

Depositional environmental evolution of Kalibiuk formation based on paleontological molluscan Study, Cisaat River section, Bumiayu, Central Java, Indonesia

Aswan¹, Elina Sufiati², Alfend Rudyawan¹, Desty Kistiani², and Thaw Zin Oo³

¹ Geology Department, Faculty of earth Sciences and Technology, Institute of Technology Bandung, Jalan Ganesa 10 Bandung, Indonesia

² Geological Museum Bandung, Jalan Diponegoro No.57, Bandung, Indonesia

³ Geology Department, East Yangon University, Thanlyin Township, Yangon Division, Myanmar

E-mail: aswan_gl@gl.itb.ac.id

Abstract. This paper presents new finding from the sedimentary sequences, overlooked by previous researchers, which provide insights to the sea level changes during the deposition of the Middle to Late Pliocene Kalibiuk Formation. Data were acquired from fieldwork via detailed measured section of each sedimentary sequence from the bottom to the upper part of the formation followed by molluscan fossil association analyses. Lithologically, the Cisaat River stratigraphic section is dominated by greenish grey claystone with some light grey fine-grained sandstone intercalation. Based on about 50 m stratigraphic section, 10 molluscan fossils associations were successfully determined. The sequence from bottom to top are: *Corbula*–*Natica* association, *Nassa* sp. association, *Olividae* – *Turricula* association, *Pecten* – *Telina* association, *Telina* – *Placuna* association, *Corbula* – *Marginella* association, *Placuna* – *Natica* association, *Turritella* association, *Turritella* – *Marginella* association and *Dentalina* – *Architectonica* association. Changes in vertical succession of the molluscan association indicates a development from shallow marine to terrestrial depositional environment before gradually overlain by terrestrial sediments of the Kaliglagah Formation. At least there are 2 deepening - shallowing sea level cycles during the deposition of Kalibiuk Formation observed from this section.

1. Introduction

The Cisaat River traverse is located to the southwest of Bumiayu, Central Java, Indonesia (Figure 1). Standard geological map of the area referred to the Majenang sheet [1], bounded by the following coordinates: 7° 09' 20.55" S; 108° 57' 13.41" E - 7° 09' 34.53" S; 108° 57' 21.76" E. The traverse, administratively, belong to the Bantarkawung district, Brebes, Central Java Province. This study focuses on the upper part of the Pliocene Kalibiuk Formation [1] and the lower part of the Pleistocene Kaliglagah Formation (Figure 2) with general bedding attitude N060°E/30°SE. This interval is included into the Cheribonian stage in the Neogene stages of Jawa [2] based on the mollusc fossils occurrence or the Zancian stage in the international geological time scale. This research was carried out due to the abundance and continuous occurrence of marine mollusc fossils across the vertical succession of the formation along the traverse and rare occurrence of benthic forams that are usually used to determine



the bathymetric depth of deposition within this sedimentary unit. Therefore a complete account of mollusc fossils analyses will be able to represent the change in depositional bathymetry ranging from tidal to shallow marine environment between the upper Kalibiuk Formation and lower Kaliglagah Formation. Sea level changes study based on molluscs fossils in Indonesia have been carried out by several researchers e.g. [3,4,5,6]. [4] have successfully analyzed the sea level changes using mollusc fossil association in the Nyalindung Formation that shows 9 cycles of shallowing and deepening sequences. This study presents a new observation and analyses of sea level changes on the overlooked sedimentary section of the Kalibiuk Formation in Cisaat River following methods presented in [4].

