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Pleistocene Coral Reef Facies in Bira, South Sulawesi

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ABSTRACT

Pleistocene coral reefs in eastern part of Indonesia formed terraces and commonly have a narrow size such as the reef in Bulukumba region. They expresses highly tectonized or uplifted area. This research is located at Bira District of Bulukumba Regency or in the southern tip of South Sulawesi Peninsula. The objective of this research is to define depositional environment based on coral reef development and to interpret palaenvironment during the reef development. Several methods were applied such as intersect lines which are perpendicular to the cliff, petrographic analyses, as well as palaeoenvironment interpretation. Three facies are described at the Pleistocene reef showing he environmental development, namely 1) Reef Fron Facies, 2) Reef Core Facies, 3) Back Reef Facies. Based on facies association and organism accumulation, the depositional environment of Pleistocene reefis interpreted to be developed in a reef complex.

Keywords: facies; Pleistocene; reef; Biral

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1. INTRODUCTION

Pleistocene coral reefs in eastern part of Indonesia including Bira area, South Sulawesi are commonly found as terraces along the coast line. The development of the reef shows a seaward direction, where the younger reef complex is attached to the older reef leeward as fringing reefs.

The condition, as an example, gives an important information concerning palaeoenvironment. This is due to coral is a sensitive organism toward climate change especially sea water condition. The reef development depends upon chemical composition and seawater condition. Some researches suggest that the increasing of CO_2 in the coral indicates that the seawater temperature is high [1] and [2]. Coral is composed by aragonite mineral which easily change (recrystallized or dissolved) to other minerals (calcite/dolomite).

The Pleistocene reef which is exposed on the surface by 2 factors (sea level fall and/or uplifting). Sea level fall caused by ice freezing in polar and vice versa, known as glacial and interglacial, on the other hand uplifting depends on tectonic activities. De Klerk shows the sea level fall in Spermonde Islands since 4500 years before present to 5 meters from present sea level [3].

The study area is mapped as a member of Walanae Formation known as Selayar Limestone with Plio-Pleistocene age [4] (Figure 1).

However Imran suggest that the Selayar Limestone developed since Upper Miocene to Pleistocene and found at least 4 terraces [5]. They developed from older reef leeward to the younger seaward (Figure 2). The development of terraces indicates an active tectonism during the reef development. Each of these terraces has a different age that can be determined by the foraminifera. The purpose of this study is to determine facies and depositional environment based on reef developments. By the end of the this research is to reconstruct palaeoclimate based on chemical elements in coral reefs and other geological aspects.

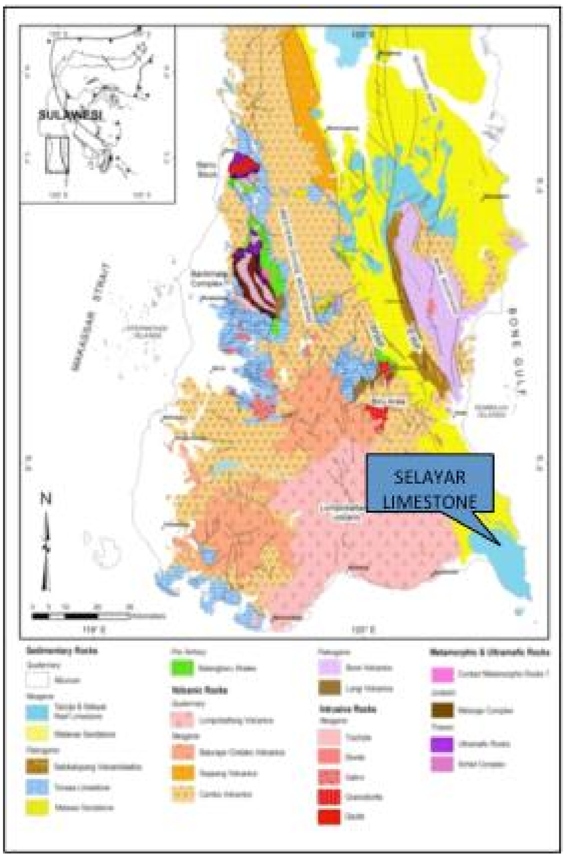

Figure 1. Geological map of western central and south Sulawesi [6], [7], [4] and [8].

