Facies distribution and limestone depositional history in Gunung Endut geothermal prospect area, Banten Province

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Abstract. Gunung Endut, located in Banten Province, has geothermal prospect area in its mountain slope. Some of the area of Gunung Endut has limestone facies which commonly deposited in marine environment. Based on the regional geological map of Leuwidamar, limestone facies are the member of Bojongmanik Formation within the Bogor Physiographic Zone. In Gunung Endut, limestone was developed during the pre-volcanic period, meanwhile most of limestone in Java are found as outcrop in Southern Mountains Zone formed during the post-volcanic period. This study focused on macroscopic and microscopic identification of limestone in order to determine the distribution of facies and the history of limestone sedimentation in the area of Gunung Endut. The macroscopic and microscopic feature of the rock samples are analyzed and classified using modified Dunham classification by Embry-Klovan. The result of the analyses will provide information about the limestone facies distribution and geological history with better detail in the study area than previously known.

Keywords: Facies, limestone, fossil, macroscopic, microscopic, distribution, history, petrography, reconstruction

1. Introduction
Gunung Endut is located in Banten Province (figure 1). The area generally consisted of volcanic rocks overlying mainly shallow marine rock deposit. The forming process of a volcanic rock is related to a Tertiary and Quaternary age although the volcanic activity is considered non-active in this region [1]. Moreover, Sujatmiko reported in his regional geological map of Leuwidamar, the limestone facies consist as the member of Bojongmanik Formation [1]. The limestone facies located only in northern area, while most of rock facies in the area is volcanic rock facies, from the center to the southern area. Previous geophysical fieldwork by Supriyanto et al that there are possibly geothermal sources based on geophysical data (i.e. gravity, magnetic, etc) [2]. However, a detailed geological fieldwork particularly for limestone studies has never been done in detail.

By definition, a limestone is any sedimentary rock containing over 50 % calcium carbonate (CaCO₃). In the natural environment a principal source of calcium carbonate is derived from the hard parts of organisms, mainly invertebrates such as mollusks. Limestones consist 10–15 % of the sedimentary rocks in the stratigraphic record [3]. In a distribution of marine facies, limestone cannot be found in all locations. Limestone only can grow in certain location, such as at 0–100 m depth with ideal temperatures of 27–30 °C. The studies on limestone in the Gunung Endut area will help reconstruct geological history of existing limestones.
2. Methodology
Geological mapping was carried out to determine the geological conditions of a certain location. From this geological mapping, we retain important data such as the lithology, especially limestone. By taking limestone samples from the limestone outcrop using geological hammer, a distribution map of limestone can be constructed. Then, the rock sample is turned into thin section sample for microscopic description under microscope. Macroscopic description of the samples was conducted to determine the forming shapes of the limestone (i.e. massive, layered, etc). Prior to the analysis, the rock samples were washed to remove impurity and clarify the matrix and fossils. The classification of limestone was compared to Dunham’s Limestone classification [4]. Subsequent to macroscopic analysis, petrographic analysis was conducted to the thin section of the samples. Petrographic analysis will provide data on the microscopic description, microstructure of the rock, and interpreting the depositional energy according to energy index [5], the fossil type based on large foraminifera [6], and the depositional environment of limestone [3].
3. Results and discussion

3.1. Bioclastic and biogenic limestone distribution
Field and macroscopic observation of limestone in the study area divide the samples into two large groups, namely the bioclastic limestone and biogenic limestone. Biogenic limestone usually has massive body with no bed or lamination. Biogenic limestone is formed on the reef area, where usually consisted of organisms that are large and able to withstand the sea waves. The main organisms in this area are branching coral and brain coral. Biogenic limestone can be characterized based on its large energy index, indicated by large number of fossils. Furthermore, the bioclastic limestone, usually have layered rock body. The layering that observed in bioclastic limestones are formed in the back reef-lagoon area, where the skeletal fragments are abundant. The layered rock bodies also characterized with the low-medium energy index, indicated by the large number of small-sized broken fossil fragments. Both field and macroscopic observation the biogenic limestone is mainly distributed northeast and southwest of study area. The bioclastic limestone usually located in the center to northwest of study area (figure 2).

