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RESEARCH ARTICLE

Depositional Environmental Changes of Cimanceuri Formation Based on Mollusk Fossil Assemblages in Bayah, Banten Province

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Abstract

Bayah is located in Lebak Regency, Banten Province. This location is chosen due to its abundant mollusk fossils which exposed along the outcrops. The aim of this research is to determine depositional environmental changes using mollusk fossil assemblages. Data obtained from a measured stratigraphic section of Cimanceuri Formation. It is dominated by very fine-fine sandstones with claystone intercalation. A total thickness of measured stratigraphic section is 4.2 meters. There are at least seventeen mollusk associations (bottom-top) consisting of 1) *Ringicula arctatoides - Olivella tomlini* were obtained. 2) *Ringicula arctatoides - Marginella (Cryptospira) ventricosa sangiranensis*. 3) *Olivella tomlini,* 4) *Ringicula arctatoides - Olivella tomlini,* 5) *Ringicula arctatoides*, 6) *Turritella (Turritella) bantamensis - Scapharca (Scapharca) gedinganensis,* 7) *Polinices aurantius - Marginella (Cryptospira) ventricosa sangiranensis*, 8) *Scapharca (Scapharca) gedinganensis*, 9) *Scapharca (Scapharca) multiformis - Timoclea bataviana*, 10) *Turritella (Turritella) bantamensis tjicumpaiensis - Ringicula arctatoides*, 11*)* *Turritella (Turritella) bantamensis - Ringicula arctatoides,* 12) *Turritella (Turritella) bantamensis tjicumpaiensis - Turritella (Turritella) bantamensis,* 13) *Turritella (Turritella) bantamensis tjicumpaiensis - Ringicula arctatoides,* 14) *Turritella (Turritella) bantamensis - Architectonica* sp., 15) *Turritella (Turritella) bantamensis tjicumpaiensis,* 16) *Turritella (Turritella) bantamensis – Turritella (Turritella) bantamensis tjicumpaiensis*, and 17) *Turritella (Turritella) bantamensis*. The condition with the most stable ecosystem is the association *of Turritella (Turritella) bantamensis tjicumpaiensis - Turritella (Turritella) bantamensis* (Association 12). At least there are seven depositional environmental changes that occur in this research area with two shallowing – deepening cycles : 1) open shallow marine, 2) subtidal – open shallow marine, 3) open shallow marine, 4) open shallow marine – subtidal, 5) subtidal, 6) subtidal – open shallow marine, and 7) open shallow marine.

Keywords: Mollusk, Depositional environment, Bayah, Cimanceuri Formation

1. Introduction

Mollusks are one of the phylum with a very abundant number of organisms, so it is potential to be used as an indicator to interpret the depositional environment. In addition, the environmental distribution of mollusks is wide ranging from marine to terrestrial. Bayah region has many marine sediment outcrops. Bayah region is chosen for studying due to its abundant mollusk fossils which exposed along the outcrops. In this location, foraminifera fossils that commonly used for interpretation of depositional environments is rarely found. Based on this condition we propose the mollusk fossils to be used as indicators of depositional environment interpretation.

Bayah is located in Lebak Regency, Banten Province (Fig. 1.). The details location have found in Cikumpay River with coordinates 106° 14' 18,282" BT; 6° 54' 48,963" LS and 106° 14' 18,084" BT; 6° 54' 49,987" LS and in the Cikuya River (Cikumpay’s tributary) with coordinates 106° 14' 0,582" BT; 06° 55' 8,776" LS (Fig. 2 and 3)

The assembly of fossils which was found in the Cimanceuri Formation is deposited in terrestrial-fluvial to littoral. Its lithology is very fine to fine-grained carbonate sandstones with claystone intercalation and contains of mollusk fossils in several places, at the top of this formation there is a coquina (Sujatmiko, et al., 1992). Mollusk and Foraminifera fossils which found in Cimanceuri Formation shows Early Pliocene (Koolhoven, 1933 in Sujatmiko, et al., 1992).

Based on Neogen Stage of Java (Oostingh, 1938 and Shuto, 1975), Cimanceuri Formation are known belong to the Sondean Stage with Turritella bantamensis tjicumpaiensis and Scapharca gedinganensis as its fossil index. These fossil index are come from Pliocene / N19-N20. (Sufiati, et al., 2014).

2. Material and Method

Twenty-two rock samples were obtained from 3 measured stratigraphic sections in Cikumpay and Cikuya Rivers (Fig. 3.). Systematically rocks sampling are carried out with an interval of ±20 cm at each layer.

Description and measurement of sediment thickness were carried out in the field. Afterwards, the samples then prepared. The preparation process aims to clean up the remaining sediment until the fossils ready to be identified.