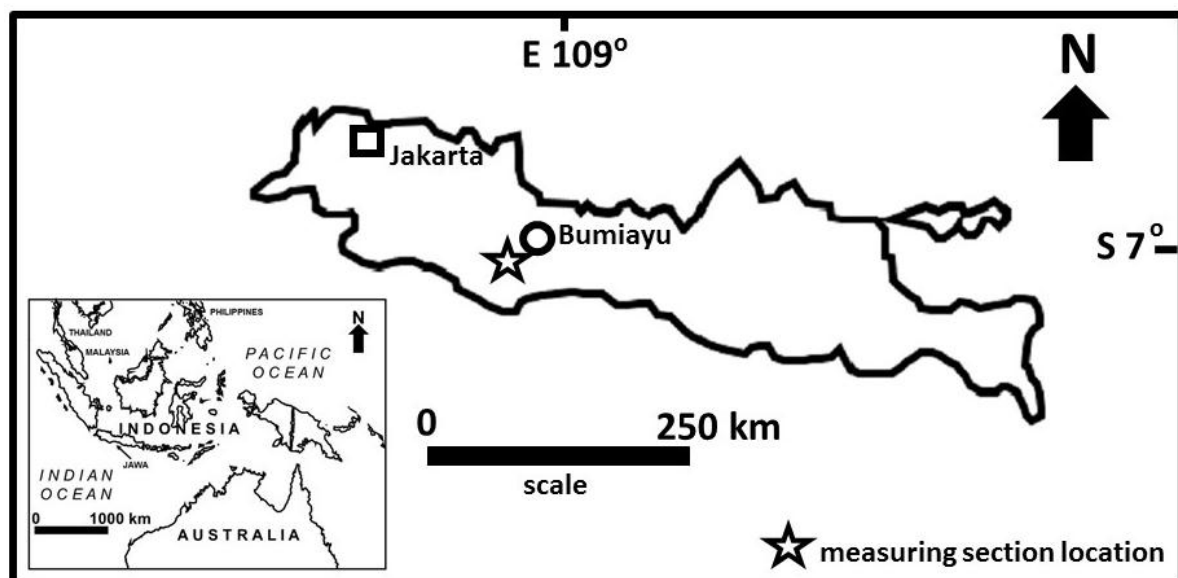


Figure 1. Map showing the location for measuring section (star sign) in Cisaat River to the southwest of Bumiayu city.

2. Geological Setting

The study area is located within the western side of the North Serayu Mountain Range [7]. Stratigraphically, the Kalibiuk Formation was deposited in the middle part of the shallowing upward sedimentary sequence during Pliocene-Pleistocene periods, above the greenish grey, fine-grained, muddy marine sediments of the Tapak Formation and below the terrestrial black shale to conglomerate of Kaliglagah Formation. Some authors suggest that the upper Tapak Formation is in interfinger relationship with the lower Kalibiuk Formation [8,9].

From old to young the Pliocene – Pleistocene stratigraphy [1] are as follows:

- Tapak Formation is characterized by coarse-grained greenish sandstone at the base and gradually fining upward towards the top with occasional yellowish-grey sandy marl intercalation. Brackish-Marine mollusc fossils taken from the upper part of the section suggest Early-Middle Pliocene age deposited in the transition to tidal environment. Total thickness may reach 500 m to the west of study area; the Kalibiuk Formation includes thick conglomerate layers containing mammal fossils (*Merycopotamus nannus* Lydekkery) and fossiliferous calcareous limestone indicating Middle Pliocene age. Lignite layers have been reported in occasional places at the top of the section.
- Kalibiuk Formation was deposited on top of the Tapak Formation. It consists of claystone and fossiliferous blue marl at the base. The middle part contains green sandstone lenses with abundance mollusc fossils while the upper part consists of thin sandstone lenses. It is interpreted to be deposited in the tidal environment. The lower part is interpreted to be interfinger with the upper Tapa Formation. Estimated total thickness of the formation may reach 500 m. The Kalibiuk Formation gradually becomes

the terrestrial Kaliglagah Formation. Balanus limestone often observed at the boundary between the Tapak and Kalibiuk Formation.

- Kaliglagah Formation consists of black claystone, green marl, volcanoclastic sandstone and conglomerate units at the base, the upper part is dominated by coarse sandstone and conglomerate, claystone and marl are rare and completely absent at the top of the section. Lignite intercalation at the base of the unit may reach 1 m thick. Total thickness of this formation is 350 meters. Figure 2 shows the geological map of the area.

