IAGI Journal
Volume 1 No. 3, December 2021: 137–142 *e*-ISSN 2776-0111

Middle Miocene Cyclic Sedimentation Based on Mollusks Taphonomic Analysis in Beach to Lagoonal Deposit of Nyalindung Formation, Sukabumi, West Java

Nisrina Bahiyah Kesuma*, Adelia Kurniadi, Eka Febriana Triastiningsih, Aswan
Geological Engineering Department-Bandung Institute of Technology,
Ganesa St. No. 10, Bandung, 40132, Indonesia
*E-mail: nisrinabahiyah@gmail.com

Article received: 23 November 2021, revised: 23 December 2021, accepted: 31 December 2021
DOI: 10.51835/iagij.2021.1.3.378

ABSTRACT

Nyalindung Formation is a Middle Miocene fossil-bearing stratum consisting of fine clastic sedimentary rocks and carbonates. Nyalindung Formation exposed in Ci Galasar River indicates beach to lagoon depositional environment with shell beads. Taphonomy of mollusks shells concentration in each shells bed was studied to understand the sedimentation cycle of Nyalindung Formation in the research area and further understand the number of cycles in the deposition of Nyalindung Formation, as well as the suspected event affecting the sedimentary cycle. According to the taphonomy classification, four types of shell beds were identified. Early Transgressive Systems Tract (Early TST) was characterized by sandstone and siltstone with poor shells fragment or none. Late Transgressive Systems Tract (Late TST) was characterized by an articulated specimen in its life position, with a low level of fragmentation. In this type of shell bed, adult specimens were found complete with high variation of other taxa. Maximum TST was recognized through high diversity of taxa, sizes and without certain orientation. Early Highstand Systems Tract (Early HST) was indicated through adult taxa articulated individually in life position accompanied by the juvenile specimen. In the Early HST sequence, shell density and species diversity are relatively low, and shallower environment shells association was obtained. Multi-event concentrations identified late Highstand Systems Tract (Late HST) with the domination of disarticulated shell and carbon streaks. Based on this classification, around ten incomplete cycles can be identified and suspected to happen at the time of deposition. These cycles are presumed to be correlated with Milankovitch Cycle, as represented by the thickness of each sedimentary cycle, which rarely exceed 2 m.

Keywords: Mollusca, Middle Miocene, Nyalindung, taphonomy, sedimentary cycles

INTRODUCTION

Nyalindung Formation is a mollusk's fossil-bearing stratum deposited in the Middle Miocene [1]. A paleontology study conducted in Nyalindung Formation showed that gastropods and bivalves fossils found in this rock unit are typical for an open sea with a swampy estuary in the east within the age of the Middle Miocene [2]. The presence of mollusks fossils may indicate paleoenvironmental aspects and the sedimentation cycles during the deposition of certain sedimentary rock formations.

The identification of sedimentation cycles through mollusks taphonomic study in the Indonesia region have been conducted in Pematang Group in Central Sumatera Basin [3], Nyalindung Formation [4], Kaliwangu Formation [5], as well as the combination of Nyalindung and Kaliwangu Formation [5]. Though the study had been done previously, the identification of shell beds still depended on the lithological characteristics since they

were quite distinctive. Nyalindung Formation exposed in most places shows a thick, very fine sandstone intercalated with silt to claystone that shows almost no noticeable difference, making it hard to identify the layer of the outcrops. In addition to that, finer-grained sedimentary rocks experience a more challenging time in preserving any sedimentary structure that indicates layers or contacts. A previous study of sedimentary cycles in the Nyalindung Formation was done in the Cijarian River, exhibiting more distinctive sedimentary rock layers such as very-fine sandstone and gravelly sandstone. Therefore, identifying shell beds in outcrops that lack sedimentary structures and features can determine whether the condition of the fossils still indicates changes despite seemingly similar and thick layers of sedimentary rocks.

The research is conducted in Kertaangsana Village, along Ci Galasar River (Figure 1). This area has been known for fossils exposure. But since the lithological characteristics are quite monotonous, identifying layers and sequences are challenging. This area was also chosen since the mollusks in this particular show significant orientation and distribution, which made the mollusks fossils the potential of showing sedimentary sequences. However, the abundance was not as high as outcrops exposed in other rivers like Ci Angsana River and Ci Talahab River.

