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Limestone Facies Change of Jonggrangan To Sentolo Formation in The Western Part of Yogyakarta-Central Java Basin

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Limestone Facies Change of Jonggrangan To Sentolo Formation in The Western Part of Yogyakarta-Central Java Basin

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Abstract. The research location is in the western of Yogyakarta-Central Java Basin, where limestone of Jonggrangan and Sentolo Formation are found with the same age but have different depositional facies characteristics. These differences will be interesting to study the historical process of its formation. The research was conducted through a series of methods. Starting from geological mapping to determine the order of rock stratigraphy, the depiction of outcrop profiles, and limestone sampling for petrographic analysis. Eventually, the depositional environment of the two rock formations was discovered. Field observation results and laboratory analysis were further integrated to determine the rock facies that make up the two formations. The rock units in the study area from old to young are the pyroxene andesite breccia unit of Upper Oligocene age and limestone. The bioclastic limestone and layered limestone units are deposited by interfingering, unconformity over the pyroxene andesite breccia unit. The Middle Miocene bioclastic limestone unit is equivalent to Jonggrangan Formation in the inner shelf environment (Restricted Lagoon and Open Lagoon facies environment). Whereas layered limestone of Middle Miocene age is equivalent to the Sentolo Formation in the lower slope environment (Restricted Lagoon, Open Lagoon, and Open Sea Shelf) facies.

Keywords: Yogyakarta basin, limestone, facies, diagenesis, petrography.

1. Introduction

The study area is in the Kalibawang area, the western part of Yogyakarta (Figure 1). In this area limestone sedimentary rocks are found above volcanic rocks. These rocks are the Jonggrangan and Sentolo Formations which are Middle Miocene aged rocks [1]. [2] describe the stratigraphy of the Jonggrangan-Sentolo Formation which are in the Middle Miocene to the Pliocene age and have an interfingering relationship between the two.

[3] researched the facies and depositional environment of the Jonggrangan Formation in the south of the study area. [4] have conducted biostratigraphic studies and facies of the Sentolo Formation by comparing locations to the west and east of the Progo River. [5] conducted a study on the development of limestone sedimentology based on petrographic data on the Sentolo Formation in the Pengasih area. [5] conducted limestone sedimentology research in the Jonggrangan Formation along the Kiskendo Cave pass in the Girimulyo area.

Conducted a study of the contact limits of the Old Andesite Formation and Sentolo Formation in the north of the study area. Conducted a biostratigraphic study of the planktonic foraminifera and sedimentation environment of the Sentolo Formation along the Niten River, Serang River and Ngramang Village, KulonProgo [6].





Figure 1. Location of the study area

The Jonggrangan limestone formation is mainly a massive bioclastic limestone while the Sentolo Formation is a layered bioclastic limestone. Parts of the Sentolo Formation are locally found with coral limestone, showing the same age as the Jonggrangan Formation, but in some places, the Sentolo Formation is younger [7].

2. Regional stratigraphy

[4] states that volcanic groups or the Old Andesite Formation [8] or in the eastern part of Gajah Mountain [9] in the western part of Yogyakarta are covered unconformably by shallow marine deposits of the Jonggrangan and Sentolo Formation. [1] stated that the first carbonate sedimentation occurred at the top of the Early Miocene and occupied the highlands to produce the Sentolo and Jonggrangan Formations which were of early of Middle Miocene age. Reefs are built on the heights of former volcanic bodies. [10] conducted research aimed at identifying and investigating coral fossils from the Jonggrangan Formation and analyzing the role of paleoecology in the structure of ancient coral reefs containing layered limestone and reef limestone.

On top of the Old Andesite Formation, besides the Jonggrangan Formation, it was also deposited unconformably with the Sentolo Formation. The relationship between the Sentolo Formation and the Jonggrangan Formation is interfingering. The Sentolo Formation consists of limestone and calcareous limestone. The lower part consists of conglomerates stacked by calcareous tuff with a tuff insertion. This rock upward gradually turns into a fine layered limestone rich in foraminifera.

