



Carbonate Facies and Sedimentation of the Klapanunggal Formation in Cibinong, West Java

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Manuscript received: November 25, 2014, revised: December 30, 2014, approved: December 31, 2014

Abstract - The limestone of Klapanunggal Formation is well exposed in Cibinong and its surrounding area, West Java. Detailed observation on carbonate rock has been conducted in this area and aims at the study of the carbonate facies and its growth environment. The method used in the field is the detailed investigation, while micropaleontologic and petrographic analyses were conducted in the laboratory. The result of this study indicates that the carbonate rocks in the studied area consist of four facies, namely: (1) boundstone facies, (2) packstone facies, (3) rudstone facies, and (4) limestone breccia facies. Based on these data, it can be interpreted that the boundstone facies was deposited in the reef front to reef crest environment, packstone facies developed on the lower slope, upper slope, and back-reef lagoon environment. Rudstone facies formed on the reef front, and breccia limestone facies formed in the lower slope. Geographically, the position of the carbonate body environment that is at the reef front, upper slope, and lower slope is expected to be in the north - northeast while the reef crest and back reef lagoon is on the South - Southwest.

Keywords: carbonate, Klapanunggal Formation, facies, environment, reef, Cibinong

INTRODUCTION

Background

The carbonate rock of Parigi Formation is one of the important targets for hydrocarbon reservoirs in the North West of the Java Basin. Some oil and gas fields in West Java, such as in the areas of Pasirjadi, Gantar, Cicauli, and Tugu, the Parigi Formation, dominated by carbonate rocks contain sizeable gas reserves of more than 1490 BCF (Budiyani *et al.*, 1991).

In the North West of Java Basin, the Parigi Formation is well exposed in several places such as in the areas of Kelapanunggal (Cibinong), Pangkalan (Karawang), Leuwiliang (Bogor), and Palimanan (Cirebon). In Cibinong area, the Parigi Formation is defined as the Klapanunggal Formation in accordance with the name of the village where carbonate rock is well exposed (Turkandi *et al.*, 1992; Effendi *et al.*, 1998). Siregar *et al.*

(2008) and Praptisih *et al.* (2009) carried out preliminary studies on the Klapanunggal carbonates. Based on gravity data, generally, the carbonate rocks occupy the high anomaly or the crest of a structural high (Kamtono and Dadan, 2012).

The distribution of carbonate rocks that exists in the subsurface and surface is basically formed through biological, chemical, and physical processes. This process produces a combination of carbonate sedimentation pattern which can be predicted. In other words, carbonate depositional environments contain a variety of carbonate facies. In relation to the carbonate reservoir, the rocks indicate that the primary and secondary porosities are controlled by facies carbonate rocks (Tucker, 2001).

The depositional environment of carbonate rocks can be reconstructed through observation of characteristics, physical properties, and biota content in the rocks. The limited number of rock

samples obtained from exploration drilling or cutting causes the reconstruction can not be done. Therefore, it is necessary to study carbonate facies based on surficial data.

In this study, observations and samplings of carbonate rocks exposed at the surface were conducted in order to assist in interpreting a sedimentation model.

Objective of the Study

The purpose of the research is to determine the facies types and sedimentation models of carbonate rocks in Cibinong and its surrounding area. This study is expected the facies model of Tertiary carbonates, by examining the characteristics and biota contents within the carbonate rocks.

RESEARCH METHODS

The research method consists of field observation and laboratory analysis. The field observation done through detailed section measurement was used to describe the facies in the field and to determine sample locations of the outcrops. The carbonate facies and their relationships to each other give an overview of the distribution and sedimentation models of carbonate rocks in the studied area. Rock samples were taken systematically in the field for laboratory analysis. The activity carried out in the laboratory is petrographic analysis of carbonate rocks. A total of 110 representative carbonate samples were collected from Klapanunggal and the surrounding areas. The petrographic analysis is used to clarify the result of interpretations based on field data and to support the interpretation of depositional environment. Classification of carbonate used in this study is the classification of Dunham (1962) and Embry and Klovan (1971).

