Bulletin of Scientific Contribution GEOLOGY

Fakultas Teknik Geologi
UNIVERSITAS PADJADJARAN
homepage: http://jurnal.unpad.ac.id/bsc
p-ISSN: 1693-4873; e-ISSN: 2541-514X

Volume 22, No.3
Desember 2024

CHARACTERISTICS OF LIMESTONES FROM THE CIBODAS FORMATION AND CIKARANG MEMBER OF JAMPANG FORMATION IN CIKANGKUNG AREA, SUKABUMI REGENCY, WEST JAVA

Muhammad Hafidz Maulana[1], Santi Dwi Pratiwi[1*]
[1] Faculty of Geological Engineering, Universitas Padjadjaran
Jl.Ir. Soekarno KM 21, Sumedang Regency, West Java 45363, Indonesia
*Corresponding author: santi.dwi.pratiwi@unpad.ac.id

ABSTRACT
This research aims to identify the lithological characteristics as well as the occurrence of larger benthic foraminifera in limestone from the Cikangkung and surrounding area, Sukabumi Regency with coordinates between 106°25'40.707" E to 106°28'23.581" E and 7°19'00.738" S to 7°21'12.833" S. The area is predominantly by rock units belonging to the Cikarang Member of the Jampang Formation and the Cibodas Formation. With focuses on classifying limestone and distinguishing the limestone from those two formations through petrographic characteristics, and microfossil analysis, four types of limestone were identified as tuffaceous limestone, grainstone, packstone, and boundstone. Petrographic analysis shows compositional differences in the tuffaceous limestone, which contains pyroclastic materials such as glass, silica minerals, and mafic minerals, in line with the high volcanic activity. Based on ten species of the larger benthic foraminifera, tuffaceous limestone was deposited during the Early Miocene (Te5), which led to the age of deposition of carbonate volcaniclastic rocks in the Cikarang Member of Jampang Formation. Meanwhile, the other three limestone types do not contain pyroclastic components, indicating low volcanic activity during their deposition and it was deposited during the Mio-Pliocene. Based on similarities in age, environment, and characteristics of grainstone, packstone, and boundstone types are grouped as part of the Cibodas Formation, which was deposited during the Late Miocene to Pliocene (Tf3–Th). This study contributes to understanding the stratigraphic differences and the geological history of the limestone in this region, highlighting the influence of volcanic and marine processes on limestone formation.

Keywords: Limestone, Cikangkung, Cibodas Formation, Cikarang Member of Jampang Formation

INTRODUCTION

The Indo-Pacific oceanic reef provinces are the primary contributors to global reef carbonate production, accounting for 75% of the total (Langer 1997). This region's high carbonate productivity aligns with its status as the Indo-Pacific center of coral and foraminifera biodiversity (Langer and Hottinger, 2000; Roberts et al., 2002). According to Murray (1973) and Boudagher-Fadel (2008), living foraminifera can tolerate a minimum temperature of 18°C and a maximum water depth of 35 meters. Their large tests dominate many carbonate platforms and are key contributors to limestone formation in tropical and subtropical regions (Hottinger, 1982),

Limestone is a carbonate rock mainly composed of calcium carbonate ($CaCO_3$) or calcium magnesium carbonate ($CaMg(CO_3)_2$), derived from organic remains or precipitation. It is classified as limestone when over 90% consists of carbonate minerals like calcite and aragonite and typically forms in tropical shallow marine environments (Tucker, 2001).

There are three main components in limestone which consist of grains, matrix, and cement (Tucker & Wright, 1990). Dunham (1962) classified limestones based on the depositional texture of the limestone, and the fundamental criterion is the nature of the framework. Its groups of limestones are divided into six categories (mudstone, wackstone, packstone, grainstone, boundstone and crystalline carbonate) reflecting their depositional environment and texture. Our research area is predominantly composed of rocks from the Cikarang Member of Jampang Formation (Tmjc) in the northern to central area and Cibodas Formation in the southern area (Sukamto, 1975). This rock unit was deposited during the Late Oligocene to Early Miocene in a deep marine environment (Ramdhani, 2024; Pratiwi et al., 2024; Pratiwi et al., 2023). During the Lower Miocene to Middle Miocene period, transgression occurred and most of the Sukabumi - Palabuhanratu area and its surroundings were affected by seawater invasion (Alif, 2011). Baumann et al. (1973) also reported the presence of Late Oligocene or Early Miocene volcanic rocks in Southern Java. Several types of large benthic foraminifera have been identified in the sedimentary rocks of the Cikarang Member of Jampang Formation, including *Lepidocyclina angulosa*, *Miogypsina kotoi*, *Miogypsina thecideaeformis*, *Cycloclypeus*, *Trillina howchini*, *Katacycloclypeus annulatus*, *Spiroclypeus*, *Eulepidina*, *Nephrolepidina*, and *Operculina* (Sukamto, 1975). The Cibodas Formation (Tmci) was deposited in shallow marine during the Late Miocene to Pliocene (Sukamto, 1975). Meanwhile, the large benthic foraminifera commonly found in the rocks of the Cibodas Formation include *Lepidocyclina verbeeki*, *Cycloclypeus*, and *Operculina* (Sukamto, 1975). Prinaldi et al (2023) suggested that the Cibodas Formation (Tmci) in the Pasiripis area, Sukabumi district is underlain by carbonate limestones and sandstones. In addition, the reef limestone unit after being examined megascopically and analyzed microscopically by petrographic analysis consists of boundstone, packstone, and wackestone (Prinaldi et al., 2023). These distinct foraminiferal assemblages provide valuable insights into differences in depositional environments and geological age histories between the two formations.

