LOWER-MIDDLE MIOCENE BIOSTRATIGRAPHY OF THE SILICICLASTIC RAMBATAN FORMATION, NORTH SERAYU BASIN

A K Gibran[1], G Waluyo[1]*, Maulidiah[1]
[1] Geological engineering department, Engineering Faculty, Universitas Jenderal Soedirman, Indonesia

Email : gentur.waluyo@unsoed.ac.id

Abstract. The discrepancies discovered in the findings of past researchers with respect to the depositional environment give rise to questions concerning the processes driving the deposition process and shifts in the depositional environment throughout the evolution of the Rambatan Formation. The present study was conducted in Cikadu Village, located in the Watukumpul District of the Pemalang Regency in Central Java, Indonesia. The primary purpose of this study is to evaluate the geological age and depositional environment of the Rambatan Formation in the chosen research location. The data suggest that the age of the rock units within the Lower Miocene - Middle Miocene period, namely within the N5 - N14 zones. Additionally, the research confirmed the presence of three indicator fossil species: Catapsydrax dissimilis, Globigerrinoides Altipelturus, and Globorotalia fohsi. In this work, paleobathymetry in the research area was measured by the use of benthonic foraminifera. The findings collected stretch from the Lower Bathyal to the Transition, and were verified by the discovery of peculiar fossils found in the Middle Neritic and Lower Bathyal environments, notably *Nodosaria sp*. and *Sphaerodina bulloides. Ammonia beccarii,* a characteristic fossil, was discovered in the transitional habitat, as described by several specialists. Based on these observations, it may be deduced that the depositional habitat runs from continental to slope.

Keywords: Rambatan formation, depositional environment, paleobathymetry, deposition process, north Serayu

1. Introduction

The Rambatan Formation or Merawu Formation is referred to by many names in regional stratigraphy and is subject to differing interpretations on its age and depositional system [1–3]. The presence of discrepancies poses challenges in the development of stratigraphy for the North Serayu basin [4]. The deposition of the Rambatan Formation occurred during the Lower Miocene to Upper Miocene period, characterised by a gravity flow system inside a submarine fan environment [5–8]. However, several scholars have interpreted that the Rambatan Formation was formed in a transitional location characterised by tidal conditions, such as sand flats and mud flats [9]. Several researchers suggest that the sediment supplies for this formation originated from the Northern area [10,11].

The variations seen in the findings of prior researchers with respect to the depositional environment give rise to enquiries concerning the mechanisms governing the deposition process and alterations in the depositional environment throughout the development of the Rambatan Formation [12]. The present study was conducted in Cikadu Village, located in the Watukumpul District of the Pemalang Regency in Central Java, Indonesia (Figure 1). The primary objective of this study is to determine the geological age and depositional environment of the Rambatan Formation in the designated research region.

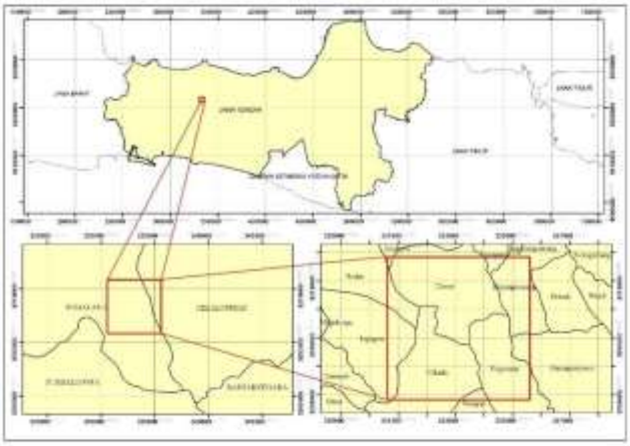

Figure 1. Research location map

2. Methods

The investigation conducted within the designated study area pertains to a biostratigraphic analysis of the Rambatan Formation. This paper provide a comprehensive elucidation of the chronological framework and depositional setting associated with the Rambatan Formation. Consequently, we conducted a selection procedure that involved selecting individuals ranging from comparatively older to younger individuals, starting from the eastern boundary of the study area and progressing towards the western boundary (Figure 2).

