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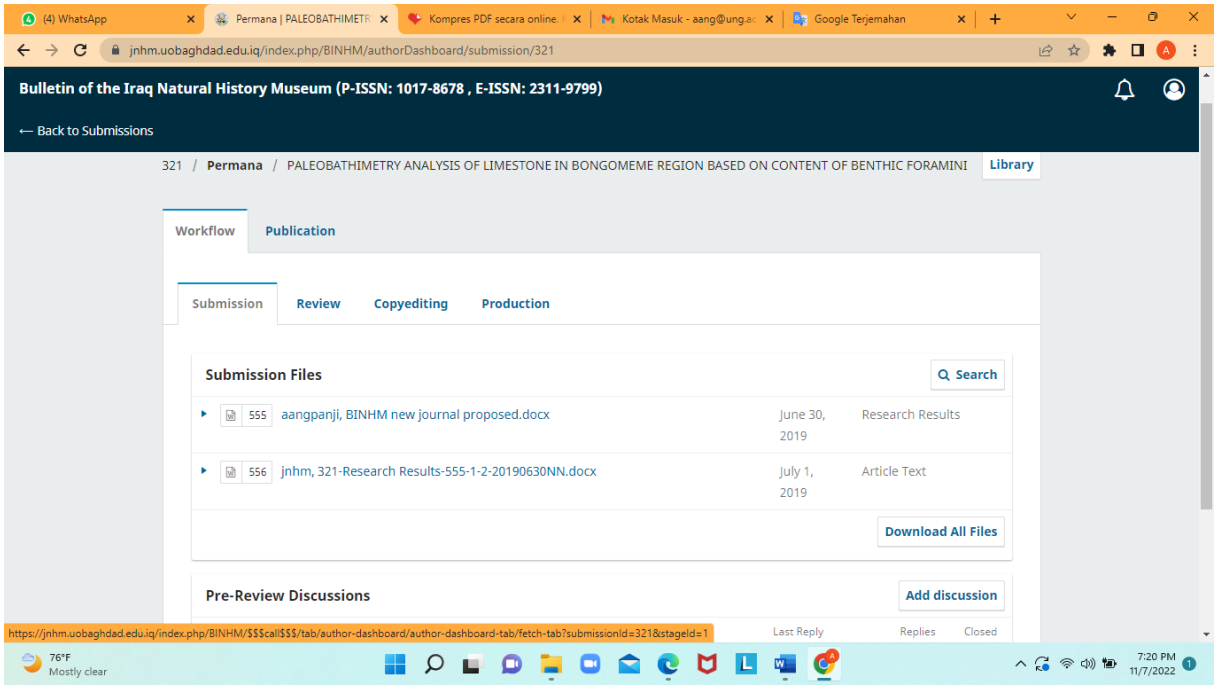
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PALEOBATHIMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL

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ABSTRACT

The location of the study is morphology of surging hills. The research material is limestone and research methods are field surveys and micropaleontological analysis. The aim of the study is to discover the species of benthic foraminifera fossil and to know paleobathimetry. The results of the analysis contained seven fossil species, namely *Ammomassilina alveoliniformis, Stelligerum Astrononion, Haynesia germanica, Nonion fabum, Praeglobobulimina ovata, Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, paleobathimetry is determined as Middle Neritic-Outer Neritic.

Keywords: Paleobathimetry, Limestone, Bongomeme, Benthic fossil.

INTRODUCTION

Sedimentation environment of carbonate (limestone), the sediment consists mostly of structured fragments produced by various types of organisms with certain ecological requirements (Meteu-Vicens *et al.*, 2008). The carbonate platform is characterized by the reestablishment of shallow sea water bentonic communities (Berggren and Prothero, 1992; Ivany *et al.*, 2000; Prothero, 2003).

Foraminifera has proven useful in reconstructing as is palaeoenvironmental in shallow sea water environments (Mendes *et al.*, 2004; Murray, 2006). The most important control in the distribution of benthic foraminiferal in the Mediterranean Sea and elsewhere are food availability and dissolved oxygen concentration (Jorissen *et al.*, 1995; De Rijk *et al.*, 1999, 2000; Murray, 2001). Analysis of paleobatimetry based on foraminifera assemblages was carried out on pliocene aged rocks in western Sahal with semi-quantitative reconstruction (Herkat and Ladjal, 2013).

Micropaleontology is a systematic study of microfossils, their morphology, classification and environmental and stratigraphic significance. For practical purposes, microfossils are any fossils, usually small, with the characteristic of which is best studied through a microscope. These include heterogeneous groups of fossils of organisms that are generally microscopic in size, for instance, foraminifera, ostracoda and radiolaria (Saraswati and Srinavasan, 2016).

The unit of reef limestone (Ql) that mapped consists of coral. Reef limestone units are also found in Tanjung Kramat Region. Petrology analysis of limestone shows the name of the limestone is kalsirudit or floatstone (Bachri *et al.*, 1997; Embry and Klovan, 1971; Grabau, 1905; Permana and Eraku, 2017; Permana, 2018).

The aim of this research is to know the species of benthic foraminifera fossil containing in limestone dan to know paleobathimetry of research.

MATERIALS AND METHODS

This research located in Bongomeme Region of Gorontalo District, Indonesia. Western area of Limboto lake located at geomorphology of surging hills. Bongomeme (1) (00° 35' 29.18"N; 122° 52' 45.82"E), Bongomeme (2) (00° 35' 34.680"N; 122° 52' 50.92" E) dan Bongomeme (3) (00° 36'41.260"N; 122° 50'44.34"E) (Picture 1).

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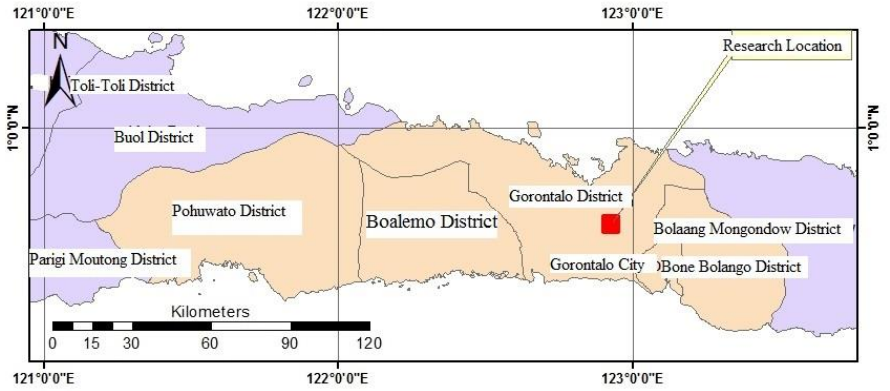


Picture 1. Research location in Bongomeme Region

Material or research material is sample of limestone containing benthic foraminifera fossil. The research method consisted of two stages, namely field survey and micropaleontological analysis. The field survey carried out field descriptions and determination of samples that were feasible to be analyzed and descriptions of petrology. Micropaleontological analysis was carried out to determine paleobatimetry based on the content of benthic foraminifera fossil (Ghosh and Sarkar, 2013; Martins *et al.*, 2015; Roozpeykar and Moghaddam, 2016). Micropaleontology analysis is using the Olympus SZ61 binocular microscope.

To prepare the preparation of benthic foraminifera fossil sample, a solution of 30-50% hydrogen peroxide (H_2O_2), blue methyl solution, 100 mesh sized filter, electric oven sample dryer and digital scales were used (Kadar, 1986).

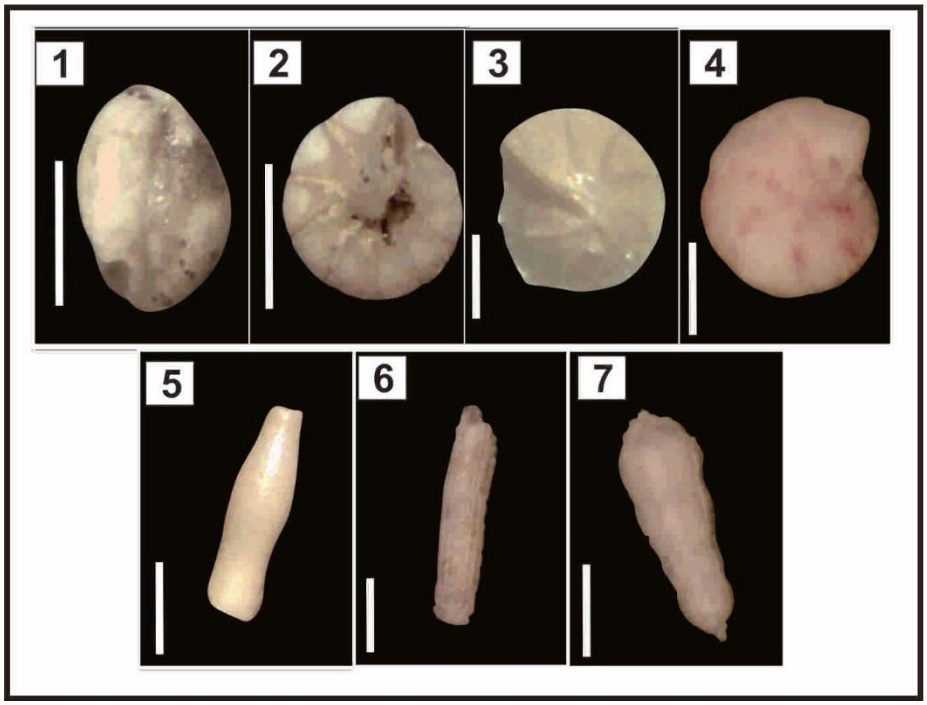
Identification of benthic foraminifera fossil for the determination of paleobathimetry refers to the classification of Tipsword *et al.*, 1966. Classification of the determination of paleobathimetry based on the depth of habitat of each benthic foraminifera species. Division of depth based on the environmental intervals of each foraminifera species. Each identified species is calculated for its abundance in each sample. The amount of abundance of one species uses the Kadar classification (1986).

All procedures, analytical methods, experimental design and preliminary materials should be provided with detail in this section. Relevant references should be quoted for a particular analytical methodology. Complete statistical procedures should be produced under separate heading of statistical analysis.

RESULTS AND DISCUSSION

Field surveys in the research area indicate that the main constituents are limestone. Petrological analysis of white limestone samples, medium sorting, floating grains in matrices and massive structures with compositions: large foraminifera, coral fragments, micrite and opaque minerals. Based on the description of the petrology, the names kalsirudit or floatstone. The results of field survey and petrological analysis which interpreted that samples of reef limestone contained large fossils of foraminifera, samples were taken for micropaleontological analysis.

The results of micropaleontological analysis shows that the number of benthic foraminifera species is varies. Bongomeme (1) there are three species of benthic foraminifera fossils namely *Haynesia germanica* (Ehrenberg, 1840), *Praeglobobulimina ovata* (d'Orbigny, 1846) and *Rhabdammina discreata* (Brady, 1881). Bongomeme (2) there are six species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879). Bongomeme (3) there are three species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839) and *Rhabdammina discreata* (Brady, 1881). Seven types of fossil species can be seen in Figure 2 (scale size 100 um).



Picture 2. Seven species of benthic foraminifera fossils found in research location : (1)*Ammomassilina alveoliniformis*, (2)*Astrononion stelligerum*, (3)*Haynesia germanica*, (4)*Nonion fabum*, (5)*Praeglobobulimina ovata*, (6)*Rhabdammina discreata* and (7)*Saccorhiza ramosa* (scale size : 100 um).

Complete classification of benthic foraminifera fossil in three different research location based on world's big data of basic foraminifera can be seen in Table 1.

Table 1. Classification of Foraminifera Bentonic Fossil Containment in Bongomeme Region

Classification	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Phylum	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*
Class	*Tubothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Monothalamea*	*Monothalamea*
Order	*Miliolida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Astrorhizida*	*Astrorhizida*
Suborder	*Miliolina*					*Astrorhizina*	*Hippocrepinina*
Superfamily	*Milioloidea*	*Nonionoidea*	*Rotalioidea*	*Nonionoidea*	*Buliminoidea*	*Astrorhizoidea*	*Hippocrepinoidea*
Family	*Hauerinidae*	*Nonionidae*	*Haynesinidae*	*Nonionidae*	*Buliminidae*	*Rhabdamminidae*	*Hyperamminidae*
Subfamily	*Siphonapertinae*	*Astrononioninae*		*Nonioninae*		*Rhabdammininae*	*Saccorhizinae*
Genus	*Ammomassilina*	*Astrononion*	*Haynesina*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza*
Species	*Ammomassilina alveoliniformis* (Millett, 1898)	*Astrononion stelligerum* (d'Orbigny, 1839)	*Haynesia germanica* (Ehrenberg, 1840)	*Nonion fabum* (Fichtel and Moll, 1798)	*Praeglobobulimina ovata* (d'Orbigny, 1846)	*Rhabdammina discreta* (Brady., 1881)	*Saccorhiza ramosa* (Brady., 1879)

The total abundance of each fossil species in each location according to [21] can be seen in Table 2 (Bongomeme 1), Table 3 (Bongomeme 2) and Table 4 (Bongomeme 3).

