GENERAL GEOLOGY AND PETROGRAPHY OF IGNIMBRITE IN TEMANGAN, MACHANG, KELANTAN.

by

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

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2017

DECLARATION

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

_____

Student

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Date:

I certify that the Report of this final year project entitled "General Geology and Petrography of Ignimbrite in Temangan, Machang, Kelantan" by Muhammad Jasman bin Salwisol, matric number E13A134 has been examined and all the correction recommended by examiners have been done for the degree of Bachelor of Applied Science (Geoscience), Faculty of Earth Sciences, University Malaysia Kelantan.

Approved by,

_____

Supervisor

Name:

Date:

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General Geology and Petrography of Ignimbrite in Temangan, Machang, Kelantan.

ABSTRACT

Geological research including lithology, geological structure, geomorphology, stratigraphy and petrology in Temangan, Machang, Kelantan. The study area have longitude 102˚8’30” to 102˚10’30” and the latitude 05˚38’30” to 05˚40’30”. The objectives in study area to analyse the petrography of ignimbrite in Temangan and to produces a geological map of the study area. The methodologies used in this project are divided by two which are mapping and field study and another one is laboratory analysis. Based on the geological mapping, the rocks found are fine-grained sandstone, ignimbrite, schist and andesite. Fieldwork includes observation of lithology. The drainage pattern that found study area are dendritic and parallel. Type of landform in study area consist of flat area and mostly covered by hilly. Ignimbrite rocks that found in study area do not have pure lava characteristics, normal pyroclastic rock, or middle rock. The track is thick ignimbrite mine like insert a plug in old fractured. Sillar ignimbrite is formed as a tuff flow. Petrography that carried out found that minerals exists in this ignimbrite rock are quartz, alkali feldspar, biotite, muscovite and hornblende. The ignimbrite found has texture of tuff. Regionally, this ignimbrite is actually a dike. The laboratory analysis is included the petrography analysis. Through detail petrographic study of ignimbrite can be concluded that this area generally consists mineral such as quartz, alkali feldspar, biotite, muscovite and hornblende.

Geology Am dan Petrografi Ignimbrite di Temangan, Machang, Kelantan

ABSTRAK

Kjian geologi termasuklah litologi, struktur geologi, geomorfologi, stratigrafi dan petrografi di Temangan, Machang, Kelantan. Longitud di kawasan kajian adalah 102˚8’30” sehingga 102˚10’30” dan latitude 05˚38’30” sehingga 05˚40’30”. Objektif di kawasan kajian adalah untuk menganalisis petrografi di Temangan dan untuk menghasilkan peta geologi di kawasan kajian. Kaedah yang digunakan dalam projek ini ialah terdiri daripada dua iaitu pemetaan dan kajian lapangan dan selain itu adalah analisis makmal. Berdasarkan pemetaan geologi, batuan yang dijumpai adalah berbutir halus batu pasir, ignimbrite, syis dan andesit. Kajian lapangan termasuk pemerhatian litologi. Pola saliran yang didapati di kawasan kajian adalah dendrit dan selari. Jenis bentuk muka bumi di kawasan kajian terdiri daripada kawasan rata dan kebanyakannya terdiri daripada bukit tinggi. Batuan ignimbrite yang terdapat di kawasan kajian tidak mempunyai ciri-ciri lava tulen, rock piroklastik normal, atau batu pertengahan. Landasan ignimbrite ini tebal dan seperti masuk palam di patahan lama. Ignimbrite sillar terbentuk sebagai aliran tuff. Petrografi yang dijalankan mendapati bahawa mineral wujud dalam ignimbrite rock ini adalah kuarza, feldspar alkali, biotit, muscovite dan hornblend. Ignimbrite didapati mempunyai tekstur tuff. Di peringkat serantau, ignimbrite ini sebenarnya daik. Analisis makmal termasuk analisis petrografi. Melalui kajian terperinci petrografi daripada ignimbrite dapat disimpulkan bahawa kawasan ini umumnya terdiri mineral seperti kuarza, feldspar alkali, biotit, muscovite dan hornblend.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This project is more focusing on the general geology and petrography of ignimbrite in Temangan, Machang, Kelantan.

1.1 General Background

Geology is the scientific study of the earth including the origin and history of the rocks and soils (Hawkins, 2008). General geology is a survey of many aspect that of geology and the Earth Science. This was from the formation solar system universe and also earth to rocks and minerals to geologic processes.

In this research, field mapping and petrography are used in order to identify the minerals and texture of the rocks. Then, the data are used for classifying and naming the types of the rocks. Field mapping is required to observed and getting the information of the study area based on the research. The method required is mapping. This method is compulsory to all geologist students in order to help them to get the data about the study area. It is important to be precise as an accurate geological map is the basis of the most geological works (Lisle et.al, 2011). Otherwise, there are several methods are used in order to classify the rocks.

Petrography is the study of the rocks and minerals under microscope. Traditionally, this study of rocks and minerals was limited in identification of rocks, minerals, and ores. It was also limited in identification the characterization of

properties such as cleavage, twinning, reflectance, and so forth (Wase Ahmad, 2000). Petrography is the knowledge of describing and classifying the rocks which emphasize heavily on the usage of polarizing microscope (Phipotts, 1989). The study is conducted by using the thin sections that prepared by rocks samples that have been found during field mapping.

1.2 Problem Statements

Although this research is recommended with sufficient information that are gathered, but the information that provided to run this research are limited. There is a lot of information that Google Earth can provides to a research but all the information that provides are in the form of images. The application of Google Earth requires an aerial of image of Temangan that not important information such as the distribution of the rocks and minerals exist in study area. For the data of GIS application also was mostly lack of updates. The data that this application published was a few decades ago and also the data not up to date within this period of time. The impacts of this problem are that it is a lot of changes and development in the area such as new buildings, schools and new roads.

The geological map also be a complication when the geological map that provided as a reference was not detail and actually not really accurate. The lithology provided by geological is not the same found when the field mapping are done.

Besides that, there is lack of the information provides from the previous researchers about this research and this study area. A lot of information need to gathered and combined to make the information given to bring the clear picture about this research and the study area. Furthermore, the information that found does not

give clear information about the geological structure, geological features, and the geomorphology of the area.

The igneous dyke presents in the study area about 10 km long and 800 m wide, trending approximately N-S. Temangan dyke was mapped on the Geological map of Malaya in 1963 as quartz phophyry. However, Aw (1967) verbalized that the Temangan Dyke is authentically ignimbrite.

1.3 Research Objectives

This draft is about my final year project that titled general geological and petrography of ignimbrite in Temangan. There are two main objectives as stated below:

i. To update the geological map of Temangan, Machang, Kelantan with a scale 1:25000.
ii. To analyse petrography of ignimbrite rock in study area.

1.4 Study Area

There are fourteen states that exist at Malaysia. One of them is Kelantan. Kelantan occupies a total of area about 14,922 km^2 and the capital city of this state is Kota Bharu. The population at Kelantan is 1,718,000 people. Kelantan is located in the north-east of Peninsular Malaysia. It is bordered by Narathiwat Province of Thailand to the north, Terengganu to the south-east, Perak to the west, and Pahang to the south. From the south-east of Kelantan is South China Sea. There are ten districts in Kelantan. That includes Gua Musang, Bachok, Jeli, Kota Bharu, Kuala Krai, Machang, Pasir Mas, Pasir Puteh, Tanah Merah, and Tumpat.

The study area is Temangan which is in a Machang district. Machang is located at Kelantan. The total area covered is 25 kilometer per square which are between 05˚38’0’’N to 05˚40’30’’N in latitude and 102˚8’0’’E to 102˚10’30’’E in longitude. In the study area, there are villages, river, hilly area, hills and roads that used by a residents. There is also the Tumpat-Gemas railway line along the study area. The main villages in the study area are Kg. Temangan Lama, Kg. Pasir Besar, Kg. Batu Besi, and Kg. Pertok. There are also palm oil plantations and rubber plantations. Figure 1.1 shows the map of Temangan district in Kelantan state of Peninsular Malaysia and Figure 1.2 shows the base map of Temangan, Machang, Kelantan.

Figure 1.1 Map of Temangan district in Kelantan state of Peninsular Malaysia.

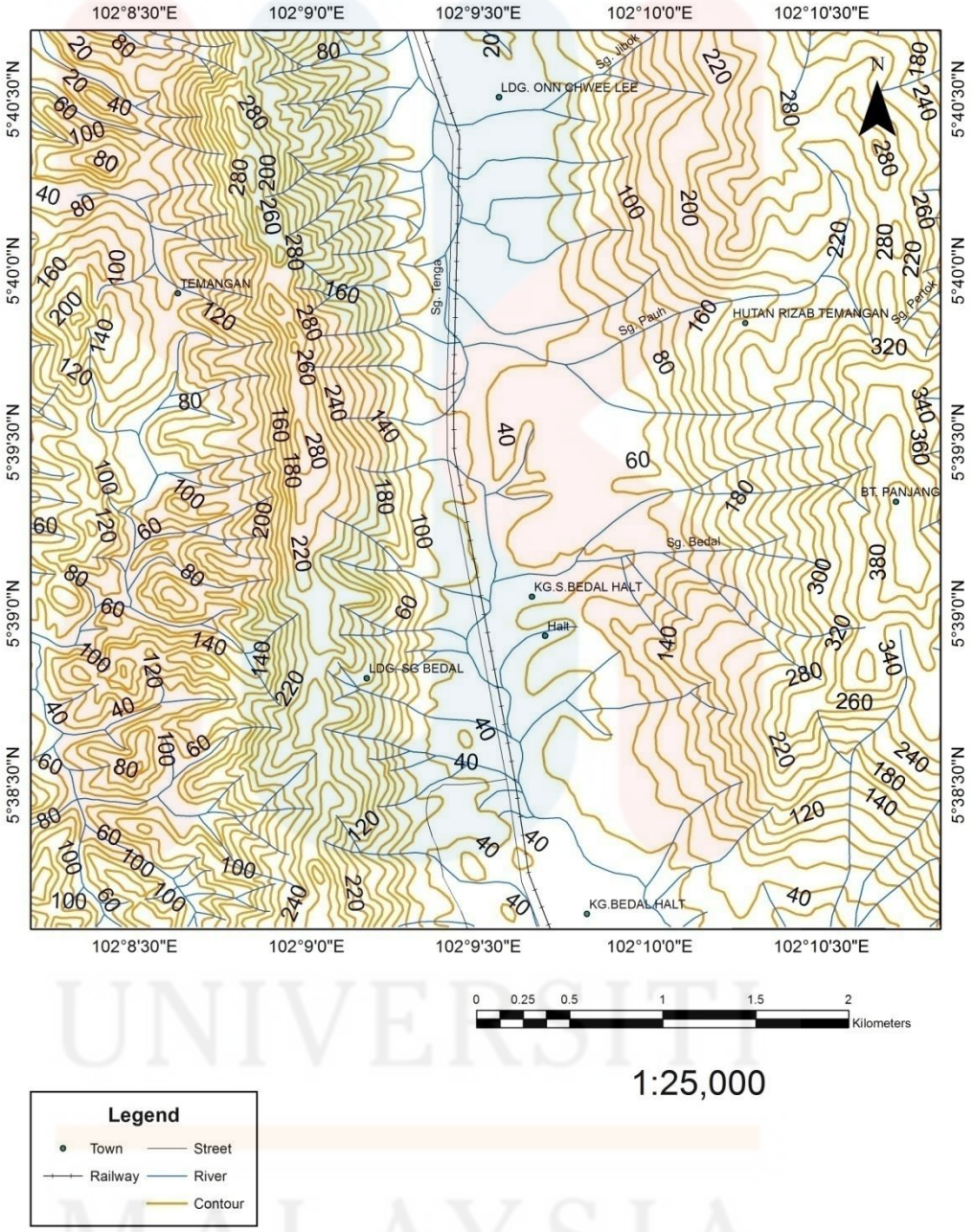


Figure 1.2 Base map of Temangan, Machang, Kelantan by using ArcGIS 10.2

1.4.1 Geography

Geography can be interpreted as knowledge of the relationship between physical environment and human lives. The aspects that will discuss include rain distribution, land use, social economic and also accessibility.

The study area is located at Temangan, Machang at Kelantan. The study area is 5km x 5km. The geography of this area is hilly to mountainous. There is no main river in study area but there are small rivers as drainage. The range contour in the study area is from the lowest being from 40 m to 380 m.

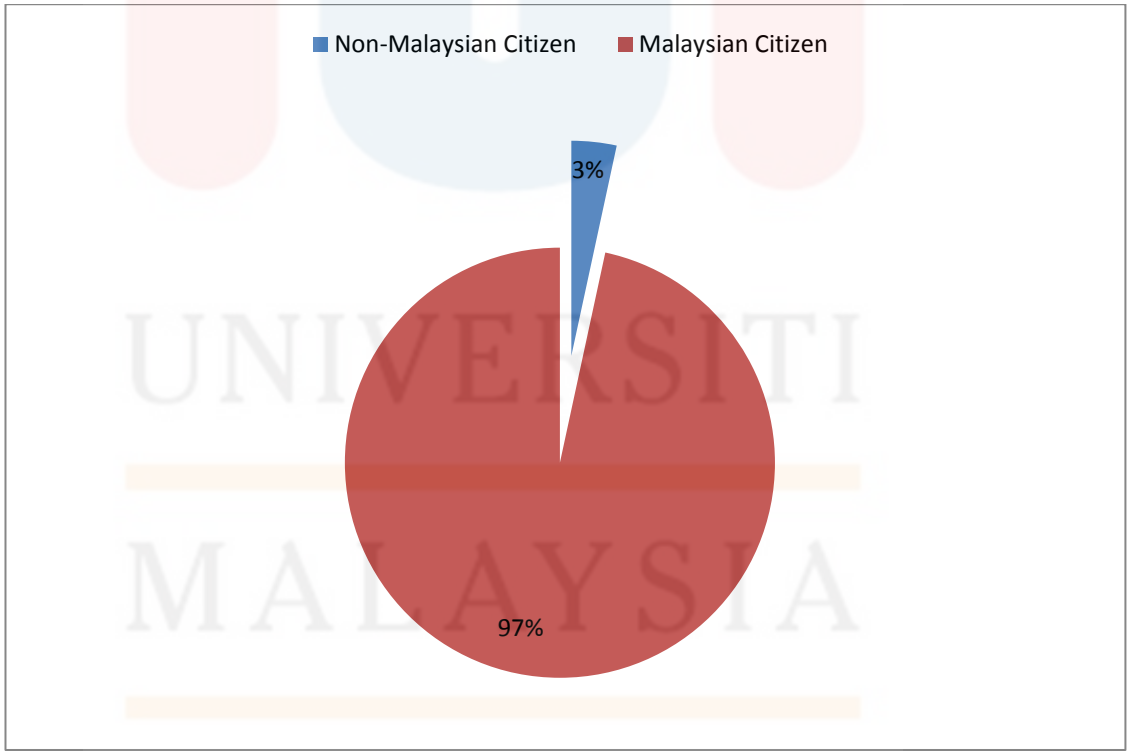
(a) People Distribution

There are villages that are located inside the study area and the most developed village is from Bandar Temangan. The population of Temangan consists of Malaysia citizens which are Bumiputera (Malay and others), non-Bumiputera (Chinese, Indians and others) and also non-Malaysian citizens. Based on the 2010 census count report from the Department of National Statistics shows that the population that exists at Temangan was recorded are 5,786 people. The common language used is Malay-Kelantanese. The Table 1.1 below shows the total by ethnic group of Temangan, Machang. Figure 1.3 shows the pie chart of total population in Temangan, Kelantan and the figure 1.4 shows the pie chart of people distribution by ethnic in Temangan, Kelantan.

Table 1.1 People distribution by ethnic in Temangan, Kelantan on 2010.