The sample approach employed in this study is point sampling, specifically conducted at regular intervals. Each sampling event is characterised by its own representative and well-defined criteria, as inferred from stratigraphic observations. Subsequently, following the collection of samples and subsequent laboratory analysis of foraminifera, the author obtained a total of five samples, as depicted in Figure 2.

The initial step in foraminifera analysis involves the collection of rock samples, which subsequently undergo a preparatory stage. The samples were collected using a standardised weight of 100 grams per sample. Afterward, the samples underwent the preparation stage following the prescribed preparation flow diagram in the micropaleontology laboratory.

3. Result

3.1. Lithology

The study area is located in the Watukumpul sub-district, precisely in the Rambatan Formation, which is the oldest formation deposited in the study area, namely the Lower Miocene-Middle Miocene. There are several lithologies in the study area that are specifically studied, namely mudstone, sandstone, and shale.

The sandstone, locally whitish ash, light brown in colour, fine sand grain size, carbonate in nature, with sedimentary structures such as parallel lamination, wave lamination, cross lamination, and convolute Thickness varies from 10 to 20 cm. The field appearance of this sandstone lithology is shown in Figure 3.a.

Mudstone, light to dark grey in colour, carbonate in nature, massive structure with a thickness of around 10–100 cm. The appearance in the field of this rock unit is shown in Figure 3.b. Shale, blackish in color, flaky structure, carbonate in nature, locally visible parallel lamination, with a thickness of around 10-50 cm. The appearance in the field for this rock unit is shown in Figure 3.c. The results of making a lithology profile at each sample point in the study area are as shown in Figure 4.