Table 2. The abundance of each benthic foraminifera fossils species in Bongomeme 1

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table 3. The abundance of each benthic foraminifera fossils species in Bongomeme 2

Species	Total	Abundance
Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Table 4. The abundance of each benthic foraminifera fossils species in Bongomeme 3

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Based on the research results, there are seven species of bentonic foraminifera fossil therefore paleobathimetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of foraminifera bentonics fossil while it was life. Analysis of paleobathimetry for each location based on Tipsword et al (1966) can be seen in Table 5 (Bongomeme 1), Table 6 (Bongomeme 2) and Table 7 (Bongomeme 3). The results of the analysis of paleobathimetry shows paleobathimetry Bongomeme 1 is Middle Neritic-Outer Neritic (20-200 meters), paleobathimetry Bongomeme 2 is Middle Neritic (20-100 meters) and paleobathimetry Bongomeme 3 equal Middle Neritic (20-100 meters).

Table 5. Paleobathimetry Analysis of Bongomeme 1

Species	Paleobathimetry								
Haynesia germanica									
Praeglobobulimina ovata									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 6. Paleobathimetry Analysis of Bongomeme 2

Species	Paleobathimetry								
Ammomassilina alveoliniformis									
Haynesia germanica									
Nonion fabum									
Praeglobobulimina ovata									
Rhabdammina discreta									
Saccorhiza ramosa									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 7. Paleobathimetry Analysis of Bongomeme 3

Species	Paleobathimetry								
Ammomassilina alveoliniformis									
Astrononion stelligerum									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Paleobathimetry analysis of the research area at the time of limestone formation was formed based on the content of benthic foraminifera fossil finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of limestone formation under the sea. The location of the research was experiencing elevation from the shallow Middle Neritic Sea to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the sea environment.

CONCLUSIONS

Based on the results and discussion, some important conclusions can be drawn. The Bongomeme area of Gorontalo Regency consisting by reef limestones containing benthic foraminifera fossil and coral fragments.

The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879).

The content of bentonic foraminifera fossil that been found can be used for the analysis of paleobathimetry. The analysis of paleobathimetry revealed that the research area was previously a shallow sea water environment. Paleobathimetry Bongomeme 1 is the Middle Neritic–Outer Neritic with a depth of 20–200 meters while Bongomeme 2 and 3 are Middle Neritic in the range of 20-100 meters depth.

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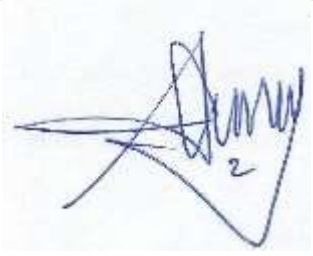

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Dear author

The paper requires the following:

1-Adding the numbers of studied sections and samples.

2-The determination of biofacies that are important in determining the palaeobathemetry in limestone rocks.

3-The study requires a stratigraphic column showing the distribution of biofacies and fossils.

4- Explaining the environmental factors affecting the distribution of foraminifera such as:

-water depth

-salinity

-Oxygen

-wave and current energy

-substrate

5- An environmental model showing the distribution of fossils.

6-Stratigraphic data to determine the palaeobathymetry in more detail.

7- The paleodepth of studied species based on previous regional and global studies.

Recommendation: Revision Required

Reviewer G:

This paper is small part of big research project ,it is better to put all these informations of the whole project together rather than split them to pieces .

The authers need proofreading, location map with all the studied sites.

Rewrite the whole paper to be clearer.

Chech the references.

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PALEO-BATHYMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL

ABSTRACT

The location of the study is morphology of surging hills. The research material is limestone and research methods are field surveys and micropaleontological analysis. The aim of the study is to discover the species of benthic foraminifera fossil and to know paleo-bathymetry. The results of the analysis contained seven fossil species, namely *Ammomassilina alveoliniformis*, *Stelligerum Astrononion*, *Haynesia germanica*, *Nonion fabum*, *Praeglobobulimina ovata*, *Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, Paleobathymetrypaleobathymetry is determined as Middle Neritic-Outer Neritic.

Keywords: PaleobathymetryPaleobathymetry, Limestone, Bongomeme, Benthic fossil.

INTRODUCTION

Limestone is the sediment that consists mostly of structured fragments produced by various types of organisms with certain ecological requirements (Meteu-Vicens *et al*., 2008). The carbonate platform is characterized by the reestablishment of shallow sea water bentonic communities (Berggren and Prothero, 1992; Ivany *et al*., 2000; Prothero, 2003).

Foraminifera has proven useful in reconstructing as is palaeoenvironmental in shallow sea water environments (Mendes *et al*., 2004; Murray, 2006). The most important control in the distribution of benthic foraminiferal in the Mediterranean Sea and elsewhere are food availability and dissolved oxygen concentration (Jorissen *et al*., 1995; De Rijk *et al*., 1999, 2000; Murray, 2001). Analysis of paleobatthymetry based on foraminifera assemblages was carried out on pliocene aged rocks in western Sahal with semi-quantitative reconstruction (Herkat and Ladjal, 2013).

Micropaleontology is a systematic study of microfossils, their morphology, classification and environmental and stratigraphic significance. For practical purposes, microfossils are any fossils, usually small, with the characteristic of which is best studied through a microscope. These include heterogeneous groups of fossils of organisms that are generally microscopic in size, for instance, foraminifera, ostracoda and radiolaria (Saraswati and Srinavasan, 2016).

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The aim of this research is to know the species of benthic foraminifera fossil containing in limestone dan to know Paleobathymetrypaleobathymetry of research.

MATERIALS AND METHODS

This research located in Bongomeme Region of Gorontalo District, Indonesia. Western area of Limboto Lake located at geomorphology of surging hills. Bongomeme (1) (00° 35' 29.18"N; 122° 52' 45.82"E), Bongomeme (2) (00° 35' 34.680"N; 122° 52' 50.92" E) dan Bongomeme (3) (00° 36'41.260"N; 122° 50'44.34"E) (Figure 1).

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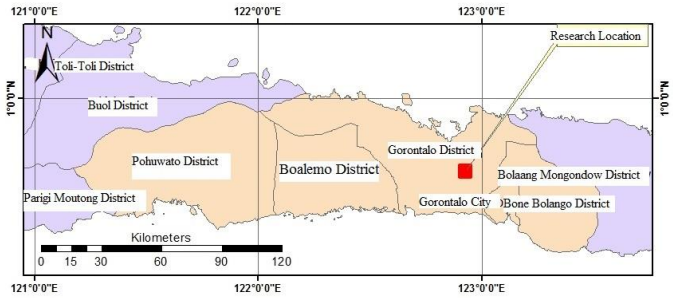

Figure 1. Research location in Bongomeme Region. The research location be marked with ……..

Commented [WU1]: maybe you can add the general research methods in your abstract

Commented [WU2]: Please provide a connecting sentence between these two sentences

Commented [WU3]: And/then?

Commented [WU4]: Bongomeme (1), (2) and (3) are the location? Please explain more clearly.

Commented [WU5]: Please add the overview of regional geology

Material or research material is sample of limestone containing benthic foraminifera fossil. The research method consisted of two stages, namely field survey and micropaleontological analysis. The field survey carried out field descriptions and determination of samples that were feasible to be analyzed and descriptions of petrology. Micropaleontological analysis was carried out to determine paleobathymetry based on the content of benthic foraminifera fossil (Ghosh and Sarkar, 2013; Martins *et al*., 2015; Roozpeykar and Moghaddam, 2016). Micropaleontology analysis is using the Olympus SZ61 binocular microscope.
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RESULTS AND DISCUSSION

Field surveys in the research area indicate that the main constituents are limestone. Based on hand specimen description, the limestone had white colour, with … to … mm grain size, medium sorting, floating grains in matrices and massive structures with compositions: large foraminifera, coral fragments, opaque mineral as a fragment and micrite as a matrix. Based on the description of the petrology, the names kalsirudit or floatstone.
The results of field survey and petrological analysis which interpreted that samples of reef limestone contained large fossils of foraminifera, samples were taken for micropaleontological analysis.
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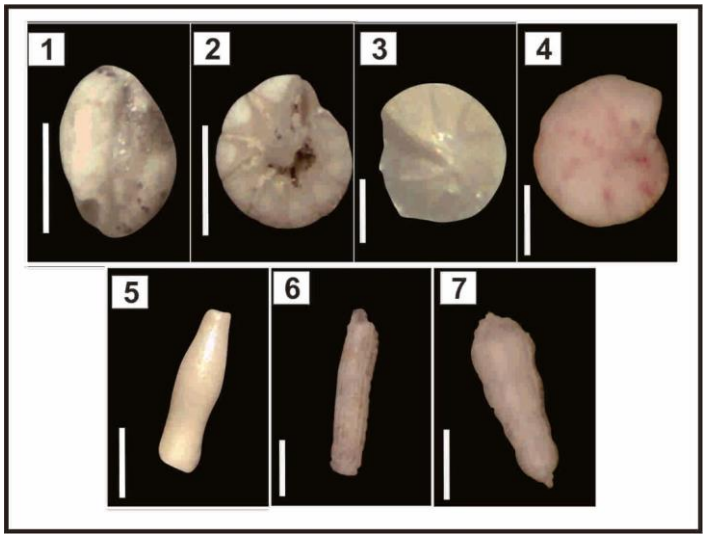

Picture 2. Seven species of benthic foraminifera fossils found in research location : (1)*Ammomassilina alveoliniformis*, (2)*Astrononion stelligerum*, (3)*Haynesia germanica*, (4)*Nonion fabum*, (5)*Praeglobobulimina ovata*, (6)*Rhabdammina discreata* and (7)*Saccorhiza ramosa* (scale size : 100 um).

Complete classification of benthic foraminifera fossil in three different research location based on world's big data of basic foraminifera can be seen in Table 1.

Table 1. Classification of Foraminifera Bentonic Fossil Containment in Bongomeme Region

Classification	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Phylum	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*
Class	*Tubothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Monothalamea*	*Monothalamea*
Order	*Miliolida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Astrorhizida*	*Astrorhizida*
Suborder	*Miliolina*					*Astrorhizina*	*Hippocrepinina*
Superfamily	*Milioloidea*	*Nonionoidea*	*Rotalioidea*	*Nonionoidea*	*Buliminoidea*	*Astrorhizoidea*	*Hippocrepinoidea*
Family	*Hauerinidae*	*Nonionidae*	*Haynesinidae*	*Nonionidae*	*Buliminidae*	*Rhabdamminidae*	*Hyperamminidae*
Subfamily	*Siphonapertinae*	*Astrononioninae*		*Nonioninae*		*Rhabdammininae*	*Saccorhizinae Saccorhiza*
Genus	*Ammomassilina*	*Astrononion*	*Haynesina Haynesia*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza ramosa*
Species	*Ammomassilina alveoliniformis* (Millett, 1898)	*Astrononion stelligerum* (d'Orbigny, 1839)	*germanica* (Ehrenberg, 1840)	*Nonion fabum* (Fichtel and Moll, 1798)	*Praeglobobulimina ovata* (d'Orbigny, 1846)	*Rhabdammina discreta* (Brady., 1881)	(Brady., 1879)

The total abundance of each fossil species in each location according to [21] can be seen in Table 2 (Bongomeme 1), Table 3 (Bongomeme 2) and Table 4 (Bongomeme 3).

Table 2. The abundance of each benthic foraminifera fossils species in Bongomeme 1

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table 3. The abundance of each benthic foraminifera fossils species in Bongomeme 2

Species	Total	Abundance
Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Commented [WU10]: *Ammomassilina alveoliniformis* is include the milliolina group. The presence of *Ammomassilina alveoliniformis* shows that the possibility of lagoonal environtment (semi-closed condition). You can compare the abundant of Milliolina vs Textulariina vs Rotaliina, and plotting in triangle diagram from Armstrong and Brasier (2005)

Table 4. The abundance of each benthic foraminifera fossils species in Bongomeme 3

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Based on the research results, there are seven species of bentonic foraminifera fossil therefore Paleobathymetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of foraminifera bentonics fossil while it was life. Analysis of paleobathymetry for each location based on Tipsword et al (1966) can be seen in Table 5 (Bongomeme 1), Table 6 (Bongomeme 2) and Table 7 (Bongomeme 3). The results of the analysis of paleobathymetry shows paleobathymetry Bongomeme 1 is Middle Neritic-Outer Neritic (20-200 meters), Paleobathymetry Bongomeme 2 is Middle Neritic (20-100 meters) and paleobathymetry Bongomeme 3 equal Middle Neritic (20-100 meters).