3.2. Limestone classification
Based on the macroscopic and microscopic analyses, using the Dunham’s limestone classification, the limestones found in the research area are classified as floatstone, rudstone, and boundstone. Classes in this classification are distinguished by the content of fossil fragments in limestone sample. Rudstone is interpreted to formed in back reef and lagoon, with medium depositional energy. Rudstone in study area generally consisted of fragments of bivalve shells, corals, or large foraminifera, with the size of more than 3mm, fragments coincide each other, and grain supported. Floatstone in study area generally the same with rudstone, but the fragments not coincide each other, and matrix supported. Boundstone is interpreted to formed in reef crest, with medium - high depositional energy. Boundstone in study area generally consisted of whole corals or coral fragments, which act as baffle and frame. Rudstone are mainly distributed in northwest of study area, elongated to northeast. Floatstone with only one sample is in the southwest of study area. Boundstone are mainly distributed in southwest and north east of study area (figure 3).

3.2.1. Large foraminifera distribution. The presence of large foraminifera can be used to determine the age as well as the depositional environment. From microscopic analysis, clear large foraminifera were only found in one station, namely BG8 station. In the BG8 large foraminifera station,

![Figure 2. Distribution of bioclastic limestones (L) and biogenic limestones (M) in study area.](image-url)
Figure 3. Distribution of rudstone (yellow border), floatstone (green border), and boundstone (blue border) in study.

it was very clearly visible because of the abundant amount (figure 4). Large foraminifera in BG8 are *Paleonummulites* sp., which can be found in Miocene to recent rock deposit with depositional environment in the reef crest. Large foraminifera also found in BG1, BG4 and BG15, but they were oblique cut so it is not easy to identify the genus.

3.3. **Dominating fossil**

The dominance of fossils in a limestone sample can help to interpreting the depositional environment and estimate its deposition energy. When the presence of many corals and little algae, the area can be interpreted as a margin platform on the reef with very strong energy. When the presence of a small coral and many algae, these areas can be interpreted as a quieter area, such as a lagoon - back reef where the area is still affected by tidal with energy that tends to be calm. In the study area, most of samples are coral dominated, either contain whole coral or coral fragments. Coral dominated limestones distributed on west and northeast of study area along with other fossil dominated like whole or fragments of mollusks. Algae dominated only found on northwest side of study area (figure 5).

3.4. **Reconstruction of carbonate facies**

After combining 4 indicators of limestone descriptions, 3 limestone facies are obtained, namely the lagoon, backreef and reef crest (figure 6). The lagoon facies are located on northwest side, has characteristics including limestone body appearance that shows a layer, low coral content and algae dominated, and macroscopic texture dominated by rudstone. The back-reef facies is located on the center, has characteristics including limestone body appearance which shows a slight trace of layer, the fragments content of coral, algae, and other mollusks like bivalve and gastropod, and macroscopic texture is dominated by rudstone. The reef facies is located on northeast and southwest side, has characteristics including limestone body appearance which tend to be massive and hard limestone body appearance, abundant coral content especially from branching and brain corals, and macroscopic texture is dominated by boundstone. Then, a line extends from A to B to show the cross-section interpretation of limestone facies (figure 7).
Figure 4. Distribution of large foraminifera in study area with *Paleonummulites* sp. sample under microscope.

Figure 5. Distribution of dominating fossils in study area. K is for coral dominated, A for algae dominated, and FL for another fossil dominated.

Figure 6. Zonation of the carbonate facies of the study area.
4. Conclusion
Based on the results of field data processing that has been interpreted, once upon a time around the age of Miocene, Gunung Endut was in a shallow marine environment that could be deposited with 3 carbonate facies. The 3 limestone facies are obtained in Gunung Endut, namely the lagoon, backreef and reef crest. Thousands of years of sea level rise and fall, which was dominated by the fall in sea level, caused Gunung Endut to now be in a terrestrial environment, with the dominant facies is the volcanic facies due to the volcanic activity during its time. However, exogenous activities such as weathering, and erosion caused limestone facies not to be covered by younger volcanic facies but exposed on the surface as rock outcrops.

Acknowledgments
This work was financially supported by Universitas Indonesia under research grant PITTA 2018 with grant contract number 2316/UN2.R3.1/HKP.05.00/2018.

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