Despite previous work on the stratigraphy and paleontology of the Ciracap area, detailed petrographic studies combined with microfossil analysis remain limited for Cibodas and Jampang Formation of Cikarang Member. Moreover, the depositional periods and processes influencing limestone formation, particularly the interplay between volcanic and marine influences, are not fully understood. Addressing this research gap is essential for refining our understanding of the formation age or depositional environment periods. The study highlights to identify differences between limestone from the Cibodas Formation (Tmci) and limestone from the Cikarang Member of Jampang Formation (Tmjc) by examining petrographic characteristics and microfossil (larger benthic foraminifera) analysis to reconstruction of age in depositional periods (Figure2). Visual analyses included the identification of sedimentary structures along with Dunham's (1962) rock types and larger benthic foraminifera age Zone based on Lunt (2013).

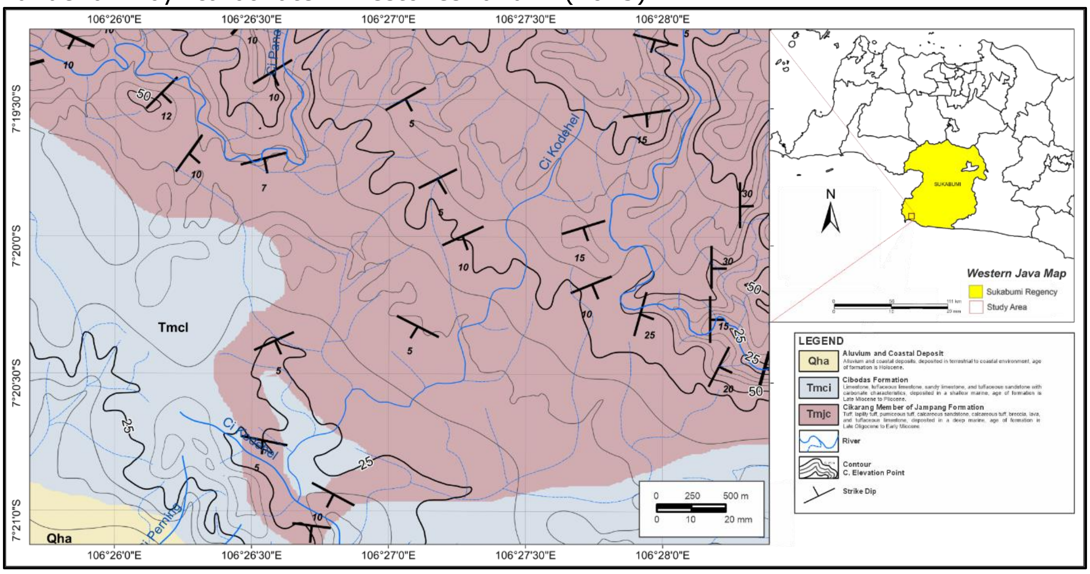


Figure 1. Map showing location of study area in Sukabumi and and geologic map of Cikangkung area. The geological formation map the study area at Sukabumi, West Java, Indonesia modified from Sukamto (1975)

METHOD

The study area is situated in Cikangkung, Sukabumi Regency, within the coordinates 106°25'40.707" E to 106°28'23.581" E and 7°19'00.738" S to 7°21'12.833" S (Figure 1).

This study was conducted in three main stages which consist of fieldwork mapping, laboratory analysis, and data interpretations. In the fieldwork stage, primary data was collected, including the identification of outcrop locations, outcrop descriptions, and rock sampling (Figure 2). In the laboratory, petrographic analysis was conducted to examine the components of the limestone using a polarizing microscope, and microfossils analysis was conducted to identify the types and abundance of foraminifera to determine the relative age and depositional environment. Output of study were derived based on the results of the petrological, petrographic, and microfossil analysis. The classification of limestone follows Dunham (1962), while the age were determined based on larger benthic foraminifera Letter Stage according to Lunt (2013). The identification of large foraminifera species refers to several references, such as Lunt & Allan (2004) and Boudaugher-Fadel (2008).

