Carbonate Facies Model and Paleogeography of Tendehhantu Formation, Northern Kutai Basin, Indonesia*

Dadan P. Amiarsa[1], Idham A. Kurniawan[2], Artedi Susanto[2], and Kristian N. Tabri[2]

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[1]Geology Department, Institut Teknologi Bandung, Indonesia (dp.amiarsa@yahoo.com)
[2]Geology Department, Institut Teknologi Bandung, Indonesia

Abstract

The Kutai Basin is one of the famous hydrocarbon producer and deepest sedimentary basin in Indonesia. Located in the Easternmost of Sundaland and formed since early Tertiary as rift basin to aborted rift after Miocene age. The present day dominant structural trend is a series of tightly folded, NNE - SSW trending anticlines and synclines forming the Samarinda Anticlinorium which is dominant in the eastern part of the basin. Different from the center of Kutai Basin, the Northern Kutai Basin has carbonate complex which is developed in Miocene age.

The research area is located in the Tendehhantu carbonate complex which is represented by two research locations i.e.: Sekerat and Kaliorang area. The methods of this research are using field observation and laboratory analysis. The field mapping has been conducted by three researchers in three different locations to observe the rock outcrops in the field locations. Each location represents each facies which are back reef, reef core, and fore reef. The laboratory analysis that have been done are petrography, calcimetry, and microfossil analysis to identify the ornament of each facies microscopically.

The “Atoll” Tendehhantu Formation has various carbonate facies. The back reef (western part) consists of mudstone facies, intercalation of wacke-packstone facies which has abundant foraminifera fossils, and rudstone facies which has abundant fragmental coral fossils. At the reef core (middle part) of the Tendehhantu Formation dominantly consists of boundstone organic buildup facies which is characterized by the growth of head coral fossils. The fore reef (eastern part) consists of rudstone and wacke-packstone facies which has abundant plantonic foraminifera.

Based on this study, paleogeography of the Tendehhantu Formation of Miocene age is most likely a carbonate Atoll with about 30 km diameter in geometry. The paleo position of the back reef is southwestern and the fore reef is northeastern.

Introduction

The study area is located in the Sekerat and Kaliorang area (Gunung Sekerat), Sengata Region, East Borneo Province, Indonesia. The study area is approximately 300 km north of Samarinda (capital city of East Borneo Province) (Figure 1A). Geologically, this area is close to the Mangkalihat high which is at the edge of the northern basin boundary of the Kutai Basin.

The main objective of this research is to understand the carbonate facies of the Tendehhantu Formation at Gunung Sekerat and paleogeography of this area especially during the middle-late Miocene. Methodology of this research is field observation to view lithology characteristic and supported by laboratory analysis to observe microscopic ornament of the lithologies. The laboratory analysis that has been done are: slab analysis, petrography, calcimetry, and microfossil analysis.

Regional Geology

Physiographically, the Kutai Basin is bounded by the Mangkalihat high in the north, the Kuching high in the west, the Meratus high with the Adang Flexure in the south, and the deep Makasar Strait Basin in the east (Figure 1B). Formed since Eocene age as a rift basin, the Mangkupa Shale is the first sediment deposited which is exposed in the northern part of the Kutai Basin (Figure 2). The subsidence occurred very intensively until early Miocene by plate rifting. The tectonic activity became more stable and the Kutai Basin became a sagging phase until Pliocene age. After this phase the Kutai Basin has tectonic inversion. Evidence of this tectonic regime is from the NE-SW trending anticlinorium. This anticlinorium is also caused by tectonic diapirism from high water content shale that was deposited rapidly (Satyana et al., 1999).

The Tendehantu Formation is formed in this phase (mid-late Miocene). The formation consists of reefal and bioclastic facies such as wacke-packstone, grainstone, and also boundstone. Build up morphology is shown in the Gunung Sekrat area and the origin people call Tendehhantu (Ghost Hill). Karstification has occurred quite intensive in this area due to the tropical climate with high rainfall annually (Amiarsa, 2011). Caverns and subsurface rivers can be observed easily in this area.

