Jurnal Akademika Kimia, 13(1): 20-24, February 2024
ISSN (online) 2477-5185 | ISSN (print) 2302-6030
http://jurnal.fkip.untad.ac.id/index.php/jak/

Analysis Levels of Calcium Oxide (CaO) in Limestone from Leok Village, Biau Sub-district, Buol District

***Vanny M. A. Tiwow, Almia Istiqomah, Paulus H. Abram, & Yuli Nurmayanti**
Program Studi Pendidikan Kimia/FKIP – Universitas Tadulako, Palu – Indonesia 94119

Received 11 April 2021, Revised 20 September 2023, Accepted 16 November 2023
doi: 10.22487/j24775185.2024.v13.i1.pp20-24

Abstract

Limestone is one of the rocks that is very abundant in Indonesia and has many benefits, especially in the field of industry. This study aims to determine the levels of calcium oxide (CaO) in limestone at Desa Leok, Kecamatan Biau, Kabupaten Buol. XRF (X-ray fluorescence) was the analytical technique utilized to ascertain the amount of calcium oxide (CaO) present in the limestone. Both the coast area and the hill area provided samples. The measurement results indicate that the level of CaO is 92.41 % in the coast area and 93.74 % in the hill area.

Keywords: Limestone, CaO, X-ray fluorescence

Introduction

Limestone formation begins underwater with marine organisms such as corals, mollusks, and foraminifera, which contribute to fragment deposition. Rock-hard and dense limestone is formed through the processes of sedimentation and diagenesis that occur over millions of years (Wang et al., 2022).

Limestone is one of the industrial minerals that is widely used by the industrial sector or construction, and agriculture, among others, for building materials, building stones, the glass industry as an excavated flux, silica brick industry, and cement industry raw materials (Sindua & Kaihatu, 2022)

Indonesia is one of the countries that produces limestone. Several islands in Indonesia, including Sumatra, Java, Nusa Tenggara, Sulawesi, Irian Jaya, and others, are reportedly home to limestone minerals. For some people, limestone may not be an ordinary thing that has no value, and is considered not very valuable because it is easy to obtain and the price is relatively cheap. However, for some others, limestone remains a very attractive mineral resource. Limestone is a sedimentary rock with the main composition of minerals calcite ($CaCO_3$), dolomite $CaMg(CO_3)_2$ and aragonite ($CaCO_3$), formed in several ways, namely organically, mechanically, and chemically. In Indonesia, limestone is often referred to as limestone, while the extraordinary term is commonly called "limestone". Limestone contains at least 50 % by weight of calcium carbonate in the form of calcite minerals (Lukman et al., 2020)

In the industry and construction, limestone is often applied and utilized. Limestone is one of the most prevalent construction materials (Kamran et al., 2022). It is an important sedimentary rock dominantly composed of calcite ($CaCO_3$) mineral (Janjuhah et al., 2021; Dong et al., 2023) and contains other elements, including magnesium (Maulana et al., 2021; Jafar et al., 2022). As a raw material, limestone is widely used in many industries, especially in the construction and cement industries. The production of Portland cement mainly depends on the availability, as it is the major raw material used in cement (Wakila et al., 2023), and the exploration of limestone as a raw material for cement is currently being intensely carried out in several regions in Indonesia (Wakila et al., 2021). The production and steel refining also use limestone material because of its high calcium carbonate content (Yang et al., 2023).

Limestone containing more than 50 % CaO (weight percent) is very well used as a building material in the form of cement (Alfarizi et al., 2020). There are two ways to use limestone: directly or by first undergoing the calcination process. The calcination process is a process that uses high temperatures during heating to change its physical properties and chemical composition (Sutama & Oemiati, 2022). One result of the calcination process is that $CaCO_3$ in limestone decomposes into CaO and CO_2 (Smadi et al., 2023).

Central Sulawesi is one of the provinces in Indonesia with abundant limestone in certain areas.