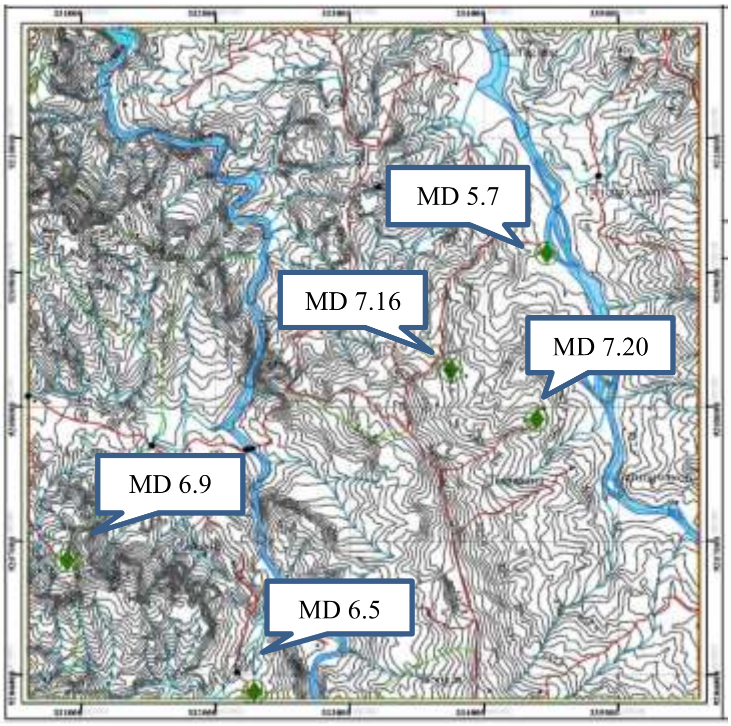

Figure 2. Sample collection map

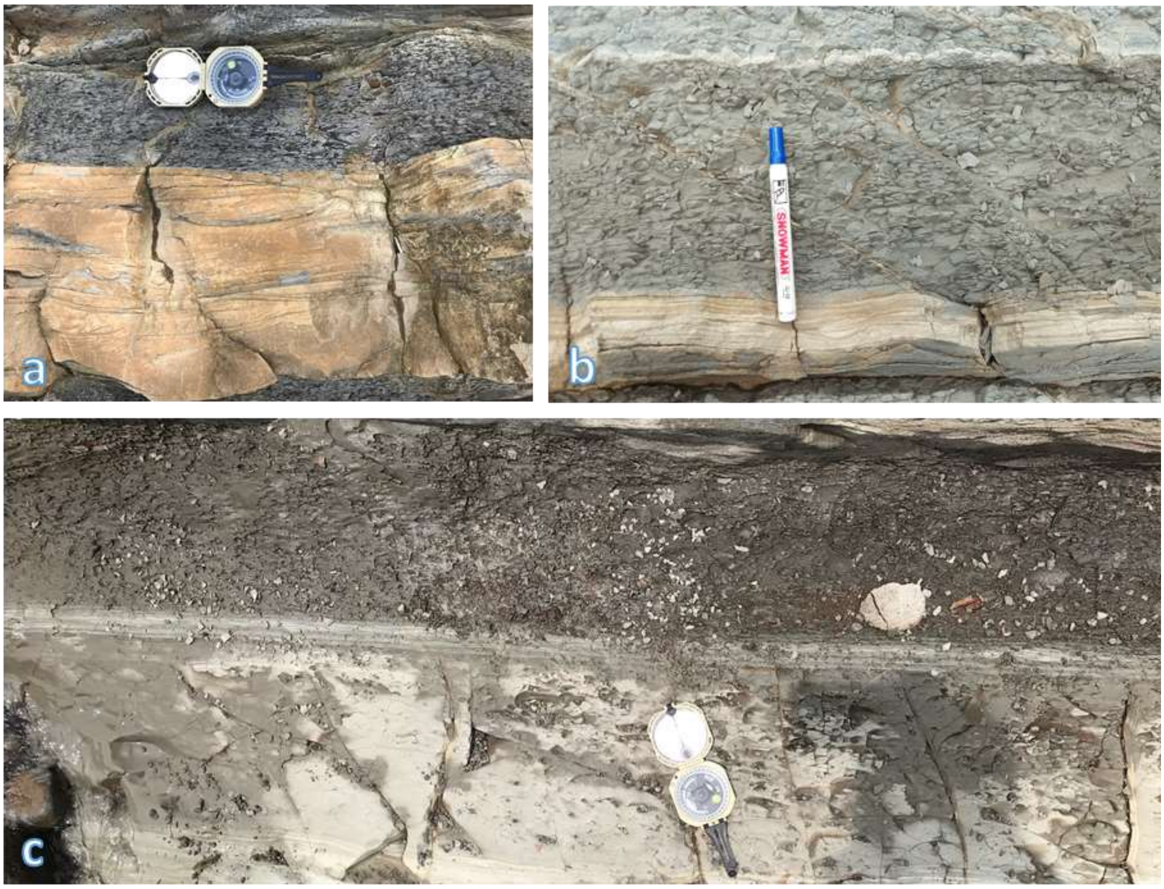

Figure 3. a) The Rambatan Formation sandstone shows cross laminations and parallel lamination stuctures; b) the Mudstone of the Rambatan formation; c) the dark shale of The Rambatan Formation.

