Geology and Depositional Environment of Sambipitu Formation in Beji area, Wonosari, Yogyakarta, Indonesia

By

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APPROVAL

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

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DECLARATION

I declare that this thesis entitled "Geology and Depositional Environment of Sambipitu Formation in Beji Area, Yogyakarta" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF SAMBIPITU FORMATION IN BEJI AREA, YOGYAKARTA.

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Abstract: The research is to study the distinct characteristic of the depositional environment of Sambipitu formation. This because the different environment carried distinct features. The previous study on Sambipitu only on regional mapping and to discovering new geology feature in the study area. In addition, the various interpretation of Sambipitu depositional environment in the previous study. This study should provide a geological map on a scale of 1:25000 and determine the depositional environment of Sambipitu formation. This research will apply the facies analysis, petrography and fossil identification. Furthermore, the mapping process for making a geological map. Sambipitu formation's lithology unit that composed by different facies that influence to vary of determination about it depositional environment. By determining the depositional environment, it leads to better understanding of the Sambipitu formation where the deposition is influenced by many factors like volcanism and carbonate evolved. Hence, this research exposed the characteristic on different facies where these facies carried distinct feature. In short, the Sambipitu formation where deposited at the shallow marine to shelf or slope. In addition, the influence from the transgression and progression of sea level.

Keywords: Sambipitu formation, Depositional environment, Facies, Geological mapping

GEOLOGI DAN PERSEKITARAN ENDAPAN FORMASI SAMBIPITU DI KAWASAN BEJI, YOGYAKARTA

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Abstrak: Kajian ini adalah untuk mengkaji ciri-ciri yang berbeza pada persekitaran pengedapan dalam formasi Sambipitu. Persekitaran yang berbeza membawa ciri berbeza bagi perbezaan situasi. Kajian sebelum ini mengenai Sambipitu hanya pada pemetaan serantau dan untuk mengenalpasti ciri geologi baru ditemui di kawasan kajian. Di samping itu, tafsiran yang pelbagai tentang persekitaran pengenapan Sambipitu pada kajian sebelumnya. Kajian ini perlu menyediakan peta geologi dalam skala 1: 25,000 dan menentukan persekitaran pengenapan formasi Sambipitu. Kajian ini akan menggunakan kaedah analisisa fasis, petrografi dan pengenalan fosil. Tambahan pula, proses pemetaan untuk pembuatan peta geologi. Unit litologi dalam formasi Sambipitu yang terdiri dari pelbagai fasis memberi pengaruh yang berbeza dalam penentuan persekitaran endapannya. Dengan menentukan persekitaran pengenapan, ia membawa kepada pemahaman yang lebih baik mengenai formasi Sambipitu di mana pemendapannya adalah dipengaruhi oleh banyak faktor seperti letupan gunung berapi dan pentas karbonat yang berkembang. Oleh itu, kajian ini mendedah ciri pada fasies yang berbeza di mana fasis ini memiliki ciri yang berbeza.

Kata Kunci: Formasi Sambipitu, Persekitaran endapan, Fasis, Pemetaan geologi

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LIST OF ABBREVIATION

S	South
E	East
HCl	Hydrochloric Acid
Litholog	Lithology Column
PPL	Plain Polarize Light
XPL	Cross Polarize Light

LIST OF SYMBOL

°	Degree
‘	Minutes
“	Seconds

CHAPTER 1

INTRODUCTION

1.1 General Background

Indonesia or Republic of Indonesia is a transcontinental state and unitary sovereign state that situated in South East Asia. Surrounded by the Indian Ocean and many more, also contain more than 13 000 small islands distribute along the state. Possessing area of 1 904 569 kilometre square, making Indonesia among the largest country and island in the world. Indonesia had a population of 261 million people, making them the 4th highest populous country in the world. Divided into 5 main islands, Sumatera, Java, Kalimantan, Sulawesi and Papua. Tectonically, Indonesia's volcanism is vigorously active from paleo time. As Indonesia lies on a subducted converging plate of Australia-Indian plat and Eurasia plate boundary, also known for Ring of Fire. Indonesia also contains various type of geology structure through the island. This is due to the plate movement. The main economy of Indonesia is their natural resources. For example, gold, tin, precious metal and element and also agriculture. The country also made up of several cultures and also much religion can be practised in the country, major are Islam.

1.2 Study Area

a. Location

Gunung Watupasar is a mountain that located in Special Region of Yogyakarta and also one of the places that include the Wonogiri Geopark of West Java. Gunung Watupasar located in the regency of Gunung Kidul, at the north-west of Wonosari. And Wonosari is located in the south of Java Island.

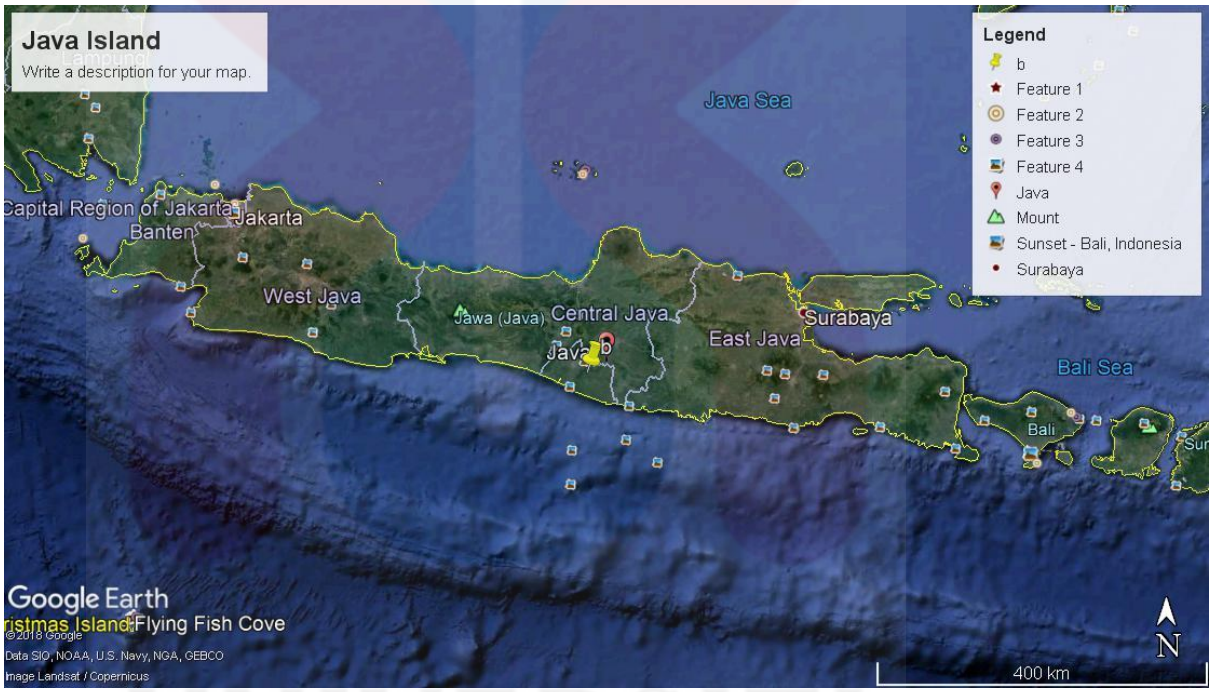


Figure **Error! No text of specified style in document.**.1.1 Java Island, Indonesia

On the north-west of Gunung Kidul is Yogyakarta city, separated by South Hill in the north of the study area. Gunung Kidul's south coast are exotic and wild, but it provides a beautiful attraction for tourist from in or out of Indonesia come to visit Yogyakarta. The study area is Gunung Watupasar area, limited to 5km × 5km make up a 25km square area to be cover and collecting data for geology mapping. The study is aligned between S 7'50"25.5 to S 7'53" 13 for latitude, meanwhile for longitudes are aligned in between E 110'30"46.5 to E 110'33"30, and can refer to the provide

base map in Map 1.1. Data collection for the specification is will be collected in the study area.

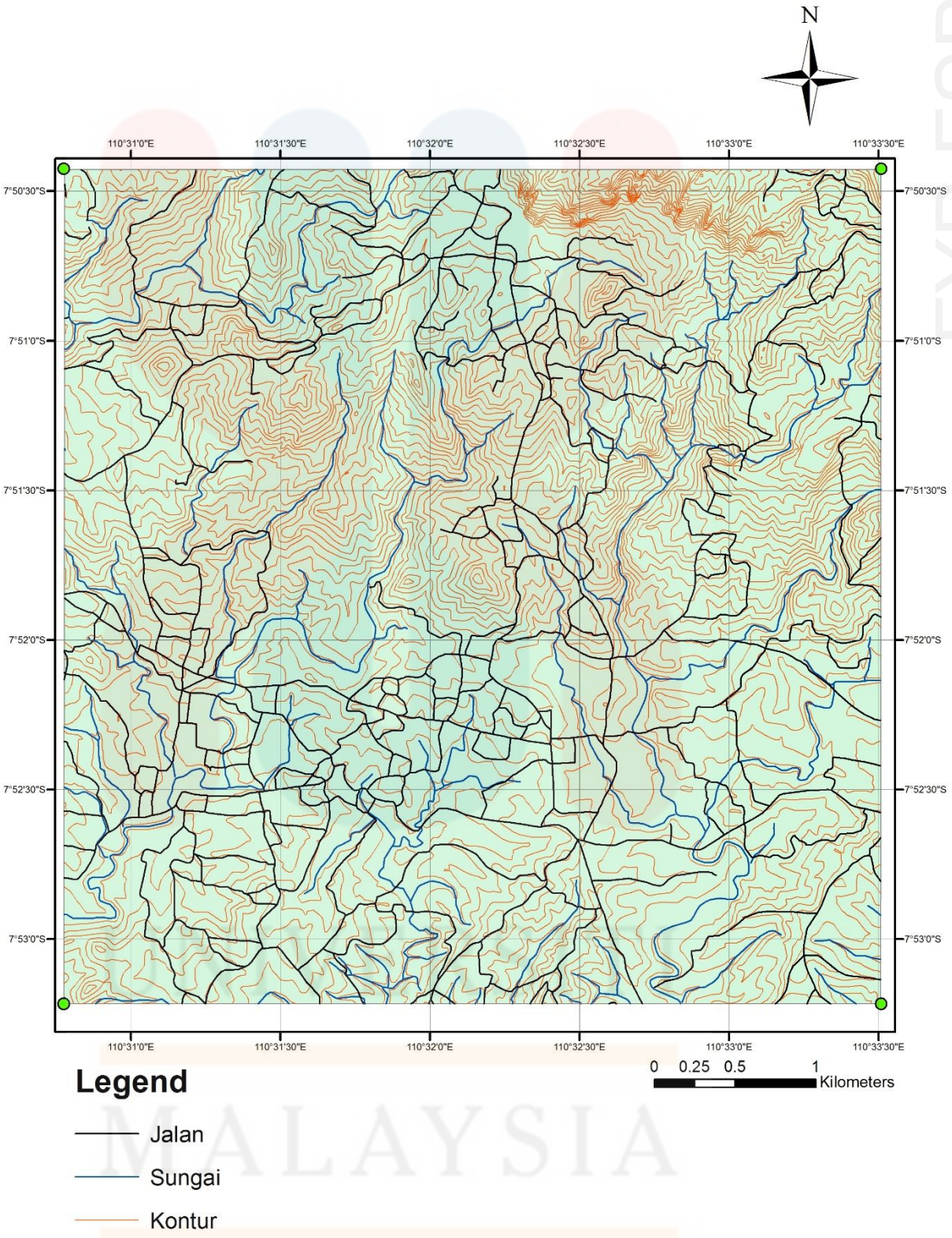


Figure 1.2 Topography map of the study area, Beji.

b. Accessibility

Yogyakarta is a city with urbanization. Thus, the road connection between towns in the area is pretty well provided and maintenance by the local authority. Most of the resident in Gunung Kidul are using a motorcycle for their movement as motorcycle are more convenient and faster than cars and else. For connection to the bigger city are also provided by existent of expressways like Janti Overpass and Lempuyangan Overpass. Since the study area in village compound, it easier to access without the difficulty, either by walking or transportation.

c. Demography

Can be classified into medium rate dense of the population over kilometre area. The native people are Javanese as the dominantly populate in the Gunung Kidul area. The beach at the south region is the main attraction for tourism aspect, attracting worldwide tourist to come to Yogyakarta every year. Besides that, the natural beauties and refreshing like waterfall also among the reason of tourist to explore Yogyakarta. Javanese culture is applied in the area as the area are native to the Javanese people.

d. Land use

Focally on the study area, the main land use is for agriculture like a paddy field. In addition, the river also provided freshwater fisheries for the local area. Plantation and development are the activities that occur in the study area. But, in some area, the plantation is not suitable due to the presence of calcareous element and limestone. But, most of the agriculture are done on slope and where there are alluvium.

e. Social economic

Yogyakarta has a very dynamic social economic. Especially when coming to agriculture and natural resources. Most of the population work as a farmer, for example, working in a paddy field. Mining precious mineral also run in small and large scale around Jawa Island. Not only that, vary of aspect like capital, ideology, health and education are changing in time due to the modernization of Yogyakarta. Thus, this increase the domestic economy and house income per capita. Yogyakarta also relies on a tertiary sector like tourism, construction, institution, administration, health, and education.

1.3 Problem Statement

The previous study only did research on the regional area of Gunung Kidul area (Surono, 2009). Since then, it almost a decade until now. In addition, the area went for changes in infrastructure and human activities. In 2009, a geological are provided by Geological Survey Centre by the scale of 1:100000. Therefore, this research will conduct to recognize a new geology feature that will add up and also provide a more detail geological map of Beji area by 1:25000 scale. Beji is located on Sambipitu Formation. Since Sambipitu Formation and surrounding formation are almost synchronise during the time of deposition, the determining of the depositional environment can be crucial and will lead to understanding the sedimentation of the study area. In addition, to determine the facies of the lithology in the study area. The presence of the biological fossil also will help the study to determine the paleocurrent and environment of deposition.

1.4 Objectives

a) To provide a geological map of study area.

b) To determine the depositional environment.

1.5 Scope of Study

The research will carry out on a 5km × 5km located Beji area, Wonosari, Yogyakarta, Indonesia. There are several aspects that are important to focus on and has to be covered in this research such as geology, sedimentary facies and deposition environment in the study area. General geology will cover the studies of geomorphology, structural geology, lithology, stratigraphy, and sediment structures. The sediment facies study will carry out by describing the potential sedimentary facies to correlate to it deposition environment by classifying them into facies association.

1.6 Significance of Study

The importance of the research will update the geological map of Beji, Wonosari, so that it will be a source of information about geological features of the study area. Enable to determine the sediment facies and the deposition environment will help to analyze sediment behaviour of the deposition time. The research also significance to provide a new detail and latest geological map of the area. And also, the result of the study can help to recognize the potential of the geoheritage area by aspects of geomorphology, palaeontology, and geological features.

CHAPTER 2

LITERATURE REVIEW

This chapter will cover the previous study and it finding that lead to this research or study to conduct in future. Among the aspect that will be covering are regional setting, stratigraphy, structural geology and historical geology. In addition, the specification of sedimentology and deposition environment also will be carried out during the research will be included. Indonesia located in South East Asia region, neighbouring to Malaysia, Singapore, and Brunei. Consist of 34 provinces that divided into smaller regencies and cities.

2.1 Regional Setting

There is a lot of geological features can be found on Indonesia. The overlain layer of rock is consist of Mesozoic, Cenozoic, recent volcanic formation and quaternary deposit. Subduction of Indian plate formed a calc-alkaline volcanic island, Java Island, Indonesia. Due to the frequent event of volcanism, the geology, of the area is affected. The active volcanism like volcanic eruptions and lava flows, forming the island. Thus the distribution of pyroclastic sediment is widespread and not to left the argillaceous sandstone and shale. State by Irham Nurwidyanto M. *et al* (2014) the study area are located in a basin called Yogyakarta Basin. And Yogyakarta Basin structure are influenced by tectonic of the subduction of Australian- Indian plate (Smyth *et al*, 2005)

2.2 Stratigraphy

Beji is believe to be on the Sambipitu formation. Sambipitu Formation is consisted dominantly sandstone and shale ((Launty D. Santi *et al*, 2007). Sambipitu formation is estimated age between Early Miocene to Middle Miocene. Figure 2.1 shows the stratigraphy of the Yogyakarta, Indonesia. Based on Figure 2.1, the stratigraphic unit of the southern mountain is divided into some different lithology and their ages. From the below, are the oldest rock in the study area. The oldest, Wungkal-Gamping formation was deposited in Late Eocene. Compose of sandstone unit, sandy marl unit, claystone unit, and limestone in lenses form. Above Wungkal-Gamping formation, with unconformity are Besole Formation that divided into three part. With sandstone and claystone unit present including some thin layer of acid tuff for the upper part. For middle part, can be found andesitic-basaltic lava with andesitic-breccia on top of it. Meanwhile, for the lower part consist of well-bedded sandstone, siltstone, claystone, shale, tuff, and agglomerate. Kebo-Butak Formation is estimate deposited during Oligocene time to the Middle Miocene. Next, Besole Formation that deposited during the Oligocene epoch until Early Miocene. Consisting of Dacitic and andesitic pillow lava, tuffaceous dacite, and in some specific location could be found diorite veins. Jaten Formation, Wuni Formation, and Nampol Formation just a small part of the stratigraphy. Jaten Formation consists of quartz sandstone, tuffaceous sandstone, siltstone, claystone, marl, and marly limestone. Meanwhile for Wuni Formation break into 2 part, middle part, and lower part. Middle part made up of tuffaceous sandstone, siltstone, and conglomerate with a probability of coal seam. For lower part, present of agglomerate breccia, silicified wood, and silicified tuff. Deposited during Middle

Miocene time, chronologically Jaten, Wuni, and Nampol Formations. Semilir Formation deposited during Early Miocene until Middle Miocene. Consisting of tuff, pumiceous breccia, dacite, tuffaceous sandstone, and shale. Next, the focus formation in the research, Sambipitu Formation that made up from intercalation of calcareous sandstone and shale. Deposited during the Middle Miocene. Nglanggran Formation basically consists of various pyroclastic rock and volcanic rock. Estimated deposited during Middle Miocene. Oyo Formation consists of tuffaceous limestone, tuffaceous marl, and well bedded andesitic tuff. Age of Oya formation is Middle Miocene. Wonosari Formation among the thickest formation in the southern mountain region. Consist dominantly limestone and a little bit of tuffaceous sandstone, marly-tuffaceous limestone, and siltstone. Deposited during the time of Middle Miocene until Late Miocene. Lastly, the younger among them, Kepek Formation. The age estimated deposited during Late Miocene. Consisting of intercalation of limestone and marl only.