*Correspondence:
Vanny M. A. Tiwow
e-mail: Vanny.Tiwow@gmail.com

For example, in the coral reefs of Donggala Regency (Islamiyati & Abram, 2020; Tasari et al., 2019), Banggai Islands Regency (Milka et al., 2023), and Morowali Regency (Tolan et al., 2023; Wakila et al., 2023), it has also been reported that limestone is abundant in Buol Regency, especially in the districts of Biau and Bokat.

Based on the previous explanation, the mineral CaO is equally important compared to $CaCO_3$ found in limestone. Therefore, the researchers are interested in analyzing the CaO content in limestone located in the Leok Village area, Biau District, Buol Regency, Central Sulawesi Province.

One method to analyze the chemical content of rocks like limestone is the X-Ray Fluorescence (XRF) method (Alfarizi et al., 2020; Rahim et al., 2023).

Methods

Tools and materials

The tools used for this research are an oven, a furnace/muffle furnace, a mortar, an analytical balance, a desiccator, a 70-mesh sieve, a beaker, a spatula, and XRF (X-Ray Fluorescence). The materials used in this research are limestone as the main material, distilled water as a sample cleaner, and aluminum foil.

Research sample

The samples used were limestone found in the mountains and on the coast of Leok Harbor.

Research method

The method used is the analysis method using XRF. X-Ray Fluorescence (XRF) is one of the analytical methods used for qualitative and quantitative analysis of elements in materials. Qualitative analysis provides information on the type of elements contained in the analyzed material. Quantitative analysis reveals the quantity of elements present in the material (Alfarizi et al., 2020; Rahim et al., 2023).

Rock sample preparation

Limestone chunks that have been taken and crushed into smaller chunks are then cleaned of the material attached to the stone using distilled water, then drained and dried in an oven at 110 °C for 6 hours. The samples that have been in the oven are then crushed using a mortar and pestle and sieved using a 70-mesh sieve. After sieving, the samples are then stored in a clean and dry container.

Water content

The empty cup is put into the oven at 110 °C for 15 minutes, then the cup is cooled in a desiccator for 5 minutes, then weighed and recorded as (W3). Weigh 10 grams of rock sample, then put it into the cup and record it as (W1). The sample is then put into the oven for 30 minutes, then cooled in a desiccator for 5 minutes and weighed using an analytical balance and recorded as (W2). This procedure is done repeatedly until a constant weight is obtained, and then calculated using the formula:

$$W = \frac{W_1 - W_2}{W_2 - W_3} \times 100\% \qquad (1)$$

Where W is the moisture content, W1 is the weight of the cup and wet stone (grams), W2 is the weight of the cup and dry stone (grams), and W3 is the weight of the cup (grams).

Ash content

Empty crucibles were put into the oven for 15 minutes at 115 °C and then cooled in a desiccator for 5 minutes; then the crucibles were weighed using an analytical balance. A 10-gram sample was weighed and then put into an empty crucible cup then closed, and put into a muffle furnace for 4 hours at 900 °C.

$$\%\text{Kadar abu} = \frac{m_3 - m_1}{m_2 - m_1} \times 100\% \qquad (2)$$

The information is that m1 is the weight of the empty cup (grams), m2 is the sum of the weight of the cup and sample (grams), and m3 is the sum of the weight of the cup and grey (grams).

Calcium oxide (CaO) content

The CaO that has been obtained is then characterized using XRF (X-Ray Fluorescence) to determine the composition and percentage of elements contained in the calcined sample, as well as to identify the number of elements contained in the calcined sample. The data obtained from XRF consists of information regarding the composition and percentage of elements found in rock samples.

Results and Discussion

Figures, photographs, and tables should appear in the Rock sampling and preparation.

Limestone samples were taken from two places, the mountainous area of Leok and the coastal area of Leok Harbor in Buol Regency. This limestone is yellowish-white in color. The distinctive yellow color of this limestone is the typical color of iron; its presence is evidenced by the Fe_2O_3 content, including the third highest (1.64 - 1.95 %) or iron content of (1.87 - 2.23 %) (Megawati et al., 2019). The texture of limestone is quite hard; because the hardness was not measured, the specific gravity and volume weight are likely in the maximum range (BJ: 2.8 g / cm3, BV: 2.6 g / cm^3).