Fig. 1. Research area, Bayah, Lebak Regency, Banten Province (Source: Google Maps).

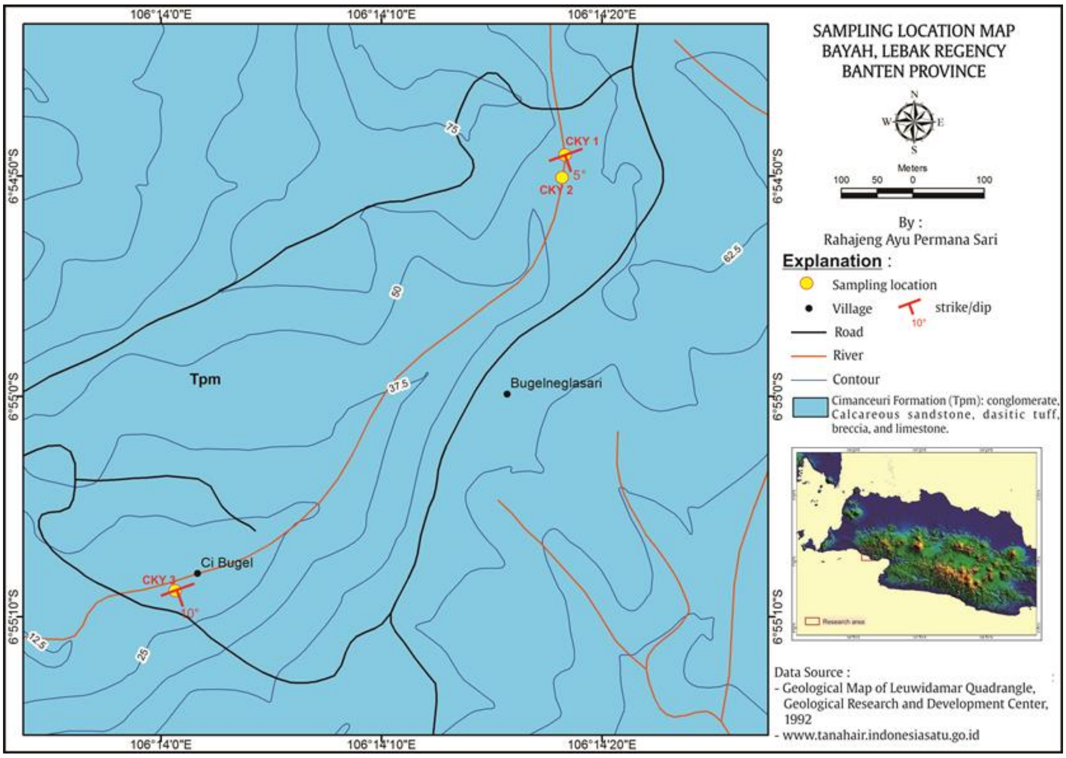

Fig. 2. Sampling location map Bayah, Lebak Regency, Banten Province.

Fig. 3. The Outcrop of CKY 3 in research area.

A binocular microscope is used to identify micro-sized mollusks. The references to identification and determination refer to Martin (1879,1880), Oostingh (1933), Leloux (2009), and Sufiati (2012), while for the ecological determination of each species refers to Abbott (1991), Okutani (2000), Aswan (2006), and Prasetyo et al. (2012). Species that have been identified are then used for determine mollusk associations of each layer.

The mollusk association zone is used to indicate mollusk fossil assemblages that live in similar habitats associated with certain lithologies. Classification of depositional environment refers to Fan (2012) (Fig. 4.). The name of mollusk fossils association is based on in-situ and abundant mollusk fossils, whether one or more species appear (Prasetyo et al., 2012). The result of these associations are used for interpretation of depositional environmental changes in Cimanceuri Formation. The mollusk fossils obtained from Bayah are stored at Bandung Geological Museum.

Shannon-Wiener's diversity index is used to identified the condition of ecosystem in research area, (Bakus, 2007):

$$H' = -\sum_{i=1}^{s} (Pi)\,(log\ Pi) \quad (1)$$

where :
H' = diversity index
s = number of species
Σ = sum
$Pi = \frac{ni}{N}$
ni = number of individuals of species i
N = the total number of individuals of all species

Low diversity (H'<1) indicates that ecosystem conditions are unstable or disturbed, moderate diversity (1<H'<3) indicates a fairly stable ecosystem, and high diversity (H'>3) indicates a stable ecosystem condition (Jurnaliah, 2011). The Shannon-Wiener's diversity index is calculated using Microsoft Excel.

