JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Analysis of Limestone Characteristics on the South Coast of Gorontalo Based on Specific Gravity and Water Absorption Tests

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Received: April 09, 2024
Revised: October 14, 2024
Accepted: November 25, 2024
Published: November 30, 2024

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DOI: 10.29303/jppipa.v10i11.7368

Abstract: The southern coast of Gorontalo has complex geological conditions. This is indicated by the strong tectonic influence with the uplift of the Quaternary limestone at high elevations. The distribution of this limestone is very unique because it is located between the dominance of volcanic and plutonic rocks that form the northern arm of Sulawesi. The purpose of this study was to focus on the characteristics of limestone on the south coast of Gorontalo based on specific gravity and water absorption tests. The research methods used to achieve these objectives consist of field geological surveys and laboratory analysis of the specific gravity and water absorption tests of coarse aggregate. The field geological survey consisted of taking limestone samples for laboratory analysis and petrological analysis. The results showed that the limestone on the southern coast of Gorontalo is dominated by the coralline floatstone facies. Characteristics of the coralline floatstone facies based on laboratory analysis showed an average specific gravity of 1.74 and an apparent specific gravity of 2.04. While the average percentage of limestone water absorption is 8.41%.

Keywords: Gorontalo; Limestone Characteristics; Specific Gravity.

Introduction

The activities of the three main plates in the world, namely the Eurasian Plate, the Pacific Ocean Plate and the Indian-Australian Plate affect the geological conditions of Indonesia in general and especially on the island of Sulawesi. The big influence of the tectonic is to form the island of Sulawesi which resembles the letter K, which each arm has its own geological conditions (Hamilton, 1979; Hutchison, 1989; Eksan et al, 2019: Madusila et al, 2021; Meidji et al, 2023; Ninasafitri et al, 2023; Modjo et al, 2024). One proof of tectonic influence is the process of uplifting limestone in the north of the Limboto Basin which is currently exposed on the surface at speeds reaching 0.0699-0.0724 mm/year (Permana et al, 2019a; Amin et al, 2019).

Geologically, the research area located on the southern coast of Gorontalo belongs to the North Arm of Sulawesi. The research area is part of the volcanic-plutonic strip of North Sulawesi which is generally composed of volcanic rocks of Eocene to Pliocene age, Neogene plutonic rocks, and sedimentary rocks which generally originate from volcanoes. The oldest rock unit in this strip is the Tinombo Formation (Eocene - Early Miocene). While the youngest rocks are reef limestones of quarter age (Bemmelen, 1949; Trail et al, 1974; Bachri, 2002; Asiki et al, 2019; Bakkar et al, 2020; Abdullah et al, 2021; Wumu et al, 2022; Elviyanti et al, 2022; Duwingik et al, 2022; Marfian et al, 2023; Napu et al, 2023).

Many studies in the Gorontalo region related to disaster mitigation and potential have been conducted (Eraku & Permana, 2020; Eraku et al., 2021; Lihawa et al.,

How to Cite:
Permana, A. P., Hutagalung, R., Eraku, S. S., & Isa, D. R. (2024). Analysis of Limestone Characteristics on the South Coast of Gorontalo Based on Specific Gravity and Water Absorption Tests. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 8624–8630. https://doi.org/10.29303/jppipa.v10i11.7368

2021). However, research on limestone in the research area is still lacking, especially regarding the physical characteristics of limestone. The novelty of this study is to determine the specific gravity value and water absorption capacity value of limestone in the research area. For this reason, detailed research on the physical characteristics of this limestone is needed through laboratory analysis of the specific gravity and water absorption of coarse aggregates. In addition, the novelty produced is the type of limestone in detail based on petrological analysis.

Bulk density is a property generally used in calculating the volume occupied by aggregates. In addition, the apparent density which is the relative density of the solid material that makes the principal particles excluding the pore spaces between the particles can be penetrated by water. While the absorption rate is used to calculate the change in weight of an aggregate due to water absorbing into the pores between the main particles compared to under dry conditions, when the aggregate is considered to have been in contact with water for a long time so that the water has fully absorbed (BSN, 2008; Arsyad et al, 2022; Mutiah et al, 2022; Waangsir et al, 2023; Silalahi et al, 2023; Tira et al, 2023; Aldania et al, 2024; Zahratun et al, 2024). Referring to this background, the research objective is to analyze the characteristics of limestone in the South Coast of Gorontalo based on the specific gravity and water absorption tests of coarse aggregate.