GENERAL GEOLOGY

The carbonates of Klapanunggal Formation discussed in this paper are exposed in the Cibinong area. The geological mapping of Cibinong and the surrounding area has been done by Achdan and Sudana (1992), Turkandi *et al.* (1992),

and Effendi *et al.* (1998), which generated the map sheets of Karawang, Jakarta and the Thousand Islands, and Bogor, in scale of 1:100.000 (Figure 1). The geology of the studied area consists of Miocene to Holocene rocks. The oldest Miocene sediments consist of rocks of the Jatiluhur Formation which is equal to the Cibulakan Formation composed of marl and silty shale, and the Klapanunggal Formation which is equal to the Parigi Formation. The Klapanunggal Formation consisting of limestone reefs is composed of large foraminifera and other fossils including molluscs and echinoderms. The Pliocene deposit consists of conglomerate, sandstone, siltstone, and mudstone sediments (the Serpong Formation). The youngest Holocene rocks consist of silt, sandstone, pebbles and gravel, and volcanic material. They forms an alluvial fan spreading from Cibinong to Bekasi, and alluvial and flood-plain deposits.

RESULTS OF OBSERVATION

The outcrop descriptions in each location determine the facies types based on observation of the characteristics, physical properties, and biota content in the rocks are presented in the carbonate facies distribution map (Figure 2).

Based on facies distribution and detailed megascopic and petrologic analyses, and also micropaleontologic data, all samples revealed four different facies, those are : boundstone, packstone, rudstone, and breccias limestone facies.

Boundstone Facies

Carbonate rocks that have a characteristic of facies boundstone are well exposed in the studied area. This facies is composed of various shapes of coral fragments floating in the packstone matrix containing foraminifera, algae, echinoid, and other microfossils. Based on the shape of its constituent, this boundstone facies is divided into three subfacies, namely: bafflestone, bindstone, and framestone subfacies.

Bafflestone Subfacies

Bafflestone subfacies is formed primarily by the colony of branching coral in the growth structure. In the packstone matrix, it contains

