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Using Biofacies Analysis of a Tertiary Algal Reef (Pinnacle Reef - Middle Eocene IIA), at Burton Guyot (IODP Site U1376) to Determine Transition from Greenhouse to Icehouse

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الملخص

في هذه الدراسة جمعت خمس وعشرون عينة من قالب صخري علي أعماق بينية بمعدل 30 سم من حجر جيري تابع للوحدة الصخرية AII منU1376 التابع للبرنامج العالمي لاستكشاف المحيط (IODP) في بورتون قويت (Burton Guyot). الغرض من هذه الدراسة هو فحص وتعريف المحتوى المرجاني والطحلبي لصخور القالب الصخري لتتبع تذبذب مستوي البحر الايوسيني. هذا الشعاب مفصول بوحدتين بركانيتين في جنوب غرب المجيط الهادي.

أحد عشر سحنة حيوية عرفت مجهريا، وهي كالتالي: الطحلبي-المرجاني الحبيبي، مُنخربي (ألابامينا) طحلب مرجاني حبيبي، مُنخربي (كطبقة هيتروستيقينا) طحلب مرجاني باكي-حبيبي، مُنخربي طحلب ملتحم، منخربي طحلبي حبيبي (طبقة اللاجينا)، مُنخربي طحلبي حبيبي (طبقة السبسويدميكروس)، مُنخربي طحلبي ملتحم – حبيبي، مُنخربي طحلب مرجاني حبيبي، مُنخربي طحلبي قنفذي باكي، ومُنخربي طحلب مرجاني واكي-باكي.

هذه الدراسة هي الأولى من نوعها في استعمال لكل من الطحالب الحمراء والمرجان في تمييز السحنات الترسيبية السالفة الذكر. نوع الطحلب الوحيد المسجل هو ليثوثامنيون كامارازي (*Lithothamnion camarasae*) وأشار إلى ظروف مناخية دافئة سادت في العصر الإيوسيني الاوسط-المتأخر. كما أن نوع المرجان المسجل الوحيد هو أيزوبورا توغيانينسيس (*Isopora togianensis*) المنتج للمرجان السكليراتيني (Scleractenian). كما أن ارتفاع نسبة الطحالب على حساب المرجان اشارت لتغير مناخي من ظروف خضراء دفيئة إلى ظروف الثلجية.

الكلمات المفتاحية: المرجان، الطحالب المرجانية، سحنة حيوية، ظروف الثلج، مُنخربات.

Abstract

Twenty-five samples were collected at 30 cm intervals from the studied cored interval within the limestone unit (AII) reported at IODP Site U1376 on Burton Guyot. The purpose of this research is to examine and identify the coral and algae suites in the studied core concerning sea level fluctuation during the Eocene time. This reef is isolated by being between two volcanic units in the Southwest Pacific Ocean. Eleven biofacies units have been established based on the fabric of the grains. The biofacies units are as follows; Algal-coral grainstone, foraminiferal algal-coral grainstone (*Alabamina*bed), foraminiferal algal-coral packstone to grainstone (*Heterostegina* bed), algal-coral grainstone, foraminiferal algal boundstone, foraminiferal algal grainstone (*Lagena* bed), foraminiferal algal grainstone (*Cibicidoides micrus*-bed), foraminiferal algal boundstone to grainstone, foraminiferal algal-coral grainstone, algal echionoidal packstone, and foraminiferal algal coral wacke-packstone. This is the first study to use both algae and coral in differentiating the units mentioned above. The only coralline red algae recognized in the samples is *Lithothamnion camarasae*. This species is a good indicator of the warm climatic conditions during the middle-late Eocene. The only species of coral found in these units is *Isopora togianensis*, a scleractinian reef builder. The high percentage of algae compared to coral indicates a climatic change from a greenhouse to an icehouse climate. The faunal trend during this time also indicates a tectonic change.

Keywords: Coral, Algae, Biofacies, Icehouse, Foraminifera.

1. INTRODUCTION

The transition from greenhouse to icehouse conditions during the late Eocene to Oligocene period (about 34-24 million years ago) was marked by significant changes in global climate, including the growth and expansion of ice sheets, a decrease in atmospheric CO_2 levels, and a shift towards cooler and drier conditions on land [1].