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Table 5. Paleobathymetry Analysis of Bongomeme 1

Species	Paleobathymetry								
Haynesia germanica									
Praeglobobulimina ovata									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 6. Paleobathymetry Analysis of Bongomeme 2

Species	Paleobathymetry								
Ammomassilina alveoliniformis									
Haynesia germanica									
Nonion fabum									
Praeglobobulimina ovata									
Rhabdammina discreta									
Saccorhiza ramosa									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 7. Paleobathymetry Analysis of Bongomeme 3

Species	Paleobathymetry								
Ammomassilina alveoliniformis									
Astrononion stelligerum									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Paleobathymetry analysis of the research area at the time of limestone formation was formed based on the content of benthic foraminifera fossil finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of limestone formation under the sea. The location of the research was experiencing elevation from the shallow Middle Neritic Sea to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the sea environment.

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CONCLUSIONS

Based on the results and discussion, some important conclusions can be drawn. The Bongomeme area of Gorontalo Regency consisting by reef limestones containing benthic foraminifera fossil and coral fragments.

The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879).

The content of bentonic foraminifera fossil that been found can be used for the analysis of Paleobathymetry. The analysis of Paleobathymetry revealed that the research area was previously a shallow sea water environment. Paleobathymetry Bongomeme 1 is the Middle Neritic–Outer Neritic with a depth of 20–200 meters while Bongomeme 2 and 3 are Middle Neritic in the range of 20-100 meters depth.

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PALEOBATHIMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL

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ABSTRACT

The location of the study is morphology of surging hills. The research material is limestone and research methods are field surveys and micropaleontological analysis. The aim of the study is to discover the species of benthic foraminifera fossil and to know paleobathimetry. The results of the analysis contained seven fossil species, namely *Ammomassilina alveoliniformis*, *Stelligerum Astrononion*, *Haynesia germanica*, *Nonion fabum*, *Praeglobobulimina ovata*, *Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, paleobathimetry is determined as Middle Neritic-Outer Neritic.

Keywords: Paleobathimetry, Limestone, Bongomeme, Benthic fossil.

INTRODUCTION

Sedimentary Sedimentation environment of carbonate (limestone), the sediment consists mostly of structured fragments produced by various types of organisms with certain ecological requirements (Meteu-Vicens *et al.*, 2008). The carbonate platform is characterized by the reestablishment of shallow sea water bentonic communities (Berggren and Prothero, 1992; Ivany *et al.*, 2000; Prothero, 2003).

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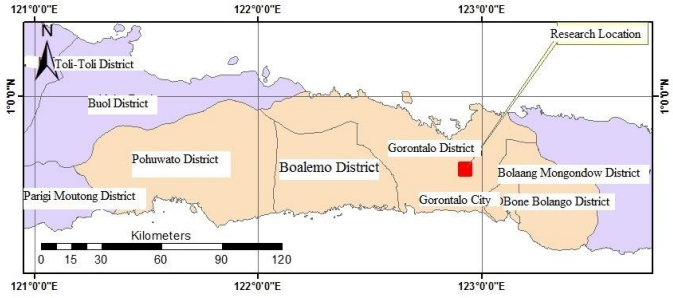

Picture 1. Research location in Bongomeme Region(reference is needed)
Map of Indonesia should be added to this map

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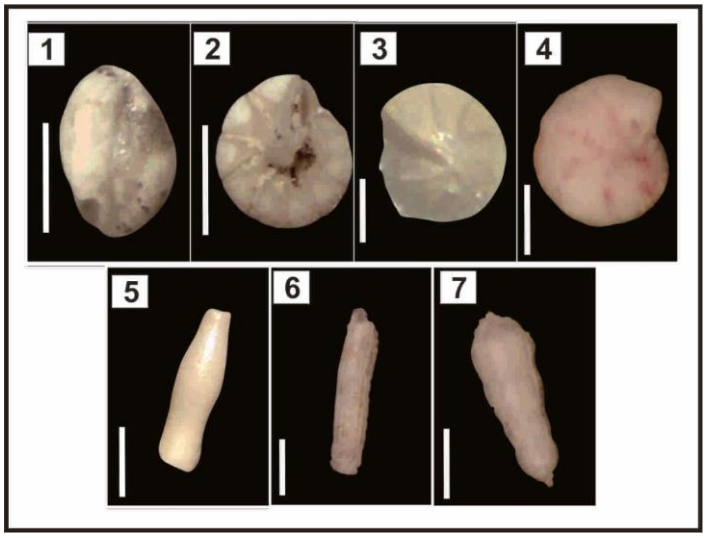

Picture 2. Seven species of benthic foraminifera fossils found in research location : (1)*Ammomassilina alveoliniformis*, (2)*Astrononion stelligerum*, (3)*Haynesia germanica*, (4)*Nonion fabum*, (5)*Praeglobobulimina ovata*, (6)*Rhabdammina discreata* and (7)*Saccorhiza ramosa* (scale size : 100 um).

Complete classification of benthic foraminifera fossil in three different research location based on world's big data of basic foraminifera can be seen in Table 1.

Table 1. Classification of Foraminifera Bentonic Fossil Containment in Bongomeme Region(reference)

Classification	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Phylum	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*
Class	*Tubothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Monothalamea*	*Monothalamea*
Order	*Miliolida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Astrorhizida*	*Astrorhizida*
Suborder	*Miliolina*					*Astrorhizina*	*Hippocrepinina*
Superfamily	*Milioloidea*	*Nonionoidea*	*Rotalioidea*	*Nonionoidea*	*Buliminoidea*	*Astrorhizoidea*	*Hippocrepinoidea*
Family	*Hauerinidae*	*Nonionidae*	*Haynesinidae*	*Nonionidae*	*Buliminidae*	*Rhabdamminidae*	*Hyperamminidae*
Subfamily	*Siphonapertinae*	*Astrononioninae*		*Nonioninae*		*Rhabdammininae*	*Saccorhizinae Saccorhiza*
Genus	*Ammomassilina*	*Astrononion*	*Haynesina Haynesia*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza ramosa*
Species	*Ammomassilina alveoliniformis* (Millett, 1898)	*Astrononion stelligerum* (d'Orbigny, 1839)	*germanica* (Ehrenberg, 1840)	*Nonion fabum* (Fichtel and Moll, 1798)	*Praeglobobulimina ovata* (d'Orbigny, 1846)	*Rhabdammina discreta* (Brady., 1881)	(Brady., 1879)

The total abundance of each fossil species in each location according to [21] can be seen in Table 2 (Bongomeme 1), Table 3 (Bongomeme 2) and Table 4 (Bongomeme 3).

Table 2. The abundance of each benthic foraminifera fossils species in Bongomeme 1

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table 3. The abundance of each benthic foraminifera fossils species in Bongomeme 2

Species	Total	Abundance
Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Table 4. The abundance of each benthic foraminifera fossils species in Bongomeme 3

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Based on the research results, there are seven species of bentonic foraminifera fossil therefore paleobathimetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of foraminifera bentonics fossil while it was life. Analysis of paleobathimetry for each location based on Tipsword et al (1966) can be seen in Table 5 (Bongomeme 1), Table 6

(Bongomeme 2) and Table 7 (Bongomeme 3). The results of the analysis of paleobathimetry shows paleobathimetry Bongomeme 1 is Middle Neritic-Outer Neritic (20-200 meters), paleobathimetry Bongomeme 2 is Middle Neritic (20-100 meters) and paleobathimetry Bongomeme 3 equal Middle Neritic (20-100 meters).

Table 5. Paleobathimetry Analysis of Bongomeme 1

Species	Paleobathimetry								
Haynesia germanica									
Praeglobobulimina ovata									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 6. Paleobathimetry Analysis of Bongomeme 2

Species	Paleobathimetry								
Ammomassilina alveoliniformis									
Haynesia germanica									
Nonion fabum									
Praeglobobulimina ovata									
Rhabdammina discreta									
Saccorhiza ramosa									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Table 7. Paleobathimetry Analysis of Bongomeme 3

Species	Paleobathimetry								
Ammomassilina alveoliniformis									
Astrononion stelligerum									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Paleobathimetry analysis of the research area at the time of limestone formation was formed based on the content of benthic foraminifera fossil finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of limestone formation under the sea. The location of the research was experiencing elevation from the shallow Middle Neritic Sea to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the sea environment.

CONCLUSIONS

Based on the results and discussion, some important conclusions can be drawn. The Bongomeme area of Gorontalo Regency consisting by reef limestones containing benthic foraminifera fossil and coral fragments.

The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879).

The content of bentonic foraminifera fossil that been found can be used for the analysis of paleobathimetry. The analysis of paleobathimetry revealed that the research area was previously a shallow sea water environment. Paleobathimetry Bongomeme 1 is the Middle Neritic–Outer Neritic with a depth of 20–200 meters while Bongomeme 2 and 3 are Middle Neritic in the range of 20-100 meters depth.

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PALEOBATHIMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL, GORONTLO DISTRICT, INDONESIA

ABSTRACT

The location of the study area is surging hills. The research material is limestone and research methods are field surveys and micropaleontological analysis. The aim of the study is to discover the species of benthic foraminifera fossils and to determine the paleobathimetry to the studied regions. The results of the analysis contained seven fossils species, namely *Ammomassilina alveoliniformis, Stelligerum Astrononion, Haynesia germanica, Nonion fabum, Praeglobobulimina ovata, Rhabdammina discreata* and *Saccorhiza ramosa.* Based on the content of benthic foraminifera fossils, paleobathimetry is determined as Middle Neritic-Outer Neritic to Bongomeme 1, while Bongomeme 2,and 3 is Middle Neritic.

Keywords: Paleobathimetry, Limestone, Bongomeme, Benthic fossil, Indonesia.

INTRODUCTION

Sedimentation environment of carbonate (limestone), the sediment consists mostly of structured fragments produced by various types of organisms with certain ecological requirements (Meteu-Vicens *et al.*, 2008). The carbonate platform is characterized by the reestablishment of shallow sea water bentonic communities (Berggren and Prothero, 1992; Ivany *et al.*, 2000; Prothero, 2003). Foraminifera has proven useful in reconstructing as is palaeoenvironmental in shallow sea water environments (Mendes *et al.*, 2004; Murray, 2006). The most important control in the distribution of benthic foraminiferal in the Mediterranean Sea and elsewhere are food availability and dissolved oxygen concentration (Jorissen *et al.*, 1995; De Rijk *et al.*, 1999, 2000; Murray, 2001). Analysis of paleobatimetry based on foraminifera assemblages was carried out on Pliocene aged rocks in western Sahal with semi-quantitative reconstruction (Herkat and Ladjal, 2013).

Micropaleontology is a systematic study of microfossils, their morphology, classification and environmental and stratigraphic significance. For practical purposes, microfossils are any fossils, usually small, with the characteristic of which is best studied through a microscope. These include heterogeneous groups of fossils of organisms that are generally microscopic in size, for instance, foraminifera, ostracoda and radiolaria (Saraswati and Srinavasan, 2016).

The unit of reef limestone (Ql) that mapped consists of coral. Reef limestone units are also found in Tanjung Kramat Region. Petrology analysis of limestone shows the name of the limestone is kalsirudit or floatstone (Bachri *et al*., 1997; Embry and Klovan, 1971; Grabau, 1905; Permana and Eraku, 2017; Permana, 2018).

The aim of this research is to know the species of benthic foraminifera fossil containing in limestone dan to know paleobathimetry of research.

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MATERIALS AND METHODS

This research located in Bongomeme Region of Gorontalo District, Indonesia. Western area of Limboto lake which located at geomorphology of surging hills. Bongomeme (1) (00° 35' 29.18"N; 122° 52' 45.82"E), Bongomeme (2) (00° 35' 34.680"N; 122° 52' 50.92" E) dan Bongomeme (3) (00° 36'41.260"N; 122° 50'44.34"E) (figure 1).

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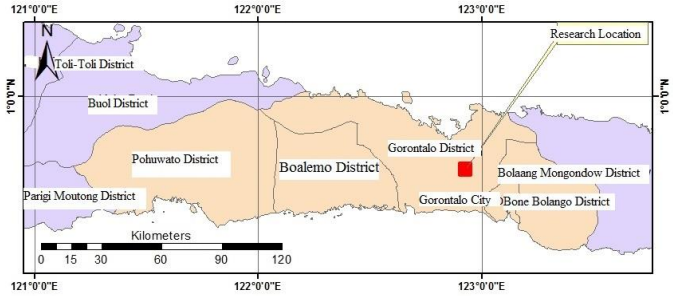

Figure 1. Location map to the studied area in Bongomeme Region, Indonesia

Material or research material of samples are limestone containing benthic foraminifera fossils. The research method consisted of two stages, namely field survey and micropaleontological analysis. The field survey carried out field descriptions and determination of samples that were feasible to be analyzed and descriptions of petrology. Micropaleontological analysis was carried out to determine paleobatimetry based on the content of benthic foraminifera fossils (Ghosh and Sarkar, 2013; Martins *et al.*, 2015; Roozpeykar and Moghaddam, 2016). Fossils identification is using by the Olympus SZ61 binocular microscope.

To prepare the benthic foraminifera fossil sample, a solution of 30-50% hydrogen peroxide (H_2O_2), blue methyl solution, 100 mesh sized filter, electric oven sample dryer and digital scales were used (Kadar, 1986).