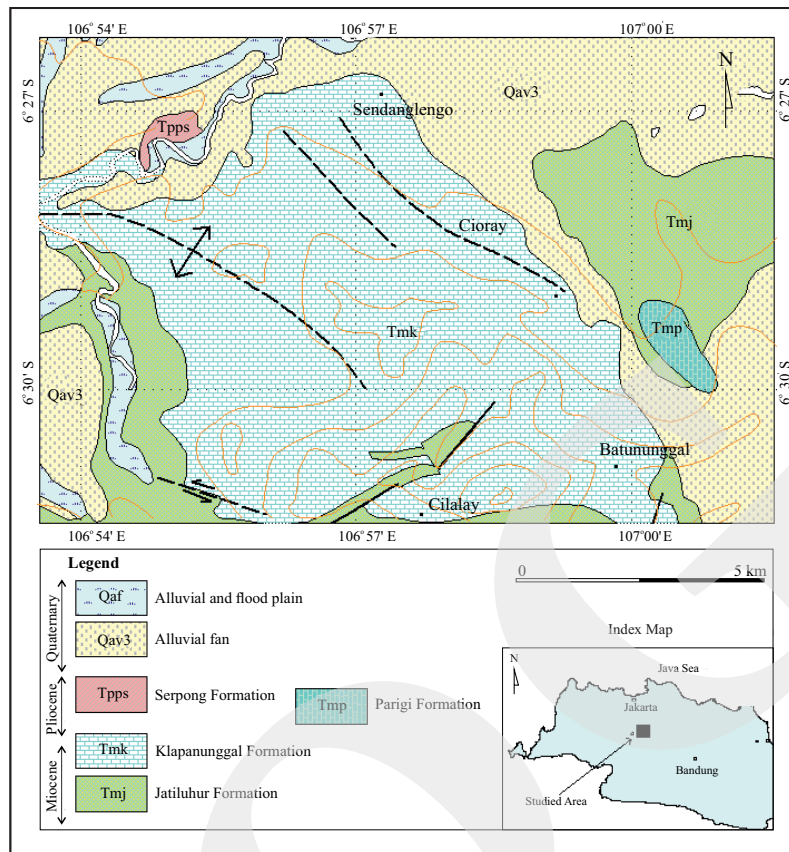


Figure 1. Geological compilation map of part of Karawang (Achdan and Sudana, 1992), Jakarta and the Thousand Islands (Turkandi *et al.*, 1992), and Bogor (Effendi *et al.*, 1998) Quadrangles, showing the distribution of Klapanunggal Formation discussed in this paper.

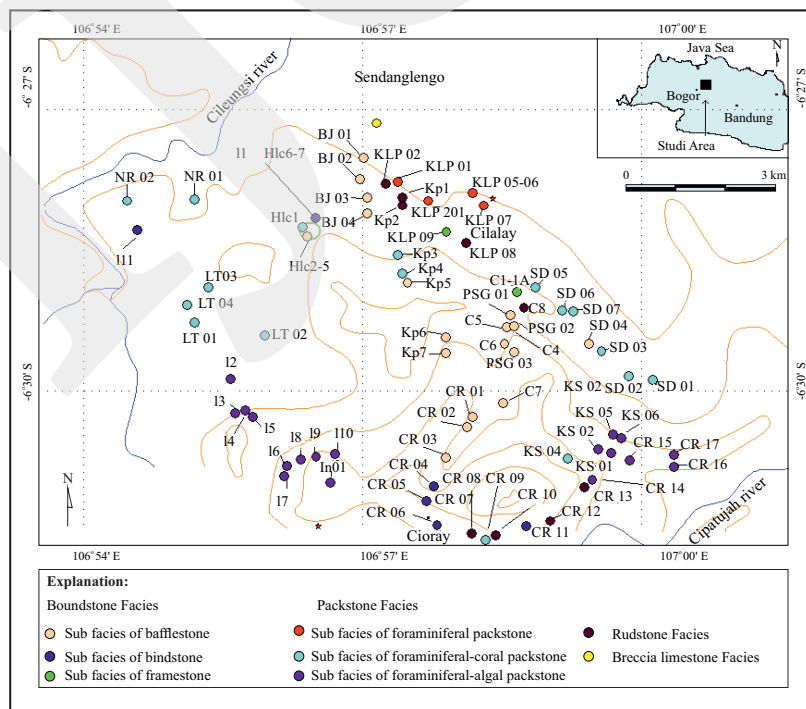


Figure 2. Outcrop sites of carbonate facies distribution map.

red algae and green algae, large foraminifera, benthos, plankton, echinoid, and fragments of molluscs; light grey, the thickness of the layers ranges between 0.2 - 0.5 cm (Figure 3a). Green algae (*Halimeda*) is relatively more abundant when compared to red algae. The type of large foraminifera found are *Lepidocyclina* sp., *Operculina* sp., *Cycloclypeus* sp., *Marginopora*, *Archaias* sp., *Borelis Spiroclypeus* sp. A detailed petrographic observation shows that fragments of branching coral are floating in a packstone matrix (Figure 3b). Bafflestone subfacies is found at the location of Hlc (2-5), KP (5-7), C (4-7), BJ 01-04, SD 04, PSG 01-03, CR 01, and CR 02 (Figure 2).

Bindstone Subfacies

The main biota types in the bindstone subfacies is platy coral floating in a packstone matrix containing bioclastic of larger foraminifera, algae, and echinoid, light grey in colour, well bedded, the thickness is about 0.5 - 1 cm.

Microscopic observation shows that the matrix of platy corals is red algae and green algae (*Halimeda*). The species of large foraminifera is *Lepidocyclina* sp. and also some benthic fossils. The shape of platy coral appearing in the outcrop shows wavy sheets (Figure 3c). The outcrop is situated at the I11, CR 04-07, and CR 11.

