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Analysis of Determination of Depositional Environment of Cinambo Formation Sandstone Member Based on Distribution of Planktonic and Benthonic Foraminifera in Sumedang Area, West Java

Ahmad Thoriq Rabbani Al Ula[1], Edy Sutriyono[2], Ugi Kurnia Gusti[3*]
[1-3] Universitas Sriwijaya

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ABSTRAK

Micropaleontological analysis is an important method in determining the relative age and depositional environment of sedimentary rocks through the identification of planktonic and benthonic foraminifera as indicators of marine paleo-environments. This study aims to determine the bathymetric environment of the Cinambo Formation Sandstone Member in the Jatigede area and its surroundings, Sumedang Regency, based on the distribution of foraminifera, determine the relative age of the rocks, and interpret the depositional environment and sedimentation dynamics. The research methods include sampling at two outcrop locations, preparation using H_2O_2, multistage sieving, and microscopic identification of foraminifera. The determination of the relative age was carried out based on the Blow (1969) classification, while the interpretation of the bathymetric environment refers to Barker (1960). The results of the analysis show the presence of planktonic fossils such as *Orphanage all over the world*, *Transitional Praeorbulina*, And *Globigerina praebulloides* which indicates a relative age of N8 – N9 or Early Miocene to Middle Miocene, while benthonic fossils such as *Fissurina wieneri*, *Osangularia bangalensis*, and *Alveolophragmium scitulum*indicates an upper bathyal depositional environment. Based on these data, the Cinambo Formation Sandstone Member was deposited in a marine environment in the lower to middle fan section (*lower – middle fan*) through the turbidite gravity flow mechanism, reflecting transgressive conditions during the Miocene in the Jatigede area.

ABSTRACT

Analisis mikropaleontologi merupakan metode penting untuk menentukan usia relatif dan lingkungan pengendapan batuan sedimen melalui identifikasi foraminifera planktonik dan bentonik sebagai indikator paleo-lingkungan laut. Penelitian ini bertujuan untuk menentukan lingkungan batimetri (kedalaman laut) dari Anggota Batugamping *Sandstone* Formasi Cinambo di daerah Jatigede dan sekitarnya, Kabupaten Sumedang, berdasarkan distribusi foraminifera, menentukan usia relatif batuan, serta menginterpretasikan lingkungan pengendapan dan dinamika sedimentasinya. Metode penelitian meliputi pengambilan sampel di dua lokasi outcrop, persiapan sampel menggunakan H_2O_2, penyaringan bertahap, dan identifikasi mikroskopis foraminifera. Penentuan usia relatif dilakukan berdasarkan klasifikasi Blow (1969), sementara interpretasi lingkungan batimetri mengacu pada Barker (1960). Hasil analisis menunjukkan adanya fosil planktonik seperti *Orbulina universa*, *Praeorbulina*, dan *Globigerina praebulloides*, yang menunjukkan usia relatif N8 – N9 atau Awal Miosen

hingga Tengah Miosen, sementara fosil bentonik seperti *Fissurina wieneri*, *Osangularia bangalensis*, dan *Alveolophragmium scitulum* menunjukkan lingkungan pengendapan upper bathyal (kedalaman laut menengah-tinggi). Berdasarkan data ini, Anggota Batugamping *Sandstone* Formasi Cinambo diendapkan di lingkungan laut pada bagian *lower–middle fan* melalui mekanisme aliran gravitasi turbidit, mencerminkan kondisi transgresif selama periode Miosen di daerah Jatigede.

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Corresponding Author:

Name: Ugi Kurnia Gusti,S.T., M.Sc.
Institution: Geological Engineering Study Program, Sriwijaya University, Jl. Srijaya Negara, Palembang, South Sumatra, 30139, Indonesia.
Email: ugikurnia@unsri.ac.id

1. INTRODUCTION

Micropaleontology is a branch of paleontology that focuses on the study of microfossils such as planktonic and benthonic foraminifera to determine the relative age and bathymetric environment of sedimentary rocks (Maulidita et al., 2022). Planktonic foraminifera play an important role in determining the relative age of a rock layer because they reflect continuous evolutionary changes, so they are widely used in biostratigraphic studies (Blow, 1969). In addition, the distribution of planktonic foraminifera is influenced by environmental factors such as temperature, water mass characteristics, and ocean current patterns, so their presence can be used to reconstruct past marine environmental conditions and climates (Hanifah et al., 2022). On the other hand, benthonic foraminifera are organisms that live on the water floor (benthos) and are divided into two groups: sessile benthos that attach to the substrate and vagile benthos that live on the substrate surface but can still move freely. Benthonic foraminifera are very sensitive to variations in depth and environmental conditions. Therefore, benthonic foraminifera are widely used as indicators in determining bathymetric environments (Barker, 1960). Small-sized benthonic foraminifera are generally found in various aquatic environments, both marine, brackish, *hypersaline*, *ultrasaline*, and freshwater. Based on their size, benthonic foraminifera are classified into two main types, namely large and small benthonic foraminifera (Sukandarrumidi, T. H. & Wiloso, 2020). This study focuses on the small benthonic foraminifera group (Nuraliza et al., 2024).

