



## Nannofossil Distribution and Age of Kendeng Zone In Kalibeng River Section of Kedungringin, Plandaan Area, Jombang, East Java

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**Abstract** - This study was carried out at Kalibeng River Section, in Kedungringin area, a site with lithology suitable for a nannoplankton research. Methods used in this research include performing a stratigraphical measurement section at the field, collecting thirty-two samples, and preparing the samples with the smear slide method using a polarizing microscope with 1000x magnification, and preparing several rock samples using SEM analysis. The analysis of nannofossil resulted in twelve genera and forty-three species. The identified genera are: *Calcidiscus*, *Coccolithus*, *Ceratolithus*, *Discoaster*, *Gephyrocapsa*, *Helicosphaera*, *Pseudoemiliana*, *Reticulofenestra*, *Rhabdosphaera*, *Sphenolithus*, *Syracosphaera*, and *Umbilicosphaera*. The presence of these genera indicates that Kalibeng River Section have abundant nannofossils and based on the nannofossil analysis, from older to younger, the studied stratigraphic sequence indicates a more detailed age determination as follows: the Marl Unit of Kalibeng is NN10-NN18 (Middle Miocene to Pliocene), Calcareous Sandstone Unit of Sonde is NN19-NN20 (Pliocene-Pleistocene), and Calcareous Claystone Unit of Sonde is NN20-NN21 (Pleistocene).

**Keywords:** calcareous fine clastics, nannoplankton, Miocene to Pleistocene, Kendeng

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## INTRODUCTION

### Background

Research of fossil is one of the most important tools for the study of sedimentary rocks and basins. First, the succession of evolutionary appearances and extinctions provides age control, which is critical for understanding basin evolution and validation of geological concepts. Second, fossils are useful for interpretation of local paleoenvironment, paleoclimate, and also

reconstruction of paleobiogeographic (Van Gorsel *et al.*, 2014).

The stratigraphic analysis shows that the Kendeng Zone is a young fold-thrust belt, which was only active within the Pliocene. In this zone, deep marine volcanoclastic sediments of Early Pliocene and older ages have been uplifted and thrust northwards since mid-Pliocene time (Lunt, 2013, in Berghuis *et al.*, 2019).

The Kendeng Zone is the southern part of East Java basinal system. The sedimentary evolution

of this basin indicates that the East Java basinal system was formed as a continuation of extension around the Makassar Strait to the east, and not as a back-arc basin. This interpretation is based on tectonically pulsed east to west trend in crustal thinning, subsidence, and trans-gression (Lunt, 2019)

The studied area is occupied by a sedimentation sequence consisting mostly of fine-grained marine sedimentary rocks that contain abundant microfossils with the age from Miocene to Quaternary. A nannoplankton research in the Kendeng Zone has been done by Choiriah *et al.* (2001), but only limited to the Bengawan Solo River in Ngawi. The results of previous study in Ngawi section show that the nannofossil contained within Kalibeng Formation consists of eighteen genera and forty-nine species, while Klitik/Sonde Formation has eight genera and twelve species. The age of Kalibeng Formation is Late Miocene to Late Pliocene (NN12-NN18), and Klitik (Sonde) Formation is of Early Pleistocene (NN19-NN20)

The purpose of this study is to determine the distribution and the age of the youngest marine sediments in Kendeng Zone based on nannofossil found in the Kalibeng River Section, and to correlate it to the similar result of the Ngawi Section.

### Stratigraphic Setting

The studied area, which is part of Kalibeng River in the Kedungringin and surrounding area, Plandaan Subregency, Jombang, East Java, is situated in the Kendeng Zone. This part of the river is classified as the type locality of Kalibeng Formation since it is located in the Kalibeng River. According to Pringgoprawiro (1983), the order of the lithostratigraphic formations in the Kendeng Zone, from the oldest to the youngest is as follows: Pelang Formation (Tomp), composed of marl and claystone with intercalation of calcarenite; Kerek Formation (Tmk), comprising interbedded marl, limestone, and sandstone; Kalibeng Formation (Tmptk), consisting of marl with intercalations of sandstone {with Atasangin Member (Tmpta) made up of breccia, sandstone, and claystone}; Sonde Formation (Tps), composed of marl, calcareous

claystone, tuff, and sandstone {with Klitik Member (Tpk) consisting of limestone}; Pucangan Formation (Qtp), composed of tuffaceous breccia, conglomerate, and tuffaceous Sandstone; Kabuh Formation (Qpk), consisting of coarse tuffaceous sandstone with cross-bedding sedimentary structure, claystone, and conglomerate; and Notopuro Formation (Qpn), comprising tuff, interbedded with tuffaceous sandstone, volcanic breccia, and conglomerate (Figure 1).

