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

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approved: September, 05, 2019; available online: January, 21, 2020

**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, Pseudoemiliania, Reticulofenestra, Rhabdosphaera, Sphe- nolithus, 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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# Background

**Introduction**

reconstruction of paleobiogeographic (Van Gor- sel *et al*., 2014).

The stratigraphic analysis shows that the

Research of fossil is one of the most impor- tant tools for the study of sedimentary rocks and basins. First, the succession of evolution- ary 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

Kendeng Zone is a young fold-thrust belt, which was only active within the Pliocene. In this zone, deep marine volcaniclastic sediments of Early Pliocene and older ages have been uplifted and thrusted 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

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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 sedimenta- tion sequence consisting mostly of fine-grained marine sedimentary rocks that contain abundant microfossils with the age from Miocene to Qua- ternary. 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 genuses 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)

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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 cor- relate 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 (Tmpkk), consisting of marl with intercalations of sandstone {with Atasangin Member (Tmpa) made up of breccia, sandstone, and claystone}; Sonde Formation (Tpso), composed of marl, calcareous

claystone, tuff, and sandstone {with Klitik Mem- ber (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 struc- ture, 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 µm). 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).

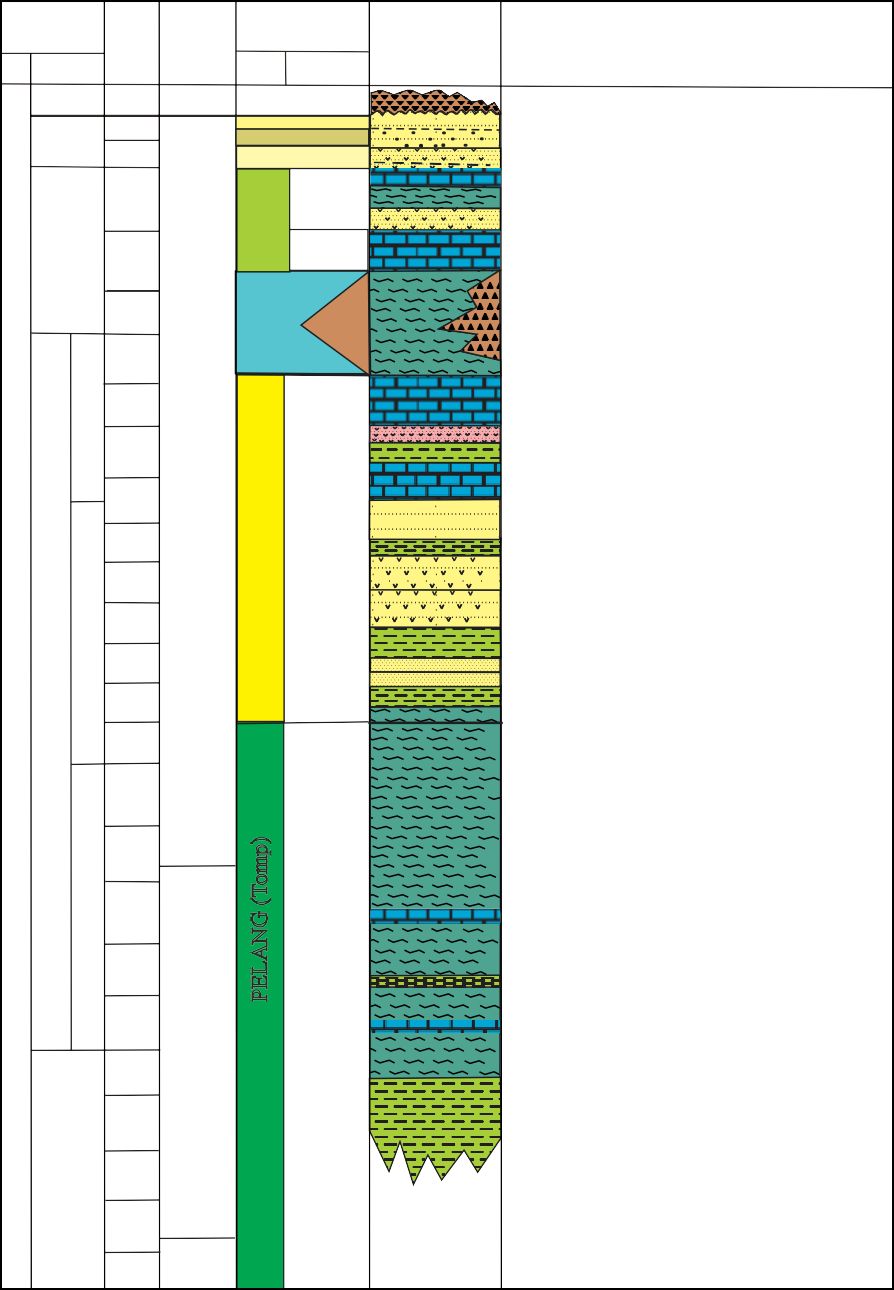
A large amount of nannofossils was collected from a small sample due to its tiny size. Rock samples that contain the fossils can be obtained from outcrop, drill core, or cutting.