Previous research has shown that foraminiferal analysis is effective in determining relative age and bathymetric environments. Blow (1969) and Barker (1960) are the main basis for determining relative age and bathymetry. Murray (2006) stated that the distribution of benthonic foraminifera is closely related to depth and environmental conditions. Nuraliza et al. (2024), Nurjanah and Idarwati (2025), and Nugraha and Mayasari (2020) showed that foraminiferal associations can be used to determine age and depositional environments in detail. Idarwati and Margareta, (2026) showed that the Baturaja Formation was deposited in a Marginal Neritic – Middle Neritic environment, while the Gumai Formation was deposited in a Transitional – Middle Neritic environment, reflecting changes in the depth of the depositional environment. This confirms that foraminiferal analysis is a reliable method in bathymetric interpretation.

This research focuses on the Cinambo Formation, specifically the sandstone member in the Jatigede area and its surroundings, Sumedang Regency, West Java Province (Sunarta et al., 2023). The objectives of this study are to determine the relative age of the rocks based on planktonic foraminifera, determine the bathymetric environment based on benthonic foraminifera, and interpret the depositional environment and the relationships of the developing sedimentary facies. A similar approach was applied by Gusti & Susilo (2019) in analyzing depositional environments through the identification of facies and architectural elements on vertical outcrops to interpret paleoflow patterns and reservoir potential, highlighting the importance of integrating field data and literature in depositional environment interpretation" (Gusti & Susilo, 2019). In addition, this study also aims to reconstruct the paleo-marine environment and sedimentation dynamics during the Miocene. The results of this study are expected to provide a more comprehensive understanding of the development of the deep-sea system in the Cinambo Formation and support the interpretation of regional geology in the Jatigede area and its surroundings.

2. RESEARCH METHOD

The research data consisted of rock samples obtained from field observations, including lithological descriptions and sampling at the research site. The method used was paleontological analysis to determine the relative age and depositional environment based on foraminifera. In the paleontological analysis stage, sample preparation and microscopic observation were carried out to determine the relative age and depositional environment. Sample preparation was carried out by crushing the rocks, soaking them in H_2O_2 solution for approximately 22 hours, washing, drying, and sieving through a multi-stage sieve (mesh 30–200). The research began with literature review and then collect the datas in form of primary data and secondary data. Primary data that this research used are rock macroscopic characteristic and the sedimentary structure of rock. Secondary data that used in this research is Digital Elevation Model (DEM) of hte research area (Heriani, 2024).

The sieved residue was then observed using a microscope to identify planktonic and benthonic foraminifera based on morphological characteristics (Dan et al., 2019). Identification and determination of relative age were carried out based on Blow's (1969) classification, while interpretation of the depositional environment referred to Barker's (1960) criteria based on depth or*fathom*from each type of foraminifera (Nurjanah & Idarwati, 2025). In this study, writer combined a literature review with direct field observations of the rock outcrops present at studied area, including observations of morphology and modern sedimentary processes, as well as sample collection for microscopic analysis of rock characteristic for rock petrographic analysis (Ugi K. Gusti, et al., 2026).

Administratively, the research area is located in Sumedang District, Sumedang Regency, West Java with a research area of 81 km2. Astronomically based on the Universal Transverse Mercator (UTM) the research area is in zone 48S. Based on geographical coordinates it is located in the West 15 108°03'-108°19' East Longitude; East 108°12' - 108°25 East Longitude; North 6°36' - 5°58 South Latitude; South 6°43' - 7°44. Transportation access is via land using buses from the Alang-alang Lebar Terminal in Palembang City to Central Jakarta with a distance of 527 km for 8 hours 19 minutes. Then the journey continues by bus to the Majalengka Terminal for 210 km for 3 hours 49 minutes (Figure 1). Furthermore, research access is carried out by motorized vehicles in Sumedang Regency and its surroundings.

