GENERAL GEOLOGY AND STRUCTURAL ANALYSIS OF KAMPUNG SUNGAI BATU, DABONG, KELANTAN

by

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A report submitted in fulfillment of the requirements for the degree of Bachelor of Applied Science (Geosciences) with Honours

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DECLARATION

I declare that this thesis entitled "General Geology and Structural Analysis of Kampung Sungai Batu, Dabong, Kelantan" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ________________________________

Name : ________________________________

Date : ________________________________

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GENERAL GEOLOGY AND STRUCTURAL ANALYSIS OF KAMPUNG SUNGAI BATU, DABONG, KELANTAN

ABSTRACT

Kampung Sungai Batu is situated at Dabong between longitude 101˚58’0”E to 102˚0’30”E and latitude 5˚23’30”N to 5˚21’30”N in Kuala Krai district at the southern part of Kelantan. The study area covers approximately 25 km^2 area. The objective of this study is to produce a geological map of the study area with scale 1:25000, to determine the most common geological structures at the study area and to analyze the pattern or direction of the present geological structures. The methods used to produce geological map is by doing the field mapping and Geographic Information System (GIS) approach. For the structural analysis, the structure of the rock is identified by field mapping, while the pattern or direction of the present geological structures is analyzed and illustrated by stereonet and rose diagram. Based on the observation in the field mapping, the study area consists of granite, andesite, sandstone, phyllite, schist and marble. The most common structural found are fault, foliation and joint. Besides, the major pattern or direction of the present geological structures oriented toward NNE-SSW. The lineament interpretation data was correlated toward the field structural data. Most of the structural data oriented toward lineament direction, which is NNE-SSW direction.

GEOLOGI AM DAN ANALISIS STRUKTUR KAMPUNG SUNGAI BATU, DABONG, KELANTAN

ABSTRAK

Kampung Sungai Batu terletak di Dabong di antara garis bujur 101˚58’0”T ke 102˚0’30”T dan garis lintangnya 5˚23’30”U ke 5˚21’30”U town dalam Daerah Kuala Krai yang terletak di bahagian Selatan Kelantan. Kawasan kajian meliputi anggaran 25 km^2 luas. Tujuan kajian adalah untuk menghasilkan peta geologi kawasan kajian dengan skala 1:25000, untuk mengenalpasti struktur geologi yang paling umum dan untuk menganalisis corak atau arah struktur geologi yang ada. Kaedah yang digunakan untuk menghasilkan peta geologi adalah dengan mengunakan berdasarkan pemetaan lapangan dan penggunaan Sistem Maklumat Geografi (GIS). Untuk analisis struktur, struktur di batu dikenalpasti dengan pemetaan lapangan, manakala corak atau arah struktur geologi yang ada dianalisis dan digambarkan dengan streonet dan rajah ros. Berdasarkan daripada perhatian di pemetaan lapangan, kawasan kajian mengandungi batuan granit, andesit, batu pasir, filit, syis dan marmar.Kebanyakan struktur yang terdapat di kawasan kajian adalah sesar, foliasi dan kekar. Selain itu, majoriti corak atau arah struktur geologi yang ada berorientasikan arah UUT-SSB. Tafsiran data kelurusan-kelurusan telah dikaitkan dengan data struktur lapangan. Kebanyakan data struktur berorientasikan kepada arah kelurusan-kelurusan, iaitu arah UUT-SSB.

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LIST OF ABBREVIATIONS

JMG	Mineral and Geosciences Department
JUPEM	Jabatan Ukur dan Pemetaan Malaysia
HCL	Hydrocloric acid
GIS	Geographic Information System
N	North
S	South
W	West
E	East

LIST OF SYMBOLS

m	Metre
km	Kilometre
mm	Millimetre
µm	Micrometre
σ	Sigma
%	Percentage

CHAPTER 1

INTRODUCTION

1.1 General Background

The structural geology is the study of deformation structures in the lithosphere in order to understand their geometry, distribution and formation. A geological structure is a geometric configuration of rocks, and structural geology deals with the geometry, distribution and formation of structures (Fossen, 2010).

Kampung Sungai Batu is located in Kuala Krai district nearby Dabong town in the southern part of Kelantan. The study area is bounded by Stong complex from the Main Granite Range. Within the study area, the area is composed of Telong formation (Lee, 2004). The study area has vicinities of acid intrusive igneous rock, sedimentary rock and metamorphic rock.

Telong formation formed in Late Permian until Late Triassic, and commonly consists or argillite rocks and marble, with a bit of tuff and andesite. The depositional environment for Telong formation is a stable shallow marine with occasional supply of fine pyroclastic material (Lee, 2004).

Kampung Sungai Batu, Dabong is chosen as the study area as it offers the ideal setting in term of geomorphology and topography, where occurrence of deformation generally faults, folds and joints take place on both local and regional in proportions of the area.

1.2 Problem Statement

Geological map is very important as it shows the geological features with detailed information about the study area and acts as a primary source of information for various aspects of land-use planning. The existing geological map provided by JMG year 2006 in GIS software that is used as a reference is not up-to-date information. For general geology of Kampung Sungai Batu, as earth undergoes certain process through the year, whether the tectonic movement or weathering process, the lithology of the area might change physically and chemically. Because of this problem, the geological mapping is conducted to update geological information and determine general geology of the study area.

Besides, heavy rainfall and erosion occurring during the past year would lead to new and further deformation. This is because as the forces causing faulting and folding take place, the magnitude and direction where the forces travel changes overtime. Therefore, the structural analysis will be done at the study area to give more accurate structural data to the community.

1.3 Research Objectives

The main objectives to complete for this study are:

i. To produce a geological map of the study area with scale 1:25000

ii. To determine the most common geological structures at the study area

iii. To analyze the pattern or direction of the present geological structures

1.4 Study area

1.4.1 Location

The study area is located at Kampung Sungai Batu, Dabong. Kampung Sungai Batu is one of the locations in district of Kuala Krai in Kelantan. The study area is located between longitude $101^{o}58'0''E$ to $102^{o}0'30''E$ and latitude $5^{o}23'30''N$ to $5^{o}21'30''N$ (Figure 1.1).

The study area covers 25 km^2 area that are located at Kampung Sungai Batu, Dabong, Kelantan. The geography of the study area is hilly on the northern part and flatter toward the south of the study area. The elevation of the study area ranges from the lowest elevation of 20 m to the highest elevation of 320 m. There are two main rivers called Sungai Pergau and Sungai Galas at the eastern part of the area. At the west part, there is also a small river called Sungai Batu.

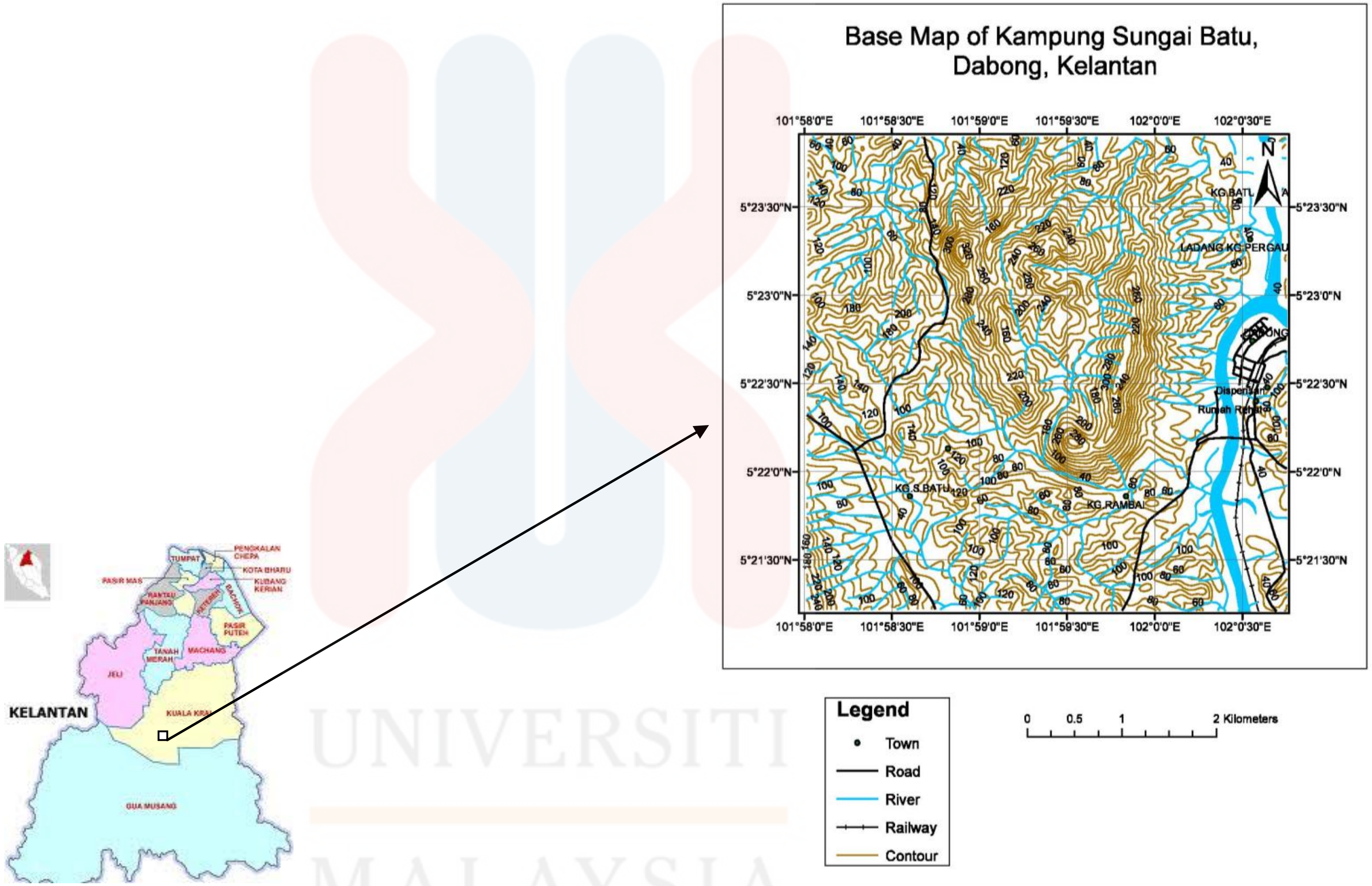


Figure 1.1 : Base Map of Study Area

1.4.2 Demography

There are some villages that can be seen in the study area, which are Kampung Sungai Batu, Kampung Rambai and Kampung Batu Sawa. The population of Dabong is around 40,659 peoples, with the 8,333 households and 9,333 living quarters (Table 1.1). The people that lived there mostly are local citizen and the common language used by the people is Malay.

Table 1.1 : Total population by sex, household and living quarters, Local Authority area and state, Malaysia, 2010 (Kuala Krai District)

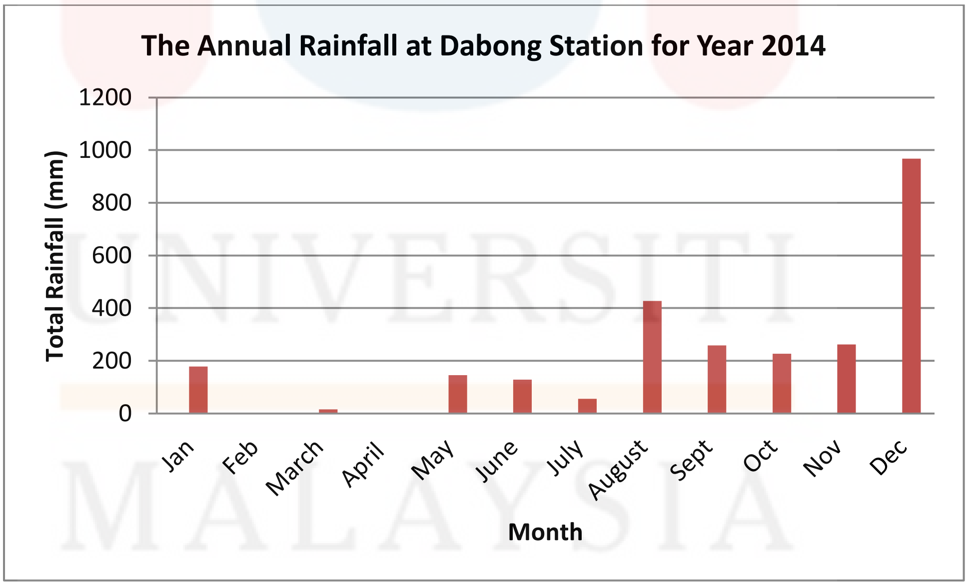
Jajahan/Local Authority Area	Population			Households	Living quarters
	Total	Male	Female		
KUALA KRAI					
M.D. Dabong	40,659	21,026	19,633	8,333	9,377
• Dabong	1,356	695	661	279	323
• Kemubu	1,133	588	545	238	269
• Manek Urai	1,638	821	817	342	373
• Remainder of M.D.	36,532	18,922	17,610	7,474	8,412

(Source : Department of Statistics, Malaysia, 2010)

1.4.3 Rainfall Distribution

Kelantan has warm and rainy seasons throughout the year. Dabong is the nearest station from the study area. Dabong station shows that the lowest rainfall collected around at the earlier of the year and the highest rainfall collected at the end of the year for year 2014 (Table 1.2). The season change is affected from the monsoon winds. Malaysia faces two monsoon winds seasons, the Southwest Monsoon from May to September, and the Northeast Monsoon from October to March. The Northeast Monsoon commonly brings in more rainfall compared to the Southwest Monsoon.

Table 1.2 : Total Annual Rainfall at Dabong Station for Year 2014



(Source : Department of Irrigation and Drainage Kelantan, 2014)

1.4.4 Landuse

The distribution of the landuse in Dabong consists of villages, small business shops, agriculture landuse and forest. The housing of the area is well spread and unplanned. Most of the houses are located near town and roads for easier accessibility for the residences. There are some schools situated there such as Sekolah Menengah Kebangsaan Dabong and Sekolah Kebangsaan Dabong. Agriculture landuse such as rubber plantation is the common land use in the study area.

1.4.5 Social Economic

The incomes of the residence in Dabong are mostly from the agriculture activity such as farming and working in the estates. The estate that can be seen at the study area is rubber plantation (Figure 1.2). There are also some small businesses that are run by some of the residences. The social economy there is dominated by the Malay of the local people.

Figure 1.2 : Rubber plantation, taken on 23th May 2016 at
5˚21'40" N , 101˚58'34" E

1.4.6 Road connection

The major connection that can be seen in the study area is Jalan Sungai Sam-Jeli-Dabong (Figure 1.3). The road connects Jeli with Dabong area. The study area can be reach by following toward the south of the road. Dabong town is one hour journey by car from Jeli town. There are also some small roads that connect major road to the villages nearby.

