CARBONATE REEF OF THE KLAPANUNGGAL FORMATION IN THE BOGOR TROUGH, WEST JAVA

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Abstract

The Late Miocene shelf-margin carbonate reef is well exposed in the study area, and named as Klapanunggal Formation. The formation is characterized mainly by thick and massive reefal limestone with large foraminifers and other types of shell fragments, such as mollusks and echinoderms, and it have been developed in a response to the decrease in sediment discharge superimposed by relative rise in sea level during the late Miocene.

Keyword: carbonate, Klapanunggal Formation, rimmed reef, shelf margin, Bogor Trough

Background

The late Miocene carbonate of the Klapanunggal Formation is well observed in the Cibinong area, northeastwards from Bogor City (Fig.1). The formation is overlaying conformably middle Miocene Jatiluhur Formation (Effendi, Kusnama, & Hermanto, 1998; Sudjatmiko, 1972) (Fig. 2). The late Miocene carbonate is one of main target reservoir in the North West Java Basin, and the study of this formation have been conducted by many researchers (e.g. Bukhari et al. 1992; Yaman et al. 1991; Burbury 1977). However, the outcrop-base study is rare to be reported.

This paper describes carbonate reef of the Klapanunggal Formation in term of depositional history and sedimentary setting in the Bogor Trough.

Geological setting

Carbonate of the Klapanunggal Formation that exposed in the northern part of the Bogor Trough is late Miocene carbonate, which is among the geologists of the oil companies, especially those working in the Northwest Java Basin, is also well known as the Parigi Formation (Fig. 2). This formation is overlaid conformably by mudstone dominated of Cisubuh Formation (Bukhari et al., 1992; Yaman et al., 1991).

Parigi Formation developed during the late Miocene (Burbury, 1977; Bukhari et al., 1992) on stable shallow-marine platforms as a buildup reef complex associated with an adjacent paleohigh. The paleohigh is not necessarily correlated with the older structure or basement highs (Burbury, 1977; Yaman et al., 1991). The Parigi Formation is distributed both onshore and offshore, and has the general strike of N–S in the north and that of NE–SW trend in the south with a maximum thickness of up to 450 m in the southern part (Yaman et al., 1991). To the north, this build-up of the reef complex tends to have low relief and seems to have developed in an enclosed environment, while in the south (onshore Java) the build-up

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developed higher relief, which is characterized by carbonate with coral-algal frameworks (Yaman et al., 1991). The outcrops of this formation are well observed not only in this study area, but also in the Pangkalan area, Karawang, about 25 km to the east of the study area.

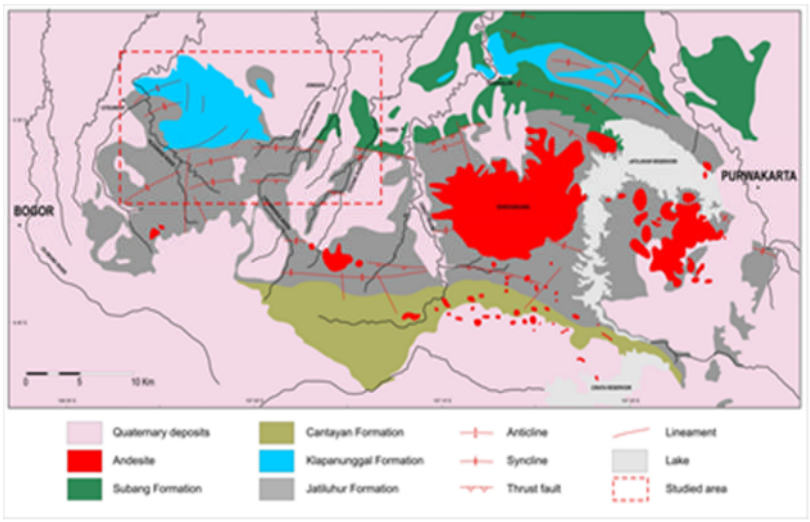

Fig. 1. Geological sketch map of the northern part of the Bogor Trough modified mainly after Sudjatmiko (1972).