# Laboratory Analysis

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

Nannoplankton is very small to identy mac- roscopically, 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 magnifica- tion, in parallel and cross Nicol views. The

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



NOTOPURO (Qpn)

KABUH (Qpk)

PUCANGAN (Qtp)

P14

Tcd

P9

P20 (N1)

P21 (N2)

P22 (N3)

N4

N5

N6

Lower

Te

N7

N8

N9

N10

N11

N12

N13

N14

N15

N16

N17

N18

N19

ATAS ANGIN

(Tmpa)

KLITIK

(Tpk)

N20

N21

PLIOCENE

N22

Lower

Tf

Middle

Upper

N23

PLEISTOCENE

Marl and claystone with calcarenite intercalation of calcarenite with larger foraminifera

Laharic breccia, tuff, tuffaceous sandstone; ﬂuviatile cross-bedded sandstone.

Volcanic conglomerate, sandstone, black claystone Marl, calcareous claystone, tuff,

sandstone with Balanus and mollusca

Corraline limestone, bedded Globigerina limestone

Massive Globigerina marl with intercalations of graded sandstone, volcanic breccia, and tuff

Hard calcarenite, bedded calcarenite, tuff, calcirudite

Tuff and agglomerate Hard calcarenite

Interbedded marl, claystone, and mudstone

TRINIL

HOLOCENE

25

20

20

10

0,5

2

MEMBER

FM

DESCRIPTION

LITHOLOGY

STRATIGRAPHY

ADAM (1970)

AGE

OLIGOCENE

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photomicrographs of fossils were taken using a microscopic camera (*Moticam*) connected to a laptop or computer. The names of genus and spe- cies 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.

MIOCENE

Middle

Early

Late

BLOW ZONATION (1969)

SONDE

(Tpso)

PELANG (Tomp)

KEREK (Tmk)

KALIBENG (

(Tmpkk)

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.