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The study of corals and algae from this period can provide valuable insights into the environmental conditions that existed during this transition. For example, the distribution of corals during the late Eocene to Oligocene period is thought to reflect changes in ocean temperature and circulation patterns, as well as changes in sea level [2]. Studies of fossil corals from this period have revealed that coral diversity declined as the climate shifted from greenhouse to icehouse conditions, likely due to changes in ocean circulation and temperature [2]. In addition, changes in the abundance and diversity of coral species can be used to infer changes in sea level, as well as changes in ocean chemistry and nutrient availability [2]. Similarly, studies of fossil algae from this period have also provided important insights into the environmental conditions that existed during the transition from greenhouse to icehouse conditions. For example, the distribution and abundance of certain types of algae, such as calcareous green algae and red algae, can be used to infer changes in water temperature and nutrient availability [3]. Overall, the study of corals and algae from the late Eocene to the Oligocene period can provide valuable information about the environmental conditions that existed during the transition from greenhouse to icehouse conditions. By reconstructing changes in sea level, ocean temperature, and nutrient availability, these studies can help to improve our understanding of the processes that drove this significant period of global climate change. This research was conducted at Site U1376. Site U1376 was one of the several locations drilled by the Integrated Drilling Expedition at Louisville Seamount Chain in the South Pacific Ocean (Fig. 1). The Integrated Ocean Drilling Program (IODP) Expedition 330's fifth site was Burton Guyot's Site U1376 (equivalent prospectus Site LOUI-7A). This site is situated on Burton Guyot (Fig. 2). This location is found atop a submerged extinct volcano in the South Pacific Ocean. The site responds to the tectonic movement of the Pacific Plate across a hot spot [2]. The core length is almost 16.7 m. It is white in color, medium-hard, with abundant fossils in the limestone. Most of the previous work on this site was geochemical analyses of the igneous basement rocks [4,5,6]. The limestone Unit (Algal reef unit) occurs between two basalt flows. The algal limestone unit is Middle Eocene in age based on fossils in this reef [7,8,9,10,11].

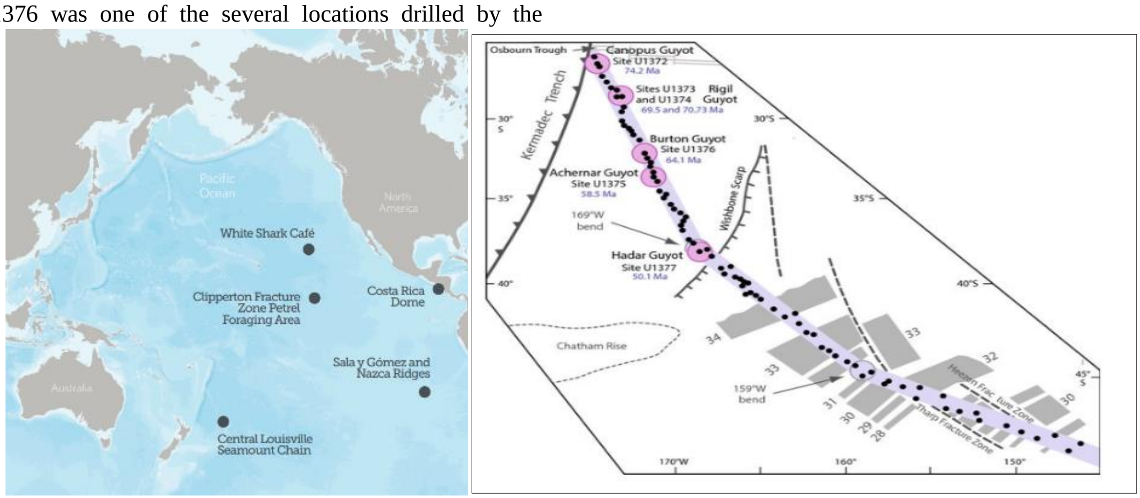

Figure 1. Location and age in millions of years of the Burton Guyot, which was drilled by IODP Expedition 330 along the Louisville Seamount Chain [8,9].

The change of the facies in the pinnacle reef is associated with many exciting features during the Early Tertiary time, such as the event at the end of the Paleocene associated with sea-level change and high global temperatures [11,12]. The final paleoenvironmental interpretation is difficult because this reef was affected by relative sea level changes, some terrigenous input, and climate change with attendant high salinity, all resulting in alteration of the facies. These kinds of reefs are promising for oil entrapment if there is a proximal source rock but this is not a significant factor in the current study.