3. Research method

The research methods used include data collection by mapping the distribution of limestone, measuring stratigraphic detail in several pathways, taking rock samples, and conducting the petrographic analysis. Mapping is carried out on the distribution of the Jonggrangan and Sentolo Formation, both of which are separated by Old Andesite Formation rocks or East Gunung Gajah rocks which are stratigraphically older. Limestone classifications are used according to [11]. The facies obtained will be compared with the carbonate facies model [12]. Some rock samples were collected for paleontological analysis (10 samples) and petrography (10 samples) in the laboratory. Field observations and laboratory analyses are then integrated to find out the rock facies that make up the two formations.

4. Research stratigraphy

4.1. Reef limestone unit

Based on field observations, the compiler of this unit has the characteristics of bioclastic limestone, reefs, and crystalline, reddish-white. Some areas are clastic, medium-coarse sand, porosity is quite good because of the dissolution process. At the bottom, there are limestone fragments of igneous gravel, there are many foraminiferas, shell fragments, elongated algae, and calcite crystals. The thickness of this unit based on the different height contours from the topographic map is $\pm 325\text{m}$.

Age determination based on planktonic fossils in this limestone unit, *Orbulina Universa* (D'Orbigny), the age for this unit is not older than N 9 [13] or Middle Miocene. In a petrographic incision found large foraminifera of *Lepidocyclina*. This foram has an age range from the Upper Oligocene to Middle Miocene [14]. Based on these data, this unit is interpreted to be deposited not older than N 9 and not younger than N 14, and the age of this unit is equivalent to the Jonggrangan Formation with the age of the Middle Miocene. Determination of the depositional environment of this unit using the calculation P / B ratio obtained values of 0% - 5.88%. From these data, the unit's settling environment is in the inner shelf environment [15].

4.2. Layered Limestone Unit

Based on field observations the compiler of this unit has the characteristics of either layered limestone between calcarenite (dominant) and calculative. The general color is gray-brown - dark brown, bioclastic, compact, parallel lamination and burrows sedimentary structures, good sorting, good porosity due to the dissolution process, there are many foraminiferas, broken mollusk shells. The thickness of this unit based on the geological cross-section reconstruction is $\pm 330\text{ m}$.

The micropaleontological analysis shows fossils of planktonic foraminifera, benthonic foraminifera, and large foraminifera in these rock units. Planktonic index fossils, as interval zones for determining depositional age, are present in layered limestone units taken from locations at Location F and Location H ie *Globorotalia praemenardii* (D'Orbigny) as the beginning of the deposition process, *Globorotalia peripheroronda* (Blow & Banner) as the end from the deposition process. From the fossil data so that the age for this unit is not older than N 10 and not younger than N 10 [13] or Middle Miocene age. This unit's age is equivalent to the Sentolo Formation with the age of the Middle Miocene.

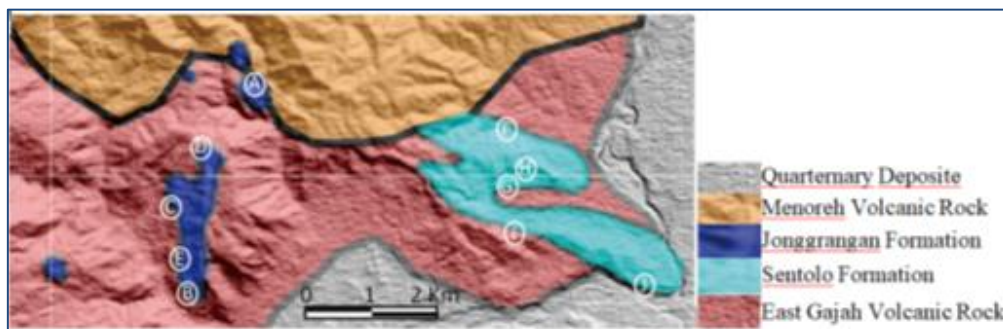


Figure2. Geological map and location for taking rock samples.