Figure 1. Limestone Sample

Water content

Water content represents the percentage of the weight of water in the pores of the total rock weight. Porosity is the ratio of the volume of pores/voids/spaces present in the rock to the total volume of the rock, which is valued as a percentage between 0 and 100 %. The pores in the rock may be partially filled with water and partly filled with air (Kemon & Laitupa, 2022)

The gravimetric method analyzes the moisture content to calculate the ratio of the material's weight change during heating. The moisture content test aims to determine the hygroscopic nature of the material. The water content in the mountain limestone sample (sample 1) is 0.38 %, 0.40 %, and 0.40 %, respectively, so that the average water content obtained in the mountain limestone sample is 0.39 %. The water content in the beach limestone sample (sample 2) is 0.66 %, 0.75 %, and 0.75 %, so that the average water content obtained in the beach limestone sample is 0.72 %. The low moisture content in sample 1 compared to sample 2 indicates that little water is still trapped in the pores of limestone in mountainous areas (sample 1).

It is known that rocks are composed of various minerals and have electrical properties (resistivity). The amount of water content affects the resistivity value. The greater the water content contained in the rock, the lower the resistivity value. Rock resistivity is the resistance of rocks to the flow of electricity. Rock resistivity is affected by porosity, water content, and minerals (Rahayu & Abram, 2020)

Ash content

Ash content analysis shows how many minerals are contained in a sample. This study aims to determine the ash content in order to assess the metal oxides present in limestone material.

The ignition process carried out in this study is in a direct way, where the sample is oxidized at a high temperature so that the residue from the combustion process is directly weighed.

Calcium oxide minerals, which are the purpose of the researcher's analysis, can be obtained through the process of ignition using the calcination method. The calcination process is a process to decompose the reaction or to release CO_2 from the $CaCO_3$ compound, which will become CaO. Temperature influences the weight of the resulting sample because the more CO_2 gas released will cause the decomposition process to accelerate (Zahara et al., 2020).

According to Handayani et al. (2020), the best temperature for the $CaCO_3$ decomposition reaction is ≥ 900 ℃. The higher the temperature, the higher the CaO content produced. In addition, the high temperature used will be able to remove the water content and organic compounds contained in limestone (Wardiana et al., 2019).

The results of the percentage of ash content obtained in this study are that the mountainous area (sample 1) obtained a percentage of ash content of 59.21 %, and the coastal limestone (sample 2) obtained a result of 63.65 %. The ash content in limestone is an inorganic material formed from mineral changes due to the combustion process.

Calcium oxide (CaO) content

The study to find out how much calcium oxide (CaO) is in limestone from Leok village, Biau sub-district, Buol Regency, was done using the X-Ray Fluorescence (XRF) method. **Tables 1, 2, 3, and 4** display the analysis results.

Table 1. The composition of coastal limestone is presented in oxide form

No	Compound	Percentage (%)
1.	CaO	92.41
2.	SiO_2	5.50
3.	Fe_2O_3	1.95
4.	TiO_2	0.096
5.	Nb_2O_5	0.0162
6.	MoO_3	0.0123

Table 2. The composition of coastal limestone in its elemental form

No	Elemental	Percentage (%)
1.	Ca	94.45
2.	Si	3.17
3.	Fe	2.23
4.	Ti	0.094
5.	Nb	0.0184
6.	Mo	0.0133
7.	In	0.0060
8.	Sb	0.0060

Table 3. The composition of mountain limestone is presented in oxide form.

No	Compound	Percentage (%)
1.	CaO	93.74
2.	SiO_2	4.57
3.	Fe_2O_3	1.64
4.	Nb_2O_5	0.0173
5.	MoO_3	0.0130

Table 4. The composition of mountain limestone in its elemental form

No	Elemental	Percentage (%)
1.	Ca	95.43
2.	Si	2.64
3.	Fe	1.87
4.	Nb	0.0196
5.	Mo	0.0140
6.	In	0.0063
7.	Sb	0.0054
8.	Sn	0.0051

The results of the analysis of CaO content obtained are that in the mountain limestone sample (sample 1), the percentage obtained is 93.74 %, and in the coastal limestone sample (sample 2), the percentage obtained is 92.41 %.