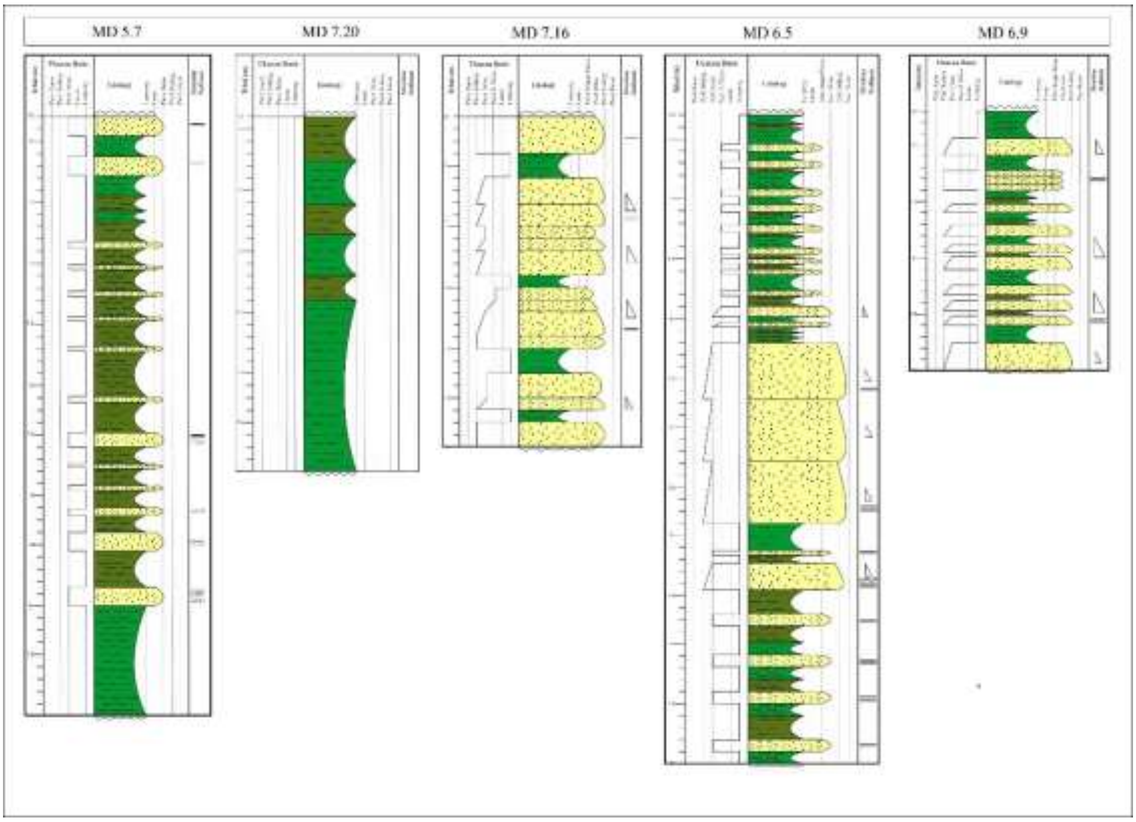

Figure 4. Lithology profile for each sample location

3.2. Age

In the study, the researchers utilised a standardised preparation weight of 100 grams for each sample. Through their investigation, they were able to identify and document the presence of 12 distinct species of planktonic foraminifera. Furthermore, the abundances of these species were shown to exhibit variations among the samples. Among the 12 species examined, three species of index planktonic foraminifera were identified based on (13) zoning scheme. These species include *Catapsydrax dissimilis, Globigerinoides altiaperturus,* and *Globorotalia fohsi*. According to the findings presented in Figure 6, the biostratigraphy of the rock age is seen.

Based on the identification of three distinct species of index planktonic foraminifera through the analysis of five samples, researchers have been able to infer the age of the Rambatan Formation using Lower Miocene to Middle Miocene biostratigraphy. Consequently, the formation has been divided into four biostratigraphic zones, arranged in chronological order from the oldest to the youngest, as outlined below:

3.2.1. Catapsydrax dissimilis Zone (N5-N6)

These zones are classified by researchers according to the frequency of species occurrence. *Catapsydrax dissimilis*. Within this particular zone, a variety of additional species of planktonic foraminifera can be found, specifically: *Globoquadrina venezuelana, Globorotalia siakensis, Globigerinoides ruber, Globigerinoides trilobus, Globigerinoides altiapelturus, Globoquadrina altispira* and *Globigerina immaturus.*

3.2.2. Globoquadrina altispira - Globorotalia scitula Zone (N6-N9)

The division of these zones is based on the initial appearance interval of *Globoquadrina altispira* and the first date of *Globorotalia scitula* Within this particular zone, a variety of additional species of planktonic foraminifera can be found, specifically *Globoquadrina venezuelana, Globoquadrina altispira, Globorotalia siakensis, Globigerinoides ruber, Globigerinoides trilobus, Orbulina universa, Catapsydrax dissimilis, Globigerinoides altiapelturus* and *Globigerina immaturus.*

