GEOLOGY AND GEOCHEMISTRY OF TOPSOIL IN NGALANG, GUNUNGKIDUL REGENCY, YOGYAKARTA, INDONESIA

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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DECLARATION

I declare that this thesis entitled **"GEOLOGY AND GEOCHEMISTRY OF TOPSOIL IN NGALANG, GUNUNGKIDUL REGENCY, YOGYAKARTA, INDONESIA"** is the results of my own research except as cited in the references. The thesis has not been accepted for any degree and not currently submitted in candidate of any other degree.

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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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Geology and Geochemistry of Topsoil in Ngalang, Gunungkidul Regency, Yogyakarta, Indonesia.

ABSTRACT

Geographically Ngalang was located in coordinate S 7°52’07.3”, S 7°52’48.25 in longitude and E 110° 34’ 33.50” , E 110° 35’ 15.0” in latitude. Ngalang area located Gunungkidul Regency comprise of varies unique geomorphology and geological value in its area. A geological map with larger scale; 1:25 000 had been produced through geological mapping activities process. The drainage pattern of Ngalang was decorated with dendritic and rectangular drainage pattern that fits into flat landscape and escarpment valley of its area. Lithologies of Ngalang area were grouped into four formations with different unique identities such as Bouma sequence and trace fossil (bioturbation). Four formation of this area made up of Semilir formation with of tuffaceous unit, overlies by volcanic lava and breccia unit of Nglanggeran formation, comformably overlies by intercalation of Sambipitu formation sandstone and clay unit and also carbonate sandstone with limestone characteristics in Oyo formation. Besides, interfingering area of Sambipitu and Nglanggeran was identified by conducted geological and grid mapping activities. Then, grid soil map was produced and sampling location was chosen. Topsoil in selected location was collected for geochemical analysis of topsoil and analysed by using X-Ray Fluorescence. The major element detected in the topsoil samples of the contact area was Si, Al, Fe, Ti, Mg, Ca, Mn, K, Na and P.

Keywords – Bouma sequence, Geochemistry of topsoil, Ngalang, Nglanggeran Sambipitu

Geologi dan Geokimia Permukaan Tanah di Ngalang, Gunungkidul, Yogyakarta, Indonesia.

ABSTRAK

Secara geografi, Ngalang terletak di koordinat S 7°52’07.3”, S 7°52’48.25 di longitud dan T 110° 34’ 33.50”, T 110° 35’ 15.0” di latitud. Ngalang terletak di daerah Gunungkidul mengandungi beberapa ciri geomorfologi unik dan ciri geologi di kawasannya. Peta geologi dengan skala 1:25 000 telah dihasilkan menerusi aktiviti pemetaan geologi. Pola saliran di Desa Ngalang membentuk jejari dan bersudut 90° yang melengkapi geomorfologi di kawasan itu seperti kawasan yang rata, bukit beralun dan lembah. Litologi di desa Ngalang terbahagi kepada empat formasi dengan kepelbagaian ciri unik seperti siri bouma dan fossil jejak (bioturbidasi) Empat formasi di kawasan ini terdiri oleh Semilir berkomposisi unit tuff, breksi dan unit volkanik dari formasi Nglanggeran, perselingan batupasir dan batu lempung dari formasi Sambipitu serta unit batuan karbonat dari Formasi Oyo. Selain itu, identifikasi kawasan perselingan antara formasi Sambipitu dan formasi Nglanggeran telah dilakukan dengan kegiatan pemetaan geologi dan pemetaan grid. Hasil dari pengolahan data lapangan telah menghasilkan peta grid tanah. Beberapa kawasan telah dipilih untuk diambil sampel tanah. Analisa geokimia oleh Spektrometri Pendafluor X-ray (XRF) telah dilakukan kepada sampel tanah permukaan yang terpilih. Unsur utama yang dianalisa ialah Si, Al, Fe, Ti, Mg, Ca, Mn, K, Na and P di kawasan perselingan.

Kata Kunci – Geokimia permukaan tanah, Ngalang, Nglanggeran Sambipitu, Siri Bouma

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LIST OF ABBREVIATION

As	Arsenic
Ca	Calcium
Cr	Chromium
Cu	Copper
Fe	Ferum (Iron)
Hg	Mercury
K	Potassium
Mn	Manganese
Mg	Magnesium
Ni	Nickel
P	Phosphorus
Pb	Plumbum (Lead)
Rb	Rubium
Sc	Scandium
Sr	Strontium
V	Vanadium
Zn	Zinc
XRF	X-Ray Fluoresnce
cm	Centimetre
Mg/kg	Milligram/gram
km	Kilometres
m	Metres

LIST OF SYMBOLS

°C	Temperature (Degree Celcius)
%	Percentage
x	Multiply

CHAPTER 1

INTRODUCTION

1.1 General Background

Geology and geochemistry of topsoil in Ngalang, Gedangsari at Gunung Kidul region, Yogyakarta were discussed in this study. This study were conducted in 25 km^2 of Ngalang area by entailed the knowledge of geological information such as structural geology, geomorphology and others. Besides, from geological mapping activities and analysis produced from laboratories.

Geology is an understanding about the Earth, how it was formed and the secret of geological feature lies beneath every detail of the Earth element. Geological information can be obtained by conducting geological mapping. This knowledge need to be discovered by future geologist in order to have updated geological information for future research. From this geological activities, history of Earth plate movement can be discovered.

Eurasian (Sunda Plate) and Australian (Sahul Shelf) plate produced current landscape of Indonesia. Besides, Indonesia also situated between two oceanic plate; Pacific Plate and Philippine Sea Plate which caused the understanding of the tectonic activities at Indonesia became very complex. The geology of Indonesia on this present-day is the result from subduction and collision during Cenozoic. The slab subducted between east Indonesia and Sumatra in Cenozoic aged Cretaceous or older.

The previous and ongoing tectonics activities produced present geology in Indonesia especially in Ngalang area that shows important value in structural geology. Ngalang area is situated at district (kecamatan) Gedangsari in the Gunung Kidul regency. The Ngalang area studied in this research includes four geological formation; Semilir formation, Nglanggeran formation, Sambipitu formation and Oyo formation. This formation entailed different lithologies and geological information in the study area.

The study of geological and geochemistry of topsoil in the study area produced geological map with a scale of 1:25 000 which covers all the geological aspects such as geomorphology, structural geology, lithologies, and stratigraphically by conducting geological mapping work for 1 month in Ngalang area.

Geochemistry of topsoil in Ngalang were analysed by X-Ray Fluorescence. The results of topsoil geochemical analysis produced different chemical content between Nglanggeran and Sambipitu formation. Hence, the understanding of these geochemical analysis will helps in agricultural activities of Ngalang citizens.

1.2 Study Area

Yogyakarta part of Southern part of the Central of the Java Island in Indonesia. This city divided into five regency (kabupaten) which includes Sleman, Kulonprogo, Gunung Kidul, Yogyakarta city and Bantul regency.

Study area of this research was located at Ngalang area in Gunung Kidul regency, Central Java Yogyakarta. Ngalang is a part of Gunung Kidul regency. This area is bordered by Desa Nglegi, Desa Patuk on the west, Desa Pengkol and Desa Nglipar on east, Desa Hargomulyo and Desa Gedangsari on the northern and also Desa Gading, Desa Playen on the east side.

Within 25 km^2 with 5km x 5km wide of study area in Ngalang, this area made up of very interesting geological features which shows unique igneous and sedimentary rock geomorphology, active and complex structural produced by tectonic activities, and others geological values since it was made up from different lithologies of different depositional environment.

Ngalang area is famous for its agriculture activities such as cultivating paddy fields and others agricultural sectors. The villagers in Ngalang area were depends on agricultural activities as their main economy sector. This study have good accessibility since it have a lot of paved and unpaved road.

1.2.1 Accessibility

Ngalang was situated 38.1 km away from the centre of Yogyakarta, Indonesia which needs 1 hour and 18 minutes by car through the main route through Bukit Bintang road. From Figure 1.1, shows alternative route from Yogyakarta city to Ngalang area by using alternatives and main road. The routes take about 40 minutes away from Yogyakarta city. Both these alternatives and main road can be accessed by many other vehicles such as motorcycle, van, car and lorry.

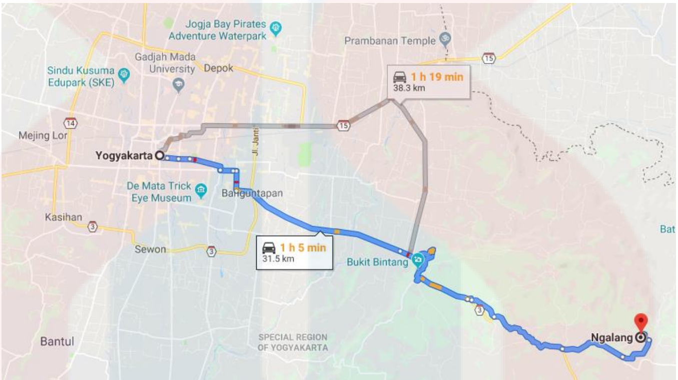


Figure 1.1: Alternative route from Yogyakarta city to Ngalang, Gedangsari.

Although Ngalang is a part of rural area, there are still bus that operating from Gunungkidul to the Yogyakarta City. This bus operating from Sambipitu area until Yogyakarta. In Ngalang area, the accessibility of the study area also good since there are many accessible road around the study area even for cars and other transportation. There are many paved and unpaved roads in the study area. Besides, most of the part of the Ngalang area were used for human activities such as agriculture, industrial, economy and also tourism activities. Hence, most of the area accessible due to human activities.

1.2.2 Demography

The population of Indonesia is estimated to be 269, 107, 063 and still increasing from the year 2000-2019 according to Worldometer (2019) as shown from Figure 1.2. Indonesia ranks number 4 for countries with a lot of population. Indonesian have median age about 28.3 years. This country has relatively young population.

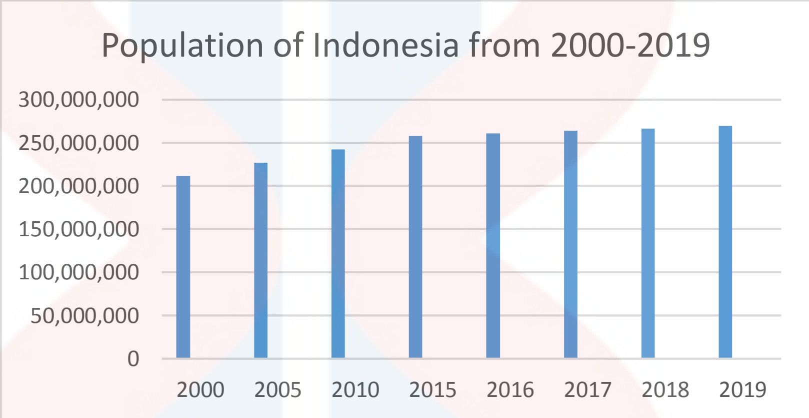


Figure 1.2: Population of Indonesia from 2000-2019 (Source: Worldometers, 2019)

While in Yogyakarta, it was reported that during 2010 that the population in Yogyakarta was 3,452, 390. Badan Pusat Statistic, Indonesia reported that the population of Indonesia decrease once every decade.

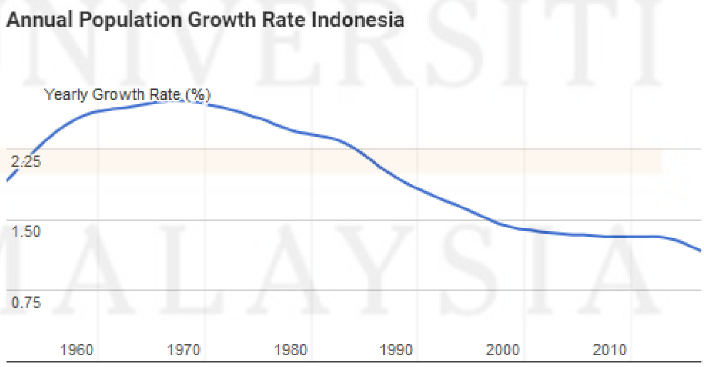


Figure 1.3 : Annual population growth rate Indonesia (Badan Pusat Statistic, Indonesia)

Indonesia has the largest Muslim population with almost 87% Indonesians declared as Muslims. The other 10% population was Christian, 2% were Hindus and others 1% were with other faiths. The majority of population are Javanese and there are a lot of Indonesia ethnic groups that are living in Yogyakarta. Besides, Yogyakarta have tropical monsoon climate which dry during August, hottest month during April and wettest during January. The climate in Yogyakarta influenced by monsoon and have temperature roughly from 26 to 27 Celsius.

The topography of Ngalang was made up of an average elevation at 100 m from the sea level. Besides, Ngalang had average rainfall of 7.8 mm which made this area be a part of tropical monsoon rainforest. Basically, it had an average number of rainy days about 85 days per year which made the area really dry. However of the rainfalls occur during December to February each year and drought season during June to November.

1.2.3 Land Use

Ngalang area situated at the centre of Gunungkidul regency, Yogyakarta is a non-urbanized area that makes agriculture as the main land use and economic purpose. There are almost 100 000 people living in this province. Most of their house are located very close to each other. This non-urbanized area people normally focused on farming, husbandry and forestry sector. The locals produced paddy, maize, banana and mango as the main source of economic income. Agricultural sector of this area are the main contributor to economy value in Indonesia. Ngalang is rural area. Most of the citizens in this area are cultivating paddy to increase social economics activity of Ngalang area.

1.2.4 Social Economics

Yogyakarta which also known as Special region of Yogyakarta It is the only royal city in Indonesia that ruled by monarchy system until today. The city famous for its agriculture, industrial, cultures and fine arts such as batik textiles, music poetry, and wayang puppetry. Social economics in Ngalang also practice the same as Yogyakarta city.

The city also a centre for the education system and have dozens of universities and schools. These universities includes public sectors such as Gadjah Mada University, Yogyakarta State University, Sunan Kalijaga State Islamic University and Indonesia Arts Institute. While for private sectors there are Muhammadiyah University of Yogyakarta, Atma Jaya University, Sanata Dharma University and Islamic University of Indonesia.

1.3 Problem Statement

The latest updated geological map in Ngalang area was updated on 2018 with a scale 1:50 000. However, the map still has not been publish. Hence a detailed geological map with 1:25 000 have been updated in order to show details information about Ngalang area. The geological mapping was conducted in order to update new geological information in terms of regional geology, geomorphology, lithology and structural geology.

Ngalang is an area which famous with agricultural activities among its citizens as the main source of income. However, different distribution of formation of Nglanggeran and Sambipitu in Ngalang produced a great different vegetation on its area. These soil will be producing different nourishment to the vegetation in both agricultural area. Hence a detailed studies between these types of soil will be greatly helpful for the citizens in the Ngalang area.

Besides, according to Surono (2009) Nglanggeran and Sambipitu were interfingering to each other. However, the interfingering area of Nglanggeran and Sambipitu formation cannot be identify clearly. Hence, geochemical studies of topsoil will be very helpful in geochemistry analysis to identify the contact area.

1.4 Objectives

I. To update the geological map of Ngalang area with a scale of 1: 25 000.
II. To investigate the elemental distribution of topsoil of Ngelanggeran and Sambipitu formation by using X-Ray Fluorescence (XRF)
III. To identify contact area of Ngelanggeran and Sambipitu formation.

1.5 Scope of Study

Geological mapping had been conducted by using geological field equipment such as GPS, hammer, and compass in order to collect geological information. Traversing in the Ngalang area have been done for 6 days. All the geological features such as lithologies, geomorphology and structural geology were covered during geological mapping. Strike and dip measurement also had been taken and interpreted in order to understand the movement of plate tectonic movement in the Ngalang area.

During geological mapping, 12 rock samples have been collected according to outcrop found during the geological mapping. The best rock samples collected had been undergoing thin section and also analysed under microscope by using 10x magnification during petrographic analysis. With all the geological information collected including petrographic analysis including the lithologies of rock, geomorphology, structural geology analysis, geological map with a scale 1: 25 000 had been produced.

In geochemical study, the best 3 soil samples have been taken from 2 different lithologies; Nglanggeran and Sambipitu. The detailed mapping in soil sampling area had been done by using grid mapping technique. The grid mapping was done in smaller scale (500 m x 500 m) focused at interfingering area. This laboratory analysis used to identify the element distribution of topsoil such as Si, Al, Fe, Ti, Mg, Ca, Mn, K and Phosphorus/. Chosen instrument was X-ray Fluorescence since it can screen the major element distribution in the topsoil. Then, interpretation from both results had been discussed in order to determine the chemical element distribution in the study area and be written in the report.

1.6 Significant of Study

This study is beneficial in updating the geological map of the Ngalang area, Gunungkidul since it is outdated for detailed scale, 1:25 000. Identifying geological information such as geomorphology, structural geology, petrographic analysis and lithology of this study area entailed the features and characteristics that will be useful for other researchers as a reference in the future.

This geological information is very beneficial since it will show the structural such as joint and fracture location. This structural information is very important in determining the distribution of resources such as groundwater and petroleum. Prediction of geohazard such as landslides and earthquake that will happen also can be predicted by using this geological information. This geological information is also very useful as base information for construction.

Using geological information as base information is very useful since it will help avoid hazards such as building collapse which helps in saving peoples from injuries and also fatal. The lithology information will give information in the distribution of rocks, its depositional environment, its origin and the age of the rocks can be revealed.

Besides, the data gathered from the analysis of geochemistry can help in improving agriculture sector in Ngalang area for farmers. Determination sources of element distribution leads to soil contamination determination in that area which can be useful to determine area which are suitable and not suitable for agriculture purpose.

Determination of soil contamination from agriculture activities will create awareness for the society in preventing soil contamination. Moreover, this study can also be useful for educational purpose especially for other researcher to have more updated geological information of Ngalang area. The data collected throughout this research also be useful for other researchers such as geoscientist and university student. Since Ngalang area was very unique, it can be nominated as geological site.

Lastly, Gunungkidul Regency also well known for its mineral resources. Hence this geochemical analysis will not only useful for villagers, but also exploration of mineral in exploitation of mineral resources.

CHAPTER 2

LITERATURE REVIEW

2.1 General Geology

Indonesia lies in the Ring of Fire Pacific which is known as highly unstable and also complex region because it is located at the southern edge of the Eurasian continent. Indonesia is bordered by active zones tectonic due to subduction event during Cenozoic (Hall, 2009). However, there are more arc, ophilitic crust and several young ocean basins in Eastern Indonesia while in the Western it is mostly underlain by continental crust.

This happened due to Pacific plate and Indo –Australia continent plate was pushing below the Eurasian continent plate. The Cenozoic subduction and collision create geology of Indonesia in these present days. Due to this, a lot of evidence from this event that can be correlated with tectonic elements.

2.2 REGIONAL GEOLOGY AND TECTONIC SETTING

Indonesia is known as a very wide archipelago with 18 000 islands spreading about 5000 km from East to West (Hall, 2009). This archipelago is situated at three major continents; India-Australia, Pacific-Phillippine Sea and Eurasia.The background of argumentation of Yogyakarta by researchers has said that its present formation is the results from uplift of the Southern mountains and Kulon Progo Mountain during early Pleistocene.

Besides, Sudarno (1997) claimed the Yogyakarta region experienced tectonic compression which results in the transform and uplifting which have been proved by Hall (2009) in Figure 2.1. This uplifting also results in Yogyakarta Basin which leads to the development of Merapi volcano. Hence, the lithology of this area is known to be paleo-valley (Mulyaningsih, *et al*., 2006).

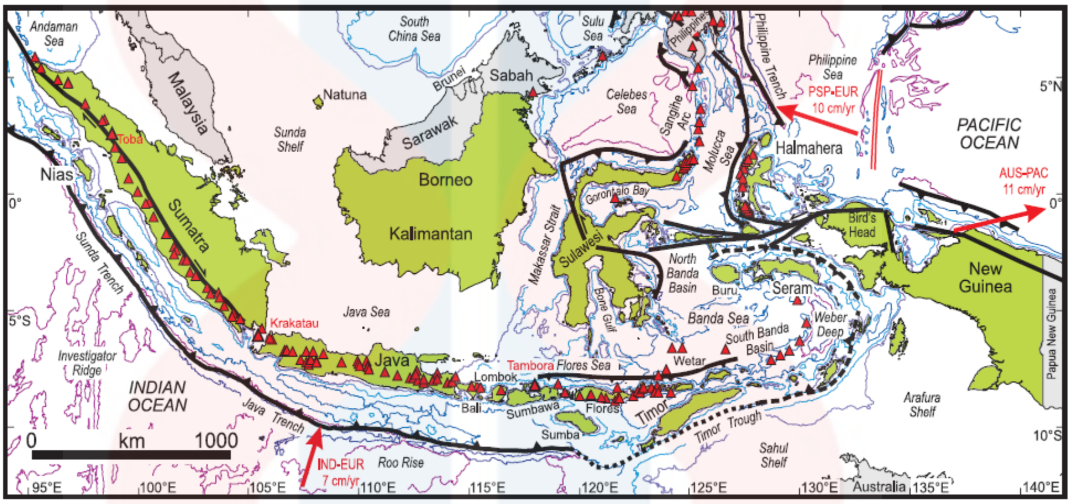


Figure 2.1: Geography of Indonesia (Hall, 2009).

Furthermore, this tectonic movement also gives result in normal and graben fault. It was formed from rock assemblages which associated with the tectonic setting of active plate margin convergent. This region is situated in the south-eastern part of Central Java, Indonesia.

2.3 Stratigraphy

2.3.1 Semilir Formation

Semilir formation was the results from a volcanic eruption during the early Miocene. This geological age was reported based on fossil track by Surono (2008). This formation overlies to the Kebo-butaks Formation at the western part and underlies Nglanggeran Formation. However, Van Bemmelen (1949) said that Semilir formation was underlying Kebo-Butaks with comformity and unconformity at different area.

Meanwhile, Surono *et al*. (1992) argued that the Semilir formation was interfingering with Nglanggeran formation and Sambipitu formation. Besides, it was also unconformity overlying to Oyo formation. This formation composed of volcanic origin material which has massive and thick characteristics. Hence the formation of Semilir might associated with the explosion of caldera (Bronto & Hartono, 2008). However, in University Gajah Mada had wrote that all of the formation was interfingering with each other as shown in Figure 2.2.

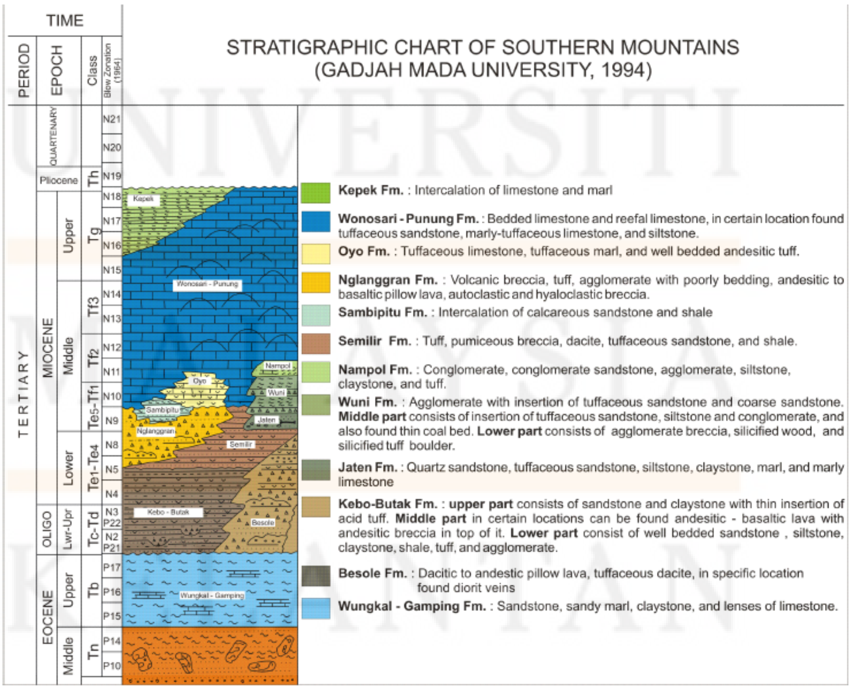


Figure 2.2: General Stratigraphy of Southern Mountain, Yogyakarta. (UGM, 1994)

2.3.2 Nglanggeran Formation

Volcanic activity during reformation of Nglanggeran was happened during Early Miocene-Middle Miocene. The formation was made up of volcanic breccia, agglomerate, tuff, lava basalt and andesite lava (Surono *et al.*, 1992). From Yudiantoro *et al*. on 2016 stated that, Nglanggeran formation composed 3 member of rock which are member of basalt Parangkusumo, Lava andesite member and pyroclastic flow member.