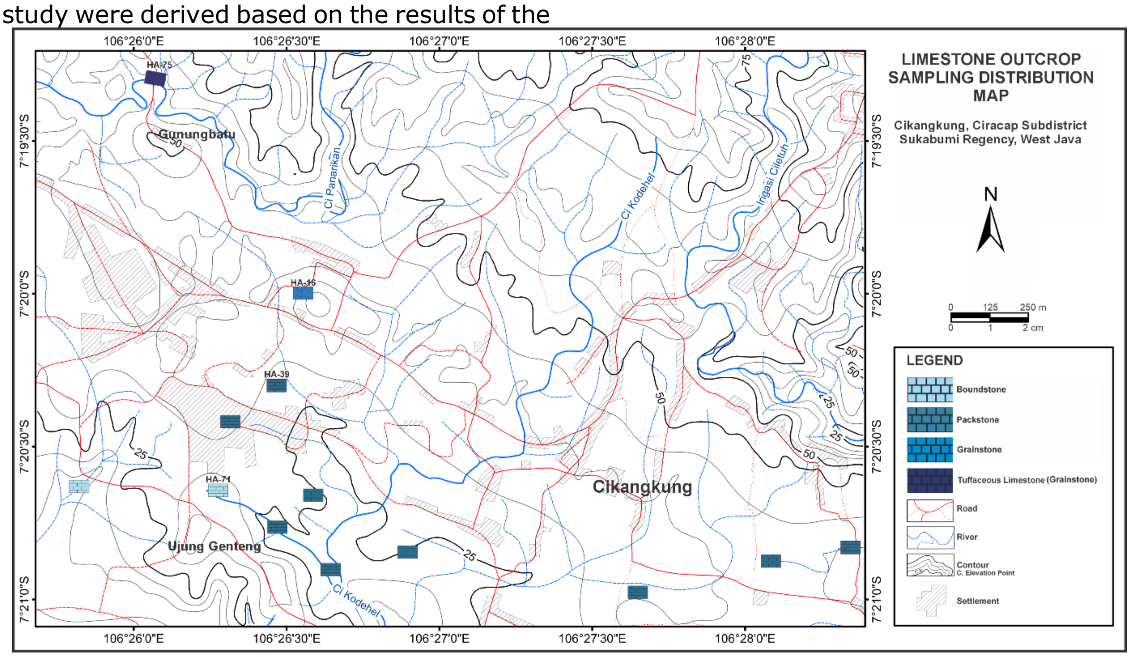


Figure 2. A geographical position of limestone outcrops sampling distribution in study area

RESULTS AND DISCUSSION

The grouping of rock units in this study was initially based on lithofacies principles, focusing on similarities in their rock characteristics, and further supported by the correlation of depositional periods determined from microfossil analysis. The outcrops found around Gunungbatu area, with mainly tuffaceous sandstone, fine tuff, sedimentary breccia, basalt lava, and tuffaceous limestone where belong to . Cikarang Member of Jampang Formation (Tmjc). The tuffaceous limestone found around the Ci Panarikan River with a thickness of approximately 90 cm. Rock samples from the Cibodas Formation (Tmci) are exposed around Cikangkung and Ujung Genteng area, Ciracap Subdistrict and typically clastic and non-clastic limestone.

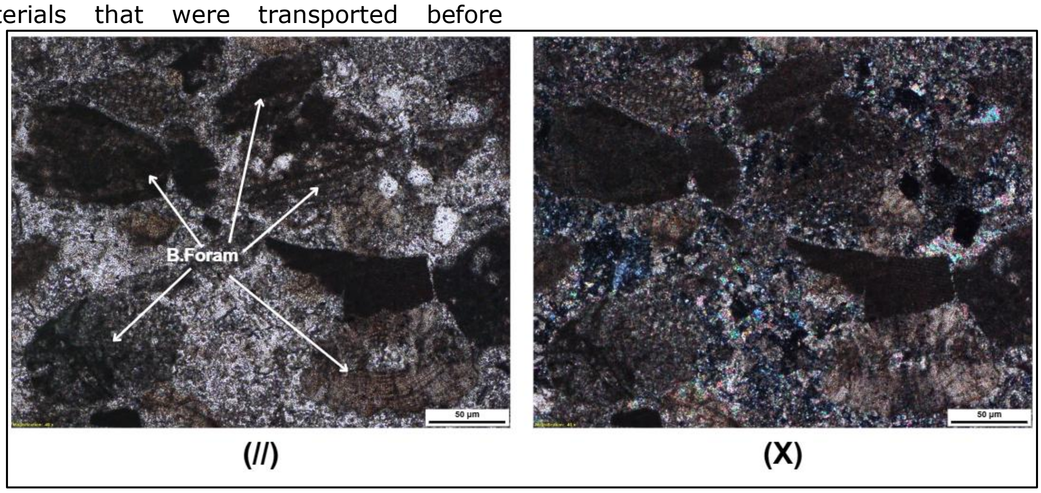
Based on the field observations and laboratory analysis, it can be concluded that there are four distinct types of limestone in the study area.

