# GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF SAMBIPITU FORMATION IN PENGKOK AREA, GUNUNG KIDUL, YOGYAKARTA, INDONESIA

by

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## DECLARATION

I declare that this thesis entitle "Geology and Depositional Environment of Sambipitu Formation in Pengkok Area, Gunung Kidul. Yogyakarta, Indonesia" 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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**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 Honours"

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Date : _____

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**GEOLOGY AND DEPOSITIONAL ENVIRONMENT OF SAMBIPITU FORMATION IN PENGKOK AREA, GUNUNG KIDUL, YOGYAKARTA, INDONESIA.**

## ABSTRACT

Yogyakarta situated in Central Java and located only 30km from the Merapi volcano area. The study area was located at Pengkok area, Gunung Kidul, Yogaykarta, Indonesia with coordinate between longitude 110°28'14.90"E to 110°30'58.05"E and 7°52'0.42"S to 7°54'43.28"S latitude. The geology, lithology unit, sedimentary facies need to update for details information in Pengkok area specially in determined their depositional environment. The objective of the study were to update a geological map with the scale of 1:25,000, to analyse the sedimentary facies in study area and to determine the depositional environemt of Sambipitu Formation. The methodes that be used in this study were lithostratigraphic column and foraminifera analysis. At the upper part of the study covered with pyroclastic breccia, epiclastic breccia, lava, epiclastic breccia sandstone, sandstone and mudstone, mudstone, carbonaceous sandstone. The tuffaceous limestone, wackestone, packstone, grainstone, rudstone and oncolites can be found at lower part study area. Previous stratigraphic measurement data and analysis show the Sambipitu Formation was fluctuation of seawater level. There were three facies analysis which were lower, middle and upper of Sambipitu Formation. The depositional enviornment of Sambipitu Formation in study area was outer neritic to upper bathyal.

**Keywords** – Depositional environment, Sambipitu Formation, Sedimentary facies, lithostratigraphy, Outer neritic to upper bathyal.

**GEOLOGI DAN PEMENDAPAN PERSEKITARAN FORMASI SAMBIPITU DI KAWASAN PENGKOK, GUNUNG KIDUL, INDONESIA.**

## ABSTRAK

Yogyakarta terletak di Jawa Tengah di mana hanya 30 km dari Gunung Api Merapi. Kawasan kajian terletak di kawasan Pengkok, Gunung Kidul, Yogyakarta, Indonesia dengan koordinat longitude 110°28'14.90"E to 110°30'58.05"E and 7°52'0.42"S to 7°54'43.28"S latitude. Geologi, lithologi dan sediment fasies perlu di kemas kini untuk maklumat yang details di kawasan Pengkok terutamanya pemendapan persekitaran. Objectif kajian ini adalah untuk mengemaskini peta geologi kawasan kajian dengan skala 1:25,000, untuk menganalisis fasis endapan di kawasan kajian dan untuk menentukan pemendapan persekitaran di Formasi Sambipitu. Kaedah yang digunakan adalah lihtosratigrafi dan analisis foraminifera. Dari segi komposisi taburan batuan, pryoclastic breccia, epiclastic breccia, lava, epiclastic breccia batuan pasir, batuan pasir dan tanah liat, batuan tanah liat dan batuan karbonat pasir yang terdapat di bahagian atas kawan kajian. Batu tufa kapur, wackestone, packstone, grainstone, rudstone dan oncolites boleh di dapati di bahagian bawah kawasan kajian. Berdasarkan hasil pengukuran dan analisis kajian lepas, Formasi Sambipitu menunjukkan fluktuasi naik dan turun muka air laut. Terdapat tiga jenis analisis fasies iaitu bawah, tengah dan atas Formasi Sambipitu. Pemendapan persekitaran Formasi Sambipitu di kawasan kajian ialah neritik luar hingga ke bathyal atas

**Kata kunci:** Pemendapan Persekitara, Formasi Sambipitu, Fassis batu sediment, lihtostratigrafi, neritik luar ke bathyal atas.

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| | |
|---|---|
| Cb | Carbonate mineral |
| Chl | Chlorite |
| Cm | Centimeter |
| Cpx | Clinopyroxene |
| E | East |
| Freq | Frequency |
| Fsp | Feldspar |
| GIS | Geographic Information System |
| Glas | Volcanic glass |
| Gm | Ground mass |
| Km | Kilometer |
| km2 | Kilometer per square |
| M | Metre |
| mm | Milimetre |
| N | North |
| Ol | Olivine |
| Opx | Orthopyroxene |
| Pl | Plagioclase |
| PPL | Plane Polarized Light |
| Qtz | Quartz |
| S | South |
| XPL | Cross Polarized Light |

## LIST OF SYMBOLS

| | |
|---|---|
| % | Percentage |
| = | Equals |
| º | Degree |
| ºC | Degree Celcius |
| σ1 | Maximum Principle Stress |
| σ3 | Minimum Principle Stress |

# CHAPTER 1

# INTRODUCTION

## 1.1 General Background

Geological map was defined as the specially made map that was done for the purposed of showing the features of geological that been present in study area. Lisle (2004) also stated that this map can show many features of geological that been present in study area which help for the future used. The completed geological map should had the map study area, title of the map, legend, scale, stratigraphy of study area, cross section, declination diagram on the centre of the sheet, grid, scale bar and north arrow. The geological features can be shown by this map includes structural geology, lithology boundaries, the formation boundaries and many more. These lithology boundaries and formation boundaries were shown by varieties of colour. The examples were the igneous rock that been show in red colour while sedimentary rock was been show in yellow colour. Next, the geological structure include fold and faults will show by strike and dip. The contour that contain in geological map was show the morphology or landform of the study area. Some of the first interpretation of rock can be analysis by the contour. Therefore, it was required to produce the details of geological map with scale 1:25.000 for further researcher.

There are 4 methods that been conducted along the research includes geological mapping, measuring section, petrography analysis and palaeontology analysis. These methods help for determined the depositional environment of Sambipitu formation in study area. Depositional environment was the placed that accumulation of sediment material happened which had physical, chemical and physical conditions where it had their special characteristic of deposition site. Based on Boggs (2006) depositional environment was a characteristic of a geomorphic order where these physical, chemical and biological processes take place where produce a certain type of sedimentary deposit. Nichols, (2009) said that the process that been meant was the process that took place during the forming process, transportation and sediment deposition.

Physical differences can be either static or dynamic elements. Static element includes basin geometry, sediment material, water depth and temperature. The dynamic elements are energy, sedimentation speed and direction as well as variation in wind, waves and water. Next for chemical were compositions of solution from sediment, geochemistry of rock origin in accumulation area. It involves oxidation, reduction, salinity and mineral solutions. Biological was about fauna and flora where sediments were deposited as well as areas along the way before being deposited. These aspect were given effect on depositional environment.

Earth surface had great morphology started from mountain, valley, flat area, deserts, and deltas to the sea. With these division analogy, depositional environment can be divide into 3 major category such as continental (land), marginal marine (transition) and marine environment (sea). There were many researcher that divide the depositional environment based on their vision. Based on Selley (1998) the depositional environment were divide into 3 major category such as terrestrial, marginal marine and sea. However, there were a few researcher divide the depositional environment into more details. Interpretation of depositional environment will not accurate if it just consider only one physical aspect from rock. Therefore, to determine the depositional environment must consider sedimentary structure, grain size, fossil contain, mineral composition and geometry of distribution rock.

Facies was one of the importance aspect for learn sedimentology. Boggs (2006) stated that in studying depositional environments it was very important to understand and clearly distinguish between sedimentation environments and facies environments. Sedimentation environment characterized by physical, chemical and biological properties that specifically operate to produce rock bodies characterized by specific textures, structures and compositions. Whereas facies refers to stratigraphic units that were distinguished by lithology, structure and organic characteristics detected in the field. The facies word was defined differently by many writers. However they generally agree that facies were characteristic that relate with sedimentary rock units. These characteristics can be in the form of physical, chemical characteristics and biology such as sediment body size, sedimentary structure, size and grain shape, colour and biological content of sedimentary rocks.

For example, cross-bedding. Based on characteristic of physical, chemical and biological the depositional environment, it can be construct where environment of sedimentary rock was deposited. This reconstruction process was dedicated facies analysis.

## 1.2 Study area

### 1.2.1 Location

Yogyakarta was a city centre that located in a flat area where near at slope of Merapi Volcano. The city and province of geology had been control by active plate of tectonic phenomena likes active subduction of Indo-Australia oceanic plate where below the Euro-Asian continental plate and also active volcano. Yogyakarta was exposed by the natural disaster and geohazard such as volcanic eruption, landslides and earthquakes.

One of the regencies in Yogyakarta was Gunung Kidul Regency. Gunung Kidul Regency was divided into 18 districts and the study area was focused in Pengkok district. Based on Ujariyadi (2016), Pengkok district basically a part of geopark as Yogyakarta was known as North Zone that call Batur Agung region with an elevation of 200 m to 700m above sea level historically and culturally part of the Central Java.

The study area was located at Pengkok, Gunung Kidul, Yogyakarta, Indonesia. The study area lies between longitude 110°28'14.90"E - 110°30'58.05"E and 7°52'0.42"S - 7°54'43.28"S latitude which it can been saw in Figure 1.1. The study area was 5 km × 5 km. There are 3 main rivers that can be found which were Oyo River, Saradan River and Pentung River. There were many facilities that been provide in study area such as clinic, mosque and schools. The location of study area in the central part of Southern Mountains along the southern part of Jawa Island. Study area also was easily reachable by vehicle and almost 23 km from the Yogyakarta city. There were many geological interest that been present in Pengkok, Yogyakarta city.

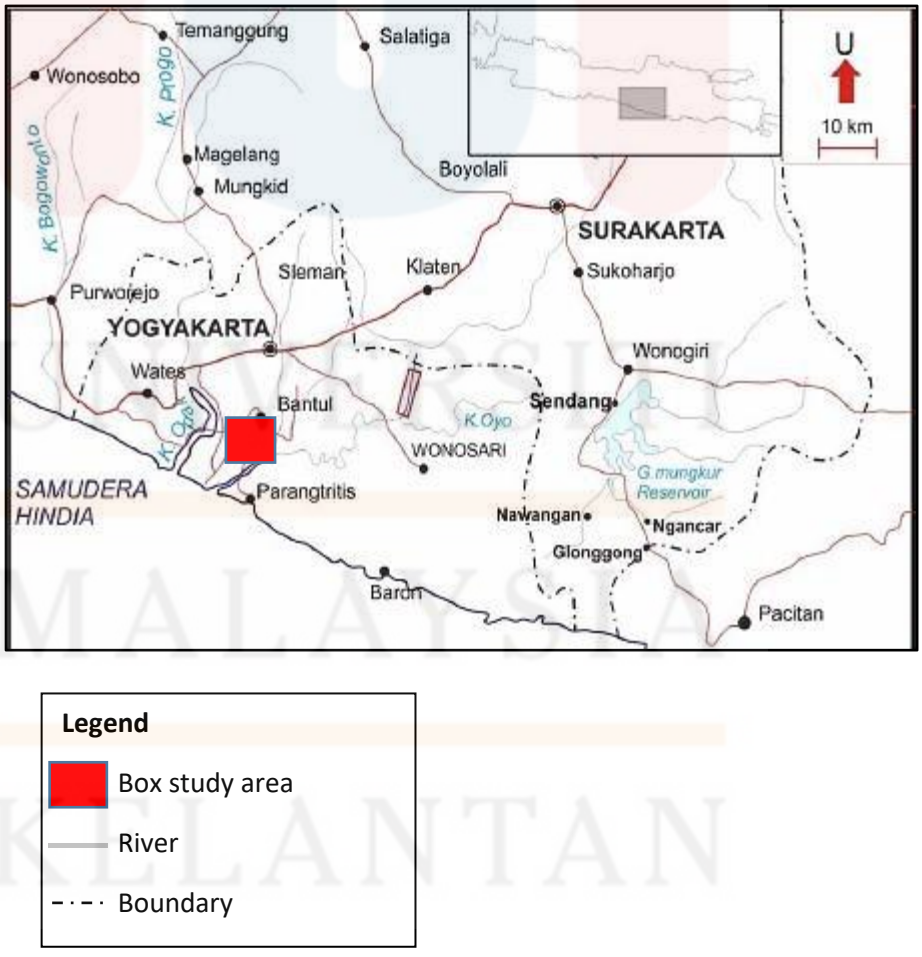



**Figure 1.1:** Location of study area (Surono & Permana, 2009).

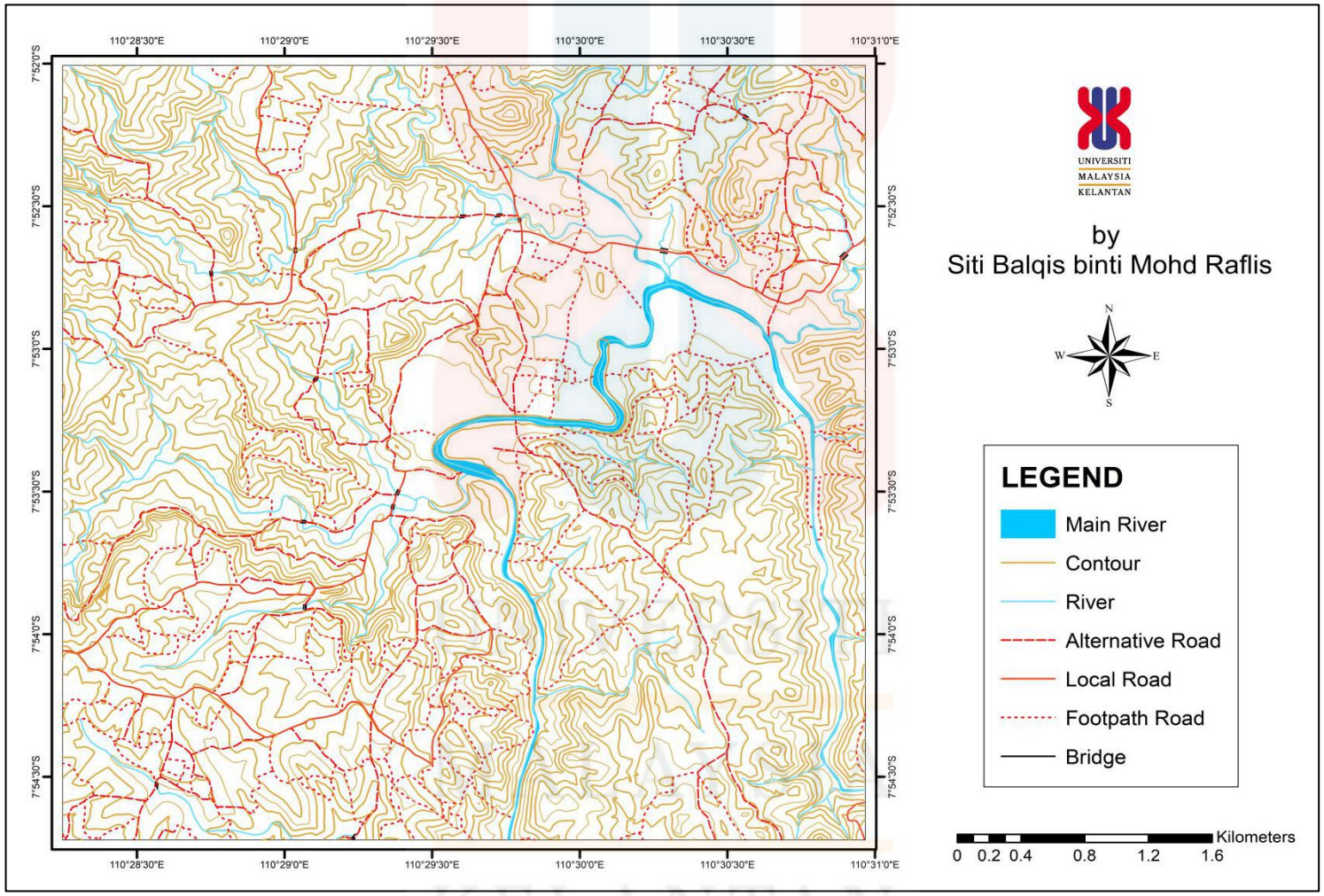



**Figure 1.2:** Base Map of study area

### 1.2.2 Road connection/ accessibility

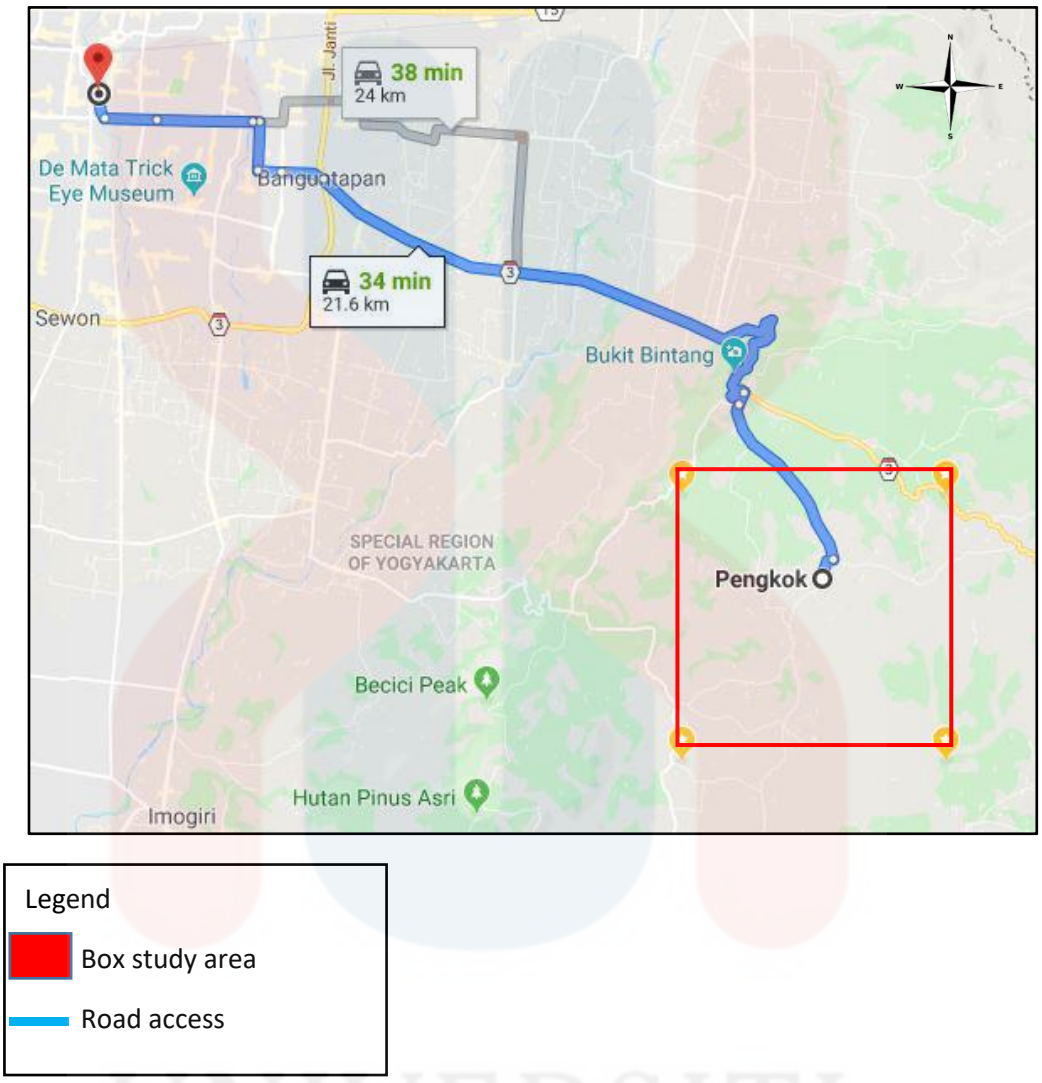



**Figure 1.3**: Accessibility of Pengkok area (Source: Google map)

Based on the Figure 1.3, Pengkok district was a rural area which locate quite far from the Yogyakarta city. The total distance of Pengkok area to the city of Yogyakarta was around 22-24 kilometres which it took about half hour. There was a no train available from Yogyakarta to Pengkok area. However, there is public transportation such as Uber and Grab car application that been available in Yogyakarta city to the study area.

The main connection system in this study area was by the road. The road became main contribution for people in Pengkok area to access other destination. There was one main road that majority the local people was used which was the connection road Yogyakarta- Wonosari.

### 1.2.3 Demography

Population growth was defined as the changes of people over the time. Natural population growth was influenced by three factors which were birth, death and population migration. The decline in population growth that occurs in Gunung Kidul Regency especially Pengkok district was more affected by out migration.

Pengkok was one of the district in Gunung Kidul Regency with the moderate population. Based on the Table 1.1, the total population were 34, 493. The total population for male was 16,574 while total population for female was 17,739.

**Table 1.1:** Total Population by district and gender in 2012

| Nama Desa *Villages* | | Laki-laki *Male* | Perempuan *Female* | Jumlah *Total* |
|---|---|---|---|---|
| (1) | | (2) | (3) | (4) |
| 1. Semoya | | 1 283 | 1 775 | 3 058 |
| 2. Pengkok | | 1 534 | 1 566 | 3 100 |
| 3. Beji | | 1 358 | 1 442 | 2 800 |
| 4. Bunder | | 1 622 | 1 661 | 3 283 |
| 5. Nglegi | | 1 575 | 1 646 | 3 221 |
| 6. Putat | | 2 006 | 2 003 | 4 009 |
| 7. Salam | | 1 594 | 1 647 | 3 241 |
| 8. Patuk | | 1 288 | 1 416 | 2 704 |
| 9. Ngoro-oro | | 1 825 | 1 906 | 3 731 |
| 10. Nglanggeran | | 1 320 | 1 295 | 2 615 |
| 11. Terbah | | 1 349 | 1 382 | 2 731 |
| Jumlah *Total* | 2012 | 16 754 | 17 739 | 34 493 |
| | 2011 | 16 813 | 17 821 | 34 634 |

(Source: Badan Pusat Statistik, 2012)

### 1.2.4 Land use

As the Indonesia had very interesting geological process, this country had been famous for natural resources. Mostly Indonesian depend on food production in Java Island because it had highly fertile soil. This was because, the Indonesia had many active volcano which indirectly made the soil fertile. Therefore, mostly land use in Java Island especially Pengkok district was agriculture land and farm. The Pengkok was a tropical climate where the area topography was variety from the flat area to the mountain area which made it suitable for multipurpose land use.

Based on the table 1.2, the total land use was 458 square kilometres. The table show the size area which is the main land used that present in Pengkok district. The land use can be categorized by wetland, dryland, building and others. The pattern of land ownership was dominated by the ground the village treasury. The non-agriculture area was 206,8 km. Majority of land used for agriculture which was 251,2 km² for wetland and dryland.

**Table 1.2:** The main land use based on district in Gunung Kidul Regency

| Nama Desa *Villages* | Tanah Sawah *Wetland* | Tanah Kering *Dryland* | Bangu-nan *Building* | Hutan Rakyat *Public Forest* | Hutan Negara *Country Forest* | Lainnya *Others* | Jumlah */Total* |
|---|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| 1. Semoya | 80,8 | 333,0 | 129,1 | 1,0 | 0,0 | 32,8 | 576,7 |
| 2. Pengkok | 124,6 | 126,6 | 170,5 | 0,0 | 0,0 | 36,3 | 458,0 |
| 3. Beji | 38,8 | 208,3 | 186,9 | 0,0 | 540,0 | 36,8 | 1 010,8 |
| 4. Bunder | 72,6 | 162,8 | 157,7 | 0,0 | 150,0 | 48,7 | 591,8 |
| 5. Nglegi | 194,1 | 372,4 | 235,4 | 0,0 | 0,0 | 128,9 | 930,8 |
| 6. Putat | 123,7 | 248,7 | 314,7 | 0,0 | 0,0 | 29,7 | 716,8 |
| 7. Salam | 57,2 | 268,2 | 181,3 | 0,0 | 0,0 | 14,3 | 521,0 |
| 8. Patuk | 17,2 | 119,2 | 132,9 | 0,0 | 0,0 | 21,7 | 291,0 |
| 9. Ngoro-oro | 198,2 | 302,6 | 192,7 | 0,0 | 0,0 | 60,3 | 753,8 |
| 10. Nglanggeran | 72,1 | 351,2 | 288,7 | 0,0 | 0,0 | 50,8 | 762,8 |
| 11. Terbah | 181,7 | 230,3 | 132,1 | 0,0 | 0,0 | 45,7 | 589,8 |
| Jumlah 2012 | 1 161,0 | 2 723,3 | 2 122,0 | 1,0 | 690,0 | 506,0 | 7 203,3 |
| *Total* 2011 | 1 079,1 | 3 497,2 | 1 526,0 | 1,0 | 690,0 | 410,0 | 7 203,3 |

(Source: Badan Pusat Statistik, 2012)

### 1.2.5 Social economic

Despite the poverty level in southern region of Yogyakarta where the Java Island was quite higher, but the effort to alleviate the poverty was shown in positive achievement. In the period of 2013 until 2017, the number and percentage of poor people in the region was decreasing even thought the poverty line had always increased.

In the past four years, the number of poor people had decreased from 21,70 thousand. In addition, the percentage of poor people also succeeded in being reduced to 18.65 percentage in year 2017. Based on the table 1.3, Gunung Kidul in 2015 was held by highest level of poor people. However, over the time, Gunung Kidul slowly reduce the percentage of poor people. Gunung Kidul recorded a significant achievement in terms of poverty. During 2013 until 2017, Gunung Kidul was succeeded reduce poverty percentage from 21.7 percent to 18.65 percent.

**Table 1.3:** The percentage of poor people in Yogyakarta, 2013-2017

**Tabel 10. Persentase Penduduk Miskin Menurut Kabupaten/Kota di D.I. Yogyakarta, 2013 – 2017**

| Kabupaten/Kota | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|
| Kulon Progo | 21,39 | 20,64 | 21,40 | 20,30 | 20,03 |
| Bantul | 16,48 | 15,89 | 16,33 | 14,55 | 14,07 |
| Gunungkidul | 21,70 | 20,83 | 21,73 | 19,34 | 18,65 |
| Sleman | 9,68 | 9,50 | 9,46 | 8,21 | 8,13 |
| Kota Yogyakarta | 8,82 | 8,67 | 8,75 | 7,70 | 7,64 |

(Source: Badan Pusat Statistik, 2017)

The reducing in percentage of poor people because there were many opportunity job toward tourism. As the Gunung Kidul was a famous geopark in Yogyakarta, the economy in this area was more to travel and tourism. The more tourism, it was help to increase investment in Gunung Kidul where at the same time it was also increasing social economy in this area. This activities of tourism drive other relevant sector such as business.

The social pattern and cultural life in the community of Gunung Kidul was influence by the region. Socio-cultural element was one of the main instruments in the development, it was related to the planning, the target, and the target achievement of development performance. The community in Gunung Kidul Regency especially Pengkok area, the traditional society was still follow the noble cultural heritage as the everyday life. To carry out the development, the government needed to adopt the social culture characteristic. This development was help to improve the community cultural The language that been used by Gunung Kidul Regency society was general local language which Jawa and the national language like Indonesia language was official used in formal environment. The example of formal environment includes education or work. 10 cultural villages were been develop with the support by government for welfare society.

## 1.3 Problem statement

Various studies had being conduct in Yogyakarta as it was full with history. However, there was limited in research conduct regarding geology and depositional environment at Pengkok district as it was located in Gunung Kidul Regency which is known as historically and culturally part of the Central Java. This was because, previous research about the depositional environment of Sambipitu Formation was more focusing at Ngalang river.

As for general geology in Pengkok, Yogyakarta Indonesia was a region that active plate tectonic and exposed to natural phenomena like active volcano. Therefore it was changed the landscape, rock unit and geological map of study area. Besides that, the smaller scale of the geological map of Gunung Kidul was limited which lead to inaccurate of formation in study area.

## 1.4 Objectives

The objective of this research were:

1) To update the geological map of Pengkok area with scale of 1:25,000

2) To analyse the sedimentary facies in Pengkok area.

2) To determine the depositional environment of Sambipitu Formation in study area.

## 1.5 Scope of the study

This final year project will focus on study of deposition environment of Sambipitu Environment in Pengkok area, Gunung Kidul. The aspects that will consider were lithology, sedimentology, petrography, stratigraphy, geomorphology and structural geology element that will found on field. Besides that, geological data found on field such as sedimentology structures was been record and interpret to relate with the depositional environment in the study area.

The Geographical Information System (GIS) was used to produce the base map and the traverse map. Coral Draw was used to produce the stratigraphic section with the symbol of sedimentary structure in study area.

## 1.6 Significant of the study

Geological mapping of the study area give the geological features and this geological mapping was been produced the map with the scale 1:25,000 which was more detail compare to the previous research and larger scale.

This study help future researcher gain information regarding the past environment of study area. Study depositional environment help in economy value as it was help in order to locate what the inside of the earth, deposition valuable of mineral and oil sources. It was attributes for sedimentary basin analysis to assess in potentiality for exploration and also for correlate the geological events, process and environment. The data or lithology that been done can been used to the

environmental researchers or government. By study the depositional environment, it can help to detect the possibility of geological hazards where the society can protect others life and made a brilliant decision for construction.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Introduction

The literature review was a part of body research. It was important as it shows the overview of final year project from many sources. The sources include the books, scholarly article, journals, internet and any sources relevant to particular issue. This literature review was help to further understand about the research paper.

## 2.2 Regional Geology and Tectonic Settings

Indonesia was formed by geological complex as it was located on active zones of tectonic setting. Indonesia was categorize by the two factors which results in the subduction process. The factors that been mention were volcanic activities and the intense of seismicity. According to Hall (2018), western Indonesia was triggered by the continental crust while eastern part of Indonesia triggered by the oceanic crust. This was because there were several young ocean and the presence of ophiolitic crust.

Indonesia had many formation form over the past 300 million years ago. This formation was built by the fragment that been rifted from Gondwana supercontinent that reach at Eurasian subduction margin. The structural geology of Indonesia that

been present today was effect from the collision at the margin and also the subduction of Cenozoic.

Based on Bemmelen (1949) stated that the shape of central part was much narrower then east and west of Java Island. The cross section was about 100-200 k. The study area was located in this area which central part of Southern Mountains. This was continued east-west from Parangtritis which was Yogyakarta to Baturetno Plain. This was formed by clastic and carbonate sediment and also volcanic rocks. In these area also consist few of famous mountains includes Gajahmungkur Mountain, Jiwo Hills which also called as Mount Sewu and Baturagung Mountains (Surono & Permana, 2009)

**2.3 Stratigraphy**

The volcano eruption and carbonate sedimentation were create the sequences of rock in the study area. The South Mountain was the mountain rock which been created by the igneous rock and clastic sediment. This mountain was form before the volcanism activities took place. The rock base was well exposed in the Jiwo Hills, south of Klaten. Later, the clastic sedimentary period took place right after volcanism activity slowly decreasing. Then, the deposition of clastic sediment was become slower and the deposition of carbonate mineral was started to growth. Therefore, this deposition of carbonate mineral was formed the unique karst which was Karst Topography of Seribu Hills.

The stratigraphy of the Southern Mountain were divided into three major periods which were the pre-volcanism, sync-volcanism and post –volcanism. The pre-volcanism was the period where before the volcanic activity started. Jiwo Group was overlay with Gamping Formation which was interfingering with Wungkal Formation. The Wungkal Formation was the oldest formation in this stratigraphy. There were different opinion on this depositional environment. However, the researcher was agree that the depositional environment for this period was marine environment.

Syn-vocanism was the volcanism period where the volcanism activity was at the peak. This volcanic activity left the thicker size of volcanic rock. The distribution of sedimentation in Southern Mountain started with Similir Formation which overlay deposited above Kebo-Butak Formation. The volcanic activities appear during Kebo-Butak Formation started more intense during the Semilir Formation. This Semilir Formation was been formed during the Early Miocene. The lithology of this formation were tuff, breccia pumice, tuffaceous sandstone and flakes (Ashari & Pandita, 2015). The peak of volcanic activities was during the Nglanggran Formation in range early Miocene to middle Miocene (Rahardjo, 1995). The lithology for this formation were polymic breccia, agglomerates, pyroclastic breccia and lava. The volcanic started to slow down deposit during middle Miocene which the deposition of Sambipitu Formation took placed.

The post-volcanism was the period that been known as carbonate period. This phase were included Sambipitu Formation, Oyo Formation, Punung Formation with interfingering with Wonosari Formation and Kepek Formation. Sambipitu Formation was the main focus as it was the specification formation in this final year project.

Based on the Figure 2.1, the Sambipitu Formation was divide into two which was lower and upper member. The lithology of Sambipitu Formation were dominated by sandstone, conglomerate, siltstone, shales and tuff. (Lauti *et al.,* 2007). The Lower part was dominated with volcanic while the Upper part was dominated with calcareous sediment. Firstly, the Lower Member of Sambipitu Formation was dominated with volcanic rock from Nglanggran Formation which had a thickness of 85 meters (Surono & Permana, 2009). The lithology of this part were grey, composed of sub-angular to sub-rounded andesite fragments of breccia and agglomerate. The grey, fine grain to coarse grain of sandstone and brownish grey to grey siltstone were the minor portion while the volcanic breccia was intercalate at the several beds.