Observation Methodology

Field observation is the main method of this research. Field mapping has been done from the treed focused area which represents each facies. Field observation observed lithology characteristics from mega scale of landscape (geomorphology) to outcrop scale for observing texture and structure of the sedimentation process (Figure 3).

Besides that, the laboratory analysis has been conducted to support the research. The laboratory analysis that has been done: slab analysis, petrography (thin section) analysis, calcimetry, and microfossil analysis. Slab analysis is the process to cut and polish the hand specimen samples to see the texture of the carbonate limestone. This analysis is mostly done for the boundstone facies. Petrography analysis is well known as one way to see the interior of some rock microscopically. This analysis has been done for almost all facies. Calcimetry analysis is the process to calculate percentage of calcite content. This analysis is done to determine the provenance of material sourced predominantly from marine or terrestrial. And the microfossil analysis especially foraminifera has been conducted to identify the age of sedimentation and depositional environment.

According to Wilson (1975), the authors divide the Gunung Sekerat into: forereef associate facies, reefcore associate facies, and backreef associate facies. The characteristic of each facies is described below:

Forereef Associate Facies

Forereef associate consists of rudstone (Embry and Klovan, 1972) and packstone (Dunham, 1962) facies. Packstone is characterized by bioclastic limestone consisting of medium grain size. Dominantly the fragments are clasts of small size coral reef such as clasts of branching corals, brachiopods, clam shell, and etc.

Rudstone is characterized by massive to poorly laminated limestone with very coarse grains. Sometimes massive head coral is present as ~~a~~ fragments. The rudstone facies is deposited in high wave energy which causes the breakdown of the strong coral reef material. The thin section photographs reveal coarse grain size due to the high energy sedimentation (Figure 4). This facies associate is deposited in the fore reef or slope environment which is dominantly caused by high energy and debris flow. This facies is in focused Area 3 (eastern side of Gunung Sekerat).

Reefcore Associate Facies

Reefcore associate facies predominantly consists of boundstone facies. Morphologically, it is seen as gentle hills to vertical cliffs. This is caused by vertical growing of coral reef to catch up to the rising sea level and diagenesis processes especially kartification after the lithification. The

boundstone facies is characterized by abundant-coral reef such as massive head coral, branching coral, platy coral with original shape or non-fragmental coral (Figure 5). The coral reef is capable to keep up and to catch up to sea level changes until it gives up caused by rapidly sea level changes. The boundstone facies is deposited in the core of the reef build up and can be a fabric of carbonate sediment provenance for other facies. This facies marks the reef core which is commonly found in focused Area 2.

Backreef Associate Facies

This environment consists of mudstone, wacke-packstone, or intercalation of both. Mudstone is characterize by very fine grain bioclastic limestone, white to grey in color, massive to laminated, and abundant microfossils. The wack-packstone is characterized by medium grained bioclastic limestone, less of mud and abundant-microfossils especially large foraminifera such as *Lepicocyclina* and *Miogypsina* (Figure 6). This facies is commonly found in focused Area 1 (western part of Gunung Sekerat).

Several samples for microfossil analysis show abundant plantonic fossils which can be used for age determination. The microfossils that are used for the analysis are foraminifera and large foraminifera. The common foraminifera found are: *Orbulina universa, Globorotalia plesotumida, Globorotalia acostaenensis, Spaerodinella subdehiscens, Orbulina suturalis, Globorotalia fohsi*. The large foraminifera commonly founded are: *Lepidocyclina spp., Miogypsina spp., Cycloclipeus spp*. Based on fossil assemblage, generally the Tendehhantu "Atoll" at Gunung Sekerat is deposited during middle to late Miocene age.

During Miocene age the paleogeography of Tendehhantu Formation at Gunung Sekerat is indicated as Atoll with the eastern side more forereef (basinward) which consists of predominantly debris carbonate bioclastic and the western side is backreef (landward) which consists of lagoonal with low energy environment.