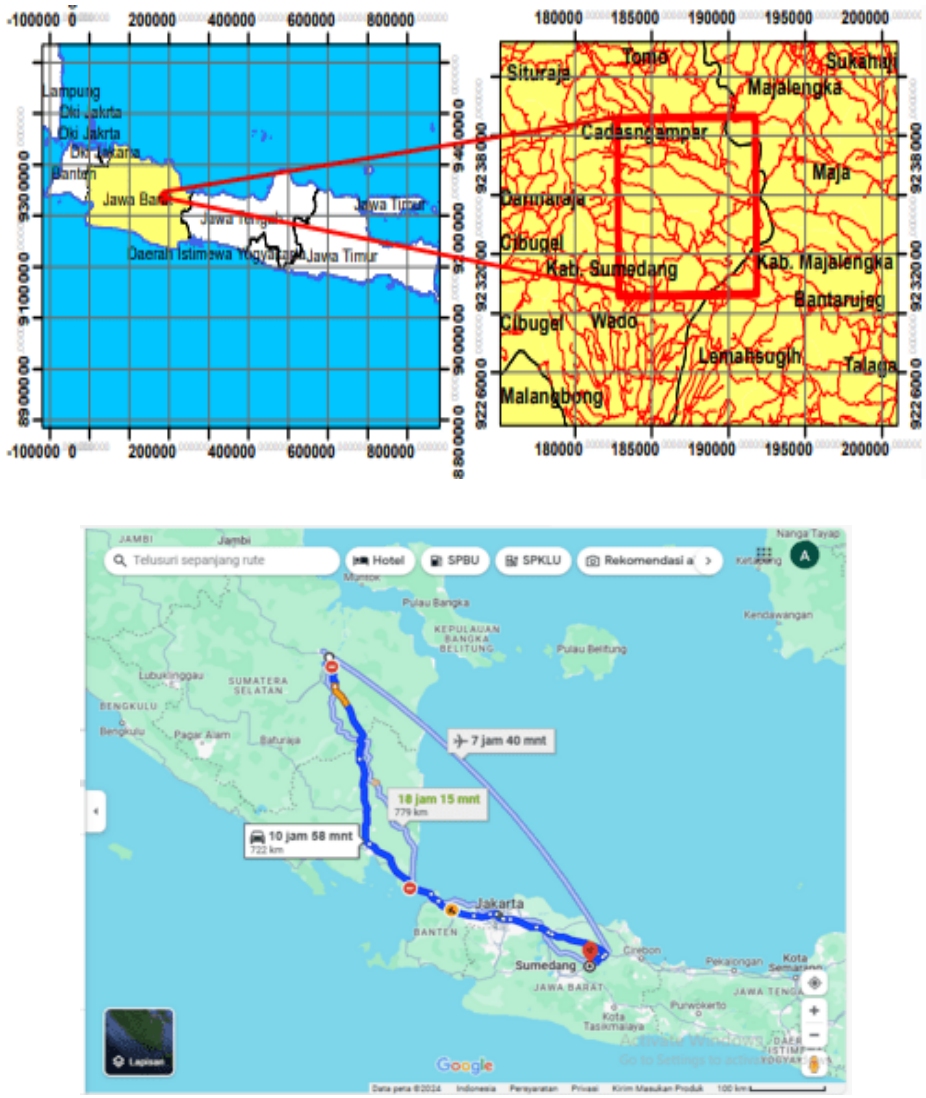

Figure 1. Accessibility of the Research Location, which shows the Cisampih area, Sumedang Regency, West Java Province, and shows the distance from Palembang city to the research location indicated by the blue line. Source: (www.googlemaps.com).

3. RESULT AND DISCUSSION

Based on the results of field observations in the research area, 2 location points were found that had Calcareous Sandstone and Carbonaceous Claystone lithology. From both research locations, sampling was carried out and two rock samples were obtained which were then analyzed paleontologically.

3.1 Calcareous Sandstone

Megascopically (Figure 2), the calcareous sandstone of this formation has a description ranging from a fresh color of gray to a weathered color of blackish gray. The grain size is included inmedium sand And fine sand in the Wenthworth scale (1922). The degree of roundness issubrounded, sortingmoderately sorted, and reacts with HCl which shows the composition of carbonate cement.

