GEOLOGY AND PETROGRAPHIC ANALYSIS OF VOLCANIC PRODUCT IN MANDALAWANGI, PANDEGLANG REGENGY, BANTEN.

By

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

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APPROVAL

"I/ We hereby declare that I/ we have read this thesis and in my/our opinion this thesis is sufficient in terms of scope and quality for the award of Bachelor of Applied Science (Geoscience) with Honours."

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DECLARATION

"I declare that this thesis with the title of "GEOLOGY AND PETROGRAPHIC ANALYSIS OF VOLCANIC PRODUCT IN MANDALAWANGI, PANDEGLANG REGENCY, BANTEN" 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."

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Date : ________________________________.

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In the name of Allah SWT, the Most Gracious and the Most Merciful, Alhamdulillah I reward and appreciate Him, consult Him for His aid and Forgiveness, and that I find sanctuary in Allah SWT from the mischiefs of our actions and the evils of our spirits. He whom Allah SWT guides will not be misled, and He whom Allah SWT misleads will never have a guide. I state that there's no deity but Allah SWT alone, with no companions, and that Muhammad is His' Abd (worshiper) and Messenger.

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Geology and Petrographic Analysis of Volcanic Product in Mandalawangi, Pandeglang Regency, Banten.

ABSTRACT

This research is about geology and petrographic analysis of volcanic product in Mandalawangi, Pandeglang regency at Banten. The study area which is Mandalawangi is surrounding by four different volcanoes which are Mount Aseupan, Mount Pulosari, Mount Parakasak, and Mount Karang. The study area is lies on the caldera, this is the reason why the area consist a lot of volcano. Previous geological map of the study area were found in scale of 1:100,000 by Santosa, (1991).Through mapping and observation that has been made for this research, the scale of the map was increase to 1:25,000 and this mapping also has add more detail data of geological information such as geomorphology, lithology, and stratigraphy of the study area. The area of Mandalawangi is mainly covered by volcanic igneous rock which is Andesite unit and Tuff unit. This research also provided new information about the mineralogy and petrology of the study area. The analysis of the volcanic product has been done by petrography study of the thin section of sample to identify the mineralogy of the rock and also by using geochemistry analysis which is X-Ray Fluorescence (XRF) analysis in order to recognise the elemental composition in the sample of rock and to determine the sources of the rock by using TAS diagram. From the result and interpretation of petrographic analysis and geochemistry analysis, all of the samples were classified into Andesite rock unit. This analysis proved that the volcanic products of the study area were coming from the same magma sources and magma series which is calc-alkaline series. The differences of the mineral size occurred due to the different time of eruption.

Geologi dan Analisis Petrografi Produk Gunung Berapi di Mandalawangi, Kabupaten Pandeglang, Banten.

ABSTRAK

Kajian ini adalah mengenai geologi dan analisis petrografi produk gunung berapi di Mandalawangi, Kabupaten Pandeglang di Banten. Kawasan kajian yang terletak di Mandalawangi dikelilingi oleh empat gunung berapi yang berbeza yang dikenali sebagai Gunung Aseupan, Gunung Pulosari, Gunung Parakasak, dan Gunung Karang. Kawasan kajian terletak di atas kaldera, ini adalah punca mengapa kawasan ini mempunyai banyak gunung berapi. Peta geologi terdahulu dari kawasan kajian yang sama didapati dalam skala 1: 100,000 oleh Santosa, (1991). Melalui pemetaan dan pemerhatian yang telah dibuat untuk penyelidikan ini, skala peta ditingkatkan kepada 1: 25,000 dan pemetaan ini juga mempunyai penambahan maklumat yang lebih terperinci mengenai geologi seperti geomorfologi, litologi, dan stratigrafi kawasan kajian. Kawasan Mandalawangi kebanyakannya diliputi oleh batuan gunung api gunung berapi yang merupakan Andesit unit dan unit Tuf unit. Penyelidikan ini juga memberikan maklumat baru mengenai mineralogi dan petrologi kawasan kajian. Analisis produk gunung berapi telah dilakukan dengan menggunakan kajian petrografi ke atas keratan nipis sampel batuan untuk mengenali mineralogi batu dan juga dengan menggunakan analisis geokimia yang merupakan analisis X-Ray Fluorescence (XRF) untuk mengetahui komposisi elemen dalam sampel batu dan untuk menentukan sumber batu dengan menggunakan gambarajah TAS. Dari hasil dan tafsiran analisis petrografi dan analisis geokimia, semua sampel dikelaskan ke dalam unit batu Andesit. Analisis ini membuktikan bahawa produk gunung berapi di kawasan kajian datang dari sumber magma yang sama dan siri magma yang merupakan siri calc-alkali. Perbezaan saiz mineral berlaku kerana berlakunya letusan dalam waktu yang berlainan.

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LIST OF ABBREVIATIONS

cm	Centimetres
km	Kilometres
mm	Millimetres
m	Metres
Si	Silica
K	Potassium
Ti	Titanium
Na	Sodium
Mg	Magnesium
Mn	Manganese
P	Phosphorus
Fe	Iron
O	Oxygen
LOI	Loss of ignition
XRF	X-Ray Fluorescence
XPL	Cross Polarized Light
PPL	Plane Polarized Light
GPS	Global Positioning System
mya	Million years ago
GIS	Geographic Information System
Px	Pyroxene
Qz	Quartz
Amp	Amphibole
Bt	Biotite
Fd	Feldspar
Pl	Plagioclase

LIST OF SYMBOLS

%	Per cent
o	Degree
‘	Minute
“	Second
>	More than
<	Less than

CHAPTER 1

INTRODUCTION

1.1 Background of Study

This study is about geology and petrographic analysis of volcanic product in Mandalawangi, Pandeglang regency at Banten. The word petrology was derived from the Greek words which are *petros*, that has the meaning of rock or stone and *logos*, which has the meaning of study. Petrology can be defined as the study of rocks. Petrography is a branch of petrology that focuses on analysis of the chemical and physical features of a particular rock sample. A complete analysis of petrography must include from the macroscopic to microscopic investigations of the rock sample.

Igneous rocks is the rock that was formed from the cooling of magma which is the molten materials consist in the earth's crust and will come out as lava when there is an eruption of volcano or caldera. The process of cooling or solidification of magma can occur in two different places which are in the subsurface of the earth or on the surface of the earth. If the magma was solidified in the subsurface, the plutonic or intrusive igneous rock will formed. However, if the magma was solidified on the earth's surface, the volcanic or extrusive igneous rock will formed.

Intrusive igneous rock was formed when the magma cooling off slowly beneath the earth's crust and harden into solid material called rock. It is very hard and coarse grained because it contains a lot of mineral. Example of intrusive igneous rock is gabbro, diorite, pegmatite and granite. Extrusive igneous rocks were formed when the magma on the earth's surface or also known lava is cooling and formed the rock. It is fine grained rock and do not contain a lot of mineral such intrusive igneous rock. Example of extrusive igneous rock is basalt, pumice, andesite and obsidian.

Igneous rock has many different textures due to its minerals contain and its process of formation. From the texture of igneous rock, the sources of the rock can be determined. There are six different types of textures which are aphinitic, phaneritic, porphyritic, glassy, pegmatite, and pyroclastic. Igneous rocks that have aphinitic texture are normally formed from the rapid crystallization of lava. The extrusive igneous rocks cool very faster, so their minerals form fine crystals which cannot be seen and distinguished by the naked eye and it can only be seen under the microscope or by using hand lens. Example of aphinitic igneous rock is andesite, basalt and rhyolite. For glassy texture, it is formed when lava from a volcanic eruption cools very faster and causes no crystallization to occur. Therefore the texture of the rock become glassy and the example of rock that has this type of texture is obsidian and pumice. Pegmatite texture of igneous rock is formed when the magma is cooling and some of the minerals increase in size. The size of minerals may increase from the centimetre to meter. Example of igneous rock that has pegmatite texture is pegmatite.

Phaneritic texture can be found in plutonic or intrusive igneous rock that has undergoes the slow process of crystallization beneath the earth surface. The slow process of crystallization causes the minerals able to increasing in size and has large crystals. The crystal in this type of texture can be seen by the naked eye. Examples of phaneritic texture of igneous rock are granite, gabbro and diorite. For porphyritic texture of igneous rock, it is caused by the rapid change of conditions as the magma continues to cool down. The minerals that had been formed earlier by the slow cooling magma, will composed of large crystals and the remaining melt magma will form a fine-grained matrix due to the sudden cooling. The porphyritic texture can also form when magma is crystallized under the earth surface but eruption occurs before the crystallization is complete and result the faster crystallizes of lava with smaller-sized crystals. The last texture of igneous rock is pyroclastic textures. It is formed when violent volcanic eruptions throw the lava into the atmosphere creating fragmental and glassy materials. These materials eventually fall to the surface as lapilli, volcanic ash and volcanic bombs.

This study was carried out to make an analysis of petrography of the volcanic product at the study area. Volcanic product or product of eruption comes in three different forms which are lava flows, pyroclastic debris, and gas. Lava flows is refer to the molten, moving layer of lava and for the solid layer of rock that forms when the lava freezes. This study is focuses on volcanic product that in the form of lava flows that become a solid layer of rock when the lava is freezes.

The analysis of the volcanic product has been done by petrography study of the thin section of sample to identify the mineralogy of the rock and also by using geochemistry analysis which is X-Ray Fluorescence (XRF) analysis in order to recognise the elemental composition in the sample of rock and to determine the sources of the rock by using TAS diagram and Harker diagram.

Igneous rock was formed from the cooling of magma. Magma has seven different types that are andesitic magma, basaltic magma, felsic magma, intermediate magma, mafic magma, rhyolitic magma, ultramafic magma. Magma has been classified based on its level of viscosity. This viscosity is depends on the silica contain in the magma. If the magma contains more silica, its viscosity will be high and if the magma contains less silica, its viscosity will be low. However, the main types of magma that usually found are basaltic, andesitic and rhyolitic magma. Basaltic magma consist about 45 – 55% of silica content, high composition of Fe, Mg, Ca and low composition of K, and Na. Andesitic magma consist of about 56 – 63% of silica content and intermediate composition of Fe, Mg, Ca, Na, and K. Rhyolite magma consist of about 70 – 75% of silica content and low composition of Fe, Mg, Ca, and high composition of K and Na. By using X-ray Fluorescence (XRF) analysis, silica content in the volcanic rock can be measure.

The study area which is Mandalawangi is located at the Pandeglang regency in Banten, Indonesia. Mandalawangi area is surrounding by four different volcanoes which are Mount Aseupan, Mount Pulosari, Mount Parakasak, and Mount Karang.

1.2 Study Area

1.2.1 Location

Indonesia is one of the well-known countries that dominated by volcanoes. This is due to its geography which is formed because of the subduction zones between the Eurasian plate and Indo-Australian plate. Indonesia has over than 130 of active volcanoes and the most active volcanoes are Mount Kelut and Mount Merapi which located at the island of Java. Most of the volcanoes of Indonesia are located on a 3,000 kilometres long chain that known as the Sunda Arc.

The study area is located at Mandalawangi and this area has been surrounded by volcanoes which are Mount Aseupan, Mount Karang, Mount Pulosari, and Mount Parakasak. The study area is lies on the caldera, this is the reason why the area consist a lot of volcano. Based on the several previous research papers, the volcano at the study area has different time of eruption. The topography of Banten province is around 0-1000 meter above sea level and the topography of the study area is about 300-700 meter. The size of the study area is approximately 5 km x 5 km square. Figure 1.1 shows that the area of Mandalawangi has been surrounded by four different volcanoes and Figure 1.2 shows the map of the Mandalawangi.

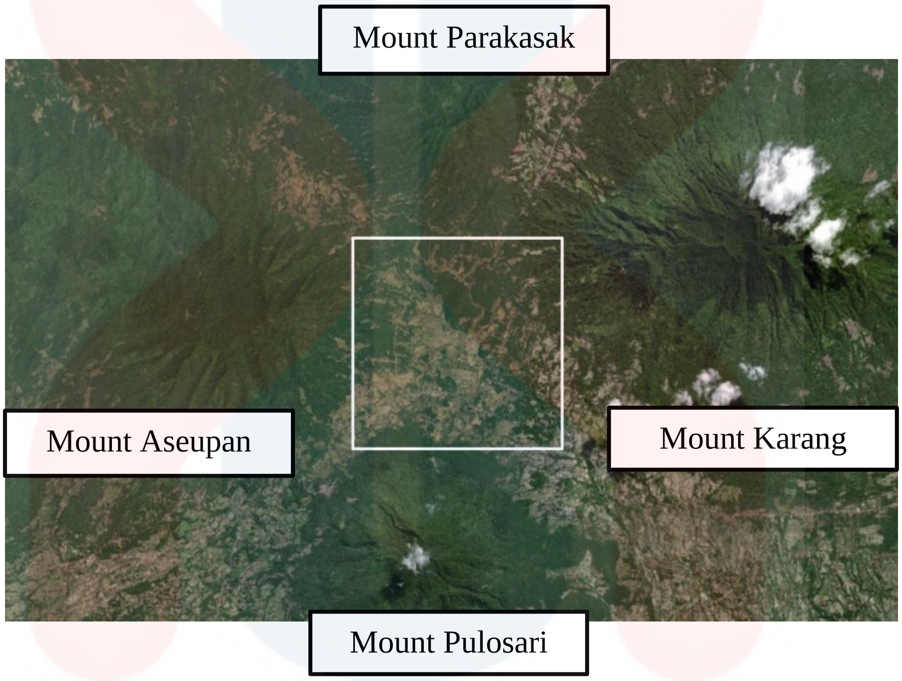


Figure 1.1: The location of the study area.

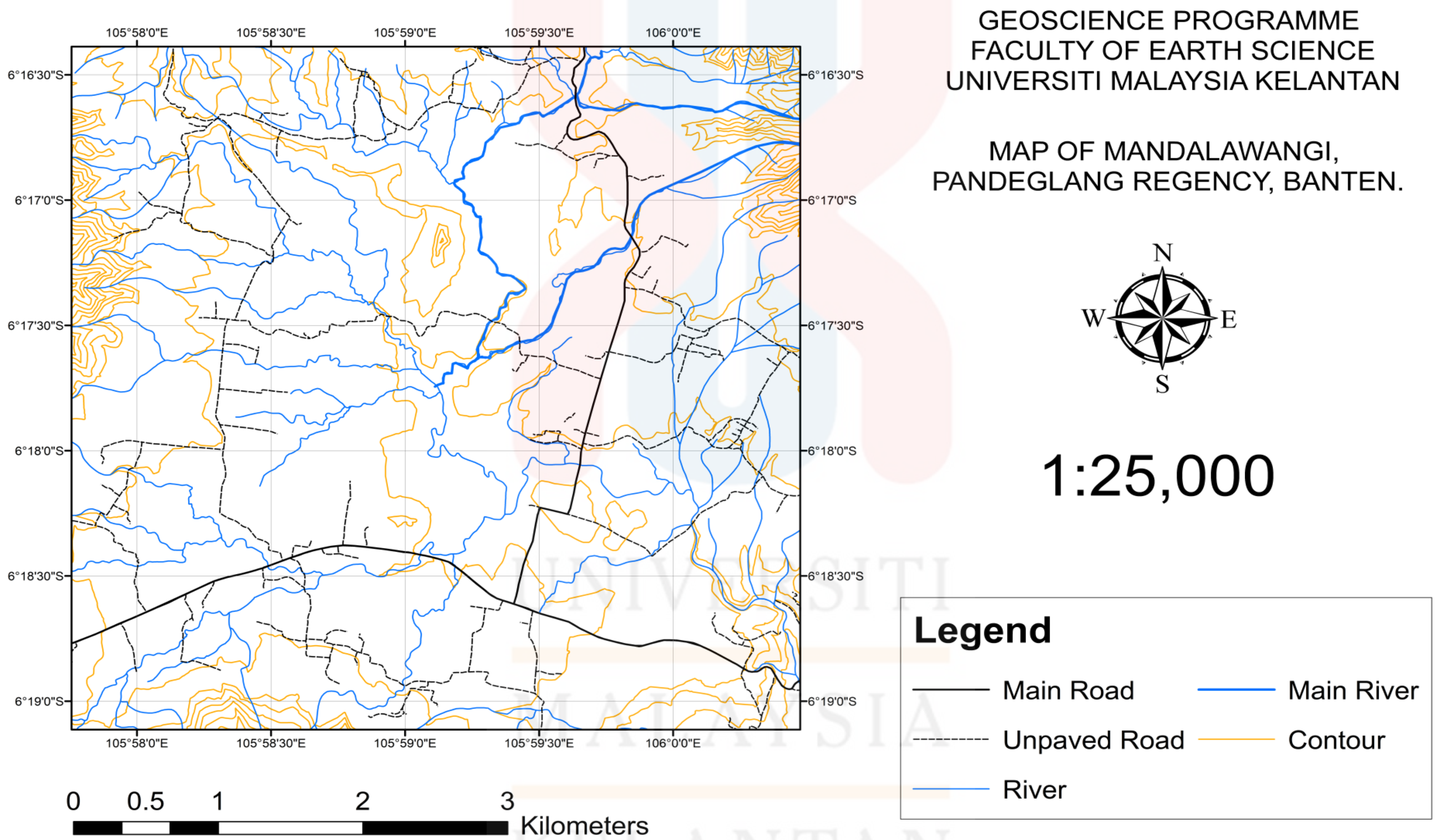


Figure 1.2: The map of the Mandalawangi.

1.2.2 Road Connection

Mandalawangi can easily be access as there is a residential area and near to the recreation area. The connection system at the study area is mainly by road. The main roads at study area are Jalan Raya Mandalawangi that connects Labuhan Regency and Pandeglang Regency and Jalan Raya Ciomas-Mandalawangi that connects Pandeglang Regency and Serang Regency. Most of the local people at Banten area and outsiders are using this road as the main connection. There are a lot of street at the study area. This is because the study area is mainly the residential area and also nears to the recreation area such Pantai Carita Anyer and Air Terjun Carita. About 40% accessibility road in Mandalawangi is an unpaved road. Most of the unpaved road is used by community as a connection from town to the residential area and also to their farm and other plantation such as paddy field, rubber plantation and many more. Figure 1.3 shows the accessibility map of the Mandalawangi.

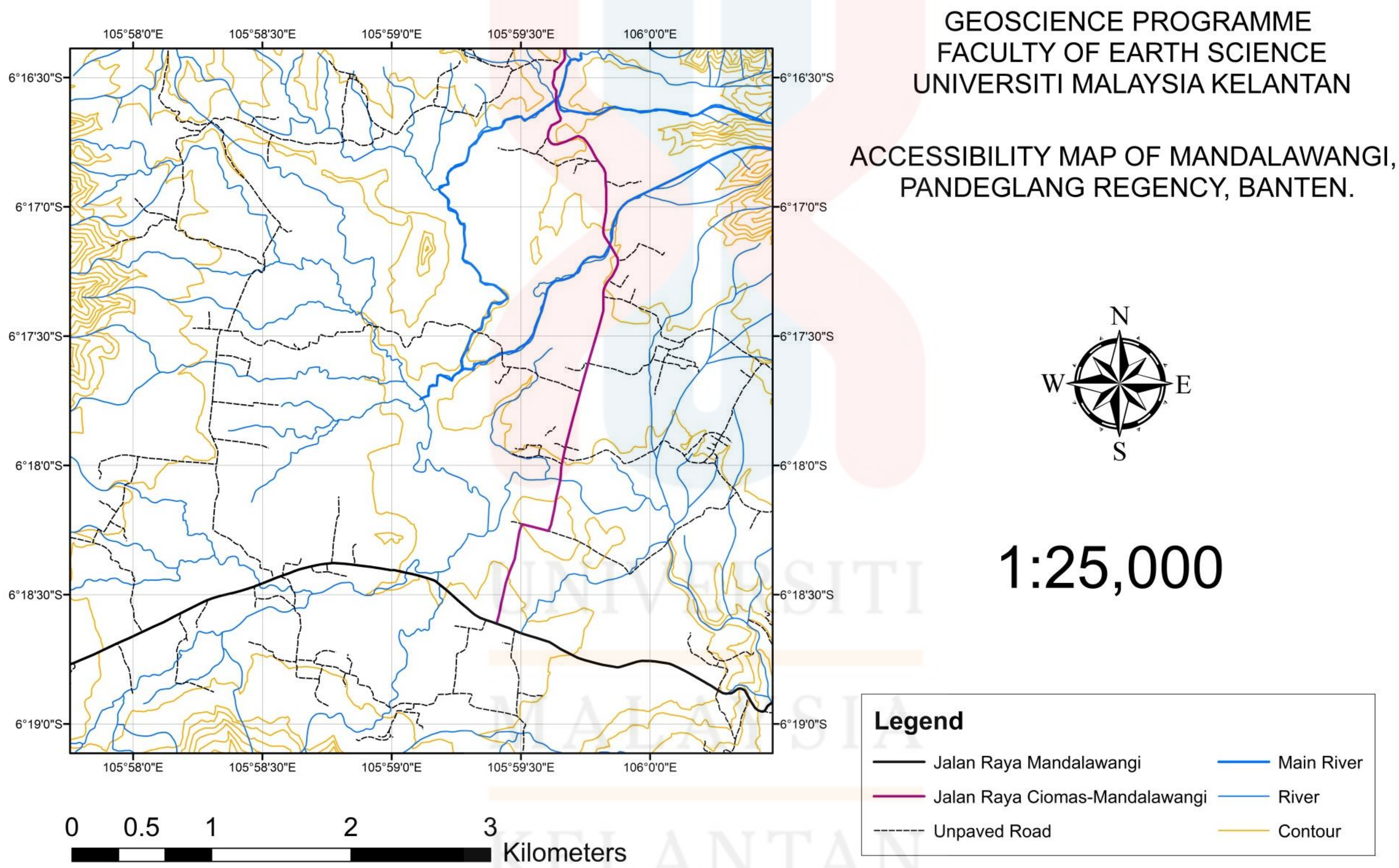


Figure 1.3: The accessibility map of Mandalawangi.

1.2.3 Demography

Indonesia is made up of over than 17,000 islands with more than 1.9 million square kilometers of land. This makes Indonesia become the fourth largest country in the world. The human population at Indonesia has estimated to be about 270 million in 2019. About 56.7% population of Indonesia is lives on Java islands which is the most populous island in Indonesia. The population density of Indonesia is about 149 individuals per square kilometers. The median age in Indonesia is 28.8 years. Figure 1.4 shows the population rate in Indonesia between years of 1950 until 2019.

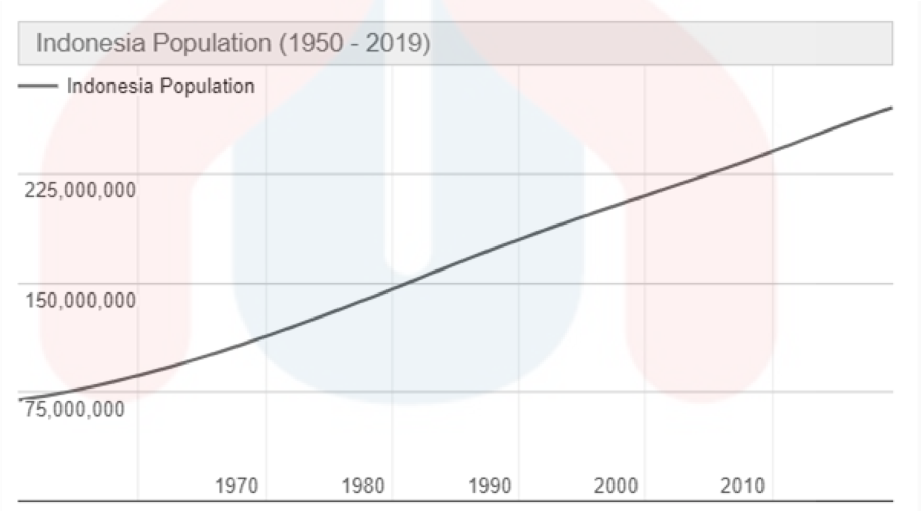


Figure 1.4: Indonesia population rate from 1950 until 2019.

Sources: Indonesia Population. (2019). Published by Worldometers. Retrieved from https://www.worldometers.info/world-population/indonesia-population/

For the population growth rate of Indonesia, Indonesia's population has increased in double number of people within 40 years which are from 119 million of people in 1971 to almost 240 million of people in 2010. Based on Central Statistic Agency, population in Indonesia are expected to increase which much higher amount of people in another 40 years. Figure 1.5 shows the population growth rate in Indonesia.

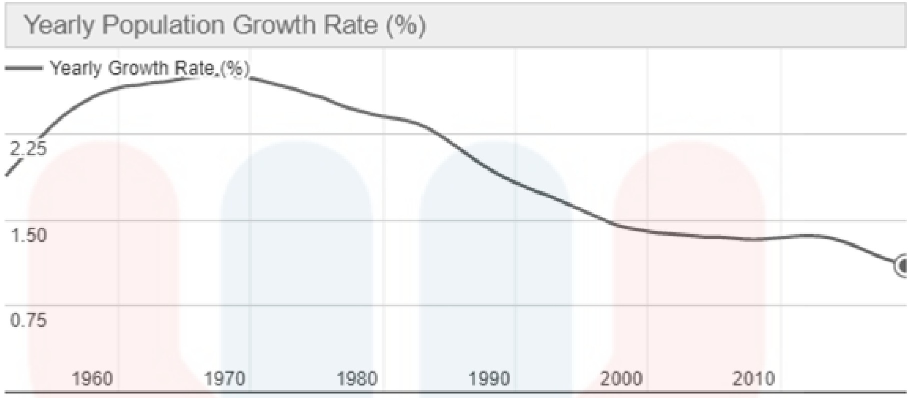


Figure 1.5: Population growth rate in Indonesia.

Sources: Indonesia Population. (2019). Published by Worldometers. Retrieved from https://www.worldometers.info/world-population/indonesia-population/

For the demography of Banten province, in the year 2010, the total of the population is about 10,632,200 people. This was about 4.4% of the total population of people at Indonesia. However, in 2016 the population growth rate was 2.23%. The population growth rate in Banten fell gradually from 3.21% in 2010 to 2.23% in 2016. This is because the expected number of population of people to be in 2016 was about 14,269,391. But, in the year 2015, the total of the population of people in Banten province is approximately about 11, 934,373 people only.

1.2.4 Rainfall Distribution

Precipitation in Indonesia has increase from 239.99 mm in November to 297.99 mm in December 2015. The average of precipitation in Indonesia from 1901 until 2015 is 238.35 mm. the higher precipitation during this period was in January of 1963 with the value of 383.27 mm and the lowest precipitation was in August of 1981 with the value of 74.70 mm. The Figure 1.6 shows the precipitation of Indonesia during 2014 to 2015 and Figure 1.7 shows the estimated precipitation of Indonesia during September of 2019.

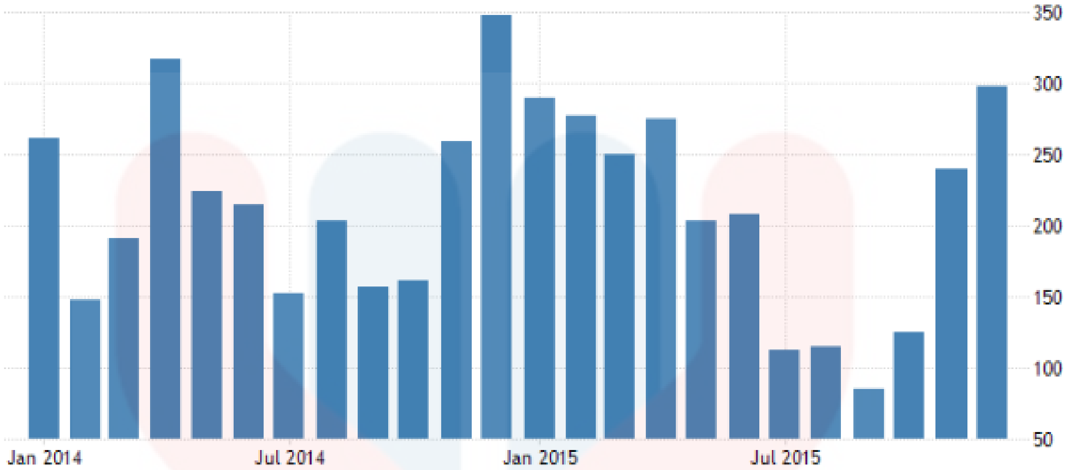


Figure 1.6: Precipitation of Indonesia during 2014 to 2015.

Sources: Indonesia Average Precipitation. Published by Trading Economics. Retrieved from https://tradingeconomics.com/indonesia/precipitation

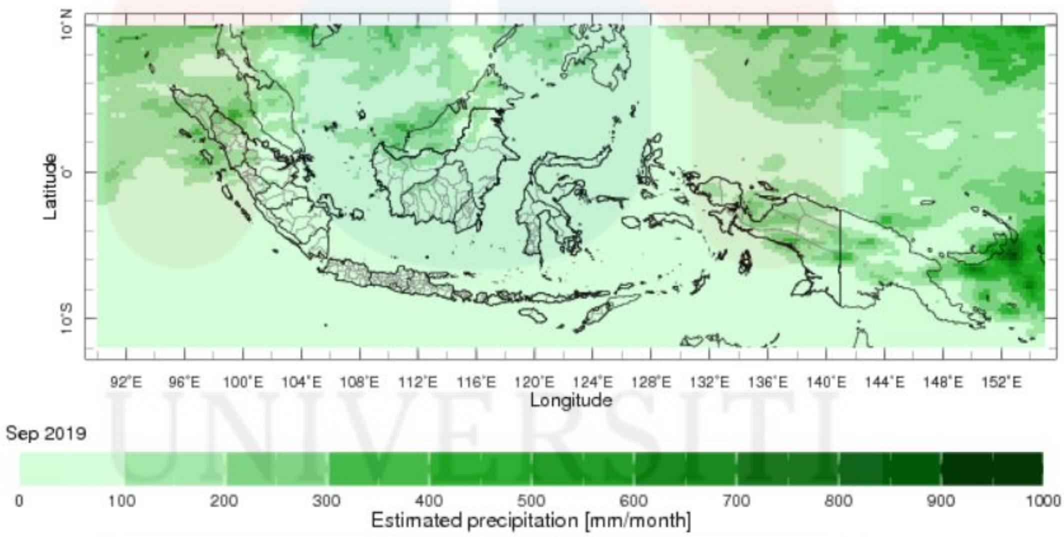


Figure 1.7: Estimated precipitation of Indonesia during September of 2019.