Determination of the depositional environment of this unit using the calculation P / B ratio obtained values of 89.93% - 93.92%. From these data, the unit settling environment is in the lower slope environment [15]. A layered limestone unit is a unit that is deposited together (interfingering) with a bioclastic limestone unit deposited in the study area.

5. Batugamping faces

5.1. Bioclastic limestone facies

5.1.1. Location A

The results of the thin-section analysis of bioclastic limestone at Location A (figure 4), show that this facies has the characteristics of light brown color, grain supported, poor sorting, irregular arrangement of grains. The condition of the grains is 90% incomplete, arranged by allochemintraclast (4%), allochem bioclast (miliolidae = 15%, red algae = 5%, coral = 7%, planktonic foram = 6%, discocyclina = 5%, nummulites = 2%) in the percentage of 40%, micrite with a percentage of 10%, and sparite with a percentage of 30% (in the form of blocky).

According to [16], the name of this rock is packstone and according to [11] is rudstone. The porosity that develops is fracture stylolites, vuggy, and moldic. These limestone characteristics are generally following Standard microfacies types (SMF): grainstone or packstone with abundant foraminifera or algae according to [12]. This facies is interpreted as being deposited on restricted platform areas (lagoon) characterized by an abundance of miliolidae as the main characters in the lagoon area.

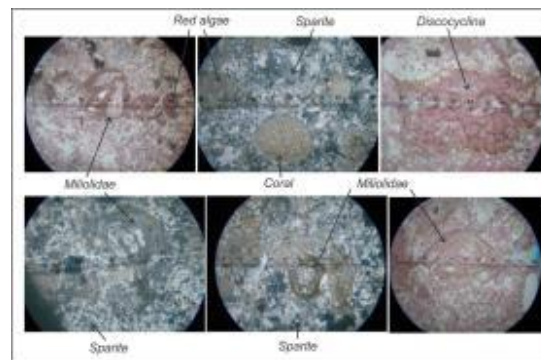


Figure 3. Miliolid appearance (Facies at Location A)

5.1.2. Location B

The results of the analysis of the bioclastic limestone thin section at Location B (figure 5), show that this facies has the characteristics of a light brown, skeleton type foraminifera, filled with a dominant matrix of sparite calcite, grain supported, poor sorting, random arrangement. The condition of the item 80% is not intact, composed by allochemintraclast = 13%, allochem bioclast (corals = 16%, red algae = 8%, planktonic foraminifera = 5%, lepidocyclina = 14%, nummulites = 6%) in the percentage of 52%, sparite with a percentage of 11% (blocky form), micrit with a percentage of 7%.

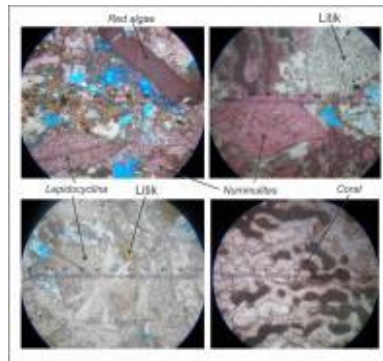


Figure 4. The appearance of Coral - Large Foraminifera grainstone (Location B)

Naming according to [16] is grainstone and according to [11] is rudstone. The developing porosity is vuggy, moldic, and intraparticle types. These limestone characteristics are generally following Standard microfacies types (SMF) is grainstone or packstone with abundant foraminifera or algae according to [12]. This facies is interpreted to be deposited in an open lagoon indicated by the appearance of red algae, it is estimated that this facies was deposited on a medium-high current flow which causes the constitution of large foraminifera (lepidocyclina) to be present in this facies. The presence of coral is an indication of detritus in the Organic Build Up part of the current, so it is estimated that these facies grows near the reef. Then the presence of plankton and land clastic sediments in these facies reinforces that these facies are deposited close to land or still in the interior platform environment.

5.1.3. Location C

The results of the bioclastic limestone thin-section analysis at Location C (figure 6), show that this facies has the characteristics of a light brown, skeleton type foraminifera, filled with a dominant matrix of calcite sparite, grain supported. The grains show poor sorting, random arrangement, grain conditions 95% are not intact, arranged by allochem intraclast = 5%, allochem bioclast (red algae = 20%, planktonic foraminifera = 4%, lepidocyclina = 8%, broken mollusca 3%) in percentage 35%, sparite with a percentage of 17%, micrite with a percentage of 8%.