2.3.3 Sambipitu Formation

Sambipitu formation located at Desa Sambipitu at Yogyakarta-Patuk-Wonosari highway. The lithology of Sambipitu formation is made up of tuffaceous sandstone and became coarser sandstone upward that interbedded with mudstone and claystone. At the lower part of Sambipitu formation do not have large content of carbonate while the upper part, the sandstone have high content of carbonate. Besides, this formation also have a slumping structure that became a hint that this formation is deposited by turbidite on proximal turbidite.

Pandita (2008) revealed that volcanic activity during Middle Miocene decreasing and deposited at Sambipitu formation. Hence this formation mostly have turbidation characteristics with intercalation of tuffaceous sandstone ans sandstone. Besides there was also trace fossil in this formation that deposited between lower bathyal and expanding toward upper neritic zone.

2.3.4 Oyo Formation

Oyo formation was deposited in shallow marine during late Miocene (Pandita *et al*, 2009). Pandita *et.al.* also stated that this formation was made up limestone, tuffaceous sandstone and wackestone. Lauti *et al* (2007) stated that Oyo formation was uncomformably ovederlying Sambipitu formation. Besides, Surono *et al* (1992) stated that Oyo formation was deposited in upper bathyal zone due to its rich ichnofossil finding.

2.4 Structural Geology

Yogyakarta region is located at the south-eastern part of Central Java, Indonesia. This province bordered by two parallel faults in the east and west formed an elongated northeast-southwest-trending central of depression. There are three parts of faulting area, includes western, eastern and central part (Barianto *et al*., 2010).

2.5 Historical Geology

During Quartenary period, all submarine caldera-forming resulting from volcanic edifice were accompanied by tsunamis that effect the Sumatra and Java (Maeno & Imamura, 2011). Peripheral of Jiwo Hills such as G. Wungkal, G. Kampak, G. Lanang and G. Jeto were seperated by the alluvium which deposited by ancient river and lake (Hussein & Novian, 2014) forming Ngalang situated at Southern Mountain.

This mountains was divided into three different volcanism period; pre volcanism, sync-volcanism and post volcanism period (Surono & Asep, 2009). Ngalang area experienced volcanism activities (Mulyaningsih, 2015). Volcanism activities were reveled by effect on geology of Jiwo plays important roll, formed gabbro, diorite intrusion and basalting lavas (Bronto *et al*., 2002). This explosive are caused by the accumulation of energy in magma chamber known as "caldera forming eruption" (Mulyaningsih, 2015).

2.6 Geochemistry of Topsoil

2.6.1 Geochemistry

Geochemistry is a field that explains the geological system by using chemistry principles. It also can be defined as the process which controls the composition, abundance, distribution of chemical compounds and isotopes in geologic environments. Investigating soil geochemistry can always be done by considering different variables which include major, minor and trace element. Geochemical survey will discover different factors influencing different pattern in geology, climate and human influences.(De Vos et al.).

2.6.2 Topsoil

Soil is the result of the interaction of the rocks with the hydrosphere, atmosphere, and biosphere (Nagy, 2017). The soil is an intermediate phase which shown thermodynamically process that changed a rock into stable species. The soil mostly has abundance of silicates, oxides, sulphides, sulphates, carbonates and chloride (Nagy, 2017).

In the soil horizons, topsoil is the upper part of the outer layer of the soil horizon which can be measured about two to eight inches. This layer has the highest concentration abiotic and biotic part. The effect of anthropogenic activities causes topsoil content to be variable (Buccianti *et al.*, 2015). Many soil sampling has been taken in between 10-20 cm in depth very shallow soils, it is the best part for sampling because it will give a less disturbed or contaminated clay-rich sample.

2.6.3 Element Distribution

Soil has a constituent of organic matter, mineral constituent, living organism, air and water (Moor, Lymberopoulou, & Dietrich, 2001). Element distribution in topsoil determined by parent material, migration of element and leaching. The distribution of these elements determines pattern which has relationship with geology and mineralisation.

From FAO Soils Bulletin in Table 2.1, some researcher workers have divided soils into three groups; Primary (major nutrients), Secondary (elements or nutrients) and trace element.

Table 2.1: Division of soil composition by FAO Soils Bulletin.

Primary Major nutrient	Nitrogen, potassium and phosphorus which are needed in large amount and usually applied to the soil as mineral fertilisers
Secondary Elements or nutrient	Calcium, Magnesium, Sulphur and Silicon are abundance in soil and plants.
Trace Elements	Minor elements that only exist in small quantity for soil. Usually described in p.p.m. Some are essential by plants. However, there are some trace element that will be harmful to the animals and human.

2.6.3.1 Trace Element and Heavy Metal in Topsoil

Trace metal is engaged with land use activities but at low concentration. The emissions of rapidly expanding industrial, agricultural sector lead to the disposal of high metal waste and usage of pesticides and fertilizers. (Wuana & Okieimen, 2011). The spillage from these activities leads to alteration of atmospheric deposition.

By FAO Soils Bulletin, distribution of trace element in topsoil changes due to weathering and soil formation process. Most common heavy metal found is lead (Pb), copper (Cu), mercury (Hg) and arsenic (As). The poorest land should be used for human activities and the best land should benefits agriculture more (Legros, 2006).

Table 2.2: Standard ranges for heavy metal elements in soil (mg/kg)

Element	Acceptance Abundance Concentration (mg/kg)	Threshold Volume (mg/kg)	Permissible Value (mg/kg)
Copper (Cu)	$100^{(a)}$	$100^{(c)}$	$30^{(d)}$
Iron (Fe)	$44500^{(b)}$	NA	NA
Manganese (Mn)	$850^{(a)}$	NA	NA
Lead (Pb)	$300^{(a)}$	$60^{(c)}$	$85^{(d)}$
Zinc (Zn)	$20^{(a)}$	$200^{(c)}$	$50^{(d)}$
Cobalt (Co)	$40^{(a)}$	$20^{(c)}$	NA

Note:

"Oregon State University (OSU),2007^{b} Department of Environmental Malaysia (DOE), 2009^{c} World Health Organization (WHO), 2008, NA, Not Available.

2.6.4 Soil Contamination

Hamaker and Thompson (1972) claimed that soil as a complex mixture which can absorb pollutants. Most of the pollutants come from steel, copper and chemical manufacturing plants. This chemical even burnt from factories and industries and released to the atmosphere. This chemical is even non-biodegradable and causes accumulation in the soils.

This accumulation transmitted to other environmental components through various pathways and contaminating deep soils, dust particles or even groundwater (Chen *et al*., 1997). Natural activities and anthropogenic activities released chemical element (Khan et al., 2007 & Wilson and Pyatt, 2007). However, Senesi *et al*. (1999) claimed that this pollutant might results from other sources such as metal deposits and weathering.

2.6.5 Sources of Contamination in Topsoil

Contaminated soil contain substances that are risky towards biological and ecological. The content of soil either to be contaminated with heavy metal or trace element. This contamination may be coming from agriculture activities, volcanic ash or lead released from the vehicle (K.Kodom *et al*., 2012)

Agricultural activities that consume pesticides and fertilisers produce different element distribution to the topsoil. Besides, the resulting volcanic ash came from the eruption of Mount Merapi also can be dangerous which can result in crop failure, human illness, and animal death.

2.6.6 Effect from Contamination of Topsoil

Groundwater is an essential use for daily purpose in Yogyakarta. The citizens depend on shallow groundwater resources. However there are different land uses that increase the contamination of groundwater with nitrate and fecal coli bacteria (Souvannachith *et al.*, 2017). Besides from Karnawati *et al* (2006), subsurface water in Yogyakarta has been contaminated by entamuba-Coli, Magnesium, Iron and others. Content of nitrate in some of the water in the area also had exceed by the recommended limit (Anon, 1997).

From the recent studies by Souvannaachith and *et al.* in 2017, a combination of nitrate and vulnerability of groundwater it reveals potential map which showing the nitrate range from low to high class. Different classes have been found in settlement and irrigated rice field area.

2.6.7 Geochemical Technique and Analysis for Soil

Geochemical work generally includes sample collection, chemical analysis of samples and interpretation of analytical results. There are a few techniques to be used in the analysis for soil. For example X-Ray Fluorescence (XRF), Induced Coupled Plasma Mass Spectrometry (ICP-MS, Atomic Absorption Spectroscopy (AAS), and Fourier-transform infrared spectroscopy (FTIR). However, the chosen instrument that was used in this study was X-Ray Fluorescence (XRF).

2.6.7.1 X-Ray Fluorescence

2.6.7.1.1 Theory and Principle of X-Ray Fluorescence

X-ray fluorescence is an analytical instrument used to determine the elemental composition of the sample. This is the best method for qualitative and quantitative analysis of sample analysis composition. XRF mostly used for minor and trace element analysis. However it is also can be used to determine major element after going through proper dilution with starch or cellulose (IAEA, 1997).

Marlborough District Council wrote about the theory and some principle of XRF in September, 2013. X-ray fluorescence spectroscopy consume high energy photons (x-rays) to bombard an atom which excite electrons that orbiting the atom. Some of these photons can be ejected from energy which tightly bounded with the nucleus of atom. When electron ejected, an electron from high energy orbital will automatically transferred to lower energy orbit. This process known as fluorescence. Thus by the measurement gain from photons emitted, concentration of element in the soil and the element that emitting the photons can be determined by XRF as shown in Figure 2.3.

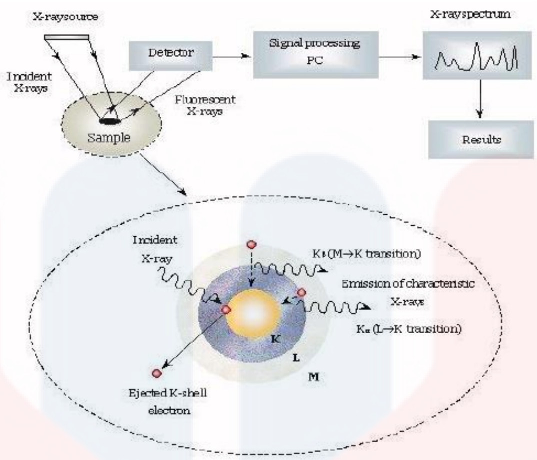


Figure 2.3: The principle of XRF detection arrangement.

2.6.7.2 Limitation of X-Ray Fluorescence

XRF is very useful for research since it can give results very quickly. However, XRF has some limitation which there are limits for measurement. This is because the normal quantitative limit of XRF is 10-20 ppm since minimum particles are required for an accurate reading. Besides, XRF only analyses surface layer of the samples (K.Kodom *et al*., 2012).

2.6.7.3 Factors Affecting Results of XRF in Soil Analysis.

From Marlborough District Council (2013) listed a few factors affecting XRF analysis in topsoil. These are soil moisture, particle size and mineralogical effects.

- **Soil Moisture**

The accuracy analysis of the samples can be affected by soil moisture. From Kalnicky *et al* (2001), the concentration of an analyse will started to decrease when the moisture content increase since the moisture in the soil absorbs x-ray. However, most of the error that associated with soil moisture due to water content is a minor case.

- **Particle Size and Mineralogical Effects**

The accuracy of XRF results mostly influenced by soil heterogeneity. (Argyranki *et al*, 1997 & Johnson *et al*, 1995). Physical matric gave effects such as changes in presence of particles, particles size, heterogeneity and sample uniformity, will gives few significance effect in sample results variability. This is because amount soil used in XRF very small. Hence proper sample preparation can reduce inference effect of moisture, grain size and others.

CHAPTER 3

MATERIALS AND METHOD

3.1 Introduction

Materials and method that used were included in this chapter. All the method and instruments needed to be figure out first to make sure whether it is suitable or not. The suitable and reliable instrument, methods and materials are really important to make sure this study research conducted smoothly. Methods used in this research study consist of preliminary studies, field studies, lab work, data processing and data interpretation.

3.2 Materials

3.2.1 Geological Mapping Equipment

Table 3.1: Equipment used for geological mapping.

Materials	Explanation
	**Global Positioning System (GPS)** GPS is worldwide used in geological mapping. Function in navigation, determined location by checking the coordinate, doing traversing, tracking the feature which involves in geological mapping
	**Compass** Compass was used to measure the orientation of geological lineation and planes with respect to the north. This compass was used geological mapping in order to find direction and find dip and strike on the body of rock.

	**Geological Hammer** Hammer was used to obtaining a fresh sample of rocks. A fresh sample of rocks will be analysed by petrographic analysis after going through a thin section.
	**Hand Lens** For observe mineral in the rocks that cannot be analysed by naked eyes during geological mapping.
	**Geology Shovel** Geology shovel was used in soil sampling for specification analysis.
	**Sample Bag** Sample bag was used to keep rock sample collected from geological mapping activities.
	**Hand Auger** Hand Auger was used as a machine to take soil samples at specific depth.
	**Measuring Tape** To measure the outcrop dimension and also the measurement of lithology and structure.

	**HCL Solutions** To identify carbonate characteristics that produce "hizz" sound.

3.2.2 Lab Instrument

Table 3.2: Lab instrument in the geological mapping.

	**Polarizing Petrographic Microscope** This optical microscope have multiple functions in optical mineralogy and petrology. This helped in petrographic analysis for detailed information of rocks description.
	**X-ray Fluorescence** X-ray Fluorescence is an instrument that always be used in geochemistry to determine element composition of chosen material.

3.2.3 Software

- **ArcGIS Software**

  ArcGIS software was used to produce a base map, digitize a map, and produce all related maps.

- **CorelDraw Software**

  CorelDraw provides a different application to create images and edit them. This software produced maps, cross section, lithology chart and final touch-up for the map.

- **Global Mapper**

  Global mapper was used to produce grid map and identifying coordinates. Global mapper provide almost same application as ArcGis. However, it was easier to use.

3.3 Methodologies

Methodology explained the methods and procedure that have been conducted throughout the whole process. The methodologies that were conducted were divided into section, Geology of Ngalang and Geochemistry of Topsoil. This methodology includes preliminary studies, geological mapping, laboratory work such as thin section and petrographic analysis and others.

3.3.1 Geology of Ngalang Area

3.3.1.1 Preliminary Study

A preliminary study was conducted by referring to a various media such as books, articles, journals and internet sources. This reference material was needed in order to collect information related to this research study. Related reference material was used to write a literature review that relatable to research study.

For the geological part, literature review helped in determining structural, lithology, depositional environment and all others geological aspect that needed to be considered during geological mapping. Hence, an overview by literature review was really important before started the mapping.

A base map of Surakarta was used as reference to produced base map for the Ngalang area. This map was produced by ArcGIS software in order to have a clearer vision for the research study area. The base map was important for preliminary studies on lithology, accessibility, rock distribution and general features of that area.

Analysis of base map were conducted in order to identify drainage pattern, lineament analysis and contour interval of the topography. This was a very important steps since it shows some ideas about geological features that important to be take note during geological mapping.

3.3.1.2 Geological Mapping

Observation method was completed by conducting surface mapping by samples collection for petrographic analysis, picture and description of the outcrop and structural analysis. Field studies were conducted for 14 days by traversing around study area to understand geomorphology, lithology, structural geology, petrography and also stratigraphy of the study area. Base map of Ngalang and Global Positioning System (GPS) had been used as a reference for traversing and data plotting.

In this phase, data of the study area such as strike and dip, rock analysis, outcrop analysis were jotted down and interpreted even at field. Petrographic description such as the colour, grain size of the minerals and expected mineral in the rock interpretation was conducted at the outcrop found in the field. The geological tools such as GPS, compass, and hammer plays important roles during this stage. By traversing in the study area, geological information had been collected in detail and precisely which covered all the study area. The geological mapping had covered geological information such as geomorphology, lithology, and structural aspects that were needed for discussion part in report writing.

3.3.1.3 Sampling

During geological mapping, rock samples were collected according to the outcrop found. These samples were taken from the outcrop in order to be observed, processed by thin section and were analysed during petrographic analysis.

The samples were taken carefully by using geological hammer. Only fresh rocks were taken as samples in order to have a better result during petrographic analysis. Then, the samples were kept in sample plastic and was sealed in order to decrease the rate of weathering process of the rock. These samples were labelled according to its outcrop coordinate, elevation, colour of the rock, vegetation available, rate of weathering and the code given to the rock.

3.3.1.4 Lab Work (Thin Section)

Thin section, a steps that cannot be avoided in petrographic analysis step. Petrographic analysis made interpretation of geomorphology of the rock to be interpreted precisely and correct with evidence since it was very hard to interpret weathered rock. During weathering some of the mineral features may be alternate due to weathering.

The samples that want to be made thin section was chosen. The orientation of the rock samples that want to be cut have been discussed, decided and mark. This was really important in order to have a nice angle for petrographic analysis description.

By using slab saw, the rock was cut according to the marked orientation until it becomes into chip size with size 3 cm x 5.5 cm with 3 mm width. The rock with chip size then was glued to the slide and waited until it dry. After that, the chip on the slide was ground into suitable thickness. Less thickness of the thin section gave the best result. The cover slip was added to cover the slide and glued until it dry. Thin section of the rock samples were done to be interpreted under microscope.

3.3.1.5 Petrographic Analysis

The samples that were made into thin section were used in petrographic analysis. This analysis was conducted in the lab by using Polarizing Petrographic Microscope. The slide was put on the microscope in chosen orientation. The slide was focused by using different magnification such as 4x, 10x and 40x. This is to have a clear view of the slide specimen through the microscope.

Many characteristics of the hand specimen were identified such as mineral content, textural, colour, fracture characteristics, and optical symmetry. These characteristics described in detail for petrographic analysis section. Petrographic analysis ensure the analysis of every rock become more detail in order to classify all the rocks by its characteristics and entail the geological features of the study area.

3.3.1.6 Geological Map

The data gathered during geological mapping have been processed and analysed. The geological map was produced by using ArcGIS 10.2 and Corel Draw X5. The data that have been plotted during geological mapping such as traverse and outcrop plotting in the GPS were extracted by using DnrGPS. The information from the GPS then was used and plotted on the base map.

Stratigraphy and lithology of the Ngalang area were also have been identified after geological mapping. All data were gathered and plotted by using Corel Draw X5. Stratigraphy of the Ngalang area were produced.The geological map with 1:25 000 of the Ngalang area, Gedangsari have been produced. Interpretation for structural and historical analysis on the map was identified by using the strike and dip plotted on the map.

3.3.2 Geochemistry of Topsoil Between Ngelanggeran and Sambipitu Formation

3.3.2.1 Preliminary Study

For the specification geochemistry of the topsoil part, a lot of articles, journal and book have been refeurerred in determining the instrument that will be chosen and how to conduct the analysis itself. After considered samples and instrument, X-Ray Fluorescence have been chosen to fulfil the requirement of the objectives. From the literature review obtained, technique of sampling by lithology have been chosen. The samples were planned to be collected and tested according to lithology.

3.3.2.2 Grid Mapping and Sampling

Grid mapping was conducted before sampling was done. Hence, grid map with 10m interval in 500 m x 500 m area was produced by using Global Mapper and ArcGis. This grid mapping session was conducted for 3 days after geological mapping was done in order to focus in just the chosen area.

After grid map was produced, the mapping session begun in order to collect and complete soil grid map. In this soil grid map, a few physical characteristics such as colour and grain size of the soil in 121 points in the grid map was collected. By this method, soil map was produced. After soil map was produced, three different soil samples from different lithology were collected for geochemistry analysis by using X-ray Fluorescence instrument.

This analysis was conducted in order to identify the distribution of chemical element in the topsoil in both different lithology; Nglanggeran formation and Sambipitu formation. The soil samples were taken about 30-40 cm in depth by using hand auger. The upper part of the soil horizons was avoided and removed in order to maintain the freshness of the sample and avoid the vegetation. Soil samples also were taken at the same depth in order to maintain the parameter of the samples. 15-20 gram of soil were taken as sample for each lithology. The samples were put in the sample plastic and labelled with coordinate and some description of the area. All the tools such as hand auger and plastic sample were cleaned before used to take different samples.

3.3.2.3 Analysis by Using X-ray Fluorescence (XRF)

The soil sample were analysed by X-ray Fluorescence (XRF) to identify the element distribution of topsoil. The constituent of topsoil important in identifying the anomaly of element distribution in the study area. Before the samples ready to be analysed by XRF, it was prepared using steps with precaution.

Sample preparation needs to be conducted carefully in order to prevent contamination which will affect the results. Equipment such as mortars, pulverisers, and mills should be produced from silicon carbide, agate and tungsten carbide. The equipment needs to be rinsed with distilled water and dried (IAEA, 1997). The samples preparation required few steps. First, 10 g of soil sample were put in an agate mortar with the addition of 2 ml of Elvacite.

After that, the sample was completely dry, it was placed in a form and pressed with 20 ton of load to make sure it was compressed. It was placed in the oven with 80℃ in temperature until it was hardened. The samples then run in XRF to obtain the results. The prepared samples were analysed by using X-ray Fluorescence (XRF) instrument. This analyser was able to identify the content of the soil samples obtained in seconds.

X-Ray Fluorescence gave result for the major and minor element of the soil samples. This analysis was conducted to screen distribution of elements in the samples such as Ca, Mn, Fe, K, As, Hg, Cu, Cr, Pb, Rb, Ni, Sr, Sc, Zn, V and also other elements.

3.3.3 Report Writing

The last step for this report writing was done by followed all the thesis writing format provided by the faculty. This thesis report was divided into six total different chapters that includes Introduction, Literature Review, Methodology, General Geology, Geochemistry of Topsoil and Conclusion with Recommendation. The report also included attachment of the geological map and all data information.

CHAPTER 4

GENERAL GEOLOGY

4.1 Introduction

All geological aspect in Ngalang area such as geomorphology, structural geology, petrography, drainage pattern and others were discussed in this chapter after geological mapping was conducted. The geomorphological part includes contour analysis, with three different types weathering; (1) Physical, (2) Chemical, (3) Biological and drainage pattern identified in the Ngalang area. Next, this chapter also discussed on the lithostratigraphy of the Ngalang area, which combined both of lithology and the stratigraphy of the study area.

Ngalang area is divided into four different formation includes; Semilir, Nglanggeran, Sambipitu and Oyo formation. All rocks unit were discussed and proved with petrographic analysis. Besides, this chapter also entailed the structural geology part with some analysis of joint by using GeoRose application with some images of founded structural characteristics such as faulting, vein and joint which changed and give impact to the topography of the Ngalang area.

Historical geology of the Ngalang area also described since this area have a very unique geological characteristics. This chapter is important in discussing general geology received from all collected data during geological mapping in order to produce geological map with scale of 1: 25000.

4.1.1 Accessibility in Ngalang

This study area was situated at Gunung Kidul district at Ngalang area and bounded with other district such as Desa Pengkok, Desa Nglegi and Desa Pendok and Desa Putat. Most of area in Ngalang covered by crops and village, hence most of the area was accessible either by paved road or main road.

Accessibility in this area were excellent since all the area were accessible and connected with main road, local road, unpaved and also paved road as shown in Figure 4.1.Hence most of the part in this study area was accessible either by walk or transportation. The villagers in Ngalang area mostly depends on transportation such as motorcycle, bicycle, cars, van and lorry. Public transportation only available approximately about 20 km from the Ngalang area. Hence the villagers mostly used their own transportation.


Figure 4.1: Paved road that can be accessible by cars and motorcycle.