3.2.3. Globorotalia fohsi Zone (N10-N11)

The division of these zones is based on the initial appearance interval of *Globorotalia fohsi*. Within this particular zone, a variety of additional species of planktonic foraminifera can be found, specifically: *Globoquadrina venezuelana, Globoquadrina altispira, Globorotalia siakensis, Globigerinoides ruber, Globigerinoides trilobus, Orbulina universa, Globorotalia scitula* dan *Globigerina immaturus.*

3.2.4. Globorotalia menardii - Globorotalia siakensis Zone (N11-N14)

The categorisation of these zones is determined by the temporal span between their earliest manifestations of *Globorotalia menardii* and last occurrence of *Globorotalia siakensis*. In this specific zone, a diverse array of supplementary species of planktonic foraminifera can be observed, particularly: *Globoquadrina venezuelana, Globoquadrina altispira, Globorotalia siakensis, Globigerinoides ruber, Globigerinoides trilobus, Orbulina universa, Globorotalia scitula* and *Globigerina immaturus.*

3.3. Depositional Environment

The paleobathymetry of the Rambatan Formation was examined by researchers through the analysis of benthonic foraminifera species, utilising a total of five samples. Based on the findings of the study, the researchers identified a total of nine species of benthic foraminifera, specifically: *Ammonia beccarii, Nodosaria Sp., Fissurina orbigyana, Pyrgo sp., Hyperamina elongate, Stilostomella lepidula, Marsipella cyclindrica, Rhizammina algaeformis and Sphaerodina bulloides.* A number of index fossils that serve as characteristic indicators of specific ecosystems were also discovered, including *Nodosaria sp.,* which is indicative of the Middle Neritic environment, and *Sphaerodina bulloides*, which is indicative of the Lower Bathyal environment.

Based on the analysis of five samples conducted by researchers, it can be inferred that the depositional environment of the Rambatan Formation can be classified according to the bathymetric environmental classification proposed by Tipsword (1966) (14), ranging from Lower Bathyal to Low Tidal. This classification is illustrated in Figure 5.