Sedimentary rocks found in the studied area contain a large amount of microfossils, including nannoplankton which is very valuable to support the objective of this study. Nannofossil is a kind of algae which belongs to the *Haptophyceae* class with a tiny size (0.5-10  $\mu\text{m}$ ). In the living state, this organism has planktonic characteristics.

## MATERIALS AND METHODS

### Field Data Sampling

This step consists of making a measurement section and detailed rock sampling to better understand the changing and development of nannoplankton, as well as determining the age of each rock layer (Figure 2).

A large amount of nannofossils was collected from a small sample due to its tiny size. Rock samples that contain the fossils can be obtained from outcrop, drill core, or cutting.

### Laboratory Analysis

Equipments needed for the analysis include rock sample, prepared slides, coverglass, grinder, dryer/oven, water, pipette, entellan liquid (functions as glue), and labels.

Nannoplankton is very small to identify macroscopically, that is why an optical (polarizing) microscope with a high magnification (1000 X), or even Scanning Electron Microscope (SEM) is needed. The nannofossil analysis was performed using a polarizing microscope by making "smear slides" that could be prepared in a few minutes.

The nannofossil analysis was done using a polarizing microscope with 1000x magnification, in parallel and cross Nicol views. The

Nannofossil Distribution and Age of Kendeng Zone In Kalibeng River Section of Kedungringin, Plandaan Area, Jombang, East Java (S.U. Choiriah *et al.* )