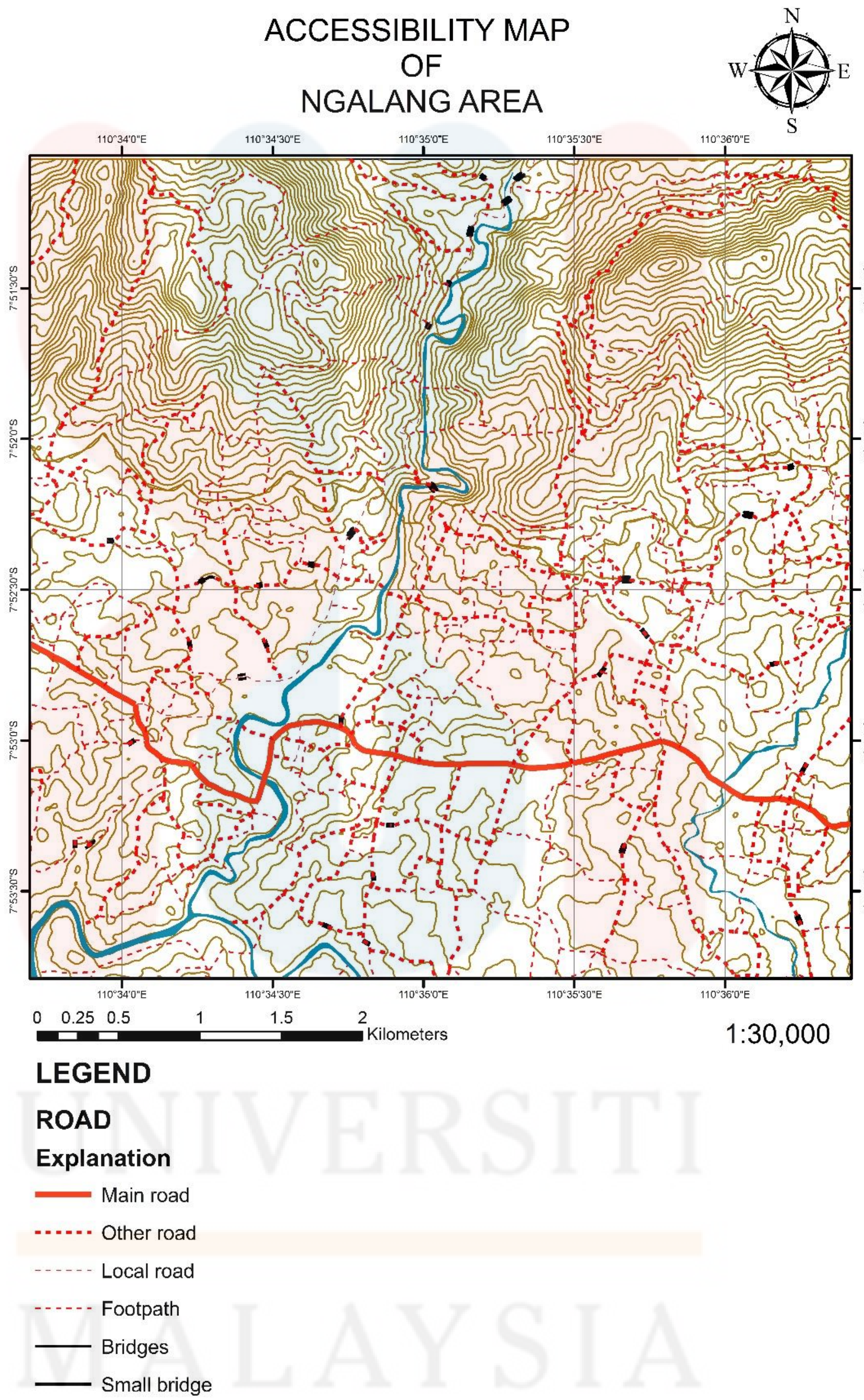


Figure 4.2: Accessibility map in Ngalang area which includes main road, local road and others.

4.1.2 Vegetation in Ngalang

Central Java is a part of contributor of Indonesian rice field together with other area such as Bali and other part and Java Island. The rice paddy area and production was increasing about 1.16% compared to 2016. This is because vegetation is a part of their daily activities and agriculture sector is the main part of their economy.

Most of the area in Gunung Kidul district especially Ngalang area filled with crops and vegetation. The vegetation in this area mostly filled by beautiful green paddy field with other plantation such as coconut tree, 'jati' tree, bamboo and eucalyptus tree by villagers. The paddy field was in terraced structure along the hillside gave a splendid and mesmerizing topography landscape such as shown in Figure 4.3.

Figure 4.3: Paddy field and vegetation crops that used by villagers for their daily activities.

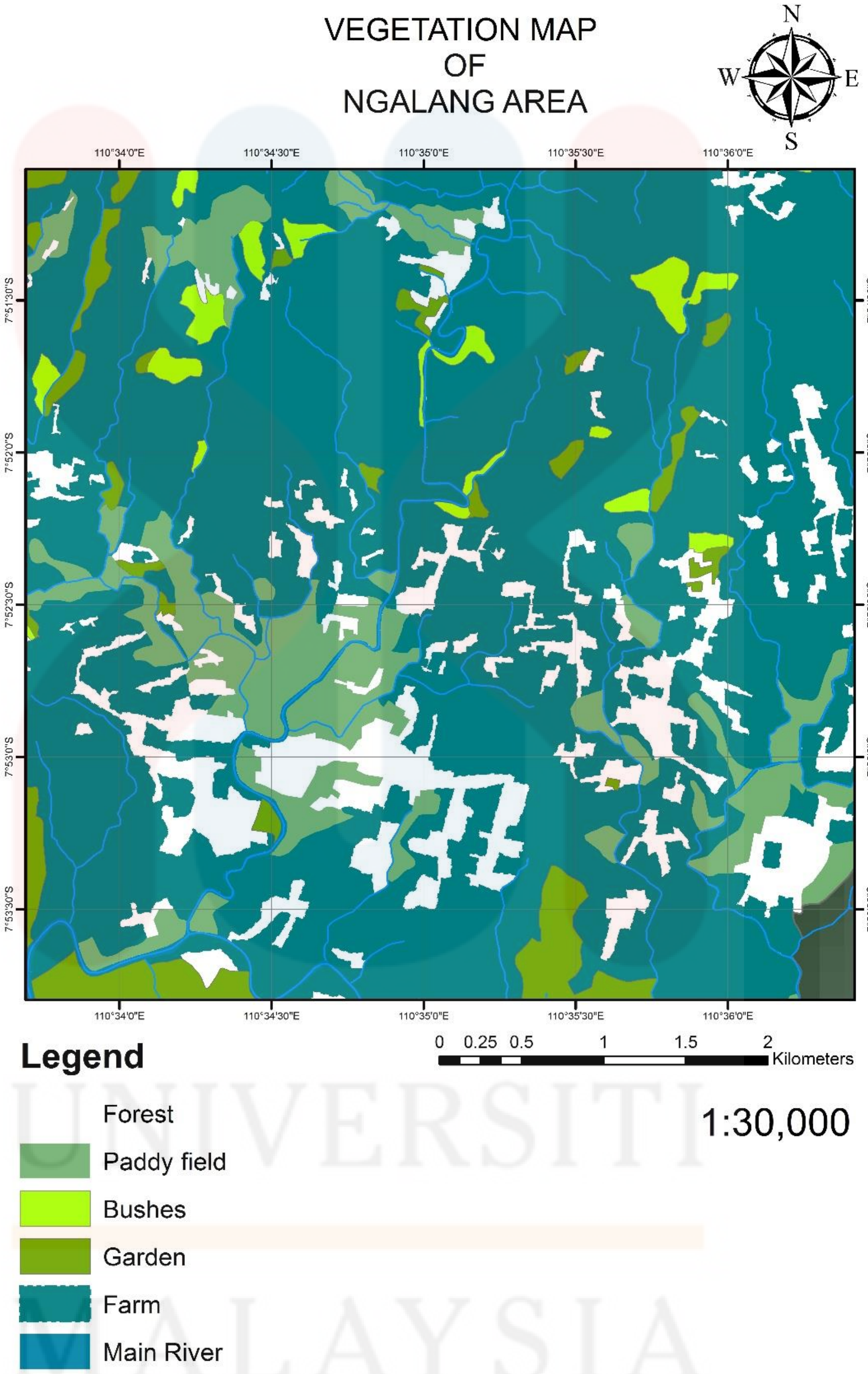


Figure 4.4: Vegetation map in Ngalang area.

4.1.3 Traverse and Observation in Ngalang

During geological mapping traversing and outcrop observation was conducted. The rock unit found was grouped and classified into different formation. The units available in the study area were exposed at most of part at the study area.

At the northern part of the map, Semilir formation was exposed in the northern. Then, towards the southern there were Ngelanggeran formation, Sambipitu and Oyo formation underlying each other. All these four formation was made up with different lithologies and rock unit.

About 121 observation point was recorded with interval 250 metres during traverse through the study area. This is because the outcrop in Ngalang area can be clearly seen in almost at all part of the study area, even across the river. The outcrops were well exposed along the river bank and also at its base. Hence, the traversing mostly was conducted by walking through the river.

The observation point was completed by jotting all the important data such as the petrology, the outcrop and picture also was taken in order to have a clear vision at the outcrop. All the traverse were plotted in Figure 4.5.

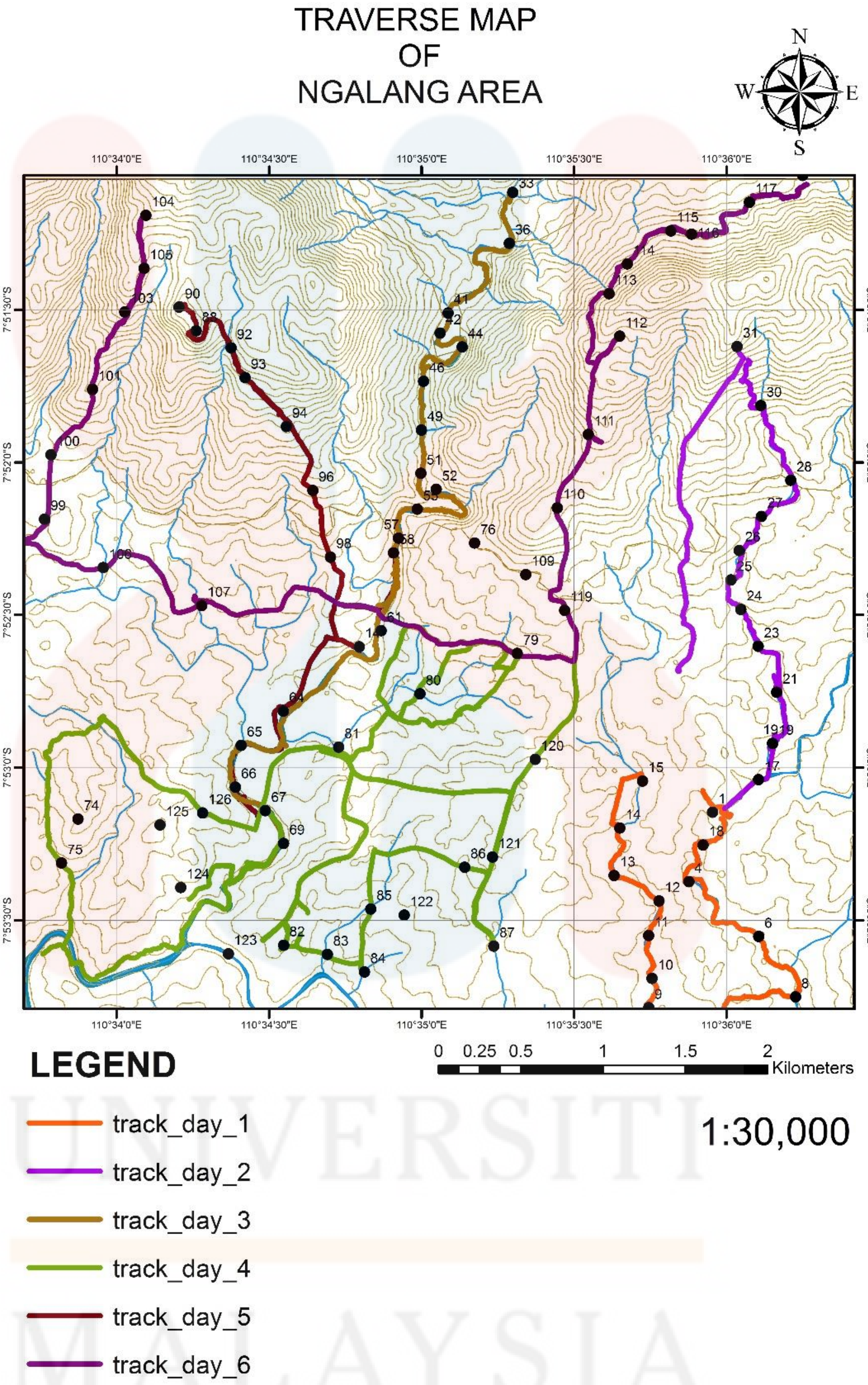


Figure 4.5: Traverse map and observation point during geological mapping in Ngalang area.

4.2 Geomorphology

Geomorphology of Ngalang can be said to have three different kind of geomorphology such as escarpment valley, hilly landscape and flat landscape. Escarpment valley in Ngalang was due to erosion of sedimentary rock and by geologic fault. Undulating hiils in Ngalang happened due to the resistivity of different types of rock.

4.2.1 Base Map Analysis

4.2.1.1 Contour Analysis

Contour gave information related to rock resistant. Contour analysis in this base map was divided into two groups. The highest demography showed that the rock was made up of volcanic or igneous rock. The contour interval was very close to each other shows that it have a very steep hills. This high demography was clearly shown by Gunung Gentong (Figure 4.6), Gunung Keruk and Gunung Genter with relative elevation 500 m – 700 m at the northern part of the map.

Figure 4.6: Geomorphology of Ngalang from Gunung Gentong.

Gunung Keruk and Gunung Gentong separated by a valley with Ngalang river. The valley was said to be matured by Davision stage (Figure 4.7) since it have flat bottomed that possessed a lateral erosion, hence forming Ngalang river. Younger landscape of Sambipitu and Oyo formation characterized by flatter topography of the original uplifted peneplain.

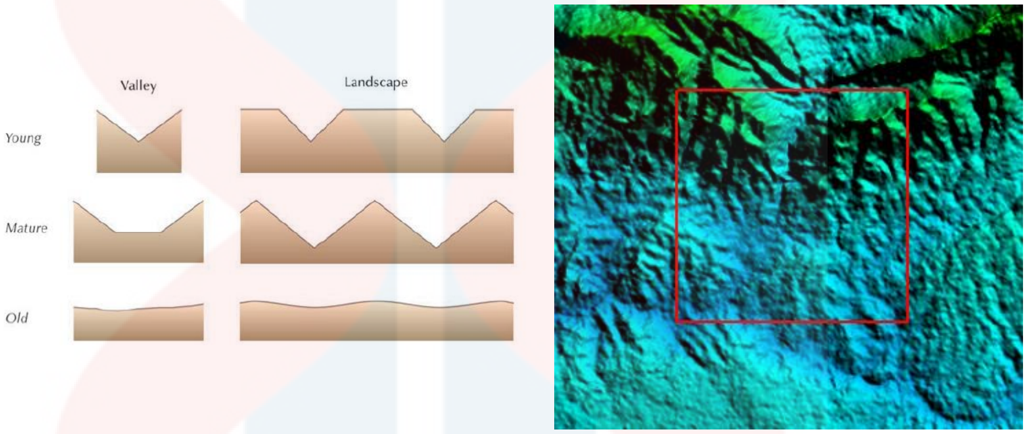


Figure 4.7: Traditional Davision Stage for valley profile (Ollier &Pain, 2006)

The contour of Sambipitu and Oyo formation was further from each other showing that it was made up of more flatty area and less resistivity rock. This flat area can be recognised as an indicator for sedimentary rock or rock with low resistant.

4.2.2 Weathering

4.2.2.1 Theory of Weathering

Weathering is the alternation of bedrock by chemical and mechanical weathering process that create regolith layer. This process lead to disintegration, discolouration and decomposition of the minerals in the rocks body. Weathering in Ngalang area can be classified into three types of weathering that includes physical, chemical and biological weathering.

The rate of weathering in Ngalang various because the formations were composed of different rock with different resistivity. Besides, depositional environment of the rock formation in Ngalang also deposited on different time and environment. Hence it have different unique characteristics. The state of weathering in rocks and sediment can be one of important aspect in order to have some description and information on climate during past and present (Tucker, 2005). Figure 4.8 shows the degradation of volcanic material due to weathering in Ngalang area.

Figure 4.8: Topsoil weathering in Ngalang area.

Besides, rate of weathering can be as an indicator for the length of exposure, degree of alteration and loss of rock strength. When exposed to the surface, rate of weathering tend to be higher and eventually soils at zone A and zone B may develop with crops and vegetation. Zone C is the weathered zone which also known as regolith situated below the soil layer. Hence Borelli & Gulli (2007) in Figure 4.9, have used different classification grade of weathering for outcrop.

CLASS	TERM	DESCRIPTION
VI	RESIDUAL AND COLLUVIAL SOILS	All rock material is converted to soil. The original rock structure is completely destroyed. The point of geological pick easily indents in depth. When the rock material is struck by the hammer don't emits sound.
V	COMPLETELY WEATHERED ROCK	All rock material is completely discoloured and converted to soil, but the original mass structure is still visible. The point of geological pick easily indents. When the rock material is struck by hammer emits a dull sound.
IV	HIGHLY WEATHERED ROCK	All rock material is discoloured. The original mass structure is still present and largely intact. The point of geological pick not easily indents. The rock material make a dull sound when is struck by hammer.
III	MODERATELY WEATHERED ROCK	The rock material is discoloured, but locally the original colour is present. The original mass structure is well preserved. The point of geological pick produce a scratch on the surface. The rock material make a intermediate sound when is struck by hammer.
II	SLIGTLY WEATHERED ROCK	Discolouration is present only near joint surface. The original mass structure is perfectely preserved. The point of geological pick scratch the surface with difficulty. The rock material make a ringing sound when is struck by hammer.
I	FRESH ROCK	The rock material isn't discoloured and has it's original aspect. The point of geological pick scratch the surface with many difficulty. The rock material make a ringing sound when is struck by hammer.

Figure 4.9: The grade of weathering description in outcrop. (Borrelli & Gulli., 2007)

4.2.2.1.1 Properties of Parent Rocks.

Different minerals have different rate of weathering. This is because different minerals have different solubility in water. Besides, rock structure also gives effect towards weathering of the rock. For example, sedimentary rock such as rocks in Sambipitu and Oyo have layers of sediment that can be easily pulled apart compared to volcanic rock in Nglanggeran formation which contained more resistant rock such as basaltic and andesitic lava.

Basically, igneous rock do not have planes of weakness that triggered the weathering. Hence the rate of weathering in volcanic rock much slower than sedimentary rocks. Grain size is one of the triggered factors for the rate of weathering. The finer the grain size, the rate of weathering will be faster. Besides, the stability of minerals as shown by Bowen reaction series in Figure 4.10 also a factor that affect rate of weathering.

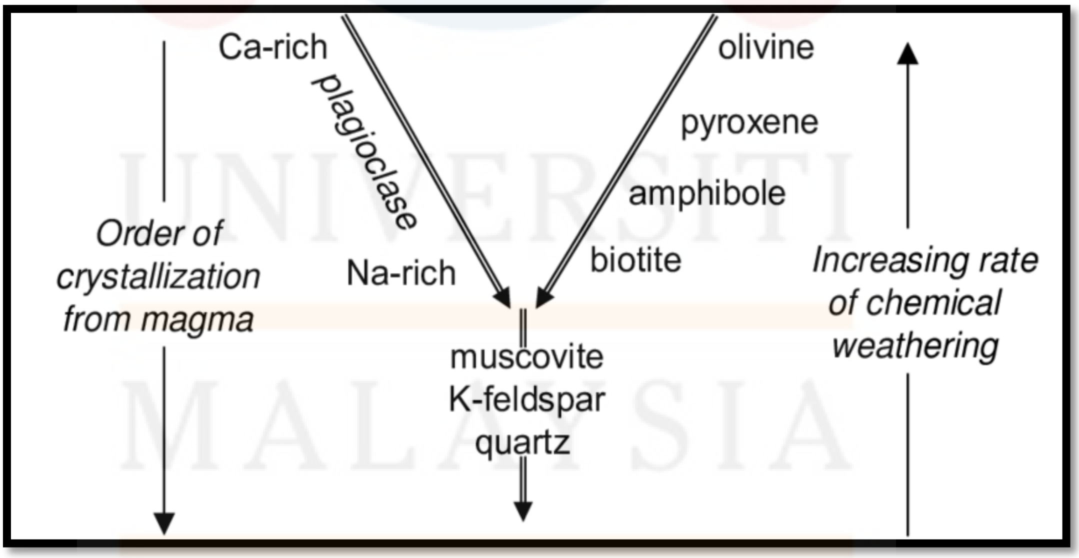


Figure 4.10: Bowen reaction series (Gammons et al., 2009)

4.2.2.2 Physical and Mechanical Weathering

Mechanical weathering basically when the rocks were broken into smaller pieces. Spheroidal weathering as shown in Figure 4.11 also known as onion-decay weathering. This weathering occur when the rock is exposed to water and air and near to the Earth's surface. Usually this type of weathering mostly occur on volcanic and igneous rock. This is because, the rocks are chemically unstable when they are exposed to the surface.

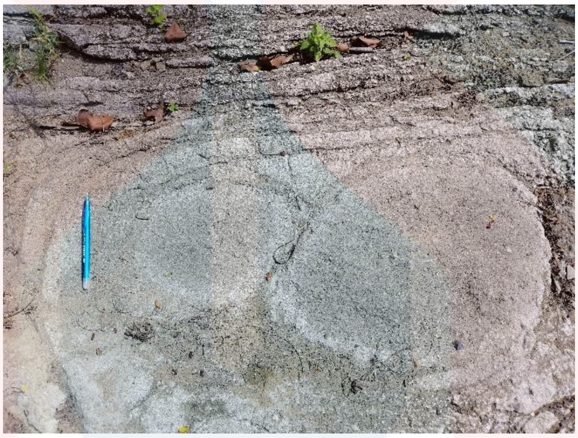


Figure 4.11: Spheroidal weathering found at Nglanggeran area.

4.2.2.3 Chemical Weathering

Chemical weathering is the breaking down of rock through chemical process. In Ngalang area, the chemical weathering mostly occur in Oyo Formation. It may cause the alteration of grains, discolouration of rocks and dissolution of grains. The dissolution of grains leads to potholes, cavers and karst. Chemical weathering involved decomposition of rocks due to chemical reactions between calcite and water.

The reaction that include in chemical weathering can be known as oxidation, carbonation and hydrolysis. These reactions include in destroying minerals and altered the minerals composition which changed the nature of the rocks.

Figure 4.12: Potholes forming due to the dissolution of grains in the carbonate sandstone at Oyo Formation.

The Figure 4.12 shows chemical weathering that found in Ngalang area especially in Oyo Formation which known to consist of intercalation of dominantly limestone and sandstone. The chemical reaction between calcite and water in the rocks causing the disintegration of the rocks until formed pot-holes. This potholes can be clearly seen in the Ngalang River and Widoro River. It started to appear within the limestones characteristics in the formation.

4.2.2.4 Biological Weathering

Figure 4.13: Biological weathering at volcanic breccia in Nglanggeran formation.

Biological process that shown in Figure 4.13 caused by various activities in living organisms such as plants, animal, fungi and microorganisms such as bacteria. The weathering may cause breaking of rock by exposing it to physical and chemical weathering. This weathering may exert extra stress or pressure on rock which cause the rocks to disintegrate.

Biological weathering by organic compounds which living organisms contribute through organic compound that contain molecules that corrode and acidify rock minerals. For example, when the plant's roots grow deeper into the soils, the roots tend to produce crevices and cracks which eventually degrade the rocks.

Biological weathering can either have advantage or disadvantages. Biological weathering might shows it advantages in creating the soil by formation of nutrient rich soil, creation of sediment and some contribution to land formation. While there is some disadvantages in erosion of soil, mass wasting and some gradual break down.

4.2.3 Drainage pattern

Drainage pattern also known as river system which forming certain patterns due to particular drainage basin such as dendritic or rectangular pattern. The patterns that formed by the stream erosion over time will reveal characteristics geologic structures, rocks and geomorphology which drained by streams sediment. These pattern were landscaped by topography of land and also effected by soft and hard rocks also the gradient of land.