Method

Materials are limestone outcrops located in two research locations, namely Tanjung Kramat Village, Hulonthalangi District, Gorontalo City. The research location is located in the South Coast of Gorontalo which is part of the North Arm of Sulawesi. Station A1 is at coordinates (N 0°29'49.45" and E 123°02'38.81"), while Station A2 is at coordinates (N 0°29' 42.77" and E 123° 02' 43.75") (Figure 1).

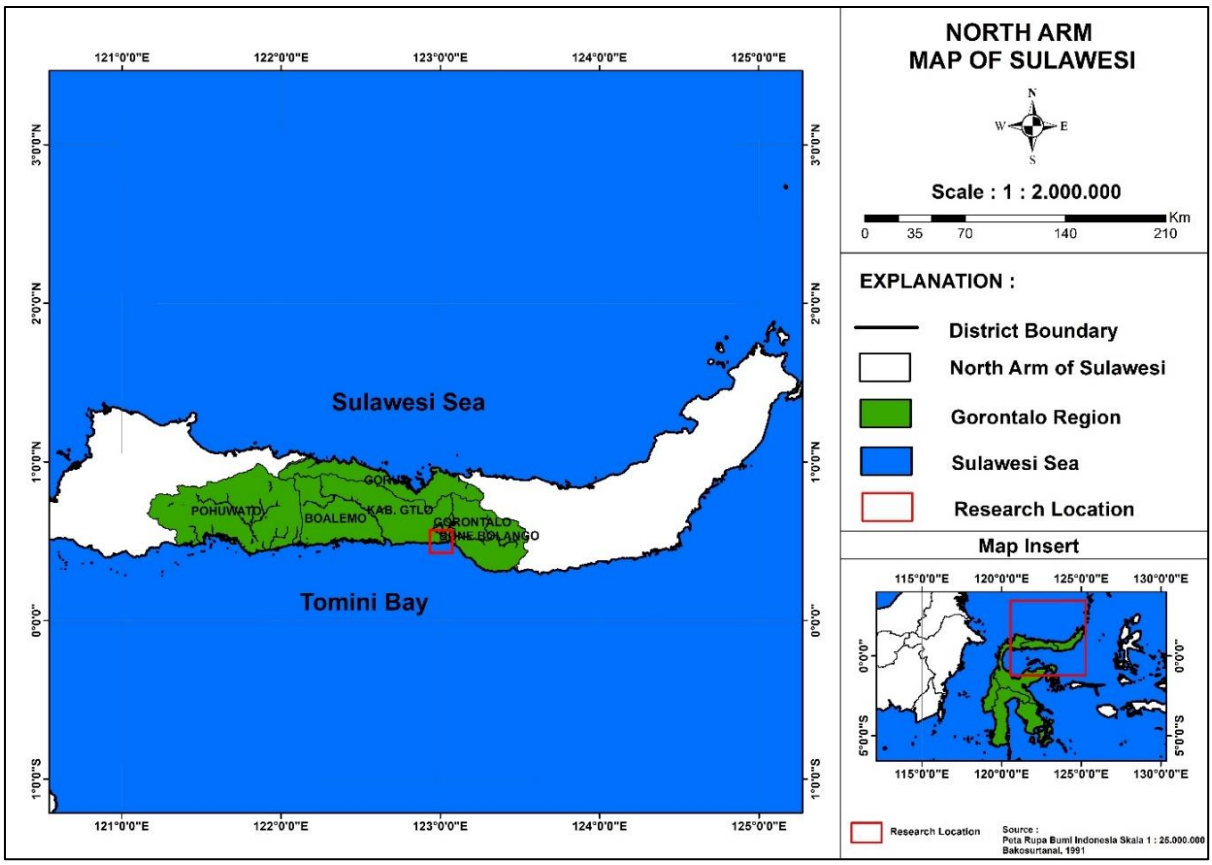

Figure 1. Map of the research location on the southern coast of Gorontalo which is part of the North Arm of Sulawesi (Bakosurtanal, 1999)