Next, the upper member of Sambipitu Formation was dominated conglomerate, and the carbonate rock form Oyo Formation which had a thickness of 138 meters. The lithology of this part were sub-rounded to rounded, fining upward, and dominated by volcanic materials of conglomerate and also the white, wackstone type of limestone. This formation also contains many of trace fossils which was formed in the bottom of bathyal environment and develop into top of neritic (Pandita, 2008)

The environmental changes in the Southern Mountains basin was clearly can see with deposited of Oyo Formation at shallow sea. This formation was composed by sandstones, calcareous tuff and conglomerates with limestone fragment. The Oyo Formation was expected to form in the Late Miocene (Pandita *et al.,* 2009

The development of limestone was increasing apparent within the Wonosari Formation. The lithology for this formation was composed of layered limestone and reef limestone. The lower part of the Wonosari Formation was estimated to have an interfingering with the top of the Oyo Formation. The age of this formation was estimated to be the Late Miocene-Pliocene (Pandita *et al.,* 2009).

Upper part of Wonosari Formation was aligned with rock units form Kepek Formation. Lithological features include layered limestone. This formation was expected to form in the Pliocene. After Pliocene, the rock with tertiary aged that been located in Yogyakarta basin and also central depression of Java Island were been covered by deposited of young volcanic. These deposits were thought to have occurred since the Pleistocene until now

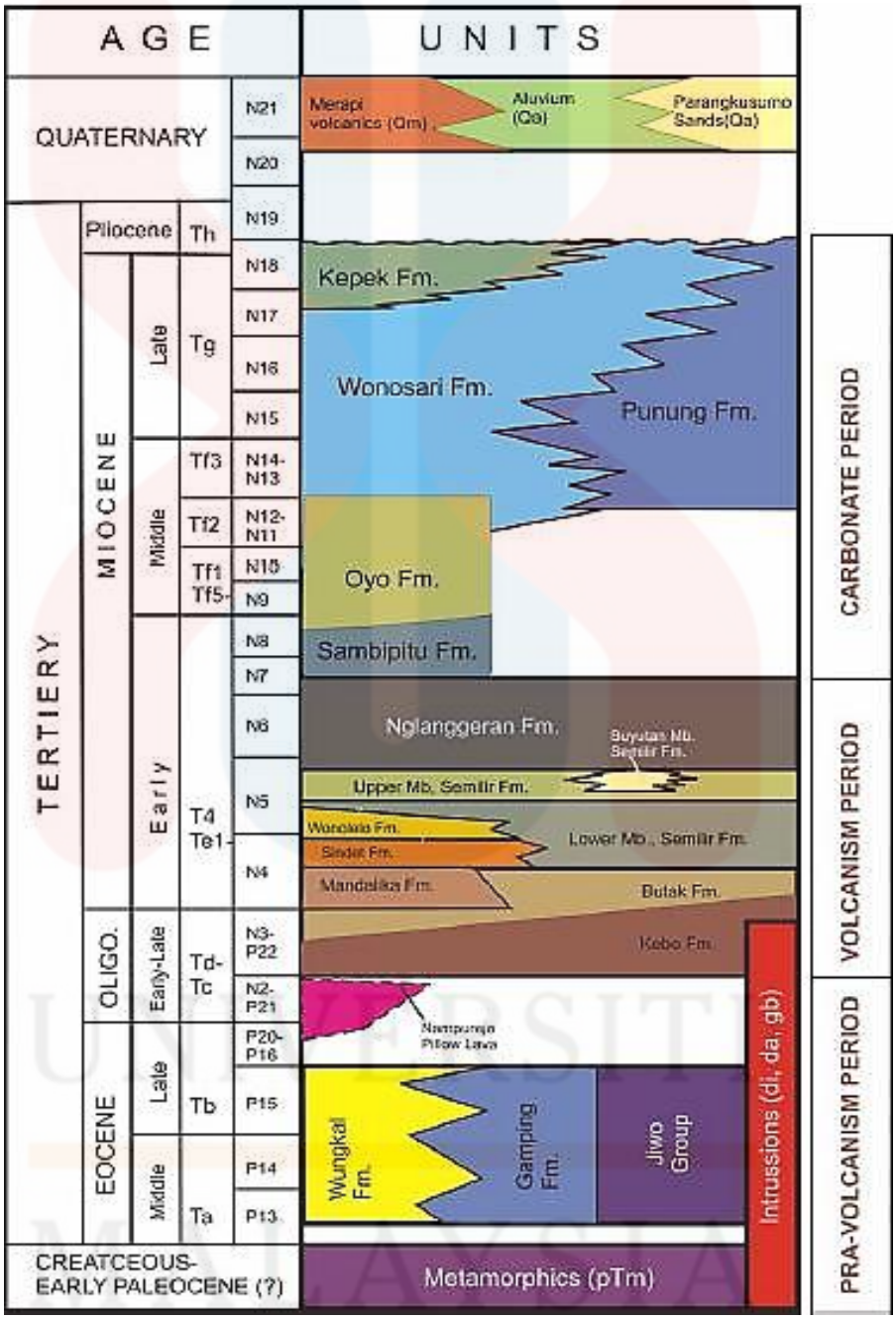



**Figure 2.1:** The stratigraphy of study area. (Surono & Permana, 2009)

## 2.4 Structural geology

Based on Prasetyadi *et al.,* (2011), the Java Island was built because of four direction major forces which were northest-southwest (Pola Meratus), north-south (Pola Sunda), east-west (Pola Java) and northwest-southeast (Pola Sumatra). The direction major force for the Southern Mountain where the study area was located from northeast-southwest and north-southeast (Samodra & Wiryosujono, 1993). Based on Surono *et al.,* (1992) stated that the geological structure that been found were joints, faulting and also folding. There are two types of folding that been found which were anticline and syncline. The direction of this folding from norhtest, southwest and eastwest. Semilir Formation, Kepek Formation, Oyo Formation and Wonosari-Punung Formation.

The fault can be categorized into three group based on the direction of force that been found in the Southern Mountain. There were form east- west, north-southeast and north-south direction (Prasetyadi *et al.,* 2011). According to Hall (2007), the thrust fault was the main types of fault that been present at the Southern Mountain.

There was an unsteady of basin which was begun to occur during the late of Oligocene. Later, this basin were filled by the deposited of sediment that create the Kebutak Formation. This formation will follow by volcanic activity and break through which resulted in Mandalika Formation, then Semilir Formation, Nglanggran Formation and follow by Sambipitu Formation. During the middle Miocene, the uplifting process was occur which form the Oyo and Wonosari-Punung Formation (Surono *et al,.* 1992).

## 2.5 Historical geology

Based on Hartono (2014),the Southern Mountain was created from the volcanic activity. According Ashari & Pandita (2015), the Sambipitu Formation was started deposited right after the volcanic activities was slow down to the end which was called as post-volcanism. This deposited of Sambipitu Formation was quite short as the carbonate organism started to flourish. Sambipitu Formation can be said as the transition of formation from Nglanggran Formation to Oyo Formation. However, this formation contain abundance of trace fossil.

Based on Surono and Permana (2009), the carbonate materials was growth and well develop during the Upper Member of Sambipitu Formation deposited. This is because, the volcanic activities was stopped which help the deposition of carbonate materials.

## 2.6 Research Specification

The specification of depositional environment of the Sambipitu formation, Pengkok district, Gunung Kidul Regency, Special Province of Yogyakarta Indonesia was selected. The facies concept must be understand in order to interpret depositional environment. This facies concept also was used in order to differentiate the various succession of unit on the basis single criteria (Nichols, 2009). In order to study the facies, the changes of horizontal and vertical direction were been considered (Lauti *et al.,* 2007). There were a lot of diverse facies distribution in Sambipitu Formation. The facies analysis were conduct by geological mapping, the physical appearance of sediment such as sedimentary structure, grain size and distribution of rock lithology.

The study of depositional environments of the sedimentary rocks need to take into consideration because it play a important role in controlling the geometries of the sediments such as grain to grain arrangement of framework particles and the accumulation of fluids within the pores of the rock. Combination of facies association and lihtofacies were used in order to interpret the depositional environment in the area. Based on the literature review, the lithofacies in the depositional environment of Sambipitu Formation show shallow marine with volcanoclastic sediment composition and carbonate materials.

Based on Surono and Permana (2009) stated that the depositional environment of lower part formation was effect by tidal current. This tidal current because of gravity flows volcanic materials form the Nglanggran Formation. Tidal sedimentary structure that been found in lower part of Sambipitu Formation was used for interpretation of depositional environment.

# CHAPTER 3

# MATERIALS AND METHODS

## 3.1 Introduction

There are a few of the materials and methods were used in order to conduct the research. These materials and method were used as it help to make the research run well and achieve the main objectives of the research.

## 3.2 Materials

The materials that been used along the research were base map, field book, stationary, tape, geology hammer, compass, handless, Hydrochloric acid (HCL), Global Positioning System (GPS) and sample bag. Along the geological mapping of study area, these materials were used in order to complete the research. All the data were recorded in field book for further analysis.

The most important material geological equipment were base map of study area where it was used in progressing of mapping. The base map needed to produce before went to the field because it is needed for preferences to access the study area. Base map was prepared follow to topography map by using ArcGIS 10.2 software (Gandhi.M, Solai.A, & Chandrasekar.N, 2010) Google earth and google map also were used for further information such as terrain map, accessibility and facilities.

The base map help in overview of geomorphology such as the landform of study area, the types of rock and also the features that contained in study area.

The tools that been used along geological mapping as follows:

a) Global Positioning System (GPS) was used to mark the location of each outcrop that been found by using coordinate along the geological mapping. GPS also help in order to know the distance of travel, navigation, to know the current position and to know elevation of coordinate that been mark.

b) Brunton compass was used to measure the reading of strike and dip of the bedding plane. Firstly, the bedding plane needed to identify for measured the strike and dip. Then, water was put on the bedding for knowing the direction of water flow. Direction of water flow was the dip of the bedding plane. After that, the right hand rule was used to know the direction of strike in order to place the compass. Compass also used to mark the azimuth of the outcrop and used for navigation if GPS is unavailable. The navigation by using compass are by shooting the highest peak of the nearest hills, reading the value then mark it on the base map.

c) Geology hammer was used to take the sample of outcrop that been found. There were two types of hammer which are chisel-tip rock hammer and pointed-tip rock hammer. Pointed-tip rock hammer was suitable for taking the fossil. Chisel-tip rock hammer was geologist usually used for sampling purpose and best used for sedimentary rocks. As the study area

was covered with sedimentary rock, this hammer was suitable for using along the geological mapping

d) Measuring tape was used to measure the dimension of outcrop. It was also used for measure the thickness of each bedding for produce the lithology of the outcrop. All these data was helpful for produce stratigraphy column.

e) Handless was used to observe and identify the mineral composition in each rock that been found. Some of the minerals were needed to see under handless for clearly view the mineral composition. The best handless was handless that attach with lamp which make it easier to observe the mineral

f) Sample bag was used for sampling purpose. The sample of rock for each outcrop that been found was placed in the different sample bag. The size of the sample was about hand size specimen. Later, the coordinate, location, date, type of the rock and the colour of the rock will mark at the sample bag.

g) Hydrochloric acid (HCL) was used for test or identify some of rock and mineral which it will reacts with the acids. The example of rock that will react with acid vigorously was limestone while the mineral that will react was calcite. This reaction helps in differentiate between the quartz mineral and calcite mineral.

h) Field book and stationary was used in order to record all the data that been collected. The sketches of the outcrop, strike and dip and lithology were recorded in field book for further analysis.

### 3.3 Methodology

There were a few of the method that were used during conducting this research. There are the preliminary studies, the field studies, laboratory works and data processing. The methods were divided into three stages which were methods before going to the field, methods during conducting the fieldwork and the method after conducting the fieldwork.

#### 3.3.1 Preliminary studies

The methods before going to the field was called preliminary studies. This method help in first overview of study area and help to collect all the important data of study area. Preliminary studies can brings the meaning of initial investigation of matters that related to proposed quality review. In this method, it was all about searching the literature review of journal, books, article reviews or others in order to get the idea about the topic of research study. These method can obtained from the supervisor, library database, Google Scholar, Google maps, Google earth and article from previous study. By reading the article or journal, it helps in roughly interpretation for what the research will be conduct. Consult with the supervisor for further explanations. The Google earth helps in obtained the geological features and

geomorphology. Next, Google maps help in obtained the clearer view of lineament in study area. This literature review was on going until the research done.

### 3.3.2 Field studies

Next method that needed in order to get the data was field studies. In this field studies, the primary data was collected during geological mapping. Primary data was defined as the data that been collected directly form observation and interpretation that made during conducting the research. There are two types of data were obtained in this research such as primary and secondary. The secondary data was obtained through literature review such geological map and topographic map.

Before started the geological mapping, there were 8 map that been produced in order to get the overview of the study area. It were include base map, land use map, vegetation map, lineament map, watershed map, drainage pattern map, landform map and assumption of rock distribution map. These map were produced by ArcGIS where give the first interpretation about study area and help in order for well plan research conduct.

Next, traversing was first conduct for observation and first interpretation in study area. It was also help for well plan traverse in study area. Then geological mapping was conduct for collected all the data such as geomorphology, geological structure and lithology in study area. These data that obtained from geological mapping help in better understanding about geology in study area.

Measuring section method was conduct for determined depositional environment of Sambipitu Formation. This data of measuring section later will produce the stratigraphic column. Firstly, continuous bed of the lithologies was identify. Then, the same bed that been identify were been measure the dimension of outcrop and thickness of bedding by using measuring tape. The strike and dip, the grains size of rock and azimuth of the outcrop also was been recorded at the same bed. After that, carefully observed and recorded the sedimentary structure that present at the bed. This was because, sedimentary structure was one of the parameter for determined depositional environment. After all the data been collected, the stratigraphic section was establish by using CorelDraw software. The sedimentary structure and lithology were record in the stratigraphic section by using symbol. This stratigraphic section later was used in order to interpret the depositional environment of Sambipitu Formation.

### 3.3.3 Laboratory works

Laboratory works were conduct after at least a month of completing the fieldwork. This method was conduct in order for further interpretation data that been collect in term of petrography analysis and palaeontology analysis. These analysis consist of the thin section preparation and the observation under microscope. The sampling of outcrop that been collect will cut into thin section and further interpret under microscope. There are a few steps in preparing the thin section. Firstly, the rock sample specimen will cut into small pieces by using diamond saw in rock cutting machine. The process of cut and thinned will continuous until the size of rock was suitable for glue it on the thin glass. Before glue it on the thin glass, one side of the rock was polished until it became flat and smooth surface. Then, the flat surface

was attach to the thin glass size 75mm x 25mm. On other side rock was continue grind on grinding machine until it become flat with different grades of carborandum power. When the specimen was about to transparent, remove it from the machine and grind the specimen by using hand on glass plate for correction of thickness. The thickness that suitable for glass plate are approximately 0.03 mm. After that, the specimen was washed and let it dried. The surface of the specimen that already flat was covered with thin glass cover slip and this thin section are ready for analyse under microscope.

### 3.3.4 Data processing, analysis and interpretation

All the collected data was been process, analysis and interpret for final result of general geology and depositional environment. For general geology, both data of primary and secondary were been process and interpret. Data that collect during geological mapping will process by ArcGIS software to produce the geological map. ArcGIS also was used along the geological mapping for export every day of traverse from GPS. All the data of strike and dip, geological structure, geomorphology and lithology were been process and analysis in this software. The base map of study area was update by the data that been collect during geological mapping as it was achieve the objective of research which is to update the geological map of study area. The geological map needed to update because some of the area was change because of plate tectonic movement. For example, the drainage that no longer exist in study area need to be remove in geological map. This precise map needed for geological map for future used. From that, the interpretation of geology in study area can been understand.

For petrography analysis, the slide of thin section was observed under microscope for further analysis and interpretation of types of rock. This analysis needed for observation of behaviour of mineral composition in the rock to determine and conformation the name of the rock. For example, siltstone and claystone were difficult for differentiate in the field. Therefore, these rock can been distinguish by thin section. This analysis of the rock helps for geological map in study area. Next, the palaeontology analysis was carried out by identify the types of fossil that been found in study area. This fossil was categorized by taxonomy, behaviour and origin which where they were form in shallow or deep marine.

The depositional environment in study area was been determined by stratigraphic column. The collected data along geological mapping such as sedimentary structure, lithology, grain size and thickness of bedding were input into Coral Draw software for produce the stratigraphic column. The sedimentary structure and lithology were record in the stratigraphic section by using symbol. From that, the pattern of depositional environment of study area was been determined.

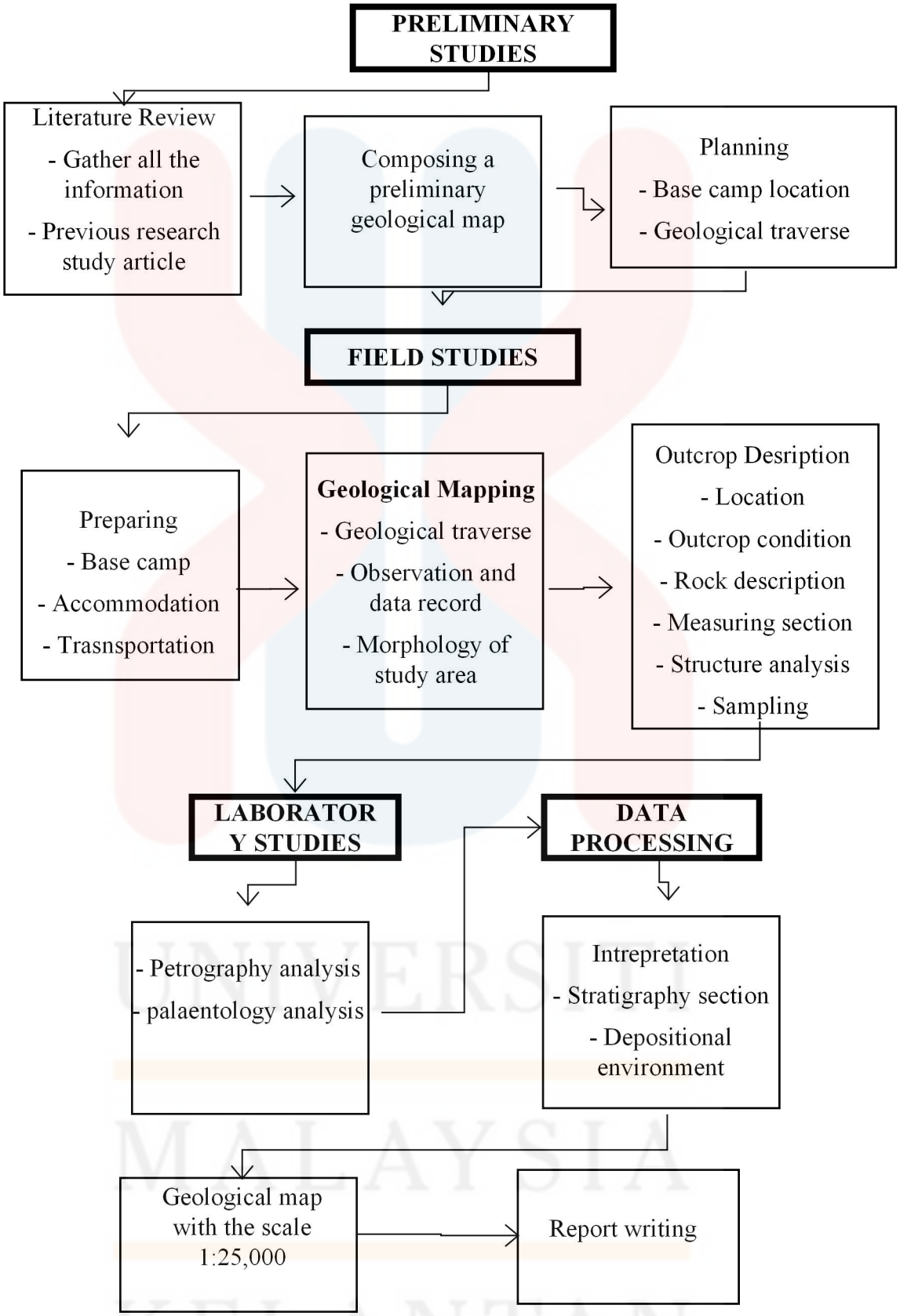



**Figure 3.1:** Flow chart of research methodology

# CHAPTER 4

# GENERAL GEOLOGY

## 4.1 Introduction

In this chapter discussed about the geology of Pengkok area and provides the details of geological information such as geomorphology, lithostratigraphy, structural geology and historical geology based on the observation at field, sampling and data analysis in study area. Geomorphological map, traverse and observation map and drainage map were produced in order to understand the characteristic of study area. This geological information was help in order to achieve the research objective.

### 4.1.1 Accessibility

Accessibility can been explained with the reachable of the study area in order to reached from one location to other location. Accessibility usually involve with the transportation and facilities of road. Accessibility was known as outcome of the transportation activities. Therefore, the socioeconomic activities and accessibility were interrelated to each other. Accessibility give the opportunity to develop the area as it was easy to reach by vehicle or walking. In Pengkok Area, it can been said as relatively accessibility as there was the direct geographic relationship between the land use and road network. This is because, the local villagers usually have daily economic activities and also cause all the location is relatively accessible.

The road act as the connecting network to all the location such as the farm to the local village. This road can been seen on Figure 4.2 that shown the all the road were connect to each other. There were types of road such as local road, alternative road, bridge and forest path. Local and alternative road can been assess by vehicle such as car and motorcycle. However, local village mostly used motorcycle as it is as the main transportation in order to reach location to other location. Forest path usually can been found in the jungle or vegetation area where this road only can assess by walking. There is no official road like tar on the road, but it is the jungle track that local village usually used for taking their plantation or reach to other village.


**Figure 4.1**: (A) the jungle road. (B) the alternative road that been found in forest. (C) the alternative road. (D) the local road

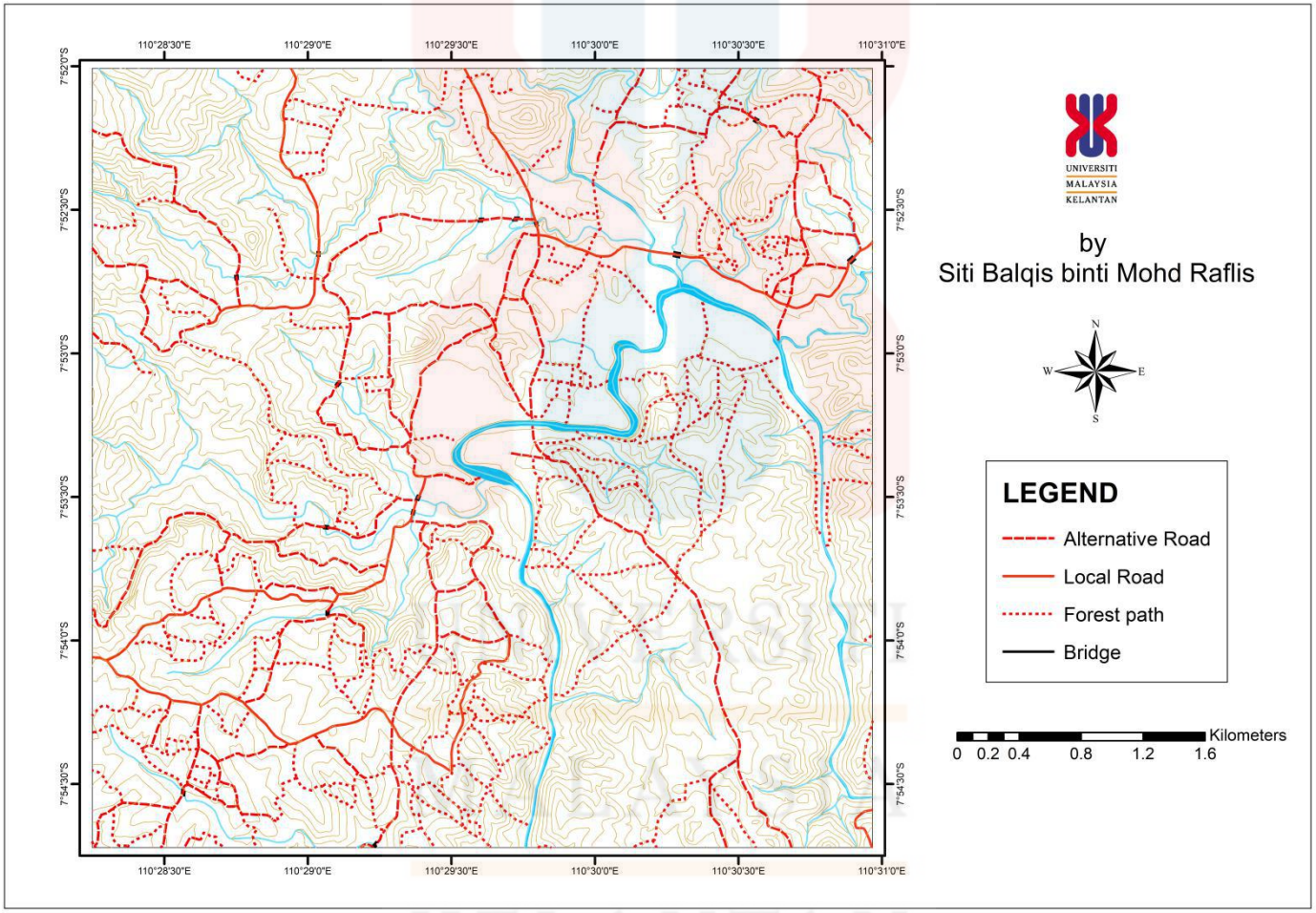



**Figure 4.2** : The accessibility map that show the connector in study area

### 4.1.2 Settlement

Settlement was the places or area that previously been uninhabited. Settlement also can includes the area or the place were already been settle by human. Gunung Kidul Regency had relatively high in population but yet still consider as rural region. There were two district that been include in study area such as Patuk disrict and Bantul district. The area in Patuk district that been covered in study area were Salam, Semoyo, Pengkok and Ngleri. The area in Bantul disctrict that been covered in study area was Jatimulyo. However, Pengkok area was covered the largest portion in study area. This area and district was been guide and manage by different area office.

**Figure 4.3:** Settlement in Pengkok area.

### 4.1.3 Vegetation

Pengkok area was rural region which the socioeconomic activity more to vegetation as the main source of income for the villagers. There is no such a forestry in study area because of the high population of people made it the space around them was been used for the vegetation. It can been said that 90% of the villagers in study area was depend on vegetation for food. They were planted various types of vegetable but majority in villager was planted the corn, chilies and potatoes. Later on, these vegetable will be sold for the money. Besides that, they also planted the paddy for their life food. Some of the villager planted the potatoes for their main source of food as replace the rice. This vegetation also was been used for feed the livestock such as cow, chicken, duck and goat which later this animals will been sold for the income. Usually the vegetation that been plant for livestock such as *lalang* grasses and paddy. Teak trees and Eucalyptus tree were been planted in study area.

All these vegetation was been planted based on the landscape of the area and it was also was been planted correlated with the types of lithology of the location. Paddy was planted at both landscape but mostly the villagers were planted the terrace paddy at the hilly landscape while the flat landscape usually was planted the corn, chilies and potatoes. The teak tress and Eucalyptus tree were been planted at the hilly landscape and usually at the Oyo Formation and Wonosari Formation. This is because, the typical of these formation usually was hilly landscape.

**Figure 4.4:** Vegetation of lalang grass

### 4.1.4 Traverse and Observation

The geological mapping in Pengkok area was been done by traversing and observation in order to collect the geological data, the rock sampling and mesuring section. Traversing was one of the method and alternative strategy mapping for get the formation contact. Based on the geological map of Indonesia Sukarta, the relative normal strike and dip in Java island was from the north to south. Therefore, the traversing was been done from north to south in order to get the formation contact and the changing of the lithology. Before going to field, traversing route and the target was been planned in order to help expected data that will been collect in the field. This traversing and observation was been conduct in order to help mapping

to work smoothly. The whole geological mapping process in study area was been took 11 days to complete collecting the data.

Generally, the traversing was been done in study area with traversing along the rivers as the outcrops at rivers were well exposed to clearly saw the rock and structures. The observation was been done by observe to every change of lithology pattern. The observation also was been made based on the features and geological structure that been found along the traverse. The changes of lithology, structures and geological structures were been marked and recorded along the mapping process. There were around 155 of observation points that been marked during the traversing. This observation points were been recorded in a field notebook and the traverse route was been tracked by using GPS. Later, this information was been used for the plotted in the map and the traverse map was been produced. The traverse and observation map showed that the study area was been covered around 90%. As the lava was appeared as the spot in randomly, traversing in details at Nglanggeran Formation need to be careful and cover all the boundary contact of lava. Therefore, traversing should be planned and estimate well in order to make it the geological mapping was process in successfully and efficient.

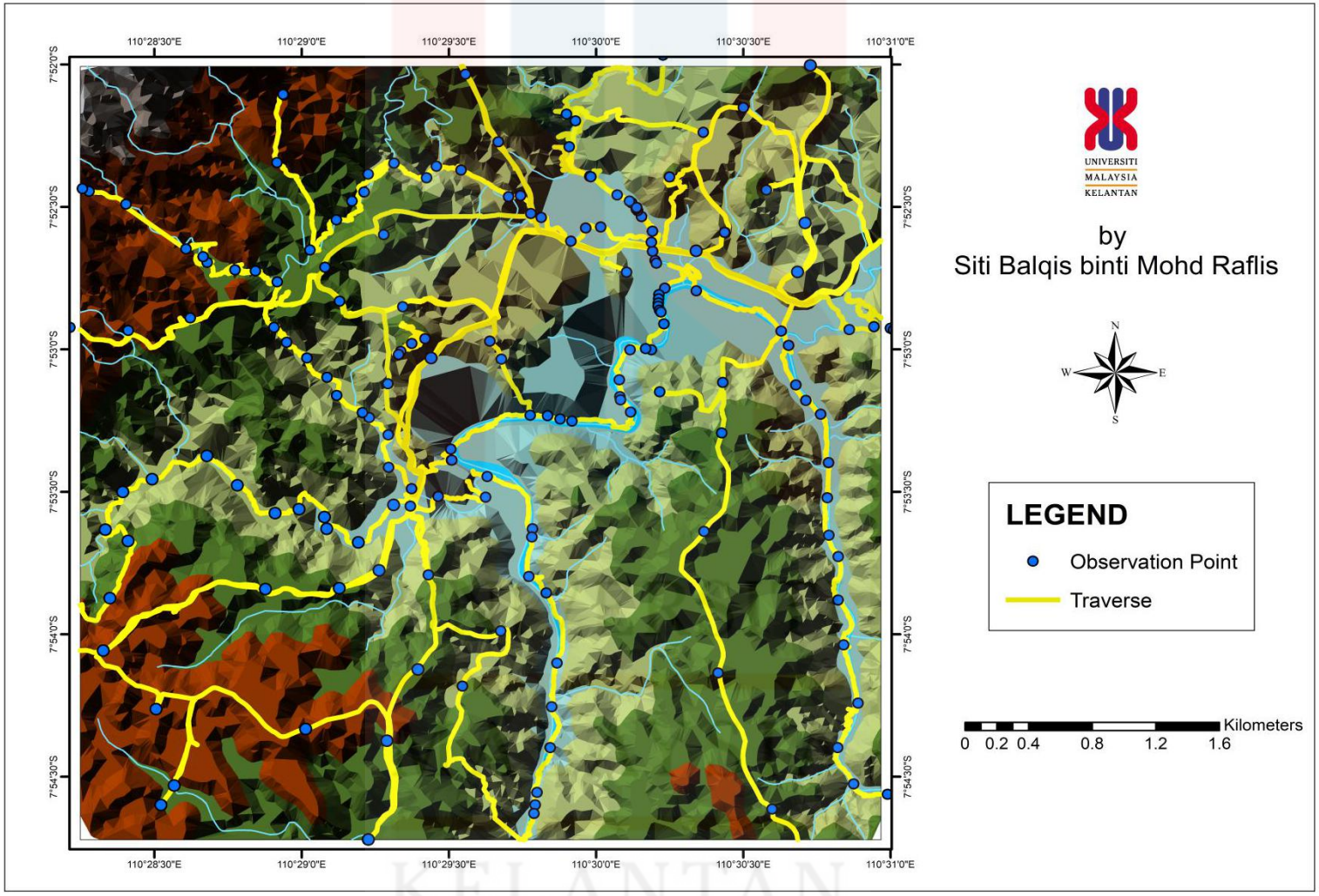



**Figure 4.5**: The map show the traverse along the 11 day of mapping.

## 4.2 Geomorphology

Geomorphology was been explained as the study of the physical earth landscape features, the process of landscape and its classification. Therefore, it can been simplify that geomorphology was about weathering process, drainage pattern and landscape classification in study area. Geomorphology of the location was important for environmental and also sustainable management in the future. Geological map also help in order to produce the geomorphological map where shows the distribution of landform. Therefore, this geomorphological map that already been produced will give the effective tool in management of natural resources, help in variety types of planning and development activities for the villagers in study area.

### 4.2.1 Geomorphologic Classification (van zuidam 1985)

Geomorphic process can know as the significant geological force which been interact with the existing earth surface. This process can be the reason for the shape and the changing of earth surface. Based on Van Zuidam, 1085, the study area was composed low-lying plain to hills.