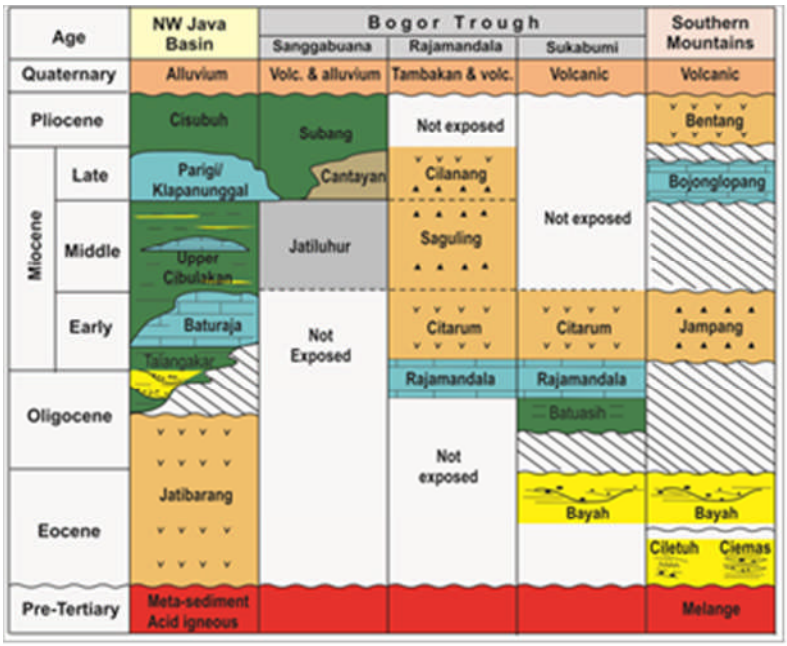

Fig. 2. Stratigraphic classification and ages of the Cenozoic stratigraphic successions in the studied and adjacent areas (after Sujanto and Sumantri, 1977; Martodjojo, 2003; Suyono et al., 2005).

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The Klapanunggal Formation in the study Area

In the study area, carbonate reef of the Klapanunggal Formation is well exposed in riverside and roadside cliffs in the Nambo area, and massive rugged topography reaching the maximum height of over 100 m or more are developed in the Cilalay area. Locally, the margin of the formation is defined by fault escarpment in the Leuwikaret area (Fig. 3). Logged sections have been commonly obtained in the Nambo area, which are available along the riverside and roadside cliffs. The outcrops in this area have gently dip and continuous. The dip of bedding surfaces of the carbonate succession varies from nearly horizontal to 30º in the Nambo area, and the dip directions are considerably variable between the locations.

The Klapanunggal Formation is considered to have formed as carbonate reefs, which are characterized mainly by thick and massive reefal limestone with large foraminifers and other types of shell fragments, such as mollusks and echinoderms (Fig. 4). The formation is well exposed in the areas of Nambo, Klapanunggal, Gunung Karang, and Leuwikaret, and its distribution covers an area of more than 42 km2 (Fig. 1).

This carbonate formation conformably overlies the Jatiluhur Formation in the study area, and also represents a lateral facies equivalent with late Miocene carbonate-dominated horizon in the middle part of the Jatiluhur Formation (Abdurrokhim & Ito, 2013). The reefal carbonate of the Klapanunggal Formation is surrounded by sandy siltstones interbedded with very thin-bedded sandstones and thick-bedded limestones of the middle Jatiluhur Formation in the western part of the study area, and is covered unconformably by the Quaternary deposits elsewhere.

The development of the Klapanunggal carbonate reefs took place mostly during the late Miocene (Burbury, 1977; Martodjojo, 2003; Sujanto & Sumantri, 1977; Yaman et al., 1991) at the shelf margin of the NW Java platform. In general, the carbonate is characterized by faintly bedded massive limestone that consists of coral boundstone and rudstone (Fig. 5), skeletal-rich grainstone, and locally dark grey wackestone and packstone (Figs. 6–7).