The drainage pattern was shown in Figure 4.14 of Ngalang area is connected by 4 main rivers named kali Ngalang, Kali Dondong, Kali Oyo and kali Kedungkeris with kali Ngalang at the middle. Ngalang river, known as the main river in Ngalang area flows southward. It is also be the main tributary of Oyo river.

The river crosses a rough morphology at the northern part of the study area since it has a constituent of tuff unit in Semilir formation and volcanic breccia of Nglanggeran formation. Then, the river flows towards the soft course of the river which composed of sedimentary rocks of Sambipitu formation and Oyo formation. The morphology of the area getting flatter towards southern. Generally, the river distributaries forming rectangular and dendritic pattern stream due to it different underlying topography. The system and shaped varies with the effect from structures and relief of the landscapes of the Ngalang.

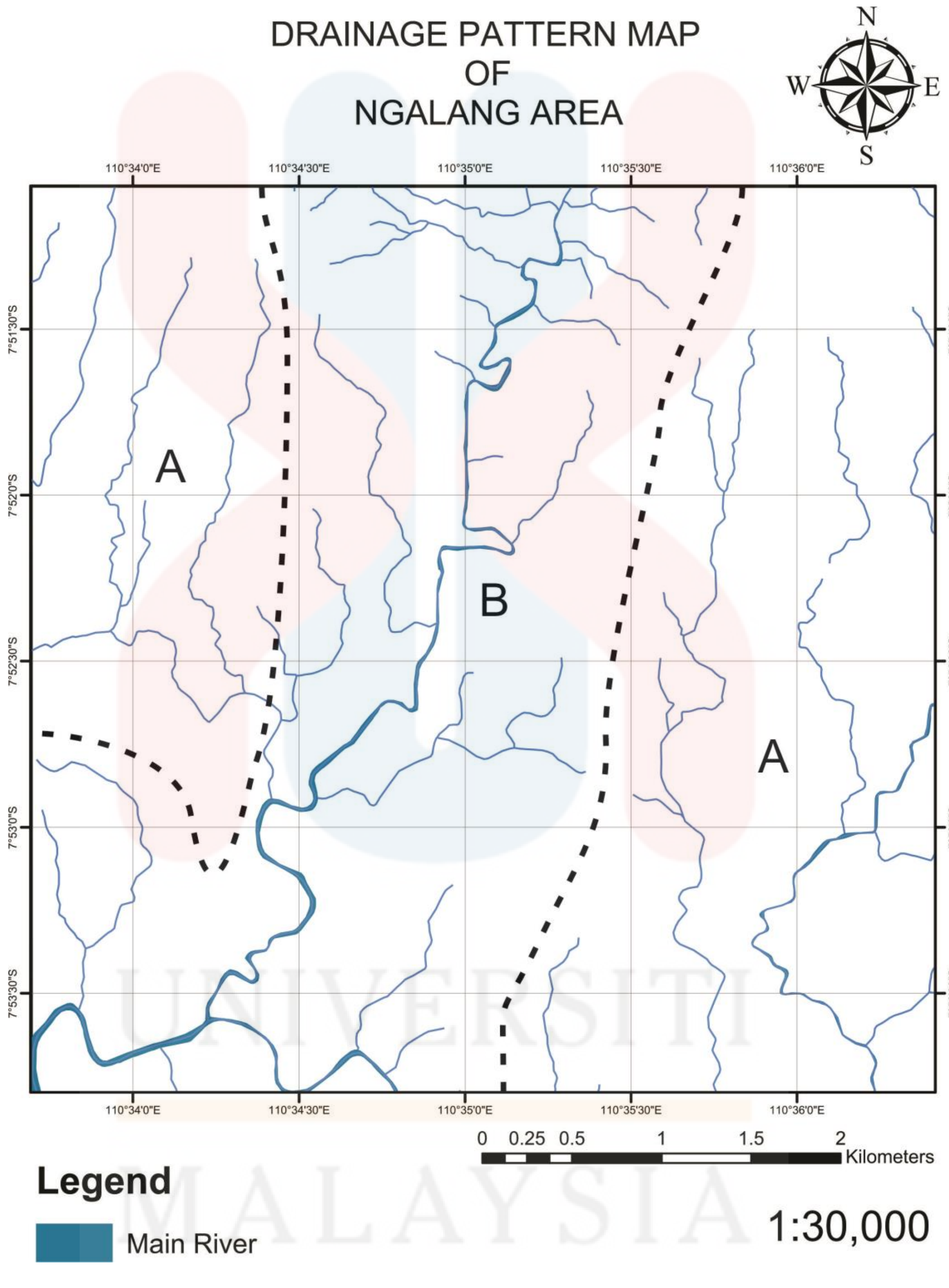


Figure 4.14: Drainage pattern map of Ngalang area. (A): Dendritic drainage pattern, (B): Rectangular pattern.

4.2.3.1 Rectangular pattern

Most of the drainage pattern in the study area showed rectangular pattern. Rectangular pattern can be identified since it have approximately 90 degrees of right angles. Usually these joints are less resistant to erosion than bulk rock. The rectangular patterns usually have a very little topography and bedding planes system, faults and fractures which form a rectangular pattern.

Hence, the rectangular patterns that formed in Ngalang was an indicator to structural such as faulting and fractures in that area. Most of the study area was effected by dextral and sinistral strike slip fault.

4.2.3.2 Dendritic pattern

Dendritic stream pattern shows twigs of a tree look-alike at some part in Ngalang area. Most of this pattern developed at the river channel which followed by the slopes of the terrain. Hence the rock types in the area must have non-porous and impervious characteristics. The rock also can be interpreted as homogenous along the river.

Few examples of the rock with dendritic drainage pattern in Ngalang area such as volcanic rock in Nglanggeran Formation and sedimentary rocks in Sambipitu Formation particularly has no specific fabric or structure hence can be eroded easily in all direction. Hence developed dendritic pattern at some part in Ngalang area.

4.3 Lithostratigraphy

4.3.1 Stratigraphic position

From geological mapping and regional map, the arrangement of all of the lithologies in Ngalang area were grouped and classified into different formation. The stratigraphic position of Ngalang area was comprised of four formation with different depositional environment. All of these formation were arranged from oldest to youngest which includes; the Semilir formation followed by Nglanggeran formation, Sambipitu formation and the youngest formation was Oyo formation.

The identification of the lithology column in the Ngalang was made based on literature review and observation of fossil during geological mapping. The stratigraphic column in Ngalang area shows that the oldest formation in this area was Semilir formation. This formation was made up of tuff unit which include tuffaceous sandstone and tuffaceous mudstone. There was also abundance of coal found deposited within this formation.

Next, Nglanggeran formation was deposited in shallow marine during early Miocene. This formation was made up of different volcanic rock due to the volcanic activities that produce the geology of present day. The rock unit in this formation can be divided into two; volcanic unit and breccia unit. The differences of this unit were depends on the source of the rock. There was no fossil found in the formation.

Stratigraphically, Sambipitu formation was comformable underlying by Nglanggeran formation with domination of volcanic breccia (Surono & Asep, 2009). The formation was deposited within shallow marine to deep sea environment or known as transitional zone between carbonate sedimentary process and volcanic activity of Nglanggeran.. This is based on a few trace fossil found in the formation named chondrites and thalasinoides. There was also bioturbation. The Ngalang area also have the most special Bouma sequence which shows that Sambitu formation was deposited.

However, through Ngalang river and Widoro river the Nglanggeran and Sambipitu formation were observed to be interfingering with each other. The interfingered was clearly can be observed in Ngalang river where sediment and volcanic rock were alternating with each other. Although Nglanggeran and Sambipitu were interfingering each other, most of the part from Nglanggeran still older than Sambipitu.

Lastly was Oyo formation. This formation was the youngest formation in the Ngalang area and believed to be deposited during middle Miocene. The formation was made up with limestone unit and sandstone carbonate. There was alternation of limestone with sandstone and tuffaceous carbonate sandstone. There was also some rudstone appear in this formation. Basically, Semiliir and Nglanggeran can be said to be deposited during volcanism period while Sambipitu and Oyo were deposited during carbonate period.

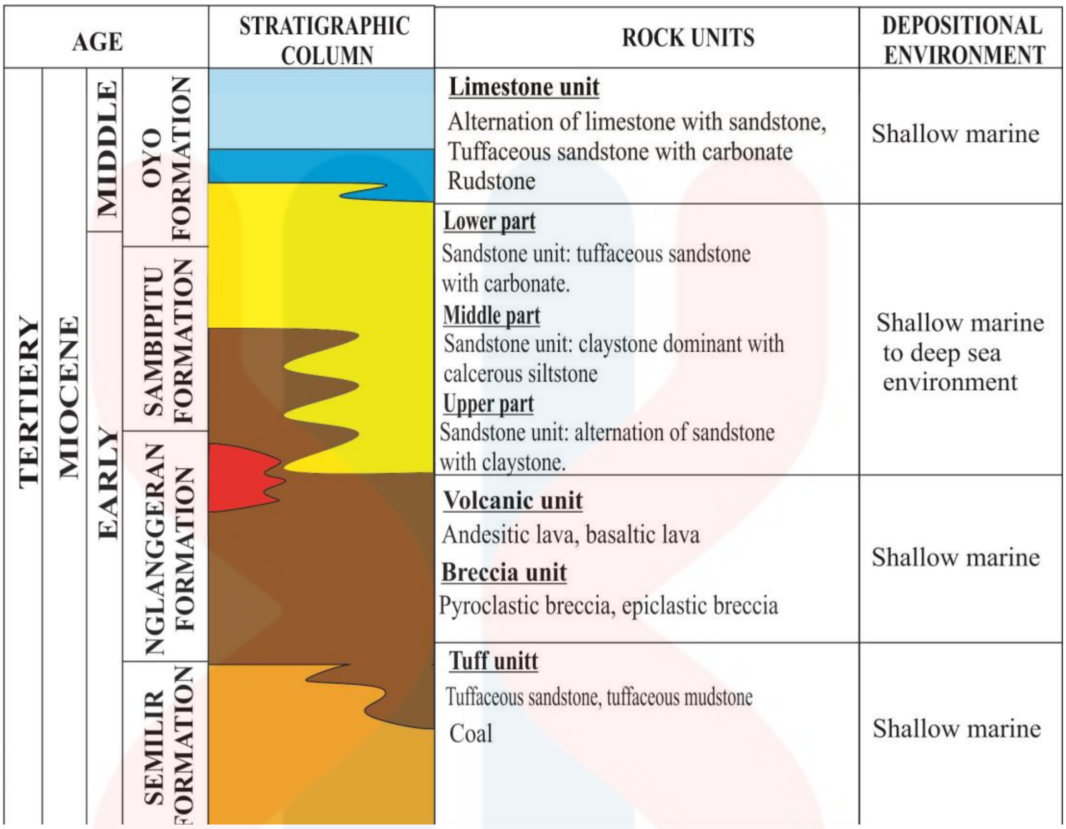


Figure 4.15 : Stratigraphic column of Ngalang area which includes Semilir, Nglanggeran, Sambipitu and Oyo formation.

4.3.2 Unit explanation

4.3.2.1 Semilir Formation

Semilir formation was deposited in Early Miocene. These formation was made up from the alternation of tuffaceous sandstone and tuffaceous mudstone and some coal. The formation can be said as the oldest formation in Ngalang area. Most of the outcrop in Semilir had undergone weathering hence most of the strata or bedding of these rocks cannot be clearly seen.

Figure 4.16: Observation point (NSW 117) were made up with alternating of tuffaceous sandstone and tuffaceous mudstone in the Semilir formation.

NSW 117 station in Figure 4.16 shows an outcrop in Semilir formation. The location of the outcrop was situated with the latitude of S 7° 51' 09.3 and longitude of 110° 36' 04". The outcrop was made up of alternation of tuff and tuffaceous sandstone which means the layer of rock was alternating with each other. This outcrop have dimension 8 metres in length and 3.3 metres in height. This outcrop was exposed to weathering with third grade rate of weathering which means it was weathered moderately. Hence, most of the rock have been integrated into soil. The outcrop was vegetated by a layer of grass and villager's crop such as banana tree

- **<u>Coal Unit</u>**

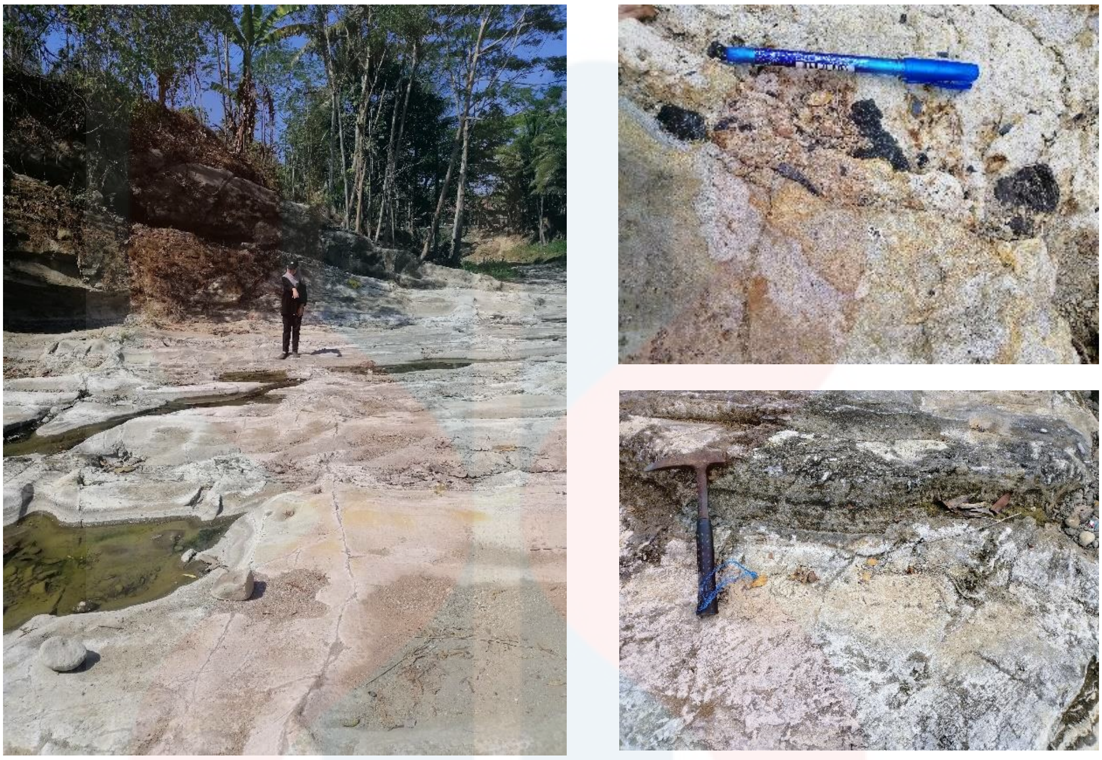


Figure 4.17: Abundance of coal deposition in outcrop of Semilir formation.

Figure 4.17 above shows the deposition of coal in Semilir formation. Coal is abundance in the Semilir Formation. These coal were deposited within tuffaceous sandstone and tuffaceous mudstone. The coal in Semilir formation was known as lignite, brown coal and charcoal (fusion coal).

These lignite present in Ngalang were considered as the lowest rank of coal since it has relatively low combustion content. This is combustible sedimentary rock that formed from naturally compressed and accumulated by pre-historic plant. Most of the lignite has brown to black in colour since it has carbon content around 60-70%. The coal in Semillir formation was deposited in swampy area.

4.3.2.2 Nglanggeran Formation

Nglanggeran formation also deposited in tertiary and can be divided into 2 different rock unit, includes volcanic unit; (1) andesitic lava, (2) basaltic lava and breccia unit; (1) pyroclastic breccia (2) epiclastic breccia. Depositional environment of Nglanggeran formation was located at shallow marine during early Miocene.

Figure 4.18: Nglanggeran formation ds in Ngalang river.

Figure 4.18 shows the distribution of volcanic rock distribution along the Ngalang river. The Ngalang river was dried up due to drought hence all the lithology in Nglanggeran formation can clearly been seen. Since Nglanggeran formation was made up from volcanic rock, there was no rock strata and layer that can be seen in this formation. Besides, these constituent of rock may come from different sources of volcanic activities.

- **Lava Unit**

Lava unit in Nglanggeran formation was made up of basaltic and andesitic lave which proven both of these lava came from two different sources. Both of these lava has different silica content since they are formed at different plate boundaries. Volcanic lava or known as volcanic bomb shown in Figure 4.19 formed when a volcano erupts and ejects viscous fragments. These fragments cool into solid fragments before they reach the ground. The bread crust may develop cracked outer surfaces as the interiors continue to expand and forming bread crust- look alike.

Figure 4.19: Bread crust as lava source.

Basaltic lava or also known as mafic lava are enriched with magnesium and iron and less in silica content. These lava were formed from the hot mantle situated at constructive plate boundaries. Basaltic lava unit has dark in colour and have high content in magnesium and iron. Besides it also have low content of silica and aluminium. Andesitic lava formed at destructive plate boundaries from melting crust. Compared to basalt, andesite have felsic characteristic which differ because of silica content in the andesite. Hence its colour appear to be greyish in colour.

- **Breccia Unit**

Figure 4.20: The boulder that was situated at the peak of Gunung Gentong.

The Figure 4.20 shows a big boulder of pyroclastic breccia situated at the peak of Gunung Gentong. This pyroclastic breccia composed of different constituent of composition of really variety small rocks fragments. The epiclastic breccia made up from an open fabric. The rocks have massive in structure.

4.3.2.3 Sambipitu Formation

Figure 4.21: Sambipitu outcrop (the intercalation of sandstone and mudstone)

Bothe (1929) called grouped and all these sedimentary layer as Sambitu formation. Sambipitu formation were well exposed especially at Ngalang river, Kali Dondong and Kali Juwet in the study area. Commonly the dipping of the bedding along the river were ranging between 8° until 15° and the river were flowing crossed the bedding strikes of the formation.

This formation have unit of claystone at the upper part of Sambipitu near to Nglanggeran as shown in Figure 4.21, the intercalation of sandstone and claystone which can be clearly seen across Ngalang river and unit of sandstone carbonate at the lower part of Sambipitu. At the upper part of Sambipitu, the formation was interfingering with Nglanggeran. The sandstone bed had about 50 to 75 cm while claystone had about 2-15cm in thickness.

Figure 4.22: Bioturbation (trace fossil) in Sambipitu formation.

Sambipitu formation as shown in Figure 4.22, was made up from very special sedimentary layers that exposed varies speciality that rare to be found anywhere but only in Sambipitu. The speciality about Ngalang area and Sambipitu especially was shown from a giant bioturbation(trace fossil) at the lower part of Sambipitu and Bouma sequence known as the most perfect turbidite system at the upper part of Ngalang.

Sambipitu, have a very large bioturbation which made the formation very special and exposed that it was deposited in transition environment. The bioturbation lies at sediment layer of intercalation of sandstone and claystone. This bioturbidation revealed that Sambipitu formation have been deposited in tidal environment. Besides, there was also other trace fossils such as Chondrites and Thalasionides.

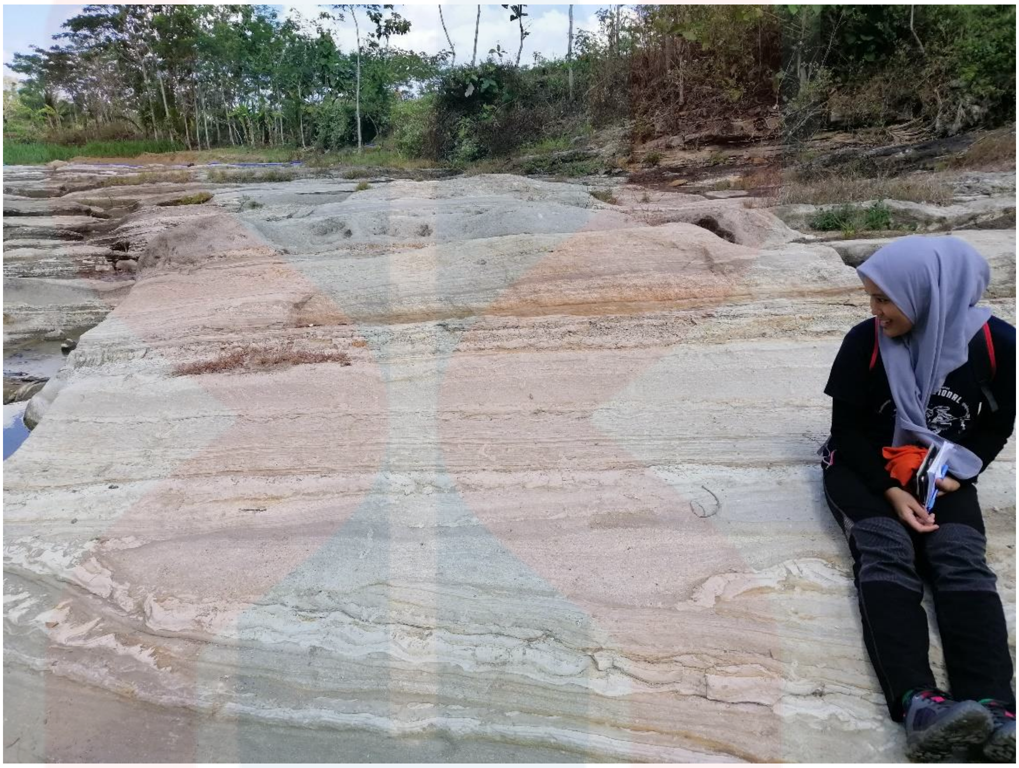


Figure 4.23: Bouma sequence in Ngalang area.

The Figure 4.23 shows the next speciality of Ngalang area, the Bouma sequence. This was a turbidite system that proved Sambipitu formation came from deep sea environment. Bouma sequence which also known as deep-water 'turbidite' deposition comprises sediments that fining upwards, consist of coarse layer at the bottom part. The Bouma Sequence represent the deposit of a turbidity current.

In 1995, Mialls described that Bouma sequence can be divided into five different division (A-E) as turbidities description. Turbidity currents in Ngalang Bouma sequence were appeared in a waning flows. Means, the currents' velocity keep decreasing produced deposition of all materials that distance from the main source (Stow, 1994).

Table 4.1: The five division of Bouma sequence can be referred as 'a' to 'e' with notation from T_a, T_b and so on. (Nicholas, 2013)

T_a	The lowest part consist of reduced turbulence with formation of bedforms that comprised of structureless sand and poorly sorted deposition.
T_b	The grain size of this layer finer than layer 'a'. The material improved in sortation. The parallel laminae mostly generated by grains seperation in upper flow regime transport which produced laminated sand.
T_c	This layer consist cross-laminated medium to fine sand, with ripple lamination. The ripple bedform stability indicated by moderate velocities. Sometimes convolute lamination occur in this division.
T_d	The decrease in flows of turbidity current produce fine sand and silt. Lamination of this layer might be less define than 'b' layer
T_e	'E' division is the top part which consist fine grain sediment of clay and silt grade. Known as pelagic deposits since the turbidity current had come to rest.

4.3.2.4 Oyo Formation

Figure 4.24: The outcrop in Oyo formation. This outcrop has alternation of tuffaceouss sandstone and limestone.

Oyo Formation was deposited during middle Miocene until late Miocene (Bothe, 1929) with depositional environment in shallow marine at neritic zone. The Oyo formation in Figure 4.24 was made up of a few lithology unit of rocks. In this formation there was alternation of limestone and sandstone and towards younger part the lithology especially the grain size of the rocks were changing gradually.

Oyo formation started to appear from Ngalang river. Most of the rocks in this formation relatively have dip from 11 degrees to 18 degrees. Especially along the Kedungkeris river and Ngalang river, the alternation of limestone and sandstone changing with the sandstone layer getting thinner and limestone getting thicker. Besides, the grain size of sandstone also become more tuffaceous when going younger. This is because the area was nearer to Wonosari formation which consist of only limestone lithology.

Figure 4.25: The limestone in Oyo formation getting thicker and showing limestone characteristics towards southward.