**Table 4.1:** The absolute elevation and morphology element based on Van Zuidam, 1985

| Absolute Elevation (Mean Sea Level) | Morphology Element |
|---|---|
| < 50 | Low land |
| 50 - 100 | Low - lying plain |
| 100 - 200 | Low Hill |
| 200 - 500 | Hill |
| 500 - 1,500 | High Hill |
| 1,500 - 3,000 | Mountain |
| > 3,000 | High Mountain |

There were two types morphology element that obvious can be seen which were low lying plain and hill. The centre part of the study area was the low - lying plain. This morphology result can been reason from the lihology of the rock. The lithology of the dominant rock was mudstone and sandstone. However, the hill area was been divide into two area where at the north and south.

The hills area at north part was the result from the volcanic rock which were pyroclastic and epiclastic breccia. This rock was high resistant to weathering because it was formed by the volcanic eruption process. Besides that, the hills area at the south part was the result from the limestone unit that was also resistant weathering compared to sandstone unit of Sambipitu Formation. This geomorphology in study area can be seen at Figure 4.6 and Figure 4.7


**Figure 4.6:** The geomoprhology observation from the top at Gunung Ireng ( E 110º 29’ 25.17”, S 07º 52’ 57.77”)

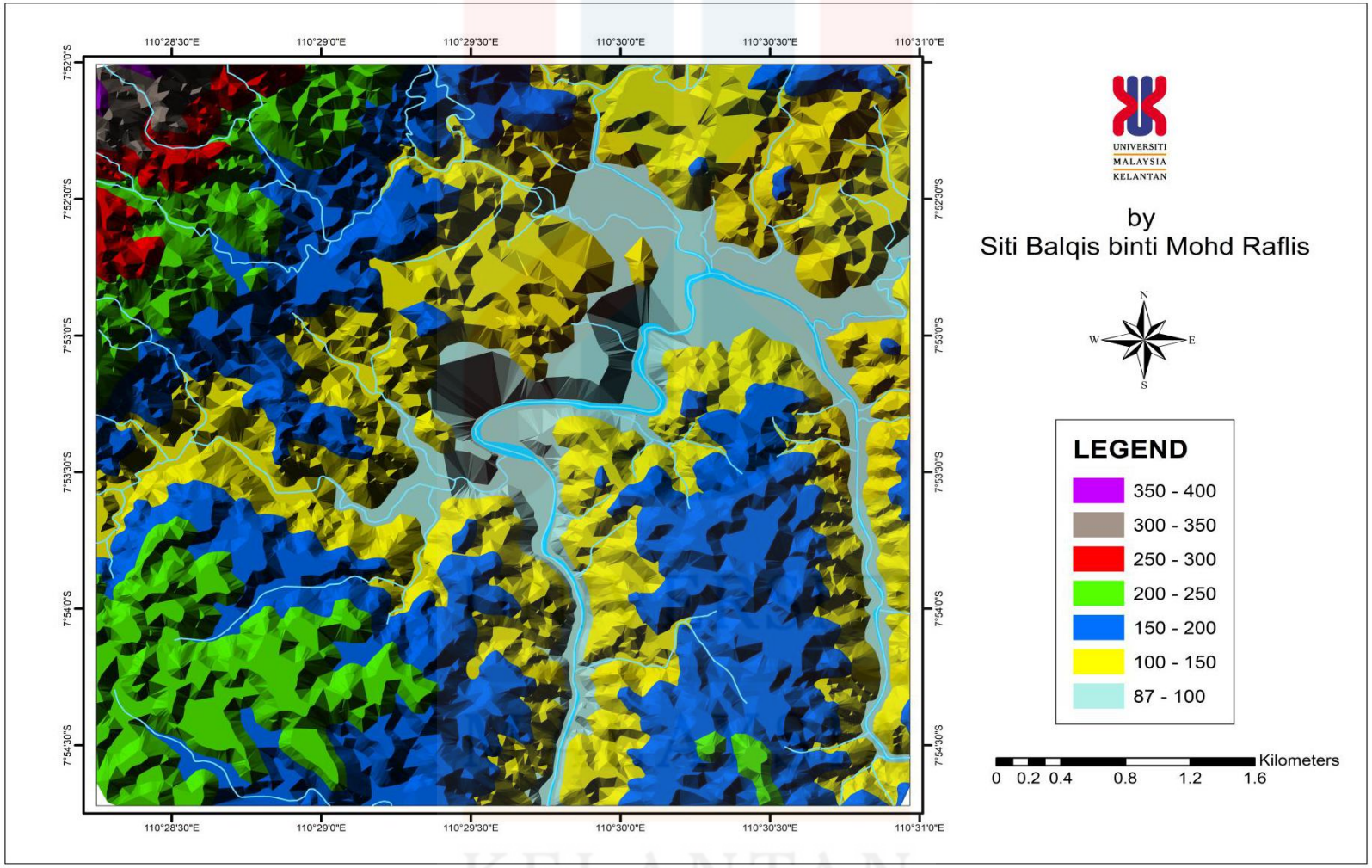



**Figure 4.7** : The geomorphological map was show the flat and hilly landscape at Pengkok area.

### 4.2.2 Weathering Process

Weathering was the process of erosion of rock that can change the structure, chemically and physically. There were three types of weathering that been found in the study area which were physical weathering, chemical weathering and biological weathering process. Rock that been undergo weathering process was turn into regolith. Regolith was been explained as the layer of unconsolidated solid material which was been covered the bedrock. This composition of regolith was depends on the parents rock that been undergo weathering process which give the benefit for the different types of plantation. The local in study area was used this regolith as soils for their vegetation.

Biological weathering was the rock that breaking down due to living organisms action. Example of living organisms were plant and animals. Biological weathering that been found in study area was involve with the plant. As the plant was growth, the root will continue creeping into the soil and rock in order to searching the nutrients. The root was filled in the fracture and joint of outcrop which make it the fracture become wider. By the time, the roots was growth and the pressure on the adjacent rock also become stronger. Therefore, the rock break down into smaller rock. Beside that, the growth of roots was produce organic acids that make the mineral in the rock dissolved.

Physical weathering can been explained by the rock disintegration without changing the chemical composition in the rock. This process involve the temperature changing in rock where it can cause the rock to expand and contract. This changing

in physical break the rock apart and it can been break into pieces if the process was continuous. While, the chemical weathering can been explained as the rock disintegration because of the changing in chemical composition of the rock. Chemical weathering usually involve the water that been react with the mineral in the rock and produce the new mineral. This reaction can been said as hydrolysis reaction. The example chemical weathering in study area was eroded limestone where the calcite mineral dissolved when interact with the water.

**Figure 4.8 :** The carbonate waterfall found at Oyo River.

Both chemical and physical weathering was been found in study area was involve water and temperature that produce interesting structures. This weathering process can been seen on the spheroidal weathering structure (Figure 4.10). Spheroidal weathering structures was one of the significant weathering structure that been cause by these physical and chemical weathering process. This structure was been formed because of the orthogonal joints. This chemical weathering more rapid at the joint intersection which the angular corner of the cuboid blocks become rounded. In study area, this structure was been found on sandstone rock. The space of the joint was been filed with the water then the chemical weathering process changing some mineral grains into different mineral where more weaker than before and the onion like structure was formed because of the physical process. The outer layer of the rock was exposed and dries quickly after wetting. However, the moisture that already been penetrates into the minor crevices inside the rock was been stayed until become decay. This result of this action, the the rock become swelling and make it flaking roughly parallel to the outer rock of surface which been called exfoliation (physical weathering)

**Figure 4.9:** The orthogonal joints that been formed the spherical structures

**Figure 4.10** : The spherical structure found on sandstone rock at Oyo River

### 4.2.3 Drainage Pattern

The drainage pattern can been found in study area was dendritic and parallel drainage pattern. Based on the Figure 4.11 the study area was majority of dendirtic drainage pattern. This was because, the Oyo River, Pentung River and Widoro River act as basin which collect all the water from the small river into it.

The dendritic drainage pattern was been found at north- west, north -east and also at south - west in study area. There were many small rivers that been joint together into the Oyo River as this river was the main river in study are. Dendritic drainage pattern was form based on uniform resistant of strata, unconsolidated sediments and not control by structure. Usually this dendritic drainage pattern was strong rock. The rock types that been surrounding this pattern was volcanic breccia which is high resistant to weathering.

The parallel drainage pattern was been found south-east part in study area. The small river flow from the hills to the low hills and connect to the Oyo River. Parallel drainage pattern was form based on uniform of resistant strata and the importance was this drainage pattern was control by structure. The strong structure was contribute such as fault to straight the parallel drainage system.

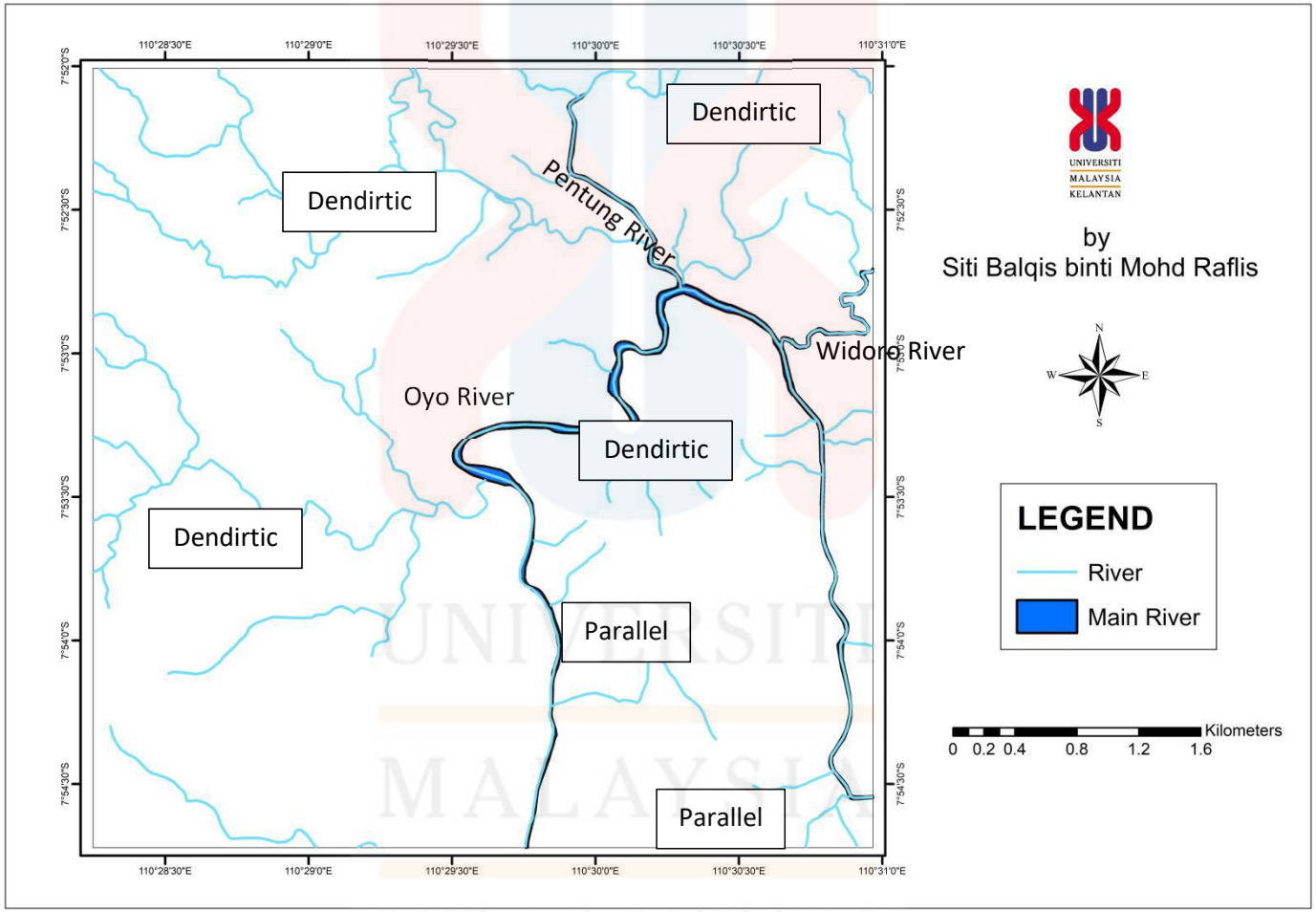



**Figure 4.11:** The drainage pattern map in study area.

## 4.3 Lithostratigraphy

The lihtologies in study area were been dominant by two types of rock which were sedimentary rock and volcanic rock. Lithologically, in study area were been divided into 8 lithologic units such as volcanic breccia, lava, epiclastic breccia, sandstone and mudstone, mudstone, carbanecous sandstone, tuffaceous limestone and limestone units. These unit were been named based on their lithologies dominant which usually these rock unit have specific characteristic that show their formation in study area.

All these lithologic unit were been recorded and divided based on their unit in geological map in study area. These data was been collected during traversing. Figure 4.12 lithology traverse map was been produced in order to identify the major distribution rock. This step was help in order to make the boundary in study area between the formation based on the rock distribution. Geological map of Pengkok area was been show in Figure 4.14

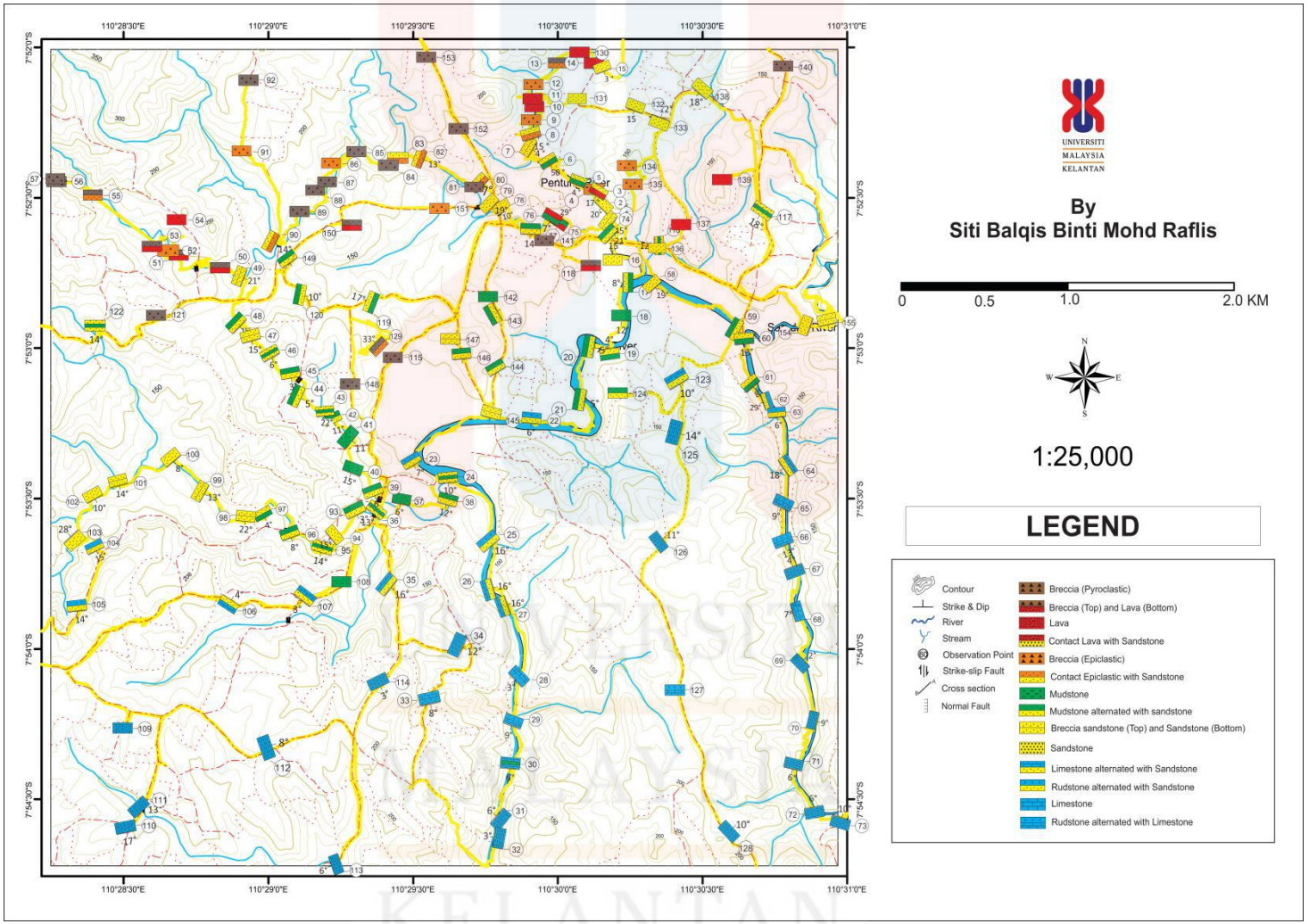
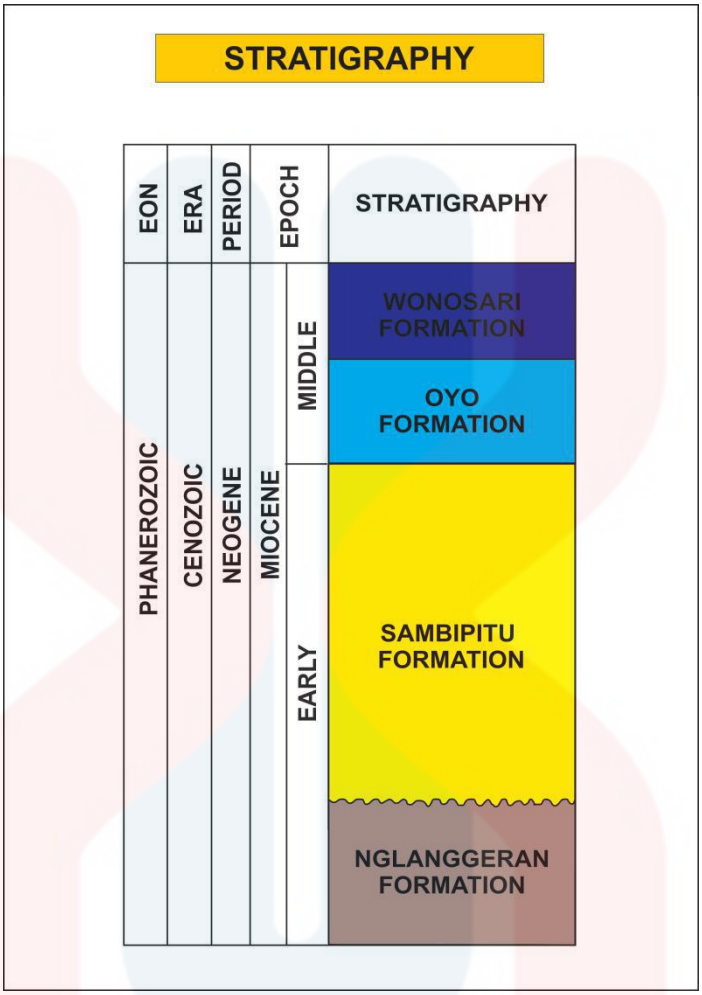



**Figure 4.12:** The lithology traverse map to show the distribution of rock

### 4.3.1 Stratigraphic Position

There are four formation involve on study area that can been identified which were Nglanggeran Formation, Sambipitu Formation, Oyo Formation and Wonosari Formation. Towards north, the number of age in formation was increasing. Nglanggeran Formation was the oldest formation and located at northern part while Wonosari Formation was the youngest formation that located at southern part of study area. This distribution can be seen on the geological map at Figure 4.14.

Nglanggeran Formation was deposited during the volcanism period. It were mostly covered by volcanic breccia, lava, tuffs and dominated by andesite volcanic rock. Early Miocene, Sambipitu Formation was deposited after the volcanic activity had slowed down. This epoch was called carbonate period as the carbonate organisms was started to flourish. It is can been seen at the upper part of Sambipitu Formation as it were present carbonate materials that been developed well due to ceased volcanic activity. Then, Oyo Formation was deposited during the middle of Miocene. It were consist of tuffaceous sandstone, packstone and wackestone. This formation was present with the fossil that indicate the shallow marine environment. While Wonosari Formation was dominated by thicken of limestone. It were consist of rudstone, grainstone and oncolites. The Figure 4.13 show the illustration of stratigraphy in study area based on the stratigraphy of position.



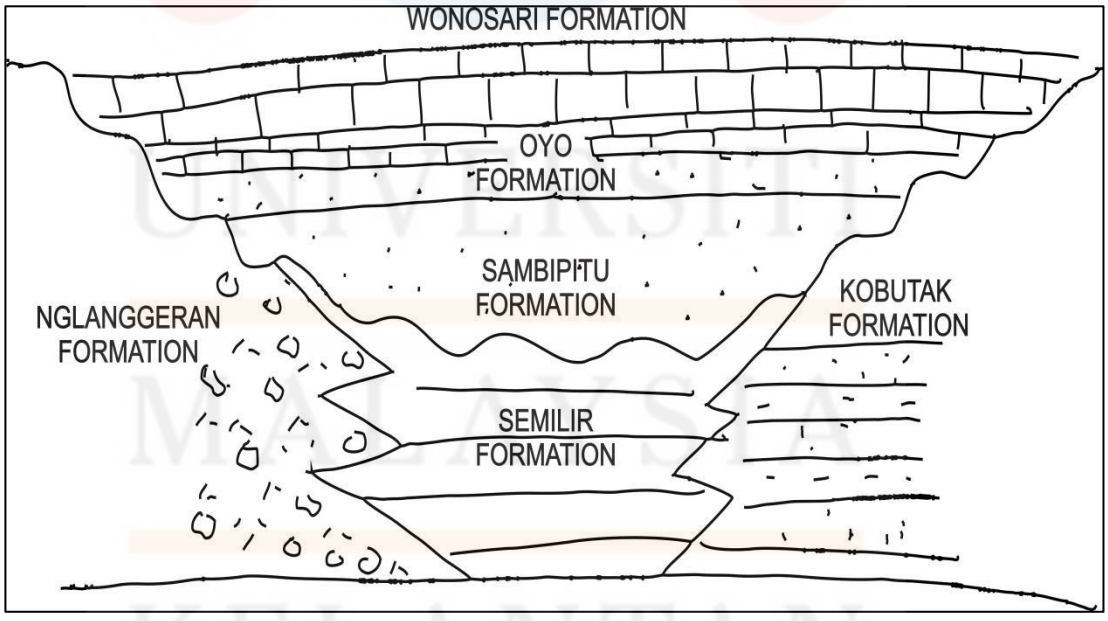
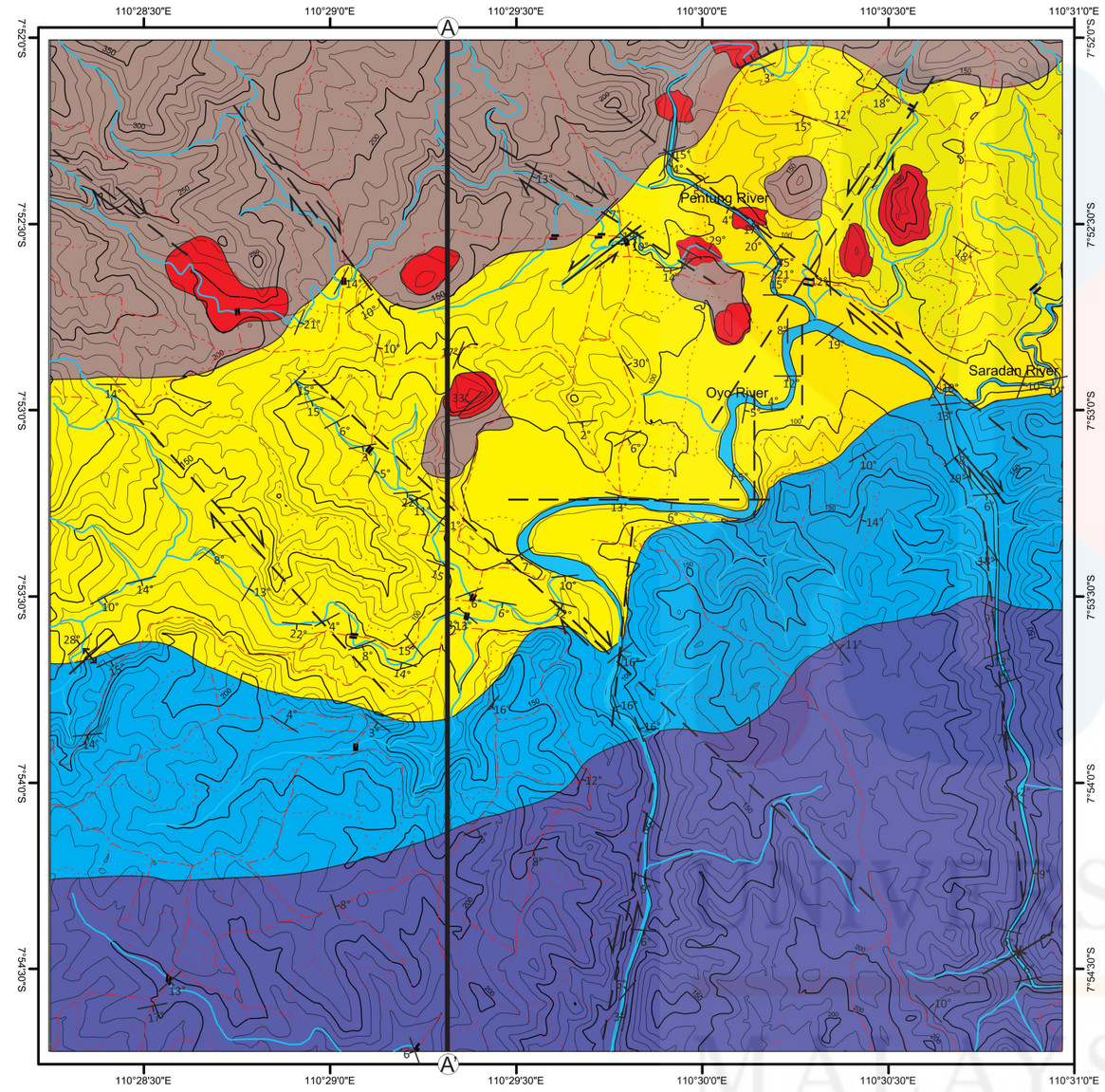




**Figure 4.13:** The illustration of stratigraphy in study area.

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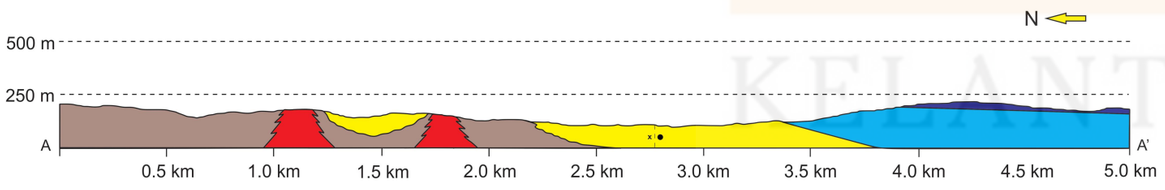


UNIVERSITI MALAYSIA KELANTAN

GEOSCIENCE PROGRAM
DEPARTMENT OF GEOSCIENCE
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# GEOLOGY OF PENGKOK AREA, GUNUNG KIDUL PROVINCE, SPECIAL REGION OF YOGYAKARTA, INDONESIA.


BY

SITI BALQIS BINTI MOHD RAFLIS , E16A0260

## STRATIGRAPHY AND LITHOLOGY

| EON | ERA | PERIOD | EPOCH | STRATIGRAPHY | LITHOLOGY UNIT AND DESCRIPTION | DEPOSITIONAL ENVIRONMENT |
|---|---|---|---|---|---|---|
| PHANEROZOIC | CENOZOIC | NEOGENE | MIDDLE | WONOSARI FORMATION | **Limestone unit:** Grainstone, rudstones and oncolites | Shallow marine |
| | | | | OYO FORMATION | **Tuffaceous Limestone unit:** Tuffaceous sandstone, wackestones and packstones | Shallow marine |
| | | | EARLY | SAMBIPITU FORMATION | **Carbonaceous sandstone unit:** Carbonaceous sandstone and breccia sandstone with limestone fragment at the upper part of Sambipitu formation.<br>**Mudstone unit:** Mudstone with interbedded of sandstone.<br>**Sandstone and Mudstone unit:** Alternation of sandstone and mudstone.<br>**Epiclastic breccia unit:** Thicken of epiclastic breccia, tuffaceous sandstone and mudstone at the lower part of Sambipitu formation. | Shallow marine |
| | | | | NGLANGGERAN FORMATION | **Lava unit:** Andesite lava and basaltic lava.<br>**Volcanic breccia unit:** Pyroclastic breccia and epiclastic breccia. | Shallow marine |

## LEGEND

- Contour
- Strike & Dip
- River
  a. Main River
  b. Stream
- Lithology Boundary
- Road:
  a.Local Road
  b.Alternative Road
  c.Bridge
- Cross Section
- Normal Fault
- Fault Structure
- Strike-slip Fault
- Syncline fold
- Anticline fold
- Strike - Slip Fault
  - Outward Movement
  - Inward Movement

**Figure 4.14:** The geological map of Pengkok area

### 4.3.2 Unit Explanation

In this subtopic was been discussed more details about lihtologic for each formation. The unit was been explained from the oldest rock unit to the youngest rock unit. The discussion involve the naming of the rock, the thickness of the rock unit, distribution location area, observation rock sample and characteristic of lihtologic. The lithologic unit was been name based on the dominant rock in location area. Each of the lithologic had in formation had different characteristics and been support with the petrography analysis. The fossil, sedimentary structure and the lihtologic was help to been related with the historical geology and depositional environment of each unit in study area. Figure 4.15 was shown the illustration of each rock unit that contain in study area.

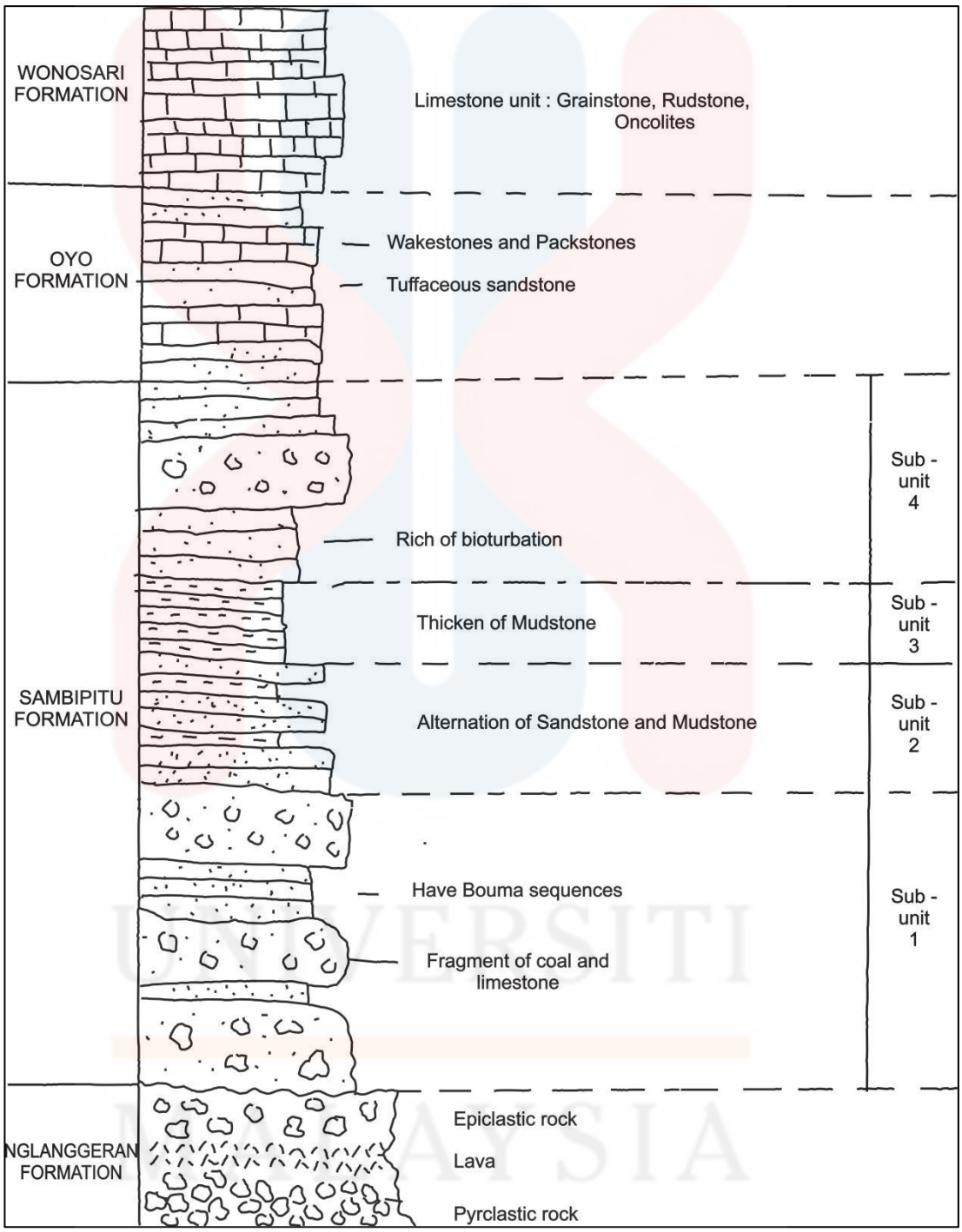



**Figure 4.15**: The illustration of rock unit in study area.

#### 4.3.2.1 Nglanggeran formation

Nglanggeran formation was the oldest formation in study area. This distribution can be seen in geological map that been colour with brown. This formation located at north part in study area. However, there was the spotted Nglanggeran Formation that been appeared on the Sambipitu Formation. This can been explained as geomorphological in study area which undulting geomopology. As the morhoplpogyical was undultling, the Nglanggeran formation was deposited first as it was the oldest formation. Later, after the volcanic activity start to slow down, the Sambipitu Formation was deposited. The cross section from the north to south in study area was show the undulting geomorphology and the Sambipitu Formation was deposited above the Nglanggeran Formation. Nglanggeran Formation was been said as the marine depositional environment. However, the limestone fragment in study area was not properly nourish compared to the Ngalang River which been used as the batchmark to study the Nglanggeran Formation.

