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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ  
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«ХАЛЫҚ» ЖҚ

# Х А Б А Р Л А Р Ы

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## ИЗВЕСТИЯ

РОО «НАЦИОНАЛЬНОЙ  
АКАДЕМИИ НАУК РЕСПУБЛИКИ  
КАЗАХСТАН»  
ЧФ «Халық»

## N E W S

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*NAS RK is pleased to announce that News of NAS RK. Series of geology and technical sciences scientific journal has been accepted for indexing in the Emerging Sources Citation Index, a new edition of Web of Science. Content in this index is under consideration by Clarivate Analytics to be accepted in the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index. The quality and depth of content Web of Science offers to researchers, authors, publishers, and institutions sets it apart from other research databases. The inclusion of News of NAS RK. Series of geology and technical sciences in the Emerging Sources Citation Index demonstrates our dedication to providing the most relevant and influential content of geology and engineering sciences to our community.*

*Қазақстан Республикасы Ұлттық ғылым академиясы «ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы» ғылыми журналының Web of Science-тің жаңаланған нұсқасы Emerging Sources Citation Index-те индекстелуге қабылданғанын хабарлайды. Бұл индекстелу барысында Clarivate Analytics компаниясы журналды одан әрі the Science Citation Index Expanded, the Social Sciences Citation Index және the Arts & Humanities Citation Index-ке қабылдау мәселесін қарастыруда. Web of Science зерттеушілер, авторлар, баспашылар мен мекемелерге контент тереңдігі мен сапасын ұсынады. ҚР ҰҒА Хабарлары. Геология және техникалық ғылымдар сериясы Emerging Sources Citation Index-ке енуі біздің қоғамдастық үшін ең өзекті және беделді геология және техникалық ғылымдар бойынша контентке адалдығымызды білдіреді.*

*НАНПК сообщает, что научный журнал «Известия НАНПК. Серия геологии и технических наук» был принят для индексирования в Emerging Sources Citation Index, обновленной версии Web of Science. Содержание в этом индексировании находится в стадии рассмотрения компанией Clarivate Analytics для дальнейшего принятия журнала в the Science Citation Index Expanded, the Social Sciences Citation Index и the Arts & Humanities Citation Index. Web of Science предлагает качество и глубину контента для исследователей, авторов, издателей и учреждений. Включение Известия НАНПК. Серия геологии и технических наук в Emerging Sources Citation Index демонстрирует нашу приверженность к наиболее актуальному и влиятельному контенту по геологии и техническим наукам для нашего сообщества.*



## ЧФ «ХАЛЫҚ»

В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект *Ozgeris powered by Halyk Fund* – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz».

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится

работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

**С уважением,  
Благотворительный Фонд «Халык»!**

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## **ANALYSIS OF THE RELATIVE AGE OF LIMESTONE AT TANJUNG KRAMAT REGION, GORONTALO CITY, INDONESIA**

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**Abstract.** The research area is located in the southern part of Gorontalo in the Tanjung Kramat Region, Gorontalo City, Indonesia. The regional stratigraphy of the Tanjung Kramat area refers to the regional geological map of the Kotamobagu Sheet, which is composed of two rock formations in order of formation from the oldest to the youngest, namely the Pinogu Volcano Formation (TQpv) and the Reef Limestone Formation (Ql). Research on limestone in the southern part of the Tanjung Kramat Region, Gorontalo City, and south Gorontalo has never been carried out, so this research is very interesting because it yields new findings. For this reason, this study aimed to analyze the relative age of the limestone in the Tanjung Kramat area, Gorontalo City, based on the content of planktonic foraminifera fossils. The research method used was a field geological survey and micropaleontological analysis (which contained planktonic foraminifera fossils). The results showed that the limestone facies consisted of three: wackestone, packstone, and coralline floatstone. Meanwhile, the results of the micropaleontological analysis showed that the planktonic foraminifera fossils in the study area consisted of 11 species, which refers to the results of quantitative analysis by overlaying the age range of each species. Finally, the relative age of the limestone, namely the Early Pliocene (N18-N19), is known.