Tuffaceous Limestone

This rock sample is hand specimen shows a fresh whitish-gray color and a weathered brownish-black color. The grain is poorly sorted with mostly subangular-subrounded shape. The grain size is approximately 1/2 - 1 mm. It is grain-supported, where the constituent fragments are closely packed together to form a compact fabric. The rock fragments are limestone (allochthonous), with many large foraminiferal shell fragments and mollusks (Figure 3). There is a significant presence of glass, ash, carbonate minerals, silica minerals, and mafic minerals.

Figure 3. Overview of the limestones outcrop at Ci Panarikan river, Gunungbatu area (HA-75 locality)

Under the microscope, the rock appears whitish-gray (PPL) and light gray (XPL), the depositional texture is observed and the components are not bound to each other (Figure 4). The grain is poorly sorted, fabric is closed (grain-supported), and the mud content is less than 10%. The constituent fragments include skeletal fragments (benthic foraminifera, a few planktic foraminifera, pteropod, algae), glass, carbonate minerals, abundant quartz minerals, amphibole minerals, other silica minerals, and iron oxides (up to 50 percent volcanic tuff). It can be concluded that the formation of this rock is allochthonous because it contains various materials that were transported before deposition. The large benthic foraminifera observed in this rock include *Planorbulinella larvarta, Cycloclypeus eidae, Lepidocyclina angulosa, Miogypsina kotoi, L.* (*Nephrolepidina*) *sumatranensis, L.* (*Nephrolepidina*) *rutteni, Nephrolepidina* sp., *Miogypsinoides* sp., *Spiroclypeus* sp., and others (Figure 5). Based on the Dunham (1962) classification, this rock is named Grainstone. The relative age of tuffaceous limestone based on larger benthic foraminifera assemblage is shown in Table 1. The large benthic foraminifera identified in thin sections indicate a relative age of Early Miocene (Te5).



B.Foram : Large Benthic Foraminifera

Figure 4. Thin-section photomicrographs of Tuffaceous Limestone (HA-75)

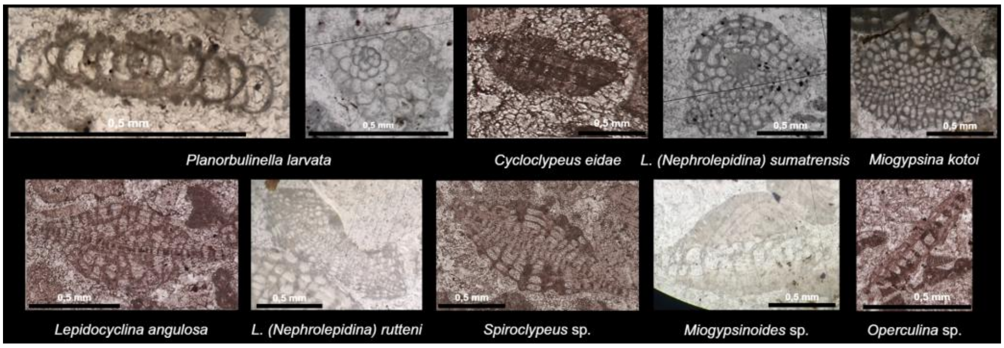


Figure 5. Larger benthic foraminifera in Tuffaceous Limestone thin section (HA-75)

Table 1. The relative age of Tuffaceous Limestone based on larger benthic foraminifera (Lunt, 2013)

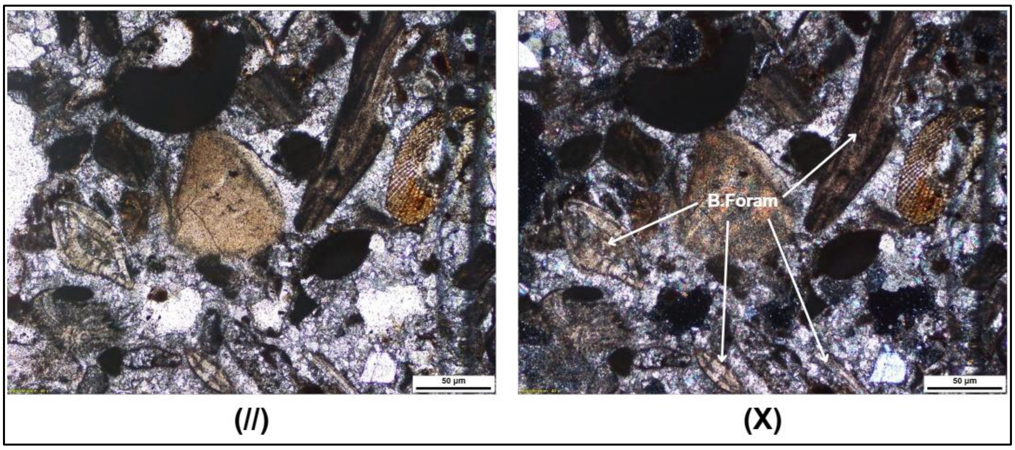
No	Letter Stage (Lunt, 2013)	Oligocene			Miocene				Pliocene	Quaternary
		L			E		M	L		
		Te1	Te2-3	Te4	Te5	Tf1	Tf2	Tf3	Th	
1	*Planorbulinella larvata* (Parker and Jones, 1865)	—	—	—	—	—	—	—	—	—
2	*Cycloclypeus eidae* (Tan, 1930)			—	—	—	—	—	—	—
3	*Lepidocylina angulosa* (Prever, 1909)	—	—	—	—	—	—			
4	*Miogypsina kotoi* (Hanzawa, 1931)				—	—	—			
5	*L (Nephrolepidina) sumatranensis* (Brady, 1875)	—	—	—	—	—	—			
6	*L (Nephrolepidina) rutteni* (van der Vlerk, 1924)	—	—	—	—	—	—			
7	*Nephrolepidina* sp. (H. Douville, 1911)	—	—	—	—	—	—			
8	*Miogypsinoides* sp. (Yabe & Hanzawa, 1928)			—	—	—				
9	*Spirocylpeus* sp. (Douville, 1905)		—	—	—					
10	*Operculina* sp. (d'Orbigny, 1826)	—	—	—	—	—	—	—	—	—