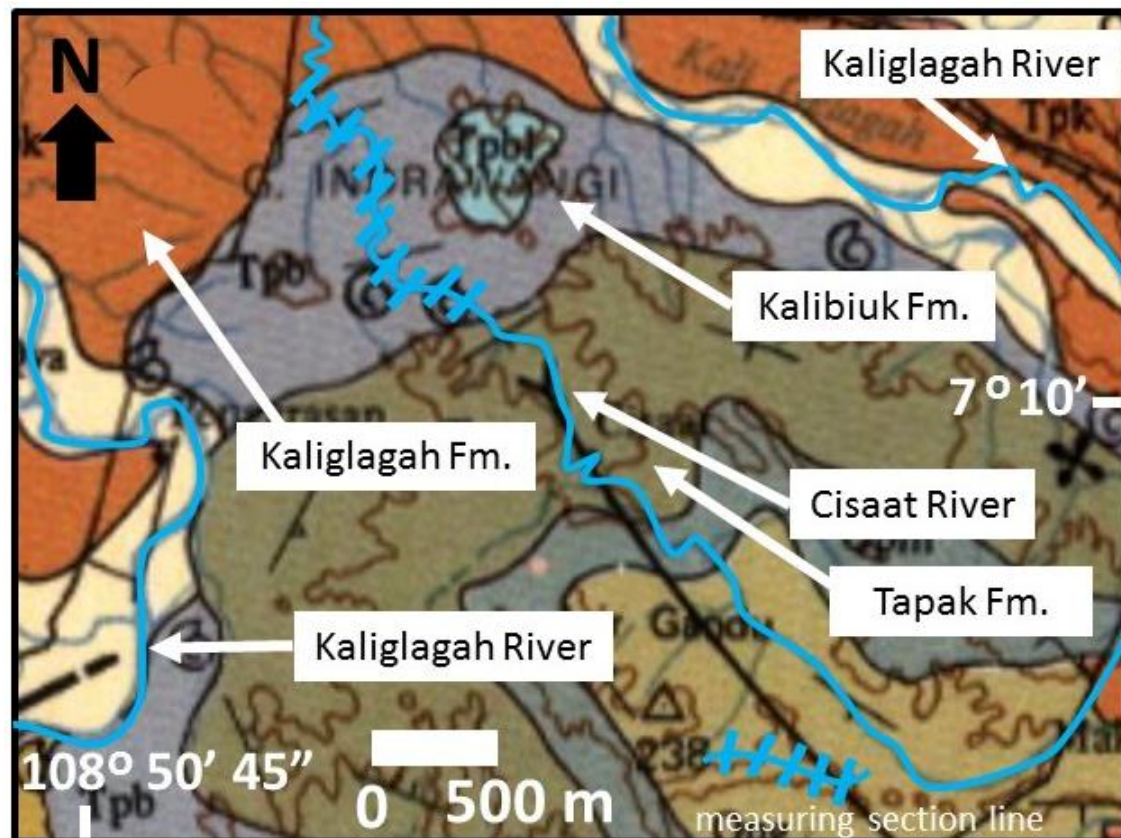


Figure 2. Local geological map of the study area [1]. Blue lines represent river.

3. Methods

The data used in this study is a measured stratigraphic section along the Cisaat River (Figure 2). Some key sections are presented in Figure 3. Lithological boundaries are determined by lithological differences or mollusc fossils content. Useful fossils in this study are those which in their taphonomy are in-situ fossils. Genus and species of each mollusc will be determined following reference from [10,11] and further grouped into mollusc fossil association based on dominance or fossil index at each depositional environment referring to [4,12]. The depositional environment interpretation of these fossil associations referring to [13]. Vertical succession of the unit from the bottom to top were then used to construct the local sea level curves in the study area in Pliocene – Pleistocene age.

4. Results

Twelve sedimentary packages of the Kalibiuk Formation yielded 70 mollusc fossils with 24 species each of Pelecypods and Gastropods. Some examples of these fossils are presented in Figure 4. Total measured thickness of the Kalibiuk Formation in Cisaat River is 5.5 meters. It is dominated by claystone with occasional sandstone intercalation. Figure 3 shows the thick claystone outcrop of the Kalibiuk Formation on the riverbank. Examples of mollusc fossils that were used as a basis of each unit

association acquired from the formations are presented in Figure 4. The stratigraphic records arranged from old (bottom) to young (top) showing ten distinguished fossil associations can be determined from the analyses summarized in Figure 5 and Table 1.

There are five depositional environments determined from the mollusc fossils in this study, they are: upper most intertidal, subtidal, lower intertidal and shallow open marine. These depositional environments are determined from the insitu mollusc fossils. Reworked fossils will not yield an accurate depositional environment interpretation. An accurate environment determination will help to develop better detail of the local sea level curve from the bottom to top part of the stratigraphy.



