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Bojongmanik Formation Sedimentation Mechanism in the Middle to Late Miocene (N9-N17) in the Rangkasbitung Basin

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ABSTRACT - The Rangkasbitung Basin, is a part of Banten Depression which was formed by a normal fault, and then filled by marine deposits. This research carried out to understand the sedimentation process of Middle Miocene Bojongmanik deposits, the age, paleoenvironment and lithology (sediment sequence). In this research, 55 samples were taken from the study area, approximately 595 km^2. Measurement of the stratigraphic section is carried out to determine the correlation both vertically and horizontally. The residue of dissolving peroxide method was carried out during the samples preparation. Then genus and species of planktonic and benthonic foraminifera were identified and determined. The foraminifera analysis guide has been used to determine the age and depositional environment. The sequences of Bojongmanik Formation were deposited in Middle to Upper Miocene (N9 to N17). Based on the planktonic foraminifera distribution, the succession of each sequence can be correlated. During Middle Miocene (N9 - N12), the lowest part of Bojongmanik Formation is deposited at 100m-200m and 100m-80m depth, while in the other site, the correlated sequence is recorded that deposited at 80m-20m depth (outer to edge of inner neritic facies). In late Middle Miocene (N13 - N14), the regression process was happened. Almost the succession was deposited on land, while in deep site, a less part of sediments was formed as land facies but the most of it deposited as marine facies. In Upper Miocene (N 15 - N 17), the sedimentation continued in the transitional to edge neritic in back mangrove to mangrove environmental setting (upper to lower delta plain), and in other sites the sediment is no longer formed. Based on distribution of benthonic foraminifera there are observed the biofacies changes laterally. In bathymetric of depositional environment maps it can be depicted two higher paleoenvironmental sites (Cigudeg and Muncang highs) and two lower sites (Leuwiliang and Jasinga basins).

Keywords: Sedimentation mechanism, Bojongmanik formation, Rangkasbitung basin.

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INTRODUCTION

Rangkasbitung Basin, located in Mandala Banten, was formed by normal faults and began its development by forming depressions (Syahbuddin, *et al.*, 1986), that filled by marine deposits (Martodjojo, 1984), stated that; the formation which filled the basin are the formation that was deposited in Middle Miocene period and has a typical rock filler of Banten Sedimentation Mandala. To understand the sedimentation mechanism of Bojongmanik

Formation during Middle Miocene period, suggests an overview of its past bathymetry and sequence of material sedimentation process are needed. The purpose of this research is to understand the deposition mechanism of Lower and Upper Bojongmanik Formation based on the characteristics of the biofasies, and to examine the relationship between evolution of Rangkasbitung Basin during the deposition of Bojongmanik Formation (Siswoyo & Thayyib, 1976).

The location of the research area is located in two provinces, namely Banten Province and West Java Province, which covered a research area of 595 km^2. Bojongmanik Formation (Syahbuddin, *et al.*, 1986) is divided into two formations, namely Lower Bojongmanik Formation which characterized by claystone units of sandstones and limestones of Middle Miocene age (N9 - N17) and Upper Bojongmanik Formation, a sandstone unit with a middle Miocene (N9 - N17) inserted claystone and limestone. Both of these units are deposited in a shallow marine environment. Rangkasbitung Basin is a part of Mandala Banten that tectonically located in Back Arc Basin (Syahbuddin, *et al.*, 1986). The results showed that Lower Bojongmanik Formation (N9 - N14)and Upper Bojongmanik Formation can be distinguished based on the pattern of events. This difference is greatly influenced by the existence of Rangkasbitung Basin.