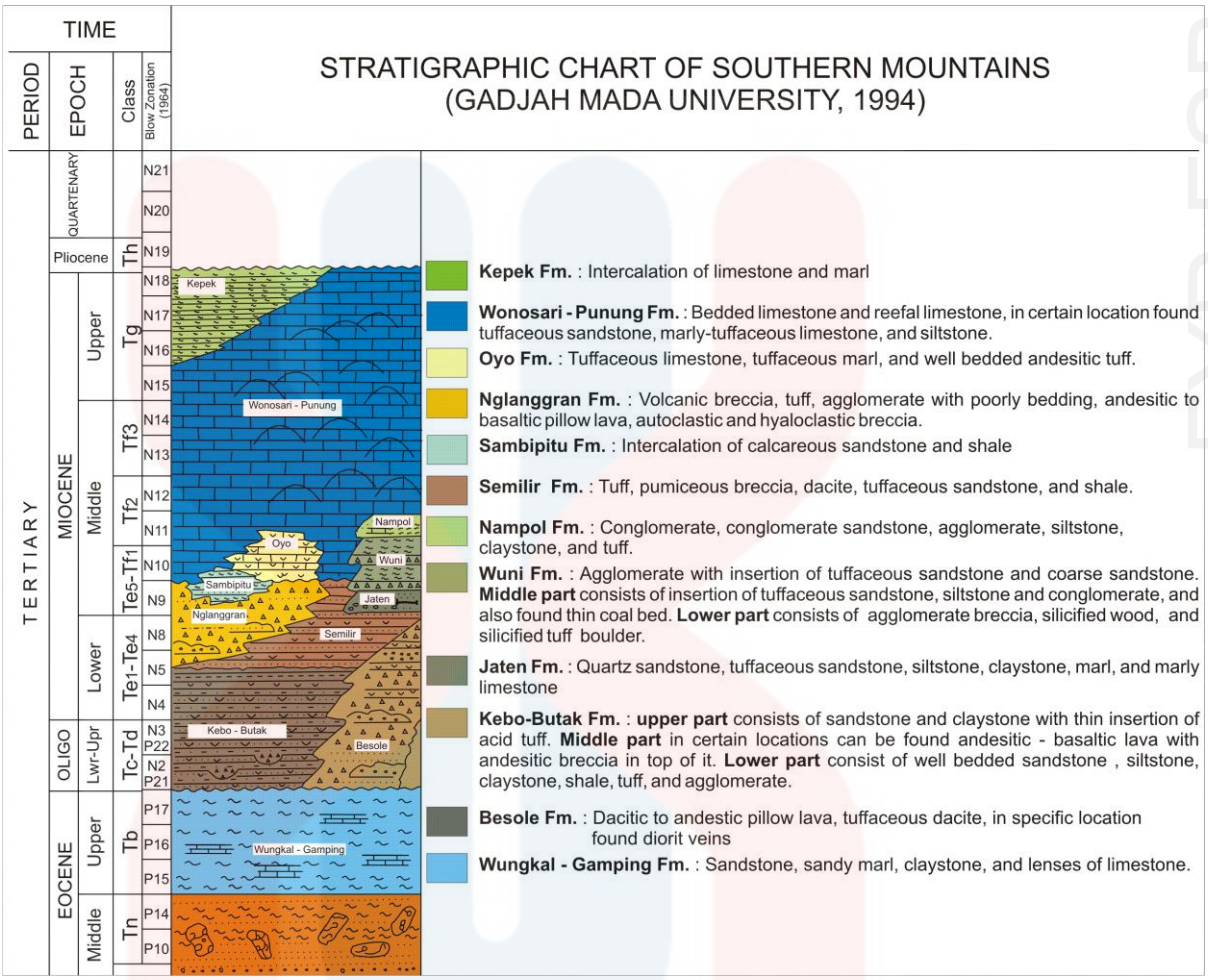


Figure 2.1 Stratigraphy of Yogyakarta, Indonesia (UGM, 1994)

Sambipitu Formation is the focal point of the research. Made up of calcareous sandstone and shale. The upper boundary of the Sambipitu formation is in contact with Oya-Wonosari Formation. The changes of the lithology from Sambipitu Formation and Oya-Wonosari Formation are by gradually or interfinger. Dominant by limestone and lime mudstone that possibly deposited during Middle Miocene time (Surono, 1992). Meanwhile, for the lower boundary, Sambipitu's characteristic like siliciclastic. The differentiation of the lithology unit gradually changes from bottom to upper boundary, from siliciclastic to calcareous (Launti D. Santy *et al*, 2007).

2.3 Geology Structure

Geology structure is indicators of the plate tectonic activities or movement. Since Java Island are close to the plate boundary of subducted Australian plate, the formation of the island are due to the volcanic activities, volcanic eruption. Volcanism activities also create the long chain of a mountain range in the middle of the Java Island, looks alike as the spine of the island. Due to the subduction of both plates, the formation of geology structure occurs frequently, minor and major in scale. Below, Figure 2.2 show briefly the regional map that include the subduction zone, volcanism activities zone and back arc zone.

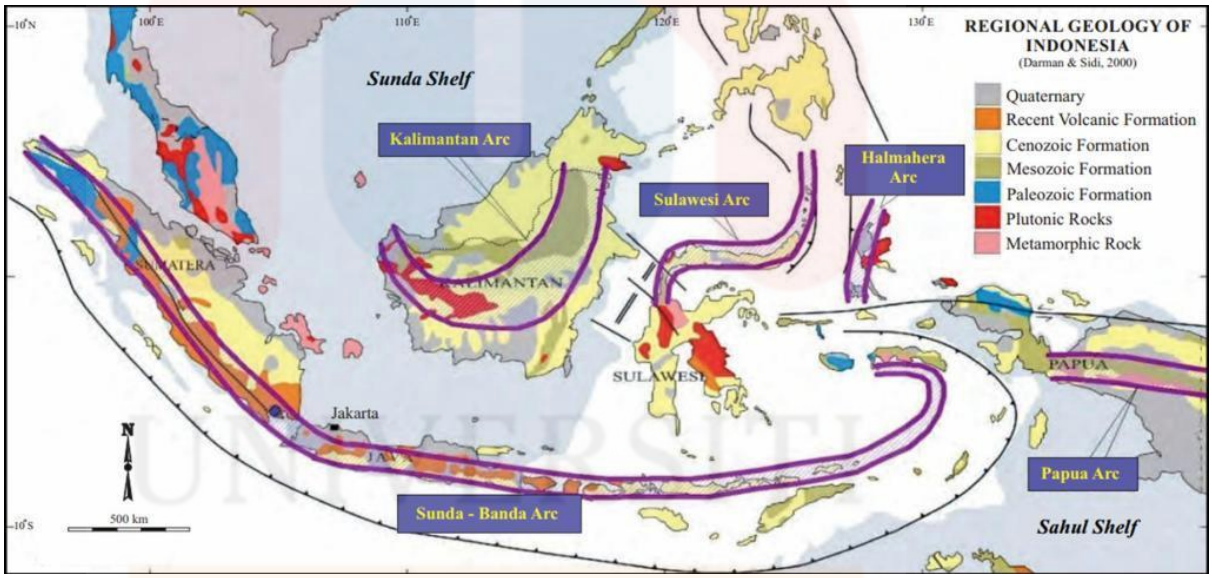


Figure 2.2 Regional Geology of Indonesia. Showing some regional structure and also the plate boundary of Australia plate and Indo-China Plate

There is no faulting happen in the west of Yogyakarta. Meanwhile, on the eastern side of the Java Island, there is fault occurred, called the Opak Fault. The younger sediment covering the western area might be the reason why there is no significant or indicator of the fault happening on the western side.

2.4 Geology History

The formation of Java Island was due to the subduction of Australian plate that causing the vigorous activity of volcanism in Java Island. It believes the subduction happened between 90 Ma to 45 Ma (Hall *et al*, 2009 & 2011). Thus, the subduction also making the oldest sediment to deposited unconformable on the bedrock in Cenozoic time (Smyth et al, 2008). Smyth recorded in 2005, stated that there is increased volcanic material in Cenozoic sandstones at the southern mountain. Also, the rise of the sea level affecting the deposition of intra-Oligocene time. Active volcanic activities formed a thick sequence of volcanic rocks and epiclastic rock throughout late Oligocene to early Miocene (Smyth, 2005& 2008). During middle Miocene to late Miocene, the volcanism activity is reduced thus, it gives chance and time for the carbonate platform to formed and developed (Smyth, 2005). Stated by Lokier and Smyth, (2000, 2005) the carbonate platform can be found during this period of time. There is unconformity that has been proposed by Lunt in 2009 that occurred due to the tectonic event during late Miocene. In addition, Bolliger (1975) said there is no deposition during the time of Pliocene at the southern mountain. The possibility that caused it was uplifted and erosion by weathering.

Furthermore, Southern mountain composed mainly of a metamorphic and meta-sedimentary rock. Both of these represent by marble, phyllites, and schists. These layer of rock are overlain by Gamping-Wungkul Formation. Both formation deposited during the same time, Middle Eocene, consisting sandstones and siltstone with limestones' lenses. Above Gamping-Wungkul formation, deposited volcaniclastic sediments and divided into several formations, Kebo-Butak formation, Semilir formation, Nglanggeran formation, and Sambipitu formation. The Kebo-Butak

formation can be studied at Baturagung escarpment, where the formation is exposed. The previous study showed that the formation is consisting volcaniclastic, basaltic tuff, dacitic to andesitic pumice and basaltic pillow. Plus, also contain locally shale, marl, and zeolite. By paleontological evidence, the formation is identified deposited during the time of Late Oligocene to Early Miocene (Sumarso, 1975). Next, Semilir formation thickening up to 460m consisting andesitic to dacitic pumice-rich volcaniclastic rocks, tuff, lapilli stone and pumice breccia. Estimated deposited in a period of Early to Middle Miocene. Laying upper the Semilir Formation are Nglanggeran formation. Believe to deposited during a period of Late Oligocene, but Soeria-Atmadja *et al* (1994), proposed that the right age is late Oligocene, estimate 24 Ma by absolute carbon dating of K-Ar isotopes. The total thickness of the formation is 530m. Lastly, Sambipitu formation, the focus of the research are consisting fine-grained volcanic sandstone, volcanic claystone, and volcanic siltstone. Believe to be thick as 230m and the present of paleontological data give out the age of deposition. The age is determined by absolute dating and the data show the age are in between Early to Middle Miocene. Also contain a calcareous unit that covers the upper part of the formation and divided into Oyo formation, Wonosari formation, and Kepek formation. Believe to be deposited in a period of Middle Miocene to Pliocene and the depositional environment are shallow marine (Bronto *et al*, 2002). In addition, Figure 2.3 below show the stratigraphy column of the Special Region of Yogyakarta.

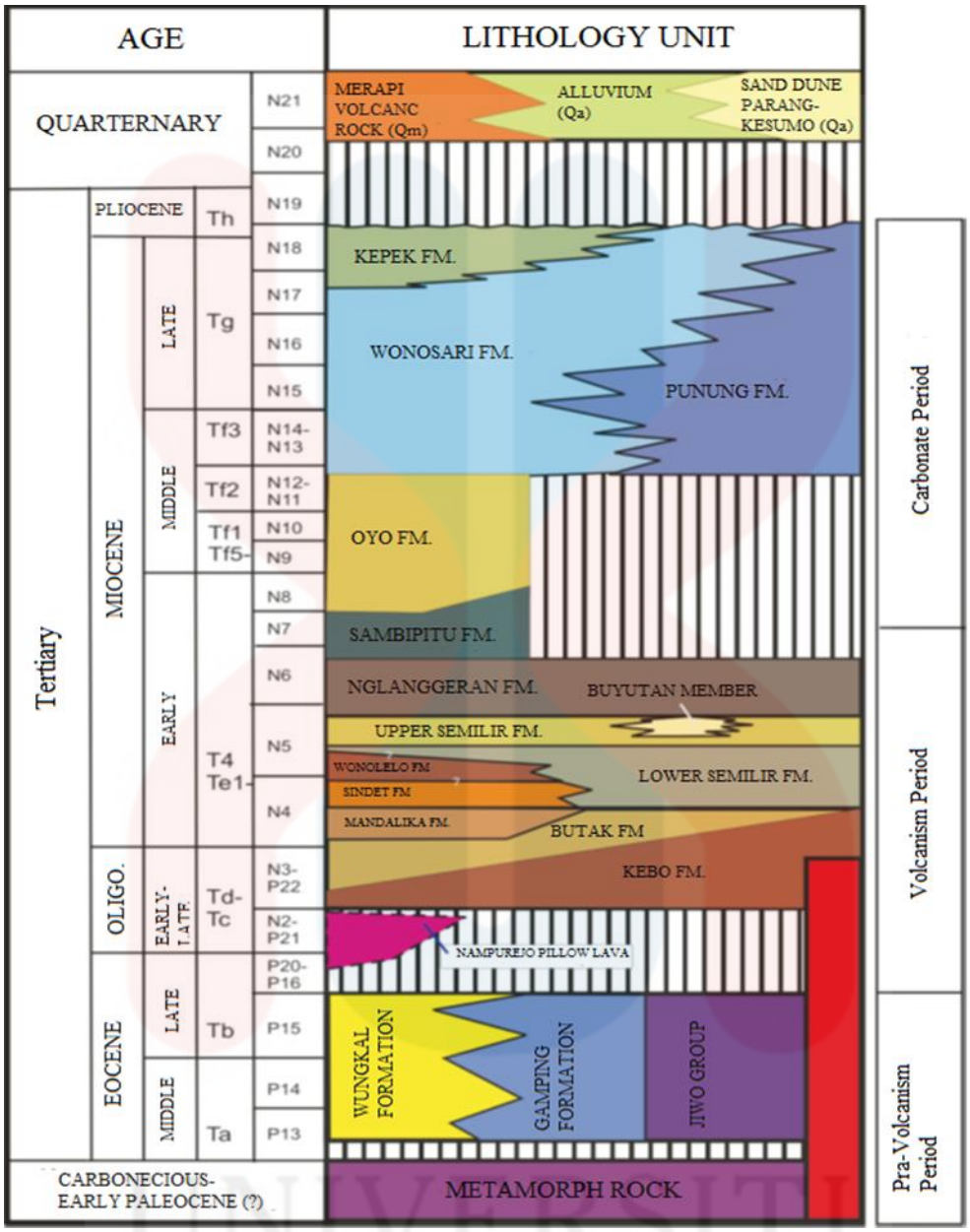


Figure **Error! No text of specified style in document.**.2.3 Translated stratigraphy column of Special Region of Yogyakarta, Indonesia

2.5 Depositional environment

Depositional environment is a branch study of sedimentology about how the deposition of sediment is affected by environment. Obviously, deposition of sediment depends on the environment during deposition. The different environment gives the different sediment structure of the rock, also giving the alteration between layers of rock. Not just that, it also helps the researcher to understand the paleo-environment

during the deposition time. The accumulation of the sediment gives a distinct characteristic and information about the paleo event. In addition, the present of paleontological evidence even helping more the researcher to understand the event occurred during deposition. Figure 2.4 shows that there is several example of depositional environment.

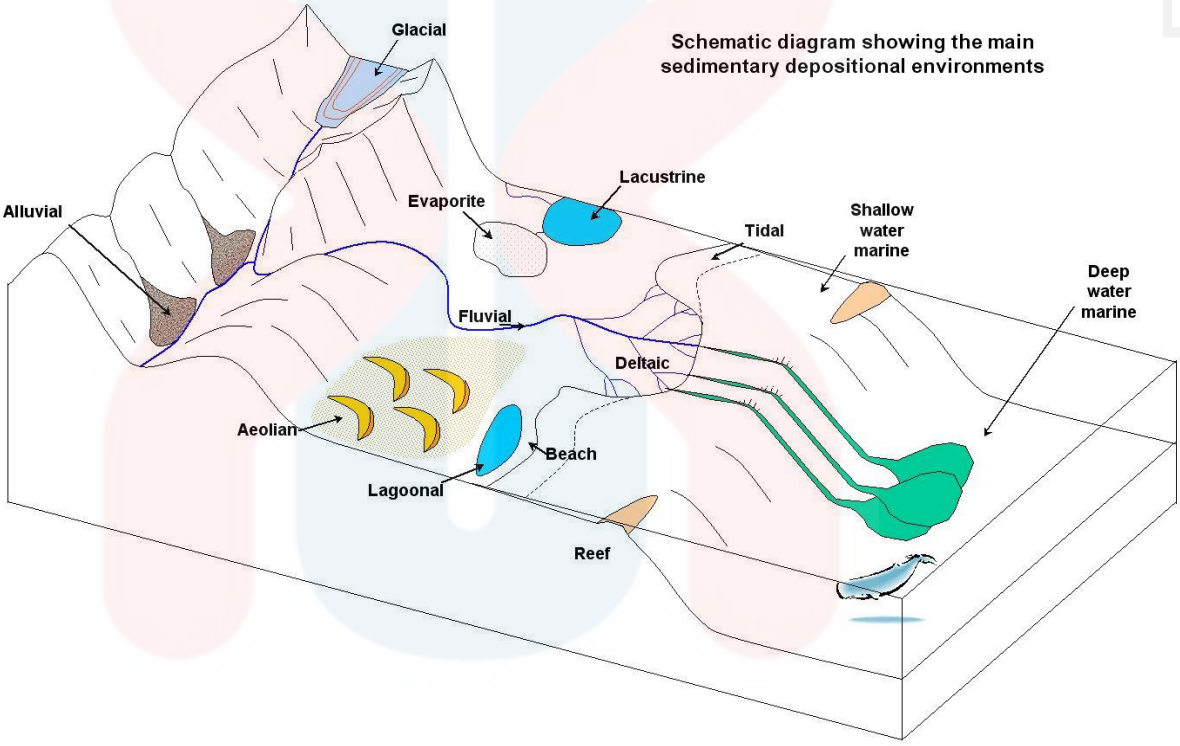


Figure 2.4 several types of depositional environment of sediments

Previous study propose that, Sambipitu formation is a transitional zone indicates by the lithostratigraphy. The transition of the lithologies between volcanic sources to carbonate formation (Surono and Permana, 2011). Futhermore, Surono and Permana (2011) also stated that, Sambipitu formation are divided into part, Lower and Upper part. Both, Lower and Upper part respectively consist of individual facies such as sandstone and breccia sandstone and for Upper part, consist of

calcareous sandstone and siltstone. By those lithology, it indicate the energy for the deposition environment are moderate. The discoveries of fossil contain in the study area, *Globoquadrina sp*. from the foraminifera family (Harman Dwi R. *et al*, 2018), indicates the environment of deposition in the marine.

CHAPTER 3

MATERIALS AND METHODS

This chapter will discuss the materials and methods that will be used and will be approached during the study running. All the preliminary study, fieldwork, laboratory investigation and data analysis are summarized below.

3.1 Materials

There are several materials that will be used to conduct the research. Global Positioning System (GPS) is used to determine the study area, to know current position and the guide of direction during the study. Next, Brunton compass act as an instrument to take data (strike-dip, rock orientation, and direction). To take a sample for laboratory work, the study will use a geological hammer. Hand lenses are used to determine the grain size of the rock beside to describe the rock. Topographic map act as a guide to access point to a particular area and defining coordinates. Measuring the outcrop will be using the measuring tape. Hydrochloric acid is used to distinguish carbonated rock like limestone. Sample bag mainly for the sampling purpose. A field notebook and stationery will be a use to jot down all observation features during fieldwork. Certain software will be used to analyze data such as ArcGIS 10.2, Stereonet and Sedlog (Creating a base map, create a rose diagram and drawing lithology, respectively). Lastly, the use of camera/ smartphone to take pictures of geological features and other during fieldwork.

3.2 Methodology

In this chapter, it will be discussing the way of approach for the research. Without the proper method or technique, the research will never reach its objective. This chapter will cover the preliminary study, process in fieldwork and laboratory work that will take place.

3.2.1 Preliminary Study

Preliminary study is like an initial start of the study. This process is mainly for collecting starting idea or problem statements for the study area. The data could be cover from many aspects that include lithology, sedimentology, stratigraphy, sediment structure, and palaeontology data. The revision of established data also helps the researcher to understand better the theory also clear things up about problem statement for the research. The previous study also gives a hint or a suggestion about the previous study especially the uncover geology features.

3.2.2 Field study

a. Geological Mapping

To provide a new geological map of study area, geological mapping has to be done during the research are carried out. This crucial method to achieve the main objective of this study. Topographical act as the base information of geological features during traverse method. Various information can be collected by conducting this geological mapping. It will cover the aspect of geomorphology, structural geology, lithology and sediments structure. Analysis data while fieldwork is important. This

includes describing the rock feature like colour, texture, grain size and any other visible features. This data will be taken from a fresh sample to reduce error from any unwanted impurities and the changes happen from the weathering process on the outcrop.

b. Sedimentology and Facies Analysis

This method will cover a lot of aspects. Lithology, sediment structure, and fossil presence are all will cover to collect data and analysis for sediment analysis. Lithology is a step where the rock is describing its physical features or characteristic. This will include the observation of the outcrop and fresh samples. From here, the rock will be identified through some aspect of rock type, colour, mineral compound and grain size. Sediment structure is one of the indicators for sediment facies analysis. This sediment structure is due to ancient paleocurrent and the depositional time. Thus, by studying this features, the determining of the deposition environment can be done and understandable. Fossil presence or biofacies help the study to define the exact age of the rock and also help determine the deposition environment and the history of the sedimentary basin.

3.2.3 Laboratory Works

a. Thin Section

A thin section is an analysis process of a rock, mineral or soil sample by using a polarizing petrographic microscope, electron microscope, and electron microprobe. A very thin sample is taken out from the rock sample by diamond saw and on flat

shape. Then the sample will be mounted on a glass slide and ground smooth with fine abrasive grit until the sample 30 micrometre. This will involve the Michel-Levy interference colour chart. Microscope with two filters, cross polarize and a polarizing filter will be used. This two filter, if the sample thin section is put at the right angle, the filter will show the properties of the mineral that contains at the thin section sample. This will help to collect data from petrography aspects as different minerals as a different mineral's properties.

b. Palaeontology Presence

Fossil present help to determine the exact age of the rock, also its formation. Fossil can be of any size from the meter down to micrometre. This biofacies analysis will help to determine the formation deposition environment and also it paleocurrent at that time.