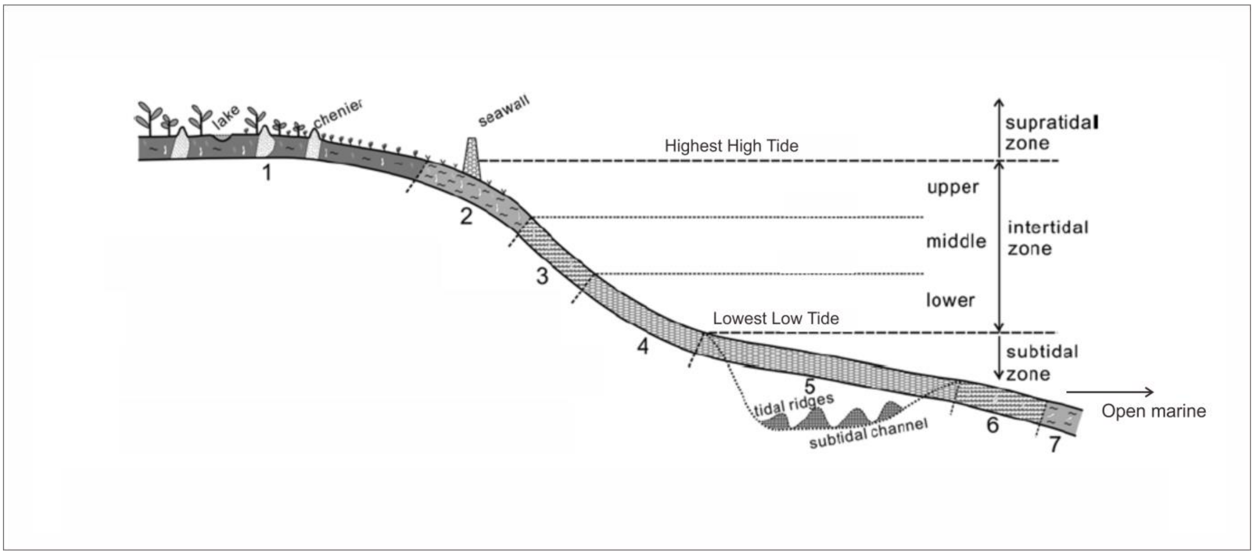

Fig. 4. Classification of tidal zone (Modified from Fan, 2012).

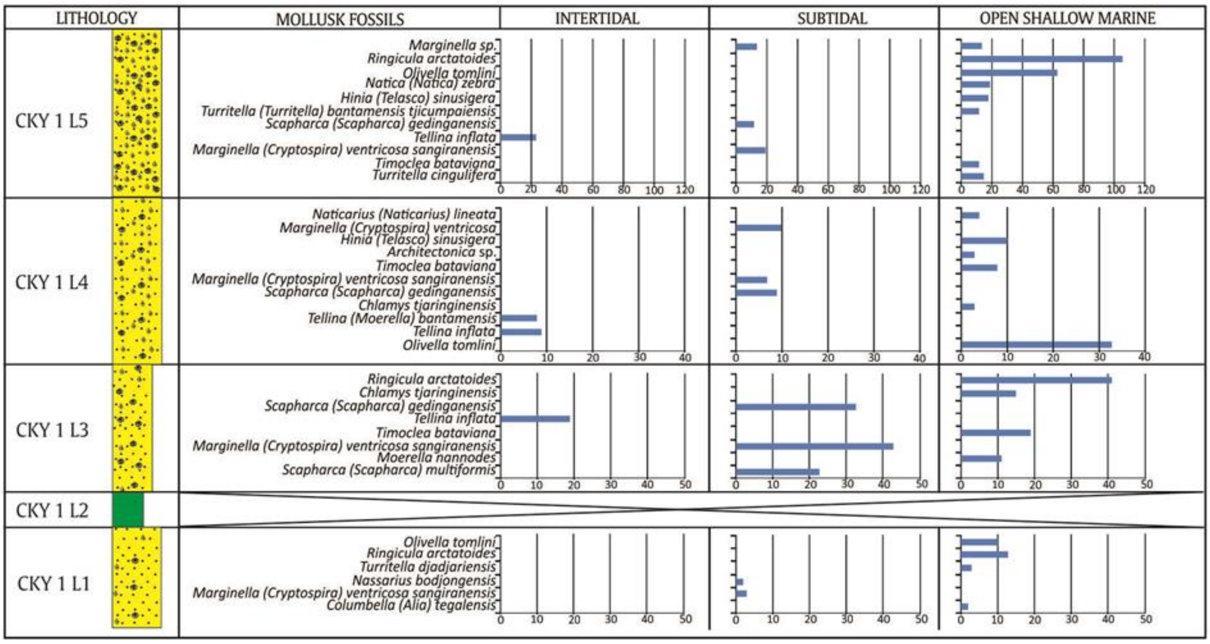

Fig. 5. Determination diagram of mollusk CKY 1.