Based on Suronon (2009), stated that the Nglanggeran Formation dominated with volcanic rocks likes andesitic breccia, angglomerate, tuff and lava. However, Nglanggeran Formation in study area were dominated with volcanic rock such as andesite breccia and lava.

**A. Volcanic breccia unit**

Volcanic breccia unit was the volcanic rock that been dominant in Nglangggeran Formation in study area. Volcanic breccia unit was been generate by the explosion at the volcanic vents which the explosion of the volcanic activity was because of the expansion of magmatic gas eruption. Different location will had the different size of fragment depends on the transportation and deposition. In field observation, generally the fragment size for both volcanic breccia unit was been range from 0.5 cm (pebbles) and more than 25.6 cm (boulder). There were two types of volcanic breccia unit which were pyroclastic breccia and epiclastic breccia. This volcanic breccia was been separated into two based on the fabric and also the matrix. This unit was been found deposited by my many periods of volcano eruption. Along the traverse, there was epiclastic and pyrcoclastic breccia outcrop that was been found in same location. This shows that the Nglanggeran Formation was been undergo many period of volcano eruption.

In field observation, pyrcolastic breccia was been identify by the close fabric with monomic fragment as Figure 4.17. The texture of outcrop was rough and emerge fragment. The dominant fragment that been found was andesite rock. The present of the pyroclastic breccia was help in order to know the area was near to vein or crater. This was because, pyroclastic breccia was been formed by the explosion of volcanic eruption and the fragment fall and deposited.The tuff rock can been found further from the volcano as the density of the tuff was light. Along the traverse, the volcanic breccia and tuff were been found, it show that the area was at foot hills. Then, the dominant of volcanic breccia and lava was been found, it show that the area was at slope hills. After that, the dominant of lava and volcanic breccia was

been found, it show that the area was near to the vein. Therefore, the pyroclastic breccia was important in this era in order to found the ancient vein. Figure 4.17 show illustration of pyroclastic distribution.

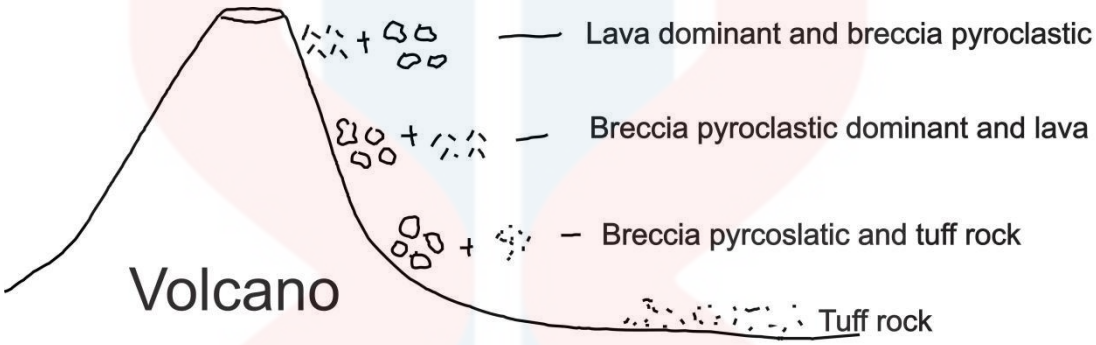



**Figure 4.16:** The distrubtion of pyroclastic

Epiclastic breccia was been formed same as pyrcolastic breccia which from volcano eruption but different medium of deposited and transportation. The medium of deposited and transportation that been involve in order to formed epiclastic breccia was water. In field observation, epiclastic breccia was been identify by the open fabric with polymic fragment. The fragment of the epiclastic breccia can been variety since it was been involve with the movement of water and deposited. The dominant fragment for epiclastic breccia that been found in study area was andesite rock. As the epiclastic breccia was involve with the strong water current, the matrix of this rock was composed of volcanic sandstone. The volcanic sediment was been carried by the water current during the high tide.

**Figure 4.17:** The pyroclastc breccia outcrop

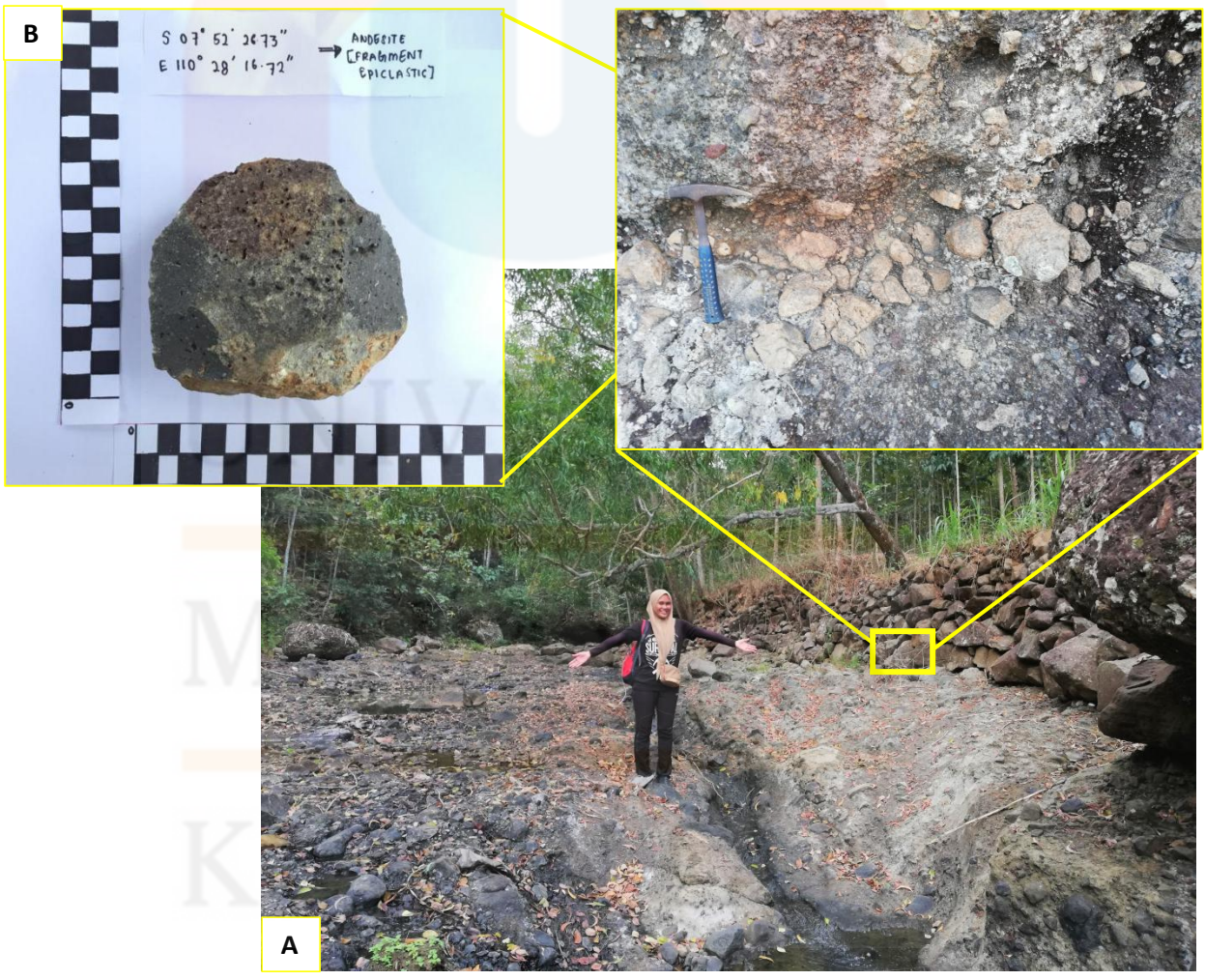



**Figure 4.18:** (A) show the both pyroclastic and epiclastic breccia in outcrop. (B) show the hand specimen of epiclastic fragment

Volcanic unit also contain structures as well as others rock unit. Pyroclastic was the rock that form due to volcano eruption. During the eruption, the volcano eject the semi molten rock which called volcanic bomb. This volcanic bomb was the fragment that was cooled into the solid fragment before reach the ground. The shape of volcanic bomb were varies. The volcanic bomb was heavy, often fly at higher speed and it does not travel very far from the vein. Therefore, the present of the volcanic bomb was indicates how near the area with the vein location.

The structures that been found in study area was bread-crust. This located at Gunung Ireng with coordinated E 110º 29’ 25.17”, S 07º 52’ 57.77”. This types of bomb was form when viscous and gas rich was been ejected form the volcanic vent. The bread-crust bomb was form when the exterior of the bomb was solidifies quickly while the soft interior continues to expand because of the gases that exsolve from the lump of lava. This structures can be seen at Figure 4.19

**Figure 4.19:** The bread-crust bomb

**B.Lava unit**

Based on the geological map, the lava unit was covered only 5% and distributed as the spotted area. Lava was been known as the primary product during the volcanic eruption. However, lava was the younger than pryroclastic product. This was because, lava will flow from the crater after the pyroclastic product was been released. The appeared of the lava as the batchmark for finding the crater of the volcano in this era. Based on the geological map , it can been said that there was small crater that can been seen in study area. Usually, the smaller volcano appear because of the biggest eruption of volcano was happen which trigger the other small volcano to built.

Figure 4.20 with the E 110º 29’ 25.17”, S 07º 52’ 57.77” and the Figure 4.23 with the E 110º 28’ 39.96” , S 07º 52’ 40.52” shows the different type of lava outcrop that present in study area. The were two types of lava unit that been present in study area which were andesite lava and basaltic lava. The outcrop of andesite lava can been found at Gunung Ireng while outcrop of basaltic lava can been found at near the river within Nglanggeran Formation.

The mineral content for both lava was been identified by petrography analysis based on the sample 19 BR D9C1 and 19 BR D4C15 as shown in Figure 4.22 and 4.25 and in the table 4.2 and table 4.3. Based on the petrography analysis, the mineral percentage in the rock was been used in order to identify the name and type of rock. Therefore, rock sample 19 BR D9C1 was basaltic lava that been name based on Streckeisen, 1976 and O’Dunn and Sill, 1986. Besides that, the altered andesite

lava was been name based on the modified form O'Dunn and Sill, 1986 which the zone of alteration was propylitic which calcite-silica group based on Leach, 1995.

**Figure 4.20:** The basaltic lava at Gunung Ireng


**Figure 4.21:** The hand specimen 19 BR D9C1 of the basaltic lava.

| | | | |
|---|---|---|---|
| No sample | : 19 BR D9C1 | Rock name | : Basaltic lava |
| Location | : Nganggeran Formation (Gunung Ireng) | Rock unit | : Lava |
| Coordinate | : E 110º 29’ 25.17” S 07º 52’ 57.77” | | |

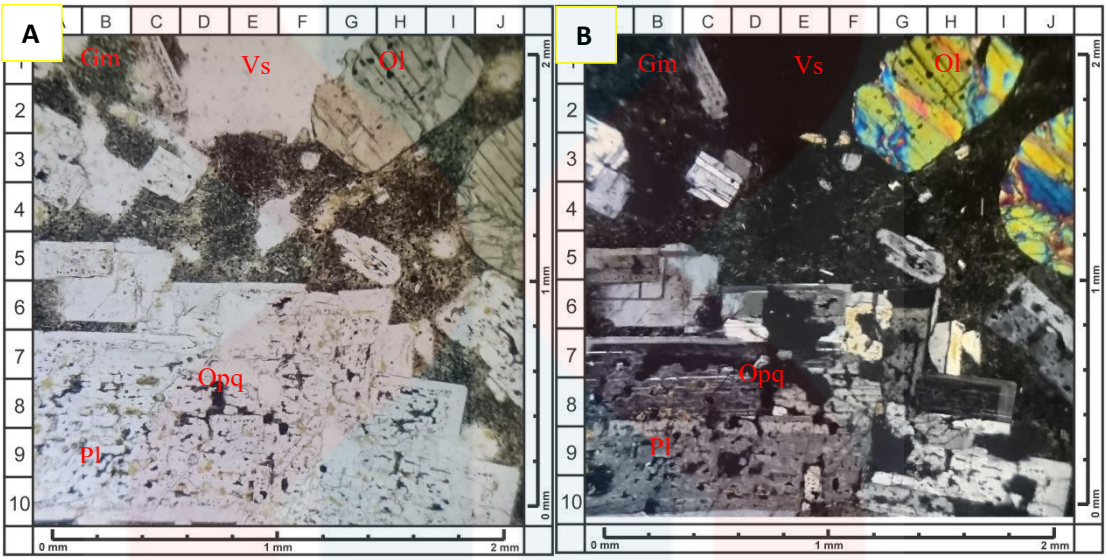



**Figure 4.22**: (A) Plane Polarized Light (PPL). (B) Cross Polarized Light (XPL)

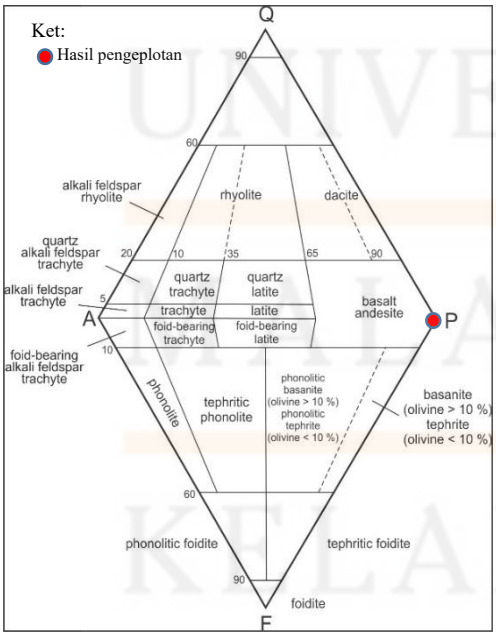
Observation under microscope :

The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation was considered massive structure, porphyro-aphanitic texture and the grain size was fine to course grain.

**Table 4.2:** Mineral composition of basaltic lava

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Plagioclase (Pl) | 50 | It was show light colour under PPL while grey colour with carlsbad-albite twinning |

| | | |
|---|---|---|
| | | under XPL. This plagioclase had subhedral-euhedral shape and had value of An 77 bytownite. Moderate pleochroism and 1 direction of cleavage. The distribution of mineral as phenocrysts and ground mass |
| Olivine (Ol) | 12 | It was show light brown colour with low relief under PPL while blue and green colour under XPL. High pleochroism and two direction of cleavage. The distribution of mineral as spotted in thin section. |
| Ground mass (Gm) | 26 | The colour of ground mass under PPL was light and dark under XPL. The mineral include were microlites quartz, microlites of feldspar and vulcanic glass. |
| Opaque mineral (Opq) | 2 | The colour for both PPL and XPL was black. |
| Vesicle and pores (Vs) | 10 | The colour for PPL was light colour and dark under XPL. |



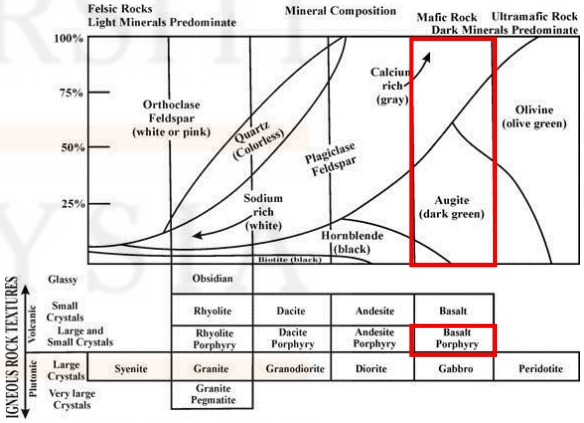



**Figure 4.23:** The andesite lava at Nglanggeran Formation.


**Figure 4.24:** The hand specimen of andesite lava.

| | | | |
|---|---|---|---|
| No sample | : 19 BR D4C15 | Rock name | : Altered andesite lava |
| Location | : Nlanggeran Formation (River) | Rock unit | : Lava |
| Coordinate | : E 110º 28’ 39.96”<br>S 07º 52’ 40.52” | | |

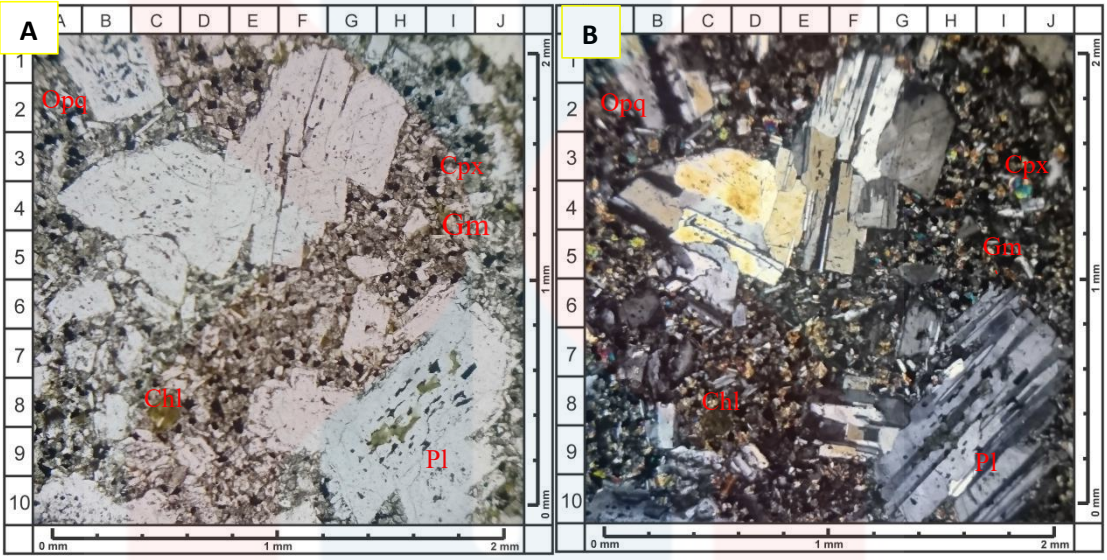



**Figure 4.25:** (A) Plane Polarized Light(PPL). (B) Cross Polarized Light (XPL)

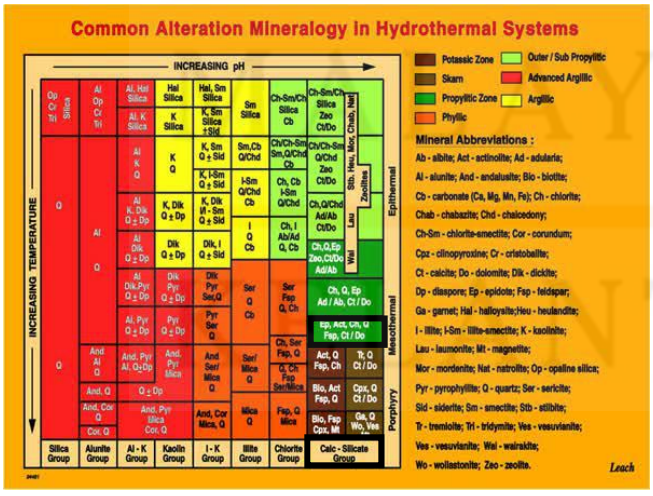
Observation under microscope :

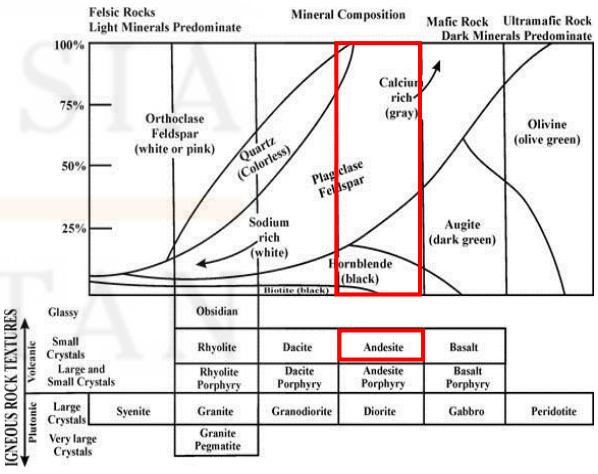
The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation based on the massive structures, porphyritic textures and moderate-fine mineral size. This rock was the alteration rock due to alteration process which was been marked by appearance of alteration index mineral in form of chlorite.

**Table 4.3:** The mineral composition of altered andesite lava

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Plagioclase (Pl) | 40 | It was show light colour under PPL while |

| | | |
|---|---|---|
| | | grey colour with albite twinning and carlsbad-albite under XPL. This plagioclase had value of An 62 labradorite. Medium pleochroism and 1 direction of cleavage. The distribution of mineral was in phenocrysts and ground mass |
| Chlorite (Chl) | 4 | It show greenish brown colour, moderate relief and moderate to poor of pleochroism under PPL while green colour under XPL. |
| Clinopyroxene (Cpx) | 3 | It show light brown colour with low relief under PPL while under XPL the colour was natural blue. The pleochroism was moderate to poor. |
| Ground mass (Gm) | 48 | It show brownish white colour under PPL and greynish black under XPL. This ground mass was arrange and build form volcanic glass, clay silicate and quartz mineral. |
| Opaque minerals (Opq) | 5 | Both in PPL and XPL, the colour was black, the shape of the mineral was subangular. |



As well as the sediment had structure, the lava also contain structure that indicate the location of vein and the flow of lava. These structure can be seen at Nglanggeran Formation. The structures that been found in study area were auto breccia and columnar joint.

Autobreccia structure (Figure 4.26) was form based on the control factor which were the velocity of lava flow and the rate of lava cooling. This structure was formed when the lava was flow, the surface cool rapidly but the inner core of lava was still moving due to liquid state or less viscous. As it moved, the upper was fracture and break up into angular shape like breccia fragment. The structure only occurs on the surface and inner core of lava does not have this structure. The present of the autobreccia help in order to know the direction of lava flow by taken the orientation.

**Figure 4.26:** The autobreccia structure at Gunung Ireng

Columnar joint was the structure that formed in rock that consist of column with usually hexagonal in shape which was separated by the joint or fracture that formed when the rock was contract during cooling. The lava contracts and relieved the stress by cracking. The contraction of cooling occur at the centers which was equally space. Thus the result of hexagonal fracture. However, if the contraction not equally space it can be cooled as other geometric of fracture like 5 sides or 4 sides. The perfection to which this was develop depends on the thickness and composition of the lava and how the fast it cooled. The columnar joint was develop perpendicular to the surface of the flow. This structure can help in order to indicates the veins or dikes area.

There were two columnar joint was found which were at Gunung Irang with coordinate E 110º 29’ 25.17”, S 07º 52’ 57.77” and near to river with coordinate E 110º 28’ 39.96”, S 07º 52’ 40.52”. These both columnar joint was colonnade set which straight and regular columns. This shape was the result from slow cooling from the base upward and rapid cooling from the top downward. This columnar joint can be seen on Figure 4.27 and Figure 4.28


**Figure 4.28:** A and B were the columnar joint near with river ( E 110º 28’ 39.96”, S 07º 52’ 40.52”)

**Figure 4.29:** The columnar joint at Gunung Ireng ( E 110º 28’ 39.96”, S 07º 52’ 40.52”)

#### 4.3.2.2 Sambipitu Formation

Sambipitu Formation was been deposited after the volcanism acitvity start to slow down. The distribution of this formation can been seen in geological map with the yellow colour. This formation was located at middle part in study area. Along the traverse, the Sambipitu Formation was been recognize by found the sandstone rock. This was because, Sambipitu Formation was been known as dominated by sandstone. In study area, the Sambipitu Formation was been further divide into four sub unit based on the different facies associated. This sub unit was been compared to Sambipitu Formation at Ngalang River as there was the best area to study this formation. This was because, Ngalang River had complete sub unit and had the best outcrop for Sambipitu Formation. It was been the reason why Ngalang River was been announce as global geopark by UNESCO.

**A. Epiclastic breccia unit**

Epiclastic breccia unit was the sub unit 1 which consider as the lower part of Sambipitu Formation. The lithologies in this unit was epiclastic breccia, tuffaceous sandstone and mudstone. Epiclastic breccia was been name to sandstone with the polymic fragment and been name as the rock in this unit was been transport by water and deposited like epiclastic Nglanggeran Formation. The fragment of the sandstone breccia can be varies and contain limestone fragment. However, the outcrop in this unit had alternate with tuffaceous sandstone and mudstone. Sandstone breccia had medium to dark grey colour of rock, varies of grain size from very course to cobble grain size. Typical of this sub unit was also would found the bouma sequence. Bouma sequence in study area was not complete and as good as at Ngalang River.

The bouma sequence that been found was graded bedded and lamination. The bouma sequence indicate that the area was turbidite deposited. The hand specimen19 BR D4C9 was been petrography analysis to know the mineral contain in tuffaceous sandstone.

| | | | |
|---|---|---|---|
| No sample | : 19 BR D4C9 | Rock name | : Crystal Tuff |
| Location | : Sambipitu Formation | Rock unit | :Epiclastic breccia unit |
| Coordinate | : E 110 28’ 56.99”<br>S 07’ 52 58.54” | | |

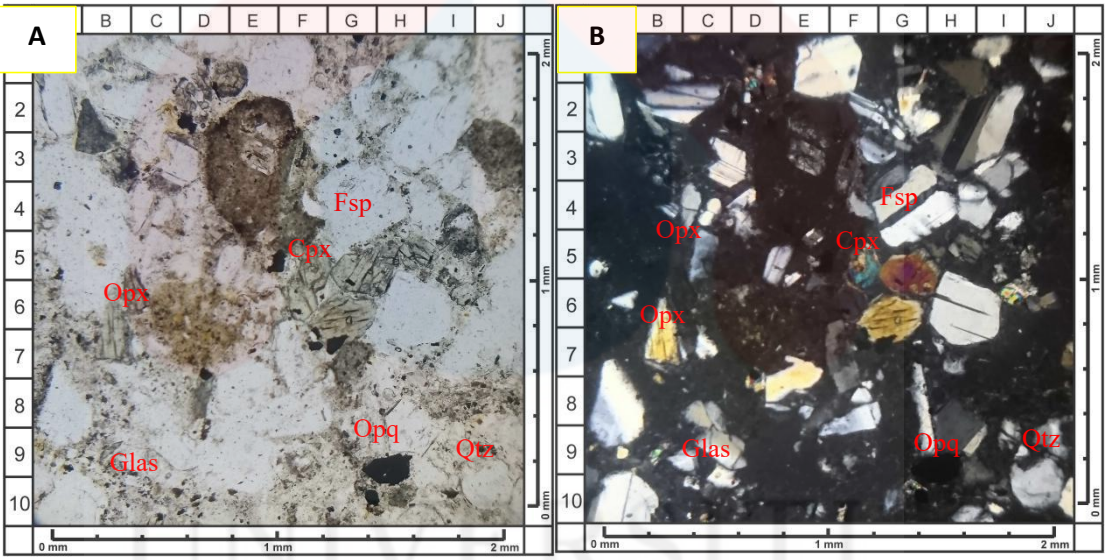


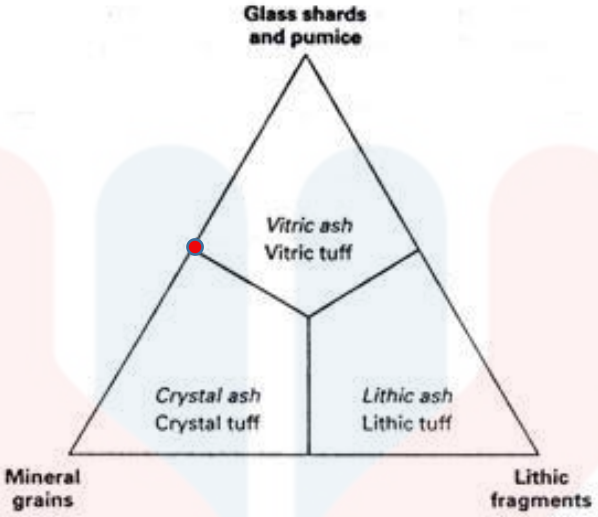

**Figure 4.29:** (A) Plane Polarized Light (PPL). (B) Cross Polarized Light (XPL)

Observation under microscope

The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation was considered massive structure, the grain size was about <1/256 – 1/2 mm, open fabric, the shape of mineral round but have edge and the mineral was medium sorted texture.

**Table 4.4**: The mineral composition of crystal tuff

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Quartz (Qtz) | 5 | This mineral was show the secondary quartz. It also show white colour under PPL while under XPL the colour was whitish grey. The relief was low with no cleavage. The shape of mineral was crystal anhedral with low pleochroism |
| Feldspar (Fsp) | 35 | It show the light colour under PPL and grey colour under XPL with the albite twinning. The shape of mineral was subhedral to euhedral. The pleochroism was medium with one direction of cleavage. |
| Clinopyroxene (Cpx) | 4 | It show the light brown with low relief under PPL and blue natural colour under XPL. The pleochroism was poor with two direction of cleavage. This mineral distributed as the spotted in thin section. |
| Orthopyroxene (Opx) | 5 | It show the light brown colour with low relied under PPL and brownish orange colour under XPL. The pleochroism was poor with two direction of cleavage. This mineral distributed as the spotted in thin section. |
| Volcanic glass (Glas) | 48 | It show whitish brown colour with relief under PPL and greynish black colour under XPL. The mineral show crystal shape and does not have cleavage. |
| Opaque minerals (Opq) | 3 | Both colour under PPL and XPL was black |




**B. Alternation of sandstone and mudstone.**

Along the traverse, the alternation of sandstone and mudstone indicate that the area was sub unit 2 of Sambipitu Formation. This sub unit can been said as the middle part of Sambipitu Formation. The sandstone that been found was medium to light grey in colour and the grain sizes range form medium to very fine grain. The mudstone that been found was silt to mud grain. Typical colour of this mudstone was light to light brownish. In field, the comperator card was been used in order to help determined the grain size of the rock. There was bioturbation that start to appear (Figure 4.30)

**Figure 4.30:** The bioturbation

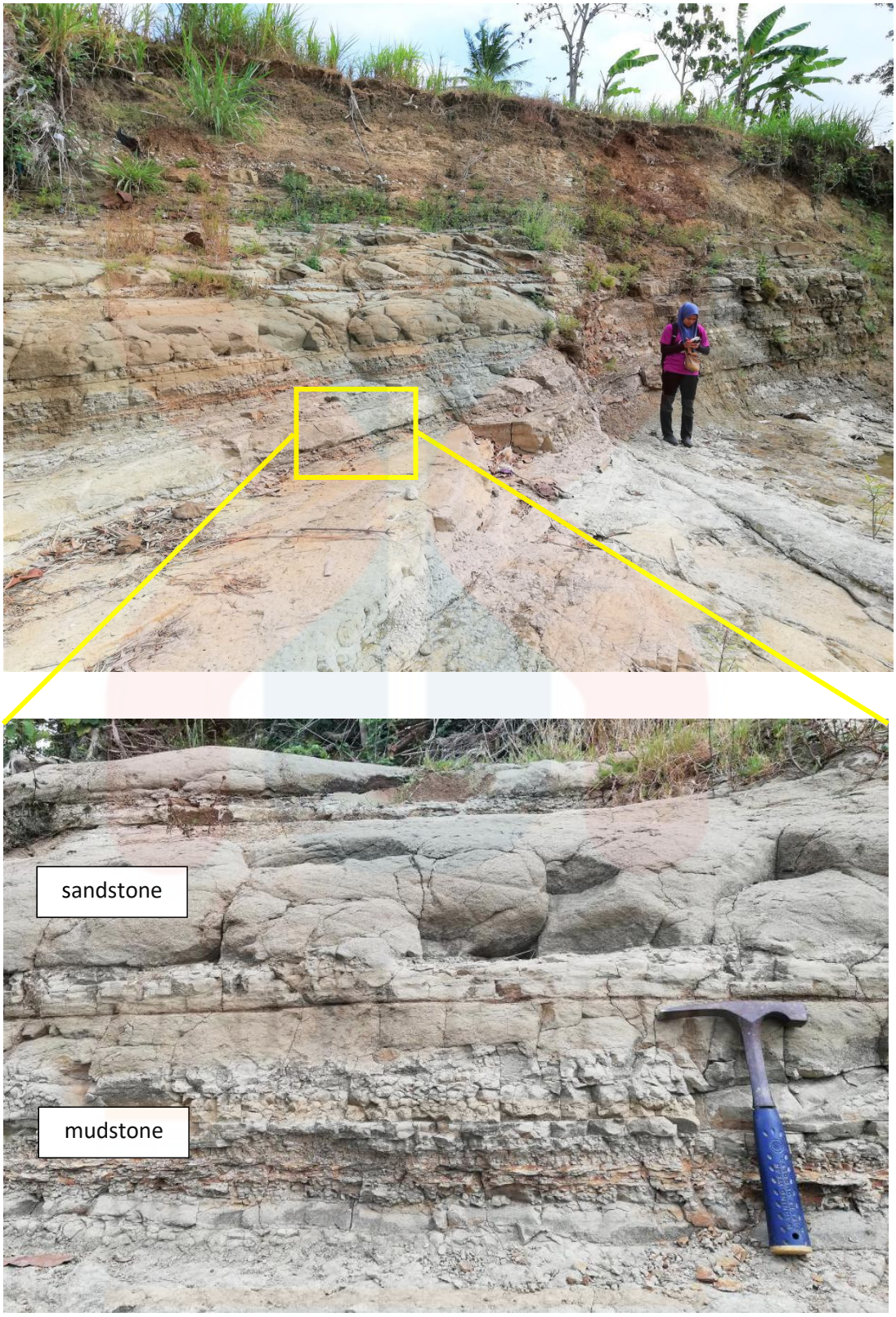



**Figure 4.31:** The alteration sandstone and mudstone outcrop.

**C. Mudstone unit**

Mudstone unit was been name as there was the massive mudstone which indicate the sub unit 3 of Sambipitu Formation. This sub unit was been said as the middle part of Sambipitu Formation. The outcrop that been found was mudstone with interbedded of sandstoe. This unit had clay to silt grain size. The dominant rock in this unit was claystone. Typical for this unit was they had cleavage on the claystone. This structure show the line crack with no movement. It was form because of the pressure solution and the degree of the deformation. This mudstone had high content of clay mineral which made it the colour of this sub unit was brownish colour.