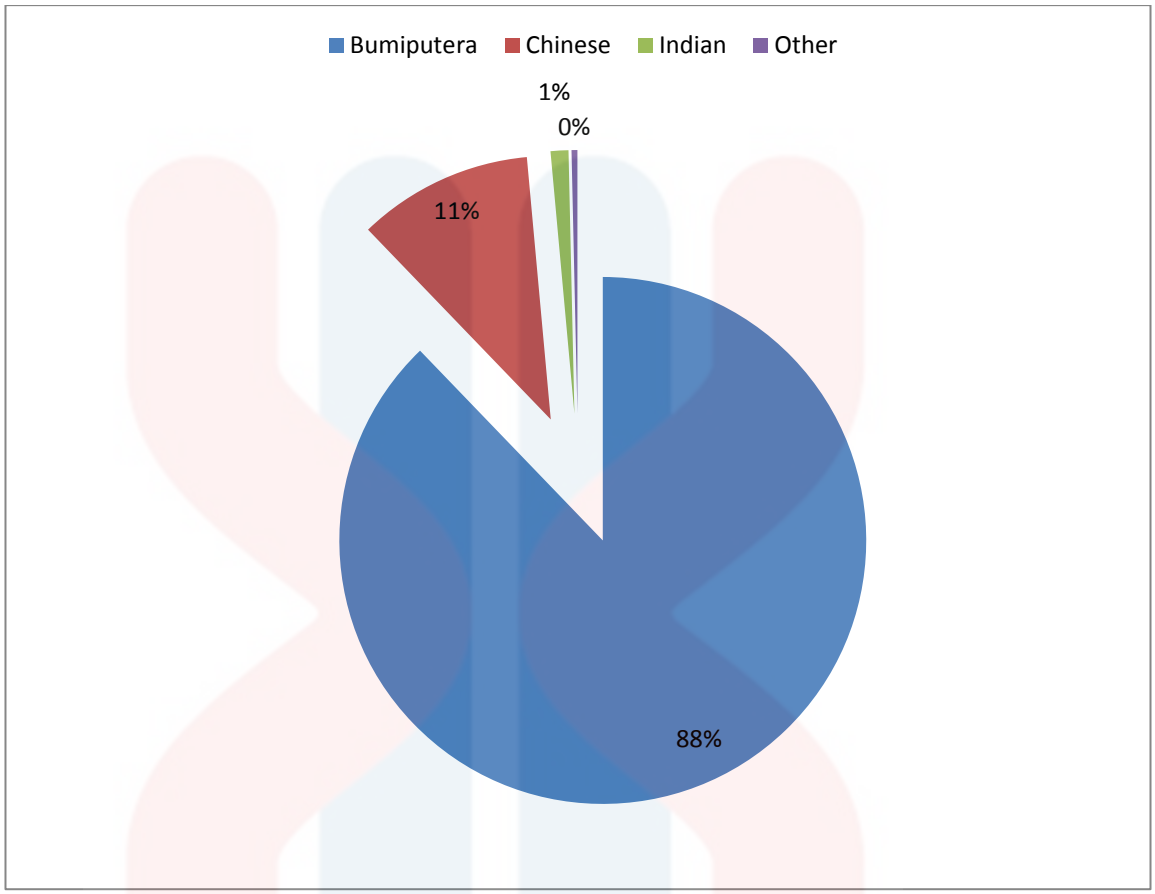
District	Total	Malaysian Citizen					Non-Malaysian Citizen
		Bumiputera		Non-Bumiputera			
		Malay	Other Bumiputera	Chinese	Indian	Others	
Temangan	5786	4897	11	601	61	20	196

Source: Department of Statistics Malaysia, 2010



Source: Department of Statistics Malaysia, 2010

Figure 1.3 Pie chart of total population in Temangan, Kelantan in 2010.

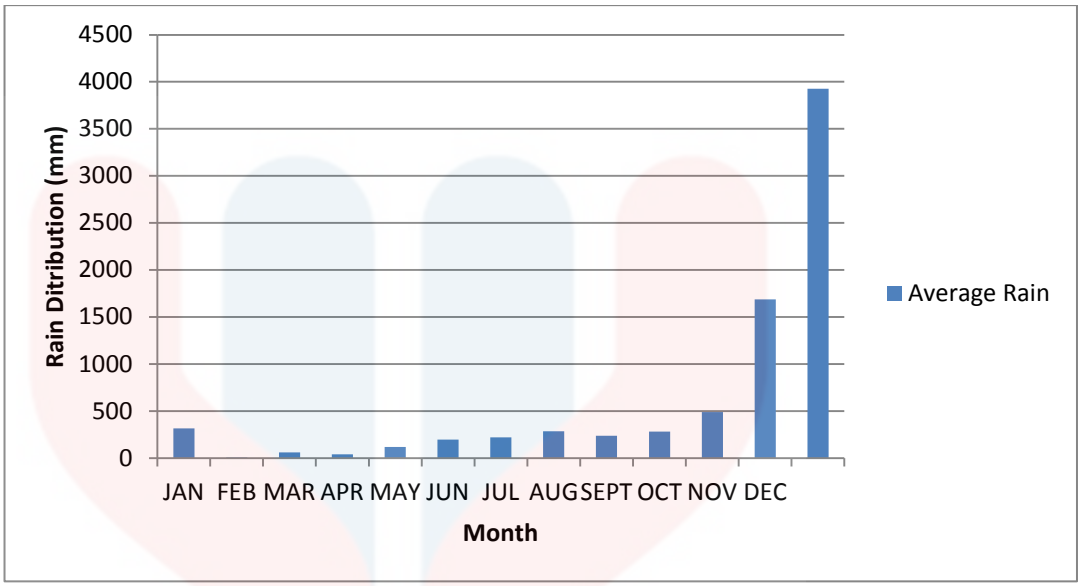


Source: Department of Statistics Malaysia, 2010

Figure 1.4 Pie chart of people distribution by ethnic in Temangan, Kelantan in 2010.

(b) Rain Distribution

Malaysia essentially observes tropical weather, without astronomically high temperatures. Sultriness however is a prevalent feature; nights in Malaysia are fairly cool. Throughout the year, the average temperature ranges from 20°C to 30°C on an average. The rainfall distribution patterns of Malaysia are influence by the seasonal wind flow patterns and the local topographic features. The east coast areas of peninsular Malaysia experience cumbersomely hefty rain spells during the northeast monsoon season but rural areas or areas covered by mountain ranges are relatively liberate from this influence. Figure 1.5 below shows rain distribution of Temangan, Machang, Kelantan in 2014.



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

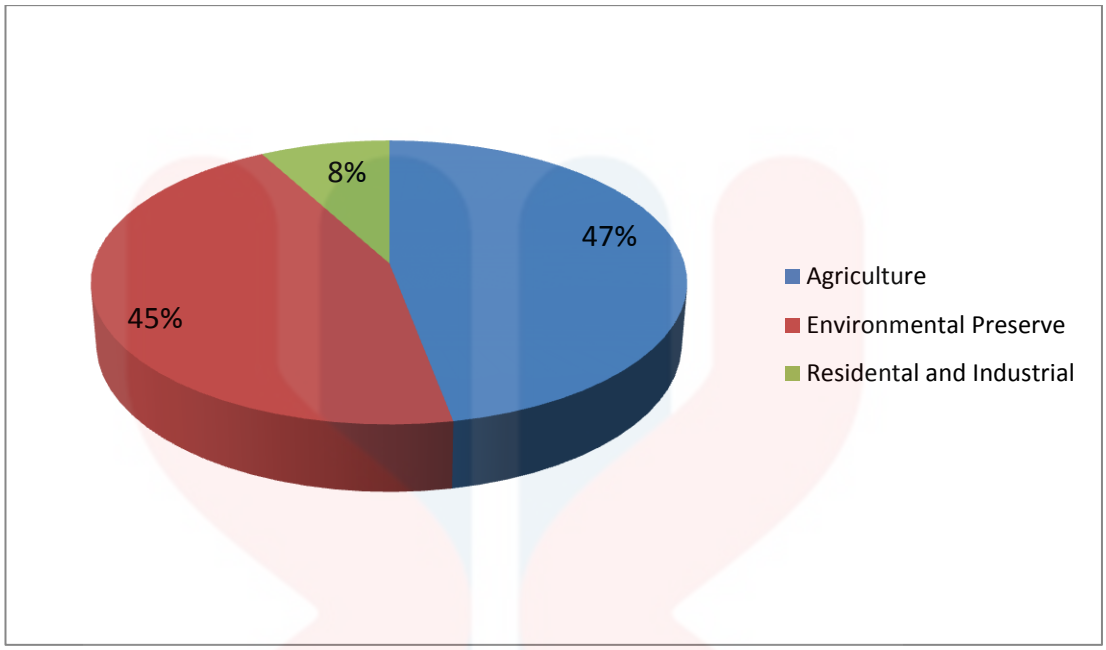
Figure 1.5 Rain distribution of Temangan, Machang, Kelantan in 2014.

(c) Land Use

Land use involves the management and modification of natural environment or wilderness into built environment such as settlements and semi-natural habitats. It additionally has been defined as the total of arrangements, activities, and inputs that people undertake in a certain land cover type.

Land use withal is an exploitation of land for the purpose of agricultural, industrial, residential, recreation, or other. The land utilization of the Temangan region consists of agriculture which is about forty-seven percent (47%), environmental preserve about forty-five percent (45%) and for residential and industrial is eight percent (8%).

In type of the agriculture of Temangan region, there are included of rubber plantation, oil palm plantation and others. For environmental preserve, Temangan forest reserve and mangrove forest are the type of environmental preserve. Figure 1.6 shows the percentage of land used in Temangan, Machang, Kelantan.



Source: Machang District Council.

Figure 1.6 Percentage of land used in Temangan, Machang, Kelantan.

(d) Social Economic

Social economic was related to social behavior and the economic itself. In science of view, social economic is the studies of how economic activity affects and is shaped by social processes. It is very important in daily life because these activities can generate income.

There are variety activities of social economic that run by the population at Temangan. The majority of this social economic was plantation. So that can be concludes that the most residents in Temangan are farmer. Some of them are run their small business such as retail store and stall. Another social economic activity is the residents who working at the iron ore quarry.

(e) Road Connection

There is only one main road connection that exits in the study area which connects a village to others. There are two type of road that can be further divided

into which are pavement and unpaved roads. Paved road is most road connection in the study area. This road can be alternative to citizens to access from Machang to Kuala Krai that additionally can be lead them to Kuala Lumpur. This road heading to Machang at north while for Kuala Krai at south in the map. Most of the road was paved road that utilized as connection to other villages.

The roads in study are bituminous road and non-bituminous road. The bituminous road connects to the town while for the non-bituminous road used to connect the main road to the plantation. In the study area consists of Tumpat-Gemas railway. Figure 1.7 below shows the bituminous roads at Temangan, Machang, Kelantan while Figure 1.8 shows the non-bituminous roads at Temangan, Machang, Kelantan. Figure 1.9 shows the map of land use in study area.

Figure 1.7 Bituminous roads at Temangan, Machang, Kelantan.

(05˚40’5.4” N, 102˚8’14.8” E)

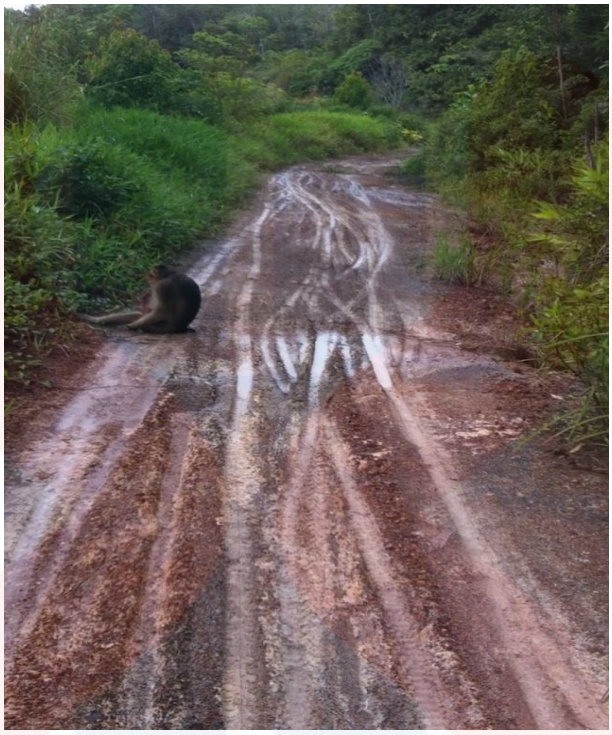


Figure 1.8 Non-bituminous roads at Temangan, Machang, Kelantan (05˚39’44.7” N, 102˚8’23.4” E)

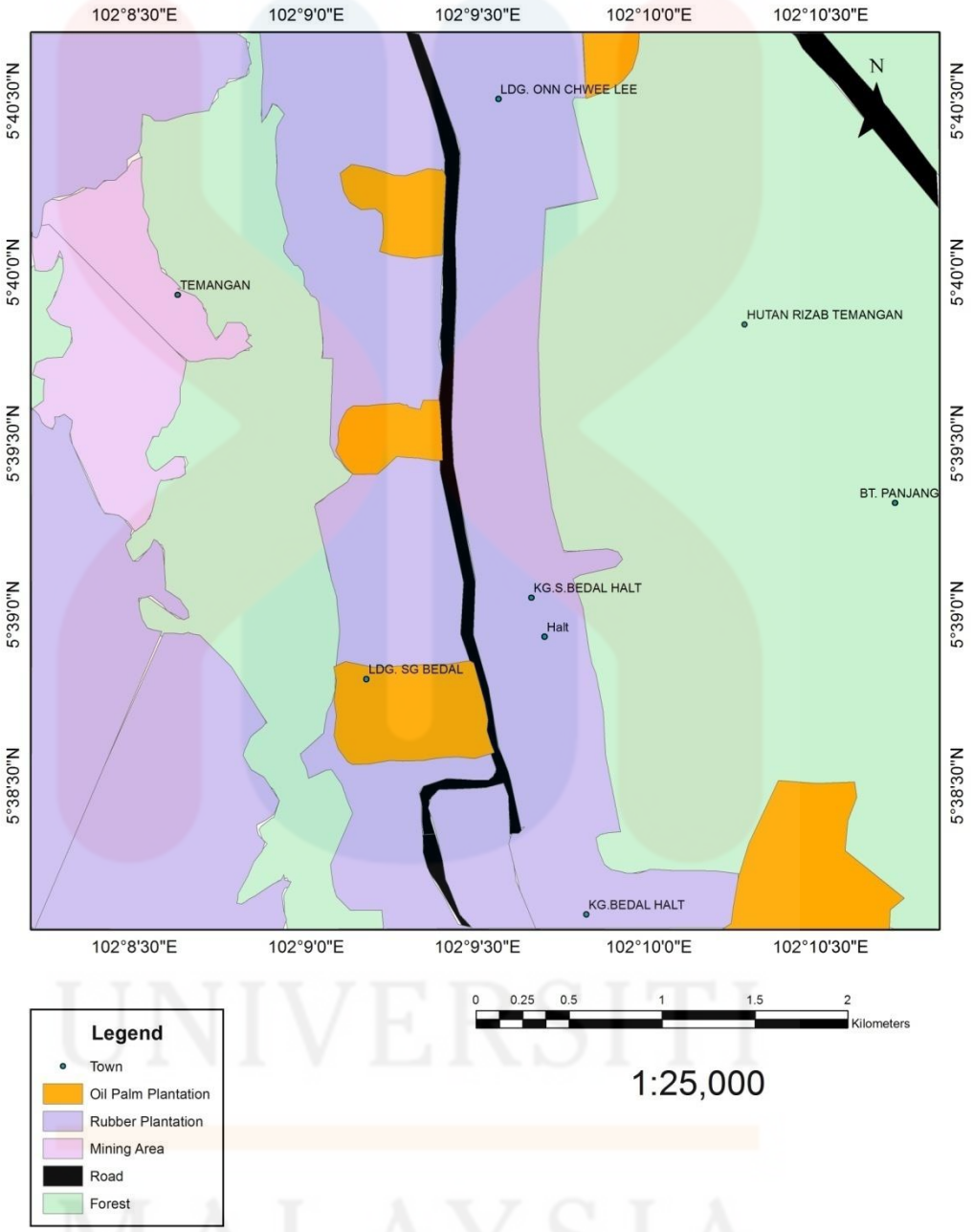


Figure 1.9 Land use map in study area.