A complete measured successions of the Klapanunggal Formation at the Nambo area is up to 240 m in thickness (Fig. 8). This formation shows a sharp contact to the underlying sandy siltstones intercalated with thin-bedded sandstones of the uppermost lower Jatiluhur Formation and is overlain by sandy siltstones with a sharp contact, which is the equivalent to the upper Jatiluhur Formation.

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Fig. 3. Limestone cliff of the Klapanunggal Formation and the Cileungsi River Valley observed from the Nanggareng area facing to the north.

Fig. 1. Head coral boundstone of the Klapanunggal Formation observed in the Cileungsi River in the Nambo area. Scale = 10 cm.

Fig. 5. Rudstone, characterized by poorly sorted, angular to sub-angular rudite-fragments of facies association 7 observed in the Cileungsi River.

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Fig. 6. Skeletal grainstone with prominent *Cycloclypeus* of facies association 7 observed in the study area. Coin diameter = 2.6 cm.

Fig. 7. Skeletal grainstone with prominent *Lepidocyclina,* showing an open framework in the lower part that gradationally passes up into a close framework. Pencil = 15 cm.

The lowermost part of the Klapanunggal Formation is characterized by thick, faintly bedded skeletal grainstone of up to 40 m thick (Fig. 8), and passes upward gradationally into a faintly bedded thick platy coral-dominated boundstone with local concentration of head coral, and finally passes up into the middle part of the formation. The middle part of the Klapanunggal Formation is characterized by thin dark grey muddy limestone that grades upward gradationally into platy coral- and/or head coral-dominated boundstone and, in turn, farther into dark grey mudstone or wackestone, indicating a shoaling-upward pattern (Fig. 9).

The external configuration of the reefal carbonate of the Klapanunggal Formation, in general, is difficult to be recognized in the field due to the combination of vegetation covers and intensely weathered surface, except in some

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parts as in the Cilalay area that represents a lateral extension of coral bioclastic distribution towards the north (Fig. 10). This feature is interpreted to have been formed when the carbonate developed laterally due to currents during a relative stillstand of sea level.

The overlying sandy siltstones have a fining- and thinning-upward pattern of a 50-m-thick interval with intercalations of 2 beds of bioclastic carbonate, and was finally completely covered with deeper siltstone-dominated deposits (Fig. 8). The intercalated beds of bioclastic carbonate (grainstone) are 3.1 m and 0.5 m in thickness and contain Cycloclypeus-dominated skeletal fragments (Fig. 6).