3.2.4 Data Processing

After all the data collection have been done, the data need to be processed. This process is crucial to do because sometimes raw data cannot be interpreted or analysed directly. This process will be conducted by the process the data to become more findable and easy to storage. Furthermore, the process will be using the ArcGIS Software to create a map, adding new geological feature and map interpretation.

3.2.5 Data analysis and Interpretation

Before the research come to end, the data that will be collected will be analysed. This analysis will be the result, thus answering the objective of the research. For this research, all data especially new geology feature and lithology boundary will be plot into a geological map of 1: 25000 scale. Every new detail will add up and the new interpretation will be deduced from this data analysis. Sampling thin section also will be analysed to the identified characteristic to distinguish every single sample. This includes the sedimentary structure recognition, deposition environment determination and facies analysis of rock unit. Identification of paleontological evidence, if present, will determine the age of the rock as well help to ensure the determination of depositional environment.

CHAPTER 4

GEOLOGY OF BEJI

4.1 Introduction

Chapter 4 will covering the geological mapping in the study area. Topic that will be covering is this chapter are accessibility, local settlement and vegetation, geomorphology, lithostratigraphy, geology structure and geology history of the study area.

a. Accessibility

The study area is located in Yogyakarta, Indonesia. To be more specific are Kampung Beji, Wonosari. To access the study area from Adisucipto Airport by mobile through National 3 towards Wonosari with estimation time in between 1 hour to 1 and half hour, influence by traffic factor. In the study area, the accessibility of the study area are well connected with main road, village road and off-road. Thus, the road and street are well maintain by the local government. Even the off-road also are good connected to the main road or the village road.

b. Settlement

Main of the people in the study area live as a villager. Study area settlement are divide into 3 village, Desa Beji, Desa Patuk and Desa Bunder.

c. Forestry and Vegetation

The study area are covered with Jati tree. Some of the place in the study area are used to be a hill paddy field that villagers works on. These Jati tree are planted to be a farm and will be used for furniture and any related product when the tree comes to maturity for production. The paddy field usually are used during raining season but in the dry season, the villagers use the empty field to planted nuts, grass for cows and goat, and other.

d. Traverse

Traverse is a track of walking that recorded by GPS, Global Positioning System device. In this study, to traverse of study area took almost 6 day to complete. The traverse are focusing on to map the rock boundary, structure and collecting data for specification. The traverse mainly cover along the stream and tributaries in the study area. The traverse are divided into 6 day of traverse. Most of the traverse are toward from north to south direction with only one traverse from east to west direction. The data collected along the traverse with the hand specimen for lab analysis. And those hand specimen sample are collected from different location and with desirable location. Sample that have been collected are clastic sedimentary rock, lime-clastic sediments, and volcanic breccia. This research traverse are as followed in Figure 4.2 below.

Day 1 traverse start at south west of the study area, through Oyo River into it smaller stream called Kali Saradan. The study when through the stream to upstream. The trend of elevation during the traverse are ascending throughout the traverse, with the maximum elevation point is 460 metre from sea level. From the traverse, found that the boundary of the Nglanggeran formation and Sambipitu formation located at

(S 7° 87’ 53.3” E 110° 52’ 12.28”), meanwhile, for the boundary between Sambipitu and Oyo formation are undefined. By observation, along the riverside were obtained agriculture activities like paddy field and vegetable crop. Besides that, the keeper of the agriculture activity use the stream as the main water source for their agriculture. Some of them built dam and small embankment to contain water and pump to their crop field. Thus, this sometime making the geology structure are invisible to collect or to reach out.

Traverse of day 2 started from the highest elevation in study area in the north and toward to the south of the study area. The high elevation are influence by the resistivity of the rock in the area. Lithology that had found are lava flow, andesite breccia, pyroclastic and epiclastic, and minor lithic tuff. The traverse through river which toward to the south. Can be seen various size of weathering product from gravel to boulder. Along the early stage of the traverse, dominantly covering area that consist andesite breccia. The boundary of the Nglanggeran formation and Sambipitu formation were found, the boundary can be shown in Figure 4.1. The boundary can be describe to be gradually changing from volcanic matter to sandstone. At some point, the boundary seem like interfingering between the two formations. Structure like fault are believe to be along the stream, as part of the stream are straight in line. But other indication cannot be required to confirm the presence of the fault. Along the traverse on Sambipitu formation, minor fault can be found on the sandstone outcrop. Thrust fault and strike slip fault are among the finding.

Figure 4.1 Boundary between Nglanggeran formation (Upper part) and Sambipitu formation (Lower part). Black line show the sharp boundary between lithology.

Day 3 traverse are focusing on the south section of the study area. This area include the Sambipitu formation and possible Oyo formation. Calcareous sandstone can be found along the traverse. The boundary of the Sambipitu formation and Oyo formation are indefinite. The transition of the carbonate contain are reducing as heading toward north. This indicate the gradual transition of the formation. Due to intensive weathering and heavy coverage and overburden, future observation are limited. But, some structure finding like cleavage and fracture can be found on claystone outcrop. Plus, fault plan also can be found, only any advance data acquisition are impossible to the area condition. Other finding can be found are lava flow at the boundary of Sambipitu formation and Nglanggeran formation.

Day 4 traverse going through west side of the study area. The focus of traverse are on the Sambipitu formation and again, the boundary with Ngalanggeran formation.

Here, found out that the boundary were sharp boundary and interfinger between the two formation. Further in the traverse, most of finding are minor fault that occurred along the Saradan stream. Cleavage on the outcrop indicate the distinct characteristic of claystone.

Day 5 as the traverse still continue and covering area on the north west of the study area. This part of area study are coincide with andesite breccia. Along the traverse, observation are limited. This is due to the intensive weathering and cover, human activities and human man-made structure. Outcrop with hornblende mineral found at very end of the traverse. Black in colour with vitreous luster that indicate the possible mineral, hornblende.

Day 6 traverse go through Kali Widoro. The traverse screen the Kali Widoro and observation found out that the lithology can be found are sandstone and claystone from the Sambipitu formation and calcareous sandstone of the Oyo formation. Not only those facies, observation also discovered siliceous sandstone, pebbly sandstone, pebbly sandstone with limestone fragment and graded bed sandstone.

From general perspective of the traverse, discovered that the study area dominated by volcanic product, sandstone and calcareous sandstone.

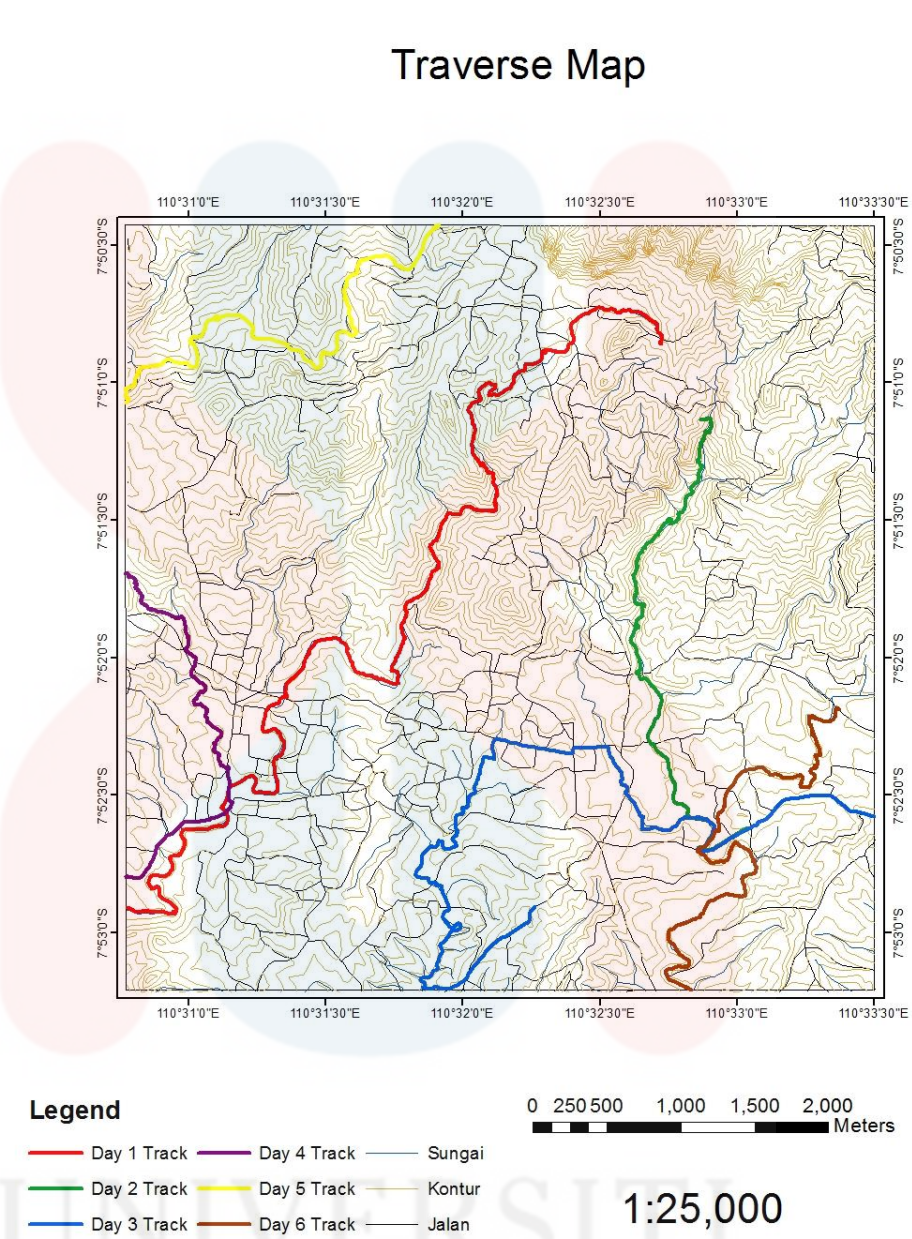


Figure 4.2 Traverse map of the study area.

4.2 Geomorphology

a. Geomorphology Classification

From the research, found that the study area are divided into 2 type of elevation. This classification of the type of geomorphology are made by using the mean elevation from the sea level. As the highest elevation is on the north of the study area, it gradually decreasing from north towards south direction. The high elevation indicated the high resistivity rock toward weathering process. This is proven by the finding of volcanic breccia that are more resistant toward clastic sedimentary rock. Some of the outcrop are exposed and can be found at 280 metre to 600 metre from above the sea level. As in the middle of the study area, found that the lithology unit are sandstone, variable grain size and thickness. Exposed outcrop can be found along the stream and tributaries and can be located at 180 metre to 320 metre of elevation. Therefore, Figure 4.3 show the region according to the elevation.

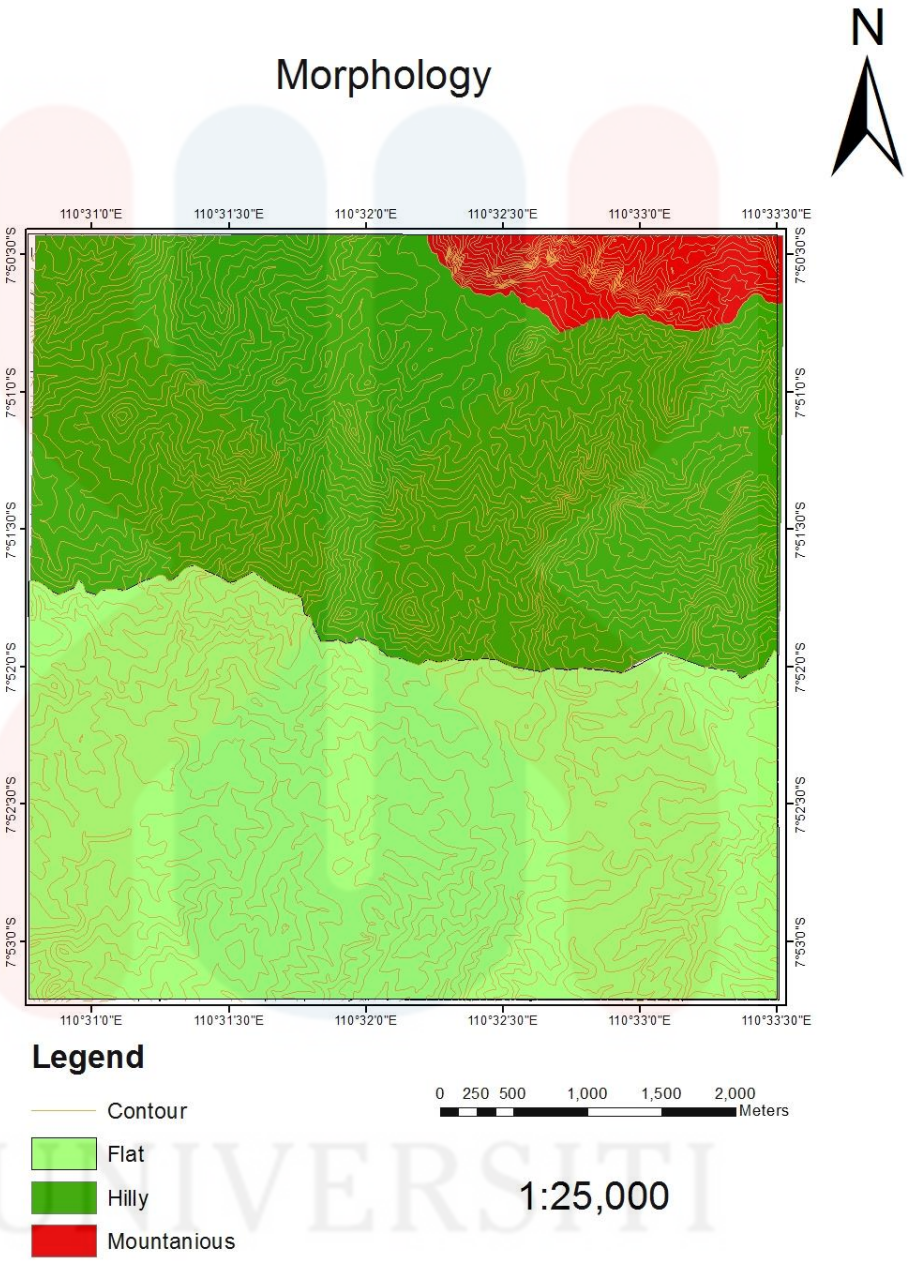


Figure 4.3 Geomorphology of study area according the elevation.

b. Weathering

Weathering is process that occurred all the time. It is a slow process with time, eroding the exposed outcrop. And weathering can be classified into 6 categories, based on table 4.2.1 below.

Table 4.2.1: Grade of weathering.

Grade	Descriptions	Terms
I	● Rock weathering sign visible ● Major discontinuity slightly discoloration	Fresh
II	● Rock materials weathering indicates discoloration and discontinuity surfaces	Slightly weathered
III	● Decomposed to soils which less than half of rock materials	Moderately weathered
IV	● Decomposed to soils which more than half of rock materials	Completely weathered
V	● Decomposed to soils all of rock materials	Highly weathered
VI	● All rock materials covered by soils ● Rock structure and materials fabric invisible ● Change in volume but soils transported significantly	Residual Soil

The table shows the indicator for grading exposed outcrop. Most of the indicator can be observes by certain structure, changes of colour and hardness. This classification show the degree of weathering that happened on the outcrop, either from low to moderate to high rate of weathering. Most of the grading of weathering can be found in the study area, but most of that can be found is from grade II to VI of weathering.

Weathering process that most occurred in study area are physical weathering and chemical weathering. Lesser are biological weathering. Figure 4.4 show the weathering process that take place on an outcrop of claystone. Also in the Figure, it show example of weathering product of chemical and physical weathering. Claystone tends to disintegrate into cleavage structure before transported by erosion medium. Beside the claystone outcrop, weathering process also happened on sandstone and andesite breccia.

Figure 4.4 Claystone outcrop that already undergone weathering process. Weathering process that involve are physical, chemical and biological.

I. Physical weathering

Physical weathering or known as mechanical weathering is caused by the change of temperature but without the chemical composition of the rocks changing.

II. Chemical Weathering

Chemical weathering is process that caused by break down of rocks by the chemical mechanism.

III. Biological Weathering

Biological weathering is caused by the animals or plants activities that burrow into the outcrop to make shelter and find moist for photosynthesis.

The observation on weathering process that occurred in the study area are intensive, influence by the erosion intensity, human activity and climate. The observation had been done on andesite breccia, sandstone, claystone and calcareous sandstone. Weathering process that occurred on andesite breccia are physical and chemical weathering. Erosion made the bond between the fragment lose and also the collision with others, like cobble and boulder erode the outcrop surface. For chemical weathering, andesite breccia outcrop tends to change colour to rust colour. This indicate the mineral contain probably iron or other mafic mineral. Physical, chemical and biological weathering occurred on other type of lithology. Erosion of water, abrasion of particle are among the physical weathering that take place. As the chemical weathering process arise, it change the coloration of the lithology ordinarily to rusty colour. This is because of the chemical reaction of oxidation of mineral contain in the lithology. Commonly, quartz are resistant to weathering, but sometime weathering

give rust stain to it outer colour. As for claystone, a distinct characteristic are cleavage. Claystone tend to break to it cleavage, thus it easier to observe and identify the claystone.

c. Drainage Pattern

Drainage pattern is a product of erosion in water catchment area. As the water flew at the weakest zone, thus it erode the surface. And this pattern eventually lead to the formation of tributaries, stream and river. These drainage pattern are an indicator for some specific lithology unit, geological structure and even show the basin of river basin. They are governed by the topography of the land, whether a particular region is dominated by hard or soft rocks and the gradient of the land. Major type of drainage pattern that command in the Earth surface are dendritic, radial, trellis, parallel, rectangular and annular while the modification drainage pattern are resembles that major pattern. Some example of the drainage pattern can refer to Figure 4.5 Below.

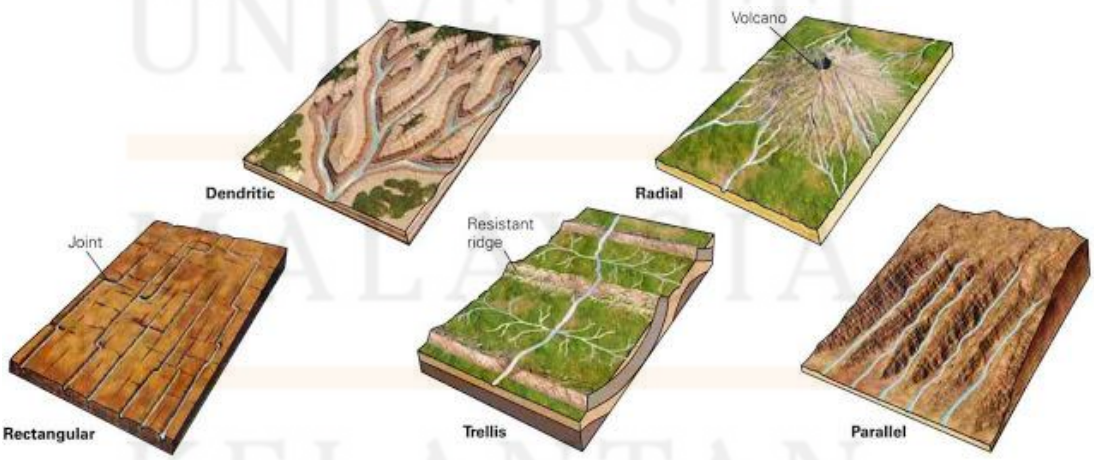


Figure 4.5 Some example of drainage pattern.

The drainage pattern in the study area possibly are sub-dendritic. The dendritic pattern more to one side rather on both side. As the stream and tributaries flow on different lithology, there are no significant different in the pattern. The river also flow on homogenous rock, creating the dendritic pattern. Thus, the drainage pattern of the study area are influence by the homogenous bedrock and also the boundary of the rock with other formation. For overview, the drainage pattern are dendritic and sub-dendritic. Below, provided a drainage pattern map for the study area in Figure 4.6.

