A Study of the Changes of Lithostratigraphy based on Bojongmanik Formation at Sajira, Banten Province, Indonesia

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Abstract: - Sajira region is geographically located in Banten Province this location was chosen because it has a complete stratigraphic sequence that characterizes the Rangkasbitung Basin. The distance to Sajira from Bogor is approximately 2 hours away. The research objective is to study the stratigraphic sequence of the Rangkasbitung Basin in the Sajira area. The Bojongmanik Formation is a typical formation of the Rangkasbitung Basin according to previous researchers in lithology there are two rock units namely the Claystone Unit of sandstone and limestone intercalation and the Sandstone unit of claystone and limestone intercalation. Observation method used to record existing geological information related the formation of exogenous and endogenous processes that work in the area. Determination of age used qualitative method while to know the depositional environment, quantitative method used based on the comparison of Planktonic foram content to the Benthic. Granulometry analysis used to determine the depositional environment quantitatively based on the grain size sorting. The results of geologically there are 3 rock units and intrusive rocks. The claystone and sandstone intercalation are the oldest units in the Sajira area based on the fossil content of Hastigerina phraesiphonifera, Orbulina universa, Orbulina suturalis, Globorotalia praemenardiand Globogerinoides subquadratus age range (N9 - N12) in deposited the Outer Neritik. As for the Sandstone and Claystone intercalation unit containing fossils of Orbulina bilobata, Globigerinoides trilobus, Globoratalia minardi, Globigerinoides subquadratus and Orbulina universa age range (N13 - N14) or Upper Middle Miocene, deposited on the edge Neritic environment. This rock unit is covered unconformably by the Genteng Formation which is characterized by the presence of silicifid wood fragments. On the basis of fossil content related to rock age, depositional environment and lithological features which show different characteristics, the Sandstone and limestone intercalation Unit should be separated and given a separate Formation name because it does not match the characteristics of the location the Bojongmanik Formation type.

Keywords: Lithostratigrafi, Bojongmanik Formation, depositional environment.

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1 Introduction

The name of Bojongmanik Formation is derived from the name of sub-district town in Central Batten [1]-[2] , The Bojongmanik Formation is a typical Banten Block deposit, specifically in the Rangkasbitung Basin and spreads out to east direction untill Leuwiliang area; this formation changes its facies to marine deposits from the Cibulakan Formation. The research area is administratively located in Cimarga District, Sajira District and Cipanas District, Lebak Regency, Banten Province. It's geographically located at 106°17'30"- 106° 22' 30" East Longitude and 6° 30' 00 "- 6° 34' 30" South Latitude (see Figure 1).

There are several different views in determining the lithological characteristics of Bojongmanik

Formation. The Bojongmanik Formation into three members [3], namely: 1). Lower Bojongmanik Formation which is characterized by a claystone unit with sandstone and limestone intercalations and 2). Upper Bojongmanik Formation with characteristics of sandstone with claystone and limestone intercalations. Sudjatmiko [4] divide Bojongmanik Formation into three members; namely the Claystone Member, Sandstone Member and Limestone Member. The age of all of the members of Bojongmanik Formation was designated Miocene.

The research of Bojongmanik Formation in Sukamarga area and its surroundings aims to reveal the detail lateral features of lithology in order to distinguish the rock units and to discover the relative age of the depositional environment. Outcrop of this formation can be observed at Ciminyak River, Ciwaru River, Muncang Village, Cilaketan River and Cigudawang River around Margaluyu Village and at Cisida and Cibungur Rivers located around Cipanas Village and Cigeulis River in Sukamaju Village.

Figure 1. The location of study area (without scale) and Administration Map of West Java Province.

The objective of the study is to find out the rock unit position of the lower and the upper parts of the Bojongmanik Formation. The method of stratigraphic measurement is carried out to determine the thickness and characteristics of the lithology based on observation and measurements, and collecting samples. Laboratory work consists of petrography, micro-paleontology and sedimentology analysis to identify and collect detail information of Bojongmanik Formation.

2. Methodology

2.1. Field Observation

Stratigraphic coloumn measurement is one of the methods used to collect field data on the basis of the following considerations:

1) Measurement of layers or outcrops in the field must follow the rules in measuring the stratigraphic cross section and determining the sampling point to fulfill the needs of micro-paleontology and sedimentography.
2) Determination of locations measurement is very flexible and is adjusted to the purpose of data requirements for analysis and stratigraphic measurement model which is quite objective because the assessment process is focused to recognize various physical, chemical or biological properties of the matter.
3) Determination of the relative age of rock units is based on lithostratigraphy in the field which is strengthened by paleontological analysis data and biostratigraphy in the laboratory.