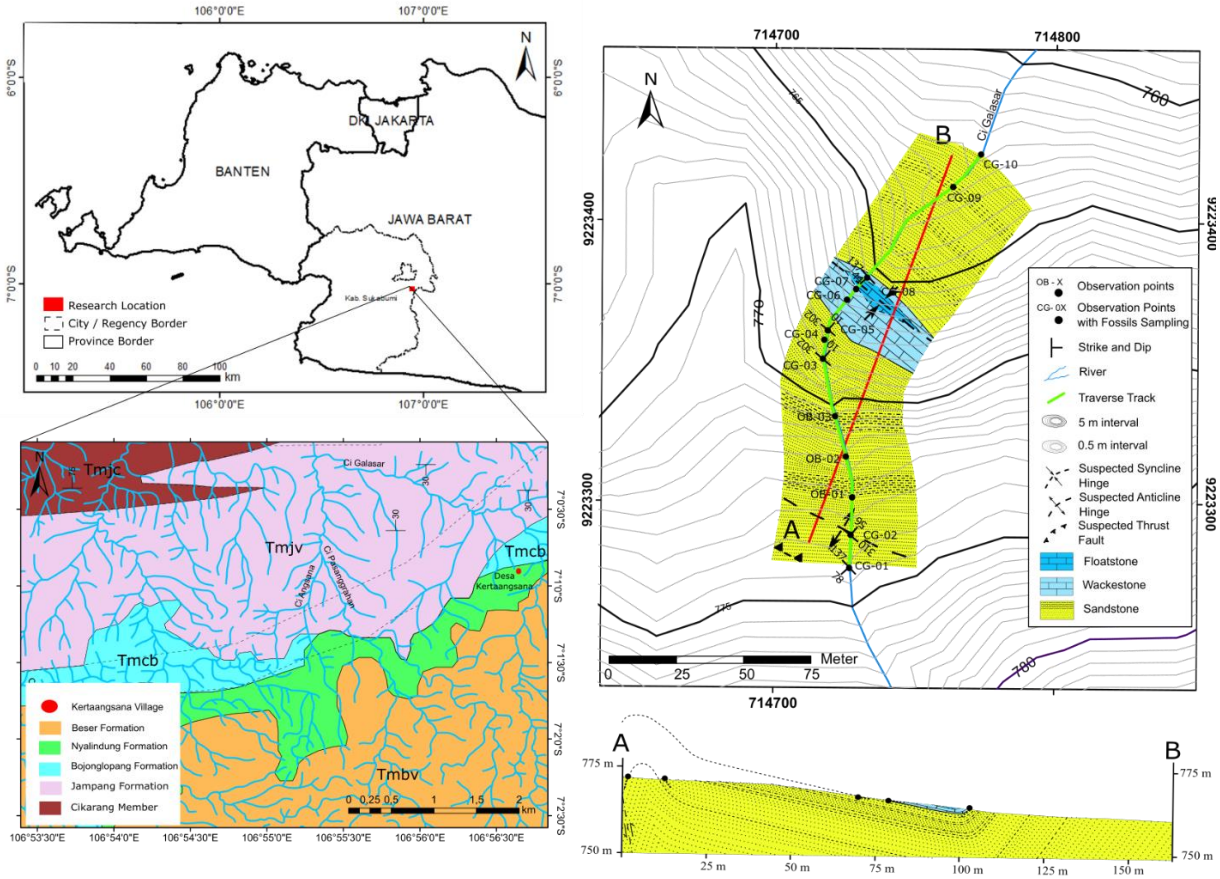

Figure 1. The traverse section is located along the Ci Galasar River, Kertaangsana Village, Sukabumi Regency, West Java. The profile section along the traverse shows a syncline and anticline pair as long as the suspected thrust fault at the north. The research was conducted in thirteen stations with CG- and OB- prefixes

SHELL BEDS AND SEDIMENTARY CYCLES

Shell beds as sedimentary cycles indicators have been used in previous research. Different cyclothems showed distinctive characteristics on shell beds [6,7]. Highstand System Tract (HST) starts at the beginning of the sea-level fall. During this HST, relative sea-level experienced a slow rise from the combined effects of subsidence and eustasy and exceeded by the sedimentation rate to create a prograding pattern. This prograding sedimentation occurs at a high turbidity level, leading to incomplete growth of mollusks, causing the early stage of HST to be characterized by dominant juvenile individuals, with some adult taxa in their original position with few disarticulated shells. Carbon streaks may be found in several places [7]. The late HST is usually identified by repetitive fragmented shell fossils and relatively barren layers [7].