Sources: Published by Indonesia CPT Precipitation Forecast – GPCC. Retrieved from https://iridl.ldeo.columbia.edu/maproom/Agriculture/Forecast/Indonesia_Precip _GPCC.

The study area which is at Banten Province has a climate of tropical and it is a city with a significant rainfall. There is a lot of rain even in the driest month of the year. The average temperature of the study area is 26.0 °C and the precipitation is averages 2622 mm. The warmest month is May with an average temperature of 26.4

°C and the coldest month of the year is January with the average temperature of 25.30 °C. The difference in precipitation between the driest month and the coldest month is 201 mm and the temperature varies by 1.1 °C throughout the year. The Figure 1.8 shows the rainfall distribution of the year of Banten province.

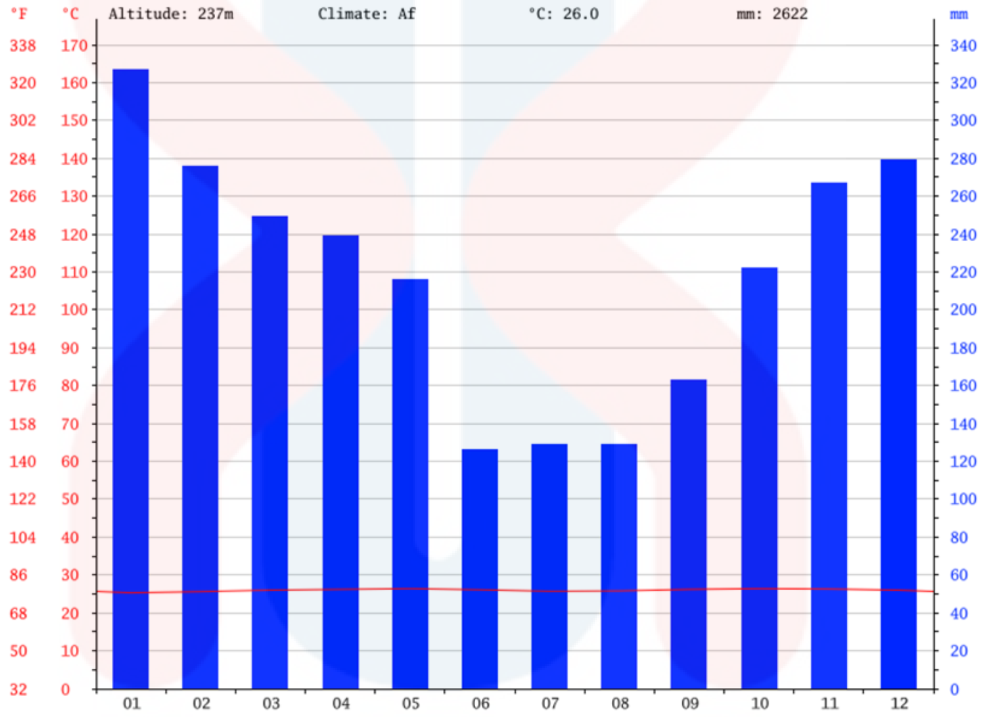


Figure 1.8: Rainfall distribution of Banten Province.

Source: Climate Banten. (n. d.). Retrieved from https://en.climate-data.org/asia/indonesia/banten/banten-621002/#climate-graph.

1.2.5 Land use

Mostly the area of Mandalawangi was covered by plantation such as paddy field, plantation and farm. This is because the area is fully covered by volcanic rock such as tuff and andesite. This kind of rock gives a good effect on the plantation due to its mineral content which is good for plant. Study area also covered by settlement such as residential area. This is because; Mandalawangi is a flat land area and was surrounded by mountain.

1.2.6 Social economic

In the study area, there are many types of socio economic activities that have being done by community which is production of crop farm, horticulture plantation and fishery. Crop farm such as paddy, maize, banana, mango, soy bean, peanut, sweet potato, cabbages, shallot, and chillies has being produced. There is also horticulture plantation which is for medication purpose such as ginger production, galanga production, turmeric production and many more plantations. Horticulture plantation for fruits production and ornamental plant also has being done by community.

1.3 Problem Statement

There are many previous researches that related to the petrographic analysis of the volcanic rock. However, there are few researches of petrographic analysis of volcanic product in the area of Mandalawangi especially by using any geochemistry analysis such as X-ray Fluorescence (XRF), X-ray Diffraction (XRD), or other geochemistry analysis. Particular research in petrology of the volcanic product need to use the analysis of thin section to identify the mineralogy of the volcanic rock and also analysis by using geochemistry analysis such as X-ray Fluorescence (XRF) to determine the elemental composition in volcanic rock or by using other geochemistry analysis to identify the composition of the volcanic product.

The area of Pandeglang and Serang regency consist about six to seven volcano, this is because the area is lies on the caldera. This means that the study area have different volcano product from different eruption. Based on the several previous research studies, the researcher just state that the volcano was erupt on different time. But further analysis on the volcanic product has not been conducted. To study the volcanic product of different eruption, a lot of analysis is need to be done in order to identify the composition of the volcanic product from different volcano and different time of eruption. So, this research is been done to make an analysis of volcanic product by using petrography study to identify the mineralogy of the volcanic product and also by using X-ray Fluorescence (XRF) analysis for determination of the elemental composition of the volcanic product from different volcano. Further analysis of XRF is by using TAS diagram and Harker diagram. This diagram can be used to determine the sources of volcanic product whether it is come from same volcano or different volcano and same or different eruption.

Other than that, previous geological map of the study area were found in scale of 1:100,000 by Santosa, (1991) which means the scale is too small for the map. The information that can be obtained from the map might not be accurate enough. On the other hand, the geological map has not been update for long time, so there must be the changes occur at that area from the side of geology due to the geological event such as earthquake, tsunamis, erosion, weathering, and so on. The latest research that has been done at the study area was at 2011. But the research was done in a large area which means the data was not too detail. Through mapping and observation that has been made for this research, the scale of the map was increase to 1:25,000 and this mapping also has update more detail data of geological information of the study area.

1.4 Objectives

The research on geology and petrographic analysis of volcanic product in Mandalawangi was carried out to achieve the several objectives which are:

1) To update the geological map of Mandalawangi with more detail data of the geological information such as geomorphology, lithology, stratigraphy and structural geology with the scale of 1:25,000.
2) To identify the mineralogy of volcanic rock by using petrographic study/ optical microscope.
3) To determine the elemental composition in volcanic rock by using X-ray Fluorescence (XRF) analysis.

1.5 Scope of Study

This research was focused on the study from the aspect of geology including the lithology, geomorphology, geological structure, mineralogy and petrology, sedimentology, stratigraphy, palaeontology, and depositional environment of the study area to produce the geological map.

The other main focuses on this study is the research specification which is the petrographic analysis of the volcanic product at Mandalawangi. Volcanic product that was study is lava flows that become a solid layer of rock when the lava is freezes. This lava flow was covered the surface part of the study area.

The analysis of the volcanic product has been done by identified the sources of the volcanic product by petrography study of the thin section of the rock sample to identify the mineralogy of the rock and also by using geochemistry analysis which is X-Ray Fluorescence (XRF) analysis in order to recognise the elemental composition in the sample of volcanic rock. X-ray Fluorescence (XRF) analysis is a laboratory-based method that usually be used for bulk chemical bulk analysis of mineral, rock, and fluid samples. Further analysis of XRF is by using Harker diagram and TAS diagram and Peccerillo and Taylor diagram. This diagram can be used to determine the sources of volcanic product whether it is come from same volcano or different volcano and same or different eruption and to determine the magma series. The Harker diagram being used for determining the evolution of the volcanic product and the TAS diagram is the diagram that was used classification of volcanic rock based on its silica content. The Peccerillo and Taylor diagram was used to determine the magmatic series.

1.6 Significant of Study

The petrographic analysis of volcanic product can provide the information about what mineral that was formed and also the determination of elemental composition of the rock can be done. From the determination of elemental composition of the rock, the distribution of the elemental composition in volcanic product at the study area which is Mandalawangi can be identify in order to determine the sources of the rock by using Harker diagram, TAS diagram and Peccerillo and Taylor diagram.

After that, there are a few researches about the petrographic analysis by using any geochemistry method has been conducted in the study area. The study will provide new information about the mineralogy and petrology of the study area. Other than that, this study will also improve public understanding about the volcanic product and how to analysis it and also can be as references for academic knowledge to student.

On the other hand, previous geological map of the study area were found in scale of 1:100,000 by Santosa, (1991). The geological map has not been updated for long time, so there must be geological event occur at that area such as earthquake, tsunamis, erosion, weathering, and so on that has changes the topography of the area. Through mapping and observation that has been made for this research, the scale of the map was increase to 1:25,000 and this mapping also has add more detail data of geological information of the study area.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter included all of the previous studies that related to the study area which is Pandeglang Regency and also the specification of this research which is petrographic analysis of volcanic product. The previous studies and research give a lot of information about general geology of the study area including the regional geology, tectonic setting, petrography, stratigraphy, geomorphology and structural geology and other information that related to the geology of the study area.

2.2 Regional Geology and Tectonic Settings

Indonesia is located between two continental plates which are Eurasian Plate and Australian Plate and two oceanic plates which are Philippine Sea Plate and Pacific Plate. This location makes Indonesia become one of the countries that lies on the Ring of Fire and this is the main reason why Indonesia consists of numerous of volcanic eruptions and earthquakes strikes. The process of subduction of an Indian oceanic plate which occurs beneath the Eurasian continental plate caused the formation of volcanic arc in the western part of Indonesia. Western Indonesia is known as the most seismically active area.

Java Island is one of the islands in Indonesia and it is the part of the volcanic arc which extends about 3,700 kilometers from the northern part of Sumatra Islands to the east of Damar Island in the southern side of Banda Sea through Java (Setijadji et al. 2006; Carlie and Mitchell, 1994; Hamilton, 1979). The formation of this volcanic arc was occurred since Mesozoic from west to east direction and divided into three segments. Formation of the Java segment was took placed at the convergent tectonic margin between the Indian-Australian oceanic plates and the south-east margin of Eurasian continental plate and it is occurred in the early of the Tertiary (Katili, 1975; Hamilton, 1979; Carlie and Mitchell, 1994 and Setijadji et al. 2006).

Banten province are specifically located between 5°7'50" and 7°1'11" south latitude and 105°1'11" and 106°7'12" east longitude (Lumban Batu, U & Poedjoprajitno, S., 2014). The Banten province area is about 9,662.92 km² and located at near the Sunda Strait's strategic sea lanes (Virginia Gorlinski, 2015). The northern part of the studied area is included in to Serang Regency, and the southern part into Pandeglang Regency, both in Banten Province.

2.3 Stratigraphy

The stratigraphy of the Pandeglang Regency is the area is made up of many different types of rock from different formation. The oldest formation is Bojongmanik Formation followed by Cipacar Formation, Bojong Formation, Young Volcanic rocks and the youngest one is Alluvial and Beach sediments (Lumban Batu, U & Poedjoprajitno, S., 2014) as shown in Figure 2.1.

Bojongmanik Formation is the oldest formation at the study area and its lithology is in the form of interlocking sandstone and clay stone, marl, limestone, conglomerate, tuff and lignite. The fossil of foraminifera found in this unit has indicated that the age of the formation is the Late Miocene-Pliocene. Depositional environment of Bojongmanik Formation is land to shallow marine. The thickness of this formation is about 400 m (Sudana and Santosa, 1992).

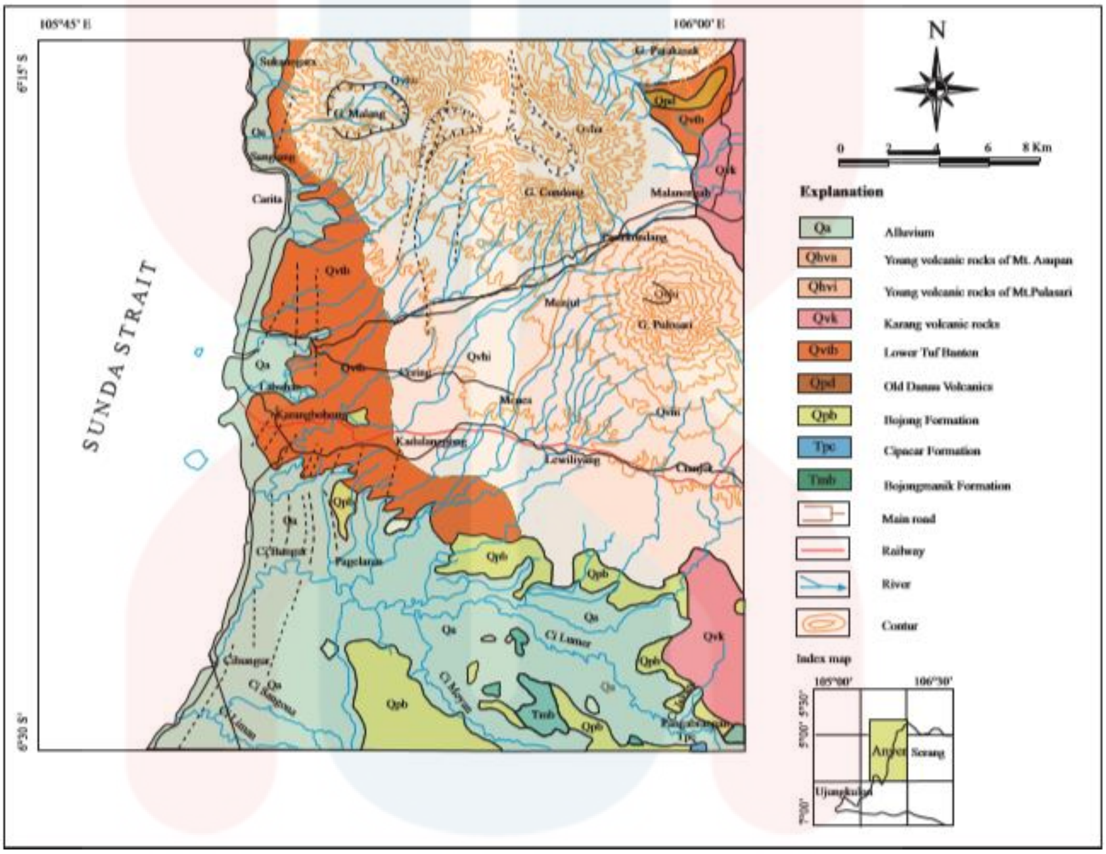


Figure 2.1: Geological map of Labuhan area, Anyer, Banten Province (Santosa, 1991).

Cipacar Formation consists of tuffs, rocky tuffs, tuff sandstones, tuff clay stone, tuff breccia and marl. The fossils of foraminifera that has found in this formation show the relative age of Pliocene which is younger than Bojongmanik Formation. This formation unit is well layered and has the thickness about 250 m and the depositional environment is shallow sea-land (Sudana and Santosa, 1992).

Bojong Formation consists of lithology in the form of coarse sandstones, carbonate clay stone, marl, limestone lens, tuff and peat. This formation has the thickness between 150-200 m and is generally well-layered. It is also overlapped unconformed by younger rock units. The fossils of foraminifera found at this formation indicate the relative age of Pleistocene and its depositional environment is the outer litoral (Sudana and Santosa, 1992).

Young volcanic rock in the Pandeglang Regency was coming from the eruption of Mount Pulosari, Mount Tempo, and Mount Aseupan. These young volcanic rocks were deposited on the continental environment of Holocene age and it is unconformable lies on the older rock unit (Sudana and Santosa, 1992).

Alluvial and Beach sediments are widely distributed in the Pandeglang Regency. Starting from the Sukanagara, Carita, Caringin to Labuhan. The sediment are widespread in the flood plain of the major rivers which is Ciliman, Cilimer and Moyan Rivers.

2.4 Structural Geology

According to Usama Zia (2014), geological structure is referring to the study of three-dimensional distribution of rock units with respect to their deformational histories. Geological structure in the study area is indicated by the lineaments presence. The geological structure of Banten area is consists of rock formation with the thickness level between 200-800 meters and the overall thickness is estimate to be more than 3,500 meters. The identification of structure can be observed well on young volcanic rock of Lower Banten Tuff which consists of tuff breccia, agglomerate, pumice tuff, lapilli tuffs, and sandy tuff. The lineaments that presence in the study area having a north-south direction and it seems that the lineaments are continuously up-through into alluvium (Lumban Batu, U & Poedjoprajitno, S., 2014).

2.5 Geomorphology

Geomorphology is a scientific study of landform and nature of the land surface as a whole and of it is various parts such as mountains and valley, rifts and scraps, lake basins and river channel profiles and pattern that to go make up the landscape. According to (Van Zuidam, 1985), geomorphology can be classified into morphology, morphometry, morphochronology and morphodynamic.

Morphology is the study of the landform or more specifically the surface of the Earth for example, river, mountain and others. Morphometry is the study about dimension and measurement of strike dip of the landform. Morphochronology is the study of age and occurrence of the every landform that was found in the Earth. Morphodynamic is the study of the formation process of the landform that is still active or maybe will active in the future.

For the geomorphology, the study area can be divided into four different units which are Mountain and Volcanic Cone Unit, Slightly Undulating Hilly Unit, Intermontane Plain Unit, and Lowland Unit. For Mountain and Volcanic Cone Unit, it consists of several volcanic cones which have altitude between 600 m and 1040 m above sea level. The morphological of Slightly Undulating Hilly Unit is characterized by series of hills which have elevations between 25 m and 400 m above sea level and the rivers and their channels have a parallel pattern, rather wide valleys with rather step to almost at cliffs (Lumban Batu, U & Poedjoprajitno, S., 2014).

For Intermontane Plain Unit, it consists of various types of young volcanic rocks and has elevations between 500 m to 616 m above sea level. Lowland Unit is formed by a wide plain, and they have elevations between 0 - 25 m above sea level and its morphological unit is made up mainly of alluvium deposits (Lumban Batu, U

& Poedjoprajitno, S., 2014). Figure 2.1 shows the geomorphological unit of the study area.

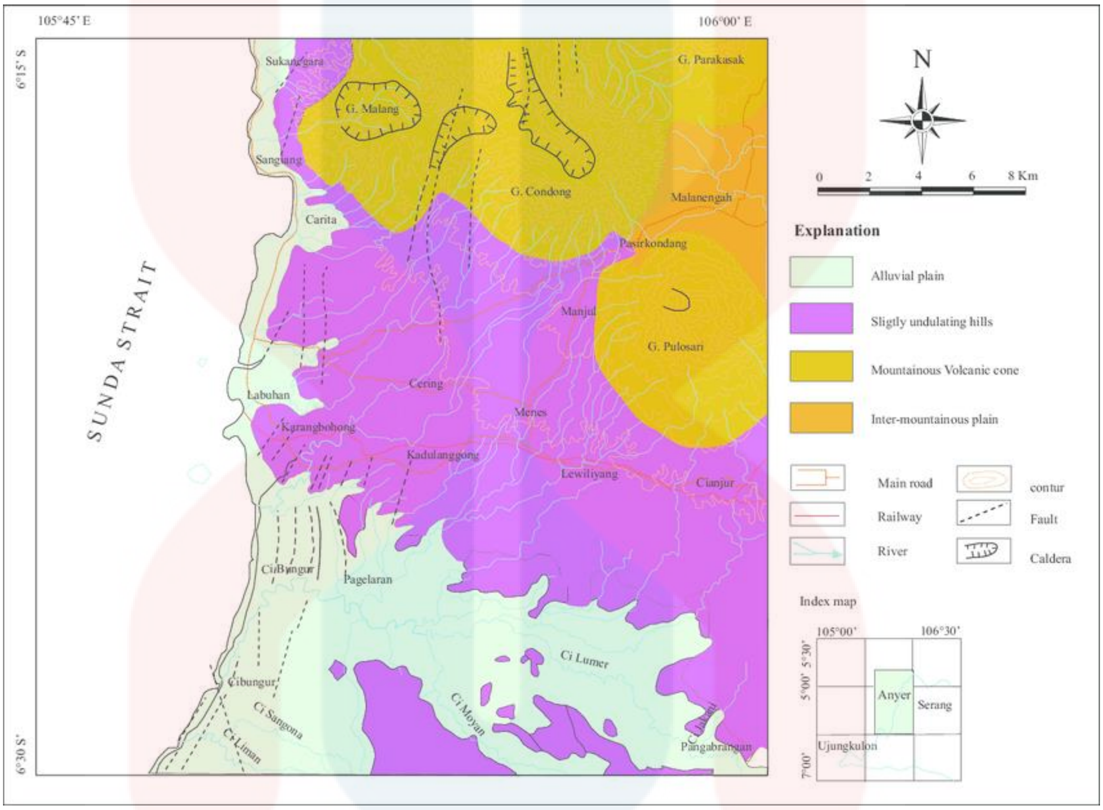


Figure 2.2: Geomorphological unit of the study area.

Sources: Santosa, S., 1991. Geological Map of the Anyer Quadrangle, West Java, scales 1:100.000. Geological Research and Development Centre, Bandung.

2.6 Historical Geology

Tectonic phase was begun during the Miocene until Pliocene together with weak volcanic activity. This process indicated by the uplifting and folding found on the Bojongmanik Formation. The area is then subsided during the Early Pliocene and followed by the deposition process of Cipacar Formation. After that, the second tectonic phase was occurred in the Pliocene to Pleistocene caused an uplifting and folding of Cipacar Formation. This tectonic process was caused the erosion process on the Bojongmanik Formation. This subsided area is then forms a shallow basin and was filled by the Bojong Formation. Thus, the Bojong Formation overlies both Bojongmanik and Cipacar Formations. The sedimentation process of Bojong Formation was occurred by volcanic activity and this formation was composed of sandy clays, sandy marls and tuff that were deposited in the terrestrial to shallow marine environment. The regional tectonic activity was ended after the deposition process of Bojong Formation and continued by volcanic activity.

2.7 Research Specification

The specification of this research is the petrographic analysis of volcanic product by microscopic studies and geochemistry analysis which is X-Ray Fluorescence analysis. X-Ray Fluorescence (XRF) is a method that being used to analyse or to determine the elemental composition that presence in the materials. The analysis materials can be in any form such as powder, liquid, or solid material and only small amount of samples is required to be analyse. This method has a lot of applications especially in the field of industry such as metal, oil, mining, analysis of waste materials and so on.

CHAPTER 3

MATERIALS AND METHODS

3.1 Introduction

This chapter discussed about materials and methods that have been used to complete the research. The method that used in this research can be divided into three different methods which is geological mapping, laboratory investigation and data analysis. Petrographic analysis was used in this research in order to identify the mineralogy of the volcanic rock and also the geochemistry analysis which is X-ray Fluorescence (XRF) has been used in this research in order to determine the elemental composition of the sample. Harker diagram, TAS diagram Peccerillo and Taylor diagram was used for classifying the type of volcanic rock and for the determination of magma sources.

3.2 Materials and Apparatus

There are some materials and apparatus that were used for this research during mapping and for analysing the data. Table 3.1 shows the list of materials and apparatus that was used.

3.2.1 Basic Materials

Table 3.1 List of material and apparatus.

Material	Explanation
Compass	A compass was used to determine the direction and also to locate the location from the North or South. Compass also being used to measure strike and dip of the surface of an outcrop such as bedding plane, foliation and fault plane.
Geological hammer	Geological hammer was used to obtain the sample of rock for laboratory work and also for chipping away weathered rock surfaces. It is also being used as the scale for photograph. A geological hammer has two heads, one on either side. Usually, the hammer consists of a combination of a flat head, with either a chisel or a pick head at the other end.
Sample bag	Sample bags are used to carry sample to laboratory. A suitable bag to insert the geological samples is canvas fabric with sewn in tie tape and a label tag on the outside to insert the sample number and location point.
Hand Lens (x10 magnification)	Hand lens was used to make the first analysis of rock samples in the field before further analysis is performed during the laboratory work. It can be used to determine features like minerals content, grain shape and the micro fossils in a rock.
Garmin Portable Global Positioning System (GPS)	Global Positioning System (GPS) is the satellite based navigation system that composed of three basic parts which are the satellites in space, monitoring stations on earth and the GPS receivers. GPS is used in mapping for finding the position, mapping lithology, measuring the elevation, save sampling point and observation point, tracking geological structures and save the descriptions of the formations when samples are collected.
50 Meter Measuring Tape	Measuring tape was used for taking the actual measurements of lithology and structures and also the dimension of the outcrop instead of pacing method.

Camera	Camera is very important for taking the photo of all interesting geological features ensuring a scale used in each instance. Photograph is important for descriptive purposes during the report writing and also for presentations.
0.1 Mol Hydrochloric Acid (HCl) solution	Hydrochloric Acid (HCl) solution was used to determine the present of calcite mineral in the rock samples. When a rock contain calcite mineral, the rock will produce a fizzed sound due to the result of reaction between HCl and calcite mineral in the rock.
Geological field book	Geological field book was used to record all the data that has been collected during mapping. This including the sketching of the outcrop, and the description of the rock sample and outcrop station. The data in the field book is very important for report writing.
Universal Serial Bus (USB) Cable	Use to connect the Global Positioning System (GPS) to computer for transferring the data that has been record.
Base map of study area	Mapping is normally being carried out at scale of 1:25,000 to 1:5000 for a geological work and it is possible to record the geometric features of folds and fractures.

3.2.2 Specific Instrument and Software:

i. X-ray Fluorescence (XRF)

ii. Polarizing Microscope

iii. ArcGIS

iv. GeoRose

v. Google Earth

vi. Corel Draw

vii. Global Mapper

3.2.3 Thin Section Equipment

i. Slab saw

ii. Trim saw

iii. Grinder

iv. Cut-off saw

v. Lap wheels

3.3 Methods

There are several methods that have been used to complete this research which are preliminary studies, field studies, laboratory work and data processing. Figure 3.2 shows the flow chart of methodology of this research.

3.3.1 Preliminary Studies

Several previous research was studied in order to understand what types of sample to be taken and also the suitable method that will be used in this research for analysis of petrographic and mineralogy. Besides, study the type of rock produce from volcano and also study the type of rock at Pandeglang and Serang regency area from the regional geological map where the area of Mandalawangi lies on. Other than that, the roughly identifying of the geology of the study area such as geomorphology, structural geology and lithology based on the base map of the study area also been done.

3.3.2 Field Studies

The geological map is important to map and to document the structure, lithology, stratigraphy and others that related to geology within the chosen study area. In geological mapping, the main is to study the feature by observing and measuring the geomorphology, lithology, stratigraphy, evidence of weathering, structural indicator and so on. In order to study the geological feature, field observation and data collection must be done during geological mapping.

The several methods that were used during field observation and fieldwork were traversing, following contact to trace contacts between different rock formations, groups and types, and form line map which are an interpretation of the form of geological structure.

Data collections have two main types that are primary data and secondary data. Primary data is a geological mapping and secondary data is referring to journal of previous study, base map, satellite imaging and GIS. This primary and secondary data need to be collect in order to complete the data that will be analysed later. During mapping, rock samples has been collected, the reading of strike and dip has been taken, and mark the sampling and observation point at the field in the Global Positioning System (GPS), and sketching and taking the picture of geological feature has been done at different places of the study area.

3.3.3 Laboratory Work

3.3.3.1 Sample Preparation

i. Petrography analysis

In order to analysis the data and samples that had been collected, thin section is necessary for identifying the type of rocks and mineral contain. This is called as petrographic analysis. Every sample that has been collected during field studies need to be prepared for thin section. There are several steps for making thin section slide of the samples that has been shows in Figure 3.1.

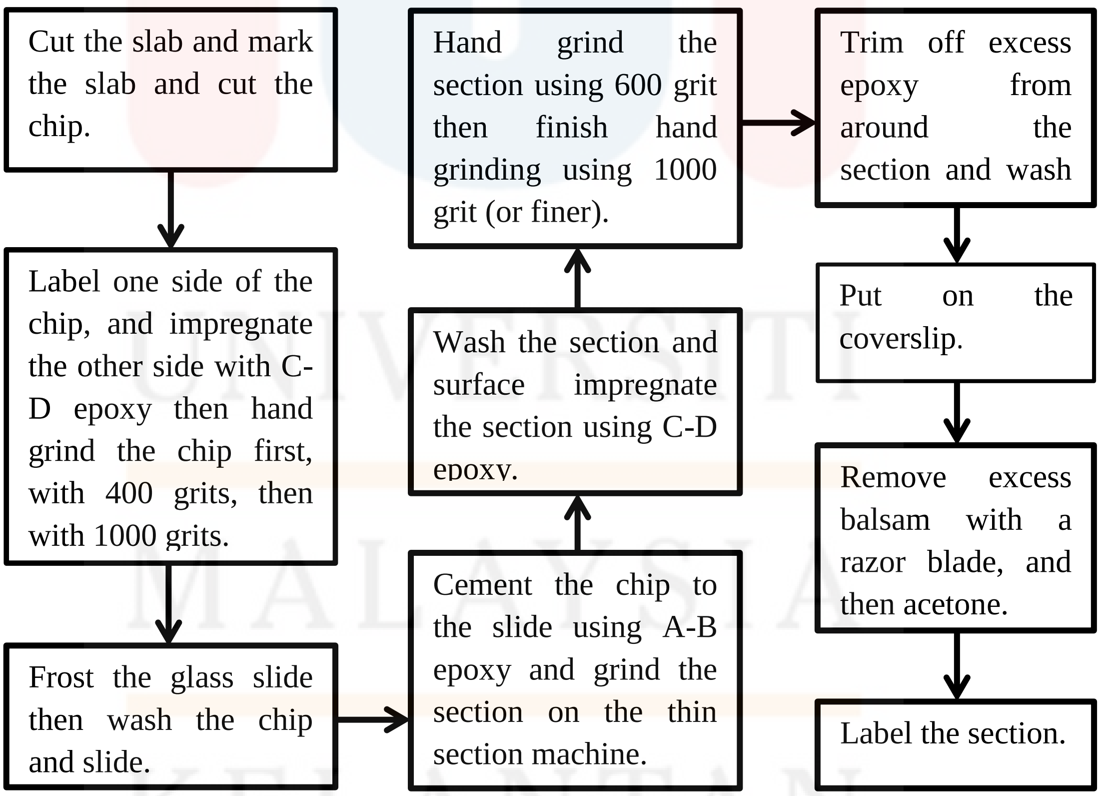


Figure 3.1: Step making thin section.

ii. X-ray-Fluorescence (XRF) analysis

For sample preparation of X-ray Fluorescence (XRF) analysis, the measurements of a sample has to be additionally pulverized, homogenized and pressed into pellet with or without a binder. Usually chromatographic cellulose, boric acid or starch are used as a binder in a proportion 1:10 by weight for minor and trace element analysis. However, major elements can be determined after proper dilution with cellulose or starch in a proportion 1:1 by weight.