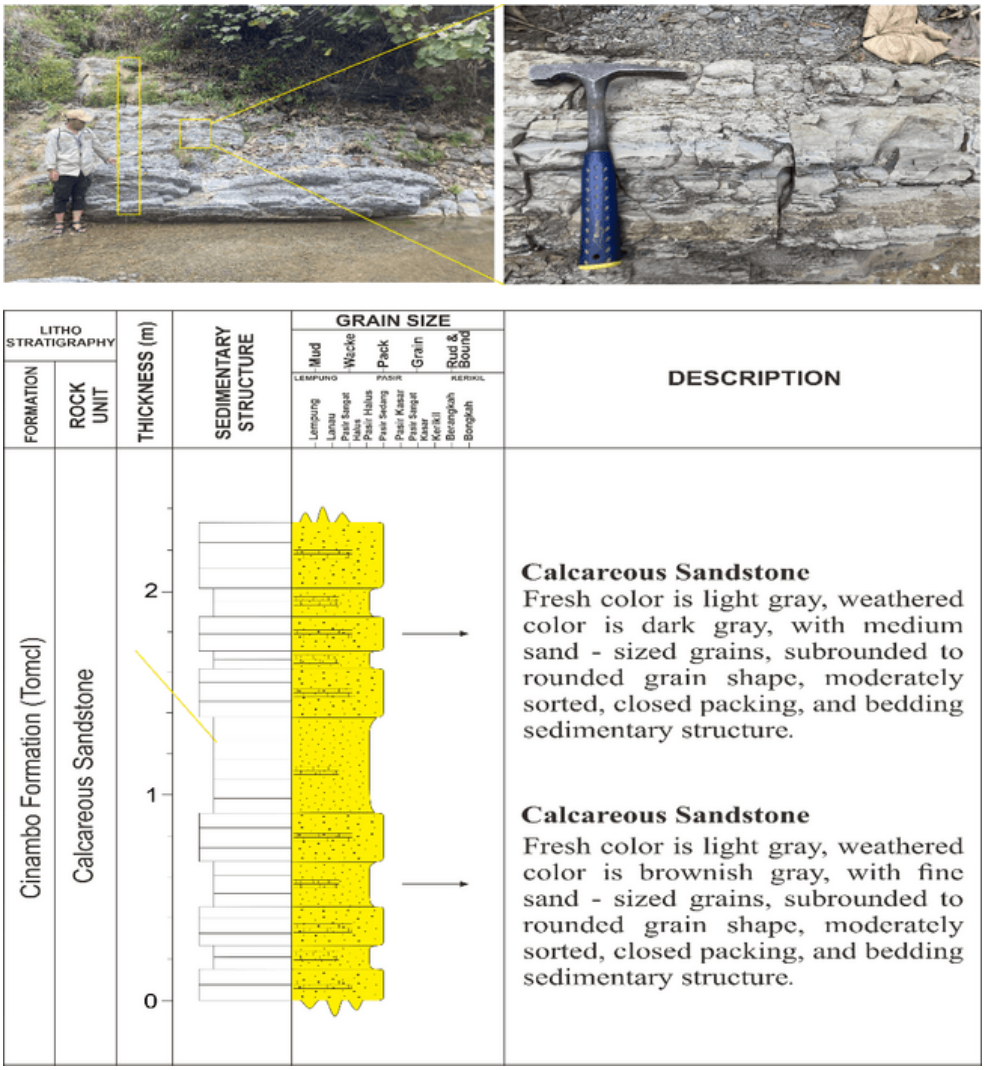

Figure 2. Lithological Outcrop Profile of the Calcareous Sandstone of the Cinambo Formation Lower Member, showing a bright gray color, with a grain size of medium sand and fine sand.

Micropaleontological observations were also conducted to obtain data on the relative age of the formation and its depositional environment. This analysis was conducted by taking carbonate sandstone samples located in Cimanintin village. Based on the analysis results, five (5) planktonic fossils and five (7) benthonic fossils were obtained. At this research location, foraminiferal analysis was carried out on Tomcl calcareous sandstone samples, obtaining planktonic fossils (Figure 3). This planktonic foraminiferal analysis was carried out to determine the relative age of the sandstone samples in the Cinambo Formation Sandstone Member (Tomcl). Next, a relative age was drawn for each fossil that had been found (Blow, 1969).

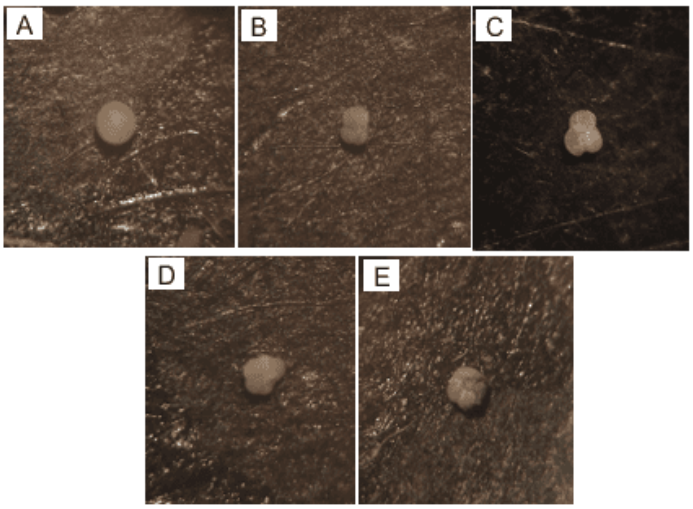

Figure 3. Planktonic fossils in the calcareous sandstone lithology of the Cinambo Formation (Tomcl): (A)Orphanage all over the world, (B) Transitory sedge, (C) Globigerina praebulloides, (D) Globorotalia praemenardi, (E)Globugarina dehicens.

In the planktonic foraminifera fossils found in the calcareous sandstone samples of the Cinambo Formation Sandstone Member (Tomcl), the relative age of the rocks was determined based on the age of the index fossils. Based on the foraminifera fossils that have been obtained,Transitional Praeorbulinais an index fossil (N8 – N9). Based on the results of the extraction, the relative age of the calcareous sandstone lithology of the Cinambo Formation Sandstone Member (Tomcl) isEarly Miocene – Middle Miocene (Figure 4).