Measurements of stratigraphic section were carried out on 11 observational lines with a total of 55 samples taken, all were used to analyze its foraminifers' fossils, both of its planktonic and bentonic nature (Boucot, 2014). The results of its analysis contents then were used to create both of its Age Similarity Contour Map and Bathymetric Contour Map. This research is important to determine the rock succession and sedimentation mechanism that occurred in the Middle Miocene (N9 - N14) to Upper Miocene (N15 - N17) periods in Bojongmanik Formation. Base on gamma ray log (log GR) interpretation using relative correlation between log shape variation and sedimentation facies (Syaiful, 2017) the analysis, Bojongmanik Formation was deposited on marine-lagoonal environment with very low wave influence. Log GR that shows shape of funnel, serrated, and symmetry, indicate shoreface, lagoon, and tidal point bar facies.

Each researcher has a role that are in-accordance with the capacity and expertise of each own respective fields, and the cohesiveness of the team has brought an interesting discussions that benefits the development of this research.

METHODOLOGY

Measurements of stratigraphic section is a standard method that were used to see variations in lithology, rock texture, and developing sedimentary structures. These characteristics are useful for the purposes of stratigraphic section correlations. The measurement of the cross-section trajectory were carried out in 11 observational lines, so that the lithology information of the area can be represented from each measurement path.

Its rock sampling are taken from each that represents the lower, middle and upper part of the rock unit, all in the purposes of foraminifers' fossil analysis requirements. The preparation of microfossils sampling was carried out by observing the results of residue peroxide solution dissolving (Jurnaliah, 2016), then followed by the identification and determination of the genus and species of plankton and benthos . After that, the determination of planktonic and bentonic fossils are generated in the forms of age range (Isnaniawardhani, 2017) and its depositional environment. Each then are plotted into a map in accordance with the sampling coordinates in the field. The contouring method is carried out to determine Age Similarity Map and Precipitation Environment Similarity Map.

To determine the depositional environment, apart from (Phelger,1951 classifications), the methods of Planton (P) / benthonic (B) ratio from (Murray, 1976) and (Boersma, 1983) ware also used as a comparison. Bathymetric Contour Maps (Gimsdale ang van Markhoven, 1955) and Age Similarity Contour Maps are used to reconstruct the sequence of sedimentation events of Lower Bojongmanik Formation and Upper Bojongmanik Formation, and its sedimentation mechanism that occurs in each age of rock layers.

RESULTS AND DISCUSSION

Observations were made on 10 research blocks with its block division as shown in Figure 1 below.

Stratigraphically, the sequence of rock units from older to younger rocks were started from Lower Bojongmanik Formation (N9 - N14) which inter-fingers Upper Bojongmanik Formation in the age range of Middle Miocene to Upper Miocene

(N9-N17). In the Leuwiliang area, the Upper Bojongmanik Formation are inter-fingering with the Cibulakan Formation (Martodjojo, 2003), which are Middle Miocene (N13-N14). The three Formations are subsequently covered inconsistently by fluviatile deposits from the Early Pliocene of Genteng Formation (Sudjatmiko,1992).

In the Late Pliocene Age, Dahu Volcano product (Effendi, *et al.*, 1998) covered the southern part of the eastern region of the study area (Leuwiliang Block). Around the Pliocene to Plistocene period, orogenesis was occurred, and it led into geological structural activity with the formation of folds and fractures that are followed by a breakthrough of Andesite - Diorite intrusion (Williams, et al 1954) and volcanic activity from Endut Volcano. In the Late Plistocene, breccia and lava products (Salak Volcano), covered the northern part of Cigudeg Block and Leuwiliang Block (Effendi, *et al.*, 1998). The stratigraphic sequences are shown in Table 1 below.

From 11 stratigraphic cross-section measurements, 8 of its lines, from West to East were correlated. The correlation results from the 8 lines of stratigraphic cross-section measurements are shown in Figure 3. According to the interpretation results of the stratigraphic section, it can be observed that the lateral distribution of Lower Bojongmanik Formation is only up to the Paniis block, while the extension of Upper Bojongmanik Formation from Leuwidamar block are stretches into Leuwiliang block and Upper Bojongmanik Formation in Leuwiliang block inter-fingering with the Cibulakan Formation (Abdurrokhim, 2016).