2. METHODS

The study is focused on Pleistocene reef which cropping out in the lower terrace. Several Methods was applied in this study are field survey, morphology and petrographic analysis. Field survey was taken on 4 line transects with perpendicular and parallel to the shoreline. In order to get geometry of the reef, morphology view was done from the highest level surround the study area. Petrography analyses on 21 thin sections were applied on matrixes for biofacies needs. Thin sections were done in Bandung from sample taken from the field. Furthermore petrography analysis was done in Petrography Laboratory in Hasanuddin University. The analysis was done under polarized microscope to take the type of mineral, as well as textural of the rock. Lithologic nomenclature was used Dunmham's Classification and Embry & Klovan. Paleontology analysis was done for identifying organism contents especially foraminifera.

Figure 2. Reef terraces found in east coast of Bira Area, at least 3 terraces and some sub terraces both at west and east coast (Foto by Imran 2000).

3. GEOLOGICAL SETTING

Neogene sedimentary sequence is dominated by volcaniclastics and alkali plutonic rocks which are widely cropped out in South Sulawesi [9] & [10]. They comprise the Early Miocene Kalamiseng Volcanics [6] and unconformably overlies the Salokalupang Formation as well as is structurally separated from the Tonasa Limestone [6]. Middle Miocene orogeny generated magmatic and volcaniclastic rocks [11] such as Sopo- and Pammusureng Volcanics and Camba Formation. They crop out mostly in the Biru Area in the eastern part and the Camba Formation in the western part. The Sopo- and Pammusureng Volcanics were deposited during the Middle Miocene [10]. On the other hand Camba Formation was accumulated in the southern arm of Sulawesi during the Middle to Upper Miocene [6]. The PammusurengVolcanics have an angular unconformable relation to the Early Miocene Kalamiseng Formation and are unconformably overlain by WalanaeVolcanics [10]. The Camba Formation unconformably covers the Tonasa Limestone and Mallawa Formation, and the upper part of the Camba Formation has an interfingering relation with the Walanae Formation in some parts [4] & [6].

In the early Middle Miocene the region again became less stable and perhaps during this time the Walanae Fault Zone (WFZ) started to develop and formed Walanae Depression [10], [7] & [10]. The NW-SE trending Walanae Fault Zone protrudes into the Walanae depression (Figure 1) and is divided into the Western Divide Mountain Range in the west and the East Walanae Fault of the Bone Mountain Range in the east [12], 10] & [13]. The Walanae depression is the major NNW-SSE trending present-day valley in the southern arm of the Sulawesi, in which the Walanae Formation was largely deposited [14].

Molasse-type sediments were deposited within the Walanae graben during the Late Miocene to Pliocene [4] & [10] in a shallow marine environment [10]. The rocks consist of coarse conglomerates, marine tuff, marls and coral limestones where they are mapped as the Walanae Formation [7] & [4]. The Walanae Formation includes the Taccipi Member (Taccipi Formation: [15] in the north and the Selayar Member in the south. In the middle and southeastern part of the southern arm, the Walanae Formation is predominantly made up of volcanics composed of alternating tuffaceous, conglomerates, volcanic breccias and an intercalation of sandstone and limestone [10], [4].

Selayar limestone is consisted of foraminirela reef, alagal reef and coral reef. It crops out in Bulukumba region in the north to Selayar islands in the south. The reef developed since Upper Miocene to Pleistocene [5]. The reef unconformable underlays the older rock (Figure 3) and form narrow fringing reef and terraces (Figure 4).