According to [16], the name of this rock is packstone and according to [11] is rudstone. The porosity that develops is the type of cavern, vuggy, and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is coated skeletal packstone or wackestone according to [12]. This facies is interpreted to be deposited in an open lagoon indicated by the appearance of red algae, it is estimated that this facies was deposited on a medium-high current flow which causes the constitution of large foraminifera (lepidocyclina) to be present in this facies.

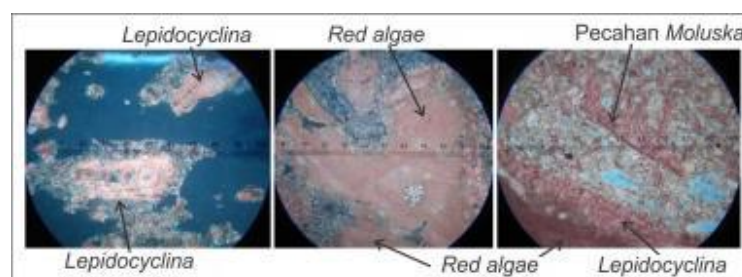


Figure 5. The appearance of Red algae - Lepidocyclinapackstone (Location Facies C)

5.1.4. Location D

The results of the analysis of the thin-section of the bioclastic limestone at Location D (figure 7), show that this facies has the characteristics of a light brown color, filled with a dominant matrix of calcite sparites, poor sorting, random arrangement. The condition of the item 95% is not intact, arranged by allochem bioclast (red algae = 22%, mollusk fraction 6%) in the percentage of 28%, sparite with a percentage of 37%, micrit with a percentage of 10%.

According to [16], the name of this rock is packstone and according to [11] rudstone. The porosity that develops is the type of vuggy, and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is worn skeletal packstone or wackestone according to [12]. This facies is interpreted as being deposited on an open lagoon which is indicated by the appearance of red algae.

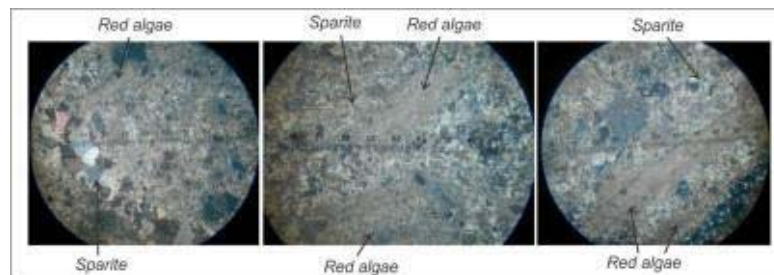


Figure 6. Red algae packstone appearance, facies at location D

5.1.5. Location E

The results of the analysis of the thin-section of the bioclastic limestone at Location E (figure 8), show that this facies has the characteristics of a light brown color, filled by the calcite sparite dominant matrix, poor sorting, random arrangement. The condition of the grains of 95% is not intact, arranged by allochem bioclast (red algae = 15%, green algae = 5%, bivalve = 2%, milliolidae = 3%, mollusk fragments 13%) in the percentage of 38%, sparite with a percentage of 30%, micrit with a percentage of 20%.

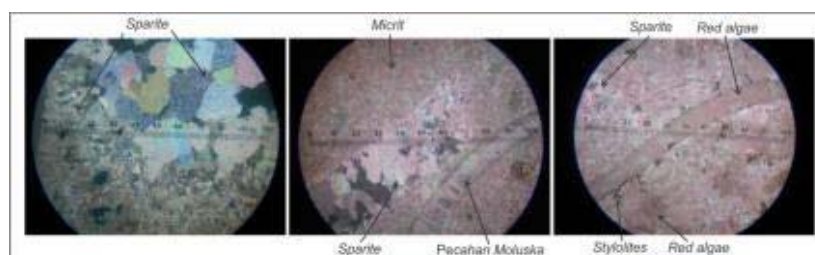


Figure 7. The appearance of Red algae packstone, Facies at Location E

Naming of this rock according to [16] is packstone and according to [11] is rudstone. The porosity that develops is the type of vuggy, and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is grainstone or packstone with abundant foraminifera or algae

according to [12]. This facies is interpreted as being deposited on a restricted platform (lagoon) which is indicated by the emergence of miliolidae as the main characters in the lagoon area.