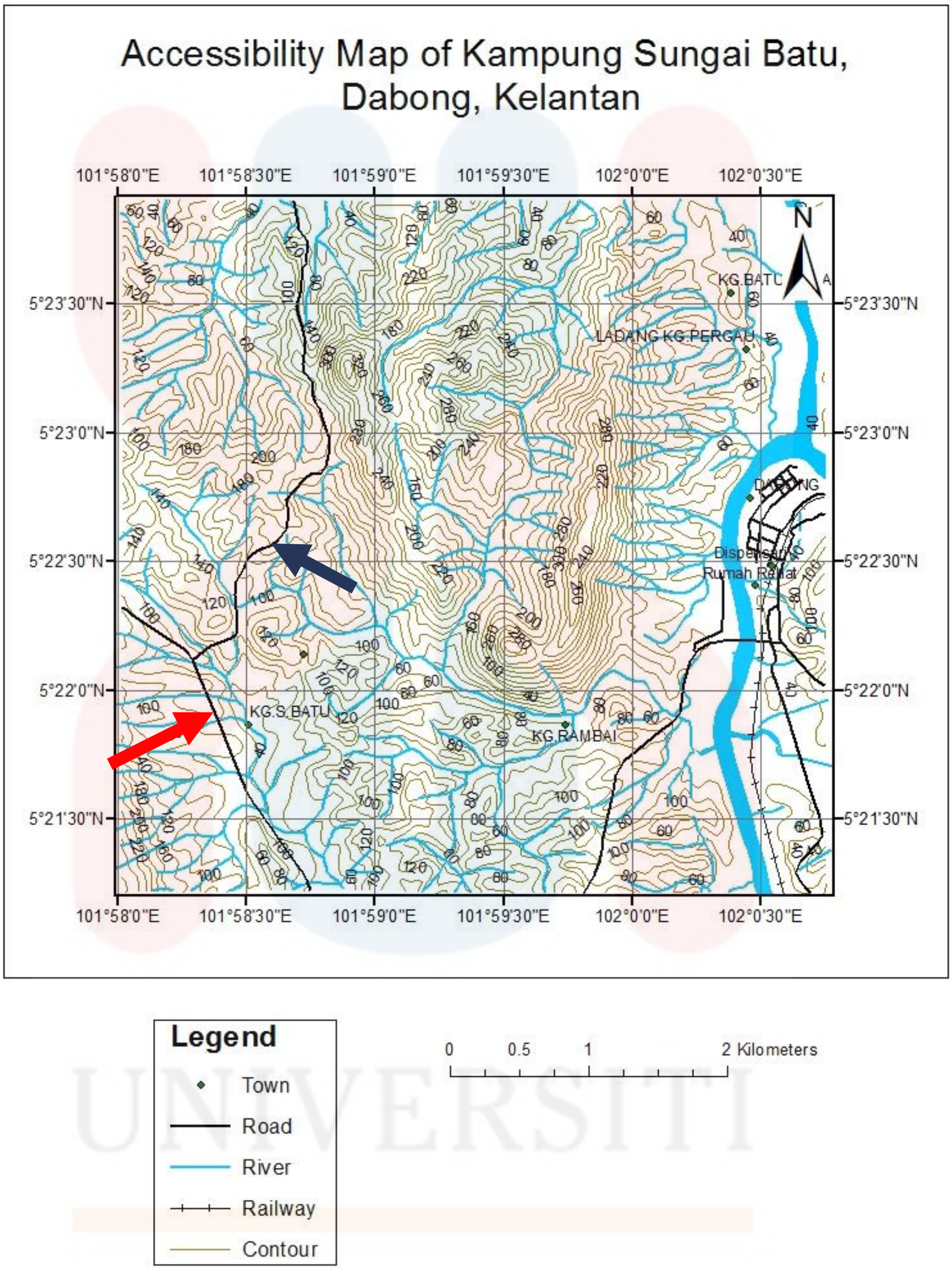


Figure 1.3 : Road connection shown at the base map of study area; red arrow shows major road access and blue arrow shows smaller road

1.5 Scope of the study

The scope of the study is to analyze geology and structural geology at the study area. The structural geology is analyzed by doing field observation and in the study area. The field work will be done by traversing, collecting rock samples and collecting strike and dip of geological structure on the area. Structural analysis is used to investigate the geological structures and deformations of the area. These primary data will then be further processed and calculated in the data analysis and preparing for the writing thesis.

1.6 Research Importance

Through this study, more precise and detailed geological map of study area will be produced, which can be used by certain parties and community at the area to serve as a reference. It is also obtained information and better understanding of the structural geology of the study area. Therefore, the data obtained through this research will provide information for further research at this area.

For structural analysis, this study can provide more detailed data about the common geological structures at the study area and the pattern or direction of the present geological structures.

1.7 Chapter's summary

This research will investigate about the structural geology that forms at the study area. The objectives, which are to generate geological map and analyze the structural geology of the study area are need to be achieved. The problems will be face is the geological data is not updated and thus, the problem will be solved by updating the geological map and structural analysis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter will discuss the literature review of the past study and the study that are related to this research. The purpose of literature review is to provide the general background of research scope and guidance in writing the report thesis. The literature review source can be obtained from books, journals and past reports. For this study, the literature review covers the geology and geological structures in Kelantan.

2.2 Geological Review

2.2.1 Regional Geology and Tectonic Settings

Kelantan is in the Central belt of Peninsular Malaysia and have varieties of rocks that include igneous rocks, metamorphic rocks, and sedimentary rocks. The regional geology of Kelantan consists of a central zone of sedimentary and meta-sedimentary rocks boarded on the west and east by granites of Main Range and Boundary Range respectively. Rocks in the Kelantan seem to align in one line from the north east, while this line actually part of the line in Peninsular Malaysia (Mustaffa Kamal & Abdul Hadi, 1998).

Igneous rocks segregates at the boundary if the east and west Kelantan. In west of Kelantan, the igneous rocks is part of the granite for Big Range with age Late Triassic, whereby the granite in the east is part of the Granite Boundary where the age being interpreted as Late Triassic or maybe older state by Liew (1983) in Mustaffa Kamal & Abdul Hadi (1998). In the middle part of Kelantan, granite is found in Gua Musang, Stong area until Jeli and Batang Merbau. The granite body relatively smaller compared to Big Granite Range and Boundary Range which mostly is Late Triassic or might be much younger that is Cretaceous (Liew, 1983).

Sedimentary rocks segregated widely in the area of granite body stated above. Their age is being interpreted range from Silurian-Ordovician until Jurassic-Cretaceous based on Mustaffa Kamal & Abdul Hadi (1998). Part of the sedimentary rock especially the older one, from Silurian-Ordovician and Permian are metamorphosed into metamorphic rocks.

The study location located in Kuala Krai district, include Kuala Balah and Dabong Area. Dabong is well known for the varies geology Stong Migmatic Complex, composed of igneous rocks that have undergone metamorphosis, forming Berangkat Tonalite, Kenorong Leucogranite and Noring Granite. The migmatite complex forms mountainous country lying about 8 km west railway towns of Kemubu and Dabong. It is readily identified from railway line by the reclining spine-like protrusion at the summit of Gunong Stong (Hutchison & Tan, 2009).

Berangkat Tonalite and Kenorong Leucogranite are the two earliest phases, which are in part of highly deformed in a manner similar to that of the marginal country. The third phase, the distinctive Noring Granite is undeformed. Berangkat Tonalite is a coarse grey K-feldspar megacrystic biotite-hornblend tonalite that locally is high deformed that may be of Permo-Triassic age as stated by Cobbing *et al*. (1992) but no dating has been carried out and the similar abundance of enclaves to Kenerong Leucogranite suggest that a Cretaceous age more be suitable (Hutchison & Tan, 2009).

Mustaffa Kamal & Abdul Hadi (1998) stated that the Gua Ikan group of caves and limestone hills are part of Gua Musang Limestone Aggregates. The study area composed of Telong formation.

Telong formation formed in Late Permian until Late Triassic, and commonly consists or argillite rocks and marble, with a bit of tuff and andesite. The lower boundaries for Telong formation are uncomfortably overlying the Gua Musang formation and uncomfortably overlain by Koh formation. The depositional environment for Telong formation is a stable shallow marine with occasional supply of fine pyroclastic materials (Lee, 2004).

2.2.2 Historical Geology

The geological formation of Kelantan ranges from Lower Paleozoic until Quaternary and can be divided into three main chronologies, which are Paleozoic, Mesozoic and Cenozoic. The Paleozoic formation in Kelantan was found in the central belt of Peninsular Malaysia. The bulk of the Upper Paleozoic sediments consist of marine Permian strata that occur as linear belts flanking Mesozoic sediments in the Central Belt. The Upper Paleozoic rock consists of Gua Musang Formation and Aring Formation in the south of Kelantan whereas Taku Schist was formed in the eastern of Kelantan. The Upper Paleozoic formation is dominated by argillaceous and volcanic facies while the rest belong to calcareous and arenaceous facies. The depositional environment is typically shallow marine with intermittent active submarine volcanism starting in the Late Carboniferous and reaching its peak in the Permian and Triassic (Lee, 2004).

According to Lee (2004), the Mesozoic formation consists of Permian-Triassic of Gua Musang, Aring and Gunung Rabong Formation, which made up mainly of shallow marine clastic and carbonates with volcanic interbeds, whereas in south part, Telong Formation was dominated by deeper marine turbidite sediment (tuffaceous with volcanic interbeds).

The Cenozoic Formation, Simpang Formation was considered to be similar to Old Alluvium (Suntharalingam, 1983). In Kelantan, Simpang Formation was found within valley and delta of Sungai Kelantan. The low winding ridge, occurred in 5 km wide zone that extended from Selising in the south to Bachok-Kubang Krian road that 20 km from the north. The ridges were commonly wide in the west and became narrower toward the east. They seem to be old as or younger than the beach ridge in the north (Bosch, 1988). The thickness of unconsolidated sediments increased eastward in Kelantan delta, with the deepest bedrock at a depth of 150 m (Bosch, 1986).

2.3 Structural Geology

According to Hutchison (1975), the structures of Peninsular Malaysia possibly started from as early as Cambrian up to Cenozoic as the structural geology shows a long and complex tectonic evolution. Peninsular Malaysia was divided into three major belts, with a less clearly defined domain in the NW direction, which are Central Belt, Eastern Belt and Western Belt (Figure 2.1).

The boundary between Central and Eastern Belt is marked by Lebir Fault Zone. (Hutchison and Tan, 2009) The Lebir Fault Zone can be traced NNW-SSE trending curve-linear lineaments along Sungai Lebir near Manek Urai in Kelantan. The lineament continues to the south before terminating at the intersection with Lepar Fault in Pahang. The fault zone is at least 10 km wide, spanning the gap between the Sungai Lebir and the eastern margin of the Taku Schist near Kuala Krai. The rocks within the fault zone are deformed into brecciated metasediments, flasered granites and mylonites. Slickensides on the fault surface that is exposed along the road-cut, indicates sinistral movement.

According to Metcalfe (2000), Peninsular Malaysia is a part of east Eurasian Plate and tectonically located to the north of currently active subduction arc zones of Sunda arc. The Peninsular Malaysia can be classified into two tecto-stratigraphic terrenes that form part of Sunda shelf, which are the East Malay and Simubu terrenes.

The Eurasian Terrene has be regarded as Permian to Triassic island arc system, which never been far drifted from ShanThai block. The stratigraphical and paleontological evidences suggest a possible origin of these terrenes is by rifting of the north-east margin of the ancient Gondwanaland landmass in the Late Permian to Late Triassic that responsible for the formation of the Central Belt and Raub-Bentong Suture (Metcalfe, 2002).

The Central Belt to the east of Bentong Suture line form as accretionary complex. This cause a thin and irregular strip and island arc sequence developed in front it, and later these detachments collided with the accreting Asian landmass and fused along the Raub-Bentong Suture. Peninsular Malaysia to the east of suture belongs to Cathaysia. A collision structure overprint has generated major N-S or NW-SW trending left slip fault and dilational Riedal and subsidiary shears and numerous splays associated with these fault (Tjia & Zaitun, 1985).

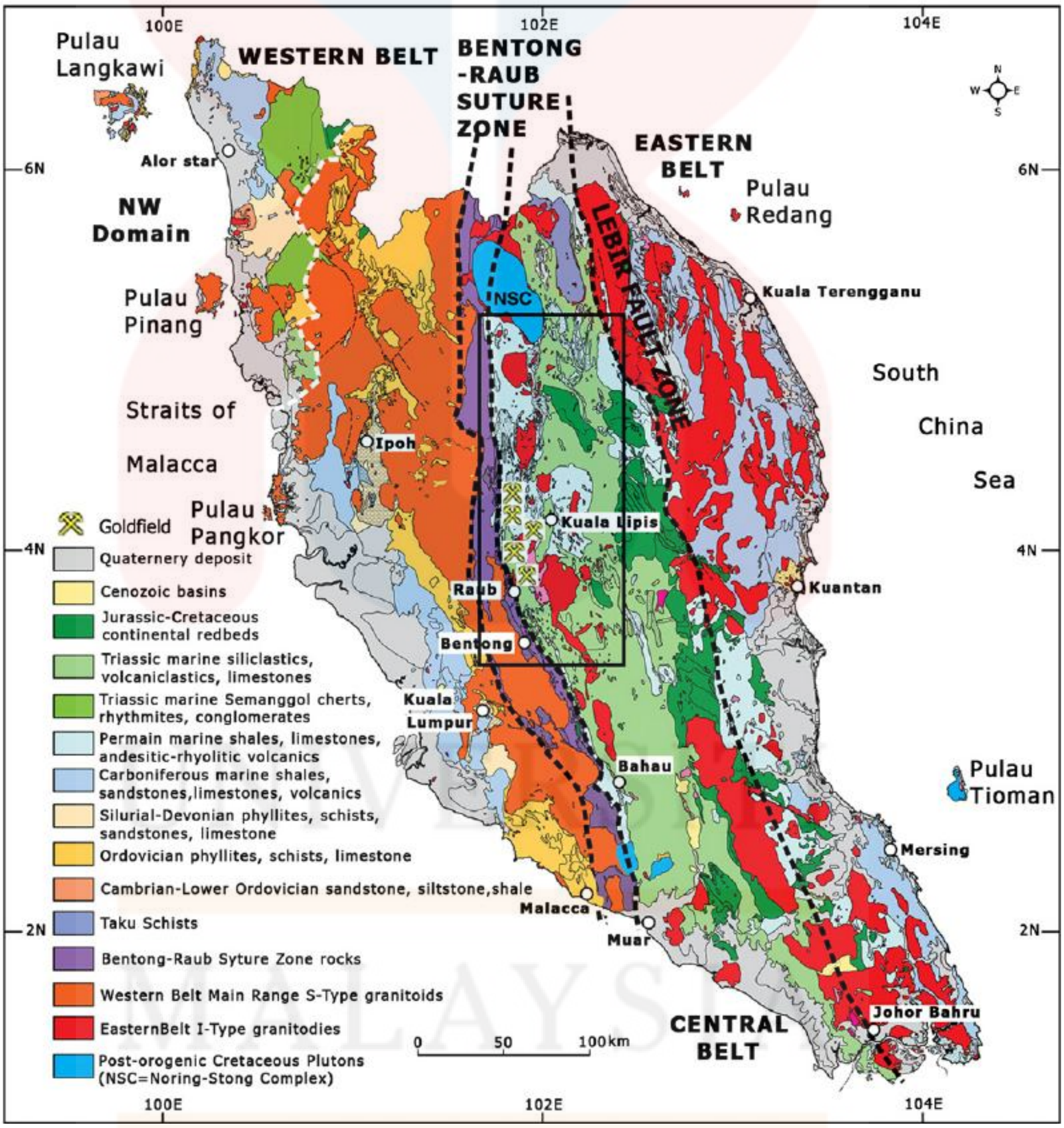


Figure 2.1 : Simplified geological map of the peninsular Malaysia.