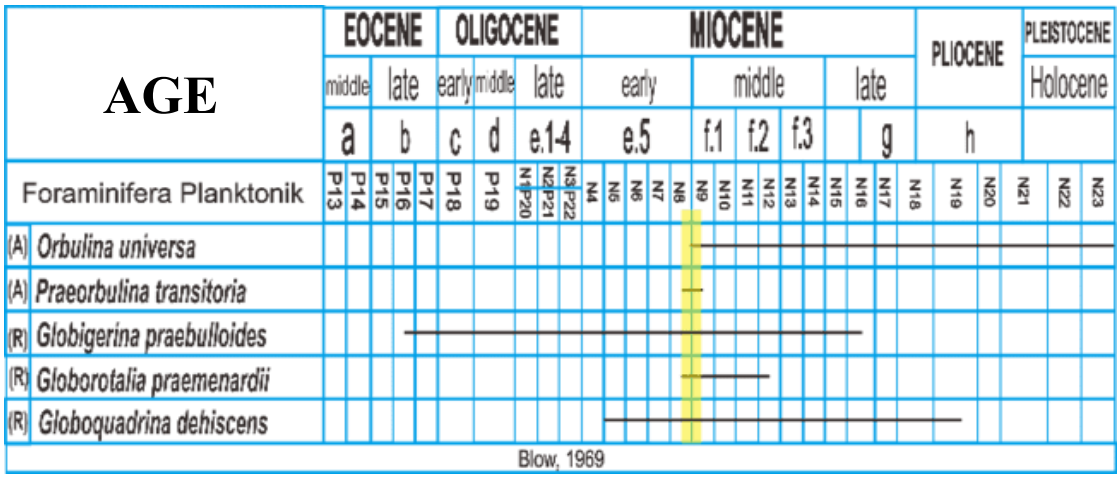

Figure 4. Relative age dating of rocks based on planktonic fossils in the Calcareous Sandstone lithology of the Cinambo Formation (Tomcl) (Barker, 1969).

In addition to determining relative age, bathymetric environment determination was also carried out based on the presence of benthonic foraminifera fossils. Benthonic foraminifera live by anchoring to the seabed and are therefore used as a benchmark for determining the bathymetric environment in a rock. Benthonic fossils (Figure 5). Next, the bathymetric environment depth was drawn for each benthonic foraminifera fossil that was found based on (Barker, 1960).

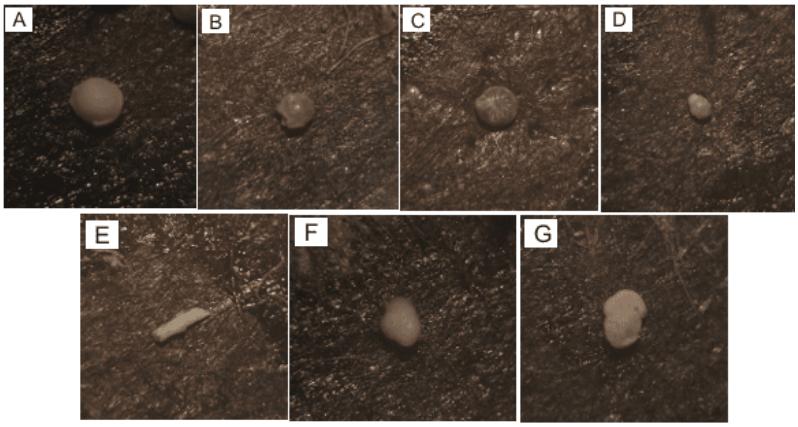

Figure 5. Benthonic Fossils of Calcareous Sandstone of the Cinambo Formation (Tomcl) below: (A)Fissurina wieneri, (B) Osangularia bangalensis, (C) Alveolophragmium scitulum (D) Loxostomum karrerianum, and (E)Hypermmina elongata (F) Allomorphina pacifica (G) Half-naked Lingulin.

The determination of the bathymetric environment was carried out based on the dominant depth of all benthonic foraminiferal fossils obtained. Based on 7 benthonic foraminiferal fossils obtained in the calcareous sandstone lithology of the Cinambo Formation Sandstone Member, the depositional environment of the rock was found to be Upper Bathyal (Figure 6).

Lingkungan Batimetri		Transisi	Neritik			Batial		Abisal
			Tepi	Tengah	Luar	Atas	Bawah	
Foraminifera Bentonik		0	20	100	200	500	2000	4000
(C)	*Fissurina wiesneri* (1100 ft)						•	
(R)	*Osangularia bengalensis*(580 ft)					•		
(C)	*Alveolophragmium scitulum*(580 ft)					•		
(R)	*Loxostomum karrerianum* (345 ft)					•		
(R)	*Hyperammina elongata* (390 ft)					•		
(A)	*Allomorphina pacifica* (620 ft)					•		
(R)	*Lingulina seminuda* (390 ft)					•		
Barker, 1960								

Figure 6. Bathymetric depth drawing of rocks based on benthic fossils in the calcareous sandstone lithology of the Cinambo Formation (Tomcl) (Barker, 1960).

3.2 Carbonaceous Claystone

In the carbonate claystone in the Sandstone Member Formation (Tomcl) with outcrop descriptions having a blackish gray weathered color and a black fresh color, with a grain size ofclay (<0.004 mm – 0.062 mm) on the Wenthworth scale (1922) (Figure 7).