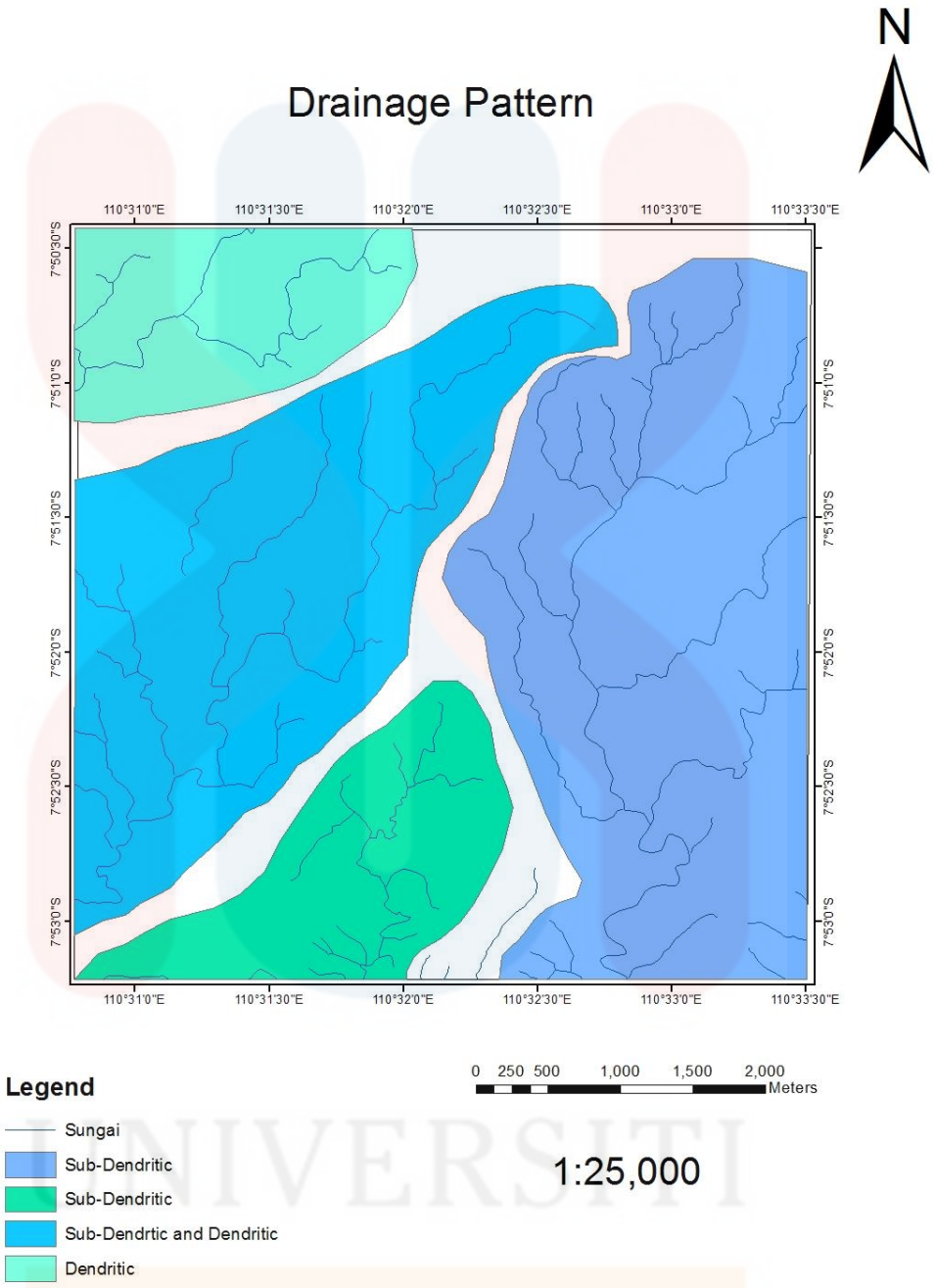


Figure 4.6 Map showing drainage pattern in study area.

4.3 Lithostratigraphy

The study area lithostratigraphy is straightforward to interpret. Three different formation consist in the study area. Nglanggeran formation, Sambipitu formation and Oyo formation. This will interpret the relative age of the study area, involving all 3 formation.

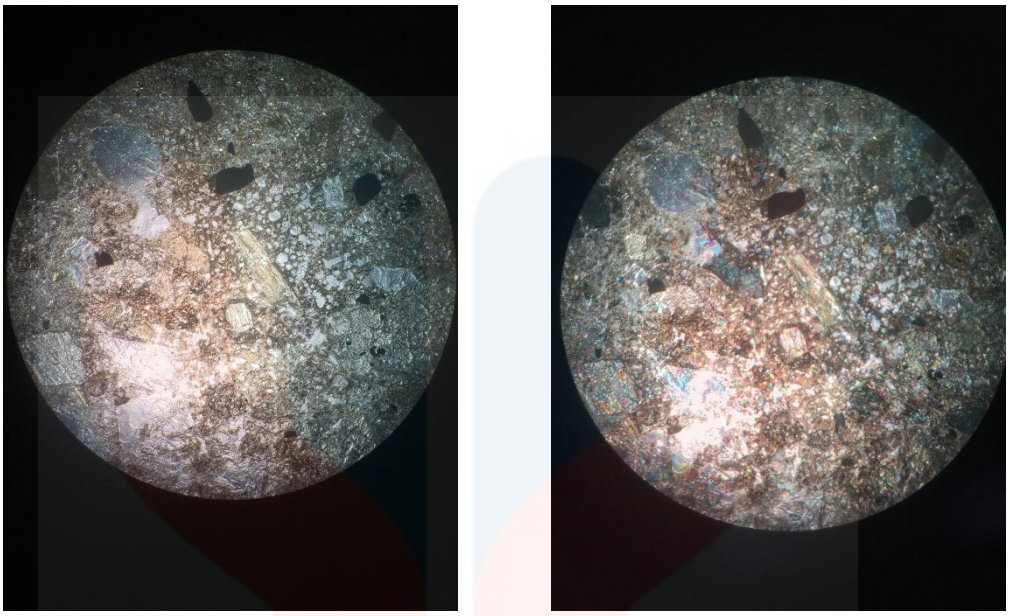
Geology structure that can be found in the study area are like faulting and folding, but in minor scale. Also, fracture can be found. Minor faulting can be found scattered around on Nglanggeran, Sambipitu and Oyo formations. As the Nglanggeran formation is a volcanic product, hence it doesn't have any bedding. But for Oyo and Sambipitu formations, it has bed. Thus, taking strike and is necessary to determine the tilting and other geology structure. In conclusion, the dipping for the lithology in the study area are tend to south, with azimuth in between 170 to 178 degree south. There is no any fossil avidence found in Nglanggeran formation, instead, Sambipitu and Oyo are abundant of fossil, trace fossil and bioturbation. But, the study found that some fragment of carbon and limestone in the Nglanggeran formation.

The Nglanggeran formation is the oldest rock in the study area compare to Sambipitu and Oyo formations. Sambipitu is overlying on the Nglanggeran formation and the youngest rock in the study area are Oyo formation.

Nglanggeran formation is the oldest formation the study area. The area covered in the study area ae on the north side of study area, and the dominant rock in the study area compare to other 2 rock formation. Dominantly dominated by andesite breccia, with minor of lithic tuff and lava flow. The photo of hand specimen show in Figure 4.7

Figure 4.7 Andesite hand specimen. At the below part of sample, seen a hornblende mineral.

The colour of the rock are dark to greyish colour, thus indicate the ultramafic to mafic possess mineral. Formed from the undersea volcano, spitted out most of the andesite breccia beside it cone structure. Nglanggeran formation is the oldest formation in the study area. This is stated by Soeria-Atmadja *et al* (1994), also some field evidence and proof. Among the data are the Nglanggeran formation is underlying under the Sambipitu formation. Furthermore, the composition of the rock consist of plagioclase, andesite mineral and some opaque minerals. The microscopic thin section photo as below in Figure 4.8



PPL XPL

Figure 4.8 Microscopic photo of thin section on Andesite Breccia, using PPL and XPL

The Nglanggeran formation form due to the volcanic activity, which was occurred during the active volcanism, during Early Miocene. Then the volcanic activity continue until to Middle Miocene, and the volcanic product feed up to the formation Nglanggeran formation.

Succeeding Nglanggeran formation is the Sambipitu formation. Generally, Sambipitu formation is a clastic sedimentary rock. Sambipitu covering at the middle of the study area, a smaller covered area to the Nglanggeran formation. It believe, the thickness of the Sambipitu formation are around 230 metre to 280 metre. Minor fault are scattered in the Sambipitu formation with various type like normal fault, strike-slip sinistral fault and reverse fault. And all this fault are believe the product of the major fault like the Opak Fault at the north west of the study area.

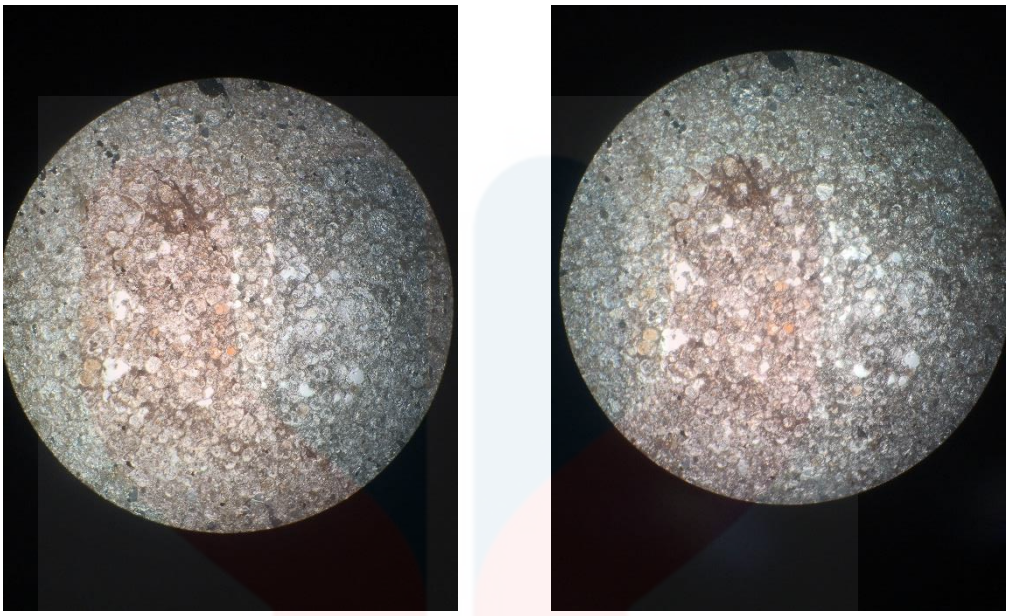
Sedimentary rock signature character are the bedding itself, as the sediment deposited on horizontal thus any tectonic movement or uplifting could tilted the bed

of Sambipitu formation. In the study, data shown that the Sambipitu formation might have tilting due to the strike and dip data. Sambipitu formation distribution are from the east to the west and the dipping direction of the lithology tend toward south, in between 170 to 178 degree. This can be the evidence on proofing the Sambipitu is overlying the Nglanggeran formation at the north part. Sedimentary structure that discovered are lamination of claystone and sandstone. Sambipitu formation contain abundance of fossil like microfossil, trace fossil and bioturbation. Among the fossil that can be found are Foraminifera and burrow.

Sambipitu formation lithology can be divided into sandstone, calcareous sandstone and claystone. In addition to some minor lithology like pebbly sand stone, breccia and siliceous sandstone. This shown the varsity of Sambipitu formation. Sambipitu formation come from various size, from medium coarse to very fine sandstone. The sandstone also contain fragment of silica, limestone, andesite mineral and feldspar. The pebbly sandstone usually found with matrix supported with either siliclastic fragment or the limestone fragment. Calcareous sandstone can be found on the Upper part of Sambipitu. The calcareous sandstone react to the Hydrochloride acid (HCl) test, in different degree as the study area moving to the southern part of study area. The hand specimen shown in Figure 4.9.

Figure 4.9 Sample from the Sambipitu formation, calcareous sandstone.

Siliceous sandstone can be found at the Lower part of the Sambipitu formation. It outcrop gave some glitter reflection when under sunlight. In addition, at the Upper part we can found the breccia. The breccia of the Sambipitu commonly found with fragment of the andesite breccia, relatively close to the boundary between the two formations at northern part. The claystone are found along the Sambipitu formation, either in massive bedding, interlayering or lamination. The colour of the claystone are yellow brownish. The claystone maybe contain opaque minerals. The microscopic photo of thin section can be look below, in Figure 4.10.

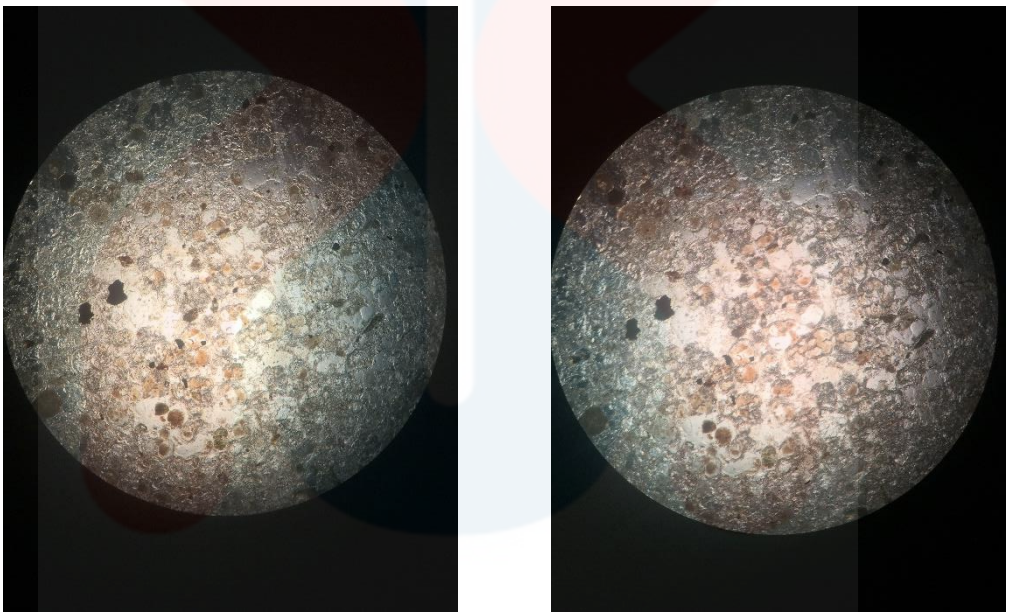


PPL XPL

Figure 4.10 Microscopic photo of Calcareous sandstone of Sambipitu formation.

The photo that shown in the Figure 4.10 is the calcareous sandstone that acquired from the Upper part of the Sambipitu formation. The presence of the micro fossil with the matrix of sparite indicate the influence of carbonate setting. The Sambipitu is contain abundance of microfossil especially Foraminifera and trace fossil like bioturbation. The microfossil of foraminifera can be identify as *Globuquadrina spp.* that usually can be found at the shallow to deep marine clastic deposition. Some of the fossil already undergone recrystallization by substitute by micrite minerals. The depositional time of the Sambipitu formation can be track back to Middle Miocene to Late Miocene. The Late Miocene can be proof to the presence of the carbonate intensity on the Upper Part of the Sambipitu, where he carbonate setting start to form due to the decreasing of the volcanism activity during the Late Miocene. The depositional environment of the Sambipitu is indicate by the facies oh it lithology, confirming the environment are marine deposit, shallow to deep water with the presence of Bouma sequence.

Lastly, the youngest Oyo formation. Oyo formation dominantly by the calcareous sandstone, in the study area. The calcareous are the influence from the carbonate platform that form during the Late Miocene. The distribution of the Oyo formation is at the southern part of the study area. The lithology main compose by the sandstone and carbonate element. The sandstone under microscopic photo, Figure 4.11, show that the main component for diagenesis are carbonate element like sparite mineral.

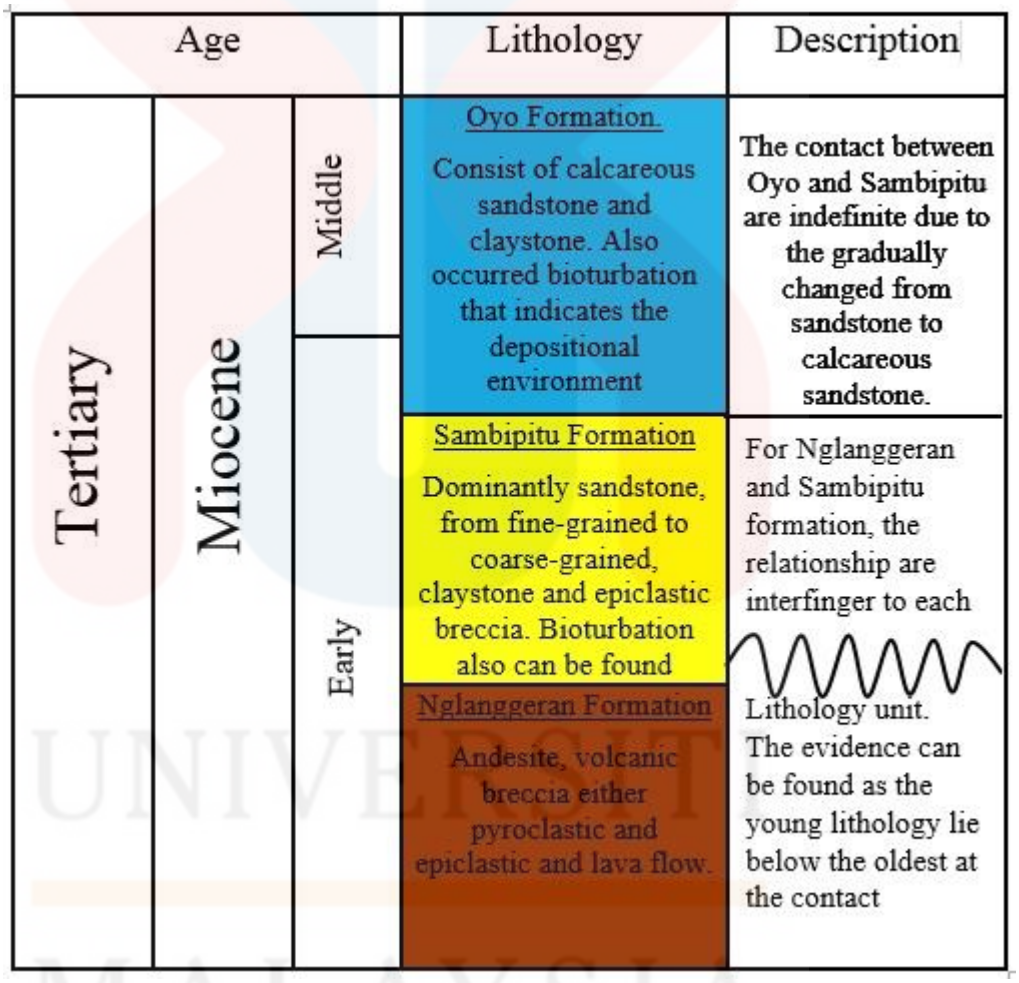


PPL XPL

Figure 4.11 In the figure, the mineral base from carbonate, micrite and sparrite.

Oyo formation also contain abundance of fossil, especially microfossil of Foraminifera. As Sambipitu formation, the family of the foraminifera are the *Globuquadrina spp*. that indicate the marine deposition environment. The calcareous sandstone of Oyo formation react vigorously with HCl, this indicate the high concentration carbonate were deposit on Oyo formation. The Oyo formation also

shown the interlayering of the sandstone and claystone. This claystone also indicate the influence of carbonate as it react slightly to the HCl test. Oyo formation begin to deposit after the declination of volcanism activity during Middle Miocene. This decreasing activity of volcanism, give opportunity for carbonate platform to form at the shallow to deep marine. Figure 4.12 shows the lithostratigraphy of the study area after the research.



4.12 Lithostratigraphy of Beji area, Yogyakarta.

4.4 Structural Geology

Structural geology is study that learn the deformation of a rock body in 3 dimensional to know about the tectonic story and ancient plate movement. This

structure also can be and instrument to study the date of occurrence and age of the rock body. Among the structural geology are cleavage, joint fault and folding.

a. Fracture

Fracture is a distinct physical appearance on the rock due to stress or tension that occur on the rock body. Can be divided into two type, differentiate by the spacing that held on the structure. In the study area, cleavage can be found scattered around the area. Although, cleavage only can be found at claystone, not on sandstone, calcareous sandstone and andesite breccia. Cleavage, showed in Figures 4.13 occur due to the weak bond of the mineral of clay in 2 dimensional.

Figure 4.13 Cleavage on the claystone outcrop

b. Fault

Fault is a physical structure that occurred on the rock. Usually happened in 2 dimensional and the main causes of faulting are due to the stress and tension that put on the rock. This several of stress and tension are product of the plate movement like, converging plat and subduction plate boundary, mid-

ocean ridge and divergent plate boundary, respectively. Furthermore, fault only happen on rock body that are brittle. In study area, fault occur across the study area. But, the sizing of the occurrence of fault are only minor in size. In might be due to major fault that occurred near to study area such as Opak fault at the north west of the study area. Example of fault occurrence are on Figure 4.14.