The determination of the location for the measurements of measured sections involves the analysis of regional geological and topographical maps with the objective that the generated information would be effective.

2.2. Research Methods

Research and laboratory methods applied in this study are:

1) Thin incisions method / petrography, was carried out to analyze the limestone intercalations in the sandstone unit with intercalations of claystone and limestone (Upper Bojongmanik Fm) and in claystone units with the intercalationns of sandstones and limestones (Lower Bojongmanik Fm) and in Badui Formation which according to previous researchers [5] underlain the Lower Bojonmanik Formation. The objective is to obtain an overview of carbonate rock facies with reference to the belt standard on [6]-[8] and to develop facies into microfacies type to help identify the limestone type based on specific characters. Samples are taken from limestone. The determination of large foraminifera is done by the observation of internal structure shape (internal morphology). Relative age determination is based on large foraminifer's content [1].

2) Analysis of micropaleontology to determine the relative age based on the presence of planktonic foraminifera using Blow zoning [9]. Whereas to find out the depositional environment two ways are carried out, first by identifying benthonic foraminifera on the basis of genus classification to

the next species to find out the depth and depositional environment [10].

The second way is based on quantitative method on benthonic foraminifera. This method is one of the excellent ways to reconstruct the ancient environments. The method used is planktonic and benthonic (P/B) ratio.

The P/B ratio evaluates changes in the ratio of planktonic and benthonic foraminifera in sediments to the part of the dominant edge [11]–[12]. This ratio can estimate the depth of the sediment in Cretaceous and Tertiary sequences in the open sea. The P/B ratio is used to determine the depth, paleoenvironment, paleoecology, water mass distribution and flow intensity as shown in Formula (1). Table 1 shows the value of the P / B ratio.

$$\text{Ratio P/B} = (P/P+B) \times 100\ \% \quad (1)$$

P is the number of planktonic foraminifera individuals.
B is the number of benthonic foraminifera individuals.

Table 1. Classification of P / B Ratios

P/B Ratio	Environment
< 20 %	Inner Neritic (Inner Exposure)
20 – 40 %	Central Neritic (Central Exposure)
40 – 70 %	Outer Neritic (O uter Exposure)
>70 %	Upper Bathyal
>90 %	Lower Bathyal

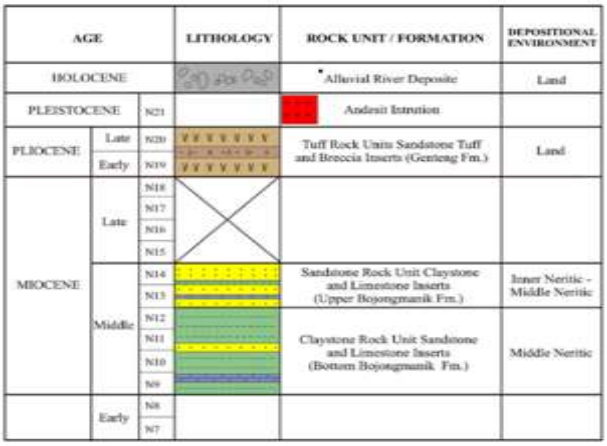
3) Granulometry Method. Granulometric analysis is used as an approach to determine the depositional environment based on the size of the rock, namely coarse clastic or fine clastic. This analysis is applied to sandstones of the sandstone unit and limestone intercalations in claystone as well as analysis of sandstone units including claystone and limestone intercalations [13].

3. Results and Discussion

The results of field observations are shown in the following stratigraphic column. Table 2 shows the stratigraphic column of the research area. There are four rock units which in stratigraphic order from old to young are as follows:

1. Claystone Rock Unit Sandstone with Limestone intercalation.
2. Sandstone Rock Unit Claystone with Limestone intercalations.
3. Tuff Rock Units Tuffaceous Sandstone with Breccias intercalations.
4. Andesite Intrusion.
5. Alluvial River Deposits.

Table 2. Stratigraphic column of the study area



3.1. Claystone Rock Unit Sandstone and Limestone Intercalation.

Claystone rock unit sandstone and limestone intercalation are the oldest units found in this area and exposed in the southern part of the study area, occupying 50% of the total study area. Claystone rock unit with sandstone and limestone intercalation are exposed in Cibungur River at Margaluyu village (See Fig. 2). The rock bedding from the north to the south having strike between N85°E-N105°E and dip ranging from 20°-28° and in the southern part having strike N260°E -N290°E and dip between 17°-30° and forms a syncline and an anticline.