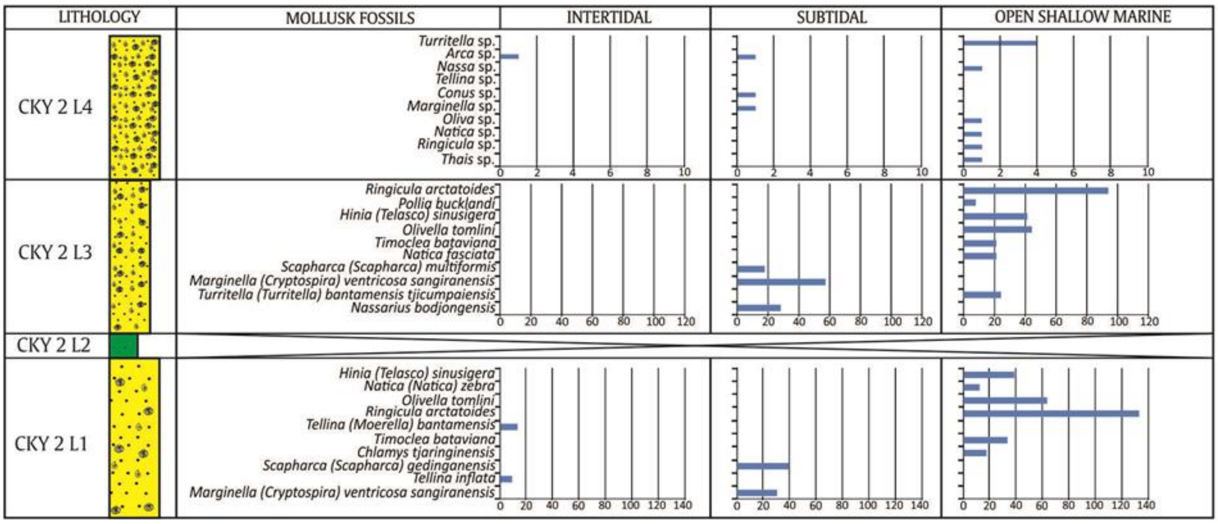

Fig. 6. Diagram determination of mollusk CKY 2.