The interesting part here is that Lower Bojongmanik Formation does not continue to reach into Cigudeg Block or Leuwiliang Block but instead stopped at Paniis Block. (Figure 2).

Thus, this situation induce a question why the expansion of Lower Bojongmanik Formation does not continue to Cigudeg block, meanwhile there is a succession that inter-fingers between Lower Bojongmanik Formation and Upper Bojongmanik Formation in this block.

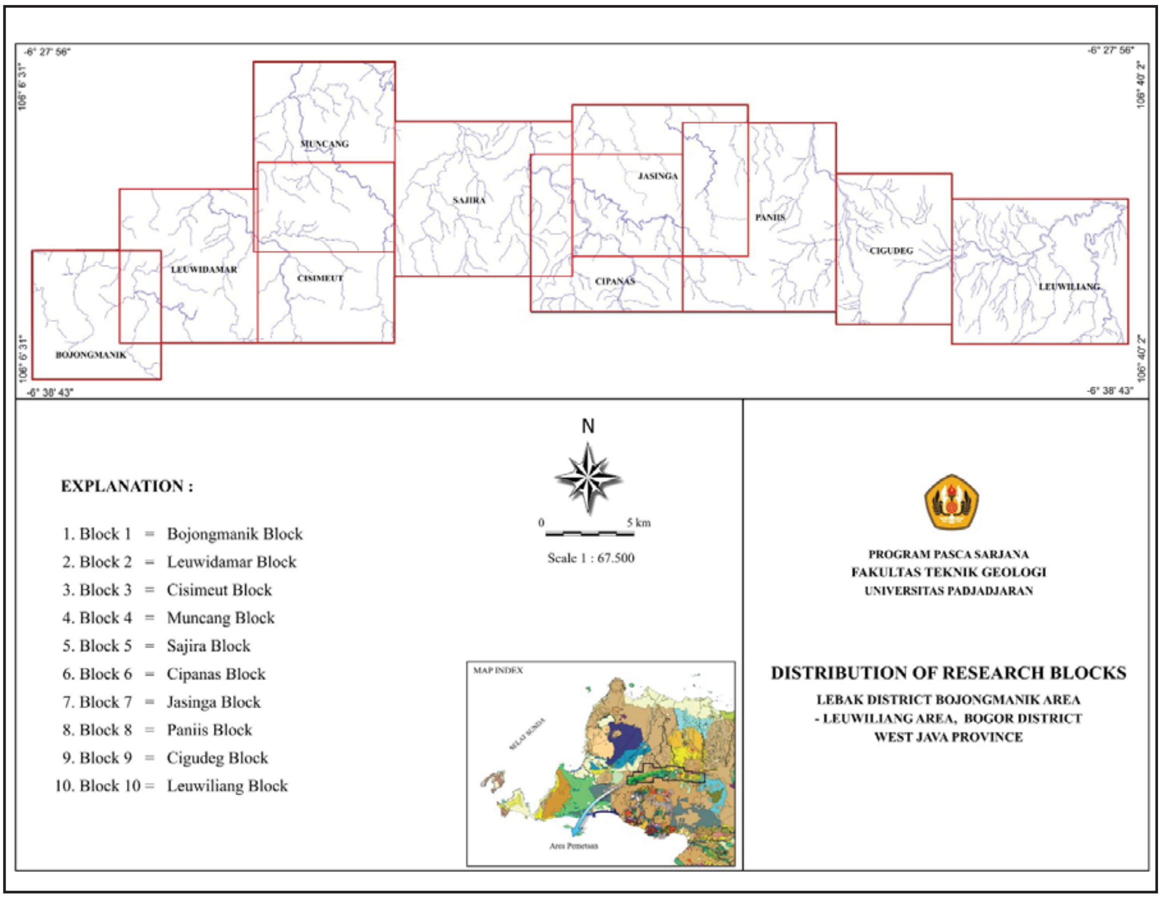

Figure 1
Research area division blocks.