In the Transgressive System Tract (TST), where the sediment supply plummets or accommodation capacity increases, the sea level rises slowly and increases its speed to reach the maximum landward level. It is known as maximum flooding surface. Low stand water reaches its minimum and creates a sequence boundary, characterized by an erosional surface preceding this event. In the early stage of TST, the erosional surface is shown with unoriented and disarticulated shells interpreted as reworked materials [7]. Concretion may also appear [6]. The late stage of TST is marked with concentrated shells layer with low to the non-fragmented articulated specimen in its living position, with high taxa diversity and adult specimen presence, although some barren layers my intercalate. The concentrated layer of shells is caused by the decrease in sedimentation rate, which creates no suspension in the water, creating a perfect condition for mollusks to grow [7].

DATA AND METHODOLOGY

This research was conducted through several stages, including literature study, field observation, and laboratory analysis, as illustrated in the flowchart (Figure 2). Before field observations, a literature study was conducted to determine the stratigraphy and paleontology of the Nyalindung Formation, mollusks taphonomy, and the appropriate area for this research.

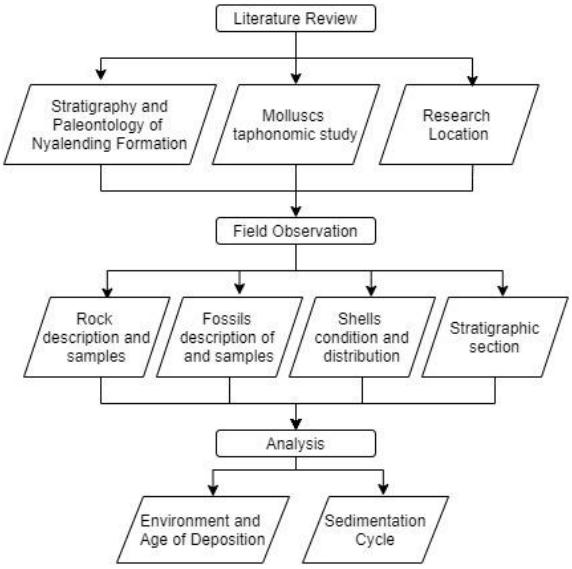

Figure 2. Research stages illustrated in a flowchart

The activity begins by measuring the stratigraphic section while taking samples and descriptions of rocks and fossils. In this study, field observations were carried out at thirteen locations along the Ci Galasar River with CG- and OB- prefixes (Figure 1). Rock samples and descriptions were obtained at all locations, while fossil samples were obtained at nine observation sites with the prefix CG. The rock descriptions obtained include color, condition, grain size and shape, packing, sorting, fragment composition, degree of compactness, and sedimentary structure when present. This

data and description will then determine the lithological units in the measured section. Fossil data was taken to describe as an indication of age and general depositional environment. This description is based on the initially identified classes, including color, condition, possible types of fossilization processes, symmetry, shell rotation direction (dextral or sinistral) for gastropods, and existing ornamentation.

Furthermore, observations were made on the shells found, which included observations on their condition and distribution. These observations are done to see changes in the composition, condition, and vertical distribution of shells which help determine the type of cyclothem, a stratigraphic sequence unit. From field observations combined with lithological sample data, fossils, and the distribution and condition of the shell, in the end, a complete measured cross-section will be obtained.

RESULTS AND DISCUSSION

The research section, interpreted from observation data, consists of three sedimentary rock units. The Sandstone Unit stratigraphically is deposited at the bottom and exposed in CG-01, CG-02, OB-1, OB-2, OB-3, CG-03, CG-08, CG-09, and CG-10. The Sandstone Unit has lithological characteristics of dark-gray sandstones that gradually become siltstone in several places, with rounded and well-sorted fragments the size of very fine sand-silt. The fragments consisted of fossil fragments (<1mm in length), hornblende, lithic, with clay-sized matrix, glauconite cement, and tiny pyrite crystals growing between the grains. Few pyroxene fragments indicate mafic igneous rocks derived materials. Alongside the composition, *Gemmula Gemmula granosa Woodward* and *Terebra talahabensis* in this unit indicates an inner neritic environment with limited water circulation identic with beach – lagoon area, with the age of Middle Miocene as was suggested by *Barycypraea murisimilis*. The Limestone A Unit is deposited over the Sandstone Unit with erosional contact. These units are found on CG-04, CG-05, and CG-07. Limestone A Unit is classified as a wackestone with neomorphic micrites. The presence of *Chione tjikoraiensis* and *Talahabia identif*ier indicates the deposition age of the Middle Miocene with a neritic environment. Limestone Unit B was deposited on top of Limestone A Unit with erosional contact. Limestone Unit B is wackestone composed of coral fragments, algae, foraminifera, and 5-10 mm mollusks. Micrites have undergone neomorphism in several places. This unit was exposed in CG-06. These units were found in a pair of anticline and syncline structures suspected to be triggered by a nearby thrust fault, as shown in Figure 1.