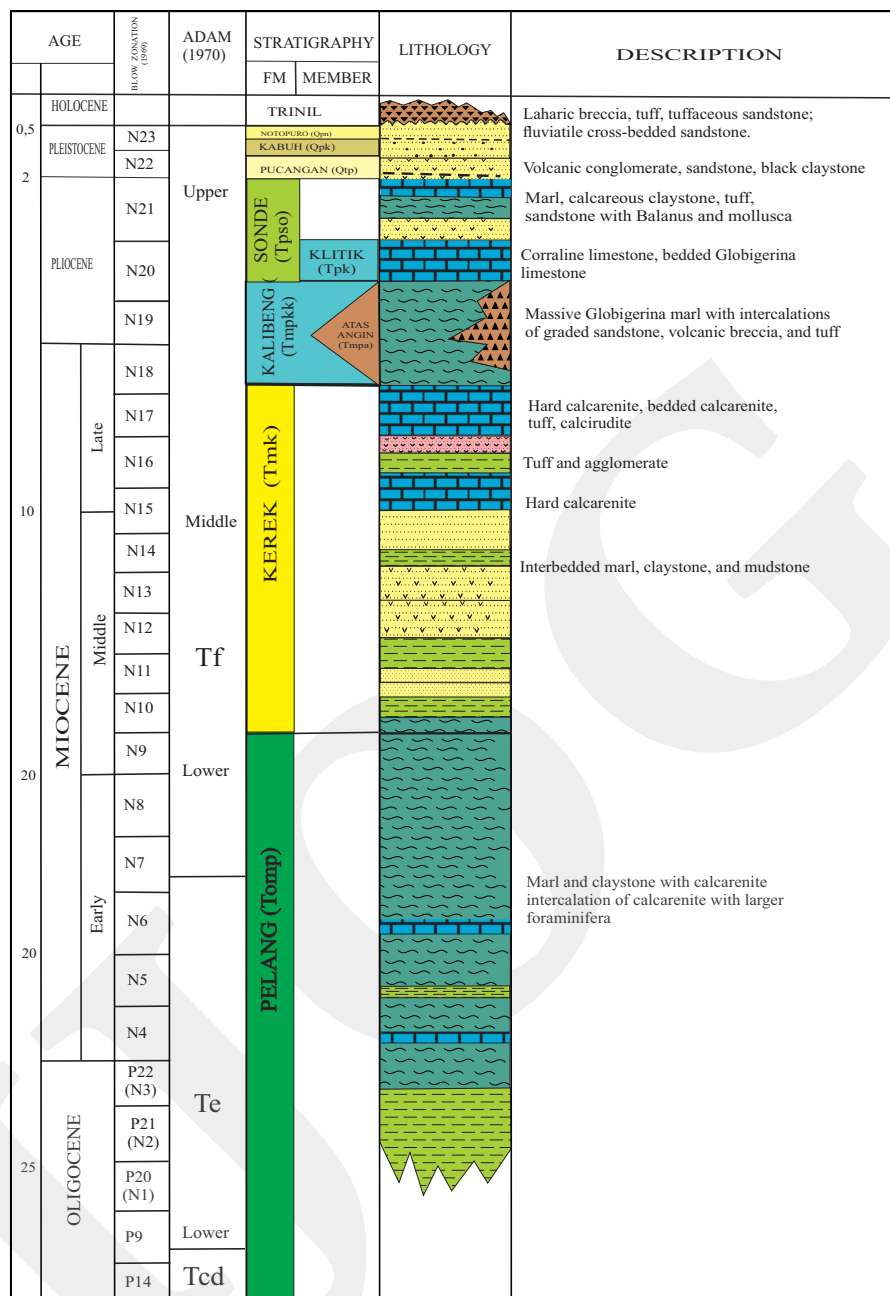


Figure 1. Stratigraphy of Kendeng Zone (modified after Pringgoprawiro, 1983).

photomicrographs of fossils were taken using a microscopic camera (*Moticam*) connected to a laptop or computer. The names of genus and species were referenced from previous researchers (Martini, 1971; Okada and Bukry, 1980; Perch-Nielsen, 1985; Aubry, 1985). The appearance of nannofossil species in each rock sample is the main data of this study.

The photomicrographs of nannofossils within the researched area were taken using a polarizing

microscope in Petrographic Laboratory UPN “Veteran” Yogyakarta and Scanning Electron Microscope of Sedimentology Laboratory, ITB.

### RESULT AND ANALYSIS

Stratigraphically, the Kalibeng River Section in the studied area is composed of Marl Unit of Kalibeng Formation, Calcareous Sandstone Unit