Grainstone

The rock sample hand specimen shows a fresh light grayish-white color with a weathered yellowish-brown hue (Figure 6), and has a very compact body of rock. and the depositional texture is recognizable. It is grain-supported, where the constituent fragments are closely packed together to form a compact fabric. The rock exhibits many pore structures formed by carbonate dissolution, and the grain size is approximately 1/2 - 1 mm. Several mollusk shells are present within the rock. Biogenic structures, including external and internal molds of shell casts, are also observed.

Figure 6. Overview of the limestones outcrop at Cikangkung area (HA-16 locality)

Under the microscope, the rock appears brownish-gray under PPL and dark brownish-black under XPL (Figure 7). The depositional texture is recognizable, and the components are not bound to each other. The grain size is poorly sorted, and grain-supported with less than 10% mud. The fragments include skeletal fragments (benthic foraminifera, planktic foraminifera, algae), non-skeletal fragments, carbonate minerals, and iron oxides. Additionally, there is mud and sparite that surrounds the fragments. It can be concluded that the rock forms allochthonous because it contains various materials transported before deposition. Large benthic foraminifera identified in this rock is consist of *Palaeonummulites* sp., *Amphistegina* sp., *Cycloclypeus* sp., *L.* (*Trybliolepidina*) sp., *Operculina* sp., and *Alanlordia* sp. (Figure 8). According to Dunham's classification (1962), this rock is classified as Grainstone. The relative age of grainstone based on larger benthic foraminifera distribution is shown in Table 2. The abundance of large benthic foraminifera in thin sections suggests deposition during the Late Miocene - Pliocene (Tf3-Th).



B.Foram: Large Benthic Foraminifera
Figure 7. Thin-section photomicrographs of Grainstone (HA-16)

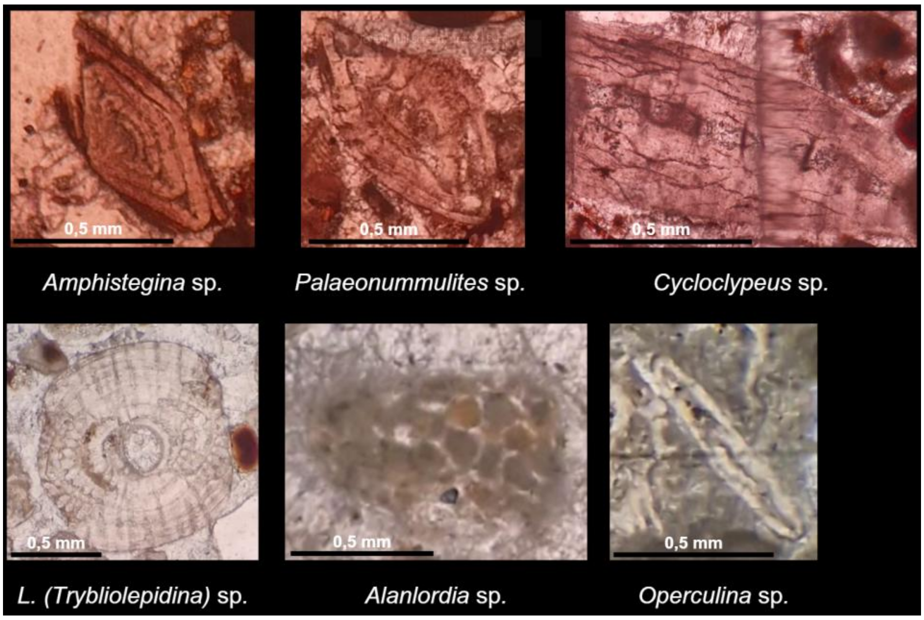


Figure 8. Larger benthic foraminifera in Grainstone thin section (HA-16)

