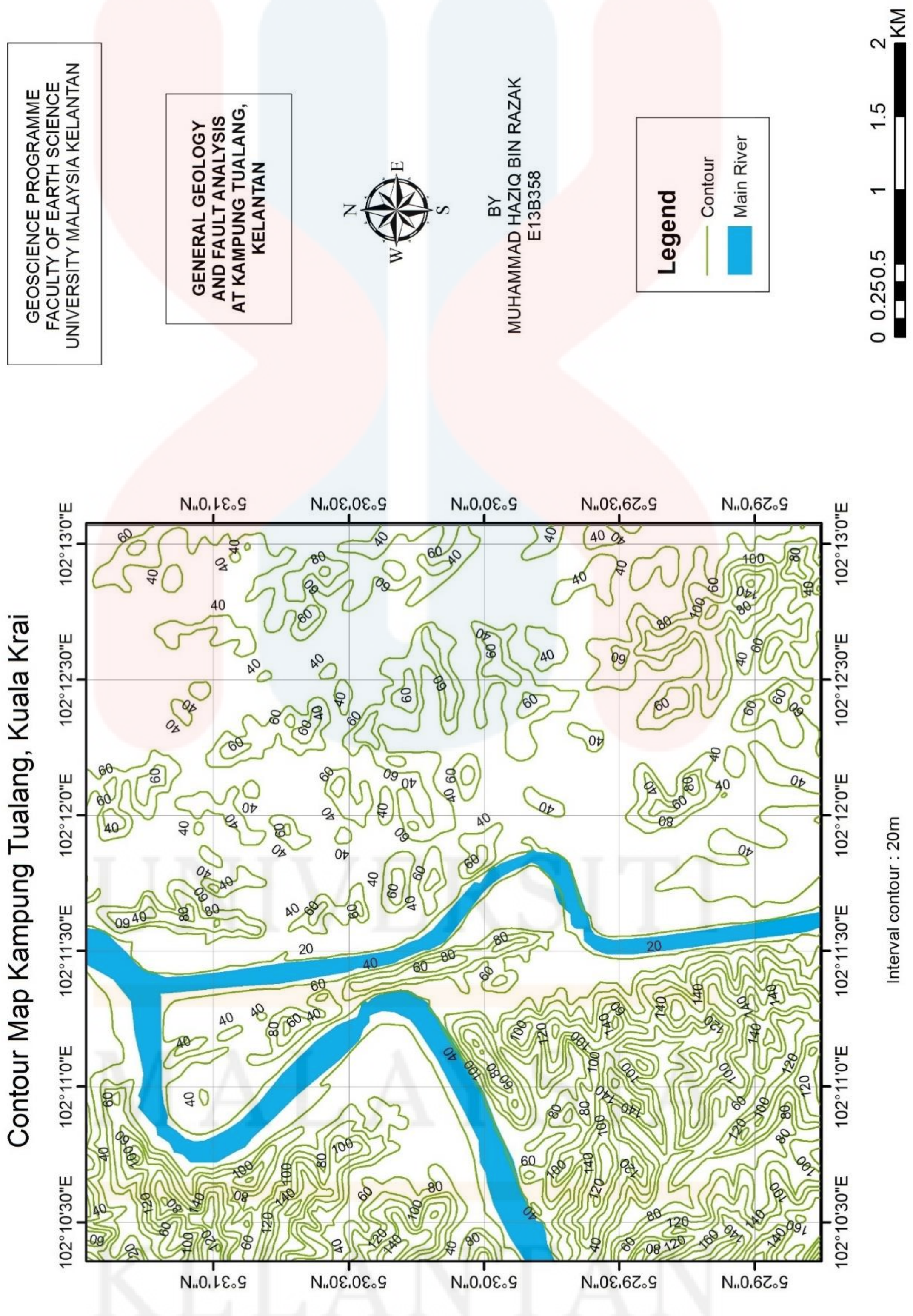


Figure 4.5: Contour Map of Kampung Tualang, Kuala Krai

4.2.2 Landform

Landform is the Earth's surface and divided into four major types which are mountains, hills, plateaus and plains. Minor landform includes buttes, canyons, valleys and basins. Tectonic plate movement causing the continent to be pushed and creating landform of hills and mountains. Landforms like valleys and canyons is being created due to the erosion of the agent of wind and water. Landform in the study area that form in the study are mostly covered by 40% of hill slopes, 45% of plains and 15% of alluvial landform. One of the obvious high slopes of hill found is as shown is shown in figure 4.6 in 100m height also for the flood plain can be seen in figure 4.7 from far distance to near distance observation.

Figure 4.6: Slope of hill

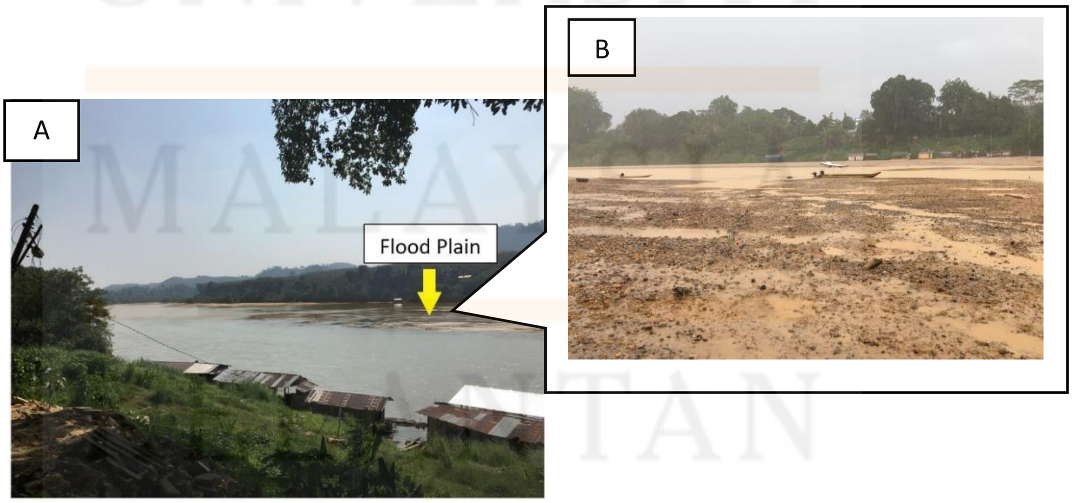


Figure 4.7: A shows by distance and B shows the zooming in of alluvial plain

Landform Map of Kampung Tualang, Kuala Krai

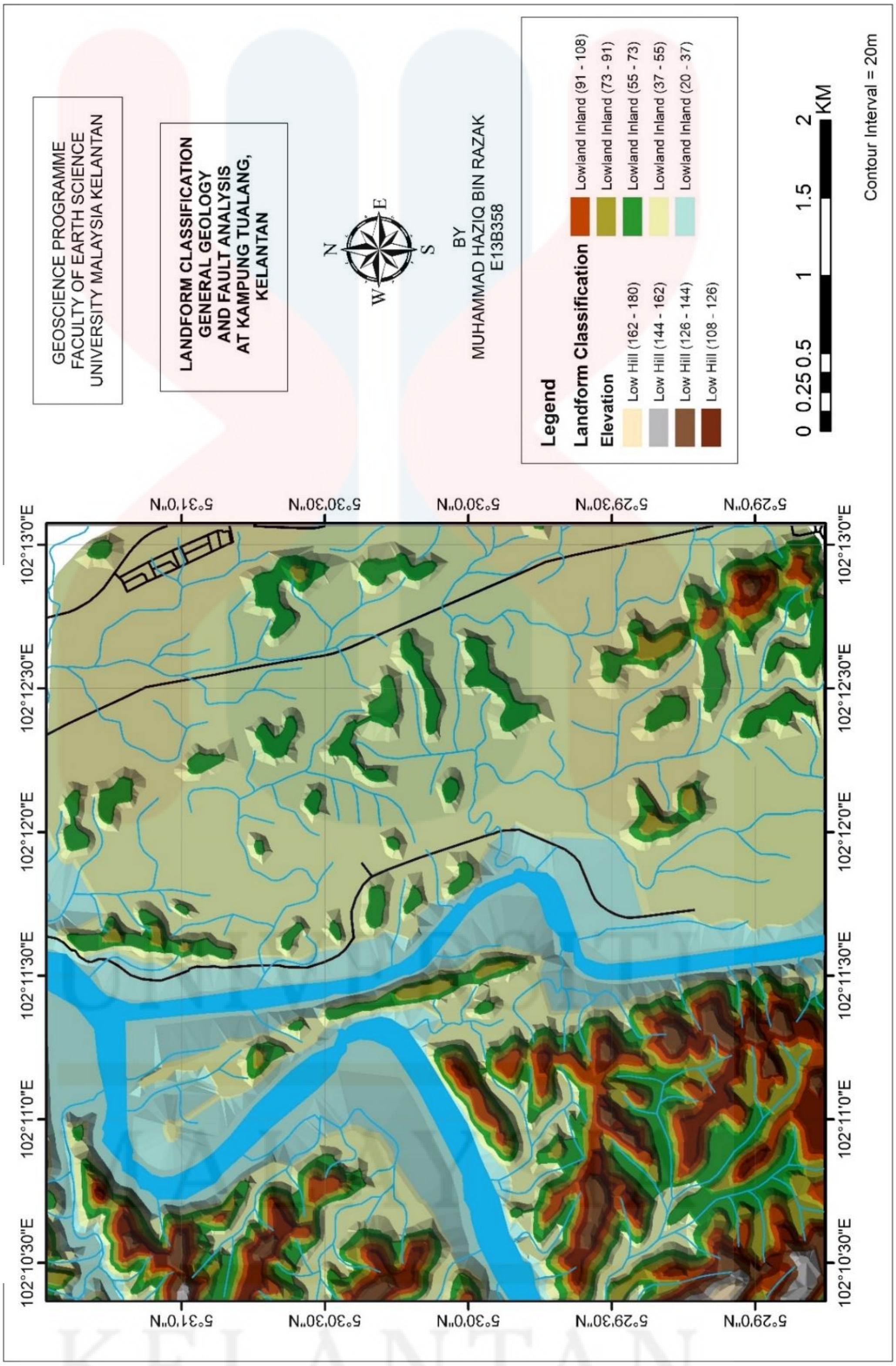


Figure 4.8: Landform Map of Kampung Tualang, Kuala Krai

4.2.3 Drainage Pattern

Sungai Galas and Sungai Lebir are the main rivers found in the study areas and is shown in Figure 4.10 and Figure 4.11. Basically, there are many types of drainage pattern such as dendritic, parallel, trellis, rectangular, angular and contorted. The types and its drawing pattern are shown in figure 4.9. Dendritic drainage pattern is the most common form of drainage pattern.

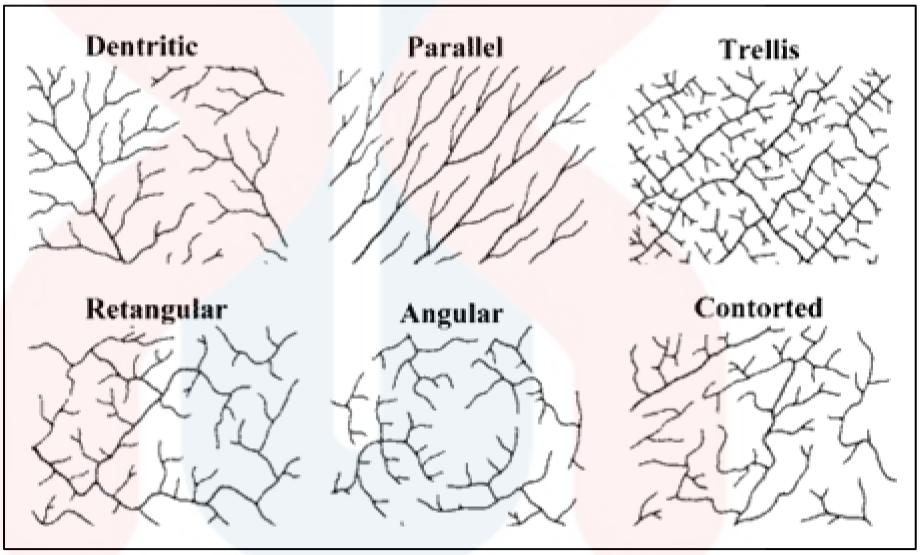


Figure 4.9: Types of drainage network pattern

(Source: Drainage network pattern)

Figure 4.14 shows a clearer visualization from a map point of view shows the drainage pattern of the study area. In the drainage pattern map of kampong Tualang, it can be said that mostly are dominant by the dendritic pattern type of river. It is also known as tributary river that has a spreading tree-like pattern with irregular branching of tributaries of many directions and at almost every single angle marked as circle in the figure. It occurs mostly in horizontal and uniformly resistant and unconsolidated sediment. It can be associated with pinnate drainage, which is also associated with steep slopes producing special dendritic pattern where tributaries are more or less parallel and joining the main river at acute angle.

Figure 4.10: Sungai Galas

Figure 4.11: Sungai Lebir

Rainfall provides water that flow downhill and joined at the valley formed between hills west of the study area near Sungai Mala and straight to the centre of the main river. All the river water in this area is influenced by the rainfall. When there is a heavy rainfall occurs, the water level increases and the current intensifies making it harder and a lot more dangerous to cross which shows in Figure 4.12. The study area also can clearly be seen of big scaled meandering river pattern system of the two main rivers of Sungai Galas and Sungai Lebir.

Figure 4.12: Heavy rainfall influence for the water level rises

Many different types of rocks were found from moderately weathered to highly weathered were transported by the river and deposited along the river of Lebir as shown in Figure 4.13.

Figure 4.13: Variations of rocks transported and deposited along the river

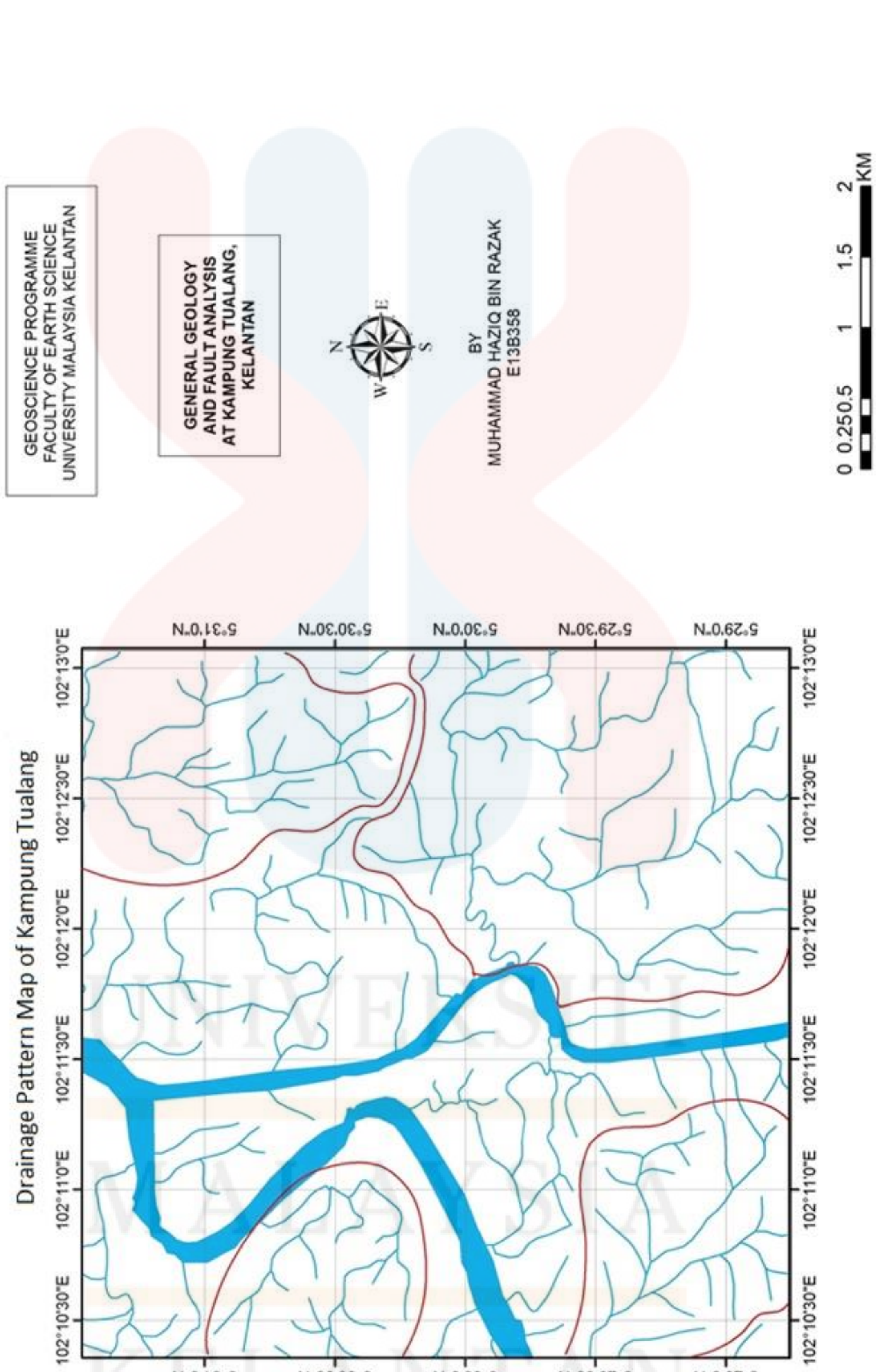


Figure 4.14: Drainage pattern map of Kampung

4.2.4 Weathering Process

Weathering process describes about the breaking down of rocks into smaller pieces. It happens when rocks are exposed on the surface of the Earth. There are three types of weathering process which are physical weathering, biological weathering and chemical weathering.

a) Physical Weathering

Physical weathering is when large rocks breaks into smaller pieces without any chemical changes. The type of physical weathering area frost wedging, abrasion, organic activity, heating and cooling (thermal expansion and contraction). The physical weathering did not change the chemical of rock. It changes the appearance of the rock. The example of physical weathering is abrasion of wind, ice, water and freeze thaw action. An example of outcrop in the study area is shown in figure 4.15 due to physical weathering and changes the shapes with the movements and being exposed.