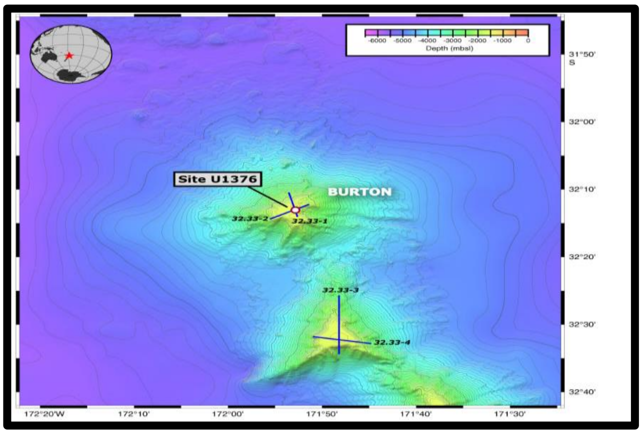

Figure 2. The bathymetric map of Site U1376 on Burton Guyot [4]

2. MATERIAL AND METHODS

The research materials originate from a cored interval from 346.92–451.22 m, all of Eocene age from Site U1376 (Limestone unit AII). The location of this site is at 32°12.99'S and 171°52.84 'W as shown in Figure 2. A petrographic analysis of the algal reef can provide a general description of the depositional environment. Details of the analysis of this limestone unit were based on both lithological nature and fossil content. Twenty-five thin sections of sixteen samples from this limestone unit were processed petrographically to evaluate and recognize the significant facies type (MFTS). The textural analysis is based on Dunham [13,14]. Foraminifera, algae, coral, echinoids, and mollusks have been observed from Limestone Unit IIA, which has a total thickness of 15 meters and 78 centimeters.

3. RESULTS

Fourteen facies have been recognized in the Burton Guyot Limestone Unit AII according to their lithologic characters (composition) and fossils assemblage (organization) in forms of benthic and planktic foraminifers, as well as the observed coral growth forms. This reef formed during the late Paleocene to the Eocene, with reef-building dominated by corals rather than algae because of raising the sea level associated with tectonic activity at this time [8,10,14]. The coral and algae- reef builders, are sensitive to paleoenvironmental conditions, and changes in their proportions over time allow for investigation of environmental change in the Paleogene [7,8,9,14].

3.1. Biofacies Units

The general lithological description of these samples is mainly white, medium-hard, and fossiliferous limestone. The observed invertebrates mainly consist of algae species; *Lithothamnion camarasae* and the coral species *are Isopora togianensis*, echinoderm fragments, and mollusk fragments. The reported microfauna includes several benthic and planktonic foraminifers and ostracod species. The age of this unit was determined by the appearance of some diagnostic foraminifera in these samples [7,8,9,12]. The age of this algal reef is Middle Eocene. The biofacies of this unit were determined based on the dominating fossils assemblage and depositional texture. Accordingly, eleven dominant facies types are recognized and listed in Table 1 and Figure 3. The facial alternation from grainstones to wack-packstones reflects environmental instability, with increased current intensity such as storm conditions, or a tectonic effect (such as submarine mass movement or earthquakes).

3.2. Depositional environment based on the crustose and frondose facies

1. The four algal crust biofacies and four sub-biofacies are: algal-coral grainstone, foralgal-coral grainstone, foralgal boundstone, and algal-echiniodial packstone are interpreted as a neritic water facies.

2. The four algal branches and six sub-biofacies are: foralgal-coral grainstone (*Alabamina* bed), algal-coral grainstone to packstone, foralgal-coral packstone to grainstone (*Heterostegina* bed), foralgal grainstone (*Lagena* bed), foralgal grainstone (*Cibicidoides* bed); foralgal-coral grainstone, foralgal-coral wackestone-packstone are interpreted as a shallow-water facies. The flooding surface and the parasequences in this section were altered in a short period, based on the branch and crust features by the *Lithothamnion camarasae. Lithothamnion camarasae* can develop hard calcareous crusts on the seafloor, and these crusts can collect over time to form a raised platform or bioherm. This platform may have an impact on the local hydrodynamics of the area, resulting in the production of various sedimentary structures and depositional environments. Furthermore, the *Lithothamnion camarasae* can aid in the production of parasequences by causing periodic changes in sedimentation rate, resulting in the generation of alternating layers of sediment with varied grain sizes. These parasequences can be utilized to analyze changes in sea level as well as oscillations in sediment supply and depositional conditions across time. Furthermore, the existence of *Lithothamnion camarasae* and its crusts in the geological section can influence flooding surfaces. When sea levels rise, for example, the crusts can operate as a barrier to sediment deposition, causing a flooding surface to form above the crust. This flooded surface can then be used to track the evolution of sea level and depositional conditions across time. Overall, *Lithothamnion camarasae* existence and activity can have a major impact on the sedimentary structures and depositional environments in a geological section, as evidenced by changes in flooding surfaces and the creation of parasequences (Figs. 3, 4).