There are 31 planktonic foram individuals that were found in Lower Bojongmanik Formation, these planktonic foraminifera (Postuma, J.A.,1971) individuals consists of 6 genus, which are; genus *Globorotalia* (10 species), genus *Globigerioides* (8 species), genus *Globoquadrina* (5 species), genus *Globigerina* (4 species),genus *Orbulina* (3 species) *and g*enus *Hastigerina* (1 species). In the upper Bojongmanik Formation, there were 23 planktonic foraminifera individuals that consists of 7 planktonic foraminifera genus, namely; genus *Globorotalia* (6 species), genus *Globigerinoides* (7 spcies), genus *Globoquadrina* (1 species), genus *Globigerina* (4 species), genus *Orbulina* (2 species), genus *Hastigerina* (2 species) and genus *Shpaeroidinellopsis* (1 species).

Therefore, to see the reconstruction (Syahrulyati, *et al.*,2020) of its underwater topography, a bathymetric contour is necessary to be made (Figure 3). This map is interpreted from 55 observation sample points. Each observation point consists of a lower, middle and upper samples, The resulting fossils were determined using Blow zoning (1969).

The resulting bathymetric map (Figure 3) Illustrates the presence of two bathymetric deep and two bathymetric heights. The first basin pattern is named Jasinga Bathymetric Deep with a depth ranging from 80 meters to 200 meters, having a fairly wide basin shape compared to the second basin, namely; Leuwiliang Bathymetric Deep. This Leuwiliang Bathymetry Deep has a depth ranging from 80 meters to 100 meters. In 8 blocks of research area,

Table 1
Stratigraphyc colomn of Rangkasbitung Basin

Age	Formation / Unit	Symbol	Intru sion	Thick (m)	General Description	Environment Deposits
Recent	I. Alluvial Deposits	I			Loose material from clay, sand, igneous rock, limestone	Land
Pleistocene	H. Laharic Breccia Unit and Lava	H			The presence of fragments of igneous rock, wood fibers and tuff of varying sizes from gravel to boulder	Land
Pliocene - Pleistocene	G. Intrusion unit F. Rock Units Endut Volcano	F	G	> 100	G. Andesite intrusion - Diorite, form volcanic neck, and Sill. F Pumice tuff, melted lava and breccias from Mt. Endut	Land
Late Pliocene	E. Rock Units Dahu Volcano	E		> 125	Characterized by the presence of monomic breccia rocks, with tuff intercalation. Breccia rocks are formed by tuff fragments	Land
Early Pliocene	D. Breccia and Tuff Units Genteng Formation	D		> 500	Reddish-white epiclastic tuff, tuff sandstones, breccias and conglomerates. Lava and lava deposits. Sedimentary structure graded bedding, parallel lamination	Flufiatil
Middle Miocen (N9 - N17)	C1. Silt Rock Unit and Sandstone Cibulakan Formation C2. Limestone Unit Cibulakan Formation	C1, C2		C1 : > 600 C2 : > 200	Carbonate siltstone, interspersed with fine sandstones. Both contain carbonate nodules. While limestone is characterized by layered to massive	Middle Neritic
	B. Sandstone Rock Unit Claystone with Limestone intercalations	B		> 400	Sandstones with claystone and limestone intercalation are found in several places as inserts of coal	Delta - Middle Neritic
Middle Miocen (N9 - N14)	A. Inserted Claystone Unit Sandstones and Limestones Lower Bojongmanik Formation	A		> 700	Claystone is dark gray. Fine-coarse sandstones, there is biotrubation. Layered limestone, smooth texture.	Outer Neritic