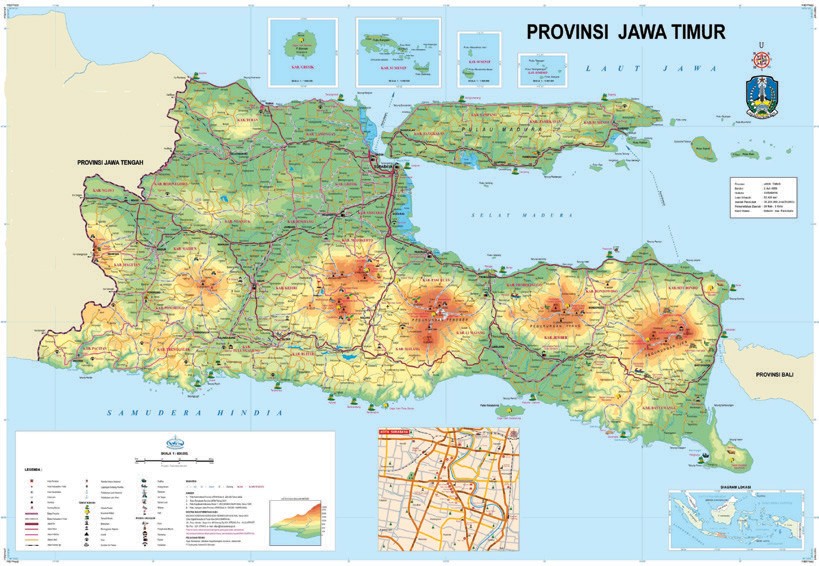
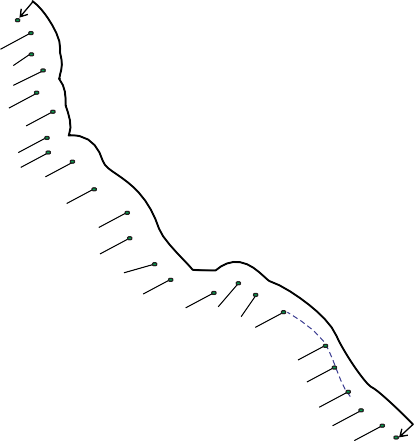
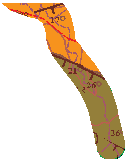
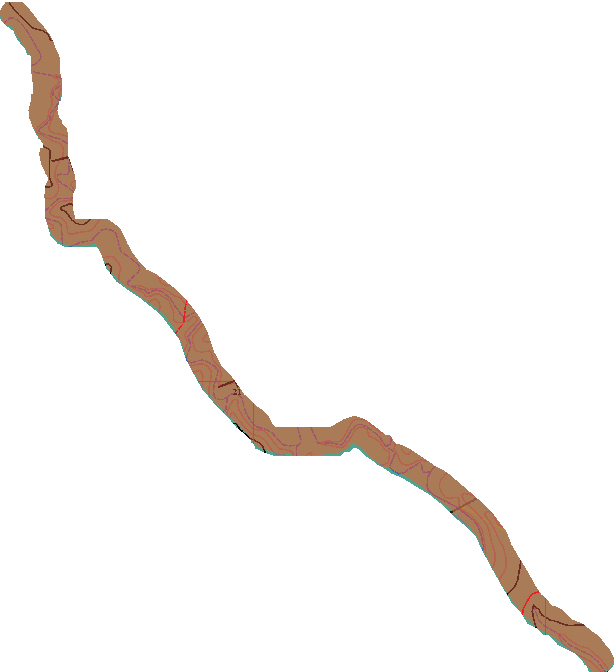
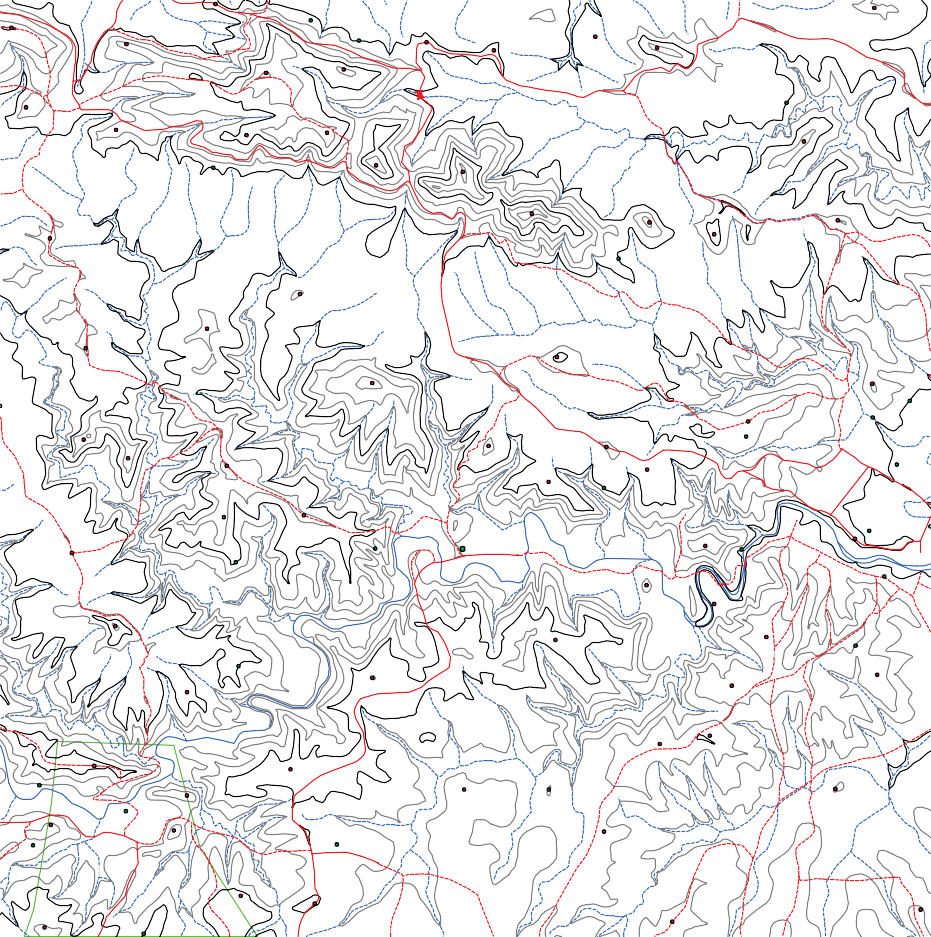
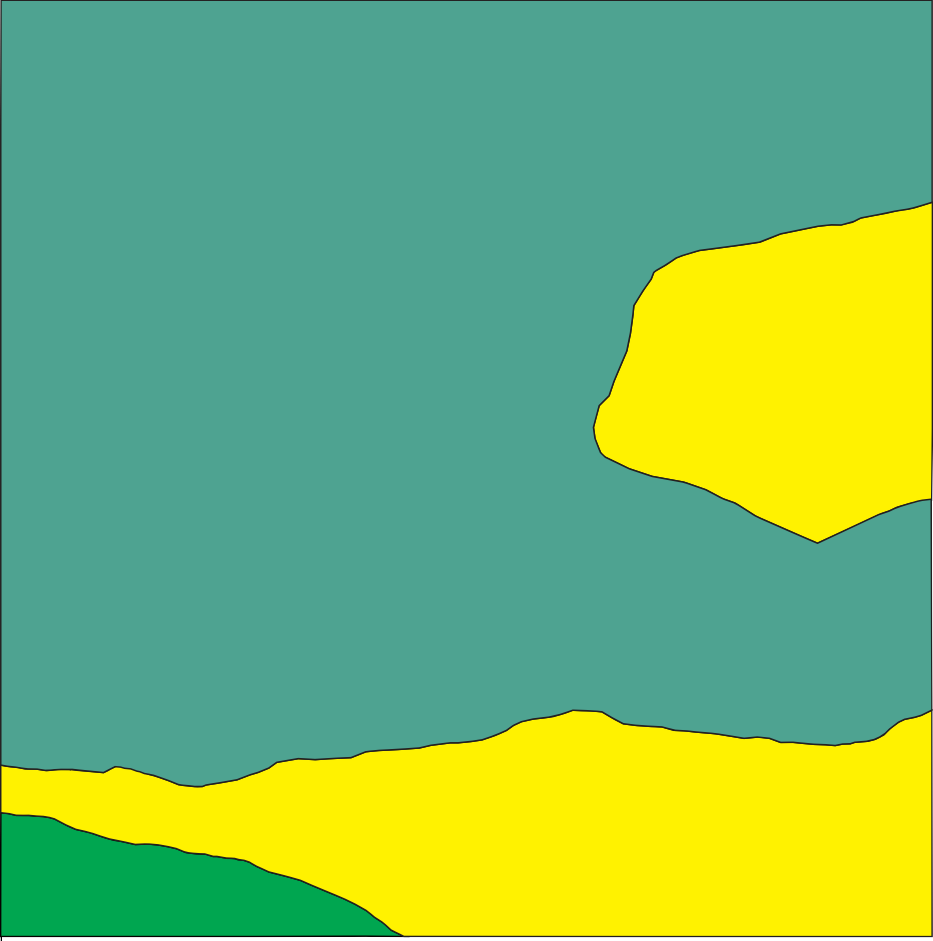
# Result and Analysis