**Figure 4.32:** Cleavage on the mudstone

**C. Carbonaceous sandstone unit:**

Carbonaceous sandstone unit was the last sub unit of Sambpitu Formation. This unit was been called sub unit 4 or been said as upper part of Sambipitu Formation. The lithologies of this sub unit was carbonaceous sandstone, breccia sandstone and thin bedding of mudstone. Mudstone was intercalation in this sub unit. The fragment of breccia sandstone was build up from limestone fragment which the size of this fragment range from fine to pebbles grain. This unit had high amount of calcium carbonates. As the near to contact of Oyo Formation, the bed of sandstone become thinner while the limestone unit become thicker. The absent of mudstone bed indicate the Oyo formation was start.

**Figure 4.33**: The breccia sandstone with the limestone fragment.

Hand specimen 19 BR D2C17 was the limestone fragment the breccia sandstone was been undergo petrography analysis. The limestone fragment was been name as rudstone based on the Embry and Klovan, 1971.

| | | | |
|---|---|---|---|
| No sample | : 19 BR D2C17 | Rock name | : Rudstone |
| Location | : Sambipitu Formation | Rock unit | :Carbonaceous sandstone unit |

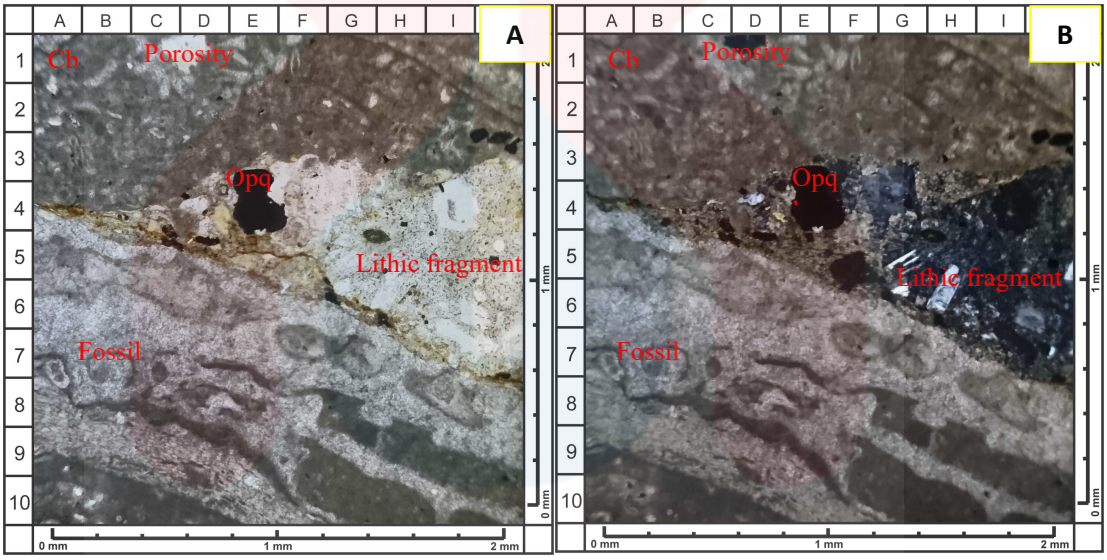



**Figure 4.34:** (A) Plane Polarized Light (PPL). (B) Cross Polarized Light (XPL)

Observation under microscope:

The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation was considered massive structure, grain size with <1/256 – >2 mm, poor sorting and close fabric.

**Table 4.5**: The mineral composition of rudstone.

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Fossil | 55 | Brown colour with low relief under PPL and brownish light colour under XPL. The pleochorism from moderate to strong which arrange by calcite mineral and clay carbonate. |
| Lithic fragment | 15 | It show brown colour under PPL and dark brown colour under XPL. This lihtic fragment made up from quartz mineral, feldspar, pyroxene, opaque mineral and volcanic glass. This lithic fragment also appeared in spotted area in thin section. |
| Carbonate mineral (Cb) | 25 | It show white brown colour with relief under PPL and light brown under XPL. The shape of mineral was crystal and does not had cleavage. |
| Opaque mineral (Opq) | 3 | Both dark colour under PPL and XPL |
| Porosity | | Light colour under PPL and dark colour under XPL |

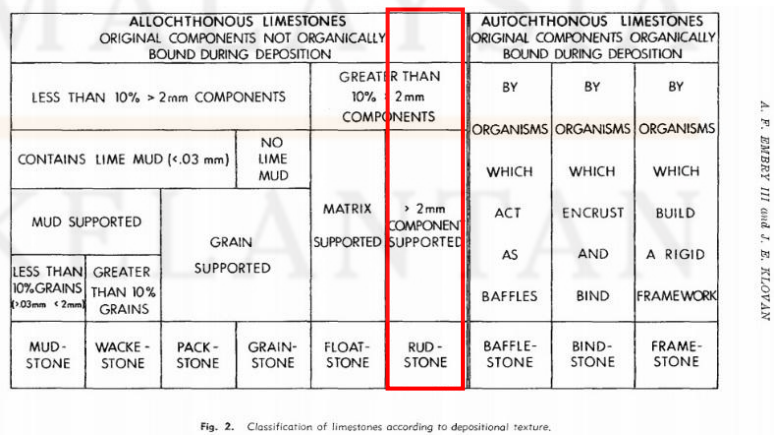



Fig. 2. Classification of limestones according to depositional texture.

#### 4.3.2.3 Oyo Formation

Oyo Formation was been deposited after the volcano activity was been stop. The carbonate organism start to nourish and deposited above the Sambipitu Formation. The distribution of this formation can be seen in geological map with the light blue colour. This formation was located at the middle part of study area which located below the Sambipitu Formation. Based on the geological map, this formation was been covered almost 15% and distributed horizontally in study area. Along the traverse, the Oyo Formation was been recognize by the appear of tuffaceous limestone and the absent of mudstone. This was because, Oyo Formation was been known as the tuffaceous limestone which lie above the Sambipitu Formation. Typical rock in Oyo Formation were fine grain limestone. Therefore, tuffaceous limestone unit was been found in study area.

**A. Tuffaceous limestone unit**

Oyo Formation was been dominant with tuffaceous limestone. Lithologies that been found in this unit were tuffaceous limestone, packstone and wackestone. Typical of this unit was the grain of limestone fine grain to very fine grain. The Dunham classification and its modification by Embry and Klovan classification was been used in order to identify the texture of carbonate rock during the field observation. This finding was been support by petrography analysis, that show the rock sample from the outcrop that been collected was wackestone.

Figure 4.35 with the E 110º 29’ 23.73”, S 07º 54’ 07.43” was tuffaceous limestone and the Figure 4.37 was packstone which shows the different types of limestone unit that been present in study area. The tuffaceous limestone in this unit had a colour of pale white and light grey after weathering. The mineral content for this unit was been identified by petrography analysis based on the sample 19 BR D7C27 as shown in Figure 4.38 and in the table 4.6. The name of this rock sample was wackestone based on Embry and Klovan, 1971 and calcareous mudrock based on modified from Pettijohn, 1975. The fossil that been found (Figure 4.38) show that the formation was shallow marine environment.

**Figure 4.35:** Tuffaceous limestone outcrop at E 110º 29’ 23.73”, S 07º 54’ 07.43”.


**Figure 4.36**: The hand specimen of tuffaceous limestone.

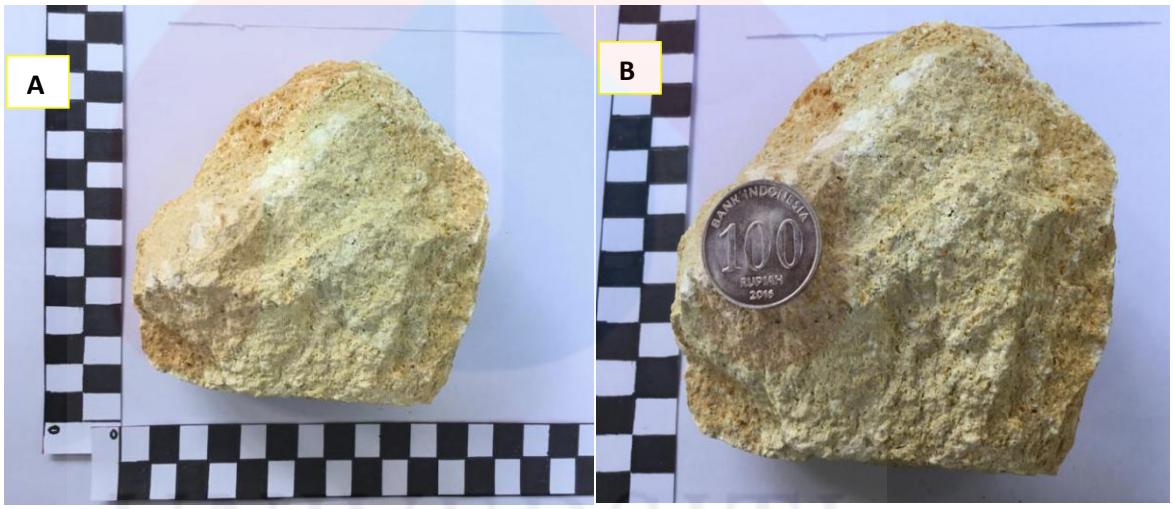



**Figure 4.37**: The hand specimen of packstone

| | | | |
|---|---|---|---|
| No sample | : 19 BR D7C27 | Rock name | : Wackestone |
| Location | : Oyo Formation | Rock unit | :Tuffaceous limestone unit |
| Coordinate | : E 110º 29’ 23.73”<br>S 07º 54’ 07.43” | | |

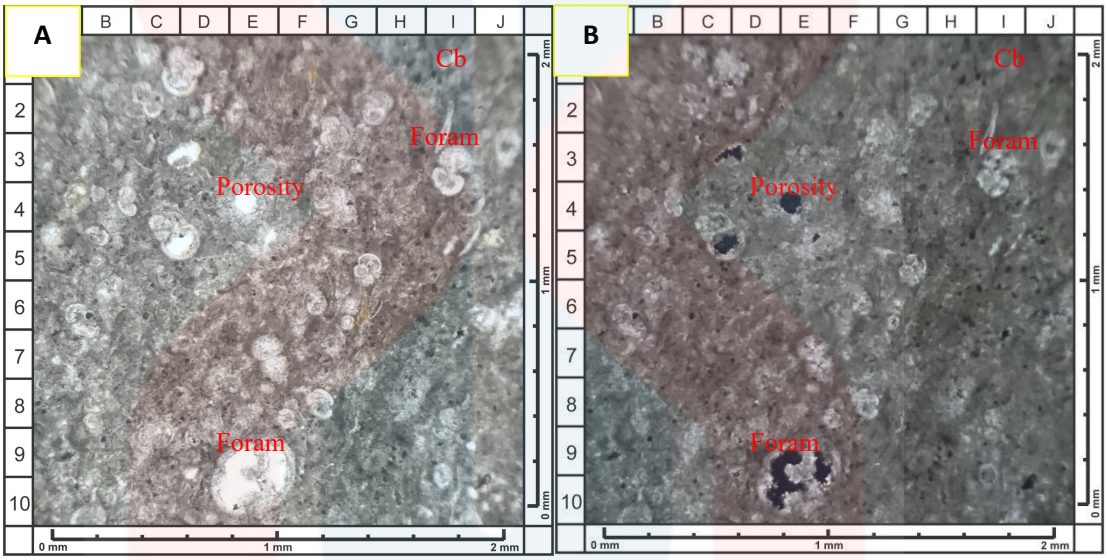



**Figure 4.38:** (A) Plane Polarized Light (PPL). (B) Cross Polarized Light (XPL)

Observation under microscope:

The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation was considered massive structure, grain size with <1/256 – 1/2 mm , well sorting and close fabric.

**Table 4.6**: The mineral composition of wackestone

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Fossil | 30 | It show light brown colour with low relief under PPL and dark brown colour under XPL. The pleochroism was moderate to high. The fossil was arrange with calcite mineral and clay carbonate. |
| Carbonate mineral (Cb) | 67 | White brown colour under PPL and dark brown under XPL. The shape of mineral was crystal and does not had cleavage. |
| Porosity | 3 | It show white colour like hollow shape under PPL and dark or black under XPL. |

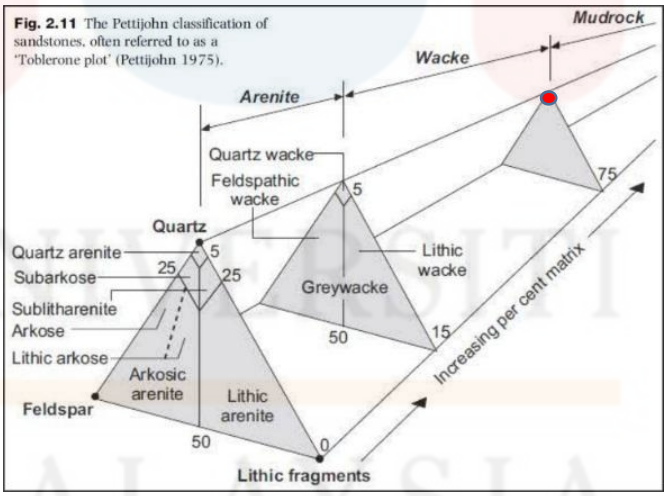


Fig. 2.11 The Pettijohn classification of sandstones, often referred to as a 'Toblerone plot' (Pettijohn 1975).

#### 4.3.2.4 Wonosari formation

Wonosari Formation was the youngest formation in study area. Based on the geological map, the distribution of this formation can been seen with the dark blue colour. The distribution of this formation was been located at the south part of the study area. Wonosari Formation was covered almost 30% and distributed horizontally. Based on the field observation, the Wonosari Formation was been recognize by massive of limestone. This finding was been support by geomorphology of the surrounding which typical geomorphology for Wonosari Formation was conical hills (Figure 4.39). Wonosari formation was marine environment which mostly built up from reef coral.


**Figure 4.39 :** Conical hils that found at Wonosari Formation which (A) with coordinate and (B) with coordinate.

**A. Limestone unit**

Lithologies that been found in this unit were grainstone, rudstone and oncolites. The Dunham classification and its modification by Embry and Klovan classification was been used in order to identify the grain of limestone unit for Wonosari Formation during the field observation. Typical grain for this unit was coarse grain which mostly the grain support. The outcrop for this unit usually grey to dark grey with resistant to weathering.

Figure 4.41 show the oncolites that been found near to Oyo River. The present of oncolites show that the Wonosari Formation was shallow water environment. The bigger size of oncolites show that the stronger turbulence was happened. Figure 4.40 show the outcrop of the rudstone and grainstone that been found in the study area.

The rock sample 19 BR D3C11 was been identify by petrogprahy analysis as shown in Figure 4.42 and in the table 4.7. Base on the petrography analysis, the rock was been name as grainstone as the component in the rock was more than 10% and grain supported with 45% of fossil.


**Figure 4.40 :** The rudstone and grainstone outcrop at Oyo River

**Figure 4.41:** The oncolites that found at Oyo River

| | | | |
|---|---|---|---|
| No sample | : 19 BR D3C11 | Rock name | : Grainstone |
| Location | : Wonosari Formation | Rock unit | : Limestone unit |
| Coordinate | : E 110º 29’ 47.37” | | |
| | S 07º 54’ 37.77” | | |

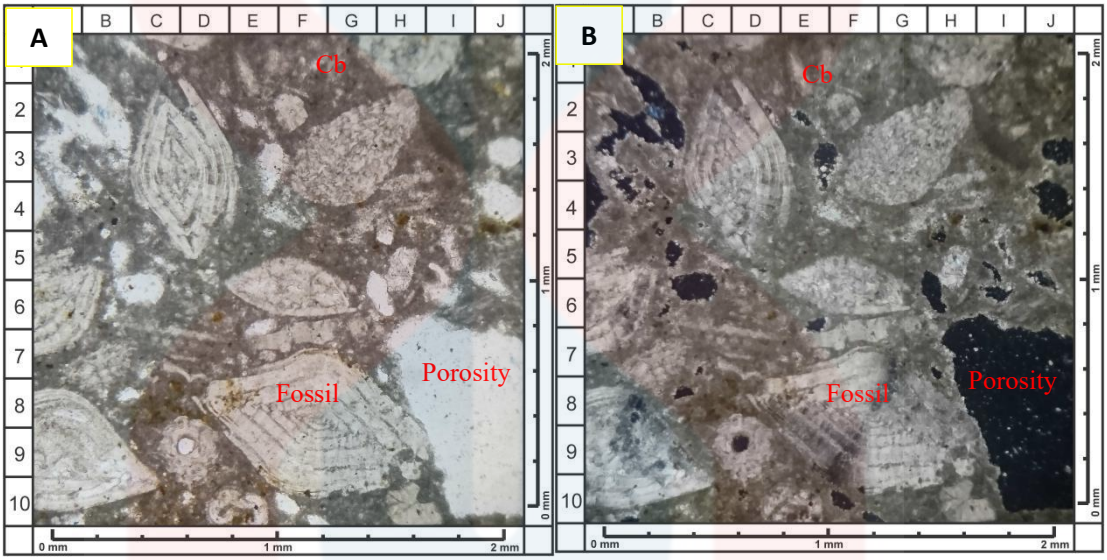



**Figure 4.42:** (A) was Plane Polarized Light (PPL) and (B) was Cross Polarized Light (XPL)

Observation under microscope:

The observation was been carried out by using the 10x magnification of ocular lens of microscope and 5x objective lens of magnification. The observation was considered massive structure, grain size with <1/256 – 1 mm, moderate sorting and close fabric.

**Table 4.7:** The mineral composition of grainstone

| Mineral description | | |
|---|---|---|
| Mineral composition | Amount (%) | Description of optical mineral |
| Fossil | 45 | Brown with low relief under PPL while dark brown under XPL. The pleochroism from moderate to strong. This fossil was arrange by mineral calcite and clay carbonate. |
| Carbonate mineral (Cb) | 40 | White brown colour with relief under PPL sand brown under XPL. There is pleochroism which the shape of this mineral was crystal. There was no cleavage can been seen |
| Porosity | 15 | White colour under PPL and dark in XPL |

## 4.4 Structural geology

Generally, all the structure that contain in study area will interpreted before went to the field as the linear by using lineament analysis. This structure had been mapped (Figure 4.43) during the preliminary studies stage. Later, this structure that been mapped will be conform during the geological fieldwork. Later, the lineament that been map will used to find out and identified the types of structure was occurred at the location during the fieldwork. This structure include the regional structure and local structure. Usually, the structure that happened in study area was associated with regional structure. Therefore, it was important to map out the structure that found during the the fieldwork.

There were several geological structures was been found in study area such as joint, fault, fold. These geological structures can easily seen in Sambipitu Formation, Oyo Formation and Wonosari Formation. There were difficult to find the structure in Nglanggeran Formation because of this formation was made up from volcanic rock and lava. However, the structure that can been found in this formation within the study area were autobreccia, columnar joint and bread crust.

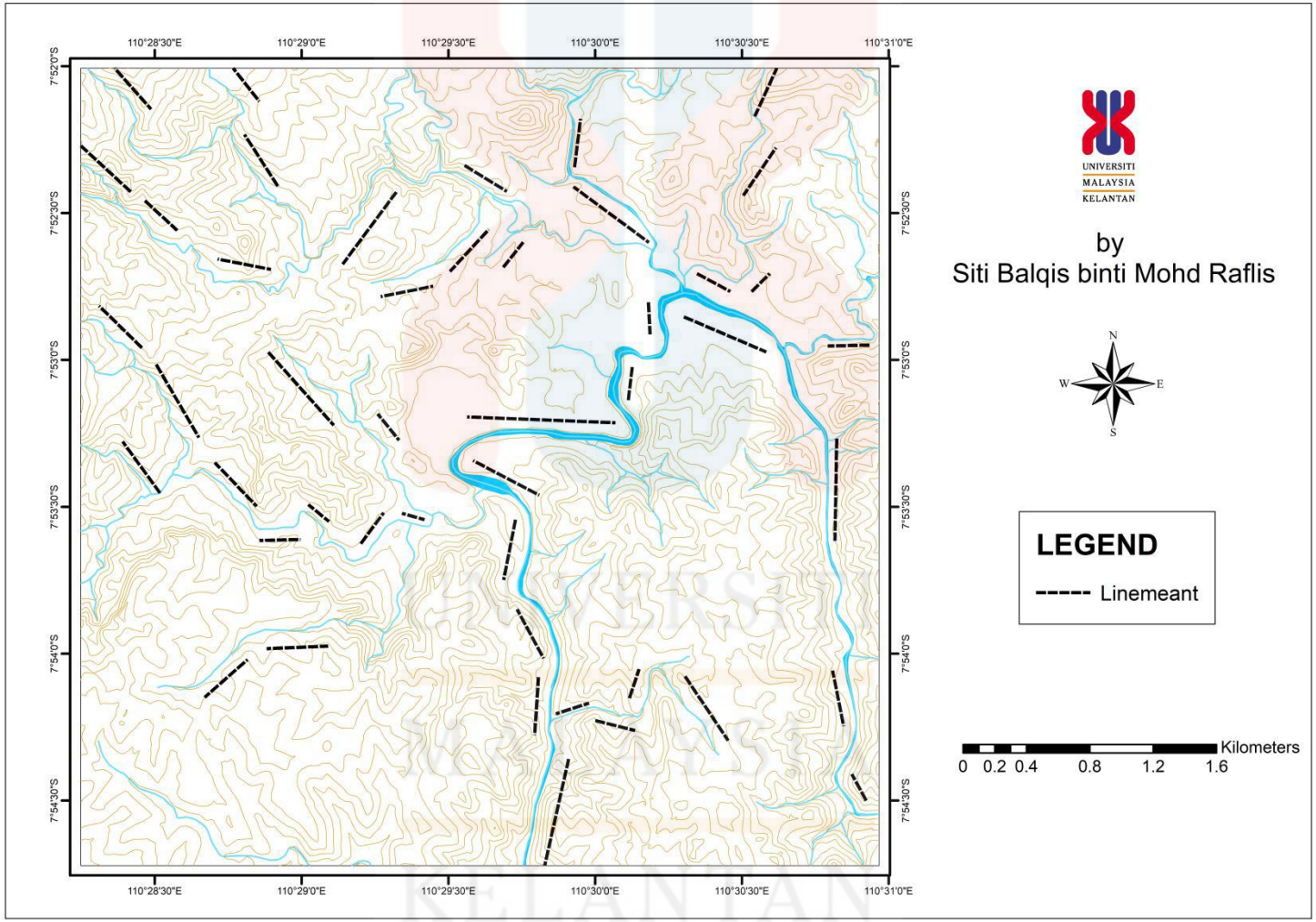



**Figure 4.43:** The lineament map

### 4.4.1 Joint

Joint was the result form the brittle fracture of rock because of the tensile stress and compression stress. To recognize joint, there was the fracture but no movement was occur. There were two types of joint that been found in study area which were non systematic joint and systematic joint that been showed in Figure 4.44 and Figure 4.46. The non systematic joint was been found at altered lava at the Pentung River showed in Figure 4.44 with 7° 52' 30.4788" S, 110° 30' 8.1972" E The joint in this outcrop was been measured to know the sigma 1 to know the direction force that been act on it (Figure 4.45)

**Figure 4.44 :** The non systematic joint at alteration of lava at the Pentung River.

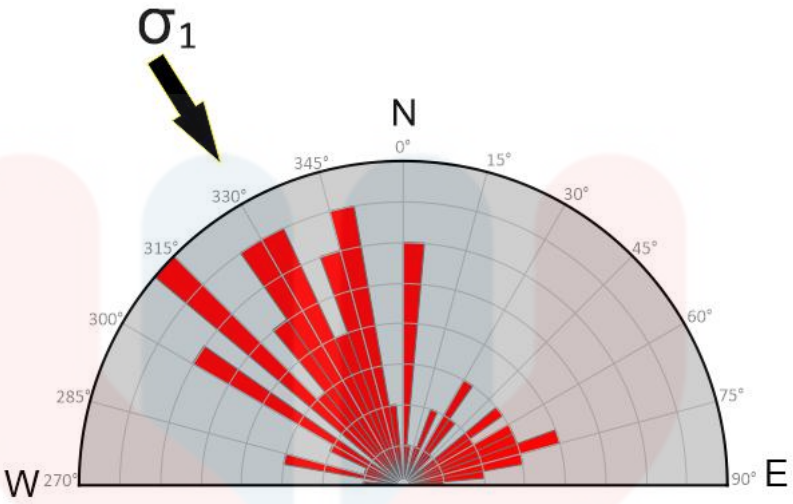



**Figure 4.45**: The direction of sigma 1 on alteration lava at Pentung River

Besides that, type of systematic joint that been found in study area was orthogonal joint which dihedral angle of 90º. Systematic joint can been used as the indicator for paleo-stress as this joint was develop by reflection of regional tectonic stress trajectories. This joint was been found on sandstone rock located at Oyo River with 7° 52' 52.3596" S, 110° 30' 12.4992" E as Figure 4.46 showed the orthogonal joint and this joint was been measured to know the σ1 in this outcrop. By measure the joint, it can been know the direction of force that been act on this outcrop (Figure 4.47)

**Figure 4.46 :** The orthogonal joint located at Oyo River

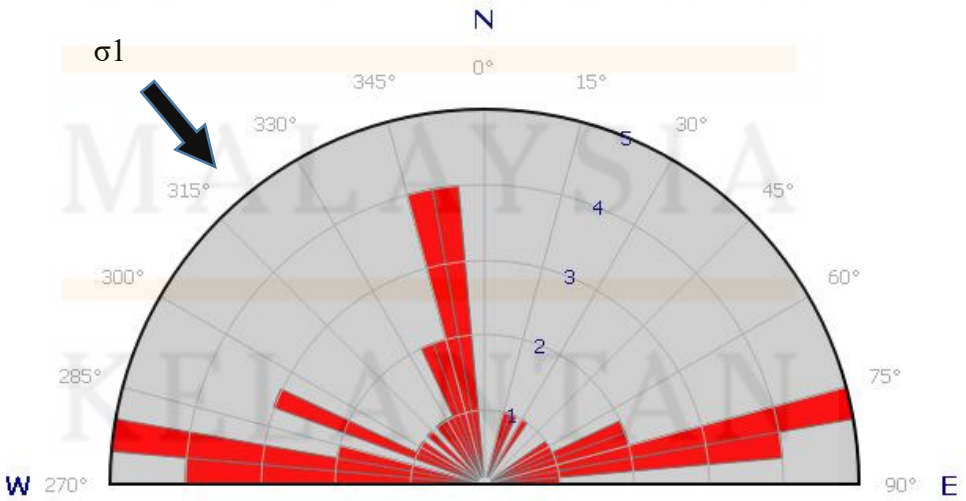



**Figure 4.47:** The direction of sigma 1 on sandstone at Oyo River

### 4.4.2 Faults

Fault can been define as the planar fracture in the rock with the displacement. There were several fault that been found in study area which were normal fault, thrust fault and strike-slip fault. Mostly structure that been observed during the field in my study area was minor structure. This minor structure was the result from the major structure that been happened in this area. It is important to know the direction of maximum and minimum principal stress during studying the fault analysis. The fault that been found can be used as the evidences for the lineament analysis. Fault also can been identify by fault evidences such as fault gauge, fault breccia and slicken-lines. This slicken lines on the fault plane was help in order to know the direction of displacement between two block of outcrop.

**A. Normal fault**

Normal fault was been identified by the movement of foot wall upward and the movement of hanging wall downward. Figure 4.48 show the normal fault at sandstone outcrop in Sambipitu Formation. Based on the Figure 4.48 , it can be seen the displacement occurred between two block or the movement of bedding. The left side block was move upward (foot wall) and other side was move downward (hanging wall). The angle of fault plane was 73º with the strike direction was N 34º E. This fault was occurred when maximum principle stress (σ1) was apply on the top which was vertical direction and the minimum principle stress (σ3) was released from the side which was horizontal direction

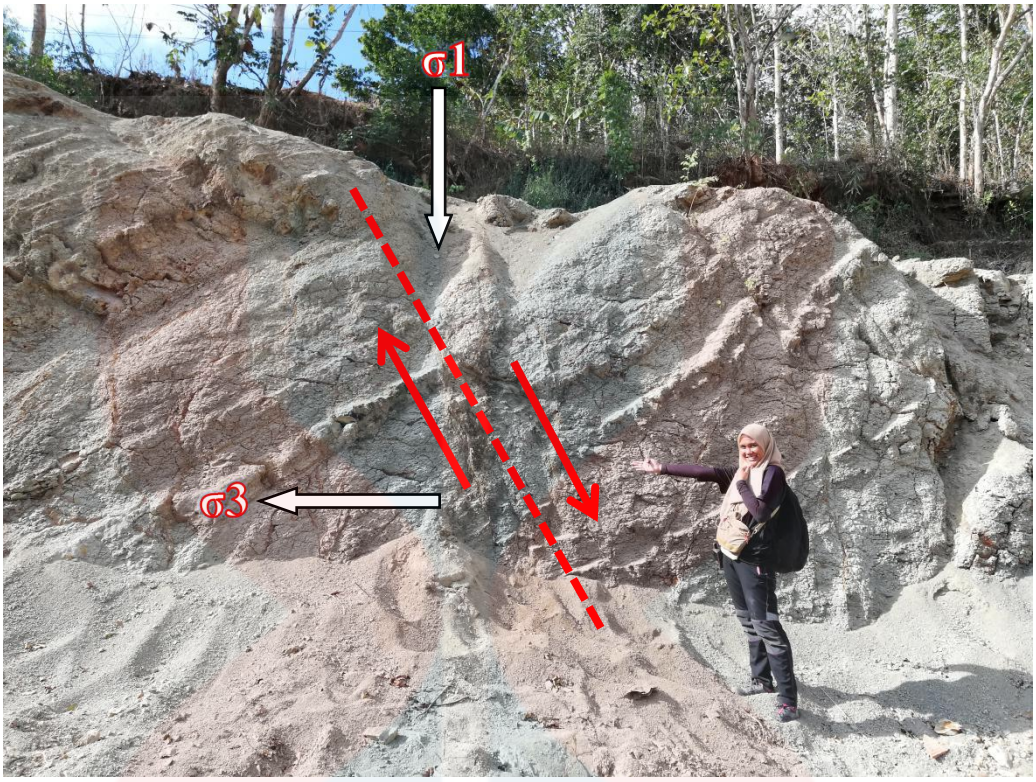



**Figure 4.48**: The normal fault located at sandstone of Sambipitu Formation

**B. Strike-slip fault**

There were two types of strike-slip fault which were dextral and sinistral strike-slip fault. Dextral strike-slip fault was right lateral while sinistral strike-slip fault was left lateral. This fault can been identify by the displacement between two block side by side horizontally direction which parallel to the line of fault . This meant that, one of the block will move inward horizontally to the observer. The naming of type strike-slip fault based on which side was been move inward. Figure 4.49 shows the dextral strike-slip fault at the sandstone rock in Sambipitu Formation. The angle of fault plane was 53º. This fault was occurred when maximum principle stress (σ1) was exerted at the front direction and the minimum principle stress (σ3) was released from the side which was horizontal direction.