When dealing with samples containing heavy elements in a light matrix, the grain size effect can be an additional source of error in XRF analysis. The way of minimizing this effect is reduction of particle size by grinding. However, different particle size reduction occurs in most grinding procedures because the various constituents are reduced in size at different rates due to their differences in hardness, which may result in segregation. In analysis of powdered materials, usually thick or intermediate samples are used. Thin samples are sometimes applied with the use of slurry technique, for very fine powder. This technique works for water insoluble materials. Water slurry is prepared out of a few milligrams of powder and a few millilitres of water.

A method of representative sampling depends on the kind of material to be analysed. For sample of rock that will be analysed by XRF, the sample must be well prepared by following this step:

1) Take the rock sample from the outcrop or sampling point of the study area.
2) Crushing and milling the rock sample until the grain size become about 0.5mm.
3) After that, take about ¼ of the sample and grinding the sample into course powder.

4) The course powder sample is then split into ¼ and the ¼ of the sample is grinding into fine powder.
5) The fine powder sample can be used for analysing under XRF.

3.3.3.2 Petrographic Analysis

The composition of the mineral in the rock can be observed under the microscope by using the thin section slide. This step is called as petrographic analysis. The polarizing microscope was used to observe to the thin section. The thin section was viewed under two different lighting conditions which is plain polarized light (PPL) and crossed polarized light (XPL). The identification of the type of rocks and its minerals contain was done by observing thin section under microscope.

3.3.3.3 Geochemical Analysis

X-ray Fluorescence (XRF) analysis is a laboratory-based method that usually be used for bulk chemical bulk analysis of mineral, rock, fluid samples and rock. XRF analysis has being used to determine the elemental composition of material by measuring the fluorescent X-ray emitted from a sample when it is excited by a primary X-ray source. By using XRF analysis, the percentage of the composition of each element can also being identify.

3.3.4 Data Processing

3.3.4.1 Geology mapping

For geology mapping, all the data of sampling checkpoint and observation checkpoint have been processed in all aspect of geology which is lithology, geomorphology, geological structure, mineralogy and petrology, sedimentology, stratigraphy, palaeontology, depositional environment and others. All the information is then processed by using the ArcGIS software to produce the geological map. And the sample has been analysed by using petrography analysis for the detail of petrology data.

3.3.4.2 Research specification

The identification of the volcanic product has been made by processing the information from the result of petrographic analysis and geochemical analysis to identify the mineralogy and elemental composition in the volcanic rock. The result form the analysis of X-ray Fluorescence (XRF) was further analysis by using Harker diagram and Peccerillo and Taylor diagram for determining the sources of the volcanic product and TAS diagram which is the diagram that was used for classification of volcanic rock based on its silica content.

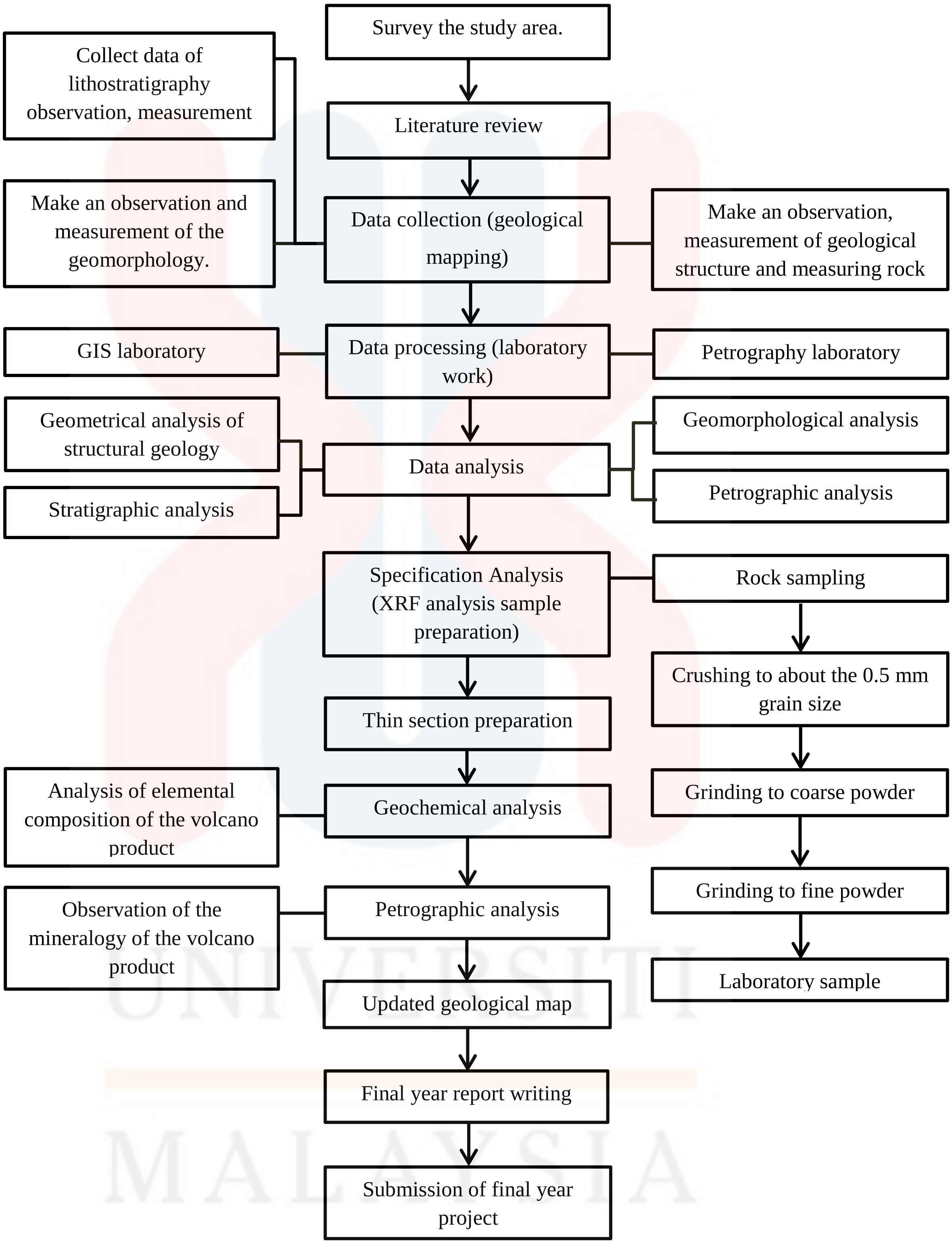


Figure 3.2: Flow chart of methodology

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

In this chapter, the geology of the study area which is Mandalawangi that are located at regency of Pandeglang, Banten, Indonesia has been discussed. The discussion includes the geomorphology, stratigraphy, petrography, structural geology, and historical geology of the study area. The study area is 5x5 km square and the geological map that has been produced was in scale of 1:25 000.

The finding data from the geological mapping has been analysed and geological map has been produced. The geological map is consists all of the geological features of the study area. In geological map, rock units are shown by using colour or can also be shown by symbols. This colour and symbol is being used to illustrate what type of rock and where they are exposed at the surface of the study area. Structural features such as folds, joints, faults, foliation, bedding and others are also shown in geological mapping. The observation location that are indicated with the symbols of strike and dip or trend and plunge that make the structural features become three-dimensional orientation are also illustrated in the geological map. However, if the study area was covered by volcanic rock such as basalt or andesite, there is no structural features can be found.

Study area which is Mandalawangi is surrounded by four different volcanoes which are Mount Aseupan, Mount Karang, Mount Parakasak and Mount Pulosari. Thus, there is no such structural features has been found.

4.1.1 Accessibility

Accessibility is a road which provides an access to a specific location or destination for example, an access to a main highway or to a place that lies within another town. Mandalawangi consist of two main roads which are Jalan Raya Mandalawangi and Jalan Raya Ciomas-Mandalawangi. This main road has been used as a connection to the nearest town such as Pandeglang town and to other regency such as Serang regency. About 40% accessibility road in Mandalawangi is an unpaved road. Most of the unpaved road is used by community as a connection from town to the residential area and also to their farm and other plantation such as paddy field, rubber plantation and many more. Figure 4.1 shows an accessibility map of Mandalawangi.

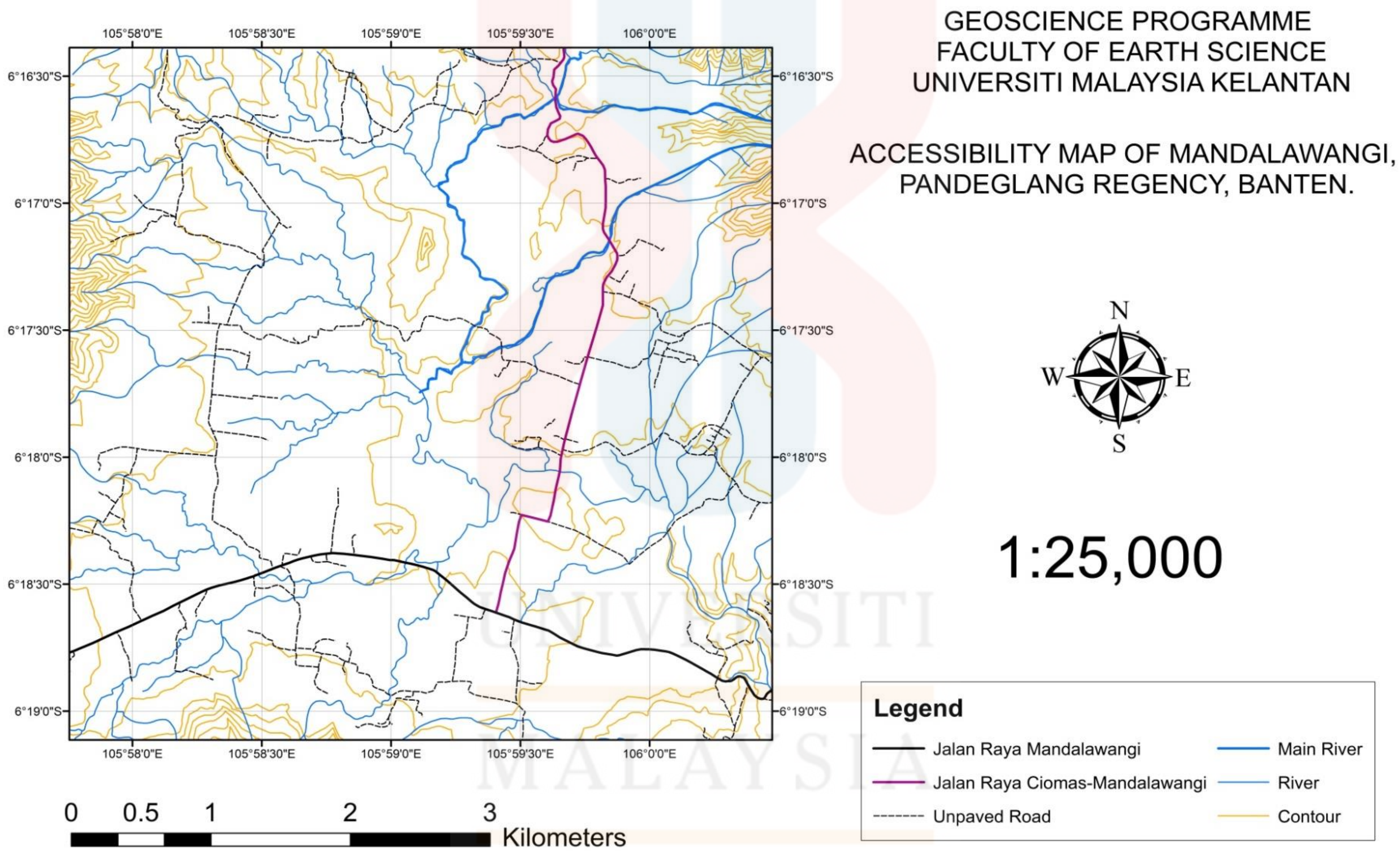


Figure 4.1: Accessibility map of Mandalawangi.

4.1.2 Settlement

Settlement is a location or a place where people live including the people who live there, the buildings, the roads, the streets and pathways that link up the building in the settlement. It can be anything which is from an isolated farmhouse to a mega city. Settlement can either be permanent settlement or temporary settlement based on number of population over time. Example of temporary settlement is a thing such as refugee camps. Some of the temporary settlement will become a permanent settlement over time. Settlement can primarily be classified according to their pattern, size and housing density.

Classification of settlement based on the size and housing density can be classified into two major categories which are rural and urban settlement. Rural settlements are small in size and have low housing and population densities while for the urban settlement, it is the larger in size and have many houses built close together. Settlement can also be categorised on the settlement hierarchy. The settlement hierarchy in Figure 4.2 shows that the size of the settlement increasing as well as the number of population. Pandeglang regency has more than one million residents and its means that this area is in the top level of the settlement hierarchy which is conurbation. Conurbation is formed when two or more towns or parts have grown and joined together to form a large urban area of 1 million residents.

For the Mandalawangi, its population is less than one hundred thousand of residents. So, it means that the area of Mandalawangi is in the fourth level of settlement hierarchy which is town. Town are the urban settlements that have more than two thousands of residents. Houses are built together and usually a town has many facilities. The number of population is increasing every year which means the hierarchy of settlement of every area will be increase over time.

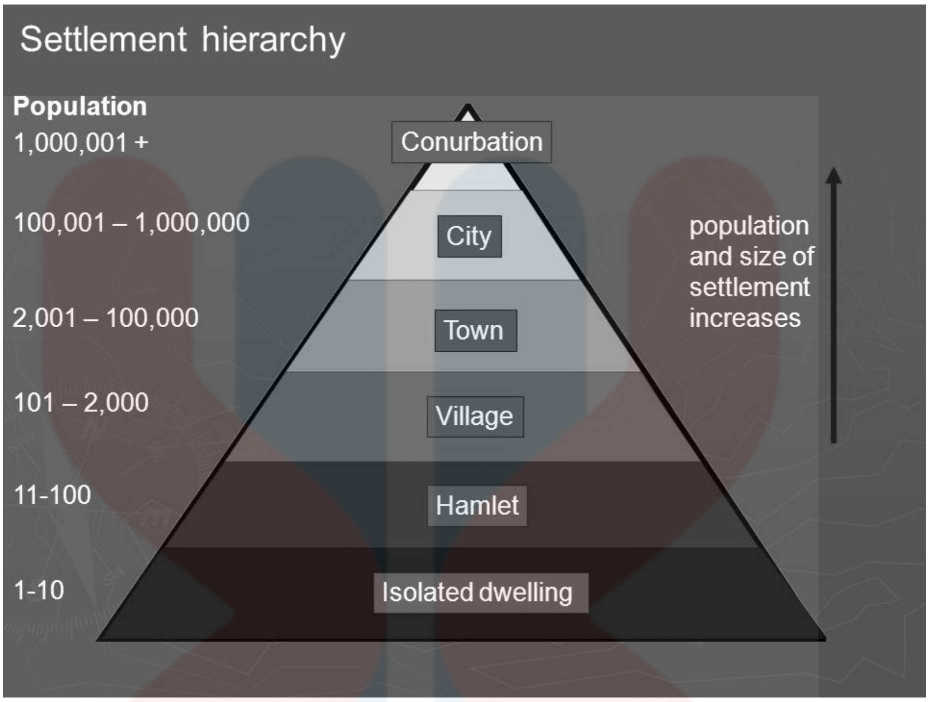


Figure 4.2: Settlement hierarchy.

The pattern of settlement is refers to the shape or distribution of a settlement. This pattern is usually influenced by its surrounding landscape. There are 4 types of settlement pattern which are dispersed or scattered pattern, nucleated pattern, linear pattern and radial pattern. Types of settlement pattern in the study area are nucleated and linear pattern. For nucleated settlement, the buildings are clustered and linked by roads. Linear settlement is the settlement where the buildings are constructed in line which is following a line of movement, such as a road, river, coastline and others. Figure 4.3 shows the pattern of settlement. Figure 4.4 shows the map of settlement of the study area.

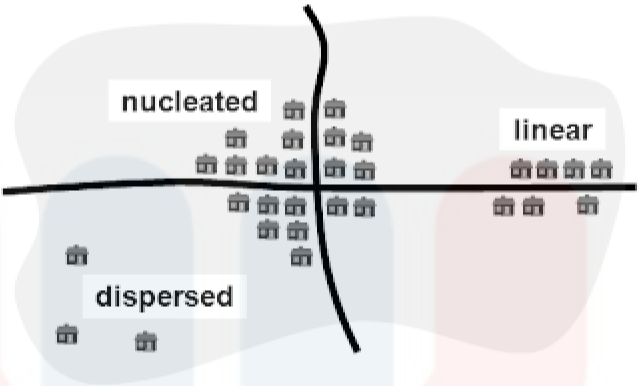


Figure 4.3: Pattern of settlement.

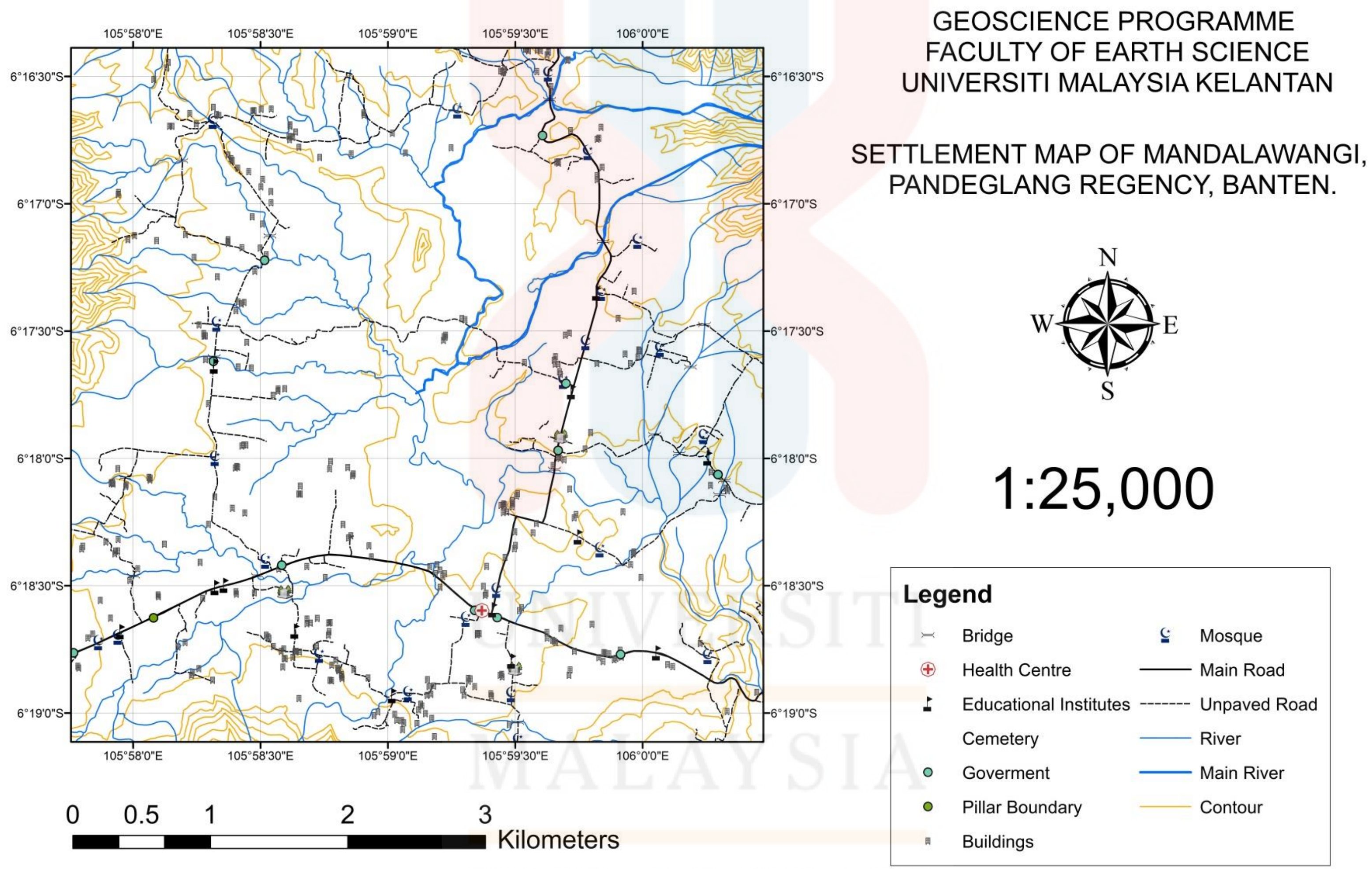


Figure 4.4: Settlement map of Mandalawangi.

4.1.3 Forestry

Forestry or vegetation can be defined as an assemblage of plant species and the ground cover they provide. In the study area, there are six types of vegetation which are weeds, paddy, bushes, plantation, dry forest, and farm. The area mostly covered by paddy, dry forest and farm as shown in Figure 4.5 and Figure 4.6. This is because the area is fully covered by volcanic rock such as tuff and andesite. This kind of rock gives a good effect on the plantation due to its mineral content which is good for plant. Figure 4.7 shows the vegetation in the study area.

Figure 4.5: Paddy field.

Figure 4.6: Farm area.

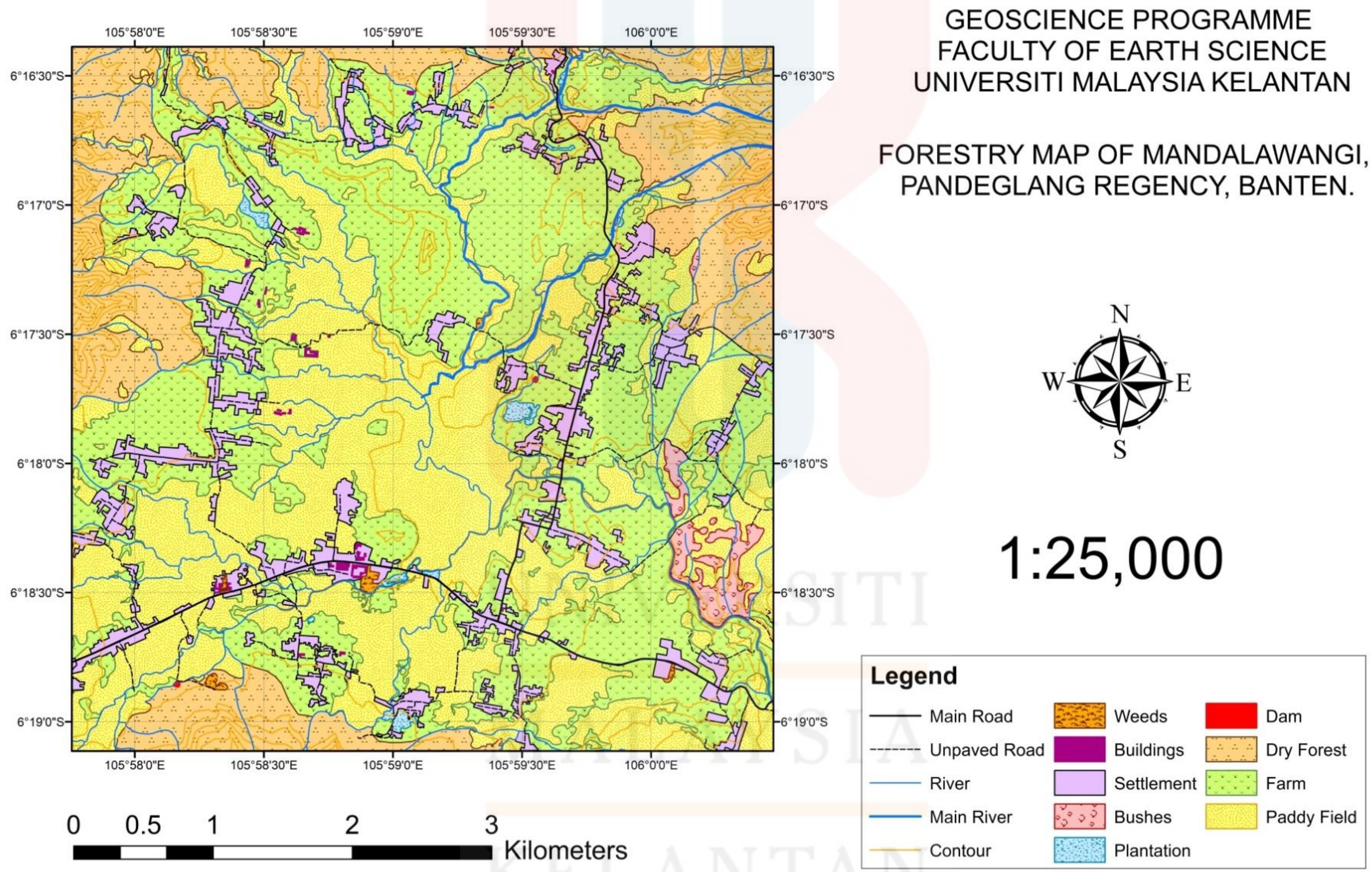


Figure 4.7: Forestry map of Mandalawangi.

4.1.4 Traverses and Observations

Figure 4.8 and Figure 4.9 showed the traverse map and the observation map. In the observation map, it shows the observation and sampling station that was done during mapping. There are 13 sampling station and about 40 observation station. The distribution of the sampling point was based on the lithology distribution in the study area. At sampling station, the rock sample was taken to be observed in the laboratory and at the observation station, only the data of the outcrop is taken without any sample. Along the traverse, the outcrops mostly are volcanic rock and it was covered by vegetation. The outcrop stations are mostly found in the paddy field and farm. This is because; there is about 70% the area of Mandalawangi was covered by paddy field and farm.