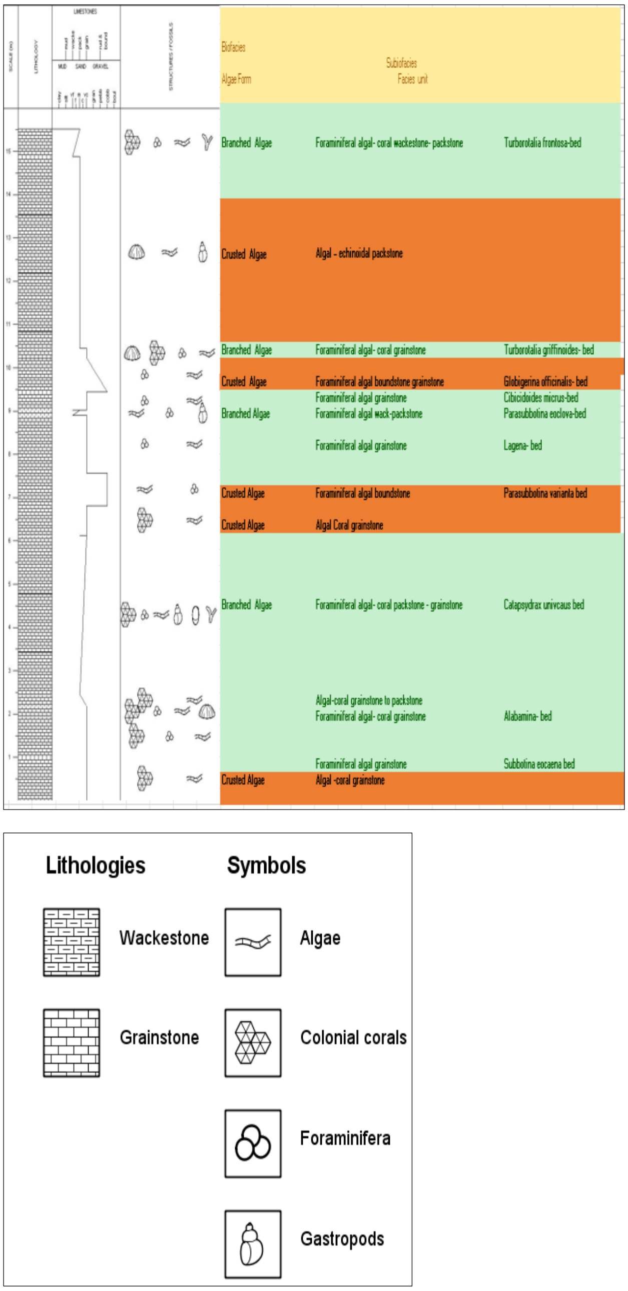

Figure. 3. General description of the studied cored Limestone Unit IIA.

Table 1. General description of the Biofacies unit (Limestone Unit IIA) At Burton Guyot.

Facies No:	Thickness	Sub-biofacies based on lithology	Based on the foraminifera	Description
1	1.01m	Algal Coral grainstone Fig. 4(1)		Composed of white to cream color, hard, with the mainly crusted type of red coralline algae (*Lithothamnion camarasae*) and some coral fragments and other unidentified bioclasts.
2	5.28m	Foraminiferal algal- coral grainstone Fig. 4(2)	*Alabamina* bed	Composed of white color, hard, fossil fragments; coral, algae, and echinoderms, gastropod and ostracod fragments, bryozoan. This bed yields abundant Subbotina eocaena , *Catapsydrax univcavus*, *Alabamina* sp.
3	0.12m	Foraminiferal algal- coral Pack-grainstone Fig. 4(3)	*Heterostegina*- bed	Composed of white color, hard, fossil fragments coral, algae.
4	0.69m	Algal Coral grainstone Fig. 4(4)		Composed of white color, medium hard, encrusted algae (*Lithothamnion camarasae*), and coral fragments. The black and pink colors are due to weathered of igneous rock fragments at the top of this section.
5	0.75m	Foraminiferal algal boundstone Fig. 4(5)		Composed of white to brown color, hard, encrusted red coralline algae, and yields *Parasubbotina varianta.*
6	2.25m	Foraminiferal algal grainstone Fig. 4(6)	*Lagena* bed	Composed of white color, medium hard, with branched coralline red algae, and foraminifera *Parasubbotina eoclova* and *Lagena* sp.,
7	0.41m	Foraminiferal algal grainstone Fig. 4(7)	*Cibicidoides micrus* bed	Composed of white to brown color, medium hard, with abundant algae, and yields a smaller benthic foraminifera *Cibicidoides micrus*.
8	0.78m.	Foraminiferal algal bound-grainstone Fig. 4(8)		Composed of white color, medium hard, yields encrusted red coralline algae, other fossils fragments, and common *Globigerina officinalis.*
9	0.19m	Foraminiferal algal- coral grainstone Fig. 4(9)		Composed of yellow to brown color, medium, hard, with branching red coralline algae, corals, echinoderm remains, and common *Turbortalia griffiinoides*.
10	4.43m	Algal – echinoid packstone Fig. 4(11,12)		Composed of white to brown color, medium hard, with abundant encrusted coralline red algae, echinoderm remains, and gastropod. This
11	0.64m	Foraminiferal algal- coral wack-packstone Fig. 4(13)		Composed of brown to black color, medium hard, with branched red algae and bryozoan fragments, and common planktic foraminifera *Turborotalia frontosa*.