Figure 4.14 Show the direction normal fault (red arrows) and its fault plane (Red line)

Due to intensive weathering and overburden cover, the study need to analyse the contour map, looking for lineament or structure. And Figure 4.15 shows the fault map in the study area.

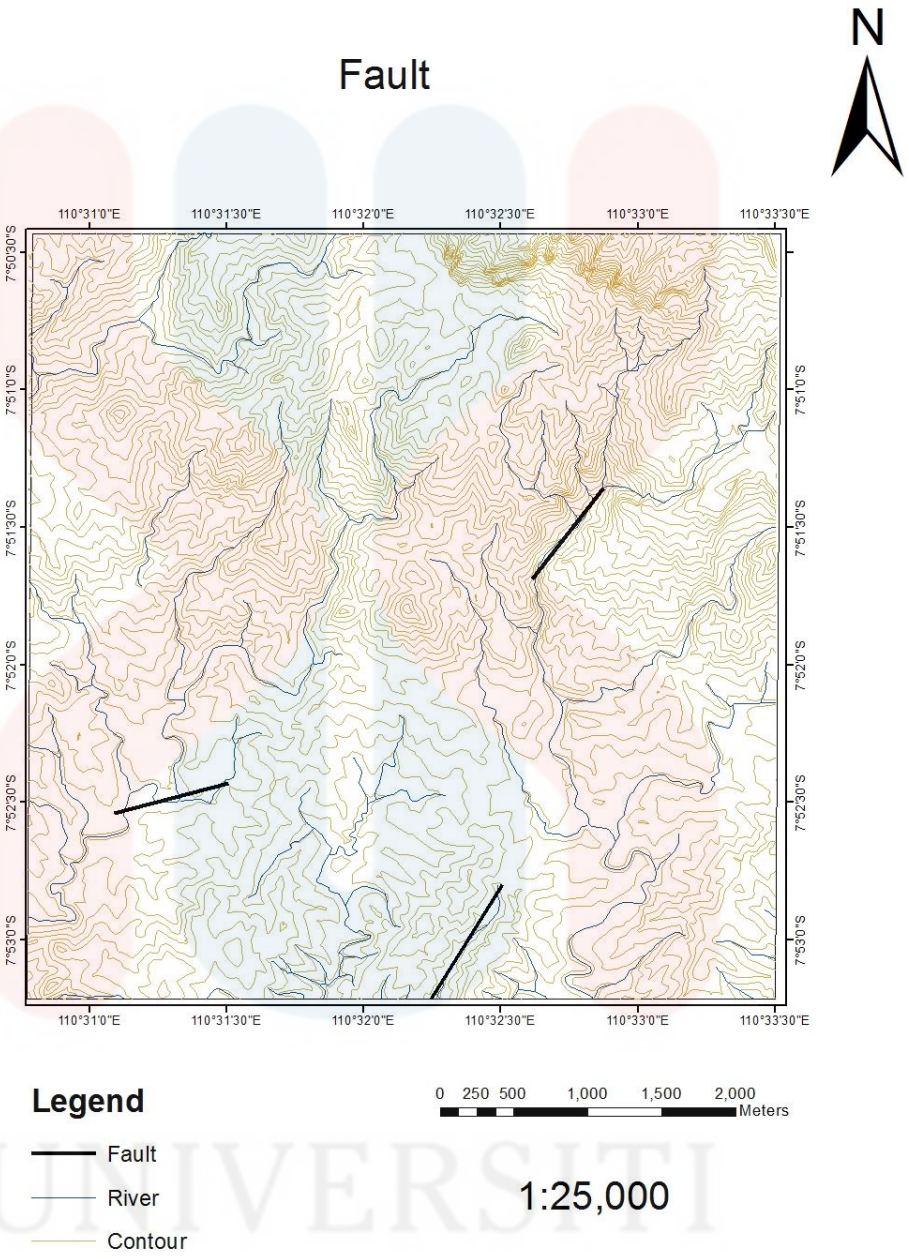


Figure 4.15 Fault map in study area.

c. Fold

Fold is a product structure that occurred when the rock body was exerted stress on it. Instead of breaking like brittle character rock, it change it shape due to it ductility. In addition, this type of structure commonly occurred on sedimentary rock. Folding can in various form and the finding in the study area are a monocline, can refer Figure 4.16 below. This monocline are indication to formed fault beneath the sedimentary bedding. Due to it ductility, the bed are uplifted on aside and without limbs as common fold.

Figure 4.16 Monocline fold, sandstone interlayering with claystone (Middle layer)

d. Mechanism of structure

Geology structure formed due to several factor like stress and tension. These force is a product of our dynamic earth lithosphere, moving plate tectonic, subduction and several more lithosphere activity. In the study area,

fold and faulting are distinct indication of these tectonic activity. Plus, the cleavage and fracture also indicate to the faulting formation in the area. After observing the fault occurrence in the study area, most likely minor faulting occurred. This can be said that those fault form due to the major fault that happen. Among the fault that can be the source of these minor fault are Opak Fault that located at the north east of study area.

e. Lineament

Beside the structure on the field, lineament analysis from the contour map can be done. Lineament is a straight feature that occur on the contour map. Lineament always related to the fault structure, fold's hinge, ridge and more. Thus, this indicate us that lineament in study area are also crucial to analysis, and even can be proof for unseen structure. For the lineament in study area, the lineament map in Figure 4.17 show a possible fault structure, only lacking of field data. In addition, the lineament reveal ridge of hill.

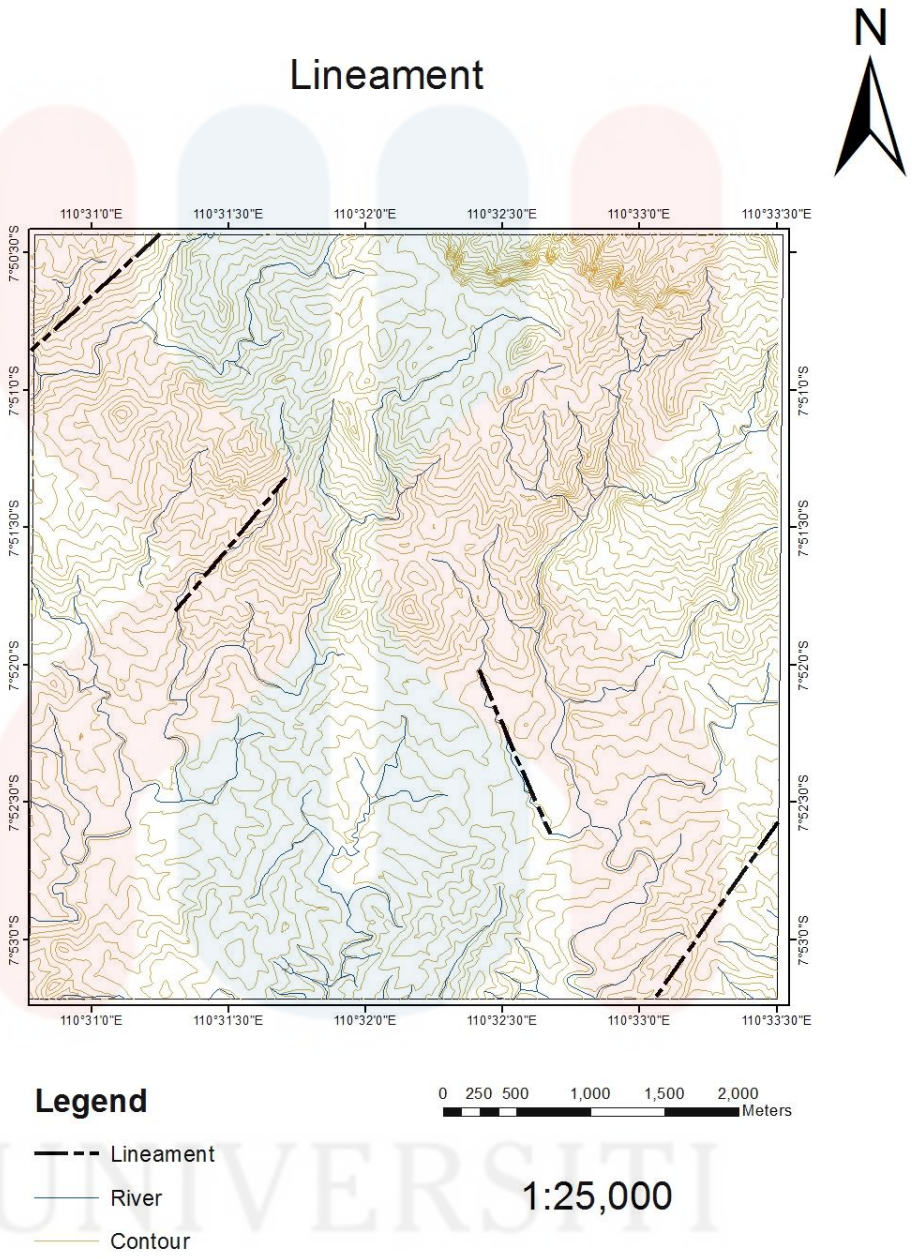


Figure 4.17 Lineament of the study area, show some possible geology structure

4.5 Geology History

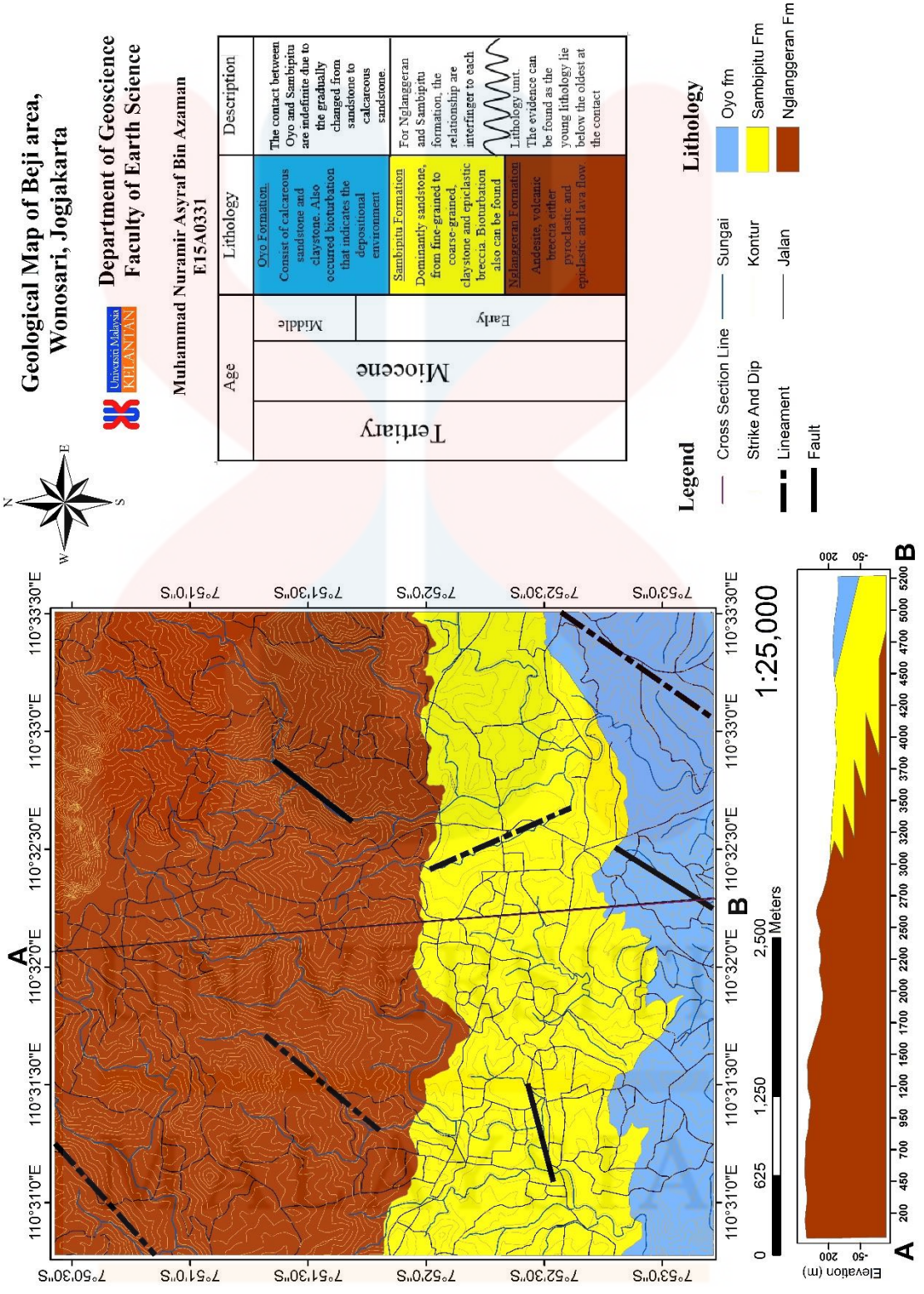
The study area consist of 3 main formation, Nglanggeran, Sambipitu and Oyo formation. Nglanggeran formation formed due to the increasing volcanism activity during the Early Miocene. The volcanism activate the black smoker beneath the sea level surface. This activity start to form a cone shape of the volcano. The undersea regurgitate it lava, dominantly contain mafic and ultramafic mineral like andesite. Most of the rock formed due to the gravity pull action, making the lava to flow to the side of the volcano. Beside the andesite outcrop, in the study area also discovered the andesite breccia. The formation of breccia is due to the process as stated above. This process called auto-breccia. Auto-breccia formed when the outer layer of the lava hardened while in the centre of lava were still in fluid condition. This created the feature of breccia on the volcanic product.

Next is the Sambipitu formation. Sambipitu formation start to deposit during the Middle Miocene to the Late Miocene, hence the volcanism activity start to decline. As the Sambipitu formation developed, Nglanggeran still active and expelling lava out. This can be show by the interfingering boundary that been discovered in the study area. In addition, the Nglanggeran already undergone erosion before the Sambipitu formation start to develop. The evidence are the discovery of epiclastic breccia, consist of andesite and sandstone fragment, sometimes mudstone and claystone. Furthermore, the sedimentary characteristic can be identified like sortiness, bedding of mudstone and transported element. Sambipitu formation divided into 2 part, Lower part and Upper Part. Lower part mainly consist of sandstone, pebbly sandstone and breccia sandstone. For Upper part, the Sambipitu formation are influence by the carbonate element, due to the progression of carbonate platform on Middle Miocene. The

Sambipitu formation stop deposit as the carbonate platform start to evolve in the Middle to Late Miocene.

The last formation to form in the study area are the Oyo formation. Oyo formation start to evolve as the volcanism activity declining in the Middle Miocene. This give the opportunity to the carbonate setting to develop and affect the formation Oyo. Oyo formation consist calcareous sandstone and claystone. The presence of the microfossil of foraminifera, *Globoquadrina spp.* prove that in the Middle Miocene, the carbonate platform start to bloom in that time.

In the end of this chapter, the last produced geological map of the study area with the title of Geology of Beji area, Yogyakarta in Figure 4.18 below.



4.18 Map of Geology of Beji area, Yogyakarta.

CHAPTER 5

DEPOSITIONAL ENVIRONMENT OF SAMBIPITU FORMATION

5.1 Introduction

The study of depositional environment purposely to become aware of the condition when the clastic sediment deposit. Besides that, the origin of clastic sedimentary can determine by the mineral dwell in the sedimentary rock. In addition, the study will help to get knowledge about the influences and factor of the rock facies like the carbonate setting, weathering process and volcanism activities. In this chapter, it will explain the data that have been collected from the research in the study area. Three method were carried out, facies analysis, lithology column and fossil analysis. Facies analysis in process that carried to identify and analysis the facies analysis. Different rock or layer have a distinct or individual characteristic. Thus, by doing this, the research will become aware of how the sedimentary rock deposit and it condition during deposition. Some facies came will some structure called sedimentary structure. This structure only applicable to sedimentary rock which it develop during pre-sedimentation, sync-sedimentation and post- sedimentation. This structure indicate very specific condition or environment of sediment deposit.

Next, lithology column help to understand more about the depositional environment. The thickness and other information like fossil, structure and facies will allow research understand the behaviour of the depositional environment. In lithology

column, the information we can exploit like the thickness, indicate the depth of marine if it marine depositional, the type fossil, to differentiate the non-marine and marine deposit, grain size of fragment, the energy during deposition and many more.

Lastly, fossil contain help to interpreting the depositional environment in aspect of non-marine or marine deposit, the age of deposition and the factor of lithification. The fossil also indicate the influence from the carbonate setting during deposition of Sambipitu formation.

5.2 Location of Specification

The location of the study are in Desa Beji, mainly focus on the Sambipitu formation. The location of the Sambipitu formation is shown in Figure 5.1. Sambipitu formation mainly dominate by sandstone, claystone and calcareous sandstone. With minor lithology of siliceous sandstone, pebbly sandstone and breccia.

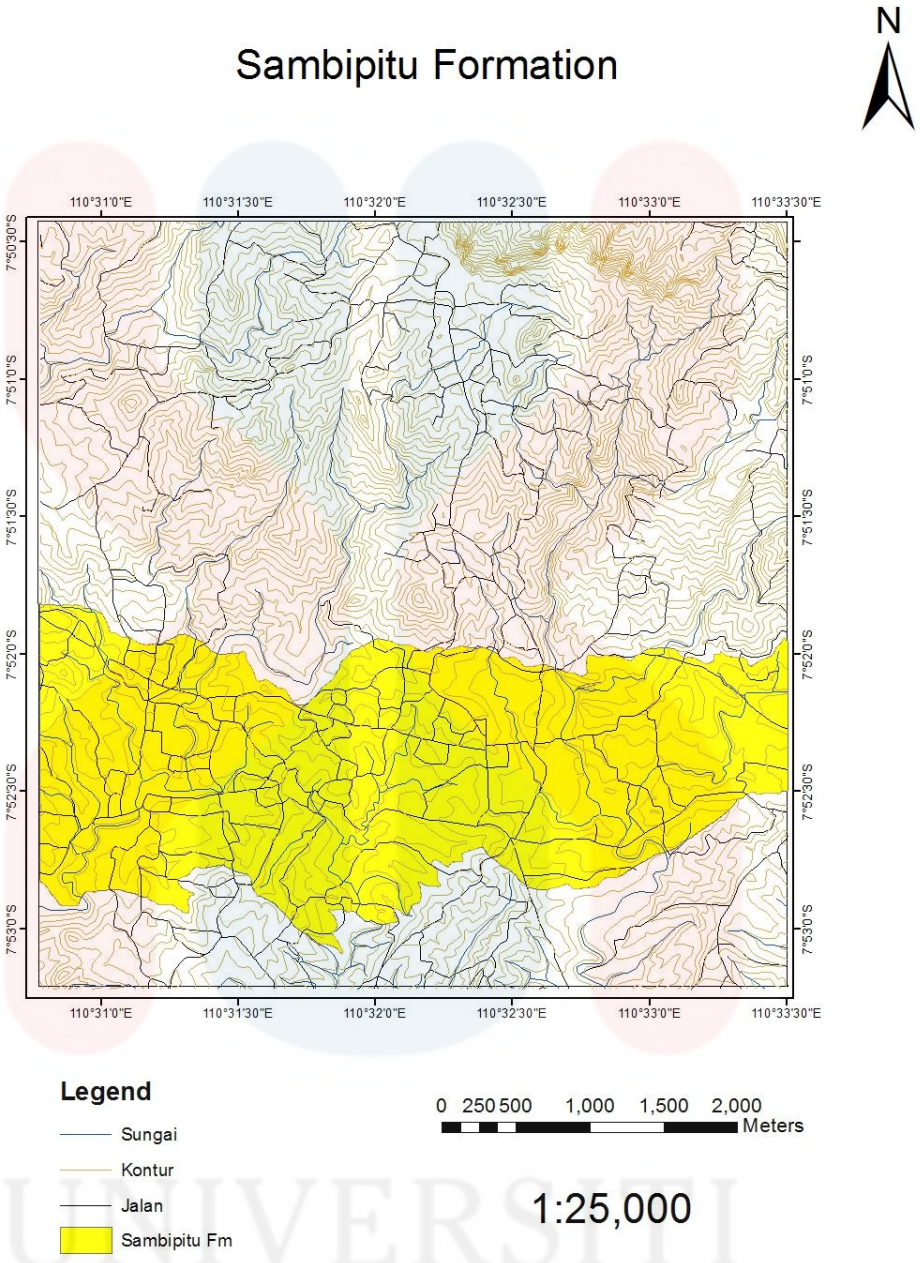


Figure5.1 The location Sambipitu formation in study area.