Framestone Subfacies

The main type of biota in this subfacies is massive coral floating in a packstone matrix containing bioclastics of larger foraminifera, algae, and echinoid, dark grey in colour, no bedding. This facies is still in its growth position (Figure 3d). The outcrop distribution of this facies is very limited, and is only found at the C1 and KLP 09 sites.

Packstone Facies

Packstone facies contains large planktonic and benthic foraminifera, and algae, opaque to light grey colour, well bedded, the layer thick-

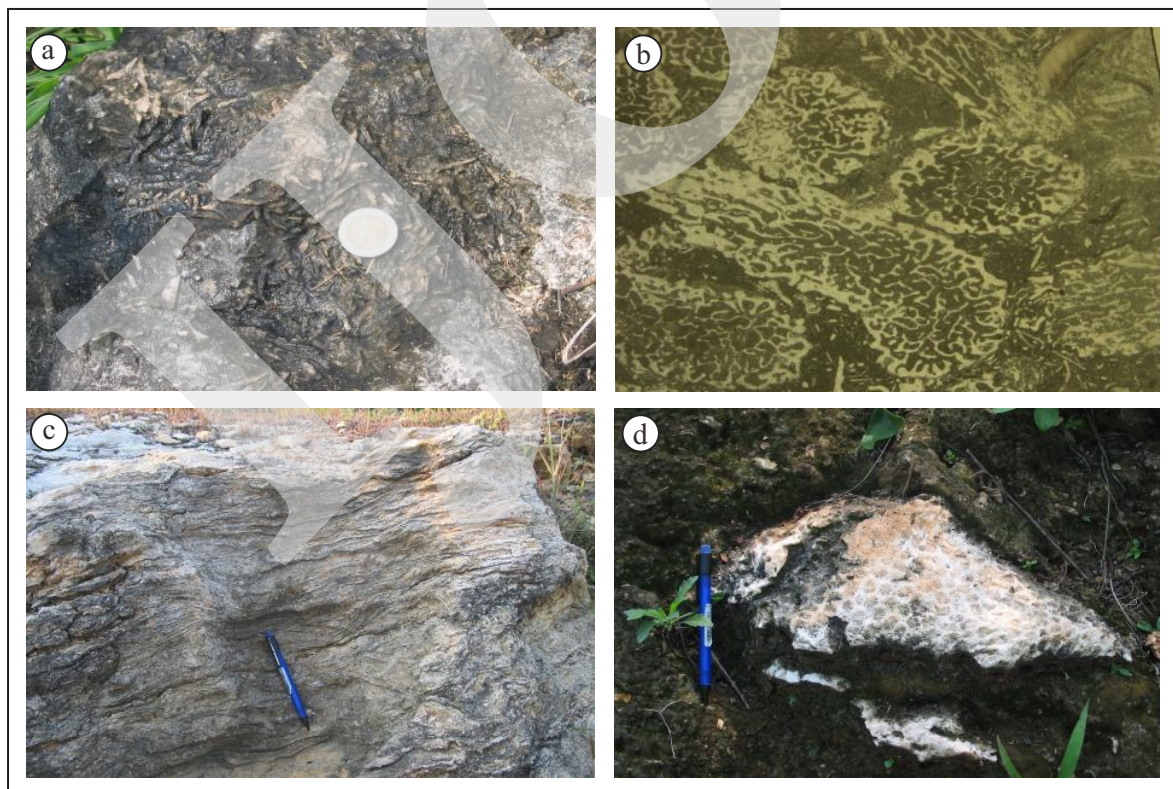


Figure 3. a). Photographs of outcrop of Bafflestone Subfacies with natural etching of branching corals (location KP5). b). Photomicrograph of Bafflestone Subfacies showing pieces of coral floating in the packstone matrix (location Hlc 4). c). Photographs Bindstone Subfacies, platy coral shows the shape of wavy sheets (location of I.11.), and d). Framestone Subfacies shows its growth position (location C1).

ness is between 0.1 and 0.50 m. In the packstone layers, the coral fragments are often recognized. Based on the physical properties and abundance of the biota, this facies can be grouped into three subfacies, *i.e.* foraminifera packstone-, foraminifera-coral packstone-, and foraminifera-algae packstone subfacies.