1.5. Scope of Study

The focus of this study of the research is to determine the general geology aspects like geological structures, geomorphology and the lithology of study area. It is covered 5 km x 5 km including al geological basic characteristics. By traversing the study area, the lithology is identified based on the availability of the outcrop.

This research also focused petrography of ignimbrite in Temangan. The purpose of this study is to determine the mineral assemblages to determine the possibilities types of minerals that can be found in ignimbrite rocks.

1.6 Research Importance

Based on study area, there is several significance of a research which is to update the geological map of Temangan. It may help to update map that were improvised from the old one to get the exact map today. The road and drainage of study area that don't exist on the old map can be updated by this research. The problem regarding of the lithology boundaries in the map can be solved by remapping at the study area. This research also helps to know the types of trace element that exists at study area of a research.

In the future, the valuable information will help researchers to understand more about the study area. It is also can helps to in the next research about petrography of ignimbrite rocks in Temangan area.

CHAPTER 2

LITERATURE REVIEW

1.0 Literature Review

Some of the articles are used to gather the information from the past research of the research study. The information of past research was taken from published and unpublished articles which are published articles is the articles that already published by researchers while unpublished is an articles that unofficially released by researchers.

This chapter actually will describe about the research that already done by previous researchers relating to this topic. This included the petrography, regional geology, structural geology and alteration that existed at my study area.

2.1 Regional Geology and Tectonic Setting

The geological mapping is needs to get the information of geological at the study that I cover. Kelantan is located at West Malaysia of peninsular Malaysia. My study are is at Temangan and the coordinate of Temangan is with latitude 102° 09' 20" E to 102° 12' 10" E and longitude 5° 39' 20" N to 5° 43' 0" N. Recent studies have greatly extended the pre-Tertiary stratigraphic range in West Malaysia. The regional geology of Kelantan consists of a central zone. Central zone consists of sedimentary and meta sedimentary rocks that bordered on the west while granites of the Main Range and Boundary Range on the east respectively. Within of the central zone, windows of granitic intrusive are existed.

There are three main geological components in West Malaysia which are Carboniferous-Premian, the Triassic ‘Arenaceous Series’, and the Mesozoic granite

(MacDonald, 1967). From Carboniferous to Permian, majority of the sedimentary rock and associated volcanic appear in Kelantan range.

The oldest rock that existed in Kelantan is about in Lower Paleozoic age. Rare occurrence of amphibolites and serpentinite has been recorded (MacDonald, 1967). On the eastern side, the Predominantly Permian volcanic-sedimentary rocks are occurs widely. The age of Taku Schist is still doubtful but it actually definitely pre-Triassic that dominates central north of Kelantan.

The youngest rocks of this state are the Jurassic-Cretaceous continental rock that lies on the Boundary Range Granite and Triassic sediments in the Gunung Gagau area. The continental are at common state between Kelantan, Terengganu and Pahang to the West in the Gunung Perlis and Gunung Pemumpu areas (MacDonald, 1967).

The Temangan ignimbrite shows that about 10 km long and 800 m wide of the prominent ridge. The ignimbrite creates a massive hard outcrop with minor flow structure. The texture on the whole of that outcrop is quite homogenous and there is no visible change occurred.

Temangan dykes have been mapped on the Geological Map of Malaya on 1963 as quartz phorphyry. It similarly known as volcanic character before it was found error by Aw (1967) which state that the Temangan dykes as an ignimbrite (Burton, 1967). There is no pure lava characteristic, normal pyroclastic rock or middle rock of ignimbrite rock at Temangan mine (Aw, 1967). The track is thick ignimbrite mine like insert a plug in old fractured. It is extrusive igneous rock.

There are several investigations at Temangan. It was formed due to transportation during intrusion of eastern granite and named the Temangan dykes as

rhyolite dykes. Temangan dykes was named by Roslina Bakar (1988) as ignimbrite based on certain characteristics present and called the volcanic rocks as pyroxene basalt. An investigation was made by Azmer (1979) at the area of Machang's river. He found that may be Machang granite undergo crystallization and the volcanic rocks especially andesite are present due to Temangan ignimbrite.

Geology is the scientific study of the earth including the origin and history of the rocks and soils (Hawkins, 2008). General geology is a survey of many aspect that of geology and the Earth Science. This was from the formation solar system universe and also earth to rocks and minerals to geologic processes.

2.2 Petrography

Petrography is the study of minerals by using microscope. Petrography was limited to identification of of rocks, minerals and ores to the characterization of properties such as cleavage, twining, reflectance, and so forth (Wase Ahmed, 2000).

The solidification of the magma or lava are formed igneous rocks that presents beneath the earth surface (R, Gill, 2010). The crystallization of minerals and the magma cools during the process of solidification of magma.

The rock that existed at Temangan which is my study area is Ignimbrite. Ignimbrite is the deposit of a pyroclastic density current which is a particle that evolved hot suspension and the rapidly flowing of gases from a volcano and the density is greater than the density of the surrounding atmosphere. This rock was formed from very poorly mixture of tuff that lithified or also can be known as volcanic ash and pumice lapili.

According to Aw (1967), ignimbrite rock at Temangan does not have pure lava characteristics, normal pyroclastic rock, or middle rock. The track is thick ignimbrite mine like insert a plug in old fractured. Sillar ignimbrite is formed as a tuff flow.

Temangan dyke that found in in Temangan was named as rhyolite dyke by Rosli (1983). He believes that Temangan dyke was formed due to the major transportation during intrusion of eastern granite.

The ash is composed of crystal fragments. This rock may be loose and may be solidified in shape was called as lapili-tuff. Since there is ignimbrite, so the alteration might be involved. This is because the large of hot ignimbrite can create some of hydrothermal activity when they tend to blanket wet soil and then they bury all the watercourse and river. The water that comes from substrates will exit from the ignimbrite in fumaroles and geysers. When this water were in boiling off process, the ignimbrite will become altered and tend to form chimneys and pocket of kaolin-altered rock.

There are also has more igneous rocks that can be found at my study area which are felsic intrusive and basic volcanic which mainly pyroclastic. These rocks are weathered andesite and ignimbrite. Other than that, there also have sedimentary rock that was found at the area which is weathered sandstone. Figure 2.1 shows the general geological map of Kelantan.

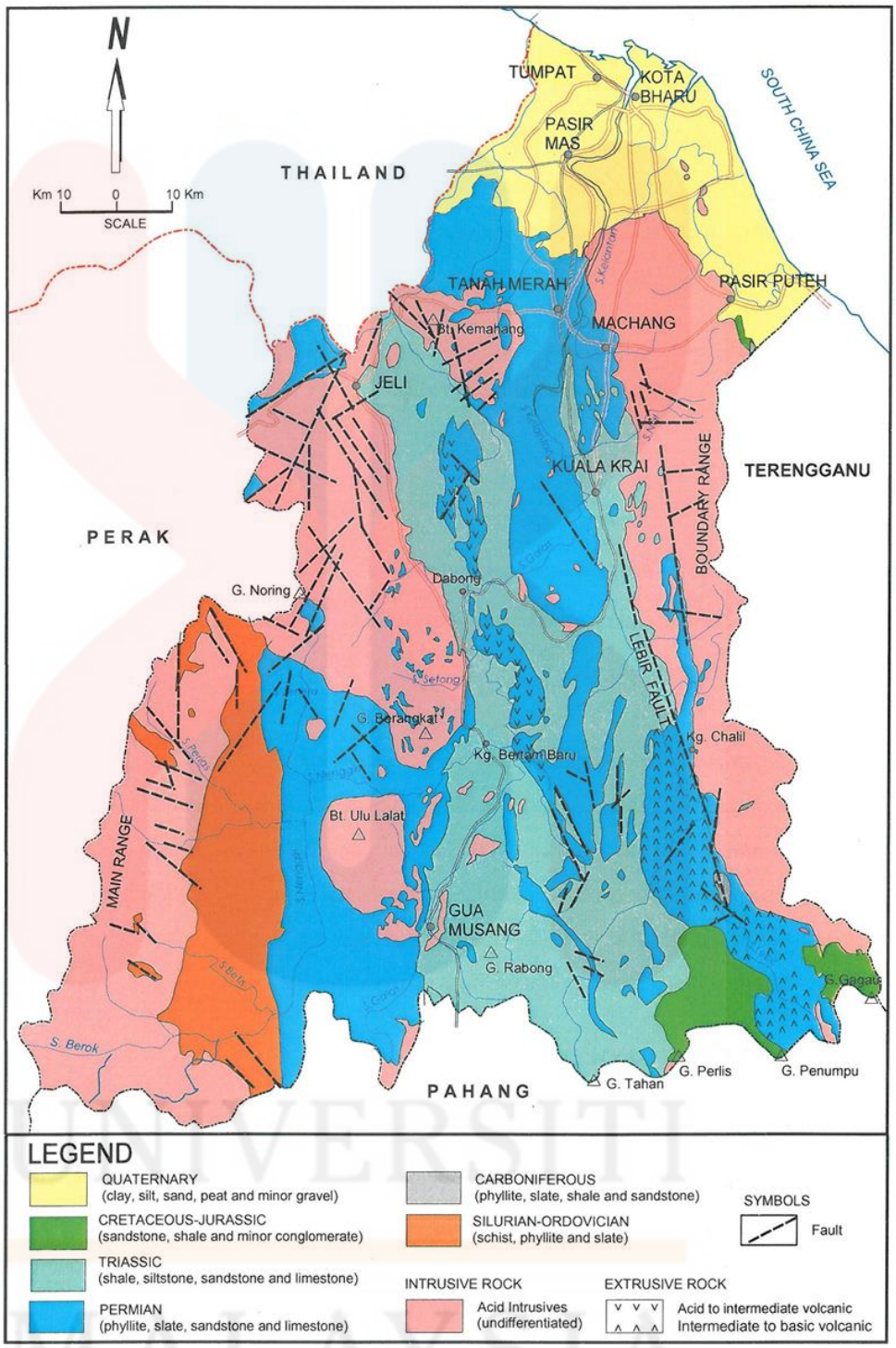


Figure 2.1 General geological map of Kelantan.

The classification of igneous rocks can be done by using several criteria. Firstly, the classification of igneous can be classified by mineral proportions. It can be identified by using relative proportions of dark and light minerals or by using the colour index. Besides, quantitative measurement of mineral proportion also can be conduct by using point counting technique (R. Gill, 2010).

Secondly, it is also can be classified by chemical composition. Basically, igneous rocks are classified into ultrabasic, basic, intermediate, and mafic. This is because of the influence by the SiO_2 content of the rocks (Le Maitre, 2002).

Thirdly, the classification of igneous rocks can be identified based on qualitative criteria. This qualitative criteria refers to grain size and texture of the igneous rocks. The range of grain size that used in this criteria whether it is fine, medium or course grained (Le Maitre, 2002).this contributes to the general texture such as aphanitic, phaneritic, porphyritic, and etc.

2.3 Regional Stratigraphy

2.3.1 Taku Schist Formation

Taku Schist Formation is the Carboniferous-Permian clastic rocks in the southern part of the Transect area. The formations comprise predominantly schists which are wholly crystalline and generally consummately schistosed. Main rock type of Taku schist formation is mica schist which consists of quartz-mica schist, mica-garnet schist and quartz-mica-garnet schist. In order to describe the metamorphic of rock that cropping out in central Kelantan, MacDonald (1967) was introduced the terms of Taku Schist. Taku schist was designated after the Sungai Taku where the good outcrop was observed. These formations comprise predominantly schist which are wholly crystalline and generally consummately schistosed.

Based on Khoo (1983) shows that the rocks of Taku Schist are majority Permo-Triassic but maybe some part also include strata of Carboniferous age. Surround the Taku Schist both along its western and eastern margin and the strata of the same age but of greenschist facies.

2.3.2 Telong Formation

Telong formation is confined to the central-south and central part of the Transect area in Malaysia, in Kampung Legeh and elongates eastwards to the Tanah Merah area. The term was named after the rock sequence cropping out along part of the Sungai Telong in the Sungai Aring area, Kelantan by Aw (1990). The Telong formation consists mainly of argillite, low grade metasedimentary and metavolcanic rocks.

In 1921 the iron ore deposit is believed to have been first covered and was prospected in the early 1930'. The ore occurs along the contact of the schist and the sedimentary rock in long narrow belt. The iron ore basically occurs on or near the crest of the north-south aligned ridges, and, where undisturbed by precious mining, takes the form of massive outcrops, large boulders, and nodules in the soil (MacDonald, 1967).

2.3.3 Iron deposits

Orin deposit is believed that been mined in 1930s and it was first discovered in 1921. Iron ore deposit is believed that have been occurs along the contact between sedimentary rock and schist in a long narrow belt. The iron ore generally occurs on or near the crest of the north-south aligned ridges, and, where undisputed by precious mining, takes the form of massive outcrops, large boulders, and nodules in the soil

(MacDonald, 1967). It was found that sandstone is older than ignimbrite. This is because the ignimbrite intruded sandstone.

2.4 Structural Geology

Structural geology is the study of the three-dimensional distribution of rock units with reverence to their deformational histories. The primary used goal of structural geology to quantifications of present-day rock geometries to denude information about the history of deformation (strain) in the rocks. This construal of the dynamics of the stress field can be linked to paramount events in the geologic past such as a prevalent goal is to understand the structural evolution of a particular area with veneration to regionally widespread patterns of rock deformation.

2.5 Research Specification Review

Ignimbrite is one of the volcanic rocks which mainly consist of pumice fragments, formed by the process of combination and firmed of material deposited by the pyroclastic flows. Ignimbrite is classified as igneous rocks.

The mineral contents of ignimbrite rocks include apatite, biotite, calcite, chlorite, feldspar, hematite, hornblade, ilmenite, magnetite, olivine, pyroxene, quartz and the compound content of ignimbrite rocks composed of calcium (Ca) and sodium chloride (NaCl).

Ignimbrite can be found in black, grey, brown and white in colours which affected by their composition and its origin place. The streak of a rock is the colour of powder produced when it is rubbed across a streak plate. The streak of ignimbrite is usually white and it has anopaque shape which cannot be seen through.

The shape of grains, the orientation of crystals within the rock and its appearance shows the texture of the ignimbrite. The texture of Ignimbrite is aphanitic which indicate fast cooling history and has an extrusive origin. The grain size of ignimbrite is fine grained where its mineral is too small to be seen without magnification. Its appearance is dull and vesicular. The appearance of ignimbrite depends on the percentage of impurities in it.

Rocks can be found everywhere around us. The amount of ignimbrite abundance depends on the types of rocks available in a particular area, their formation process, weathering, climatic conditions, composition, erosion and their properties. As for ignimbrite rocks, they are distributed all around the world including in Asia which are Burma, Cambodia, China, India, Indonesia, Malaysia, Japan, Thailand, and in Turkey, Africa, Australia, America and also around Europe countries including Germany, Italy, Poland, Portugal and Spain.

Rocks are formed at the hard outer crust of the Earth which is made up of minerals. It has been used by humans since ages. From the Stone Age, rocks are used for various purposes. This shows that rocks play an important role in our life.

Hence by using the ideas and technology, humans had found out advantages and the applications in various fields by using rocks. All of us use products consist of rocks in our daily life. Rocks had been used in wide range starting from food, medicines, jewelry, roads, tools, floors, monuments and also statue. From ancient times, many types of rocks had been used to build blocks of structures and houses. Until now they are still being used for the same purposes. Similarly, there is wide range of uses of ignimbrite. Ignimbrite was used in architecture and construction. In construction industry, ignimbrite was used to build houses or walls and in

construction aggregate. It also used in building stone for decorative walls and paving. It can be concluded that ignimbrites have many advantages especially in construction.

CHAPTER 3

METHOD AND MATERIALS

3.0 Introduction

This chapter will focus on the materials that will be use in doing this research and the methods used to complete the research. In this research, Figure 3.1 is the research flow chart that was used to ensure that the objectives can be achieved.

3.1. Materials

Methodology is the most paramount part in conduction a research as it tells step by step procedure of this study. The purpose of this chapter is to present the methodology in detailed that used to consummate the objectives of this research. This chapter will describe about the materials used and procedure to determining the general geology of Temangan and to prosper the research about petrography of ignimbrite in Temangan, Machang, Kelantan.