Furthermore, the location for collecting data for lithology column are along Kali Saradan, this illustrated in Figure 5.2 below. The estimation of the lithology

column are about 250 metre to 255 metre long. The lithology column will covering about from the Upper part of Sambipitu formation to possible Lower part of Sambipitu formation at the southern part. The data collected along the river that took about 1500 metre of traverse. The collected by measuring the thick of same bed or on the same outcrop that discovered along the Kali Saradan.

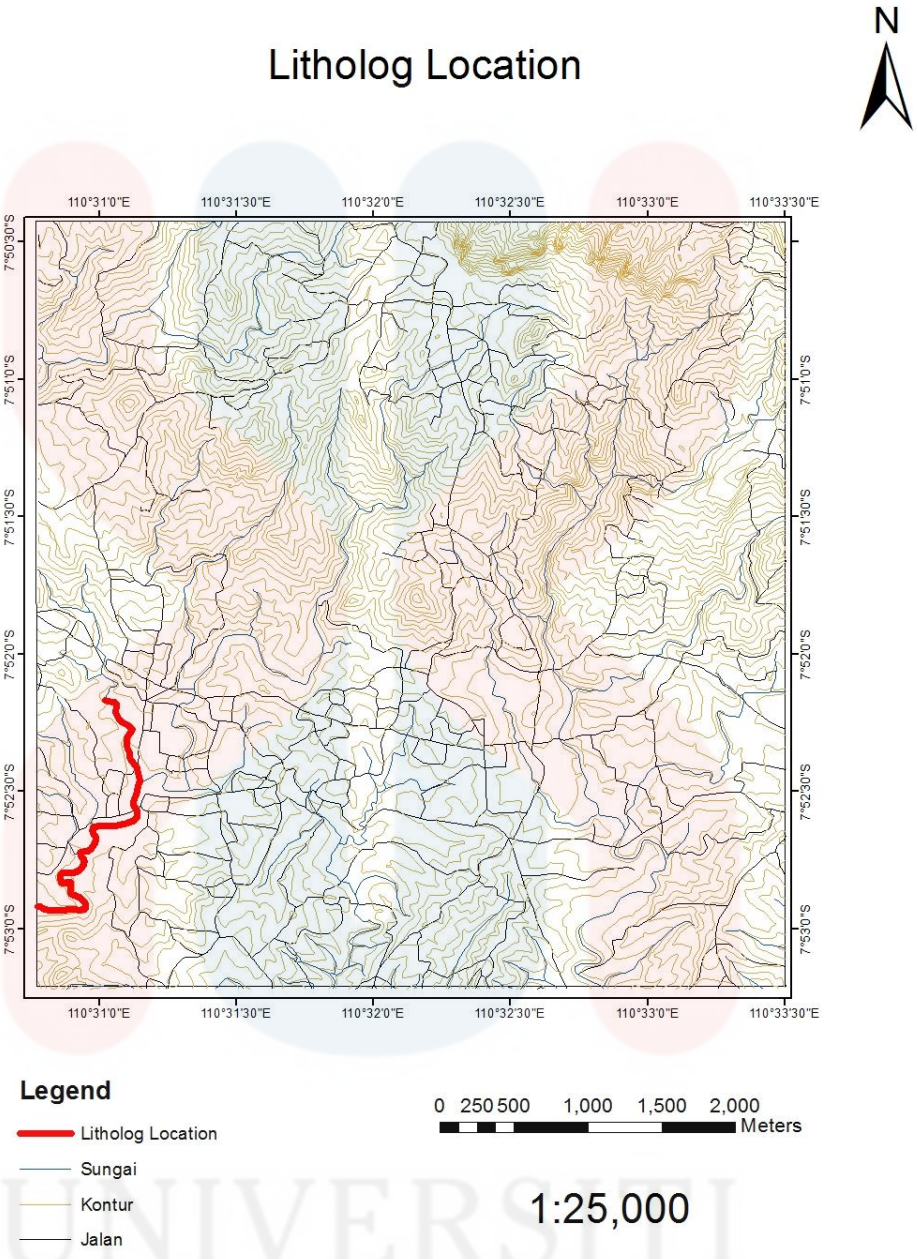


Figure 5.2 Location for lithology column data collected.

5.3 Lithology column

Facies analysis is a study the distinct characteristic of individual facies. Every single facies has its own feature, influence by the condition during the deposition and its environment.

The study begin with the Lower part of Sambipitu. Lower part Sambipitu are the oldest bed to developed. Generally, Sambipitu formation are dominated by sandstone, with associated of claystone and minor sub-unit lithology unit. The length of lithology column are about 253 metre, covering from Lower part boundary to the Upper part boundary at the southern part of the study area. The lithology column will be divided into 10 part, and will be explain below with the interval of 25 metre each. For the full lithology column, refer to Appendix A.

The first part is the Lower part boundary shown below (Figure 5.3). Overlying on the Nglanggran formation, the relationship between these 2 different rocks are interfingering and gradual conformity. The first part, dominant by claystone and sandstone. The interlayering between the claystone and sandstone show the different energy level during the deposition of sediment. Plus, most of the claystone formed in lamination. Lamination mostly indicate very low energy and shallow environment. The interchange of sandstone bed and lamination bed of claystone, indicate the changing in energy and lamination indicate the depth of the environment. The discovery of trace fossil, bioturbation in the sandstone show that the deposit of the Sambipitu located in marine environment. From the size of the bioturbation, the study estimate that the deposition depth are shallow. Furthermore, the grain size of the sandstone are fine to very fine size. This suggest that the sand sediment deposit far from the shore.

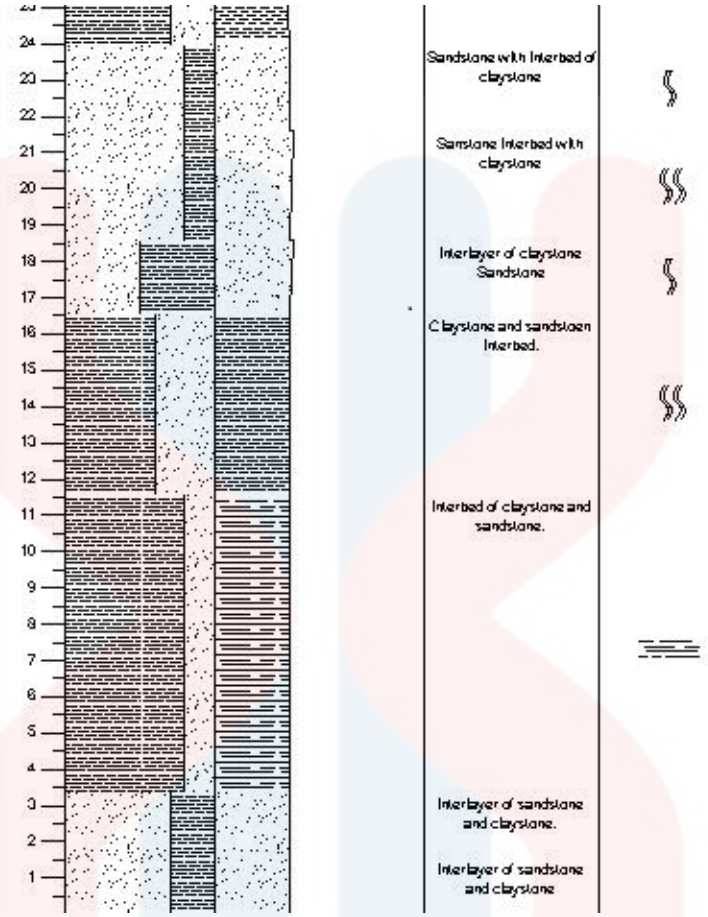


Figure 5.3 Lithology column of Lower part Sambipitu, 1 to 25 metre.

For the second part, the litholog are dominat by sandstone and claystone. But, some part of sandstone, refer to Figure 5.4, associated with the pebbly, larger size of fragment. In addition, those fragment discovered are to be limestone fragment and andesite fragment. Andesite mineral are believe product erosion from the Nglanggeran formation. But for the limestone fragment are still unknown. Still, the sandstone and claystone are interlayering to other. The thickness of sandstone are more than 10 metre yet insertion of claystone lamination in it. From these data, the interpretation from this part of litholog indicate that the deposition environment are high energy, but alternating with low energy that deposit clay. As this part of lithology dominate by claystone lamination and sandstone massive bed, it show that the energy is low with shallow depth and vice versa.

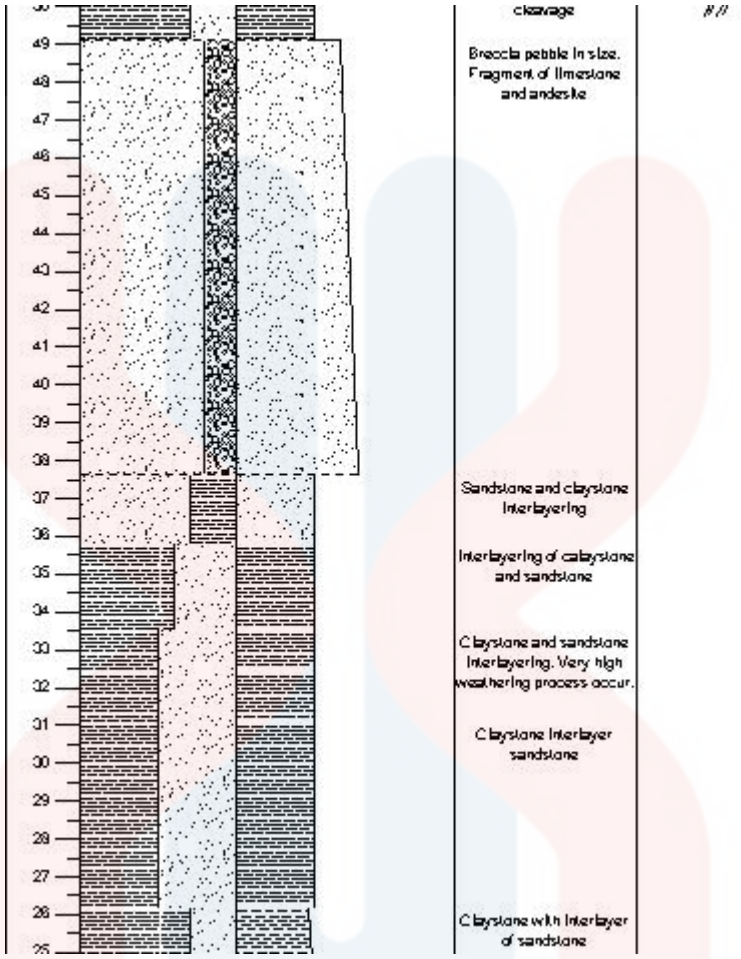


Figure 5.4 Sambipitu lithology column, 25 to 50 metre

For the third part, ranging from 50 to 75 metre shown in Figure 5.5. Still dominate by sandstone. In fact, some part of the lithology are massive with sandstone bed with the interlayering of claystone. The study discover pebbly sandstone with foreign mineral. Based on the lithology, due to the dominant of sandstone indicated that the energy level is high but alternating with low energy due to the claystone formed. Besides that, the occurrence of bioturbation in the sandstone indicate the shallow depth marine. The grain size of the sandstone are fine size. The thick bed of sandstone denote the high volume sedimentation happened during high transportation energy and a little deep depth.

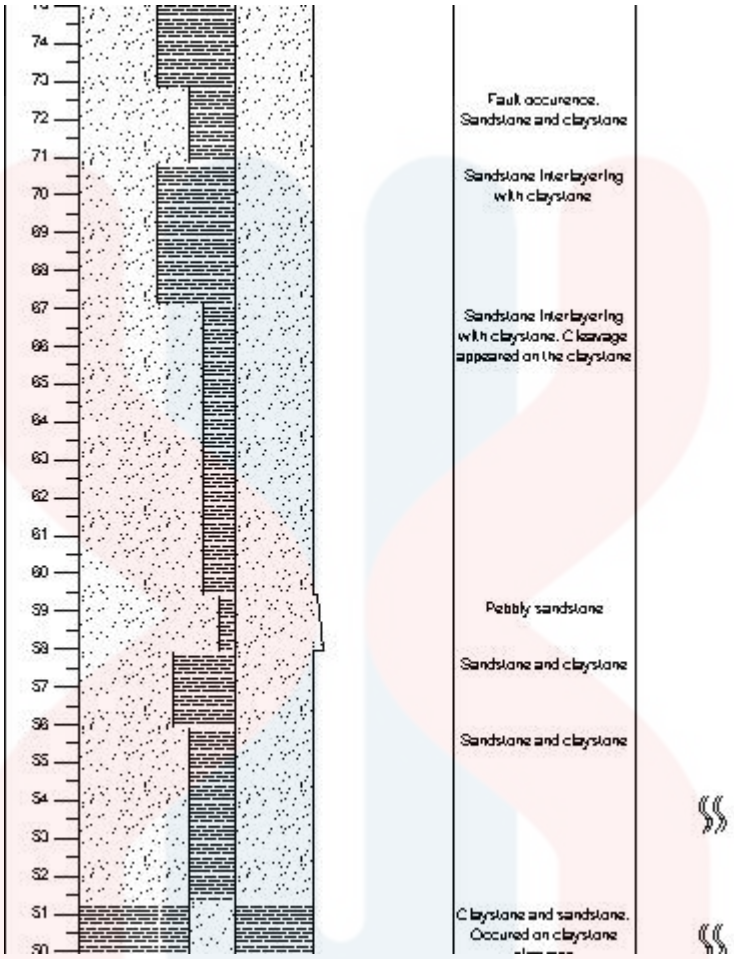


Figure 5.5 Sambipitu lithology column, 50 to 75 metre.

The fourth part are predominate by sandstone. The lithology column shown in Figure 5.6. But along the lithology data, there was interlaying of claystone. Bioturbation occurred on sandstone bed. The intensity of bioturbation are moderate and the size are medium. Sedimentary structure that present are planar lamination, which imply the low energy environment and the shallow deepness. The grain size are predominant fine sandstone, but in certain part are pebbly. And this pebbly sandstone show that during the deposition time, the energy are high in a short time. In addition, the outcrop not only designate interlayering, the sandstone and claystone interlamination.

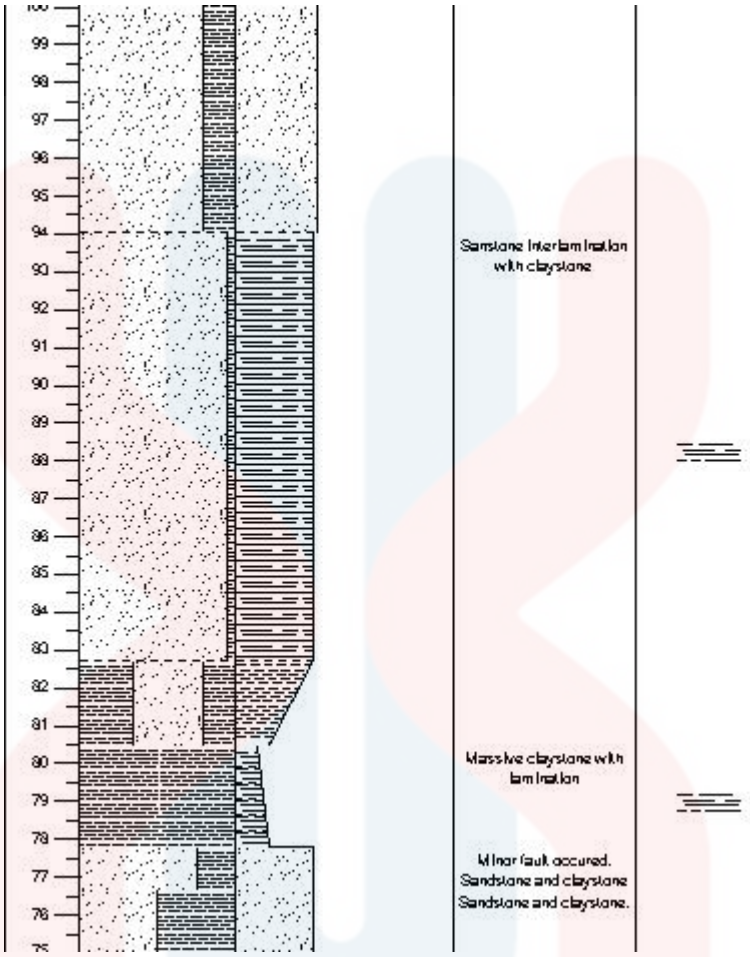


Figure 5.6 Sambipitu lithology column, 75 to 100 metre.

The next part (Figure 5.7), predominant by claystone and sandstone. The interlayer between sandstone and claystone continue from 100 metre to 125 metre. In addition, the bed of individual layer sandstone and claystone are distinct. Along the lithology column, sandstone are major unit. This suggest that during the deposition of sediment, it possess a high level energy. Further, lamination also indicate that the energy decreasing to very low energy. In addition, massive claystone with lamination bed show that at a time, the energy was disrupt and very slow before it regain it high energy level. Looking at the thickness of the sandstone, alleges that the shallow deep marine. The sand already transported along away due to the grain size of sandstone. Stated by Surono and Permana A. (2009), the Lower part Sambipitu is about 85 metre

and 138 metre are the Lower part. But in the study, the Lower part probably about 166 metre thick.

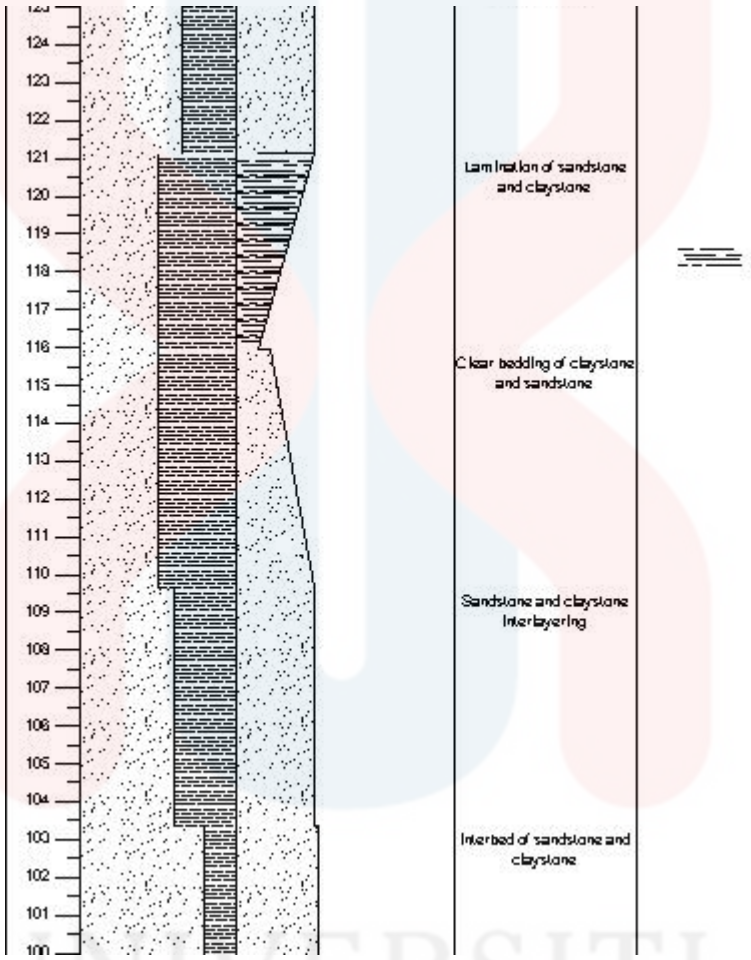


Figure 5.7 Sambipitu lithology column, 100 to 125 metre.

Succeeding part of Sambipitu in Figure 5.8, the lithology column are possess by sandstone and claystone. The bed are interlayering with each other. The sandstone indicated the high energy level while the claystone layer suggested the low energy environment with no sand deposit. Unlike previous part, this part do not have any sedimentary structure. The grain size of the sandstone are fine, suggest that the fragment already undergone high intensive erosion before deposited.

