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Late Miocene Molluscan Stage of Jawa Insight from New Field Studies

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Abstract. Neogene stratigraphic stages of Jawa based on molluscan index fossils firstly compiled by Oostingh in 1938. This concept is widely used by palaeontologists, both for application in and outside Jawa. Based on the estimated ages of previous researchers the Neogene stages from old to young are: Rembangian stage considered equivalent to Early Miocene, Preangerian stage (Middle Miocene), Odengian stage (Upper Miocene), Cheribonian stage (Early Pliocene), Sondian stage (Late Pliocene) and Bantamian stage (Early Pleistocene). Further studies to determine a more precise age of each stage are often difficult due to lack of planktonic foraminifera fossils and other age index fossils within the sedimentary deposits that are mostly shallow marine sediments. This study focuses to re-examine the age of sediments of Preangerian and Odengian Stages on new field studies. The type locality and rock units that are correlated with these stages are part of the well-exposed Nyalindung formation around Sukabumi area. The studies were carried out in four main fosill-rich sedimentary sequences that are exposed along Cijarian, Citalahab, Ciangsana and Ciodeng rivers. More detailed ages were obtained from the sediments. The exposed sequences along the Ciangsana and Citalahab rivers are Middle Miocene (N9-N14) while the Cijarian and Ciodeng rivers sequences were deposited between Middle to early Late Miocene (N9-N16). The Nyalindung formation in the Cijarian river also contain *Vicarya sp*, an index fossil that marks a rise in sea level in the Miocene (12 Ma), which previously only been reported from the Ciangsana river sediments.
Keywords: Late Miocene, Molluscan, Jawa, Age, Neogene

1. Introduction

Neogene stratigraphy in Jawa was divided into 6 stages based on the index molluscs fossil [1, 2]. These stages distinguish the Neogene from Early Miocene to Pleistocene, namely: Rembangian (equivalent to Early Miocene), Preangerian (Middle Miocene), Odengian (Late Miocene), Cheribonian (Early Pliocene), Sondian (Late Pliocene) and Bantamian (Pleistocene). Subsequent studies on these stages are often unfruitful due to difficulties in finding planktonic foraminifera within the type section of each stage which are mostly shallow marine deposits. This study focuses to re-examine the age of sediments from the type formation or type locality based on [1], that is believed to be the equivalent to the Preangerian and Odengian Stage using mollusc and foraminifera fossil association,. The type locality/formation sections of these sedimentary rocks are stratigraphically included in the Nyalindung Formation that exposes around the city of Sukabumi (Figure 1). Four locations of mollusc-rich

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sedimentary sequence are exposed in Cijarian River, Citalahab River, Ciangsana River and Ciodeng River. [3], [4], [5], and [6] previously conducted research on the Nyalindung Formation, however there are some key river traverse that were overlooked until now. Two important traverses were visited; they are Ciangsana River and Cijarian River next to Ciodeng Village. The results suggest that the age obtained from these two sections are in higher resolution, moreover some locations suggest a completely different age compared to the previous results.