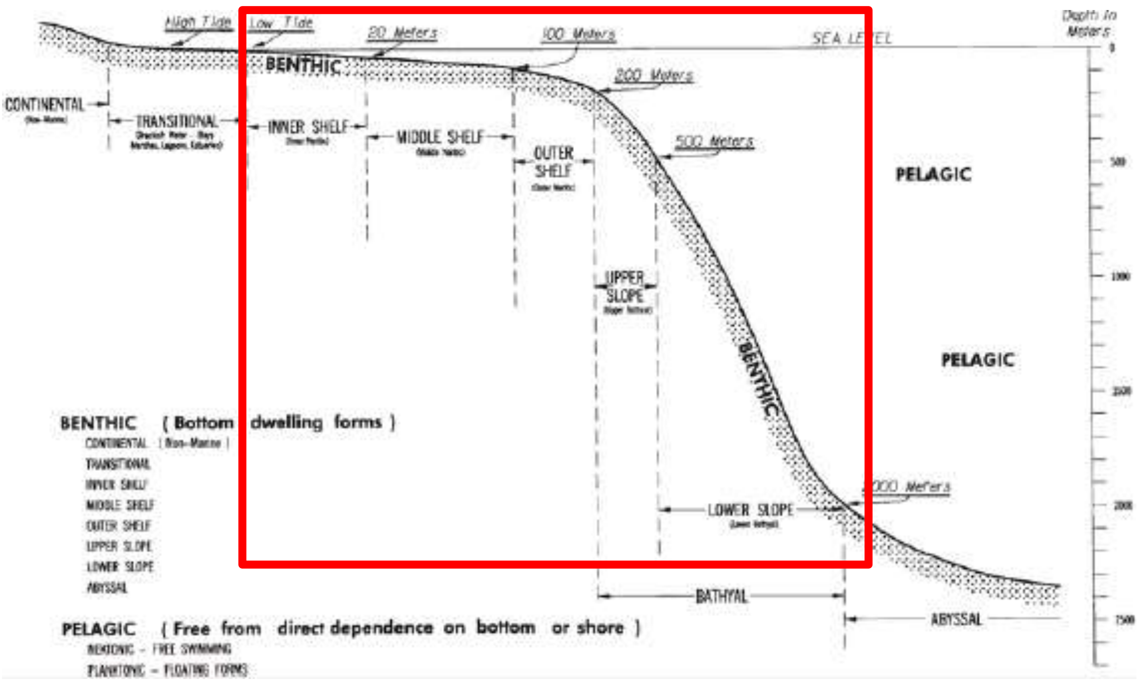

Figure 5. Paleobathimetric Sections of the research area on Tipsword, 1966 [14]