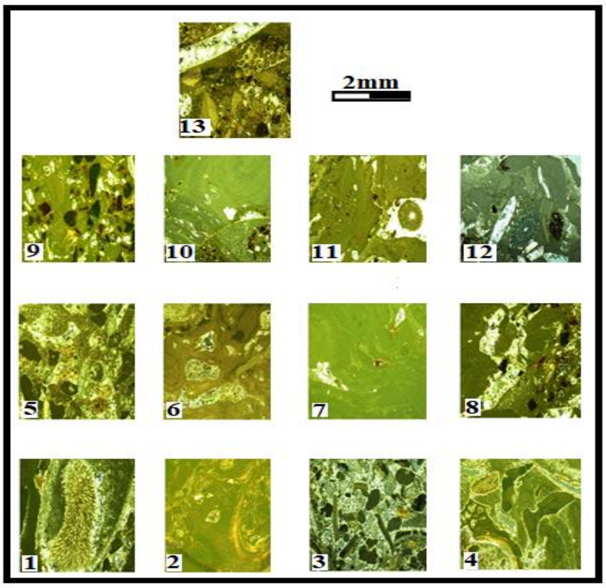

Figure 4. Photomicrographs of the Burton Guyot Biofacies unit (Limestone Unit IIA-IODP Site U1376).

3.4 Distribution of the Fauna from the Algal Reef (Limestone Unit) - IOPD Section (U1376)

In the IOPD Section **(**Algal Reef-Middle Eocene**);** the main active grazing herbivores are echinoderms and gastropods. The omnivorous species are foraminifera and ostracods. Thin sections of 25 samples collected at different intervals from the core were examined and found to be enriched by the rhodophyte coralline red algae. The distribution of the identified micro-and macroinvertebrate fossils from this unit (Fig. 5). Assemblages of both crustose and frondose forms of the rhodophytes occur in the eight distinct zonations within the algal limestone reef. This significant alteration of the zone is a good indicator of rapid sea-level change during that time and represents a unique opportunity to examine an algal reef, which developed in isolation. It is an obvious algal reef unit with a high percentage of algae (65%) shown in Figures 6a and 6b. The presence of the coral shows us the changing of the environment from the greenhouse (Eocene) to the icehouse (Oligocene). The "greenhouse" condition, or a warmer, more constant climate, existed on Earth between 56 and 33.9 million years ago during the Eocene period. Coral reefs were ubiquitous and diverse during this time, with sizable reef systems existing in many regions of the globe. Earth, however, changed to an "icehouse" state during the Oligocene period, which lasted from roughly 33.9 to 23 million years ago, when the climate became cooler and more changeable. Since it became harder for them to live in equatorial locations due to the cooler water temperatures and changes in ocean chemistry, coral reefs started to deteriorate during this time and shifted their distribution towards more subtropical and temperate latitudes. The variety and spread of coral reefs significantly drop, and the types of corals that are present shift as the world moves from the greenhouse to the icehouse state. For instance, massive, intricate "framework" reefs dominated coral reefs during the Eocene and smaller, easier "patch" reefs predominated during the Oligocene. The presence and distribution of various coral fossil types, changes in the sedimentary structures, and depositional environments connected to coral reefs are all examples of how this shift can be seen in the geological record. [8,9,10,14]

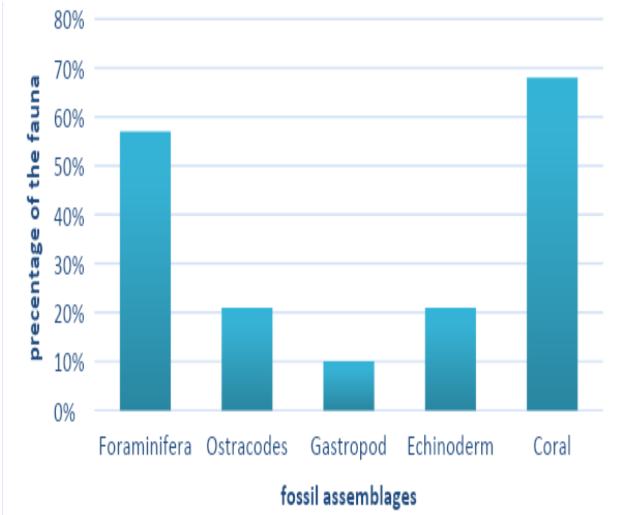

Figure 5. Histogram showing the distribution of the reported fossils in the algal reef (Limestone Unit IIA) in the thin sections.