**Keywords:** Limestone, Planktonic, Foraminifera Fossils, Relative Age

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## ГОРОНТАЛО ҚАЛАСЫНДАҒЫ ТАНЖУНГ КРАМАТ ОБЛЫСЫНДАҒЫ ӘКТЕСТІҢ САЛТЫСТЫҚ ЖАСАСЫН ТАЛДАУ

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**Аннотация.** Зерттеу аймағы Индонезияның Горонтало қаласы, Танжунг Крамат аймағындағы Горонталоның оңтүстік бөлігінде орналасқан. Танжунг Крамат аймағының аймақтық стратиграфиясы ең көнеден ең жасына қарай түзілу реті бойынша екі жыныс түзілімдерінен тұратын Котамобагу парағының аймақтық геологиялық картасына жатады, атап айтқанда Пиногу жанартау қабаты (TQrv) және рифтік әктас түзілімі (Q1). Танжунг Крамат аймағының оңтүстік бөлігіндегі, Горонтало қаласы мен оңтүстігіндегі Горонталодағы әктастарды зерттеу ешқашан жүргізілмеген, сондықтан бұл зерттеу өте қызықты, өйткені ол жаңа нәтижелер береді. Осы себепті, бұл зерттеу планктоникалық фораминифера қазбаларының мазмұны негізінде Горонтало қаласындағы Танжунг Крамат аймағындағы әктастың салыстырмалы жасын талдауды мақсат етті. Қолданылған зерттеу әдісі далалық геологиялық барлау және микропалеонтологиялық талдау

болды (оның құрамында планктондық фораминифералар қазбалары бар). Нәтижелер әктас фацияларының үшеуден тұратынын көрсетті: вактас, құйма тас және маржанды флоатстан. Сонымен қатар, микропалеонтологиялық талдау нәтижелері зерттелетін аймақтағы планктондық фораминифера қазбалары 11 түрден тұратынын көрсетті, бұл әр түрдің жас аралығын қабаттастыру арқылы сандық талдау нәтижелеріне сілтеме жасайды. Соңында, әктастың салыстырмалы жасы, атап айтқанда, ерте плиоцен (N18-N19) белгілі болды.

**Түйін сөздер:** әктас, планктондық, фораминифераның қазбалары, салыстырмалы жасы

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## **АНАЛИЗ ОТНОСИТЕЛЬНОГО ВОЗРАСТА ИЗВЕСТНЯКА В РЕГИОНЕ ТАНДЖУНГ КРАМАТ, ГОРОНТАЛО**

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**Аннотация.** Район исследований расположен в южной части Горонтало в регионе Танджунг Крамат, город Горонтало, Индонезия. Региональная стратиграфия района Танджунг Крамат относится к региональной геологической карте листа Котамабагу, который состоит из двух скальных образований в порядке формирования от самого старого к самому молодому, а именно формация вулкана Пиногу (TQrv) и формация рифового известняка (Q1). Исследования известняка в южной части региона Танджунг Крамат, в городе Горонтало и на юге Горонтало никогда не проводились, поэтому это исследование очень интересно, поскольку оно дает новые результаты. По этой причине это исследование было направлено на анализ относительного возраста известняка в районе Танджунг Крамат, город Горонтало, на основе содержания планктонных окаменелостей фораминифер.

Используемый метод исследования представлял собой полевую геологическую съемку и микропалеонтологический анализ (который содержал планктонные окаменелости фораминифер). Результаты показали, что известняковые фации состоят из трех фаций: уэжстоуна, пакстоуна и кораллового флоатстоуна. Между тем, результаты микропалеонтологического анализа показали, что ископаемые планктонные фораминиферы на исследуемой территории состоят из 11 видов, что относится к результатам количественного анализа путем наложения возрастного диапазона каждого вида. Наконец, известен относительный возраст известняков, а именно ранний плиоцен (N18-N19).

**Ключевые слова:** известняк, планктон, ископаемые фораминиферы, относительный возраст

### Introduction

The study site is situated in the southern region of Gorontalo, specifically in the Tanjung Kramat area of Gorontalo City. Tanjung Kramat regional stratigraphy refers to the regional geological map at scale 1:250,000 Kotamobagu sheets (Apandi & Bachri, 1997), which shows two rock formations in formation order from oldest to youngest, namely the Volcano Formation (TQpv) and the Reef Limestone Formation (Ql). The Pinogu Volcano Formation (TQpv), believed to have originated during the Pliocene-Pleistocene period, comprises various lithologies such as tuff, lapilli tuff, breccias, and lava. Volcanic breccias exist in the Bone Mountains, Mount Mondalia, and Pusian. The tuff exposed atop Mount Lemibut and Mount Lolombulan is mainly pumice, light yellow, medium to coarse-grained, and interspersed with lava made of intermediate magma to basal tuff and lapilli tuff and andesite surrounding the Bone River. The Reef Limestone Unit Formation (Ql) deposition occurred in an unconformable overlapping manner and is believed to have taken place during the Holocene epoch. The present geological formation comprises an elevated reef limestone unit that predominantly consists of coral and deposited limestone facies, specifically coralline floatstone, that has undergone diagenesis (Apandi & Bachri, 1997; Permana et al., 2022).