Foraminiferal Packstone Subfacies

The subfacies is characterized by the abundance of large foraminifera. The other biotas present are red algae, coral fragments, benthos, and plankton. The outcrop of foraminiferal packstone shows a good bedding, with a small portion has been altered into the chalk (Figure 4a). Populations of planktonic and benthic foraminifera are relatively bigger than the algae and coral types population. Petrographic analysis of rock samples shows granules of bioclastics consisting of large foraminifera, red algae, and corals. Figure 4b

exhibits the shape of the relatively undeformed large foraminifera (*Lepidocyclina* sp.). This subfacies is found in the location of KLP 01, KLP 201, KLP 05, KLP 06, and KLP 07.

Foraminiferal-coral Packstone Subfacies

The subfacies, light grey in colour, is well bedded with a layer thickness of between 20 - 40 cm. Branching coral pieces are floating in the layers (Figure 4c). Petrographic analysis of rock samples shows granules of bioclastics consisting of large foraminifera (*Lepidocyclina* sp., *Borelis* sp.) red algae, and green algae (*Halimeda*), benthic and fragments of molluscs. This subfacies is found in the location of KP3, KP4, SD 01-03, SD06-07, KS 04, HLc 1, NR 01-02, Lt 01-04, and CR 09.

Foraminiferal-algal Packstone Subfacies

The subfacies of foraminiferal-algal packstone is characterized by the abundance of red algae