Figure 4.15: Weathered outcrop caused by physical weathering

b) Biological Weathering

Biological weathering which is due to the activities from animals and other organisms causes the rocks to breakdown through chemical or physical processes. Some biological organisms that contribute to these processes include bacteria, plants and animals. It happens when rock is break by its roots and acids of the plants dissolving the rocks as shown in figure 4.16 where it grows along the outcrop. The accumulation of organic material helps dissolution process of minerals in rocks.

Figure 4.16: Hill covered by plant due to biological weathering

c) Chemical Weathering

Chemical weathering process is a process in which rocks are broken down or altered by chemical process. During the chemical weathering, the mineral will change to more stable form. Usually water is the main agent of chemical weathering process when oxygen and carbon dioxide starts to dissolve. Chemical weathering is a process which water is being acidic and reacts to form new mineral such as silicate to clay in minerals grains. Figure 4.17 shows the chemical weathering on the site of study area.

Figure 4.17: Chemical weathering by rain and sunlight process due to reaction

4.3 Stratigraphy

The stratigraphy describes the geometrical and age relations between the various lenses, beds and formations in geologic systems of sedimentary origin. The element of stratigraphy that deals with the information and classification of the rocks of the Earth based on their lithology and their stratigraphic relations.

4.3.1 Stratigraphic column

Stratigraphic column can produce by arrange it accordingly by the rock's age the as shown in table 4.1. This is done by using geological time scale starting the oldest from the bottom to the youngest at the top of the column.

Table 4.2: Stratigraphic column of Kampung Tualang

Era	Period	Type of Rock	Lithology
Mesozoic	Triassic	Volcanic	Ignimbrite
Paleozoic	Permian	Argillaceous	Mudstone, Breccia
	Carboniferous	Metamorphic rock	Schist

4.3.1 Lithology

a) Sample 1

Figure 4.18: Outcrop of ignimbrite

Figure 4.19: Hand specimen of ignimbrite

The hand specimen is located at N 102° 11' 3" and E 05° 31' 16" with the elevation of 24m which is at the side of the river. The colour is red brownish. It has coarse grain size.

Location : Pasir Lalat	Name of Rock: *Ignimbrite*
Rock Type **:** Igneous Rock	
Description of Mineralogy	

Composition of Mineral	***Amount (%)***	***Description of Optical Mineralogy***
Quartz / Q (4E)	**35%**	***True colour is colourless, interference colour is white to black which is in first order, shape is subhedral, low relief.***
Biotite / B (4C)	**15%**	***True colour is dark brown, interference colour is brown which is in second order, and shape is between subhedral to anhedral, medium relief. It has perfect cleavage. The angle of extinction is 90°.***
Heavy metal (4F)	**10%**	***Appears black on both plain and cross polarization.***

<u>Photo</u>

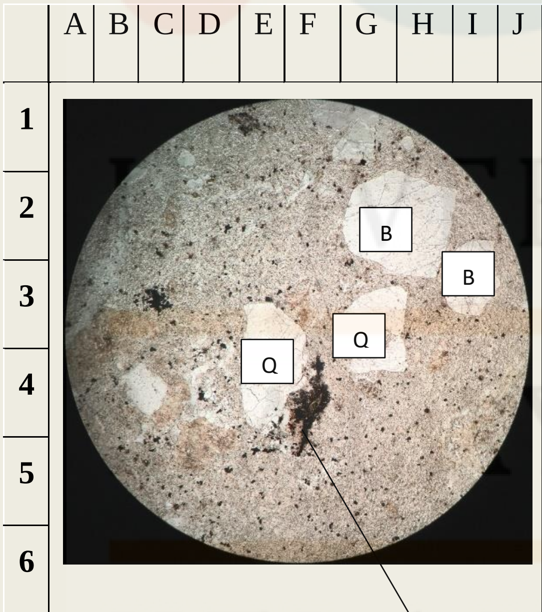


Figure 4.20: Plain Polarize (4x10)

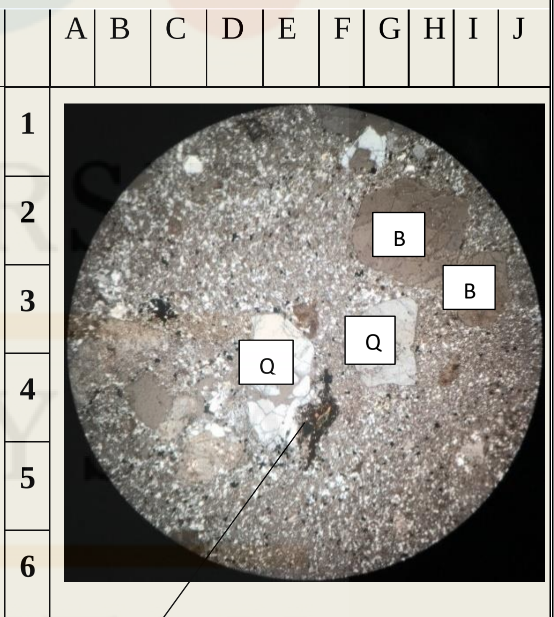


Figure 4.21: Cross Polarize (4x10)

Heavy Metal

b) Sample 2

Figure 4.22: Outcrop of mudstone

Figure 4.23: Hand specimen of mudstone

The outcrop is located at N 102° 11' 38" and N 05° 31' 26"along tualang road. The colour is light grey. It has fine grain size and soft smooth to touch by bare hands. It is the formed of silt and clay also have the same as shale but not many lamination

Location : Batu Geale	Name of Rock: *Mudstone*	
Rock Type **:** Sedimentary Rock		
Description of Mineralogy		
Composition of Mineral	***Amount (%)***	***Description of Optical Mineralogy***
Quartz / Q (3E)	**25%**	***True colour is colourless, interference colour is white to black which is in first order, shape is subhedral, low relief.***
Plagioclase / P (2I)	**15%**	***True colour is light brown, interference colour is greyish black which is in first order. The shape is between subhedral to anhedral, medium relief.***
Heavy metal (1H)	**15%**	***Appears black on both plain and cross polarization***
Groundmass (4G)	**45%**	***Also, known as matrix and a fine grain mineral***

<u>Photo</u>

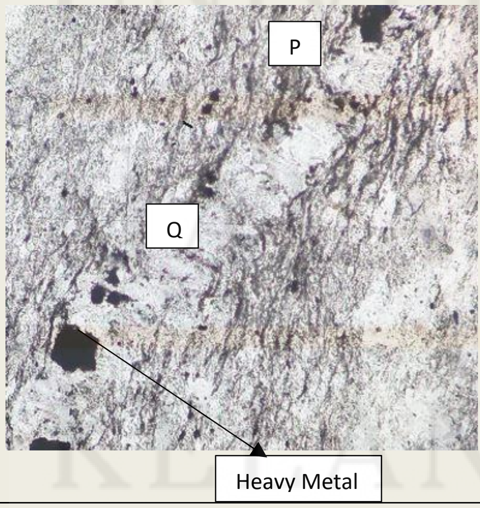


Figure 4.24: Plain Polarize (4x10)

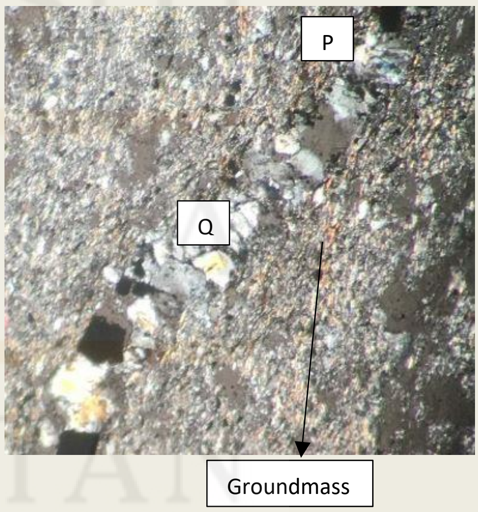


Figure 4.25: Cross Polarize (4x10)

c) Sample 3

Figure 4.26: Outcrop of breccia

Figure 4.27: Hand specimen of breccia

The outcrop is located at coordinate N 05° 30' 5" and E 102° 11' 49" at the abandoned quarry site. It is hill cutting outcrop. The hand specimen is obtained the fault line consisting fragments of angular stones. It has coarse grain sized that can be seen by naked eyes.

Location : Batu Cheneh		Name of Rock: *Breccia*
Rock Type **:** Sedimentary Rock		
Description of Mineralogy		
Composition of Mineral	***Amount (%)***	***Description of Optical Mineralogy***
Quartz (4F)	**35**	***True colour is colourless, interference colour is white to black which is in first order, shape is subhedral, low relief.***
Alkali Feldspar (2D)	**20%**	***True colour is colourless, interference colour is grey to blacish which is in first order, shape in between subhedral to anhedral, medium relief. Have twinning.***
Calcite (4B)	**10%**	***True colour is colourless, interference colour is orange to blue which is in third order, shape is anhedral, medium relief***
Groundmass (3D)	**35%**	***Also, known as matrix and a fine grain mineral***

Photo

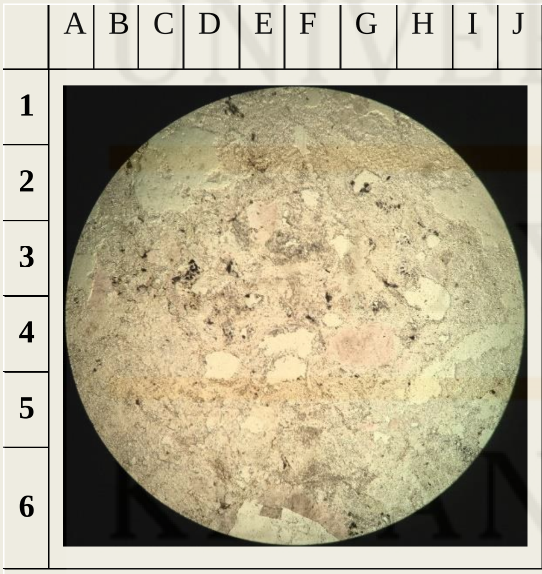


Figure 4.28: Plain Polarize (4x10)

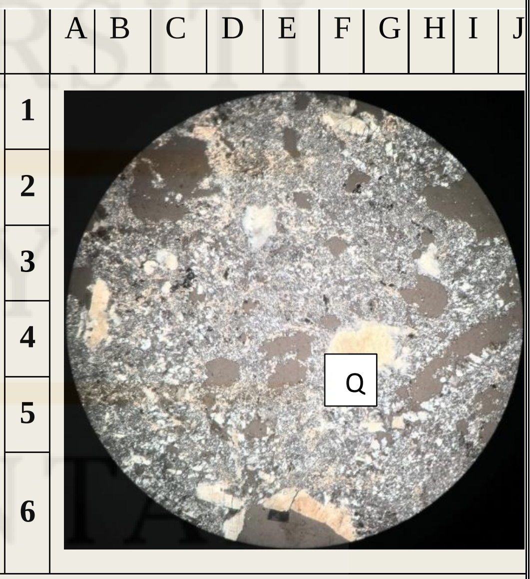


Figure 4.29: Cross Polarize (4x10)

d) Sample 4

Figure 4.30: Outcrop of schist

Figure 4.31: Hand specimen of schist

The outcrop and hand specimen is located at coordinate N 05° 29' 51" and E 102° 10' 38.5" at the elevation of 28m. The hand specimen that being taken has extremely weathered by chemical weathering due to the agent of the water from the river. The colour is dark blue. It is foliated with layers.it has fine grain size.

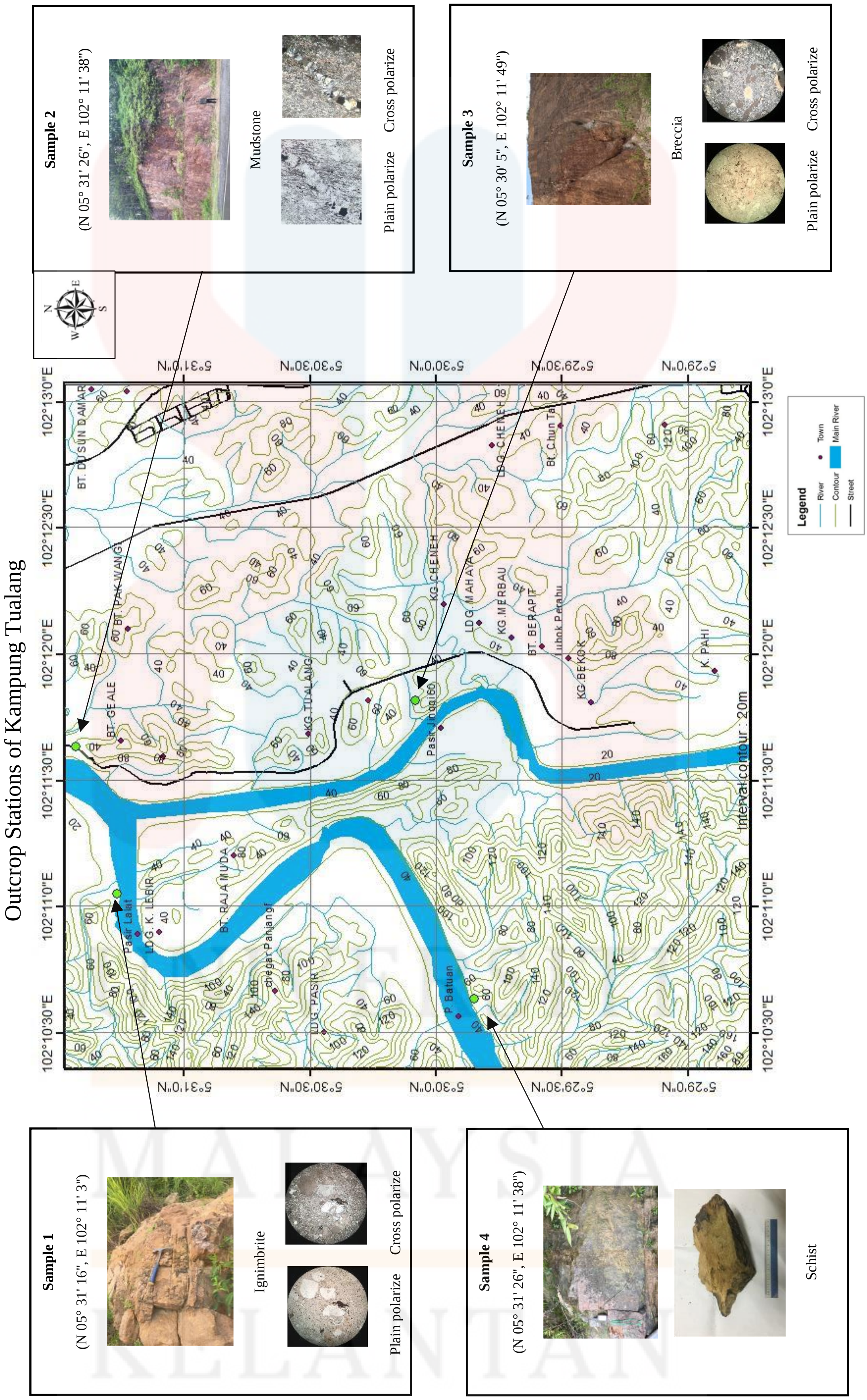


Figure 4.32: Outcrop Stations Kampung

4.4 Structural Geology

This topic will focused on the distribution of geometric and formation of the Earth’s geological structures. The movement of the tectonic plate causes shearing, intrusion, fundamental contact especially fault widespread rocks in all units.

4.4.1 Fault Analysis

It will be discussed in chapter 5.