(Source : Metcalfe , 2013)

2.3.1 Deformation

According to Fossen (2010), the deformation can be defined as the transformation from an initial to a final geometry by means of rigid body translation, rigid body rotation, stain and volume change. The term commonly refers to the distortion that is expressed in a rock. The term deformation also can be mean as changes occur in the form and shape of the rock.

Structural geology is the study of three-dimensional distribution of rock unit with respect to their deformational histories. There are three types of structure geology, which are primary structure, secondary structure and compound structures. The primary structures are the structure that developed at the time of formation of the rocks. Secondary structures are the structures that develop in rocks after formation as a result of their subjection to external forces. Compounds structures are form by combination of events some of which are contemporaneous with the formation. (Rowland *et al.*, 2006).

2.3.2 Folding

According to Fossen (2010), folds are referred as wavelike appearance or form, which resembles to ocean waves. They are best shown in stratified formation such as in sedimentary rocks, but any layered or foliated rock for example, banded gabbros or granite gneiss also may display folds. Some folds are large with few miles or kilometres away, the width of others to be measured in feet or metre or even in fraction of an inch.

The axial plane or axial surface of a fold is the plane or surface that divides the folds as symmetrical as possible (Figure 2.2). In some folds, the axial plane is vertical while in others, it is inclined and in still other, it is horizontal. The sides of a folder are referred as limbs or flanks. A limb extends from the axial plane in one fold of the axial plane in the next. The highest zone of a fold is called hinge zone and the lower zone is called trough (Edward *et al.*, 2010).

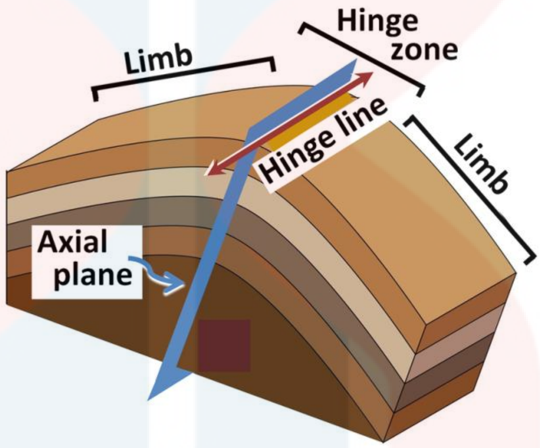


Figure 2.2 : Terminology of Fold

(Source : Ohare, 2010)

On the basis of dip relationships, three major types of folds can be classified, which are anticline fold, monoclines fold and over turned fold. Anticline fold is the strata on opposite limbs dip towards the axis, where the folds that concave upwards. Monoclines fold is the folds in which horizontal or gently dipping beds are modified by simple step like bends. Over turned fold is the axial plane is inclined and both limbs dip in the same direction but usually at different angles (Edward *et al.*, 2010).

2.3.3 Faulting

Faults are fractures in the Earth's crust along which slippage or displacement has occurred and caused the formerly continuous beds have been dislocated in a direction parallel to the surface of the fault. The displacement may vary from a few inches or less, to many miles (Fossen, 2010).

When subjected to great pressure, the Earth's crust may have to withstand shear force in addition to direct compression. If the shear forces become enormous, movement will take place along the plane of failure until the unbalanced forces are equalized and a fault will be the result.

The vertical component of the displacement between two originally adjacent points is called throw of the faults. The block above the fault is called hanging wall and the underlying block is termed as foot wall (Figure 2.3). The horizontal component of displacement is called the heave and the angle of inclination to the vertical is called the Hade of the fault (Edward *et al.*, 2010).

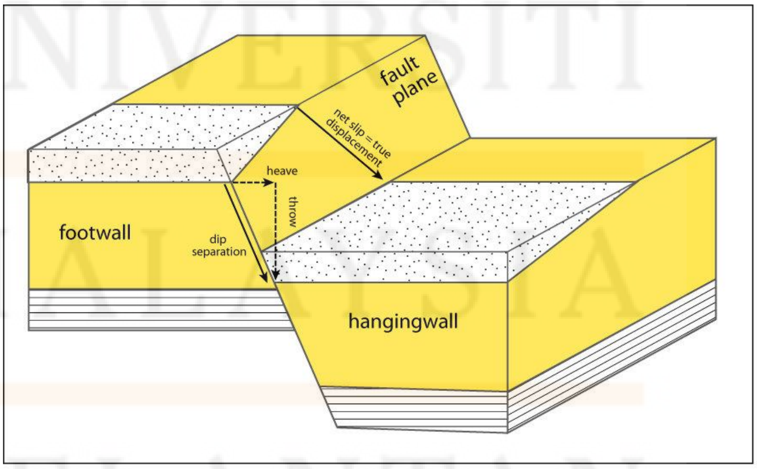


Figure 2.3 : Fault autonomy

(Source : Krabbendam, n.d.)

The two common types of faults are normal faults and reversed fault. In a normal fault, the hanging wall is displaced downward relative to the footwall. In the reversed faults, the hanging wall is displaced upwards relative to footwall. If the faults dip at angles less than 45˚, the term high thrust fault is applied. Strike slip faults are the high angle fractures in which displacement is horizontal, parallel to the strike of the fault plane with little or no vertical movement (Edward *et al.*, 2010).

2.3.4 Joint

Joints can be defined as the planes or surface which intersect rocks, but along which there has been no significant displacement parallel to the joint surface. When displacement parallel to the fracture is measureable, the fracture is known as a fault. Joints result either from tension or shear stress acting on rock mass.

The cause of stresses may be due to contraction, compression, unequal lift, subsidence, earthquake or other earth phenomena. Tension joints arise, for instance by drying and resultant shrinkage of sedimentary deposits, or igneous rocks by contraction and cooling. Shear joints may arise from compression of sedimentary or igneous rocks (Rowland *et al.*, 2006).

2.3.5 Geometric analysis

According to Fossen (2010), the analysis of the geometry of the structures is referred to as geometric analysis. This includes the shape, geographic orientation, size and geometric relation between the main structure and related smaller-scale structures. Geometric analysis is the classic descriptive approach to structural geologic analytical method build on.

2.3.6 Strain Ellipsoid

Rowland *et al.*, (2006) stated that the deformation in rocks is described in terms of the change in shape or size of an imaginary sphere. During homogeneous deformation the imaginary sphere within the rock becomes an ellipsoid. Before considering three-dimensional deformation, however, it is instructive to examine deformation in two dimensions. Upon deformation, the circle becomes an ellipse. This ellipse is called a strain ellipse, and its orientation and dimensions characterize the deformation of the plane in which it lies. Figure 2.4 contains the strain ellipse representing the deformed circle.

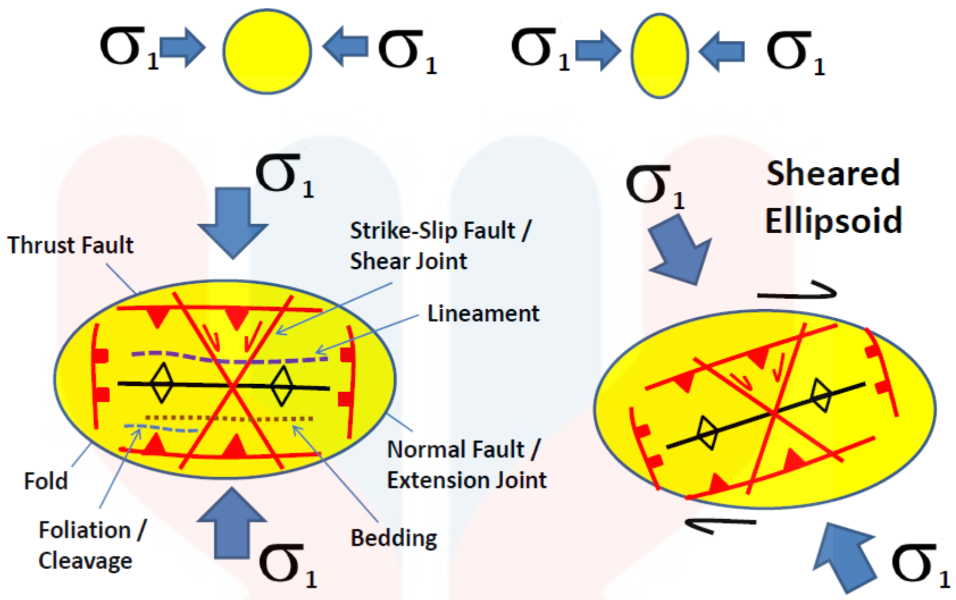


Figure 2.4 : Strain ellipsoid

(Source : Rowland *et al.*, 2006)

CHAPTER 3

MATERIALS AND METHODOLOGIES

3.1 Introduction

This chapter will discuss on the materials and methodologies used in completing this study. Figure 3.1 shows the flow chart of the materials and method that are used in study. The flow chart is divided into 4 phases, which are preliminary research, field studies, data analysis and reporting.

3.2 Preliminary Research

Preliminary studies provide an initial overview of the study area. Studies have been done through a reference library, observation of topographic maps and geological map also observations from the satellite image. Reference library aims to acquire general knowledge on geology and geological structures of the study area. It includes the process of reading previous reports, books, journals, proceedings and others.

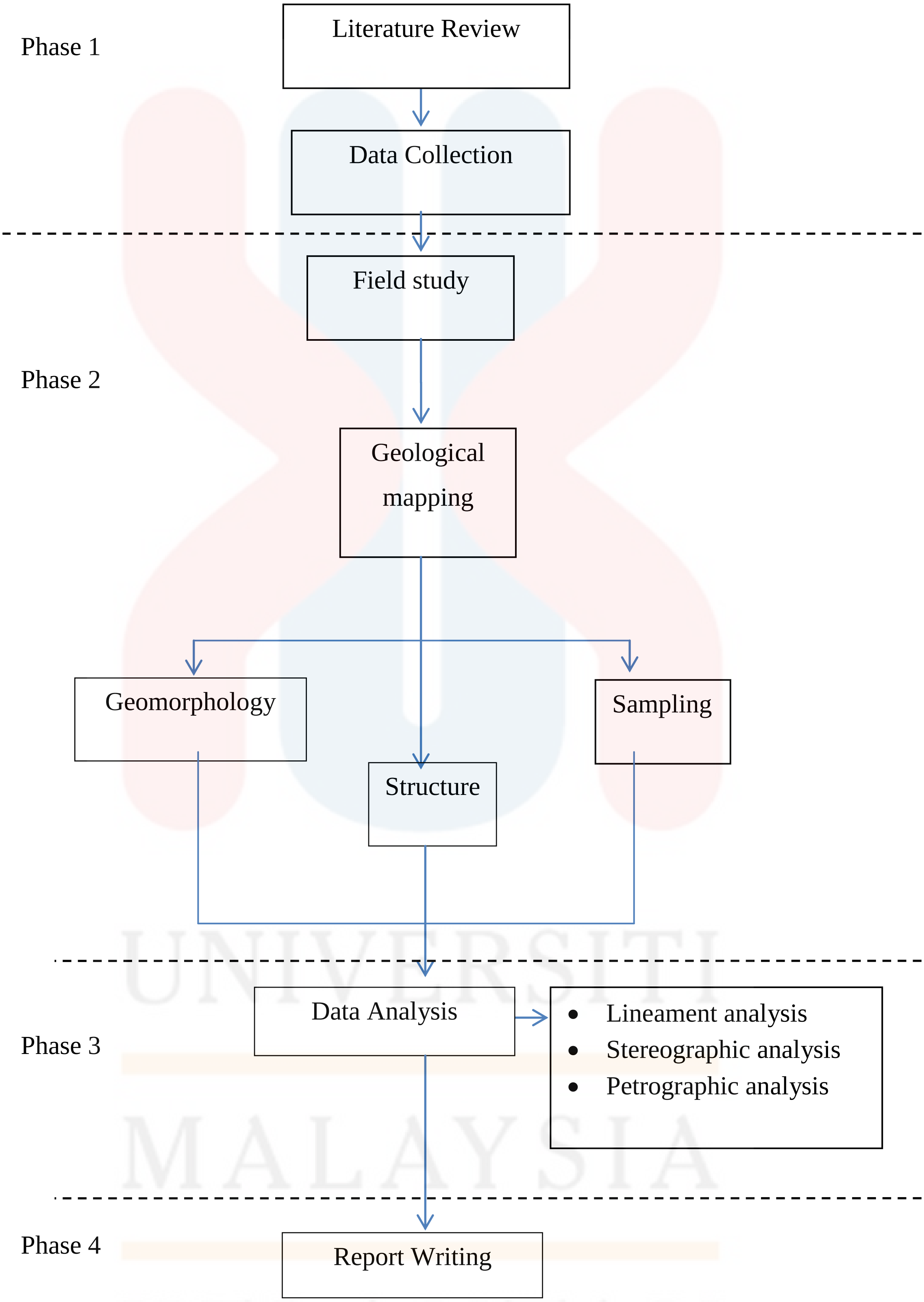


Figure 3.1 Research Flow Chart of the Study

3.3 Materials

The materials used in this study are fieldwork materials and laboratory materials. The fieldwork materials were used to support methods during field works in order to collect data. The fieldwork tools are base map, Brunton compass, Estwing rock pick hammer, Geographic Positioning System, Hydrochloric Acid, hand held lens, measuring tape, digital camera, sample bag, field notebook and stationery. Laboratory material was used to prepare thin section and optical microscope for petrographic analysis.

The software was used to interprete, analyze geological features of the study area and producing geological map. The software used is ArcGIS 10, GeoRose and Stereonet.

3.4 Field Study

The geological mapping was conducted in this study. An observation in the field is next step after preliminary study of the study area. This study aims to find out a more details about the study area. The base map provided in an earlier study was being used at field. Fieldwork is divided into five main types that are traverse, rock sampling, geological mapping and geomorphological mapping and collecting strike and dip of geological structure.

3.4.1 Traverse

Traversing is determined through observing the topographical map and set by passing point of interest in the study area. Traverse was conducted either by following river traverse or road traverse. The pathway were then automatically recorded and constructed from point of localities via GPS.

For traverse method, the start of each daily traverse contained the following information written on the top of the description page, such as name of traverse, date and time. The spatial attribute of each observation station along field traverse lines was recorded. The attributes of geologic features are briefly described as they appear on the outcrop, such as strike, dip, faulting and folding at each field observation point. The station number was labelled on the base map and the coordinates of the station is recorded.