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

|  |
| --- |
|  |
|  |
|  |

|  |
| --- |
| **19** |
| D-24 |
|  |

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



**620000**.000000

**621000** .000000

**622000**.000000

**623000**.000000

**624000**.000000

156.73

KABUPATEN JOMBANG

201.8

134.04

181.01

154.78

N

168.52

0

500

171.99

100

1.000

Meters

171.71

207.88

219.66

115.51

150

230.3

230.63

137.3

142.63

150

**10**

D-1

Klitih

126.81

134.33

**13**

**14**

138.75

**18**

D-2

D-3

D-4

156.27

**12**

**14** 75.47

**16**

145.17

Pule

D-5

D-6

D-7

D-8

99.79

Putuk

**14**

124.26

DESA KLITIH

**24**

125

128.42

125.15

127.42

116.23

Klitih

118.55

D-9

D-10

100

120.17

116.47

136.15

D-11

Nampu

Kedungringin

Tondowesi

51.31

92.79

K. Beng

100

D-12

**21**

Temple

D-13

D-14

73.1

61.46

D-15 D-16

166.74

D-17

D-18

100

112.74

98.3

DESA PULE

D-19 D-20

D-21 D-22

D-23

111.25

112.96

83.62

98.61

111.42

D-24Pule

**19**

**12**

**12**

**15**

97.51

104.38

D-25

**18**

**16**

Papringan

**11**

97.56

**11**

88.6

**21**

**26**

63.46

DESA PINGGIR 96.79

Ngepung

D-26 **20**

**21**

17

Pinggir

**16**Perning

**13**

80.84

25

Pinggir

D-27 **17**

D-28

Sumberbutak

**18**

DESA PINGGIR**26** D-30

**21** D-29

104.82

D-31

**19**

D-32 100.7

78

**18**

100

D-33

**26**

82.27

**16**

114.28

**620000**.000000

**UNIT LITHOLOGIC SYMBOLS :**

**621000** .000000

**622000**.000000

**623000**.000000

**624000**.000000

**MAP INDEX :**

Calcareous Claystone Unit of Sonde

Calcareous Sandstone Unit of Sonde Marl Unit of Kalibeng Sampling Location

Strike/Dip

Sample ID Sinistral Strik-slip Fault

**Kedungringin, Jombang**

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

137.5

150

137.5

187.5

125

187.5

200

212.5

150

137.5

100

87.5

187.5

112.5

200

162.5

112.5

100

112.5

212.5

212.5

137.5

100

62.5

212.5

137.5

125

125

125

137.5

50

150

175

150

112.5

200

162.5

137.5

187.5

212.5

137.5

162.5

137.5

125

162.5

175

137.5

212.5

112.5

112.5

100

62.5

62.5

75

225

62.5

100

100

150

150

**9173000**.000000

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**9178000**

137.5

150

50

**9174000**.000000

**9175000**.000000

**9176000**.000000

**9177000**.000000

87.5

112.5

125

87.5

112.5

125

50

137.5

112.5

200

87.5

62.5

137.5

150

125

87.5

50

125

125

87.5

87.5

125

100

175

125

87.5

200

225

75

225

125

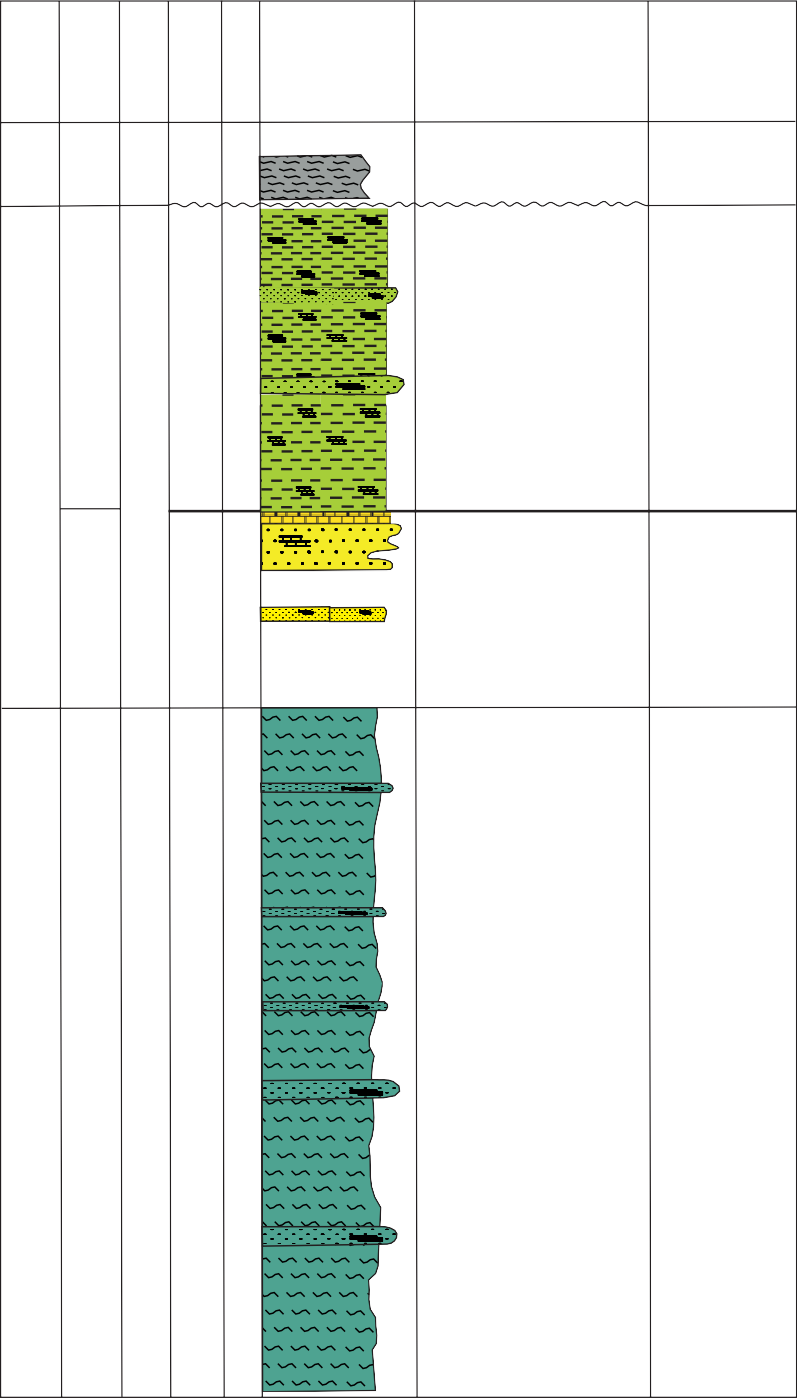
The analysis of nannofossil in the studied area reveals that within a total of thirty-three samples of rock thirteen genera and forty-three species of nannofossil (Table 1 and Figure 4) are identified.