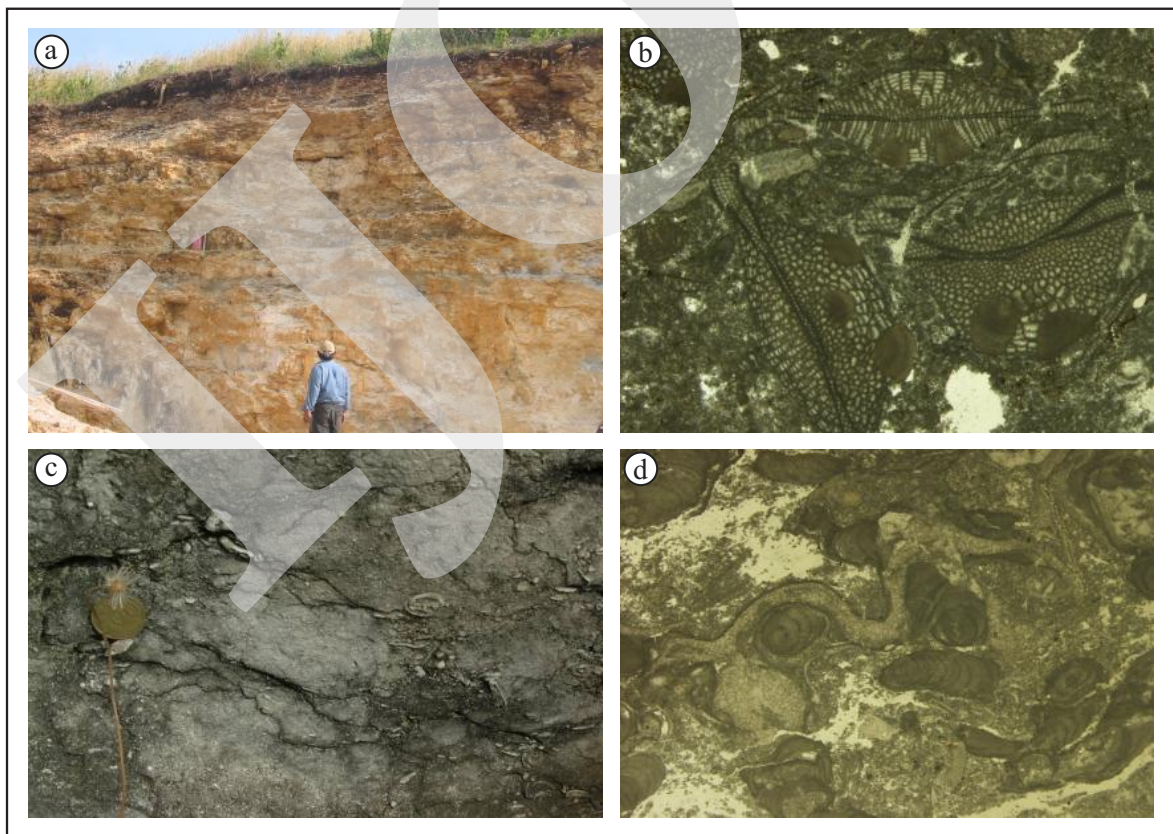


Figure 4. a). Photograph of foraminiferal-algal packstone layers, thickness 20-30 cm (location CR 15). b). Photomicrograph of foraminiferal-algal packstone facies in IN 01 shows the shape intact of *Lepidocyclina* sp. (location IN 01). c). Photograph of foraminiferal-coral packstone sub-facies at the location of KP3, show fragments of coral and molluscs. d). Photomicrograph of red algae of foraminiferal-algal packstone subfacies (I.9).

and green algae species (Figure 4d). Other organisms that appear in the subfacies are large foraminifera, benthic foraminifera types, molluscs, and echinoid. Large foraminifera species were identified as *Lepidocyclina* sp., *Spiroclypeus* sp., *Miogyopsina* sp., *Cycloclypeus* sp., and *Operculina* sp. This subfacies is found at the location of CR 14-17, KS 02, KS 05-06 and CR 09. Outcrops at locations I (2-10) are generally argillaceous, dark grey in colour, sometimes alternating with clay.

Rudstone Facies

The rudstone facies is characterized by the abundance of coral fragments. The corals found in the location of KLP 01 and KLP 02 is massive (Figure 5). At the location of KP1 and KP2 the coral fragments are embedded in packstone



Figure 5. The fragments of massive corals in the rudstone facies (location KLP 01).

matrix containing bioclastic granules of large foraminifera, benthos, and molluscs. Other locations of the outcrop are represented by CR 08, CR 10, CR 12, and CR 03.

Breccia Limestone Facies

The distribution of breccias limestone facies is very limited and only found on the northern part of the studied area. This facies is found at location of C9 and C10 (A-F) inserted in packstone facies. The thickness of the layer is 1 to 1.5 m, bedded, and wavy layers. Limestone breccia fragments occurring 20 - 40 cm in-size are tapered and embedded in packstone texture (Figure 6).



Figure 6. Fragment of limestones with packstone texture (a) 20 - 40 cm in-diameter set within limestone breccia facies (location C.10).

DISCUSSION

The results of this study have identified three carbonate facies namely: boundstone facies, packstone facies, rudstone facies, and limestone breccia facies. By referring to the characteristics of those facies, their depositional environments can be interpreted (Wilson, 1975; Flugel, 2004). The distribution of Klapanunggal carbonate facies including interpretation of depositional environment are presented in Figure 7.

The Boundstone Facies is characterized by the abundance of coral as the main constituent of the rock. This facies can be divided into three subfacies, namely: Framestone Subfacies, Bafflestone Subfacies, and Bindstone Subfacies. Based on the distribution and its finding position, the Framestone Subfacies is suggested to be formed in two environments. Framestone with very limited distribution as is found in the location of C1 and is associated with bafflestone is interpreted to be deposited on the lower slope environments. The wide distribution of Framestone Subfacies tends to indicate a reef crest environment. The Bafflestone Subfacies is dominated by branching corals, while the Bindstone Subfacies is dominated by platy corals. The presence of this species indicates that the depositional environment of the reef system is the reef front. In those two subfacies abundant green algae (*Halimeda* type) occurs. In general, the *Halimeda* is an indicator of lagoon environments, but *Halimeda* is also present in