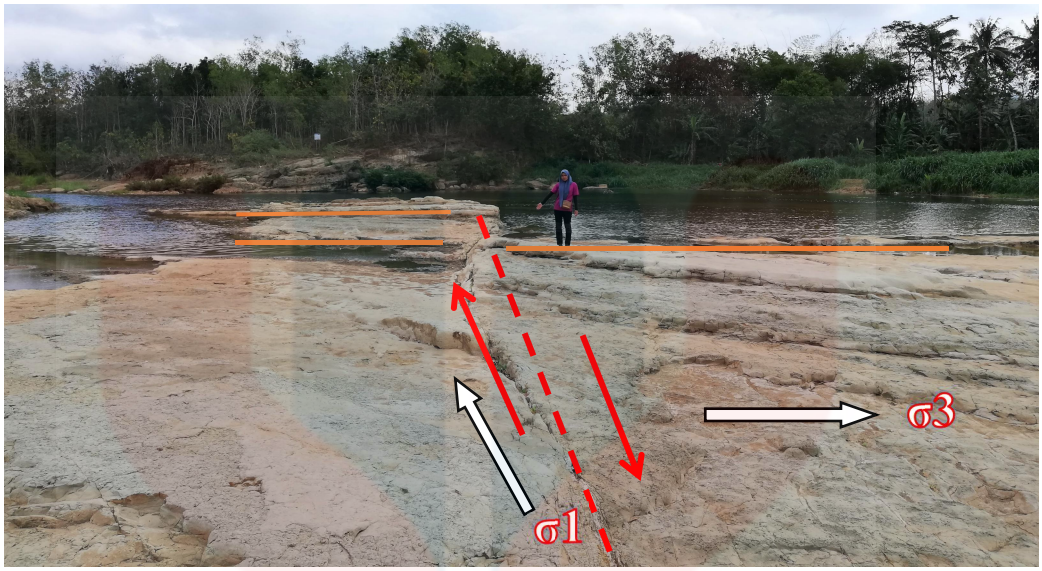



**Figure 4.49:** Dextral strike-slip located at sandstone of Sambipitu Formation in Oyo Formation.

### 4.4.3 Fold

The fold that been observed in the study area was located at Oyo River. The gentle anticline folding was been identified by the dip angle which was 16º that been show in Figure 4.50. This folding was been found at Oyo Formation.

**Figure 4.50 :** The gentle anticline at Oyo Formation.

# CHAPTER 5

# DEPOSITIONAL ENVIRONMENT OF SAMBIPITU FORMATION

## 5.1 Introduction

Depositional environment was about study the past environment and the origin of the rock deposited through the mechanism surrounding. Different environment would give the different of characteristic of rock that will deposited. This chapter were covered the depositional environment of Sambipitu Formation which were sandstone rock that been deposited at Pentung River and Saradan River.

## 5.2 Facies analysis

Based on the detailed stratigraphic log of facies analysis on Figure 5.4 and Figure 5.5 that was been carried out Pentung river and Widoro River (Figure 5.1). The details of lithostratigraphy and description on table 5.1 and table 5.2. Sambipitu Formation, it can be interprate that there were four facies association that been involve. These four facies association was been divided into Sub-unit 1, Sub-unit 2, Sub-unit 3 and Sub- unit 4. These four facies will be group by Lower, Middle and Upper Sambipitu Formation.

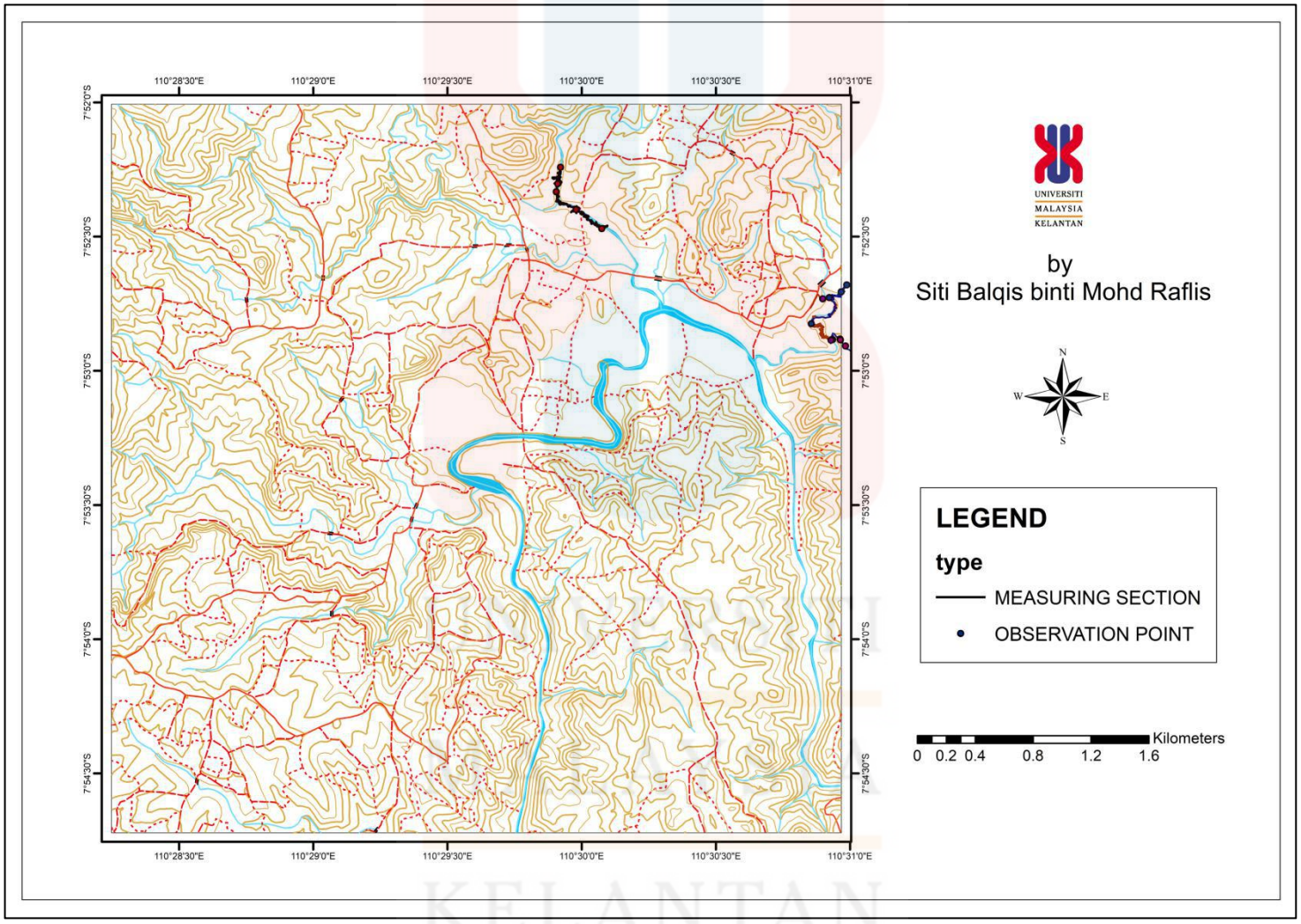
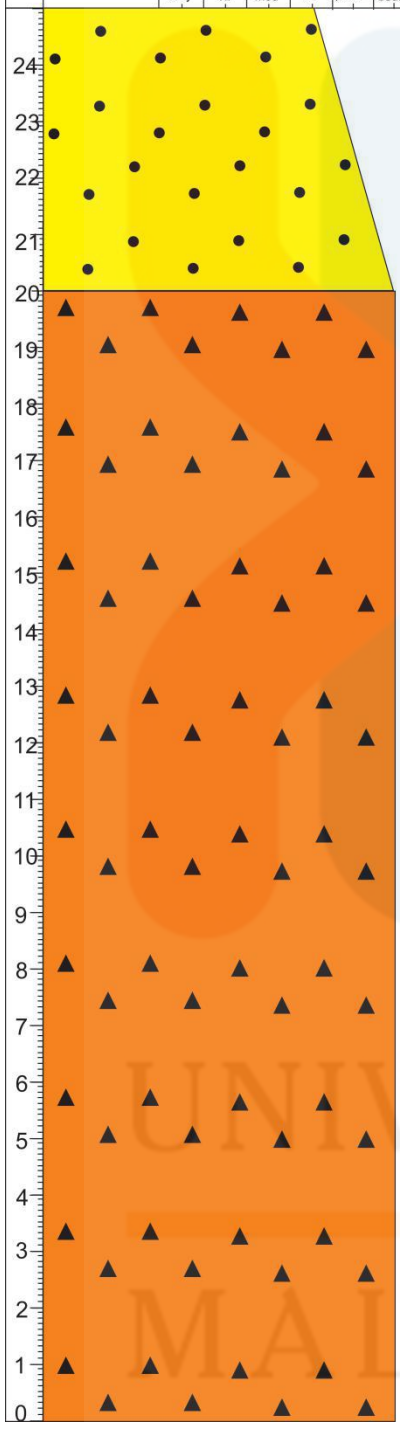


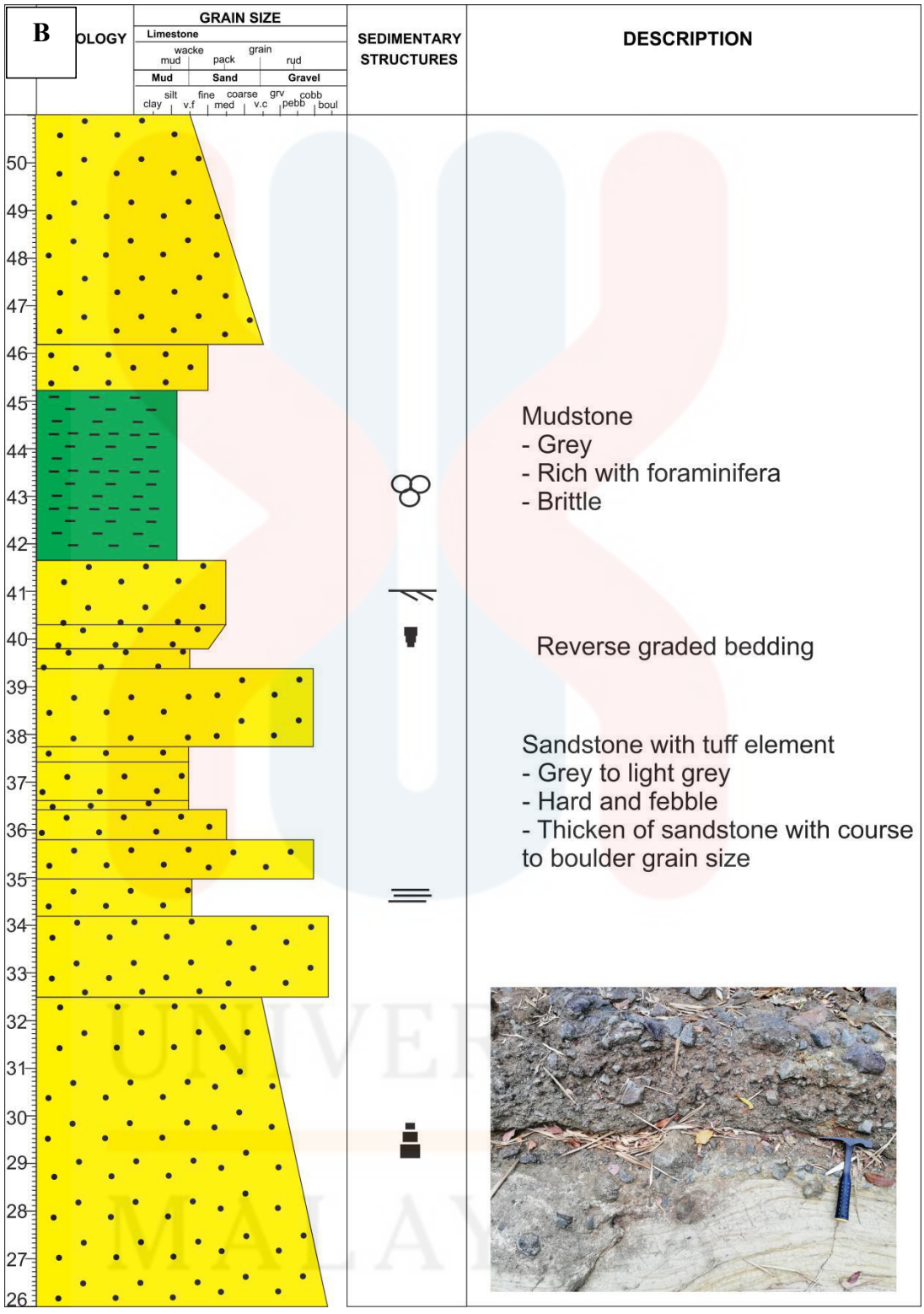

**Figure 5.1:** The location of measuring section

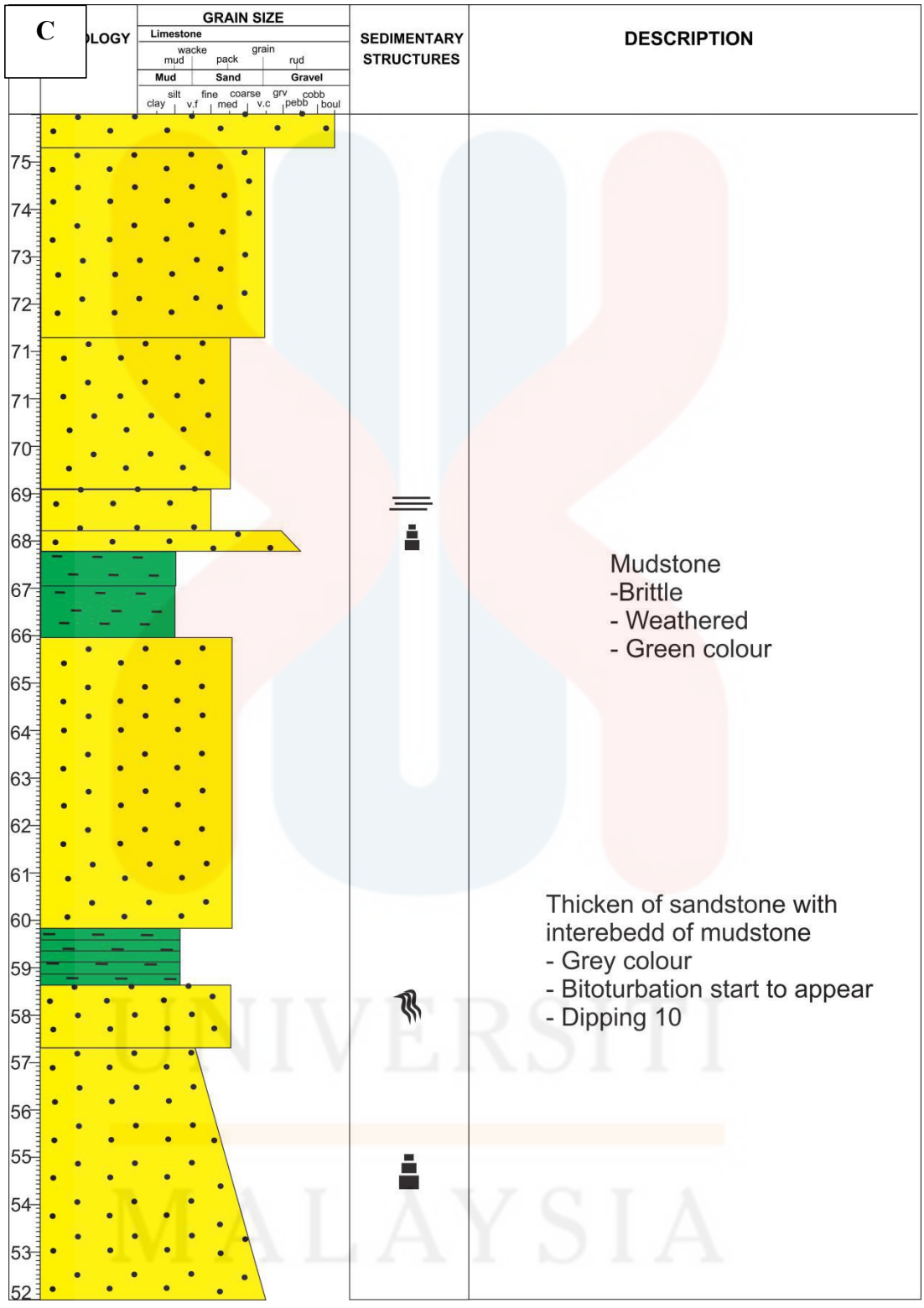
| A | OLOGY | GRAIN SIZE | SEDIMENTARY STRUCTURES | DESCRIPTION |
|---|---|---|---|---|
| | | Limestone: mud, wacke, pack, grain, rud<br>Mud / Sand / Gravel<br>clay, silt, v.f, fine, med, coarse, v.c, grv, pebb, cobb, boul | | |

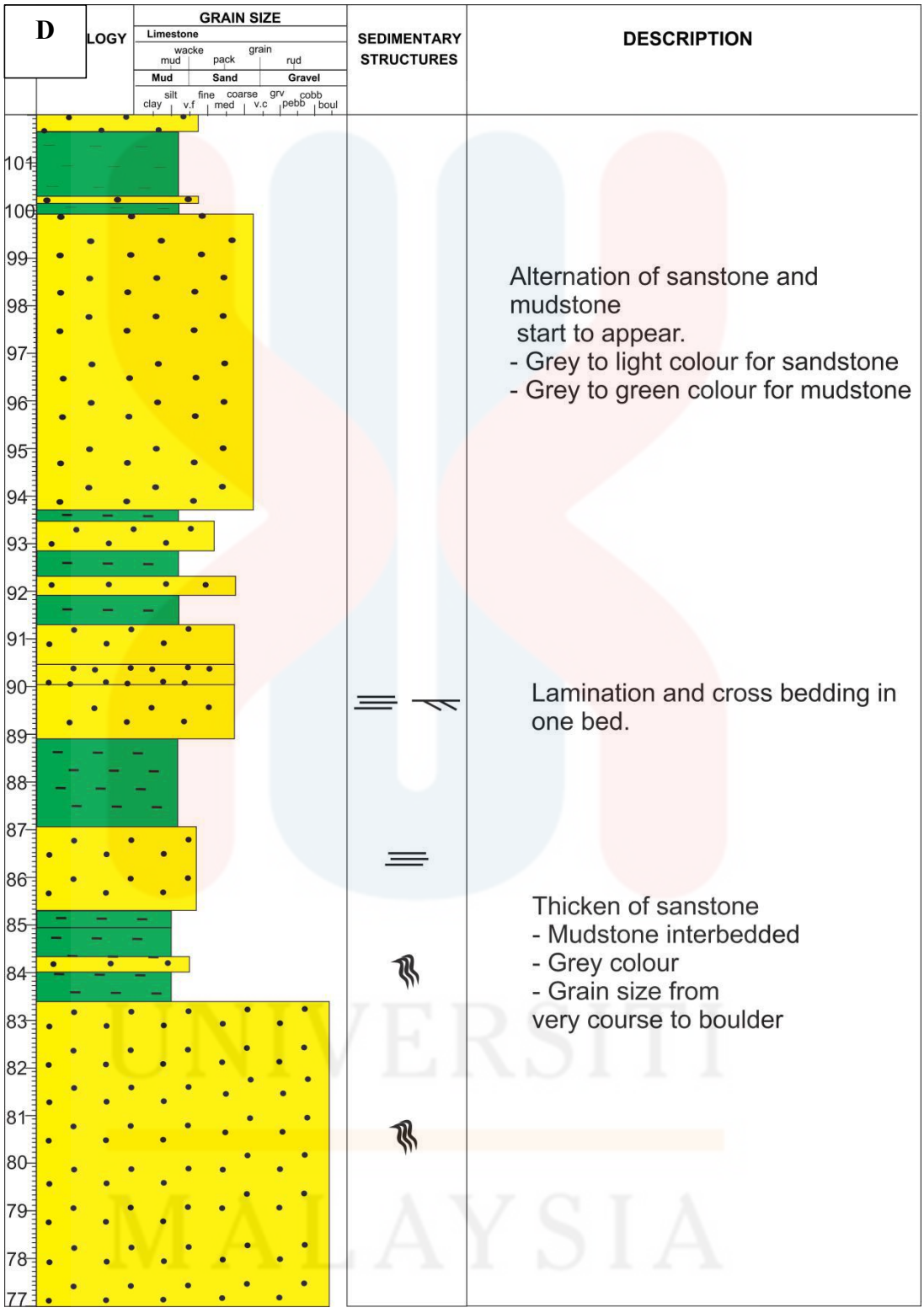



Breccia sandstone
- Grey to light grey
- Andesite and tuff fragment
- Graded bedding from boulder to very course grain
- N 75 E/ 15

Epiclastic volcanic breccia
- Dark grey to blakck in colour
- Mostly andesite
- Gravel to boulder fragment size







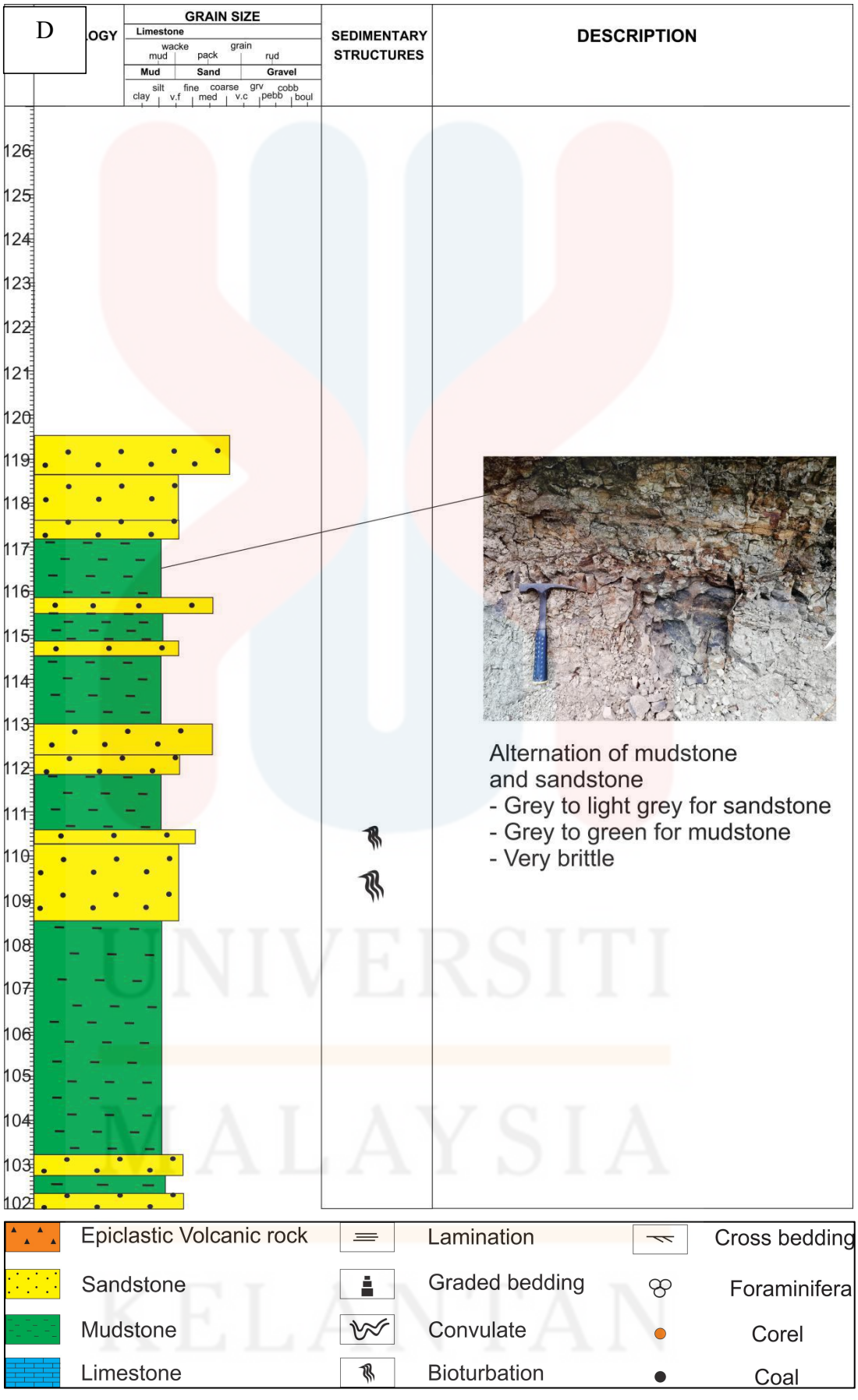
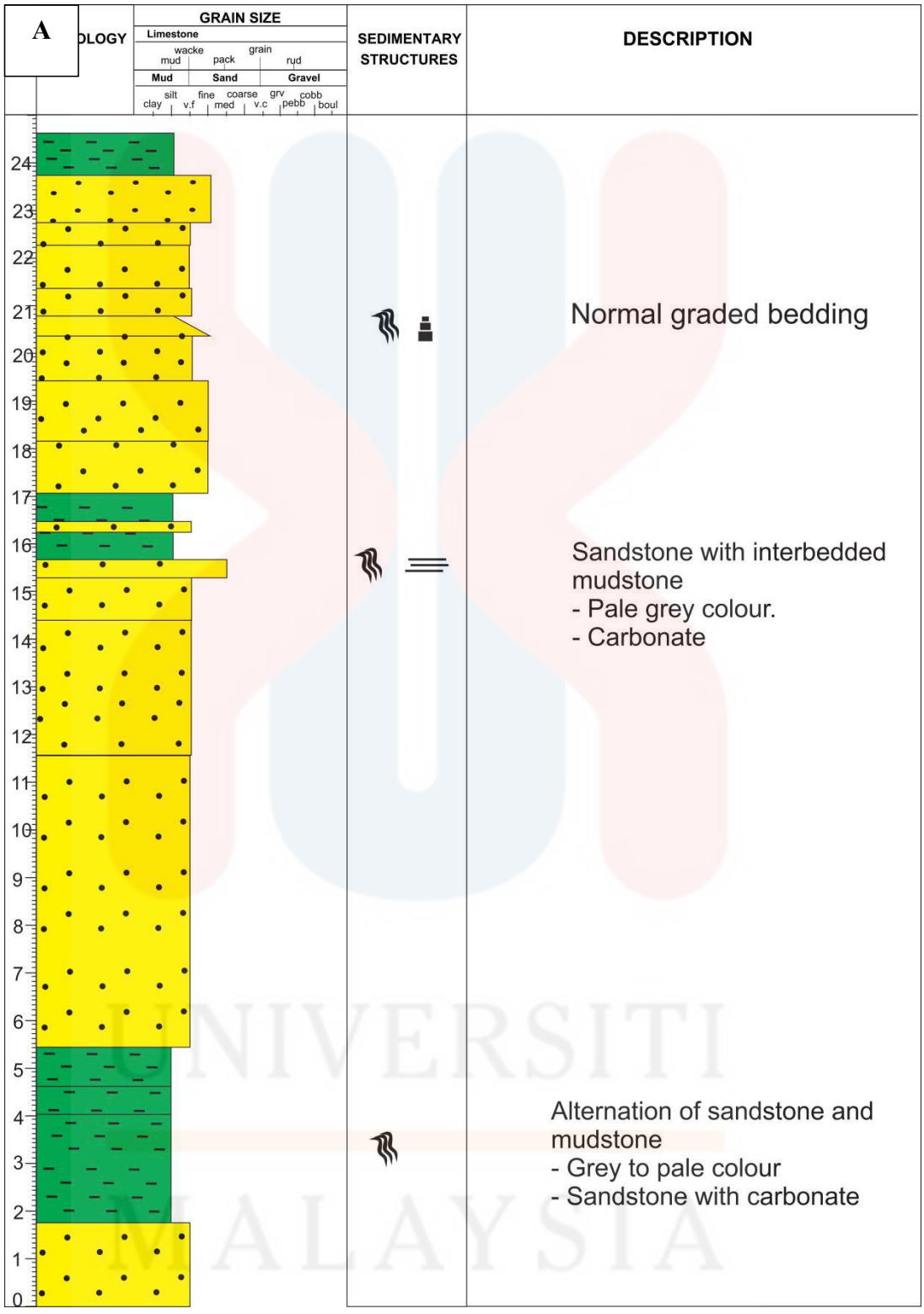
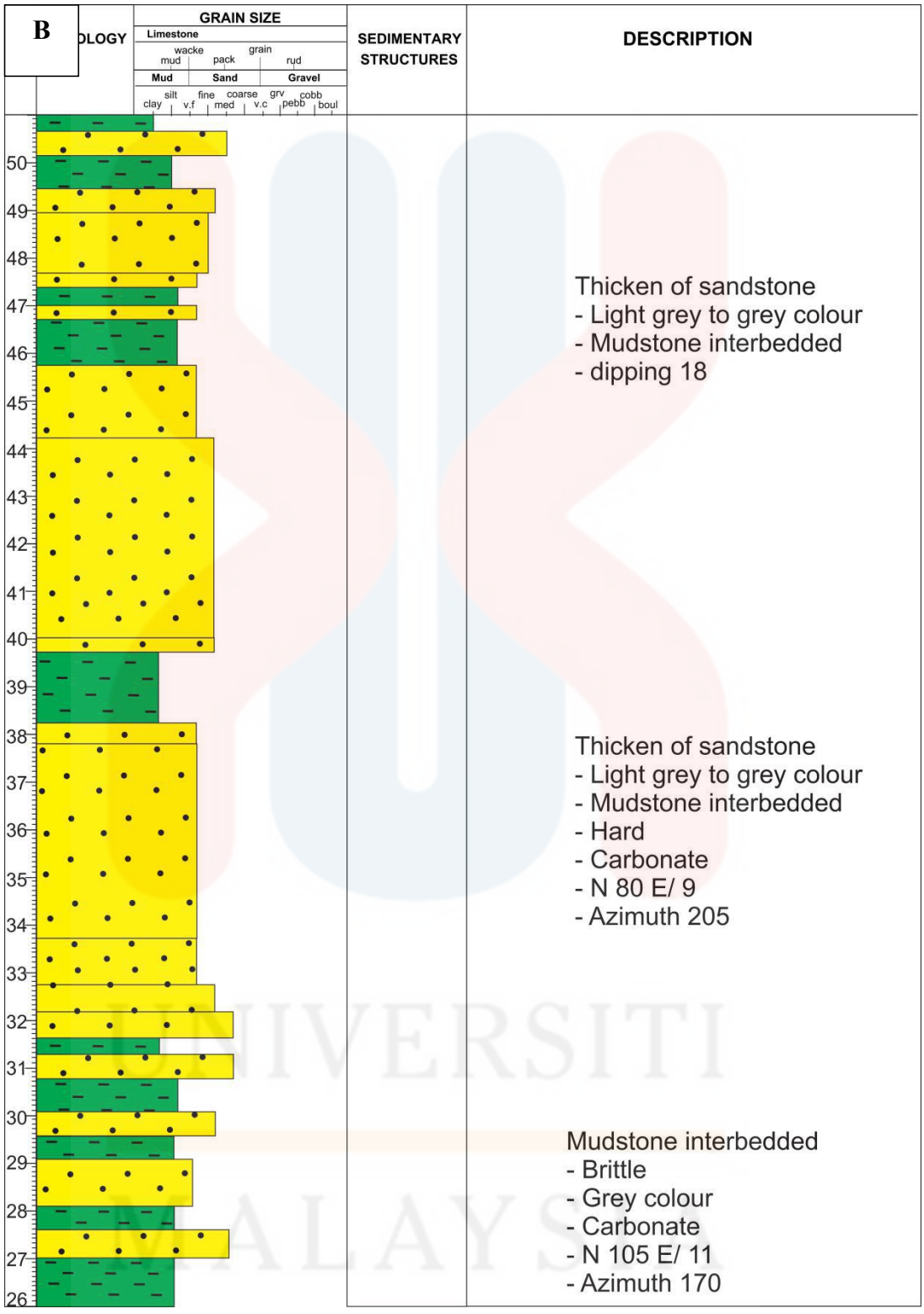
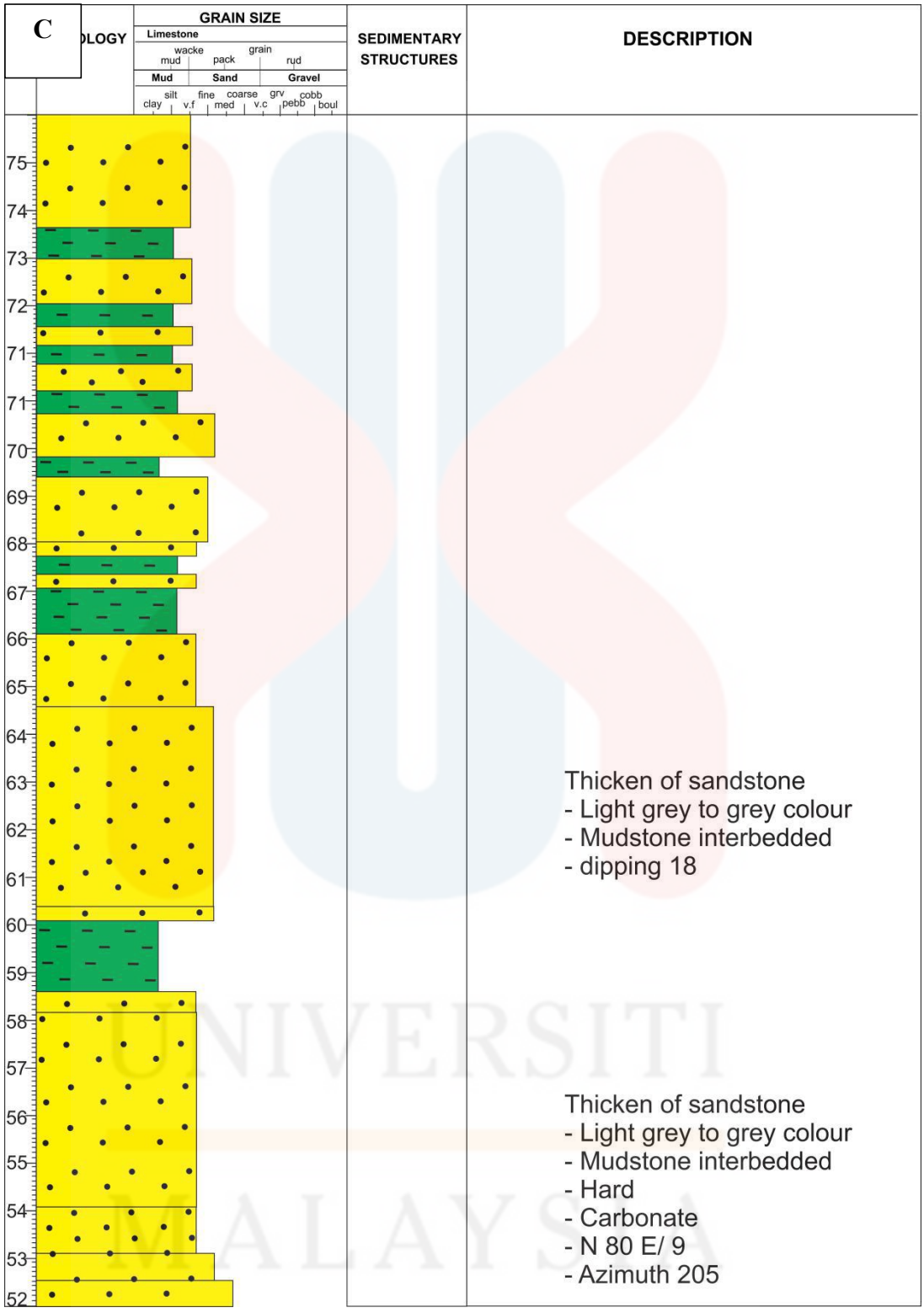
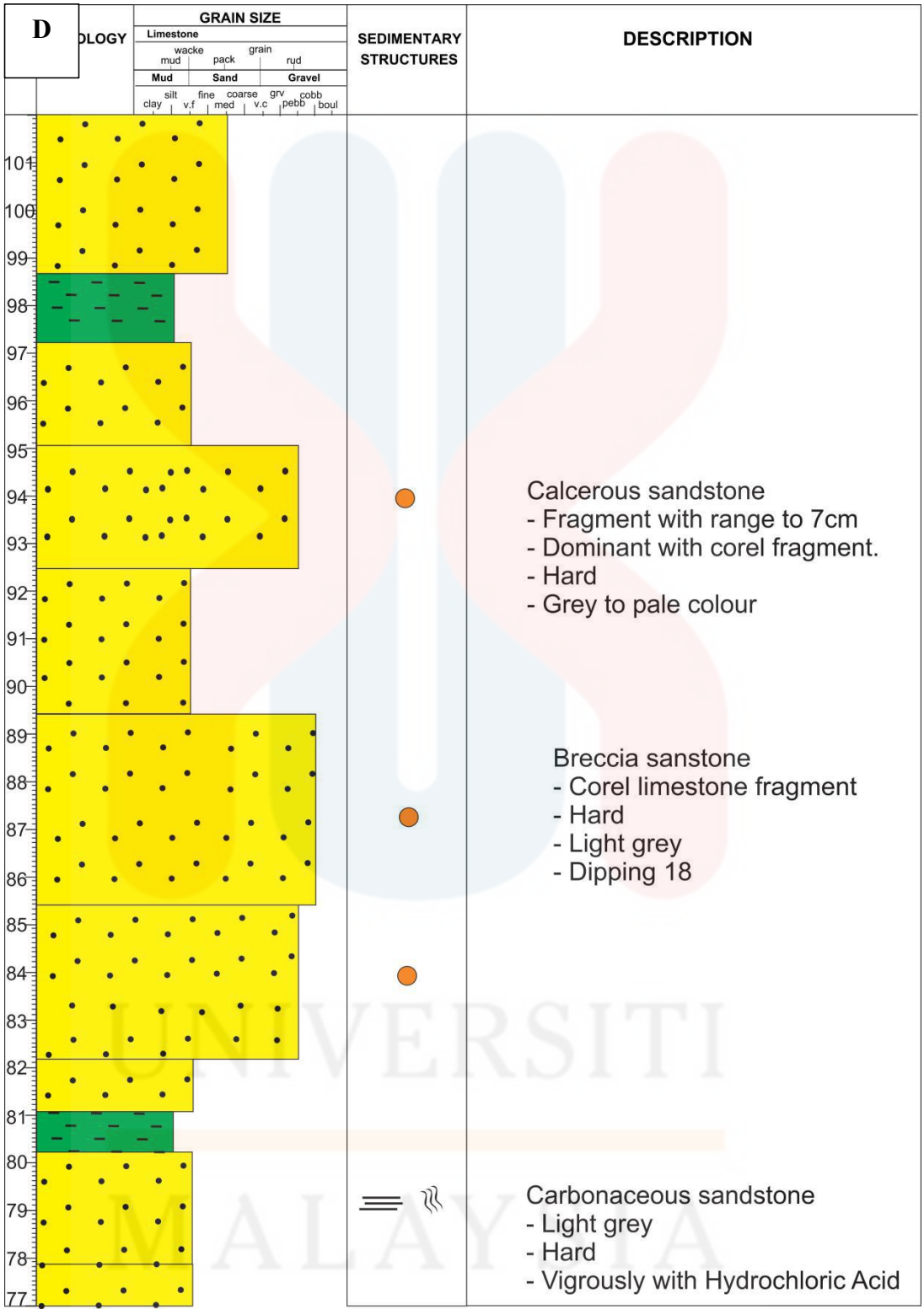