4.4.2 Joint Analysis

Rose diagram is being done for fault where it is used by software GeoRose. To determine the direction of the forces that act on the rock and continents. The reading of extension joint is being taken from three points at the study area which are Batu Cheneh, Batu Geale and Pasir Lalat, Kuala Krai and Batu Raja Muda.

a) The first location is located at Batu Cheneh, Kuala Krai where it is an abandoned quarry site. The coordinates are N 05° 30' 5'' and E 102° 11' 48''. The elevation of the site is 43 meters and the type of outcrop is hill cutting. Figure 4.33 shows the rose diagram where the force being taken slightly from the North-northWest (NNW) and South-south East (SSE) approximately 345 to 165-degree direction line. Besides that, for the tension from the North East-east (NEE) and South West-west (SWW) approximately 260 to 75-degree direction line. The table 4.3 shows the reading of the Extension Joint and the figure 4.33 shows the rose diagram of Batu Cheneh, Kuala Krai.

Table 4.3: Reading of the Extension Joint Structure 1 (Strikes)

1	171	11	149	21	174	31	228	41	150
2	178	12	143	22	181	32	223	42	153
3	197	13	152	23	172	33	253	43	159
4	164	14	157	24	190	34	217	44	151
5	163	15	151	25	163	35	225	45	156
6	165	16	165	26	162	36	235	46	155
7	167	17	150	27	168	37	255	47	131
8	174	18	167	28	199	38	237	48	127
9	164	19	170	29	194	39	239	49	121
10	145	20	189	30	188	40	247	50	125
51	123	61	191	71	213	81	174	91	176
52	154	62	203	72	258	82	190	92	173
53	160	63	185	73	262	83	213	93	218
54	144	64	187	74	202	84	233	94	276
55	141	65	222	75	122	85	242	95	196
56	169	66	244	76	148	86	185	96	185
57	160	67	201	77	160	87	207	97	184
58	208	68	196	78	183	88	186	98	169
59	159	69	215	79	187	89	173	99	163
60	173	70	202	80	184	90	185	##	160

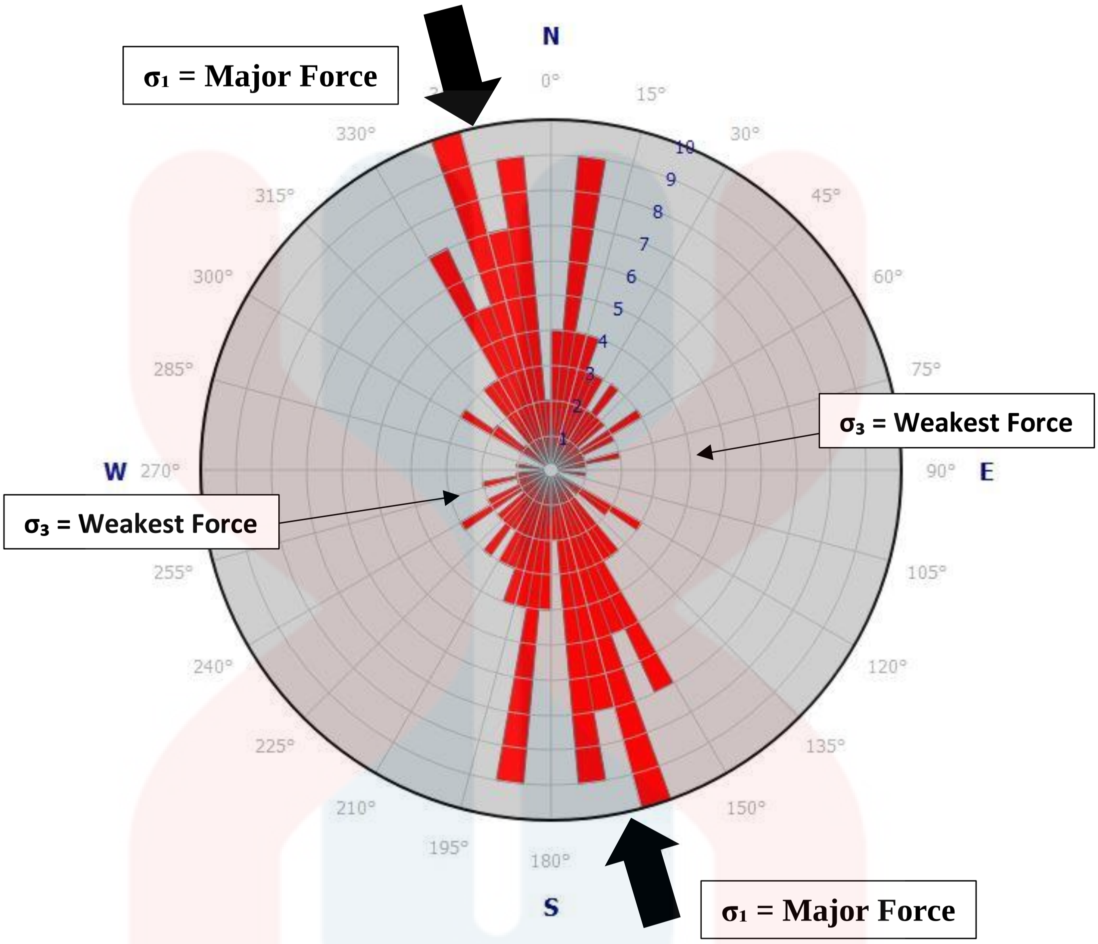


Figure 4.33: Rose Diagram of the extension joint 1 analysis of Batu Cheneh, Kuala Krai

b) The second location is located at Batu Geale, Kuala Krai. The coordinate is N 05° 31' 26.6" and E 102° 11' 37.6". The elevation of the site is 54 meters. The type of outcrop is road cutting outcrop. Figure 4.34 shows in the rose diagram showing that the force being taken from the North West-West (NWW) and South East-East (SEE) approximately 280 to 100-degree direction line. Moreover, for the tension is slightly from the North West (NW) and South East (SE) approximately 10 to 190-degree direction line. The table 4.4 shows the reading of the shear joint and the figure 4.34 shows the rose diagram of Batu Cheneh, Kuala Krai.

Table 4.4: Reading of the Shear Joint Structure 2 (Strike)

1	246	11	263	21	218	31	260	41	211
2	240	12	265	22	243	32	270	42	262
3	210	13	304	23	317	33	181	43	258
4	286	14	214	24	214	34	294	44	260
5	259	15	286	25	221	35	213	45	297
6	268	16	253	26	196	36	104	46	219
7	261	17	260	27	297	37	281	47	271
8	237	18	329	28	290	38	248	48	231
9	218	19	254	29	294	39	288	49	233
10	219	20	241	30	293	40	299	50	252
51	192	61	213	71	314	81	284	91	277
52	296	62	281	72	221	82	299	92	296
53	298	63	219	73	280	83	243	93	238
54	305	64	241	74	306	84	232	94	272
55	293	65	277	75	259	85	241	95	260
56	299	66	281	76	298	86	262	96	254
57	310	67	284	77	297	87	284	97	246
58	214	68	305	78	299	88	265	98	235
59	284	69	205	79	311	89	290	99	237
60	261	70	296	80	287	90	261	100	209

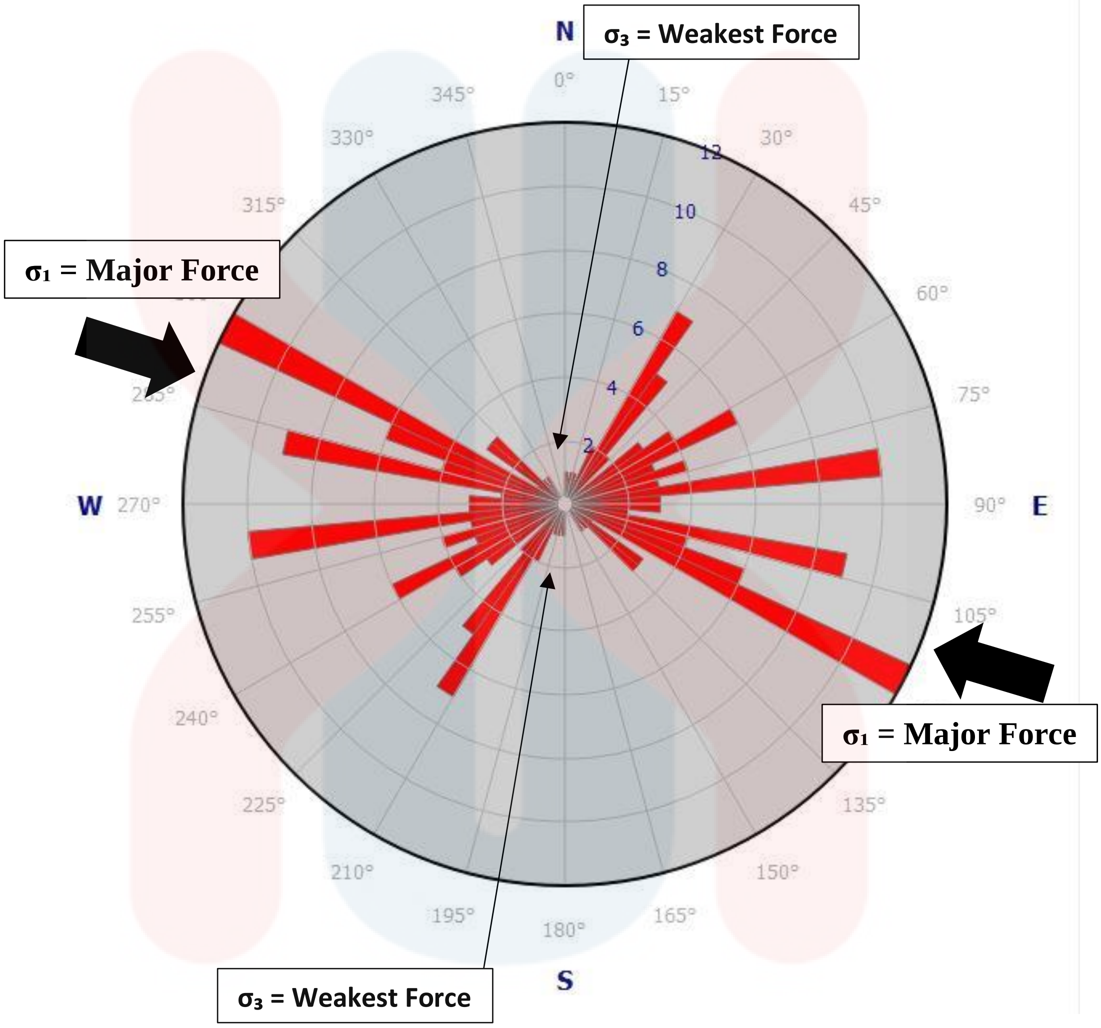


Figure 4.34: Rose Diagram of the shear joint structure 2 analysis of Batu Geale, Kuala Krai

c) Third location is located at Pasir Lalat, Kuala Krai. The coordinates are N 05° 31' 15.5" and E 102° 11' 1.8". The elevation of the site is 24 meters. The type of outcrop is natural cutting outcrop. The result shown in the rose diagram in figure 4.35 shows that the force being taken from the North West (NW) and South East (SE) approximately 15 to 195-degree direction line. Moreover, for the tension is slightly from the North West (NW) and South East (SE). The table 4.5 shows the reading of the shear joint and the figure 4.35 shows the rose diagram of Batu Cheneh, Kuala Krai.

Table 4.5: Reading of the Shear Joint Structure 3

(Strike)

1	349	11	25	21	226	31	64	41	41
2	345	12	129	22	18	32	18	42	62
3	353	13	269	23	316	33	10	43	56
4	310	14	262	24	220	34	16	44	29
5	291	15	264	25	220	35	14	45	241
6	348	16	254	26	262	36	228	46	254
7	347	17	249	27	210	37	350	47	10
8	5	18	232	28	30	38	269	48	190
9	256	19	94	29	24	39	358	49	78
10	332	20	91	30	81	40	230	50	76
51	346	61	18	71	19	81	18	91	266
52	14	62	226	72	21	82	266	92	268
53	16	63	17	73	22	83	4	93	134
54	230	64	289	74	20	84	118	94	256
55	292	65	291	75	281	85	135	95	210
56	266	66	331	76	240	86	16	96	348
57	229	67	346	77	67	87	21	97	75
58	283	68	81	78	210	88	341	98	317
59	317	69	288	79	92	89	16	99	348
60	27	70	265	80	310	90	144	100	2

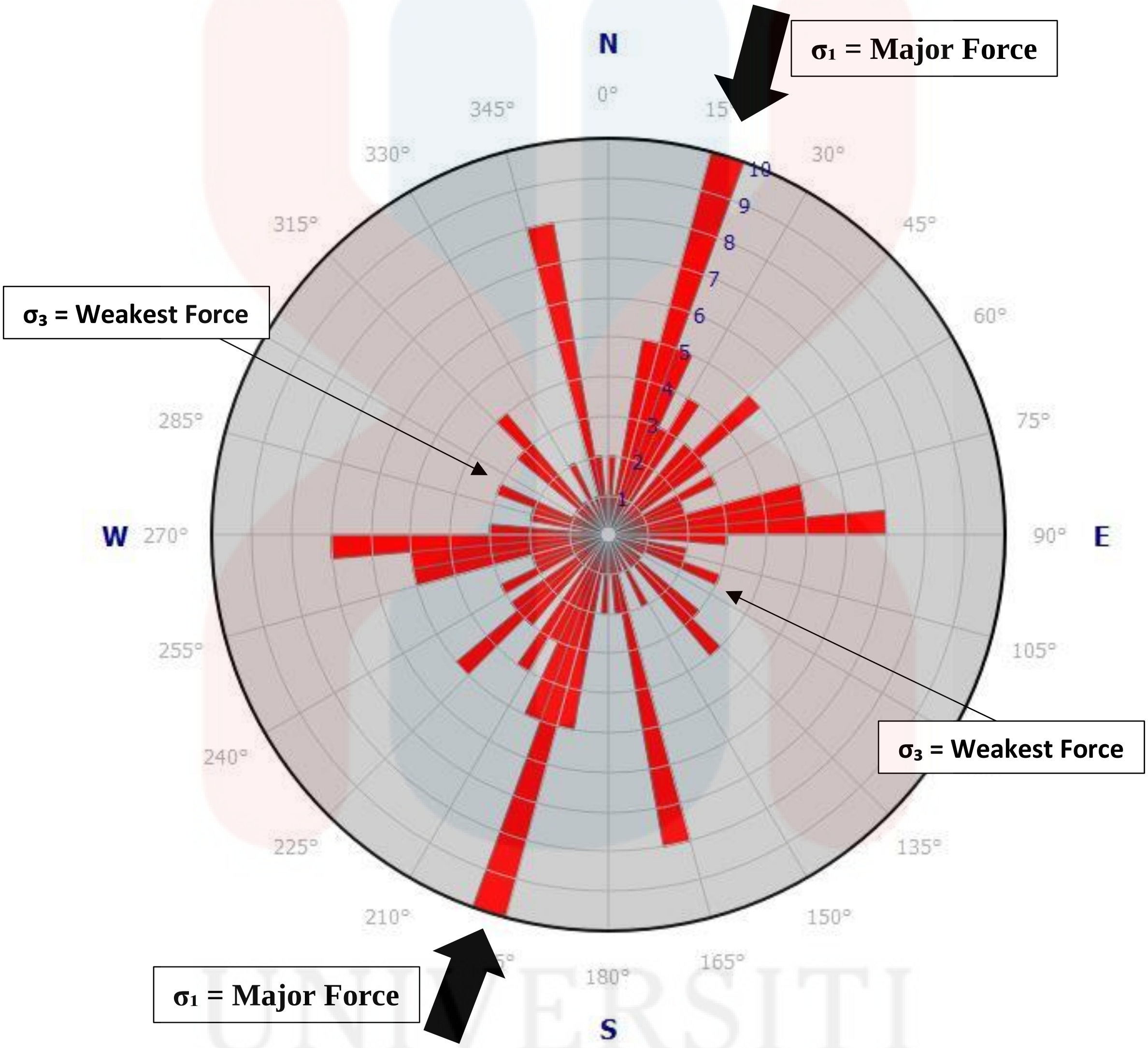


Figure 4.35: Rose Diagram of the shear joint structure 3 analysis of Pasir Lalat, Kuala Krai

d) Forth location is located at the Batu Raja Muda, Kuala Krai. The coordinates are N 05° 30' 30" and E 102° 11' 22". The type of hill cutting outcrop, an abandoned quarry site. The result shown in the rose diagram in figure 4.36 shows that the force being taken from the North West (NW) and South East (SE) approximately 120 to 295-degree direction line. Moreover, for the tension is from the North East (NE) and South West (SW) approximately 30 to 210-degree direction line. The table 4.6 shows the reading of the extension joint and the figure 4.36 shows the rose diagram of Batu Raja Muda, Kuala Krai.