The nannofossils found in Marl Unit of Kali- beng 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 pliopelagicus, Discoaster altus, Dis-*

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



Symbol of Lithology

Description of Lithology

Depositional Environment

Loose material from weathering and reworked of older rocks

Calcareous claystone Sonde, dominated by calcareous claystone with intercalation of calcareous sandstone, calcareous siltstone, massive and lamination stuctures.

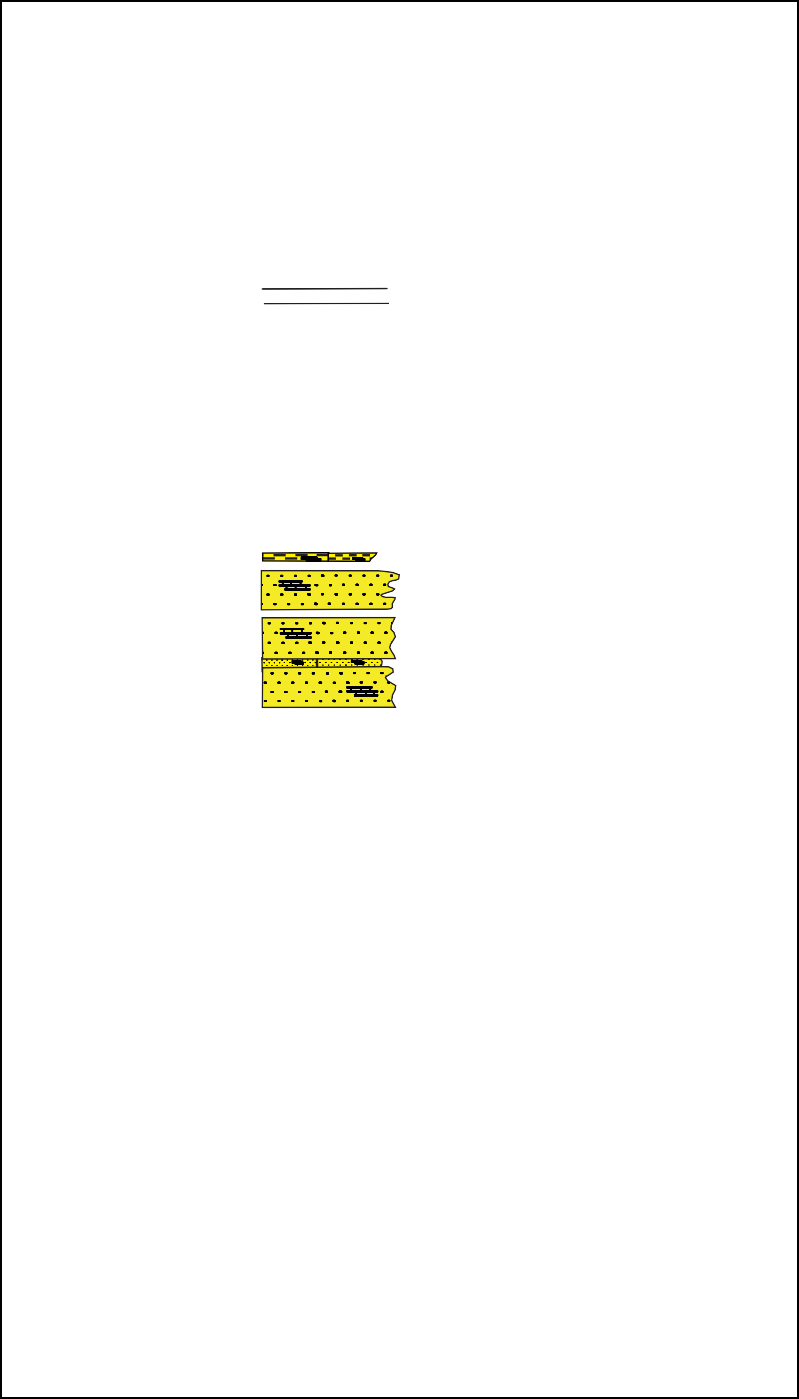
Lagoon

Calcareous sandstone Sonde dominated by calcareous sandstone with intercalation of calcareous claystone, limestone, and calcareous siltstone.