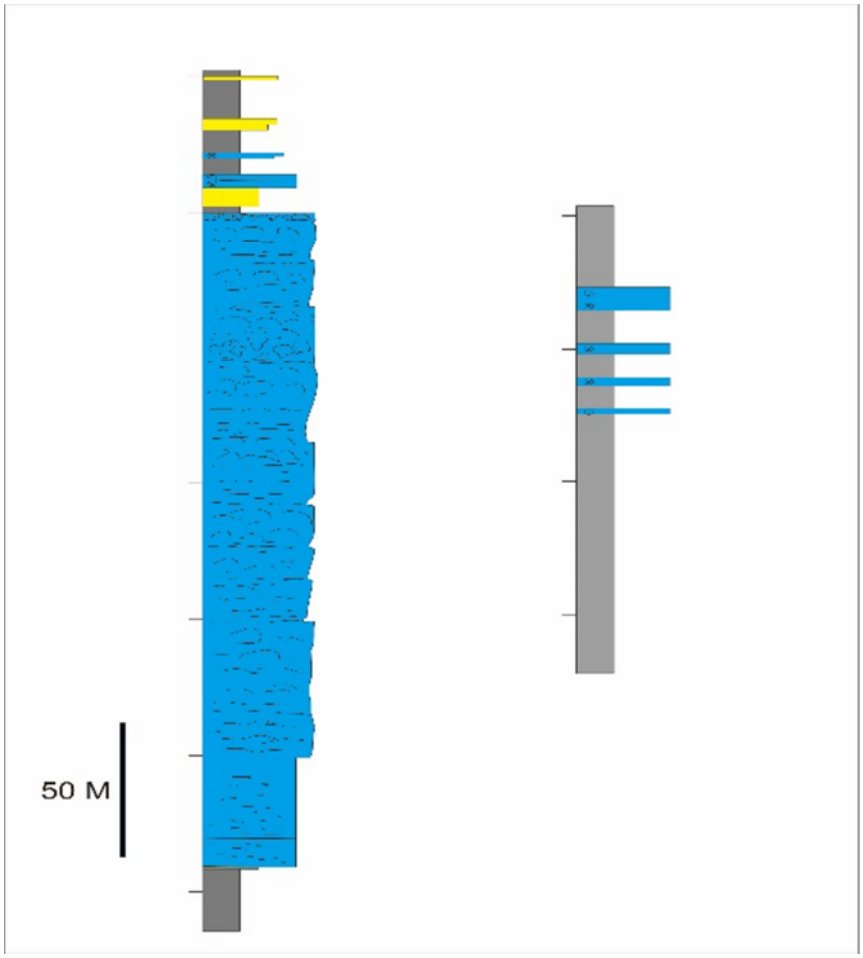

Fig. 8. Measure section of the Klapanunggal Formation in Nambo area, (2) reef carbonate built-up, (b) thick-bedded limestone facies.

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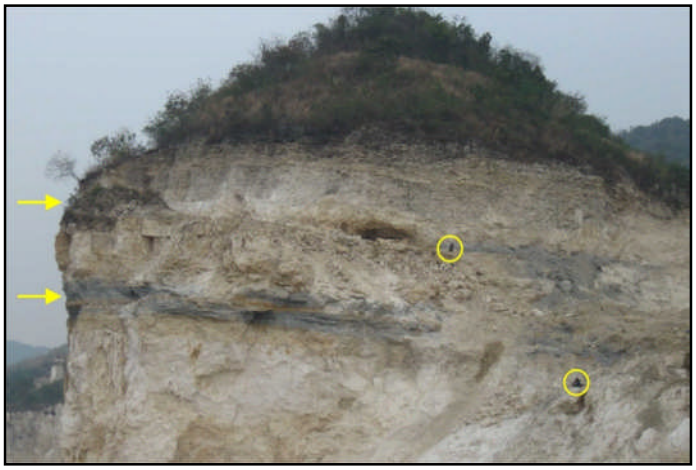

Fig. 9. Shoaling-up parasequences sets of carbonate reefs of the Klapanunggal Formation as response to the stepped rising of relative sea level during a lowstand stage observed in the Cilalay area. Figure circled for scale.

Fig. 10. Clinoform of coral bioclastic limestone, indicating progradation of a coral reef during relative sea-level stillstand observed in the Cilalay area.

Depositional History

Carbonate reef development in the northern part of the Bogor was formed in response to the interplay between the falling and ensuing rising stages of relative sea level and the fluctuation in sediment discharge from the hinterlands in slope and shelf-margin environments. The high discharge of sediments from the hinterlands in the north (e.g. Clift and Plum, 2008) promoted active progradation of the slope–shelf-margin system to the south during the middle Miocene. The progradation was subsequently followed by the development of reefal carbonate as a response to the decrease in sediment discharge superimposed by relative

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rise in sea level during the late Miocene.

During the middle Miocene, the sediments were transported southward through the broad shelf of the NW Java Basin into the deep-water Bogor Trough. Some large intraclasts in several coarse-grained sandstone beds in the lower part of the Jatiluhur Formation were likely derived from reefal carbonate that constitute the middle part of the Upper Cibulakan Formation during relative sea level fall (e.g. Arpandi and Patmosukismo, 1975).