The thickness of the rock unit based on the measurement of the geological cross section is about 455 m. The lower part of the rock unit is dominated by claystone intercalated by limestone (Figure 2), locally limestone found as a lenses in claystone. The presence of limestone decreases in the middle part of the rock unit and to be replaced by sandstones as the intercalation in the rock unit. In the upper part of the rock unit are found intercalations between sandstone and claystone with sequence of sandstone showing a thicknening upwards.

The claystone is blackish gray, with the size of clay minerals, soft - massive, in some locations it is found to be flake and contains nodule of sandy limestone and is rich in mollusca. The megascopic description of petrology from limestone is generally brownish gray in color, composed of algae, shells of mollusca, large foram fossils, showing clastic texture, rounded to rounded grain shape, partially

intact, compact and solid fragments, and a small portion converted to calcite [14].

There are two sample locations of these limestone outcrops, namely from the areas of Margaluyu and Muncang Villages. The purpose of which is to find out the types of limestone in this area, whether the species are the same or different, in order to clarify the depositional conditions.

The results of thin section analysis of limestone taken at Margaluyu Village show brownish gray in color, composed of coral shells, algae and forams, measuring 0.3 - 2 mm, rounded grain shape - angled, open container, poor sorting. Composition: Algae, Coral and Foram with 80% composition and 20% Micrite. Microscopically the name of the rock is: *Packstone* [15].

Figure 2. Claystone outcrop exposed at Cibungur River.

Table 3. Limestone Classification in Margaluyu Village [15]

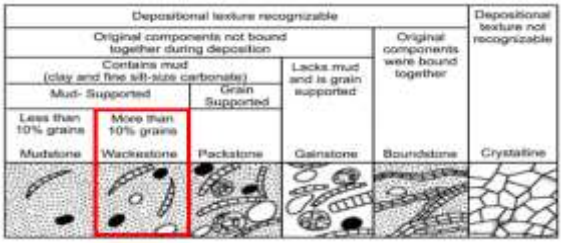
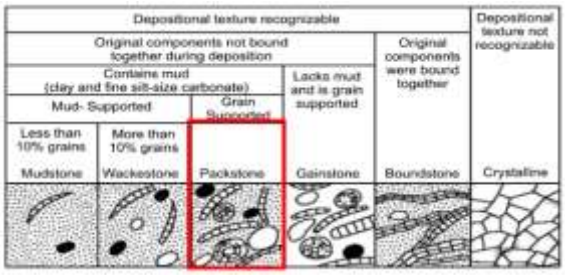


Table 4. Classification of Limestone in Muncang Village [15]



The results of limestone incision samples taken in Muncang Village, microscopically brownish, bioclastic, coarse-grained (micrite) limestone, consisting of feldspar, quartz, rock fragments, fossil fragments and ore minerals embedded in the calcite microcrystalline matrix and carbonate mud (See Table 3 and Table 4). Composition: fossils = 20%, mud = 65%, opaque minerals = 5%, microcrystalline calcite = 10%. Rock Name: *Wackestone* [15].

Figure 3. The intercepted rock in the claystone rock units exposed at Margaluyu Village for (a) Limestone and (b) Sandstones

The presence of sandstones as intercalation in the Claystone Rock Unit. Sandstone and Limestone intercalation that are found in the field are megascopically light gray, with a texture: the size of medium sand - coarse sand (1-2 mm), grain shape angled - angled, open container, moderate sorting, carbonate cement and mineral composition consisting of quartz minerals, lithic feldspar (See Fig. 3).

3.2. Relative age Determination.

On determining the relative age of the rock unit, samples were taken from three locations representing the lower, central and upper parts. Samples from Cigudawang River represent the lower part, samples from the Cilaki River represent the central part, and samples from the Cisuda location represent the upper part. Relative age determination applies Blow classification [16]. The sample that represents the lower part contains the fossils of *Hastigerina phraesiphonifera, Orbulina universa, Orbulina suturalis,Globorotalia praemenardiand Globogerinoides subquadratus.* It shows the relative age of $N_9 - N_{12}$ on the basis of fossils index *Globorotalia praemenardi* can be seen in Table 5.