Identification of benthic foraminifera fossil for the determination of paleobathimetry refers to the classification of Tipsword *et al.*, 1966. Classification of the determination of paleobathimetry based on the depth of habitat of each benthic foraminifera species. Division of depth based on the environmental intervals of each foraminifera species. Each identified species is calculated for its abundance in each sample. The amount of abundance of one species uses the Kadar classification (1986).

All procedures, analytical methods, experimental design and preliminary materials should be provided with detail in this section. Relevant references should be quoted for a particular analytical methodology. Complete statistical procedures should be produced under separate heading of statistical analysis.

RESULTS AND DISCUSSION

Field surveys in the research area indicate that the main constituents are limestone. Petrological analysis of white limestone samples, medium sorting, floating grains in matrices and massive structures with compositions: large foraminifera, coral fragments, micrite and opaque minerals. Based on the description of the petrology, the names kalsirudit or floatstone.

The results of field survey and petrological analysis which interpreted that samples of reef limestone contained large fossils of foraminifera, samples were taken for micropaleontological analysis.

The results of micropaleontological analysis shows that the number of benthic foraminifera species is varies. Bongomeme (1) there are three species of benthic foraminifera fossils namely *Haynesia germanica* (Ehrenberg, 1840), *Praeglobobulimina ovata* (d'Orbigny, 1846) and *Rhabdammina discreata* (Brady, 1881). Bongomeme (2) there are six species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879). Bongomeme (3) there are three species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839) and *Rhabdammina discreata* (Brady, 1881). Seven types of fossil species can be seen in Figure 2 (scale size 100 um).

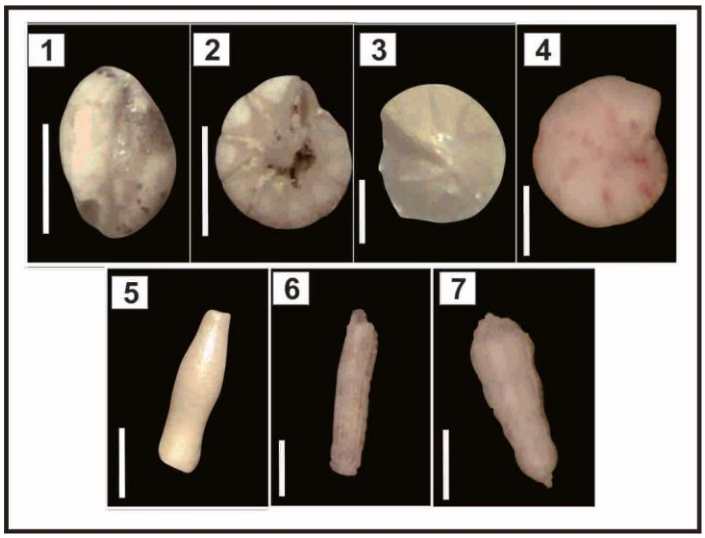

Figure 2. Seven species of benthic foraminifera fossils found in research location : (1)*Ammomassilina alveoliniformis*, (2)*Astrononion stelligerum*, (3)*Haynesia germanica*, (4)*Nonion fabum*, (5)*Praeglobobulimina ovata*, (6)*Rhabdammina discreata* and (7)*Saccorhiza ramosa* (scale size : 100 um).

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Complete classification of benthic foraminifera fossils in three different research location based on world's big data of basic foraminifera can be seen in Table 1.

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Order	*Miliolida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Astrorhizida*	*Astrorhizida*
Suborder	*Miliolina*					*Astrorhizina*	*Hippocrepinina*
Superfamily	*Milioloidea*	*Nonionoidea*	*Rotalioidea*	*Nonionoidea*	*Buliminoidea*	*Astrorhizoidea*	*Hippocrepinoidea*
Family	*Hauerinidae*	*Nonionidae*	*Haynesinidae*	*Nonionidae*	*Buliminidae*	*Rhabdamminidae*	*Hyperamminidae*
Subfamily	*Siphonapertinae*	*Astrononionin*ae		*Nonioninae*		*Rhabdammininae*	*Saccorhizinae Saccorhiza*
Genus	*Ammomassilina*	*Astrononion*	*Haynesina Haynesia*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza ramosa*
Species	*Ammomassilina alveoliniformis* (Millett, 1898)	*Astrononion stelligerum* (d'Orbigny, 1839)	*germanica* (Ehrenberg, 1840)	*Nonion fabum* (Fichtel and Moll, 1798)	*Praeglobobulimina ovata* (d'Orbigny, 1846)	*Rhabdammina discreta* (Brady., 1881)	(Brady., 1879)

The total abundance of each fossil species in each location according to [21] can be seen in Table 2 (Bongomeme 1), Table 3 (Bongomeme 2) and Table 4 (Bongomeme 3).

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Table 2. The abundance of each benthic foraminifera fossils species in Bongomeme 1

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table 3. The abundance of each benthic foraminifera fossils species in Bongomeme 2

Species	Total	Abundance
Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Table 4. The abundance of each benthic foraminifera fossils species in Bongomeme 3

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Based on the research results, there are seven species of bentonic foraminifera fossils therefore paleobathimetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of foraminifera bentonic fossils while it was life. Analysis of paleobathimetry for each location based on Tipsword et al (1966) can be seen in Table 5 (Bongomeme 1), Table 6 (Bongomeme 2) and Table 7 (Bongomeme 3). The results of the analysis of paleobathimetry shows paleobathimetry Bongomeme 1 is Middle Neritic-Outer Neritic (20-200 meters), paleobathimetry Bongomeme 2 is Middle Neritic (20-100 meters) and paleobathimetry Bongomeme 3 equal Middle Neritic (20-100 meters).

Table 5. Paleobathimetry Analysis of Bongomeme 1

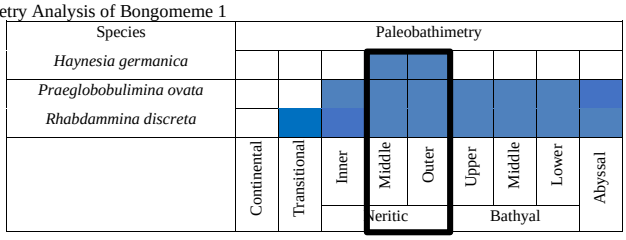


Table 6. Paleobathimetry Analysis of Bongomeme 2

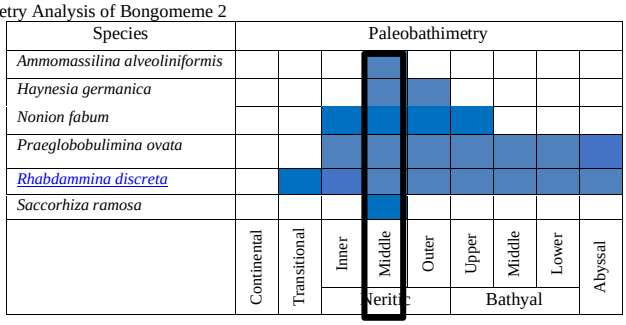
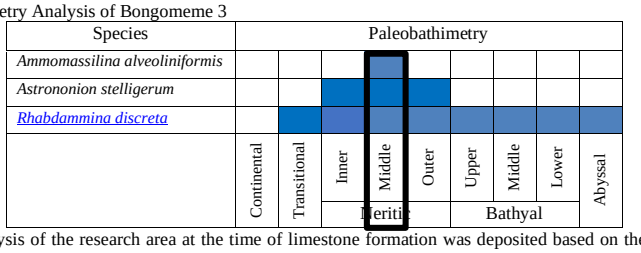


Table 7. Paleobathimetry Analysis of Bongomeme 3



Paleobathimetry analysis of the research area at the time of limestone formation was deposited based on the content of benthic foraminifera fossils, finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of limestone formation under the sea. The location of the research was experiencing elevation from the shallow Middle Neritic Sea to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the sea environment.

CONCLUSIONS

Based on the results and discussion, some important conclusions can be mentioned. The Bongomeme area of Gorontalo Regency consisting by reef limestones containing benthic foraminifera fossil and coral fragments.

Commented [s23]: Reef more shallow do not reach to 200m, 20 -40 m only!! You must to different between reef and neritic environments!!

The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879).

The content of bentonic foraminifera fossil that been found can be used for the analysis of paleobathimetry. The analysis of paleobathimetry revealed that the research area was previously a shallow sea water environment. Paleobathimetry Bongomeme 1 is the Middle Neritic–Outer Neritic with a depth of 20–200 meters while Bongomeme 2 and 3 are Middle Neritic in the range of 20-100 meters depth.

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Revised Results/Authors Response

Part	Comments from Reviewer H (321-718-1-5-20190927)	Author's Response
Abstract	The location of the study is morphology of surging hills. The research material is limestone and research methods are field surveys and micropaleontological analysis. The aim of the study is to discover the species of benthic foraminifera fossil and to know paleobathimetry. The results of the analysis contained seven fossil species, namely *Ammomassilina alveoliniformis, Stelligerum Astrononion, Haynesia germanica, Nonion fabum, Praeglobobulimina ovata, Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, paleobathimetry is determined as Middle Neritic-Outer Neritic	Thank you for your input. We have already revised it.
Introduction	Sedimentation	Thank you for your input. We have already revised it.
	Mediterranean Sea and elsewhere	Thank you for your input. We have already revised it.
	The unit of reef limestone (Ql) that mapped consists of coral. Reef limestone units are also found in Tanjung Kramat Region. Petrology analysis of limestone shows the name of the limestone is kalsirudit or floatstone (Bachri *et al.*, 1997; Embry and Klovan, 1971; Grabau, 1905; Permana and Eraku, 2017; Permana, 2018).	Thank you for your input. We have already revised it.
	dan	Thank you for your input. We have already revised it.
Materials and Methods	Stratigraphic sections are needed	Thank you for your input. We have already revised it.
	Picture 1. Research location in Bongomeme Region(reference is needed) Map of Indonesia should be added to this map	Thank you for your input. We have already revised it.
	paleobatimetry	
	Tipsword *et al.*, 1966	
	All procedures, analytical methods, experimental design and preliminary materials should be provided with detail in this section. Relevant references should be quoted for a particular analytical methodology. Complete statistical procedures should be produced under separate heading of statistical analysis.	Thank you for your input. We have already removed it.
Results and Discussion	The results of micropaleontological analysis shows that the number of benthic foraminifera species is varies. Bongomeme (1) there are three species of benthic foraminifera fossils namely *Haynesia germanica* (Ehrenberg, 1840), *Praeglobobulimina ovata* (d'Orbigny, 1846) and *Rhabdammina discreata* (Brady, 1881). Bongomeme (2) there are six species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Haynesia*	Thank you for your input. We have already revised it.

	germanica (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879). Bongomeme (3) there are three species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839) and *Rhabdammina discreata* (Brady, 1881). Seven types of fossil species can be seen in Figure 2 (scale size 100 um). References not found in the list	
	Table 1. Classification of Foraminifera Bentonic Fossil Containment in Bongomeme Region(reference)	Thank you for your input. We have already revised it.
Conclusion	Based on the results and discussion, some important conclusions can be drawn. The Bongomeme area of Gorontalo Regency consisting by reef limestones containing benthic foraminifera fossil and coral fragments. The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879). The content of bentonic foraminifera fossil that been found can be used for the analysis of paleobathimetry. The analysis of paleobathimetry revealed that the research area was previously a shallow sea water environment. Paleobathimetry Bongomeme 1 is the Middle Neritic–Outer Neritic with a depth of 20–200 meters while Bongomeme 2 and 3 are Middle Neritic in the range of 20-100 meters depth.	Thank you for your input. We have already revised it.

Part	Comments from Reviewer C (321-746-1-5-20191007)	Author's Response
	1-Adding the numbers of studied sections and samples. 2-The determination of biofacies that are important in determining the palaeobathemetry in limestone rocks. 3-The study requires a stratigraphic column showing the distribution of biofacies and fossils.	Thank you for your input. We have already revised it. In the text, we have added the abundance of bentonic foraminifera for the determination of paleobathymetry, as well as the addition of lagoonal environment interpretations to provide a small picture of environmental conditions.

	4- Explaining the environmental factors affecting the distribution of foraminifera such as: -water depth -salinity -Oxygen -wave and current energy -substrate 5- An environmental model showing the distribution of fossils. 6-Stratigraphic data to determine the palaeobathymetry in more detail. 7- The paleodepth of studied species based on previous regional and global studies.	
Title	PALEO-BATHYMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL	Thank you for your input. We have already inserted that in the text.
Abstract	maybe you can add the general research methods in your abstract	Thank you for your input. We have already inserted that in the text.
Introduction	Please provide a connecting sentence between these two sentences	Thank you for your input. We have already revised it.
	And/then?.	Thank you for your input. We have already revised it.
Material and Methods	Bongomeme (1), (2) and (3) are the location? Please explain more clearly.	Thank you for your input. We have already inserted the location map in the text.
	Please add the overview of regional geology	Thank you for your input. We have already revised it.
	Figure 1. Research location in Bongomeme Region. The research location be marked with …….. (Formatted English (United State)	Thank you for your input. We have already revised it.
	Maybe you can add the large benthic foram for support your result	Thank you for your input.
Result and Discussions	matrix supported or mud supported?	Thank you for your question. We have already revised it.
	How much fragment with >2mm grain size? Please add this point on the text	Thank you for your question. We have already revised it.