5.2. Layered Limestone Facies

5.2.1. Location F

The results of layered limestone thin-section analysis at Location F (figure 9), show that this facies has the characteristics of light gray, type of foraminifera skeleton, filled with calcite dominant sparite matrix, grain supported, poor sorting, random arrangement. The condition of the item 90% is not intact, composed by allochem intraclast = 16%, allochem bioclast (coral = 5%, red algae = 8%, lanktonic foraminifera = 2%, lanktoni = 3%, miliolidae = 2%, lepidocyclina = 18%, discocyclina = 2%, nummulites = 1%, gastropods = 3%) in the percentage of 44%, sparite with a percentage of 12% (blocky form), micrit with a percentage of 8%.

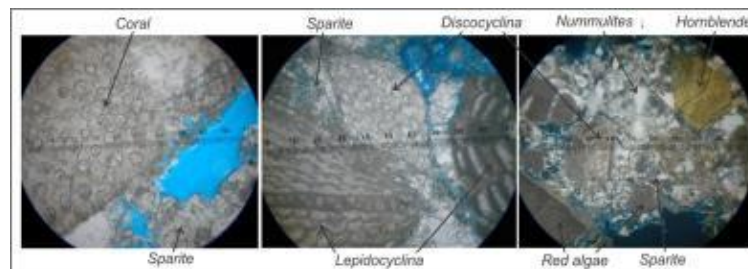


Figure 8. The appearance of Coral - Large Foraminifera grainstone, Location Facies F

The name of this rock according to [16] is grainstone and according to [11] is rudstone. The porosity that develops is the type of vuggy and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is grainstone or packstone with abundant foraminifera or algae according to [12]. This facies is interpreted to be deposited on a restricted platform (lagoon) which is indicated by the emergence of miliolidae, it is estimated that these facies is deposited on medium-high currents which causes the constitution of large foraminifera (lepidocyclina) and planktonic foram present in this facies.

5.2.2. Location G

The results of layered limestone thin-section analysis at Location G (figure 10), show that this facies has the characteristics of light brown, skeleton type by planktonic foraminifera, grain supported, filled by micritic and sparite matrices, poor sorting, random arrangement, grain condition 80 % incomplete. Composed by allochem intraclast = 14%, allochem bioclast (Coral = 2%, Red algae = 2%, Foram planktonic = 12%, Foram planktonic = 5%, lepidocyclina = 7%, Nummulites = 2%, broken mollusk = 6%) in the percentage of 36%, sparite with a percentage of 14%, micrit with a percentage of 10%.

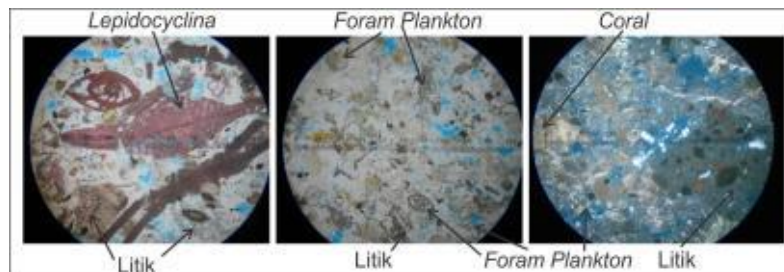


Figure 9. The appearance of planktonic Foraminifera - *Lepidocyclus* at Location G.

According to [16], the name of this rock is packstone and according to [11] is rudstone. The porosity that develops is intraparticle, vuggy, and moldic types. These limestone characteristics are generally following Standard microfacies types (SMF) is worn skeletal packstone or wackestone according to [12]. This facies is interpreted as being deposited on an open lagoon, which is indicated by the appearance of *lepidocyclus* and red algae, deposited with a calm - moderate current.