There are two research methods, namely field geological survey and laboratory analysis (Ghaneswara et al, 2023; Triyani et al, 2024; Robot et al, 2024; Wowiling et al., 2024; Damogalad et al, 2024; Mooduto et al, 2024; Permana et al, 2024). The field geological survey consisted of taking limestone samples for laboratory

analysis and petrological analysis (Boften et al, 2023; Sandi et al, 2023; Permana et al,2019b;2020;2021a;2021b; Supardi et al, 2022). For petrological analysis, namely a complete description of the limestones in the research location, starting from the texture, structure and composition of rocks so that the names of limestones can be determined in detail using classification (Embry & Klovan, 1971). While the laboratory analysis consists of two analyzes, namely the specific gravity test and the water absorption of coarse aggregate (Figure 2) (BSN, 2008; Rismalinda, 2015; Wiloso & Ratmy, 2018; Dumin et al, 2018; Soehardi, 2018; Putri & Soehardi, 2020; Moses et al, 2020; Mardani et al, 2020; Hakzah et al, 2021; Supardi et al, 2023).

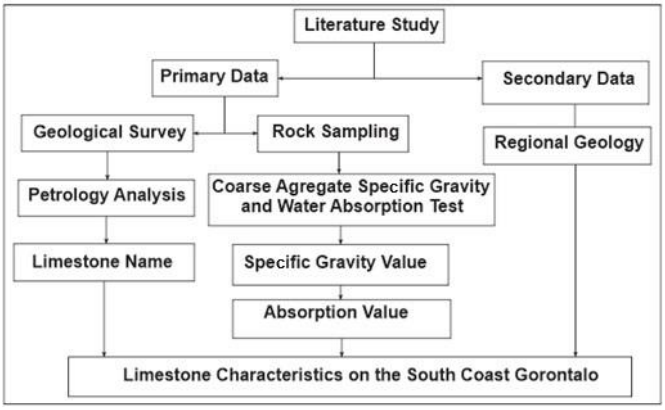

Figure 2. Research flowchart.

Figure 3. Laboratory analysis of the specific gravity and water absorption of coarse aggregate. (A) Drying the sample using an oven before weighing and (B) Weighing the sample in water.

Laboratory analysis consisted of two analyzes, namely the specific gravity and water absorption tests of coarse aggregate which were carried out at the Soil Mechanics Laboratory, Faculty of Engineering, Universitas Negeri Gorontalo (Figure 3). The equipment used for laboratory analysis of specific gravity and coarse aggregate water absorption tests refers to (BSN, 2008; Gazalie et al, 2022) consisting of six tools. First, a scale with an accuracy of 0.1% and equipped with equipment to hang the test sample container in water in the middle of the scale. Second, the test sample container is a wire basket with a size of 3.35 mm or according to the size of the test sample. Third, a water tub is a watertight water tub. Fourth, a hanging tool is a wire used to hang the container and test sample. Fifth, a glass, as a test sample container when baked and soaked. Sixth, an oven with adjustable heat at (110+-5) °C.

Result and Discussion

Petrological analysis of limestone outcrops at Stations A1 and A2 showed white rocks, poorly sorted, open packed, floating grains in the matrix (matrix supported) and massive structure. This limestone has been recrystallized because it is very porous and composed of coral, large foraminifera, micrite and opaque minerals (Figure 4). Based on this description, the limestone facies are the coralline floatstone facies (Embry & Klovan, 1971).