Oyo formation was made up from the alternation of limestone and sandstone. In Figure 4.25, most of the limestone layers in Oyo formation getting thicker towards southern of Ngalang area. The formation started to have limestone characteristics such as decreasing in grain size, have ashy colour and potholes. Potholes happens when the mineral especially carbonate in the rocks dissolve due to reaction with the water.

4.3.3 Petrographic Analysis

Table 4.2: Description of Wackestone

Date	:	19 July 2019	**Location**	:	Kedungkeris river
Sample Code	:	NSW 004	**Coordinate**	:	S 7° 53’ 22.3”
Rock Name	:	Wackestone			E 110° 35’ 52.5”
Colour	:	White to greyish			
Structure	:	Massive			
Texture	:	Very fine to medium grain size			
Mineral Composition Description					
Feldspar	**2%**		**Fossil**	**20%**	
Calcite	**25%**		**Opaque mineral**	**2%**	
Carbonate clay mineral	**47%**		**Pore cavity**	**4%**	
Classification:					

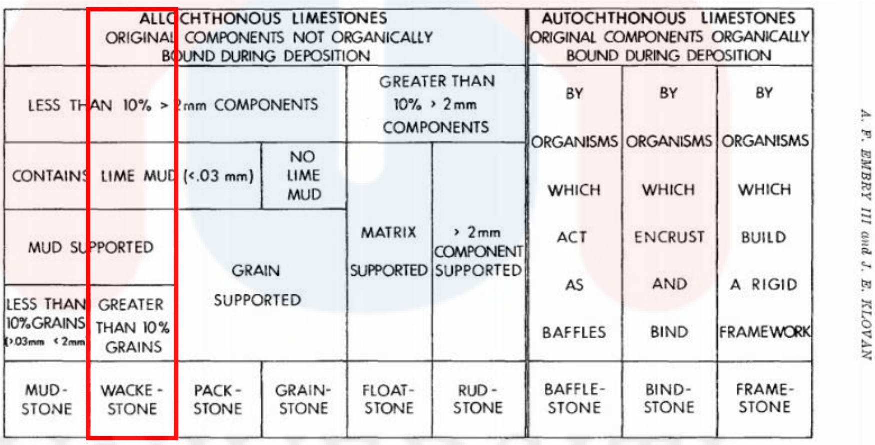
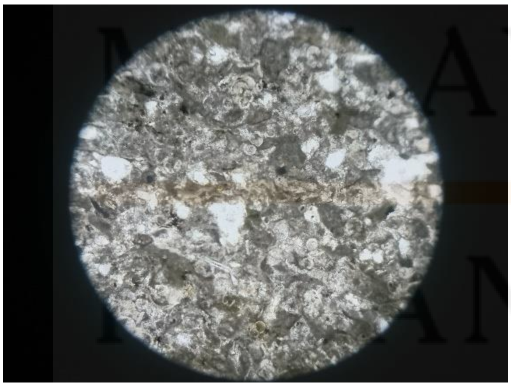


Fig. 2. Classification of limestones according to depositional texture.

Photo:

PPL



XPL

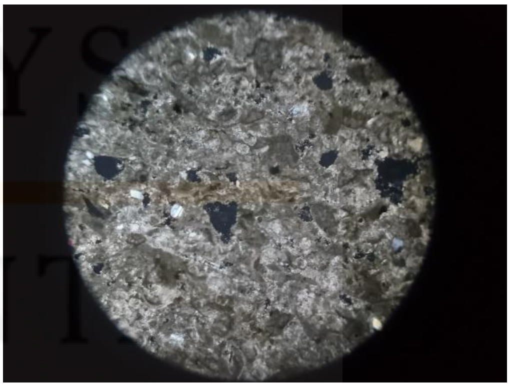


Table 4.3: Mineral description in wackestone.

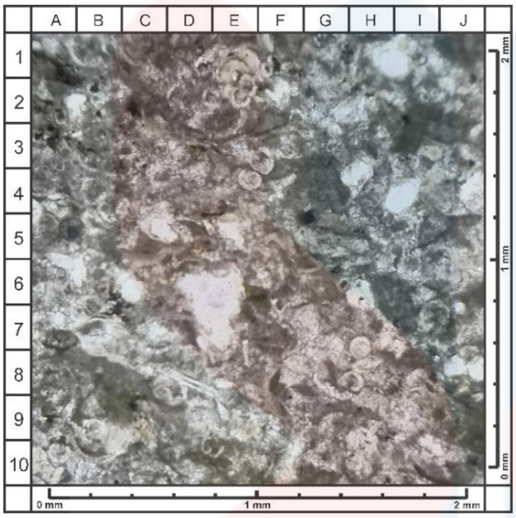
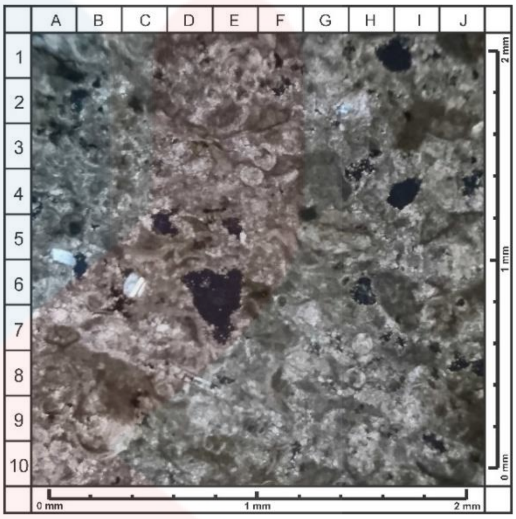
<table>
<tr><th>PPL (Plane Polarized Light)</th><th>XPL (Cross Polarized Light)</th></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">Microscopic observation :
The observations were carried out at 10x ocular magnification and 5x objective. The observation on the thin section were classified as massive structure, good sorting with closed fabric. The texture includes mineral with grain size approximately with size <1/256 – 1/3 mm.</td></tr>
<tr><td>Mineral composition :
Fossil (E1)
In PPL and XPL, the fossils have low relief, weak pleochroism, composed of calcite minerals and carbonate clays. It has a distinctive shape (according to organism shape). Present in the incision. Fossil abundance: 20%
Feldspar (C6)
In PPL (bright colour) and XPL (pink gray), the feldspar in subhedral-euhedral, twin orbit, moderate pleocroism, one-way hemisphere, present to spread in the incision. Abundance: 2%.</td><td>Calcite (A10)
In PPL (bright white) and XPL (multicolour). Invisible hemisphere, has a very high-low relief (double reflection) and strong pleochroism. The calcite spread in the incision as a microlyte base mass. Abundance: 25%
Carbonate Clay mineral (C1)
In PPL (white-brown) and XPL (pink to brownish). Relief-pleochroism. The mineral was in crystalline form and invisible cleavage. Abundance: 47%
Opaque mineral (A1)
It present in dark colour either in PPL or XPL. Abundance: 2%</td></tr>
</table>

Table 4.4: Description of Framestone in Sambipitu formation.

Date	:	19 July 2019	**Location**	:	Kedungkeris river
Sample Code	:	NSW 006	**Coordinate**	:	S 7° 53' 33.2"
Rock Name	:	Framestone			E 110° 36' 06.3"
Colour	:	Ashy gray			
Structure	:	Massive			
Texture	:	Very fine to medium grain size			
Mineral Composition Description					
Calcite	**10%**	**Fossil**	**60%**		
Carbonate clay mineral	**30%**	**-**	**-**		

Classification: (Embry &Klovan)

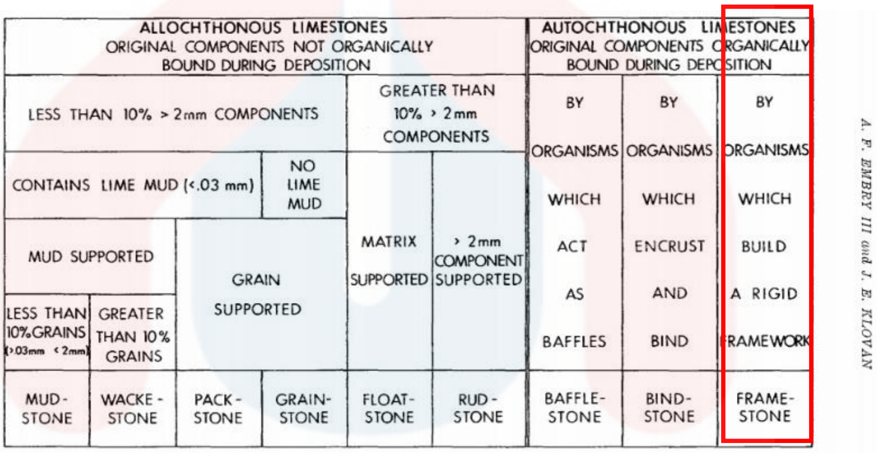
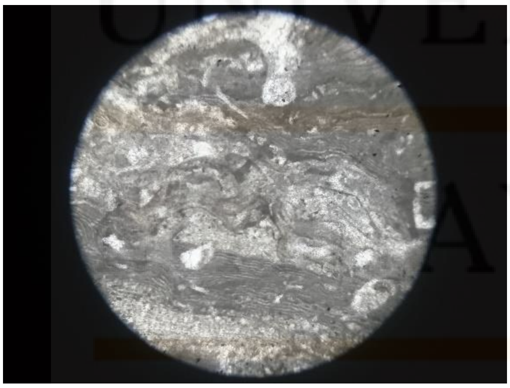


Fig. 2. Classification of limestones according to depositional texture.

Photo:

PPL



XPL

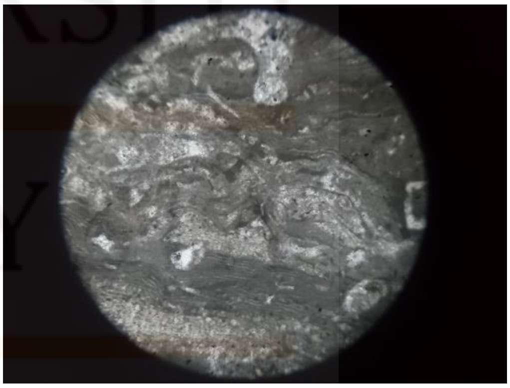


Table 4.5: Mineral description of Framestone

<table>
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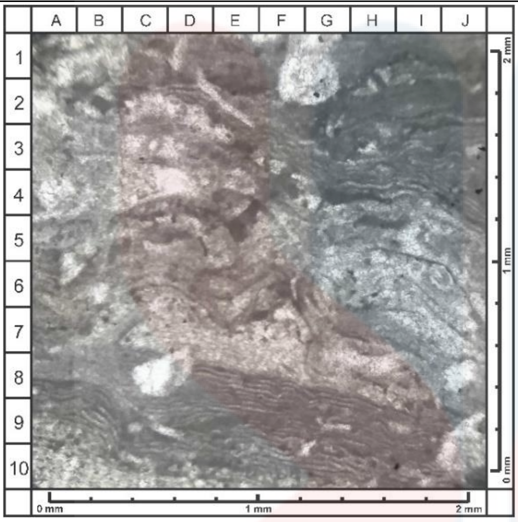
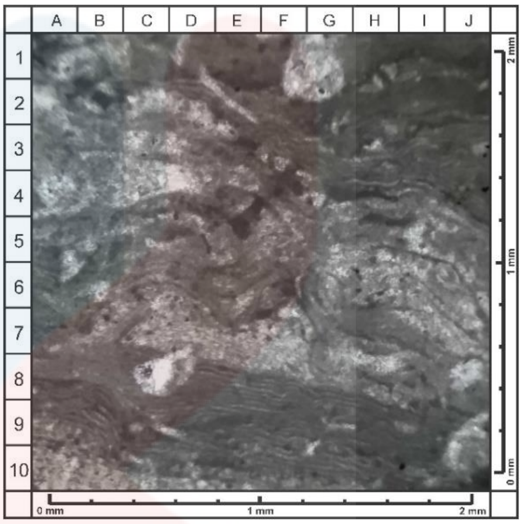
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Microscopic observation :
The observation was done in ocular magnification 10x and objective 5x. The structure identified as massive with grain size ranging between <1/256 – >2 mm. The rock have bad sortation with closed fabric.</td></tr>
<tr><td>Mineral composition :
Fossil (E9)
The fossil appeared as brown colour in PPL and brown to pinkish in XPL. It have low relief with pleochroism ranging from weak to strong. Composed of calcite mineral and clay carbonate. It has distinctive shape (depends on its organism). Abundance: 60%.</td><td>Calcite (D4)
Alteration from mineral plagioclase Ca. In PPL it appeared as bright white and have multicolour in XPL. Invisible in cleavage. Have relief range from high to loe (double reflection). It have strong pleochroism. Present in the thin section. Abundance: 10%
Carbonate Clay mineral (A3)
The mineral showed brownish white in PPL and pink-brownish in XPL. No relief and no pleochroisme. Have crystalline shape and cleavage does not present. Present in thin section. Abundance: 30%.</td></tr>
</table>

Table 4.6: Description of andesite from Nglanggeran.

Date	:	26 July 2019	**Location**	:	Gunung Gentong
Sample Code	:	NSW 088	**Coordinate**	:	S 7° 51’ 29.5”
Rock Name	:	Andesite			E 110° 34’ 12.3”

Colour	:	Grey with some brown patches due to weathering
Structure	:	Massive
Texture	:	Very fine grain size

Mineral Composition Description

Plagioclase	**40%**	**Opaque mineral**	**1%**
Quartz	**3%**	**Base mass**	**52%**
Pyroxene (Clino)	**4%**	**-**	**-**

Classification: Schmidt, 1981

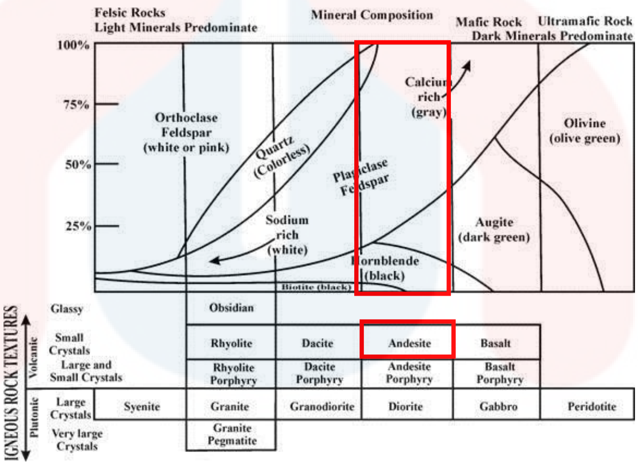
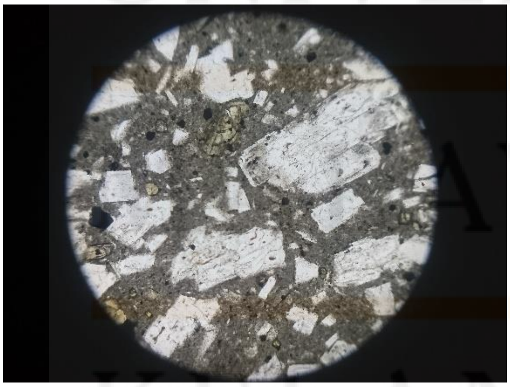


Photo:

PPL



XPL

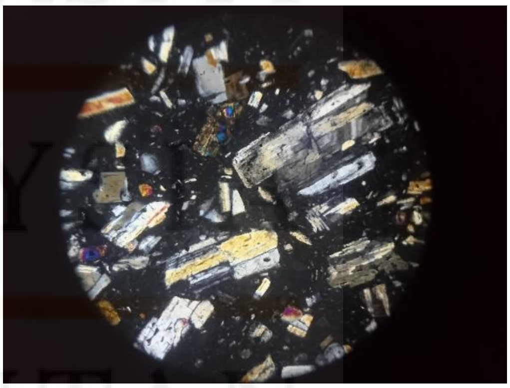


Table 4.7: Mineral composition of andesite.

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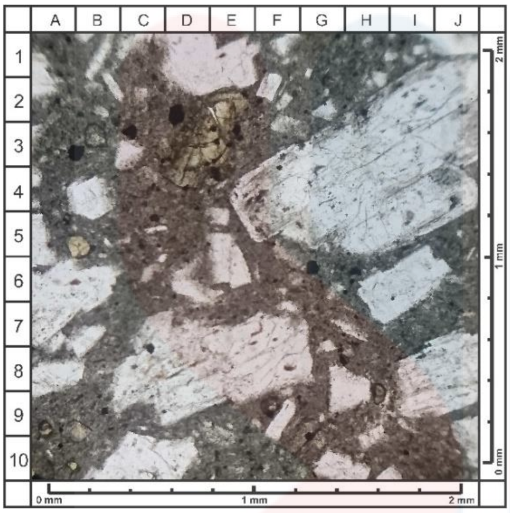
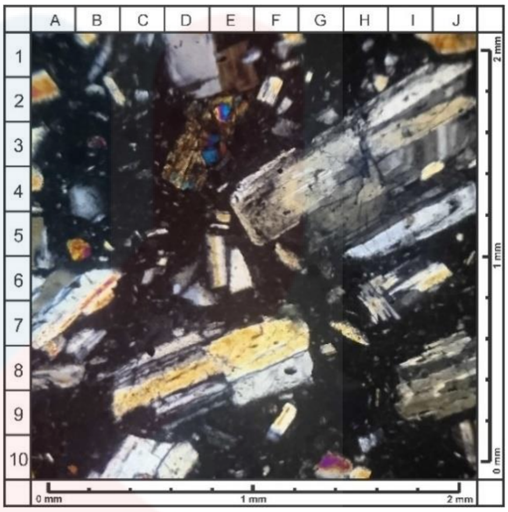
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">Microscopic observation :
The observation was done in ocular magnification 10x and objective 5x. The structure identified as massive with grain size ranging between fine to medium. The rock have aphanitic texture.</td></tr>
<tr><td>Mineral composition :
Plagioclase (I4)
In PPL, plagioclase turned out to be bright in colour. In XPL plagioclase turned out to be red to greyish. Subhedral-euhedral, moderate pleichroisme, 1 cleavage. Moderately spreading in thin section as phenocryst. Abundance: 40%
Quartz (D6)
In PPL-white in colour. In XPL- white to greyish until grey. The quartz has low relief without cleavage. Low pleichroism. Have annehedral crystal shape. Abundance: 3%</td><td>Pyroxene (D3)
In PPL, pyroxene appear to have bright brown. XPL it appear to have from blue-purple-pinkish-brown until orange. Low relief. Low spotted of pleichroism in thin section. Abundance: 4%
Carbonate Clay mineral (A3)
In PPL it have bright in colour and dark colour in XPL.
Basic Mass (A9)
Have bright in colour at PPL and dark in XPL. Made up from quartz microlite, feldspar and volcanic glass. Widely spread in thin section. Abundance: 52%
Opaque Mineral (D2)
In PPL and XPL it looks dark. Abundance:1%</td></tr>
</table>

Table 4.8: Description of basalt from Nglanggeran.

Date	:	26 July 2019	**Location**	:	Gunung Gentong
Sample Code	:	NSW 065	**Coordinate**	:	S 7° 51’ 43.3”
Rock Name	:	Basalt			E 110° 34’ 25.3”
Colour	:	Dark grey to blackish in colour			
Structure	:	Massive			
Texture	:	Very fine grain size			
Mineral Composition Description					
Plagioclase	**30%**	**Opaque mineral**	**7%**		
Pyroxene (Clino)	**8%**	**Base mass**	**49%**		
Pyroxene (Ortho)	**6%**	**-**	**-**		

Classification: Schmidt, 1981

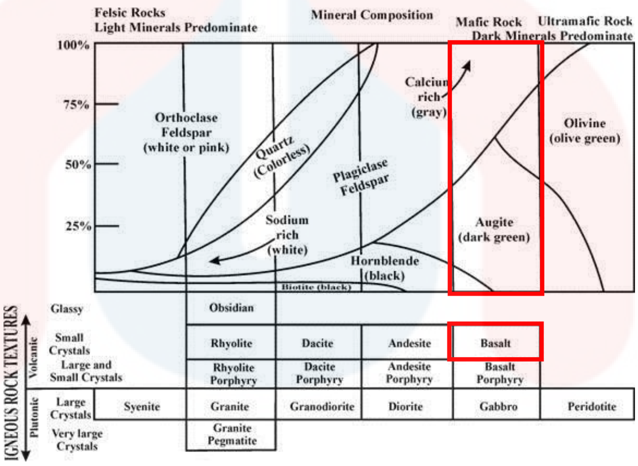
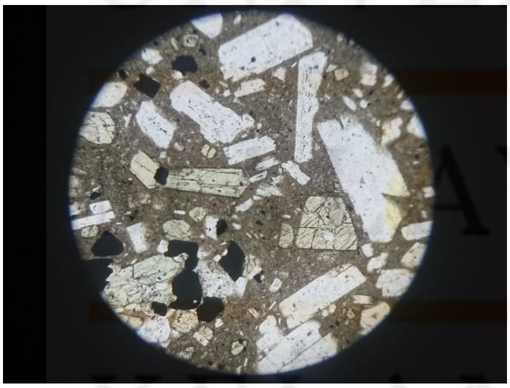


Photo:

PPL



XPL

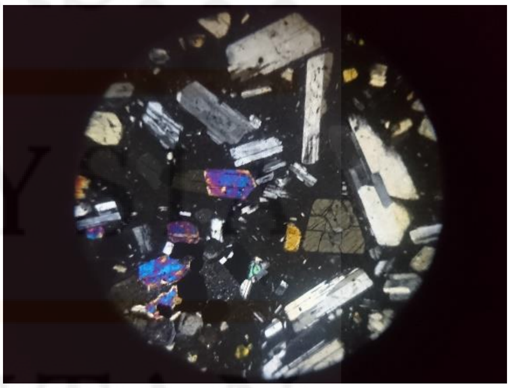


Table 4.9: Mineral composition of basalt.

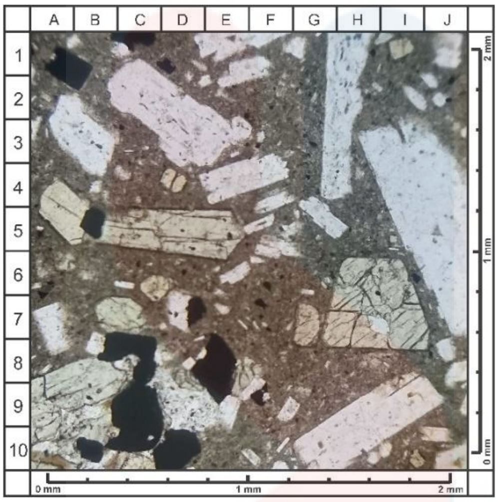
PPL (*Plane Polarized Light)*	**XPL (*Cross Polarized Light)***
	
Microscopic observation : The observation was done in ocular magnification 10x and objective 5x. The structure identified as massive with grain size ranging between fines to hard. The rock have porphory-aphanitic texture.	
Mineral composition : **Plagioclase (B3)** In PPL, plagioclase turned out to be bright in colour. In XPL plagioclase turned out to be red to greyish. Subhedral-euhedral. It have moderate pleichroisme, 1 cleavage. Moderately spreading in thin section as phenocryst and base mass. Abundance: 30% **Pyroxene – Clino (D5)** In PPL-bright brown in colour In XPL it appear to have from blue-purple-pinkish-brown until orange. Low relief with 2 cleavage. Low pleichroism. Have annehedral crystal shape. Abundance: 8%	**Pyroxene – Orto (H7)** In PPL, pyroxene appear to have bright brown. In XPL it appear to have from yellow-greyish-brownish until orange. Low relief. Have 2 cleavage Low spotted of pleichroism in thin section. Abundance: 6 % **Basic Mass (A9)** Have bright in colour at PPL and dark in XPL. Made up from quartz microlite, feldspar and volcanic glass. Widely spread in thin section. Abundance: 49% **Opaque Mineral (D2)** In PPL and XPL it looks dark. Abundance:7 %

Table 4.10: Description of Packstone from Oyo formation.