Table 2. The relative age of Grainstone based on larger benthic foraminifera (Lunt, 2013)

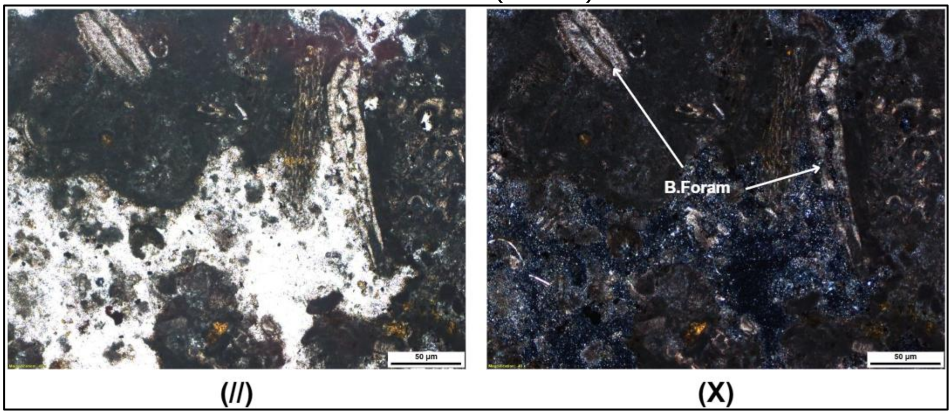
No	Letter Stage (Lunt, 2013)	Oligocene			Miocene					Pliocene	Quaternary
		L			E		M		L		
		Te1	Te2-3	Te4	Te5	Tf1	Tf2	Tf3		Th	
1	*Paleonummulites* sp. (Schubert, 1908)										
2	*Amphistegina* sp. (d'Orbigny, 1826)										
3	*L. (Trybliolepidina)* sp. (van Der Vlerk, 1928)										
4	*Operculina* sp. (d'Orbigny, 1826)										
5	*Alanlordia* sp. (Banner and Samuel, 1995)										
6	*Cycloclypeus* sp. (W.B. Carpenter, 1865)										

Packstone

This rock sample is a hand specimen, a fresh yellowish-white color with a weathered yellow-brown hue. The depositional texture is recognizable, grain-supported and the grain size is approximately 1/4 - 1 mm and subrounded (Figure 9). Several mollusk shells (bivalves and gastropods), bryozoans, and other shell fossils are present within the rock. Biogenic structures in the form of external and internal molds are also observed as shell casts.

Figure 9. Overview of the limestones outcrop at Ujung Genteng area (HA-39 locality)

Under the microscope, the rock appears dark gray (PPL) and brownish-gray (XPL). The fragments include skeletal fragments (benthic foraminifera, planktic foraminifera, algae, corals, bryozoans), containing a high percentage of skeletal fragments and carbonate minerals. Additionally, there is micrite (mud) (Figure 10). It can be concluded that the deposition of this rock is allochthonous because it contains various materials transported before deposition. Large benthic foraminifera identified in this rock include *Amphistegina* sp., *Palaeonummulites* sp., *Alanlordia* sp., *Operculina* sp., *Sporadotrema* sp., and *Cycloclypeus eidae* (Figure 11). According to Dunham's classification (1962), this rock is classified as Packstone. The relative age of packstone based on larger benthic foraminifera is indicated in Table 3. The abundance of large benthic foraminifera in thin sections from this sample suggests deposition during the Late Miocene - Pliocene (Tf3-Th).



B.Foram: Large Benthic Foraminifera

Figure 10. Thin-section photomicrographs of Packstone (HA-39)

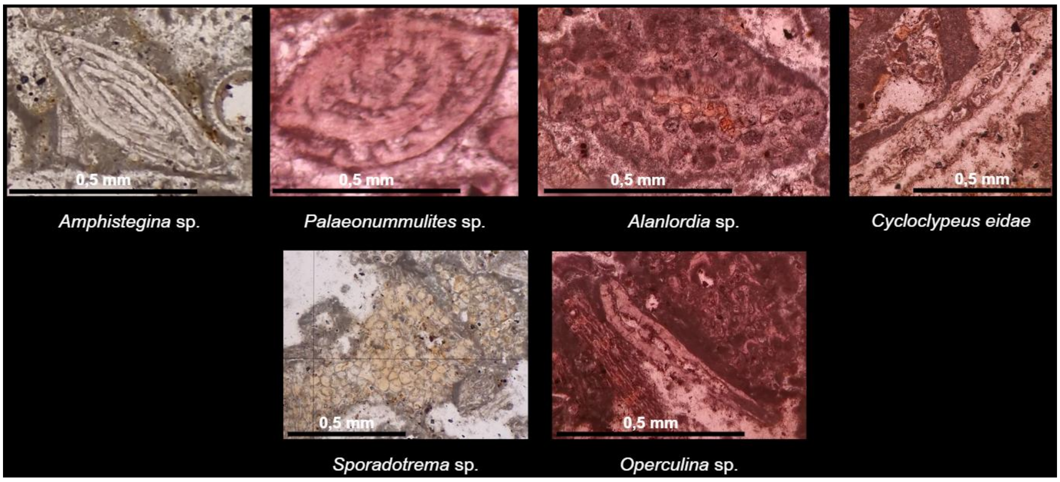


Figure 11. Larger benthic foraminifera in Packstone thin section (HA-39)