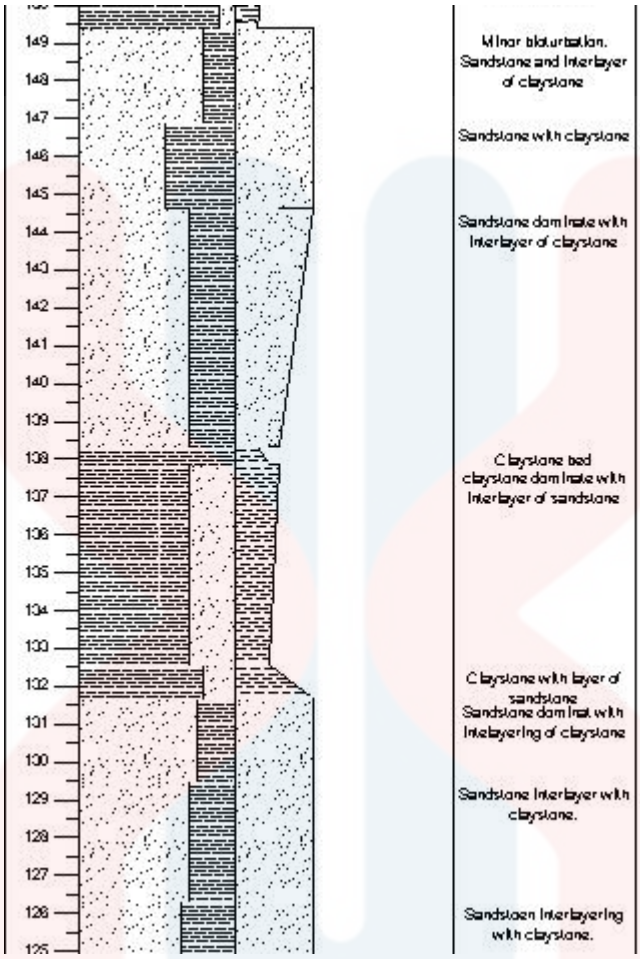


Figure 5.8 Sambipitu lithology column, 125 to 150 metre.

Next, the sandstone and claystone still dominate the lithology column. But the condition of the bed are various. Some part of it, discovered lamination of claystone with interbed with sandstone bed. The relation between the beds are gradational, interchange between sandstone bed and claystone bed or claystone lamination. Not only interlayering, this part consist of massive bed of sandstone and claystone. The grain size frequently in fine size. But the sandstone can be shift to very sandstone when close to the conformity of bedding. The study did not discovered any biological evidence. The lithology column provided in Figure 5.9.

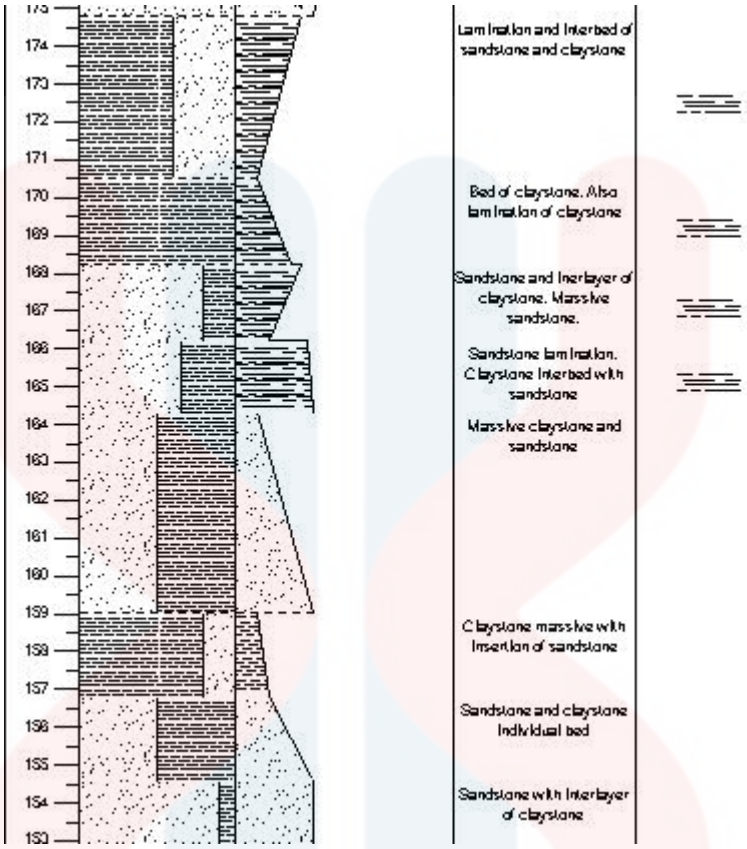


Figure 5.9 Lithology column of Sambipitu, 150 to 175 metre.

In the following part in Figure 5.10, the lithology column start with massive bed of sandstone, where the sandstone grain size is fine to moderate. The bed relationship to succeeding bed are gradationally change, from massive bed of sandstone to bed of interlayering of sandstone and claystone with horizontal planar lamination. At 190 metre, the sharp boundary emergent to separate the layer of claystone. Again, the claystone gradually change to sandstone bed before alter to pebbly sandstone. This pebbly sandstone fragment from limestone, which react with HCl test. By this finding, it indicate that the changes of influence in the sandstone component of Sambipitu. The sandstone could be called calcareous sandstone. Indicate by the thickness of the lithology unit, the depositional condition for deposition are alternating high energy and low energy level.

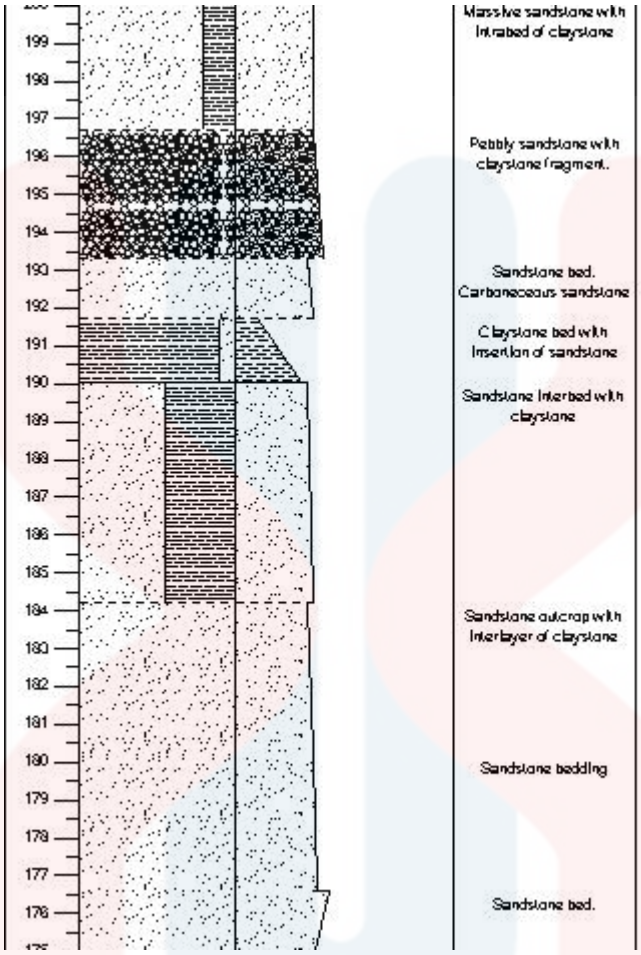


Figure 5.10 Lithology column of Sambipitu, 175 to 200 metre.

Next one in Figure 5.11, sandstone bed with interlayer of thin bed and lamination of claystone. Most of the sandstone grain size are fine before it gradually change to moderate when relate to the pebbly sandstone. The pebbly sandstone are dominate by fragment type. In the pebbly sandstone discovered trace fossil of bioturbation. At the top of it, lay a bed of claystone with horizontal planar lamination. From the part, the sandstone indicate the study that the situation of deposition are high energy with only low energy at a time when depositing claystone lamination. The planar lamination also suggest that the depth of environment are shallow. Next, the bed of pebbly tuffaceous sandstone. Tuffaceous are product from volcanism activity. Even with the carbonate setting already develop, the volcanism activity still spout out the ash and deposit with the sandstone. In addition, there are

insertion of carbon. Carbon signify the present of coal, older that Sambipitu formation itself.

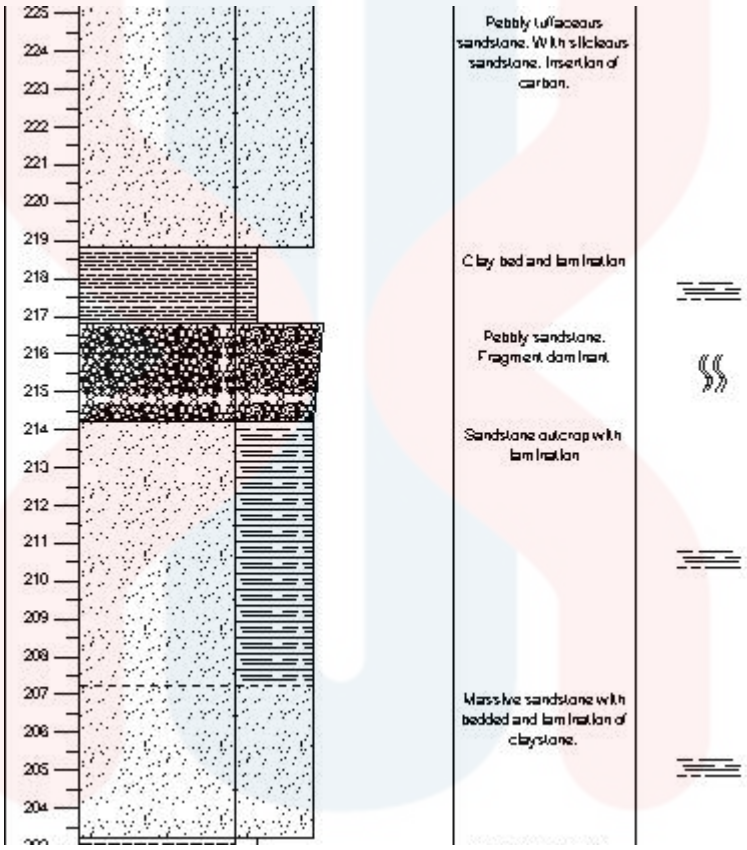


Figure 5.11 Lithology column of Sambipitu, 200 to 225 metre.

The last part shown below in Figure 5.12. This part indicate the different component of the sandstone. At the Upper part, the sandstone are not influence by carbonate material. But this part were indicate the influence from carbonate when test with HCl solution. Dominant by sandstone and claystone, the sandstone alternating from fine size to very fine sandstone. The study did not find any trace fossil. The sandstone bed suggest that the depth of environment are shallow. Plus, the claystone deposit interlayering with the sandstone. And most of the outcrop are reacting with HCl solution, indicated the calcareous element deposited with the lithology unit.

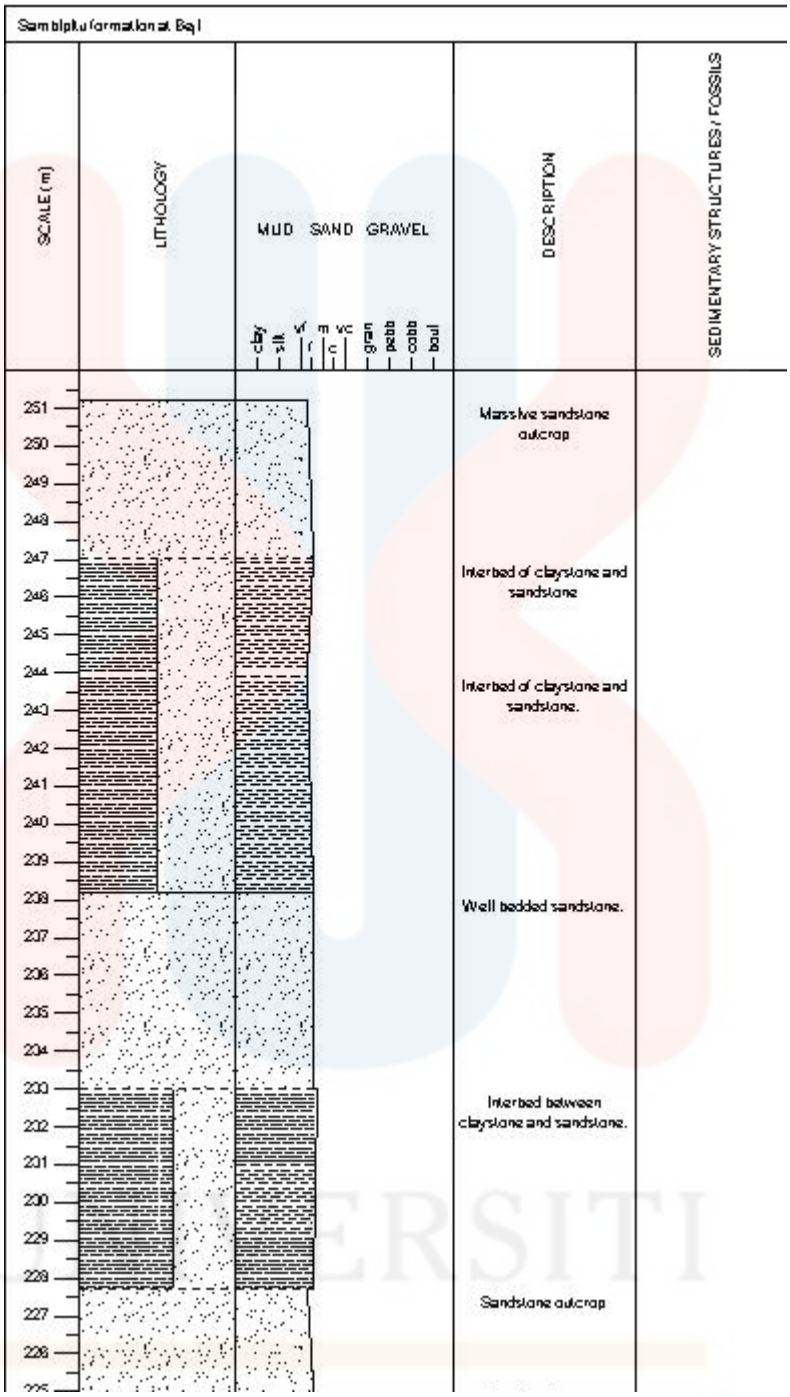


Figure 5.12 Lithology column of Sambipitu, 225 to 251 metre.

5.4 Facies analysis

In this subtopic, the discussion is about the facies of the lithology unit that comprise in the Sambipitu formation. The study will focusing on the distinct characteristic of the different facies. There are some different facies in the Sambipitu, sandstone bed, claystone bed, calcareous sandstone bed, pebbly sandstone bed, breccia sandstone bed and lamination of claystone.

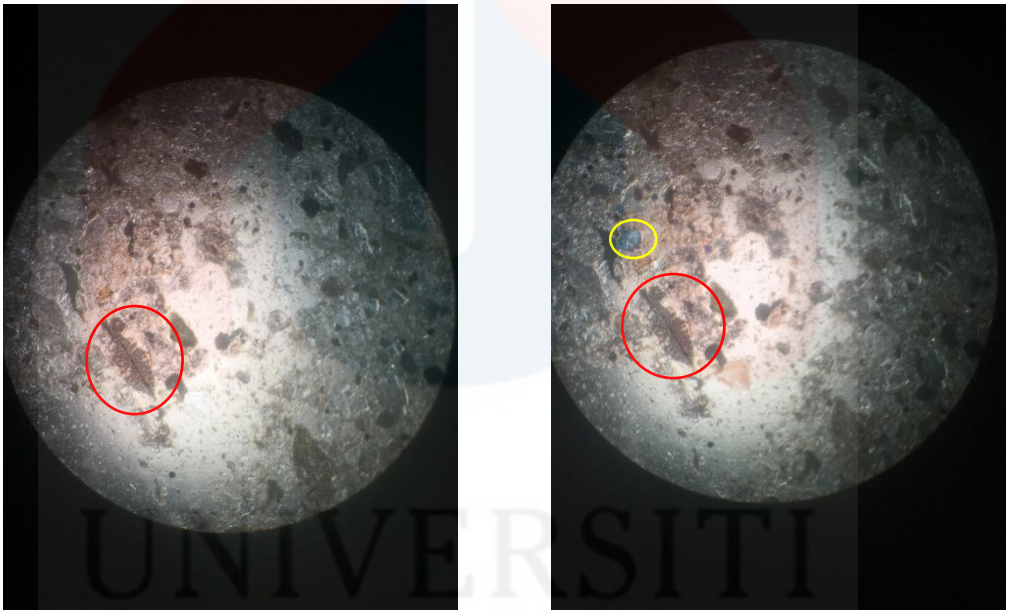
In the study, the facies are divided into 3 facies. This facies are identified by their own individual characteristic. This facies are name into Facies A, Facies B and Facies C. All this facies indicate some specific feature that will reveal their condition of depositional environment. The facies were picked from Lower part, Middle and Upper part of Sambipitu.

Firstly, Facies A are dwell dominantly by sandstone, claystone and breccia. For the lithology, the sandstone grain size are fine to very. And some of the part of it, indicates siliceous characteristic. The sandstone commonly discovered into well bedded, the outcrop can show if Figure 5.13 below. Next, the claystone are among lithology that found in the study area. Generally, the claystone are found in lamination structure, rarely in well bed layer. In addition, the claystone that discovered tend to have cleavage. Lastly in Facies A are the breccia. The outcrop of breccia can be seen in Figure 5.14 below. The breccia is matric supported, which is sandstone. While the fragment are from andesite from Nglanggeran formation.

Figure 5.13 Well bedded sandstone in Facies A

Figure 5.14 Breccia, matrix-supported. The matrix are sandstone and the fragment are andersite material from Nglanggeran formation.

Sedimentary structure that available on Facies A are horizontal planar lamination. Commonly discovered on claystone outcrop. For the sandstone, mostly formed in well bedded. From various thickness, thin to massive bed. Meanwhile for the breccia, located a spot where near to the boundary of Sambipitu and Nglanggeran formation. From the aspect of fossil presence, discovered that in Lower part of Facies A trace fossil of bioturbation and microfossil. Thin section analysis are provided below in Figure 5.15. From the thin section, the microfossil can be identified, from the family of Foraminifera, *Globuquadrina spp.* Besides that, glauconite mineral where it indicates the marine deposition.



PPL XPL

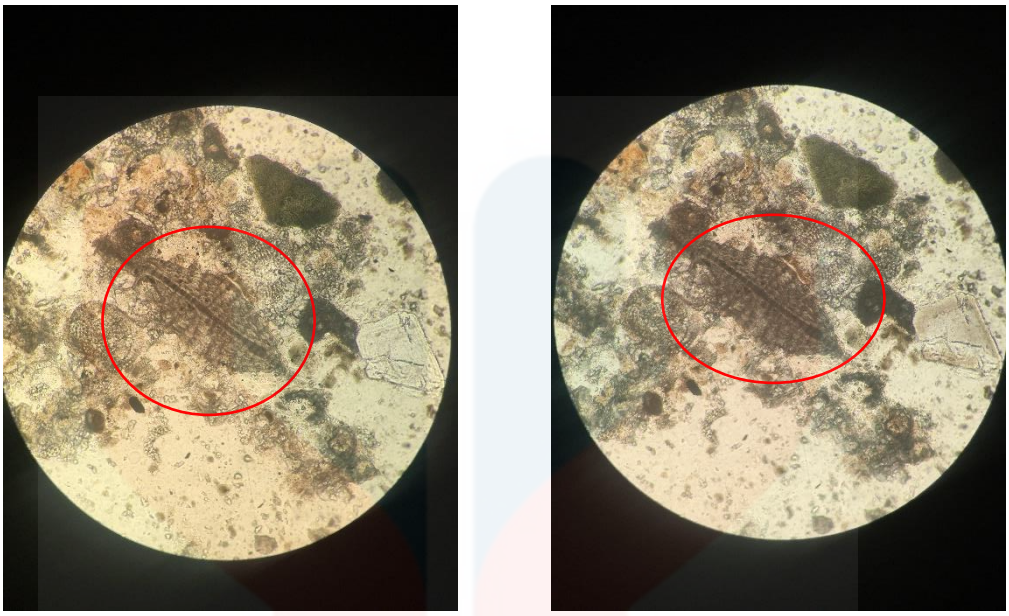
Figure 5.15 Thin section of sandstone. In red circle are microfossil Foraminifera, Globuquadrina spp. In the yellow circle, are plagioclase minerals.

Next, Facies B, where the study pick from the middle of the Sambipitu formation. Facies B contain argillite sandstone, pebbly sandstone, claystone and calcareous sandstone. The argillite sandstone discovered in well bed with in the

between is claystone that in lamination. Here, the found out that the sandstone has adding element, which is carbonate. Hence, the sandstone called calcareous sandstone due to the carbonate element. The hand specimen for the calcareous sandstone can be seen in Figure 5.16. Claystone are found in horizontal planar lamination. Sometimes, it form a bed with the claystone are in lamination.