For materials used in this study, it was divided by two categories which are materials used for mapping and site visit and another used to analyze the data and laboratory equipments. Field studies have been conducted from early September until the end of November. It is involves traversing around the study area to identify the outcrop present at the research area. Traversing the area was conducted along the roads, streams and rivers. The materials used in mapping and site visit is the equipments that usual used by geologist doing their research which are geologist's hammer such as chisel hammer, hand lens, compass, Global Positioning System (GPS), sample bag, field book, and topographic base map.

RESEARCH FLOW CHART

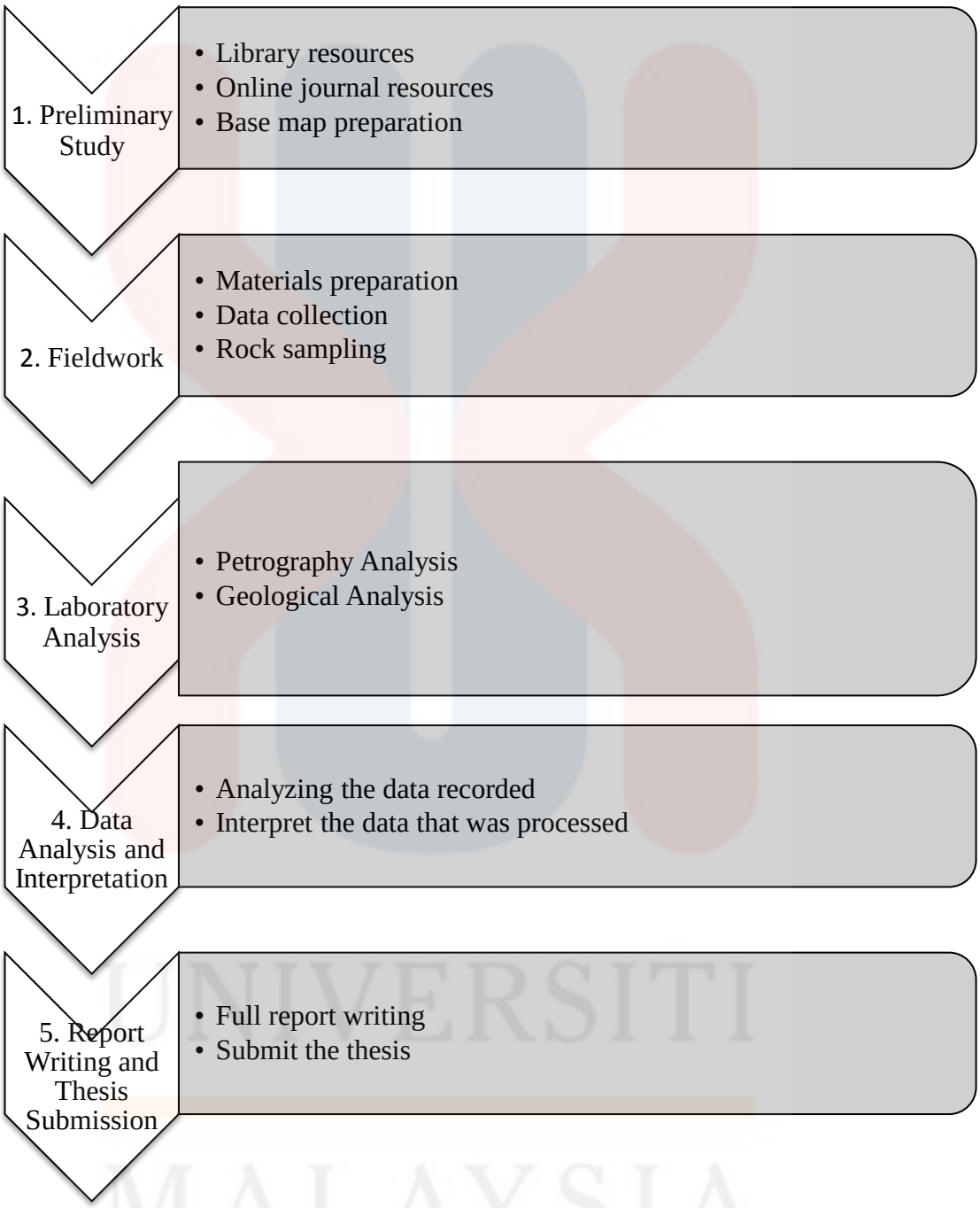


Figure 3.1 Research flowchart of this research

3.1.1 Geologist's Hammer

Figure 3.2 The chisel-head rock hammer

Geologist's hammer (Figure 3.2) also known as rock hammer. It is a hammer that used to breaks and splits rock samples. It is also used to obtain the fresh surface of rock to determine the rock composition and in field of mineralogy. Sometimes this hammer used as a scale on the field.

3.1.2 Hand Lens

Figure 3.3 The hand lens

Hand lens (Figure 3.3) is a hand held or optical magnifying system that usually are more than two element of optical that used in the field to enlarged images of rock, minerals or fossils about five times to twenty times from the real size.

3.1.3 Compass

Figure 3.4 The compass

Compass (Figure 3.4) is the tools that can helps geologist to determine the location and the direction of an area by aid of base map. Compass also can be used to determine the strike and dip direction which can help to determine the direction of force in the study area.

3.1.4 Global Positioning System (GPS)

Figure 3.5 The GPS

Global Positioning System (Figure 3.5) is a system that provide the location and time formation in anywhere around the earth in all weather condition by space based navigation. It is also widely use far tracking the tracks that monitoring object or personal movement. Other than that, GPS also be used for mapping by creating maps around the world and GPS helps getting from one location to another by it navigator.

3.1.5 Sample Bag

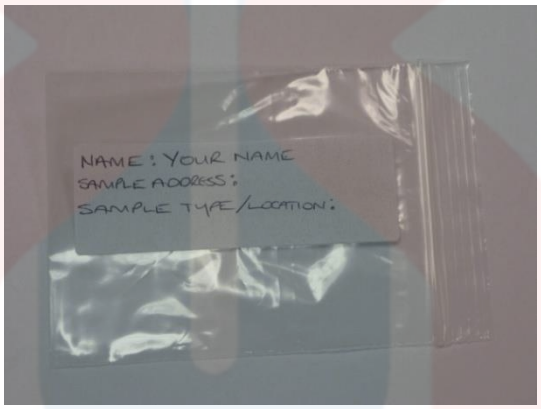


Figure 3.6 The sample bag

Sample bag (Figure 3.6) are required to collect the rock samples and prevent them from any disturbance that can affect the original condition of the rock samples.

3.1.6 Field Book

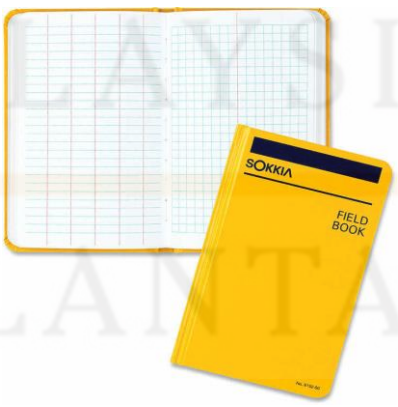


Figure 3.7 The field book

Field book (Figure 3.7) is the medium to record the data while in the field. It is used to record the geological data and the detailed data of the sample of rock that found at study area.

3.1.7 Topographic Base Map

Figure 3.8 Topographic base map

Topographic base map (Figure 3.8) is a map that used to know the exact location of study area. Topographic map is a type of map characterized by astronomically immense-scale detail and quantitative representation of palliation, customarily utilizing contour lines, but historically utilizing a variety of methods. These maps depict in detail ground palliation, drainage, forest cover, administrative areas, populated areas, conveyance routes and facilities including roads and railways, and other man-made features. This map is needed to guide and conduct technique to cover the study area.

3.1.8 Hydrochloric Acid (HCL)

Figure 3.9The HCl

Hydrochloric (Figure 3.9) acid was used to observed rocks in order to differentiate between chloride and calcite. Hydrochloric acid also used to distinguish dolomite, carbonate rocks and limestone.

3.1.9 Polarizing Microscope

Figure 3.10 The polarizing microscope

Mineral identification can be analyzed in details by using optical mineralogy in thin section. The minerals can be determined by using the polarizing microscope (Figure

3.10) which has two polarizing filters oriented at right angles to each other. By using this polarizing microscope can describe petrography description, porosity, colour, grain sizes and mineral abundance.

3.2 Methods

There are several steps or methods that used in this research. Those steps are survey of study area, preliminary study, field work and data collection, laboratory work and structure analysis, interpretation data and last but not least writing report and submission of thesis.

3.2.1 Survey of Study Area

It was done to examine and to survey the study area to determining the purpose road that should be taken for further research study.

3.2.2 Preliminary Study

The study of the journals, books, articles and other trusted resources which related to the study was conducted in order to get a wide view of this research. On this part, base map was created using software ArGIS 10.0.

Rock sampling was used in order to be as samples in this research. To get the rock sample in an outcrop, the geologist's hammer was used to break it from an outcrop. Rock sample was collected for later used in the laboratory investigation. The samples are taken based on the availability in study area and it are used to distinguish based on several characteristics such as type of rock, texture, colour and grain size. After sample was taken from an outcrop, the sample are put in sample bag with labeled.

During the field investigation, samples are collected for later investigation needs in the laboratory. The samples are collected from the available outcrop and it was used to be distinguished based on the several characteristics such as texture, grain, colour, or crystal colour and types of rocks. The samples are put in sample bag with some details needed before it was used to made thin sections.

Petrography is the study of minerals by using microscope. Thin sections is needed in type to identified the mineral exists in the samples. Thin section is the study of this petrography microscope. It was made to study the mineral composition. In order to prepare thin sections, the small pieces of the rock samples are cut by using rock cutting machine. Then the samples are ground by using silicon carbide powder. After that, it was glued on the glass slide. Before it becomes thin section, it was cut until the samples become a slice. Lastly the sample was ground by silicon carbide powder again until it became almost transparent or translucent.

3.2.3 Field work and Data Collection

Site visit is required to observed and getting the information of the study area based on the research. The method required is mapping. This method is compulsory to all geologist students in order to help them to get the data about the study area. By doing this mapping, it will produce complete geological map and also can help to update the previous map. Mapping will include topography, land used and drainage pattern in the study area.

3.2.4 Laboratory work and Structure Analysis

Laboratory work is needed to be done for this section of outcrop that found while doing the mapping method in the study area. Petrography method is used to carry out the detailed description of rock textures.

3.2.4.1 Thin Section

This section was prepared in this step. When to come to analyze the petrology, thin section was one of the important steps that must to do. Firstly, the rock must be cut to prepare the thin section. The other steps that must be follows are preparation of slides to uniform thickness, thinning the specimens, lapping specimen to the chosen thickness and polishing the specimen.

After done all the steps preparing thin section, the next step was to analyze the thin section. Thin section was observed by using microscope. After observing the thin section, point counting will be done. Point counting is the steps that describe the rock in an unbiased and quantitative way. Point will be done after thin section has been observed. Point counting is a statically technique. It is involved looking the number of the grain of the slide.

3.2.4.2 Petrography

The laboratory analysis is most important method that must be done. It includes the petrography analysis. This method was more focusing on the detailed description of the rock samples through the thin section method. So the mineral content and the textures of the rock can be described. The specific names of rocks can be interpreted by the point counting process of the minerals that have been observed under the polarizing microscope.

3.2.5. Interpretation and Discussion of Laboratory Work and Structure Analysis

After laboratory work and structure analysis were done, the data was gained. Then, an interpretation of the formation of the iron and the factors to event of iron can formed based on the theory and the past studies that related to the study scope. Thus, whole complete detailed result can be made with full data and reliable theories to apply in research study.

3.2.6. Writing Report and Submission of the Thesis.

From the beginning of the study, the report was wrote in type of preliminary study which are introduction, background, problem statement, objectives, significance of the study, and all that has been covered in Chapter 1, Chapter 2 and Chapter 3. This report has been write base on the past journal and past studies and also by the mapping that has been done.

The data collected from the field work after analyze and the interpreting data will be used for the chapter of the study. After finish writing the report, submission of the thesis will be done on the specific time to the faculty.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter characteristics such as geomorphology, landform, drainage pattern, lithology and structural geology of the study area will be explained. These information are crucial as it can help to get better understanding about the study area itself and specification study.

Through traversing as seen on Figure 4.4 below, it can be concluded that there are various agricultural activities took place such as rubber plantation, shown by Figure 4.1 and oil palm plantation. The other part comprises of forest and mining area.

Figure 4.1 Rubber plantation

Quartz vein also can be found in study area. The second most abundant mineral that exists in the continental crust of the earth after feldspar is quartz. Quartz has different varieties and it have been commonly used in the making of jewelry and hardstone carving.

Quartz also can be found in the vein of rock that cut through it. In certain issue, quartz vein do not have any quartz crystal but may be it sometimes reasonable to follow the large scale of quartz vein such as the quartz vein that already folded from the old quartz vein. Figure 4.2 and Figure 4.3 shows quartz vein that can be found in study area.

Figure 4.2 Quartz vein that found in the sandstone area

Figure 4.3 Quartz vein that exists in the weathered schist rock.

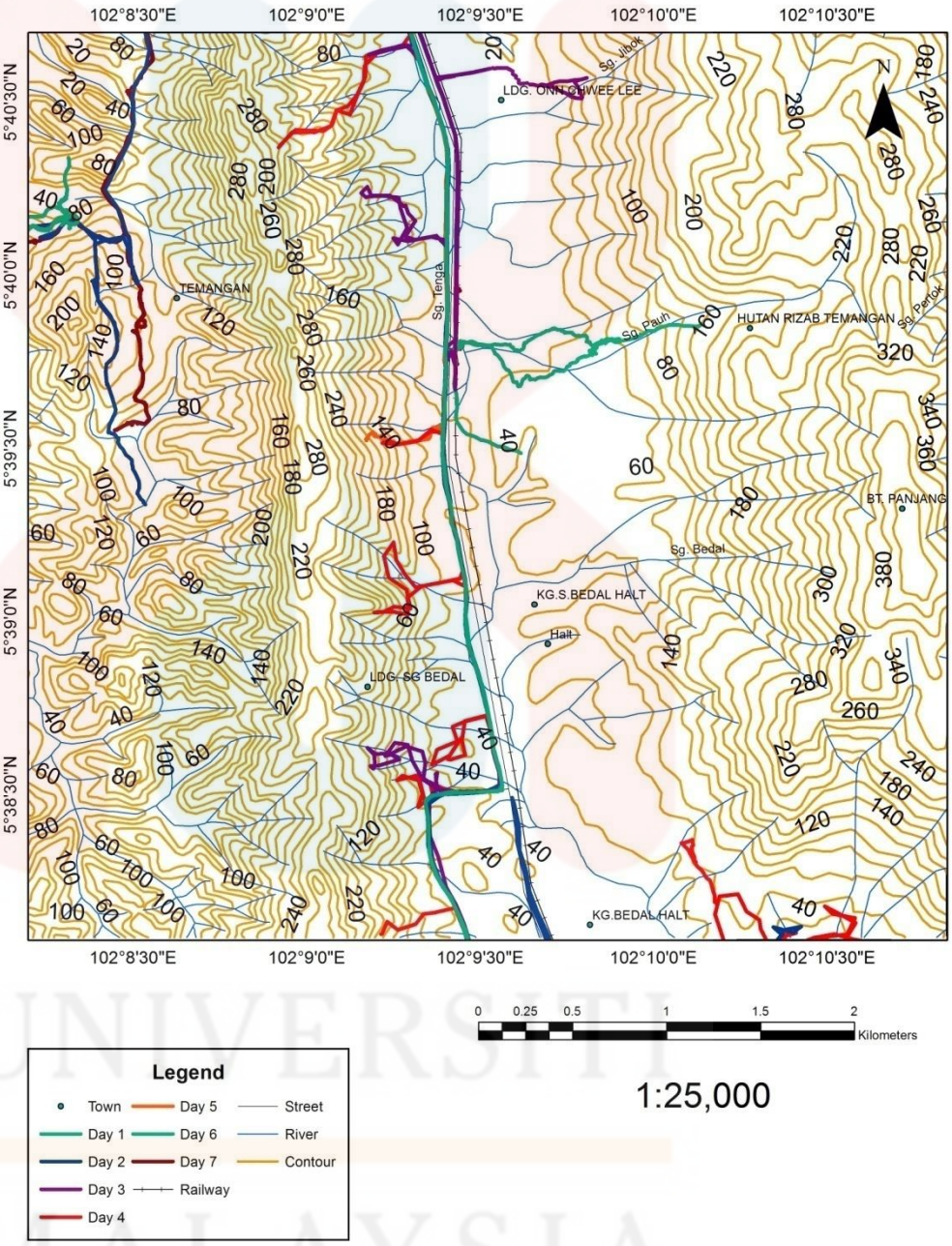


Figure 4.4 Traverse Map

4.2 Geomorphology Process

Geomorphology term comes from Greek where Geos means Earth, morphs means form while logos means knowledge. Geomorphology is the scientific study that consists of the origin of the landform that created by physical, biological or chemical such as by erosion of the wind, water or ice and the laying down of the material that has been eroded by depositional process. According to (Worcester, 1939) geomorphology is defined as broader where it is not only about the science of landforms because geomorphology encompasses the topics of earth genesis, in general, such as the formation of the formation of the ocean basin and continental platform also other minor structures such as plain, plateau, mountain and more. Geomorphologist studied the landforms to provide the information about how that landforms was formed and to study the history and development of the landform.