	What the reason about this statement? If your reason only from the presence of large benthic foram, that's not enough. You should explain the geometry of limestone and its composition. Reef limestone must contain dominant of coral or algae fragment. That's called the reefal limestone. More dominant of coral and algae fragment, the closer it is to the reef.	Thank you for your question. We have already revised the reef limestone into reefal limestone.
	Ammomassilina alveoliniformis is include the milliolina group. The presence of *Ammomassilina alveoliniformis* shows that the possibility of lagoonal environtment (semi-closed condition). You can compare the abundant of Milliolina vs Textulariina vs Rotaliina, and plotting in triangle diagram from Armstrong and Brasier (2005)	Thank you for your input. We have already inserted the analysis as your suggestion.
	For more effective, please explain in order: Location 1, fossil contain, paleobathymetry based on fossil. Then, location 2, etc.	Thank you for your question. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Paleobathymetry	Thank you for your input. We have already revised it.
	Add the discussion chapter, that consist of the different from your 3 location, and discussion about the depositional environment on general.	Thank you for your question. We have already revised it.

Part	**Comments from Reviewer G (321-761-1-5-20191016)**	**Author's Response**
	-This paper is small part of big research project ,it is better to put all these informations of the whole project together rather than split them to pieces . -The authers need proofreading, location map with all the studied sites. -Rewrite the whole paper to be clearer. -Chech the references.	Thank you for your input. We have already revised it.

Title	Formatted : Font :11 pt	Thank you for your input. We have already revised it.
Abstract	Neritic to Bongomeme 1, while Bongomeme 2,and 3 is Middle Neritic.	Thank you for your input.
Introduction	Re –write!	Thank you for your input. We have already revised it.
	Is that formation name?	Thank you for your input. We have already revised it.
Material and Methods	Where the field description?	Thank you for your question. We mean geological survey. We have already revised it.
	Not found with references list	Thank you for your input. We have already inserted it.
	What is the weight for each sample?	Thank you for your question. In this study, preparations were carried out on samples with a weight of 100gr on each sample.
	Where the statistical analysis? You are just collect the number of species!!	Thank you for your input. We have already removed it.
Result and Discussions	Figure to the field or outcrop? The description to the section, number of rock samples, depth etc?	Thank you for your input. We have already inserted it in the text.
	Where this analyses? thin section? Where the figures	Thank you for your question. We mean the handspecimen description. We have already revised it.
	The main classification of foraminifera? Which one use?	Thank you for your question. The classification is referring to each reference of benthic foraminifera that found.
	What is that?	
	Reef more shallow do not reach to 200m, 20 -40 m only!! You must to different between reef and neritic environments!!	Thank you for your input. We have already revised it into reefal limestone.

PALEOBATHYMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL, GORONTALO DISTRICT, INDONESIA

ABSTRACT

The location of the study area is surging hills in Bongomene area, Gorontalo, Indonesia. In this study, a geological survey and sampling were taken, then an analysis of the content of benthic foraminifera was performed in each sample. The aim of the study is to discover the species of benthic foraminifera fossils and to determine the paleobathymetry to the studied regions. The results of the analysis contained seven fossils species, namely *Ammomassilina alveoliniformis, Stelligerum Astrononion, Haynesia germanica, Nonion fabum, Praeglobobulimina ovata, Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, paleobathymetry is determined as Middle Neritic to Outer Neritic in Bongomeme 1, while in Bongomeme 2 and 3 is Middle Neritic.

Keywords: Paleobathymetry, Bongomeme Limestone, Benthic foraminifera fossil.

INTRODUCTION

Limestone is the sediment consists mostly of structured fragments produced by various types of organisms with certain ecological requirements (Meteu-Vicens *et al.,* 2008) and commonly occurs and has wide distribution in the carbonate platform. The carbonate platform is characterized by the reestablishment of shallow sea water benthic communities (Berggren and Prothero, 1992; Ivany *et al.,* 2000; Prothero, 2003).

Foraminifera has proven useful in reconstructing as is palaeoenvironmental in shallow sea water environments (Mendes *et al.,* 2004; Murray, 2006). The most important control in the distribution of benthic foraminiferal are food availability and dissolved oxygen concentration (Jorissen *et al.,* 1995; De Rijk *et al.,* 1999, 2000; Murray, 2001). Analysis of paleobathymetry based on foraminifera assemblages was carried out on Pliocene aged rocks in western Sahal with semi-quantitative reconstruction (Herkat and Ladjal, 2013).

Micropaleontology is a systematic study of microfossils, their morphology, classification and environmental and stratigraphic significance. For practical purposes, microfossils are any fossils, usually small, with the characteristic of which is best studied through a microscope. These include heterogeneous groups of fossils of organisms that are generally microscopic in size, for instance, foraminifera, ostracoda and radiolaria (Saraswati and Srinavasan, 2016).

Based on previous study, the study area is included to Reef Limestone Formation (QI), that consists of reef limestone. In addition to this area, the eef limestone units are also found in Tanjung Kramat Region. Petrology analysis of limestone shows the name of the limestone is calcirudite or floatstone (Bachri *et al.,* 1997; Embry and Klovan, 1971; Grabau, 1905; Permana and Eraku, 2017; Permana, 2018).

The aim of this research is to identify the species of benthic foraminifera fossil containing in Bongomeme limestone and to determine the paleobathymetry.

MATERIALS AND METHODS

This research located in Bongomeme Region of Gorontalo District, Indonesia. Western area of Limboto lake which located at geomorphology of surging hills. The study area divided into three location, that is Bongomeme (1) (00° 35' 29.18"N; 122° 52' 45.82"E), Bongomeme (2) (00° 35' 34.680"N; 122° 52' 50.92" E) and Bongomeme (3) (00° 36'41.260"N; 122° 50'44.34"E) (Figure 1). The stratigraphic section of this study can be seen in Figure 2.

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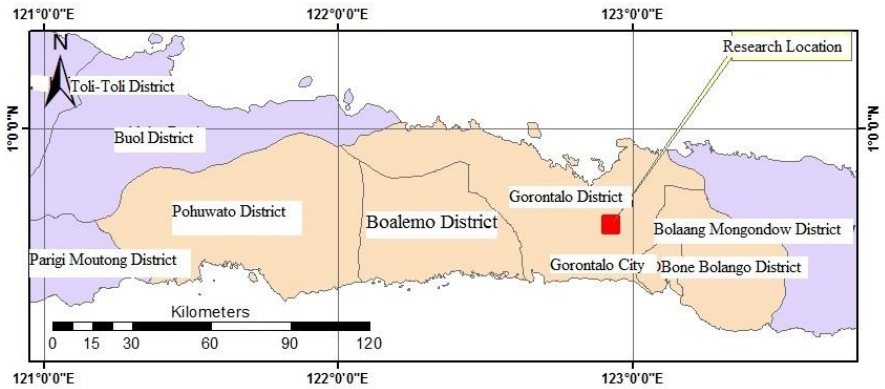

Figure 1. Location map to the studied area. That's located in Bongomeme Region, Indonesia

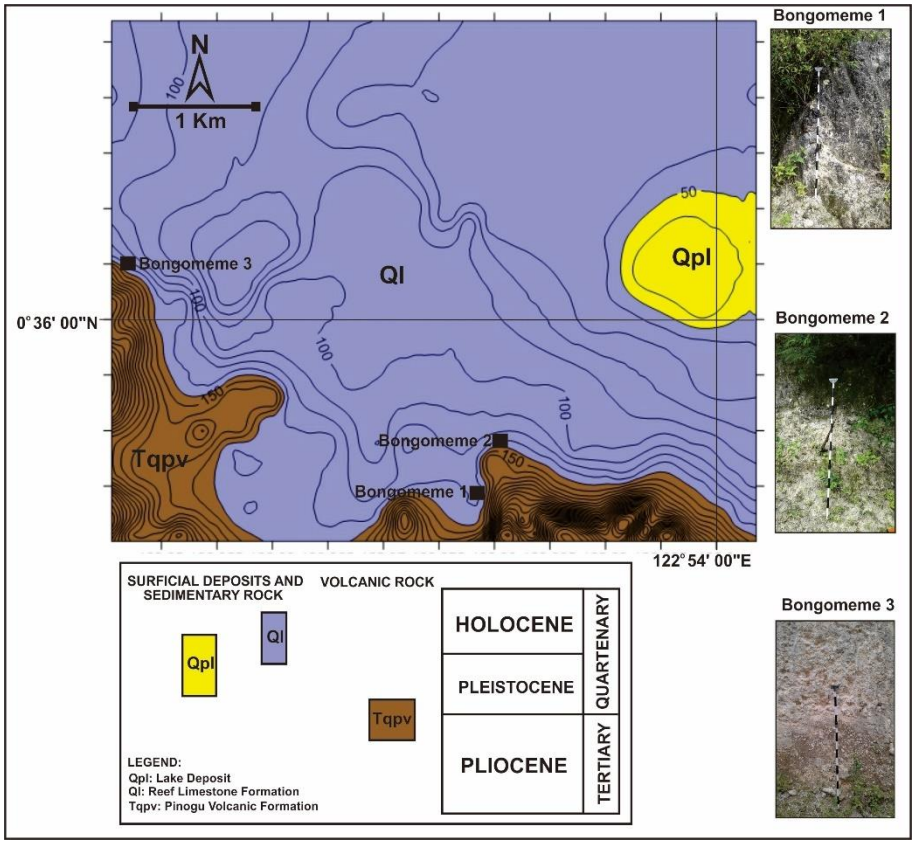

Figure 2. The stratigraphic sections of this study, divided into three location that is Bongomeme 1, Bongomeme 2 and Bongomeme 3. The geological map is according to Bachri., *et al* (1997).

Material or research material of samples are limestone containing benthic foraminifera fossils. The research method consisted of two stages, namely field survey and micropaleontological analysis. The field survey carried out is geological survey and determination of samples that were feasible to be analyzed and descriptions of petrology. Micropaleontological analysis was carried out to determine paleobathymetry based on the content of benthic foraminifera fossils (Ghosh and Sarkar, 2013; Martins *et al.*, 2015; Roozpeykar and Moghaddam, 2016). Fossils identification is using by the Olympus SZ61 binocular microscope.

In this study, preparations were carried out on samples with a weight of 100gr on each sample. To prepare the benthic foraminifera fossil sample, a solution of 30-50% hydrogen peroxide (H_2O_2), blue methyl solution, 100 mesh sized filter, electric oven sample dryer and digital scales were used (Kadar, 1986).

Identification of benthic foraminifera fossil for the determination of paleobathymetry refers to the classification of Tipsword *et al.*, 1966. Classification of the determination of paleobathymetry based on the depth of habitat of each benthic foraminifera species. Division of depth based on the environmental intervals of each foraminifera species. Each identified species is calculated for its abundance in each sample. The amount of abundance of one species uses the classification of Kadar (1986).

RESULTS AND DISCUSSION

Geological surveys in the research area indicate that the main constituents are limestone. Based on handspecimen description, the limestone has white color, medium sorting, floating grains in matrix and bedding structures with abundance of >2mm granules of 15%. The compositions arelarge benthic foraminifera, coral fragments, and opaque minerals as a fragment matrix in the form of micrite. Based on the description of the petrology, the names calcirudite or floatstone. In addition, based on kandungan coral fragment, interpreted that the limestone in the Bongomeme area is a reefal limestone, which forms around (both near or little far) from the reef build-up.

The results of geological survey and handspeciment description which interpreted that samples of reef limestone contained large fossils of foraminifera, samples were taken for micropaleontological analysis.

The results of micropaleontological analysis shows that the number of benthic foraminifera species is varies. Bongomeme (1) there are three species of benthic foraminifera fossils namely *Haynesia germanica* (Ehrenberg, 1840), *Praeglobobulimina ovata* (d'Orbigny, 1846) and *Rhabdammina discreata* (Brady, 1881). Bongomeme (2) there are six species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879). Bongomeme (3) there are four species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Lamellodiscorbis* (Loeblich and

Tappan, 1987) and *Rhabdammina discreata* (Brady, 1881). Seven types of fossil species can be seen in Figure 3 (scale size 100 um).