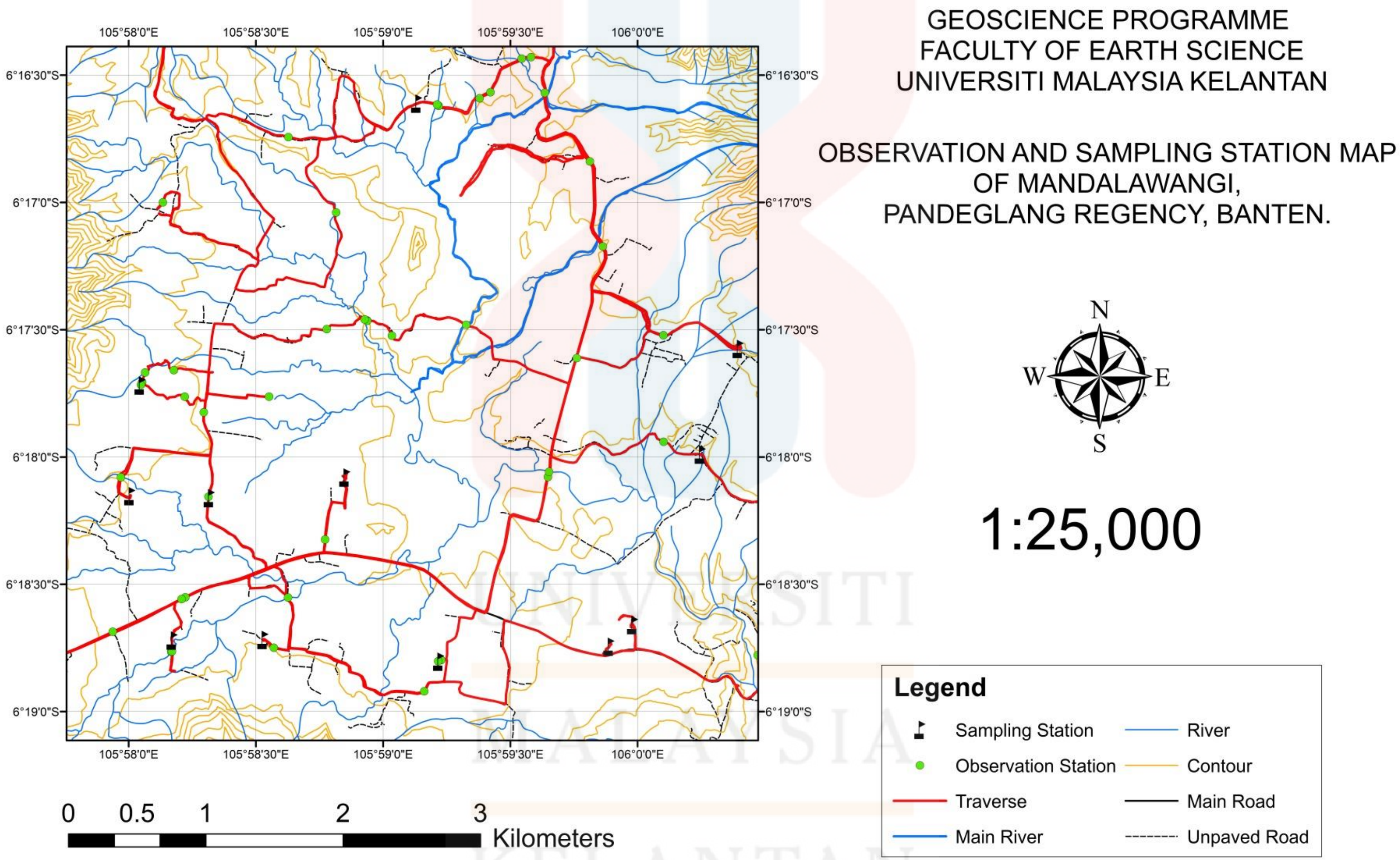


Figure 4.8: Observation map of Mandalawangi

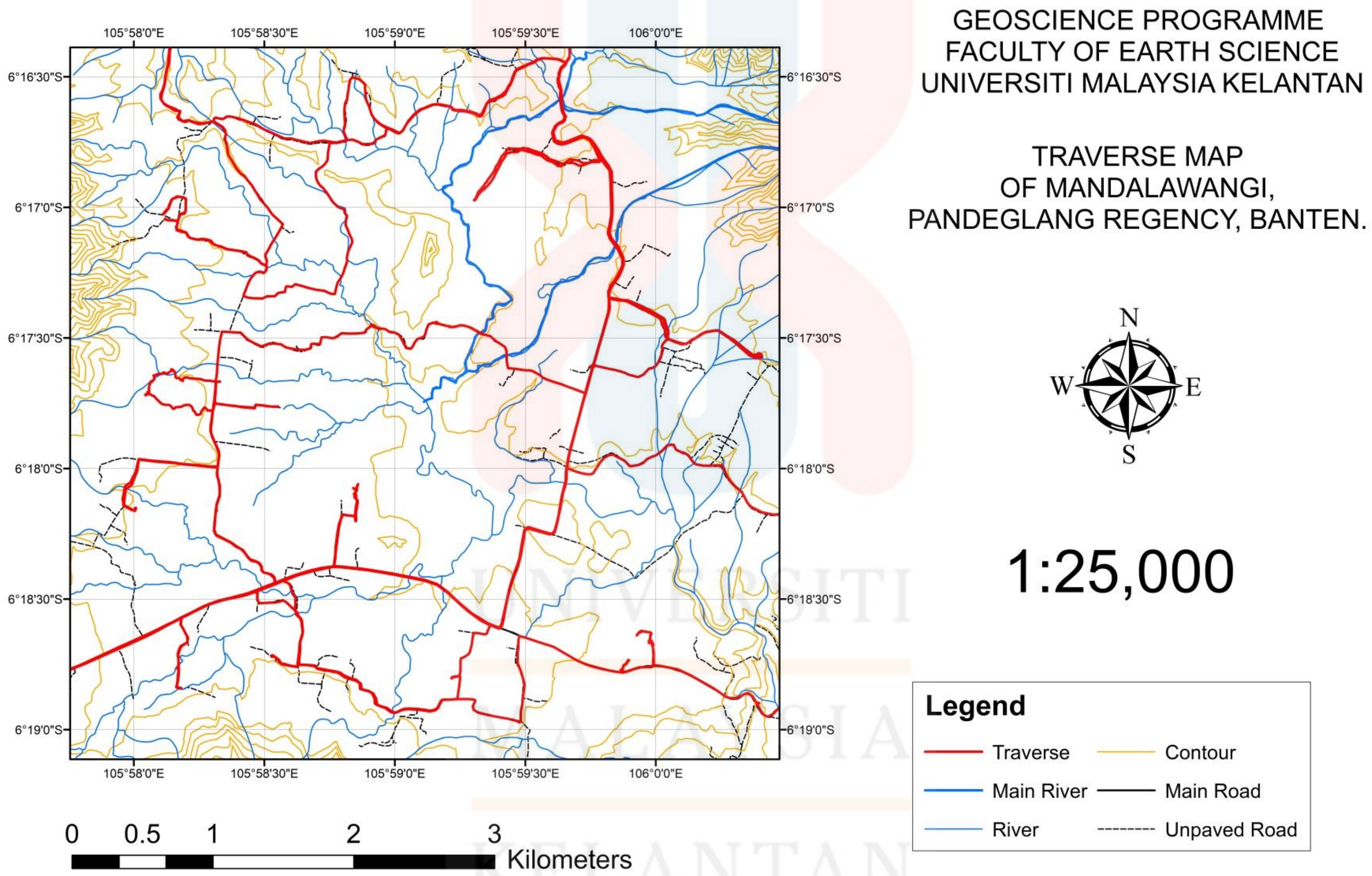


Figure 4.9: Traverse map of Mandalawangi.

4.2 Geomorphology

Geomorphology is the study of landforms including their processes, form, and sediment at the surface of the Earth. Landforms are form from the process of erosion and deposition, as rock or sediment is breaking down, it is then being transported and deposited to other places. Different climatic environment will formed the different type of landform. Geomorphology process are mostly occur in slow rate, however, if there is a large event such as flood, landslide, tsunamis, earthquake and volcanic eruptions is occur, it may cause the rapid change to the environment. In the study area, type of landform that can be found is steep mountains unit and hilly to steep unit as shown in Figure 4.10. Figure 4.11 show the geomorphology map of the Mandalawangi. The range elevations of the study area are about 300 to 600 meters.

Figure 4.10: Mountainous and hilly landform.

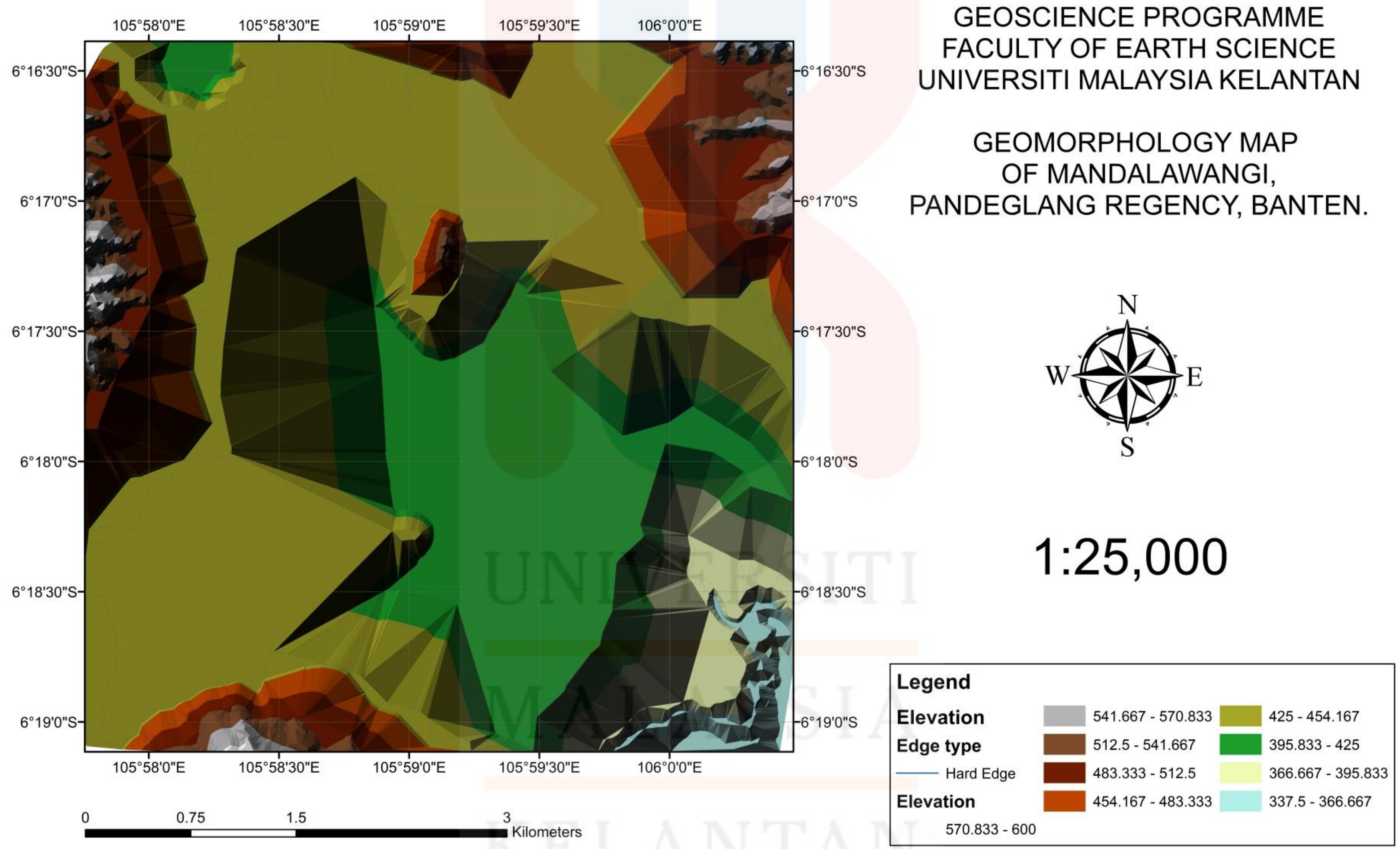


Figure 4.11 Geomorphology map of Mandalawangi.

4.2.1 Geomorphological Classification

The geomorphological classification was determined using classification of geomorphology by Van Zuidam (1985). Several aspects of geomorphology that must be considered which are:

i) Morphology is the aspect that studies the relief in general.

- Morphology – the features that cover the surface of the earth such as hill, ridge, valley, mountains, plains and alluvial fan.
- Morphometry – aspects that measure quantitatively from particular landform such as slope, slope shape, relief, rate of erosion, elevation and drainage pattern.
- Morphography – can be classified as the geomorphological extents area.

ii) Morphogenesis is the aspect the aspect that focused on the morphology process which is the process that controlled the developments and formations of the landforms. Morphogenesis is related to the structural geology, geological processes and lithology.

- Active Morphostructure – is come from the endogenetic process which is related to the uplifting, folding and faulting.
- Passive Morphostructure – the landform that classify based on rock structure and lithology.
- Morphodynamic – formed from exogenetic process which relate to the forces from glacier, water, volcanism and climate.

Table 4.1 Relation between absolute elevations with morphography.

Absolute Elevation	Morphography
<50 meter	Lowland
50 meter – 100 meter	Medium lowland
100 meter – 200 meter	Low hill
200 meter – 500 meter	Medium hill
500 meter – 1500 meter	High hill
1500 meter – 3000 meter	Mountain
>3000 meter	High mountain

(Source: Van Zuidam, 1985)

Table 4.2 Relation between relief unit, slope and topographic differences.

Relief Unit	Slope (%)	Topographic differences (m)
Flat – almost flat	0 - 2	< 5
Undulating / gentle slope	2 -7	5 – 50
Undulating – rolling / sloping	7 - 15	25 - 75
Rolling-hilly / moderately steep	15 - 30	75 - 200
Hilly – steeply dissected / steep	30 - 70	200 - 500
Steep mountains	70 -140	500 -1000
Very steep mountains	>140	>1000

(Source: Van Zuidam, 1985)

Table 4.3 Geomorphologic classification according to Van Zuidam (1985).

Code	Geomorphology Unit
S	Structural
V	Volcanic
D	Denudational
M	Marine/beach
F	Fluvial
G	Glacial
K	Karst
A	Aeolian

(Source: Van Zuidam, 1985)

In the study area, the elevation is around 300 meters to 600 meters which is medium hill to high hill according to the geomorphology classification by Van Zuidam (1985). Morphology in the study area is related to the volcanism as it is located in the surface of caldera. The study area had been surrounded by volcano. Volcanism is the morphology that has interaction between exogenetic and endogenetic processes that formed an irregular and distinctive morphology. Volcano morphology does not only depend on the eruption products and types, but it is also controlled by its activity rate, structural and erosion factors that had been applied upon it.

Based on the geomorphological observations at the field and also the correlation to the topography of the study area, the geomorphological classification had been interpret by using the geomorphological classification according to Van Zuidam (1985). The relief unit in the study area are hilly to steep unit with the topographic differences of 300 to 500 meters and the steep mountains unit with the topographic differences of 500 to 1000 meters.

4.2.2 Drainage Pattern

Drainage pattern is a pattern that was created by erosion of streams, rivers and lakes over times. Its reveals the characteristics of the rocks whether particular region is dominated by hard rock or soft rock and also the characteristic of geological structures of the particular area. Drainage pattern are controlled by the topography and gradient of the land. There are eight main types of drainage pattern which are dendritic pattern, trellis drainage, rectangular drainage, parallel drainage, radial drainage, centripetal drainage, deranged drainage and angular drainage. There are two types of drainage pattern that was identified in the study area which are dendritic drainage pattern and rectangular drainage pattern.

Dendritic drainage pattern is the most common drainage pattern and it is formed in the area that consist of rock that cannot easily been eroded in all directions. It also formed in the area that underlain by homogenous material which is the subsurface geology has the same the level of resistance towards weathering and erosion. So, there is no any apparent control over the direction that the stream takes. The streams are joining the larger stream at degree of less than 90 or also called as acute angle. Examples of rock that can be found in the area that consist of dendritic pattern are volcanic rock, gneiss, granite and sedimentary rock that has not been folded. In the study area, dendritic drainage pattern has been found as shown in the Figure 4.12. This is because; most of the study area is composed of the same type of lithology unit which is andesite except for the north part of the area that was covered by tuff unit.

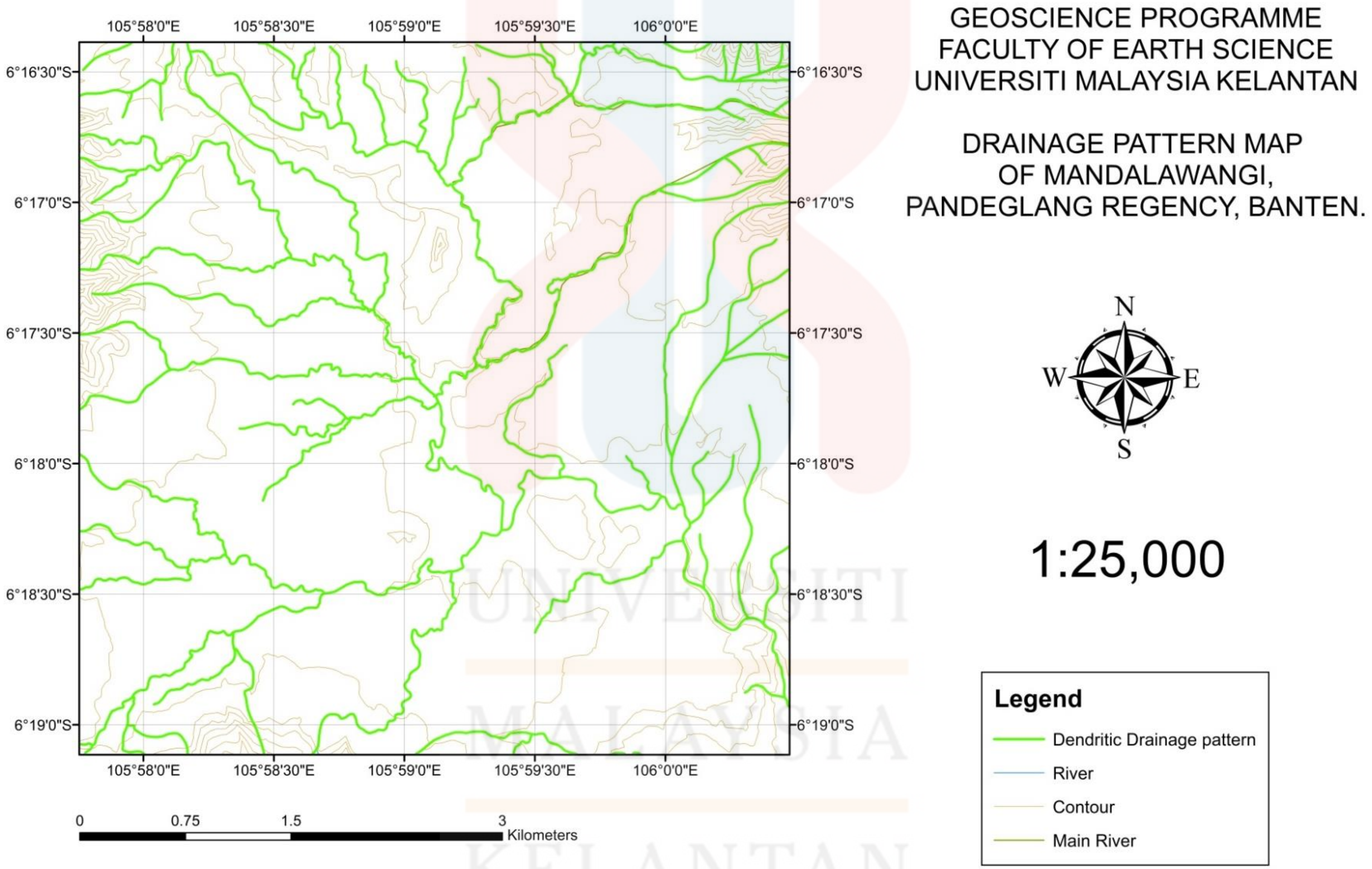


Figure 4.12 Drainage pattern map of Mandalawangi.

4.2.3 Weathering

Weathering is process of breaking down rocks, minerals, soils, wood and artificial material due to the exposure to the atmosphere, water and biological organisms of the Earth for long time. Weathering process is occurring in the same place with little or no any movement. This process is different with erosion process because erosion process involves the movement of the rocks and minerals by many types of agent such as gravity, water, snow, ice, wind, and waves. This agent will transported and deposited the material to other places. The effect of weathering towards the rock can be classified into six different grade of weathering which is fresh, fairly weathered, slightly weathered, moderately weathered, highly weathered, completely weathered and residual soil. A brief description on weathering grade classification by Paul (2006) is shown in Table 4.4.

Physical weathering or also called as mechanical weathering or disaggregation, is the process of weathering that cause rock to break down without any chemical change. These types of weathering occur due to the factor of temperature, pressure, frost and others. These factors will repeat the process of melting and freezing of water or expanding and shrinking of surface layer of rocks that was baked by the sun. This repeated process will later form crack on the rock. Crack that was produce from the result of this process cause the surface area of the rock to increase. When the rock has high surface area, it will have high tendency to become more exposure to the chemical action which later will increase the rate of disintegration. This type of weathering can be found in the study area. Figure 4.13 shows the physical weathering at the study area.

Chemical weathering is a weathering process that caused by chemical reactions either by water or any other substances that dissolved in the rock. Chemical weathering is different with physical weathering because it changes the composition of the rock and this type of weathering often transforming them into different chemical reaction when there is an interaction of water with the mineral. The mineral composition in the rock will form a new or secondary mineral as the result of this weathering. Chemical weathering is occurring by the help of geological agents such as oxygen and water and also by biological agents like microbial and plant-root metabolism acids. There are several types of chemical weathering which are solution, hydrolysis and oxidation. Solution is the types of chemical weathering in which the rock was remove by acidic rainwater solution. For hydrolysis, acidic water breakdown the rock and produce clay and soluble salts. Oxidation is the process of rock breaking down by oxygen and water and often cause the rock to rusty and the coloured of the weathered surface become reddish brown due to the iron rich. This type of weathering can be found in the study area and literally can be found in the stream. This is because the rock has been weathered due to the water in the stream. Figure 4.14 shows the rock that has been weathered by chemical reaction in the study area.

Biological weathering is the process weakening and subsequent of rock by plant, animals and microbes in the rock. The weathering process that was cause by plant occur when the growing root of the plant put stress and pressure to the rock and caused the rock to breakdown. Microbial activity can also breaking down the rock which is by altering the chemical composition of the rock causing the rock to become more sensitive and weak. Animal is the one of the agent that can cause the weathering process to occur. This is because, the burrowing animals can move the fragment of the rock to the surface which later causing the rock to expose to more intense chemical, physical and biological weathering process. Biological weathering is the most type of weathering that was found at the study area. This is because; the area of Mandalawangi was highly covered with vegetation. Figure 4.15 shows the outcrop station that was undergoes a biological weathering.

Figure 4.13: Outcrop that was undergoes physical weathering.

Figure 4.14: Outcrop that was undergoes chemical weathering.

Figure 4.15: Outcrop that was undergoes biological weathering.

Table 4.4 Weathering grade classification.

Term	Description	Grade
Fresh	No visible sign of material weathering.	IA
Fairly weathered	Discolouration on major discontinuity surface.	IB
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity of surfaces. All the rock material may be discoloured by weathering and may be somewhat weaker than its fresh condition.	II
Moderately weathered	Less than half of the rock material is decomposed and disintegrates to soil. Fresh or discoloured rock is present either as a continuous frame work or as core stones.	III
Highly weathered	More than half of the rock material is decomposed and disintegrated to soil. Fresh or discoloured rock is present either as a continuous frame work or as core stones.	IV
Completely weathered	All rock material is decomposed and disintegrated to soil. The original mass structure is largely intact.	V
Residual soil	All rock material is converted to soil. The VI mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

(Source: Paul, 2006)

4.3 Lithostratigraphy

The study area which is Mandalawangi consists of two types of lithology unit which are Tuff unit and Andesite unit. The Tuff unit covered the northern part of the study area and the Andesite unit covered the others part. The Andesite unit has been separated into three parts because it is coming from the different volcano eruption which is Mount Aseupan, Mount Pulosari and Mount Karang. The stratigraphy column of the lithology of study area has been made based on Santosa S., 1991.

Stratigraphy Column

EON	ERA	PERIOD	EPOCH	LITHOLOGY	LITHOLOGY UNIT	DESCRIPTION
Phanerozoic	Cenozoic	Quarternary	Pleistocene to Holocene	QHVA	Andesite	QHVA = Young volcanic rocks of Mount Aseupan. Colour of the rock is dark to light grey. Fine grain texture.
			Pleistocene to Holocene	QHVI	Andesite	QHVI = Young volcanic rocks of Mount Pulosari. Colour of the rock is greyish. Coarse grain texture. Grain size of the rock is bigger than the Karang volcanic rocks.
			Pleistocene to Holocene	QVK	Andesite	QVK = Karang volcanic rocks. Colour of the rock is light grey. Coarse grain texture. Grain size of the rock is smaller than. Young volcanic rocks of Mount Pulosari.
			Pleistocene to Holocene	QVTB	Tuff	QVTB = Upper Tuff Banten. Rock is highly weathered. Consist of red clayed tuff intercalation.

(Source: Santosa S., 1991

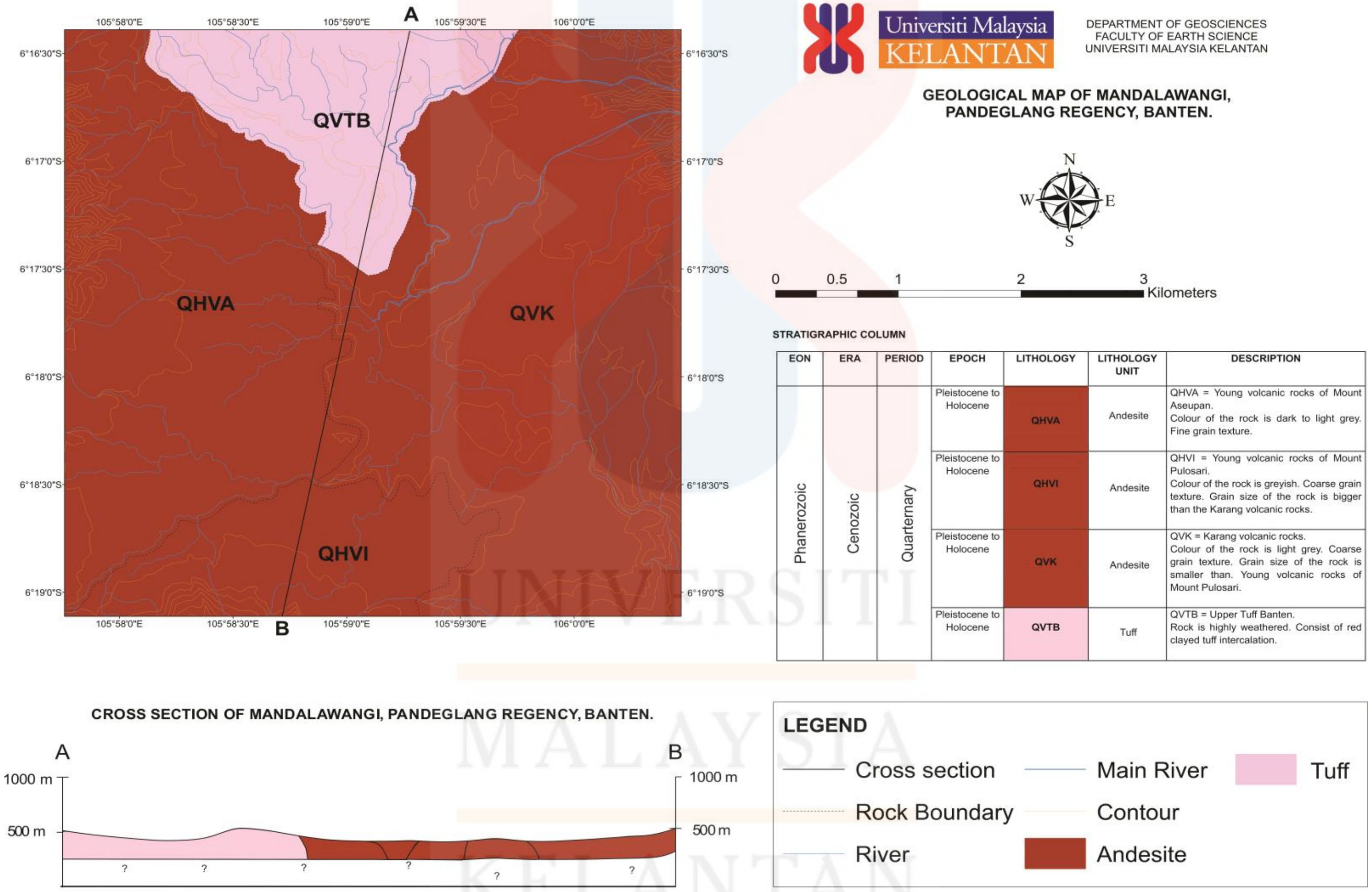
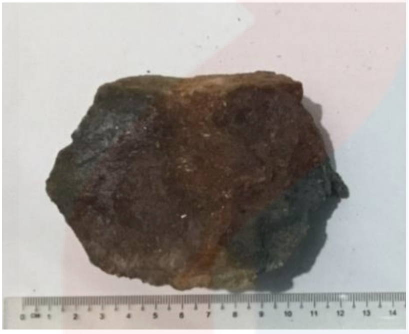


Figure 4.16 Geology map of Mandalawangi

4.3.1 Unit Explanation

4.3.1.1 Young volcanic rocks of Mount Aseupan (QHVA)

i) Lithology Characteristics

SAMPLE	CHARACTERISTICS
OCK 6 	Rock: Andesite Sampling location: Paddy field Texture: Porphyritic Grain size: Fine grain Colour: Dark grey Weathering stage: Slightly weathered
OCK 9 	Rock: Andesite Sampling location: Paddy field Texture: Porphyritic Grain size: Fine grain Colour: Dark grey Weathering stage: Slightly weathered
OCK 10 	Rock: Andesite Sampling location: Paddy field Texture: Porphyritic Grain size: Fine grain Colour: Light grey Weathering stage: Slightly weathered

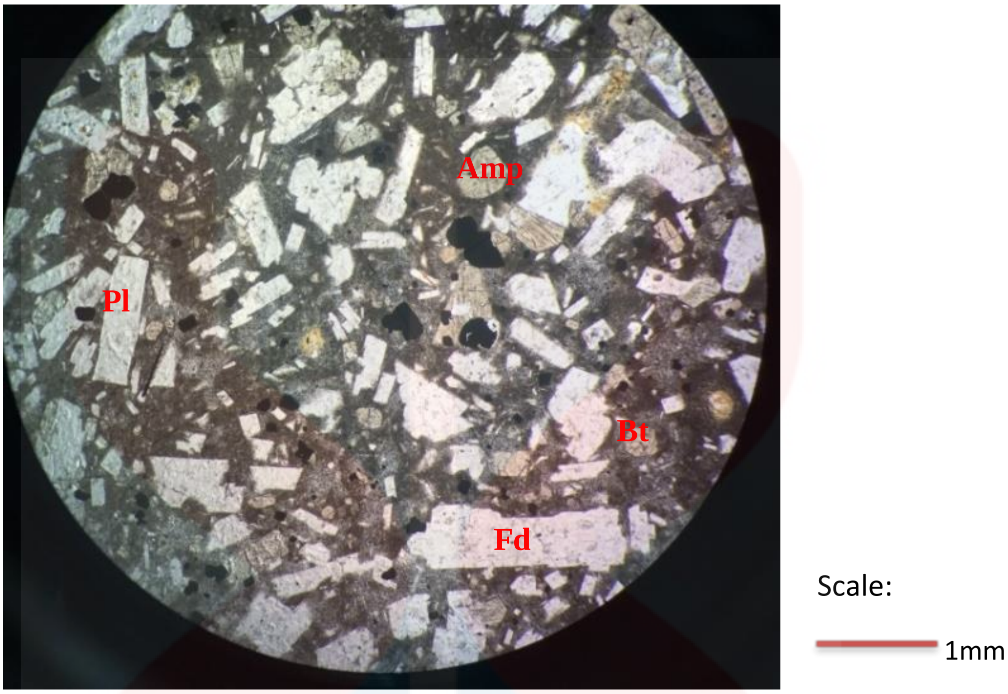
ii) Distribution of Rock Unit

Young volcanic rock from the eruption of Mount Aseupan which is andesite was mostly found at the East area of the Mandalawangi. This rock unit was widely distributed at the surface of the Mount Aseupan. Total stations of outcrops found in the study area for this rock unit are 20 stations. The samples of OCK 6, OCK 9, OCK 10 and OCK 11 are belonging to this rock unit. Figure 4.17 shows the outcrop station of sample OCK 9.