5.2.3. Location H

The results of layered limestone thin-section analysis at Location H (figure 11), show that this facies has brown characteristics. Types of skeletons by planktonic foraminifera, grain supported, filled with micritic and sparite matrices, poor sorting, random arrangement, 80% grain condition is not intact. Composed by allochem intraclast = 7%, allochem bioclast (foram planktonic = 25%, foram planktonic = 10% broken mollusk 5%) in the percentage of 40%, sparite with a percentage of 28%, micrit with a percentage of 10%.

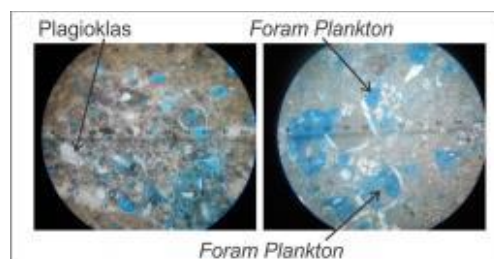


Figure 10. The appearance of planktonic Foraminifera, Facies at Location H

According to [16], the name of this rock is packstone and according to [11] is rudstone. The developing porosity is the type of burrow, vuggy, and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is worn skeletal packstone or wackestone according to [12]. This facies is interpreted to be on an open sea shelf, which is indicated by the appearance of abundant planktonic foraminifera.

5.2.4. Location I

The results of layered limestone thin-section analysis at Location I (figure 12), show that this facies has the characteristics of light brown, skeleton type by planktonic foraminifera, grain supported, filled by micritic and sparite matrices, sorting quite well, 70% grain condition is not intact. Composed by allochem intraclast = 4%, allochem bioclast (foram planktonic = 35%, foram planktonic = 19%,

lepidocyclina = 1%, broken mollusk 1%) in the percentage of 56%, sparite with a percentage of 15%, micrit with a percentage of 10%.

According to [16], the name of this rock is packstone and according to [11] is rudstone. Experiencing the compacting process, it can be seen from the relationship between the grains showing concavo-convex, the porosity that develops is the type of vuggy and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is worn skeletal packstone or wackestone according to [12]. This facies is interpreted to be on an open sea shelf, which is indicated by the appearance of abundant planktonic foraminifera, the appearance of lepidocyclina but not so dominant.

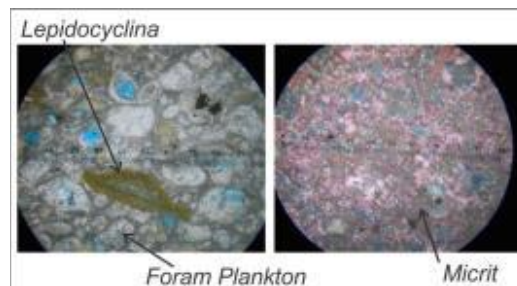


Figure 11. The appearance of planktonic Foraminifera (Facies at Location I)

5.2.5. Location J

The results of layered limestone thin-section analysis at Location J (figure 13), show that this facies has the characteristics of light brown, skeleton type by planktonic foraminifera, grain supported, filled with micritic and sparite matrices, poor sorting, random arrangement, grain condition 85 % incomplete. Composed by allochem intraclast = 4%, allochem bioclast (planktonic foram = 30%, planktonic foram = 10%) in the percentage of 40%, sparite with a percentage of 25%, micrit with a percentage of 10%.

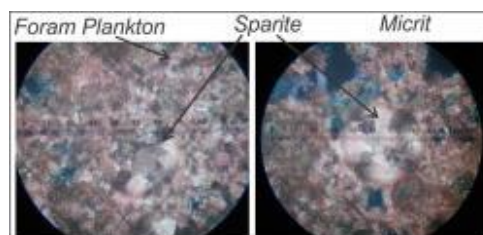


Figure 12. Planktonic Foraminifera Appearance (Facies at Location J)

Naming [16] packstone and according to [11] rudstone. Experiencing the compacting process, it can be seen from the relationship between the grains showing the suture, the porosity that develops is the type of vuggy and moldic. These limestone characteristics are generally following Standard microfacies types (SMF) is worn skeletal packstone or wackestone according to [12]. This facies is interpreted to be on an open sea shelf, which is indicated by the appearance of abundant planktonic foraminifera.