Figure 3. Kalibiuk Formation outcrop in Cisaat River, Bumiayu, Central Java

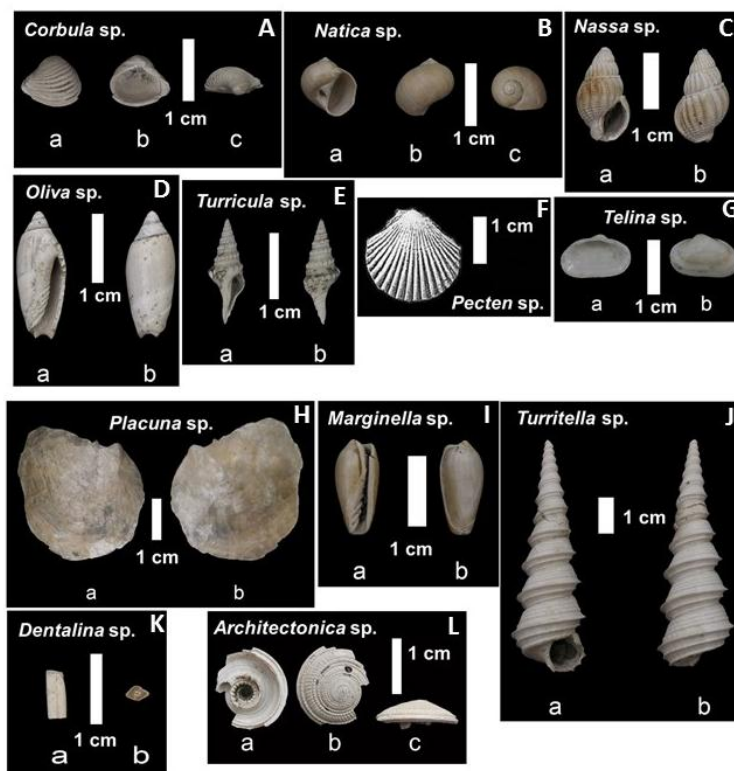


Figure 4. Examples of molluscan fossils found in Kalibiuk Formation, Cisaat River, Bumiayu, Central Java.