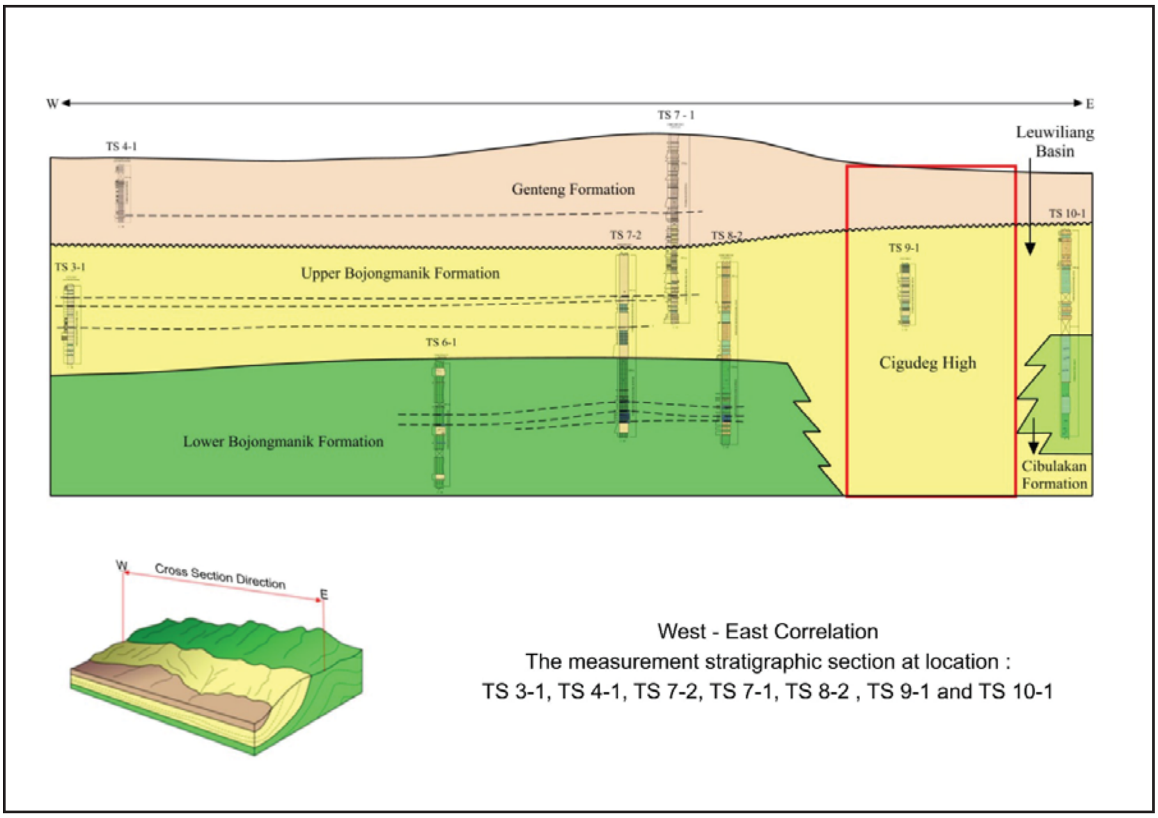

Figure 2
East-West stratigraphic correlation.

the contents of bentonic microfossils were found in the form of; *Epodides* sp (5 – 200m), *Elphidium* sp (20 – 200m), *Uvigerina*, *Robulus*, *Amphistegina*, *Texularia*, *Eponides*, Kopecká, (2012).

Based on the paleobathymetric inveronment map (Figure 3) this study area can be divided into East deep bathymetric (Jasinga) and West deep bathymetric zone (Leuwiliang) which is separated by higt bathymetric zone in between (Cigudeg).

The Lower Bojongmanik Formation is deposited in Jasinga Bathymetry Deck, with its depth ranging from 80 meters to 200 meters. The Upper Bojong-manik Formation is deposited in Leuwiliang Basin with a depth of 80 meters to 100 meters. These two basins are adjacent to each other in the direction of West - East and separated by Cigudeg bathymetry height.

During the Middle Miocene period (N9 - N12) Blow, (1969) there was a sedimentation process of Lower Bojongmanik Formation that fills Jasinga bathymetry Basin, while at this same period, Upper Bojongmanik Formation was simultaneously deposited in Leuwiliang bathymetry Basin.

