Nannofossil Diversity and Biostratigraphy of Kebo Butak Formation from Kalinampu Area, Bayat - Central Java

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Abstract. The research location is part of the Kebo Butak Formation, where the outcrop is well-exposed in Kalinampu, Jarum Village, Bayat – Central Java. Nannofossil was prepared on 20 samples using gravity settling and observed under a light microscope with 1000x magnification. Nannofossil analysis of abundances and diversity in this area revealed 21 species and 7 genera. Biostratigraphic analysis showed that the Kebo Butak Formation in Kalinampu section can be divided into Furcatolithus predistentus Zone (CNO4/NP24), Sphenolithus ciperoensis Zone (CNO5/NP25), Shenolithus delphix Zone (CNO6/NP25) and Discoaster druggii Zone (CM1/NN1). These results confirm that the Kebo Butak Formation age was deposited in a marine environment during the Late Oligocene (26.93 Ma) to Early Miocene (23.06 Ma).

1 Introduction

Nannofossils are a group of microfossils with sizes of 0.25 to 30 µm that are a major component of oceanic phytoplankton. Nanofossils belong to unicellular marine algae and autotrophic organisms, which are the most important primary producers that precipitate CaCO3. The importance of nanofossils in determining relative age is due to their abundance of millions of specimens (per gram of carbonate sediment), taxonomic diversity, rapid evolution, and wide distribution in the marine [1].

Among the geosciences, biostratigraphy is a paleontological method that refers to the evolution of fossils that contribute to organizing rock units into age sequences and connecting them geographically. Since nanofossil is an important contributor to marine sediments, the analysis of nanofossil assemblages provides a good way, as a biostratigraphic tool, to determine the age of sedimentary rocks [2].

The Kalinampu is a research area located in the Jarum Village, Bayat-Central Java, about 36 km south of Yogyakarta (Fig.1). Geologically, the Bayat area is included in the Southern Mountains Zone. The Southern Mountains Zone has exposed many marine sedimentary rocks ranging in age from the Eocene to the Miocene. The Southern Mountains Zone in the Bayat area, based on the geologic sheet map [3], is composed of marine sediments consisting of the

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Wungkal Gamping Formation with Middle Eocene age, the Kebo Butak Formation is Late Oligocene to Early Miocene age, and the Semilir Formation is Early Miocene age. Meanwhile, one of the studies on paleontology conducted by [4] to determine the age of the Kebo Butak Formation in Kalinampu, Bayat, using the planktonic foraminifera biostratigraphy method, resulted in the age of Kebo Butak Formation ranging from the Middle Eocene (P12) to Late Oligocene (P22).

The significant age difference in the Kebo Butak Formation is interesting to reconfirm, especially in [4] in Kalinampu, Bayat area. This study used nanofossil biostratigraphy methods intending to know in more detail the age and whether there are differences in age resulting from previous researchers who used planktonic foraminifera.

![Fig. 1. Geological map of Southern Mountains Area [5] and research location in Kalinampu, Bayat, Klaten (image from Google Earth taken on October 9, 2023).](image)

## 2 Materials and Methods

Measured stratigraphy is undertaken to ascertain the sequence of rock layers or stratigraphy along the research path. Sample collection represents the foremost activity in this research, where the researcher employs a probability sampling method with a sampling range of approximately 0.5 - 2 meters. The targeted rock samples comprise claystone or finely-grained sedimentary rocks exhibiting carbonate characteristics. The purpose of collecting samples in this study is to facilitate micropaleontological analysis.

The biostratigraphic analyses of the calcareous nanofossil are executed by meticulously preparing the 20 selected samples utilizing standard laboratory techniques. The samples were subjected to the pipette strew slide method, where a small amount of sample was pipetted onto a glass slide and allowed to dry [1]. An immersion oil layer was applied for microscope observation and enhanced visibility. A transmitted light microscope was utilized for slide examination. The slides were examined using a transmitted light microscope.