An understanding the geomorphology and its process lead to the understanding of the physical geography. The example of the landforms are hills, mountain, karst, alluvium plain, floodplain and how low gradient foot slope. In this topic will discuss about topography, drainage system, and weathering process.

Zuidam (1985) state that the distinction of the elevation is basically measured from the surface of the ocean or as on the ground of the ocean level is thought to be a field that has zero number in height. The significance of perceiving in the distinction in height is to describe about condition of the morphology and morphogenetic landforms. As an examples such as slopes, mountains and fields. Table 4.1 shows that the classification for relief elevation.

Table 4.1 The Classification for Relief Elevation.

Relief/Landform	Elevation (m)
Lowland	≤5
Low-laying plain	5-100
Low Hill	100-200
Hill	200-500
High Hill	500-1500
Mountain	1500-3000
High Mountain	≥3000

(Source: Zuidam, 1985)

4.2.1 Topography

Topography is the physical features of the surface area that include of the relative elevation. It is also comes from the position of natural and man-made features. The topography of an area are refer to the surface of the shapes and features themselves, or a description of maps.

The physical features of study area include mountainous that extends to height of 390 meters on the eastern part and 280 meters on the western part. The terrain of study area includes of several hills that can be found in study area. The topography in Temangan, Machang, Kelantan comprises of high hills and flat land. High hills that can be found in study area covered about two three of the total region. The ridge region consists of two narrow long hills the eastern of the study area are covered by long high hills and the ridges reach 380 meter and the lowest elevation is zero.

It different on the western part of the region when the region is quite low compared to the region that existed in the eastern part of the study are. It has low, irregular, rolling hills that have highest elevation 180 meter to 280 meter. They separated from each other by the flat land. Topography involves recording of relief of terrain, three-dimensional quality of the surface and identification of specific landforms. Most of the residential areas are concentrated along the roads for easier connection. The houses are mostly built along the roads. The main road extends from north to south that connecting two district which are Temangan and Kuala Krai. Figure 4.5 shows that the hill landform that exists in the area. Figure 4.6 shows the 3D map of study area while Figure 4.7 shows that the topographic map in Temangan, Machang, Kelantan.

Figure 4.5: The hills landform that exists in the study area.

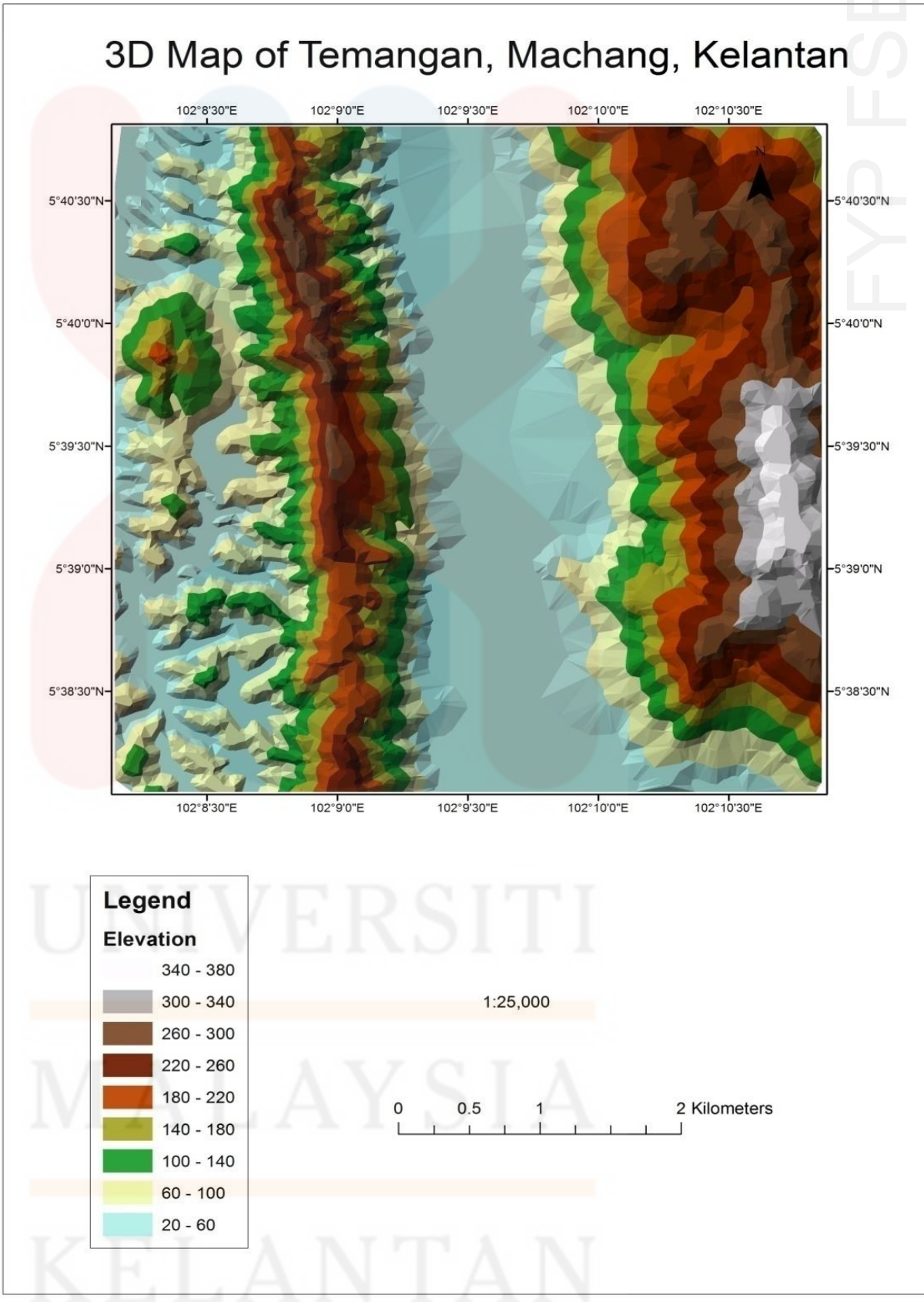


Figure 4.6 3D Map of Temangan, Machang, Kelantan.

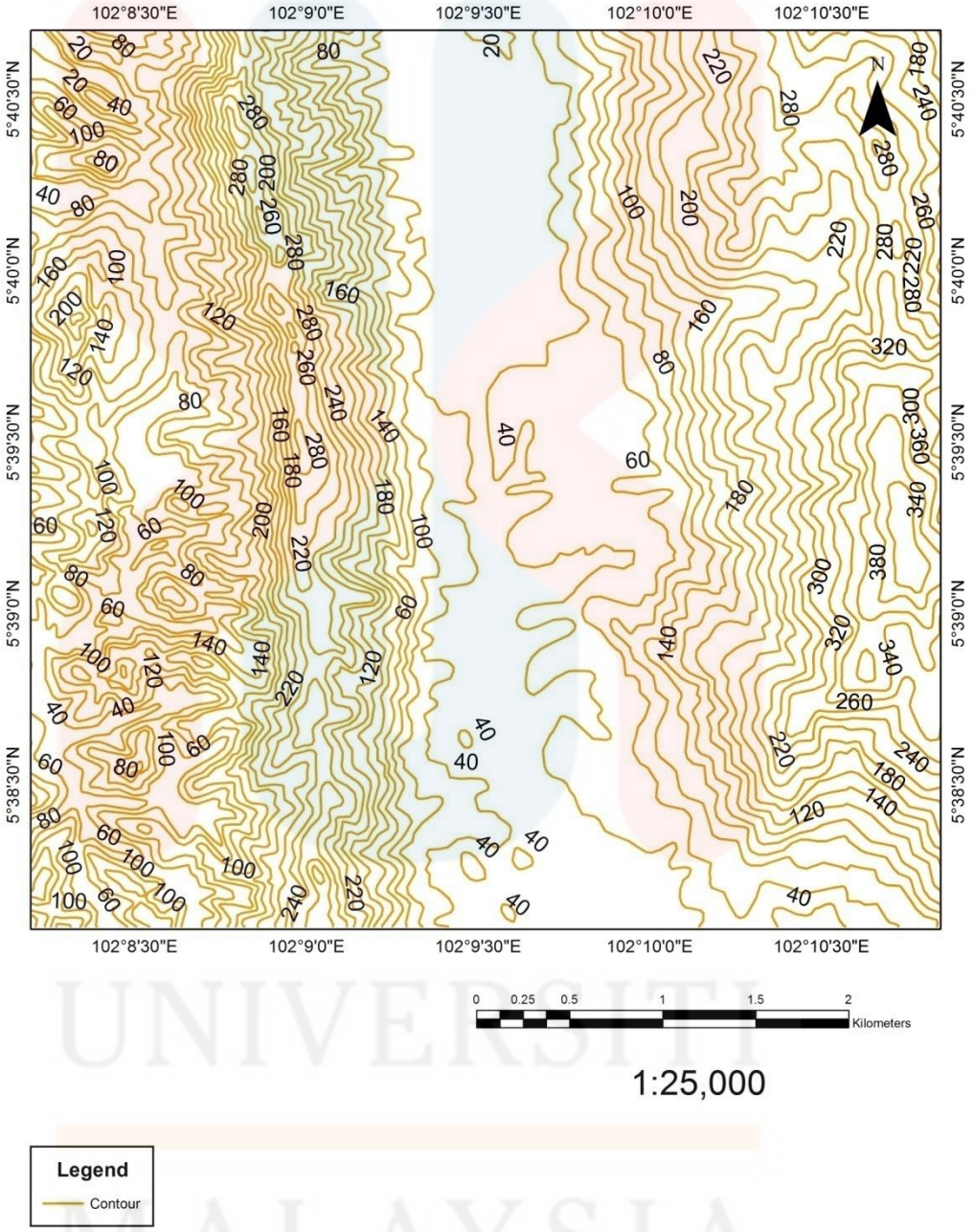


Figure 4.7 Topographic Map of Temangan, Machang, Kelantan.

4.2.2 Drainage Pattern

Drainage pattern is the pattern that formed by the rivers, stream, and lakes in a particular drainage basin. They are controlled by the gradient of the land, topography of the land whether they are dominated by hard or soft rock. The stream are formed due to the force of the rainfall on the surface. Is started as a sheetwash because of the thin surface of water flow occurs during rainfall before it erodes the surface that then creating a small rill channel and can merge with smaller watercourse joining larger trunk stream that known as drainage network.

There are several types of drainage system according to their pattern which are dendritic, parallel, trellis, rectangular, radial, centripetal, deranged, annular and discordant depending on the topography and geology of the land. The types of drainage pattern indicate different geomorphology. The various types of drainage pattern are important to determine the type of the rock structure. River patterns are determine by the slope and the structure of the topography and they are evolving through natural selection. Drainage patterns usually conduct to determine the structure and chronology of events and also for the mineral research.

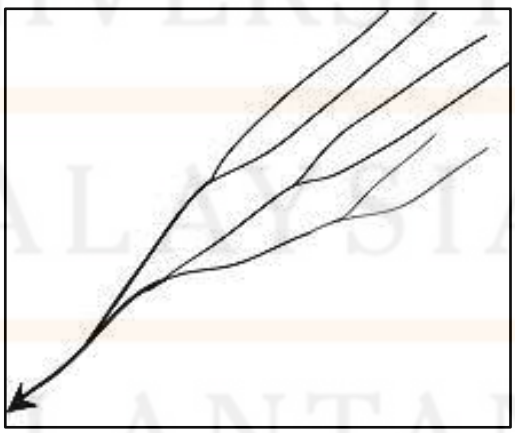


Figure 4.8 Parallel Drainage Pattern

Parallel drainage pattern is a pattern of a rivers caused by a steep slopes by some relief as shown in Figure 4.8 above. The streams are swift and straight because of the steep slopes flowing into the main river and all of them are in same direction. This type of drainage described slopes surface and elongate landforms like outcropping resistant rock band. Parallel drainage pattern is the minor pattern that exists in study area. Each drainage pattern is influenced by the type of lithology and their structure. This parallel drainage pattern in this study area influenced by the steep slope with some relief in the eastern part of the region.

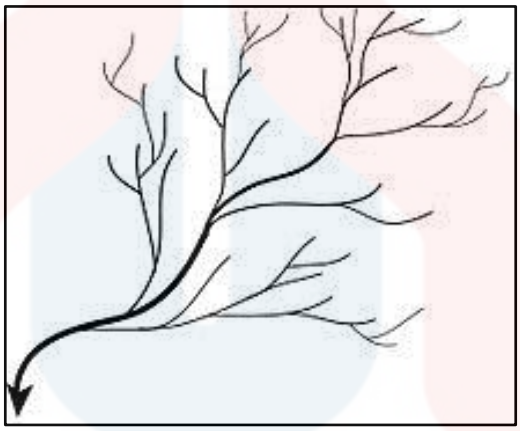


Figure 4.9 Dendritic Drainage Pattern

A dendritic drainage pattern (Ritter, 2003) is the most common form and looks like the branching pattern of the rocks. It is contributes with many streams which are then joined together into the main river as shown in Figure 4.9 above. Dendritic system form the v-shaped valleys that cause the rock types must be impervious and non-porous. This type of drainage pattern is the major pattern that exists in study area. It is influenced by the homogeneous lithology and joining the streams to the main river. Figure 4.10 shows that the drainage pattern of Temangan, Machang, Kelantan.