Table 3. The relative age of Packstone based on larger benthic foraminifera (Lunt, 2013)

No	Letter Stage (Lunt, 2013)	Oligocene			Miocene					Pliocene	Quaternary
		L			E		M		L		
		Te1	Te2-3	Te4	Te5	Tf1	Tf2	Tf3		Th	
1	*Amphistegina* sp. (d'Orbigny, 1826)										
2	*Palaeonummulites* sp. (Schubert, 1908)										
3	*Alanlordia* sp. (Banner and Samuel, 1995)										
4	*Operculina* sp. (d'Orbigny, 1826)										
5	*Sporadotrema* sp. (Hickson, 1911)										
6	*Cycloclypeus eidae* (Tan, 1930)										

Boundstone

This rock sample is a hand specimen, a fresh yellowish-white color and a weathered brownish-black color. It is hard in texture. The depositional texture is recognizable. The rock shows porosity structures resulting from the dissolution of carbonate materials. The outcrop structure suggests the possibility of a binding structure formed by the remnants of the organisms composing it. The outcrop shows a reef structure (Figure 12).

Figure 12. Overview of the limestones outcrop at Ujung Genteng area (HA-71 locality)

Under the microscope, the rock appears dark gray under PPL and brownish-gray under XPL. The depositional texture is recognizable, and the components are bound to each other. The bound components form interconnected chains, creating a compact (binding) structure that stabilizes the components during deposition. The grain size is moderately sorted and pore space is open. The main skeletal components that are bound together belong to thread-shaped green algae. The fragments consist of skeletal fragments of green algae. The minerals include opaque minerals, quartz, and glauconite (Figure 13). There is carbonate cement filling the spaces between the fragments and serving as a binder. Additionally, there is micrite (microcrystalline calcite) comprising a mud. Vuggy porosity is present, consisting of voids created by meteoric dissolution. This rock is likely autochthonous because its primary binding components are algae that grew in situ, along with other components that formed in the same environment. According to Dunham's classification (1962), this rock is classified as Boundstone.

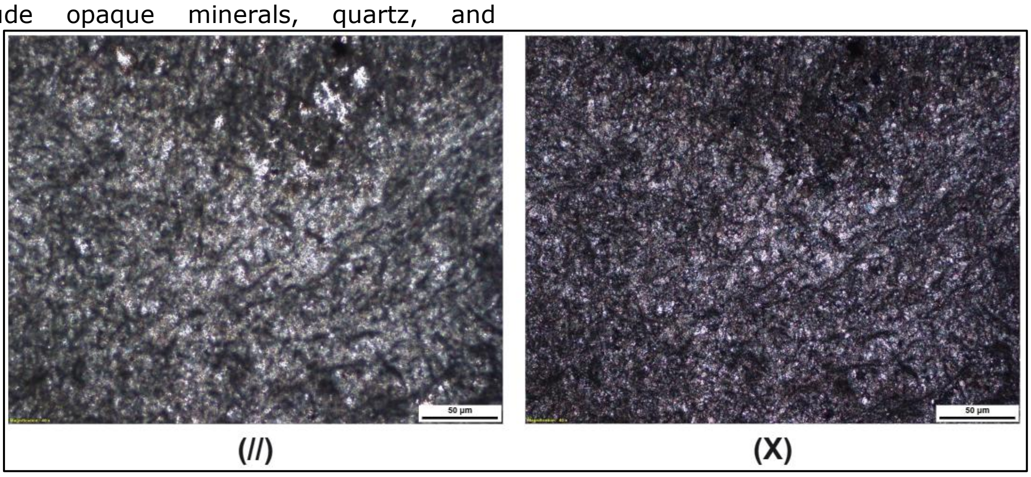


Figure 13. Thin-section photomicrographs of Boundstone (HA-71)

CONCLUSION

The results of this study indicate that four distinct types of limestone outcrop in the Cikangkung area of Sukabumi Regency, namely tuffaceous limestone, grainstone, packstone, and boundstone, lead to their classification into the Cikarang Member of the Jampang Formation and Cibodas Formation. Ten benthic foraminifera species in tuffaceous limestone samples, and six species from grainstone and packstone have been identified from those two formations. Based on petrographic and microfossils analysis, the tuffaceous limestone, characterized by its pyroclastic components (glass, silica minerals, and mafic minerals), corresponds to the Early Miocene (Te5). This aligns with a period of high volcanic activity, resulting in the deposition of carbonate volcaniclastic rocks associated with the Cikarang Member of the Jampang Formation. On the other hand, the grainstone, packstone, and boundstone types of limestone, which lack pyroclastic components, were deposited during the Late Miocene to Pliocene (Tf3–Th). These limestones reflect low volcanic activity and are grouped as part of the Cibodas Formation based on their similarities in age, depositional environment, and lithological characteristics. This finding highlights the influence of volcanic activity on the depositional history and composition of the limestones, offering valuable insights into the regional geological formation evolution for future research.