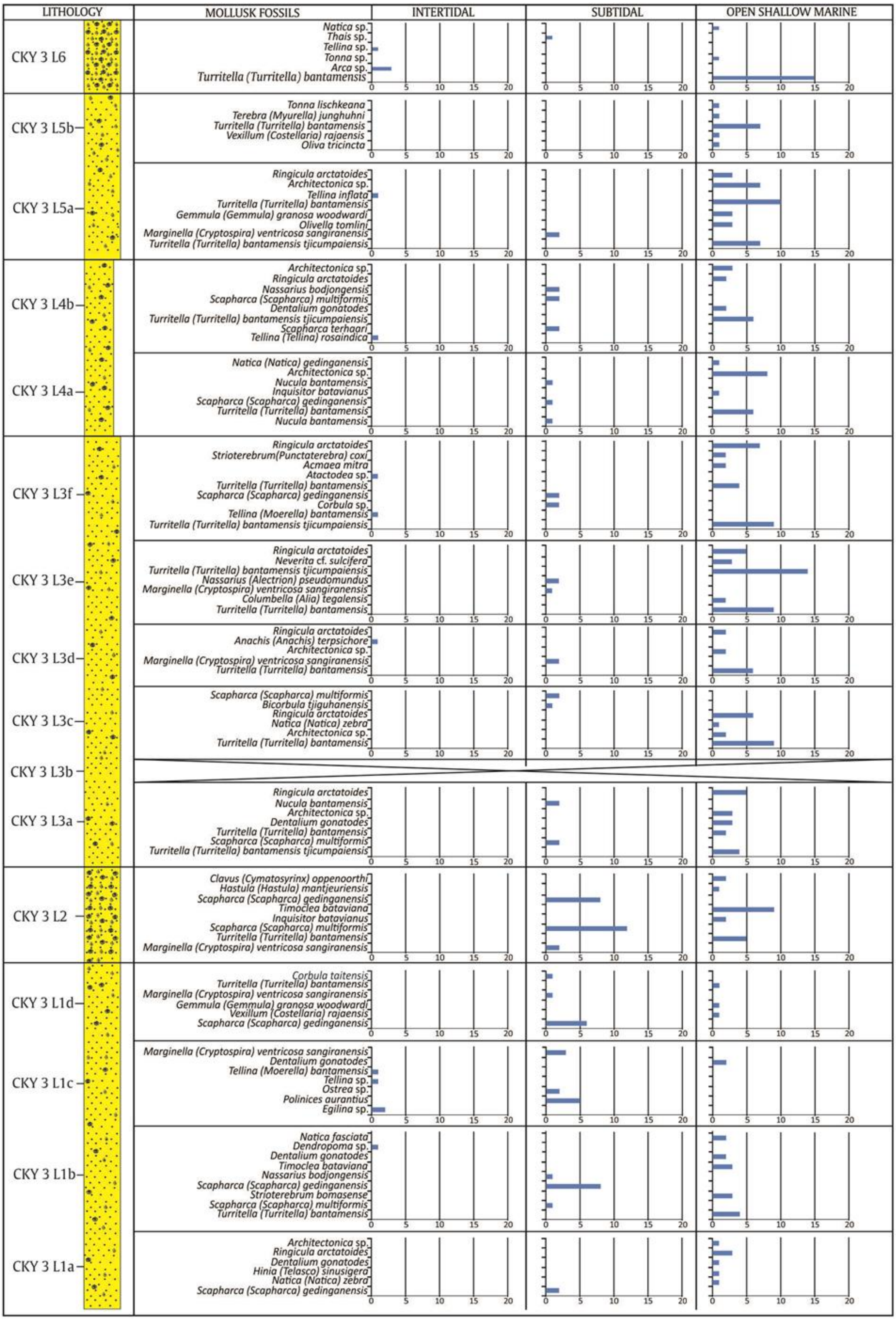

Fig. 7. Diagram determination of mollusk CKY 3.

3. Result and Discussion

Based on this research, 2373 mollusk fossils were obtained from 22 samples which is taken from Cikumpay and Cikuya rivers. Its consist of 222 species (56 bivalves, 164 gastropods, and 2 scaphopods). The data of dominant mollusk fossil species in CKY 1, CKY 2, and CKY 3 showed by graphic (Fig. 5,6, and 7). The dominant mollusk fossils are used to determine depositional environmental.

Lithology and mollusk fossils association in CKY 1 and CKY 2 shows similarities so they are interpreted as the same layer. Based on the strike / dip measurements, CKY 3 is interpreted to be younger than CKY 1 and CKY 2. Total thickness of measured stratigraphic section is 4.2 meters. The lithology is dominated by very fine-fine grained calcareous sandstones with non-calcareous claystone intercalation. At the top, there is a coquina sandstone with abundant mollusk fossils (Fig. 8.).

The results of determination represents 17 mollusk associations with 10 species variations. From these associations, it can used to analyze the depositional environmental changes from old to young layers which are correlated with local sea level changes. Classification of the depositional environmental is divided into 3, namely: intertidal, subtidal, and open shallow marine. At least there are seven depositional environmental changes that occurs in this research area, there are: open shallow marine environments that change slightly to open shallow marine – subtidal environment and then back to open shallow marine environment. Furthermore, the environment will revert gradually to subtidal, then slowly deeper into open shallow marine environment.

The diversity index value of the samples which is taken from this study ranged from 1,095 - 3,182 (Table 1.). The highest diversity index value is at CKY3 L5a, while the lowest diversity index value is at CKY3 L6. This can be interpreted that the research area is a medium – high productivity area and has a fairly stable – stable ecosystem.

Based on the mollusk fossil associations, two shallowing-deepening sea level local cycle was occurred at the Cimanceuri Formation (Fig. 8). Start from association 1 (CKY1 L1), it is an open shallow marine environment characterized by association of *Ringicula arctatoides - Olivella tomlini* (Fig.9). In association 2 (CKY1 L3) there are still abundant *Ringicula arctatoides* but it is also followed by the abundance of *Marginella (Cryptospira) ventricosa sangiranensis* (Fig.10). These fossils has an intertidal-subtidal environment. It can be interpreted that sea level becomes shallow and returning to open shallow marine environment on the layer above it. Its showed by associations *Olivella tomlini, Ringicula arctatoides - Olivella tomlini*, and *Ringicula arctatoides* (Association 3,4,5) respectively. In association 6 (CKY3 L1b) the environment returns to shallow again. it is showed by an abundance *of Turritella (Turritella) bantamensis - Scapharca (Scapharca) gedinganensis* at the same time. Furthermore, in Associations 7 and 8 (CKY3 L1c & L1d) is getting shallowing until subtidal environment, which is characterized by the abundant of *Polinices aurantius - Marginella (Cryptospira) ventricosa sangiranensis* and *Scapharca (Scapharca) gedinganensis* associations.