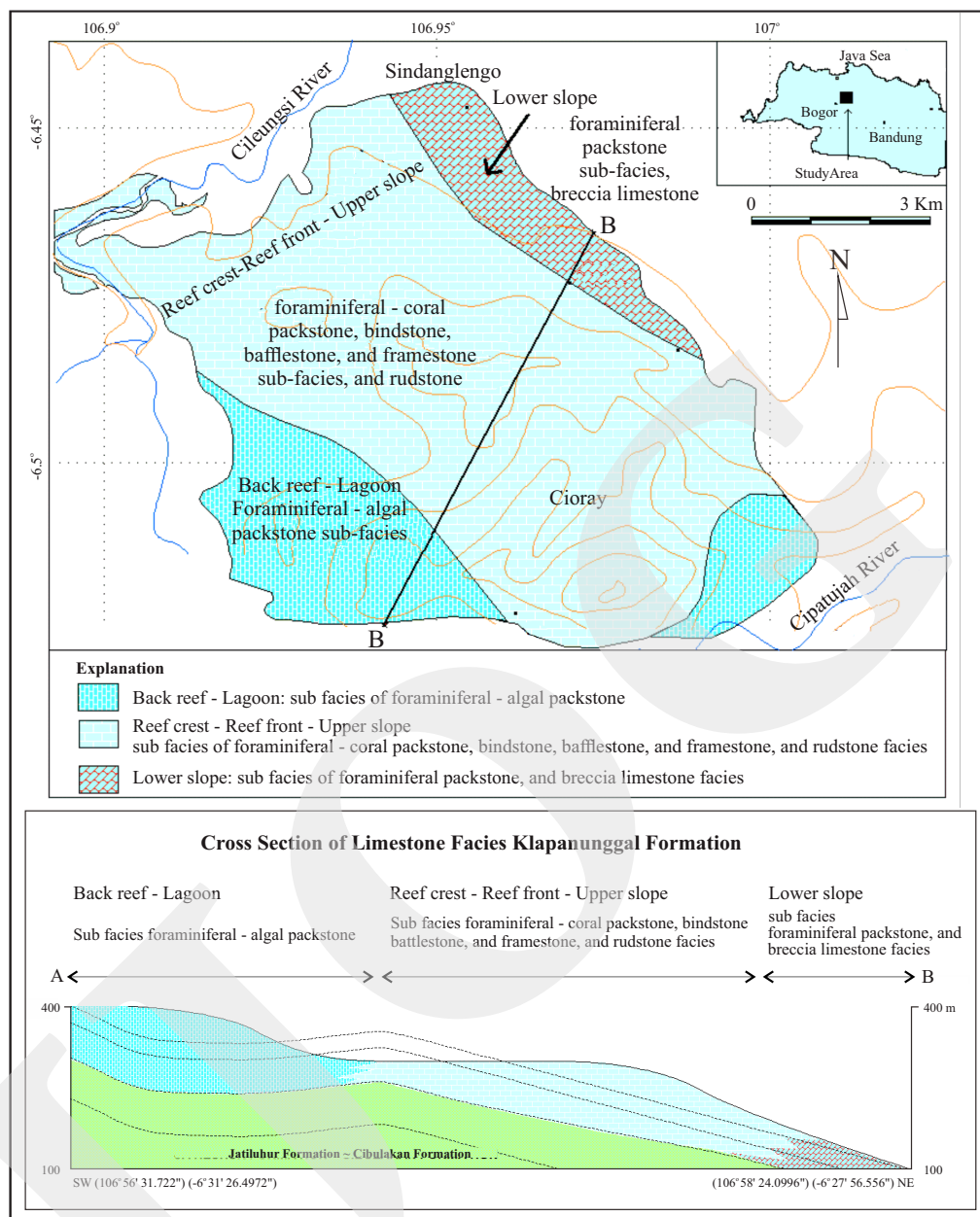


Figure 7. Carbonate facies distribution and environments of the Klapanunggal Formation.

the reef front environment (Johnson, 1961). In Indonesia, *Halimeda* is also found abundantly on the reef front environment of Wonosari Limestone Formation (Siregar *et al.*, 2004). In the reef front environment.