The Tendehhantu (Ghost Mountains) “Atoll” consists of sub-circular, sub-horizontal platform with a diameter of about 30 kilometers. The Atoll is surrounded by a sharp edge, which shows a superficial morphology remarkably like a “spur and groove” system and which is a common feature on the windward side of many recent reefs. This morphology is only well developed on the southern and eastern border of the Tendehhantu (Suessli, 1976).

Conclusion

Based on the field observation and laboratory analysis it can be concluded that:

- The Tendehhantu "Atoll" facies can be divided into: forereef associate facies, reefcore associate facies, and backreef associate facies.
- The general age of deposition is middle-late Miocene.

- The paleogeography of the Tendehhantu Formation at Gunung Sekerat is mostly a 30 km diameter Atoll with basinward in the eastern side and landward in the western side

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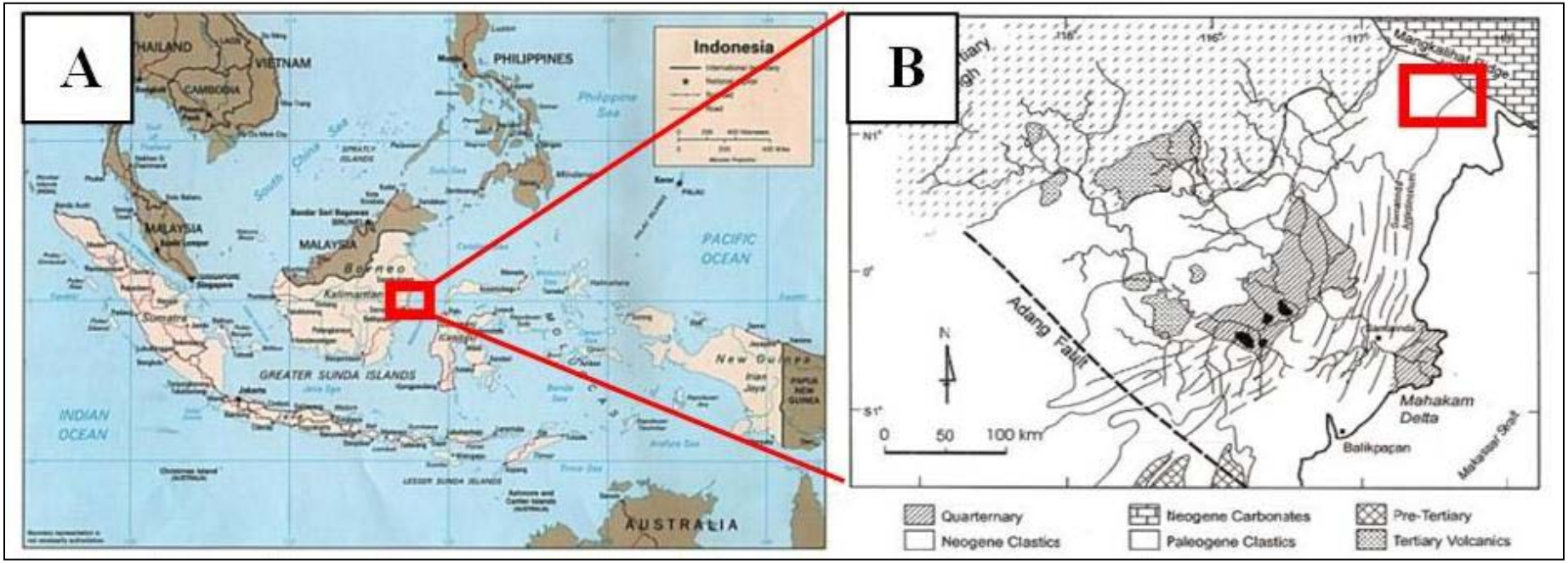

Figure 1A. Location of the study area (red box is study area).

Figure 1B. General geological map of the Kutai Basin, The Tendehantu Formation is located in the northern part of the Kutai Basin (Darman and Sidi, 2000).