Foraminifera are generally adaptable, able to survive and multiply in various aquatic environments (Boltovskoy & Wright, 1976; Murray, 2006). Certain foraminifera are organisms that coexist with coral reef ecosystems. The existence of foraminifera is significantly impacted by a range of environmental factors, including sediment type, depth, salinity, nutrients, and currents. As a result, Foraminifera can serve as a useful tool for determining relative age and environmental conditions (Boltovskoy & Wright, 1976; van Marle, 1987; Valchev, 2003; Permana et al., 2020). Most sedimentary deposits are comprised of microfossils, with the specific type of microfossil present being heavily influenced by factors such as the sediment's initial age, depositional setting, and deposition history. A sediment sample of 10 cm<sup>3</sup> has the potential to yield more than 10,000 individual specimens and over 300 distinct species. The implication is that the number of depicted ecological and biological generations can number in the hundreds, representing thousands or possibly hundreds of thousands of years of specimen accumulation (Armstrong & Brasier, 2005).

The investigation of limestone in the southern area of Tanjung Kramat Region, Gorontalo City, and south Gorontalo has not been previously conducted, rendering this study highly intriguing as it presents new findings. This research aimed to examine the chronological age of the limestone in the Tanjung Kramat region of Gorontalo City, utilizing the presence of planktonic foraminifera fossils as a basis for analysis.

**Research materials and methods.**

*Research Locations*

The research location is in Tanjung Kramat Village at coordinates 122°2'30"–122°3'00" East Longitude and 00°29'34"–00°30'20" North Latitude, precisely in the highland morphology. The research material is limestone outcrops, which spread along the south coast of Gorontalo. The stratigraphic position of the study area can be seen on the geological map of the Tanjung Kramat Region, Gorontalo City (Figure 1).

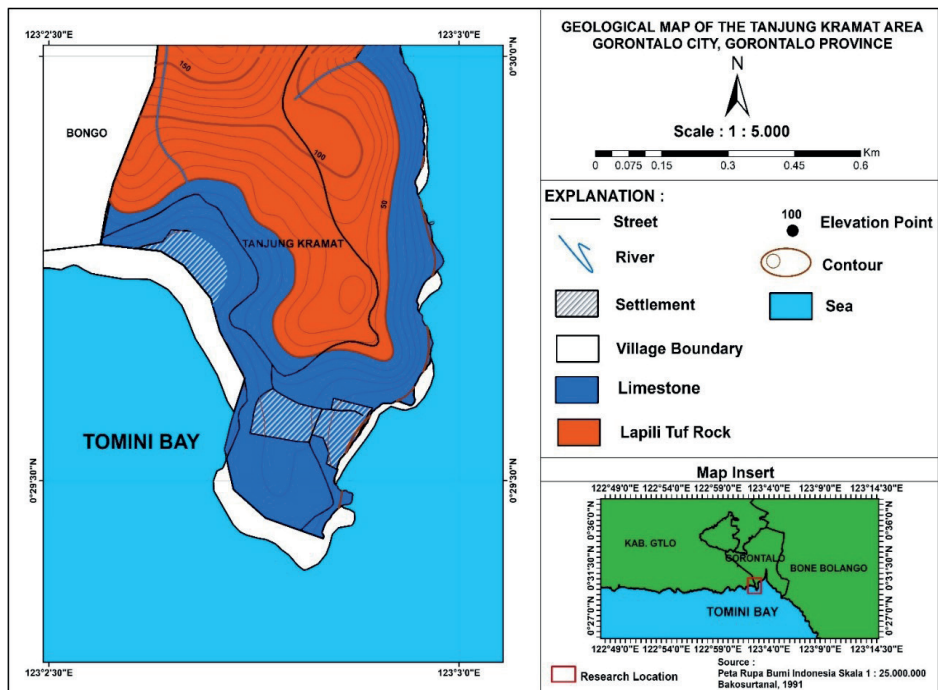


Figure 1. Distribution of limestone outcrops with other rocks on the geological map of the Tanjung Kramat Region, Gorontalo City, Indonesia

*The type of research*

The two primary research methodologies are qualitative and quantitative, encompassing field surveys and laboratory analysis. The research employed qualitative analysis via field surveys, specifically by collecting viable rock samples from rock outcrops on a hill. Additionally, quantitative analysis was conducted utilizing the techniques outlined by Kadar (1986) and Blow (1969) to determine the type of species and the number of species in abundance in the Laboratory of Paleontology and Micropaleontology.