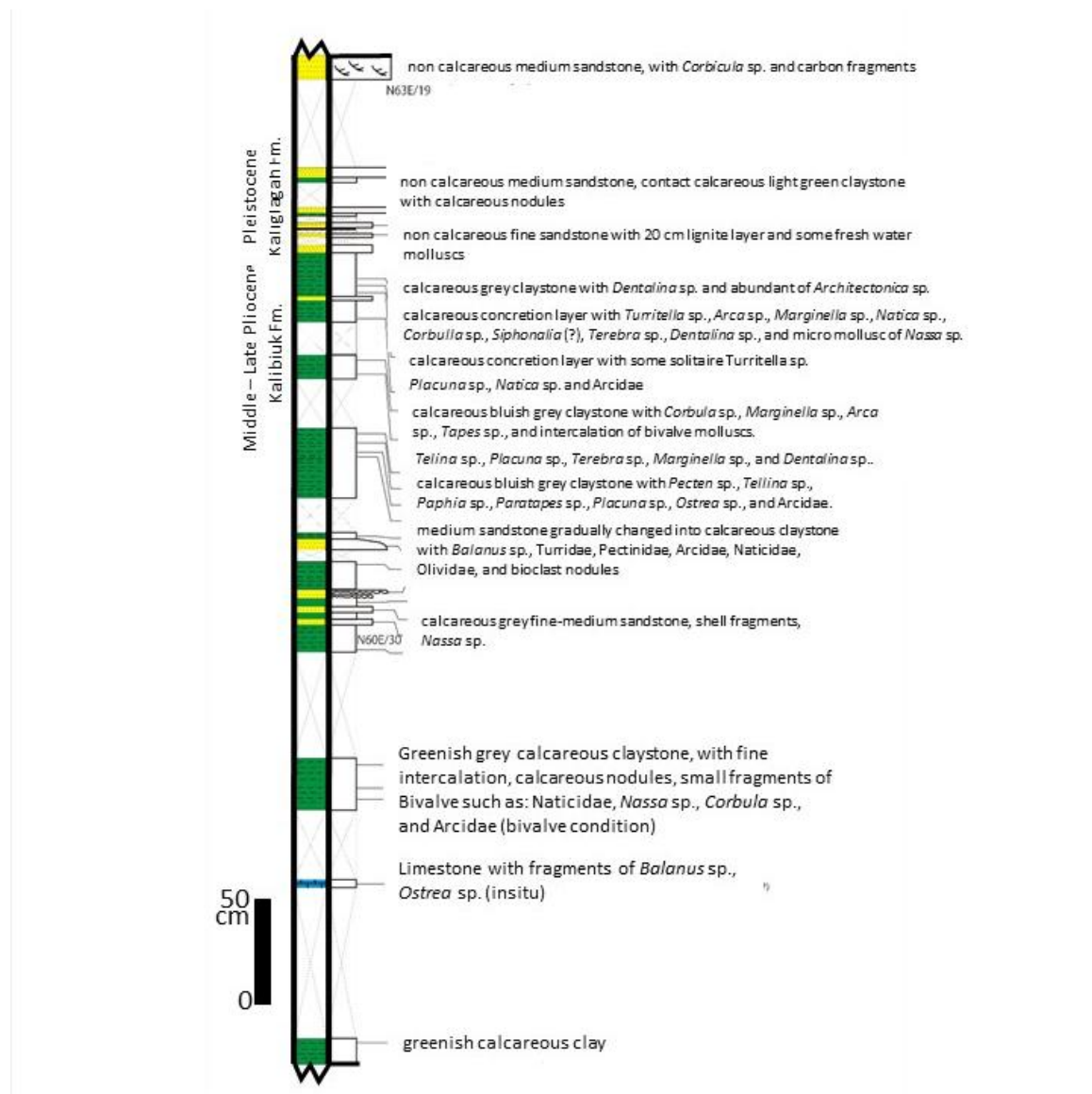


Figure 5. Kalibiuk Formation stratigraphic column, Cisaat River section, Bumiayu, Central Jawa, Indonesia. Note: The coarse clastics dominance towards the top of the section.

Table 1. Vertical succession from top (10) to bottom (1) from the Kalibiuk Formation.

Layers	Fossil Association	Paleodepositional Environment
10	<i>Dentalina</i> – <i>Architectonica</i> association, <i>Dentalina</i> sp. and <i>Architectonica</i> sp. found within the grey calcareous claystone and associated with insitu and complete pelecypods fossils.	Quiet uppermost intertidal
9	<i>Turritella</i> – <i>Marginella</i> association found in the calcareous claystone and associated with other less dominant fossils such as <i>Arca</i> sp., <i>Corbulla</i> sp., <i>Siphonalia</i> sp., <i>Terebra</i> sp., <i>Dentalina</i> sp., and micro mollusc <i>Nassa</i> sp.	Transitional, close to the open marine; lower intertidal

8	<i>Turritella</i> association mostly found in carbonate concretion in the upper part of the bluish claystone. <i>Turritella</i> sp. found as solitary fossil species with variations from juvenile to adult species, also found coral and echinoid fragments in the carbonate concretion.	Shallow marine	open
7	<i>Placuna</i> – <i>Natica</i> association found in claystone and associated with less dominant Arcidae fossils.	Lower intertidal	
6	<i>Corbula</i> – <i>Marginella</i> association found in calcareous claystone and associated with other less dominant fossils such as <i>Arca</i> sp. and <i>Tapes</i> sp.	Uppermost intertidal	
5	<i>Telina</i> – <i>Placuna</i> association found in bluish mudstone and associated with other less molluscs such as <i>Cytherea</i> sp., <i>Arca</i> sp., <i>Paphia</i> sp., <i>Placuna</i> sp., <i>Terebra</i> sp., <i>Marginella</i> sp., and <i>Dentalina</i> sp.	Lower intertidal	
4	<i>Pecten</i> – <i>Telina</i> association found in bluish calcareous mudstone and associated with other less dominant molluscs such as <i>Placuna</i> sp., <i>Ostrea</i> sp., <i>Paphia</i> sp., <i>Paratapes</i> sp., broken Arcidae fragments	Quiet marine	open
3	<i>Oliva</i> - <i>Turricula</i> association found in medium-grained sandstone. Other fossils that are less dominant are Pectinidae, Arcidae and <i>Balanus</i> sp..	Shallow marine	open
2	<i>Nassa</i> association within calcareous sandstone intercalation. <i>Nassa</i> sp. is both in complete and broken form while other fossils are mostly broken.	Subtidal	
1	<i>Corbula</i> – <i>Natica</i> association in complete form within mudstone. Generally fossils are small and broken. Samples also contain <i>Nassa</i> sp. and Arcidae	Shallow environment; upper intertidal	tidal most

5. Discussion

Local sea level curve from the study has been successfully developed from the fossil association (Figure 6). Previous studies [8,9] suggested that towards the top of the Kalibiuk Formation the depositional environment became shallower closer to the terrestrial condition. There were at least 2 deepening – shallowing cycles during the depositional period of the Kalibiuk Formation found in Cisaat River. The base of the Kalibiuk Formation (Unit 1; Table 1) in Cisaat River was deposited in the uppermost intertidal environment. The sediments were gradually deposited at deeper depth towards shallow open marine shown by the fossil association in Unit 2, 3, 4. Shallowing episode started during the deposition of Unit 5 sediments in lower intertidal environment. Maximum drop sea level in this first cycle attained during the deposition of Unit 6 depositional environment returned to the uppermost intertidal. Unit 7 and 8 represent the second deepening episodes and unit 9 and 10 indicate the final shallowing episodes before the Kalibiuk Formation was gradually overlain by Kaliglagah Formation that was deposited in the terrestrial setting.