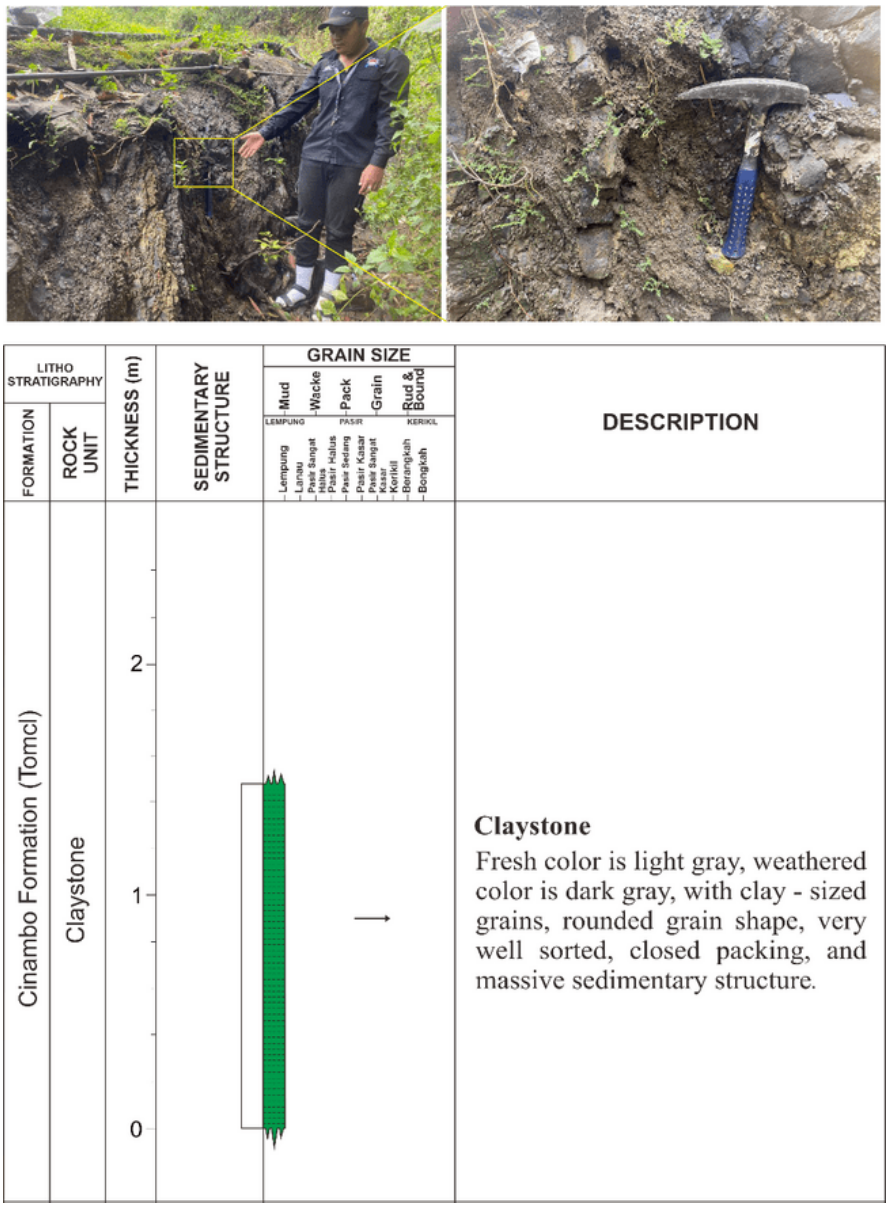

Figure 7. Outcrop profile of the lower member of the Cinambo Formation claystone, with a characteristic blackish gray color, with a grain size ofclay.

Micropaleontological observations were also conducted to obtain data on the relative ages of the formations and their depositional environments. This analysis was conducted by sampling carbonate sandstones located in Cimanintin village. The analysis yielded five planktonic fossils and five benthonic fossils.

At this research site, foraminiferal analysis was conducted on samples of claystone from the Cinambo Formation, Sandstone Member (Tomcl), and planktonic fossils were obtained (Figure 8). This planktonic foraminiferal analysis was conducted to determine the relative age of the carbonate claystone samples from the Cinambo Formation, Sandstone Member (Tomcl). Next, relative ages were drawn for each fossil found (Blow, 1969).

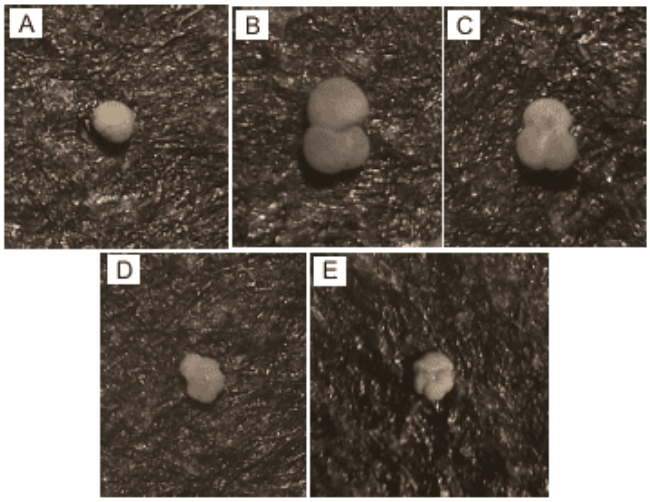

Figure 8. Carbonate Rock Plankton Fossils of the Cinambo Formation (Tomcl): (A) Orphanage all over the world, (B) Transitional Praeorbulina, (C) Globigerina praebulloides, (D) Globorotalia praemenardii, (E)Globoquadrina dehiscens.

In the planktonic foraminifera fossils found in the carbonate mudstone samples of the Cinambo Formation Sandstone Member, the relative age of the rocks was determined based on the age of the fossils.index. Based on the foraminifera fossils that have been obtained,Transient pracorbulinis an index fossil (N8 – N9). Based on the results of the extraction, the relative age of the carbonate claystone lithology of the Cinambo Formation Sandstone Member isEarly Miocene – Middle Miocene (Figure 9).