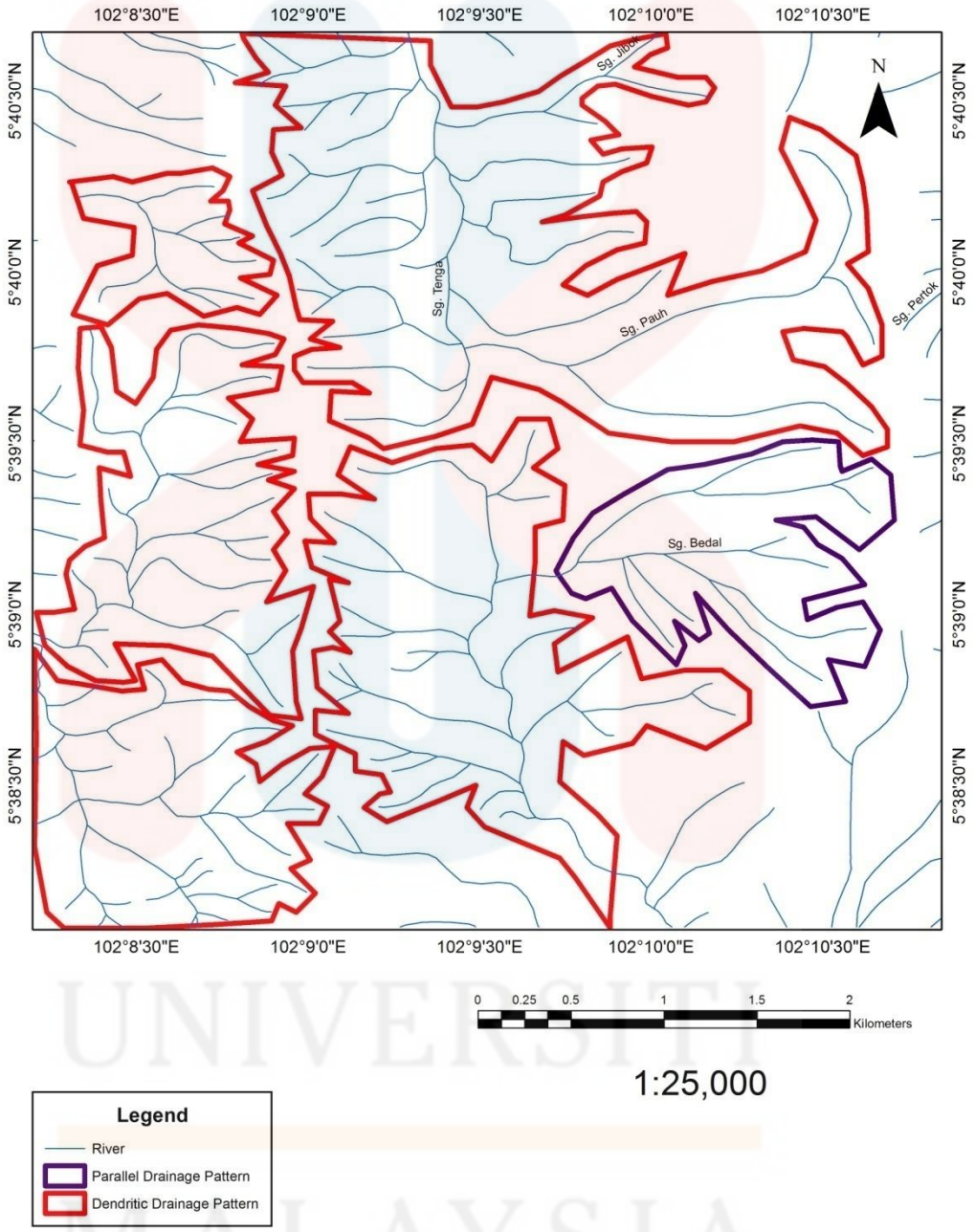


Figure 4.10 The drainage map showing dendritic pattern showing of Temangan, Machang, Kelantan.

4.2.3 Weathering Process

Weathering process is the breakdown and alteration of bedrock by chemical and mechanical process that creates a regolith that can make it can be transport away from the site. Weathering process can be occurs in which involve the movement of the minerals and rocks by agents such as water, wind, snow, ice, wave and gravity. This process can change the state of the rocks which is from the hard state to the weaker state and softer state that available them to be eroded.

a) Chemical Weathering

Chemical weathering is the processes that involve the changes to the minerals that make up a rock. Rocks that have been occur this process will exactly different with the old one. Some of the rocks will be looks like it have been sculptured by sculptor while the other will looks like have been painted by red colour. Chemical weathering has three categories which are by hydrolysis, oxidation and solution.

Hydrolysis is the chemical weathering that break down the chemical of the substance when the rocks combined with water. Another type of chemical weathering is oxidation. Oxidation is the chemical weathering that break down the chemical reaction when the substance reacted with oxygen. Oxidation is the easiest to be detected because it may cause rust. This process basically occurs on metal rocks type causes it is easy to be weathered when it reacted with oxygen. Lastly but not least, is about solution. Solution divided by two which are carbonation and acid rain. Carbonation is about the carbon dioxide that reacts with rainfall that formed weak acid. This weak acid will dissolve the limestone that next will create spectacular cave system such as stalagmites and stalactites while acid rain is the rainfall that already pollute

by sulphur dioxide and nitrogen dioxide that released by factory. This acid rain will damage the real structure of the rocks. Figure 4.11 below shows that the chemical weathering observed in study area.

Figure 4.11 Chemical weathering observed at the surface of mica schist outcrop.

b) Biological Weathering

Biological weathering is the form of weathering that caused by the growth of roots and burrowing of animals. This living organism can cause this weathering in many ways such as the tree that put it root through the crack or joint of the rock. An algae or others tiny bacteria also can effect biological weathering. This is because it will break rocks down in order to get the nutrients that they need. Figure 4.12 below shows that an algae that produced chemicals that help break down the rock.

Figure 4.12 An algae that produce chemicals that help break down the rock.

c) Mechanical Weathering

Mechanical weathering is the process that breaks from big solid rocks into the small pieces and this process may separate the different minerals without involving any chemical reactions. Basically occur on the surface of the earth. This is because the changes of the temperature on the surface of the earth during hot days and cool night cause things to expand and contract then that movement can cause rocks to break apart. The process sometimes is assisted by water.

From Figure 4.13, it can be conclude that it have been disrupted by rain, wind and temperature.

Photograph 4.13 Rock break during mechanical weathering.

4.2.4 Weathering Profile

Table 4.2 Weathering grades of different rock (Paul M. Santi, 2006)

Weathering process	General description
VI-Residual soil	The rock is completely changed to soil in which the original rock texture has been completely destroyed.
V-Completely decomposed	The rock is changed to soil in which the original rock texture is (mainly) preserved.
IV-Highly decomposed	50-100 percent soil from decomposition of the rock mass.
III-Moderate decomposed	Up to 50 percent soil from decomposition of the rock mass.
II-Slightly decomposed	100 percent rock; discontinuity surfaces or rock material may be discoloured.
I-Fresh	100 percent rock; no discoloration, decomposition, or other change.

4.3 Stratigraphy

Stratigraphy is the study of rock layers or strata that usually to studied about sedimentary rocks. The age of the rocks later will be describe by the layer which is deposited first and which is intruded later. In this study area, the oldest rock is quartz mica schist with Permian age while the youngest rock is ignimbrite that was intruded in Triassic age. Based on the Figure 4 (something), the geological map is shown the lithology of the rocks that existed in Temangan.

Based on the geological map in Figure 4 (something) and observation in Temangan, it can be conclude that about 70 percent of the area covered by magmatic rocks which are ignimbrite and andesite. The colour of ignimbrite is pink to dark brown while andesite dark greenish. It is about 25 percent of study area covered by ignimbrite. These rocks were found in four different localities which are at Locality 1, Locality 2, Locality 3 and Locality 4.

a) Taku Schist Formation

Quartz mica schist found in study area. This type of rock is the lowest percentage to be found in study area about 5 percent only. The rock were found at Locality 8 which placed at foot hill. This rock undergoes weathering process with the presence of clay properties. The colour of the rock is dark purple. This rock is sheet like grained which can split into layer.

b) Telong Formation

Fine-grained sandstone also can be found in study area. This type of rock covered 20 percent of study area. Fine-grained sandstone found in Locality 7 and this outcrop experienced weathering process. This is because the surface of the rock not fresh and was weathered. This rock is dark grey in

colour and the size of the grain is fine grain. Figure 4.17 shows the hand specimen of fine-grained that found in study area.

Figure 4.17 Hand specimen of fine-grained sandstone

c) Tanah Merah Volcanic

Almost 50 percent of the research area covered was found andesite rocks. There were two localities where the andesite was found which are at Locality 5 and Locality 6.

Andesite at Locality 5 found at Temangan Reserve Forest along the river. For the Locality 6, andesite rock found at oil palm plantation. At that locality can be found big outcrop and placed near to each other. Andesite rock is aphanitic which has small grain that hardly to be detected by using naked eyes. The texture of the andesite is phorphyritic because there are some of the pnenocryst in smaller constitutes matrix. Figure 4.15 shows the outcrop of andesite while Figure 4.16 shows the hand specimen of andesite in study area. Table 4.3 shows the description of thin section of andesite.

Figure 4.15 Outcrop of andesite rock.

Figure 4.16 Hand specimen of andesite.

Table 4.3 The description of thin sectin of andesite.

Name of Rock: Andesite

Rock Type **:** Igneous Rock

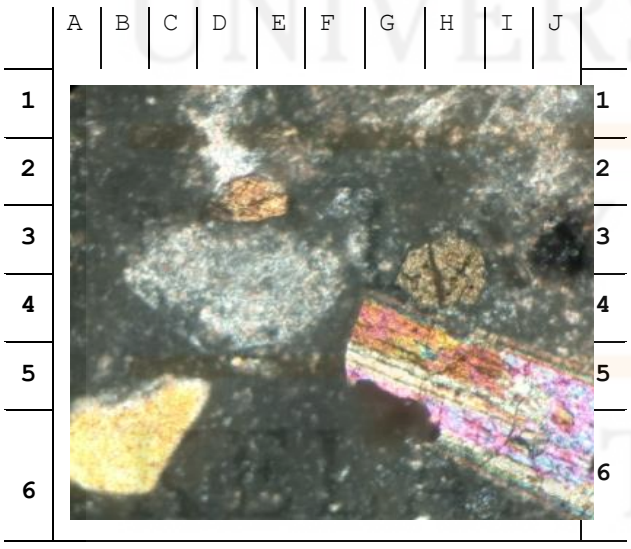
Location : Oil palm plantation

Microscopy **:**

Absorbtioncolouris brownish grey, interference colour is greyish, texture is porphyritic, shape is subhedral to anhedral, size of minerals in between 0.25 – 6.82 mm. Minerals composition are pyroxene, biotite and crystallite (plagioclase), quartz and calcite.

Mineralogy Description

Composition of Mineral	***Amount*** **(%)**	***Description of Optical Mineralogy***
Pyroxene	**70**	The absortion colour are brown and pale pinkish. There are cleavages exists in pyroxene. This pyroxene is low birefringe and it is first order colour.
Hornblende	**20**	The absorbtion colour of hornblende is yellow-green to dark brown. There are cleavages that found in hornblende.
Magnetite	**10**	Subhedral to auhedral in shape. Absorbtion colour of this mineral is crystal colour light brown no cleavage exists in thismagnetite.



//– Nikol

d) Temangan Ignimbrite

Ignimbrite rock that was found at Locality 1 were at small river in rubber plantation. This rock experienced weathering process along the small river. In Locality 2, the sample was crop out from the outcrop uphill. This ignimbrite weathered at the surface. Ignimbrite at Locality 3 was found at oil palm plantation. It was found at small river that exists in that oil palm plantation and this rock also experienced weathering process. And for the ignimbrite at Locality 4, it was found at small waterfall that existed in oil palm plantation.

The ignimbrite rocks found in study area with different localities are pinkish to dark brown in colour. These rocks are volcanic rocks that have pyroclastic texture and composed of the fine grain matrix with some phenocryst in it. The minerals found in this rock are quartz, muscovite, alkali feldspar and lithic fragment. The texture of the rocks is between tuff and rhyolite lava. This is the evidence that this rock was put as a tuff flow. Figure 4.14 shows the hand specimen of ignimbrite found in study area.

Figure 4.14 Hand specimen of ignimbrite

e) Alluvial

Alluvial deposits are the youngest types of rock found study area. The age of this rock is Quaternary age. Alluvial deposits are characterized as the loose, unconsolidated soil or sediments that have been eroded caused by the erosion of the riverbank. Basically, alluvial consist of variety of materials including of sand, silt and clay. It was widespread in the flat valley of Kelantan River include stream channel and floodplain deposits.

4.4 Lithostratigraphy of Study Area

Lithostratigraphy is the subdiscipline of stratigraphy that geologist used to study about strata or rock layers. Based on Table 4.4, it shows the lithostratigraphy column in Temangan while Figure 4.18 shows the geological map in Temangan, Machang, Kelantan.

Table 4.4: The lithostratigraphy column in Temangan.

Lithology	Description	Unit	Period	Era
	Alluvial mainly consist of sand, silt and clay. Spread through flat river valley.	Alluvium	Quaternary	Cenozoic
	Ignimbrite	Temangan Ignimbrite	Triassic	Mesozoic
	Andesite	Telong Formation	Permian-Triassic	
	Fine-grained sandstone	Telong Formation		
	Quartz-mica schist	Taku Schist	Permian	Paleozoic

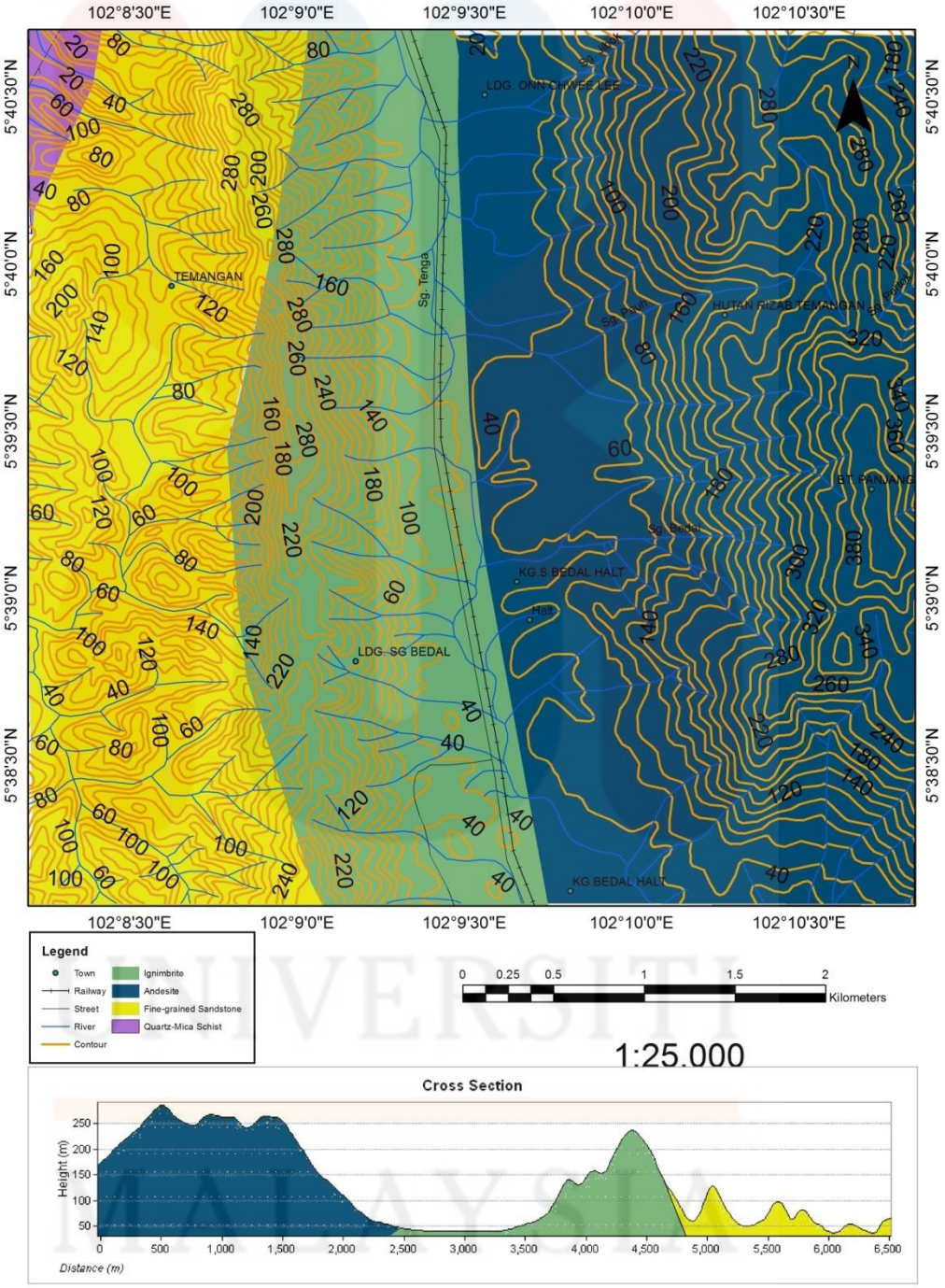


Figure 4.18 Geological map of study area.

Hand Specimen

Based on the geological mapping and field observation, it can be interpreted that all of the study area consist of andesite, ignimbrite, sandstone and schist.There are four samples found for ignimbrite rocks that were found at Locality 1, Locality 2, Locality 3 and Locality 4.For andesite rocks, there are two samples found in study area. They were found at Locality 5 and Locality 6. For fine-grained sandstone, there only one sample has been taken. This is because most of them experienced weathering process. Fine-grained sandstone was found at Locality 7.Quartz mica schist is the lowest percentage can be found in study area. Most of them undergoes weathering process with the presence of clay.