The environment has changed back into an open shallow marine slowly which is indicated by the abundant presence of intertidal-subtidal mollusk fossils, *Scapharca (Scapharca) multiformis* and the abundance of open shallow marine environment fossils, *Timoclea bataviana* (Association 9). Hereafter, the sea level was becomes deeper with consecutively association of *Turritella (Turritella) bantamensis tjicumpaiensis – Ringicula arctatoides, Turritella (Turritella) bantamensis – Ringicula arctatoides, Turritella (Turritella) bantamensis tjicumpaiensis – Turritella (Turritella) bantamensis, Turritella (Turritella) bantamensis tjicumpaiensis – Ringicula arctatoides, Turritella (Turritella) bantamensis – Architectonica* sp., *Turritella (Turritella) bantamensis tjicumpaiensis*, *Turritella (Turritella) bantamensis – Turritella (Turritella) bantamensis tjicumpaiensis,* and *Turritella (Turritella) bantamensis* (Association 10-17).

Table 1. Table Diversity index in this study

Location	Total number of individuals	Number of species	Diversity index
CKY3 L6	22	6	1,095
CKY3 L5b	13	8	1,567
CKY3 L5a	74	37	3,182
CKY3 L4b	43	28	3,144
CKY3 L4a	29	17	2,375
CKY3 L3f	51	29	2,957
CKY3 L3e	45	16	2,282
CKY3 L3d	26	16	2,548
CKY3 L3c	25	11	1,942
CKY3 L3a	50	31	3,07
CKY3 L2	65	23	2,613
CKY3 L1d	13	8	1,738
CKY3 L1c	36	24	2,869
CKY3 L1b	44	28	3,036
CKY3 L1a	9	6	1,677
CKY2 L4	15	12	2,338
CKY2 L3	455	61	2,98
CKY2 L1	499	57	2,847
CKY1 L5	387	45	2,689
CKY1 L4	138	38	2,969
CKY1 L3	287	45	2,963
CKY1 L1	47	19	2,392
Total	2373		