The study area requires much traverse as possible in order to give accurate depiction of the geological map. Therefore, field observation along with assumption and estimation plays an important role in perfecting the geological map as some data can be out of reach in term of accessibility or dangerous setting of deformation. For instance, if the outcrop is heavily covered by the vegetation, the boundary will be drawn by estimation approximately between different lithologies.

3.4.2 Rock Sampling

Rock sampling was done by breaking the exposed outcrop of the rock in the fresh area. The rock sample taken should be fresh and has palm-sized. It is important to avoid taking sample that is heavily weathered because it can give wrong result in further analysis. The geological hammer was used to break the rock in the field. The rocks were hammered in order to take sample and to observe the fresh exposure part of the rock.

In rock sampling, the weathered part of the outcrop was avoided in order to ensure the rock sample taken from the particular outcrop can give accurate characteristics and the real condition of the rock.

Rock sampling was done by selecting the rock that is on bedding plane to ensure the cutting process in preparing the thin section easier resulting better data. The sampled rock was put in sealed sample bag which then the locality of the sample and number of sample will be marked on the sample bag.

3.4.3 Geological mapping

Geological mapping was carried out to collect the following criteria such as orientating, traversing and sampling. The lithology and geological structural were observed by sight, touching and also using the camera for further studies. Other structural geology features such as strike and dip will be determined by using left-hand rule and a Brunton compass. Sketches were included to support the geomorphic information. GPS were used to provide the information such as the coordinate of the sampling taken place and the study area for the report use.

Orientation description is important in geological mapping. The linear features in rocks are called lineation. The orientation of the lineation is described by a trend and plunge. The trend can be given as an azimuth or bearing. The plunge is a number between 0 (for horizontal lines) and 90 (for vertical lines). Planar features in rocks include bedding, faults and foliations.

3.4.4 Geomorphological mapping

The landform of the study area was studied by observing the surrounding of the area. Geomorphological mapping for weathering was conducted by observing weathering rocks or outcrop found. The drainage pattern was also been identified. Drainage pattern is the pattern formed by the streams, rivers, and lakes in a particular drainage basin. The patterns are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks, and the gradient of the land. Then, all of the observations were described carefully and some of the data was documentated using the camera.

3.4.5 Collecting Strike-Dip Geological Structure

In the field, the strike and dip was collected for the structural analysis. The steps in measurement of the azimuth and plunge of a lineament began by selecting the part of the feature. The edge of the clipboard was placed on the linear feature; the clipboard was hold vertical and parallel to the feature to create a vertical line above it. The long side of Brunton compass was hold against the vertical side of the clipboard and measured the azimuth of the lower end of the linear feature to north by checking the round spirit level. For plunge, set the compass dial so the instrument can be used as a clinometer. Brunton compass was placed along the linear features and the reading the plunge angle from the compass is taken.

3.5 Laboratory Investigation

For this study, the laboratory works that has been done are preparing thin section, petrography analysis and updating geological map. Laboratory work was done to prepare the thin section of the rock samples. A thin section was prepared to study the mineral properties of the rock. The fresh rock was cut down to prepare the glass side. Then, the glass was being frost and marked the rock. The rock was mark according to the orientation. The slab was needed to be to reduce the size. After that, the side from which the thin section has been polished and the slide was glued to the chip. The slide was grinded to the correct thickness and lastly, the slip cover was added at the top of thin section.

After preparing thin section, the petrographic analysis had been done. Petrographic analysis is the analysis to determine the rock type and mineral composition of the rock. The detailed analysis of mineral by using petrographic microscope in thin section is important to understanding the origin of the rock. The preferred method for classifying any rock type, igneous, sedimentary, or metamorphic, is based on texture and composition, usually mineralogical composition of the rock. (Winter, 2001)

The updating geological map was been done in GIS. The data collection from the field work will be input into GIS to generate database for the study area. GIS interpreted, analysed the data and produced geological map.

3.6 Data Analysis and Interpretation

3.6.1 Lineament analysis

The lineament of the study area is obtained from photointerpretation from Google imagery. The parameter of the lineament analysis shows that the high topographic elevation is indicated as positive lineament, and associated with compression force. While, the low topographic elevation is indicated as negative lineament, and associated with tension force. The trend of both features is plotted in Rose diagram.

GIS is also can be used for to identify geological structures such as fault segment in the urban area.

3.6.2 Stereographic analysis

The stereographic analysis was conducted on conjugate fault found. The orientation of conjugate fault planes was plotted on the stereonet as plane. The orientation data of joints was plotted in Rose diagram. The major trend of joints is determined by the results. The sequence of deformation and stress associated with the deformation event is deducted based on field observation and structural analysis data.

3.7 Report Writing

The finding is reported in the form of geological map and complete thesis book along with field photographs. The report writing is done by compiling all the six chapters in the full report thesis.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

This chapter gives the information about the general geology of the study area, including geomorphology, stratigraphy, and historical geology. All the data were obtained from field observation and laboratory data analysis.

Traverse map shows the location of station during the field mapping (Figure 4.1). At the station, the field activities that had been conducted are collecting rock sample, geomorphological observation and measurement on the structural. All data collected for each station that was marked in the traverse map as shown in Table 4.1.

Table 4.1 : Activities for each station

Station (S)	Coordinates	Activities/ Observation
S1	N 05˚22’04.99” E101˚58’18.0”	Collecting rock sample (marble), geomorphological observation, measurement on structural
S2	N05˚21’58.5” E101˚58’20.9”	Collecting rock sample (granite), geomorphological observation
S3	N05˚21’25.6” E101˚58’41.9”	Geomorphological observation
S4	N05˚21’32.6” E101˚58’29.7”	Collecting rock sample (schist), measurement on structural

S5	N05˚21’25.6” E101˚58’18.1”	Geomorphological observation
S6	N05˚23’19.9” E101˚58’43.2”	Collecting rock sample (andesite), measurement on structural
S7	N05˚21’52.4” E101˚59’38.7”	Geomorphological observation
S8	N05˚22’11.2” E102˚00’27.1”	Geomorphological observation
S9	N05˚22’0.6” E102˚00’33.8”	Collecting rock sample (sandstone)
S10	N05˚22’32.6” E102˚00’19.2”	Collecting rock sample (Phyllite), geomorphological observation, measurement on structural
S11	N05˚22’36.7” E102˚00’19.9”	Measurement on structural
S12	N05˚23’38.9” E101˚59’41.5”	Geomorphological observation, measurement on structural

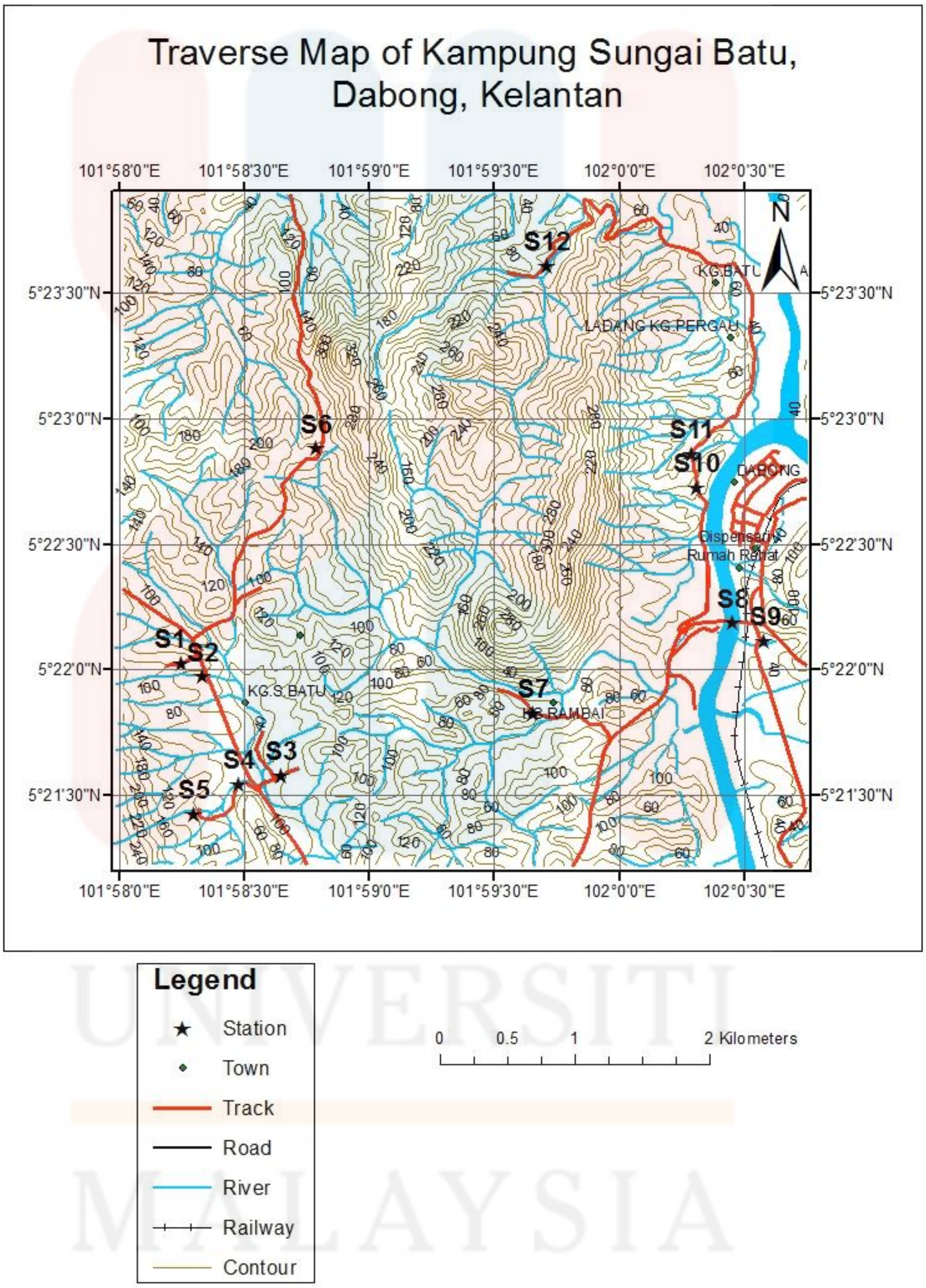


Figure 4.1 : Traverse map of study area

4.2 Geomorphology

Geomorphologic study is conducted based on topographic map, aerial photographs and also from the field observation. The geomorphology area includes topography and drainage pattern, which can give a brief view about the type of rocks in the study area.

4.2.1 Topographic Unit Classification

For topographic unit classification, the topography in the study area can be divided into two main features, which are hill area and undulating area based on Table 4.2. The study area is hilly on the west and centre part and flatter toward the east part of the study area (Figure 4.2). The elevation of the study area ranges from the lowest elevation of 20 m to the highest elevation of 320 m.

The hilly landform, which has mean elevation range from 76 m to 300 m, covered 70% of study area. Undulating area has mean range elevation 31 m to 75 m and located at the west part in the study area. There is a little part of mountainous landform at the western part of study area, which has mean elevation more than 301 m.

Geomorphology analysis is carried out at the study area, the type of rocks that found in the area is identified based on contour pattern. In the study area, the hilly area has the characteristic of igneous rock. Meanwhile, the undulating area consists of sedimentary rocks and metamorphic rocks.

Igneous rock is classified as the major rock constituent in the study area. This is because the majority part of the study area has hilly landform. There is also metamorphic rock that undergoes metamorphism process, which can be found nearby acid intrusive granite. The metamorphic rock can be found at the foothill area in the south-west part of study area.

Table 4.2 : Topographic unit classification

Classification	Topography Unit	Mean Elevation (m)
1	Low lying	<15
2	Rolling	16-30
3	Undulating	31-75
4	Hilly	76-300
5	Mountainous	>300

(Source : Hutchison and Tan, 2009)

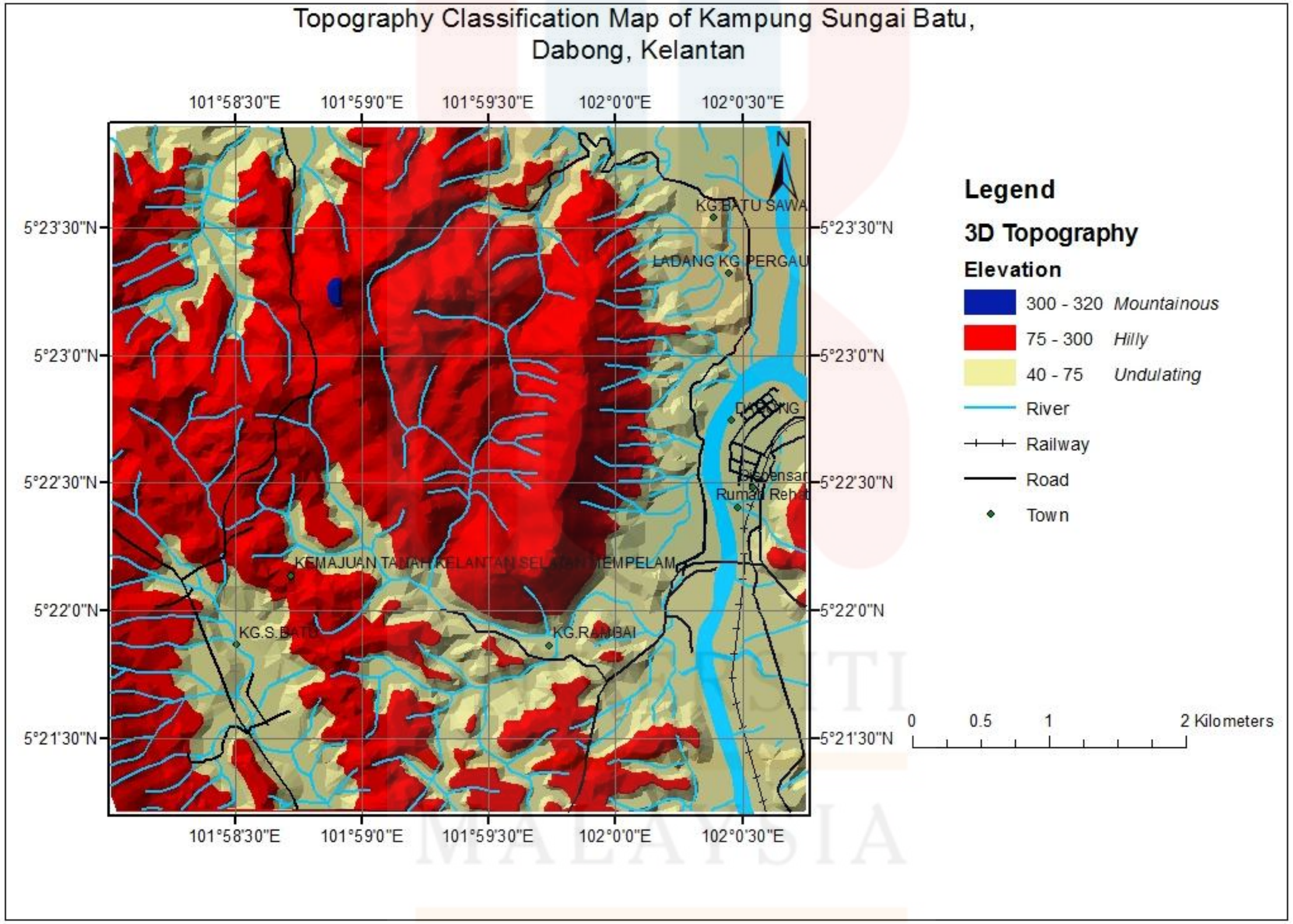


Figure 4.2 : Topographic Classification Map of Study Area

4.2.2 Drainage pattern

Drainage patterns are classified based on the main characteristics of their form and texture. Their shape or pattern develops is affected from the presence of bedrock structure and surface topography. The drainage pattern analysis is carried out based on the topographic map and aerial photographs.