Date	:	22 July 2019	**Location**	:	Ngalang river
Sample Code	:	NSW 059	**Coordinate**	:	S 7° 53’ 33.6.”
Rock Name	:	Packstone			E 110° 34’ 22.0”
Colour	:	White to yellowish			
Structure	:	Massive			
Texture	:	Very fine to medium grain size			
Mineral Composition Description					
Fossil	**50%**		**Pore cavity**	**4%**	
Carbonate clay mineral	**45%**		**Opaque mineral**	**1%**	
Classification:					

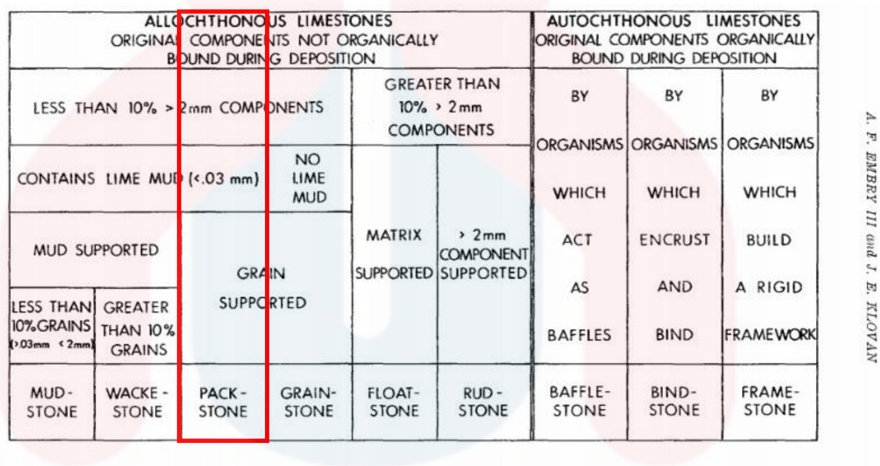
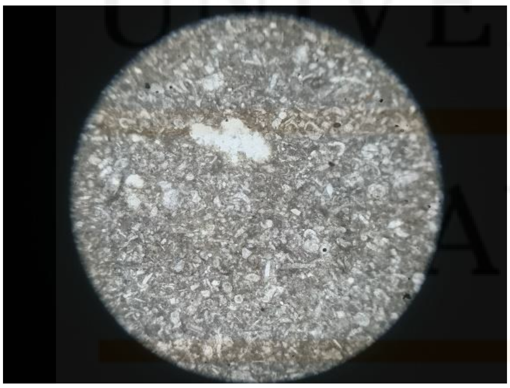


Fig. 2. Classification of limestones according to depositional texture.

Photo:

PPL



XPL

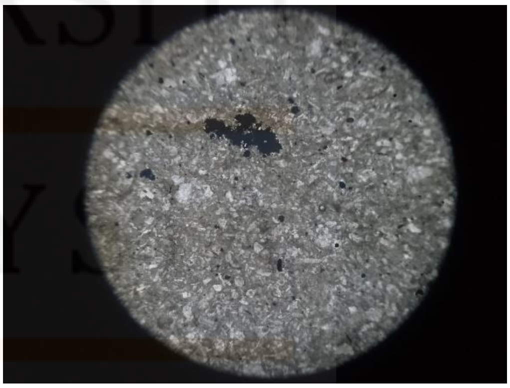
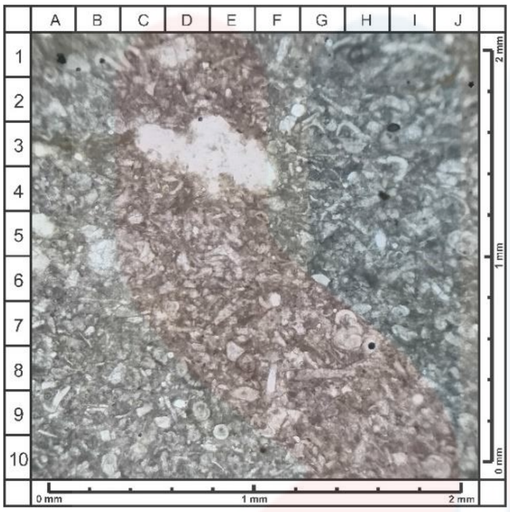
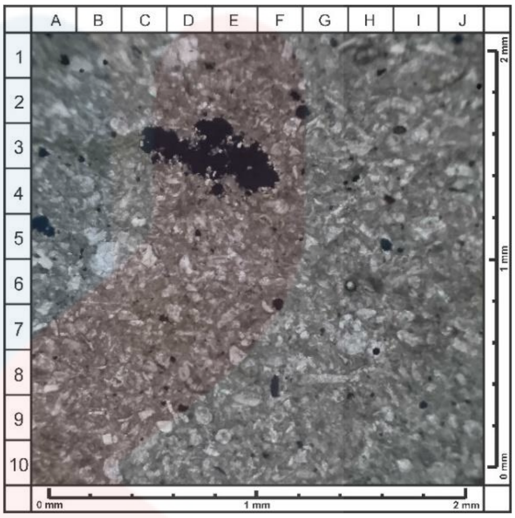


Table 4.11: Mineral composition of Packstone.

PPL (*Plane Polarized Light)*	**XPL (*Cross Polarized Light)***
	
Microscopic observation : The observations were carried out at 10x ocular magnification and 5x objective. The observation on the thin section were classified as massive structure, good sorting with closed fabric. The texture includes mineral with grain size approximately with size <1/256 – 1/8 mm.	
Mineral composition : **Fossil (B5)** In PPL and XPL, the fossils turned out to be brown –pinkish in colour. Have low relief, weak until strong pleochroism. Composed of calcite minerals and carbonate clays. It has a distinctive shape (according to organism shape). Present in the incision. Fossil abundance: 50%	**Carbonate Clay mineral (J1)** In PPL (white-brown) and XPL (pink to brownish). Relief-pleochroism. The mineral was in crystalline form and invisible in cleavage. Abundance: 45% **Pores (D6)** In PPL it have bright white in colour and in XPL it looks dark. Abundance: 4%. **Opaque Mineral (D2)** In PPL and XPL it looks dark. Abundance:1 %

4.4 Structural Geology

The geological mapping activities that was conducted proved that the present geology in Ngalang area was effected by tectonic activities. The tectonics activities in Indonesia during Cenozoic formed major structures in Indonesia. The main structure in Ngalang was strike slip fault that give a very big impact to the morphology of that area. Before geological mapping was conducted, base map and shuttle radar topography mission (SRTM) analysis was done.

From satellite image shuttle radar topography mission (SRTM), there was a big lineament that separated mountain and forming a valley named Kali Ngalang. The strike-slip fault can be observed by the presence of valley with low relative mountain that moved towards NE-SW.

4.4.1 Lineament Analysis

Lineament analysis is a linear feature in geomorphology that expressed structure such as faulting, joint or fracture. It is another parameter that have been used in order to have general ideas for artificial recharge structures. However these lineament may also indicates linear zones of fractures, bending deformation, crust that were increasing in permeability (Igor, 2016).

In Ngalang, lineament analysis was very useful to make structural analysis especially in Ngalang river. Ngalang river has almost 8- 10 km of of linear line through all these four formation. The lineament shows along all the formation includes, Semilir, Nglanggeran, Sambipitu and Oyo formation. Hence, the changes in physical characteristics of the lithology within these rocks can be seen clearly.

4.4.2 Cleavage

Figure 4.26: Cleavage in Sambipitu formation.

Cleavage or marked as compaction cleavage was found at claystone in Sambipitu formation as shown in Figure 4.26. This structure was also known as penetrative tectonic planar structure in a rock. Besides, cleavage occur when rocks with fine grain composition were affected by pressure solution. Pressure solution is a dissolution of minerals with grain to grain contacts. This deformation mechanism need a high stress until the rock experience compaction.

Cleavage occur when the mineral and grains have been reoriented and have undergone deformation and metamorphism. Pore space collapse can also be a part of a stress and reformation of the primary foliation. However, this cleavage also can be said as a result from tectonic foliation. Hence, from Figure 4.27, the cleavage can be categorized as slaty cleavage with slaty shape less than 1 mm.

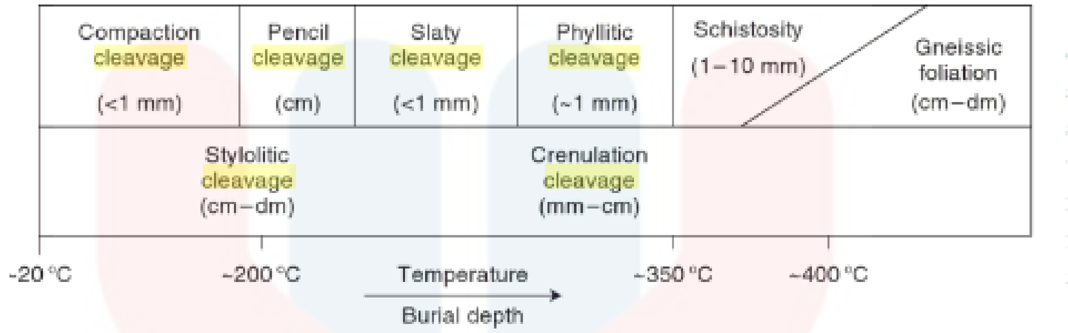


Figure 4.27: The figure shows the temperature needed for cleavage to be happened.(Nicholas, 2013)

4.4.3 Joint

4.4.3.1 Joint analysis

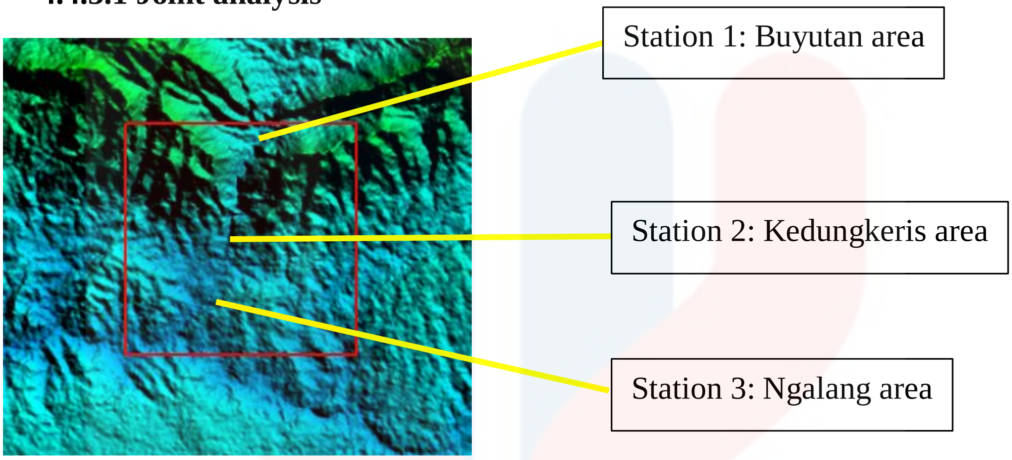


Figure 4.28: SRTM image of Ngalang area.

Figure 4.28 shows different station of joint analysis in Ngalang area by Shuttle Radar Topography Mission image (SRTM). The joint analysis was conducted in 3 station and each station produced different image of rose diagram.

<u>STATION 1: DESA BUYUTAN</u>

Table 4.12: Joint reading at coordinate S 07° 51” 09.2’, E 110° 35” 17.5’.

Strike/Dip	**Strike/Dip**	**Strike/Dip**	**Strike/Dip**
N 175° E/ 82°	N 280° E/ 36°	N 301° E/ 65°	N 304° E/ 59°
N 155° E/ 59°	N 145° E/ 85°	N 280° E/ 78°	N 210° E/ 41°
N 155° E/ 75°	N 324° E/ 55°	N 257° E/ 76°	N 360° E/ 69°
N 230° E/ 62°	N 165° E/ 45°	N 255° E/ 50°	N 220° E/ 72°
N 360° E/ 25°	N 360° E/ 67°	N 350° E/ 60°	N 245° E/ 49°
N 135° E/ 36°	N 025° E/ 4°	N 185° E/ 76°	N 265° E/ 51°
N 160° E/ 61°	N 148° E/ 61°	N 180° E/ 76°	N 020° E/ 65°
N 170° E/ 82°	N 310° E/ 46°	N 165° E/ 61°	N 015° E/ 49°
N 085° E/ 65°	N 027° E/ 64°	N 032° E/ 64°	N 355° E/ 40°
N 095° E/ 60°	N 312° E/ 33°	N 055° E/ 50°	N 260° E/ 49°
N 085° E/ 75°	N 313° E/ 52°	N 293° E/ 66°	N 130° E/ 65°
N 140° E/ 75°	N 349° E/ 49°	N 360° E/ 45°	N 255° E/ 47°
N 155° E/ 70°	N 354° E/ 49°	N 009° E/ 61°	N 175° E/ 40°

N 095° E/ 71°	N 075° E/ 49°	N 100° E/ 68°	N 100° E/ 68°
N 010° E/ 45°	N 100° E/ 68°	N 100° E/ 68°	N 075° E/ 62°
N 020° E/ 72°	N 075° E/ 49°	N 075° E/ 49°	N 095° E/ 26°

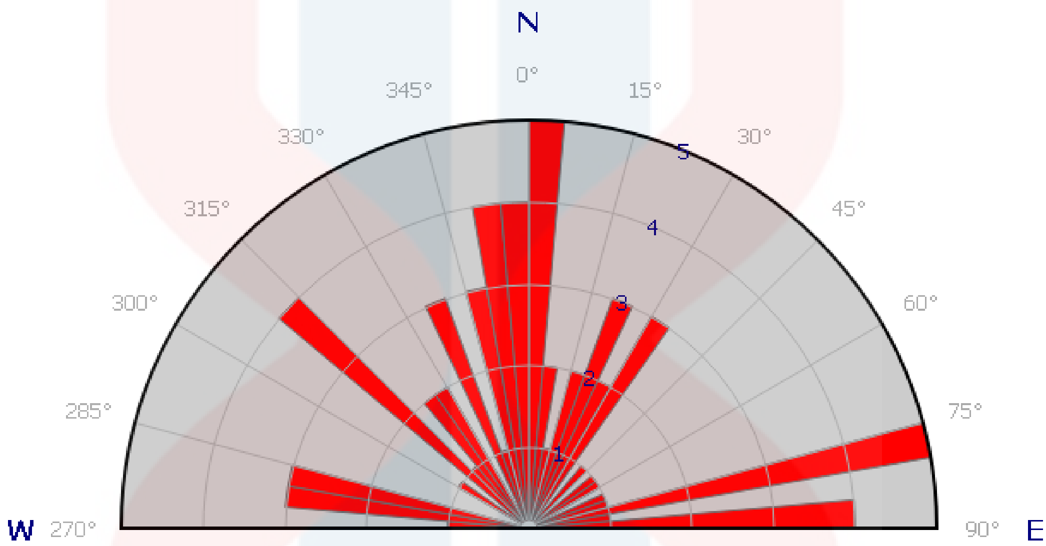


Figure 4.29: Rose diagram at station 1: Desa Buyutan

STATION 2: DESA KEDUNGKERIS

Table 4.13: Joint reading at coordinate **S 07° 53" 09.1', E 110° 35" 59.3'**

	Strike/Dip	Strike/Dip	Strike/Dip
N 20° E/ 66°	N 065° E/ 64°	N 300° E/ 63°	N 340° E/ 46°
N 3° E/ 56°	N 020° E/ 56°	N 344° E/ 62°	N 090° E/ 61°
N 275° E/ 51°	N 122° E/ 54°	N 085° E/ 52°	N 260° E/ 81°
N 326° E/ 61°	N 125° E/ 46°	N 115° E/ 71°	N 030° E/ 54°
N 235° E/ 49°	N 309° E/ 65°	N 172° E/ 59°	N 060° E/ 56°
N 014° E/ 80°	N 165° E/ 64°	N 84° E/ 69°	N 315° E/ 64°
N 300° E/ 70°	N 064° E/ 61°	N 295° E/63°	N 145° E/ 54°
N 016° E/ 64°	N 161° E/ 62°	N 045° E/ 57°	N 200° E/ 72°
N 329° E/ 37°	N 115° E/ 80°	N 080° E/ 82°	N 280° E/ 74°
N 019° E/ 69°	N 295° E/ 56°	N 097° E/ 70°	N 150° E/ 82°
N 006° E/ 67°	N 325° E/ 70°	N 142° E/ 54°	N 240° E/ 76°

N 335° E/ 66°	N 285° E/ 64°	N 076° E/ 65°	N 170° E/ 63°
N 304° E/ 62°	N 110° E/ 80°	N 176° E/ 79°	N 084° E/ 63°
N 304° E/ 62°	N 284° E/ 54°	N 020° E/ 72°	N 260° E/ 54°
N 045° E/ 55°	N 280° E/ 30°	N 220° E/ 60°	N 176° E/ 79°

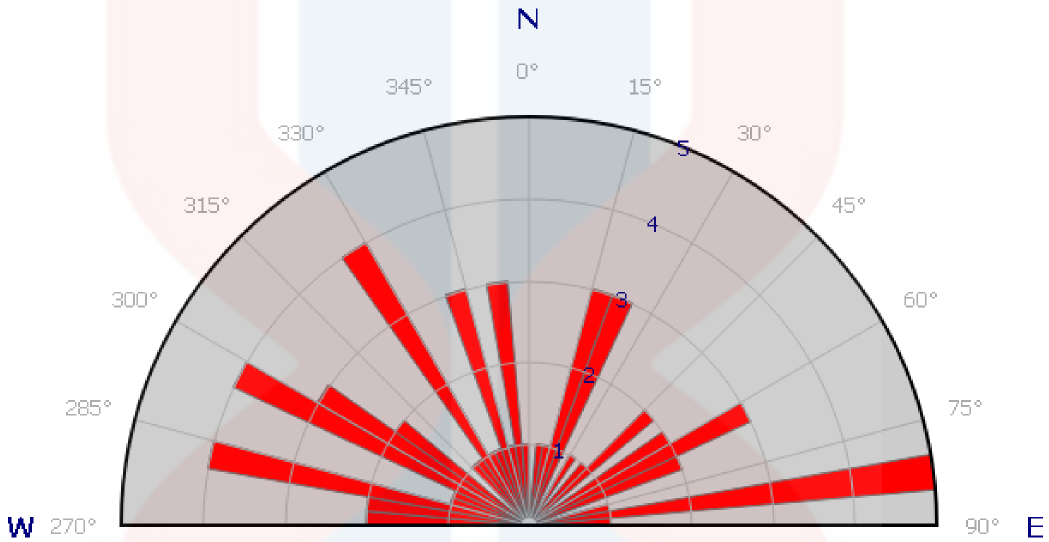


Figure 4.30: Rose diagram at station 2: Desa Kedungkeris.

STATION 3: DESA NGALANG

Table 4.14: Joint reading at coordinate **S 07° 51" 09.2', E 110° 35" 17.5'**

Strike/Dip	Strike/Dip	Strike/Dip	Strike/Dip
N 280° E/ 62°	N 290° E/ 64°	N 085° E/ 81°	N 234° E/ 80°
N 160° E/ 76°	N 018° E/ 64°	N 295° E/ 74°	N 185° E/ 72°
N 290° E/ 64°	N 085° E/ 71°	N 243° E/ 74°	N 200° E/ 20°
N 294° E/ 59°	N 285° E/ 34°	N 190° E/ 83°	N 125° E/ 73°
N 295° E/ 71°	N 100° E/ 80°	N 273° E/ 82°	N 275° E/ 83°
N 204° E/ 50°	N 290° E/ 82°	N 285° E/ 82°	N 220° E/ 81°
N 107° E/ 60°	N 310° E/ 82°	N 115° E/ 83°	N 215° E/ 83°
N 100° E/ 52°	N 185° E/ 75°	N 035° E/ 66°	N 305° E/ 70°
N 202° E/ 52°	N 290° E/ 76°	N 110° E/ 80°	N 045° E/ 76°
N 105° E/ 54°	N 295° E/ 79°	N 275° E/ 69°	N 200° E/ 56°
N 010° E/ 34°	N 293° E/ 57°	N 142° E/ 69°	N 325° E/ 35°
N 200° E/ 62°	N 289° E/ 61°	N 185° E/ 74°	N 190° E/ 71°
N 290° E/ 56°	N 205° E/ 61°	N 295° E/ 69°	N 055° E/ 80°

N 110° E/ 59°	N 110° E/ 74°	N 040° E/ 85°	N 045° E/ 35°
N 105° E/ 79°	N 238° E/ 69°	N 235° E/ 75°	N 090° E/ 82°
N 279° E/ 74°	N 020° E/ 85°	N 234° E/ 84°	N 035° E/ 80°
N 020° E/ 69°	N 340° E/ 78°	N 025° E/ 83°	N 036° E/ 66°
N 290° E/ 80°	N 235° E/ 74°	N 105° E/ 76°	N 034° E/ 76°

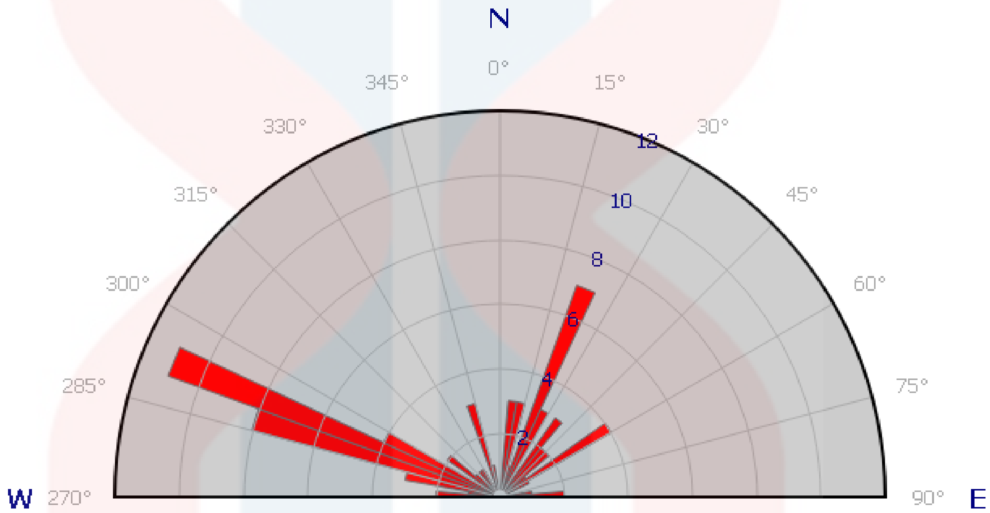


Figure 4.31: Rose diagram at station 3: Desa Ngalang.

Figure 4.29 until Figure 4.31 shows different force direction of joint analysis (shown in Table 4.12 until Table 4.14). The force analysis were taken at conjugated joint and divided into gash and fracture joint. Different direction of force proved that the strike slip in Ngalang happened at different period and segment. However, these joint analysis still not enough to describe the whole forces direction that occur in Ngalang area.

4.4.3.2 Conjugated Joint

Figure 4.32: Conjugated joint at Kedungkeris area.

Conjugated joint shown in Figure 4.32 was a fracture or cracks that happened within a body rock where no displacement between the rocks body but experienced tectonic force. These joint present in form of vertical, horizontal or inclines in all different types of rock. The reading of joint were taken in order to produce rose diagram analysis and measured by using the same technique as normal bedding. Rose diagram analysis were done to detect the initial forces in the outcrop.

There were three station chosen for joint analysis. The reading of strike dip for joints in each of the station were taken between 60-70 readings. First station was located at Buyutan area in Semilir formation, second station was at Kedungkeris area in Sambipitu formation and third station was at Ngalang in Oyo formation. All these joint were taken along the Ngalang river.

4.4.3.3 Sheeting Joint

Figure 4.33: Sheeting joint found in Ngalang river at Nglanggeran formation.

From Figure 4.33 shown a sheeting joint formed at Ngalang River. It was situated in Nglanggeran formation and was found at S 07° 52’ 07.3”, E 110° 35’ 06.0. These joints were extensive fractures which formed and developed parallel likely natural slopes.

Sheeting joint might be confused by a bedding since it have a bedding-shape like. Some of the sheeting joint usually developed at shallow dip angles where high compressive stress were located at shallow depth. The sheeting joint always occur in strong and massive rock.

4.4.4 Fault

Topography of Ngalang area nowadays happened because of tectonic force which produced by different kind of faulting. Strike slip fault was the major fault in this area. Besides that, Ngalang area also composed of other type of structure, such as thrust fault and normal fault.