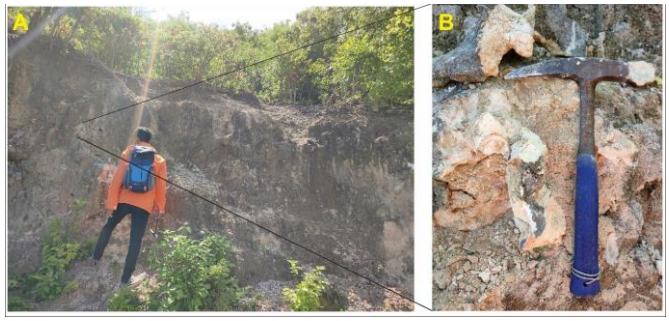

Figure 4. Field geological survey at the research site. (A) Limestone outcrop on hillside and (B) Limestone outcrop at close range.

The results of the laboratory analysis of the specific gravity and water absorption tests of coarse aggregate focused on the coralline floatstone facies can be seen in full in Table 1. Based on Table 1, it is known the value of dry sample weight, surface dry saturated sample weight (SSD) and sample weight in water. The measurement value of each examination number in the laboratory can be seen the average value.

Table 1. Results of laboratory analysis measurements

Inspection	Unit	Station A1	Station A2	Average
Weight of dry sample	[A] Gram	678.16	306.82	492.49
Weight of surface dry saturated sample	[B] Gram	738.41	331.16	534.79
Weight of sample in water	[C] Gram	346.99	155.71	251.35

Based on the measurement results of each examiner number in the laboratory, it can be seen that the values

of bulk specific gravity, surface dry saturated specific gravity (SSD), apparent specific gravity (apparent) and absorption (absorption). The calculation uses the formula referring to (BSN, 2008) consisting of Specific gravity formula (Equation 1), Surface dry saturated formula (Equation 2), Apparent specific gravity formula (Equation 3), and Absorption formula (*absorption*) (Equation 4). Complete result of calculating the average bulk specific gravity value, surface dry saturated specific gravity (SSD), apparent specific gravity (apparent) and absorption (absorption) can be seen in Table 2.

$$\text{Specific gravity formula} = \frac{A}{(B - C)} \quad (1)$$

$$\text{Surface dry saturated formula (SSD)} = \frac{B}{(B - C)} \quad (2)$$

$$\text{Apparent specific gravity formula} = \frac{A}{(A - C)} \quad (3)$$

$$\text{Absorption formula (}absorption\text{)} = \left[\frac{B - A}{(A)}\right] \times 100\% \quad (4)$$

Table 2. The calculation results of bulk specific gravity, surface dry saturated specific gravity (SSD), apparent specific gravity (apparent) and absorption.

Inspection	Unit	Station A1	Station A2	Average
Bulk specific gravity		1.73	1.75	1.74
Surface dry saturated		1.89	1.89	1.89
Apparent specific gravity		2.05	2.03	2.04
Absorption	%	8.88	7.93	8.41

Specific gravity has meaning as the relationship between mass and volume. Objects that have a large density will have a large mass density. So, the more compressed the particles that make up an object, the greater the density value for the same object. Density is a measurement of the mass per unit volume of an object. The higher the density of an object, the greater the mass of each volume. The average density of each object is the total mass divided by the total volume. An object that has a higher density will have a lower volume than an object of the same mass that has a lower density. Density values are widely used to determine the type of material.

Conclusion

Based on the results and discussion, the study on the analysis of limestone characteristics on the South Coast of Gorontalo based on specific gravity and water absorption tests resulted in the conclusion that the limestone outcrops at the two research stations were coralline floatstone facies. The average value of bulk specific gravity is 1.74, surface dry saturated specific gravity (SSD) is 1.89, apparent specific gravity is 2.04 and absorption is 8.41%.

Acknowledgments

The authors wish to express their profound appreciation to all individuals and institutions whose support made the implementation and completion of this research possible.

Author Contributions

Conceptualization, A. P. P and R. H.; methodology, A. P. P, R. H and S. S. E.; validation, D. R. I.; formal analysis, A. P. P.; investigation, A. P. P, R. H and S. S. E.; resources, S. S. E and D. R. I.; data curation, A. P. P and D. R. I.; writing—original draft preparation, A. P. P.; writing—review and editing, A. P. P.; visualization, A. P. P and R. H. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

Regarding this study, the author declares that there is no conflict of interest.

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