There are two types of drainage patterns at the study area which are dendritic and sub-parallel. (Figure 4.3). Dendritic pattern is the most found pattern which covered over half of the study area, while sub- parallel pattern is found at the west south area. Based on the study of drainage map shown in Figure 4.5, it can be observed that the river pattern is unevenly distributed. This is probably because of the difference in elevation between east and west part of the study area.

Dendritic drainage pattern is the most common type, has spreading, tree- like pattern with an irregular branching of tributaries in many direction and at most any angles. This pattern develops in gently sloping basins with fairly uniform rock type. Dendritic patterns form where the underlying rock structure does not strongly control the position of stream channels. Hence, dendritic patterns tend to develop in areas where the rocks have a roughly equal resistance to weathering and erosion and are not intensely jointed like sandstone and shale.

For sub-parallel pattern, the pattern shows relatively less parallel then the parallel pattern. The parallel to sub parallel drainage is from characteristic of the basaltic pattern. This is because of the result of stepped topography.

Besides, the stage of the river is also important. There are two main rivers which are Sungai Pergau and Sungai Galas, which both show to be at the old stage river (Figure 4.4 and Figure 4.5). This is due to the characteristics of the rivers which has very low steepness in the river gradient. Moreover, the rivers have very wide floodplain and have a lot of meanders curve. These characteristics are abundant and prominent features for an older river.

Besides, the rivers also have a lot of sand deposits at the centre of the rivers. This shows that the rivers are capable to transport small-sized sediments like silts and clays. The channels of the rivers are wide due to extensive lateral erosion and the water flows is quite slow.

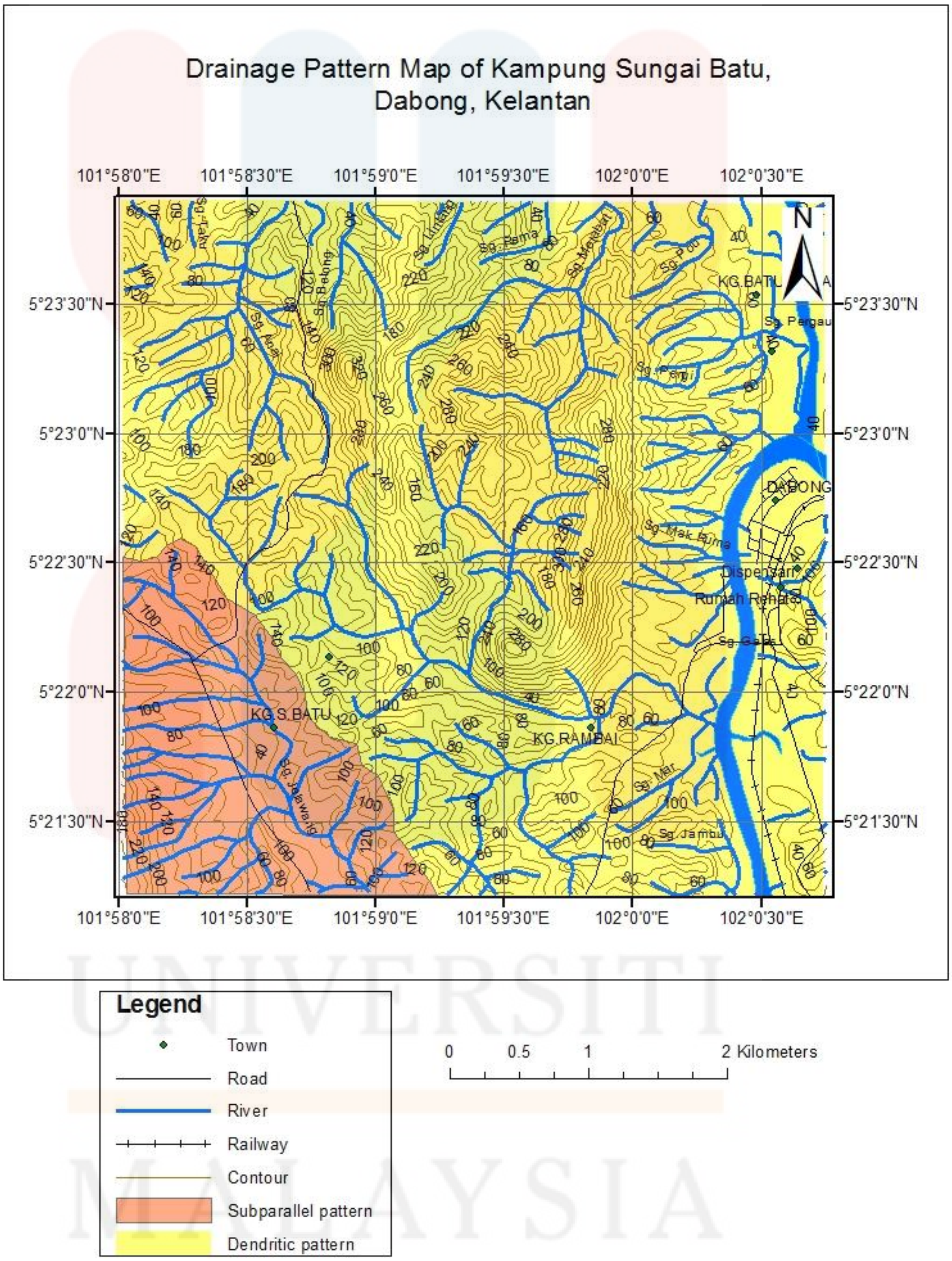


Figure 4.3: Drainage Map of Study Area

Figure 4.4 : Old stage river (Sungai Pergau)

Figure 4.5 : Old stage river (Sungai Galas)

4.2.3 Weathering

Weathering in the study area can be classified into physical, chemical and biological weathering process. As Malaysia has hot and humid climate throughout the year, the climate can influence the weathering process as the temperature and humidity are the factors affecting weathering.

i) Chemical weathering

Chemical weathering alter the chemical composition of the rock The marble found at Sungai Batu shows that it undergoes chemical weathering and as the results the joints are develop on its surface (Figure 4.6). This process occurs when the water that contains with carbonic acid react with calcite mineral, dissolving into fine particles and washed away along the joint by running water.

Schist that has been found near the main road is covered with loose material like soil, which probably to be the weathering product of the schist. The schist is weathered into clay size mineral due to chemical weathering effect and soil-like texture shown in Figure 4.7. The schist probably undergoes hydrolysis process that was caused by heavy rainfall, as when the chemical reactions occur, it caused the rock to become soft and made erosion process easier to happen.

Sedimentary rock is easily affected by chemical weathering. These rocks can be easily washed away during the heavy rain and being weathered into loose particles, as the rock also become very soft even when not mixed with water.

Figure 4.6 : Chemical weathering

Figure 4.7 : Schist with soil-like texture

ii) Biological weathering

For biological weathering, the rock is break down because of biological activity of plants, animals and microbes. In the study area, most of granite outcrop found was covered by vegetation like small plants, which may be indicates that biological weathering might take place as growing plant roots can exert stress or pressure on rock (Figure 4.8).

iii) Physical weathering

For physical weathering, the process involves where the rock break up when there is change in temperature and pressure on the rock. Physical weathering depends on the force act on rock mass. Phyllite found at the cut slope show the force act due to change in temperature and pressure. These pressure cause phyllite to break up into smaller pieces physically (Figure 4.9).

Figure 4.8 : Biological weathering

Figure 4.9 : Physical weathering

4.3 Stratigraphy

Stratigraphic studies is the subdivision of a sequence of rock strata into map able units, determining the time relationships that are involved, and correlating units of the sequence or the entire sequence with rock strata elsewhere.

4.3.1 Lithology unit

In the study area, there are three main lithology units which are igneous rock unit, metamorphic rock unit and sandstone unit. Igneous rock unit consists of granite and andesite, while metamorphic rock composed of marble, schist and phyllite. The characteristics of the rocks exposed are described in detail below from the oldest to the youngest of the rock.

A) Andesite

The outcop is located at N05˚23’19.9”, E101˚58’43.2” which is at the north west of study area. The height of outcrop is 3.5 m and the width of the outcrop is 6.0 m (Figure 4.10). The outcrop is near the road and at the hill landform. Some part of the outcrop is covered by vegetatation.

Figure 4.10 : Andesite outcop

Based on the hand specimen shown in Figure 4.11, the texture of the rock shows that it has moderately rough surface. Besides, it also shows it is aphanitic rock which is very fine grain size that cannot be seen by naked eyes, which only can be seen under microscope. The rock is an extrusive igneous rock and has a black, gray and milky white in colour.

Figure 4.11 : Hand specimen

From the microscopic observation, the grain size of the minerals is small (Figure 4.13). The rock contain with 15% quartz, 10% alkali feldspar and 70% plagioclase. According to QAP diagram for volcanic rock types, the rock can be classified as andesite (Figure 4.12).

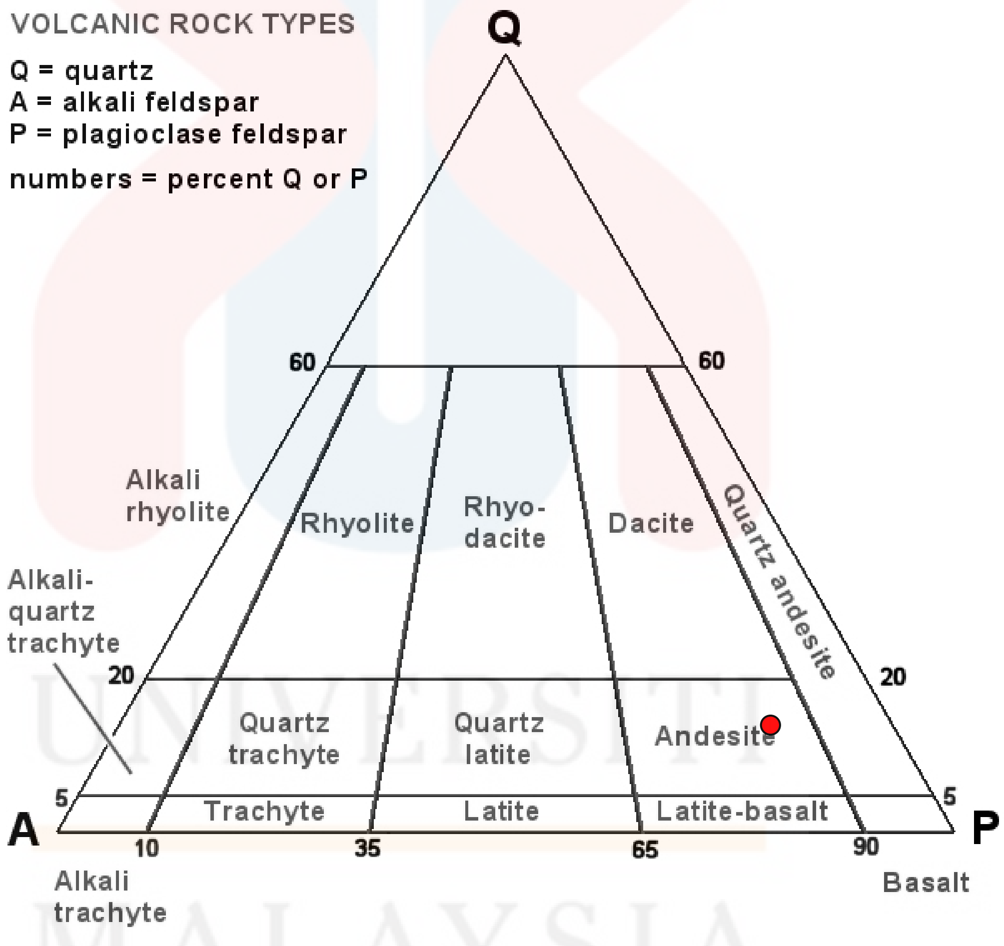


Figure 4.12: QAP diagram of the rock sample

(Source : Alden, 2008b)

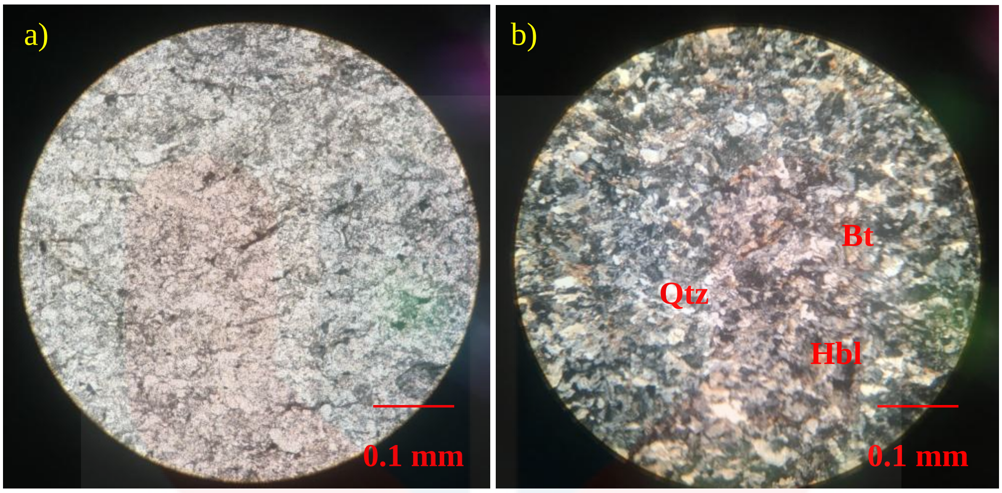


Figure 4.13 : Thin section analysis under 4x10 magnification a) plain polarize, b) cross polarize

B) Sandstone

The outcrop is located at N05˚22’0.6”, E102˚00’33.8” which is at the east of the study area. The outcrop is near a road and covered with vegetation (Figure 4.14). The outcrop is highly weathered.

Figure 4.14: Sandstone outcrop

Based on hand specimen, the rock has gritty and smooth texture on the surface (Figure 4.15). The rock has fine grained size. The colour of the rock is reddish brown.