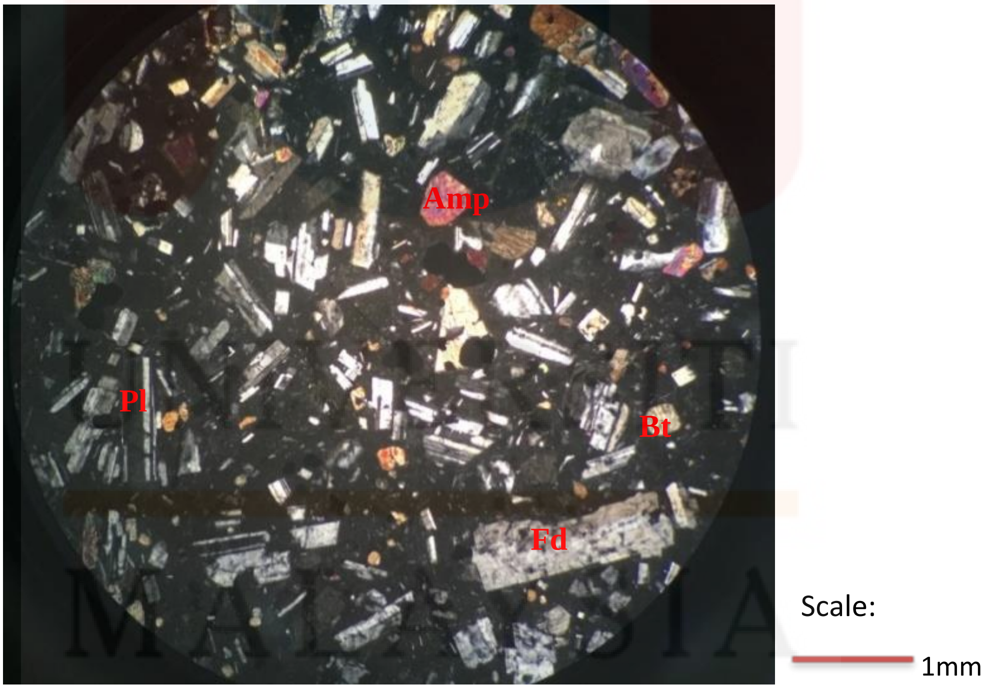
Figure 4.17: Outcrop of sample OCK 9.

iii) Petrography of Rock Unit

From the observation of samples in thin section by using petrographic microscope, mostly the sample from this rock unit has porphyritic texture. The colour is pale green, pale brown and colourless and the index colour is mesocratic which is 30%. 10% belong to the phenocryst and the other 20% is the percentage of groundmass. This rock unit is composed of feldspar, plagioclase, biotite and amphibole as major mineral and quartz and pyroxene as minor mineral. The general mineral shape of this rock unit is hypidiomorphic which is most of the mineral is in subhedral shape and it is inequigranular porphyritic size. The degree of crystallinity is holocrystalline because from the sample of thin section of this rock unit, it shows that the sample is composed of only crystal. Based on the Streckeisen classification diagram (1976), the thin section of this unit sample is classified as andesite. Figure 4.18 shows the thin section analysis of the sample OCK 9.



Plane Polarized Light (PPL) lens (4 x magnifications).

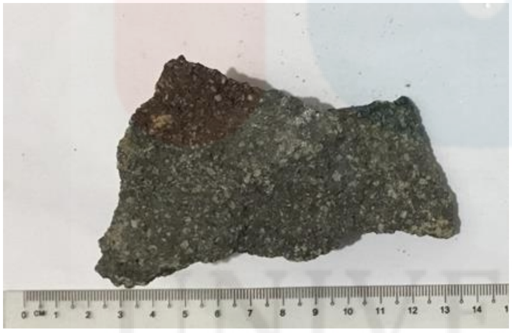


Cross Polarized Light lens (4 x magnifications).

Figure 4.18: Thin section of andesite of Mount Aseupan from the station of OCK 9.

4.3.1.2 Young volcanic rocks of Mount Pulosari (QHVI)

i) Lithology Characteristics

SAMPLE	CHARACTERISTICS
OCK 1 	Rock: Andesite Sampling location: Settlement area Texture: Porphyritic Grain size: Medium grain Colour: Grey Weathering stage: Slightly weathered
OCK 2 	Rock: Andesite Sampling location: Settlement area Texture: Porphyritic Grain size: Medium grain Colour: Dark grey Weathering stage: Fairly weathered
OCK 13 	Rock: Andesite Sampling location: Paddy field Texture: Porphyritic Grain size: Fine grain Colour: Light grey Weathering stage: Slightly weathered

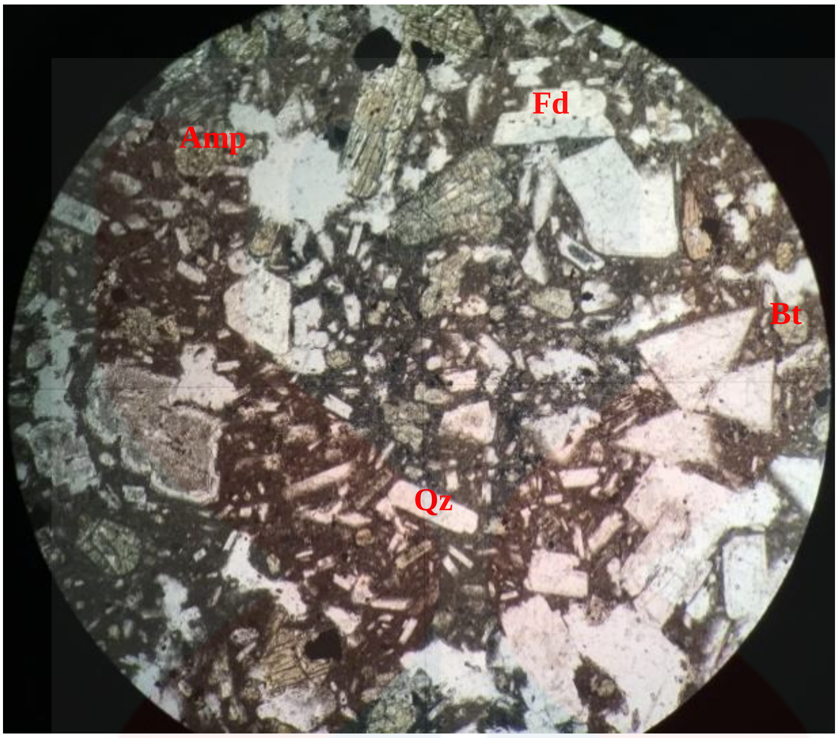
ii) Distribution of Rock Unit

Young volcanic rock from the eruption of Mount Pulosari which is andesite was mostly found at the South area of the Mandalawangi. This rock unit was widely distributed at the surface of the Mount Pulosari. Total stations of outcrops found in the study area for this rock unit are 9 stations. The samples of OCK 1, OCK 2, and OCK 13 are belonging to this rock unit. Figure 4.19 shows the outcrop station of sample OCK 2.

Figure 4.19: Outcrop of sample OCK 2.

iii) Petrography of Rock Unit

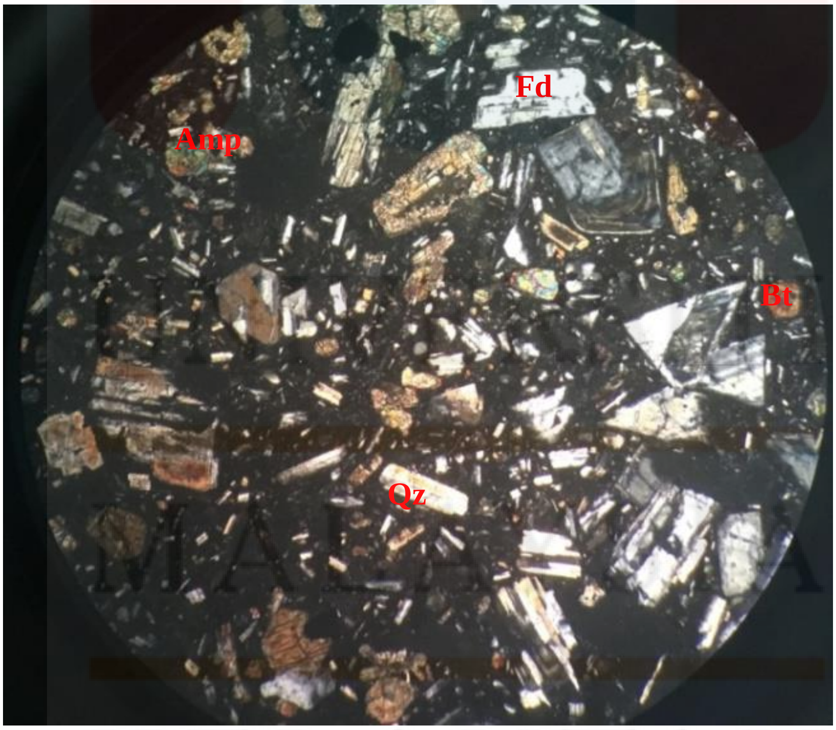
From the observation of samples in thin section by using petrographic microscope, mostly the sample from this rock unit has porphyritic texture. The colour is pale green to white and the index colour is mesocratic which is 45%. 30% belong to the phenocryst and the other 15% is the percentage of groundmass. This rock unit is composed of feldspar, plagioclase, amphibole and biotite as major mineral and pyroxene and quartz as minor mineral. The general mineral shape of this rock unit is hypidiomorphic which is most of the mineral is in subhedral shape and it is inequigranular porphyritic size. The degree of crystallinity is hypocrystalline because from the sample of thin section of this rock unit, it shows that the sample is composed of crystal and glass. Based on the Streckeisen classification diagram (1976), the thin section of this unit sample is classified as andesite. . Figure 4.20 shows the thin section analysis of the sample OCK 9.



Scale:

1mm

Plane Polarized Light (PPL) lens (4 x magnifications).



Scale:

1mm

Cross Polarized Light (XPL) lens (4 x magnifications).

Figure 4.20: Thin section of andesite of Mount Pulosari from the station of OCK 2.

4.3.1.3 Young volcanic rocks of Mount Karang (QVK)

i) Lithology Characteristics

SAMPLE	CHARACTERISTICS
OCK 3 	Rock: Andesite Sampling location: Farm area Texture: Porphyritic Grain size: Medium grain Colour: Light grey Weathering stage: Fairly weathered
OCK 4 	Rock: Andesite Sampling location: Settlement area Texture: Porphyritic Grain size: Fine grain Colour: Grey Weathering stage: Fairly weathered
OCK 5 	Rock: Andesite Sampling location: Settlement area Texture: Porphyritic Grain size: Medium grain Colour: Light grey Weathering stage: Fresh

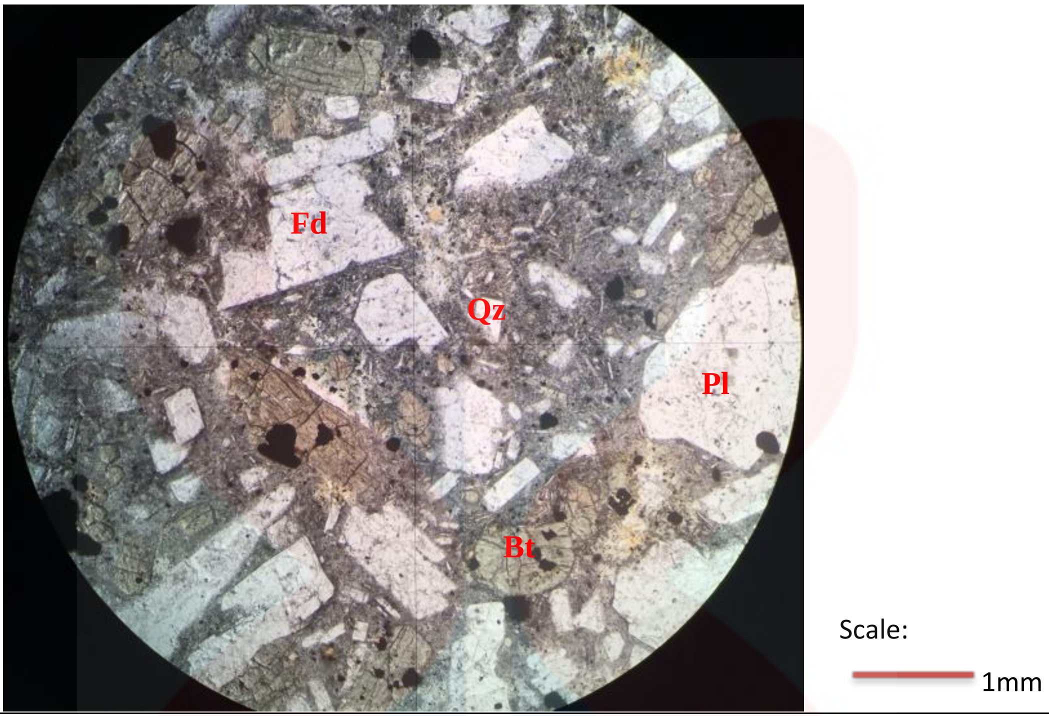
ii) Distribution of Rock Unit

Young volcanic rock from the eruption of Mount Karang which is andesite was mostly found at the West area of the Mandalawangi. This rock unit was widely distributed at the surface of the Mount Karang. Total stations of outcrops found in the study area for this rock unit are 14 stations. The samples of OCK 3, OCK 4, OCK 5, and OCK 8 are belonging to this rock unit. Figure 4.21 shows the outcrop station of the sample OCK 5.

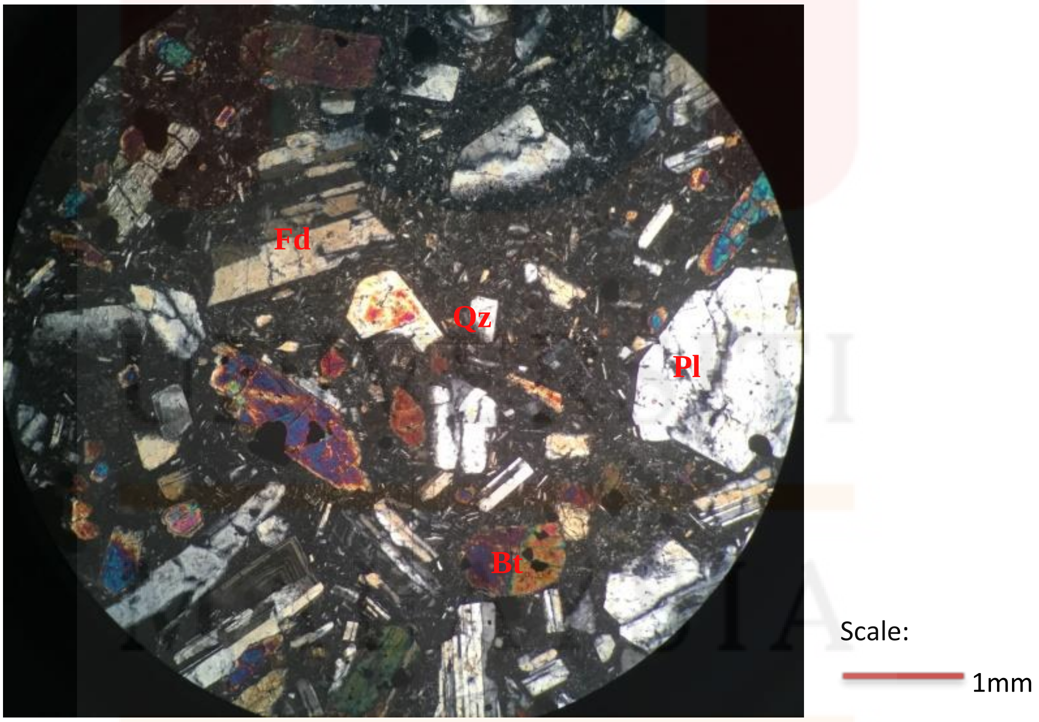
Figure 4.21: Outcrop of sample OCK 5.

iii) Petrography of Rock Unit

From the observation of samples in thin section by using petrographic microscope, mostly the sample from this rock unit has porphyritic texture. The colour is light grey to white and the index colour is leucocratic which is 20%. 15% belong to the phenocryst and the other 5% is the percentage of groundmass. This rock unit is composed of feldspar, plagioclase, amphibole, and biotite as major mineral and quartz and pyroxene as minor mineral. The general mineral shape of this rock unit is hypidiomorphic which is most of the mineral is in subhedral shape and it is inequigranular porphyritic size. The degree of crystallinity is hypocrystalline because from the sample of thin section of this rock unit, it shows that the sample is composed of crystal and glass. Based on the Streckeisen classification diagram (1976), the thin section of this unit sample is classified as andesite. Figure 4.22 shows the thin section analysis of the sample OCK 3.



Plane Polarized Light (PPL) lens (4 x magnifications).



Cross Polarized Light (XPL) lens (4 x magnifications).

Figure 4.22: Thin section of andesite of Mount Karang from the station of OCK 3.

4.3.1.4 Upper Tuff Banten (QVTB)

i) Lithology Characteristics

Figure 4.23 shows the hand specimen of sample OCK 12 on field observation. The location of this sample is at the settlement area. The name of the rock is tuff. The type of rock is volcanic rock. From the observation, the sample is orange to red in colour. The sample is highly weathered due to process of weathering.

Figure 4.23 Sample of OCK 12.

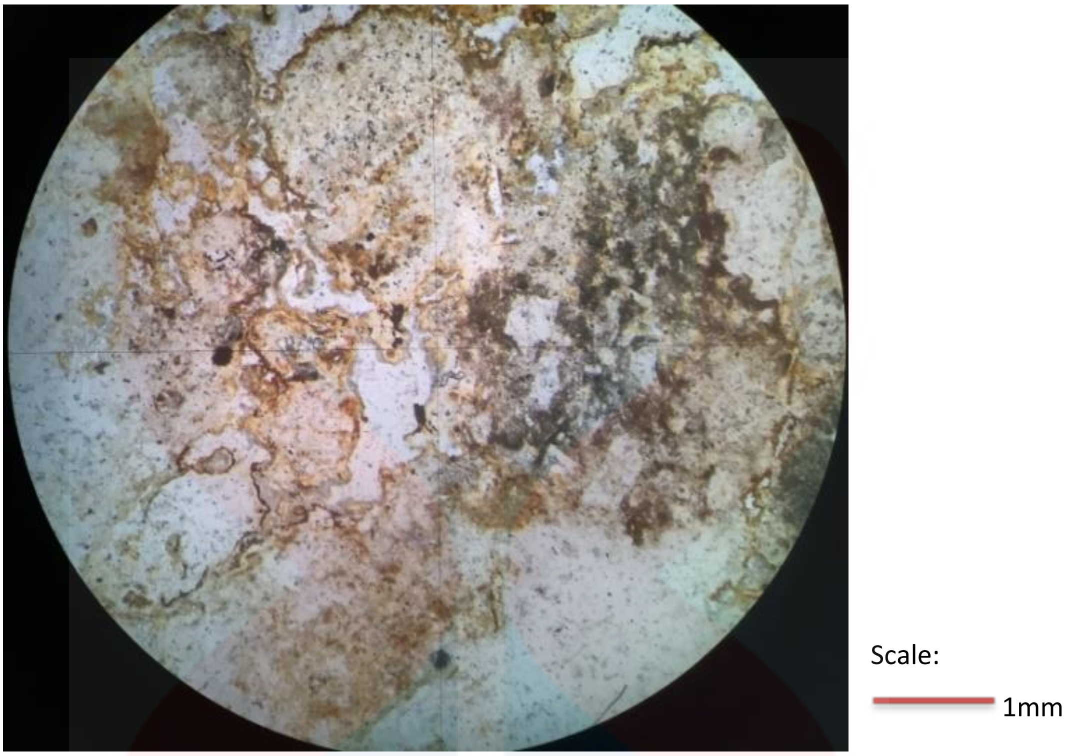
ii) Distribution of Rock Unit

Upper Tuff Banten was mostly found at the North area of the Mandalawangi. This rock unit was widely distributed at the surface of the Mount Parakasak. Total stations of outcrops found in the study area for this rock unit are 9 stations. The sample of OCK 12 is belonging to this rock unit. Figure 4.24 shows the outcrop station of the sample OCK 12.

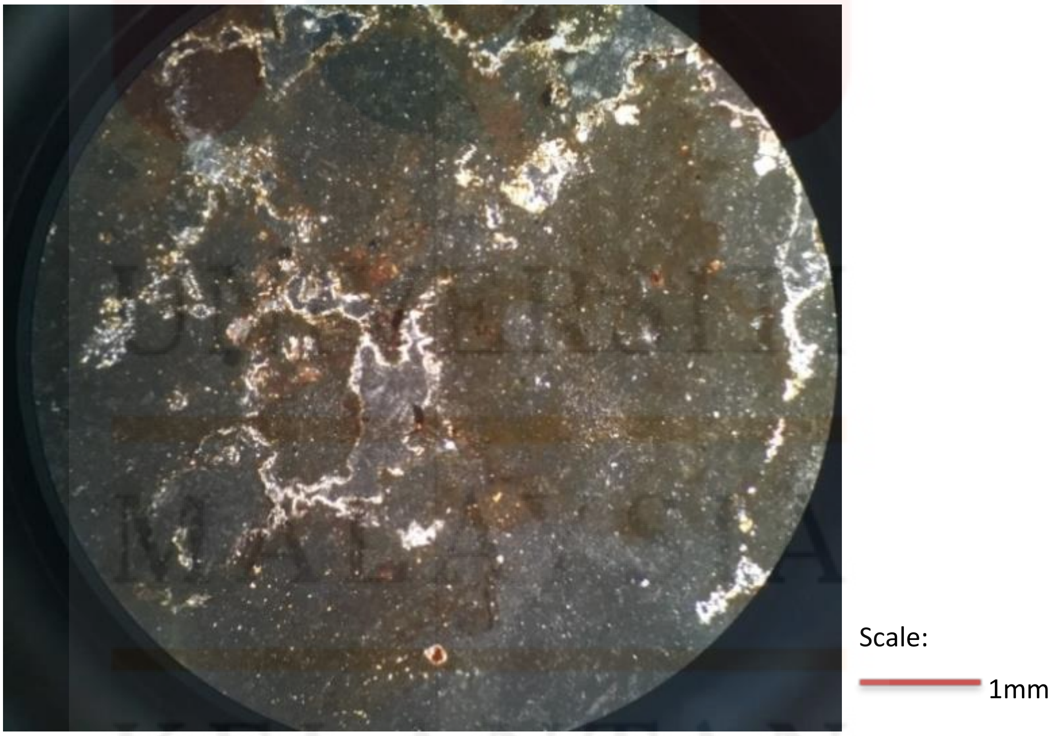
Figure 4.24 Outcrop of sample OCK 12.

iii) Petrography of Rock Unit

From the observation of samples in thin section by using petrographic microscope, mostly the sample from this rock unit was highly weathered. The grain shape is sub-rounded and its fabric is mud supported. Figure 4.25 shows the thin section analysis of the sample OCK 12.



Plane Polarized Light (PPL) lens (4 x magnifications).



Cross Polarized Light (XPL) lens (4 x magnifications).

Figure 4.25: Thin section of tuff from station of OCK 12.

4.3.2 Relative Age and Depositional Environment/Magmatism

In the study area, there is no fossils has been found. Therefore, the regional map and regional stratigraphy from Santosa (1991) was used as reference to reconstruct the stratigraphy of the study area in order to determine the unit relative age. From the stratigraphy reconstruction, Andesite unit from the eruption of Mount Karang is younger than the Tuff unit that was found in the north part of the study area. However, it is become the oldest unit when being compared with Andesite unit from the eruption of Mount Aseupan and Mount Pulosari. Andesite unit from the eruption of Mount Aseupan is the youngest unit among the entire unit that was found in the study area. Tuff unit is the oldest unit in the Mandalawangi and it is originated from the eruption of volcano in the area of Pandeglang regency.

The age of the rock unit at the study area is in the period of Quarternary which is from Pleistocene to Holocene epoch. For the depositional environment, there is no indicator can be found as there is no any evidence of structure found within the study area. No any faulting, folding, joint or other structures found to conclude that the rock was formed due to process of intrusion, uplifting or other process. So, the Andesite unit from the eruption of Mount Aseupan, Mount Pulosari and Mount Karang is related with the magmatism activity.

4.4 Geological Structure

The area of Mandalawangi is composed young volcanic rock with the age of Quarternary period. There is no deformation has occur at this area as there is no sign of geological structure such as joint, fault, fold or others structures had been found during mapping. So, the geological structure in this area is indicated by the presence of lineaments having a north-south direction. Figure 4.26 shows the lineament map of Mandalawangi.

Based on the result of lineament analysis, its shows that the lineaments are continuously up-through into alluvium unit. It should also be taken into account that the emergence of Tertiary rocks in this area are probably caused by tectonic activities. However, the area has undergoes a volcanic activity that causing the area being covered by young volcanic rock. Result analysis from Georose software shows that the main forces are come from the direction of 330^o. Figure 4.27 shows the result of Georose.

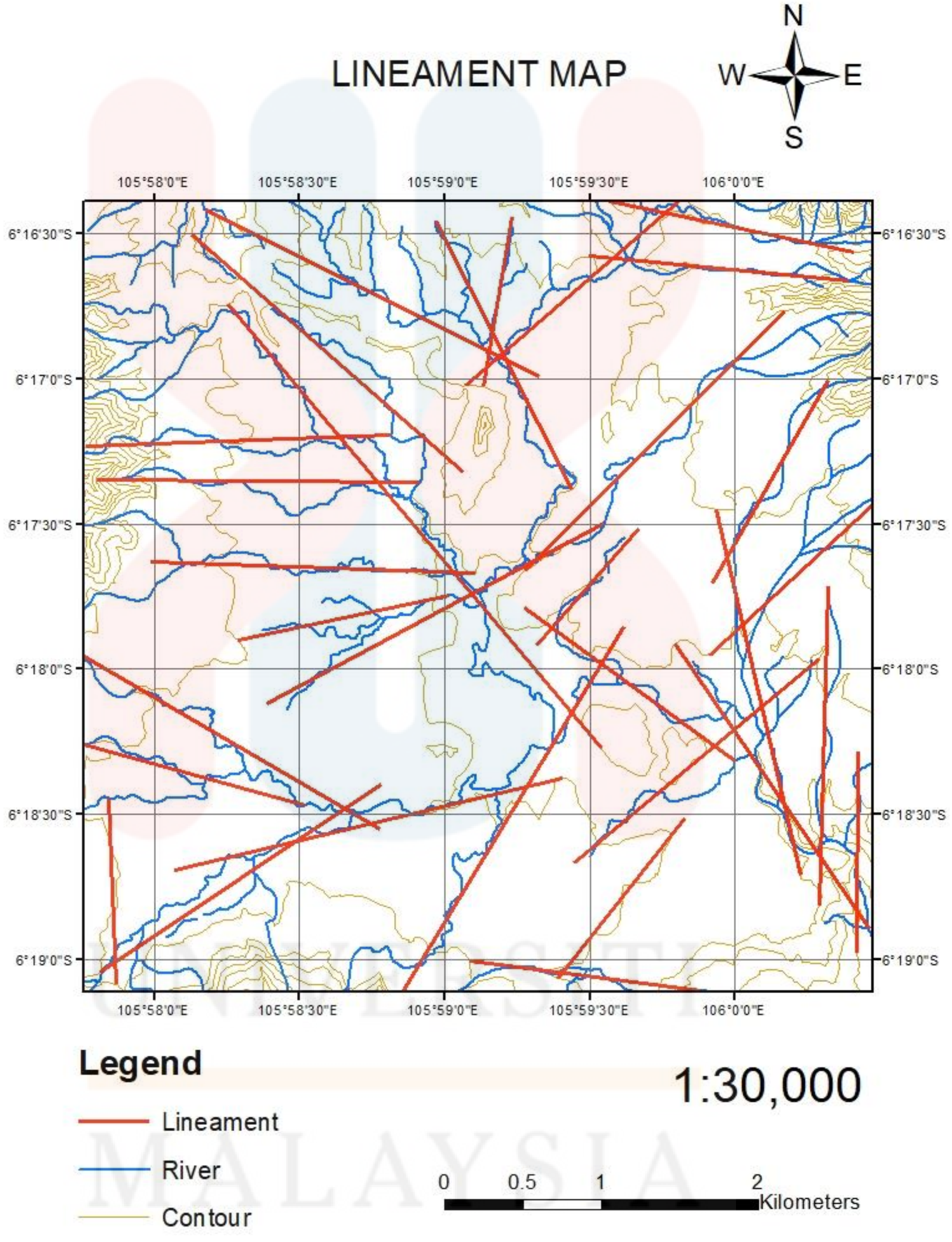


Figure 4.26 Lineament Map of Mandalawangi.

Table 4.5 Azimuth of Morphological Lineament in the study area.

No	Azimuth (N˚E)
1	150 – 330
2	122 – 302
3	135 – 315
4	50 – 230
5	2 – 182
6	1 – 181
7	178 – 358
8	41 – 221
9	139 – 319
10	77 – 257
11	146 – 326
12	31 – 211
13	140 – 320
14	92 – 272
15	56 – 236
16	167 – 347
17	6 – 186
18	63 – 243
19	26 – 206
20	137 – 317
21	8 – 188
22	128 - 308
23	87 – 267
24	16 – 196
25	120 – 300
26	168 – 348
27	12 – 192
28	99 – 279
29	130 – 310
30	91 – 271
31	36 – 216

Table 4.6 Lineament classification based on azimuth alignment.