The observation and documentation of calcareous nanofossils were conducted using an Olympus BX53 at 1000× magnification, while photomicrographs were captured with an Olympus Stream DP27 camera. The nanofossils were identified and classified according to established taxonomic schemes [6], and the Nannotax3 web (https://www.mikrotax.org/Nannotax3) was used to provide more detailed new information about species.
The First Occurrence (FO) and Last Occurrence (LO) of a fossil are the depths at which that taxon first appears and last disappears in a stratigraphic section, respectively. The boundaries of a biozone are defined by the FO and LO of the taxon, namely the biodatum. Name of the zone using the name of the biodatum or species that becomes the upper or lower boundary of the zone. The nannofossil is calculated using the quantitative method by counting the 200 Fields of View. Calcareous nannofossil abundances were determined using a standard semiquantitative scale, where abundance was (A) abundant (>10–100 specimens per field of view[FOV]), (C) common (>1–10 specimens per FOV), (F) few (1 specimen per 1–10 FOV), and (R) rare (1 specimen/>10 FOV) [1].

3 Results and Discussion

3.1 Results

3.1.1 Diversity of Nannofossils

The nannofossils present in the studied area exhibit remarkable preservation. The determination of biodatum ages is derived from multiple sources. Through meticulous analysis, a total of 21 species were identified from 7 different genera (Table 1).

Table 1. Diversity and taxonomy of nannofossils of Kebo Butak Formation

<table>
<thead>
<tr>
<th>Phylum</th>
<th>Class</th>
<th>Order</th>
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<th>Species</th>
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3.1.2 Biostratigraphy

The nannofossils present in the studied area exhibit remarkable preservation. The First Occurrence (FO) and Last Occurrence (LO) are identified to delineate the biozonation of nannofossils in 20 samples. The First and Last Occurrences were identified by assessing 20 samples, and 3 biodatums were successfully identified (Table 2). The nannofossil biozonation employed the standard system outlined by [7] and [8] to delineate the biozones. All of the biodatums are illustrated in Fig 2.
1. **Furcatolithus predistentus** Zone (CN04/NP24)

This zone is defined by the Last Occurrence (LO) of *Furcatolithus predistentus* at KN5, signifying the top of the CNO4 zone and bearing an absolute age of 26.93 million years. However, this is a partial range zone because the biodatum at the bottom of this zone is not found. *F. predistentus* has a small size, between 3 - 8 µm, with a large apical spine and flat or slightly depressed at the base. The apical stem tapers strongly for about half its length and gradually to a pointed or bifurcating tip (fig 2). The estimated age of this zone is Older than 26.93 Ma [8]. *Discoaster cf. Williamsii*, *Discoaster cf. distinctus*, and *Discoaster nodifer* are reworked fossils from the Eocene age.

The nomenclature of this zone is based on the presence of the index fossil *Furcatolithus predistentus*. The occurrence of *Furcatolithus predistentus* within this zone is notably pronounced, particularly in occurrences KN5. This zone is equivalent to the NP24 Zone by [7].

**Table 2.** Distribution of nannofossil from the Kalinampu area and absolute age based on [8]

2. **Furcatolithus ciperoensis** Zone (CN05/NP25)

This zone is defined by the Last Occurrence (LO) of *Furcatolithus predistentus* as the base of CNO5 in sample KN5 and the Last Occurrence (LO) of *Furcatolithus ciperoensis* as the top of CNO5 in sample KN13. The Last Occurrence of *Furcatolithus predistentus* signifies an absolute age of 26.93 Ma, whereas the Last Occurrence of *Furcatolithus ciperoensis* signifies an absolute age of 24.36 Ma [8]. *F. ciperoensis* is small, between 4 - 10 µm, with a nearly uniform taper from the base to the tip of the apical spine. The extinction lines do not cross but appear as two outward curving lines, with the bright area continuing between them to the base, in contrast to the appearance of *F. Distensitus* (fig 2). The estimated age of this zone is 26.93 - 24.36 Ma [8]. *Helicosphaera ethologa* acts as a reworked fossil from NP23-NP24.