Given that Jasinga bathymetry Basin is wider than Leuwiliang Basin, but in the same period sedimentation process occurs, it can be assumed that the filling of Jasinga bathymetry basin are occurred quickly, possibly due to the slope factor being filled with fine material (clay). Meanwhile, Leuwiliang Basin is filled with material in the form of relatively coarse sandstones (Sukamto, 1992) with a relatively sloping topography which makes the sedimentation process runs slower.

The bathymetric basin model that generated in the study area shown in Figure 4.

The Lower Bojongmanik Formation was deposited at a depth of 80m to 200m and the Upper Bojongmanik Formation was deposited at a depth of

80m to 100m (Siswoyo, Thayyib,1976) in the Middle Miocene (N9 - N12) period. In Cigudeg block, there were found an inter-fingering structure between Lower Bojongmanik Formation and Upper Bojongmanik Formation that Middle Miocene Period (N9 - N12) Blow, (1969) and the sedimentation process of Lower Bojongmanik Formation ends in Cigudeg Block inter-fingering with Upper Bojong-

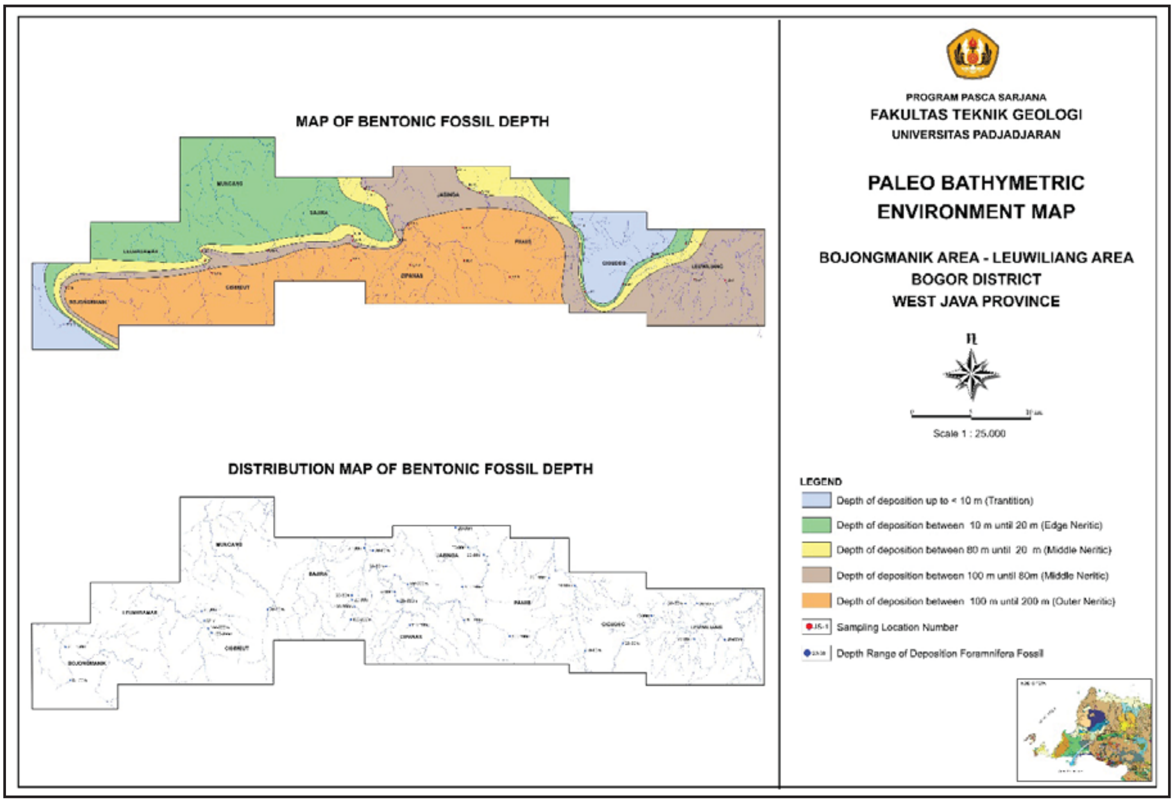

Figure 3
Paleobathymetric environment map based on bentonic fossil analysis.