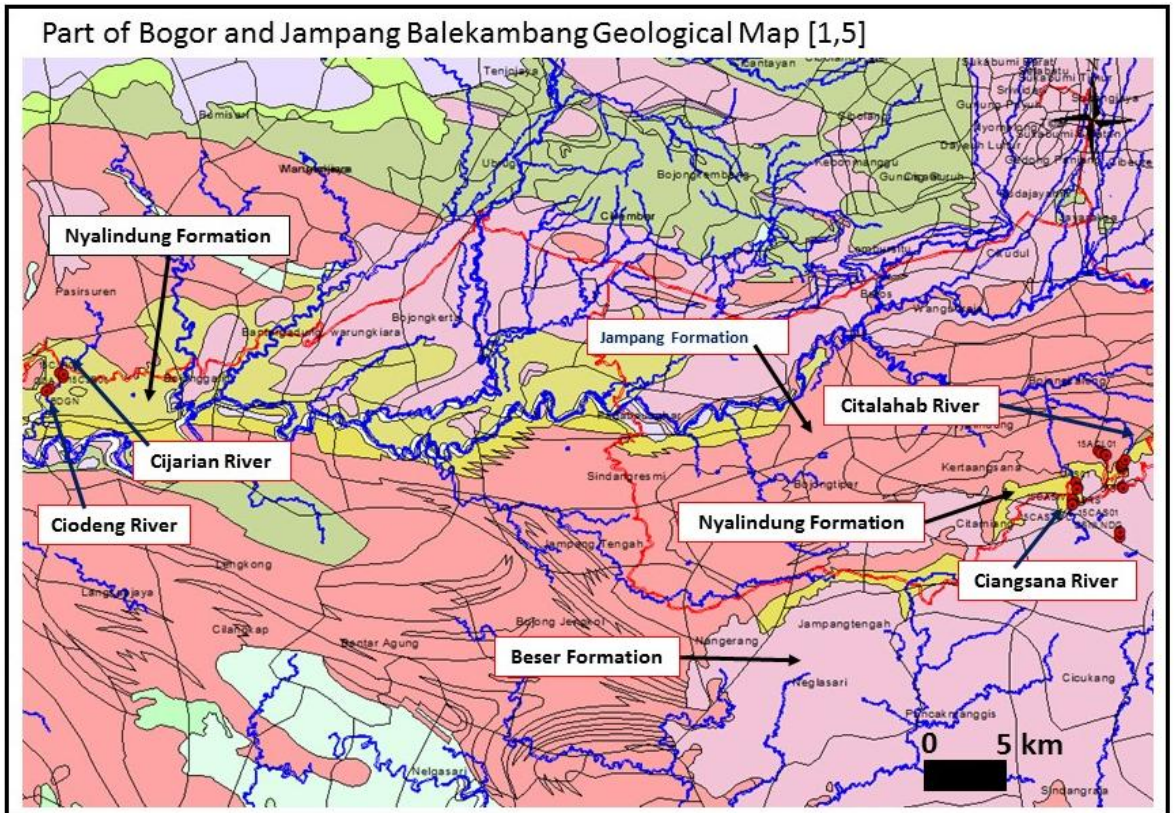


Figure 1. Research locations map shows sampling location along: Cijarian, Ciodeng, Citalahab and Ciangsana rivers.

2. Geological Setting

The study area is located within the Southern Mountain physiography zone according to [2] on the west side of the Bogor Basin [7]. The Nyalindung Formation is the main focus of the study which was found in stratigraphy contact with the Jampang Formation in the north and the Beser Formation in the south [8, 9].

The Jampang Formation has three members [8, 9], namely: (1) Flow breccia of andesitic pyroxene composition that overlies conformably the (2) Tuff and Breccia member. The Jampang member is interpreted to be Early Miocene. The Nyalindung Formation consists of green calcareous glauconitic sandstone, claystone, marl, sandy marl, tuffaceous marl, conglomerate, breccia and limestone. Tuffaceous marl along Cijarian, Citalahab, Ciangsana Rivers and Ciodeng Village are rich in molluscs (Figure 2a-d). The unit is estimated of Middle Miocene (N 13) in age and conformably overlies the Lengkong Formation. Beser Formation consists of two members, they are: (1) Volcaniclastic member and (2) Lava member. The main part of this formation comprises of volcanic breccia, laharic breccia, tuff breccia, tuffs and conglomerate. Rough terrain often represents the Lava Member (or also known as Cikondang Member). The Beser Formation overlies the Cimandiri and Jampang Formation unconformably [8, 9]. It is interpreted to be deposited in the terrestrial to beach environment.

3. Methods

Representative samples were collected from the field especially from the fossil-rich beds of the Nyalindung Formation. Locations were selected from previous type sections of Neogene stages of [1]. Preangerian stage is represented by exposures along Cijarian (Figure 2a), Citalahab (Figure 2b), Ciangsana (Figure 2c), and Ciodeng (Figure 2d) rivers; represents the Odengian stage. Samplings were designed to stratigraphycaly represent each part of the lower, middle and upper part of the formation in each transects. Monotonous lithology association is observed in the study area. It consists of bedded calcareous mudstone and sandstone with abundant molluscan fossils.

The samples were washed using H_2O_2 for a full day to separate the finer clastics fragments from the planktonic forams specimens. The samples then dried in an oven for 10 minutes. Once the samples are dry, they are ready to be analysed the foraminifera fossils content of each sample from each location under the binocular microscope. Age range of each sample will be determined from foraminifera association according to [10] age zonation or foraminifera age index fossil content. Foram fossil occurrence in the sample from each particular location is arranged stratigraphically from the oldest (bottom row in the table) to the youngest (top row in the table) as shown in Table 1-4.



Figure 2. Nyalindung outcrops that rich of mollusc fossils along: Cijarian River (2a), Citalahab River (2b), Ciangsana River (2c), and Ciodeng River (2d).

4. Results

The following results are the age of the Nyalindung Formation determined from the planktonic foraminifera association in each location (Table 1-4). Age index fossils can be seen in Figure 3.

1. Cijarian River transect: Middle Miocene – early Late Miocene (N9 – N16) based on the *Orbulina universa* (3a)*, Globoquadrina altispira* (3b) and *Globigerinoides obliquus obliquus* (3c) fossil association.
2. Citalahab River transect: Middle Miocene - late Middle Miocene (N9 – N14) based on the *Orbulina universa, Globorotalia fohsi fohsi* (3d) and *Globorotalia siakensis* (3e) fossil association.
3. Ciangsana River transect: Middle Miocene - late Middle Miocene (N9 – N14) based on the *Orbulina universa*, *Globorotalia siakensis*, dan *Globigerinoides subquadratus* (3f) fossil association.