4.4.4.1 Strike-slip Fault

Figure 4.34: Dextral strike slip that occur in Ngalang

Strike-slip fault is a vertical fractures where both of the block moved horizontally as shown in Figure 4.34. It have minimum and maximum stress in both horizontal planes to one another. The strike slip can either happened in dextral or sinistral strike slip. Ngalang strike slip fault line was relatively trending towards northwest-southeast.

According to Rickard (1972) Ngalang strike slip was classify based on very long lineament along Ngalang river which forming the escarpment topography and undulating hill. The valley that separated Gentong mountain and Genter mountain was a results from strike slip.

Furthermore Dicky and Hita (2016) also clarify that mega strike-slip fault in Ngalang was produced from different segment of tectonic movement period that causing other effect to the Ngalang river. These effects were sag pond, brecciation due to movement of the plate, micro-fault, horst-graben fault and other fault. The figure 4.35 shows the after effect of the strike slip fault. The sag pond was located at Nglanggeran formation near Dusun Karangayar, Ngalang.

Figure 4.35: Sag pond in Dusun Karangayar, Ngalang area.

4.4.4.2 Reverse Fault

Figure 4.36: Thrust fault at Ngalang river at coordinate S 07° 51" 35.7', E 110° 35" 07.3'

The Figure 4.36 was thrust fault which located in Ngalang river. The thrust fault was categorized as reverse fault. Excessive force on the rock strata causing the hanging wall to move upwards which altered the original strata layers. This reverse fault can be categorized into thrust fault since the angle of the fault plane was less than 45 degree.

This thrust fault was located at S 07° 51" 35.7', E 110° 35" 07.3' along Ngalang river. The lithologies of this thrust fault was made up by layers of pyroclastic breccia and epiclastic breccia. Since this outcrop was made up of volcanic rock, there was no bedding or strata found in this formation.

4.4.5 Fold

4.4.5.1 Anticline

Figure 4.37: Anticline at the small dam in Oyo Formation at Oyo river.

The Figure 4.37 shows an anticline at a small dam at Oyo river. The anticline has dipping up to 30 degree away from the centre of the oldest bed. It was a part of deformation that caused due to the tectonic activities and experienced compression. In structural geology it was a part of fold with A-shaped and has the oldest strata at the lower bed.

4.5 Historical Geology

Java geology was made up of calc-alkaline volcanic island arc due to the subduction of the Indian plate. The evolution of geology in Java influenced geology of Ngalang area until producing a unique geological features. Generally, Ngalang area made up with Semilir formation with constituent of pumice breccia overlying Nglanggeran formation. Nglanggeran formation arranged by the intercalation on tuffaceous breccia and lava with basalt and andesite component (Bronto & Hartono, 2008).

Underlying the Nglanggeran formation was Sambipitu and Oyo formation. With constituent of sandstone and claystone towards southern, the sandstone started to have some carbonate characteristics and alternation of carbonate sandstone limestone. Towards southern, limestone characteristics of the formation started to appear.

Ngalang was made up with different lithology that have different types of depositional environment, starting from Semilir and Nglanggerann that was deposited in shallow marine but have different constituent of volcanic product, Sambipitu formation from transitional zone and lastly Oyo formation from shallow marine.

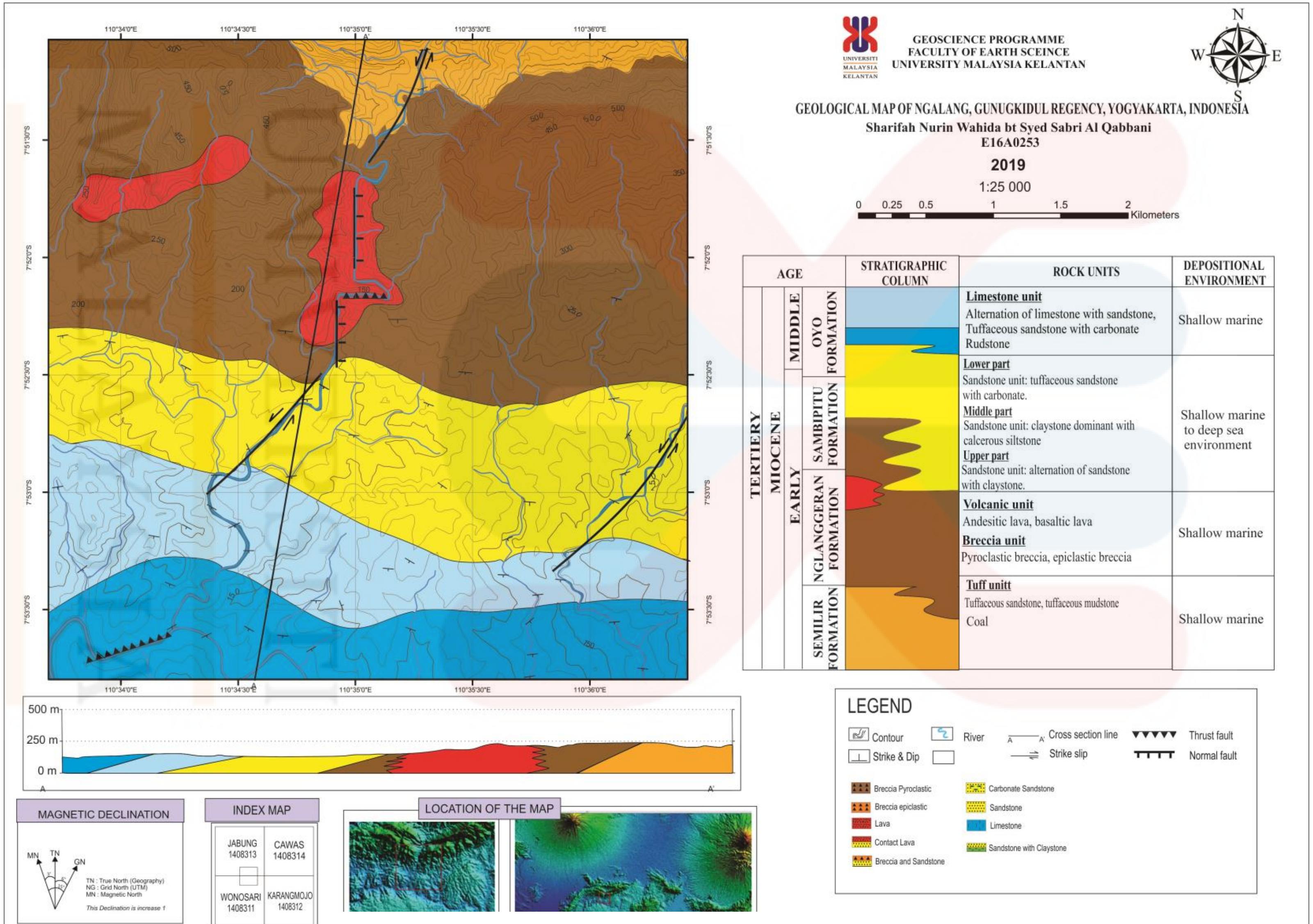


Figure 4.38: Geological map of Ngalang area

CHAPTER 5

GEOCHEMISTRY OF TOPSOIL IN NGALANG AREA

5.1 Introduction

Geochemistry of topsoil deals with different chemistry element can be tested by using different kind of geochemistry analysis. Geochemistry of topsoil between two different formation; (1) Nglanggeran and (2) Sambipitu in Ngalang area gives different understanding of chemical element and geology characteristics of the area. Nglanggeran formation composed of volcanic soil can be differ in physical and chemical characteristics compared to Sambipitu formation.

Besides, these two formation were inter-fingering with each other. Hence geochemical analysis was conducted in the contact area in order to have distinctive features of these formation. After done with geological mapping, grid mapping for geochemistry of topsoil area was determined. In order to achieve the objective, grid mapping was conducted in 500 m x 500 m area with 121 observation point. The determination of sampling points were done after soil map was produced. The soil map produced shows different part of soil segment in Nglanggeran and Sambipitu of Ngalang area with closed up scale 500 m x 500 m.

The soil map was produced by using Globber Mapper, ArcGIS and CorelDraw. It was done to identify the distribution of volcanic soil and sedimentary soil in location A. From the observation of grid map, three checkpoint were chosen from for soil sampling. This soil sample was collected with precaution step in order to maintain the purity of the soil.

In this geochemical studies X-Ray Fluorescence (XRF) was used as analysis technique in this chapter. XRF was chosen because of it was fast, non-destructive, and requires minimum steps in sample preparation (Jamaluddin, 2018). This analysis were conducted after all the steps in field survey, determination of sampling area and sampling were conducted. The data used in this chapter was primary data. Three different samples of topsoil were taken directly in Ngalang at different geological formation.

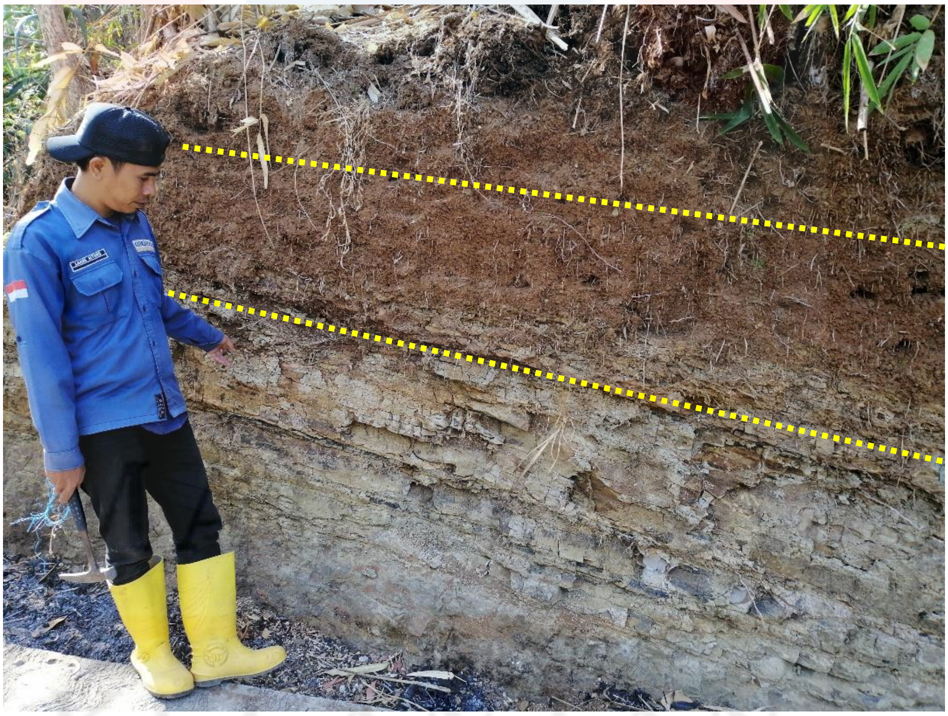


Figure 5.1: The soil horizons that exposed due to weathering and hills cutting at the roadside.

Figure 5.1 shows the soil horizon Ngalang area with predominantly made up from latosol or also known oxisols by USDA soil taxonomy. The oxisols soil type usually found in tropical rainforest with high content of aluminium and iron oxides. Oxisols characterized as highly weathered, leached acidic and low in base saturation (Foy, 1992).

For this geochemical analysis, three soil sample were taken in the chosen area considering different chemical element constituent of topsoil. The first sample was taken in Nglanggeran formation and named as Nglanggeran soil. Next, was soil sample 2 that was taken at Sambipitu formation. Lastly soil sample 3, contact area of Sambipitu and Nglanggeran formation soil was taken and labelled as contact.

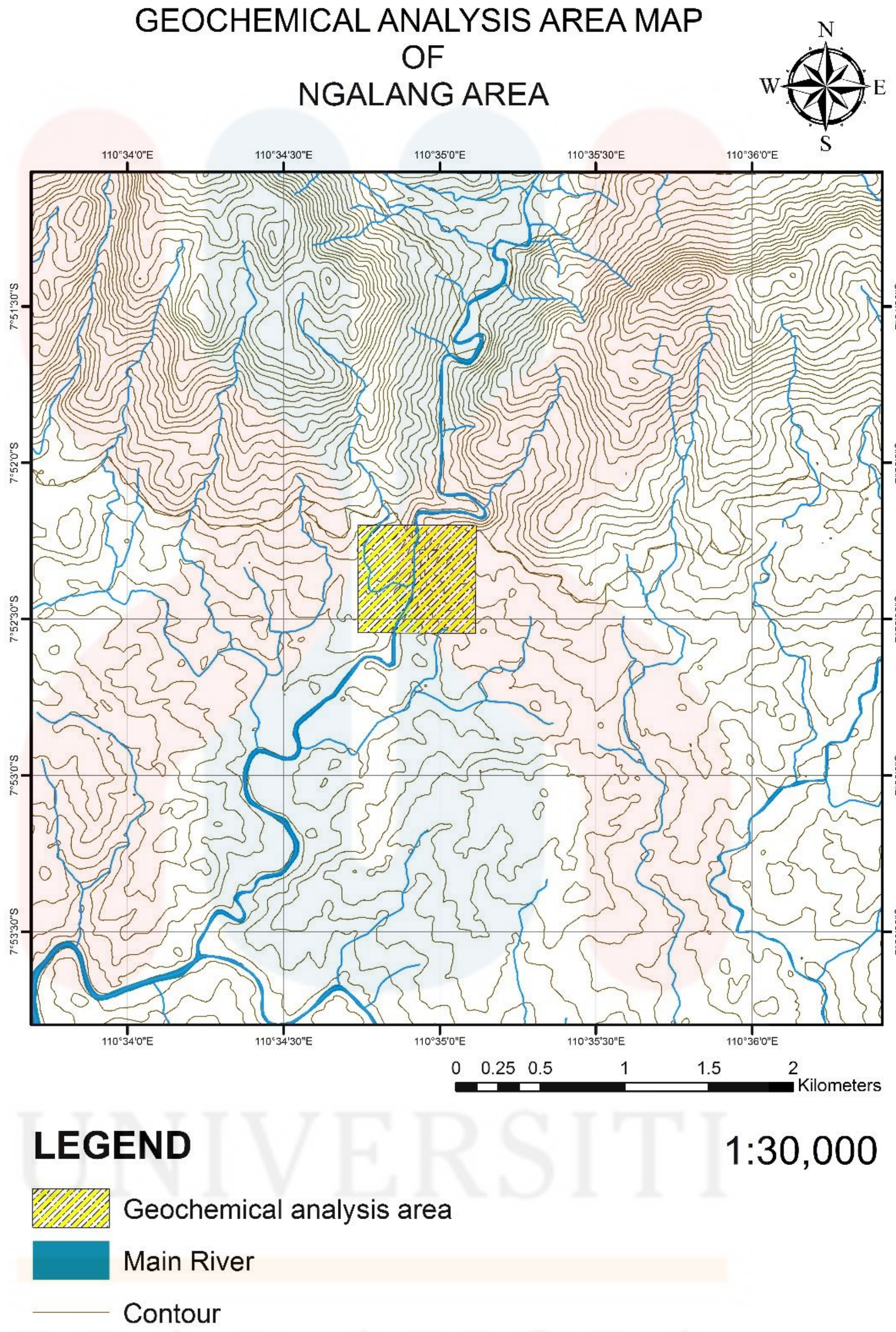


Figure 5.2: Geochemical analysis area.

5.2 Results

5.2.1 Grid Mapping

Table 5.1: Physical distinctive between Nglanggeran and Sambipitu soil.

<table>
<tr><th>Nglanggeran soil</th><th colspan="2">Sambipitu soil</th></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><th>Nglanggeran formation</th><th>Formation</th><th>Sambipitu formation</th></tr>
<tr><td>Ranging from red to brownish in colour.</td><td>Colour</td><td>Ranging from light yellow to light brown in colour</td></tr>
<tr><td>Clayey and silty.</td><td>Texture</td><td>Sandy</td></tr>
<tr><td>The grain size may range between 0.05 mm to 0.02 mm</td><td>Grain size</td><td>The grain size may range between 2 mm until 0.05 mm.</td></tr>
</table>

Table 5.1 shows difference physical characteristics of Nglanggeran and Sambipitu soil. The physical characteristic of Nglanggeran soil mostly have reddish to brownish colour and these soil were clayey in texture. Compared to Sambipitu's soil, these soil mostly have bright yellow and tend to have coarser grain size. The observation from physical characteristics were used during grid mapping and was plotted. The plotted data were used to produce soil map.

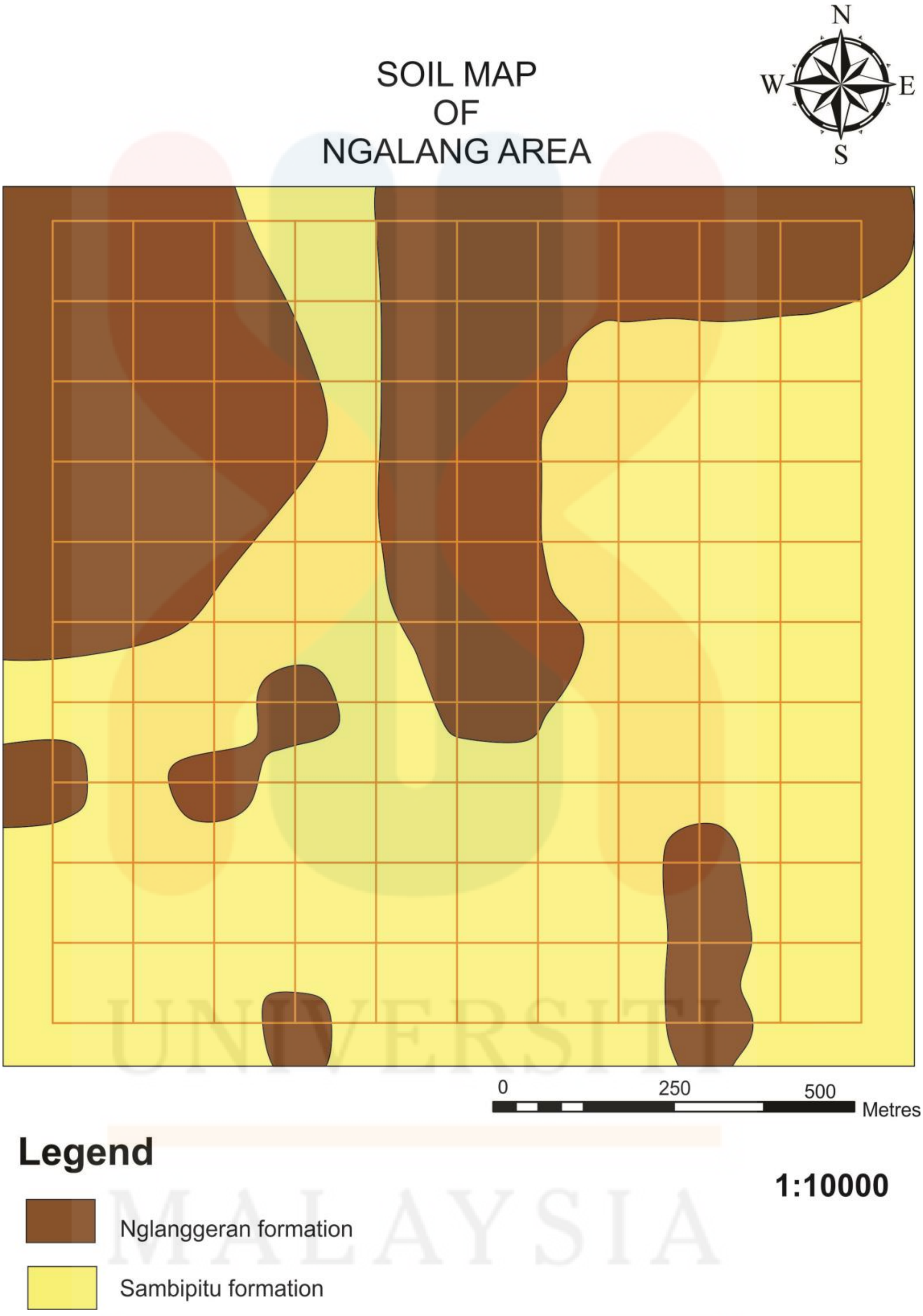


Figure 5.3: Soil map of the geochemical analysis area.

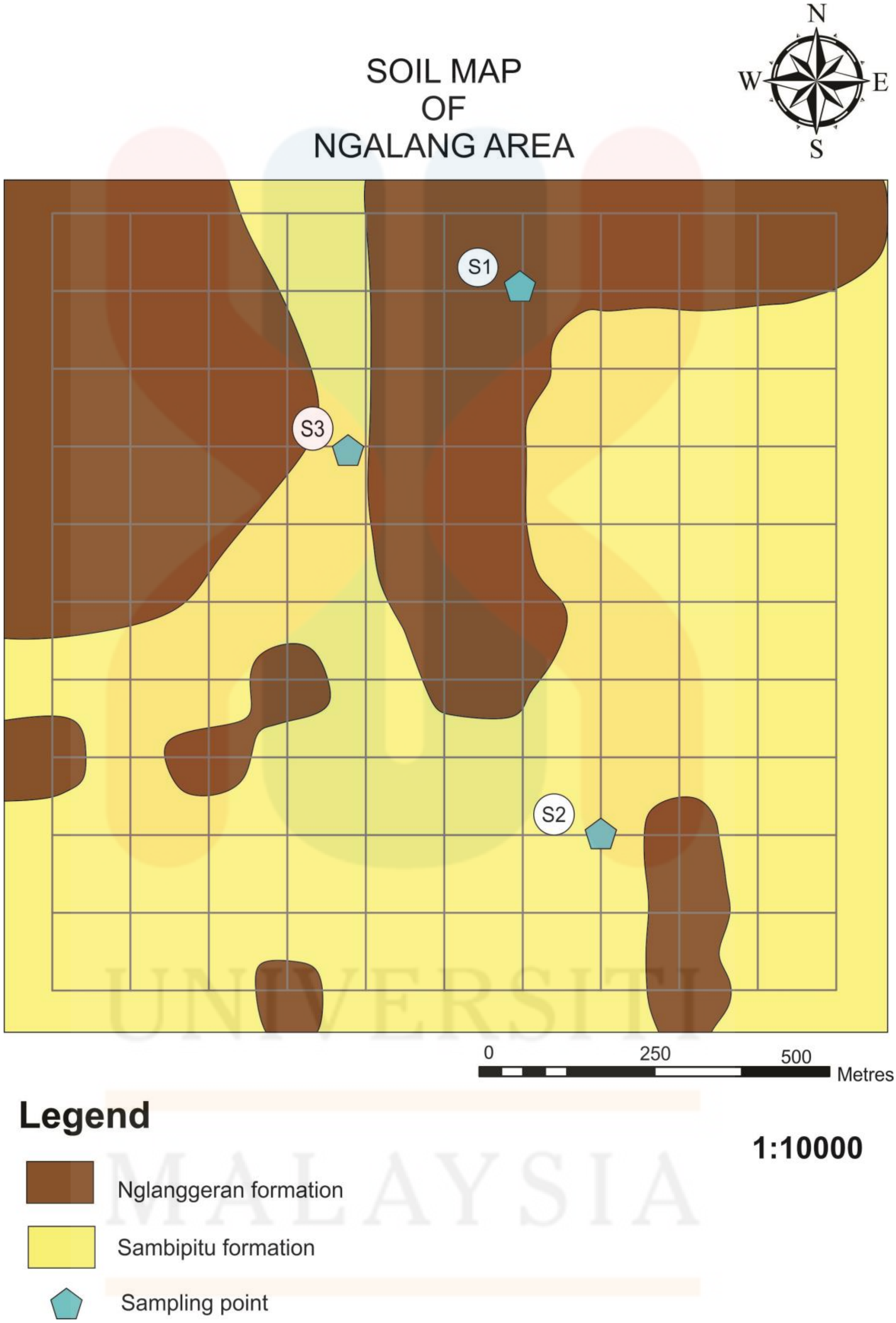


Figure 5.4: Sampling point after soil map of the geochemical analysis area was produced

Figure 5.3, shows the soil map of the geochemical analysis area with coordinate S 7°52’07.3”, S 7°52’48.25, E 110° 34’ 33.50” and E 110° 35’ 15.0” . This area was grouped based on the lithology and soil physical characteristics of the topsoil. Grid mapping were conducted with 121 observation in order to have precise and detail information about the geochemical analysis area.