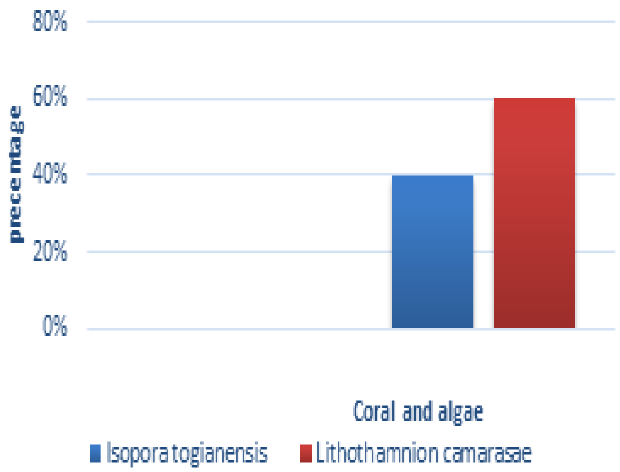

Figure 6a. Histogram showing the distribution of the coral (*Isopora togianensis*) against the red algae (*Lithothamnion camarasae*) in the Algal Reef (Limestone Unit IIA).

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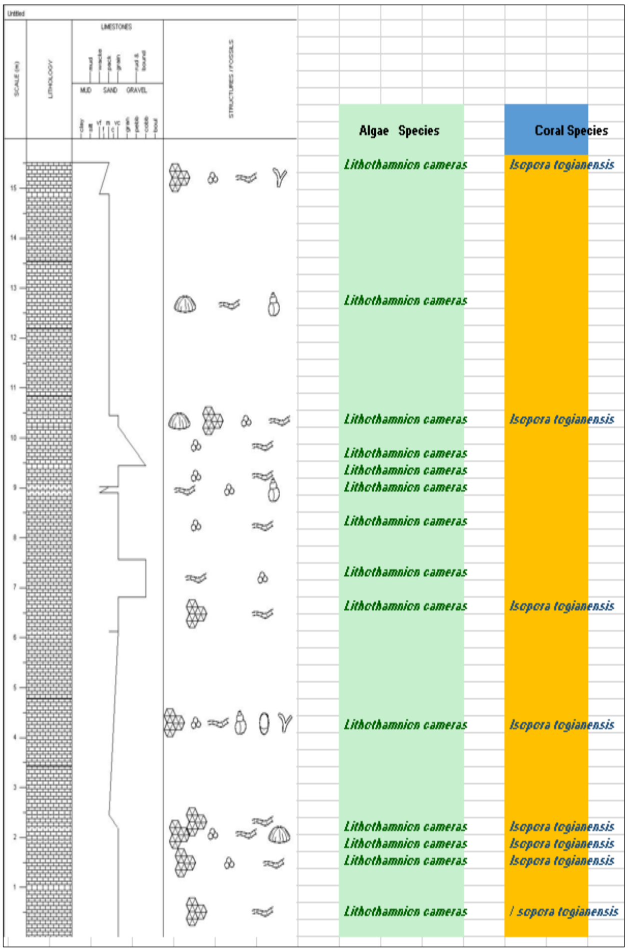

Figure 6b. Distribution of the coral (*Isopora togianensis)* against the red algae (*Lithothamnion camarasae*) in the column section (limestone unit IIA).