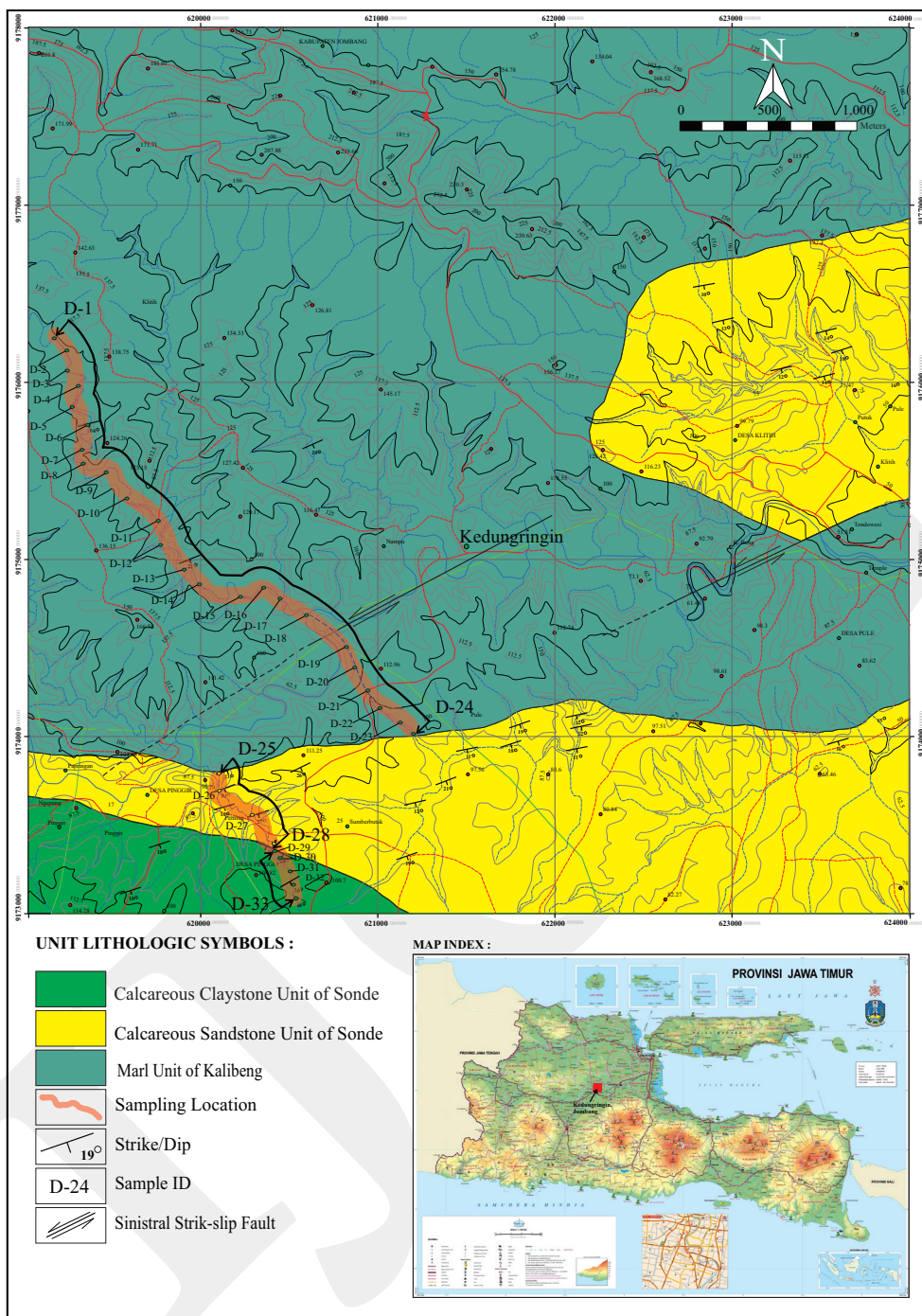


Figure 2. Location of calcareous sediment sampling for the nannoplankton analysis within the background of the geological map of Kedungringin area.

of Sonde Formation, and Calcareous Claystone Unit of Sonde Formation (Figure 3).

The analysis of nannofossil in the studied area reveals that within a total of thirty-three samples of rock thirteen genera and forty-three species of nannofossil (Table 1 and Figure 4) are identified.

The nannofossils found in Marl Unit of Kalibeng Formation are represented by sample D.1 to D.24 consisting of twelve genera with thirty-nine species (Table 1).

They comprise *Calcidiscus leptoporus*, *Ceratolithus acutus*, *Coccolithus pelagicus*, *Coccolithus pliipelagicus*, *Discoaster altus*, *Dis-*

Nannofossil Distribution and Age of Kendeng Zone In Kalibeng River Section of Kedungringin, Plandaan Area, Jombang, East Java (S.U. Choiriah *et al.* )

Epoch	Formation	Lithology Unit	Thickness	Symbol of Lithology	Description of Lithology	Depositional Environment
Holocene		Alluvium sediment	12 m		Loose material from weathering and reworked of older rocks	
Pleistocene	Sonde	Calcareous sandstone	47,5 m		Calcareous sandstone Sonde dominated by calcareous sandstone with intercalation of calcareous claystone, limestone, and calcareous siltstone.	Inner to Middle Shelf
		Calcareous claystone	89,9 m		Calcareous claystone Sonde, dominated by calcareous claystone with intercalation of calcareous sandstone, calcareous siltstone, massive and lamination structures.	Lagoon
Late Miocene to Late Pliocene	Kalibeng	Marl	446,3 m		Marl of Kalibeng, consisting of marl dominated, massive structure with intercalation of calcarenite limestone, calcareous sandstone, lamination and load cast sedimentary structures.	Inner to Middle Bathyal

Figure 3. Stratigraphy of Kedungringin, Jombang, East Java.