Azimuth Group		Frequency	Length (kilometre)	Length (%)
0° - 10°	181° - 190°	4	7.2	12.50
11° - 20°	191° - 200°	2	3.1	5.38
21° - 30°	201° - 210°	1	2.3	3.99
31° - 40°	211° - 220°	2	3.7	6.42
41° - 50°	221° - 230°	2	5.9	10.24
51° - 60°	231° - 240°	1	1.9	3.30
61° - 70°	241° - 250°	1	1.9	3.30
71° - 80°	251° - 260°	1	2.4	4.17
81° - 90°	261° - 270°	1	1.1	1.91
91° - 100°	271° - 280°	3	4.1	7.12
101° - 110°	281° - 290°	-	-	-
111° - 120°	291° - 300°	1	1.5	2.60
121° - 130°	301° - 310°	3	4.7	8.16
131° - 140°	311° - 320°	4	8.0	13.90
141° - 150°	321° - 330°	2	4.0	6.94
151° - 160°	331° - 340°	-	-	-
161° - 170°	341° - 350°	2	3.9	6.77
171° - 180°	351° - 360°	1	1.9	3.30
Total length			57.6	100
Total frequency		31	-	-

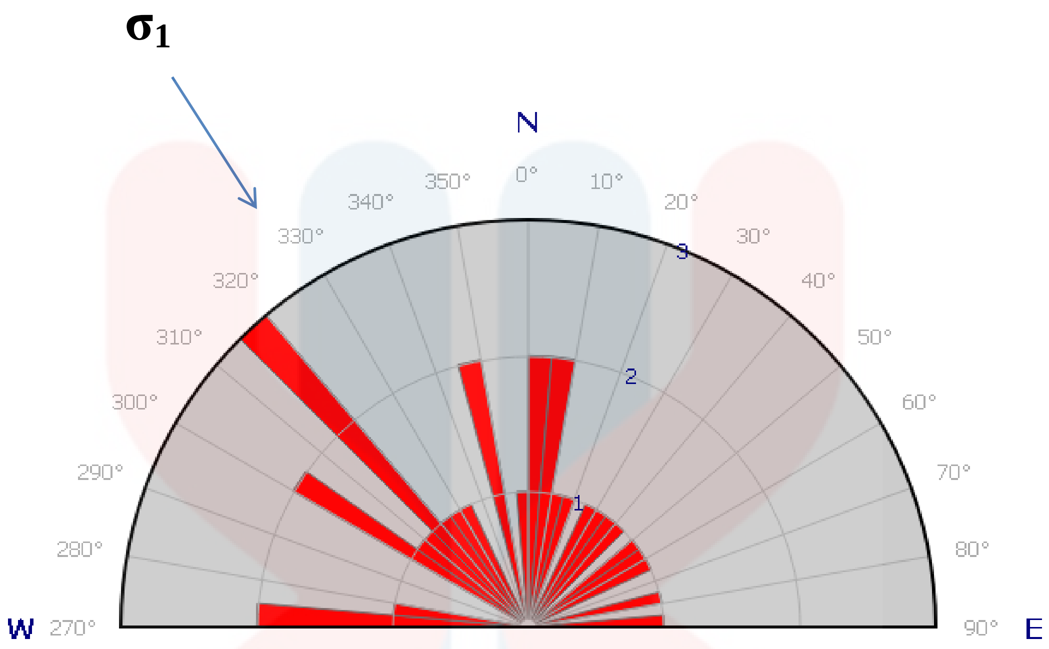


Figure 4.27 Rose Diagram shows that the direction of main forces is 330°.

4.5 Historical Geology

Volcanoes in West Java Quarternary start with the single chain at the westernmost part. Westernmost zone consist of Krakatau Volcano complex in the offshore and Danau complex in the onshore. Danau complex consist of Danau and Karang volcanoes. It is about 60 kilometre the distance between Krakatau complex and Danau complex.

Based on the previous research at the study area, the geological features are distinctly associated with active tectonic activities that occur since the Late Miocene to Holocene. Based on the stratigraphy, it is clearly indicates that at least three phases has occur during that period. Tectonics of phase one occurred in the Late Miocene, phase two happen in the Pliocene to Late Pleistocene and phase three is on-going in the Holocene. Volcanic activity has occurred since the Early Pleistocene.

Tectonically the studied area is controlled by the Sunda arc system which is the transition of Sumatra oblique subduction zone. This tectonic condition lead to the formation of some geological phenomena and besides, this area become vulnerable to geological disaster such as earthquake, liquefaction, volcanic eruption and landslide.

CHAPTER 5

PETROGRAPHIC AND GEOCHEMISTRY ANALYSIS OF VOLCANIC PRODUCT

5.1 Introduction

This chapter discussed more on petrographic and geochemistry analysis of volcanic product in Mandalawangi. Analysis of volcanic product is chosen in the specification of this research because the area of Mandalawangi is been surrounding by volcano which are Mount Pulosari, Mount Aseupan, Mount Karang, and Mount Parakasak. The surface of the study area is mostly cover by volcanic rock which is the product from the eruption of the volcano. This research intended to investigate the volcanic product from the eruption of Mount Aseupan, Mount Karang and Mount Pulosari. Therefore, three samples of every volcano are taken for petrographic analysis and five samples from the study area is taken for geochemical analysis.

5.2 Petrographic Analysis

5.2.1 Mount Pulosari

i) **Station 1**

a) **Station Description**

Figure 5.1: Outcrop of OCK 1.

Checkpoint	:	OCK 1
Location	:	S 06˚ 18’ 43.24” , E 105˚ 58’ 10.28”
Date	:	07 August 2019
Time	:	10.46 a.m.
Elevation	:	429 metres
Activity	:	Sampling point
Place	:	Settlement area, paddy field
Geomorphology (landform)	:	Volcanic
Lithology	:	Igneous rock
Rock specification	:	Basalt/ Andesite
Structural geology	:	-
Types of weathering (level of weathering)	:	Physical weathering (fairly weathered)
Land use	:	Resort, settlement
Vegetation	:	Paddy field, bushes

b) Megascopic Description

 **Figure 5.2:** Hand specimen of sample OCK 1.	Name of rock: Andesite
	Type of rock: Extrusive Igneous rock (volcanic)
	Colour: Greyish
	Grain size: Medium-grained
	Texture: Porphyritic
	Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
	Level of weathering: Slightly weathered
	Composition: Intermediate

c) Microscopic Description

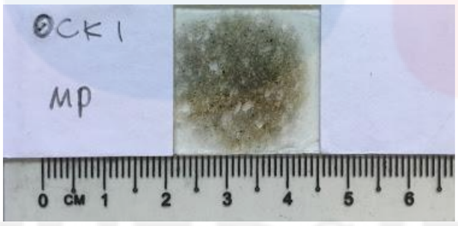
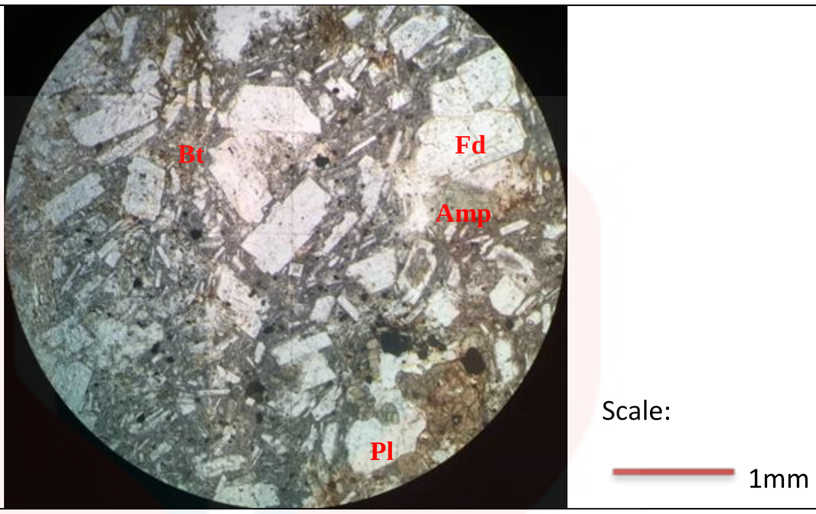
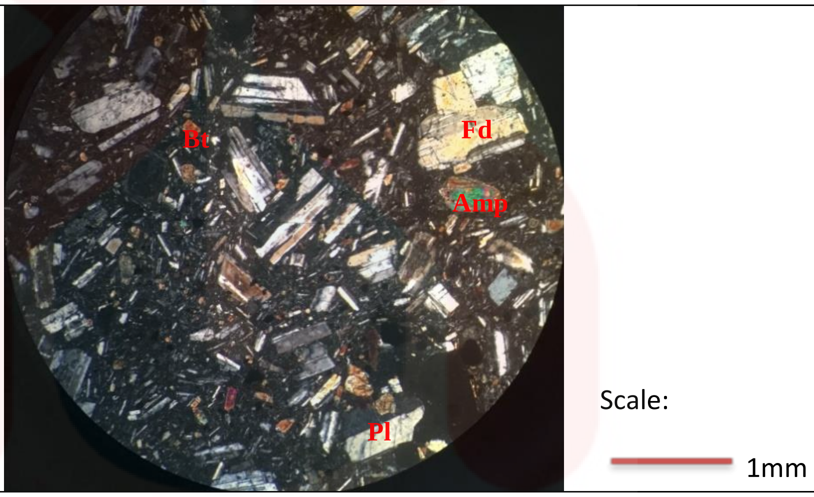


Figure 5.3: Thin section of sample OCK 1.

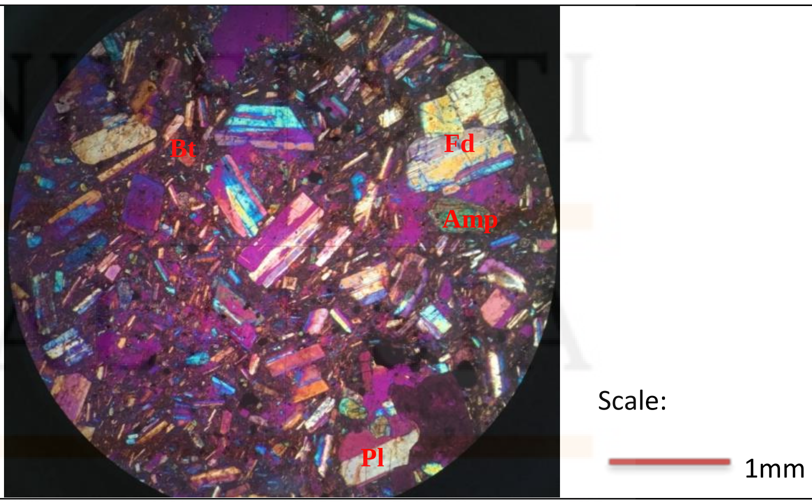
Colour	:	Light
Textural	:	Porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Hypo-crystalline
General mineral size	:	Inequigranular-poprhyritic
Mineral composition	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



Plane Polarized Light (PPL) lens.



Cross Polarized Light (XPL) lens.

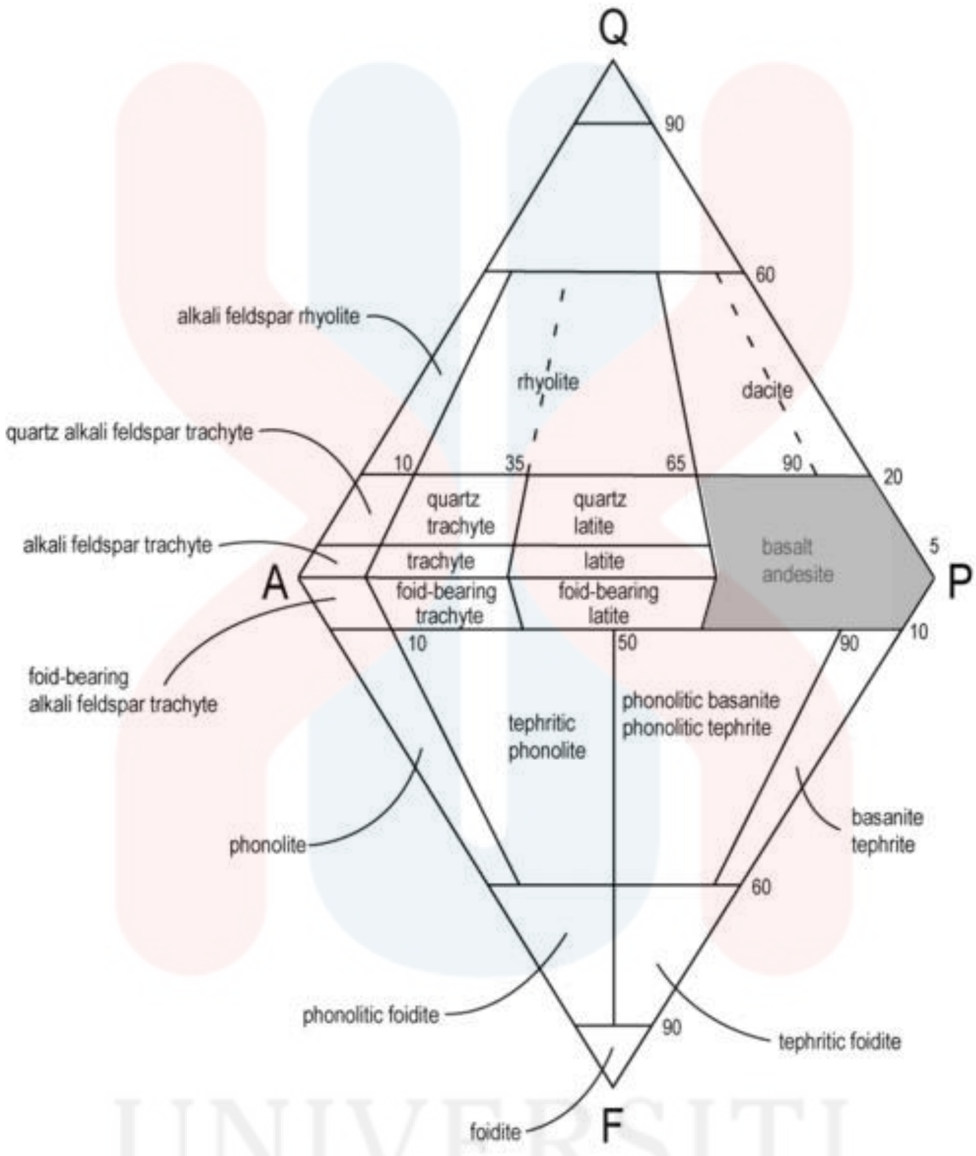


Gypsum lens.

Figure 5.4: Thin section showing the mineralogy of sample OCK 1.

d) Mineralogy Description

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	No	No	No	No
Inclusion	:	Yes	No	Yes	No	No	No
Mineral shape	:	Subhedral	Euhedral	Anhedral	Subhedral	Anhedral	Anhedral
Colour	:	Colourless	White	Pale green	Brown pale	Colourless	Brown pale
Pleochroism	:	No	No	No	No	No	No
Relief	:	Low	High	High	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	No	Yes	No	No	No	No
Twinning	:	Yes	Yes	No	No	No	No
Birefringence	:	1^{st} order	1^{st} order	2^{nd} order	2^{nd} order	2^{nd} order	2^{nd} order

QAPF Diagram Classification:

Name of rock: Andesite

(Source: Streckeisen, 1976)

ii) Station 2

a) Station Description

Figure 5.5: Outcrop of OCK 2.

Checkpoint	:	OCK 2
Location	:	S 06˚ 18' 43.10" , E 105˚ 58' 31.68"
Date	:	07 August 2019
Time	:	11.09 a.m.
Elevation	:	450 metres
Activity	:	Sampling point
Place	:	Settlement area
Geomorphology (landform)	:	Volcano
Lithology	:	Igneous rock
Rock specification	:	Andesite
Structural geology	:	-
Types of weathering (level of weathering)	:	Biological weathering (Fairly weathered)
Land use	:	Settlement, farm
Vegetation	:	Farm

b) **Megascopic Description**

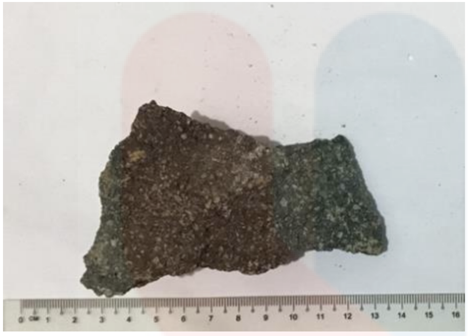


Figure 5.6: Hand specimen of sample OCK 2.

Name of rock: Andesite
Type of rock: Extrusive Igneous rock (volcanic)
Colour: Dark grey
Grain size: Medium-grained
Texture: Porphyritic
Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
Level of weathering: Fairly weathered
Composition: Intermediate

c) **Microscopic Description**

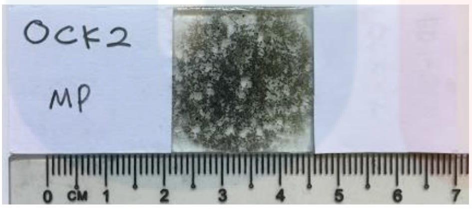
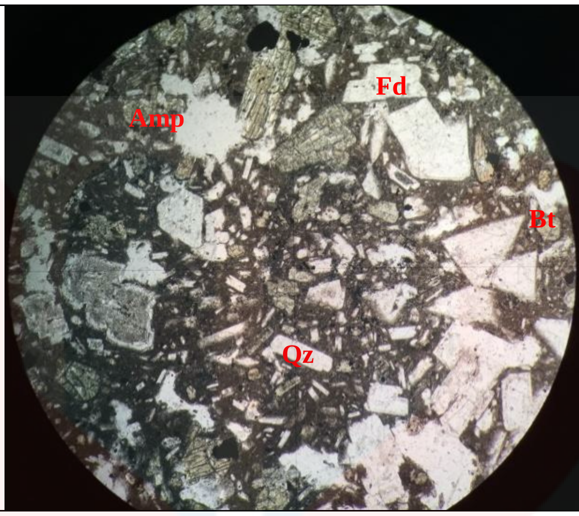


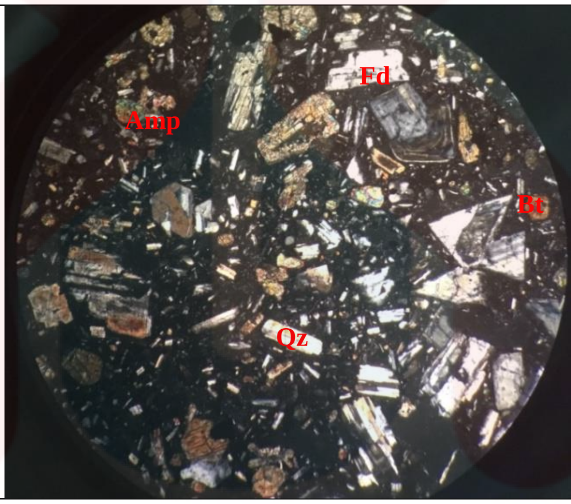
Figure 5.7: Thin section of sample OCK 2.

Colour	:	Pale green, white
Textural	:	Porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Hypo-crystalline
General mineral size	:	Inequigranular-porphyritic
Mineral composition (%)	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



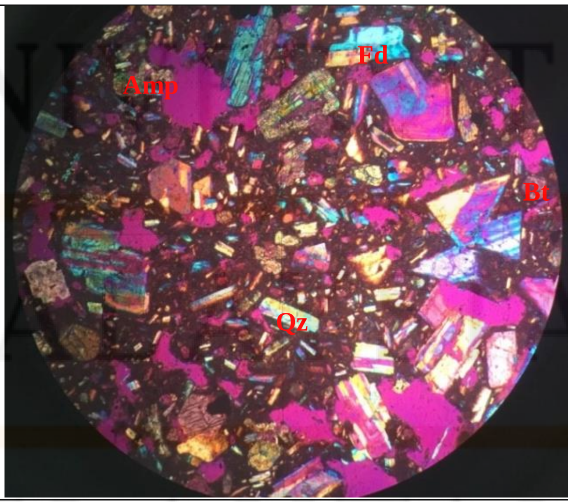
Scale: 1mm

Plane Polarized Light (PPL) lens.



Scale: 1mm

Cross Polarized Light (XPL) lens.



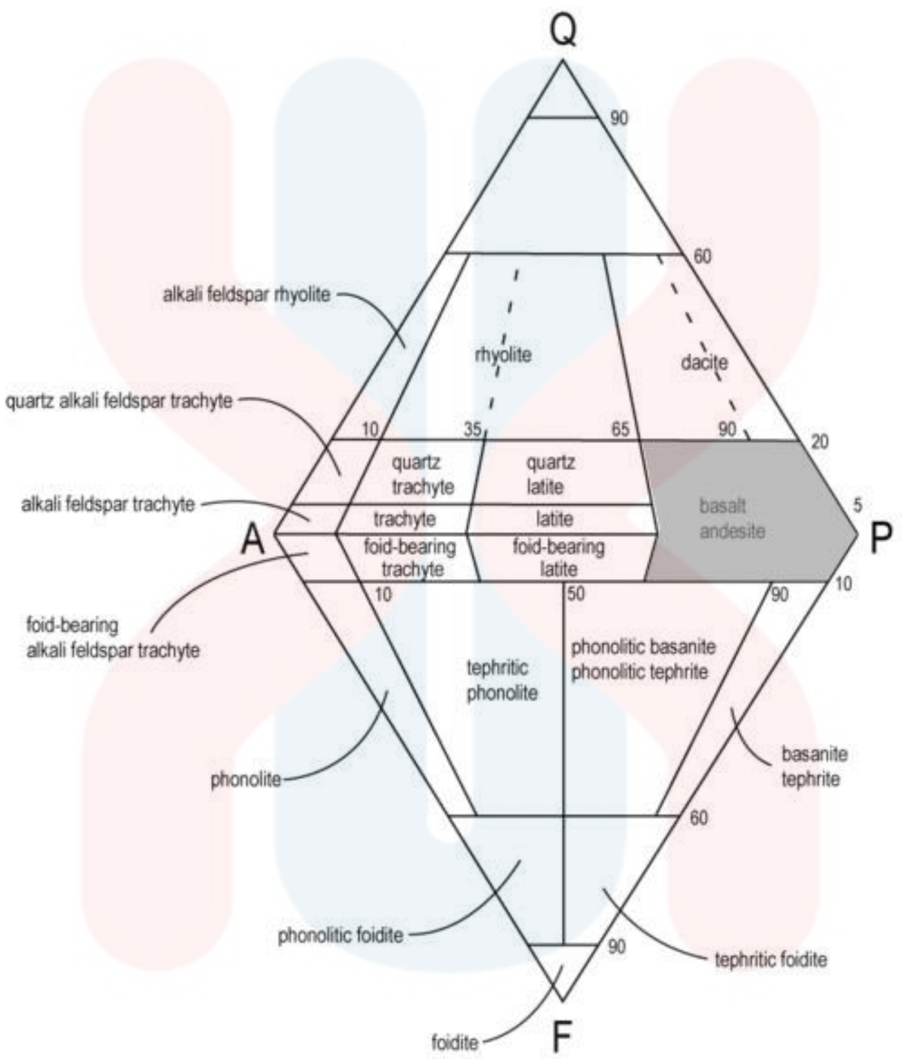
Scale: 1mm

Gypsum lens.

Figure 5.8: Thin section showing the mineralogy of sample OCK 2.

d) Mineralogy Description

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	2 direction	No	No	2 direction
Inclusion	:	Yes	Yes	No	Yes	No	No
Mineral shape	:	Subhedral	Euhedral	Subhedral	Subhedral	Subhedral	Subhedral
Colour	:	Colourless	Colourless	Grey	Green to brown	Colourless	Colourless
Pleochroism	:	No	No	No	Weak	No	No
Relief	:	Low	Low	Low	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	Yes	Yes	No	No	Yes	Yes
Twinning	:	Yes	Simple	No	No	Yes	Yes
Birefringence	:	1^{st} order	1^{st} order	2^{nd} order	1^{st} order	1^{st} order	2^{nd} order

QAPF Diagram Classification:

Name of rock: Andesite

(Source: Streckeisen, 1976)

5.2.1.2 Mount Karang

i) Station 1

a) Station Description

Figure 5.9: Outcrop of OCK 3.

Checkpoint	:	OCK 3
Location	:	S 06˚ 18’ 44.70” , E 105˚ 59’ 53.29”
Date	:	07 August 2019
Time	:	11.43 a.m.
Elevation	:	421 metres
Activity	:	Sampling point
Azimuth of outcrop	:	116˚
Place	:	Farm area
Geomorphology (landform)	:	Volcano
Lithology	:	Igneous rock
Rock specification	:	Andesite
Structural geology	:	-
Types of weathering (level of weathering)	:	Biological weathering (Fairly weathered).
Vegetation	:	Farm, forest, bushes.

b) **Megascopic Description**

Figure 5.10: Hand specimen of sample OCK 3.

Name of rock: Andesite
Type of rock: Extrusive Igneous rock (volcanic)
Colour: Light grey
Grain size: Medium-grained
Texture: Porphyritic
Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
Level of weathering: Fairly weathered
Composition: Intermediate

c) **Microscopic Description**

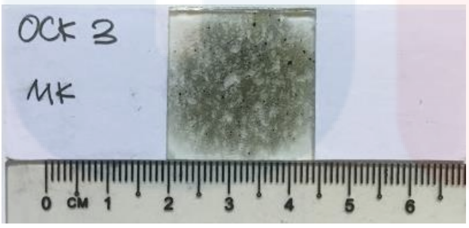
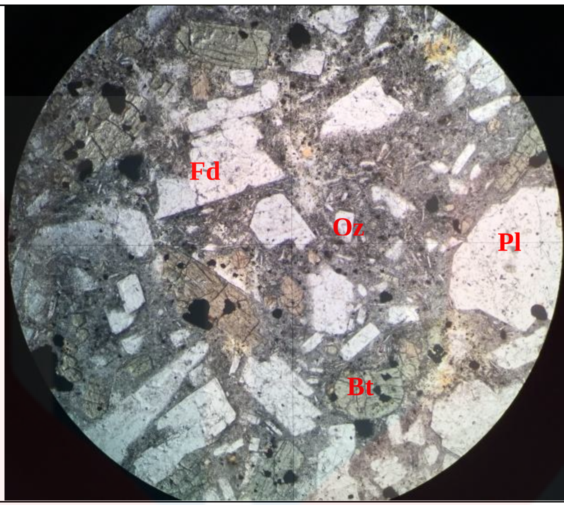


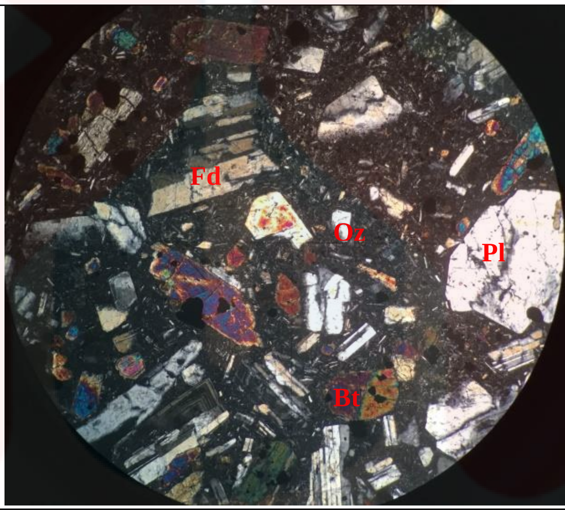
Figure 5.11: Thin section of sample OCK 3.

Colour	:	Light grey
Textural	:	Porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Hypo-crystalline
General mineral size	:	Inequigranular-porphyritic
Mineral composition (%)	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



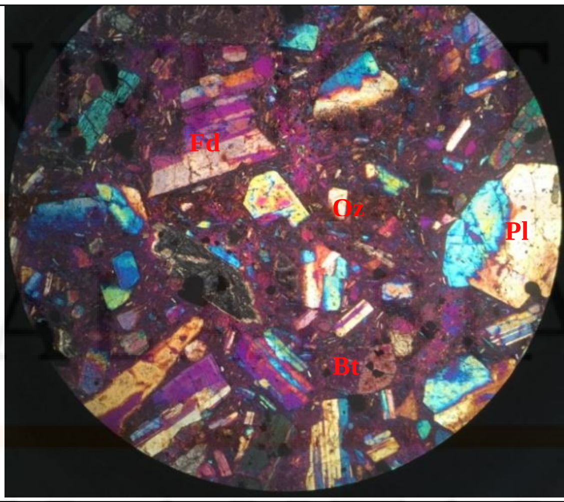
Scale: 1mm

Plane Polarized Light (PPL) lens.



Scale: 1mm

Cross Polarized Light (XPL) lens.



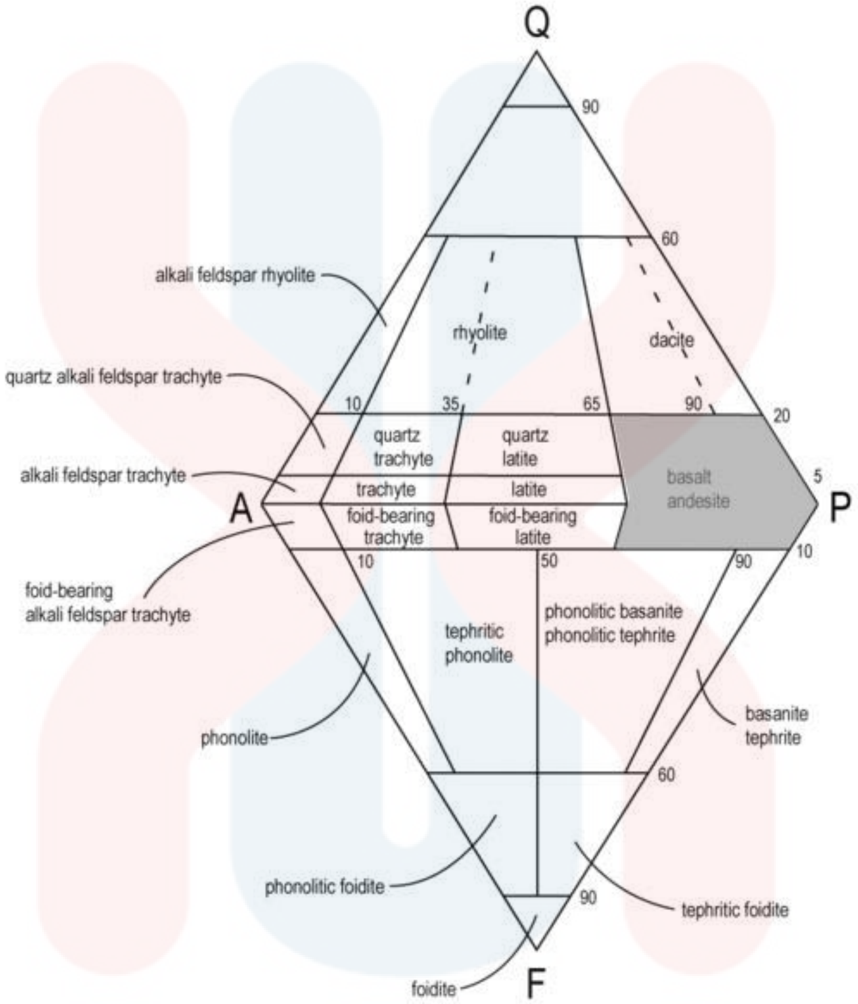
Scale: 1mm

Gypsum lens.