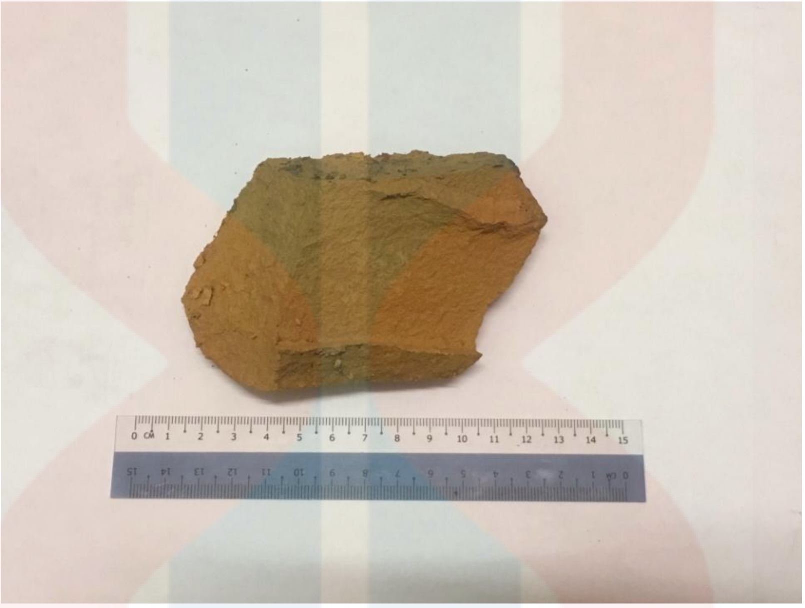


Figure 4.15 : Hand specimen

C) Schist

The outcrop is marked at N05˚21’32.6”, E101˚58’29.7” which at the south west of the study area. The outcrop is quite large, which dimension 12 m height and 22 m width. The outcrop is at 20 m from the main road. The outcrop is highly weathered (Figure 4.16). Figure 4.17 shows that the outcrop contains quartz vein.

rock has gray, brown, and orange in colour.

Figure 4.16 : Schist outcrop

Figure 4.17: Quartz vein

In hand specimen, the texture of the rock shows that it has moderately irregular and rough surface with foliation (Figure 4.18). The grain size of schist is in medium grain. The mineral of the rock composed of quartz, feldspar and biotite. The rock has gray, brown, and orange in colour.

Figure 4.18 : Hand specimen

D) Phyllite

The outcrop is found at east part of the study area with coordinate N05˚22’32.6”, E102˚00’19.2”. The outcrop is located at the cut slope near a road. The height of the outcrop is 3 m while the width is 5 m. The outcrop is highly weathered. The outcrop also has foliated structure (Figure 4.19).

Figure 4.19 : Phyllite outcrop

From the hand specimen, the texture of the rock is rough surface with foliation. The rock has foliation structure as the grain size mineral is fine grain and dense with slaty cleavage. The colour of the rock is dark grey and brown in colour (Figure 4.20).

Figure 4.20 : Hand specimen

E) Marble

The outcrop is situated at south west part of study area with coordinate N 05˚22’04.99”, E101˚58’18.0”. The outcrop is at the river under the bridge (Figure 4.21). The size if the outcrop is 0.8 m height and 3 m width. The outcrop has a lot of joints.

Figure 4.21: Marble outcrop

The hand specimen shows that the texture of the rock is moderately rough surface (Figure 4.22). It has medium grained size as the interlocking calcite crystals with the naked eye. The rock is milky white in colour. It reacts with HCL. From the microscopic analysis, it composed mainly of calcite mineral (Figure 4.23).

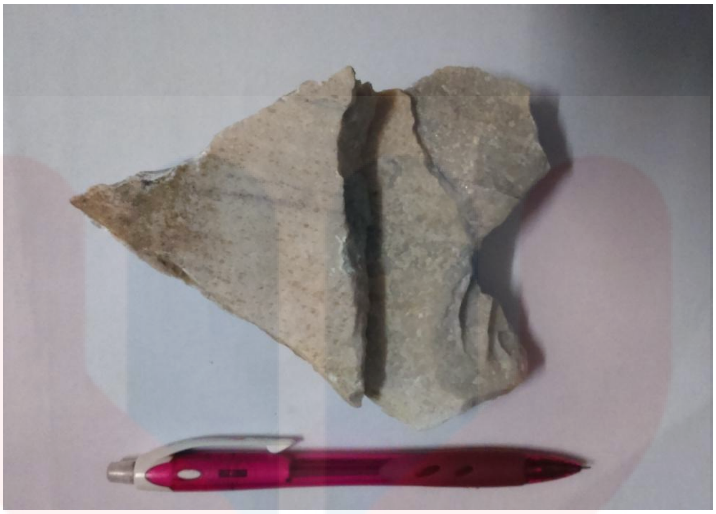


Figure 4.22 : Hand specimen

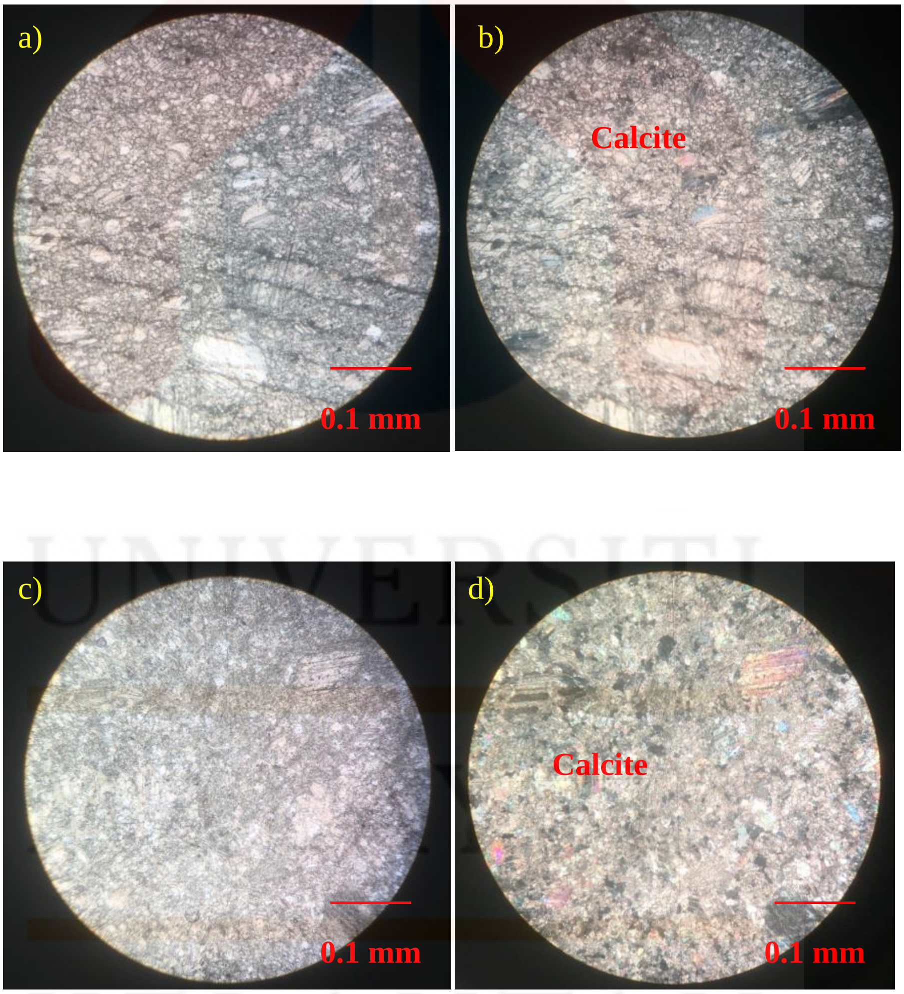


Figure 4.23: Thin section analysis under 4x10 magnification, a) plane polarize, b) cross polarize, c) plane polarize, d) cross polarize

F) Granite

The outcrop is located at N05˚21'58.5", E101˚58'20.9" which is on southern part of the study area. It is near the main road and beside the villager's house (Figure 4.24). The outcrop has dimension of 1.0 m width and 0.5m height.

Figure 4.24 : Granite outcrop

The hand specimen shows that the texture shows it has rough surface with shiny quartz and dull white feldspar Figure 4.25). The rock has holocrystalline characteristics as it composed wholly of crystal.

Besides, it also shows phaneritic which is coarse grain size that can be seen with naked eyes. The grain is range from 0.01 mm to 0.03 mm. The rock composed of feldspar, quartz and biotite mineral. Feldspar is in light and dull milky white and grey in colour while biotite shows shiny black and quartz shows it is in shiny milky white in colour.

Figure 4.25 : Hand specimen

For the petrography analysis shown in Figure 4.27, QAP diagram in Figure 4.26 is used to classify the plutonic igneous rock based on mineral composition. The rock has the percentage of quartz (Q) of 50%, alkali feldspar (A) of 40% and plagioclase (P) of 10%. From the results, the rock is called granite. Granite is felsic plutonic igneous rock as it has high contain of silica content.

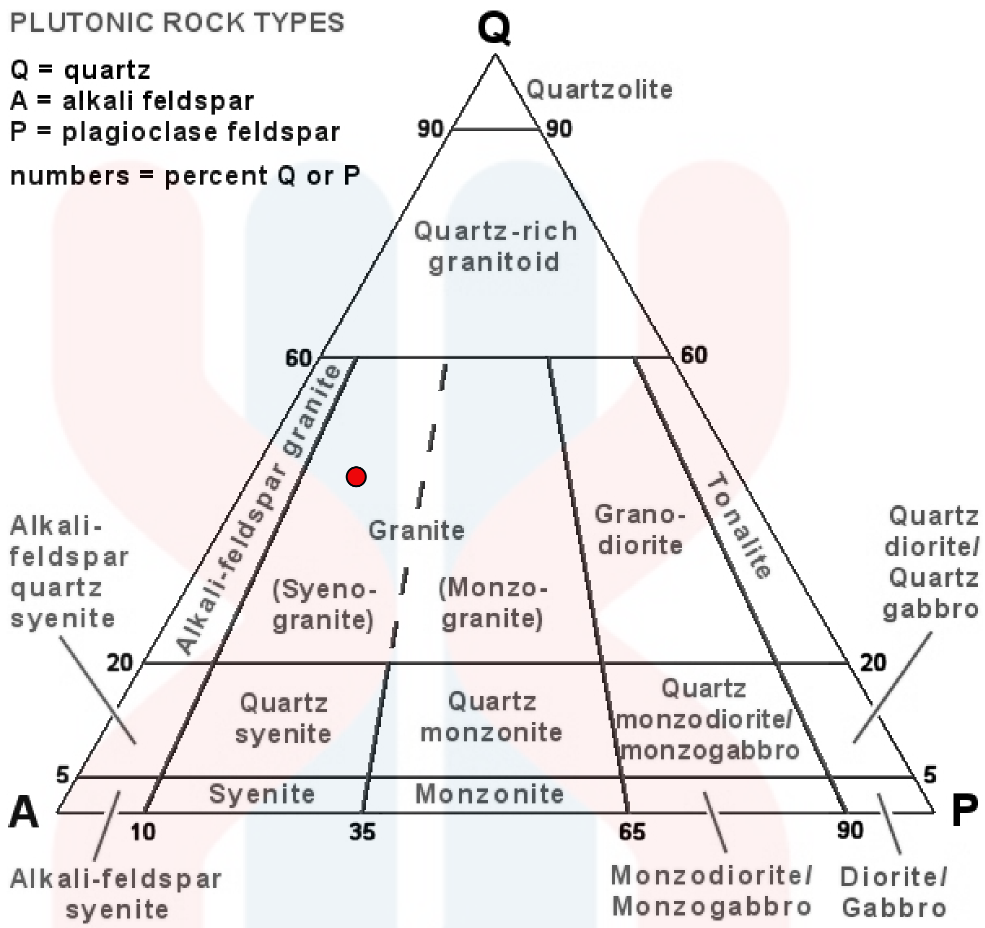


Figure 4.26 : QAP diagram of the rock sample

(Source : Alden, 2008a)

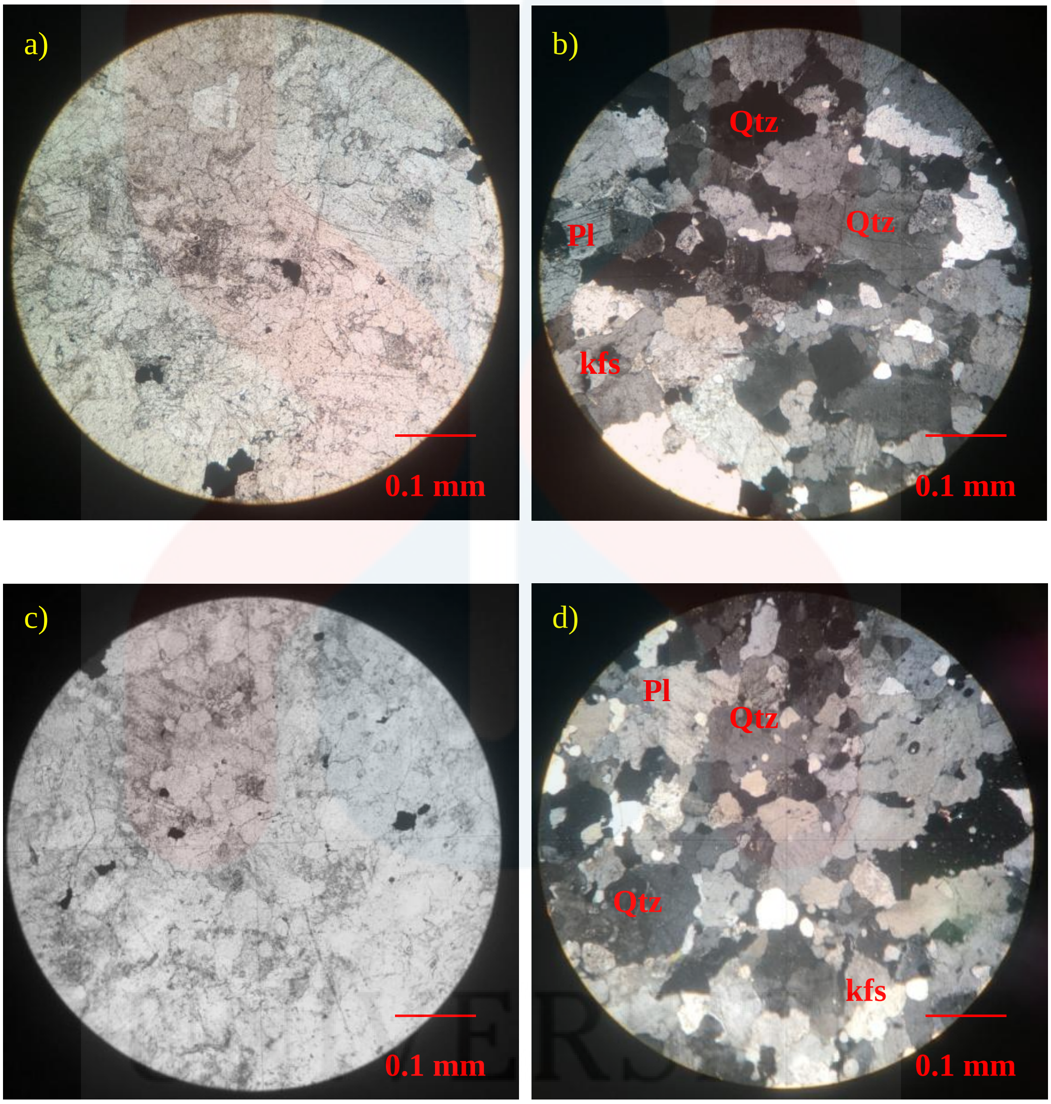


Figure 4.27 : Thin section analysis under 4x10 magnification a) plane polarize, b) cross polarized, c) plane polarize, d) cross polarized

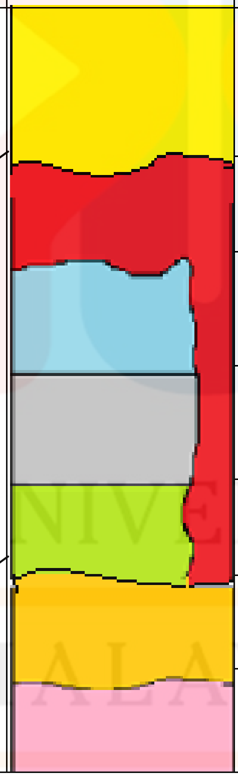
4.3.2 Lithostratigraphy

Lithostratigraphic units describe the bodies of rock that presents in the study area, which are defined and characterized on the basic of their lithologic properties and their stratigraphic relations. Lithostratigraphy of the study area was proposed based on outcrop study, hand specimen analysis, petrography and literature reviews.