The sample that represents the middle part contains the fossils of Orbulina universa, Globorotalia siakensis, Globorotalia miocenica, Globorotalia praemenardi. Shows the relative age of N9 – N12 (See Table 6). Whereas based on the results of fossils analysis representing the upper part, the following collection was obtained, namely Orbulina universa, Globoquadrina subdehiscens, Globoquadrina advena, astigerina phraesiphonifera with the range relative ages of N9 - N12 can be seen in Table 7.

Based on the content of the fossil index, namely the presence of Globorotalia praemenardii, Globorotalia siakensis, Orbulina universa and Globoquadrina advena, Hastigerina phroesiphonifera, it can be concluded that the age of Claystone Rock Unit Sandstone and Limestone intercalation is N9 - N12 or Middle Miocene.

3.3.Determining Depositional Environment.

The depositional environment of Claystone Rock Unit Sandstone and Limestone intercalation was determined based on below the sea level or in the outer neritic zone. The foraminifera benthonic analysis applies a range of bathymetry [17]. The analysis of fossil foraminifera benthonic that was found in Cigudawang River oobservation site, shows collection of foraminifer's benthonic fossils consisting of Eponides, Rotalia sp and Elphidium sp. which shows the depth of 100-200 meters.

Table 5. The Relative age of Planktonic Foraminifera in the Lower Part o Claystone Rock Unit Sandstone and Limestone intercalation [16]

Relative age / Foraminifera Planktonic	Miocene																	Pliocene	
	Early					Middle						Late							
	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21
Orbulina universa																			
Orbulina saturalis																			
Globorotalia praemenardi																			
Globigerinoides subquadratus																			
Hastigerina phraesiphonifera																			

Table 6. The Relative age of Planktonic Foraminifera in theCentral Part of Claystone Rock Unit Sandstone and Limestone intercalation [16]

Relative age / Foraminifera Planktonic	Miocene																	Pliocene	
	Early					Middle						Late							
	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21
Orbulina universa																			
Globorotalia siakensis																			
Globorotalia praemenardi																			
Globorotalia Mioceneica																			

Table 7. The Relative age of Planktonic Foraminifera in the Upper Part of Claystone Rock Unit Sandstone and Limestone intercalation [16]

Relative age / Foraminifera Planktonic	Miocene																	Pliocene	
	Early					Middle						Late							
	N4	N5	N6	N7	N8	N9	N10	N11	N12	N13	N14	N15	N16	N17	N18	N19	N20	N21
Orbulina universa																			
Globoquadrina subdehiscens																			
Globoqudrina advena																			
Hastigerina phraesiphonifera																			

Table 8. The Environmental Range of Foraminifera Bentonics in the Lower Part of Claystone Rock Unit Sandstone and Limestone intercalation [18]

Depth / Foraminifera Benthonic	Depositional Environment					
	Transition 0-5 meter	Neritic			Bathyal	
		Edge 5-20 m	Middle 20-100 m	Outer 100-200 m	Upper 200-500 m	Central 500-1000 m
Eponides sp						
Uvigerina sp						
Rotalia beccarii						
Elphidium						

Table 9. Environmental Range of Foraminifera Benthonic on Upper Part of Claystone Rock Unit Sandstone and Limestone intercalation [18]

Depth / Foraminifera Benthonic	Depositional Environment					
	Transition 0-5 meter	Neritic			Bathyal	
		Edge 5-20 m	Middle 20-100 m	Outer 100-200 m	Upper 200-500 m	Central 500-1000 m
Rotalia beccarii						
Robulus sp						
Amphistegina						
Elphidium sp						

Based on the bathymetry range in Table 8 and Table 9 it can be concluded that the depositional environment of Claystone Rock Unit Sandstone and Limestone intercalation is 20-100 meters or in the central neritic depositional environment.

The results of granulometric analysis show the distribution pattern of freedom shell, 11 feet as shown in the following grain size distributions (See Figure 4). The results of the calculation of P/B ratio with the value of P/B ratio 44% based on the classification [11]-[12] the deposition is included in the outer neritic environment (outter exposure).