Figure 5.12: Thin section showing the mineralogy sample OCK 3.

d) Mineralogy Description

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	1 direction	No	No	2 direction
Inclusion	:	Yes	Yes	No	Yes	No	No
Mineral shape	:	Euhedral	Subhedral	Subhedral	Subhedral	Anhedral	Subhedral
Colour	:	Colourless	Colourless	Pale green	Pale brown	Colourless	Pale brown
Pleochroism	:	No	No	Weak	No	No	No
Relief	:	Low	Low	Low	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	Yes	Yes	Yes	No	No	Yes
Twinning	:	Yes	Carstbad	Yes	No	No	Yes
Birefringence	:	1^{st} order	1^{st} order	2^{nd} order	2^{nd} order	2^{nd} order	2^{nd} order

QAPF Diagram Classification:

Name of rock: Andesite

(Source: Streckeisen, 1976)

ii) Station 2 of Mount Karang

a) Station Description

Figure 5.13: Outcrop of OCK 5.

Checkpoint	:	OCK 5
Location	:	S 06˚ 17’ 59.42” , E 106˚ 00’ 14.80”
Date	:	07 August 2019
Time	:	1.22 p.m.
Elevation	:	418 metres
Activity	:	Sampling point
Azimuth of outcrop	:	136˚
Place	:	Kaki Gunung Karang, settlement area
Geomorphology (landform)	:	Volcano
Lithology	:	Igneous rock
Rock specification	:	Andesite
Structural geology	:	-
Types of weathering (level of weathering)	:	Biological weathering (Fairly weathered)
Land use	:	Settlement, farm
Vegetation	:	Farm, forest

b) Megascopic Description

 **Figure 5.14:** Hand specimen of sample OCK 5.	Name of rock: Andesite
	Type of rock: Extrusive Igneous rock (volcanic)
	Colour: Greyish
	Grain size: Medium-grained
	Texture: Porphyritic
	Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
	Level of weathering: Fairly weathered
	Composition: Intermediate

c) Microscopic Description

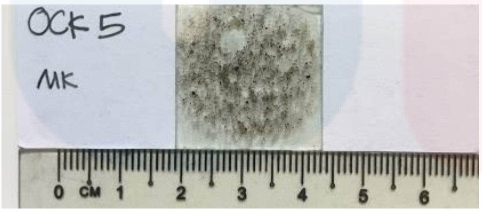
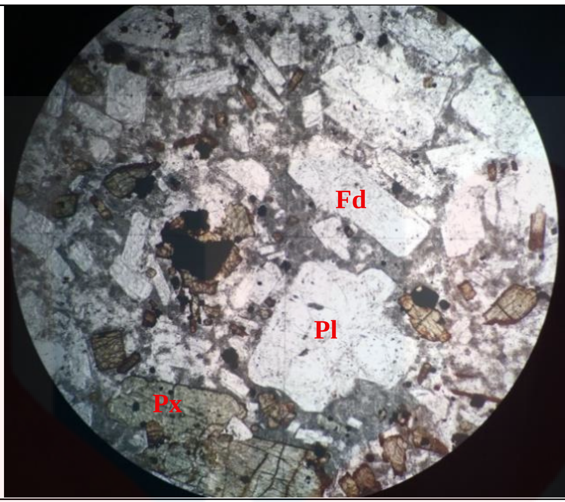


Figure 5.15: Thin section of sample OCK 5.

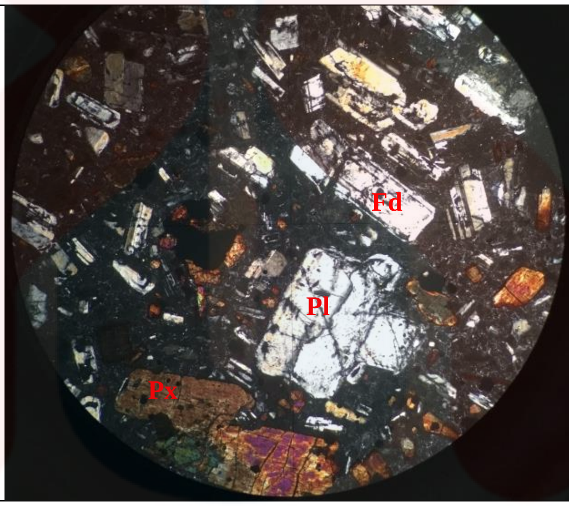
Colour	:	Pale green, pale brown, colourless.
Textural	:	Porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Holo-crystalline
General mineral size	:	Inequigranular-porphyritic
Mineral composition (%)	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



Scale:

1mm

Plane Polarized Light (PPL) lens.



Scale:

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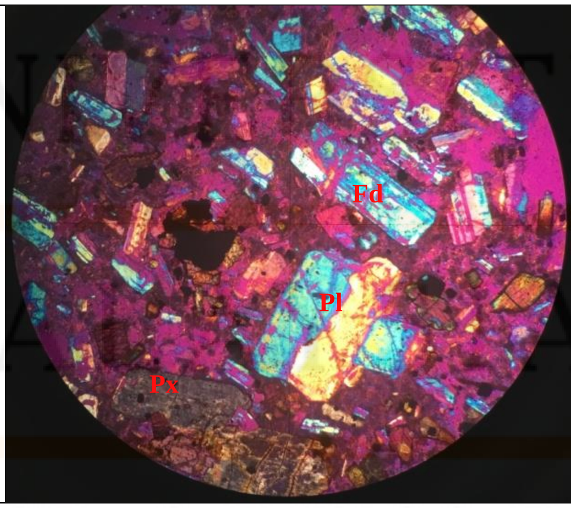
Cross Polarized Light (XPL) lens.



Scale:

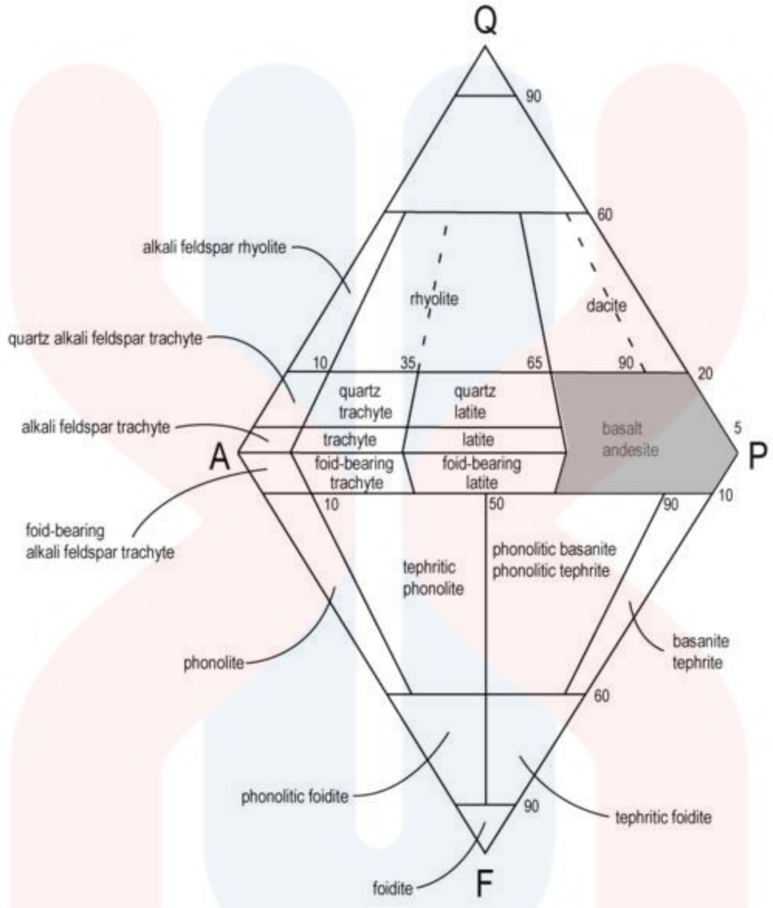
1mm

Gypsum lens.

Figure 5.16: Thin section showing the mineralogy of sample OCK 5.

d) **Mineralogy Description**

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	2 direction	No	No	2 direction
Inclusion	:	Yes	Yes	No	Yes	No	No
Mineral shape	:	Subhedral	Euhedral	Subhedral	Subhedral	Subhedral	Subhedral
Colour	:	Colourless	Colourless	Grey	Green to brown	Colourless	Colourless
Pleochroism	:	No	No	No	Weak	No	No
Relief	:	Low	Low	Low	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	Yes	Yes	No	No	Yes	Yes
Twinning	:	Yes	Simple	No	No	Yes	Yes
Birefringence	:	1st order	1st order	2nd order	1st order	1st order	2nd order

QAPF Diagram Classification:

Name of rock: Andesite

(Source: Streckeisen, 1976)

5.2.1.3 Mount Aseupan

i) Station 1

a) Station Description

Figure 5.17: Outcrop of OCK 9.

Checkpoint	:	OCK 9
Location	:	S 06˚ 18’ 09.21” , E 105˚ 58’ 00.31”
Date	:	08 August 2019
Time	:	11.30 a.m.
Elevation	:	447 metres
Activity	:	Sampling point
Azimuth of outcrop	:	180˚
Place	:	Paddy field
Geomorphology (landform)	:	Volcano
Lithology	:	Igneous rock
Rock specification	:	Basalt
Structural geology	:	-
Types of weathering (level of weathering)	:	Physical and biological weathering (Fairly weathered)
Land use	:	Paddy field, settlement.
Vegetation	:	Paddy field

b) Megascopic Description

Figure 5.18: Hand specimen of sample OCK 9.

Name of rock: Andesite
Type of rock: Extrusive Igneous rock (volcanic)
Colour: Dark grey
Grain size: Medium-grained
Texture: Porphyritic
Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
Level of weathering: Fairly weathered
Composition: Intermediate

c) Microscopic Description

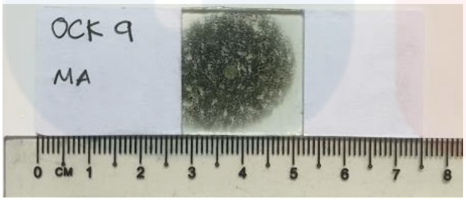
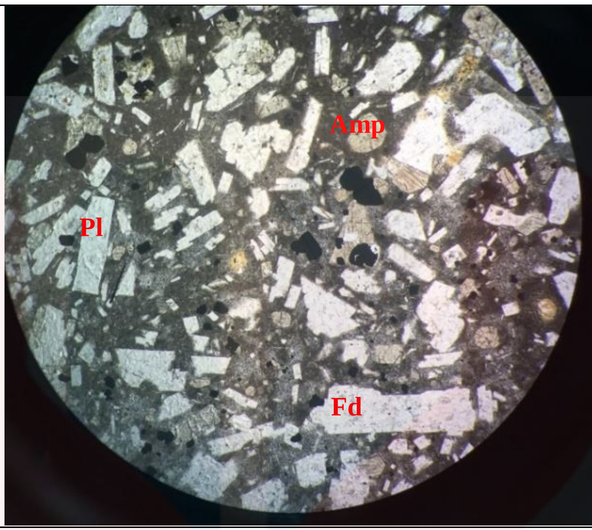


Figure 5.19: Thin section of sample OCK 9.

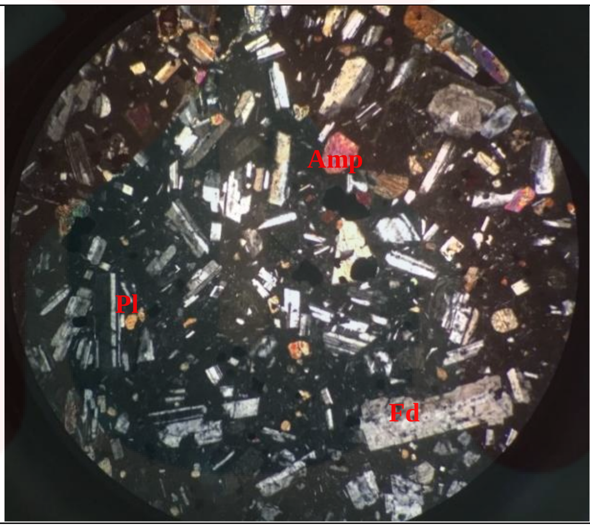
Colour	:	Pale green, pale brown, colourless
Textural	:	porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Holocrystalline
General mineral size	:	Inequigranular-porphyritic
Mineral composition	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



Scale:

1mm

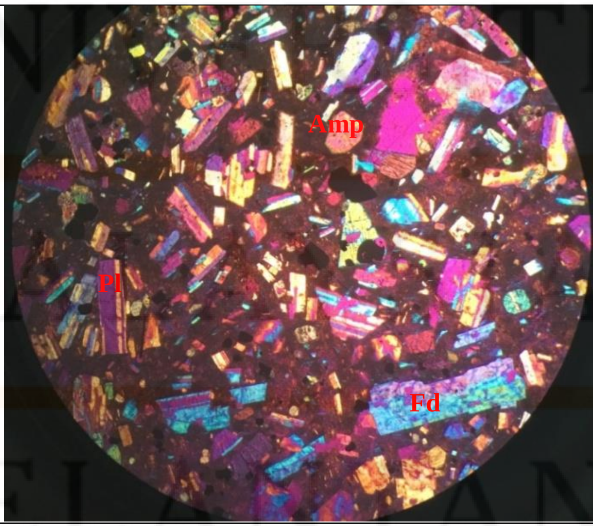
Plane Polarized Light (PPL) lens.



Scale:

1mm

Cross Polarized Light lens.



Scale:

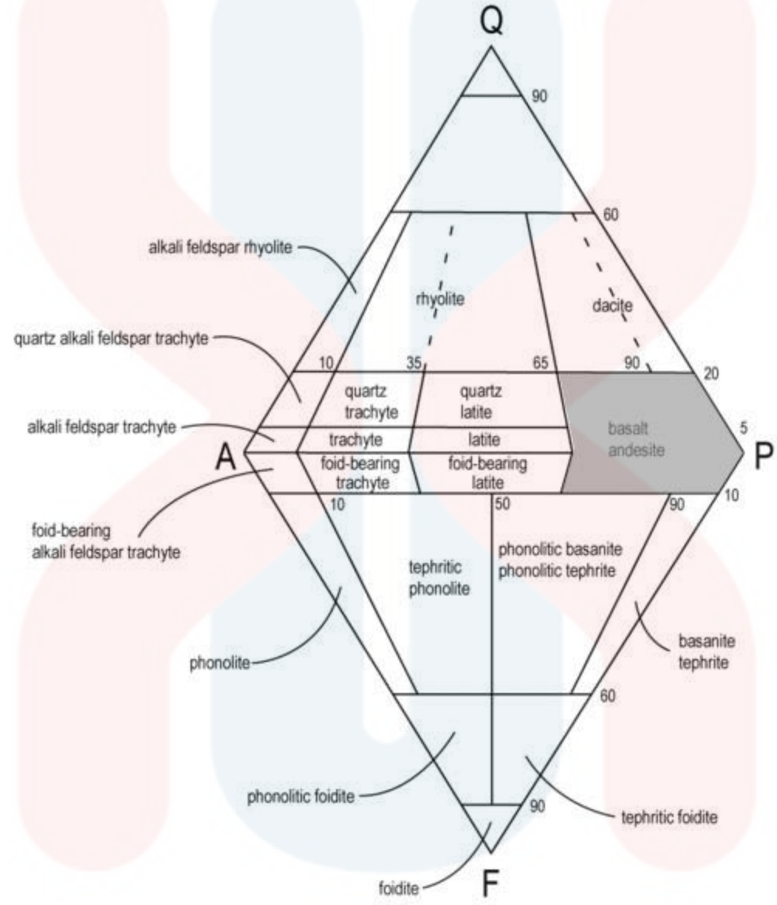
1mm

Gypsum lens.

Figure 5.20: Thin section showing the mineralogy of sample OCK 9.

d) Mineralogy Description

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	1 direction	No	No	No
Inclusion	:	Yes	Yes	No	Yes	No	No
Mineral shape	:	Euhedral	Subhedral	Subhedral	Subhedral	Anhedral	Subhedral
Colour	:	Colourless	Colourless	Pale green	Pale brown	Colourless	Pale brown
Pleochroism	:	No	No	Weak	No	No	No
Relief	:	Low	Low	Low	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	Yes	Yes	Yes	No	No	Yes
Twinning	:	Yes	Simple	Yes	No	No	Yes
Birefringence	:	1^{st} order	1^{st} order	2^{nd} order	2^{nd} order	2^{nd} order	2^{nd} order

QAPF Diagram Classification:

Name of rock: Andesite

(Source: Streckeisen, 1976)

ii) Station 2

a) Station Description

Checkpoint	:	OCK 10
Location	:	S 06˚ 18' 09.69" , E 105˚ 58' 19.04"
Date	:	09 August 2019
Time	:	11.18 a.m.
Elevation	:	434 metres
Activity	:	Sampling point
Azimuth of outcrop	:	263˚
Place	:	Paddy field
Geomorphology (landform)	:	Volcano
Lithology	:	Igneous rock
Rock specification	:	Andesite/ Basalt
Structural geology	:	-
Types of weathering (level of weathering)	:	Physical weathering (partially)
Land use	:	Settlement, paddy field
Vegetation	:	Paddy field

b) Megascopic Description

Figure 5.21: Hand specimen of sample OCK 10.

Name of rock: Andesite
Type of rock: Extrusive Igneous rock (volcanic)
Colour: Greyish
Grain size: Medium to coarse grained
Texture: Porphyritic
Mineral composition: K-feldspar, Plagioclase, Amphibole, Pyroxene (minor)
Level of weathering: Fairly weathered
Composition: Intermediate

c) Microscopic Description

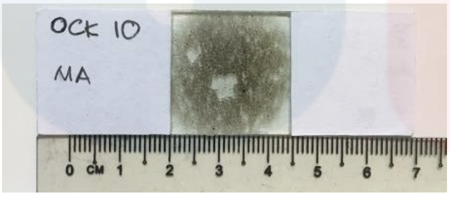
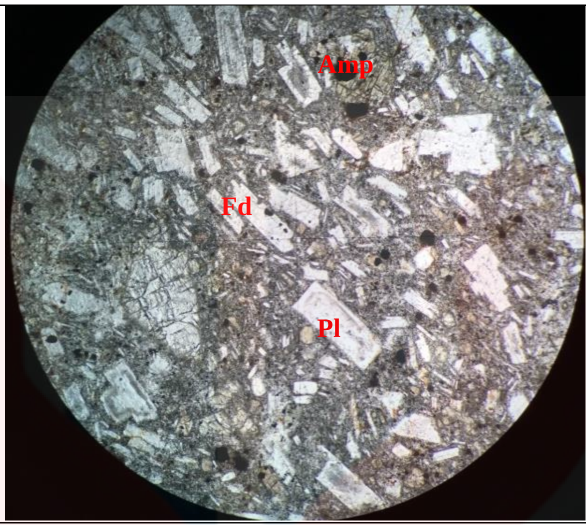


Figure 5.22: Thin section of sample OCK 10.

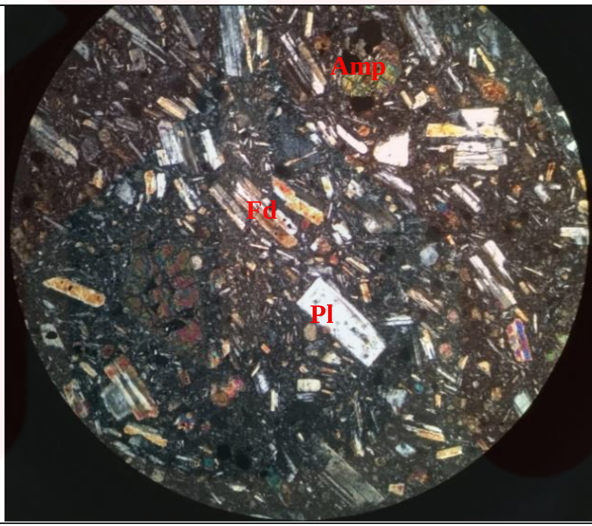
Colour	:	Pale green, colourless
Textural	:	Porphyritic
General mineral shape	:	Hypidiomorphic
Crystallinity degree	:	Holocrystalline
General mineral size	:	Inequigranular-porphyritic
Mineral composition (%)	:	Feldspar, Plagioclase, Amphibole, Biotite, Quartz (minor) and Pyroxene (minor)
Name of rock	:	Andesite



Scale:

1mm

Plane Polarized Light lens.



Scale:

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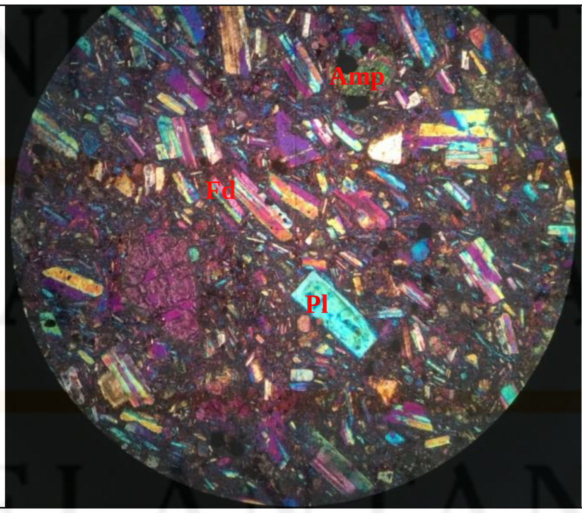
Cross Polarized Light (XPL) lens.



Scale:

1mm

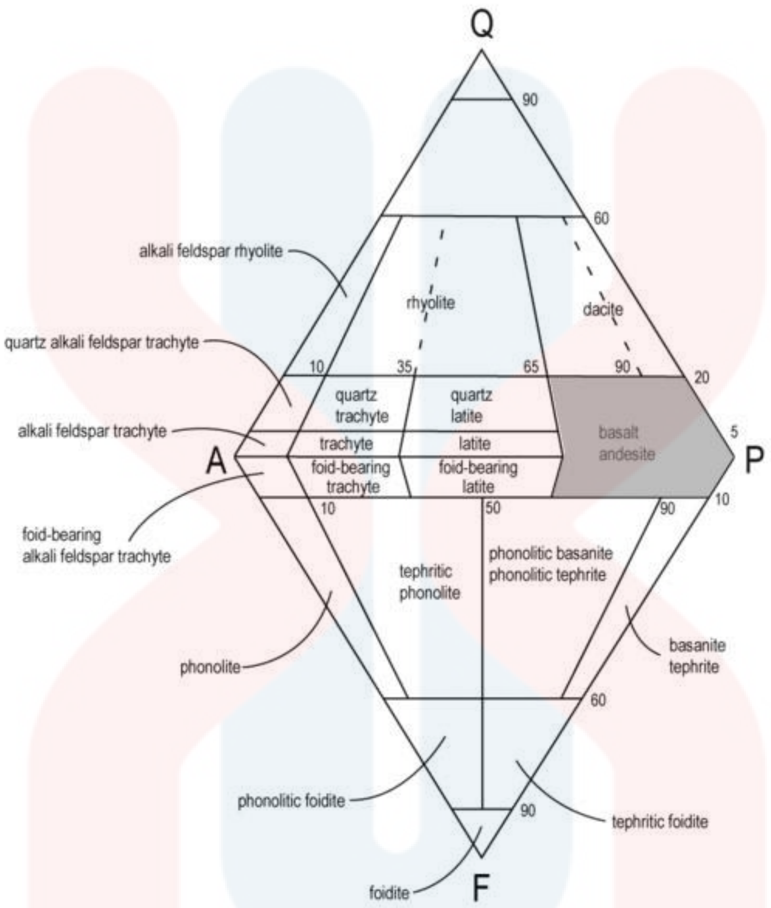
Gypsum lens.

Figure 5.23: Thin section showing the mineralogy of sample OCK 10.

d) Mineralogy Description

The composition of the rock							
Mineral	:	Feldspar	Plagioclase	Amphibole	Biotite	Quartz	Pyroxene
Cleavage	:	1 direction	1 direction	No	No	No	No
Inclusion	:	Yes	No	Yes	No	No	No
Mineral shape	:	Subhedral	Euhedral	Anhedral	Subhedral	Anhedral	Anhedral
Colour	:	Colourless	White	Pale green	Brown pale	Colourless	Brown pale
Pleochroism	:	No	No	No	No	No	No
Relief	:	Low	High	High	Low	Low	Low
Refraction index	:	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$	$n_{mineral} < n_{medium}$
Zoning	:	No	Yes	No	No	No	No
Twinning	:	Yes	Yes	No	No	No	No
Birefringence	:	1^{st} order	1^{st} order	2^{nd} order	2^{nd} order	2^{nd} order	2^{nd} order

QAPF Diagram Classification:



Name of rock: Andesite

(Source: Streckeisen, 1976)

Based on the result of petrography analysis of the sample from Mount Aseupan, Mount Pulosari and Mount Karang, it shows that all of the samples having the same mineralogical properties. The only differ that can be observe was the grain size of the mineral in the thin section. The grain size of mineral from the sample of Mount Karang is the biggest size among all of the samples. The distribution size of the sample is same. For the grain size of the mineral in the sample from Mount Aseupan, it shows the smallest size and the distribution size of the mineral is same. However, for the mineral from the sample of Mount Pulosari, it has different sizes which vary from small size to bigger size. This proved that all of the samples are coming from the same magma source but it may differ in the time of eruption. This is the reason why the size of the mineral is different.

5.3 Geochemistry analysis (X-ray Fluorescence (XRF) analysis)

5.3.1 Major Element

Major element is including ten elements listed as oxide which are Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K and P. Usually, data of major element data are used in classification of rock, construction of variations diagrams and as a means of comparison with experimentally determined rock composition. The analysis of X-ray Fluorescence (XRF) was done on five samples of rock from the study area. The result of XRF analysis of this sample is shown in Table 5.1.

Table 5.1 Geochemical analysis result of the samples from study area.

Major Element (% weight)	OCK 5	OCK 6	OCK 9	OCK 11	OCK 13
SiO_2	58.43	57.24	58.99	61.19	58.86
TiO_2	0.49	0.64	0.83	0.70	0.67
Al_2O_3	20.63	18.17	17.52	16.02	19.26
Fe_2O_3	6.86	9.04	9.13	7.24	8.47
MnO	0.14	0.14	0.17	0.13	0.16
MgO	0.68	1.78	1.3	1.02	1.09
CaO	3.65	6.71	5.61	3.94	5.55
Na_2O	2.71	2.84	4.35	4.00	3.18
K_2O	1.12	0.90	1.10	1.44	0.86
P_2O_5	0.32	0.22	0.25	0.21	0.22
LOI	4.67	1.94	0.4	3.81	1.35

Andesite rocks from the Mount Aseupan, Mount Pulosari and Mount Karang have a narrow range of major element composition which is within 57.24 until 61.19 weight per cent SiO_2. The geochemical data obtained from X-Ray Fluorescence analysis are then normalized before processing them in software known as GNDkit, Janousek, Farrow & Erban (2016). The major element are normalized to 100% anhydrous weight and FeO are changed to total FeO* for plotting and modelling. The types of rock, magmatic series, origin of magma and depth of origin magma can be determined from the geochemical data obtained.

The LOI value from the result of X-Ray Fluorescence analysis shows that either the rock samples are highly weathered or the rock interacted with volatile substances during the formation of rock. The value can affect the plotting diagram as the percentage of weight if each element is not accurate. So the data that have high value of LOI are not suitable for data interpretation. The geochemical data than can be used or suitable for interpretation is the data that have LOI value less than 2.00.

5.3.2 Identification of the type of rock

Bas, Maitre, Streckeisen and Zanettin (1986) classification diagram or also known as Le Bas et. al (1986) is used for the identification of types of rocks as shown in Figure 5.24. The determination of the types of rocks by using geochemical data is more accurate compared to only observe the rocks under petrographic observation. The classification diagram is used in classifying the types of rocks by using total alkali silica (TAS) diagram, which is one of the classification diagrams that used for volcanic rocks. The geochemical data that are used are total alkali value which is $Na_2O + K_2O$ and silica value which is SiO_2. This data are then being plotted on Le Bas et. al (1986) diagram. Using the plotting value of $Na_2O + K_2O$ and SiO_2

on the classification diagram, rocks in the study area which is Mandalawangi are Andesite from the eruption of volcano that surrounded the area. Based on the plotting, the rocks are only in the intermediate phase. Another plotting diagram from Cox, Bell & Pankhurst (1979), shown in Figure 5.25 is also used to prove that the results obtained from the Le Bas et. al (1986) diagram is valid.

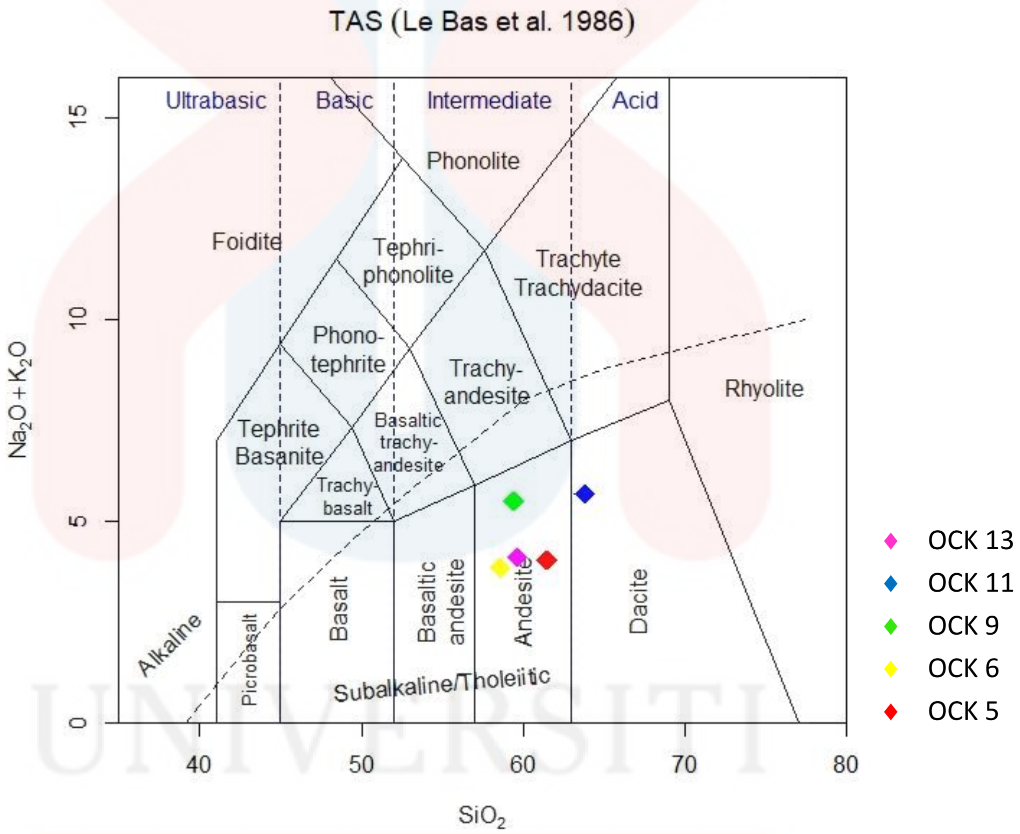


Figure 5.24: Distribution of five samples of rocks from Mandalawangi in Le Bas et. al (1986) diagram.