*coaster asymmetricus*, *Discoaster blackstockae*, *Discoaster bolli*, *Discoaster brouweri*, *Discoaster calcaris*, *Discoaster druggii*, *Discoaster challengerii*, *Discoaster hamatus*, *Discoaster intercalaris*, *Discoaster neorectus*, *Discoaster perplexus*, *Discoaster pentaradiatus*, *Discoaster quadramus*, *Discoaster surculus*, *Discoaster*

*triradiatus*, *Discoaster tristellifer*, *Discoaster variabilis*, *Gephyrocapsa caribbeanica*, *Gephyrocapsa oceanica*, *Helicosphaera carteri*, *Helicosphaera selli*, *Pseudoemiliana lacunosa*, *Pseudoemiliana ovata*, *Reticulofenestra haqii*, *Reticulofenestra minuta*, *Reticulofenestra minutula*, *Reticulofenestra pseudoumbilicus*,

Table 1. Distribution of Nannofossils in Kalibeng River Section, Jombang Area

FORMATION	UNIT OF LITHOLOGY	AGE	ZONE OF NANNOPLANKTON (Martini, 1971)	SPECIES OF CALCAREOUS NANNOFOSSIL																																																				
				NUMBER OF SAMPLES																																																				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41												
KALIBENG	Marl Unit	Miocene to Pliocene	NN10-NN18	D.24	•	•	-	/	•																																															
				D.23	-	o	-	o	-	•		•																																												
				D.22	•	•	-	o		o		-	-	-	-	•																																								
				D.21	o		-	o		o		•																																												
				D.20	•	o	o	-	o	•	•		•																																											
				D.19	/	/	o		o																																															
				D.18	-	o	o	o		•	•	•																																												
				D.17	-	•	-	•	/	•	/	-	•																																											
				D.16	-	/	/	-	/	•																																														
				D.15	-	/	-	•	•	•	•																																													
				D.14	/	•			o																																															
				D.13	/	•		-	•																																															
				D.12	-																																																			
				D.11	o	•	•	-	-	•																																														
				D.10	-																																																			
				D.9	•	•	•		•																																															
				D.8	o		-	-	•	•	-																																													
				D.9?	•				o	•	•																																													
				D.10	-																																																			
				D.5	-	-	-			•	-	•	-																																											
				D.4	-	•		•	-	•																																														
				D.3	•	•		•																																																
				D.2																																																				
				D.1	•																																																			

Notes: / Abundance of Nannofossils species, o: Common (6-10), •: Frequent (2-5), - : Occasional (1)

*Reticulofenestra rotaria*, *Rhabdosphaera clavigera*, *Sphenolithus moriformis*, *Sphenolithus abies*, *Sphenolithus neoabies*, *Syracosphaera* sp., and *Umbilicosphaera jafari*.

The nannofossils recognized in Calcareous Sandstone Unit of Sonde Formation are

derived from sample D.25 to D.28 consisting of ten genera with fourteen species; those are: *Calcidiscus leptoporus*, *Coccolithus pelagicus*, *Coccolithus pliipelagicus*, *Discoaster triradiatus*, *Gephyrocapsa caribbeanica*, *Gephyrocapsa oceanica*, *Helicosphaera carteri*, *Helicosphaera*

Nannofossil Distribution and Age of Kendeng Zone In Kalibeng River Section of Kedungringin, Plandaan Area, Jombang, East Java (S.U. Choiriah *et al.* )