Table 4.6: Reading of the Extension Joint Structure 4 (Strike)

1	72	11	48	21	31	31	72	41	92
2	75	12	40	22	62	32	61	42	106
3	36	13	162	23	101	33	126	43	121
4	93	14	127	24	173	34	349	44	127
5	353	15	343	25	90	35	353	45	76
6	154	16	110	26	189	36	36	46	46
7	110	17	22	27	65	37	20	47	128
8	148	18	42	28	71	38	24	48	333
9	172	19	27	29	55	39	34	49	26
10	36	20	17	30	76	40	122	50	146
51	160	61	113	71	76	81	101	91	65
52	33	62	84	72	51	82	123	92	101
53	122	63	112	73	93	83	125	93	108
54	127	64	92	74	230	84	133	94	151
55	356	65	88	75	193	85	134	95	132
56	48	66	168	76	31	86	112	96	101
57	122	67	215	77	116	87	35	97	113
58	128	68	145	78	95	88	15	98	103
59	91	69	187	79	36	89	64	99	119
60	96	70	70	80	48	90	84	100	154

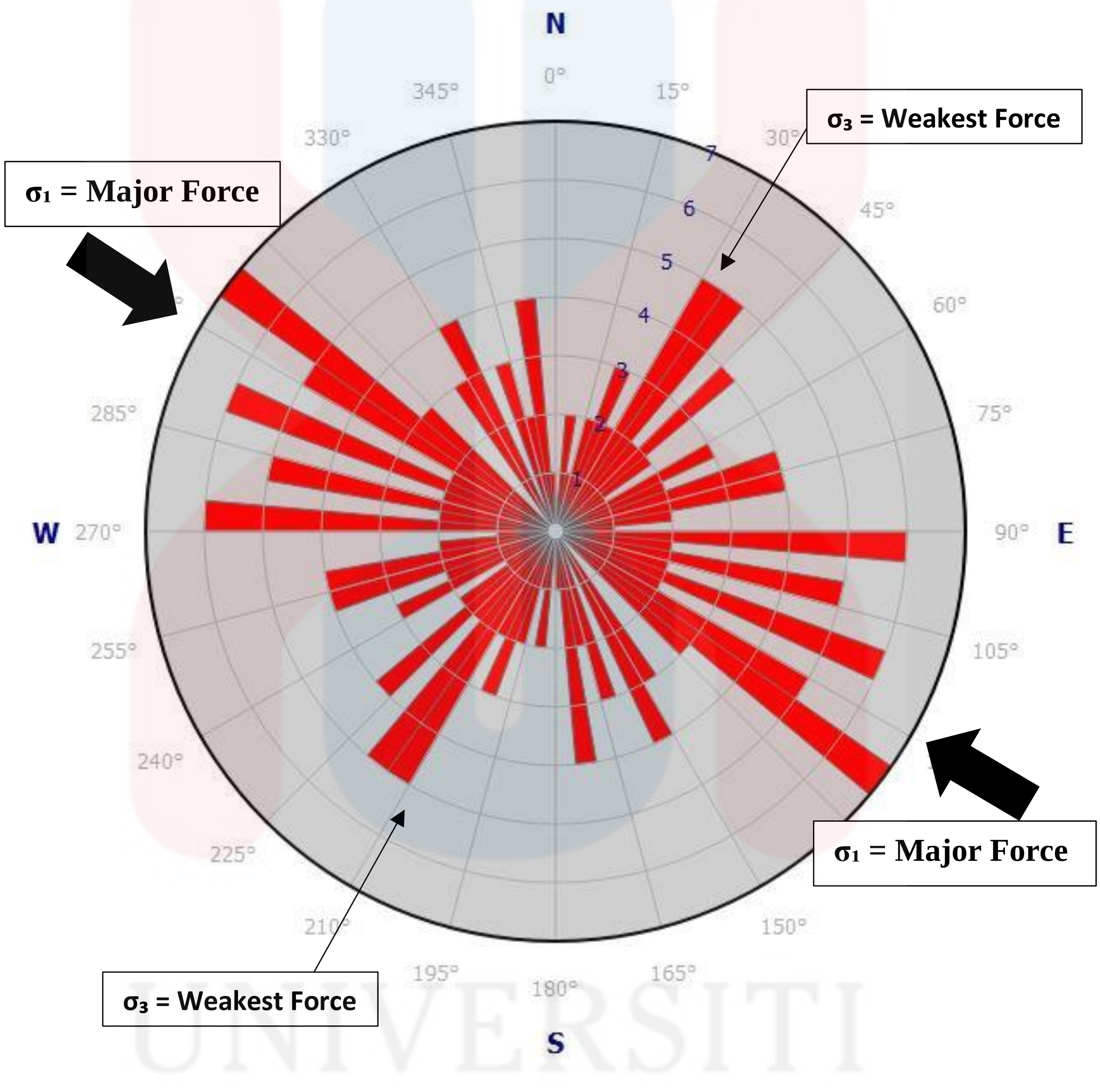


Figure 4.36: Rose Diagram of the extension joint 4 analysis of Batu Raja Muda, Kuala Krai

4.4.3 Foliation

The foliation is located at the Batu Raja Muda, Kuala Krai. This foliation is caused by the major fault and deform the layers of schist and mudstone which can be seen in figure 4.31. The coordinates are N 05° 30' 33" and E 102° 11' 20". The type of outcrop is hill cutting outcrop, an abandoned quary site. Thus, as metamorphic rock undergoes as their response to tectonic activity. The direction with the reading strike and dip of the foliation is shown in figure 4.37. It is interbedded with schist (top) and mudstone (below).

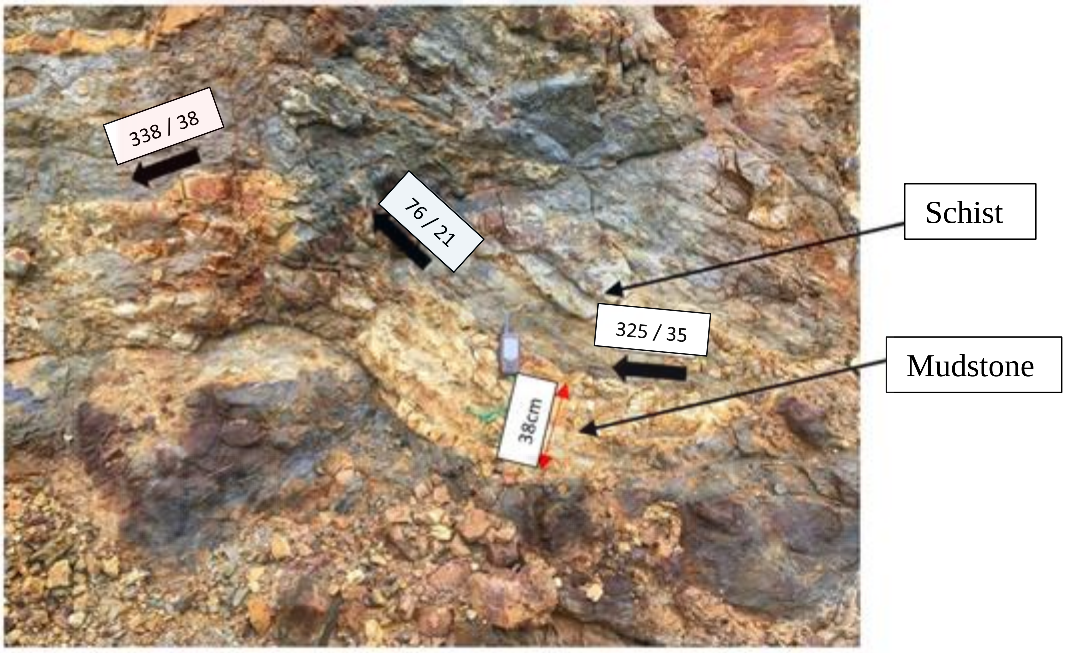


Figure 4.37: Direction of the foliation with the reading of strike and dip

4.4.4 Lineation

Lineament is a linear feature recognized on aerial photograph, satellite imagery and topographic maps. In this study, terrain mode was being used via google earth to identify them. Lineament is controlled by geological structures formed such as joints, faults, ridges, valleys and the boundaries of rock. Lineaments generally are defined only at the regional scale but also defined in local scale to fit the study area. Local lineament analysis was collectively formed based along for some distance of continuously mountains or hills. For this study area, in figure 4.38 shows the lineament via google map.

Lineament Map of Kuala Krai

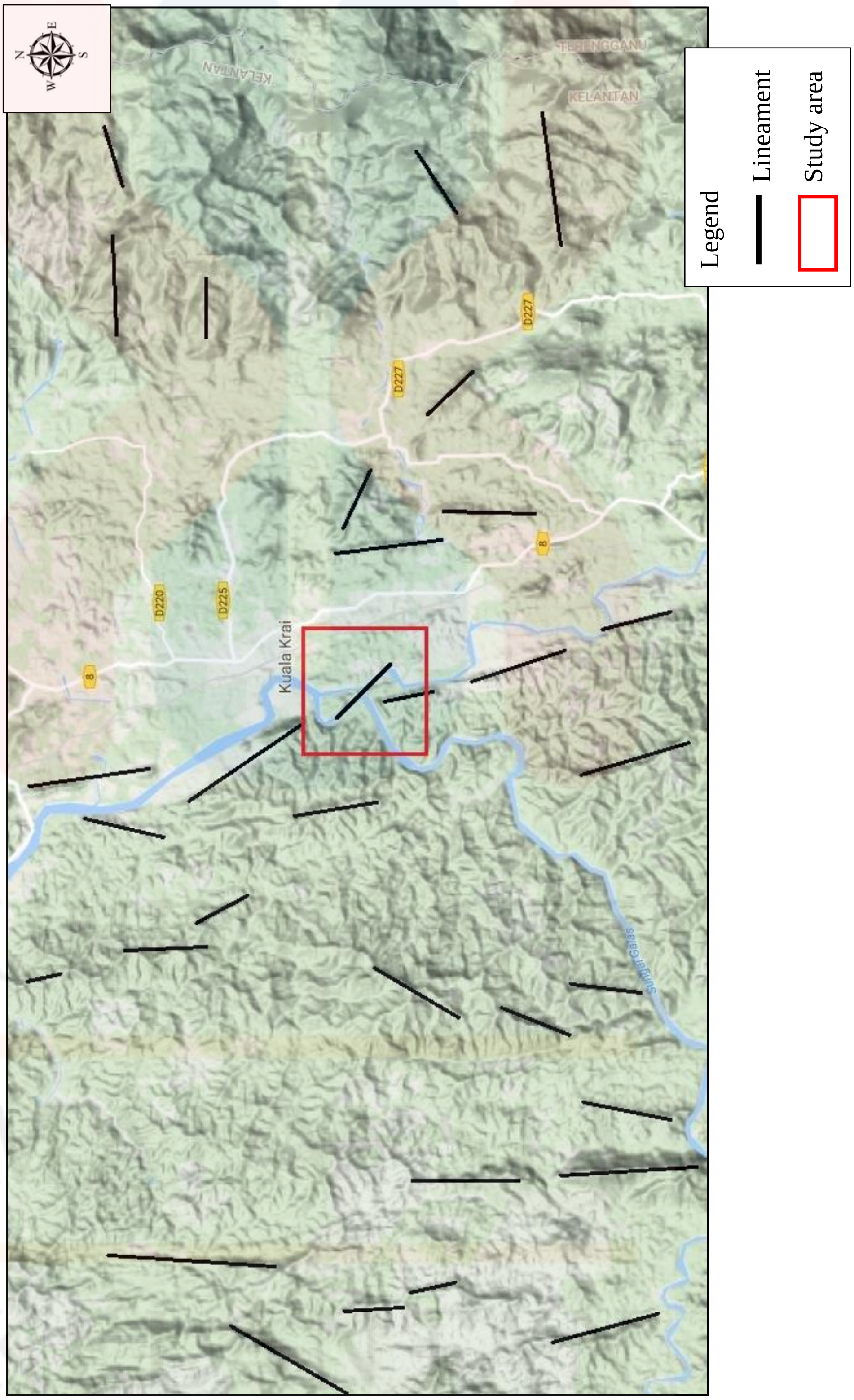


Figure 4.38: Lineament shown on Terrain Map via Google Map

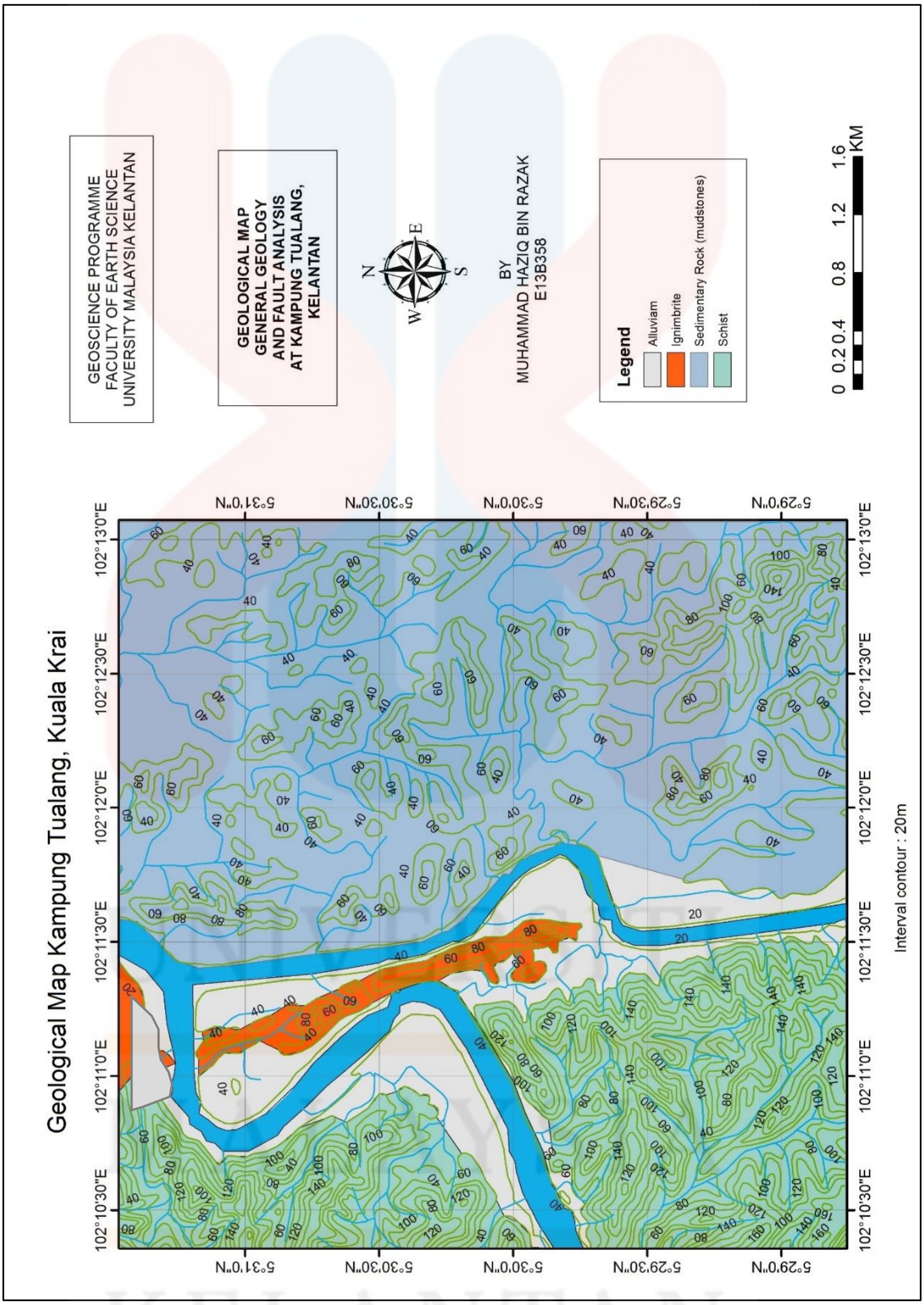


Figure 4.39: Geological Map of Kampung Tualang, Kuala Krai

CHAPTER 5

FAULT ANALYSIS

5.1 Introduction

Fault is a movement along surface or zone of one sided to another surface in the direction of parallel or two sides have been moves of each other. Earthquake occur when two blocks being stuck together and suddenly slip apart from each other. The surface where things happen is called fault plane. A shaking or vibrating is happened when the slip occurs due to the releasing energy suddenly in the Earth. The pressure and friction built at the depth in the Earth causes the plate slide quietly to past one another. Stress is being collected and at the point breakage it reaches a strain and accumulated potential energy is released as the earthquake.

Faults are surfaces across which Earth material has lost cohesion and across which there is perceptible displacement. Faults are often structural features of first-order importance on the Earth's surface and its interior. They affect blocks of the Earth's crust thousands or millions of square kilometres in area, and they include major plate boundaries. The main purpose is to determine the characterize deformation structure (geometry), to characterize flow path followed by particles during deformation (kinematic), and to infer the direction and magnitude of the forces involved during deformation (dynamic).