4. Ciodeng Village: Middle Miocene - middle Late Miocene (N12 – N17) based on the *Hastigerina siphonifera* (3g), *Sphaeroidinellopsis seminulina* (3h) dan *Globigerina praebulloides* (3i) fossil association.

Table 1. Age analysis of Nyalindung Formation along Cijarian river based on planktonic foraminifera fossils. Sequence from bottom to top in the table represent old to young stratigraphy.

No	Sample No	AGE	Planktonic Zonation [10]	Planktonic Foraminifera Content
1	15 B CJR	Middle - Late Miocene	N9 - N16	*Orbulina universa, Globoquadrina altispira*
2	15 A CJR	Middle Miocene	older than N16 and younger than N9	*Orbulina universa, Globigerinoides obliquus*

Table 2. Age analysis of Nyalindung Formation along Citalahab river based on planktonic foraminifera fossils. Sequence from bottom to top in the table represent old to young stratigraphy.

No	Sample No	AGE	Planktonic Zonation [10]	Planktonic Foraminifera Content
1	15 CTL 05 BF	Middle Miocene	N12 - N14	*Orbulina universa, Globorotalia siakensis*
2	15 CTL 05 AF	Middle Miocene	N12 - N14	*Orbulina universa, Globorotalia siakensis*
3	15 CTL 04 CF	Middle Miocene	N12 - N14	*Orbulina universa, Globorotalia siakensis*
4	15 CTL 04 BF	Middle Miocene	N12 - N14	*Orbulina universa, Globorotalia siakensis*
5	15 CTL 03 BF	Middle Miocene	N12 - N14	*Orbulina universa, Globorotalia siakensis*
6	15 CTL 02 B F	Middle Miocene	N10 - N11	*Orbulina universa, Globorotalia fohsi fohsi*
7	15 CTL 02A F	Middle Miocene	N10 - N11	*Orbulina universa, Globorotalia fohsi fohsi*
8	15 CTL 01 B FA	Middle Miocene	N9 - N10	*Orbulina universa*
9	15 CTL01 A FA	Middle Miocene	N9 - N10	*Orbulina universa*

Table 3. Age analysis of Nyalindung formation along Ciangsana river based on planktonic foraminifera fossils. Sequence from bottom to top in the table represent old to young stratigraphy.

No	Sample No	AGE	Planktonic Zonation [10]	Planktonic Foraminifera Content
1	IV B 15 CAS 9 BF	Middle Miocene	N14	*Orbulina universa, Globorotalia siakensis*
2	IV B 15 CAS 8 BF	Middle Miocene	N14	*Orbulina universa, Globorotalia siakensis*
3	IV B 15 CAS 7 BF	Middle Miocene	N9 - N13	*Orbulina universa, Globigerinoides subquadratus*
4	IV B 15 CAS 6-2F	Middle Miocene	N9 - N13	*Orbulina universa, Globigerinoides subquadratus*
5	IV B 15 CAS 6-1 F	Middle Miocene	N9 - N13	*Orbulina universa, Globigerinoides subquadratus*
6	IV 15 CAS 5F	Middle Miocene	N9 - N13	*Orbulina universa, Globigerinoides subquadratus*
7	15 CAS 04 F	Middle Miocene	N9 - N13	*Orbulina universa*
8	15 CAS 03 F	Middle Miocene	N9 - N13	*Orbulina universa*
9	15 CAS 02 F	Middle Miocene	N9 - N13	*Orbulina universa*
10	15 CAS 01 FB	Middle Miocene	N9 - N13	*Orbulina universa*
11	15 CAS 01 FA	Middle Miocene	N9 - N13	*Orbulina universa*

5. Discussion

The Prangerian stage mentioned in [1] covers a wide range of Middle Miocene age, however based on the analyses results from the sample in Cijarian river suggest an even wider age range to reach early Late Miocene. The new age results of the Odengian stage from the Cijarian river around Ciodeng village suggest an older age range of late Middle Miocene – middle Late Miocene compared to Late Miocene [1].

The occurrence of *Vicarya sp*. (Figure 4) as a Middle Miocene fossil index along the Cijarian river section is another new finding in the study. Previous studies [1, 3-4] were successfully recognised this fossil along the Ciangsana River (Figure 2c). *Vicarya verneulli callosa* (Figure 5) fossil marked the global sea level rise during the Middle Miocene [11] (N13; based on [10]). This recent finding suggests that the sea level rise was recorded by the Nyalindung formation.