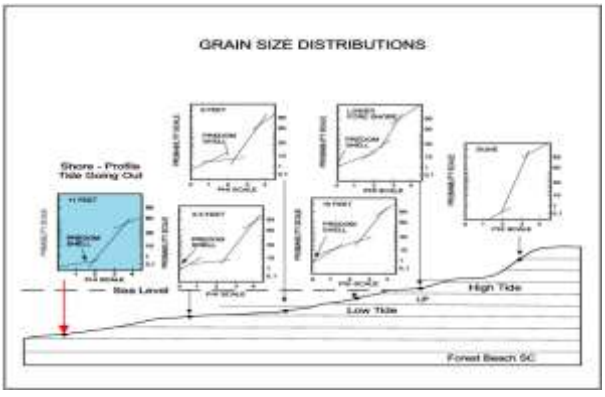


Figure 4. Large item distribution onClaystone Rock Unit Sandstone and Limestone intercalation, which is located at a depth of 11 Feet

The stratigraphic position between units of Claystone Rock Unit Sandstone and Limestone intercalation with other rock units underneath in the study area is not found, so it can be concluded that the Claystone Rock Unit Sandstone and Limestone intercalation are the oldest rock units in the study area. The stratigraphic relationship between these rock units with the overlaying other rock units, namely Sandstone Rock Unit Claystone and Limestone intercalation is aligned conform, based on the relative age range of this unit which is between N13 -N14 or Middle Miocene Final Section.

3.4. Sandstone Rock Unit Claystone and Limestone intercalation.

The conditions of this unit in the field are not continuous because it is covered by vegetation and intensive weathering. The thickness of Claystone Rock Unit Sandstone and Limestone intercalation based on the geological cross section reconstruction is more than 150 meters. The thickness of the Bojongmanik Formation in its type locality is 350 meters. The unit composes of the same lithological characteristics, namely in the form of Sandstone Rock Unit, Claystone and Limestone intercalation.

The best outcrops of these rock units are found in the Ciwaru River, Cilaketan River, in the area around the Muncang Village. It is characterized by claystone sandstone intercalation with coal lenses.

Other outcrops found in the Cibungur River are characterized by Sandstone Rock Unit Claystone and Limestone intercalation.

The main characteristic of the Sandstone Unit (Bojongmanik Formation) that distinguishes the claystone unit from the lower Bojongmanik Formation is the presence of increasingly dominant sandstones and the presence of claystone as an intercalation. The characteristic of sandstone in Bojongmanik Formation is the presence of lignite intercalation with a thickness of 10 cm to 2 meters and presence of tuff.

Based on field observations, sandstones are light gray, medium grained and increasingly upward the grain is rougher, well divided, and compact until cracked, rounded grain shape - rounded, medium porosity in limestone, tuffaceous, conglomerates and in some locations are found quarry. Based on petrographic analysis the name of the rock is "*Calcareous Fedsphatic Arenite Sandstone*".

Claystone and limestone vary in thicknesses, namely claystone ranges from 20 cm - 60 cm while limestone is 10 cm - 25 cm, upward it becomes thinner. Claystone is light gray, compact to cracked, has the limey character and tuff and it contains a lot of mollusca shells as found in Cimangeunteung River, Cibeureum River and around Cigebas River. White limestone - muddy, massive, smooth, clay is present as a mixture.

3.5. Relative age and Fossils Content.

Relative age determination of Sandstone Rock Unit Claystone and Limestone intercalation was carried out on the basis of the content of planktonic foraminifera fossils namely Orbulina bilobata, Globigerinoides trilobus, Globoratalia minardi, Globigerinoides subquadratus and Orbulina universa [19]–[20] (it shows relative age N13 – N14 or Upper Middle Miocene. According to Boggs biostratigraphy in the science of stratigraphic the determination of rock strata is based on the fossils contents (See Table 10, 11 and 12).

Table 10. Relative age Range of Sandstone Rock Unit Claystone and Limestone intercalation in Cibungur River location.

Relative age / Foraminifera Planktonic	Miocene																Pliocene		
	Early					Middle						Late							
	N 4	N 5	N 6	N 7	N 8	N 9	N 10	N 11	N 12	N 13	N 14	N 15	N 16	N 17	N 18	N 19	N 20	N 21
Orbulina bilobata																		
Globigerinoides trilobus																		
Globigerinoides subquadratus																		
Globorotalia menardi																		
Orbulina universa																		
Sphaerodinellapsis subdehiscen																		

Table 11. Relative age Range of Sandstone Rock Unit Claystone and Limestone intercalation in Cibungur River sample location.