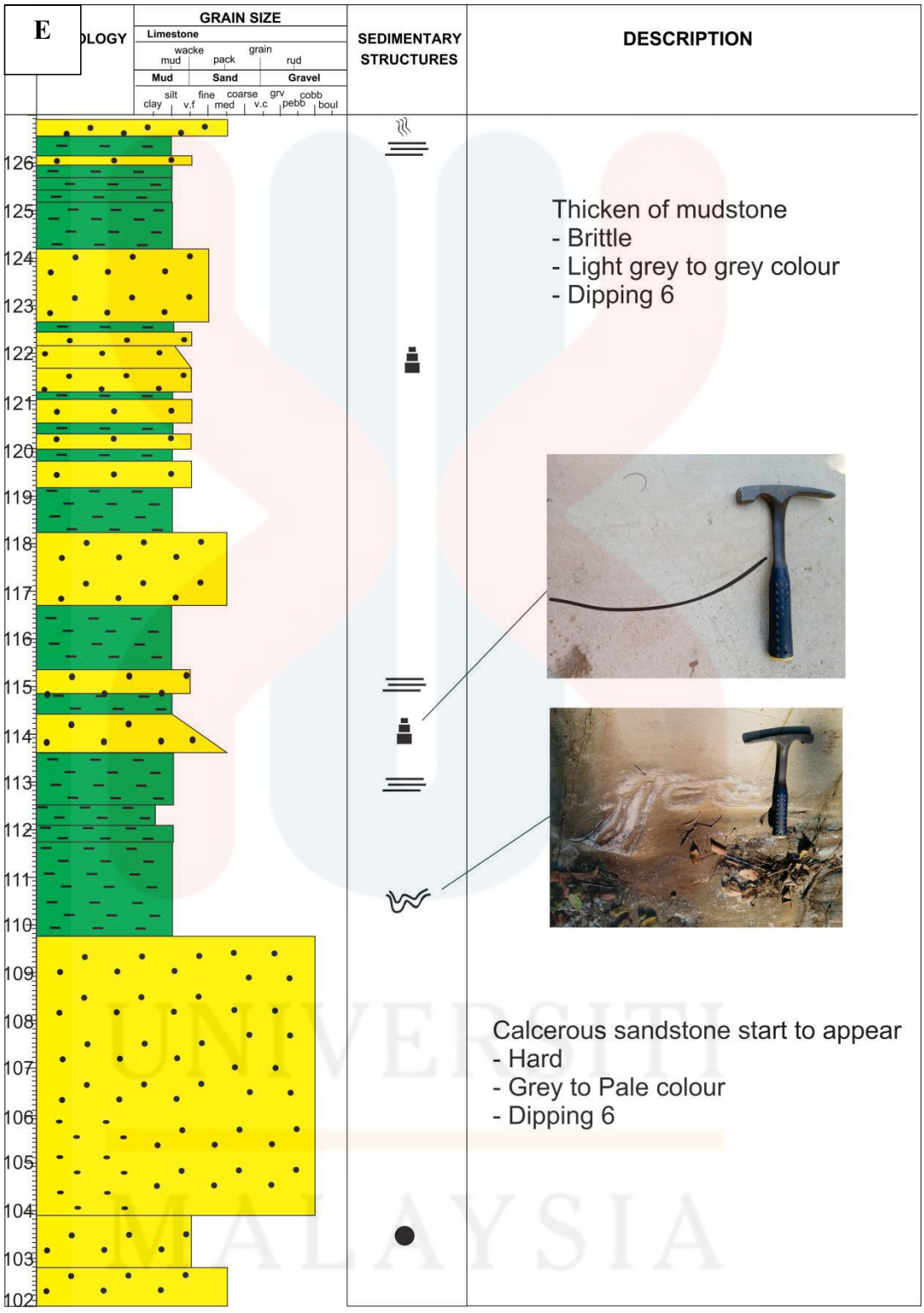

**Table 5.1:** A-D , The details lithostratigraphy of Pentung River, cm

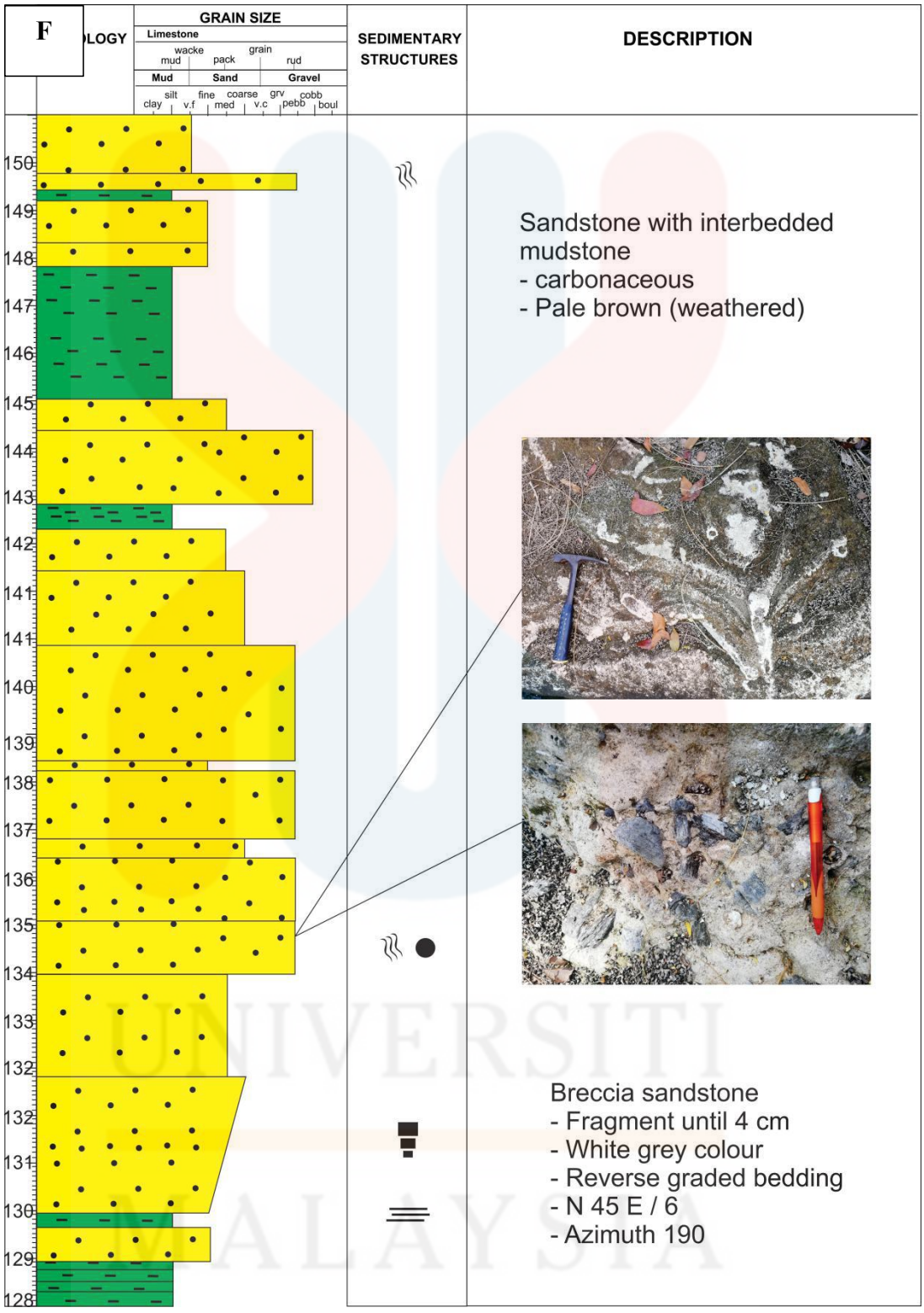


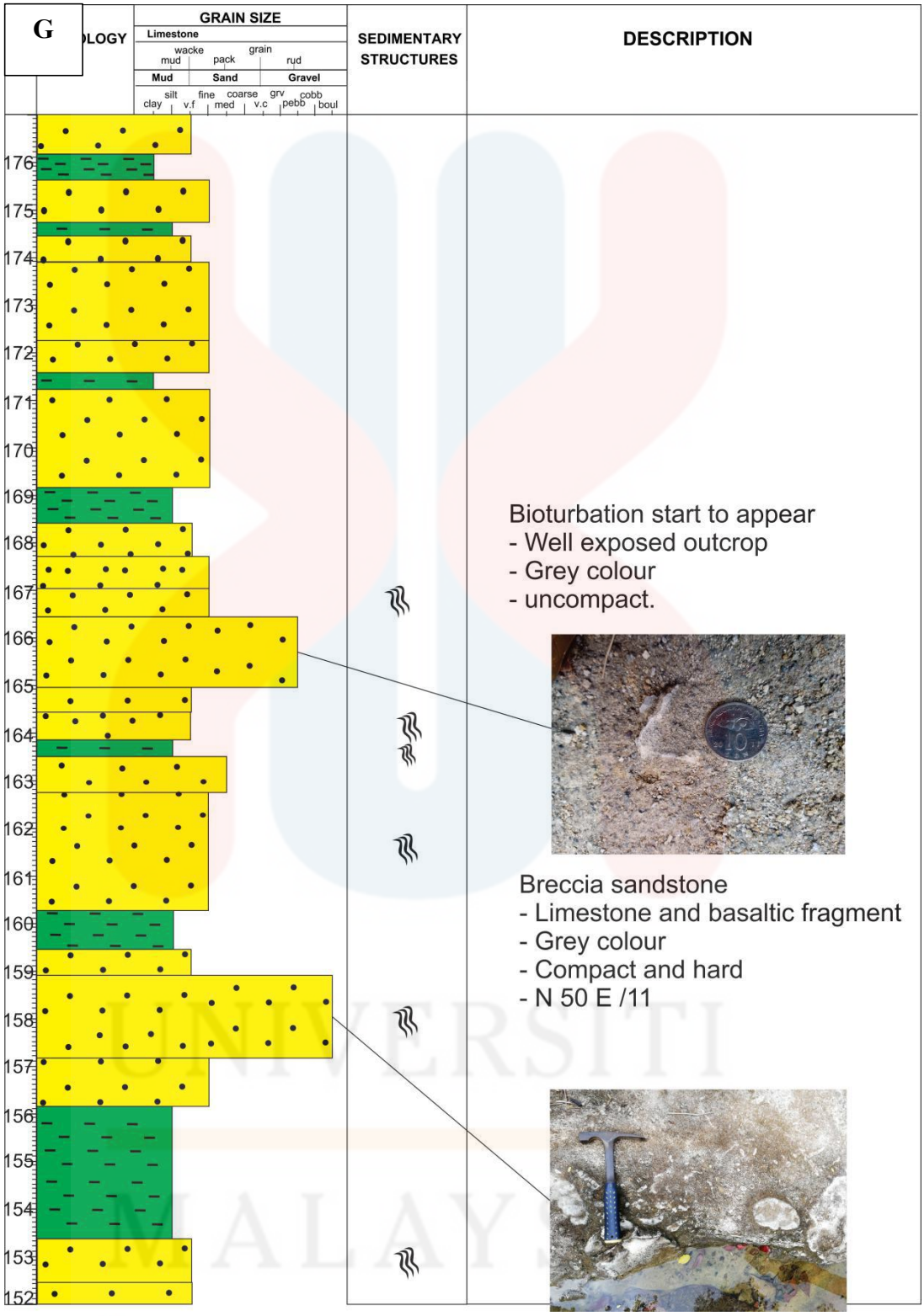


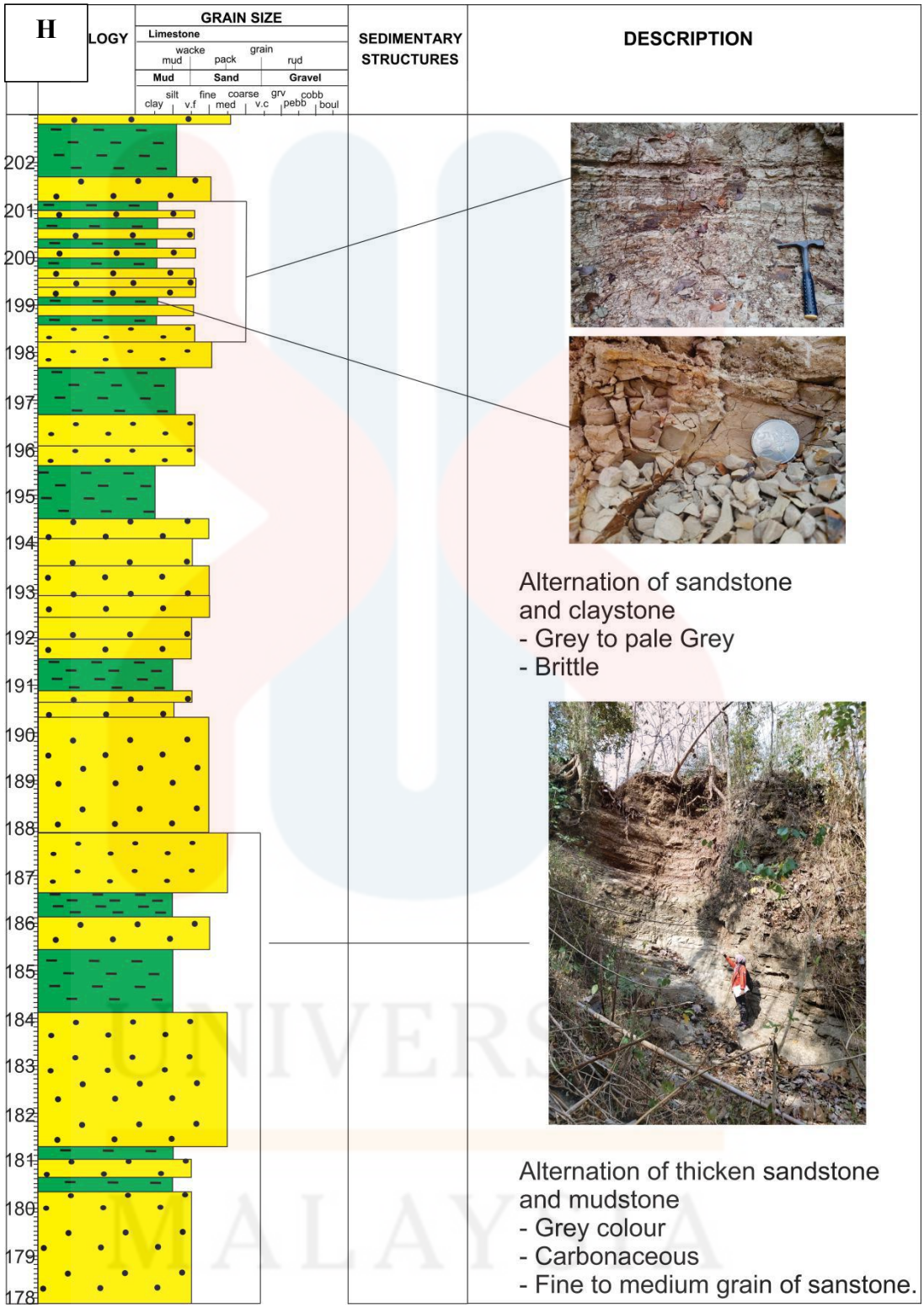


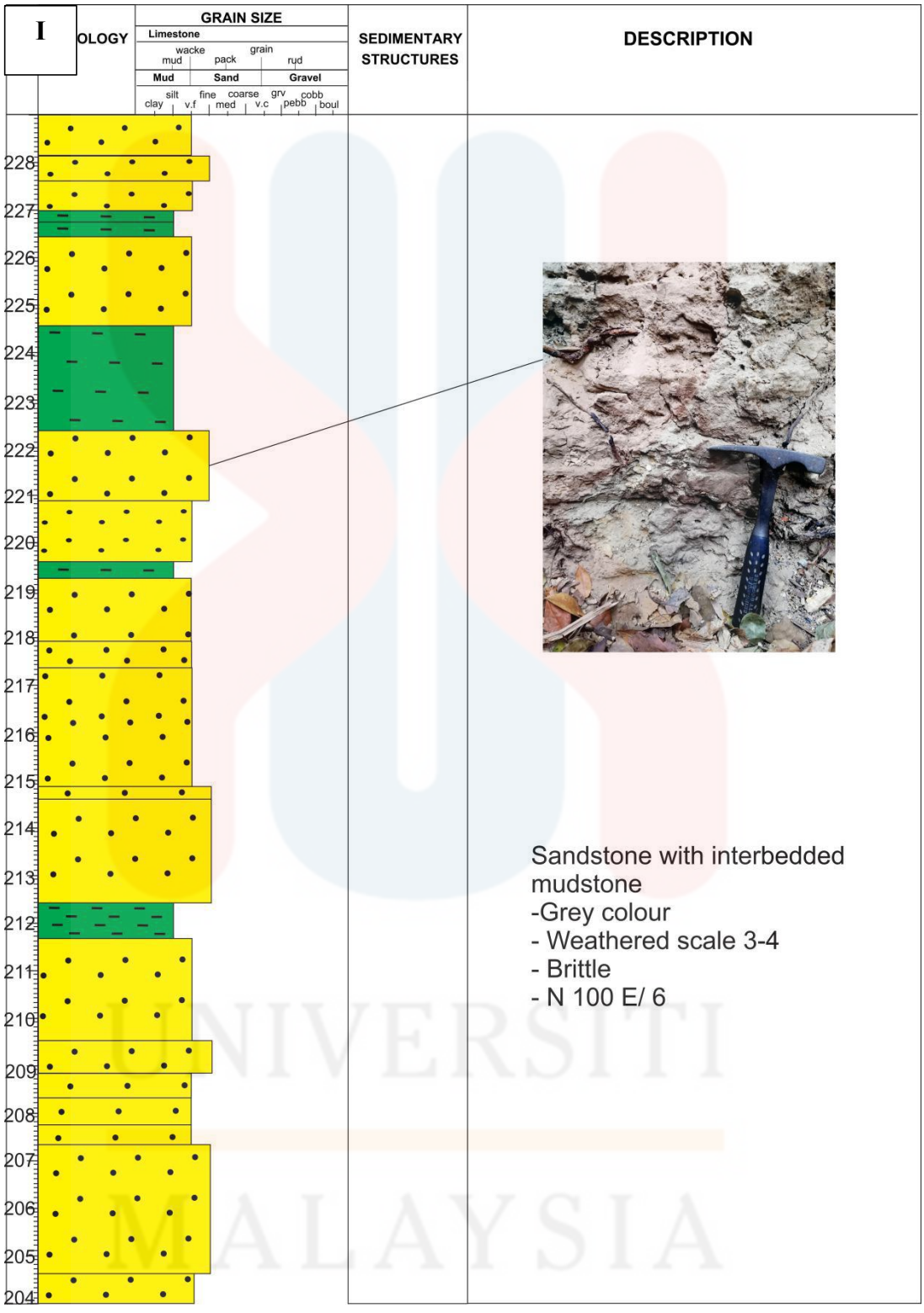


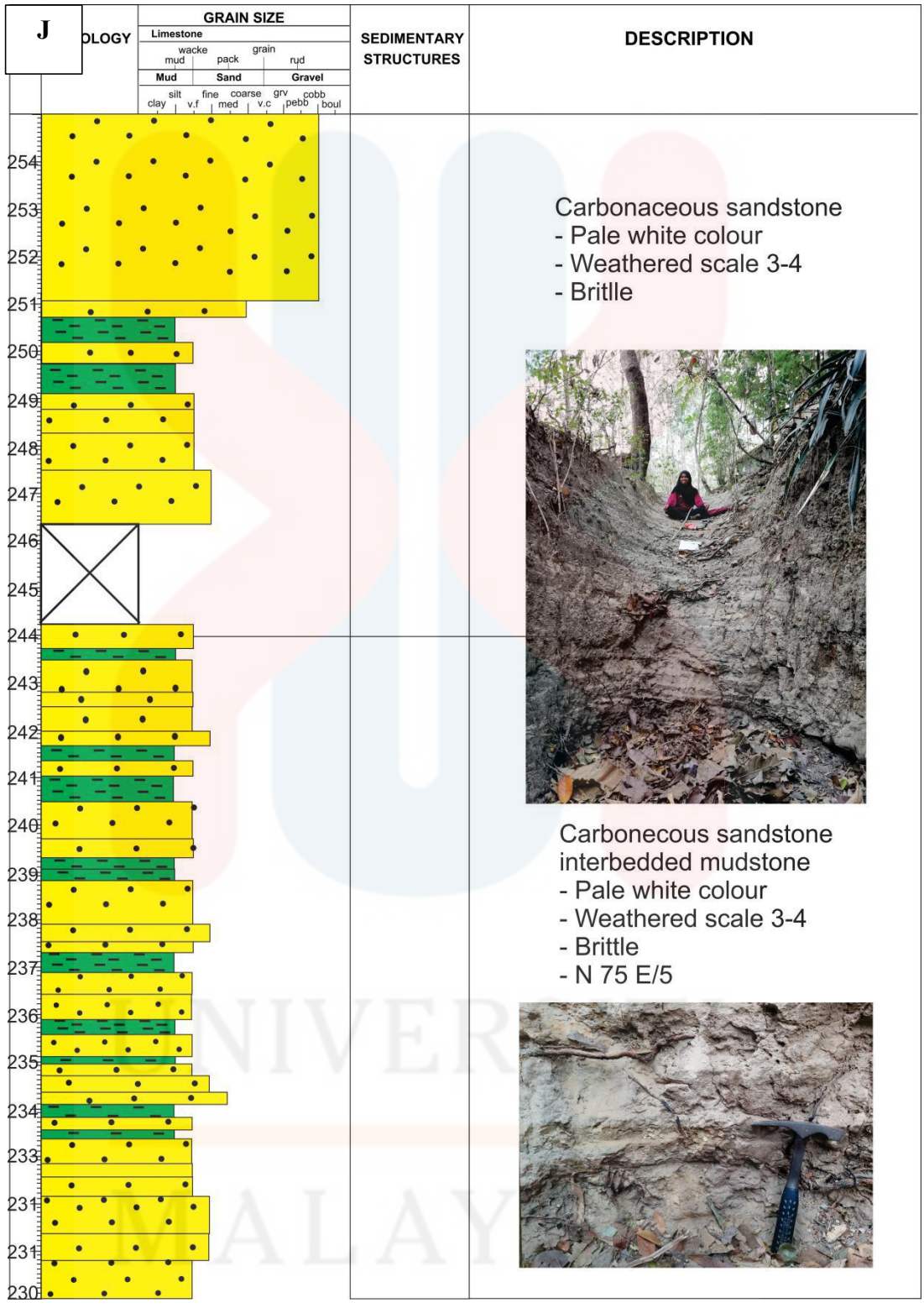












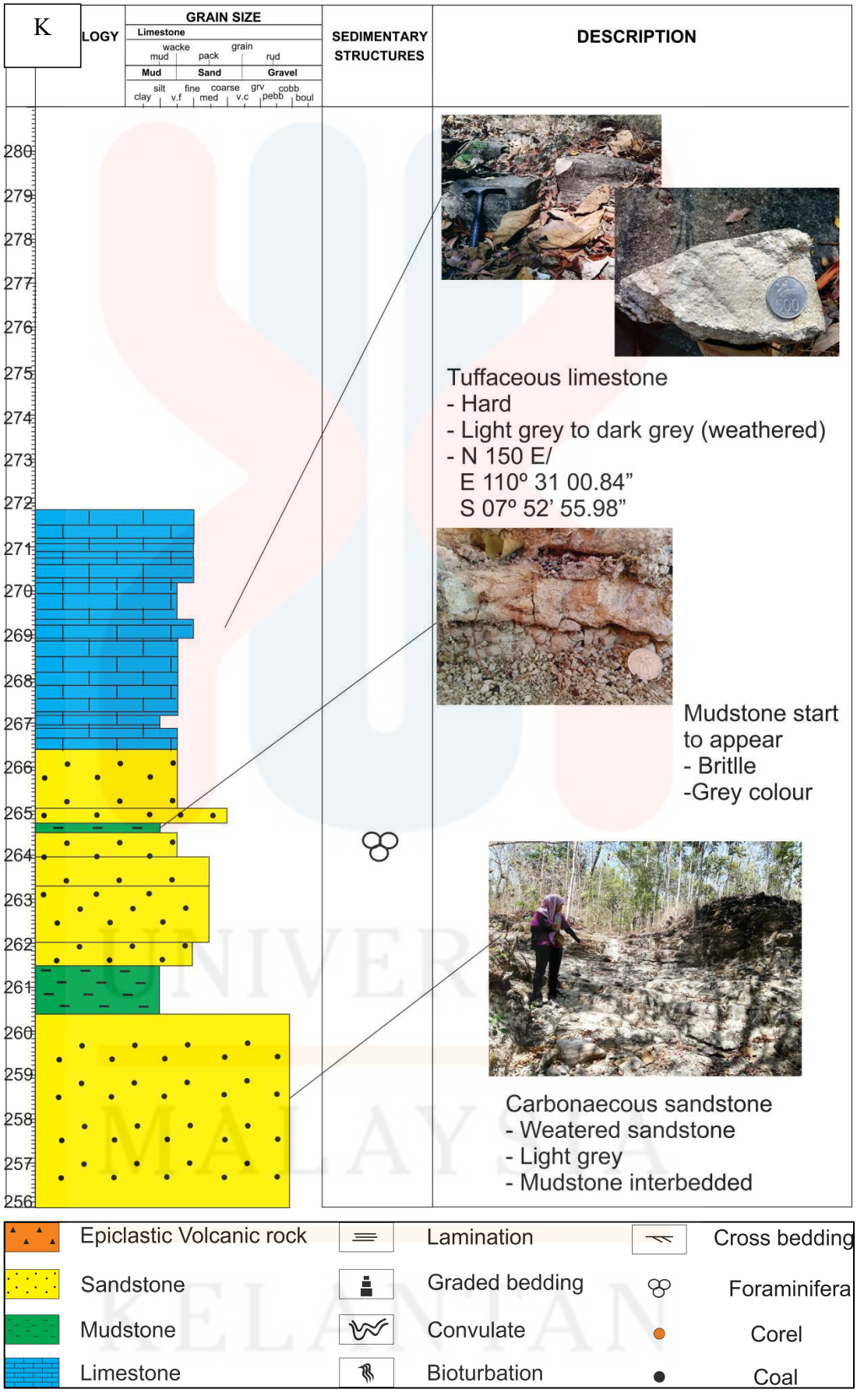



**Table 5.2:** A-K, The details lithostratigraphy of Saradan River, cm

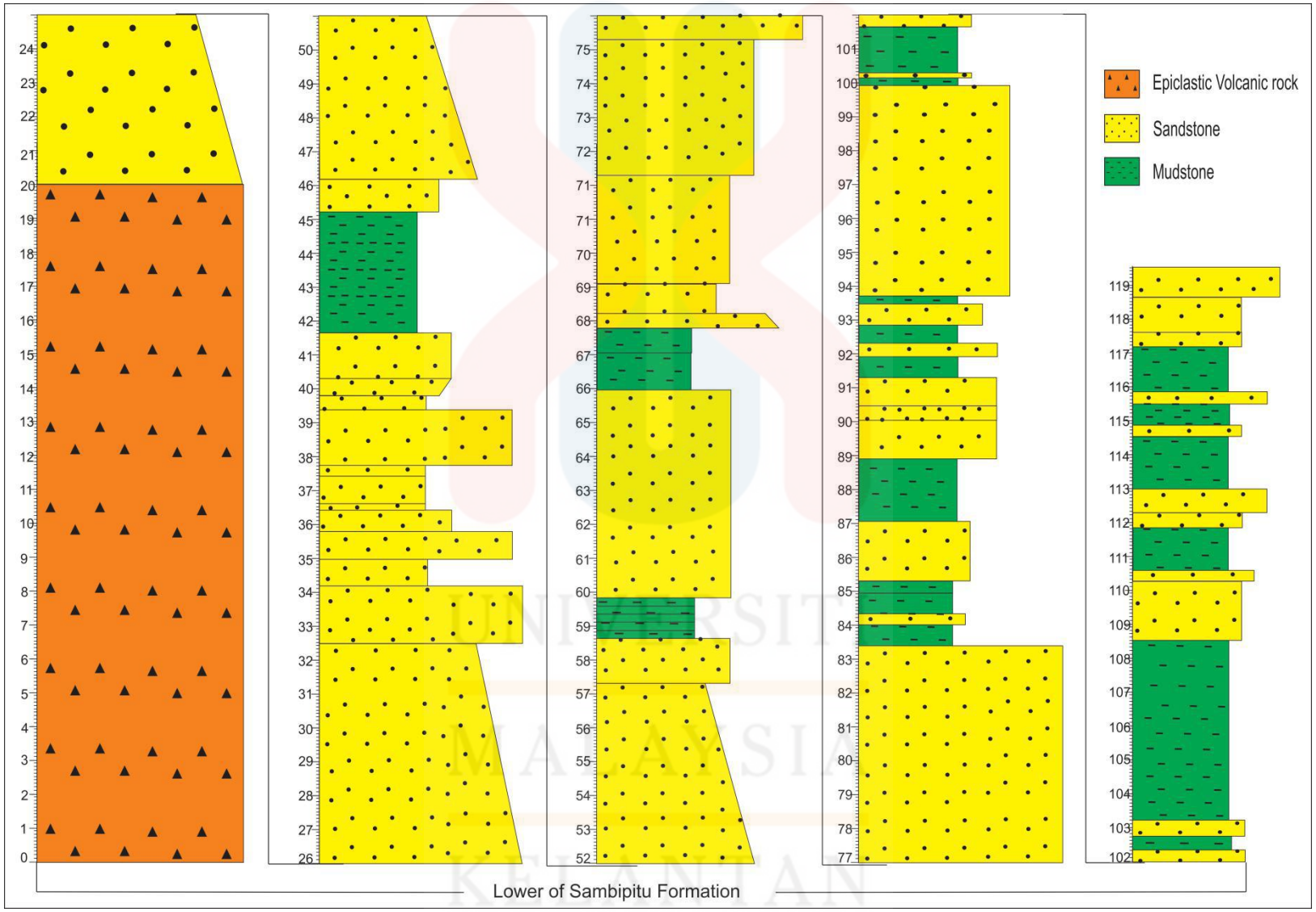
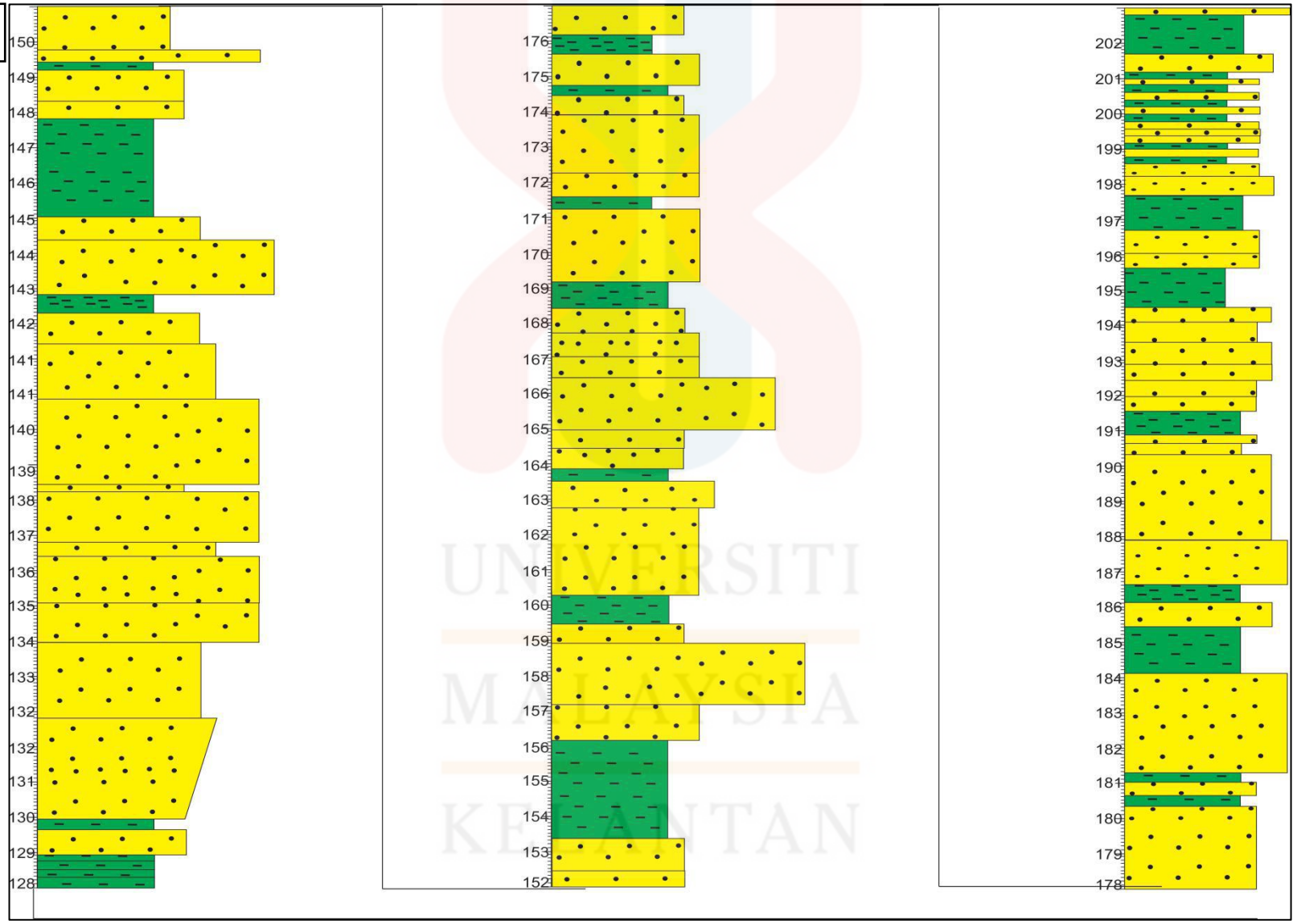



**Figure 5.2:** The litholog of facies analysis on Pentung river


A
Middle of Sambipitu Formation

**B**



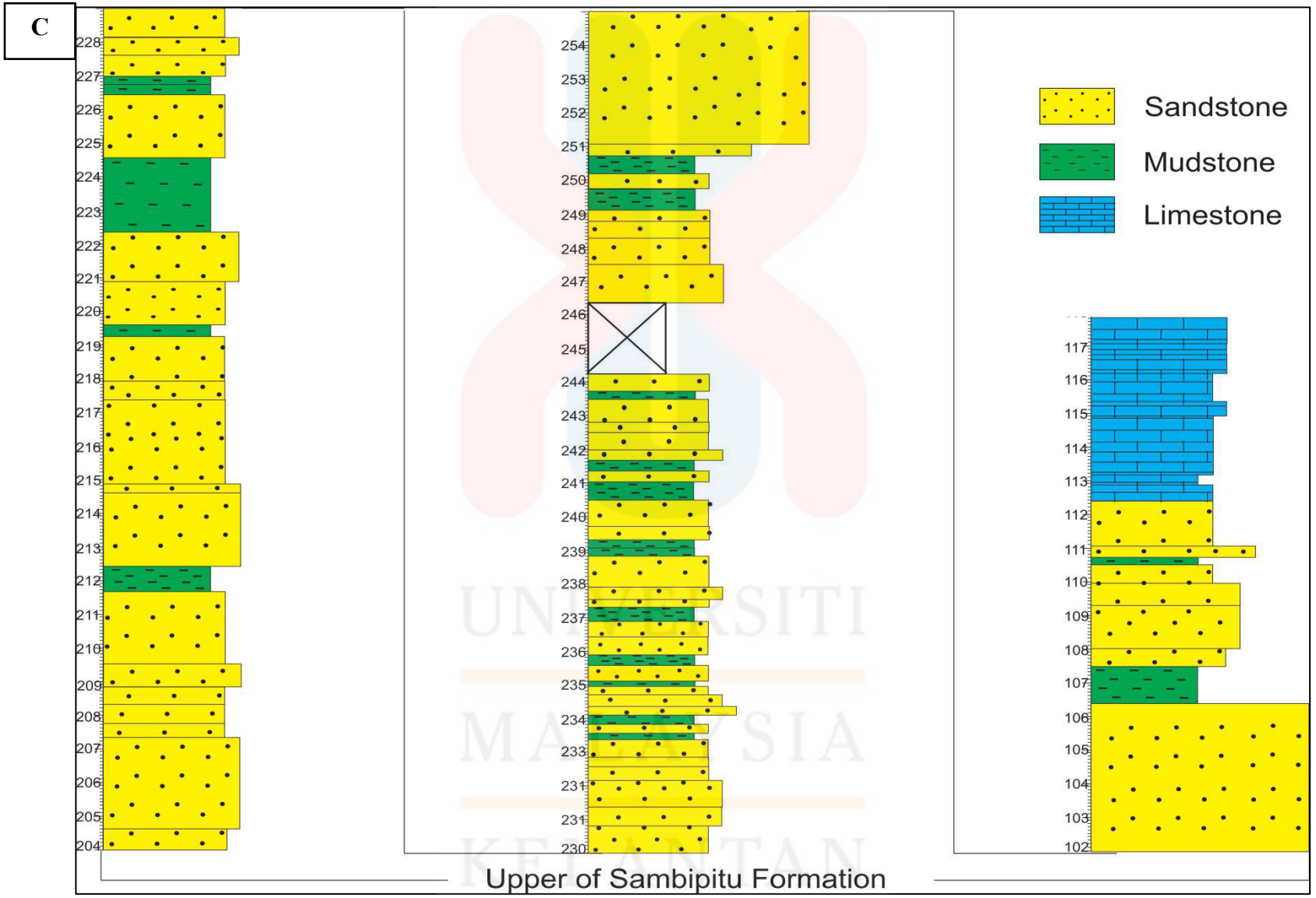



**Figure 5.3:** A-C, The litholog facies analysis on Saradan river, cm

### 5.2.1 Lower Sambipitu Formation

There were four different facies that can been identify which were epiclastic volcanic rock (0-20cm), Epiclastic sandstone with interbeded mudstone (21-84 cm) and alternation between mudstone and sandstone (84-120 cm). The epiclastic breccia are come from Nglanggeran Formation which dark brown to black colour, angular to sub-angular basaltic fragment. The epiclastic volcanic rock was consist of product of volcano. The diagment fragment can be from pebbles to boulder. This unit facies consist of dominant tuffaceous sandstone. The abundance trace fossil looks like wormhole were found at very fine to medium sandstone. The intercalated mudstone and sandstone was about 37 cm. The fossil show that lives in the tidal of zone. The colour for this facies brownish and dak grey. The cleavage that been found mostly at the very fine sandstone and mudstone. The sedimentary structure that been found were graded bedding, reverse graded bedding and lamination. Based on the Figure 5.2 the changes of the bedding as finning upward and coarsening upward was been effect by tidal.

### 5.2.2 Middle Sambipitu Formation

This middle of Sambipitu formation can be seen on Saradan River at Figure 5.3. The alternation of sandstone and mudstone. The grained size of this facies about fine to medium grain sizes. The mudstone was become thicken then the lower part. This thicken of mudstone happen when the high energy level that effect by wave action was drop make the mudstone deposited. The colour of mudstone of this unit was grey to light brown. The sedimentary structure that been found are normal graded bedding,

lamination and bioturbation. The lamination that been found at fine to silt grain size. This depositional environmnet was been support by analysis forminifera table 5.3.

### 5.2.3 Upper Sambipitu Formation

The lithologies facies that been found in this upper Sambipitu Formation are alternation of carbonecous sandstone and mudstone. The colour of carbonecou sandstone was pale grey with the grain size from medium to very course. The Saradan river was connect from Sambipitu Formation to Oyo Formation. From this, the limestone fragment was become abundance when near to Oyo Formation. This facies also abundant of trace fossil and coral of body fossil. The sedimentary structure were that be found were lamination, graded bedding, convulate. This facies also content coal which was been transport from the land and deposited in this facies. Therefore, the depostional environment of this facies was outer neritic. The foraminifera that be found can be on table 5.4.

## 5.3 Fossil analysis

The fossil analysis was been done at Pentung River, Oyo River and Saradan river. There were three checkpoint in this fossil sample can be seen at Figure 5.4. This fossil analysis was been conducted in order to know depositional environment of Sambipitu Formation. BCS1 was the checkpoint to know the depositional environment from Nglanggeran Formation to Sambipitu Formation (Lower Sambipitu Formation). BSS5 was checkpoint in middle of Sambipitu Formation. BSS1 was the checkpoint from Oyo Formation to Sambipitu Formation (Upper Sambipitu).

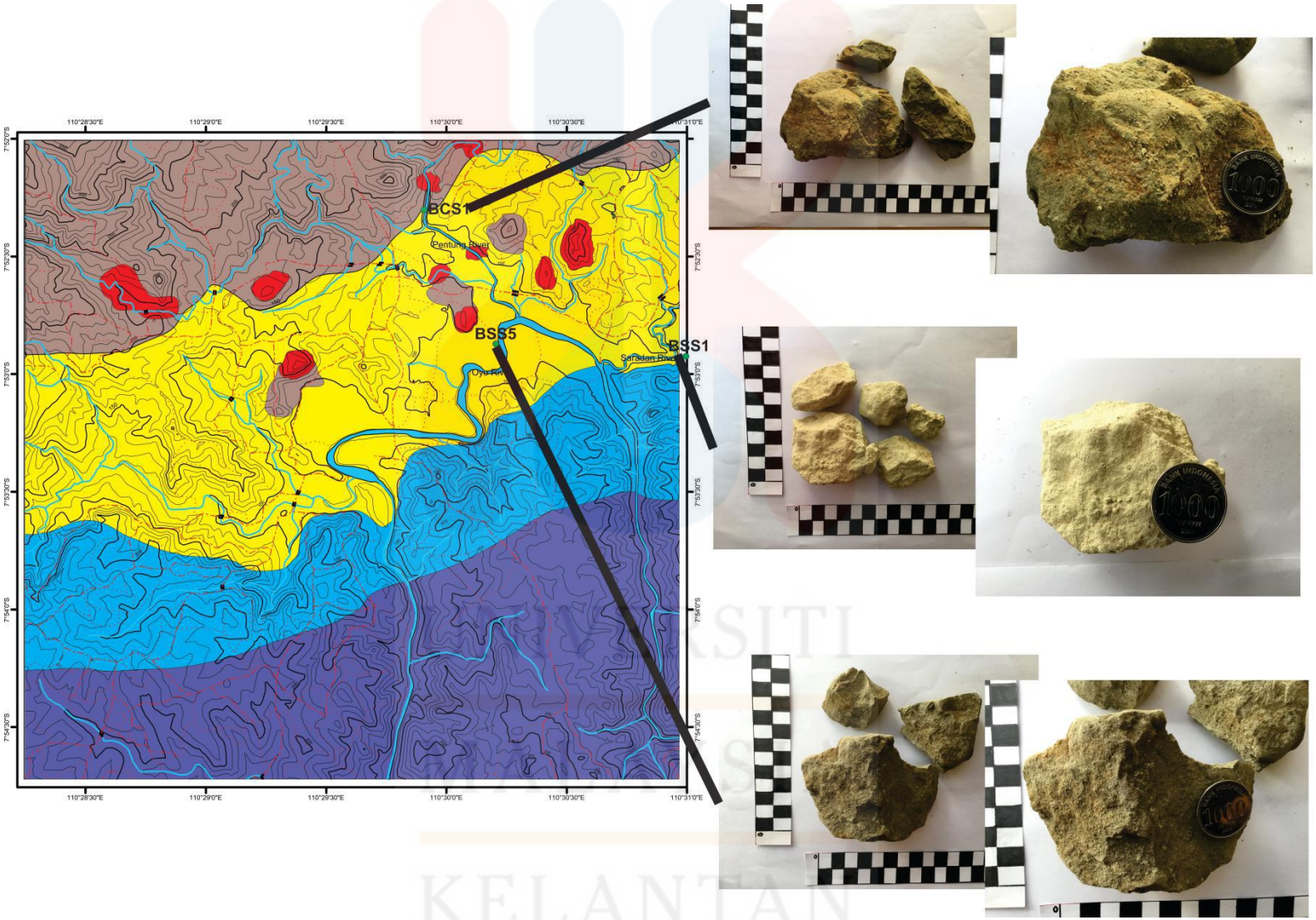



**Figure 5.4:** The checkpoint of hand specimen taken for fossil analysis.

**Fossil analysis sample BCS1 ( Lower Sambipitu Formation)**

**Table 5.3:** The foraminifera comtent in hand speciment BCS 1

| Types of fossil : Microfossil | | | | |
|---|---|---|---|---|
| Code sample : BCS 1 (weight : 1 gram) | | | | |
| **Foraminifera Planktonic** | | | | |
| No | No of Plate | Name of Fossil | Frec | Description |
| 1 | 1,2,8,14,29,33 | *Globigerinoides trilobus trilobus* | 16 | Midd N4 – N23 |
| 2 | 3,15,19,40 | *Globigerinoides obliquus extremus* | 10 | N 17 –N 21 |
| 3 | 4,13,16,32 | *Globigerinoides trilobus immaturus* | 22 | Midd N4 – N23 |
| 4 | 5, | *Sphaerodinellopsis disjunta* | 2 | N9 – N17 |
| 5 | 6,9,25,31,34 | Undetermination | 2 | - |
| 6 | 7,37 | *Globigerinoides quadrilobatus* | 4 | Midd N4 – N23 |
| 7 | 10,23,27,38 | *Globorotalia acostaensis acostaensis* | 27 | N16 – N23 |
| 8 | 11,18 | *Globigerinoides trilobus sacculifer* | 5 | Midd N4 – N23 |
| 9 | 12 | *Globorotalia pseudopima* | 8 | N 17 –N 23 |
| 10 | 20, | *Globigerinoides subquadratus* | 4 | N4 – N23 |
| 11 | 21 | *Orbulina bilobata* d'Orbigny | 6 | N9 – N23 |
| 12 | 22,36 | *Globorotalia humerosa humerosa* | 15 | N 17 –N 23 |
| 13 | 24,41 | *Hastigerina siphonifera* | 14 | Midd N12 – N23 |
| 14 | 26,28,30 | *Globigerinoides ruber* | 2 | N5 – N13 |

Conclusion :

Based on the final appearance of Globigerinoides ruber and the initial appearance of Globorotalia pseudopima, Globigerinoides obliquus extremus, Globorotalia humerosa humerosa , the relative age range for this rock sample was N13 - N17 (Middle Miocene - Late Miocene). Based on the abundance of large foraminifera content it can be interpreted that this sample was deposited in the depth zone of the Outer Neritic - Upper Bathyal (Tipsword, 1966).

**Fossil analysis hand specimen BSS5 (Middle Sambipitu Formation**

**Table 5.4:** The foraminifera content in hand specimen BSS5

| Types of Fossil : Microfossil | | | | |
|---|---|---|---|---|
| Sample code : BSS 5 (weight : 1 gram) | | | | |
| **Foraminifera Planktonic** | | | | |
| No | No of Plate | Name of Fossil | Frec | Description |
| 1 | 6,20 | *Sphaerodinellopsis seminulina* | 28 | N17 – N 20 |
| 2 | 7,23,24,47 | *Globorotalia acostaensis acostaensis* | 3 | N16 – N23 |
| 3 | 9 | *Globorotalia scitula gigantea* | 2 | N10 – N16 |
| 4 | 10,11 | *Globorotalia scitula* | 2 | N9 – N23 |
| 5 | 13,31,35 | *Globigerinoides trilobus immaturus* LeRoy | 6 | Midd N4 – N23 |
| 6 | 14,16,48 | *Sphaerodinellopsis disjunta* | 6 | N9 – N17 |
| 7 | 17 | *Sphaerodinellopsis multilobata* | 1 | N 12 – N 16 |
| 8 | 15,18,19,25, 36,43 | *Globigerinoides subquadratus* | 20 | N4 – N23 |
| 9 | 21,26,32 | *Globorotalia mayeri* | 10 | N3 – N14 |
| 10 | 22, 44,45 | *Globorotalia pseudopima* | 10 | N 17 – N 23 |