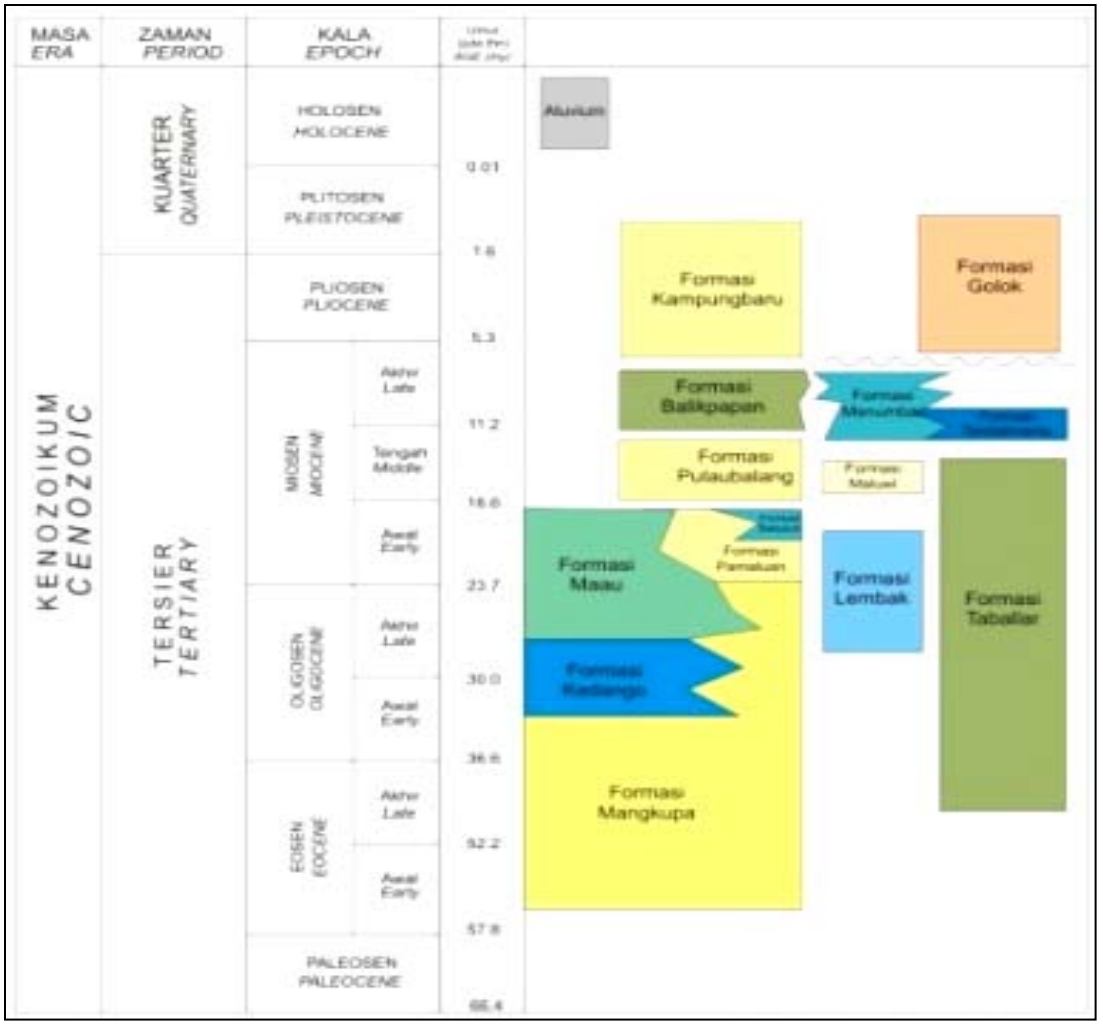

Figure 2. General columnar stratigraphy of the northern part of the Kutai Basin. The Tendehhantu Formation is formed during the middle-late Miocene age (Sukardi et al., 1995). Note this figure is blurry.