Inner to Middle Shelf

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



Late Miocene to Late Pliocene

NN10-NN18

Kalibeng

Marl

446,3 m

Pleistocene

Holocene

Epoch

Martini (1971)

Formation

NN20-NN21

NN19-NN20

SSonde

Alluvium Lithology

Calcareous sandstone

47,5 m

Calcareous claystone

89,9 m

sediment

12 m

Unit

Thickness

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

*triradiatus, Discoaster tristellifer, Discoaster variabilis, Gephyrocapsa carribeanica, Ge- phyrocapsa oceanica, Helicosphaera carteri, Helicosphaera selli, Pseudoemiliania lacu- nosa, Pseudoemiliania ovata, Reticulofenestra haqii, Reticulofenestra minuta, Reticulofenestra minutula, Reticulofenestra pseudoumbilicus,*

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

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|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FORMATION** | **UNIT OF LITHOLOGY** | **A G E** | **ZONE OF NANNOPLANKTON**  **( Martini, 1971)** | | ***SPECIES OF CALCAREOUS NANNOFOSSIL*** | | | | |
| **NUMBER OF SAMPLES** | *Calcidiscus leptoporus Ceratolithus acutus Coccolithus pelagicus Coccolithus pliopelagicus Discoaster altus Discoaster asymmetricus Discoaster berggrenii Discoaster blackstockae Discoaster bolli Discoaster brouweri Discoaster calcaris Discoaster chalengeri Discoaster druggii Discoaster hamatus Discoaster intercalaris Discoaster neorectus Discoaster pentaradiatus Discoaster perplexus Discoaster quadramus Discoaster quinqueramus Discoaster surculus Discoaster triradiatus Discoaster trisstellifer Discoaster variabilis Emiliania huxleyi*  *Gephyrocapsa caribbeanica Gephyrocapsa oceanica Helicosphaera carteri Helicosphaera granulata Helicosphaera selli* .  *Pseudoemiliania lacunosa*  *Pseudoemiliania ovata Reticulofenestra haqii Reticulofenestra minuta Reticulofenestra minutula Reticulofenestra pseudoumbilicus Reticulofenestra rotaria Rhabdosphaera clavigera Sphenolithus abies*  *Sphenolithus moriformis Sphenolithus neoabies* | | | |
|  |  |  | **NN** | |  | 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 | |
| **SONDE** | **Calc.Claystone** | **Early Pleistocene to Late Pleistocene** | **NN20-NN21** | **21** | D.33 | ● ● ● ─ ● ● ● | | | |
| D.32 | ● ─ ● ● ● ● | | | |
| **20** | D.31 | — ─  ● ─ ● ● ─ ─  ● ─ ─ ─ ● ● ● ● o | | | |
| D.30 |
| D.29 |
| **SONDE** | **Calc. Sandstone** | **Pliocene to Early Pleistocene** | **NN19-NN20** |  | D.28 | o ─ ─ ● ● ● | | | |
| **19** | D.27  D.26 D.25 | ─ |  | — ─ ● ─  ● ─ ─ ● ─ ● ●  — o ─ ─ ─ ─ o ● o ─ ● ● | |
|  |  |  |  | **18** | D.24 | ● ● ─ **/** ● ● ─ ─ / o | | | |
| **17** | D.23 | — o ─ o ─ ● | | | ● ─ / ─ ● ● ● / ● |
|  |  |  |  | **16** | D.22 | ● ● ─ o ─ ─ ─ ─ ─ ● ─ o / ●    o ─ o ─ ● ─ ● ● ● ─ / o o /  ● o o ─ o ● ● ● ─ ● ─ ── ─ ● / o /  **/ /** o o / ● o ● ● / | | | |
| D.21 |
| D.20 |
| D.19 |
|  | D.18 | ─ |  | o o o ● ● ● ─ ● ─ ● ● ● ● ● / | |
| D.17 | ─ |  | ● ── ● **/** ● / ─ ● ─ ● ● ● ─ ● ● o ● / o / | |
| D.16 | ─ |  | **/ /** ─ **/** ● ● ● o ● / ● / | |
|  |  |  |  |  | D.15 | ─ |  | **/** ─ ● ● ● ● ● ● ● ● ● ● ─ ● / | |
| **KALIBENG** | **Marl Unit** | **Miocene to** | **NN10-NN18** | **14- 15** | D.14 | **/** ● o ─ ─ ● / ● ● o  **/** ● ─ ─ ● ─ ─ ─ ● ● ● / ● o  — ─ ─ ●  o ● ─ ─ ● ● ─ ─ ● ● ●  — ● ─ ● / ●  ● ● ● ● ─ ─ ● | | | |
| D.13 |
| D.12 |
| D.11 |
| D.10 |
| D.9 |
| **13?** | D.8 |  | ─ | o ─ ─ ● ● ─ ─ ─ ● ● ─ ─ ● ● ●  ● o ● ● o ─ ─  — ─ ● o ● | |
| D.9 |
| D.10 |
| **12** | D.5 | — ─ ─ ● ─ ● ─ ─ o ● ─ ● o | | | |
| **11** | D.4 | ─ |  | ● ● ─ ● ● ─ ●  ● ● ● ─ ● ─ ─ ● ─  ● ─ ─ ● ─ ─ | |
| D.3 |
| D.2 |
| **10** | D.1 | ● ─ ─ ─ ● ─ ─ ─ ─ o ─ ● ─ ─ | | | |