ACKNOWLEDGEMENTS

This research is a part of the study from research fund by HRU Riset Kompetensi Dosen Unpad, Universitas Padjadjaran, Indonesia with grant number 1955/UN6.3.1/PT.00/2024. We extend our gratitude to our colleagues for their technical support during the fieldwork and constructive discussions throughout the course of this study.

REFERENCES

Alif, S. A. (2011). Geologi Sejarah Daerah Sukabumi-Palabuanratu. *Bulletin of Scientific Contribution*, 9, 42-48.

Baumann, P., de Genevraye, P., Samuel, L., Mudjito, dan Sajekti, S. (1973). Contribution to The Geological Knowledge of South West Java*. Proceeding Indonesian Petroleum Association. 2nd Annual Convention,* 105-108.

Boudaugher-Fadel, M. K. (2008). *Evolution and geological significance of larger benthic foraminifera*. UCL press.

Dunham, R. L. (1962). Classification of carbonate rocks according to depositional texture. In W. E. Ham (Ed.), *Classification of carbonate rocks* (pp. 108-121). American Association of Petroleum Geologists Memoir.

Hottinger, L. (1982). Processes determining the distribution of larger foraminifera in space and time. *Facies*, 6(1), 4-15.

Langer, M. R. (1993). Epiphytic foraminifera. *Marine Micropaleontology*, 20(1-2), 235–265.

Langer, M. R. & Hottinger, L. (2000). Biogeography of selected larger foraminifera. *Micropaleontology*, 46, 105–126.

Lunt, P. (2013b). Foraminiferal micropalaeontology in SE Asia. In A. J. Bowden, F. J. Gregory, & A. S. Henderson (Eds.), *Landmarks in foraminiferal micropalaeontology: History and development* (pp. 193-206). The Geological Society.

Lunt, P., & Allan, T. (2004). A history and application of larger foraminifera in Indonesian biostratigraphy, calibrated to isotopic dating. In *GRDC Workshop on Micropalaeontology* (Vol. 112).

Murray, J. W. (1973). *Distribution and ecology of living benthic foraminiferids*. London, England: Heinemann.

Pratiwi, S. D., Chiyonobu, S., & Oktavia, D. (2023). Lingkungan Pengendapan Purba Berdasarkan Sphenolithus Dan Reticulofenestra Kala Miosen Pada Formasi Jampang, Ciletuh, Jawa Barat. *Bulletin of Scientific Contribution: GEOLOGY*, 21(3), 137-146.

Pratiwi, S. D., Nurdrajat, N., Pratiwy, F. M., & Chiyonobu, S. (2024). Calcareous nannofossil assemblages and age determination in Leuwi Kenit, Ciletuh Palabuhanratu Geopark, Indonesia. *Biodiversitas Journal of Biological Diversity*, 25(7).

Prinaldi, D. R., Pratiwi, S. D., & Rosana, M. F. (2023). Karakteristik Petrologi dan Petrografi Satuan Batugamping Terumbu dan Batupasir Karbonatan Pada Formasi Cibodas Daerah Pasiripis dan Sekitarnya, Kabupaten Sukabumi, Provinsi Jawa Barat. *Padjadjaran Geoscience Journal*, 7.

Ramdhani, M. A. G., Pratiwi, S. D., & Patonah, A. (2024). Umur Batuan Sedimen Anggota Cikarang Formasi Jampang di Sungai Cigangsa, Kecamatan Surade, Kabupaten Sukabumi Berdasarkan Nannofosil Gampingan. *Bulletin of Scientific Contribution: GEOLOGY*, 22(1), 65–70.

Roberts, C. M., McClean, C. J., Veron, J. E. N., Hawkins, J. P., Allen, G. R., McAllister, D. E., Mittermaier, C. G., Schueler, F. W., Spalding, M., Wells, F., Vynne, C., & Werner, T. B. (2002). Marine biodiversity hotspots and conservation priorities for the tropical reefs. *Science*, 295(5558), 1280–1284.

Sukamto, R. (1975). Peta Geologi Lembar Jampang dan Balekambang, Jawa, Skala 1:100.000. Pusat Penelitian dan Pengembangan Geologi, Direktorat Jenderal Geologi dan Sumberdaya Mineral, Departemen Pertambangan dan Energi, Bandung, Jawa Barat.

Tucker, M. E., & Wright, V. P. (1990). *Carbonate sedimentology*. Blackwell Publishing.

Tucker, M. E. (2001). *Sedimentary petrology: An introduction to the origin of sedimentary rocks* (3rd ed.). Wiley-Blackwell.