Relative age / Foraminifera Planktonic	Miocene																Pliocene		
	Early					Middle						Late							
	N 4	N 5	N 6	N 7	N 8	N 9	N 10	N 11	N 12	N 13	N 14	N 15	N 16	N 17	N 18	N 19	N 20	N 21
Globigerinoides subquadratus																		
Globorotalia menardi																		
Orbulina universa																		
Globigerinoides trilobus																		
Orbulina bilobata																		

Table 12. Relative age Range of Sandstone Rock Unit Claystone and Limestone intercalation in Cibungur River sample location

Relative age / Foraminifera Planktonic	Miocene											Pliocene						
	Early					Middle						Late						
	N 4	N 5	N 6	N 7	N 8	N 9	N 10	N 11	N 12	N 13	N 14	N 15	N 16	N 17	N 18	N 19	N 20	N 21
Orbulina universa																		
Globorotalia menardi																		
Globigerinoides trilobus																		
Globigerinoides subquadratus																		

3.6. Depositional Environment

The microfossil analysis at the TD-41 and TD-52 locations shows the results of benthos foraminifera as follows: *Robulus sp, Cibicides sp, Elphidium* and *Pyrgo*. The microfossil analysis of TD-41 and TD-52 locations obtains the results of benthos foraminifera and *Pyrgo*. On the basis of the content of bentonic foraminifera, it shows the ocean depositional environment in the Middle Neritic Zone or at a depth between 20 m to 100 m [21]. On the other hand,it is also found *Ostracoda* which shows the depositional environment at a depth of 20 meters to 100 meters (Table 13 and 14).

Noting lithological variations, namely sandstones with silt clay intercalation, limestones and lignite and the presence of "parallel laminate", "Graded bedding" and "Cross bedding" sediment structures in the Ciwaru River by comparing with the environmental model depositional (See Fig. 5). it can be concluded that the depositional environment of these rock units is the Delta Depositional Environment, in the "Distal Mouth Bar" to "Distributaries Mouth Bar". The sedimentary structures found in Ciwaru River are also found in the Cibeureum Girang River and the lower Citundun River. The results based on granulometric analysis show the coastal deposition environment in the "Predom Shell" which is the delta depositional environment.

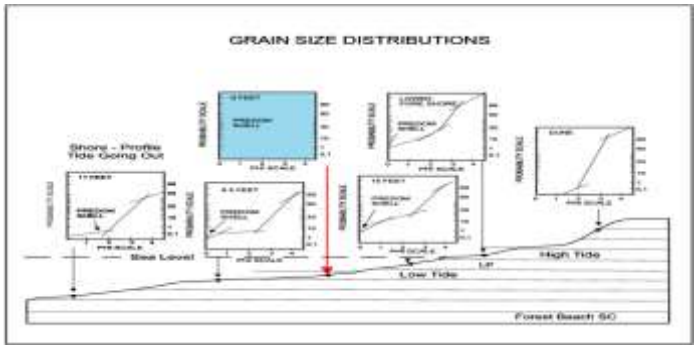


Figure 5. Large item distribution on Claystone Rock Unit Sanstone and Limestone insert, which is located at a depth of 9 feet.

Table 13. Range of Depth Zone Sandstone Rock Unit Claystone and Limestone intercalation (Sample TD-41)

Depth / Foraminifera Benthonic	Depositional Environment					
	Transition 0-5 meter	Neritic			Bathyal	
		Edge 5-20 m	Central 20-100 m	External 100-200 m	Upper 200-500 m	Central 500-1000 m
Robulus sp						
Cibisides sp						
Pyrgo sp						
Elphidium sp						

Table 14. Range of Depth Zone Sandstone Rock Unit Claystone and Limestone intercalation (Sample TD-41)

Depth / Foraminifera Benthonic	Depositional Environment					
	Transition 0-5 meter	Neritic			Bathyal	
		Edge 5-20 m	Central 20-100 m	External 100-200 m	Upper 200-500 m	Central 500-1000 m
Elphidium sp						
Cibicides sp						
Pyrgo sp						
Ostracoda sp						
Robulus sp						

These granulometric results are in accordance with that conducted at the location of the Cibeureum River showing the *Fredom Shell - Low tide* environment at a depth of 5 feet.

3.7. Stratigraphic Position

Based on the appearance in the field, the pattern of distribution and the rocks'relative age of Sandstone Rock Unit Claystone and Limestone intercalation (Upper Bojongmanik) it is concluded that it has a West-East distribution pattern which is in the same direction with general direction of the slope direction to the North. It ranges from 15^0-25^0. The Sandstone Claystone Unit and limestones (Lower Bojongmanik) with a direction of West - East spread in the direction of the rock with the direction of the slope to the North ranging from 15^0 - 25^0.