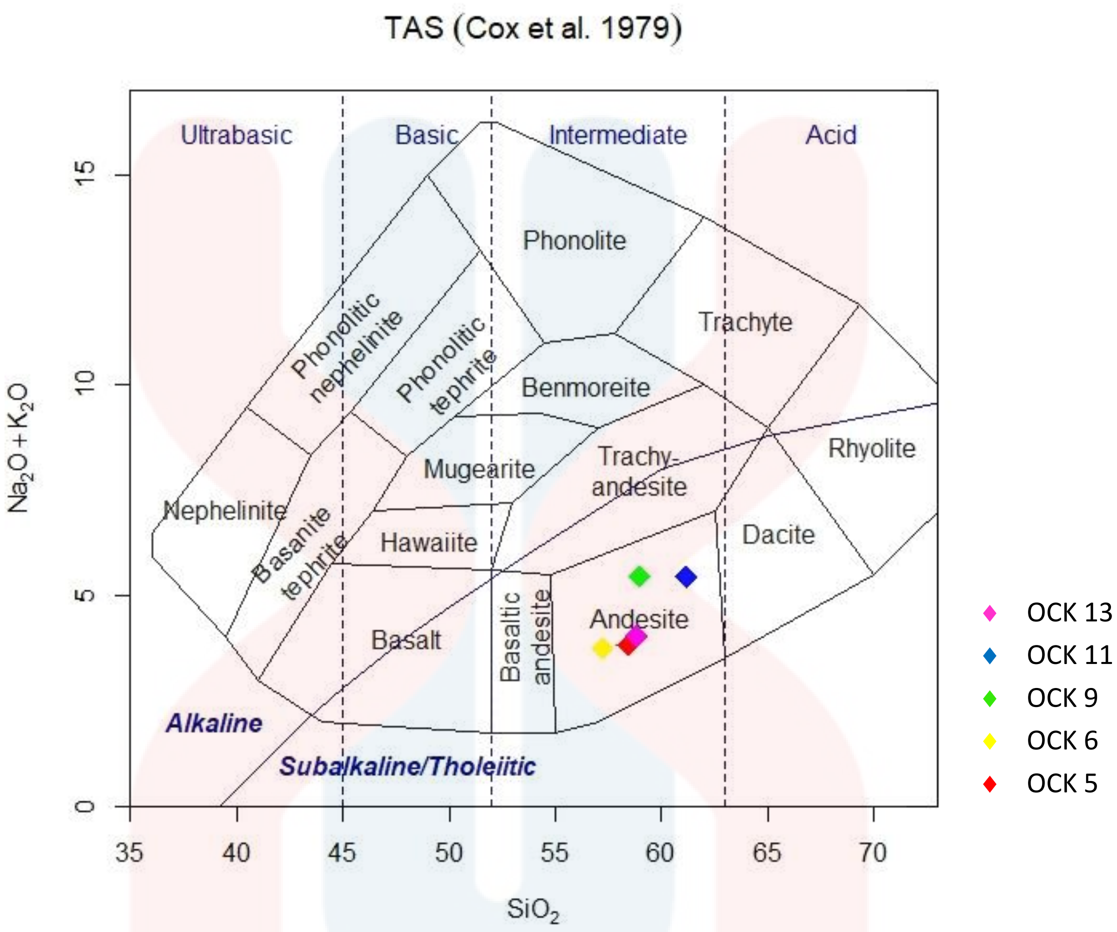


Figure 5.25: Distribution of andesite samples in Cox et. al diagram (1979).

Another way to identify the types of rocks is by using silica content in a rock as introduced by Whitford (1979) as shown in Table 5.2 The classification of volcanic rocks in Mandalawangi based on silica (SiO_2) content from the result of X-Ray Fluorescence (XRF) analysis is shown in Table 5.3.

Table 5.2 Classification of volcanic rocks based on its silica content.

Name of rock	Silica content (SiO_2)
Basalt	<52 %
Andesitic Basalt	52 % - 56 %
Andesite	56 % - 63 %
Dacite	63 % - 70 %
Rhyolite	>70 %

Table 5.3 Classification of volcanic rocks in Mandalawangi based on its silica content.

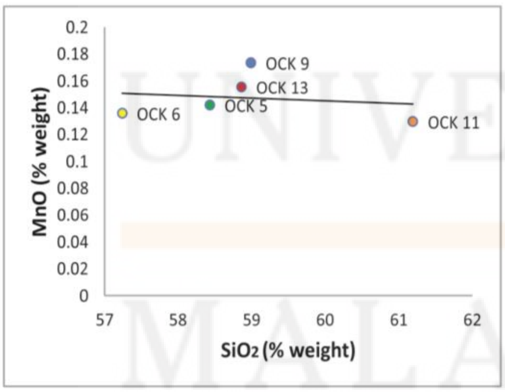
Sample	Silica content, SiO_2 (%)	Name of rock
OCK 5	58.43	Andesite
OCK 6	57.24	Andesite
OCK 9	58.99	Andesite
OCK 11	61.19	Andesite
OCK 13	58.86	Andesite

Based on Table 5.3, all of the samples show the same result which is Andesite rock. This is because, all of the samples has the silica content in the range of 57.24 % to 61.19% which in the range of Andesite rock. However, the sample of OCK 11 has a different result compared to using TAS diagram in Figure 5.25 and Figure 5.26. The difference may be occur because of the value of silica content used as in TAS diagram, normalized value are used while in Table 5.1 raw data value was used. TAS diagram is more accurate as the normalized values helped in remove the loss during ignition of the samples.

5.3.4 Harker Diagram of Major Elements

The Figure 5.26 shows the result of geochemical analysis of samples from the study area being plotted on Harker diagram. It is a diagram that shows variation in the amount of each element compared to the amount of SiO2. SiO_2 and MgO content are usually forming a horizontal axis because this compound can act as informative indicators in describing the evolution of magma. It is commonly used in investigating the sequence of crystallization of minerals during the cooling of an igneous magma. Different oxide elements indicate different types of minerals crystallize first.

SiO_2 content was used as horizontal axis because all of the samples from the study area are andesite rock. So, SiO_2 content show more variation compare to MgO content. Different types of oxides on the vertical axis will indicate different types of minerals that initiate the crystallization process.



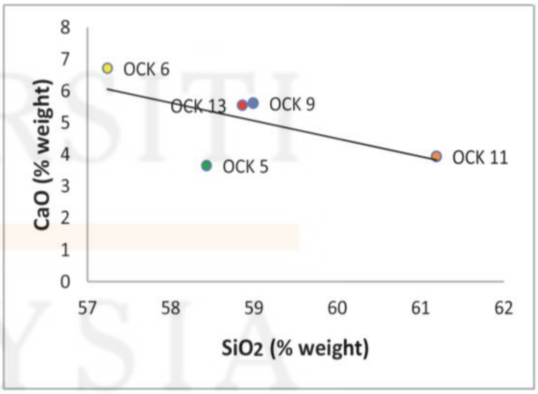


Figure 5.26 (a): Harker Diagram of major elements against SiO_2 of Andesite in Mandalawangi.

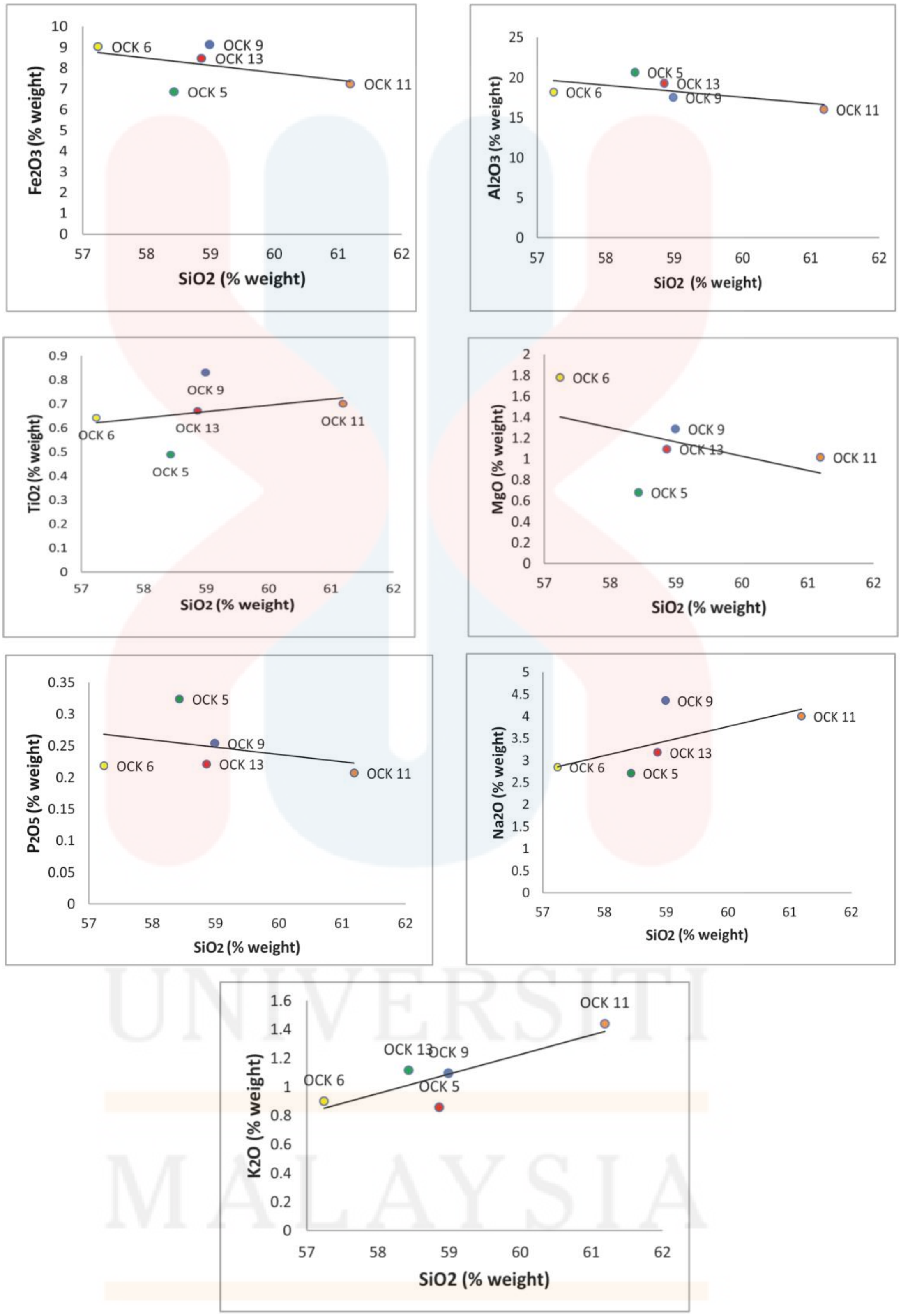


Figure 5.26 (b): Harker Diagram of major elements against SiO_2 of Andesite in Mandalawangi.

Based on Figure 5.27 the graphs shows negative linear trends with correlation between Cao, P_2O_5, MnO, MgO, Al_2O_3, Fe_2O_3 and the graphs shows the positive linear trends with correlation between Na_2O, TiO_2 and K_2O. K_2O graph shows increasing linear trend with increasing silica as potassium (K) is an incompatible element and available in plagioclase, thus it has no other crystal tied to it.

CaO graph shows decreasing linear trend as Ca is bind in plagioclase, and it decreased due to the plagioclase and pyroxene separation. MgO graph also shows a negative linear because Mg decreases due to the fractionation of Mg mineral as a result of pyroxene crystallization. Al_2O_3 and CaO graphs also show decreasing linear trend as an indicator of plagioclase and amphibole separation, as both Al and Ca elements are bind with both minerals plagioclase and amphibole. FeO graph shows decreasing because of the separation of amphibole and pyroxene minerals.

Based on the Harker diagram and interpretation above, all of these samples fall on the trends and showing the correct trends for andesite magma series which are trends of Al_2O_3, CaO and MgO showing the decreasing trends while trends of Na_2O and K_2O showing the increasing trends. These trends follow the crystallization order of Bowen's reaction series as shown in Figure 5.27.

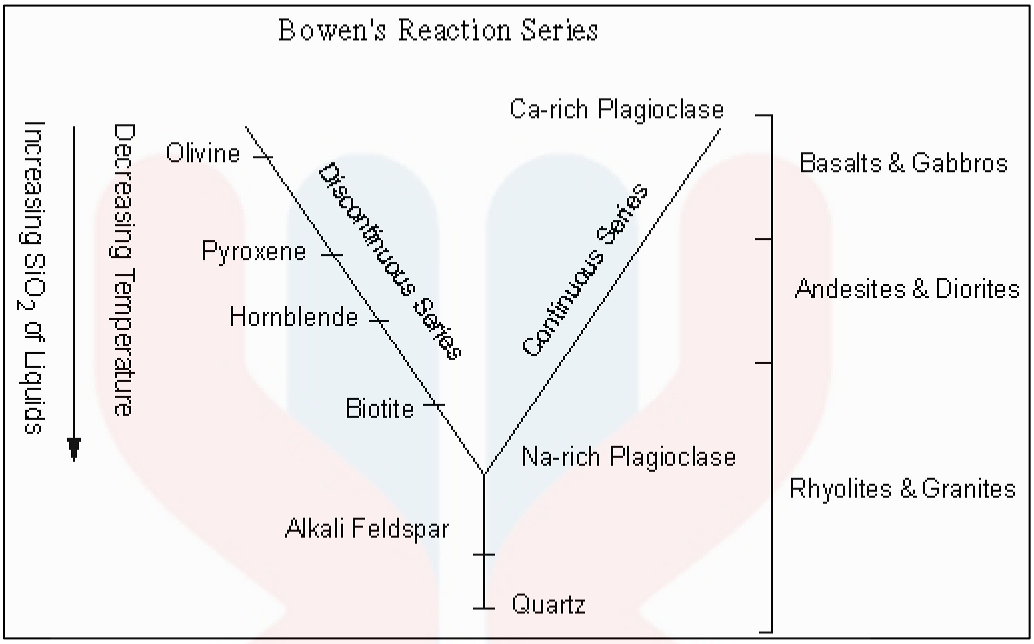


Figure 5.27: Bowen's Reaction Series.

5.3.5 Classification of Magmatic Series

Harker diagram proved that all of these samples are related to each other and is coming from the same magma sources and magma series. So, to determine the magmatic series of the samples of study area, Mandalawangi, binary classification diagram are used to compare the results. Peccerillo & Taylor (1976) diagram is the most common diagram used to classify the magmatic series. The diagram used value of potassium content K_2O and silica content SiO_2. The result is shown in Figure 5.29.

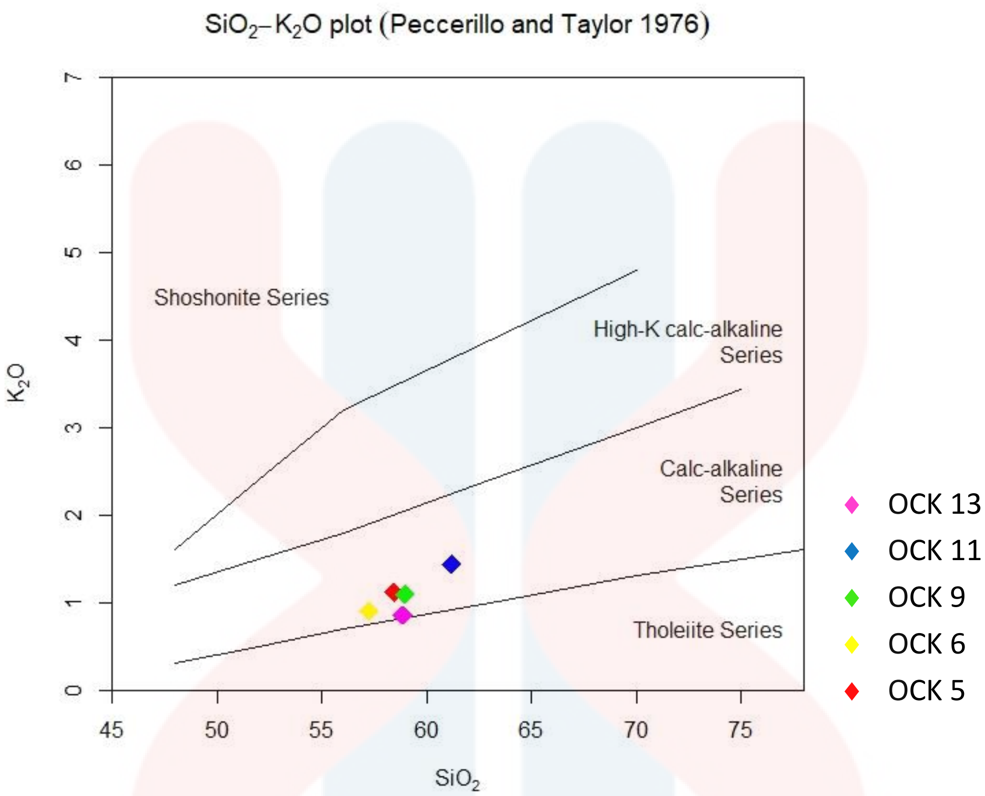


Figure 5.28: Classification of magmatic series based on Peccerillo and Taylor (1976).

Based on Figure 5.29 all of the samples were being classified into same magmatic series which is calc – alkaline series. Thus, it proved that all of these samples are related to each other in terms of magmatic evolution even though the magma was coming from different volcano and different time of eruption.

CHAPTER 6

CONCLUSION

6.1 Conclusion

This chapter concludes the results that obtain from the research of Geology and Petrographic Analysis of Volcanic Product in Mandalawangi, Pandeglang Regency, Banten. The geological map of Mandalawangi with the scale of 1:25,000 was produced. The data of geology of the study area such as structural geology, lithology, geomorphology and stratigraphy were obtained from the field observation, literature review and secondary data which are satellite imaginary. For the specification part, volcanic product from the study area had been studied by using petrographic analysis and geochemistry analysis.

From the geological map that was produced, Mandalawangi area was composed of two lithology unit which are Tuff unit and Andesite unit. However, the Andesite unit was differentiated into three different units due to its different eruption time and also coming from the different volcano. The geomorphology of the study area was classified into one geomorphology unit which is volcanic geomorphology unit. The study area has the elevation of about 300 to 600 meters and being classified in steep hill to mountainous unit. Only one types of drainage pattern in the study area which is dendritic drainage pattern. This is because, the study area composed of the homogenous lithology which is andesite rock unit. For the structural geology, no any structure had been found. This is due to the volcanism activity that was occurred and covered the surface of the study area.

For the specification, from the result and interpretation of petrographic analysis and geochemistry analysis by using Harker diagram and TAS diagram (Le Maitre et al, 2002), all of the samples were classified into Andesite rock unit. From the interpretation of Peccerillo and Taylor, (1976) diagram, it proved that the volcanic products of the study area were coming from the same magma sources and magma series which is calc-alkaline series. The differences of the mineral size occurred due to the different time of eruption. This research study is completed and all of the objectives were achieved.

6.2 Recommendation

This thesis can be used as references for the student or any researcher who want to study on petrographic analysis of the volcanic product. This research used two types of analysis method which is by using microscopic study and geochemistry analysis by using X-Ray Fluorescence analysis.

For further study in this particular field, another method of analysis can be used to compare the result and to make sure that the result is accurate. To achieve the better result, more samples need to be analysing by using geochemistry analysis. This will make sure that the result is accurate. The analysis of trace element can be done for better understanding in the magmatic evolution.

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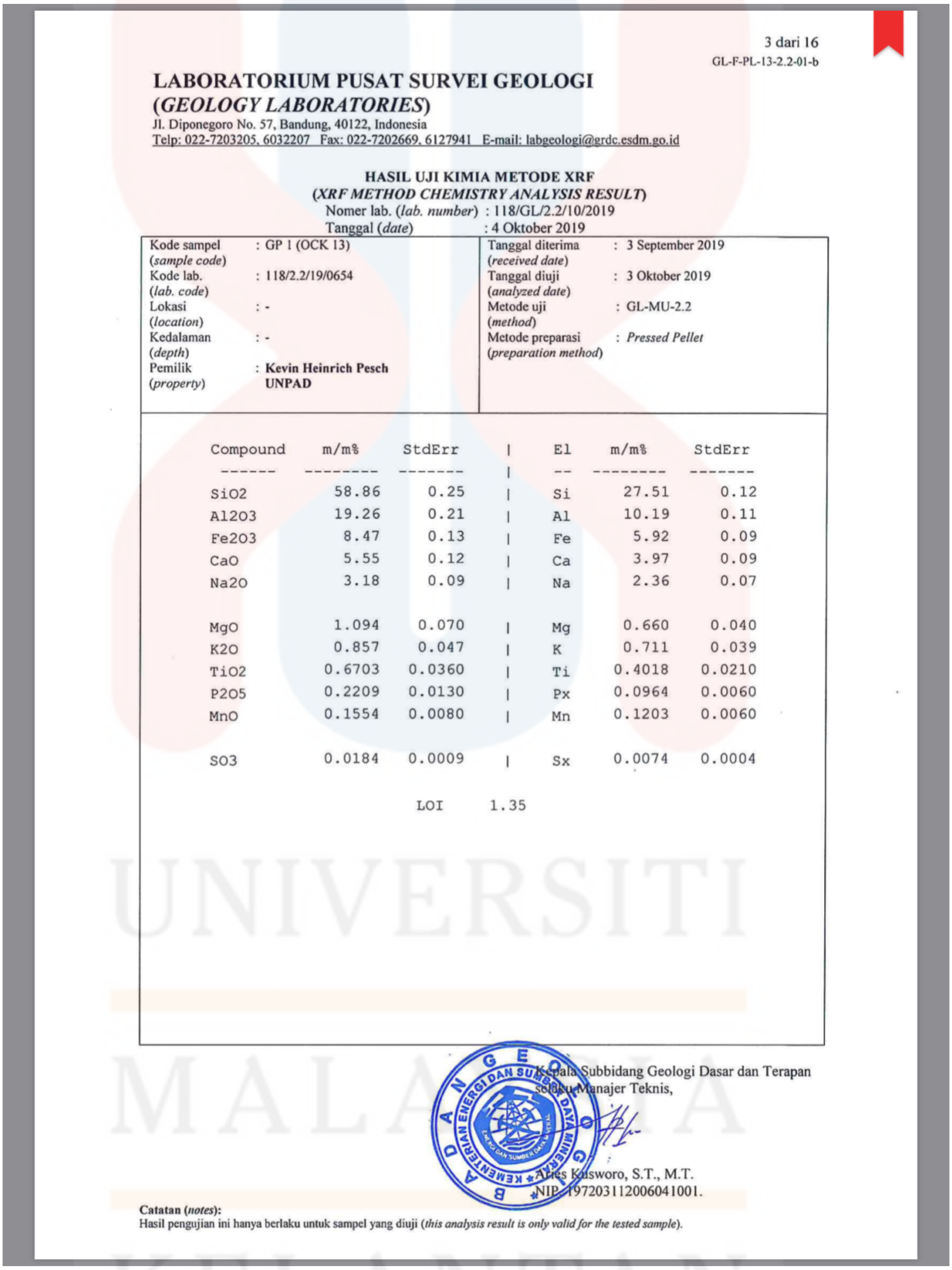
APPENDICES

Result of X-Ray Fluorescence (XRF) analysis.



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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 118/GL/2.2/10/2019
Tanggal (*date*) : 4 Oktober 2019

Kode sampel (*sample code*)	: GP 1 (OCK 13)	Tanggal diterima (*received date*)	: 3 September 2019
Kode lab. (*lab. code*)	: 118/2.2/19/0654	Tanggal diuji (*analyzed date*)	: 3 Oktober 2019
Lokasi (*location*)	: -	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Kevin Heinrich Pesch UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	58.86	0.25	Si	27.51	0.12
Al2O3	19.26	0.21	Al	10.19	0.11
Fe2O3	8.47	0.13	Fe	5.92	0.09
CaO	5.55	0.12	Ca	3.97	0.09
Na2O	3.18	0.09	Na	2.36	0.07
MgO	1.094	0.070	Mg	0.660	0.040
K2O	0.857	0.047	K	0.711	0.039
TiO2	0.6703	0.0360	Ti	0.4018	0.0210
P2O5	0.2209	0.0130	Px	0.0964	0.0060
MnO	0.1554	0.0080	Mn	0.1203	0.0060
SO3	0.0184	0.0009	Sx	0.0074	0.0004

LOI 1.35

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selaku Manajer Teknis,

Aries Kusworo, S.T., M.T.
NIP. 197203112006041001.

Catatan (*notes*):
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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 118/GL/2.2/10/2019
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Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Kevin Heinrich Pesch UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	58.43	0.25	Si	27.32	0.12
Al2O3	20.63	0.21	Al	10.92	0.11
Fe2O3	6.86	0.12	Fe	4.80	0.08
CaO	3.65	0.10	Ca	2.61	0.07
Na2O	2.71	0.08	Na	2.01	0.06
K2O	1.115	0.060	K	0.926	0.050
MgO	0.680	0.050	Mg	0.410	0.032
TiO2	0.4884	0.0260	Ti	0.2928	0.0160
P2O5	0.3237	0.0190	Px	0.1413	0.0080
MnO	0.1420	0.0070	Mn	0.1100	0.0060
SO3	0.0146	0.0008	Sx	0.0058	0.0003

LOI 4.67

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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
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Tanggal (*date*) : 4 Oktober 2019

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Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Kevin Heinrich Pesch UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	61.19	0.25	Si	28.60	0.12
Al2O3	16.02	0.19	Al	8.48	0.10
Fe2O3	7.24	0.12	Fe	5.07	0.08
CaO	3.94	0.10	Ca	2.82	0.07
Na2O	4.00	0.10	Na	2.97	0.07
MgO	1.017	0.070	Mg	0.614	0.040
K2O	1.439	0.060	K	1.195	0.050
TiO2	0.7000	0.0380	Ti	0.4196	0.0230
P2O5	0.2070	0.0120	Px	0.0903	0.0050
MnO	0.1297	0.0070	Mn	0.1004	0.0050
SO3	0.0081	0.0006	Sx	0.0032	0.0003

LOI 3.81

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selaku Manajer Teknis,

Ahes Kusworo, S.T., M.T.
NIP 197203112006041001.

Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 118/GL/2.2/10/2019
Tanggal (*date*) : 4 Oktober 2019

Kode sampel (*sample code*)	: GA 1 (OCK 9)	Tanggal diterima (*received date*)	: 3 September 2019
Kode lab. (*lab. code*)	: 118/2.2/19/0657	Tanggal diuji (*analyzed date*)	: 3 Oktober 2019
Lokasi (*location*)	: -	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Kevin Heinrich Pesch UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	58.99	0.25	Si	27.58	0.12
Al2O3	17.52	0.20	Al	9.27	0.11
Fe2O3	9.13	0.13	Fe	6.39	0.09
CaO	5.61	0.12	Ca	4.01	0.09
Na2O	4.35	0.10	Na	3.23	0.08
MgO	1.287	0.070	Mg	0.776	0.040
K2O	1.095	0.050	K	0.909	0.050
TiO2	0.8297	0.0440	Ti	0.4974	0.0270
P2O5	0.2536	0.0150	Px	0.1107	0.0070
MnO	0.1733	0.0090	Mn	0.1342	0.0070
SO3	0.0086	0.0007	Sx	0.0034	0.0003

LOI 0.4

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

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Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).

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HASIL UJI KIMIA METODE XRF
(*XRF METHOD CHEMISTRY ANALYSIS RESULT*)
Nomer lab. (*lab. number*) : 118/GL/2.2/10/2019
Tanggal (*date*) : 4 Oktober 2019

Kode sampel (*sample code*)	: GA2 (OCK 6)	Tanggal diterima (*received date*)	: 3 September 2019
Kode lab. (*lab. code*)	: 118/2.2/19/0653	Tanggal diuji (*analyzed date*)	: 3 Oktober 2019
Lokasi (*location*)	: -	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Kevin Heinrich Pesch UNPAD**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	57.24	0.25	Si	26.76	0.12
Al2O3	18.17	0.20	Al	9.62	0.11
Fe2O3	9.04	0.13	Fe	6.32	0.09
CaO	6.71	0.13	Ca	4.79	0.09
MgO	1.78	0.09	Mg	1.07	0.05
Na2O	2.844	0.080	Na	2.110	0.060
K2O	0.900	0.050	K	0.747	0.041
TiO2	0.6413	0.0340	Ti	0.3845	0.0200
P2O5	0.2184	0.0130	Px	0.0953	0.0060
MnO	0.1358	0.0070	Mn	0.1052	0.0050
SO3	0.0450	0.0022	Sx	0.0180	0.0009

LOI 1.94

Kepala Subbidang Geologi Dasar dan Terapan
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Catatan (*notes*):
Hasil pengujian ini hanya berlaku untuk sampel yang diuji (*this analysis result is only valid for the tested sample*).