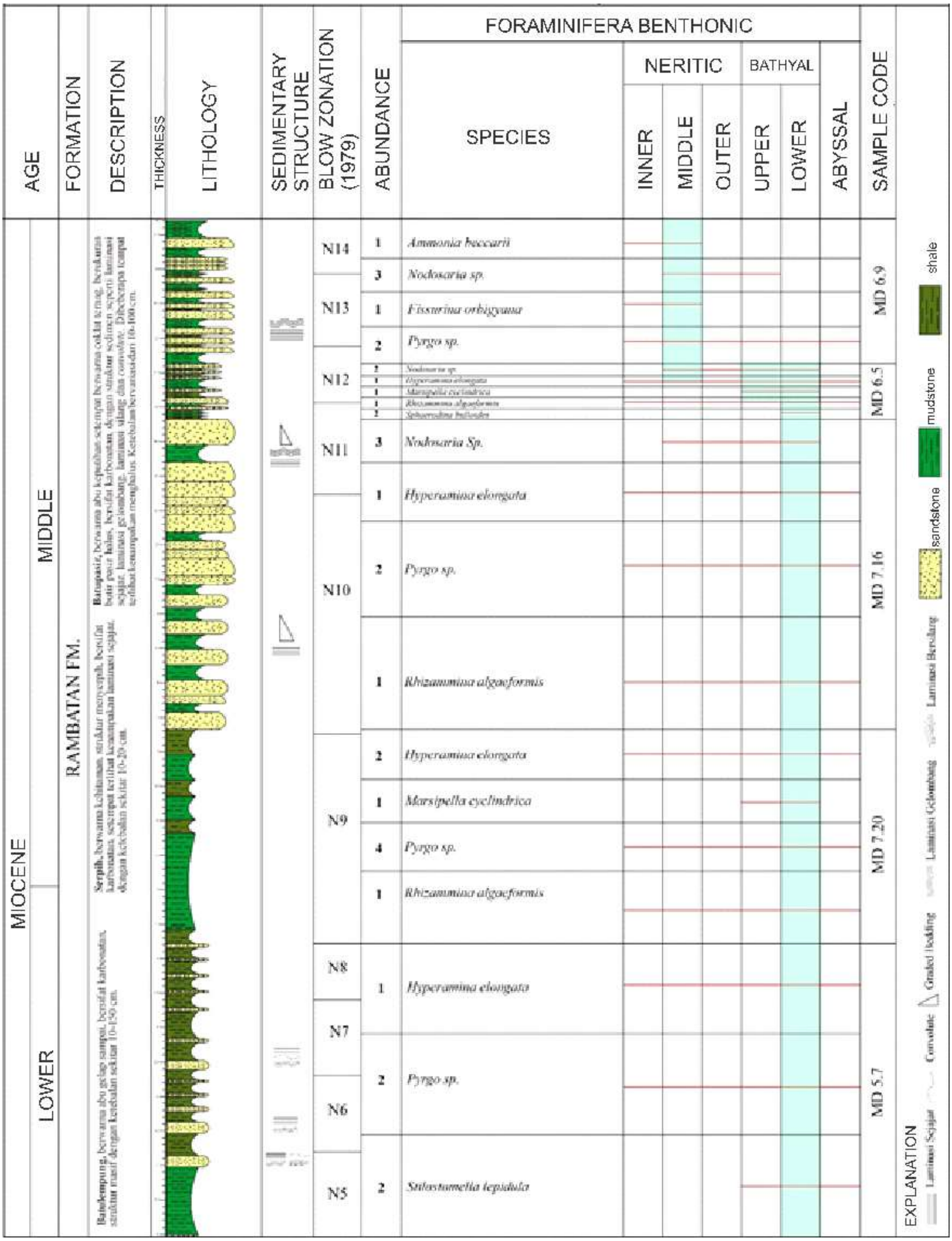

Figure 6. Depositional Environment and Biostratigraphic profile

4. Discussion

The age of the rocks in the Rambatan Formation inside the specific research region is determined to be quite old, ranging from N5-N14 (Lower Miocene to Middle Miocene), based on the findings of stratigraphic analysis conducted in the study area, with particular emphasis on the special study area, in accordance with [13] zoning. In the field of paleobathymetry determination, the classification of index fossils, as outlined by Tipsword, is employed. The rocks within the designated study area are situated within the Lower Batial to Low Tidal zones. The correlation analysis conducted between paleobathymetry and the marine depositional environment yielded findings indicating that the Rmbatan formation depositional environment can be classified as Continental to Slope. The identity is further substantiated by the presence of sediment features, including parallel lamination, cross lamination, wave lamination, convolute, slump, and hearing bone.

The paleobathymetric analysis utilised the classification system proposed by [15] and Boltovskoy and Wright (1976) [16] to determine the paleo-water depths. The presence of the index fossil *Ammonia beccarii* indicated its occurrence in the Edge Neritic environment, with an estimated depth range of 0-100 m (Bandy, 1967) [15]. Additionally, Boltovskoy and Wright (1976) [16] identified this index fossil in the Intertidal Zone, suggesting a water depth of 0 m. Hence, the research region can also be construed as being situated within a transitional environment. The geological record is characterised by the presence of the *Ammonia beccarii* index fossil, which originated at a depth of 0 metres [17].

The observed depositional pattern exhibits a transition from a finning upward trend to a coarsening upward trend, accompanied by a variation in the mudstone lithology from thickening upward to thinning upward. These variations suggest a shift in the depositional environment towards increasing shallowness. In addition to this, the analysis of paleobathymetric zones and rock deposition patterns reveals the occurrence of a transgression event. This phenomenon occurs when the sediment supply is insufficient to fill the accommodation area, resulting in a relative rise in sea level and a retrogradation pattern. A regression phenomenon can arise when sediment supply surpasses accommodation regions, resulting in a basin ward movement of the coastal line and the formation of a progradation pattern.

This assertion is supported by the deposition pattern and is shown to be connected with the sedimentation model as described by Nichols (2009) [18] (Figure 7). Additionally, the concept of Global Eustacy, as proposed by Haq et al. (1987) [19], is taken into consideration (Figure 8).