On the basis of lithological transformation from the Claystone Rock Unit Sandstone and Limestone intercalation it is concluded that increasingly towards North, the presence of sandstones becomes dominant and turns into Sandstone Rocks Unit Claystone and Limestone intercalation of Bojongmanik Formation, hence the contact with the rock units above is a conformity which is confirmed by the relative age range of Claystone Rock Unit Sandstone and Limestone intercalation namely Middle Miocene (N9-N12) and the Sandstone Rock Unit Claystone and Limestone intercalation are Middle Miocene (N13-N14) [22]-[23]. It can be concluded that the stratigraphic relationship between the Sandstone Rock Unit Claystone and Limestone intercalation with Claystone Rock Unit Sandstone and Limestone intercalation underneath is a conformity, while the stratigraphic relationship between the Bojongmanik Formation and the rock unit above namely Tile Formation measured the field shows a difference in angle which might conclude the angular unconformity.

3.8. Tuff rock units with tuffaceous sandstones and breccias intercalation.

This rock units in the field are characterised by tuffs which intercalate with tuffaceous sandstones and breccias. This unit is exposed in the north, locally, spread from West to East, occupying 18% of the total research area. In the field shows that the bedding of this rock units is generally poor, in a few places bedding of rock can be measured. The strike/dip of the rock bedding ranges from N241^{0}E - N250^{0}E with a large slope ranging from 10^0-12^0. The thickness of the tuff rock unit with tuffaceous sandstones and breccias sandstones is about 120 meters. The physical characteristics of this lithology unit rock are dominated by ephiclastic Tuff rocks, the insertion of tuffaceous sandstones, increasingly upward, these units are brecciated containing silicified wood fragments which are characteristic of the Genteng Formation.

Figure 6. Tuffs outcrop representing the middle part of the rock. Exposed at Sindangsari Village, Sajira.

Petrologic description of these rock units consists of tuffs with yellowish white, clastic, hard to brittle with mineral composition consisting glasses, lithic crystals, grain with the sizes of 0.2-0.5 mm, matrix supported, rounded grain shape, bad sorting. Petrographic analysis of tuffs which was

taken from location ST-57 shows a brownish white color, fine grain, anhedral - subhedral grain shape with the mineral composition consists of 2% fragments (quartz and opaque minerals), measuring 0.07-0.8 mm. The matrix (98%) consists of a brownish-white volcanic glass. Name of Rockis *Tuff Glass*. The Tuffs outcrop representing the middle part of the rock at Sindangsari Village can be seen in Fig. 6.

Megascopic in tuffaceous sandstones, light gray, grain size 0.5-1.0 mm, angular grain shape, medium packing, medium sorting, silica cement with mineral composition: quartz, feldspar, lithic, and glass. Petrographic description of the incision of clastic sedimentary rock taken at the site, light brown tuffaceous sandstones, consisting of lithic, K-feldspar, Calcite, Quartz and metal minerals as matrices. The basic mass is in the form of glass and clay minerals. Packets are open - floating, intraparticle and interparticle porosity, moderate sorting, angular shape of the corners to the point where they are broken, the grain size ranges from fine to 0.4 mm. Mineral composition: Glass: (30%), Lithic (25%), K-feldspar: (22%), Quartz: (6%), Metal Minerals (2%), Clay (15%).

Figure 7 outcrop of tuff with breccias and sandstones intercalation that represents the upper part of the rock units. Exposed at Sindangsari Village, Sajira.

The relative age of Tuff rocks and tuffaceous sandstone units found in the study area was determined by the superimpose asssigning the age of the Genteng Formation is Pliocene. The determination of the depositional environment of tuff rock units with tuffaceous sandstones intercalation is based on the physical characteristics of lithology found in the field. It composes of tuffs and tuffaceous sandstones which contain silicified wood. Silicified wood indicates the deposition of terrestrial environment. In several locations sedimentary structures of Genteng Formation are found, showing that the Genteng Formation is an ephiclastic rock deposited in a terrestrial environment. The outcrop of tuff with breccias and sandstones intercalation that represents the upper part of the rock units at Sindangsari Village can be seen in Fig. 7.

The stratigraphic relationship of Tuff rock unit tuffaceous sandstones intercalation with the rock units underneath, namely the Sandstone Rock Unit Claystone and Limestone intercalation of the Bojongmanik Formation is an unconformity, while the relation of these rock units to the overlaying units which is alluvium of the river is the erosion surface [].