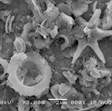
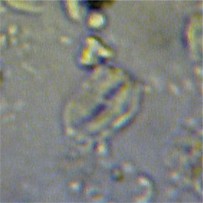
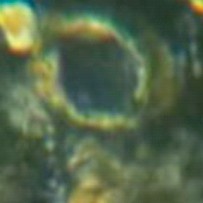
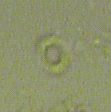
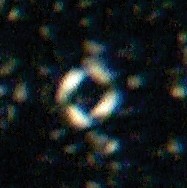
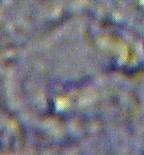
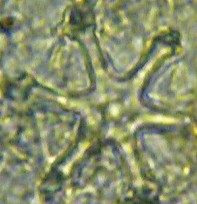
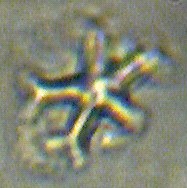
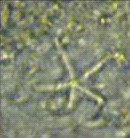
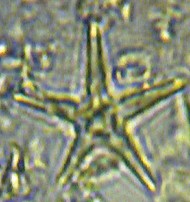
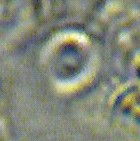
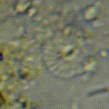
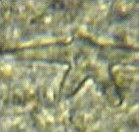
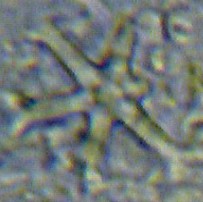
Notes: / Abudance of Nannofossils species, **o**: Commond (6-10), **●**: Frequent (2-5), **─** : Occasional (1)

**Pliocene**

*Reticulofenestra rotaria, Rhabdosphaera clavig- era, Spenolithus moriformis, Spenolithus abies, Spenolithus neoabies, Syracosphaera* sp.*,* and *Umbilicosphaera jafari.*

The nannofossils recognized in Calcare- ous Sandstone Unit of Sonde Formation are

derived from sample D.25 to D.28 consisting of ten genera with forteen species; those are: *Calcidiscus leptoporus, Coccolithus pelagicus, Coccolithus pliopelagicus, Discoaster triradia- tus, Gephyrocapsa carribeanica, Gephyrocapsa oceanica, Helicosphaera carteri, Helicosphaera*



*Calcidiscusleptoporus (// Nicol, 6 µm)*

*Calcidiscusleptoporus*

*(X Nicol, 6 µm) (// Nicol, 13 µm) (X Nicol, 13 µm) (// Nicol, 12 µm) (X Nico,l12 µm)*

*Coccolithus pelagicus*

*Coccolithus pelagicus Coccolithus pliopelagicus Coccolithus pliopelagicus*

*Discoasteraltus*

*(// Nicol)*

*Discoaster blackstockae Discoaster asymmetricus Discoaster asymmetricus Discoaster berggrenii*

*(// Nicol )*

*(// Nicol)*

*(// Nicol)*

*(X Nicol)*

*Discoaster bolli*

*(// Nicol)*

*Discoaster brouweri*

*(// Nicol)*

*Discoaster calcaris Discoaster challengeri Discoasterdruggi Discoasterhamatus*

*(// Nicol)*

*(// Nicol)*

*(// Nicol)*

*(// Nicol)*

*Discoaster intercalaris*

*(// Nicol)*

*Discoaster pentaradiatus (// Nicol)*

*Discoaster perplexus*

*(// Nicol)*

*Discoaster quadramus Discoaster quinqueramus Discoaster triradiatus*

*(// Nicol)*

*(// Nicol)*

*(// Nicol)*

*Discoaster tristellifer (// Nicol)*

*Discoaster variabilis (X Nicol)*

*Discoaster surculus (X Nicol)*

*Gephyrocapsa caribbeanica Gephyrocapsa oceanica Helicosphaera carteri*

*(X Nicol , 4-5 µm) ( X Nikol, 3.5 to 6)*

*(// Nicol)*

*Helicosphaera carteri (X Nicol)*

*Helicosphaera granulata (X Nicol)*

*Ceratolithus acutus (X Nicol)*

*Pseudoemiliania lacunosa Pseudoemiliania lacunosae Pseudoemiliania ovata*

*(// Nicol, >4µm) (X Nicol, >4µm) ( // Nicol, 3-4µm)*

*Pseudoemiliania ovata ( X Nicol 3-4µm)*

*Reticulofenestra pseudoumbilica (X Nicol, and // Nicol,, 6 µm)*

*Reticulofenestra minuta Reticulofenestra minuta Reticulofenestra minutula Reticulofenestra pseudoumbilica*

*(// Nicol <3μm)*

*(X Nicol, 3 µm) (X Nicol 3-5 µm)*

*(X Nicol, 7 µm)*

*Reticulofenestra rotaria Rhabdospaera clavigera Scyphosphaera globulata Sphenolithus abies*