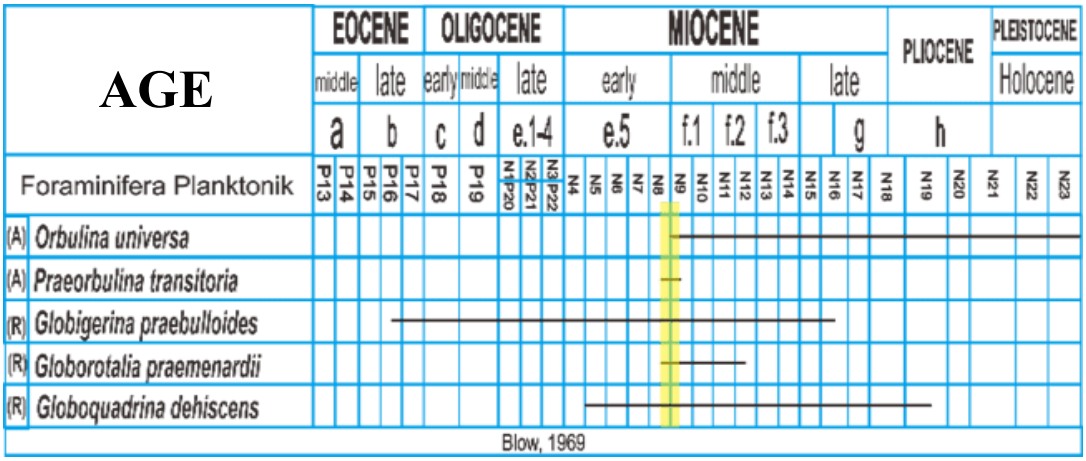

Figure 9. Relative age dating of rocks based on planktonic fossils in the Carbonate Claystone lithology of the Cinambo Formation (Tomcl) (Barker, 1969).

In addition to determining relative age, bathymetric environment determination was also carried out based on the presence of benthonic foraminifera fossils. Benthonic foraminifera live by anchoring to the seabed and are therefore used as a benchmark for determining the bathymetric environment of a rock. Benthonic fossils (Figure 10). Next, the bathymetric environment depth was drawn for each benthonic foraminifera fossil that was found based on (Barker, 1960).

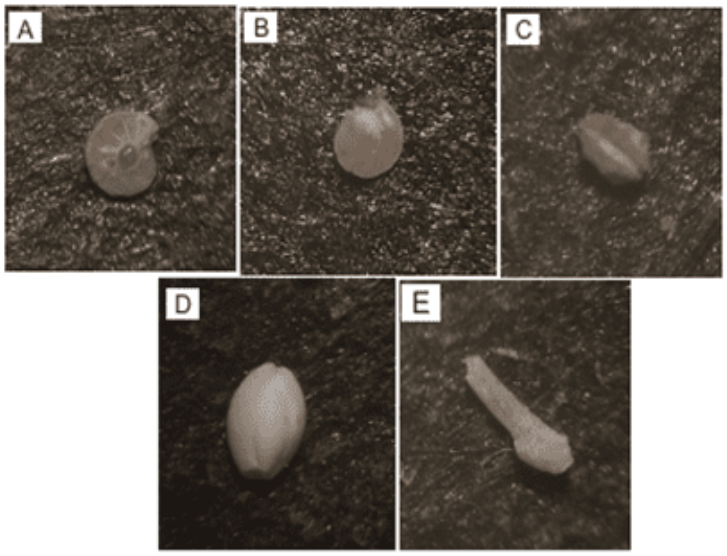

Figure 10. Carbonate Benthic Clay Fossils of the Cinambo Formation (Tomcl): (A) Alveolophragmium scitulum, (B) Osangularia bangalensis, (C) Spirocullina antlarum (D) Triloculina tigonula, and (E) Major joints.

The determination of the bathymetric environment was carried out based on the dominant depth of all benthonic foraminiferal fossils obtained. Based on 5 benthonic foraminiferal fossils obtained in the carbonate mudstone lithology of the Cinambo Formation Sandstone Member, the depositional environment of the rock was found to be Upper Bathyal (Figure 11).

Lingkungan Batimetri		Transisi	Neritik			Batial		Abisal
			Tepi	Tengah	Luar	Atas	Bawah	
Foraminifera Bentonik		0	20	100	200	500	2000	4000
(A)	*Alveolophragmium scitulum* (542 ft)					•		
(C)	*Osangularia bengalensis* (580 ft)					•		
(R)	*Spiroculina antillarum* (350 ft)					•		
(R)	*Triloculina trigonula* (630 ft)					•		
(R)	*Articulina mayori* (435 ft)					•		
Barker, 1960								

Figure 11. Bathymetric depth drawing of rocks based on benthonic fossils in the Carbonate Claystone lithology of the Cinambo Formation (Tomcl) (Barker, 1960).