3.5. Systematic paleontology

3.5.1. Algal Taxonomy

Phylum: Rhodophyta Kiessling, 2003

Class: Florideophyceae Cornquisrt, 1960

Subclass: Corallinophycidae Cornquisrt, 1960

Order: Corallinales Silva,and Johanson, 1986

Family: Hapalidiaceae Gray,1864

Genus: Lithothamnion Heydrich,1897b

Lithothamnion camarasae Stanley, 2016

Plants can be found in the form of microscopic algal nodules (rhodoliths) or as single branches. They are fruticose, with long, slender branches (up to 6 mm long and 1 mm broad, with unusual 2 mm diameter) and apical dichotomous divisions. Adjacent branches may merge, and the filaments of both branches may be fused together. Encrusting growth forms might appear as lateral flat expansions on occasion. [8,18,19] Red algae known as *Lithothamnion camarasae* are typically found in tropical and subtropical areas of the world's oceans. Being calcareous algae, it can accumulate on the bottom and produce raised platforms called bioherms by forming hard, calcified structures. *Lithothamnion camarasae* has a crustose growth form, which refers to the fact that it continuously produces a crust-like layer on the substrate's surface. This layer is made up of closely spaced, calcified cells that, depending on the surrounding environment, can produce a range of distinct textures and patterns. *Lithothamnion camarasae* is a key component of marine ecosystems because it offers a platform for a range of different creatures such as algae, invertebrates, and fish to live on. It is also a useful resource for humans because it may be used in a range of industrial and agricultural uses, such as animal feed and fertilizer. [20,21] Type localities of this species at the San Salvador hill in the Sierra de Montroig, and about northwest of Camarasa in the eastern Pyrenees Lleida, Catalonia, Northeast Spain [21,22] and the age is Middle-Late Eocene [16,18]. Finally, the species is reported from San Salvador, Spain, France, Poland, Australia, Greece, India, Italy, the United States, and Hawaii [16,18].

3.5.2. Coral Taxonomy

Phylum: Cnidaria Chamberlain et al, 2019

Class: Anthozoa Stanley 2016.

Subclass: Hexacorallia Haeckel 1896

Order: Scleractinia Oken,1815

Family: Acroporidae Oken,1815

Genus: *Acropora* Oken,1815

Acropora togianensis and the new record *Isopora togianensis. Isopora togianensis* is a coral species in the Acroporidae family that was originally described in 2008 by Verona's team [25]. The species was described in an article titled "Scleractinia of the Coral Sea: new non-indigenous records and notes on their taxonomy and distribution" in the scientific journal Zootaxa. The species was identified in the Togian Islands in Indonesia's Gulf of Tomini. Its morphology is distinguished by its compact growth form, which produces small, spherical colonies with short branches. Corallites (individual skeletal cups that comprise the colony) are tightly spaced and have noticeable ridges on their walls. The description of this species: Colonies feature thick, strong branches that grow out from a solid base and are round in cross-section. The branches taper slightly and have a single dome-shaped axial corallite. Radial corallites are tiny and submerged. The coenosteum is made up of thin spinules with developed tips that are elevated into tubercula resembling Montipora. [26] The age is late Paleocene to Eocene [26], and with regard to distribution, the species is reported from Indonesia, Eastern New Guinea, and the rest of the Pacific Ocean [27].

4. DISCUSSIONS

The coral *Isopora togianensis* can reveal vital details about the environmental circumstances present at the time of its deposition in a sedimentary rock unit. The coral species *Isopora togianensis* is often found in shallow tropical waters in the photic zone, where light penetration is adequate for photosynthesis to take place. Small benthic foraminifera distribution, in addition to corals, can shed light on the environmental circumstances surrounding the sedimentary rock unit's formation. Small benthic foraminifera are common in tropical shallow habitats, especially on coral reefs, where they can be utilized to detect changes in water depth, temperature, and nutrient availability, among other environmental factors. The distribution of small benthic foraminifera likewise varies as water depth rises. The diversity and richness of tiny benthic foraminifera frequently increase in settings of intermediate depth, such as continental shelves, reflecting the rising complexity of the environment. Small benthic foraminifera are often scarce in deep-sea habitats, which reflects their poor productivity and slow rates of sedimentation. Overall, the presence of *Isopora togianensis* and tiny benthic foraminifera can be used to understand the environmental conditions that existed during sedimentary rock unit deposition. These creatures can be utilized to reconstruct the paleoenvironment and paleoclimate of many places of the world by providing vital information regarding water depth, temperature, and nutrient availability.

The restricted distribution of the algal species in this unit (*Lithothamnion camarasae*) in the South Pacific Ocean during the late Paleocene to Eocene seems to be attributable to the tectonic and eustatic forces (Pacific Plate and the Indo-Australian Plate). Evidence to support this statement: i) Geological mapping: geological mapping has shown that the East Tasman Plateau's location in the southern Pacific Ocean coincides with the distribution of the *Lithothamnion camarasae.* This plateau is thought to have developed due to volcanic activity and tectonic forces brought on by the movement of the Indo-Australian plate and the Pacific plate. ii) Paleoenvironmental reconstructions: paleoenvironmental reconstructions based on fossil evidence imply that throughout the late Paleocene to Eocene, the East Tasman Plateau was a shallow marine environment. This is in line with the habitat needs of the calcareous alga *Lithothamnion camarasae*, which thrives in shallow maritime habitats with abundant sunlight. iii) Sea Level Fluctuations: It is also believed that eustatic influences, such as sea level fluctuations, contributed to the dispersion of *Lithothamnion camarasae*. Global sea levels were rising from the late Paleocene to the early Eocene because of things like increased volcanic activity and the melting of polar ice sheets. This might have made the East Tasman Plateau a more conducive place for *Lithothamnion camarasae* to colonize. iv) According to phylogenetic research, *Lithothamnion camarasae* and related species may have evolved in the southern hemisphere and then spread to other parts of the world via ocean currents. This supports the hypothesis that the species was initially restricted to the South Pacific Ocean because of the tectonic and eustatic factors that sculpted the area's marine habitat throughout the late Paleocene to Eocene eras. Overall, tectonic and eustatic processes appear to have contributed to the restricted distribution of *Lithothamnion camarasae* in the South Pacific Ocean from the late Paleocene to the Eocene. This finding is supported by geological mapping, paleoenvironmental reconstructions, changes in sea level, and phylogenetic analyses.