5.2 Type of faults

Fault divides the rocks it cuts into two fault blocks as shown in figure 5.1 and its movement directions. Faults are categorized into three general groups based on the sense of slip or movement. If the main movement on the fault plane is down and up, the fault is known as a dip-slip fault. Where the main sense of slip is horizontal the fault is known as a strike-slip fault. Oblique-slip faults have significant components of both strike and dip slip.

Normal fault – this fault movement is due to the tensional forces and results in extension. The foot wall (upwards) is the first thing to encounter before reaching the hanging wall (downwards). Reverse fault – the hanging wall (upwards) is the first thing to encounter before reaching to foot wall. (downwards). This fault movement is due to the compressional forces and results in shortening. Strike-slip fault – the blocks moving left or right along nearly to the vertical fault plane. This motion is caused by shearing forces. Oblique-slip fault – the blocks on the fault plane moves sideways and causing strike and dip to be measurable and significant.

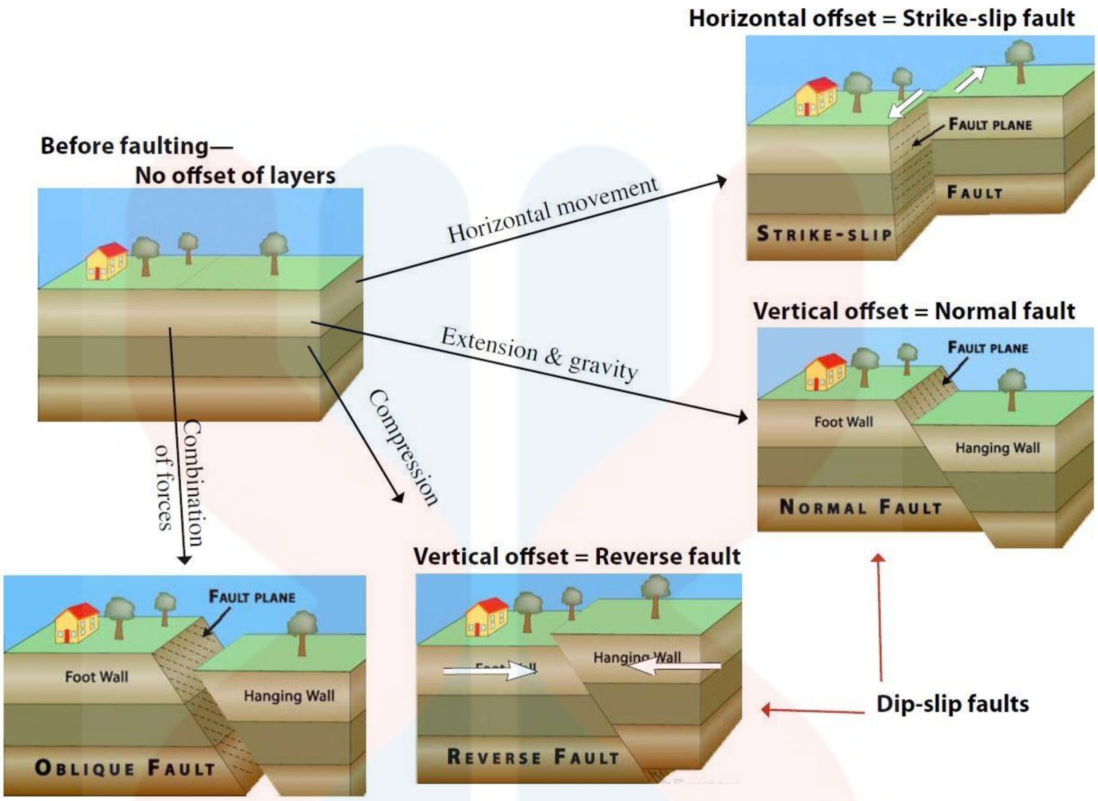


Figure 5.1: Type of faults and its movement planes

5.3 Lineament Analysis

Lineament Map of Kampung Tualang

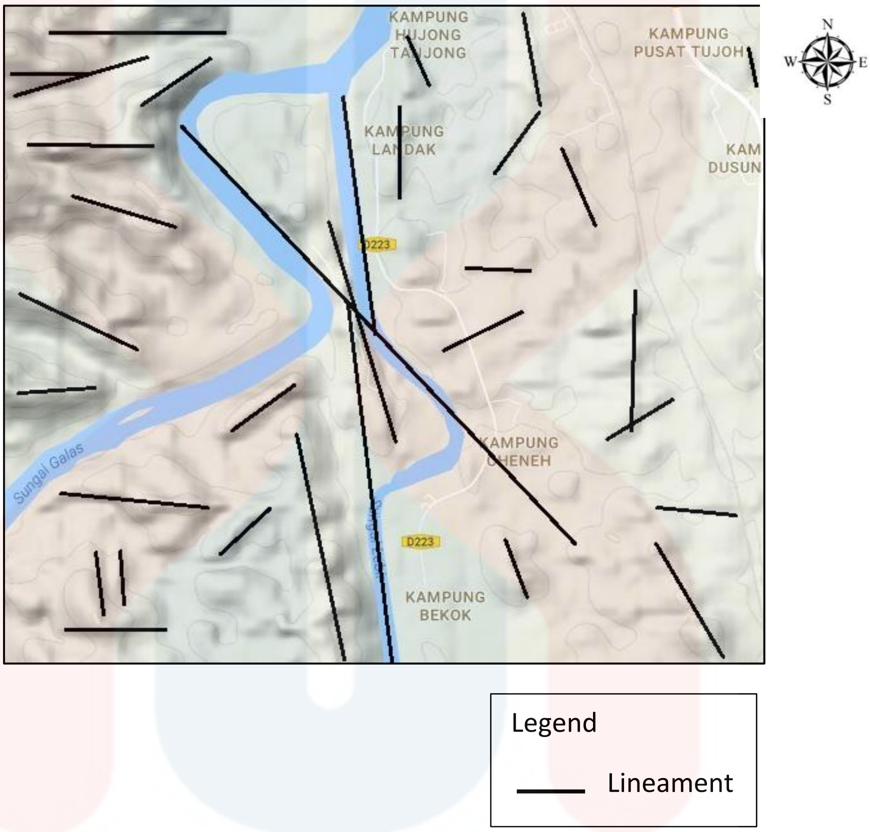


Figure 5.2: Lineament shown on Terrain Map via Google Map

5.3.1 Direction from lineament

From the lineament map shown on terrain map via google map as in figure 5.2, the lineament directions can be obtained and processed to gain the direction of faulting force and also the tension. The result shown in the rose diagram in figure 5.3 shows that the major force being taken from the North West (NW) with South East (SE) approximately 310 to 130-degree direction line. Moreover, for the tension is from the North East (NE) and South West (SW) approximately 50 to 230-degree direction line. The table 5.1 shows the reading of the lineament analysis and the figure 5.3 shows the rose diagram of Kampung Tualang, Kuala Krai.

Table 5.1: Reading of the lineament analysis of Kampung Tualang

1	270	12	356	23	350
2	270	13	352	24	35
3	255	14	48	25	350
4	234	15	349	26	340
5	273	16	353	27	273
6	288	17	354	28	245
7	297	18	344	29	2
8	267	19	318	30	60
9	233	20	352	31	280
10	277	21	360	32	340
11	270	22	335	33	330

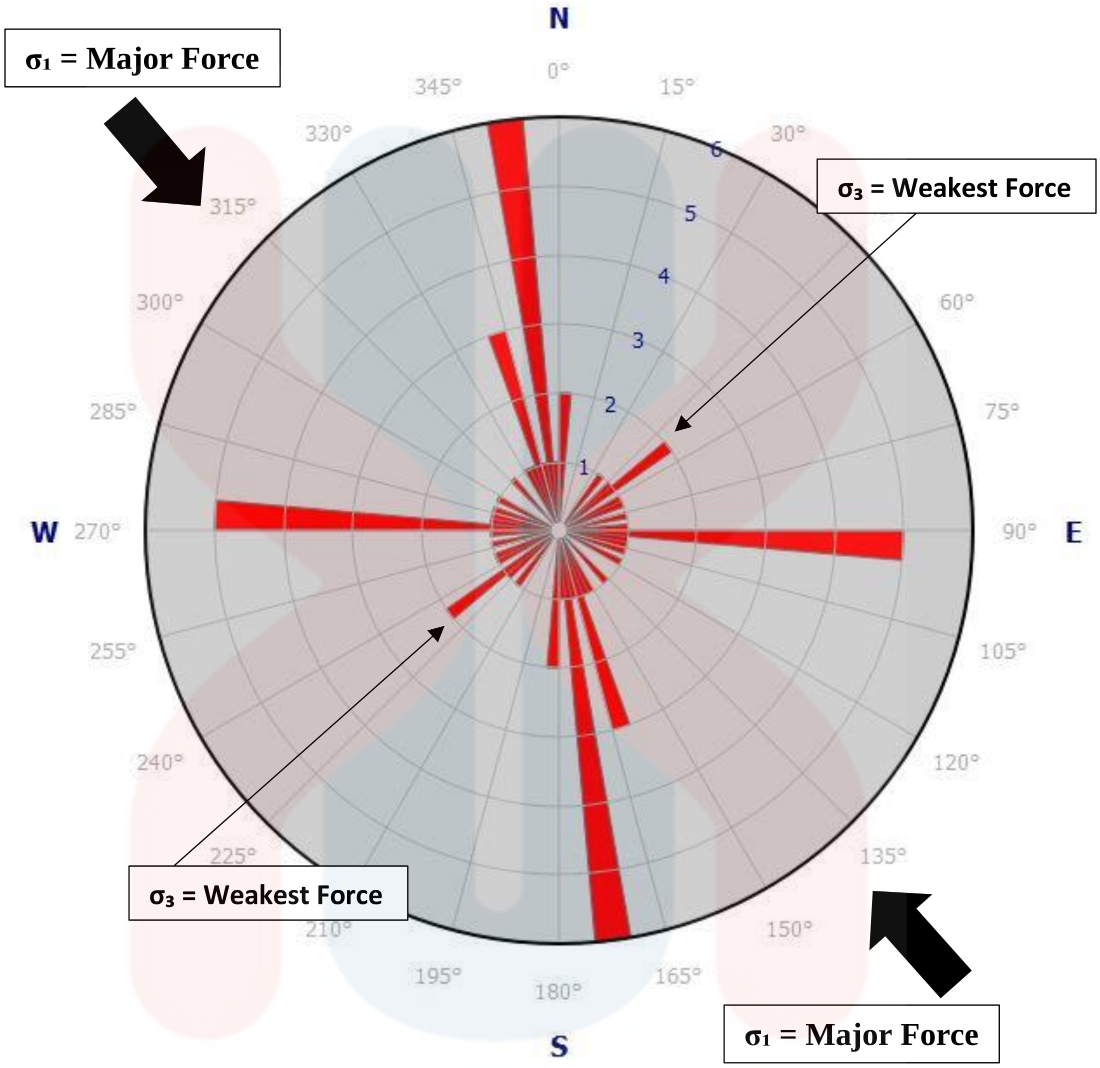


Figure 5.3: Rose diagram of the fault analysis of Kampung Tualang

5.4 Tualang Fault

5.4.1 Direction of lineament

The lineament is clarified as a feature of the structural geology of a fault which explains the expression of a lineament features that needs to be in the base as an indicator of detecting a faulting. A lineament is a pattern representation by photograph, map, model of the earth's surface and the figure must be straight or continuous and related to the solid features of the Earth.

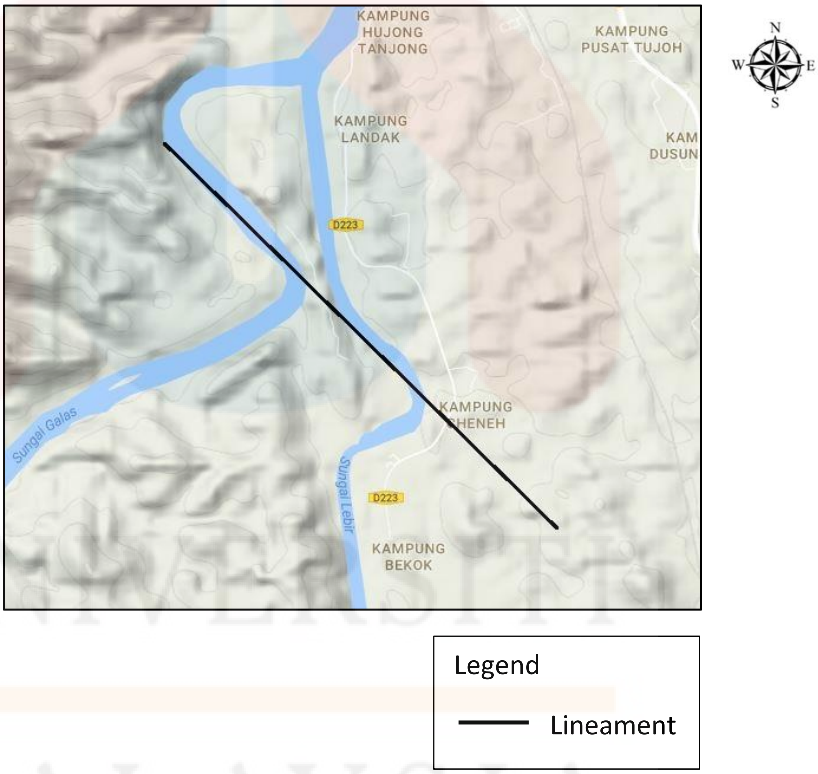


Figure 5.4: Black line shows the line of lineament of Tualang Fault

5.4.2 Data collected

(Normal Fault Station 1)

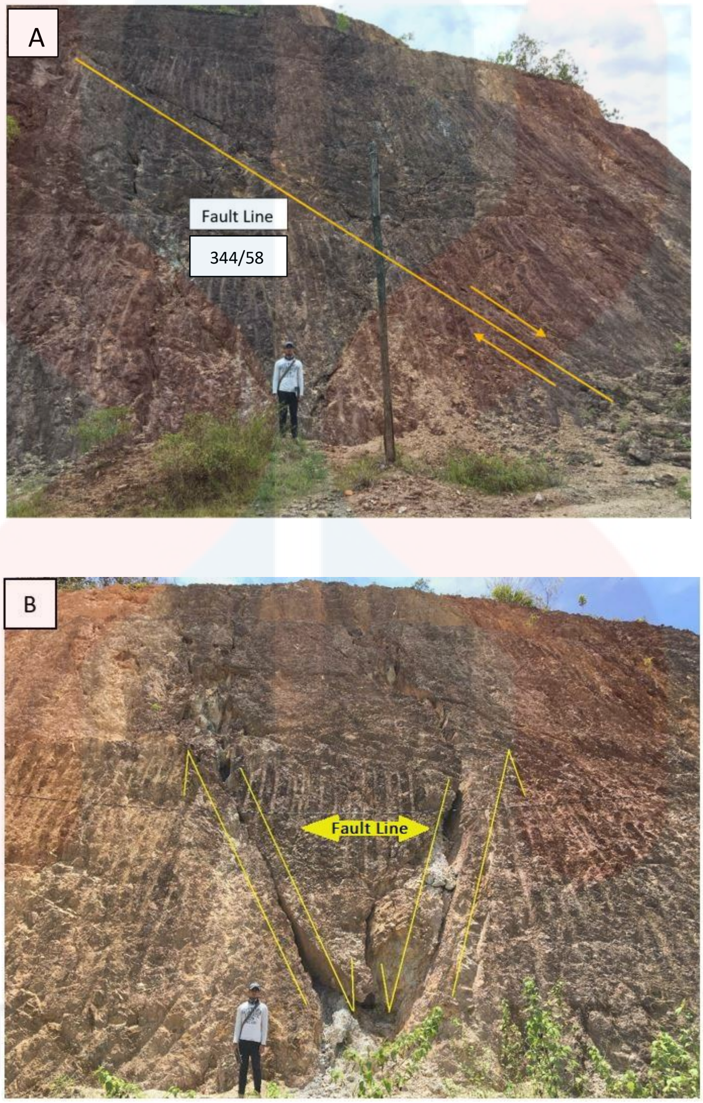


Figure 5.5: A and B shows the Fault Damage Zone. The outcrop is about 40m high.

In normal fault station 1 which is located at Pasir Jinggi, Kuala Krai in coordinates of N 05° 31' 05" and E 102° 12' 22" at the elevation of 41m, at hill cutting outcrop is exposed within 300 meters at the abandoned quarry site. On the the site found breccia as shown in figure 4.27 as a proof of geological structure of fault occurs. The yellow line shown in figure 5.5 shows the direction of fault that causes the outcrop to moves.

5.4.3 Geomorphology of Tualang fault

i) River offset

Based on figure 5.6, an offset occurs on the river, the red coloured line which forms the river to become approximately straight line proves that the faulting made the river to follow its structure line. Other than that, the black coloured line is a line of the major fault happening in Kampung Tualang, Kuala Krai. The main river that includes the Sungai Galas and Sungai Lebir along the black coloured line bends the river to follow the faulting line and changes the river into a meandering type of river.