### *Tools and Materials*

Implementation of this research requires several tools and materials to achieve the goal. The research tools consisted of a camera, plastic samples, waterproof markers, labels, stationery, toothpicks, filters of 60, 100, 125, and 200 mesh sizes, and an Olympus SZ61 binocular microscope, for the research materials needed, namely hydrogen peroxide solution ( $H_2O_2$ ) and blue methyl solution.

### *Stages of Research Implementation*

The process of conducting research involves several stages:

The spot sampling method was employed to collect rock samples. The chosen rock must possess the capacity to harbor fossils of planktonic foraminifera, specifically limestone that is finely grained.

Stages of laboratory work. Samples of limestone with possible fossil content were submitted to the Laboratory of Paleontology and Micropaleontology. The laboratory procedures encompass three distinct stages, namely, the preparation of a sieve display, the identification of fossils in samples utilizing a binocular microscope, and the creation of a fossil list.

### *The technique of analyzing data*

The laboratory findings, which yielded fossil species of planktonic foraminifera, were subsequently subjected to quantitative analysis concerning the frequency of occurrence of each species. Subsequently, it is imperative to conduct a quantitative analysis by superimposing the age range of individual planktonic foraminifera fossil species to ascertain the antiquity of the limestone. Identification of planktonic foraminifera fossils refers to Postuma (1971), Bolli et al. (1985), Berggren (1992;1995a;1995b), Li et al. (2003), and Permana et al. (2021).

## **Results and Discussion**

### *A. Lithology*

The geological composition of the study area comprises two distinct rock formations, specifically the Lapili Tuff Unit, a type of pyroclastic rock, and the Limestone Unit. The study area is characterized by two distinct geological units: the Lapili Tuff Unit in the northern region and the Limestone Unit in the southern part. Description of the Unit In the field, lapilli tuff has a brownish-gray hue with a texture of volcanic rock pieces (andesite and basalt), while the tuff matrix is a pebble to gravel in size, has poor sorting, is open packed, and has an angular grain form. This particular unit is equipped with numerous tension joints and shear joints. The stereographic analysis of the tension joint within the research region indicates that the plane's overall orientation is  $N 111^\circ E/78^\circ SW$ . The stereographic examination of the shear joints  $N 90^\circ E/43^\circ S$  and  $N 100^\circ E/60^\circ SW$  enables the identification of the release joint  $N 318^\circ E/56^\circ NE$  and the extension joint  $N 116^\circ E/80^\circ SW$ . The primary stresses affecting the joints in the Tanjung Kramat region were determined to be  $\sigma_1 = 64^\circ, N 275^\circ E$ ,  $\sigma_2 = 24^\circ, N 121^\circ E$ , and  $\sigma_3 = 46^\circ, N 5^\circ E$ , as per the joint analysis conducted. The interface linking the Lapili Tuff Rock Unit and the Limestone Unit is characterized by an unconformity field at a bearing of  $N 95^\circ E/23^\circ SW$ .

The wackestone, packstone, and floatstone facies were identified through petrological



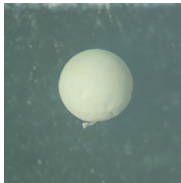
analysis of the limestone in the study area. The three predominant limestone facies consist of shell grains from microscopic foraminifera, algae, and coral, while non-shell grains consist of quartz, lithic fragments, and opaque minerals. Granules embedded in a matrix of carbonate mud, most of which have undergone recrystallization into microcrystalline calcite, were found to have the predominant cavity type of vuggy and matrix dissolution (Figure 2).