3.3 Sedimentation Environment

During the Early Miocene, the study area underwent a sedimentation process that produced the Lower Member of the Cinambo Formation (Tomcl). This unit is dominated by sandstone lithology deposited through a gravity flow mechanism (gravity flow) in the deep sea fan system (Reading & Richards, 1994). The sedimentary material deposited is clastic sediment (Boggs, 2006) which originates from the erosion of rocks on the surrounding land, then transported to the deep sea environment through the sediment transport system on the basin slope (Einsele, 2000).

The deposition process occurs through turbidite currents, which carry sand and clay material to deeper parts of the basin. These deposits form alternating layers of sandstone and shale (Tucker,

2001), but are generally dominated by sandstone. This reflects the influence of turbidite currents, which have relatively high energy during deposition.

This interpretation of the depositional environment is supported by the results of benthonic foraminiferal analysis, which indicates deep-sea conditions. Furthermore, the presence of sedimentary structures in the sandstone, such ascross lamination And parallel laminationwhich is included in the Bouma Tb – Tc sequence also shows sedimentation processes by turbidite currents. These characteristics indicate that the Lower Member of the Cinambo Formation was deposited in a lower to middle deep-sea fan environment (lower – middle fan) (Walker, 1992) in a deep-sea fan system (Mutti & Ricci Lucchi, 1972). A schematic model of the depositional environment of the Lower Member of the Cinambo Formation is shown in (Figure 12).

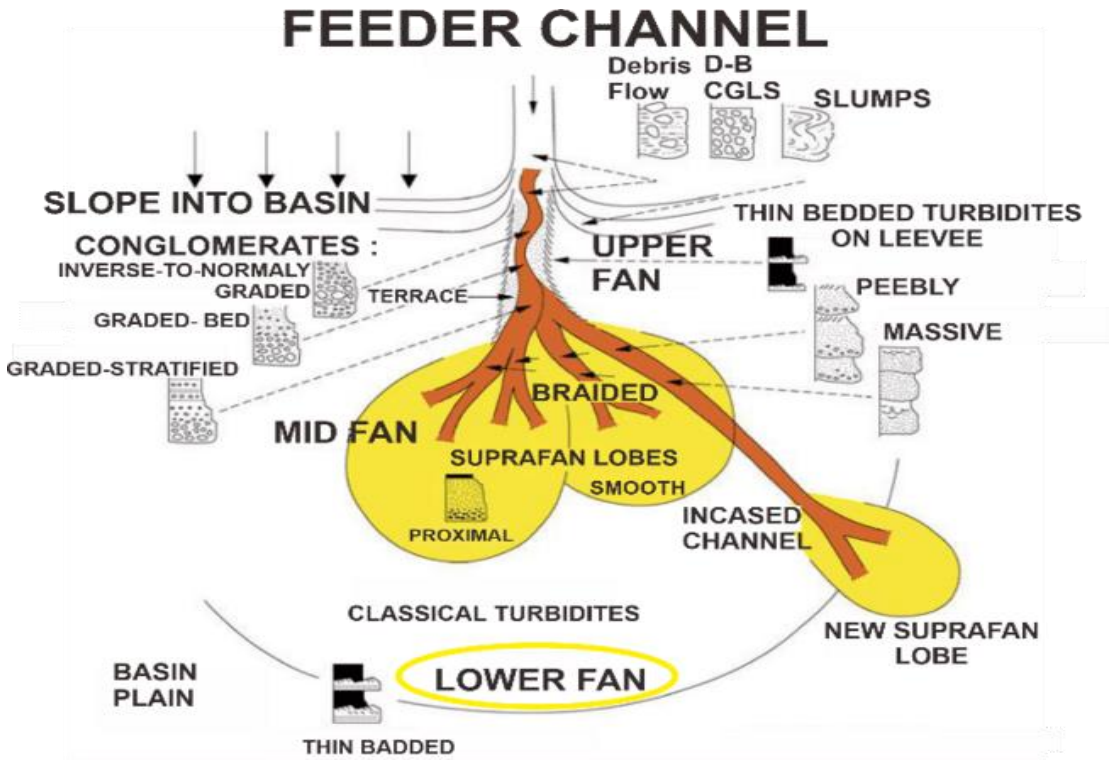

Figure 12 Schematic model of the depositional environment of the Cinambo Formation in the environmentmarine, Cinambo sandstone member onlower fanmarked with a yellow circle (Walker, 1978).

4. CONCLUSION

The research area focuses on the Cinambo Formation Sandstone Member. Based on two observation locations, the relative age of the rocks ranges from N8 to N9 (Early Miocene to Middle Miocene) based on the presence of planktonic foraminiferal index fossils. Benthonic foraminiferal analysis indicates that the depositional environment was Upper Bathyal, reflecting deep-sea conditions. Sedimentologically, the Cinambo Formation Lower Member (Tomcl) is dominated by sandstone lithology associated with shale in the form of alternating layers. This character indicates deposition by gravity flow mechanisms in the form of turbidite currents. The presence of sedimentary structures such asparallel lamination And cross laminationwhich is included in the Bouma Tb – Tc sequence (Bouma, 1962) strengthens this interpretation. Based on the integration of

paleontological and sedimentological data, the Lower Member of the Cinambo Formation is interpreted to have been deposited in a deep-sea fan system, specifically in a fan environment lower fan (Mutti & Ricci Lucchi, 1972).

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