4.5 Field Observation and Mapping

Field observation and mapping is one of the important processes in geological research because it counts as one of the methodology used in the research. The geological pattern of the area such as drainage pattern, geomorphological and rock types can be identified from the field observation and mapping.

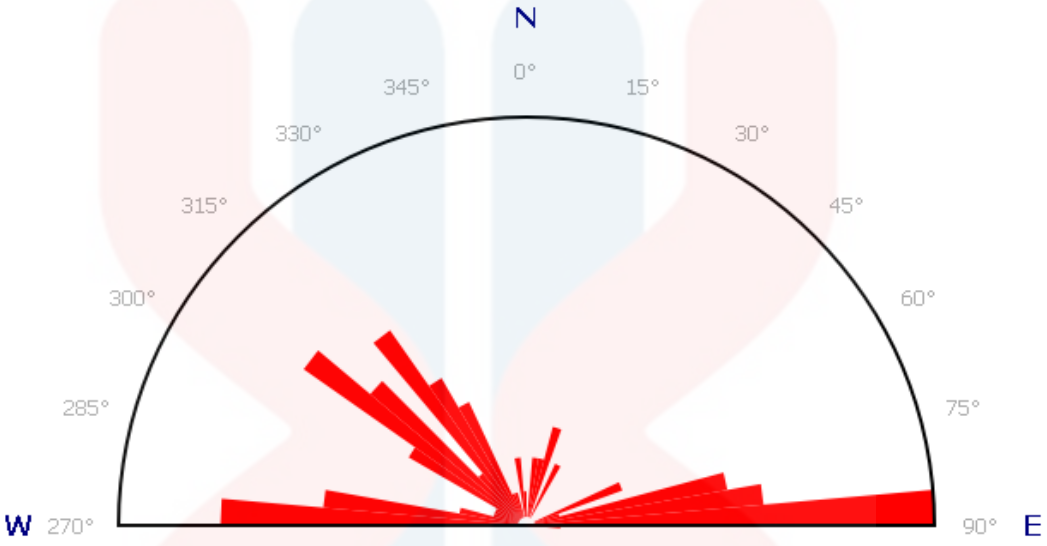
4.6 Structural Geology

Structural geology is the study of the three-dimensional distribution of rock units with respect to their deformational histories. It is also the processes that result in the formation of geologic structures and how these structures can affect the rocks.

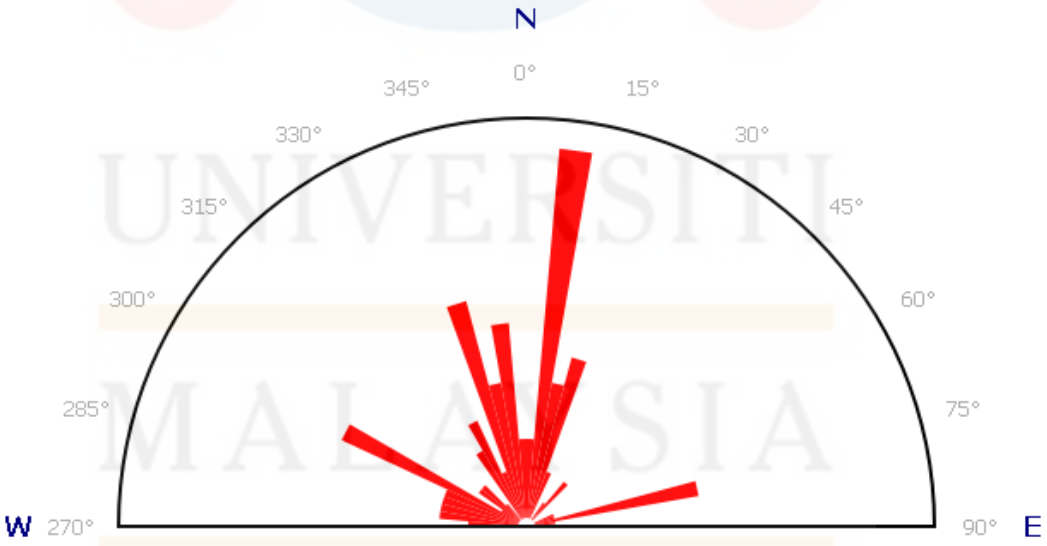
4.6.1 Joint

Joint is the fracture of the rock that natural occurrence in the layer or body of the rock that lacks of visibility to the surface of the plane. There are several joint that can be found in study area. The joints usually are the structures created by the force

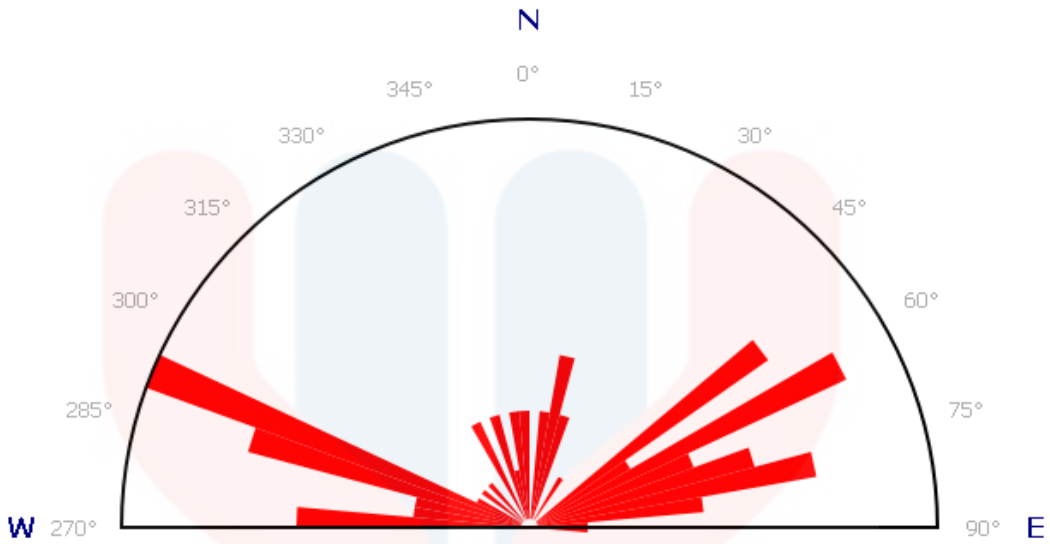
that exerted on the rock body. The brittle behavior of the rocks will displace the blocks to one another with approximately planar discontinuities (Ramsey, 1967)



The first locality data was collected from the outcrop North- West part of the map. The forces come from north-west is 315˚ direction that formed joint. Type joint of the first locality is the extensional joint.



The second locality data was collected from the outcrop upper North- West part of the map. The forces come from North-East is 15˚ direction that formed joint. Type joint of the second locality is the extensional joint.



The third locality data was collected from the outcrop South- West part of the map. The forces come from North-West is 290˚ direction that formed joint. Type joint of the third locality is the extensional joint.

4.6.2 Fault

The fault process occurs when the rocks are break causes of the movement of the earth crust. This movement basically conducted to make some an earthquake. The movements of the earth crust effect of the stress that may build up over a period of time before it release a huge amount of energy that can create an earthquake.

Faults are divided by three which are normal fault, thrust fault and strike-slip fault. Normal fault is the fault that moves towards the downthrown block but still the youngest rocks is remains in the above of the oldest rock. It difference with thrust fault. This is because that the thrust fault is the break that effects the oldest rocks will be placed above the youngest rocks and for the strike-slip fault it the type of fault that occurs in vertical or horizontal of the fault plane. It proved that the ignimbrite rock is older than fault because the fault occurred on ignimbrite rock. Figure 4.19 shows fault that found in study area.

Figure 4.19 Fault that exists in study area.

4.6.3 Fold

Fold happen beneath of earth results of the slow deformation under pressure and high temperature that cause the structure of the rocks curved or bent from their origin. Upfolds are called as anticlines while downfolds are called as synclines. Folds can be categorized into five types which are symmetrical fold, asymmetrical fold, overfold, recumbent fold and overthrust fold. The folding that existed in study area is monocline. Figure 4.20 shows the folding in study area.

Figure 4.20 Folding that exists in study area.

4.6.4 Lineament Analysis

Lineament is the linear feature in landscape that express the underlying geological structure such as fault. Fracture zones, shear zones and dykes also can give rise to lineament. Positive and negative lineament can be measured in geological or topographic map and can be appear obvious on satellite photograph.

Positive lineament was done by measuring the angle of the straight line of the ridges of hills while for negative lineament was done by measuring the all the drainage. Rosenet are used to measure the rose diagram for both positive and negative lineament to get the direction of forces, tensions and shear. Figure 4.21

shows the lineament analysis in Temangan, Machang, Kelantan while Figure 4.22 shows the lineament analysis in Temangan, Machang, Kelantan.

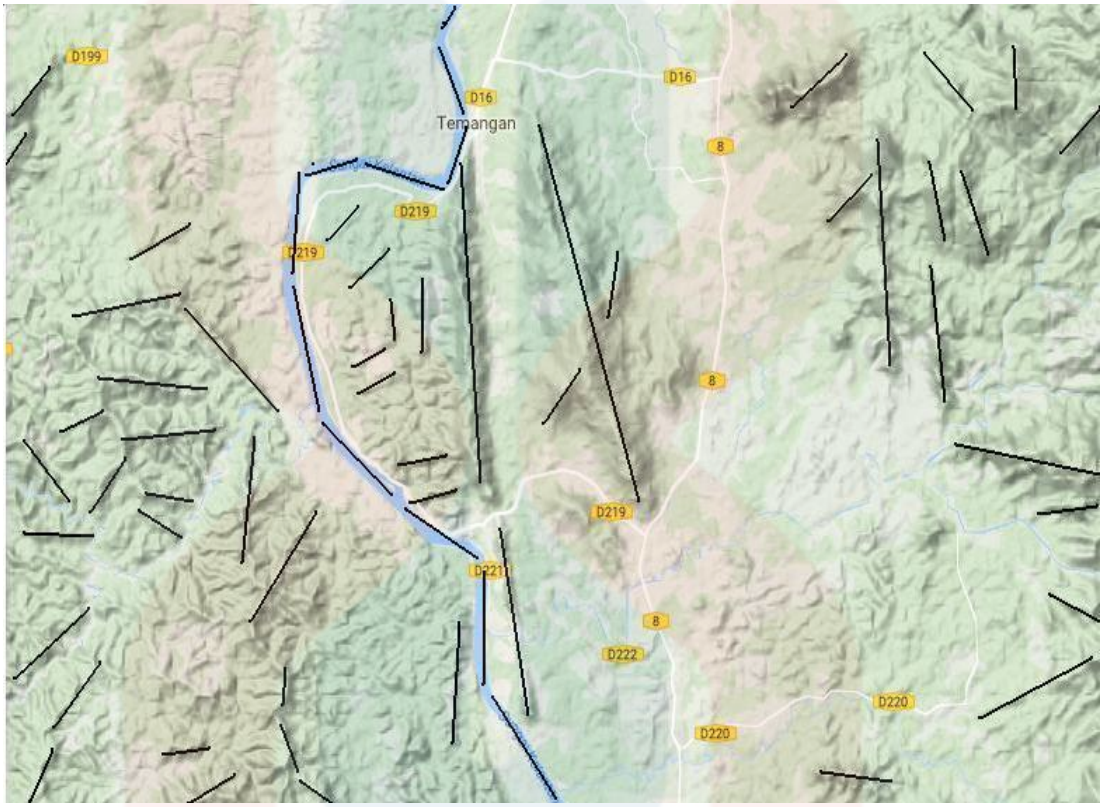


Figure 4.21 Lineament in Temangan, Machang, Kelantan

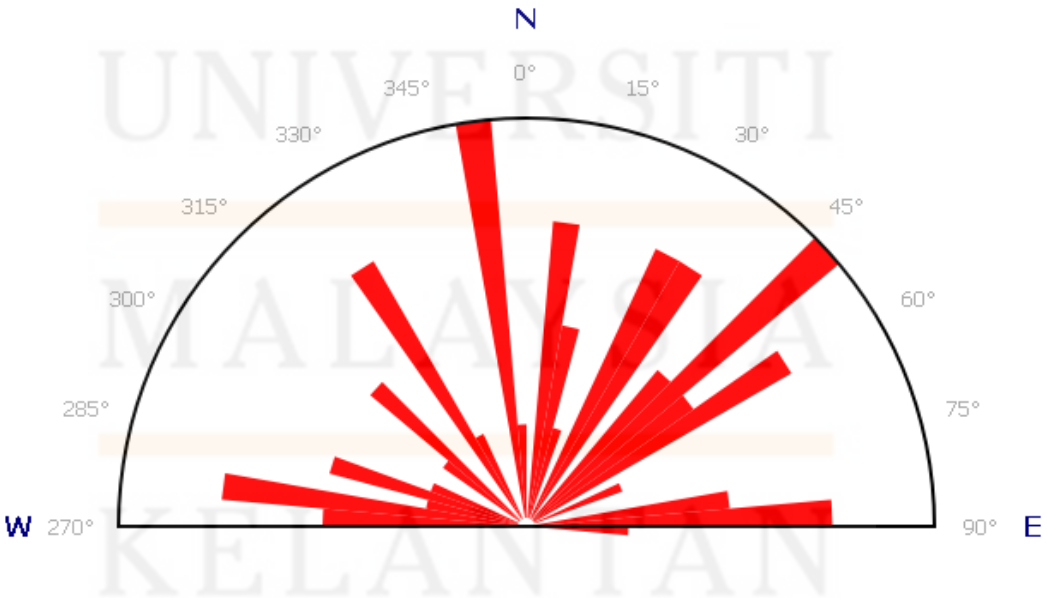


Figure 4.22 Lineament analysis in Temangan, Machang, Kelantan

The direction of the main force that exerted on the rock body is from the 45˚ North-East. They coming in two opposite direction that compress the rock and forming the geological structures such as joints and fractures.

CHAPTER 5

PETROGRAPHY OF IGNIMBRITE

5.1 Introduction

This chapter will comprise the petrography result from the thin section that has been analyzed by using polarizing microscope. The samples were collected to be discussed respectively on their petrography and mineralogy. Minerals are identified based on their optical properties in thin sections that analyzed by using polarizing microscope. Then, the thin sections classified based on their mineralogical composition and texture.

5.2 Introduction of Ignimbrite Rocks

Ignimbrite rock is the type of pyroclastic rock. Pyroclastic rocks are classified as volcanic rock type. It is volcaniclastics rock that formed by the accumulation of the fragments during explosive eruption. The materials that come out from the explosive eruption were transported by mechanical action such as wind or water before it solidified and formed pyroclastic rock. Pyroclastic rocks are identified based on size and abundance of their fragmental pieces of the rocks. There are divided by four categories which are fine tuff, coarse tuff, lapilli tuff or lapillistone and lastly is agglomerate or sometimes pyroclastic breccias. Ash that came out from explosive eruption considered as pyroclastic because it is a dust that made up from volcanic rock.

Products of pyroclastic from the eruption were widespread in about tens of kilometers, formed interlayers of volcanic tuffs mainly of compound basaltic-trachytic composition. The origin of rocks clearly can be defined by the shape of the

fragments. Pyroclastic deposits consist of fragments that are not arranged together. Tuff is the pyroclastic deposit that experienced lithified. One of the most magnificent forms from pyroclastic deposits is ignimbrite that formed by high temperature gas and ash mix of a pyroclastic flow event.

Ignimbrite is one of the volcanic rocks which mainly consist of pumice fragments, formed by the process of combination and firmed of material deposited by the pyroclastic flows. Ignimbrite is classified as igneous rocks. The mineral contents of ignimbrite rocks include apatite, biotite, calcite, chlorite, feldspar, hematite, hornblade, ilmenite, magnetite, olivine, pyroxene, quartz and the compound content of ignimbrite rocks composed of calcium (Ca) and sodium chloride (NaCl). Ignimbrite can be found in black, grey, brown and white in colours which affected by their composition and its origin place. The streak of a rock is the colour of powder produced when it is rubbed across a streak plate. The streak of ignimbrite is usually white and it has anopaque shape which cannot be seen through.