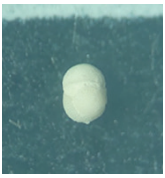


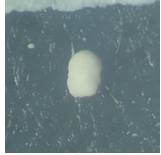
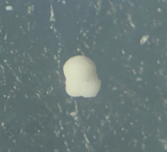



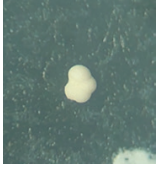
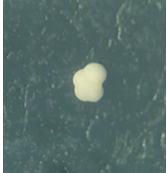
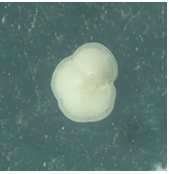
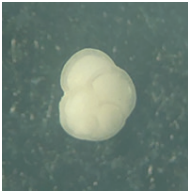
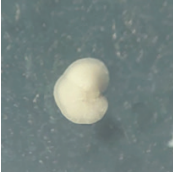



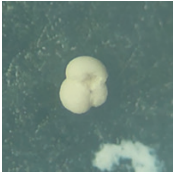
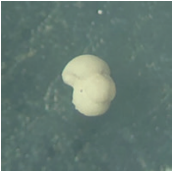
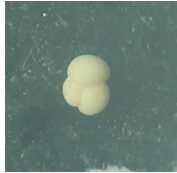


Figure 2. Wackestone facies outcrops that are evenly distributed among other limestone facies

*Fossil Content of Planktonic Foraminifera and Relative Age*

Limestone samples from the Tanjung Kramat Region underwent micropaleontological analysis. The study site's planktonic foraminifera fossils were composed of 11 species, including *Orbulina universa* (d'Orbigny, 1839), *Globigerinoides trilobus* (Reuss, 1805), *Globigerinoides immaturus* (LeRoy, 1939), *Hastigerina siphonifera* (d'Orbigny, 1839), *Globorotalia obesa* (Bolli, 1957), *Globorotalia tumida* (Brady, 1877), *Globorotalia menardii* (d'Orbigny in Parker, Jones & Brady, 1865), *Globorotalia merotumida* (Blow & Banner, 1965), *Globigerinoides ruber* (d'Orbigny, 1839), *Pulleniatina primalis* (Banner & Blow, 1967), and *Globigerinoides conglobatus* (Brady, 1879) (Figure 3).

|           | Species                                       | Picture (scale size: 100 µm) |   |             |
|-----------|---|------------------------------|---|-------------|
|           |   | Ventral View                 | Peripheral View   | Dorsal View |
| Species 1 | <i>Orbulina universa</i><br>(d'Orbigny, 1839) |                              |  |             |

|           |   |   |   |  |
|-----------|---|---|---|--|
| Species 2 | <i>Globigerinoides trilobus</i> (Reuss, 1805)                           |    |    |    |
| Species 3 | <i>Globigerinoides immaturus</i> (LeRoy, 1939)                          |    |    |    |
| Species 4 | <i>Hastigerina siphonifera</i> (d'Orbigny, 1839)                        |    |    |    |
| Species 5 | <i>Globorotalia obesa</i> (Bolli, 1957)                                 |    |   |    |
| Species 6 | <i>Globorotalia tumida</i> (Brady, 1877)                                |   |   |   |
| Species 7 | <i>Globorotalia menardii</i> (d'Orbigny in Parker, Jones & Brady, 1865) |  |   |  |
| Species 8 | <i>Globorotalia merotumida</i> (Blow & Banner, 1965)                    |  |   |  |
| Species 9 | <i>Globigerinoides ruber</i> (d'Orbigny, 1839)                          |  |  |  |



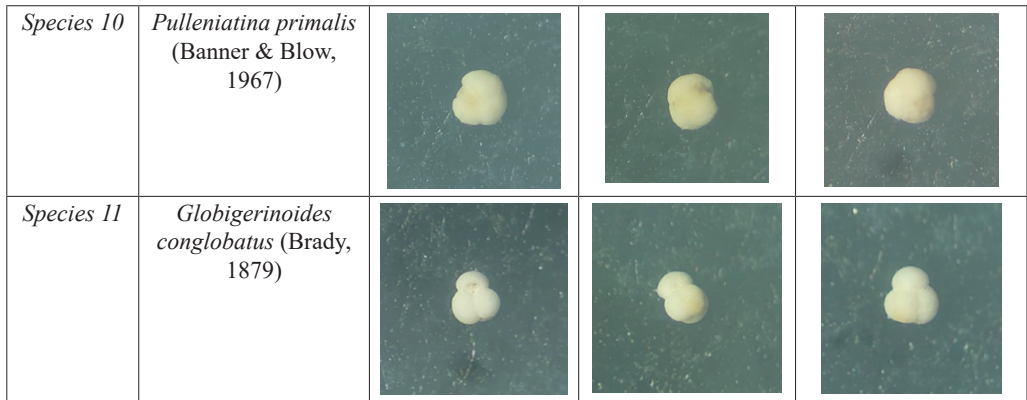


Figure 3. Eleven species of planktonic foraminifera fossils in the Tanjung Kramat area, Gorontalo City, Indonesia