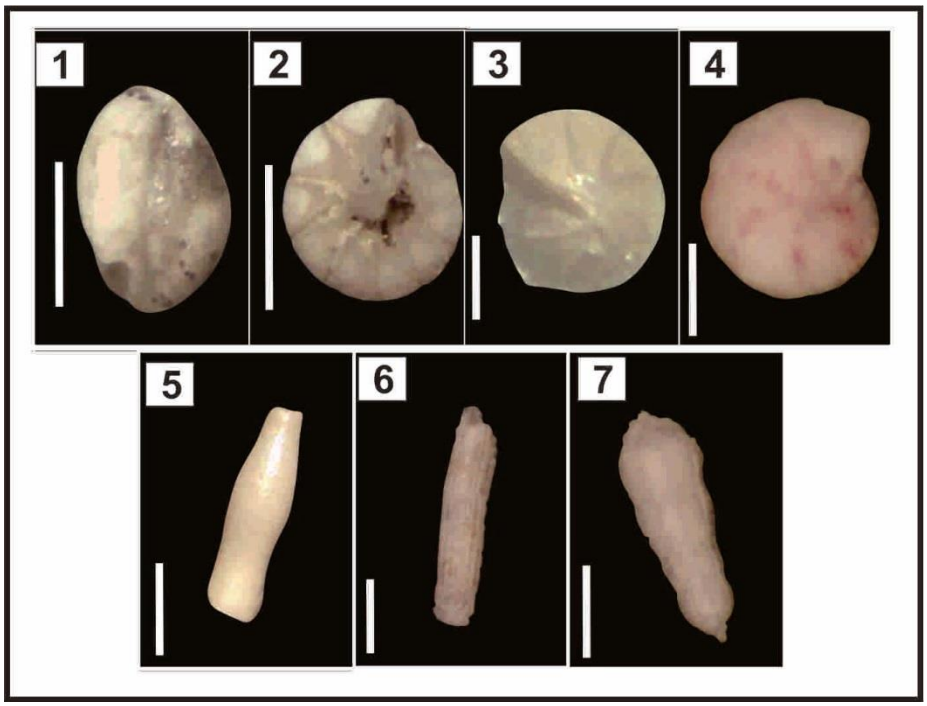

Figure 3. Seven species of benthic foraminifera fossils found in research location: (1) *Ammomassilina alveoliniformis*, (2) *Astrononion stelligerum*, (3) *Haynesia germanica*, (4) *Nonion fabum*, (5) *Praeglobobulimina ovata*, (6) *Rhabdammina discreata* and (7) *Saccorhiza ramosa* (scale size: 100 um).

Complete classification of benthic foraminifera fossils in three different research location can be seen in Table 1.

Table 1. Classification of Foraminifera Benthic Fossil Containment in Bongomeme Region.

Classification	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Phylum	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*	*Foraminifera*
Class	*Tubothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Globothalamea*	*Monothalamea*	*Monothalamea*
Order	*Miliolida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Rotaliida*	*Astrorhizida*	*Astrorhizida*
Suborder	*Miliolina*	Rotaliina	*Rotaliina*	*Rotaliina*	*Rotaliina*	*Astrorhizina*	*Hippocrepinina*
Superfamily	*Milioloidea*	*Nonionoidea*	*Rotalioidea*	*Nonionoidea*	*Buliminoidea*	*Astrorhizoidea*	*Hippocrepinoidea*
Family	*Hauerinidae*	*Nonionidae*	*Haynesinidae*	*Nonionidae*	*Buliminidae*	*Rhabdamminidae*	*Hyperamminidae*
Subfamily	*Siphonapertinae*	*Astrononioninae*		*Nonioninae*		*Rhabdammininae*	*Saccorhizinae*
Genus	*Ammomassilina*	*Astrononion*	*Haynesina Haynesia*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza Saccorhiza*
Species	*Ammomassilina alveoliniformis* (Millett, 1898)	*Astrononion stelligerum* (d'Orbigny, 1839)	*germanica* (Ehrenberg, 1840)	*Nonion fabum* (Fichtel and Moll, 1798)	*Praeglobobulimina ovata* (d'Orbigny, 1846)	*Rhabdammina discreta* (Brady., 1881)	*ramosa* (Brady., 1879)

The total abundance of each fossil species in each location according to (Kadar, 1986) can be seen in Table 2 (Bongomeme 1), Table 3 (Bongomeme 2) and Table 4 (Bongomeme 3).

Table 2. The abundance of each benthic foraminifera fossils species in Bongomeme 1

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table 3. The abundance of each benthic foraminifera fossils species in Bongomeme 2

Species	Total	Abundance

Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Table 4. The abundance of each benthic foraminifera fossils species in Bongomeme 3

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Lamellodiscorbis	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Based on the research results, there are seven species of bentonic foraminifera fossils therefore paleobathymetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of benthic foraminifera fossils while it was life. Analysis of paleobathymetry for each location based on Tipsword *et al* (1966) can be seen in Table 6 (Bongomeme 1), Table 7 (Bongomeme 2) and Table 8 (Bongomeme 3). The results of the analysis of paleobathymetry shows that paleobathymetry of the limestone Bongomeme 1 area is Middle Neritic - Outer Neritic (20 - 200 meters), paleobathymetry of the limestone Bongomeme 2 area is Middle Neritic (20 - 100 meters) and paleobathymetry of the limestone in Bongomeme 3 area is Middle Neritic (20 - 100 meters).

The presence of *Ammomassilina alveoliniformis* species which belongs to the suborder Milliolina, indicates the lagoon environment. To prove this, do a comparison of the Rotaliina - Textulariina - Miliolina suborder uses a triangle diagram of Armstrong and Brasier (2005). A comparison of the Rotaliina-Textulariina-Miliolina suborder can be seen in Table 5, and the plotting of triangular diagram of Armstrong and Brasier (2005) can be seen in Figure 4. Based on this analysis, it is known that limestone at the location includes hypersaline lagoons, which are formed under hypersaline sea water conditions due to semi-closed water circulation which is likely caused by a barrier. If we looking at the composition of limestone that composed by coral fragments, it is interpreted that the barrier is reef build-up.

Table 5. Comparison of Rotaliina – Textulariina – Miliolina suborder

Location	Miliolina		Rotaliina		Textulariina		Total
	Specimen	%	Specimen	%	Specimen	%	
Bongomeme-1	0	0,0	3	100,0	0	0,0	3
Bongomeme-2	2	28,6	5	71,4	0	0,0	7
Bongomeme-3	1	50,0	1	50,0	0	0,0	2

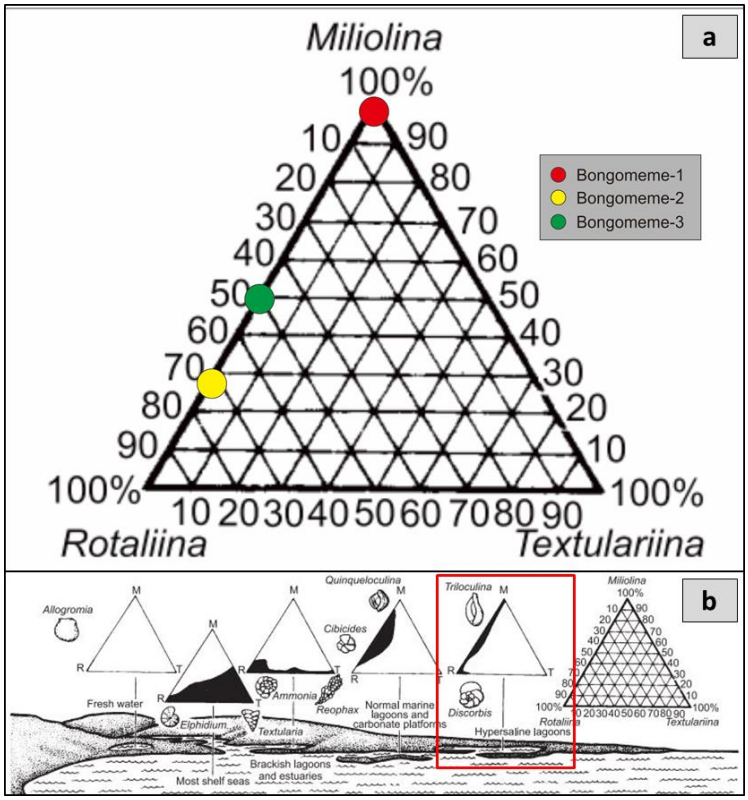

Figure 4. Comparison of the Rotaliina - Textulariina - Miliolina suborder uses a triangle diagram of Armstrong and Brasier (2005). (a) Plotting of comparison of Rotaliina – Textulariina – Miliolina, suborder ,(b) The interpretation of lagoonal condition environment.

Table 6. Paleobathymetry Analysis of Bongomeme 1

Species	Paleobathimetry								
Haynesia germanica				■	■				
Praeglobobulimina ovata			■	■	■	■	■	■	■
Rhabdammina discreta		■	■	■	■	■	■	■	■
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
				Neritic		Bathyal			

Table 7. Paleobathymetry Analysis of Bongomeme 2

Species	Paleobathimetry								
Ammomassilina alveoliniformis				■					
Haynesia germanica				■	■				
Nonion fabum			■	■	■	■			
Praeglobobulimina ovata			■	■	■	■	■	■	■
Rhabdammina discreta		■	■	■	■	■	■	■	■
Saccorhiza ramosa				■					
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal

			Neritic	Bathyal	

Table 8. Paleobathymetry Analysis of Bongomeme 3

Species	Paleobathimetry								
Ammomassilina alveoliniformis									
Astrononion stelligerum									
Rhabdammina discreta									
	Continental	Transitional	Inner	Middle	Outer	Upper	Middle	Lower	Abyssal
			Neritic			Bathyal			

Paleobathymetry analysis of the research area at the time of limestone formation was deposited based on the content of benthic foraminifera fossils, finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of limestone formation under the marine. The location of the research was experiencing elevation from the shallow marine Middle Neritic to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the marine environment, with hypersaline lagoon condition

CONCLUSIONS

Based on the results and discussion, some important conclusions can be mentioned. The Bongomeme area of Gorontalo Regency consisting by reefal limestones containing benthic foraminifera fossil and coral fragments.

The results of micropaleontological analysis showed that there were seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) *and Saccorhiza ramosa* (Brady, 1879).

The analysis of paleobathimetry revealed that the research area was previously a shallow marine environment, which the paleobathymetry of the limestone Bongomeme 1 area is Middle Neritic - Outer Neritic (20 - 200 meters), paleobathymetry of the limestone Bongomeme 2 area is Middle Neritic (20 - 100 meters) and paleobathymetry of the limestone in Bongomeme 3 area is Middle Neritic (20 - 100 meters).

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[BINHM] Editor Decision

Kotak Masuk

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Our decision is to: Accept Submission

Please note that we will be able to process your manuscript only after receiving the completed non-refundable publishing fees of (150) US dollars. You can send the money via western union to

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Dear Editor

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The Editorial Team of Bulletin of the Iraq Natural History Museum is pleased to inform you that your manuscriptM has been accepted for the publication. This manuscript will be published in the next issue.

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Thank you for sending the Letter of Accepted. We hope that proof of manuscript can be sent immediately so that we can immediately correct it to be sent back before it is published in this month's journal issue. Thank you for your attention.

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Date: 8/12/2019

Number of Manuscript

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Received date

29.6.2019

To\ Aang Panji Permana / Department of Geological Engineering, Gorontalo State University, Gorontalo, Indonesia

Subagyo Pramumijoyo/ Department of Geological Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia

Akmaluddin / Department of Geological Engineering, Universitas Gadjah Mada, Yogyakarta, Indonesia

Acceptance Letter

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The Editorial Board of the Bulletin of the Iraq Natural History Museum have reviewed your paper entitled :

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After a consideration of the reviewers' opinions , the editorial board have decided to accept your manuscript for publication .

It will be published in the next issue.

Best Regards

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Editor in Chief
8/12/2019

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PALEOBATHYMETRY ANALYSIS OF LIMESTONE IN BONGOMEME REGION BASED ON CONTENT OF BENTHIC FORAMINIFERA FOSSIL, GORONTALO DISTRICT, INDONESIA

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ABSTRACT

The location of the study area is surging hills in Bongomene area, Gorontalo, Indonesia. In this study, a geological survey and sampling were taken, and then an analysis of the content of benthic foraminifera was performed in each sample. The study aims to discover the species of benthic foraminifera fossils and to determine the paleobathymetry to the studied regions. The results of the analysis contained seven fossils species, namely *Ammomassilina alveoliniformis, Stelligerum astrononion, Haynesia germanica, Nonion fabum, Praeglobobulimina ovata, Rhabdammina discreata* and *Saccorhiza ramosa*. Based on the content of benthic foraminifera fossils, paleobathymetry is determined as Middle Shelf to Outer Shelf in Bongomeme 1, while in Bongomeme 2 and 3 is Middle Shelf.

Keywords: Benthic foraminifera, Bongomeme, Fossils, Limestone, Paleobathymetry.

INTRODUCTION

Limestone is the sediment consists mostly of structured fragments produced by various types of organisms with specific ecological requirements (Meteu-Vicens *et al.*, 2008) and commonly occurs and has wide distribution in the carbonate platform. The carbonate platform is characterized by the reestablishment of shallow seawater benthic communities (Berggren and Prothero, 1992; Ivany *et al.*, 2000; Prothero, 2003).