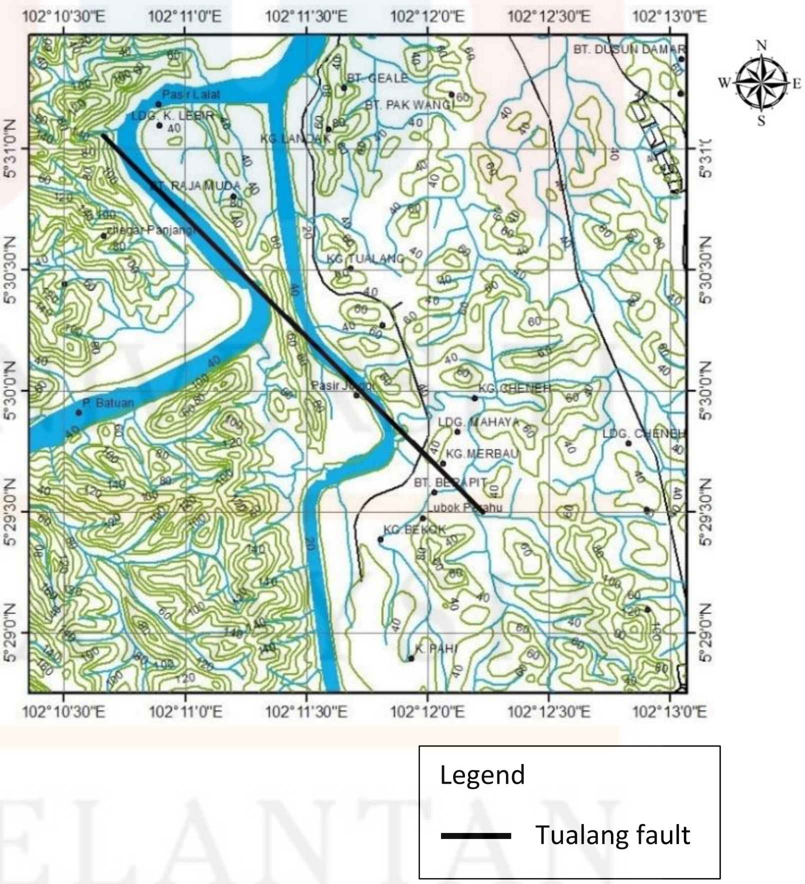


Figure 5.6: River offset

ii) Hill offset

Based on figure 5.7, offset of the hills is seen on the Base map which shows the yellow coloured region has higher elevation rather than the green coloured region which has lower elevation. This also proves that the Tualang fault representing as the black coloured line seperates the landform into two plane of elevation which clearly can be seen.

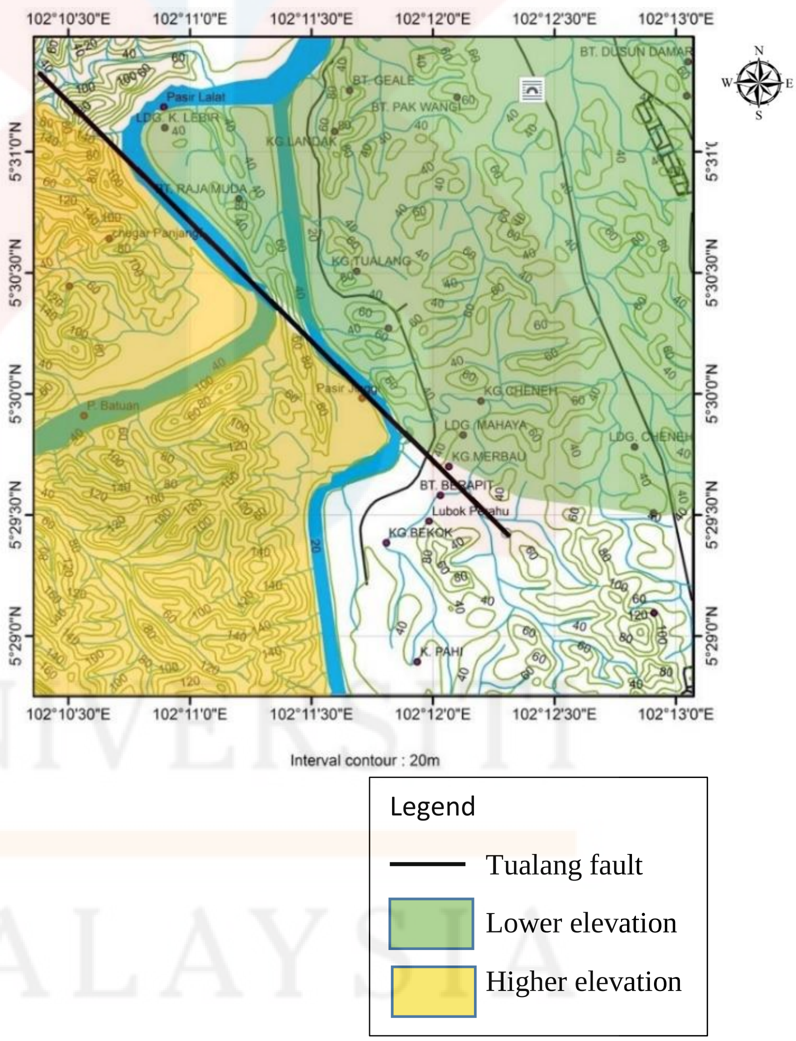


Figure 5.7: Hills offset of Tualang fault

5.4.2 Type of fault

As we can see from the faulting identification from figure 5.4 to 5.7, this can conclude that Tualang fault is a sinistral strike slip type due to its characteristic like in figure 5.8

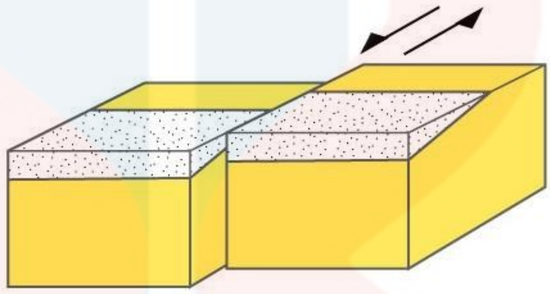


Figure 5.8: Sinistral strike slip fault type

5.4.3 Faulting Analysis

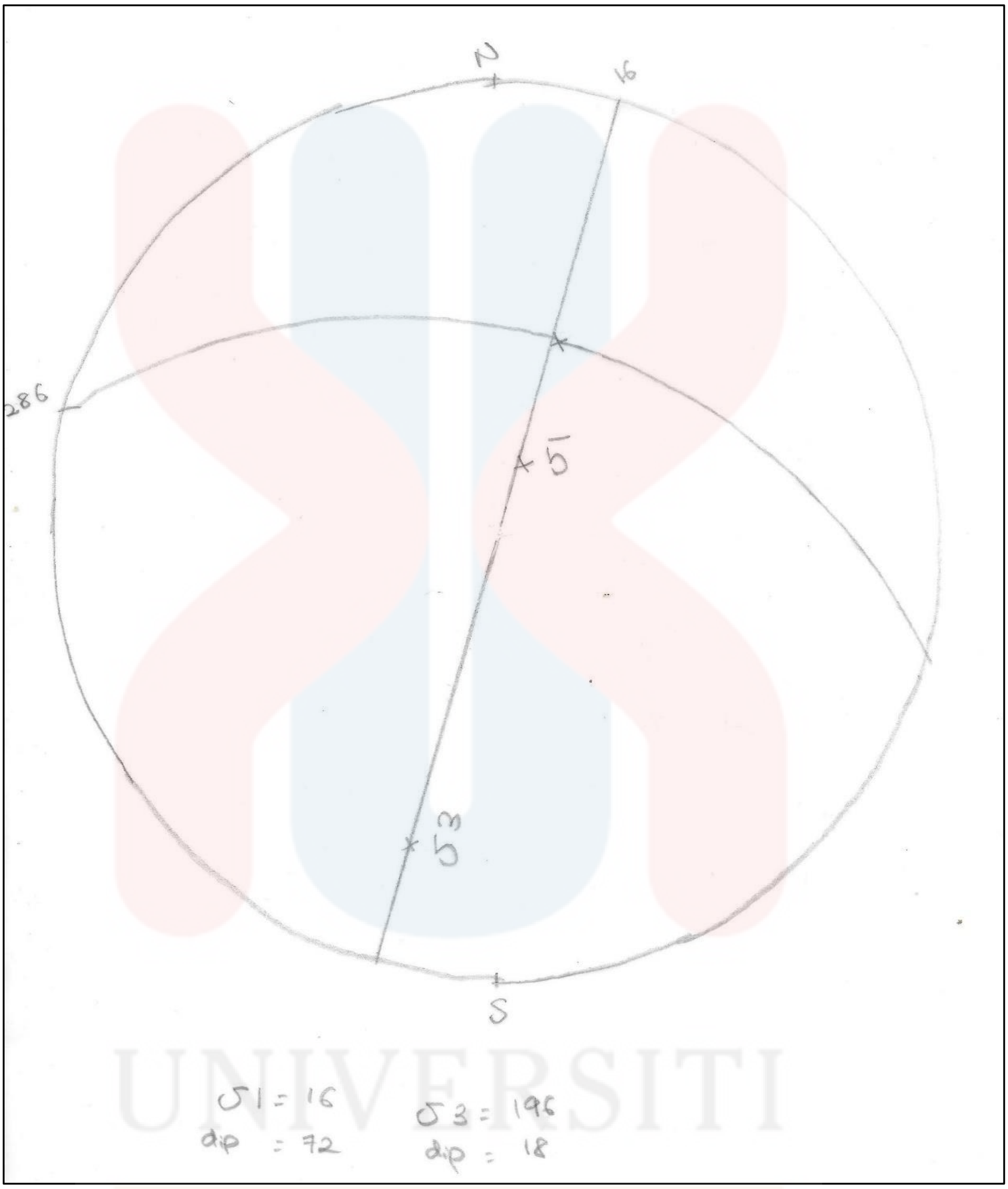


Figure 5.9: Stereograph Reading 1

As refer to stereograph in figure 5.9, the position of strong force (σ_1) is 16/72 and the weak force (σ_3) is 196/18. Thus, the direction of extensional force of the normal fault is North North-East (NNE) and South South-West (SSW).

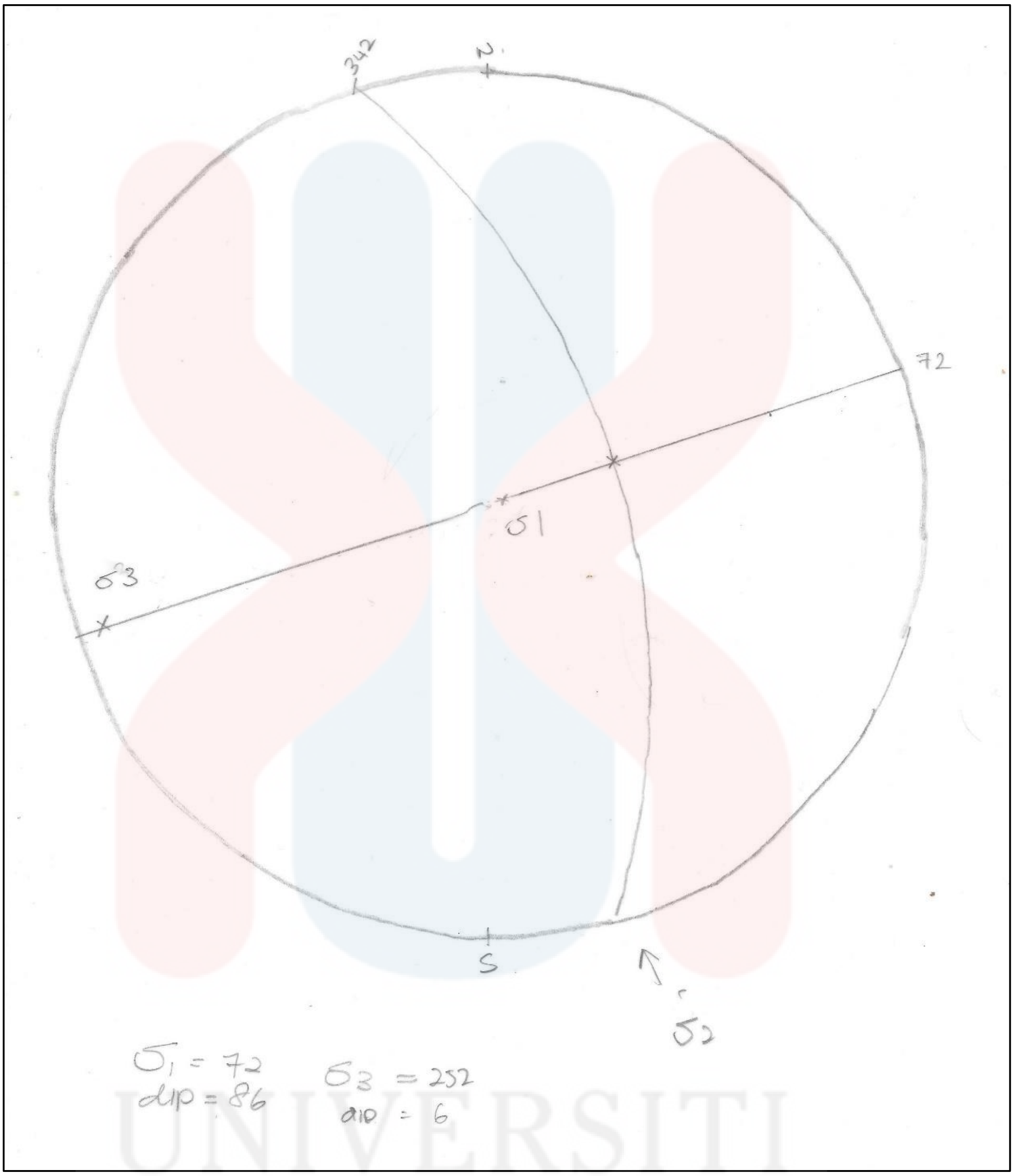


Figure 5.10: Stereograph Reading 2

As refer to stereograph in figure 5.10, the position of strong force (σ_1) is 72/86 and the weak force (σ_3) is 252/6. Thus, the direction of extensional force of the normal fault is North East-East (NEE) and South West-West (SWW).

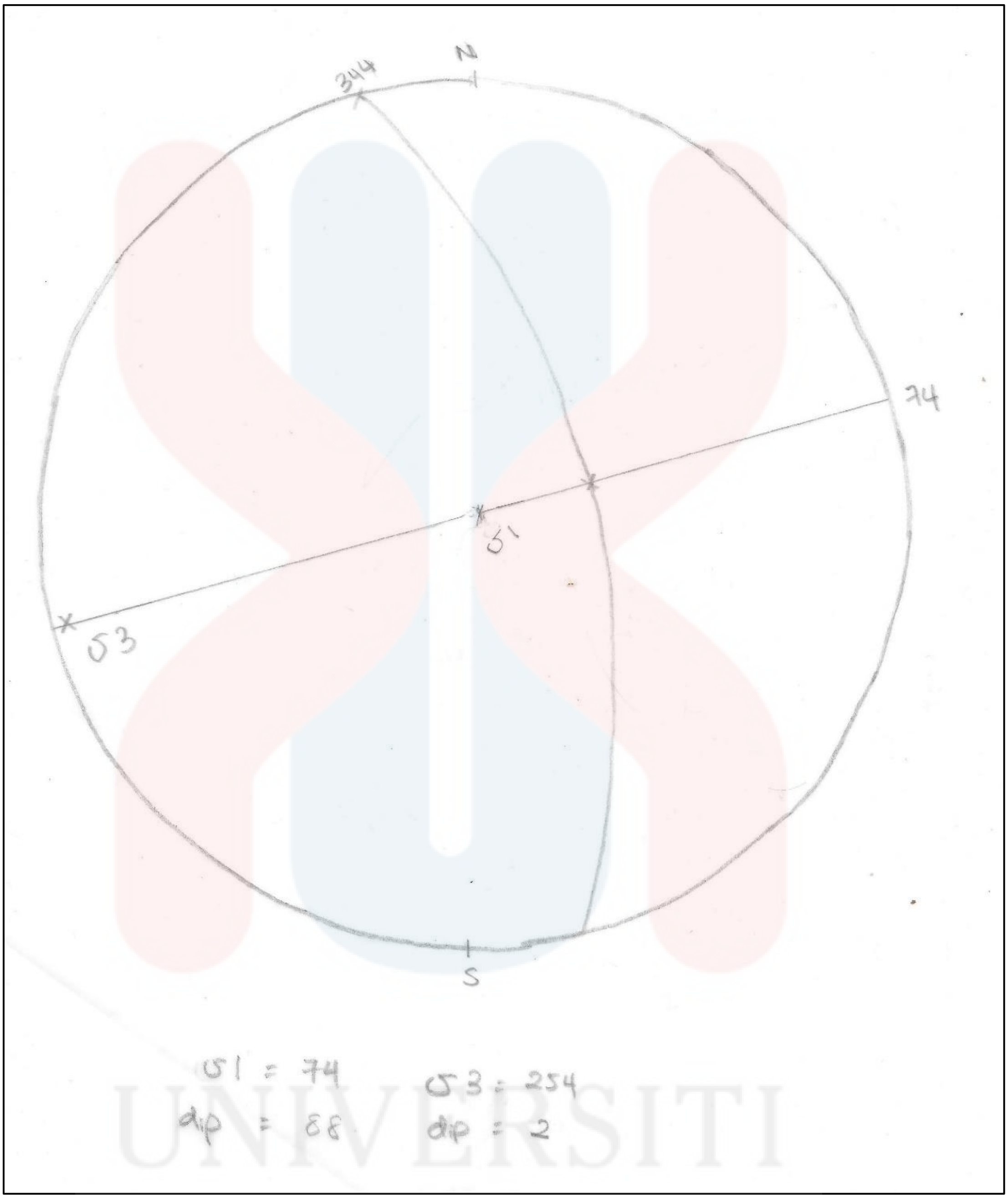


Figure 5.11: Stereograph Reading 3

As refer to stereograph in figure 5.11, the position of strong force (σ_1) is 74/88 and the weak force (σ_3) is 254/2. Thus, the direction of extensional force of the normal fault is North East-East (NEE) and South West-West (SWW).