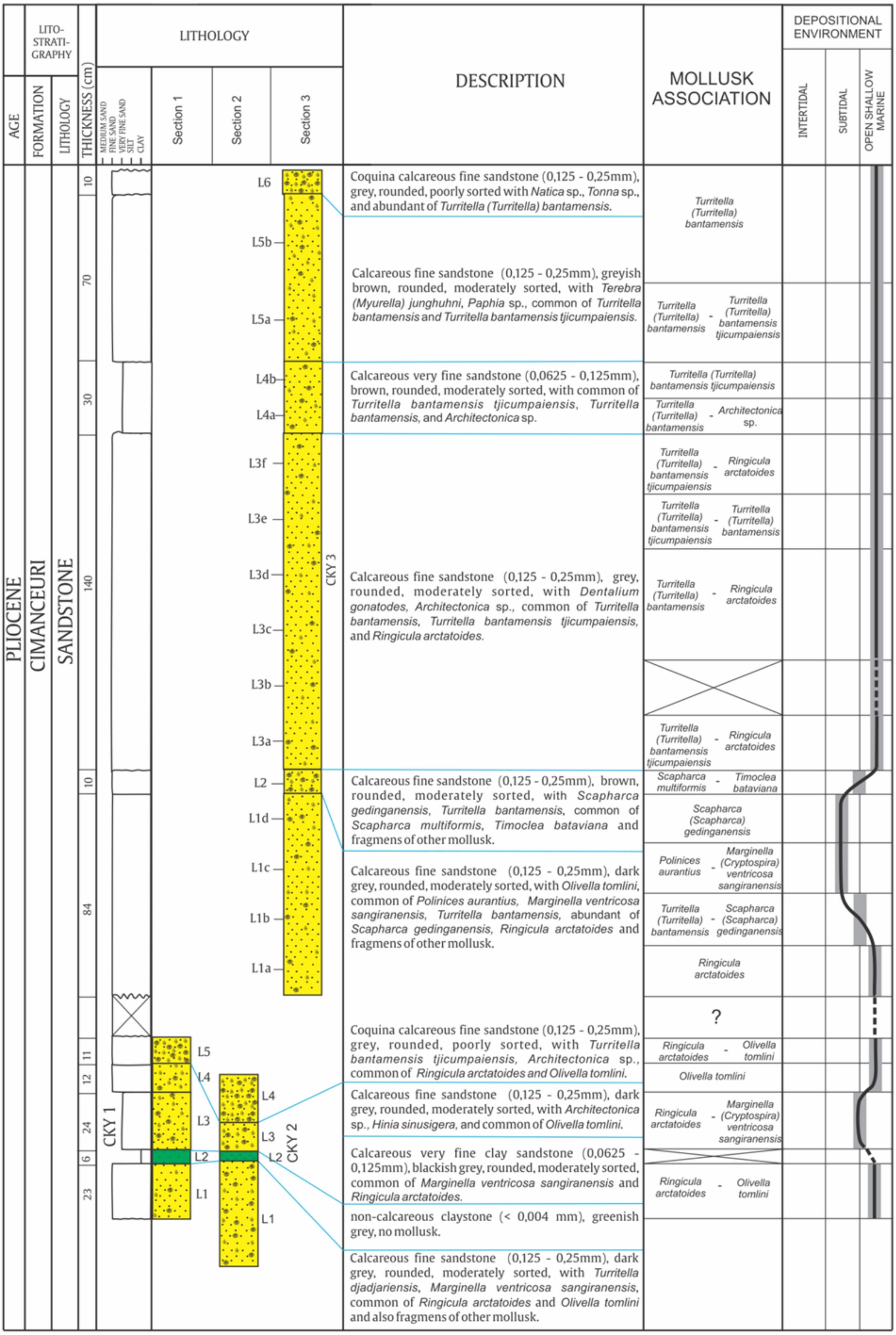

Figure 8. Composite stratigraphic coloumn and local sea levelchanges in research area (getting to the right → deeper).

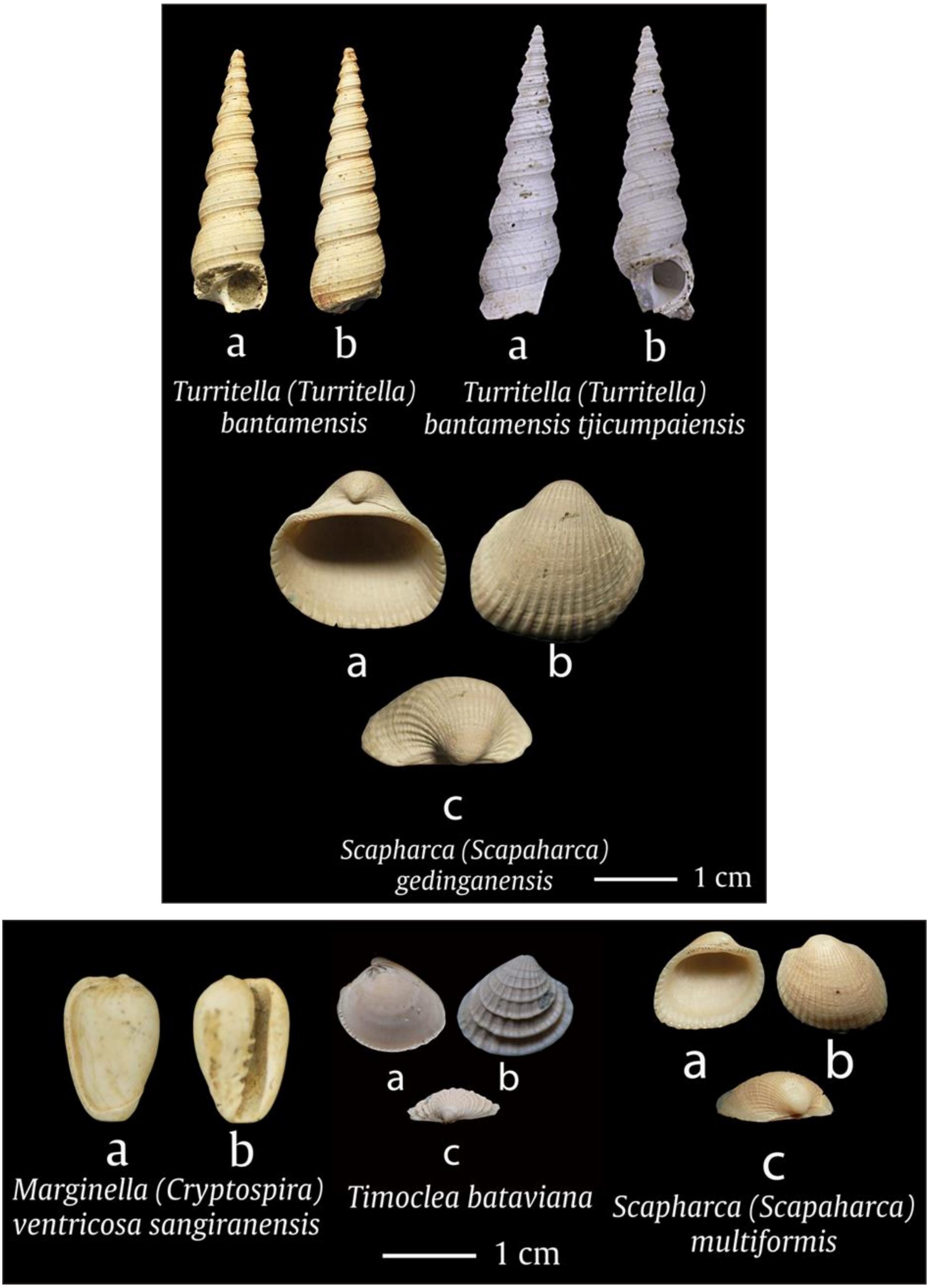

Fig. 9. The Examples of macro-mollusk fossils in this study (Gastropods, a: Ventral view, b:Dorsal view; Bivalvia, a:Internal view, b:Eksternal view, c: Dorsal view).