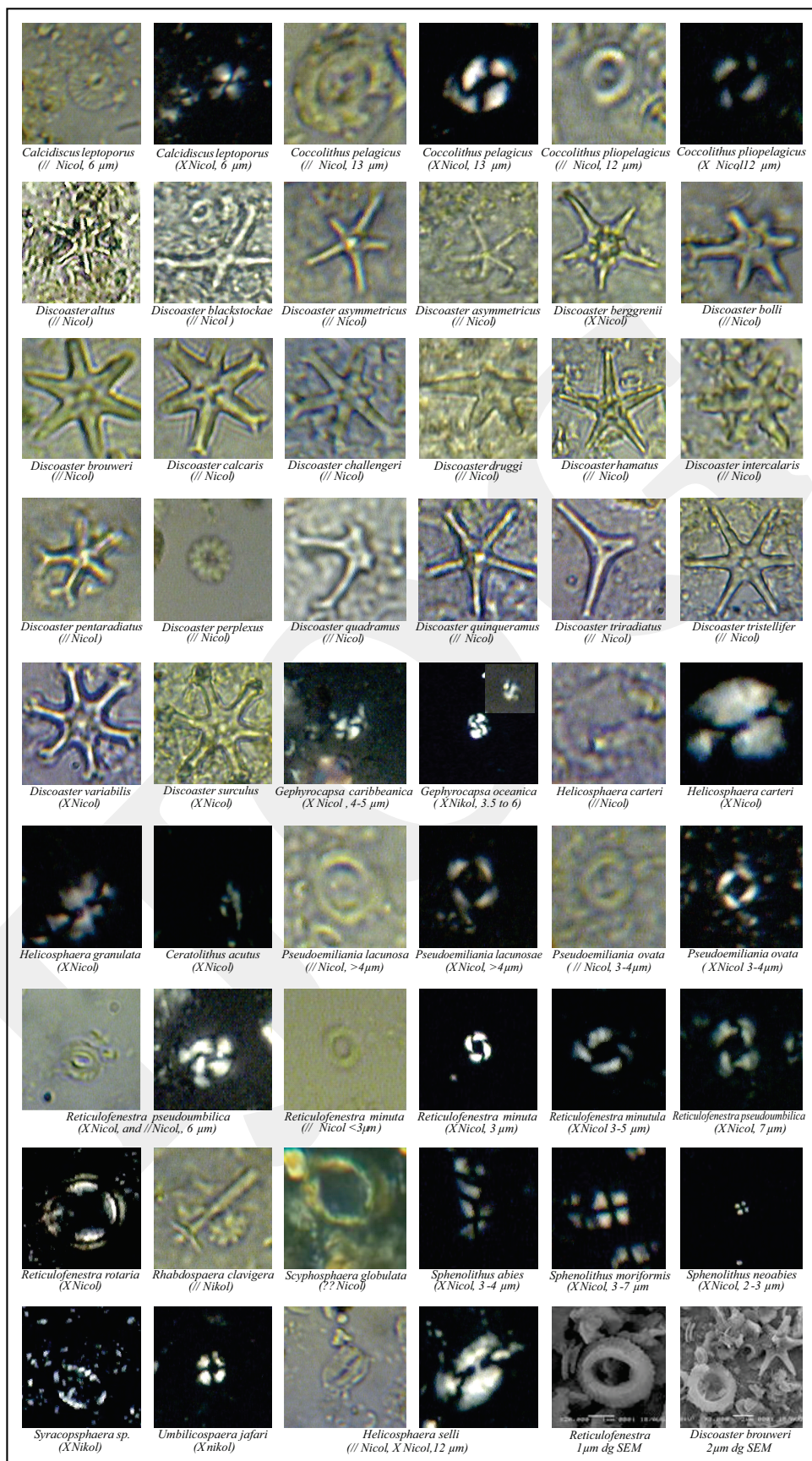


Figure 4. Photomicrographs of nannofossil species (1000x) in the researched area.

*selli*, *Pseudoemiliana lacunosa*, *Pseudoemiliana ovata*, *Reticulofenestra minuta*, *Rhabdosphaera clavigera*, *Syracosphaera* sp., and *Umbilicosphaera jafari*.

The nannofossils found in Calcareous Claystone Unit of Sonde Formation derived from sample D.29 to D.33 consist of eight genera with eleven species (Table 1), such as: *Calcidiscus leptoporus*, *Coccolithus pelagicus*, *Coccolithus pliopelagicus*, *Discoaster triradiatus*, *Gephyrocapsa caribbeanica*, *Gephyrocapsa oceanica*, *Helicosphaera carteri*, *Helicosphaera kamptnari*, *Reticulofenestra minuta*, *Rhabdosphaera clavigera*, and *Syracosphaera* sp.

The occurrence result of twelve genera and forty-three species indicates that the age of Marl Unit of Kalibeng is NN10-NN18, Calcareous Sandstone Unit of Sonde is NN19, and Calcareous Claystone Unit of Sonde is NN20-NN21, according to the classification of Martini (1971).

The index fossil used to indicate age in this research is the first and the last appearance of species *Ceratolithus acutus*, *Discoaster asymmetricus*, *Pseudoemiliana lacunosa*, *Discoaster surculus*, and *Sephyrocapsa oceanica*.

## DISCUSSION

The studied area belongs to the type locality of the Kalibeng Formation in Kendeng Zone, with the order of stratigraphy from older to younger consists of Marl Unit of Kalibeng Formation,

Calcareous Sandstone Unit, and Calcareous Claystone Unit of Sonde Formation (Figure 3).

Result of the previous study carried out by Choiriah (2001) in Bengawan Solo River of Ngawi Section, shows the presence of nineteen genera and fifty-two species. Kalibeng Formation contains eighteen genera and forty-nine species, while Klitik and Sonde Formations have eight genera and twelve species. Kalibeng Formation is of Late Miocene to Late Pliocene (NN12-NN18) in age while, Klitik (Sonde) Formation is of Pleistocene (NN19-NN20) (Table 2).