manik Formation. By using the planktonic presence ratio (P) to bentonic (B) method (Murray, 1976) from the Lower Bojongmanik Formation sample, the P / B ratio values ranged from (44% - 63.0%) at several river routes for example in Cirangrang River blok Muncang rare of P/B (44% - 45%) in the Cikakak river P/B rare of (55%). According to Murray (1976) and Boersma (1983) showing the depositional environment, Outer Neritik. The results of this calculation are in accordance with the classification of Phleger et.all (1969) which shows the depth ranges (100m - 200m), the presence of benthonic fossils *Amphistegina* that live at a depth of 15 meters to 120 meters and *Robulus immaturus* who live at a depth of 15 meters to 200 meters, confirms that the depth of the Jasinga Basin is 100m to 200m.

In Late Middle Miocene Period (N13 - N 14), the result of regression process (Adams, 1999) resulted in Lower Bojongmanik Formation, turns it into a land, and only a few remained in the ocean, while in Upper Bojongmanik Formation, only a few of it turns into land, due most of it remained in the form of oceans while the process of sedimentation still occurs. This sedimentation process resulted Upper Bojongmanik Formation to inter-fingers with Cibulakan Formation (Martodjojo, 2003) around Leuwiliang block and Lower Bojongmanik Formation to inter-fingers with Upper Bojongmanik Formations in Muncang block during N13 to N 14 (Blow, 1969).

During Upper Miocene Period (N15-N17), The Upper Bojongmanik Formation in Muncang Bathymetry Height are still forming and deposited at a depth of 80m to 10m or in the Middle to Transitional Neritic environment (Boucot, 2014). The direction of sedimentation, basin, and supply of Bojongmanik Formation interpreted relatively to the north (Syaeful, 2017), and based on pollen fossil content by (Rahandjo, *et al.*, 2006) is *Upper Delta Plain* - *Lower Delta Plain*, or *Backmangrove environment* - *Mangrove* .

In terms of lithology, Lower Bojongmanik Formation has different characteristics from Upper Bojongmanik Formation (Syahrulyati et.all,1989) Claystone unit with intercalation of sandstone and limestone is a feature of Lower Bojongmanik Formation in Middle Miocene (N9 - N12) Blow, (1969). Meanwhile, in the Upper Bojongmanik