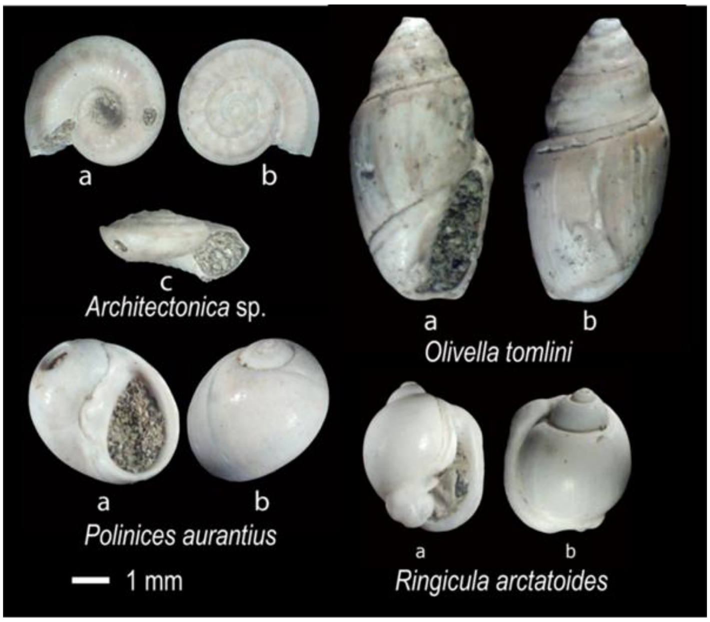

Fig. 10. The Examples of micro-mollusk fossils in research area (a: Ventral view, b:Dorsal view

In summary, the whole mollusk fossil association assemblages above are interpreted as sea level rise. Similar results also stated in several previous research: Martodjojo (2003) explained Banten in Pliocene, remains in the south where the environment is transitional environment (Cimanceuri Formation). The Bogor Basin environment in Pliocene is divided into two parts. Most of The Bogor Basin environment is terrestrial occupied by volcanic arc but Southern Mountains Region has subsidence and transgression, according to Zhong et al (2004) the history of eustatic sea level change since the Pliocene began with a rapid rise from 5.33 to 5.1 Ma. The sea level at highstand between 5.1 and 3.7 Ma, Roza et al (2015) reported fluctuations began to occur during the Middle Pliocene where sea level tended to increase (transgression) and fell back to the Late Pliocene, and Morley et al (2016) stated that major transgression occurred across the Sunda Shelf at the beginning of the Pliocene.

4. Conclusion

There are seven depositional environmental changes that occur in this study with two shallowing – deepening cycles. Depositional environmental changes (bottom-top) consist of: 1) open shallow marine, 2) subtidal – open shallow marine, 3) open shallow marine, 4) open shallow marine – subtidal, 5) subtidal, 6) subtidal – open shallow marine, and 7) open shallow marine. This result similar to several previous research that stated in Pliocene sea level tended to rise. In this area 17 mollusk fossils associations were obtained, namely 1) *Ringicula arctatoides - Olivella tomlini*. 2) *Ringicula arctatoides - Marginella (Cryptospira) ventricosa sangiranensis*. 3) *Olivella tomlini,* 4) *Ringicula arctatoides - Olivella tomlini*, 5) *Ringicula arctatoides*, 6) *Turritella (Turritella) bantamensis - Scapharca (Scapharca) gedinganensis*, 7) *Polinices aurantius - Marginella (Cryptospira) ventricosa sangiranensis,* 8) *Scapharca (Scapharca) gedinganensis*, 9) *Scapharca (Scapharca) multiformis - Timoclea bataviana,* 10) *Turritella (Turritella) bantamensis tjicumpaiensis - Ringicula arctatoides,* 11) *Turritella (Turritella) bantamensis – Ringicula arctatoides,* 12) *Turritella (Turritella) bantamensis tjicumpaiensis - Turritella (Turritella) bantamensis ,* 13) *Turritella (Turritella) bantamensis tjicumpaiensis - Ringicula arctatoides,* 14) *Turritella (Turritella) bantamensis - Architectonica* sp., 15) *Turritella (Turritella) bantamensis tjicumpaiensis*, 16) *Turritella (Turritella) bantamensis – Turritella (Turritella) bantamensis tjicumpaiensis*, and 17) *Turritella (Turritella) bantamensis*. The most stable ecosystem condition is the association of *Turritella (Turritella) bantamensis tjicumpaiensis - Turritella (Turritella) bantamensis* (Association 15/CKY L5a) with the value of diversity index is 3,182.

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