Figure 3. Field view of unconformable contact between Walanae Volcanic at the lower part and Pleistocene reef at

4. PLEISTOCENE REEF FACIES

As mentioned above that at least 3 terraces are identified on the western coast line. This study shows that the terraces reflect a different reef development period and are composed of different organisms. Three facies are found at the Pleistocene Reef, namely) Reef front facies, b) Reef core facies, and c) Back reef facies. They mainly consist of delicate branching coral, platy-like coral, robust branching coral, massive coral and in some places contain *Tridacna sp.* The outcrops generally compose of two layers separated by erosion beds and dipping 30^{O}-80^{O} to the west. In the southern tip, the reef is unconformable underlain by Walanae volcanics (Figure 3). Two notches are found in the reef indicating sea level fluctuation.

A. Reef Front Facies

Reef Front Facies locates on southern tip and angular-unconformably overlies the older rock of Walanae volcanics and at the bottom of the reef is marked by abundant burrowing structure. The bed is characterized by bioclastic-grainstone and continues to the branching coral dominated limestone (Figure 5A). The abundantly presence of burrowing structure indicates shallow subtidal and intertidal pond [16]. Branching corals are commonly presence to the top of the facies and in a certain places also develop massive coral and red algae (Figure 5C). Based on microscopic texture of matrixes the facies is commonly composed of red algae, gastropods and foraminiferal fragments.

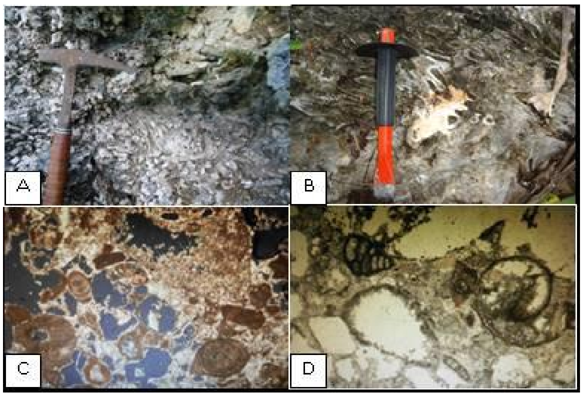

Figure 5. Field view of branching coral (A & B) cropping out at the southern part of Pleistocene reef (just right the top of siliciclastics rock). Microphotograph of matrixes of the Reef Front Facies consists of foraminifera rich grainstone (C), and coral fragments bioclastic grainstone (D).

The facies corresponds to the standard of fore slope microfacies zone [17], [18]. The rich fragmental components (Figure 5C) within the matrixes show a high deposition of eroded organisms surround depositional environment of the matrix. It means that the source of the fragments closes to their depositional environment. The same type of branching coral (*A. cervicornis*) has been studied at intermediate depth on the fore reef in Carribian reef complexes [19]. Based on data (organism association and textural properties) supported

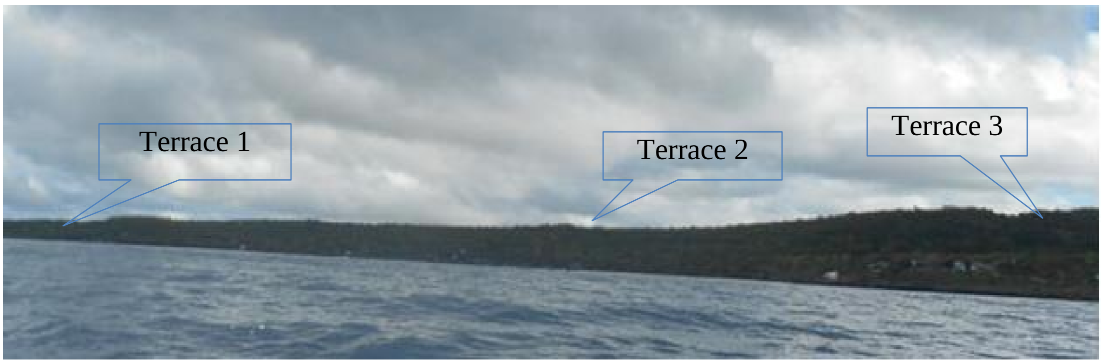

Figure 4. Morphology of west coast showing 3 sub terraces of Pleistocene reef.

by several studies mentioned above the facies is interpreted to developed within front reef zone.