Figure 5.16 Hand specimen of calcerous sandstone.

To adding the proof on about the calcareous element, thin section analysis had been done (Figure 5.17). The presence of microfossil, in abundancy, signify the study about the influences of the carbonate element. In addition, the study found glauconite mineral that commonly found in marine deposit.



PPL XPL

Figure 5.17 Thin section photo on PPL and XPL. In the red circle, the presence of microfossil of Foraminifera, *Globuquadrina spp.*

In addition, the bioturbation also detected on the facies. The bioturbation are burrow. And the size of burrow are various form medium to small burrow. The picture of calcareous sandstone hand specimen and outcrop bioturbation can be seen in Figure 5.18 and 5.19 below.

Figure 5.18 Bioturbation, burrow on calcareous sandstone.

Figure 5.19 Hand specimen calcareous sandstone with burrow on it.

Lastly is the Facies C. Facies C is from the Upper part of Sambipitu. Facies C mainly dominate by calcareous sandstone, claystone and pebbly sandstone. So, the calcareous sandstone are argillite in grain size. Within it, the calcareous element might more concentrated due to the degree of react with HCl test. Meanwhile, the claystone are usual in lamination. But some part are mixed with the sandstone. For the pebbly sandstone, it are matrix-supported conglomerate. With the fragment are from the claystone, limestone and carbon. For the matrix are argillite sandstone. The sedimentary structure that can be found in the study are horizontal planar lamination, generally on the claystone. While for the calcareous sandstone were formed in well bedded, from thin to thick and the pebbly sandstone also in well bed form. Furthermore, the Facies C have abundant of trace fossil and microfossil. The picture of outcrop with trace fossil and thin section are shown in Figure 5.20 and 5.21 below.

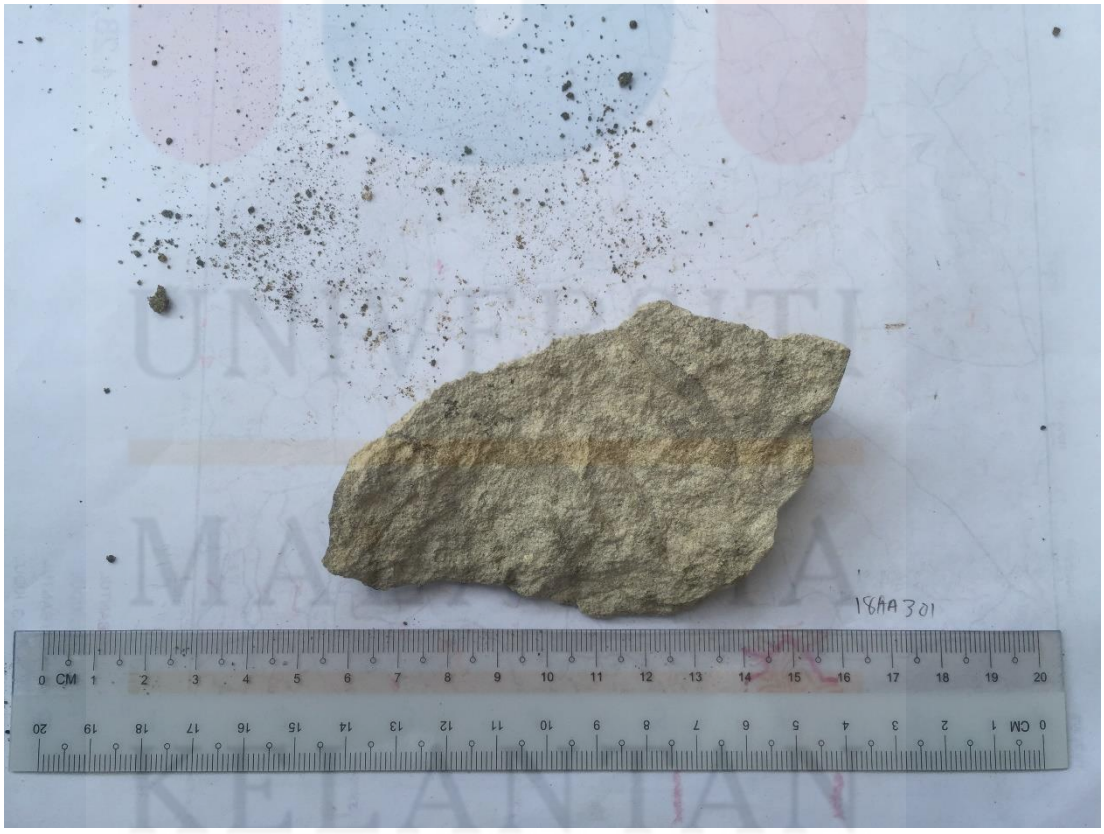
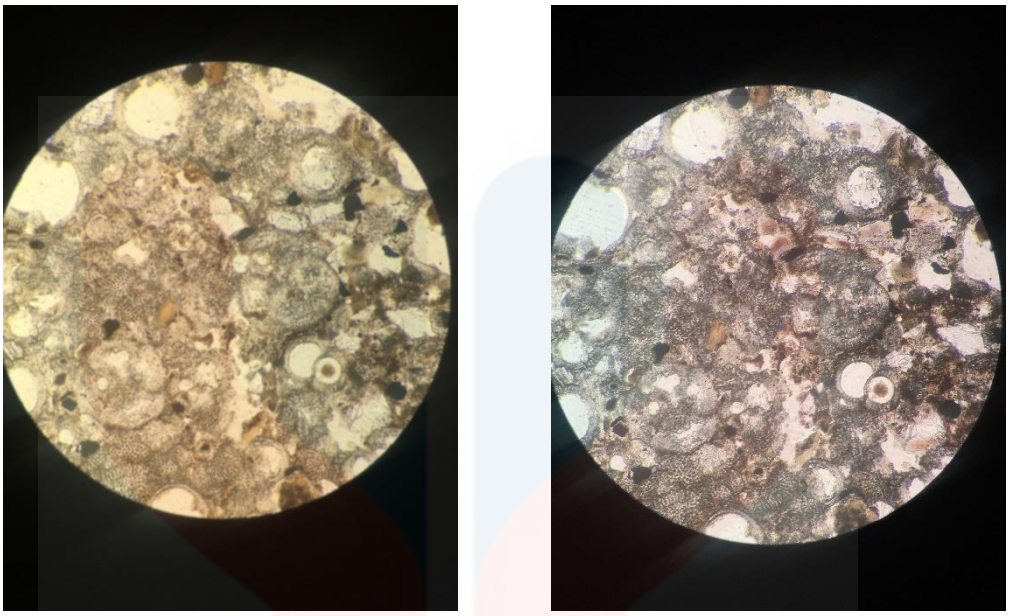


Figure 5.20 Calcareous sandstone with bioturbation, medium size burrow.



PPL XPL

Figure 5.21 Thin section of calcareous sandstone, microfossil of Foraminifera, *Globuquadrina spp.* in the like ring shape. Also in the photo are present of insertion of sparite and micrite minerals

In addition, the research also discovered a very thick bed of claystone and sandstone. And below of it lie bed of pebbly sandstone. Below, the study provided photo of the massive bed of claystone and sandstone outcrop and the pebbly sandstone hand specimen (Figure 5.22 and Figure 5.23).

Figure 5.22 Thick bed of claystone and sandstone, which is interlayering to each other.

Figure 5.23 Hand specimen of pebbly sandstone with the limestone fragment.

From the facies analysis, the Sambipitu reveal some distinct characteristic about it depositional environment. Among it are the glauuconite mineral, microfssil of Forminifera and biturbation. In addition, the lamination of the claystone provide some perspective of the depositional environment. As well as the thickness of the sandstone bed.

5.5 Fossil Presence

In the study area discovered that the Lower part of Sambipitu are presence of fossil. But only in low number. Furthermore, on the Upper part are abundant of fossil, especially the microfossil. The trace fossil are among the main discovery in the study area. But they are bioturbation, which is a burrow. The burrow are from various size, where indicate the depth of the burrow habitat. The microfossil that discovered are from the Foraminifera family. The microfossil have been identified under microscopic observation for general recognition. And the closes possible are from the *Globuquardina spp*. This also stated by Harman Dwi R. *et al* (2018) for the microfossil present. Furthermore, most of the thin section observation, identified the fossil were already alter with micrite and sparrite mineral. The example of thin section analysis are below in Figure 5.24. In addition, the study also discovered a fragment of unknown macrofossil on the pebbly sandstone. The photo of hand specimen are below, Figure 5.25.

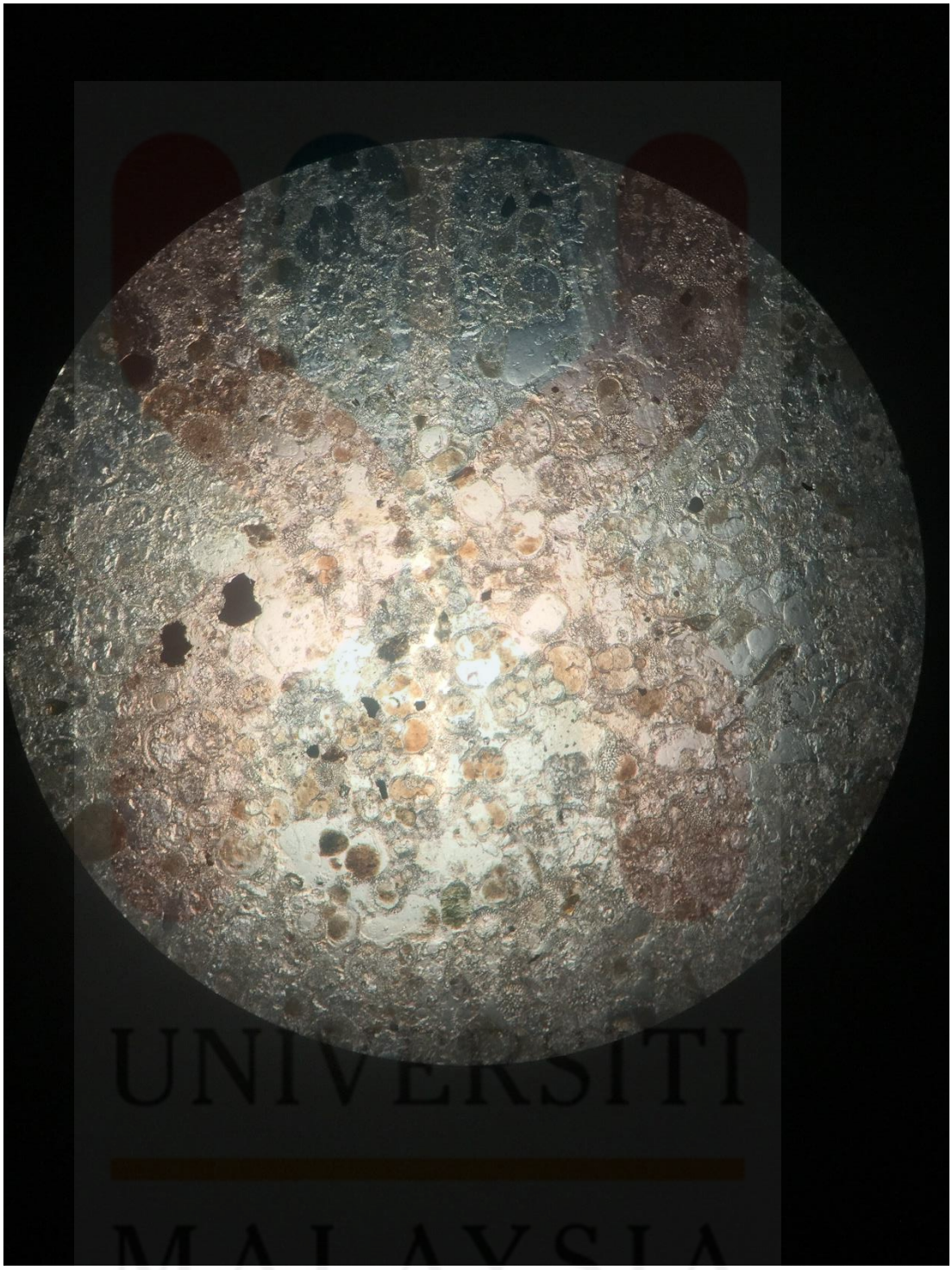


Figure 5.24 Microfossil, believe to be *Globuquadrina spp.* Sparrite and micrite already change the origin carbonate mineral, thus, difficult to identified the microfossil. The thin section under PPL. The cloudy are sparrite mineral and the cavity of fossil are infill with micrite mineral.

Figure 5.25 Unidentified macrofossil fragment (in red circle) on pebbly sandstone.

5.6 Determination of Depositional Environment

From the analysis of lithology column, facies analysis and fossil presence, the depositional environment of Sambipitu formation are shallow marine to the shelf or

slope with the alternating energy lever. In addition, the factor of progression and transgression of the sea tide influence the deep. In fact, the Sambipitu might be the transitional deposit between the volcanism activities and the development of carbonate platform.

Firstly, the thickness of the sandstone indicate the depth of the depositional environment. As the bed of sandstone are thicker, the deeper the depth of the marine. In addition, the sandstone itself indicate the high energy level, due to the density of the sand itself, required high energy to deposit.

Next, the lamination of claystone in Sambipitu formation suggest that the depositional environment are shallow and low energy environment. This contrary with the sandstone deposit, where sandstone deposit are thick bed and high energy environment. Therefore, there was changes in the energy level and the depth of the environment. Thus, suggest that there were progression and transgression occurred during the deposition.

To prove that the non-marine or marine deposit, the data collected indicate that Sambipitu formation were deposited on marine environment. In supporting, the presence of marine microfossil like Foraminifera family, *Globuquadrina spp.*, in addition with the abundancy of bioturbation along the Sambipitu formation.

Furthermore, the size of burrow are decreasing as the research study from the Lower part to Upper part Sambipitu. This suggest that the Upper part deposited into deep marine while for the Lower part on the shallow marine. In fact, the calcareous element increasing in concentration when test with HCl solution. This suggest that the Upper part Sambipitu were influence by the developed carbonate platform in the Late Miocene.

At the Upper part of Sambipitu, the massive claystone also significantly related to deep marine. Where the deposition of clay sediment in the low energy environment. the model of the formation of Sambipitu can be illustrated in Figure 5.26 and Figure 5.27 below, where the research believe that Lower and Upper part of Sambipitu were deposited in different time.

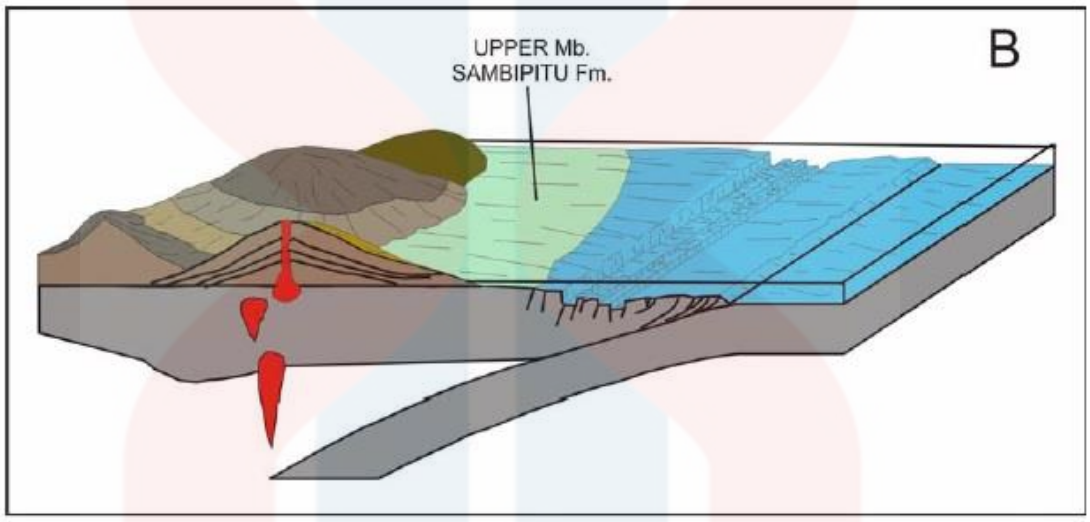


Figure 5.26 Show that the formation of Lower part of Sambipitu formation at the early stages

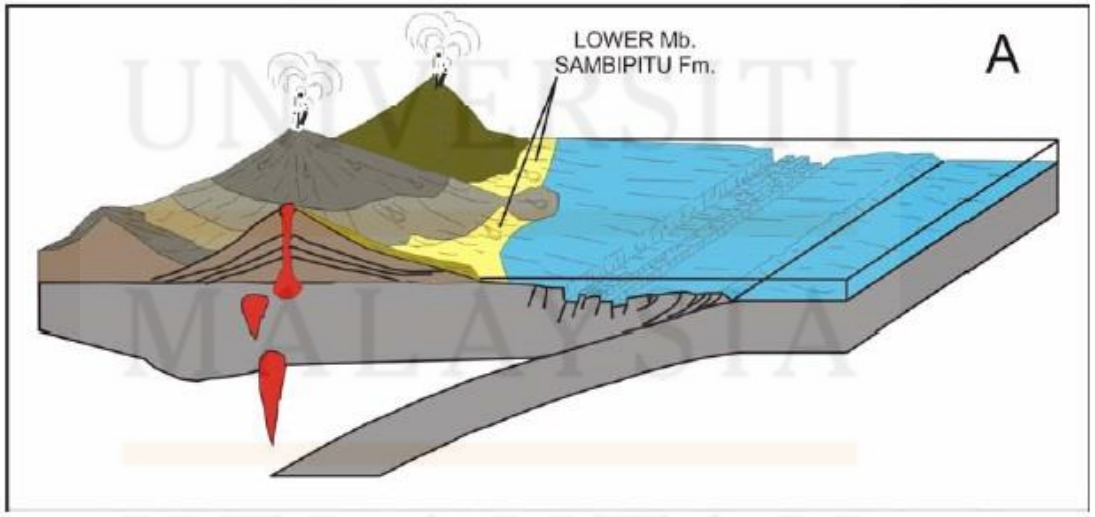


Figure 5.27 Shows that the formation Upper part of Sambipitu in other different time. And believe that this the time the Sambipitu formation get it calcacerous charateristic

CHAPTER 6

CONCLUSION & RECOMMENDATION

6.1 Conclusion

The research objective are to provide a new geological map and to determine the depositional environment of Sambipitu formation. This chapter will conclude the research objectibe and the result from the study.

Firstly, the objective of providing the new geological map are archieve. By using the Arcgis software, the research provide a new geological map, which is consist new details of geology feature. In addition, the map produce are in scale 1:25000.

Further, the depositional environment of Sambipitu are determine. The determination of the depositional environment are crucial to make more understandable, thus, in future the potential of geology Sambipitu can be clarified. Besides that, the information about depositional environment make the future research comprehend the geology feature relate to the depositional environment.

From the geological mapping, the finding was the boundary of Nglanggeran with Sambipitu formation and Sambipitu and Oyo formation. Boundary Nglanggeran and Sambipitu formation are graditionally and interfingering to each other. This suggest that different mechanism of deposit. Secondly, the boundary between Sambipitu and Oyo formation, which gradual. This indicates by the calcareous sandstone and the degree of the reaction towards HCl test.

For depositional environment, the study find that the environment are in marine with indicator of fossil, sedimentary structure and carbonate material. From the study also, the study know that the Sambipitu formation are deposit in marine environment with adding factor of progression and transgression. This conclude from the data collected and interpretation.

6.2 Recommendation

In this study, there are aspect that the study impossible to cover. So, those aspect will be recommend in this subtopic. Firstly, the research suggest to make a study on geochemistry on the calcareous sandstone Sambipitu and Oyo formation. It believe by studying the geochemistry of those 2 formation will reveal the distinct characteristic that differentiate both formation.

Second recommendation are the study of rock fall hazard in the Nglanggeran formation. The reason is the Nglanggeran formation are compose of breccia andesite that tend to weather into cobble to boulder size. As the settle are built on and aside of cliff, lose breccia expose villager to the hazard of rock fall.

Lastly, the research recommend the study of paleocurrent of Sambipitu formation. This will help better understanding of the deposition of Sambipitu. In addition, to understand the paleocurrent in ancient time and relation with the structure reveal.

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APPENDIX A

Lithology Log