Intrusion outcrops of andesitic rocks are found in the Geblegan region in contact with the tuff rock unit with tuffaceous ssandstones intercalation. The igneous rock shows brownish gray in colour, hypocrystalline and aphanitic textures. Mineral composition consisted of plagioclase, K-feldspar, mafic minerals, and glass. The diorite outcrops exposed at GunungPasir, Cimarga District can be seen in Fig. 8.

Figure 8. Diorite outcrops exposed at GunungPasir, Cimarga District.

Description of the petrography of diorite rock which was taken from Gunung-Pasir shows brownish-grey colour with textures holocrystalline, aphanitic, euhedral-subhedral crystal form; crystal size 0.1-1.5 mm; porphyritic in-equigranular with mineral composition consists of andesine plagioclase (60%), pyroxene (10%), quartz (5%), opaque minerals (5%) and glass (20%). Igneous rock name: Andesite.

The relative age of andesite is determined by using crosscutting relationship rules and influenced by orogenenic activiy (tectonics). Based on crosscutting relationship rules that andesite was intruded the claystone rock units and andesite was associated , so the and andesite rocks in the study area are estimated to form together with orogenesa, namely orogenesis of Late Pliocene - Early Pleistocene.

3.9. Units River Alluvial

The naming of these units is based on the alluvial river material found in the study area in the form of floodplains and sandpit deposits which are composed of loose material from clay to lump. This unit occupies around ± 5% of the research area. Generally these alluvial sediment units occupy areas with flat relief, scattered around the Cilaki River and the Cibeurang River. The thickness of this unit is based on observations in the field between 0.5-4.0 meters. This sedimentary unit is composed of angular to rounded clay, sand, gravel, and crustal alluvial material, and built of igneous fragments, breccias fragments, sandstone fragments and limestone fragments and silicified wood sand and clay. Alluvial sediment units are the youngest units in the study area. The stratigraphic relationship between units of alluvial deposits with older rock units underneath is limited by the field of erosion. The Point bars and flood plains deposit found on the Cilantuk River can be seen in Fig. 9.

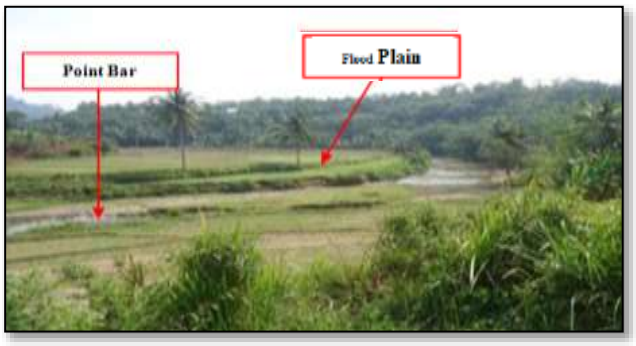


Figure 9. Point bars and flood plains deposit found on the Cilantuk River

4. Conclusions

Stratigraphically, the first deposited lithology is Claystone Rock Unit Sandstone and Limestone intercalation starting at N_9 or Early Middle Miocene as Claystone rock unit with sandstone and limestone intercalation deposited. This rock units were deposited until N_{12} in middle neritic - outer neritic enviironment.

The deposition of this unit lasted up to N14 or at the Middle Miocene. The paleo-geographic condition of the study area at that time (N13 - N14) was in the form of a transition-neritic area. In N15 or during the Late Early Miocene, the research area began to experience an orogenesis or tectonics resulted in the regression and followed by volcanic activity produvcing pyroclastic rocks and then deposited in the study area as ephiclastic deposits consisting of tuffed intercalation with tuffaceous sandstones and breccias sandstones as Tile Formations which are thought to have formed at the beginning of the Pliocene. The tectonic process continued until Pleistocene resulting in the formation of folding, lifting and rearing of the rocks of the Bojongmanik Formation and the Genteng Formation.

Lithologicaly, Bojongmanik Formation in the Sukamarga area can be distinguished into two distinct rock units, namely the Rock Unit intercalation of Sandstone and Limestone as the oldest sediment exposed in the study area. The blackish clay is sometimes thin or absent. Sandstone units with claystone and limestone intercalations and coal lenses conformably located below the rock units. Contact of unconformity was found between Sandstone Units, the intercalations of claystone and limestone with the Genteng Formation[29]which is characterized by the appearance of silicified wood. The uniyd were intruded by Andesitic Stone resulted in the formation of Tuff rock units, Tuff breccias and sandstones.

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