Regarding the fossils content, microfossils were used to indicate the depositional environment in Sandstone Unit since this unit is quite thick and showed few to no lithological characteristics changes. There were also no significant changes in the macrofossils composition that would indicate obvious environmental changes. Though, based on microfossil identification, the presence of *Ammonia* sp. in the bottom layer, barren in some layers, and *Nonionella* sp. in the top layer of the Sandstone Unit succeeded in identifying the depositional environment to be the beach – lagoonal area. The restricted circulation area was also concluded from a brownish deposit in the Ammonia sp. fossil with pyrite crystals growing between pores. For Wackestone and Floatstone units, the depositional setting was determined to be a

reef barrier of a lagoon considering their position towards the sandstone unit to be confirmed. This position is confirmed by the presence of *Talahabia identifi*er, which is indicative of the Middle Miocene, the same depositional age shown by the presence of *Barycypraea murisimilis* in the Sandstone Unit.

Based on shell beds identification, ten incomplete cyclothems can be identified through the section (Figure 3). Overall, the section showed distinctive late stages of TST, and both early and late-stage of HST. In several places, Late TST and Early HST stages could not have differed yet are still consistent with shell beds characteristics. The thickness of the cycles ranges from 1 – 2.5 meters, with most of the cycles having less than or equal to 2 meters in thickness.

Early HST shell beds in the research section are characterized by layers with abundant fragmented and disarticulated adult shells and intact juvenile individuals, as seen in Pictures C and D in Figure 3. In addition to shells, the appearance of carbon streaks also indicates the early stage of HST in the floatstone layer, which is shown in Picture A. Early HST can be seen in every cyclothem identified, though, in cycle 9, the clear distinction between the early and late stages of HST could not be observed.