The nomenclature of this zone is based on the presence of the index fossil *Furcatolithus ciperoensis*. The occurrence of *Furcatolithus ciperoensis* within this zone is notably pronounced and continues to appear until KN13. This zone is equivalent to the NP25 Zone by [7].

3. **Sphenolithus delphix** Zone (CN06/NP25)

This zone is defined by the Last Occurrence (LO) of *Furcatolithus ciperoensis* as the base of CNO6 in sample KN13 and the Last Occurrence (LO) of *Sphenolithus delphix* as the top of
CNO6 in sample KN17. The Last Occurrence of *Furcatolithus ciperoensis* signifies an absolute age of 24.36 Ma, whereas the Last Occurrence of *Sphenolithus delphix* signifies an absolute age of 23.06 Ma. There is no indication of reworked fossils identified in this zone. The estimated age of this zone is 24.36 - 23.06 Ma [8]. *S. delphix* has a size of 5-12 µm with a single apical spine and flaring proximal cycle. The flaring proximal cycle (at 45° position), giving an almost Y-shaped profile, is the distinctive feature of this species (fig 2).

The nomenclature of this zone is based on the presence of the index fossil *Sphenolithus delphix*. This zone is equivalent to the NP25 Zone by [7]. The occurrence of *Sphenolithus delphix* within this zone is notably pronounced in sample KN16 and continues to appear until KN17.

4. *Discoaster druggii* Zone (CNM1/NN1)

This zone is defined by the Last Occurrence (LO) of *Sphenolithus delphix* at KN17, signifying the base of the CNM1 zone and bearing an absolute age of 23.06 million years. However, the base of this zone remains elusive. The *Discoaster druggii* zone is a partial range zone because the biodatum at the top of this zone is not found. There is no indication of reworked fossils identified in this zone. The estimated age of this zone is Younger than 23.06 Ma [8].

The nomenclature of this zone is based on the species index (*Discoaster druggii*) of the CNM1 zone from [8]. This nomenclature was used because no index fossils were found from the CNM1 zone in this study. This zone is equivalent to the NN1 Zone by [7].

![Fig. 2. Nannofossil of Kebo-Butak Formation from Kalinampu. 1. *Furcatolithus predistentus* (KN5). 2. *Furcatolithus ciperoensis* (KN13). 3a-b. *Sphenolithus delphix* (KN16). Scale bar: 5 µm; a: 0 degree view, b: 45 degree view.]

3.2 Discussion

The biostratigraphic results in this study were also compared with the biostratigraphic results of [4], which also used the Kalinampu section in the Kebo Butak Formation. The results of this comparison show a significant age difference. Our biostratigraphic results show a younger age in the Oligocene–Early Miocene range with nanofossil zones NP24–NN1 (3 zones), while [4] conducted an age of Middle Eocene–Oligocene with plankton foraminifera zones P12–P22 (9 zones).

The results of our analysis also show the presence of fossils of the Eocene age, but we include these fossils as reworked fossils, such as *Discoaster* cf. *Williamsii*, *Discoaster* cf. *Distinctus*, and *Discoaster nodifer*. It should be noted that the Eocene reworked fossils found in the Kebo Butak Formation cannot be used to determine its age. The formation age is determined by examining the youngest fossils in the sample. These fossils include *Furcatolithus predistentus*, *Furcatolithus ciperoensis*, and *Sphenolithus delphix*. Based on this analysis, it can be concluded that the Kebo Butak Formation in the Kalinampu, Bayat section shows a Late Oligocene-Miocene age.
We would like to be thankful to the Geological Engineering Department, Faculty of Engineering, Universitas Gadjah Mada, for funding this research.

References

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