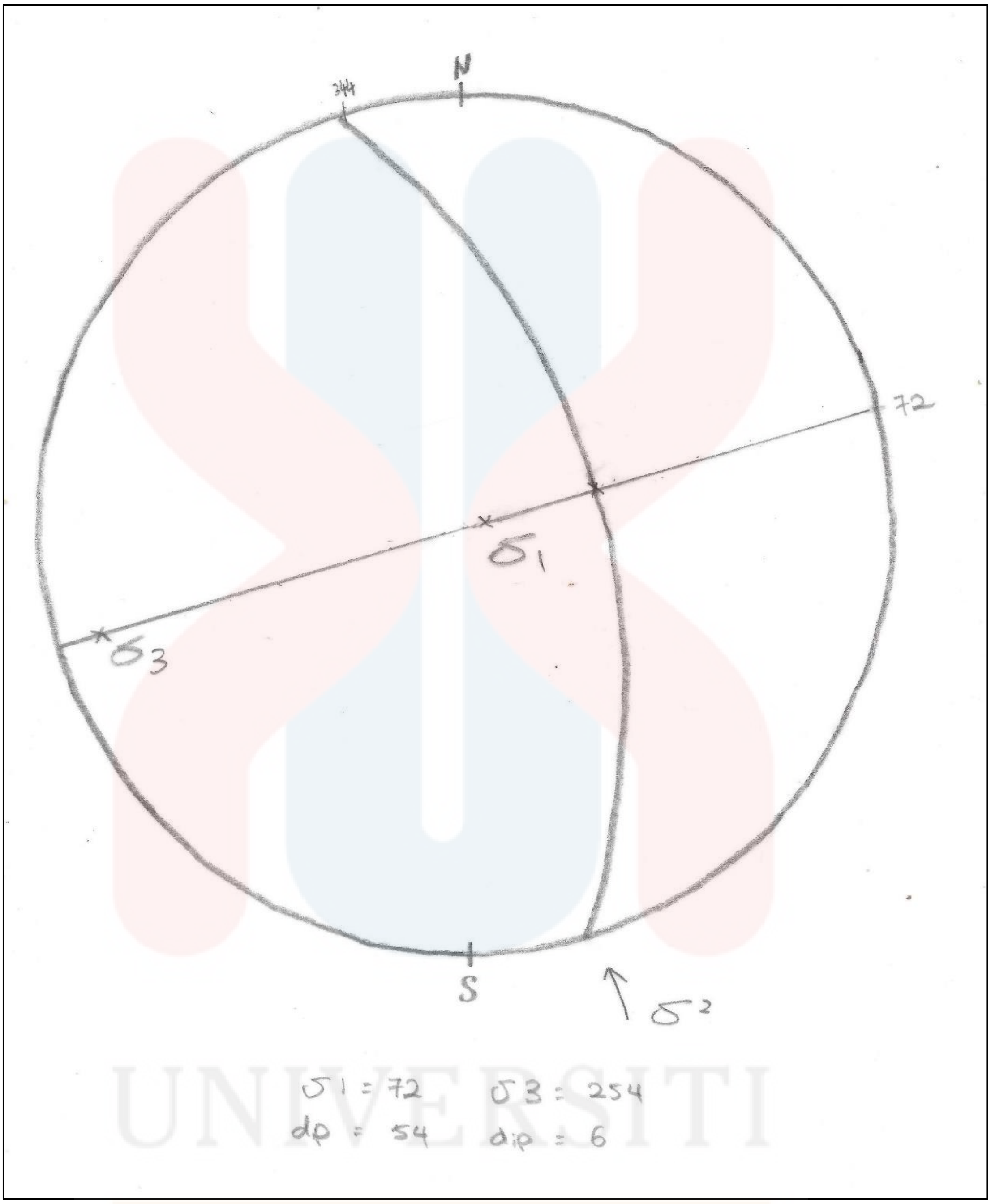


Figure 5.12: Stereograph Reading 4

As refer to stereograph in figure 5.12, the position of strong force (σ_1) is 72/54 and the weak force (σ_3) is 254/6. Thus, the direction of extensional force of the normal fault is North East-East (NEE) and South West-West (SWW).

Table 5.2: Summary of Tualang fault analysis result

<table>
<tr><td>Fault station 1</td><td>σ_1</td><td>σ_3</td></tr>
<tr><td rowspan="2">Reading 1</td><td>16/72</td><td>196/18</td></tr>
<tr><td>NNE-SSW</td><td>NNE-SSW</td></tr>
<tr><td rowspan="2">Reading 2</td><td>72/86</td><td>252/6</td></tr>
<tr><td>NEE-SWW</td><td>NEE-SWW</td></tr>
<tr><td rowspan="2">Reading 3</td><td>74/88</td><td>254/2</td></tr>
<tr><td>NEE-SWW</td><td>NEE-SWW</td></tr>
<tr><td rowspan="2">Reading 4</td><td>72/54</td><td>254/6</td></tr>
<tr><td>NEE-SWW</td><td>NEE-SWW</td></tr>
</table>

5.5 Lebir Fault

5.5.1 Direction of lineament

The direction of lineament can have initial proof of the tectonic movement of a structural activity such as faulting by analysing on the map. In figure 5.13, the Lebir fault is older regarding the age than the Tualang fault because it has been passed and cuts through by Tualang fault. It also shows that the Lebir fault have moved and splits into two displacement.

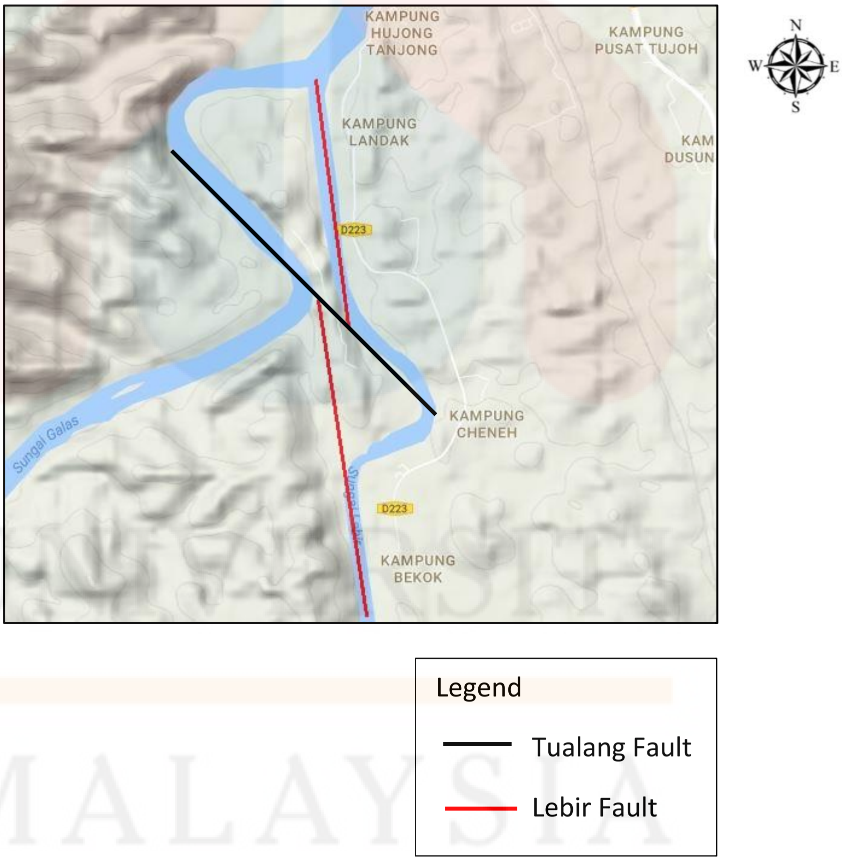


Figure 5.13: Two major fault intersection one and another.

5.52 Data collected

(Fault Station 2)

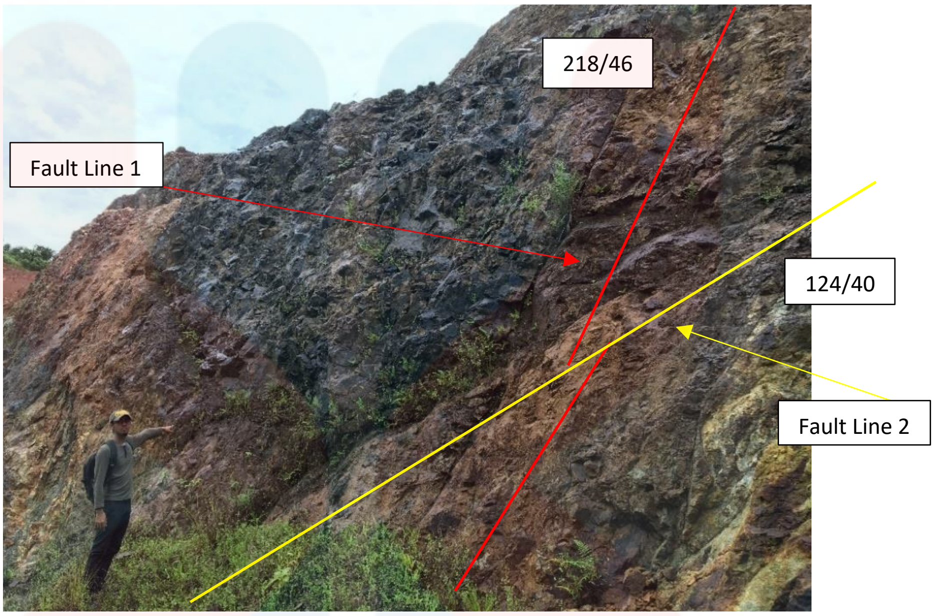


Figure 5.14: Structural plane is cut by a faulting activity. The outcrop is about 60 m high.

In normal fault station 1 shows two faulting at the Batu Raja Muda, the coordinates are N 05° 30' 32.8" and E 102° 11' 20"'. Figure 5.14 shows the red line representing as the (fault line-1) and the yellow line representing as the (fault line-2). (Fault line-1) has the reading strike and dip of 218/68 while the yellow line representing the fault line has the reading strike and dip of 124/46. As from the structural faulting activity, it can be said that the Fault Line-2 is younger than the Fault Line-1 because Fault Line-1 occur first then Fault Line-2 comes after and cut the Fault Line-1. This location is at the center between the two major faults, so this faulting activity between two planes can be seen a lot at the site.

5.5.3 Geomorphology of Lebir fault

i) River offset

The river offset shown in figure 5.15 shows early Lebir river (red line), current Lebir river (purple line) and the Tualang fault (black line). The origin Lebir river is actually a straight normal river but due to the Tualang fault, it has changed to the meandering type of river.

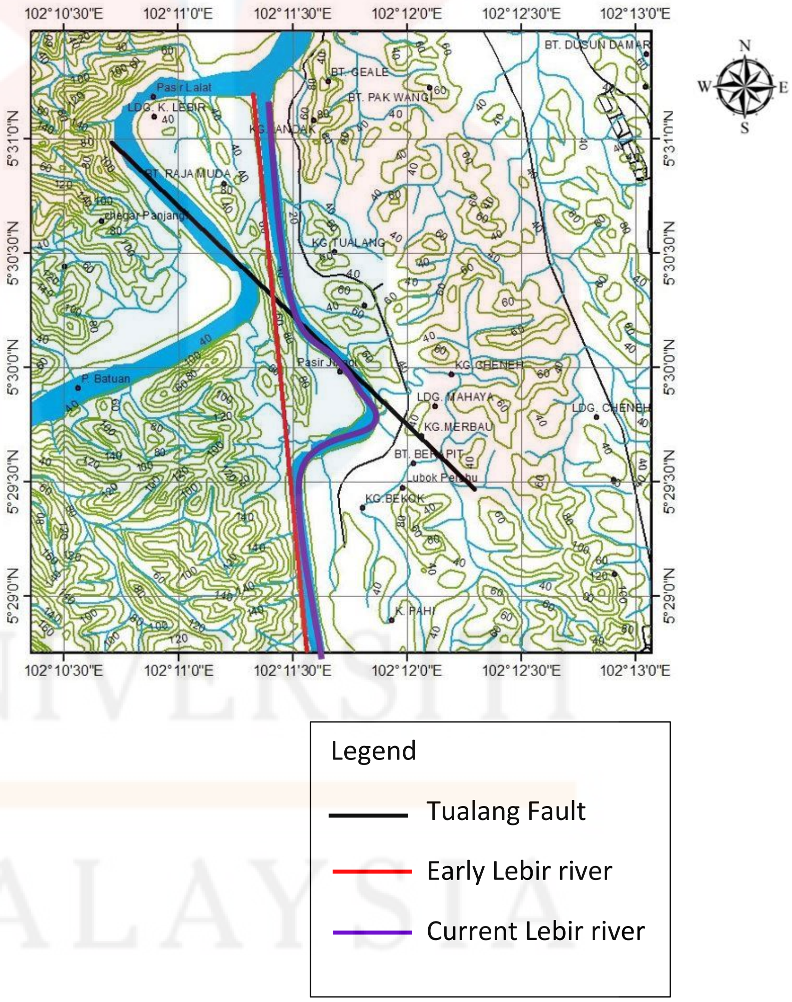


Figure 5.15: River offset of Lebir fault

ii) Hill offset

The hill offset of Lebir fault in the figure 5.16 below shows the two seperation of contour due to the Lebir fault tectonic movement. The orange region represents the high elevation and the blue elevation represents the lower elevation.

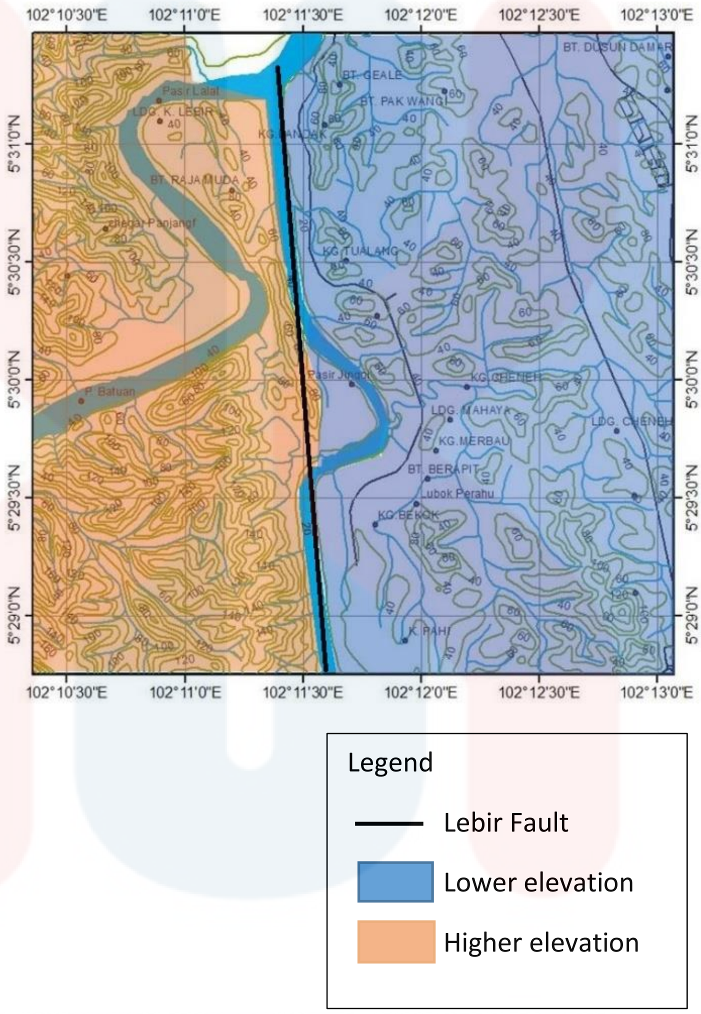


Figure 5.16: Hill offset of Lebir fault

5.5.4 Type of fault

Lebir fault is a thrust fault because schist is on the high elevation than sediments, but actually the schist is older than the sediments according to the geological time scale. This can be proved in figure 5.18 that the schist is above the mudstone. It can be said that, Lebir fault is a thrust fault which is lower than 45° and the older rock (schist) is on top of the younger rock (mudstone). Figure 5.16 is a concept type of Lebir fault in 3-Dimensional.