The lithostratigraphic column of the study area is shown in Table 4.3. Rock that was found in the study area composed of igneous rock, metamorphic rock and sedimentary rock. These rock aged from Late Permian to Upper Triassic. The oldest rocks are andesite and sandstone, which involved in certain part of Telong Musang formation that formed in Late Permian until Late Triassic period.

During Triassic period, granite is believed from Stong Intrusion, which caused the formation of metamorphic rock from the metamorphism near the intrusion. Metamorphic rock like schist, marble and phyllite found in the study area support the evidence of metamorphism that occurred due to intrusion. The alluvium is formed during Quaternary period.

Table 4.3 : The lithostratigraphic column of study area

ERA	PERIOD	UNIT	LITHOLOGY	DESCRIPTION
CENOZOIC	Quaternary	Alluvial		Alluvial consists mainly of sand, silt and clay. Widespread in the flat river valley
		unconformity		
MESOZOIC	Triassic	Stong Migmatite Complex		Granite : Greyish-white colour, intrusive igneous rock
				Marble : Milky white in colour, non-foliated metamorphic rock
				Phyllite : Dark grey in colour, has slaty texture
				Schist : Greyish brown in colour, has schistose texture
		unconformity		
PALEOZOIC	Permian	Telong Formation		Sandstone : Reddish brown in colour, argillaceous sedimentary rock
				Andesite : Grey in colour, extrusive igneous rock

4.4 Structural Geology

Will be discussed in detail in Chapter 5.

4.5 Historical Geology

The study area consists of rocks from Permian until Quaternary period based on the lithostratigraphic column shown in Table 4.1. Telong formation formed in Late Permian until Late Triassic consists of andesite and sandstone at the study area.

The metamorphic rock and granite formed associated with Stong Migmatite Complex during Triassic period as the granite intrude the metamorphic rock, which are shist, phyllite and marble. Then, in Quaternary period, the alluvium is formed.

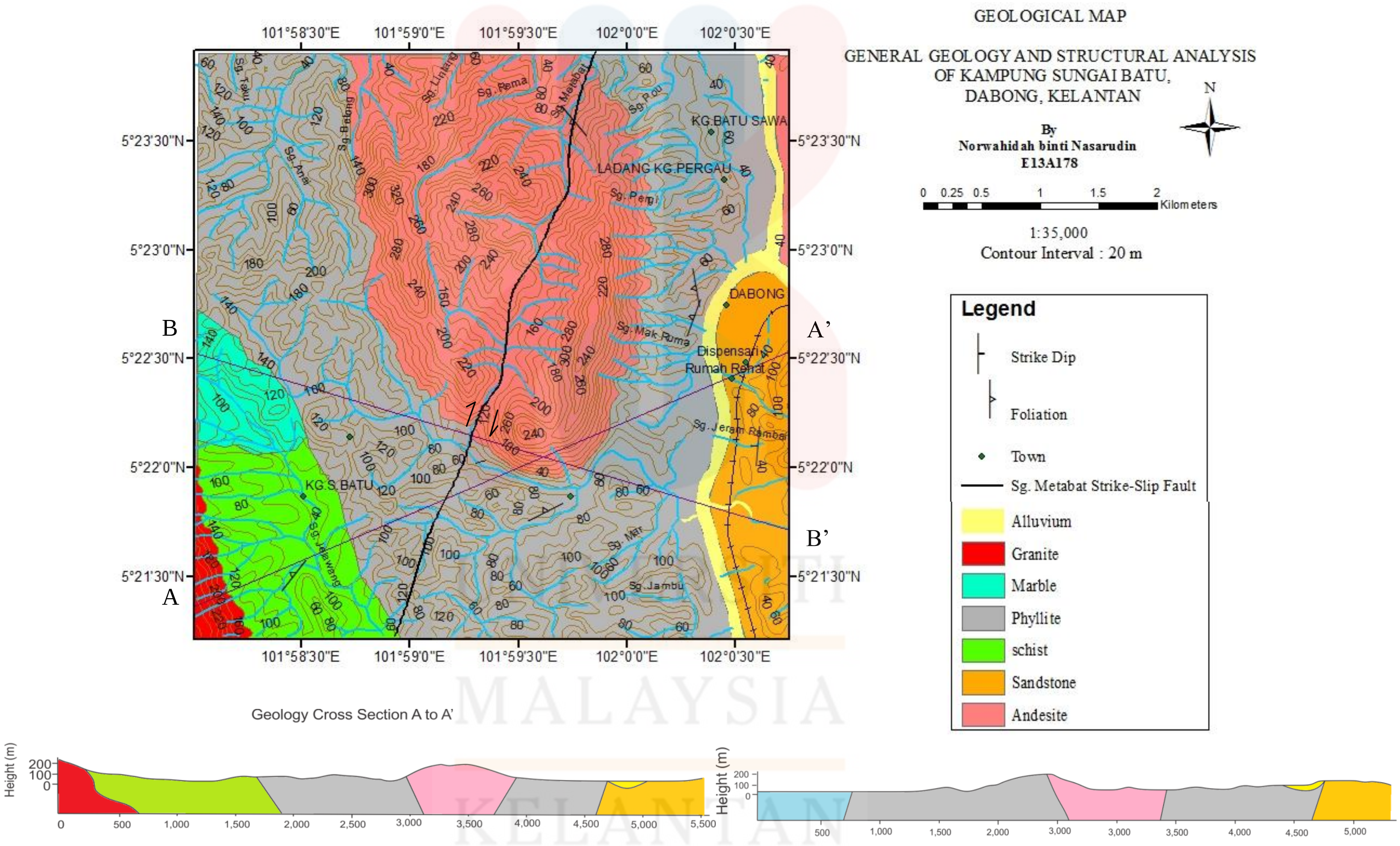


Figure 4.28 : Geological Map of Study Area

CHAPTER 5

STRUCTURAL ANALYSIS

Structures in Kampung Sungai Batu would be analyzed based on field observation and statistical methods. The main focus of this chapter is to observe the structures at study area in order to determine the most common geological structures at the study area and to analyze the pattern or direction of the present geological structures.

5.1 Lineaments

Lineaments are straight or gently curving features of Earth's surface, which commonly expressed on Earth's surfaces as ridges and depression. Photointerpretation method was used by using Google Maps Terrain to interpret these linear features in regional scale. Figure 5.1 shows the lineament that considered in a large scale area around the study area. The orientation of each lineament is measured and plotted into rose diagram to determine the force direction. The result for the lineament analysis in Figure 5.2 shows that the major direction force (σ_1) is NNE-SSW .

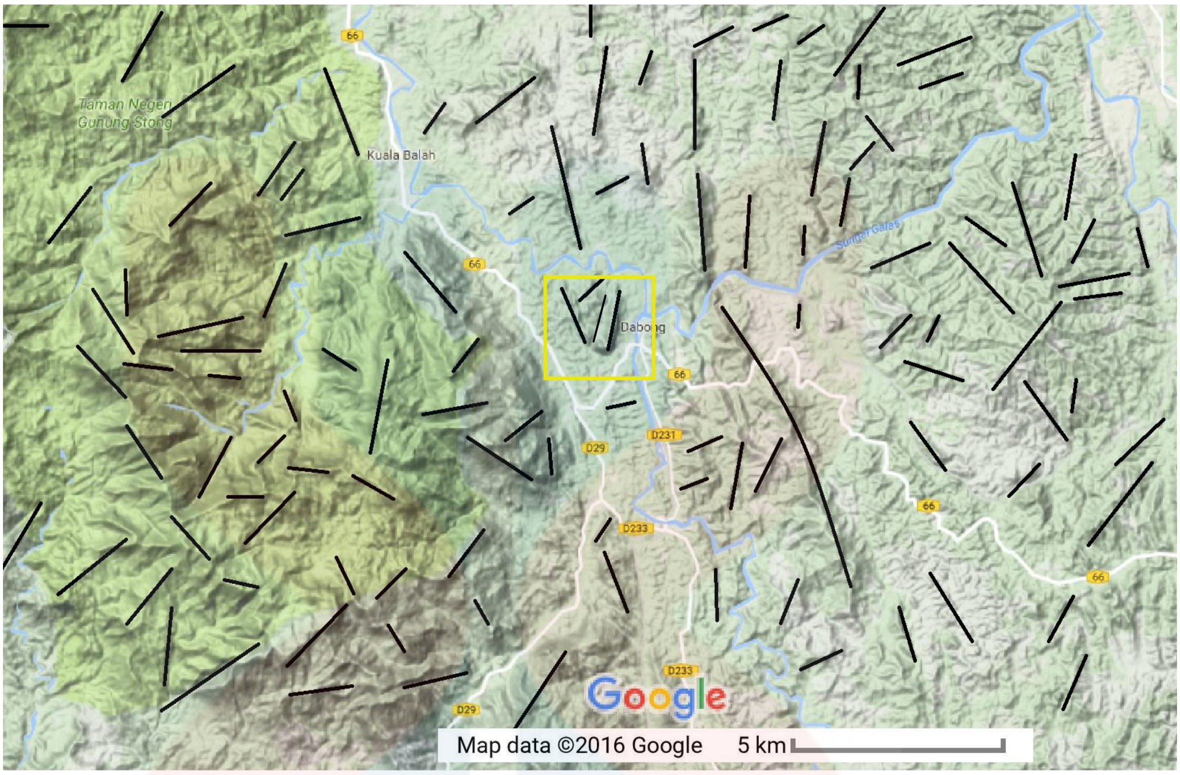


Figure 5.1 : Lineament of Study Area ; yellow box shows the study area.

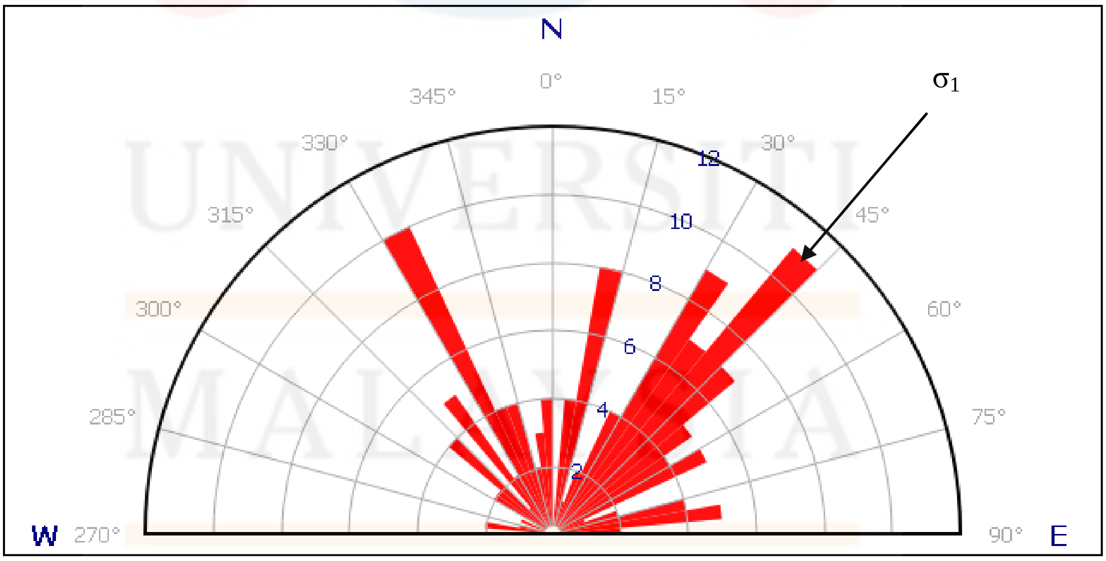


Figure 5.2 : Rose diagram of lineament

From the lineament analysis of the study, by using GIS method, a strike-slip fault can be recognized in the study area named Sg Metabat strike-slip fault, which named from the name of the river that is Sg Metabat (Figure 4.28).

The fault surface is usually near vertical and the footwall moves to the right with very little vertical motion. Strike-slip faults with right-lateral motion are also known as dextral faults.

5.2 Fault

In study area, a fault recognised as a normal fault was found as shown in Figure 5.3 with coordinate at N05˚21'32.6", E101˚58'39.7. A normal fault is a dip-slip fault in which the hanging wall has moved down relative to the footwall. The fault exist in the study area is a secondary structure as it is because of the extensional force imposed on rocks which occurred after the original formation of the rock cause the hanging wall moved downward relative to footwall.

The fault analysis was been done by stereonet analysis. This method is used to determine the principal stress. The fault plane was plotted by using stereonet to get tension stress (σ_3). Stress that occurs on normal fault is tension stress (σ_3) which acts against the force of normal faults in the study area. Based on streonet analysis on normal fault, tension stress direction is southwest.

Figure 5.3 : Normal fault

5.3 Foliation

Foliation structure is present in the study area. Foliation is a repetitive planar fabric present layering in a metamorphic rock. It is caused by shearing forces which is pressures pushing different parts of the rock in different directions or differential pressure, which is higher pressure from one direction than in others. The layers form parallel to the direction of the shear, or perpendicular to the direction of higher pressure (Marshak, 2012).

There are two locations were the foliation can observed. The first station is at N05˚22’32.6, E102˚00’19.2”. The foliation can be found at phyllite outcrop near the road. The foliation direction is shown in Figure 5.4.