Table 4. Age analysis of Nyalindung formation along Ciodeng river based on planktonic foraminifera fossils. Sequence from bottom to top in the table represent old to young stratigraphy.

No	Sample No	AGE	Planktonic Zonation [10]	Planktonic Foraminifera Content
1	Ci VII A	Middle Miocene - Not Older Than Late Miocene	N12 - N23	*Hastigerina siphonifera*
2	Ci VIII A	Early - Middle Miocene	N6 - N17	*Sphaerodinellopsis seminulina, Globigerina praebulloides*

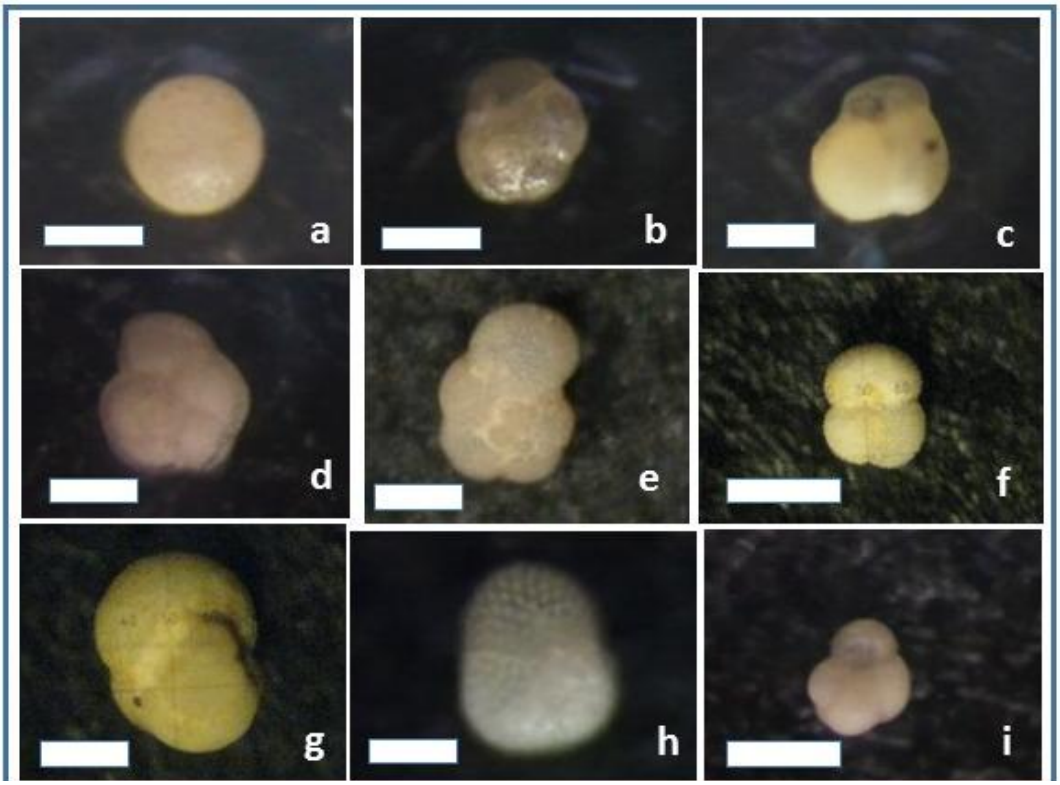


Figure 3. Age index fossils determined from this study: *Orbulina universa* (a), *Globoquadrina altispira* (b), *Globigerinoides obliquus obliquus* (c), *Globorotalia fohsi fohsi* (d), *Globorotalia siakensis* (e), *Globigerinoides subquadratus* (f), *Hastigerina siphonifera* (g), *Sphaeroidinellopsis seminulina* (h), *Globigerina praebulloides* (i). White scale bar: 0.25 mm.



Figure 4. *Vicarya sp*. as a Middle Miocene fossil index found along the Cijarian river.



Figure 5. *Vicarya verneulli callosa* found along Ciangsana river fossil marked the global sea level rise during the Middle Miocene

6. Conclusions

The Nyalindung formation age is different in three river sections; (1) Citalahab River (Preangerian: early Middle Miocene~late Middle Miocene), (2) Cijarian River (Preangerian: early Middle Miocene~early Late Miocene), (3) Ciangsana River (Preangerian: early Middle Miocene ~late Middle Miocene). These three new ages from each representative Preangerian stage are results of a more detailed determination from the Middle Miocene age assigned by [1].

The Nyalindung formation age in Ciodeng River (Odengian) is late Middle Miocene - middle Late Miocene compared to Late Miocene suggested by [1].

Vicarya verneulli callosa fossil occurrence in Ciangsana and Cijarian rivers marks the global sea level rise in the Middle Miocene.

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