The shape of grains, the orientation of crystals within the rock and its appearance shows the texture of the ignimbrite. The texture of Ignimbrite is aphanitic which indicate fast cooling history and has an extrusive origin. The grain size of ignimbrite is fine grained where its mineral is too small to be seen without magnification. Its appearance is dull and vesicular. The appearance of ignimbrite depends on the percentage of impurities in it.

Rocks can be found everywhere around us. The amount of ignimbrite abundance depends on the types of rocks available in a particular area, their formation process, weathering, climatic conditions, composition, erosion and their properties. As for ignimbrite rocks, they are distributed all around the world

including in Asia which are Burma, Cambodia, China, India, Indonesia, Malaysia, Japan, Thailand, and in Turkey, Africa, Australia, America and also around Europe countries including Germany, Italy, Poland, Portugal and Spain.

Rocks are formed at the hard outer crust of the Earth which is made up of minerals. It has been used by humans since ages. From the Stone Age, rocks are used for various purposes. This shows that rocks play an important role in our life. Hence by using the ideas and technology, humans had found out advantages and the applications in various fields by using rocks. All of us use products consist of rocks in our daily life. Rocks had been used in wide range starting from food, medicines, jewelry, roads, tools, floors, monuments and also statue. From ancient times, many types of rocks had been used to build blocks of structures and houses. Until now they are still being used for the same purposes. Similarly, there is wide range of uses of ignimbrite. Ignimbrite was used in architecture and construction. In construction industry, ignimbrite was used to build houses or walls and in construction aggregate. It also used in building stone for decorative walls and paving. It can be concluded that ignimbrites have many advantages especially in construction

5.3 Petrography Analysis

There are four ignimbrite rock were taken from study area. The samples were taken to be analyzed through hand specimen and also in thin section analysis. Grain size, colour and texture of the rocks can be identified by analyzed through hand specimen. By thin section analysis, minerals that can be existed in rock easily detected. The thin sections were observed under cross and plain polarized to describe the physical properties.

5.3.1 Hand Specimen.

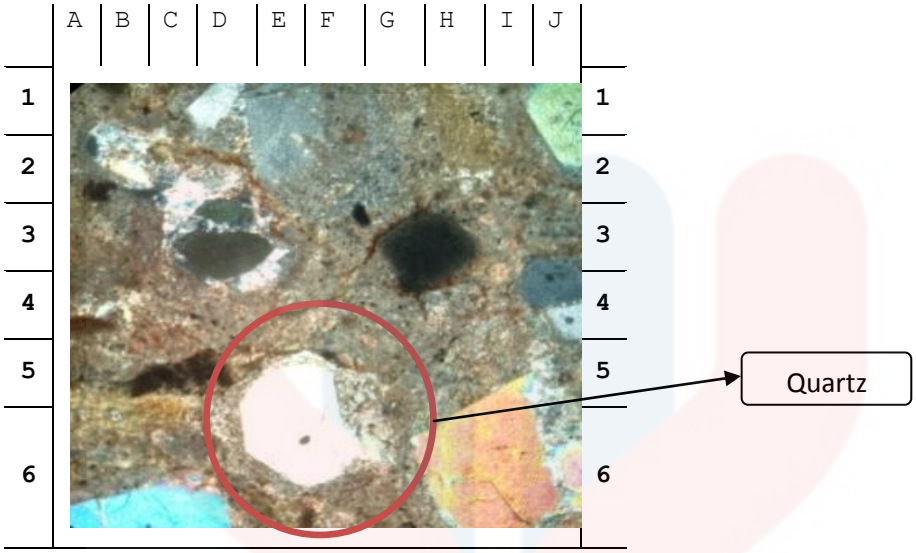
Hand specimen of ignimbrite rock has been taken from various places to compare the grain size, colour and texture of the rock. This specimen has been taken in four different localities. The colour of the rock is change due to weathering process that occurs on this type of rock. These rocks have pyroclastic texture and their matrix size is fine. The size of phenocryst ranging from 2mm to 7mm.

5.2 Minerals in Thin Section

There are several common minerals that have been identified by using polarizing microscope in thin sections. All of them are distinguish by the optical characteristics that clearly found in thin sections. Minerals that existed in ignimbrite rocks under the thin sections are:

a) Quartz

Basically, under plane polarized quartz is the mineral that colourless in thin section. It has low relief and lacking of the cleavage and twinning. In contrast, when under plane polarized microscope, it is distinguished by shiny white colour. Figure 5.1 shows quartz under cross polarized.



//– Nikol

Figure 5.1 Quartz under cross polarized

b) Alkali Feldspar

Alkali feldspar is the feldspar that rich in alkali element such as sodium and potassium. The birefringence colour of alkali feldspar is low and the cleavage presence also low. In plane polarized, it is colourless and there is no pleochroism. The particular twinning of alkali feldspar can be seen under cross polarized. Figure 5.2 shows alkali feldspar under cross polarized.

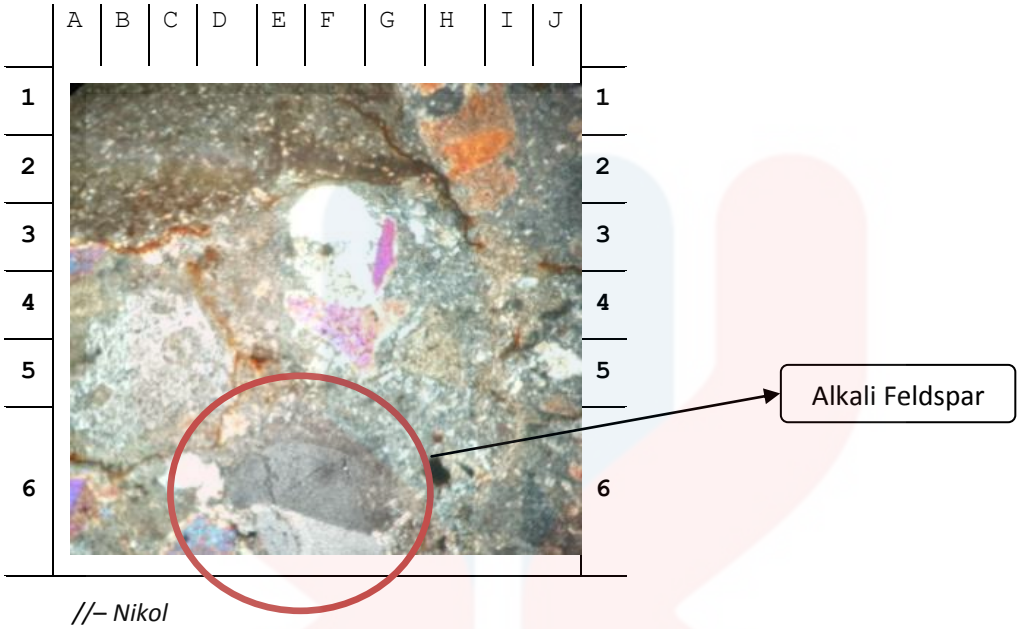


Figure 5.2 Alkali feldspar under cross polarized

c) Hornblende

Hornblende is the mineral from amphibole group. The colour of hornblende is yellowish dark green. It is shows the pleochroism from green to dark. This mineral has moderate relief to high relief and the interference colour of hornblende is second order. In the figure below, the colour of hornblende under cross polarized microscope is yellowish to brown. It has distinctive diamond shape. It can be differentiated from biotite by bird's eye extinction characteristic. Hornblende does not possess this kind of extinction. Figure 5.3 below shows hornblende under cross polarized.

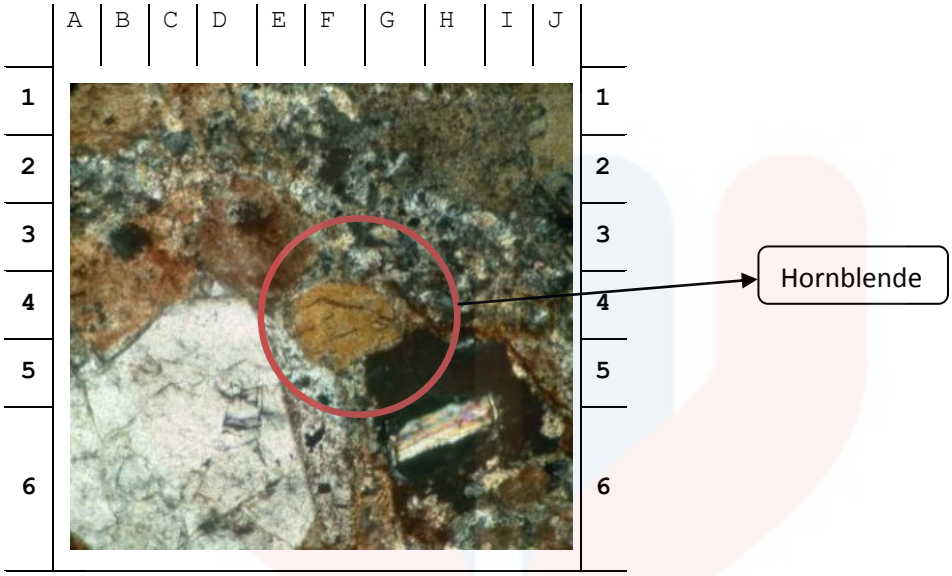


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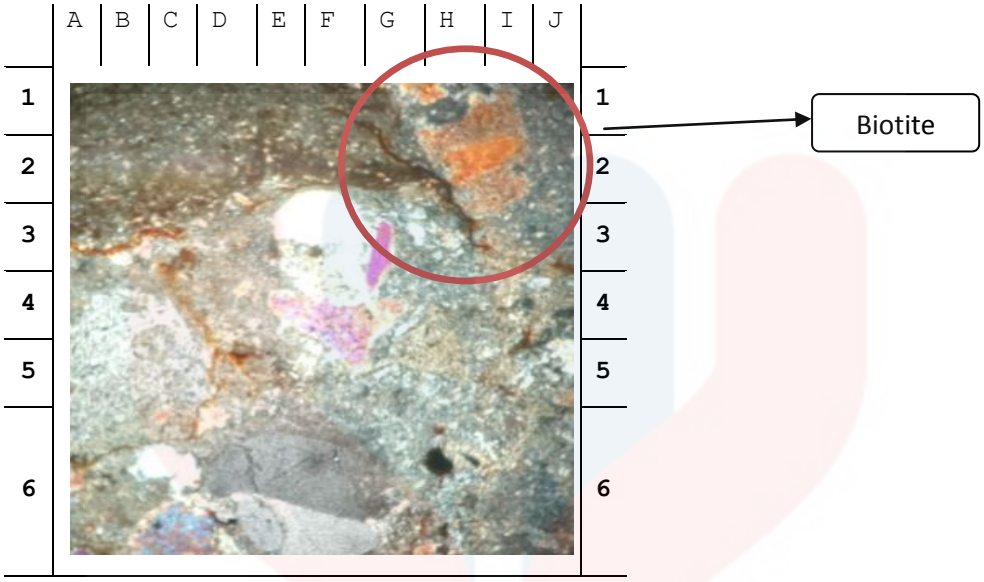
Figure 5.3 Hornblende under cross polarized

d) Biotite

Biotite is the mineral within the mica group. Usually the colour of biotite is brown to black but sometimes greenish in colour. It has tabular form and sometimes in euhedral form. The cleavage of biotite is perfect that easily seen in thin section. This mineral has low to moderate relief and has high interference colours such as orange to violet. It can be distinguished from muscovite by its colour under plain polarized. Under plane polarized, biotite has the colour of yellowish to brownish. Figure 5.4 shows biotite that found under cross polarized.

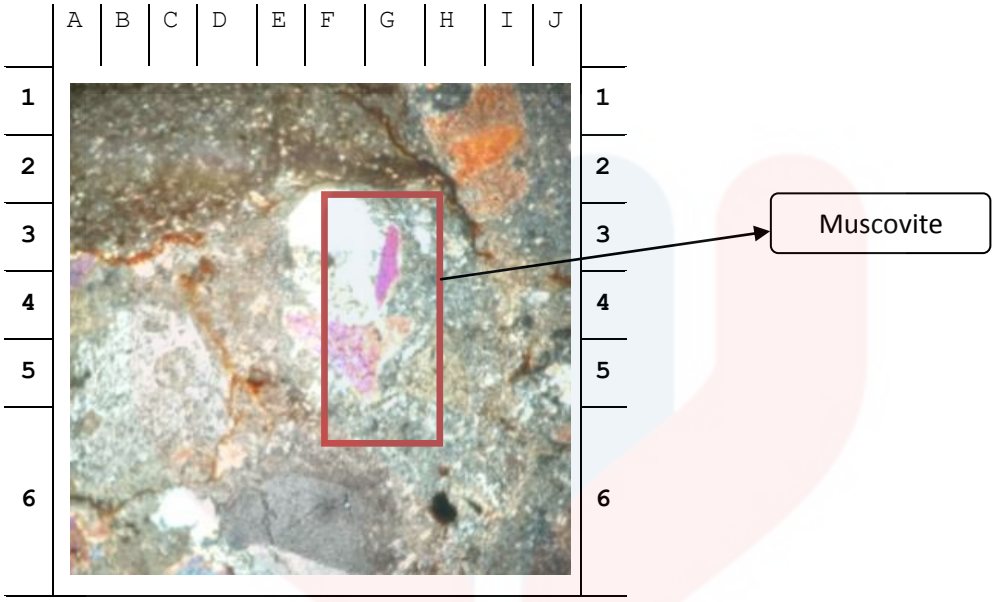


//– Nikol

Figure 5.4 Biotite under cross polarized

e) Muscovite

Muscovite has widespread in the characteristics of sedimentary, igneous and metamorphic rocks. Muscovite present in small amount in the thin section, under plane polarized microscope, muscovite is colourless but under cross polarized microscope, it shows high interference colour of the third order which is purplish. It exhibits bird's eye extinction. Figure 5.5 shows muscovite under cross polarized.



//– Nikol

Figure 5.5 Muscovite under cross polarized

Based on general observation, roughly the percentage of quartz is 25 percent, alkali feldspar is 15 percent and matrix is 60 percent. Quartz has shape of subhedral. The average size of this quartz is 5 mm. In comparison with alkali feldspar has anhedral to subhedral shape with size about 0.6 mm. The type of this alkali feldspar is monoclinic in which sanidine can be found.

5.3 Discussion

Basically, ignimbrite made up of quartz, alkali feldspar, biotite, hornblende and muscovite. Minerals such as biotite and hornblende have relation with intermediate magma whereas quartz, muscovite and alkali feldspar is felsic magma. Intermediate magma has higher content of Fe, Mg, Ca, Na, K whereas felsic magma has lower content of Fe, Mg, Ca but higher content of SiO_2 K and Na.

Ignimbrite was formed by the ash that flow out from volcanic eruption. It comprises of ash and scattered lithic fragments. There are two main models which have been proposed for the deposition of ignimbrite known as the *en masse* deposition and the progressive aggradation models. En masse deposition occurred when the pyroclastic flow in a way such that it is laminar and came to a stop as a whole. Whereas for progressive aggradation model suggested that ignimbrite formed from uninterrupted current. The differences observed between ignimbrite and within the ignimbrite itself are the product of temporal changes to the condition of the flow that caused the deposition of ignimbrite.

CHAPTER 6

CONCLUSION AND SUGGESTION

6.1 Conclusion

Through geological mapping carried out in the study area, it can be concluded that this area is made up of three types of rock which are metamorphic rock, igneous rock and sedimentary rock. The metamorphic rock is represented by schist, ignimbrite and andesite on the other hand represent igneous rock. Sedimentary rock is proved by the presence of fine-grained sandstone. There are various structural features can be found, those are joint, fault and folding. Generally the landform that meet up of study area are fluvial and hilly area. The river in this area made up of small stream with width of 1.5 meter. Through detail petrographic study of ignimbrite can be concluded that this area generally consists mineral such as quartz, alkali feldspar, biotite, muscovite and hornblende.

6.2 Suggestion

This study can be improved by implementing other technique such as geochemical analysis so that a more detail information about mineral can be detected. Thus, a relation between minerals, rocks and magmas can be established.

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