In detail, the presence of each fossil species are *Orbulina universa* (d’Orbigny, 1839) N9-N23, *Globigerinoides trilobus* (Reuss, 1805) N4-N23, *Globigerinoides immaturus* (LeRoy, 1939) N4-N23, *Hastigerina siphonifera* (d’Orbigny, 1839) N12-23, *Globorotalia obesa* (Bolli, 1957) N5-N15, *Globorotalia tumida* (Brady, 1877) N18-N23, *Globorotalia menardii* (d’Orbigny in Parker, Jones & Brady, 1865) N18-N23, *Globorotalia merotumida* (Blow & Banner, 1965) N17-N19, *Globigerinoides ruber* (d’Orbigny, 1839) N6-N23, *Pulleniatina primalis* (Banner & Blow, 1967) N17-N23, and *Globigerinoides conglobatus* (Brady, 1879) N18-N23. Quantitative analysis by overlaying each species’ age range finally identified the limestone’s relative age in the Tanjung Kramat area, Gorontalo City, namely the Early Pliocene (N18-N19) (Table 1).

Table 1. Relative ages of the wackstone facies in the Tanjung Kramat area, Gorontalo City

| SPECIES                            | MIOCENE |    |    |    |    |    | PLIOCENE |     |     | HOLOCENE |     |     |     |     |     |     |     |     |     |     |  |
|------------------------------------|---------|----|----|----|----|----|----------|-----|-----|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
|                                    | E       |    |    | M  |    |    | L        | E   | M   | L        |     |     |     |     |     |     |     |     |     |     |  |
|                                    | N4      | N5 | N6 | N7 | N8 | N9 | N10      | N11 | N12 | N13      | N14 | N15 | N16 | N17 | N18 | N19 | N20 | N21 | N22 | N23 |  |
| <i>Orbulina universa</i>           |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globigerinoides trilobus</i>    |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globigerinoides immaturus</i>   |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Hastigerina siphonifera</i>     |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globorotalia obesa</i>          |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globorotalia tumida</i>         |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globorotalia menardii</i>       |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globorotalia merotumida</i>     |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globigerinoides ruber</i>       |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Pulleniatina primalis</i>       |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |
| <i>Globigerinoides conglobatus</i> |         |    |    |    |    |    |          |     |     |          |     |     |     |     |     |     |     |     |     |     |  |

Information :  
 E : Early  
 M : Middle  
 L : Late

The micropaleontological analysis indicates a discernible disparity in the chronological age of the limestone present in the Tanjung Kramat region of Gorontalo City compared to the older researcher's findings. According to regional geological data (Bachri et al., 1997), the study location is a Quaternary limestone included in the Reef Limestone Formation (Q1). However, the findings of this study indicate a different geological era, specifically the Early Pliocene of the Tertiary period (Table 2).

Table 2. Comparison of limestone research in the South Gorontalo Region between Bachri et al. (1997) and Permana et al. (2023).

| Age/Era  | Bachri et al (1997)   | Permana et al (2023)  |
|----------|---|---|
| Quarter  | The reef limestone lithology in the Reef Limestone Unit Formation (Q1) is interpreted as the Late Pleistocene-Holocene age. |   |
| Tertiary |   | The three limestone facies are wackestone, packstone, and coralline floatstone facies. The age of limestone N18-N19 (Early Pliocene). |

## Conclusion

Concerning the findings and discussion, the analysis of the relative age of the limestone in the Tanjung Kramat region of Gorontalo City, based on the fossil composition of planktonic foraminifera, yields several noteworthy conclusions:

The geological formation observed in the Tanjung Kramat Region of Gorontalo City is characterized by three distinct limestone facies, specifically wackestone, packstone, and coralline floatstone.

There are eleven species of planktonic foraminifera fossils in the study area.

The age of limestone in the Tanjung Kramat area of Gorontalo City was determined through quantitative analysis, which involved overlaying the age range of each species. The results indicate that the limestone is relatively young, dating back to the Early Pliocene (N18-N19).

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