*(X Nicol)*

*(// Nikol)*

*(?? Nicol)*

*(X Nicol, 3 -4 µm) (X Nicol, 3 -7 µm (X Nicol, 2 -3 µm)*

*Sphenolithus moriformis*

*Sphenolithus neoabies*

*Syracopsphaera sp. Umbilicospaera jafari (XNikol) (X nikol)*

*Helicosphaera selli (// Nicol, X Nicol,12 µm)*

*Reticulofenestra 1µm dg SEM*

*Discoaster brouweri 2µm dg SEM*

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

*selli, Pseudoemiliania lacunosa, Pseudoemiliania ovata, Reticulofenestra minuta, Rhabdosphaera clavigera, Syracosphaera* sp.*,* and *Umbilico- sphaera jafari.*

The nannofossils found in Calcareous Clay- stone 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, Gephy- rocapsa carribeanica, Gephyrocapsa oceanica, Helicosphaera carteri, Helicosphaera kamptnari, Reticulofenestra minuta, Rhabdosphaera clavig- era,* 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 Calcare- ous 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 t h e last appearance of species *Ceratolithus acutus, Discoaster asym- metricus, Pseudoemiliana lacunose, Discoaster*

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*surculus, and Sephyrocopsa 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 Sec-

tion 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 Sand- stone Unit) is of Pleistocene (NN19) and Cal- careous 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**

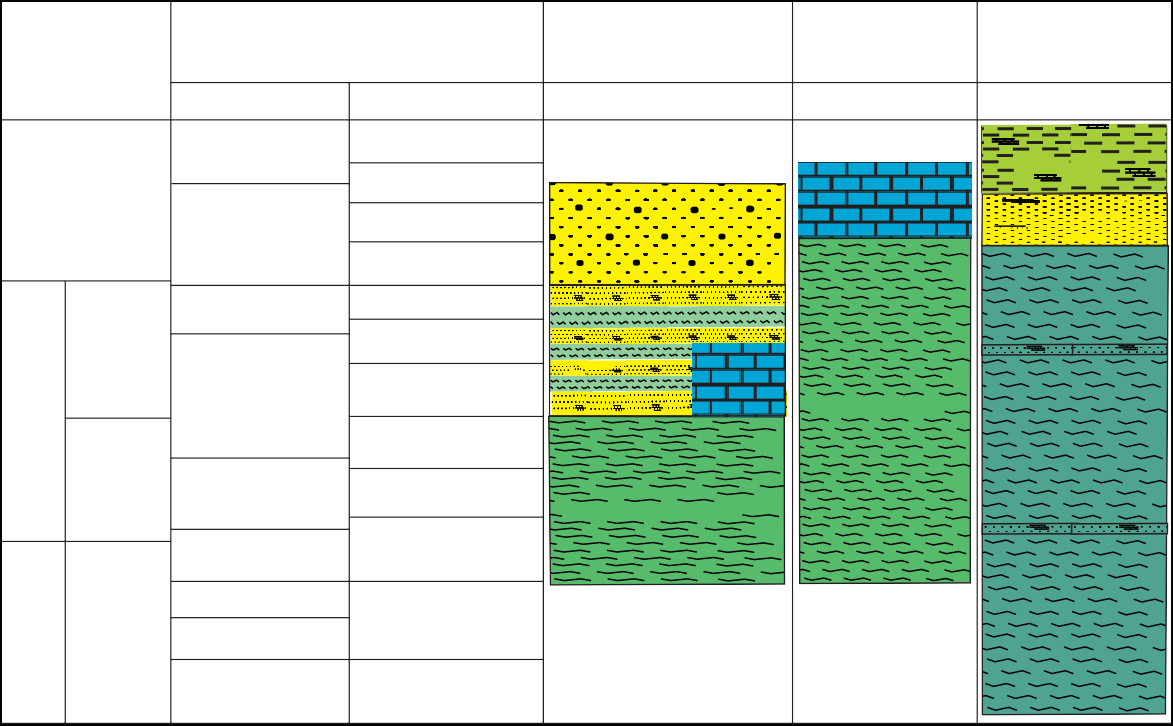
Calcareous Claystone Unit Sonde 8 11 NN20-N21 (Pleistocene) Calcareous Sandstone Unit Sonde 10 14 NN19 (Pleistocene)

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)

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



AGE

BIOSTRATIGRAPHIC CORRELATION CHART

FORAMINIFERA

N23

PLEISTOCENE

N22

N20

NANNOFOSSIL NN.21 NN.20 NN.19 NN.18

NN.17 NN.16

NN.15 NN.14 NN.13

NN.12

Pringgoprawiro, 1983 Strat. Kendeng Zone

Foraminifera

Choiriah, 2001 Ngawi Section

Nannofossil

Pucangan

Klitik

Choiriah, 2019 Jombang Section

Nannofossil

~~Son~~d~~e~~

Sonde

N21

LATE

Sonde Klitik

Kalibeng

Kalibeng

EARLY

K~~ali~~b~~en~~g

LATE

N19

N18

N17 N16

N15

NN.11

MIOCENE

PLIOCENE

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Figure 5. Age differences of Kalibeng, Klitik, and Sonde Formations of the Kendeng Zone based on foraminifera (Pring- goprawiro, 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 (Pleisto- cene), while the age of Calcareous Claystone Unit of Klitik Formation is NN20-NN21 (Pleistocene). The distribution of nannofosil in the Kalibeng River, Jombang, indicates fewer genera and spe- cies 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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