B. Reef Core Facies

The Reef Core facies is characterized by the abundantly presence of coral fragments (Figure 6A). Coral fragments and lack of lime mud imply a high sedimentation rate in the high water current. The upper part of the reef consists of massive coral with a growth position (Figure 6) as a dominant organism to the leeward (Pliocene Reef). The corals are of the family Faviidae, and Poritidae standing as high as 1.5 m, with a diameter of 10-45 cm. Molluscs (giant *Tridacna sp.* (Figure 6F), small pelecypod and gastropods are present at the basement of this facies. In the leeward, the coral reef consists of a rhodolith channel-like layer composing rhodolithic rudstone (Figure 6C and 6D).

Figure 6 Outcrop of reef core facies showing rhodolite channel-like deposits at lower bed (A), and in some places, *Tridacna* sp. are present (B) at the upper part of the reef core facies. (C) and abundant coral fragments (D).

The association of organisms and rock texture suggest a shallow marine environment with high energy and sufficient temperature, light, salinity, and nutrients. This type of environment appropriates to a reef front zone as suggested by James [20], [21]. The presence of rhodolite channel-like is probably influenced by upwelling current from Makassar Strait. Fragments of red algae (Rhodolith) and rock fragments contained in this facies interpreted that it experienced transport and accumulated in the channels at the top of fore reef [20] or on the reef framework [1].

At the upper part of the reef, a line of notch (Figure 6B) is well preserved indicating an abrasion process after the reef development. It means that the position of sea level reached the top of the reef core facies at 7 m high from recent sea level. The presence of notch indicates that sea level fall and/or uplifting reef after reef core developed.

C. Back Reef Facies

Back reef facies locates in the northern part of reef complex or toward Pliocene reef and predominantly consists of branching coral. It is (Figure 7B). It has boundstone texture (especially bafflestone) and its matrix commonly as packstone texture. Other organisms found within this facies are giant mollusc (Tridacna) and skeletal from coral, algae and foramainifera of *Calcarina sp.* (Figure 7B, C, D, E). The facies is well preserved along the coastline and stands out 2 – 3 m high (Figure 7A). It is dominated by branching coral from Acroporidae (Figure 7B).

The accumulation of organisms and limestone textures imply that the facies was developed in the back reef and formed a narrow lagoon. The presence of corals of the genus Acropora as a fragile organism suggests a low energy environment with high sedimentation rate. Such environmental deposition corresponds to the back reef.

The back reef facies experienced sea water abrasion marked as a notch. The notch spread out parallel to the recent coastline at latitude of 7 m from recent sea level and has same latitude as the notch in the core reef facies. This phenomena means that the position of sea level was at the upper part of the back reef facies at 7 m high from recent sea level. The presence of notch indicates that sea level fall and/or uplifting of reef occurred after development of back reef and reef front facies.

Figure 7 Ourcrop of back reef facies along the west coast (A)with abundant branching coral (B) and small amount of red algaein thin section (C) rare Tridacna sp (D) and *Calcarina sp*in thin section (E).

5. Conclusion

Pleistocene reefs that developed in Bira gives a good information about the palaeoclimate at that area. It can be seen from sea level fluctuations during and after the reef development. Based on the distribution of organisms and their facies association, rock texture and skeletal dominance, Pleistocene reef is interpreted as a narrow reef complex (Figure 10). The reef consists of a) reef front, core reefs and back reef. Each reef is characterized by a specific organism and the texture.

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