Foraminifera has proven useful in reconstructing as is palaeoenvironmental in shallow seawater environments (Mendes *et al.*, 2004; Murray, 2006). The most critical control in the distribution of benthic foraminiferal is food availability and dissolved oxygen concentration

(Jorissen *et al.*, 1995; De Rijk *et al.*, 1999, 2000; Murray, 2001). Analysis of paleobathymetry based on foraminifera assemblages was carried out on Pliocene aged rocks in western Sahal with semi-quantitative reconstruction (Herkat and Ladjal, 2013).

Micropaleontology is a systematic study of microfossils, their morphology, classification and environmental and stratigraphic significance. For practical purposes, microfossils are any fossils, usually small, with the characteristic of which is best studied through a microscope. These include heterogeneous groups of fossils of organisms that are generally microscopic, for instance, foraminifera, ostracoda and radiolaria (Saraswati and Srinavasan, 2016).

Based on the previous study, the study area is included in Reef Limestone Formation (QI), which consists of reef limestone. In addition to this area, the Reef limestone units are also found in Tanjung Kramat Region. Petrology analysis of limestone shows the name of the limestone is calcirudite or floatstone (Bachri *et al.*, 1997; Embry and Klovan, 1971; Grabau, 1905; Permana and Eraku, 2017; Permana, 2018).

This research aims to identify the species of benthic foraminifera fossil containing in Bongomeme limestone and to determine the paleobathymetry.

MATERIALS AND METHODS

This research located in Bongomeme Region of Gorontalo District, Indonesia. Western area of Limboto Lake which located at geomorphology of surging hills. The study area divided into three location, that is Bongomeme (1) (00° 35' 29.18" N; 122° 52' 45.82" E), Bongomeme (2) (00° 35' 34.680" N; 122° 52' 50.92" E) and Bongomeme (3) (00° 36' 41.260" N; 122° 50' 44.34" E) (Map 1). The stratigraphic section of this study can be seen in Diagram (1).

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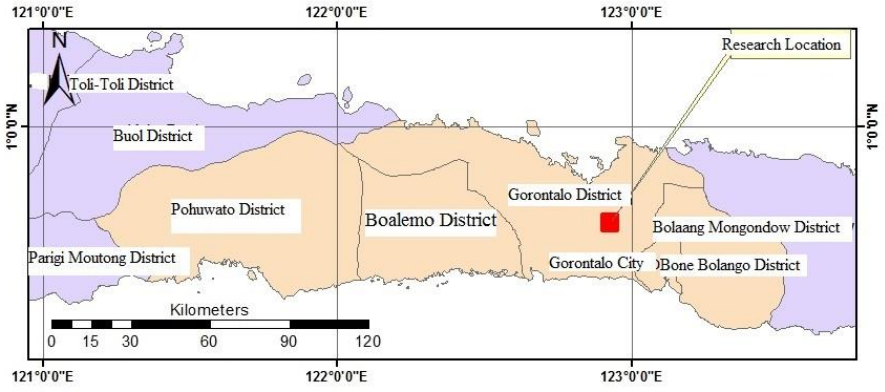


Map (1): Location map to the studied area; that's located in Bongomeme Region, Indonesia.

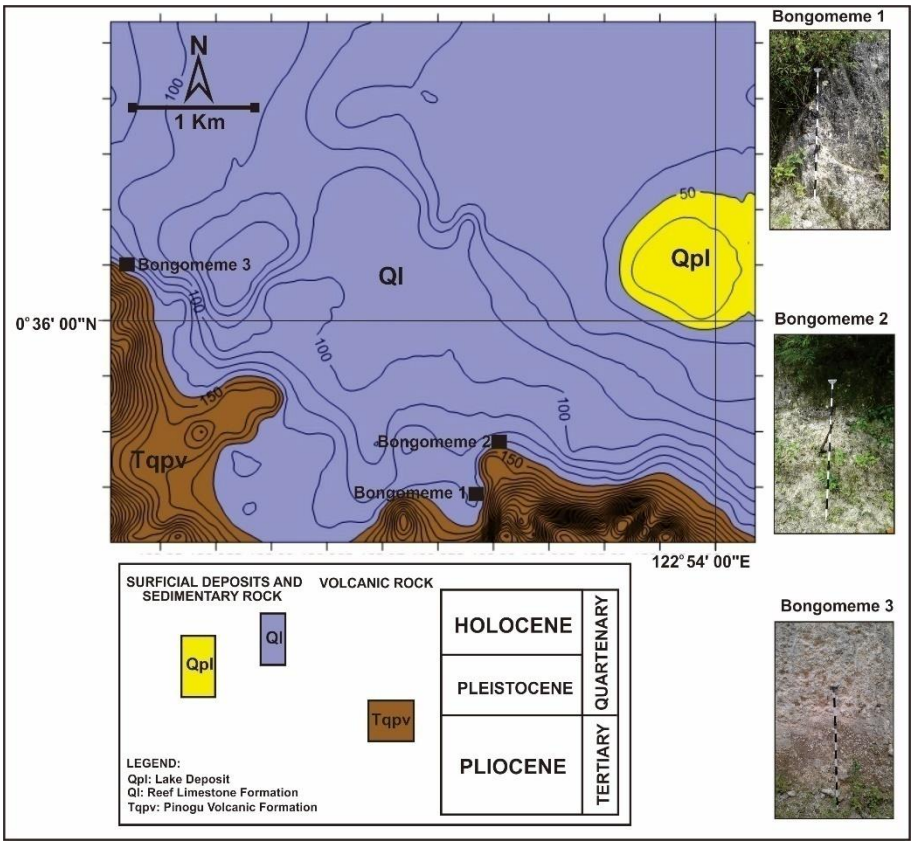


Diagram (1): The stratigraphic sections of this study, divided into three locations that is Bongomeme 1, Bongomeme 2 and Bongomeme 3. The geological map is according to Bachri *et al* (1997).

Material or research materials of samples are limestone containing benthic foraminifera fossils. The research method consisted of two stages, namely field survey and micropaleontological analysis. The field survey carried out is geological survey and determination of samples that were feasible to be analyzed and descriptions of petrology. The micropaleontological analysis was carried out to determine paleobathymetry based on the content of benthic foraminifera fossils (Ghosh and Sarkar, 2013; Martins *et al.*, 2015; Roozpeykar and Moghaddam, 2016). Fossils identification is using by the Olympus SZ61 binocular microscope.

In this study, preparations were carried out on samples with a weight of 100gr on each sample. To prepare the benthic foraminifera fossil sample, a solution of 30-50% hydrogen peroxide (H_2O_2), blue methyl solution, 100 mesh sized filter, electric oven sample dryer and digital scales were used (Kadar, 1986).

Paleobathymetry analysis of limestone in Bongomeme

Identification of benthic foraminifera fossil for the determination of paleobathymetry refers to the classification of Tipsword *et al* (1966) and Jones (1994). Ranking of the determination of paleobathymetry based on the depth of habitat of each benthic foraminifera species. Division of depth based on the environmental intervals of each foraminifera species. Each identified species is calculated for its abundance in each sample. The amount of abundance of one species uses the classification of Kadar (1986).

RESULTS AND DISCUSSION

Geological surveys in the research area indicate that the main constituents are limestone. Based on Hand specimen description, the limestone has white color, medium sorting, floating grains in the matrix (component supported) and bedding structures with an abundance of >2 mm granules of 15%. The compositions are large benthic foraminifera, coral fragments, and opaque minerals as a fragment matrix in the form of micrite. Based on the description of the petrology, the names calcirudite or coralline rudstone. Besides, based on the content of coral fragment, it interpreted that the limestone in the Bongomeme area is a Reefal limestone, which forms around (both near or little far) from the reef build-up. The chart of facies distribution and paleobathymetry of this study can be seen in Diagram (2).

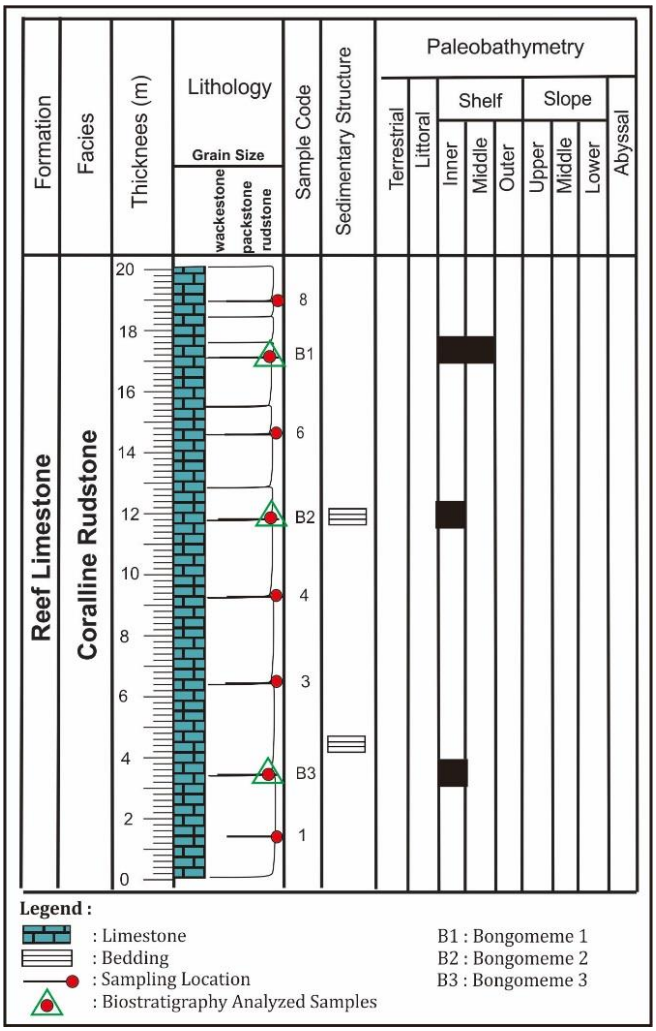


Diagram (2): Chart of facies distribution and paleobathymetry in research location (Bongomeme).

The results of geological survey and Hand specimen description which interpreted that samples of reef limestone contained large fossils of foraminifera, samples were taken for micropaleontological analysis.

The results of micropaleontological analysis shows that the number of benthic foraminifera species is varies. Bongomeme (1) there are three species of benthic foraminifera fossils namely *Haynesia germanica* (Ehrenberg, 1840), *Praeglobobulimina ovata* (d'Orbigny, 1846) and *Rhabdammina discreata* (Brady, 1881). Bongomeme (2) there are six species of benthic

foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879). Bongomeme (3) there are four species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Lamellodiscorbis* (Loeblich and Tappan, 1987) and *Rhabdammina discreata* (Brady, 1881). Seven types of fossil species can be seen in Plate (1).

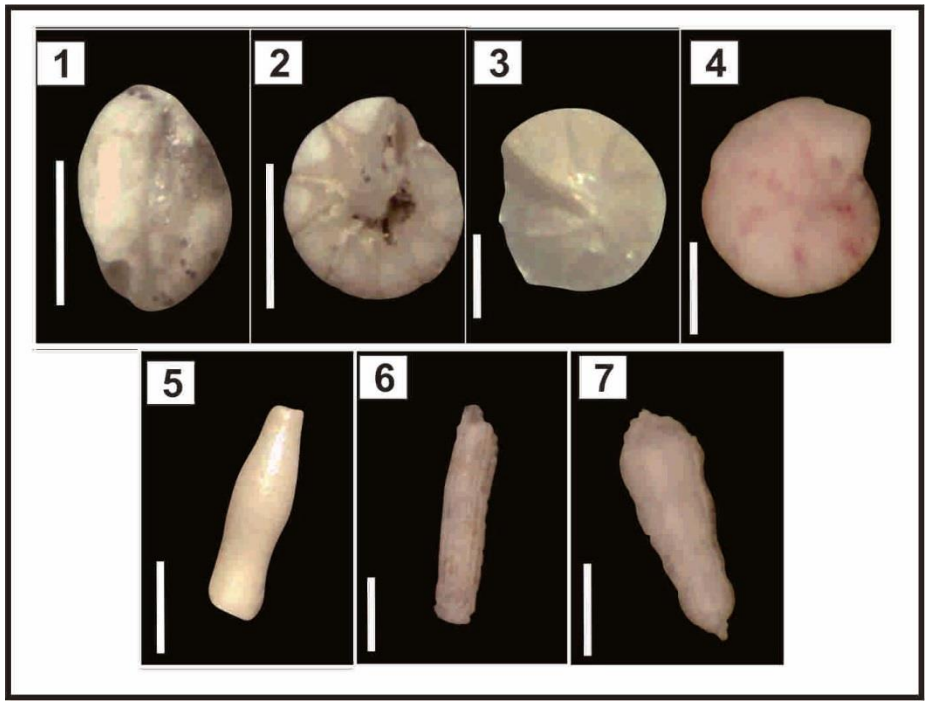


Plate (1): Seven species of benthic foraminifera fossils found in research location; (1) *Ammomassilina alveoliniformis*, (2) *Astrononion stelligerum*, (3) *Haynesia germanica*, (4) *Nonion fabum*, (5) *Praeglobobulimina ovata*, (6) *Rhabdammina discreata*, (7) *Saccorhiza ramosa* (scale size: 100 um).