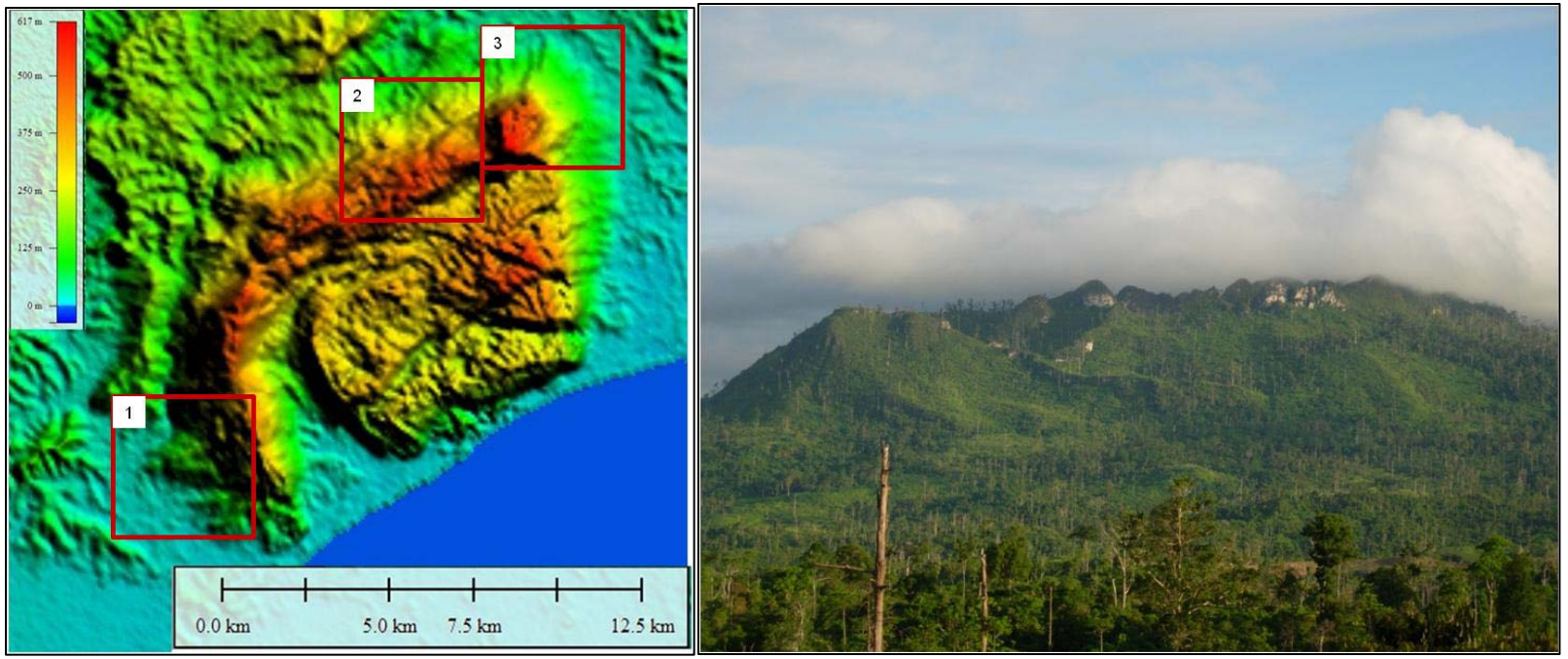

Figure 3. Satellite image (left) and landscape morphology (right) of the Tendehhantu Hills. Red boxes on the satellite image map are the research areas conducted by three researchers.

Figure 4. Rudstone outcrops (left), head coral fragment of rudstone facies (middle), thin section photograph shows coarse grain matrixes at the same facies. This carbonate facies is located at the fore slope.

Figure 5. Gentle morphology of carbonate build up facies (left), consist of boundstone; abundant of coral reef fossil which can be seen from slab analysis (middle), thin section photographs shows ornament of coral body (right).

Figure 6. Intercalation bioclastic limestone which consists of mudstone and wacke-packstone (left), mudstone facies which is characterized by very fine grained carbonate sediment (middle), thin section photograph of packstone facies which has abundant foraminifera and other fossils (left).