The low diversity of the algae and coral is indicative of the meso-oligotrophic paleoenvironment. Even though they are not the only creatures that help limestone grow, corals and algae can be particularly significant in shallow marine habitats. Corals and algae are frequently the predominant primary producers in these ecosystems, which means they oversee a large portion of the ecosystem's photosynthesis. This indicates that they have the potential to have a substantial impact on the carbon cycle by modifying the amount of carbonate ions in seawater, which are required for the creation of calcium carbonate. Corals and algae can also build a structure that offers a solid foundation for other creatures to thrive on. This may result in the growth of intricate ecosystems that can support a wide variety of marine species. These organisms contribute to the creation of limestone as they decay and accumulate skeletons. Overall, although not having the greatest diversity of organisms in shallow marine habitats, algae and corals can still be extremely important in the development of limestone because they can provide a stable substrate and contribute to the carbon cycle.

The eleven established biofacies and fourteen sub-biofacies are controlled and manifested by sea level rising and falling during the Eocene time, as reflected by the interplay between the crustose and frondose forms of the rhodophytes (*Lithothamnion camarasae*) and associated taxa. To explain the previous statement in more detail, sea level oscillations were prevalent throughout the Eocene epoch because of variations in the planet's climate and tectonic activity. The distribution of marine species and the sediments they left behind were significantly shaped by these sea level variations. The calcareous algae *Lithothamnion camarasae* is a member of the rhodophytes, a group of organisms that is highly sensitive to variations in sea level. Sea level variations that took place throughout the Eocene can be understood by examining the interactions between the crustose and frondose forms of *Lithothamnion camarasae* and related species. *Lithothamnion camarasae* typically associates frondose forms with deeper water and times of low sea level, while crustose forms are typically associated with shallow marine settings and times of high sea level. Crustose species of *Lithothamnion camarasae* would have been able to colonize shallow marine settings and create large biostromes during periods of high sea level. The construction of varied biofacies that were abundant in both calcareous and non-calcareous species would have resulted from these biostromes, which would have offered a stable substrate for other organisms to thrive on. When the sea level was low, on the other hand, frondose forms of *Lithothamnion camarasae* would have been constrained to deeper water settings, resulting in the establishment of biofacies that were dominated by other deep-water creatures. As a result, there would have been less variety of sub-biofacies and creatures. Overall, the interaction of the frondose and crustose forms of *Lithothamnion camarasae* and related species indicates the Eocene Sea level variations. This interplay may be utilized to reconstruct the biofacies and sub-biofacies that were prevalent in various regions of the earth and offers insightful information about the environmental conditions that prevailed at the time.

5. CONCLUSIONS

In conclusion, the presence of *Isopora togianensis* coral and small benthic foraminifera, along with the restricted distribution of *Lithothamnion camarasae* algae, provide valuable insights into the environmental circumstances and processes that occurred during the deposition of sedimentary rock units. *Isopora togianensis* and small benthic foraminifera can be used to reconstruct the paleoenvironment and paleoclimate by indicating water depth, temperature, and nutrient availability. The distribution of *Lithothamnion camarasae* algae in the South Pacific Ocean during the late Paleocene to Eocene can be attributed to tectonic and eustatic forces, as supported by geological mapping, paleoenvironmental reconstructions, sea level fluctuations, and phylogenetic research. The low diversity of algae and coral in shallow marine habitats indicates a meso-oligotrophic paleoenvironment, with corals and algae playing significant roles in limestone development and the carbon cycle. The interplay between crustose and frondose forms of *Lithothamnion camarasa*e and associated taxa during sea level variations in the Eocene provides insights into the biofacies and sub-biofacies that existed, highlighting the environmental conditions prevalent at that time. Overall, these findings demonstrate the importance of these organisms in understanding past environmental conditions and processes in sedimentary rock units**.**

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