| 11 | 27,29,33,34, 46 | *Globigerinoides obliquus obliquus* | 14 | N8 – N19 |
| 12 | 28,30 | *Globigerinoides obliquus extremus* | 18 | N 17 – N 21 |
| | | | | |
| **Foraminifera Bentonic** | | | | |
| No | No of Plate | Name of Fossil | Frec | Description |
| 1 | 12 | *Bolivina semicostata* | 2 | Depth: 279 m |

Conclusion:

Based on the final appearance of Globorotalia mayeri and the initial appearance of Sphaerodinellopsis seminulina, Globorotalia pseudopima, Globigerinoides obliquus extremus, the relative age range for this rock sample was N14 - N17 (Middle Miocene - Late Miocene). Based on the zones the collection species contained, it can be interpreted that deposited on the depth zone of the upper Bathyal (Tipsword, 1966)

**Fossil analysis hand specimen BSS1 (Upper Sambipitu Formation)**

**Table 5.4:** The foraminifera content in hand specimen BSS1

| Types of Fossil : Microfossil | | | | |
|---|---|---|---|---|
| Code of sample : BSS1 (weight : 1 gram) | | | | |
| **Foraminifera Planltonik** | | | | |
| No | No of Plate | Name of Fossil | Frec | Description |
| 1 | 14,15,16,48 | *Globigerinoides trilobus immaturus* | 9 | Midd N4 – N23 |
| 2 | 17, 34,37,47 | *Globorotalia pseudopima* | 11 | N 17–N 23 |
| 3 | 22,43 | *Globorotalia scitula* | 3 | N9 – N23 |
| 4 | 13,25, 38, 47 44 | *Globigerinoides obliquus extremus* | 11 | N 17–N 21 |
| 5 | 18, 26, 35 | *Globigerinoides obliquus obliquus* | 5 | N8 – N19 |
| 6 | 27,30,42 | *Globigerinoides subquadratus* | 22 | N4 – N23 |
| 7 | 28,32 | *Globorotalia archeomenardii* | 3 | N6 – N10 |
| 8 | 29 | *Sphaerodinellopsis seminulina* | 11 | N 17–N 20 |
| 9 | 31 | *Globigerinoides quadrilobatus* | 1 | Midd N4 – N23 |
| 10 | 33, 40,46 | *Globorotalia acostaensis acostaensis* | 14 | N16 – N23 |
| 11 | 36 | *Globorotalia humerosa humerosa* | 1 | N 17–N 23 |
| 12 | 41 | *Globigerinoides ruber* | 2 | N5 – N13 |
| | | | | |
| **Foraminifera Bentonic** | | | | |
| No | No of Plate | Name of Fossil | Frec | Description |
| 1. | 11 | *Marginulinopsis tenuis* | 1 | Depth: 108,20 m |
| 2. | 19, 20 | *Pseudonodosaria comatula* | 2 | Depth: 177,32 m |
| 3. | 21,23 | *Bolivina semicostata* | 2 | Depth: 279 m |
| 4. | 24 | *Heterolepa ornata* | 1 | Depth: 276,05 m |

Conclusion:

Based on the final appearance of Globigerinoides ruber and the initial appearance of Globorotalia pseudopima, Globigerinoides obliquus extremus, Sphaerodinellopsis seminulina , Globorotalia humerosa humerosa, then the relative age range for this rock sample is N13 - N17 (Middle Mieocene to Late Mieocene).

Based on the zones the collection of points of species contained, it can be interpreted was deposited on the depth zone of the Outer Neritic - Upper Bathyal (Tipsword, 1966).

### 5.5 Suggestion Depostional environment of sambipitu formation

Based on the paramater of facies associations, sedimentary structures and also foraminifera that been present in study area, the depositional environment of Sambipitu Formation was deeping marine with turbidite. Regionally, the lithology of Sambipitu Formation show the characteristic of shallow marine. However, the research was been conduct and found that this formation show the evidence of range environment from outer neritic to upper bathyal environment as indicated by the presence of benthic, planctonic. Turbidite structure was the reason changes the grain size of particle in rock.

The series of deposition rock from the lithology set shows that the fining upward and coarsening upward. This fining upward show that the depositional environment was upper bathyal which is deep marine. This area can be seen at middle Sambipitu Formation. The fining upward of lihtolog show that the water was calm. Besides that, the coarsening upward was show the depositional environment was outer neritc. This area can be seen at uppper and lower of Sambipitu Formation. Therefore, Sambipitu Formation was undergo tidal activity which changing in energy level from the high energy level to low energy level then high again. The suggestion of depositional environment for this formation can be seen at Figure 5.5. The orange line was show the depositional environment of Sambipitu Foramation.

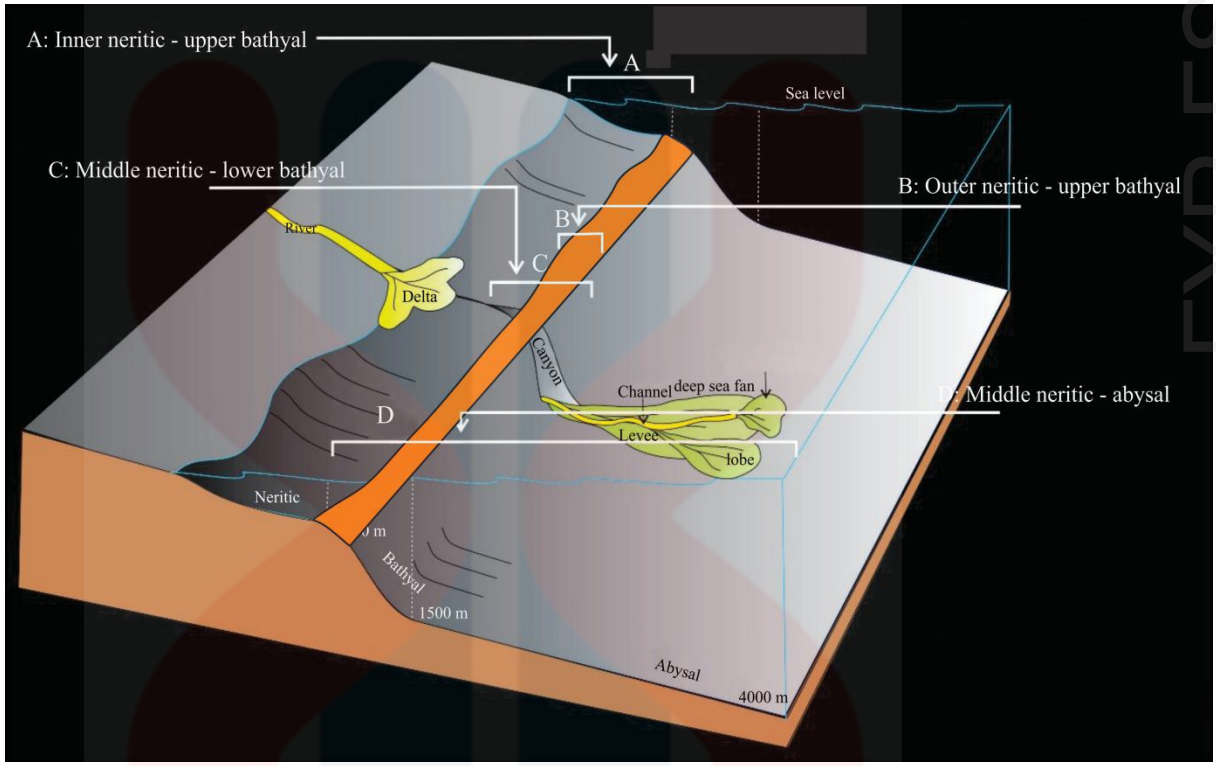



**Figure 5.5:** The illustration of depositional environment of Sambipitu Formation. Modified image form (Astuti, Isnaniawardhani, Abdurrokhim & Sudradjat, 2019)

# CHAPTER 6

# CONCLUSION AND RECOMMENDATION

## 6.1 Conclusion

As a conclusion, all the information and data from the reading, geological mapping and analysis are important in order to produce geological map, lithology and interpretation of depositional environment in study area. This study area is located at Pengkok area, Gunung Kidul, Indonesia which mostly have complex structure and well exposure of outcrop along the river.

The geomorphology of the area can be see at north and south part are compose of hilly landscape and middle study area is covered with flat landscape. These geomorphology are mostly depends on structure and lihtology of study area. Besides that, there are dendritic drainage pattern that been dominant in study area.

There are several types of lihtology unit such as volcanic breccia, lava, epiclastic breccia, sandstone and mudstone, mudstone, carbonaceous sandstone, tuffaceous limestone and limestone unit. The measuring section is conducted along the Pentung River and Saradan River. This measuring section is conducted in betweetn contact of Nglanggeran Formation with Sambipitu and contact of Sambipitu with Oyo Formation. Depositional environment for Sambipitu Formation

is neritic to upper bathyal with changes in sea level which it will be easier to located the transition state.

The structure that been found are joint, fault and folding. The structure that been found are local structure and follow the regional structure. The measuring section is occured at different placed because the main river connect between three formation such Nglanggeran Formation with Sambipitu Formation and Sambipitu Formation with Oyo Formation.

## 6.2 Recommendation

There are some suggestions that been identified in order to enhance the research which make it the research become details. Firstly, the geochemistry methode will help in order to identify the characteristic and properties of the rock to know the inclusion of limestone fragment in Sambipitu Formation. Next, the details micropaleontology methode will help in order to correlate the lihtolog between two river.

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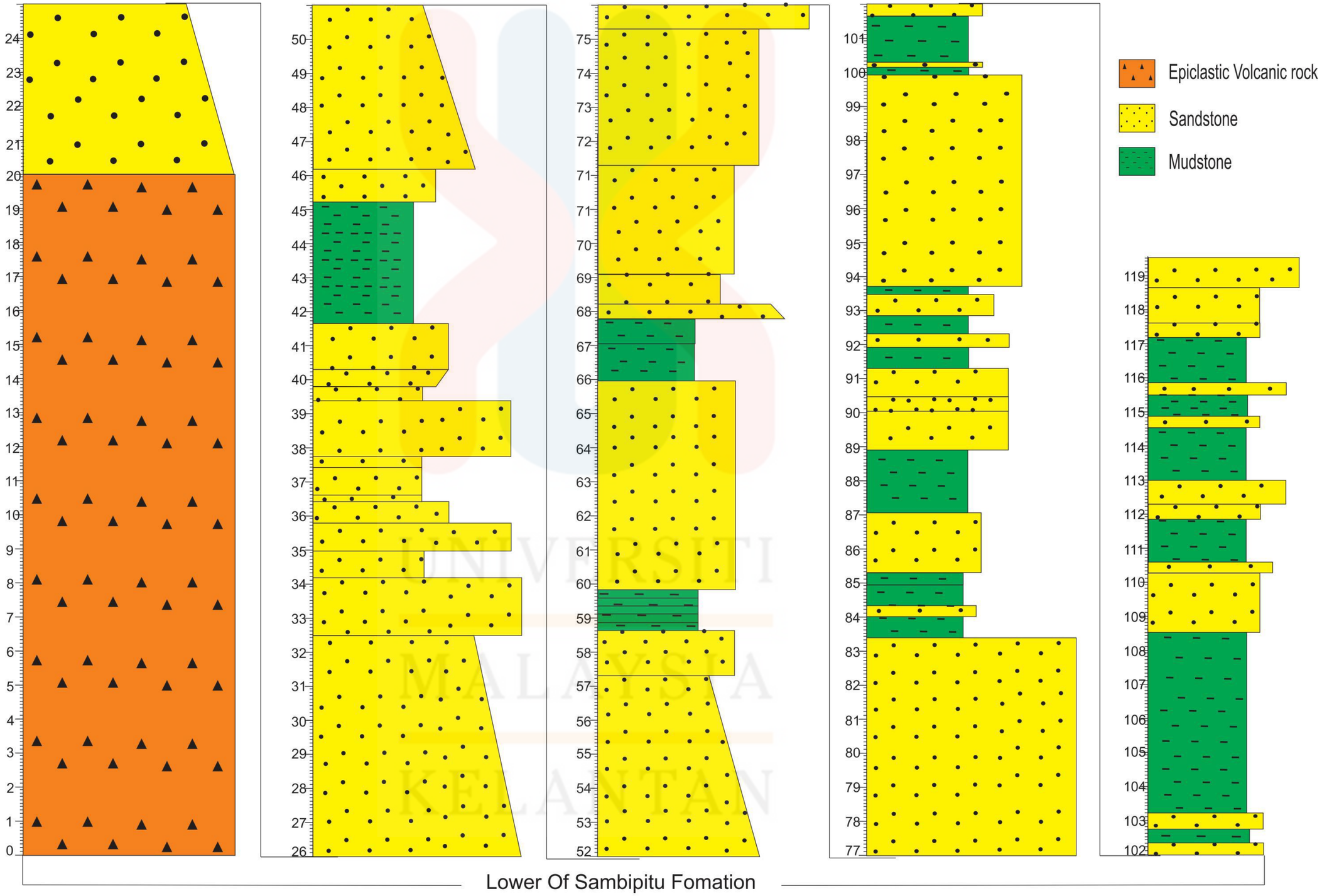
Epiclastic Volcanic rock
Sandstone
Mudstone
Lower Of Sambipitu Fomation

## APPENDICES B- LITHOSTRATIGRAPHY OF SARADAN RIVER

## APPENDICES B- LITHOSTRATIGRAPHY OF SARADAN RIVER