Complete classification of benthic foraminifera fossils in three different research location can be seen in Table (1)

Table (1): Classification of Foraminifera Benthic Fossil Containment in Bongomeme Region (Hayward *et al.*, 2018 a, b, c, d, e).

Classification	Species 1	Species 2	Species 3	Species 4	Species 5	Species 6	Species 7
Phylum	Foraminifera	Foraminifera	Foraminifera	Foraminifera	Foraminifera	Foraminifera	Foraminifera
Class	Tubothalamea	Globothalamea	Globothalamea	Globothalamea	Globothalamea	Monothalamea	Monothalamea
Order	Miliolida	Rotaliida	Rotaliida	Rotaliida	Rotaliida	Astrorhizida	Astrorhizida
Suborder	Miliolina	Rotaliina	Rotaliina	Rotaliina	Rotaliina	Astrorhizina	Hippocrepinina
Superfamily	Milioloidea	Nonionoidea	Rotalioidea	Nonionoidea	Buliminoidea	Astrorhizoidea	Hippocrepinoidea
Family	Hauerinidae	Nonionidae	Haynesinidae	Nonionidae	Buliminidae	Rhabdamminidae	Hyperamminidae
Subfamily	Siphonapertinae	Astrononioninae		Nonioninae		Rhabdammininae	Saccorhizinae
Genus	*Ammomassilina*	*Astrononion*	*Haynesina*	*Nonion*	*Praeglobobulimina*	*Rhabdammina*	*Saccorhiza*
Species	*alveoliniformis* (Millett, 1898)	*stelligerum* (d'Orbigny, 1839)	*germanica* (Ehrenberg, 1840)	*fabum* (Fichtel and Moll, 1798)	*ovata* (d'Orbigny, 1846)	*discreta* (Brady, 1881)	*ramose* (Brady, 1879)

The total abundance of each fossil species in each location according to (Kadar, 1986) can be seen in Table (2) (Bongomeme 1), Table (3) (Bongomeme 2) and Table (4) (Bongomeme 3).

Table (2): The abundance of each benthic foraminifera fossils species in Bongomeme 1.

Species	Total	Abundance
Haynesia germanica	1	Very Rare (VR)
Praeglobobulimina ovata	2	Rare (R)
Rhabdammina discreta	9	Frequent (F)

Table (3): The abundance of each benthic foraminifera fossils species in Bongomeme 2.

Species	Total	Abundance
Ammomassilina alveoliniformis	2	Rare (R)
Haynesia germanica	1	Very Rare (VR)
Nonion fabum	1	Very Rare (VR)
Praeglobobulimina ovata	3	Rare (R)
Rhabdammina discreata	5	Rare (R)
Saccorhiza ramosa	3	Rare (R)

Table (4): The abundance of each benthic foraminifera fossils species in Bongomeme 3.

Species	Total	Abundance
Ammomassilina alveoliniformis	1	Very Rare (VR)
Astrononion stelligerum	1	Very Rare (VR)
Lamellodiscorbis	1	Very Rare (VR)
Rhabdammina discreta	9	Frequent (F)

Paleobathymetry analysis of limestone in Bongomeme

Table (5): Paleobathymetry Analysis of Bongomeme 1.

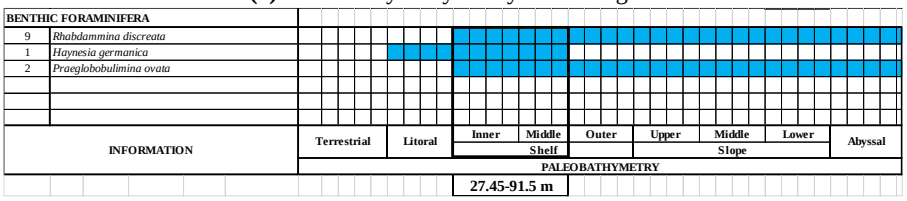


Table (6): Paleobathymetry Analysis of Bongomeme 2.

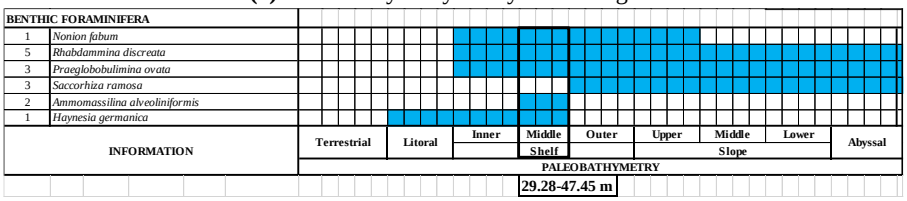
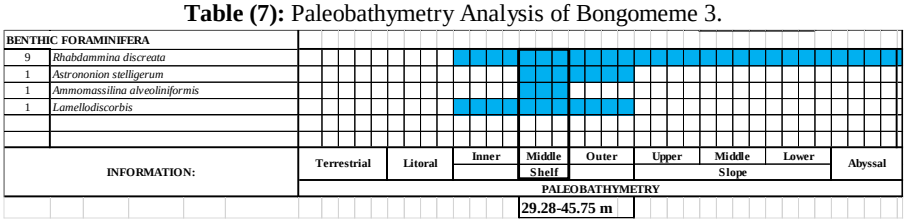


Table (7): Paleobathymetry Analysis of Bongomeme 3.



Based on the research results, there are seven species of benthic foraminifera fossils; therefore, paleobathymetry analysis could be carried out. The analysis was carried out by overlaying the presence of species of benthic foraminifera fossils while it was life. Analysis of paleobathymetry for each location based on Tipsword *et al* (1966) and Jones (1994) can be seen in Table (5) (Bongomeme 1), Table (6) (Bongomeme 2) and Table (7) (Bongomeme 3). The results of the analysis of paleobathymetry shows that paleobathymetry of the limestone Bongomeme 1 area is Middle Shelf - Outer Shelf (27.45-91.5 meters)(Jones, 1994). Paleobathymetry of the limestone Bongomeme 2 area is Middle Shelf (29.28 – 47.45 meters) (Jones, 1994) and paleobathymetry of the limestone in Bongomeme 3 area is Middle Shelf (29.28 – 45.75 meters) (Jones, 1994).

The presence of *Ammomassilina alveoliniformis* species which belongs to the suborder Milliolina indicates the lagoon environment. To prove this, make a comparison of the Rotaliina - Textulariina - Miliolina suborder uses a triangle diagram of Armstrong and Brasier (2005). A comparison of the Rotaliina-Textulariina-Miliolina suborder can be seen in Table (8), and the plotting of triangular diagram of Armstrong and Brasier (2005) can be seen in Diagram (3).

Based on this analysis, it is known that limestone at the location includes hypersaline lagoons, which are formed under hypersaline sea water conditions due to semi-closed water

circulation which is likely caused by a barrier. If we looking at the composition of limestone that composed by coral fragments, it is interpreted that the barrier is reef build-up.

Table (8): Comparison of Rotaliina – Textulariina – Miliolina suborder.

Location	Miliolina		Rotaliina		Textulariina		Total
	Specimen	%	Specimen	%	Specimen	%	
Bongomeme-1	0	0,0	3	100,0	0	0,0	3
Bongomeme-2	2	28,6	5	71,4	0	0,0	7
Bongomeme-3	1	50,0	1	50,0	0	0,0	2

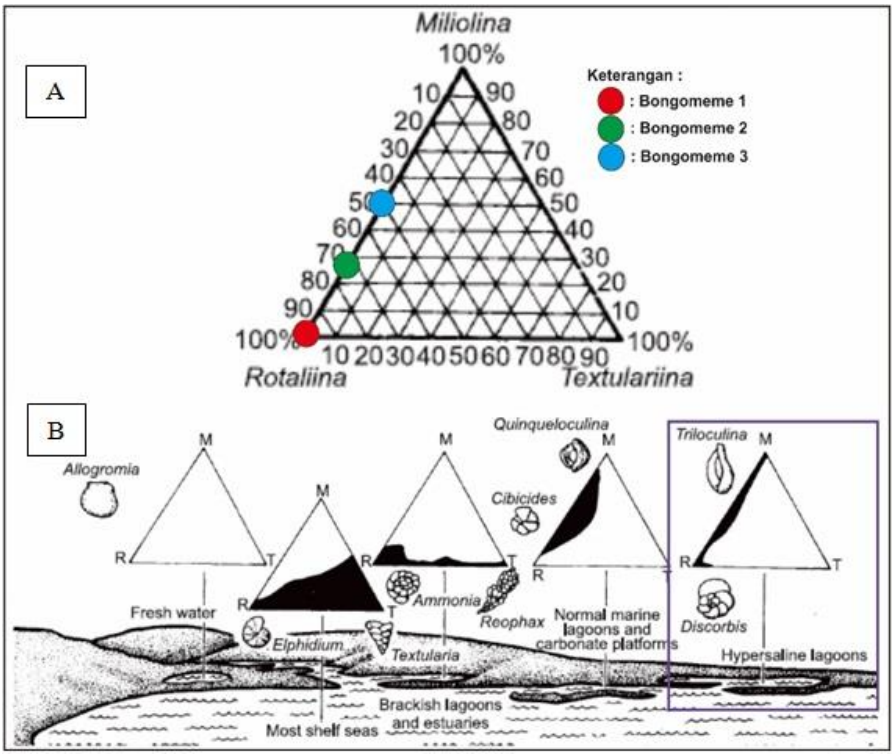


Diagram (3): Comparison of the Rotaliina - Textulariina - Miliolina suborder uses a triangle diagram of Armstrong and Brasier (2005); (A) Plotting of comparison of Rotaliina - Textulariina - Miliolina, suborder, (B) The interpretation of lagoonal condition environment.

Paleobathymetry analysis of the research area at the time of limestone formation was deposited based on the content of benthic foraminifera fossils, finally could answer the research objectives. The Bongomeme area of Gorontalo Regency, which is currently formed by elevations above sea level of 49 meters to hundreds of meters, is based on the history of

limestone formation under the marine. The location of the research was experiencing elevation from the shallow marine Middle Neritic to now land. This fact is strengthened by data on the presence of benthic foraminifera fossils which characterize the marine environment, with hypersaline lagoon condition

CONCLUSION

Based on the results and discussion, some important conclusions can be mentioned. The Bongomeme area of Gorontalo Regency consisting by reefal limestones containing benthic foraminifera fossil and coral fragments.

The results of micropaleontological analysis have showed that there are seven species of benthic foraminifera fossils namely *Ammomassilina alveoliniformis* (Millett, 1898), *Astrononion stelligerum* (d'Orbigny, 1839), *Haynesia germanica* (Ehrenberg, 1840), *Nonion fabum* (Fichtel and Moll, 1798), *Praeglobobulimina ovata* (d'Orbigny, 1846), *Rhabdammina discreata* (Brady, 1881) and *Saccorhiza ramosa* (Brady, 1879).

The analysis of paleobathimetry has revealed that the research area was previously a shallow marine environment, which the paleobathymetry of the limestone Bongomeme 1 area. The result of the analysis of paleobathymetry shows that paleobathymetry of the limestone Bongomeme 1 area is Middle Shelf - Outer Shelf (27.45-91.5 meters). Paleobathymetry of the limestone Bongomeme 2 area is Middle Shelf (29.28 – 47.45 meters) and paleobathymetry of the limestone in Bongomeme 3 area is Middle Shelf (29.28 – 45.75 meters).

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تحليل الأحفوريات الحجرية من الحجر الجيري في منطقة بونجوميمي بناء على محتوى إحفوريات المنخريات القاعية ، مقاطعة كورونتالو ، إندونيسيا

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تأريخ الاستلام: 2019/07/29، تأريخ القبول: 2019/12/08، تأريخ النشر: 2020/06/24

الخلاصة

تقع منطقة الدراسة في تلال سيرجنج، في منطقة بونجوميمي، كورونتالو، إندونيسيا. في هذه الدراسة، جرت عملية المسح الجيولوجي والنمذجة، وبعد ذلك تم تحليل محتوى المخرمات القاعية في كل نموذج. تهدف الدراسة الى اكتشاف انواع من إحفوريات المخرمات القاعية وتحديد الاعماق القديمة للمناطق المدروسة. بينت نتائج التحليل وجود سبعة انواع إحفوريه، تسمى *Stelligerum astrononion*، *Ammomassilina alveoliniformis*، *Haynesia germanica*، *Nonion fabum*، *Praeglobobulimina ovata*، *Rhabdammina discreata* و *Saccorhiza ramose*.

استناداً الى محتوى إحفوريات المخرمات القاعية، حدد العمق القديم على انه الرف المتوسط الى الخارجي في بونجوميمي 1، بينما في بونجوميمي 2 و 3 هو الرف المتوسط.