Turritella – *Marginella* association (Unit 6) represents the most optimum condition for molluscs to live. This is due to the observation that shows there are more variations in fossil genera within the beds carrying this association; the fossils are also commonly found in complete forms.

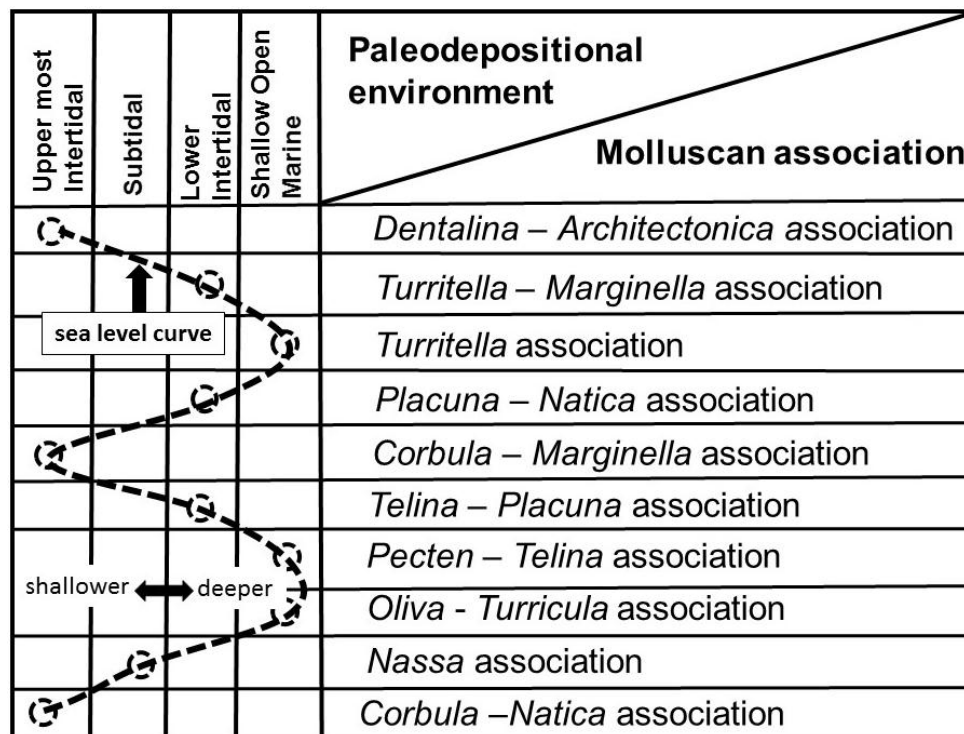


Figure 6. Local sea level change during the deposition of the Kalibiuk Formation in the Middle-Late Pliocene.

6. Conclusions

The study presents local sea level curve during the deposition of Middle-Late Pliocene Kalibiuk Formation generated from 2 deepening and shallowing cycles demonstrated by 10 mollusc fossils association.

From bottom to top the depositional environments are as follow: (1) upper most intertidal (*Corbula – Natica* association), (2) subtidal (based on *Nassa* association), (3) shallow open marine (marked by *Oliva – Turricula* association), (4) quiet open marine (*Pecten – Telina* association), (5) lower intertidal (*Telina – Placuna* association), (6) upper most intertidal (*Corbula – Marginella* association), (7) lower intertidal (*Placuna – Natica* association), (8) shallow open marine (*Turritella* association), (9) lower intertidal (*Turritella – Marginella* association), and (10) upper most intertidal (*Architectonica – Dentalina* association). Optimum condition for molluscs development in the Kalibiuk Formation is represented by the beds carrying *Turritella-Marginella* association.

Acknowledgements

We would like to express our gratitude to the Geology Study Program at ITB for the support and opportunity to use the facility during the work of this study. We would also like to thanks to the Dean and all staff of Faculty of Earth Sciences and Technology (FITB) – ITB and Head of Geology Expertise Group and staff, who helped the author by giving the permission to do this collaboration research. Our thanks also to Irman Yudi Abdurrahman from Bandung Geological Museum for provided geological map of research area. The field research was funded by Bandung Geological Museum.

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