The Packstone Facies of the Klapanunggal Formation cropping out in several places shows different characters from one to another location which can be divided into three sub-facies, those are foraminiferal packstone-, foraminiferal-coral packstone-, and foraminiferal-algal packstone

sub-facies. The Foraminiferal Packstone Sub-facies is exposed in the vicinity of the C10. In some parts of the outcrops, rocks originated from an avalanche from the top are recognized, called Limestone Breccia Facies. Based on the presence of this facies, the Foraminiferal Packstone Sub-facies is suggested to be deposited within the lower slope of the reef system. The Foraminiferal-coral Packstone Sub-facies found at the location KP3 and KP4, contains faunas comprising planktonic foraminifera and branching coral. The sub-facies

is associated with Rudstone Facies. This evidence illustrates that this subfacies was deposited in the upper slope of the reef environment system.

The Foraminiferal-algal Packstone Subfacies occurs in the southwestern and eastern part of the studied area. The characteristics of this subfacies in the location are quite different from the packstone characteristics of the other locations. The layers of this subfacies often mix with a layer of dark grey claystone that sometimes is sandy. Another feature recognized is a cross-bedding structure. This condition shows that this environment has been mixed with clastic sediments. Grain biotas comprising red algae and green algae (*Halimeda*) are found in abundance at this location, indicating a shallow marine depositional environment. Based on the fact, it is interpreted that the depositional environment of Foraminiferal-algal Packstone Subfacies is back reef - lagoon.

The Rudstone Facies is dominated by coral fragments which in-place is massive or embedded in packstone matrix. This subfacies is suggested to be formed on the reef front system. The facies is also inserted in the Bindstone Subfacies.

On the basis of observation on the character, physical properties, and biota content, the growth model of Klapanunggal carbonates can be constructed. Geographically, back reef and lagoon environment, located in the southwestern part with the amount of clay and sandy material, indicate that the deposition of carbonate rocks is strongly influenced by the supply of clastic material. Subsequently, to the northeastwards, grow reef crest, reef front, and upper and lower slopes occurred. Regionally, onshore structural features in West Java comprise alternating basins and structural highs. From west to east they are the Tangerang High, Ciputat Basin, Rengasdengklok High, Pasir Putih Basin, Pamanukan - Kandanghaur High and Horst, Jatibarang Basin, and the Cirebon Trough. Carbonate of the Parigi Formation which is now in subsurface, is situated in the structural highs trending north-south to the northwest- southeastward since Late Miocene and coincided with the deposition of volcanoclastic rocks of the Halang Formation in Central Java (Clement and Hall, 2007). Development of carbonates in the studied area is relatively close to the

Ciputat Basin. The growth of Parigi Formation, subsurface located between Ciputat and Jatibarang Sub-basin occurs at the back-arc basin of Oligo-Miocene volcanic rocks (Satyana, 2005).

The interpreted depositional environment based on the facies data in this area support the information that the carbonates have grown at a structural high and to the northeast towards the Ciputat Basin in the Cibarusa area.

CONCLUSION

The study of facies and carbonate growth environment of the Klapanunggal Formation indicates that the four facies of carbonate rocks comprise boundstone facies, packstone facies, rudstone facies, and limestone breccia facies. The boundstone facies was deposited in the reef front to reef crest environment; packstone facies developed on the lower slope, upper slope, and back-reef lagoon environment; the rudstone facies was formed in the reef front, whilst the breccia limestone facies was deposited in the lower slope. Back reef and lagoon environments were located in the southwestern part, and sequentially to the northeastwards occurred reef crest, reef front, and upper and lower slopes. The facies data in this area support the information obtained from all laboratory analyses, where the carbonates have been grown in a structural high and to the northeast towards the Ciputat Basin in Cibarusa area.

ACKNOWLEDGEMENTS

The authors would like to thank the Head of Research Centre for Geotechnology who has offered an opportunity for authors to publish this manuscript. Also thanks to Mr. Kuswandi who have helped in data collection and preparing thin section at the laboratory.

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