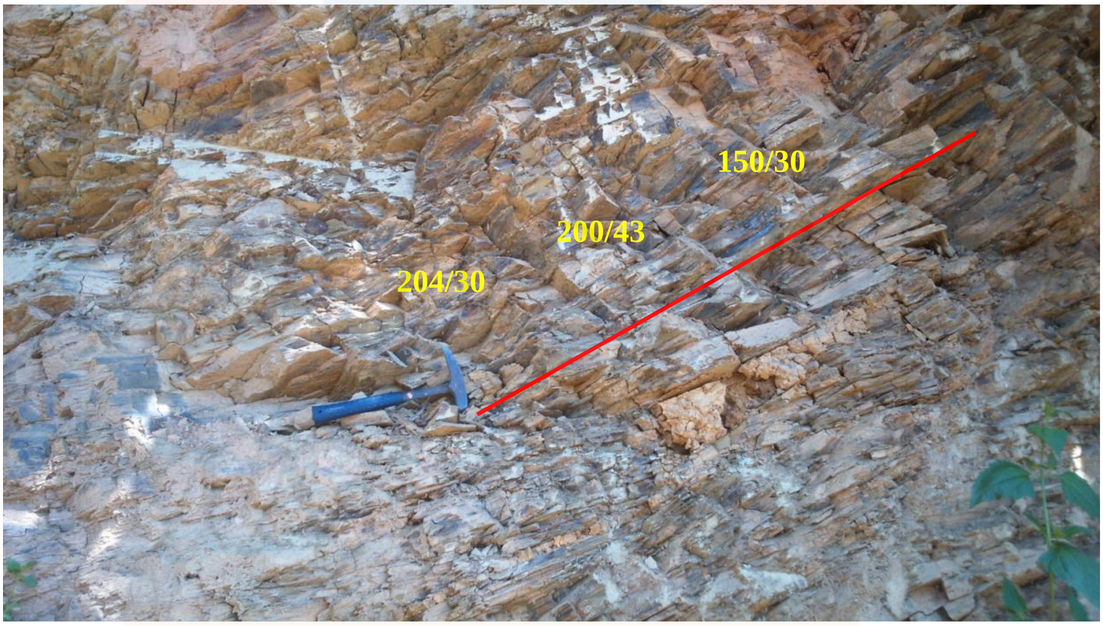


Figure 5.4 : Foliation at location 1

The second station is at N05˚21’25.6”, E101˚58’18.1”. The foliation can be found at phyllite outcrop at the rubber plantation. The foliation direction is shown in Figure 5.5.

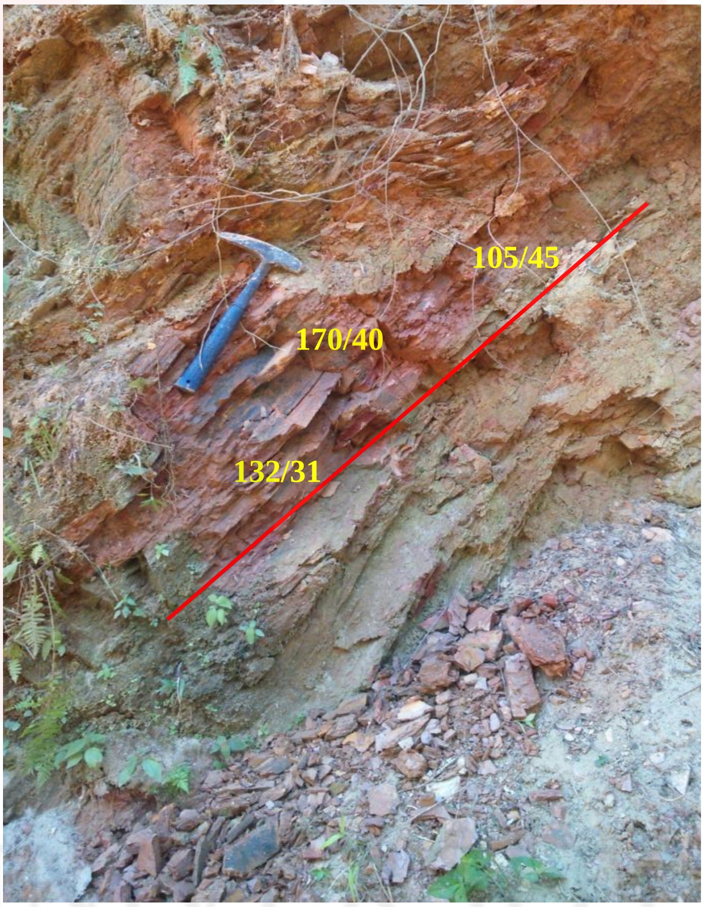


Figure 5.5 : Foliation at location 2

5.4 Joints

The joint analysis was conducted at three locations. For each station, the strike is measured on the surface of the rock about 100 readings and plotted into rose diagram to determine the direction force.

Location 1 is located near at road with coordinate N05˚23’19.9”, E101˚58’43.2” on an andesite outcrop (Figure 5.6). The joints that can be found at the rock are conjugate shear joints and the length of the joints ranges from 0.1 m to 2.0 m.

Conjugate joint is the sets of systematic joints intersect to form a joint system and the angles at which joint sets within a joint system commonly intersect is from 30˚ to 60° within a joint system and the compression force is about 45˚ from the majority of joint surface direction. From the rose diagram in Figure 5.7, the compression force (σ_1) is at NNE-SSW direction while tensional force (σ_3) is at NNW-SSE.

Figure 5.6 : Joints at location

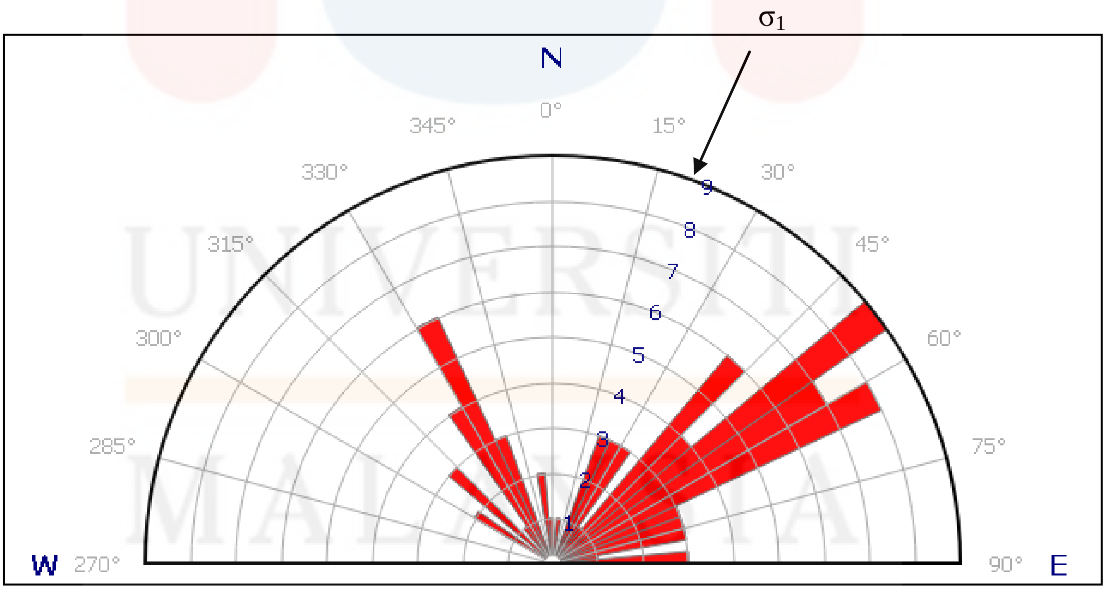


Figure 5.7: Rose diagram of joint analysis for location 1

Location 2 is situated at N05˚22’32.6”, E102˚00’19.2” on a phyllite outcrop shown in Figure 5.8. The joints that can be found at the rock are an extension joints because of the crack opening occur and the compression force is act on the surface of the rock. The length of the joints range from 0.2 m to 1.5 m. From the rose diagram in Figure 5.9, the compression force (σ_1) is at NNW-SSE direction while tensional force (σ_3) is at NNW-SSE.

Figure 5.8 : Joints at location 2

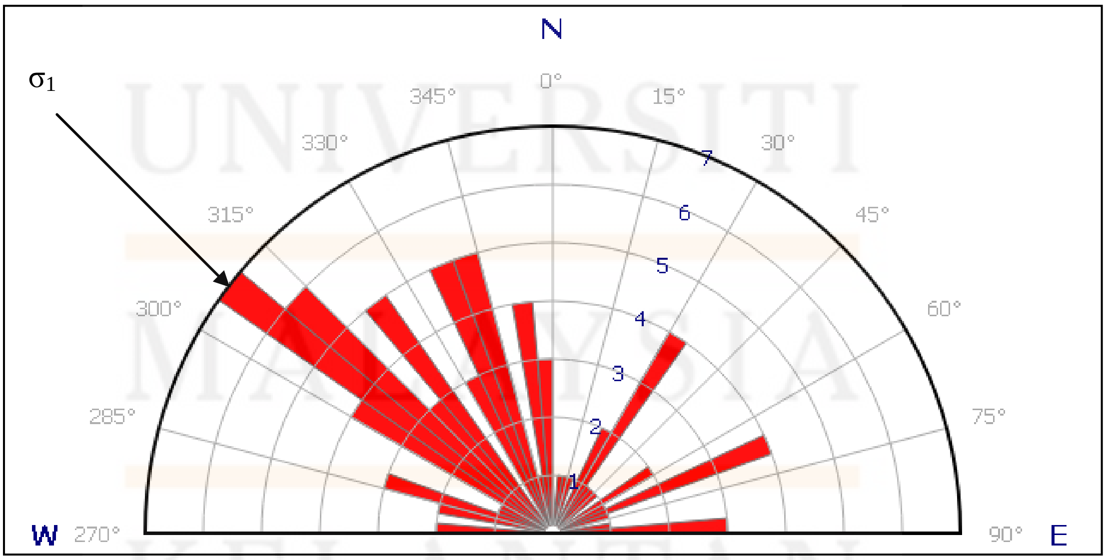


Figure 5.9 : Rose diagram of joint analysis for location 2

For Location 3, it is located near a river with coordinate N 05˚22’04.99”, E101˚58’18.0” on a marble outcrop shown in Figure 5.10. The joints that can be found at the rock are an extension joints because of the crack opening occur and the compression force is act on the surface of the rock. The length of the joints range from 0.1 m to 1.0 m. From the rose diagram in Figure 5.11, the compression force (σ_1) is at NE-SW direction while tensional force (σ_3) is at NNW-SSE.

Figure 5.10 : Joints at location 3

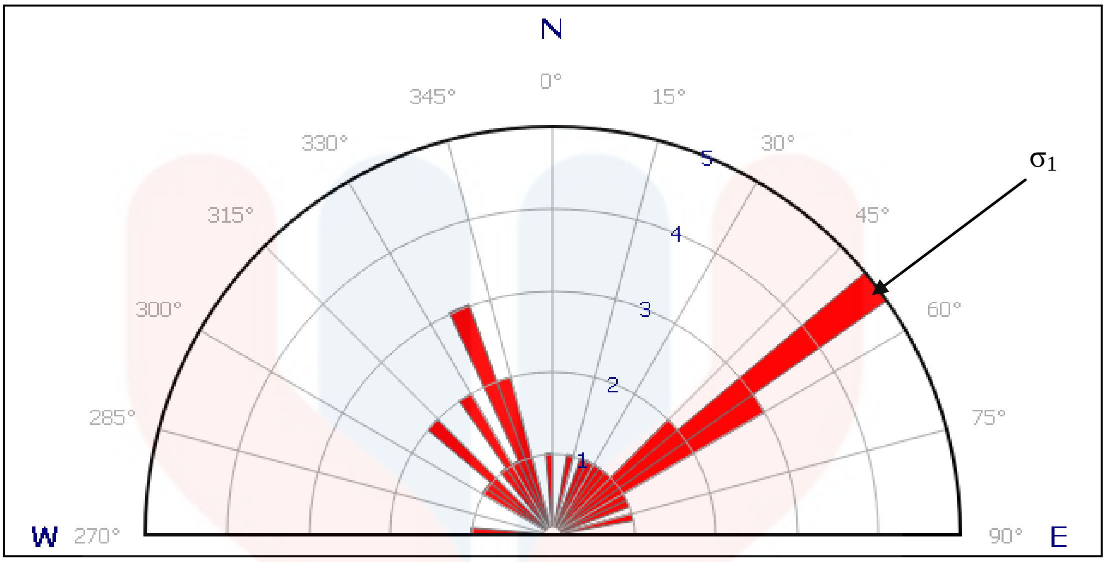


Figure 5.11 : Rose diagram of joint analysis for location 3

5.5 Relation between structures in study area

The structures that can be found in the study area are fault, foliation and joint. The most common structure geological structure is the fault, joint and foliation structure because form the field observation, fault, joint, foliation can be found and observed.

The fault that was found is normal fault from field observation and strike-slip fault from GIS. The foliation structure can found in metamorphic rock at the study area, while joint structure can be found in igneous rock and metamorphic rock.

From fault analysis, fold analysis and joint analysis, the major pattern or direction of the present geological structures in the study area is NNE-SSW direction. The lineament interpretation data was correlated toward the field structural data. Most of the structural data oriented toward lineament direction, which is NNE-SSW direction.

CHAPTER 6

CONCLUSION AND SUGGESTION

This chapter will provide the conclusion for the overall research, including the objectives, methods and result data interpretation analysis. From the problems that had been faced throughout conducting the research, the recommendation or suggestion is made in order to prevent the problems and difficulties to happen for the future research. Moreover, it is also required as it gives a general idea for the people and other researcher to understand the overall research and use the research for other purposes.

From this research, people will get the general knowledge about the general geology and structural geology about the study area. So, it is important to give the initial information about the characteristics of the study area, such as the geomorphology, stratigraphy, structural geology and historical geology of the study area form the research.

6.1 Conclusion

For the conclusion, the objectives of the research are achieved. The main objectives to complete for this research, which are to produce a geological map of the study area, to determine the most common geological structures at the study area and to analyze the pattern or direction of the present geological structures are been completed in this research.

For the first objective, the geological map of the study area has been produced. From the geological map, there are three types of rock that can be found in study area, which igneous rock, metamorphic rock and sedimentary rock. The igneous rock consists of granite and andesite rock, while metamorphic rock composed of phyllite, marble and schist and sedimentary rock contains of sandstone rock. The age of the rock ranges from Permian to Tertiary period as it associate with a part of Telong formation, Stong Migmatite Complex and alluvium unit.

For the second and third objectives, the most common geological structures at the study area has been determined the pattern or direction of the present geological structures has been analyzed. The most common geological structures at the study area are foliation and joints. From the observation of the structures at the study area, the pattern or direction of the present geological structures shows toward oriented in NNE-SSW. The lineament interpretation data was correlated toward the field structural data. Most of the structural data oriented toward lineament direction, which is NNE-SSW direction.

6.2 Suggestion

The suggestion is important to improve the results and data analysis obtained so that more accurate results and interpretations can be done. The first suggestion is to use a better source of images for the lineament analysis. The better images such as aerial photograph instead of Google Map image can give more accurate interpretation to the lineament. This is because the lineament is an essential component in the structural geology in order to know the direction pattern.

Besides, a new and updated technology can be use for the lineament analysis which is using latest ArcGIS software as GIS method is a powerful tool to identify geological structures such as fault segment in the urban area where it is difficult to access. This can reduce the time consuming in the field and can save a lot of time.

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