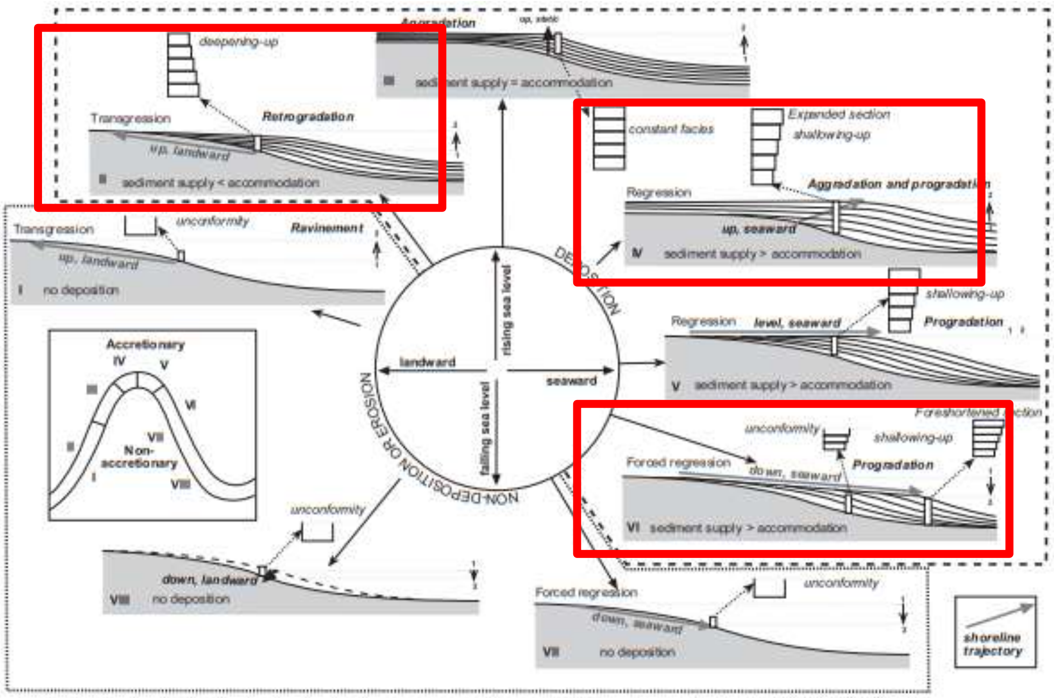

Figure 7. The deposition patterns observed in the study area are derived from the modeling conducted by Nichols (2009) (18).

Furthermore, the theory of the depositional patterns in the research area is reinforced by the worldwide eustacy chart created by Haq et al. (1987). This chart demonstrates that alterations in sea level lag took place during the Lower Miocene to Middle Miocene (Figure 8).

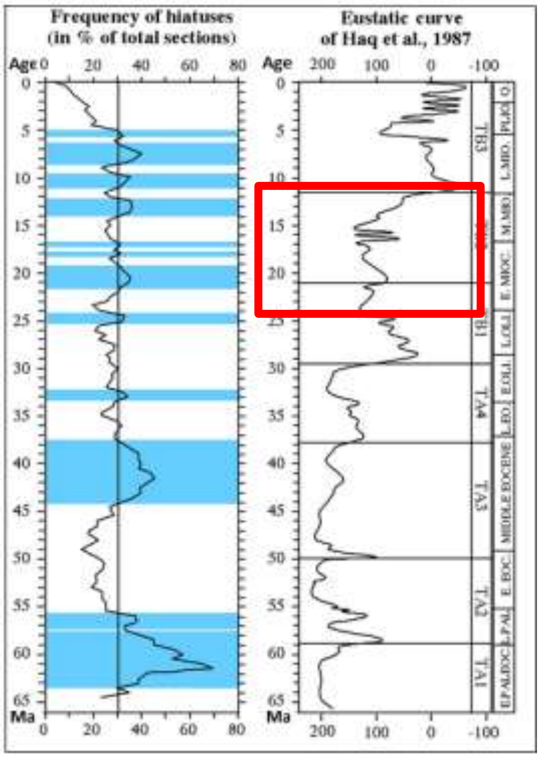

Figure 8. The Global Eustasy Chart, as presented by Haag et al. (1987) [19], is deemed suitable for the prevailing conditions in the study area

5. Conclusion

The biostratigraphic analysis of the Mudstone Unit within the Rambatan Formation was conducted using five rock samples and focused on planktonic foraminifera. The findings indicate that the age of the rock units within the Lower Miocene - Middle Miocene period, specifically within the N5 - N14 zones. Additionally, the analysis revealed the presence of three index fossil species: *Catapsydrax dissimilis, Globigerrinoides Altipelturus, and Globorotalia fohsi*. In this work, paleobathymetry in the research area was assessed by the utilisation of benthonic foraminifera. The findings obtained ranged from the Lower Bathyal to the Transition, and were substantiated by the identification of distinctive fossils found in the Middle Neritic and Lower Battial habitats, specifically *Nodosaria sp.* and *Sphaerodina bulloides*. *Ammonia beccarii*, a characteristic fossil, was discovered in the transitional environment, as reported by multiple specialists. Based on these findings, it may be inferred that the depositional habitat spans from continental to slope.

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