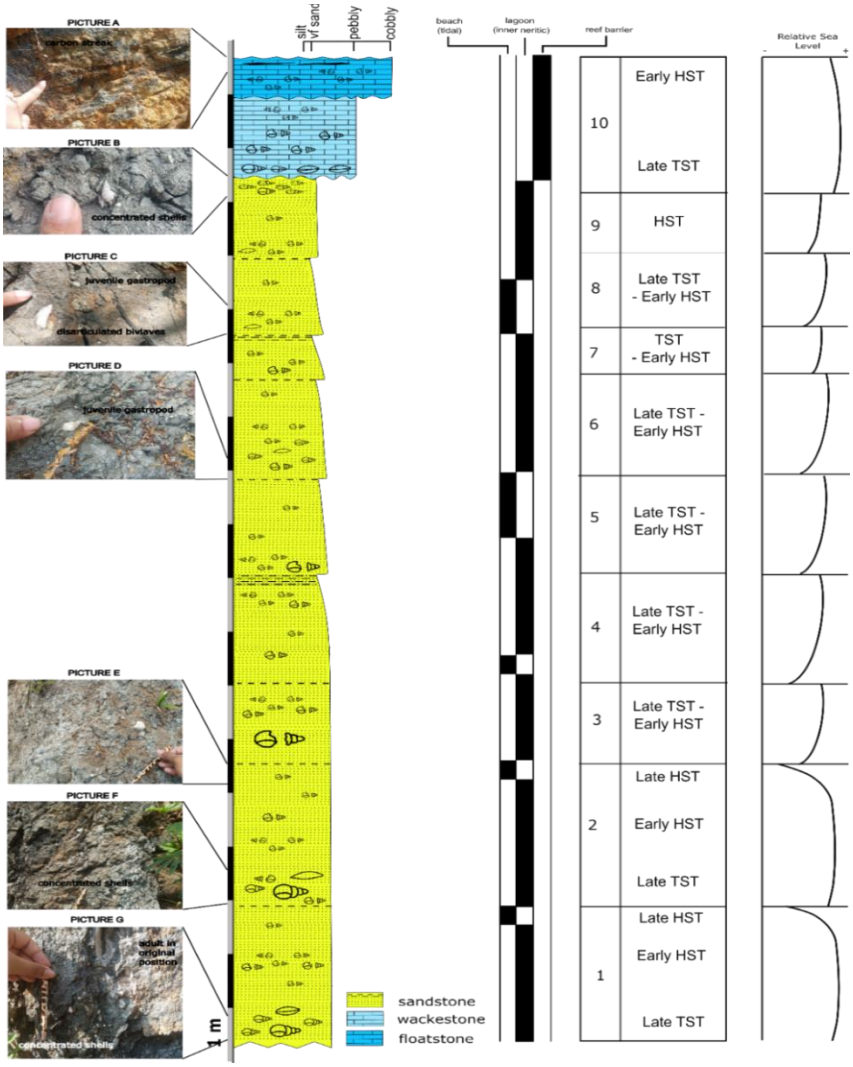

Figure 3. Measured section of the research area with outcrops photos, stratigraphic units, environment changes, sedimentary cycles, and relative sea level

Late HST in the research section showed repetitive barren and fragmented shells layer, though mostly barren layers, as seen in Picture E of Figure 3. Alongside the Early TST shells beds, minimum exposure was probably erosion which mostly happens during Late HST to Early HST. However, this cycle unit was only exposed in cycles 1 and 2.

The late TST sequence exposed in the section is indicated by the presence of a concentrated layer of shells, with a wide variety of taxa and sizes ranging from juvenile to adult, as were shown in cycles 1, 2, and 10 and depicted through Picture B, F, and G of Figure 3. Though not ideal, these shell bed characteristics were also exposed in most cycles, except for cycle 9, and later be interpreted as a transition between Late TST and Early HST sequence. These transition shell beds were identified through the same level of abundance between disarticulated shells fragment presence of an intact juvenile but with an overall lack of shells presence.

Stratigraphically, Nyalindung Formation in the research section was affected by sea-level changes, as the mollusks, taphonomic study shows. At least ten cycles of sea-level change were recorded in this sedimentary unit, though it was incompletely exhibited. By considering the average thickness of the cyclothems, the cycles are suspected to be the 6th order cycle, representing 41,000 years. They can further be interpreted as the effect of the Milankovitch Cycle [4]. Furthermore, these results are consistent with previous studies, though they showed more than nine cyclothems from the mollusks taphonomy study [4].

CONCLUSION

The mollusks shells exposed in the dominantly massive sandstone layers section of Nyalindung Formation were able to indicate changes that successfully divided the sedimentary units into several cycles, despite showing the same lithological characteristics. These changes can be correlated to sea-level changes that happened in 41,000 years.

ACKNOWLEDGMENT

We would like to express our gratitude to family, friends, colleagues, and Bandung Institute of Technology for the endless support throughout this research.

REFERENCES

1. Martodjojo, S. *Evolusi Cekungan Bogor*; Penerbit ITB: Bandung, 2003;
2. Syarifin Paleontologi Formasi Nyalindung. *Bull. Sci. Contrib.* **2011**, *9*, 17–27.
3. Aswan; Graha, S.; Suryadi, D.; Wiguna, T.; Qivayanti, S.I. Oligocene cyclic sedimentation deduced from taphonomic analysis of molluscs in lacustrine deposits of the Pematang Group, Pesada Well, Central Sumatra Basin. *J. Math. Fundam. Sci.* **2016**, *48*, 66–81, doi:10.5614/J.MATH.FUND.SCI.2016.48.1.7.
4. Aswan; Ozawa, T. Milankovitch 41 000-year cycles in lithofacies and molluscan content in the tropical Middle Miocene Nyalindung Formation, Jawa, Indonesia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2006**, *235*, 382–405, doi:10.1016/J.PALAEO.2005.11.004.
5. Aswan, A.; Rijani, S.; Riza, Y. Shell Bed Identification of Kaliwangu Formation and its Sedimentary Cycle Significance, Sumedang, West Java. *Indones. J. Geosci.* **2013**, *8*, doi:10.17014/IJOG.V8I1.151.
6. Cantalamessa, G.; Di Celma, C.; Ragaini, L. Sequence stratigraphy of the Punta Ballena Member of the Jama Formation (Early Pleistocene, Ecuador): Insights from integrated sedimentologic, taphonomic and paleoecologic analysis of molluscan shell concentrations. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2005**, *216*, 1–25, doi:10.1016/J.PALAEO.2004.09.012.
7. Parras, A.; Casadío, S. Taphonomy and sequence stratigraphic significance of oyster-dominated concentrations from the San Julián formation, Oligocene of Patagonia, Argentina. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2005**, *217*, 47–66, doi:10.1016/J.PALAEO.2004.11.015.