6. Discussion

The facies environment of the study area (figure 19) is divided into bioclastic limestone and layered limestone environments. Bioclastic limestone units with bioclastic limestone lithology occur in restricted

lagoon facies (restricted circulation shelf & tidal flats) and open lagoon (shelf lagoon open circulation) environments. Shown by the emergence of Red algae and Miliolidae, then reinforced by the presence of coral and clastic sediments, which indicates its presence not far from the environment of organic build-up, and still near land.

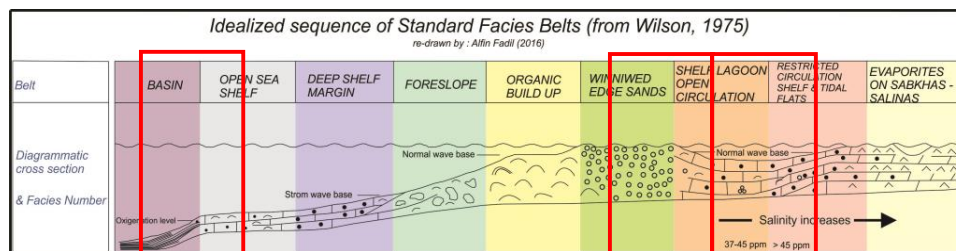


Figure 13. Facies environment according to Wilson (1975)

Layered limestone unit with layered bioclastic limestone lithology, indicating that this limestone is a limestone originating from the deposition, not growing in its place of origin. The facies environment is located in three environments, namely the restricted lagoon, open lagoon, marked by the appearance of red algae and miliolidae, indicating that they are deposited with a calm - moderate current. The appearance of coral fragments indicates that it is still near the organic build-up area, then there are lithic rocks that indicate that it is still deposited near land or exposed old volcanic bodies [17]. The open sea shelf environment is indicated by the abundance of planktonic foraminifera, although there is large foraminifera it is not dominant, this can be indicated that this environment is deposited with calm currents.

7. Conclusion

Bioclastic limestone facies are deposited in restricted lagoon environments (restricted circulation shelf & tidal flats) to open lagoon (shelf lagoon open circulation), characterized by the presence of miliolidae and red algae.

Layered limestone facies are in restricted lagoon environments (open circulation shelves & tidal flats), open lagoon (shelf lagoon open circulation) are characterized by miliolidae to open sea shelf environments, characterized by an abundance of planktonic foraminifera.

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Preface

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PREFACE

The International Conference on Engineering, Technology and Innovative Researches (ICETIR) 2020 is held in September 2nd 2020, organized by the Faculty of Engineering, Universitas Jenderal Soedirman. This conference is aimed to communicate the results of research in the field of engineering and to jointly contribute to society through innovative research. In 2020, we highlight the theme “**Sustainable Engineering and Technology for Reshaping our Community**”.

However, due to the covid19 and travel restriction, we held the conference virtually through zoom meeting, inviting the keynote speakers from the various fields of engineering, along with the accepted papers, which consist of some tracks, i.e., information system, software engineering, computer engineering, mechanical engineering, geological engineering, industrial engineering, electrical power, telecommunication, control systems, agriculture engineering, and civil engineering. On this occasion, we have received submissions from authors originated from 5 countries (Indonesia, Taiwan, Malaysia, Saudi Arabia, Japan), with the attendance number were around 100 participants. We had plenary and parallel session for each presenter with 10 minutes talk, followed by 4 minutes of discussion (question answer session).

We would like to acknowledge all supports for the success of this conference, especially, the board of reviewers, the board of editors, the organizing committee, the sponsors, and all conference participants. We hope that the 2nd ICETIR 2020 has been an excellent discussion forum in the field of engineering.

Sugeng Waluyo

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