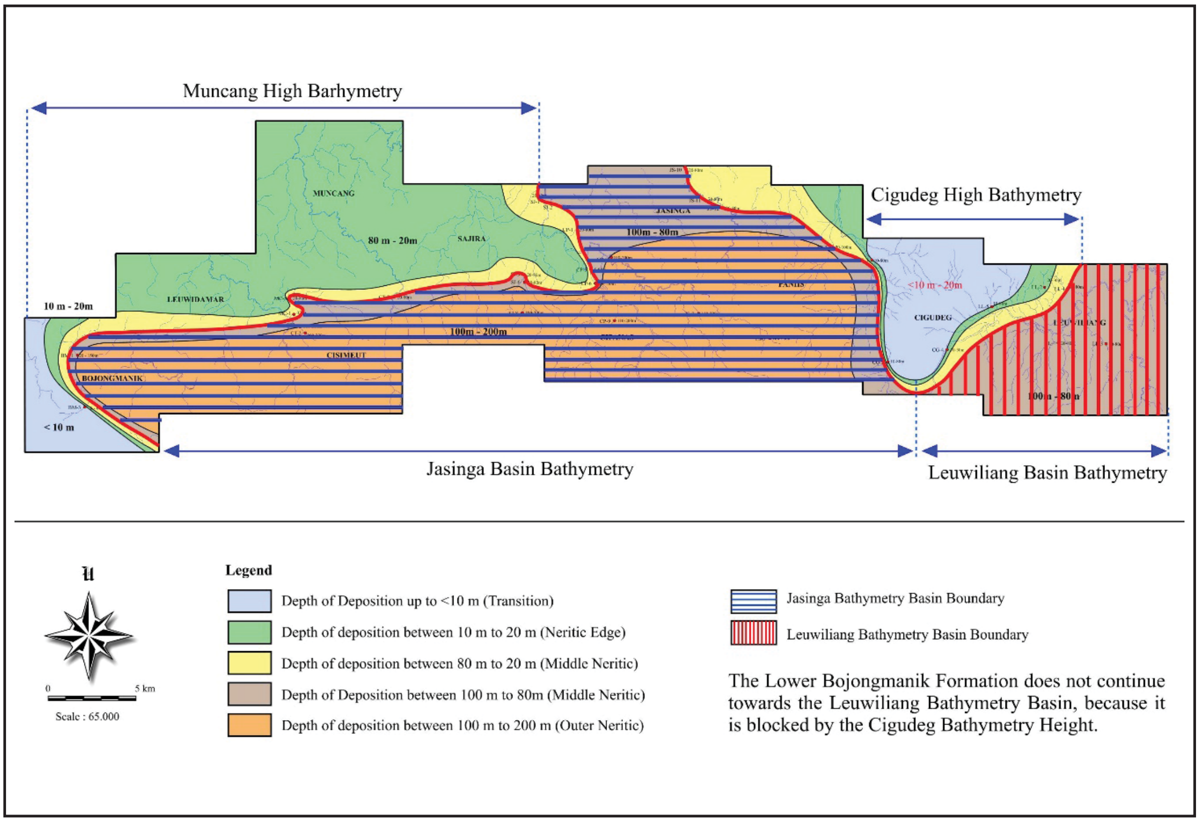

Figure 4
Paleobathymetry / paleodepth of sub-basin Rangkasbitung.

Formation, it consists of interbedded sandstone and clay stone, with intercalated limestone (Siswoyo,Thayib, 1978). This unit is of middle Miocene (Blow, 1969) age (N13-N14), deposited in the transitional environment to the middle tufan sandstone (3-80m).

Several previous researchers stated that, the norther Bojongmanik Formation are deposited, the shallower its environment were found based on data found in the Serpong area, (Syaeful, 2017) mentioned, based on the analysis, Bojongmanik Formation was deposited on marine-lagoonal environment with very low wave influence (Nichols,.

The presence of planktonic and benthic foraminifera fossils on the Tuffan Sandstone Intercalation Unit and the Tuffan Conglomerate (Bojongmanik Formation), (Sudjatmiko & Santosa, 1992).

CONCLUSION

The Lower Bojongmanik Formation and the Upper Bojongmanik Formation have inter-fingers connection as evidenced by the finding of the same age variations in Cigudeg Block (Middle Miocene N9 - N12) and Muncang Block (Middle Miocene N13 - N14) Blow, W.H. (1967, 1969).

The interfingering connection between Lower Bojongmanik Formation and Upper Bojongmanik Formation in Cigudeg block was caused by different sedimentation speed between the two formations, whereas Lower Bojongmanik Formation is settling faster than Upper Bojongmanik Formation. While in Muncang Block, the factor that causes the inter-fingers connection between the two, is due to the fact that both of them are deposited together in a marine environment of "Edge Neritic" is regretion (Syahrulyati, *et al.*,2020).

The Lower Bojongmanik Formation and the Upper Bojongmanik Formation (Syahrulyati et.all,1989) have different lithological characteristics, ages, and depositional environment, therefore. Lower Bojongmanik Formation needed a new formation name. The name proposed was Jasinga Formation, which comes from its related and recognizable location (Syahrulyati, *et al.*,1989).

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GLOSSARY OF TERMS

Symbol	Definition	Unit
sp	species	
P/B	presence ratio planktonic (P) to bentonic (B)	
TS3-1	Number of location measuring section	
Log GR	gamma ray log	

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