After the topsoil was grouped based on physical characteristics, these soil groups were analysed in order to choose sampling point of the topsoil. Hence, 3 soil sampling point were chose and named as S1- Nglanggeran topsoil, S2—Sambipitu topsoil and S3-Contact between Nglanggeran and Sambipitu topsoil.

5.2.2 Geochemical Analysis by X-Ray Fluorescence (XRF)

5.2.2.1 Nglanggeran Formation

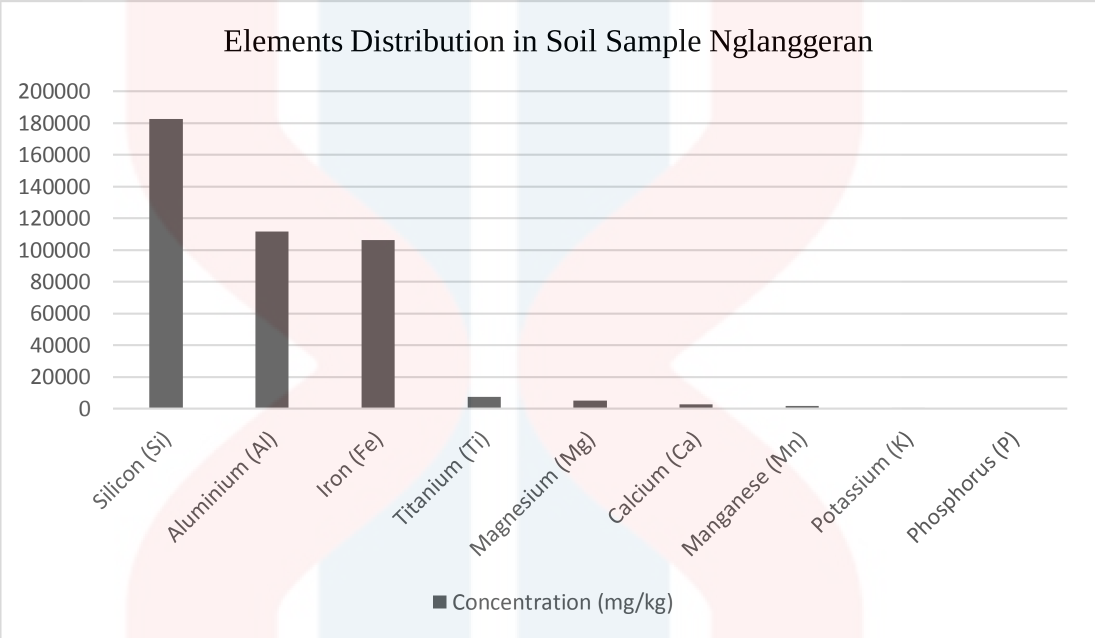


Figure 5.5: Bar chart for element distribution in Nglanggeran.

From geochemical analysis of Nglanggeran soil contain high value of Silica content with value 182600 mg/kg as shown in Figure 5.5. The high content of Al can be related soil natural resources such as agricultural activities (Rajsic et al., 2008). Aluminium (Al) and Iron (Fe) recorded as a part of abundance element in this formation. However, the Titanium (Ti), Magnesium (Mg), Calcium (Ca), Manganese (Mn), Potassium (K) and Phosphorus (P) was decreasing gradually in the soil sample.

5.2.2.2 Sambipitu Formation

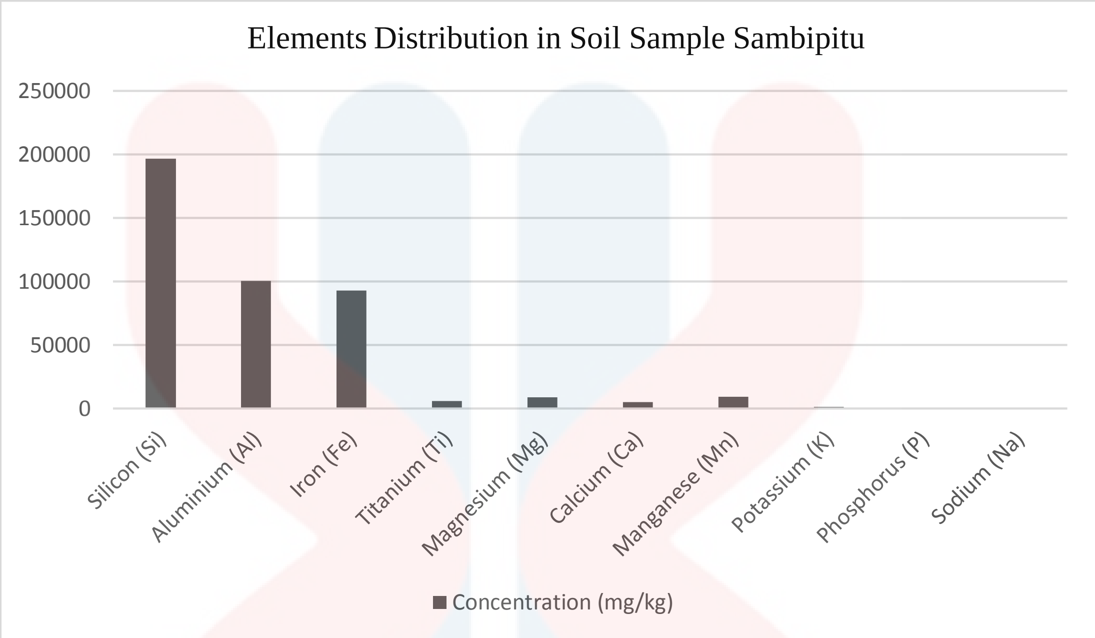


Figure 5.6: Bar chart for element distribution in Sambipitu.

From Figure 5.6, geochemical analysis from Sambipitu soil shows a constituent composition of element rich in silicon (Si) element because of the present of quartz mineral in sandstone of Sambipitu Formation with value 197,000 mg/kg. Besides, the formation also composed of Aluminium (Al) with value 100,400 mg/kg and Iron (Fe) element with value 9,300. However, the formation also have a small chemical element such as Magnesium (Mg), Calcium (Ca), Titanium (Ti), Manganese (Mn), Phosphorus (P) and Sodium (Na). These element were increasing gradually.

5.2.2.3 Contact of Nglanggeran and Sambipitu

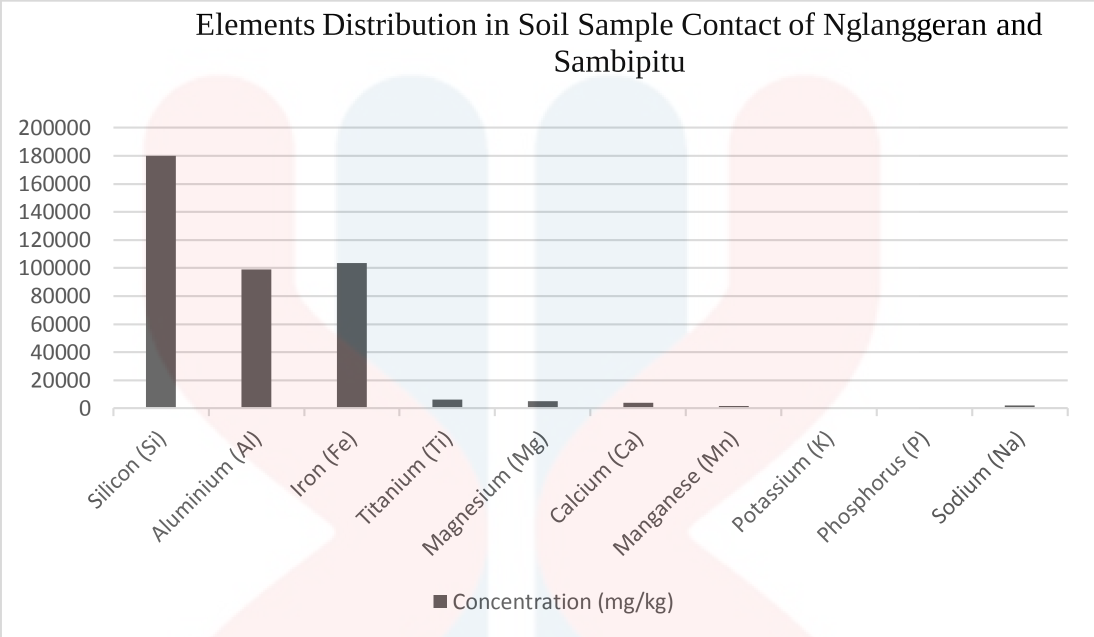


Figure 5.7: Bar chart for element distribution at the contact of Sambipitu and Nglanggeran.

From Figure 5.7, the expected area of Sambipitu and Nglanggeran contact soil shows a constituent composition of element rich in silicon (Si) element with value 179,900 mg/kg because of the present of quartz mineral in sandstone of Sambipitu Formation. Besides, the formation also composed of Aluminium (Al) and Iron (Fe) element. However, the formation also have a small chemical element such as Magnesium (Mg), Calcium (Ca), Titanium (Ti), Manganese (Mn), Phosphorus (P) and Sodium (Na). These element were increasing gradually.

5.3 Discussion

5.3.1 Elemental Distribution in Geochemical Analysia Area

The element distribution in topsoil of geochemical analysis area in Ngalang was a crucial discussion since the villagers in Ngalang were cultivating their crops as their daily activities. Hence, it was very important to preserve the nutrition of Ngalang topsoil in order to have a better understanding of soil nutrition in the area. From geochemical analysis of XRF detected 10-11 element in the soil samples and gave varieties of geochemical content between all the geochemical elements.

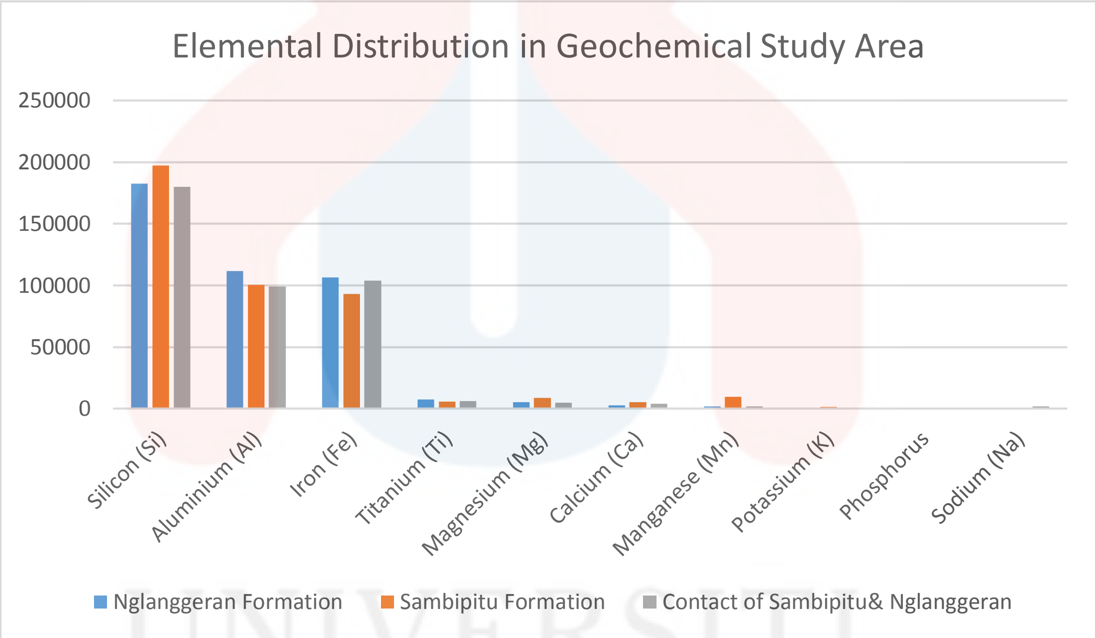


Figure 5.8: Elemental distribution of topsoil in Ngalang

All screened element by XRF shown in Figure 5.8 gave varieties of values. All these screened element include Silicon, Aluminium, Iron, Titanium, Magnesium, Calcium, Manganese, Potassium, Phosphorus and Sodium. The elemental distribution from three samples shows that silicon (Si) was the highest element found in the three sample of topsoil in the geochemical analysis study area. Most of the chemical content in the topsoil of geochemical studies area showing results that have almost same value of element. However, at sampling point 2 (Sambipitu formation) and sampling point 3 (contact between both formation) Sodium (Na) started to appear.

Silicon mostly found in the form of SiO_2 and SiO_4. This element considered as the most abundance element in Earth's crust and it was abundantly found in Ngalang either in Sambipitu formation or Nglanggeran formation. The silicon might be a product because of the process weathering of silica and quartz mineral. Usually the median for SiO_2 content in topsoil may be ranging from 68% until 67.7% in the topsoil. Grain size and silica correlation have a good correlation in soil survey.

Aluminium may present in acidic forest soil such as Nglanggeran (Weselic, 1990). This was shown by the Nglanggeran topsoil sample since it has the the highest amount of Aluminium. However, Sodium (Na) was not a part of plant nutrition. Sodium with high content will facing sodicity and salinity problem which lead to poor soil structure. However, it is not good to have high content of sodium for agricultural purpose.

Iron is the third highest element in geochemical study area. The iron may effect in term of soil physical characteristics. Besides, high amount of iron will produce reddish colour of soil. However the other elements such as Titanium, Magnesium, Calcium, Manganese, Potassium, Phosphorus and Sodium shows low amount in the topsoil at geochemical study area.

5.3.2 Contact area of Nglanggeran and Sambipitu Soil

Interfingering between Nglanggeran and Sambipitu formation recorded by Surono (2009) might be a phenomenal in geological history of Gunungkidul. The contact between these two formations was undefined correctly. By conducting grid mapping from physical characteristics plotting, undulating figure of Nglanggeran soil and Sambipitu by classify it according to physical characteristics was clearly shown in Figure 5.3.

These physical characteristics data was supported by the three samples taken from the geochemical area analysis and tested by using XRF. The results from analysis as shown in Figure 5.8 gave results of chemical element distribution. These values were ranging differently. Thus, the geochemical element in topsoil of the contact area can be interpreted were spreading around in the geochemical analysis area.

Table 5.2: Average mineralogical and nutrient element of common rocks on the Earth's land surface (Klein& Hurlbut, 1999)

Mineral constituent	Igneous rock	Shale	Sandstone	Nutrient element constituent	
	%			Major	Minor
Feldspar	59.5	30.0	11.5	Na, Ca, K	Cu, Mn
Micas	3.8	-	-	K, Ca, Mg, Na, Fe	Ni, Cu,
Clay	-	25.0	6.6	Mg, K, Fe, Na, Ca	-
Carbonates	-	5.7	11.1	Mg, Ca, Fe	-
Amphiboles & Pyroxenes	16.8	-	-	Mg, Ca, Fe	Ni, Cu, CO, Zn, Mn

The topsoil in Ngalang area mostly have high content in Silicon, Iron and Magnesium and low value in Titanium, Magnesium, Calcium, Manganese, Potassium, Phosphorus and Sodium . The appearance of sodium from the “Sambipitu” and “Contact” sample due to presence of mineral such as feldspar, and micas in both formation might be because of the accumulation of the element in the sample. However, all of the samples have majority high in silicon due to abundance of quartz and silicates in both of the formations.

Hence, the distribution of element in the topsoil sample collected proved that the geochemical analysis area chosen was a part of contact area of Nglanggeran and Sambipitu. However the area might be spreading more than 500 m^2 area which need further details studies in soil sampling and analysis.

CHAPTER 6

CONCLUSION & RECOMMENDATIONS

6.1 Conclusion

Ngalang area was located at Gunungkidul regency known as the best area for geological studies. The area comprise of very different unique geomorphology formed by escarpment valley, undulating hill and flat landform that covered its area. Dendritic and rectangular drainage pattern and different rate of weathering due to different resistant of the rock unit. Besides, Ngalang area also comprise of different rock lithologies which was grouped into four different formation such as Semilir, Nglanggeran, Sambipitu and Oyo formation towards southern with different depositional environment. Most of the rock was dipping relatively between 10° until 17° S/E.

Semilir was the oldest formation recorded in this area. It have comprise of volcanic material and was deposited in swampy area. The swampy area produce low grade, non-commercialized coal such as lignite and bituminous type. Underlying the Semilir formation there was Nglanggeran formation with comformably undulating volcanic rock such as lava with andesite and basaltic component. Besides Nglanggeran also composed of angglomerate, pyroclastic and epiclastic breccia.

The speciality of Ngalang was shown in Sambipitu formation with turbidite system, the Bouma sequence that have a complete layer which shown clearly. Besides, at the lower part of Sambipitu there was also bioturbation, a giant trace fossil that deposited in shallow environment. These both special characteristics entailed that Sambipitu was deposited in transitional zone from shallow until deep marine. However, some studies said that Sambipitu and Nglanggeran formation was interfingering each other. The last formation in this study area was Oyo formation.

The formation was comprise of alternating of carbonate sandstone with abundance of calcerous fossil in its rocks. Towards Southern, the carbonate characterstics of the Oyo formation staring to form due the composition of carbonate in the formation. Besides with a long lineament formed along Ngalang river adorn the landscape of Ngalang and gave special structural element such as mega strike slip along the Ngalang river. With all the methods applied hence the map with 1:25 000 scale was produced.

To achieve the second and third objectives geochemical analysis of topsoil in Ngalang was conducted with geological grid mapping and supported by X-ray Fluorescence Spectrometry results. The result shown from grid mapping shows the interfingering characteristics in Ngalang by undulating grouped by characteristics figure in the map. The interfingering results in the finding of few geochemical distribution in geochemical analysis at Ngalang area such as Silicon, Aluminium, Iron, Phosphorus, Sodium, Magnesim, Potassium, Manganese, Titanum and Calcium.

The elemental distribution screened by XRF produced 10-11 geochemical major element of topsoil in Ngalang. These elemental distribution can be correlated with the interfingering idea since the elements were spreading in the 500 m^2 area. The constituent of the element proved that the geochemical analysis area was at the contact area.

To study about Ngalang area was full of excitement and towards a bundle of discovery. Ngalang area has a very unique and complex geological value that should be conserve and preserve. It should be nominated as geological sites and being appreciated until the next generation. By conducting research in this area, a new geological map with 1:25 000 scale was updated. Besides, the geochemical element of topsoil in the study area was discussed and the contact area of Nglanggeran and Sambipitu was proven by geochemical data from XRF supported by grid mapping.

6.2 Recommendations

Ngalang can be said as the best geological sites that have many geological values such as structural geology, different kind of fossils distribution, different unique lithologies just within its area. Hence, a lot of research and exposure to students about geology can be conduct at here. Besides, geological aspects of Ngalang area was very unique, it will be very precious if the value of geology aspect will be protect and preserve.

The geology, soil map and geochemical analysis of the topsoil real contact between Nglanggeran and Sambipitu can be identify. Hence more than 10 samples need to be taken and be analyse to have a better discussion and results on the geochemical analysis part in order to achieve the objectives

Besides, geochemical study of topsoil can be improved by using better analysis machine such as Induced Coupled Mass Spectrometry and Atomic Adsorpbtion Spectrometry (AAS). This is because, X-ray Fluorescence Mass Spectrometry may hava a lot of advantages but due to abundance of geochemical elements of the Earth materials, XRF may have some limitation.

Furthermore, in handling geochemical samples for analysis, a lot of precaution steps need to be considerate. Starting from taking the samples a lot of preparation in term of the way sample will be take also have to be considered. Therefore it is better if geological mapping was done before further to the next step.

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APPENDIX A

LABORATORIUM PUSAT SURVEI GEOLOGI
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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)

Nomer lab. (*lab. number*) : 047/L/GL/2.2/10/2019
Tanggal (*date*) : 8 Oktober 2019

Kode sampel (*sample code*)	: Contact	Tanggal diterima (*received date*)	: 2 September 2019
Kode lab. (*lab. code*)	: 232/2.2/19/0952	Tanggal diuji (*analyzed date*)	: 7 Oktober 2019
Lokasi (*location*)	: S 7° 52' 19.3" E 110° 34' 53.6"	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Sharifah Nurin Wahida Universitas Padjadjaran**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	38.48	0.24	Si	17.99	0.11
Al2O3	18.70	0.21	Al	9.90	0.11
Fe2O3	14.82	0.16	Fe	10.37	0.11
TiO2	1.03	0.04	Ti	0.62	0.03
MgO	0.84	0.04	Mg	0.50	0.02
CaO	0.556	0.024	Ca	0.397	0.017
Na2O	0.270	0.017	Na	0.200	0.012
MnO	0.2093	0.0090	Mn	0.1621	0.0070
K2O	0.0833	0.0040	K	0.0691	0.0033
P2O5	0.0538	0.0033	Px	0.0235	0.0014
SO3	0.0355	0.0018	Sx	0.0142	0.0007

LOI 24.6

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Ames 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*).

APPENDIX B

LABORATORIUM PUSAT SURVEI GEOLOGI
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Jl. Diponegoro No. 57, Bandung, 40122, Indonesia
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HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 047/L/GL/2.2/10/2019
Tanggal (*date*) : 8 Oktober 2019

Kode sampel (*sample code*)	: Sambipitu	Tanggal diterima (*received date*)	: 2 September 2019
Kode lab. (*lab. code*)	: 232/2.2/19/0953	Tanggal diuji (*analyzed date*)	: 7 Oktober 2019
Lokasi (*location*)	: S 7° 52' 27.1" E 110° 37' 58.1"	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Sharifah Nurin Wahida Universitas Padjadjaran**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	42.13	0.24	Si	19.70	0.11
Al2O3	18.98	0.21	Al	10.04	0.11
Fe2O3	13.30	0.15	Fe	9.30	0.11
MgO	1.47	0.06	Mg	0.89	0.03
TiO2	0.99	0.04	Ti	0.59	0.02
CaO	0.709	0.030	Ca	0.507	0.022
K2O	0.157	0.008	K	0.131	0.006
MnO	0.1216	0.0050	Mn	0.0942	0.0041
P2O5	0.0652	0.0040	Px	0.0284	0.0017
SO3	0.0463	0.0023	Sx	0.0185	0.0009
Na2O	0.0295	0.0053	Na	0.0219	0.0039

LOI 21.7

Kepala Subbidang Geologi Dasar dan Terapan
selaku Manajer Teknis,

Agus 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*).

APPENDIX C

GL-F-PL-13-2.2-01-b

LABORATORIUM PUSAT SURVEI GEOLOGI
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Telp: 022-7203205, 6032207 Fax: 022-7202669, 6127941 E-mail: labgeologi@grdc.esdm.go.id

HASIL UJI KIMIA METODE XRF
(XRF METHOD CHEMISTRY ANALYSIS RESULT)
Nomer lab. (*lab. number*) : 047/L/GL/2.2/10/2019
Tanggal (*date*) : 8 Oktober 2019

Kode sampel (*sample code*)	: Nglanggeran	Tanggal diterima (*received date*)	: 2 September 2019
Kode lab. (*lab. code*)	: 232/2.2/19/0954	Tanggal diuji (*analyzed date*)	: 7 Oktober 2019
Lokasi (*location*)	: S 7° 52' 16.1" E 110° 34' 00"	Metode uji (*method*)	: GL-MU-2.2
Kedalaman (*depth*)	: -	Metode preparasi (*preparation method*)	: *Pressed Pellet*
Pemilik (*property*)	: **Sharifah Nurin Wahida Universitas Padjadjaran**		

Compound	m/m%	StdErr	El	m/m%	StdErr
SiO2	39.06	0.24	Si	18.26	0.11
Al2O3	21.10	0.22	Al	11.17	0.12
Fe2O3	15.21	0.16	Fe	10.64	0.11
TiO2	1.25	0.05	Ti	0.75	0.03
MgO	0.84	0.04	Mg	0.51	0.02
CaO	0.367	0.016	Ca	0.262	0.011
MnO	0.219	0.009	Mn	0.169	0.007
K2O	0.0784	0.0037	K	0.0650	0.0031
SO3	0.0360	0.0018	Sx	0.0144	0.0007
P	0.0212	0.0013	P	0.0212	0.0013

LOI 21.44

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*).