The CaO content in mountain limestone (sample 1) is higher than coastal limestone. This is because coastal limestone (sample 2) has undergone a sedimentation process, so that the elements or chemical compounds that are still pure have changed. In contrast, mountain limestone (sample 1) grows in situ, which allows the elements of its chemical compounds to remain pure and unchanged (Islamiyati & Abram, 2020).

The calcination process with high temperatures also affects the CaO content produced, which is also huge at > 90 % (Handayani et al., 2020). The high level of CaO in limestone compared to other oxide minerals shows that limestone in Leok village, Biau sub-district, Buol Regency is excellent for use as a raw material for cement/catalyst production, because the standard for limestone used in the production process must have a percentage of CaO content of 50 % (Alfarizi et al., 2020; Sirin et al., 2020).

Conclusions

In Leok Village, located in the Biau Sub-district of Buol District, the CaO content of limestone in the mountainous area is 93.74 %, with an average moisture content of 0.39 % and an ash content of 59.21 %. In contrast, the limestone in the coastal area has a CaO content of 92.41%, with an average moisture content of 0.72 % and an ash content of 63.65 %.

Acknowledgment

The author would like to thank the supervising lecturer for providing advice and input for this paper. To the chemistry laboratory staff of FKIP UNTAD, thank you for your assistance to the author during the research.

References

Alfarizi, Y., Budiadi, E., & Trisnaning, P. T. (2020). Analisis geokimia xrf untuk menentukan kualitas batugamping di bukit tarjarang Pt. semen padang, Indarung, kec. Lubuk Kilagan, Padang, Sumatra Barat. *GEODA, 1*(2), 19-28.

Dong, G., Liu, X., Yin, L., Fu, X., Song, J., Zhao, X., & Pei, W. (2023). Development characteristics and genetic analysis of dense limestone reservoirs in the Taiyuan Formation of the Ordos Basin, China. *Journal of Natural Gas Geoscience, 8*(5), 307–317.

Handayani, L., Zuhrayani, R., Putri, N., & Nanda, R. (2020). Pengaruh suhu kalsinasi terhadap nilai rendemen CaO cangkang tiram (crassostrea gigas). *Jurnal Tilapia, 1*(1), 1-6.

Islamiyati, A. D., & Abram, P. H. (2020). Analisis kadar kalsium oksida (CaO) pada batu karang dari daerah pesisir pantai desa Bayang kecamatan Dampelas kabupaten Donggala. *Media Eksakta, 16*(1), 057-062.

Jafar, N., Ridwan, F., & Thamsi, A. B. (2022). Identification of rare earth metal content in fly ash and bottom ash coal combustion of PT Bosowa Energi PLTU Jeneponto regency. *International Journal of Engineering and Science Applications, 9*(2), 78-83.

Janjuhah, H. T., Kontakiotis, G., Wahid, A., Khan, D. M., Zarkogiannis, S. D., & Antonarakou, A. (2021). Integrated porosity classification and quantification scheme for enhanced carbonate reservoir quality: Implications from the miocene Malaysian carbonates. *Journal of Marine Science and Engineering, 9*(12), 1-22.

Kamran, A., Ali, L., Ahmed, W., Zoreen, S., Jehan, S., Janjuhah, H. T., Vasilatos, C., & Kontakiotis, G. (2022). Aggregate evaluation and geochemical investigation of limestone for construction industries in Pakistan: An approach for sustainable economic development. *Sustainability, 14*(17), 1-21.

Kemon, F. O. A., & Laitupa, K. (2022). Studi pengaruh kadar air dan porositas terhadap nilai kuat tekan uniaksial batu andesit di Saoka Sorong provinsi Papua Barat. *Jurnal Penelitian Tambang, 5*(1), 23-26.