Carbonate reefs of the Klapanunggal Formation developed in the shelf margin (Fig. 11), which are interpreted to be the source of thick-bedded limestone in the middle part of Jatiluhur Formation. On the basis of the reconstruction of distribution patterns of carbonate built-up forms from the subsurface data, it is clear that the shelf margin was typically rimmed by a semi continuous barrier of reefs. The available subsurface data indicates that this shelf margin was far away from the hinterlands in the north and the carbonate build-ups developed low relief for developing a protected calm shallow-sea environment, where carbonate sediments characterized by a coral-algal framework developed, in particular along the southern margin (Sujanto, 1982: Yaman et al., 1991). The carbonate rimmed NW Java shelf is thought to have been more than 100 km wide (cf. Atkinson, Gaynor, & Vavra, 1993; Purantoro, Butterworth, Kaldi, & Atkinson, 1994).

Although the major causal mechanism of the development of the wide and carbonate-rimmed shelf sea still remains controversial, the interplay between the relative rise in sea level and the decline of active shedding of siliciclastic sediments from the northern hinterland seems to have played an important role in the formation of the carbonate factory in the shallow sea behind the Bogor Trough to the north during the late Miocene.

Because any karstification of exposed carbonate is not observed within the Klapanunggal Formation carbonate-reef succession, the stepped rising in relative sea level, which was documented in the stacking of shoaling-upward carbonate cycles (i.e., parasequences) during the lowstand stage followed by the subsequent rise in relative sea level, is interpreted to have developed a deeper depositional environment (Zahara, 2012). Conseqeuntly, any shorter-term fall in relative sea level is not evident in the carbonate succession.

Finally, the siltstone- and claystone-dominated strata that is formally defined as the Subang Formation is a widely exposed unit in the onshore Bogor Trough and represents the final stage sedimentation in the trough, characterized by deepening again in the trough (Sudjatmiko, 1972; Djuri, 1973). The subsurface equivalent of this unit, known as the Cisubuh Formation, has been reported to occur in the offshore area of the NW Java basinal area (Arpandi & Patmosukismo, 1975; Suyono, Sahudi, & Prasetya, 2005).

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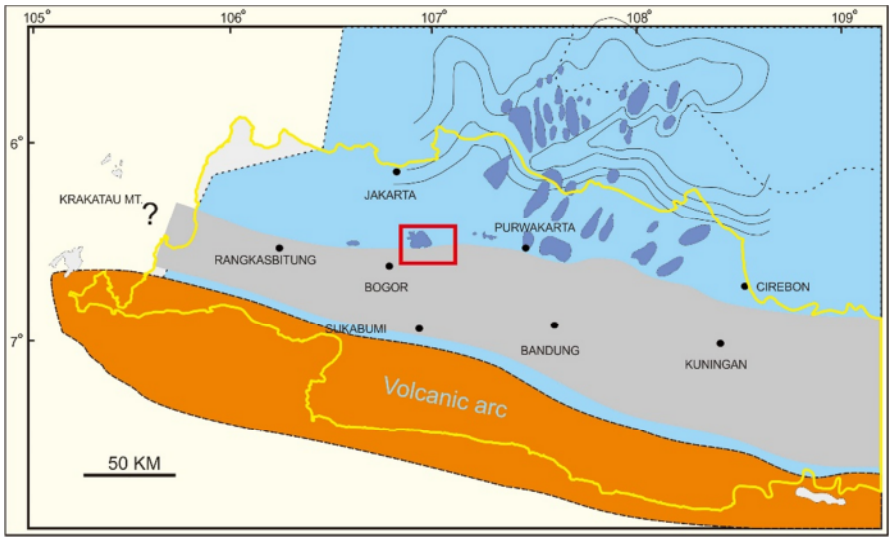

Fig. 11. Paleogeographic setting of the southern margin of the Sundaland during the late Miocene (after Martodjojo, 2003; Atkinson *et al*., 1993; Purantoro *et al*., 1994). Carbonate reefs of the Klapanunggal Formation in the study area are thought to have developed as rimmed-reef carbonate that developed in a shelf margin of the NW Java Platform during an early rise in relative sea level.

Conclusion

The late Miocene carbonate reef of the Klapanunggal Formation have been developed in a response to the decrease in sediment discharge superimposed by relative rise in sea level during the late Miocene. The reef developed in the shelf margin in between NW Java Basin and Bogor Trough, which is typically rimmed by a semi continuous barrier of reefs.

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