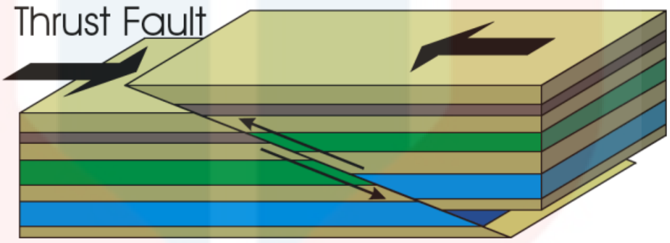


Figure 5.17: Thrust fault type

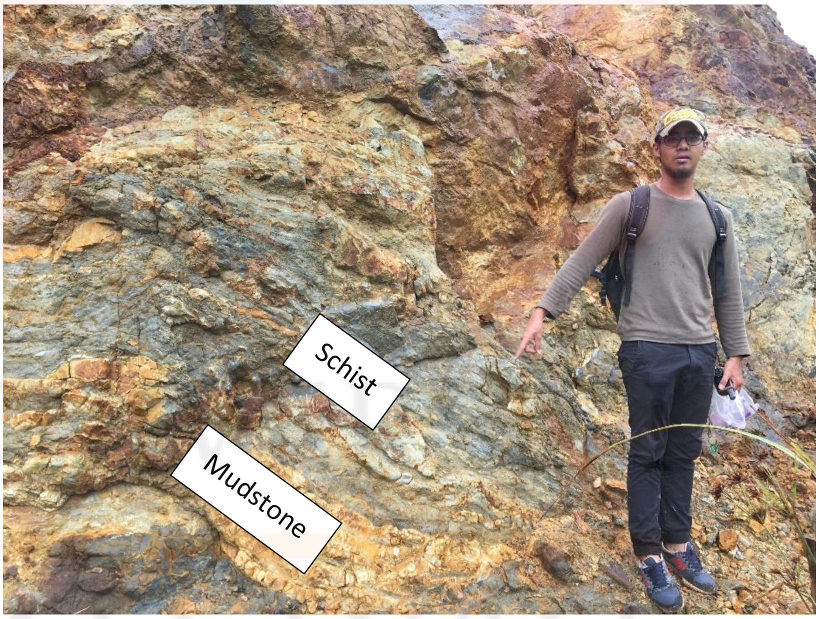


Figure 5.18: Schist (older) is on top of mudstone (younger)

5.5.5 Fault Analysis

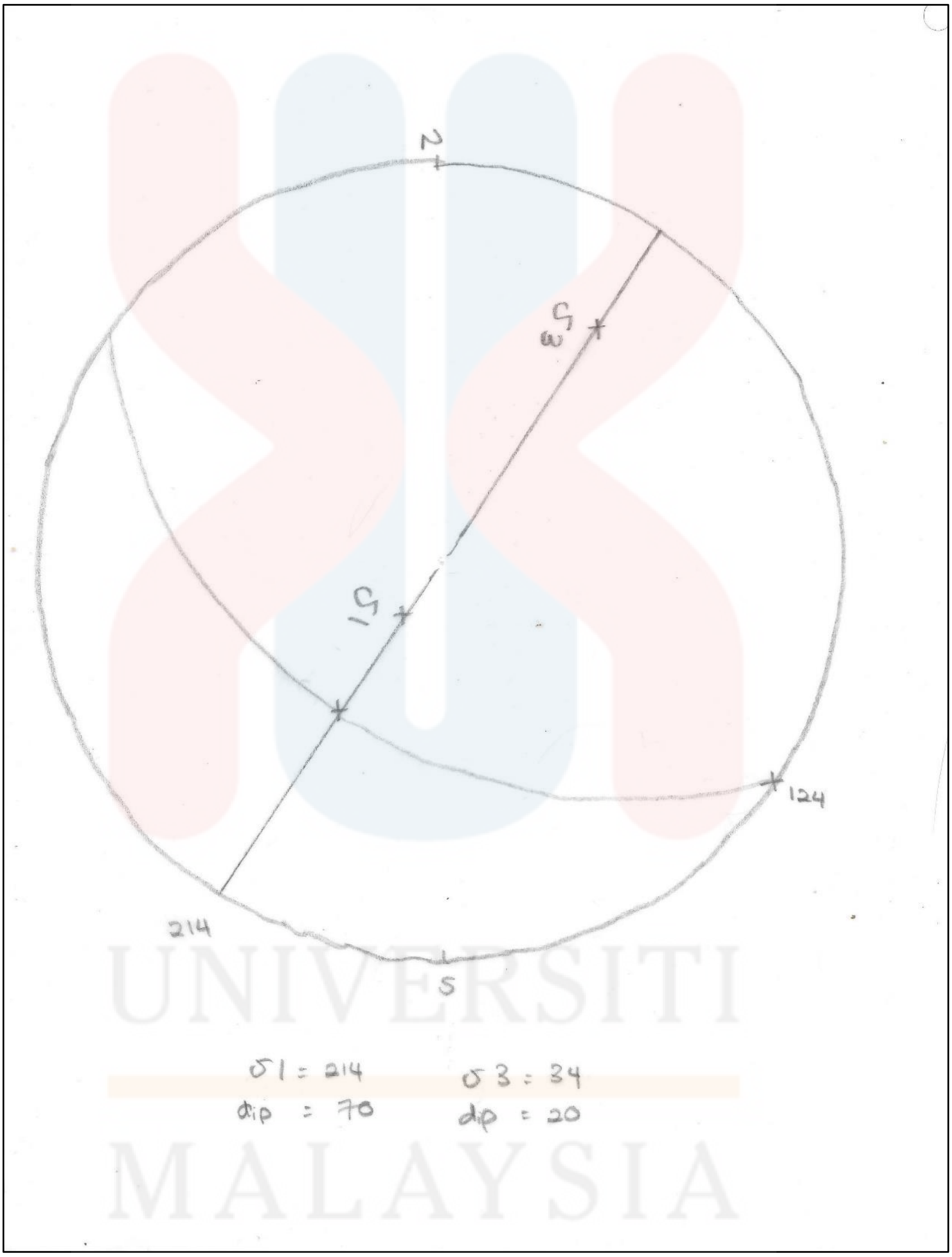


Figure 5.19: Stereograph Reading 1

As refer to stereograph in figure 5.19, the position of strong force (σ_1) is 214/70 and the weak force (σ_3) is 34/20. Thus, the direction of extensional force of the normal fault is North East (NE) and South West (SW).

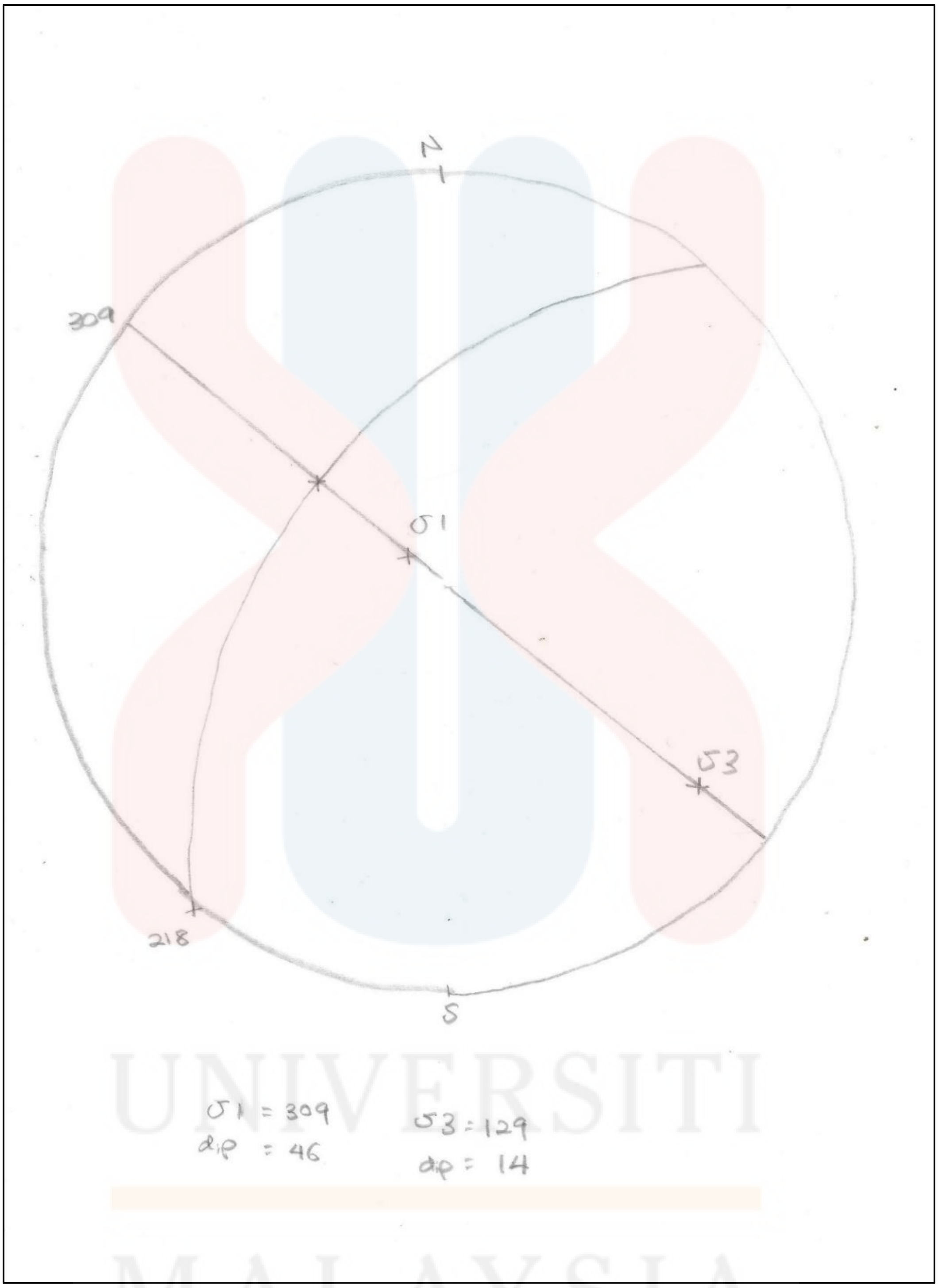


Figure 5.20: Stereograph Reading 1

As refer to stereograph in figure 5.20, the position of strong force (σ_1) is 309/46 and the weak force (σ_3) is 129/14. Thus, the direction of extensional force of the normal fault is North West (NW) and South East (SE).

Table 5.3: Summary of Lebir fault analysis result

<table>
<tr><td>Fault Station 2</td><td>σ_1</td><td>σ_3</td></tr>
<tr><td rowspan="2">Reading 1</td><td>214/70</td><td>34/20</td></tr>
<tr><td>NE-SW</td><td>NE-SW</td></tr>
<tr><td rowspan="2">Reading 2</td><td>309/46</td><td>129/14</td></tr>
<tr><td>NW-SE</td><td>NW-SE</td></tr>
</table>

5.6 Faulting mechanism

The Peninsular Malaysia is formed by welding of Sibumasu and East Malaya or Indochina plates. The Bentong-Raub Suture is distributed in the southernmost part of Peninsular Thailand. As there occur northwards subduction of Palaeo-Tethys ocean beneath Indochina and collision of Sibuasu terrane with Indochina.

The regional structures is controlling the shape of the Peninsular Malaysia with North North-West (NNW)to South South-East (SSE) structural line. This NNW-SSE are the initiators of the other major fault in the Peninsular Malaysia including the Lebir fault. These structures followed by the lithologies bedrock are the main reason of controlling the surface geomorphology.

5.6.1 Stress and principal stress

By collecting the data joint analysis data accordingly, detail observation and analysing has been done. It can be said that the direction of principal stress (σ_1) is North West (NW) to South East (SE) from all of the four readings in different location to determine a well-suited result summary.

5.6.2 Strain ellipsoid

The purpose of strain is to explain how every line in a body or an in this study area changes in length and angle during deformation. The strain ellipsoid shown on the right of the figure 5.21 shows the maximum force (σ_1) which lies on North West (NW) to South East (SE). By knowing the maximum force, the strain ellipsoid shows the folds, fractures, anthithetic, synthetic, reverse. All of these structural characteristic can easily be identify in the right direction due to the identification of the maximum force (σ_1).

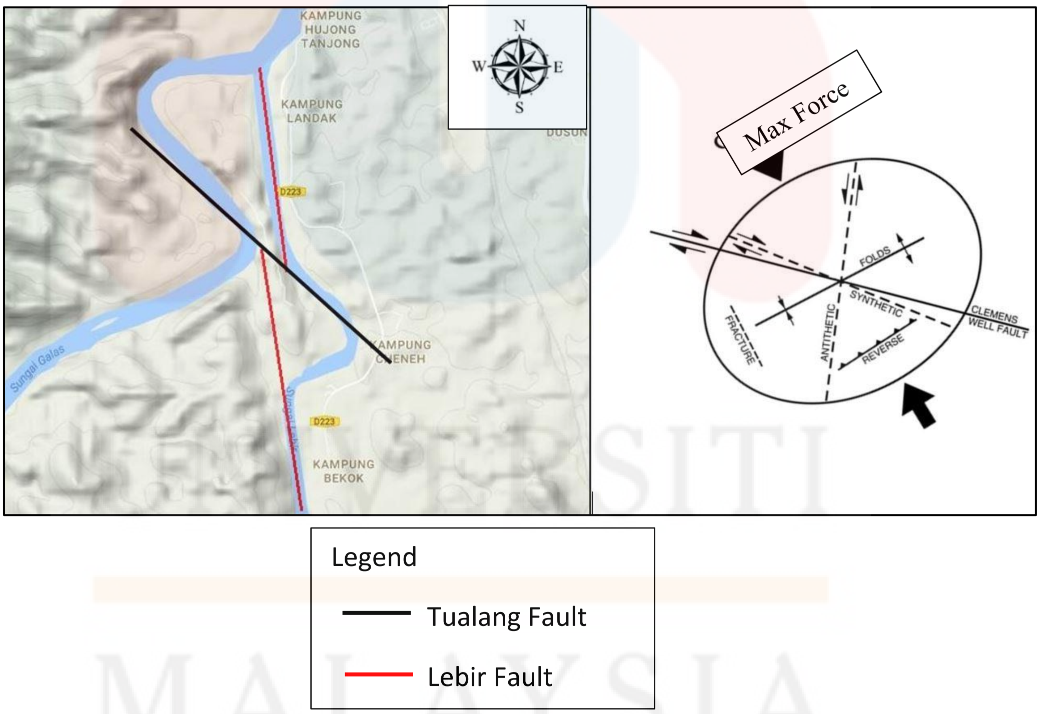


Figure 5.21: Strain ellipsoid

CHAPTER 6

6.1 Conclusion

This chapter concluded that the result from the research, general geology and fault analysis of Kampung Tualang, Kuala Krai, Kelantan. Detail maps are generated by doing a complete mapping besides focusing on the entitle research of fault analysis in by obtaining geological structures information which include one foliation analysis, six fault analysis, four joint analysis and lineament analysis in regional context for the whole study area.

Some of the sub-structural analysis is not fix, it is due to the limitations of access area and geological structures exposed of the study area. The data of the ones that obtained is enough to represent the past tectonic force and stress during the brittle and ductile deformation of mechanic deformation.

After the structural analysis is done the mechanic deformation is determined which are the ductile deformation had occurred before the brittle deformation due to the σ_1 is trending in the direction North West (NW) to South East (SE) direction. The foliation, minor fault, hill offset also river offset and lineaments proves that the faulting has the initiator which are the major of Tualang fault and Lebir fault.

Every surface of the Earth's landform has a trigger to shapes and deform with the movement of tectonic plates and cause displacement and layering. Moreover, the goal of this research has succeeded to produce a geological map and analysing of presence of a fault in the study area.

6.2 Recommendation

This research about the fault analysis will be a base reference for upcoming researches to help support other mapping activity. The first step of acquiring any data can be useful with the help of exploration of aerial support such as photogrammetry by drones to easily observe and save the time to interpreted geological structural data. Knowing the structures of the earth will open new doors of exploration or to avoid any disaster such as this study area which has wide flood plain area.

Lastly, well analysing the study area before entering is a good strategy to avoid high budget capacity and time to be waste. If this achieve, a geological mapping will be done in quite a short time with high quality faulting analysis database by imagery and accuracy.

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