Results of the study from Kalibeng River Section of Kedungringin, Plandaan Area, Jombang, indicate the occurrence of twelve genera and forty-three species. Kalibeng Formation (Marl Unit) containing twelve genera and thirty-nine species, sends to indicate that the age of this formation ranges from Middle Miocene to Late Pliocen (NN10 to NN18).

While Sonde Formation (Calcareous Sandstone Unit) is of Pleistocene (NN19) and Calcareous Claystone Unit of Klitik Formation is Pleistocene (NN20 to NN21) in age (Table 2 and Figure 5).

The results of the study show the differences in age, especially for the Sonde/Klitik Formation. Based on the nannofossil analysis, the Klitik/Sonde Formation is of Pleistocene, which is younger than the age based on the foraminifera analysis (Pliocene). The correlation of the same formation based on foraminifera biostratigraphy with nannofossil is shown in Figure 5.

Table 2. Correlation of Nannofossil Distribution and The Age of Unit/Formation

Kalibeng River, Kedungringin Section, Jombang, 12 Genus and 43 species			
Unit/Formation	Genus	Species	Age
Calcareous Claystone Unit Sonde	8	11	NN20-NN21 (Pleistocene)
Calcareous Sandstone Unit Sonde	10	14	NN19 (Pleistocene)
Marl Unit of Kalibeng	12	39	NN10-NN18 (Late Miocene-Late Pliocene)
Bengawan Solo River, Ngawi Section, 19 Genus and 52 Species			
Unit/Formation	Genus	Species	Age
Limestone Unit of Klitik/Sonde	8	12	NN19-NN20 (Pleistocene)
Marl Unit of Kalibeng	18	49	NN12-NN18 (Pliocene)



AGE		BIOSTRATIGRAPHIC CORRELATION CHART		Pringgoprawiro, 1983 Strat. Kendeng Zone	Choiriah, 2001 Ngawi Section	Choiriah, 2019 Jombang Section
		FORAMINIFERA	NANNOFOSSIL	Foraminifera	Nannofossil	Nannofossil
PLEISTOCENE		N23	NN.21			
		N22	NN.20			
			NN.19			
			NN.18			
PLIOCENE	LATE	N21	NN.17			
		N20	NN.16			
			NN.15			
	EARLY	N19	NN.14			
			NN.13			
			NN.12			
MIOCENE	LATE	N18	NN.11			
		N17				
		N16				
		N15				

Notes: Regional stratigraphy of Kendeng Zone (Pringgoprawiro, 1983) is prepared based on foraminifera from several regions, especially the location of the formation type.

Figure 5. Age differences of Kalibeng, Klitik, and Sonde Formations of the Kendeng Zone based on foraminifera (Pringgoprawiro, 1983) and nannofossil (Choiriah, 2001).

### CONCLUSION AND RECOMENDATION

The analysis results conducted during this study identify the presence of twelve genera and forty-three species, showing this section has abundant nannofossils. The age of Marl Unit of Kalibeng Formation is NN10–NN18 (Middle Miocene to Pliocene), Calcareous Sandstone Unit of Sonde Formation is NN19–NN20 (Pleistocene), while the age of Calcareous Claystone Unit of Klitik Formation is NN20–NN21 (Pleistocene).

The distribution of nannofossil in the Kalibeng River, Jombang, indicates fewer genera and species than that of Bengawan Solo River, Ngawi. Kalibeng River, Jombang, has twelve genera and forty-three species, while the Bengawan Solo River, Ngawi Section, has nineteen genera and fifty-two species.

The correlation results show that the age of Kalibeng Formation in Jombang is older, indicating NN10–NN18 (Middle Miocene to Late Pliocene) compared to the Kalibeng Formation in

Ngawi which is NN12 to NN18 (or Late Miocene to Late Pliocene).

Sonde Formation (Calcareous Sandstone Unit and Calcareous Claystone Unit) in Jombang is younger than Klitik/Sonde Formation in Ngawi. Sonde Formation in Jombang indicates NN19–NN21 (Pleistocene), while that in Ngawi shows NN19 to NN20 (Pleistocene).

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