Lukman., Sujianto, A. E., Sutarno., & Nas, C. (2020). Feasibility analysis of limestone industry development as a leading mining product of Rembang Central Java district. *International Journal of Psychosocial Rehabilitation, 24*(9), 4448-4459.

Maulana, N. D., & Mahbub, R. M. (2021). Analisis geokimia batugamping kristalin sebagai bahan baku semen portland daerah Ngerdani dan sekitarnya, kecamatan Dongko, kabupaten Trenggalek, Jawa Timur. *GEODA, 2*(01), 5-8.

Megawati., Alimuddin., & Kadir, L. A. (2019). Komposisi kimia batu kapur alam dari indutri kapur kabupaten Kolaka Sulawesi Tenggara. *Saintifik, 5*(2), 104-108.

Milka, Y., Keteng, F., & Tandi, J. F. (2023). Pemanfaatan material lokal domato di kabupaten Banggai Kepulauan dalam komposisi campuran material lapis pondasi perkerasan jalan. *Jurnal Sains dan Teknologi Tadulako, 9*(2), 66-79.

Rahayu, R., & Abram, P. H. (2020). Analisis jenis dan kandungan logam pada batuan buangan dari pertambangan emas Poboya. *Media Eksakta, 16*(2), 122-127.

Rahim, H., Basir, M. M., & Diana, S. (2023). Analisis kadar CaO bebas dan lime saturation factor (lsf) pada klinker di PT. semen bosowa Maros. *Jurnal Teknologi Kimia Mineral, 2*(1), 7-10.

Sindua, N. J., & Kaihatu, J. E. (2022). Social impact of limestone processing on the community of Lobong village, West Passi district, Bolaang Mongondow regency, North Sulawesi. *Proceeding of SHS Web of Conferences* (pp. 1-4). London: EDP Sciences.

Sirin, Y. A., Jamarun, N., Sisca, V., Zilva., & Olivia, R. (2020). Utilization of limestone as catalyst in biodiesel production. *Journal of Pharmaceutical Sciences and Research, 12*(5), 635-638.

Smadi, E., Chinnici, A., Dally, B., & Nathan, G. J. (2023). Effect of heating rate on the kinetics of limestone calcination. *Chemical Engineering Journal, 475*(November), 1–11.

Sutama, A., & Oemiati, N. (2022). Studi mikrostruktur beton ringan geopolimer dengan scanning electron microscope (SEM) dan x-ray diffraction (XRD). *Jurnal Deformasi, 7*(2), 145–160.

Tasari, S., Iqbal., & Badaruddin. (2019). Penentuan lama kalsinasi kalsium karbonat $CaCO_3$ dari batu kapur Tanjung Karang Donggala. *Gravitasi, 18*(2), 137-147.

Tolan, T. M., Jahidin., & Hasan, E. S. (2023). Analysis of limestone occurrence using resistivity method in block A of PT graha batu perdana mining area Bungku Pesisir sub-district Morowali district. *Jurnal Rekayasa Geofisika Indonesia, 5*(03), 146-155.

Wakila, M. H., Bakri, S., & Syam, N. I. (2023). Quality analysis of limestone for the raw material of cement making industry in Tangofa Village, Bungku Pesisir sub-district, Morowali regency. *Journal of Geology & Exploration, 2*(2), 75-83.

Wakila, M. H., Chalik, C. A., Asmiani, N., Munir, A. S., Idris, M., & Juradi, A. (2021). Analisa kualitas batu gamping sebagai bahan baku semen pada daerah Waangu-angu kab. Buton prov. Sulawesi Tenggara. *Jurnal GEOSAPTA, 7*(1), 2963-2869.

Wang, Y., Lei, L., Hu, X., Liu, Y., Shi, C. (2022). Effect of diethanolisopropanolamine and ethyldiisopropylamine on hydration and strength development of Portland cement. *Cement and Concrete Research, 162*(December), 1–12.

Wardiana, A. E., Shalli, F. G., Saputra, E. C., & Cahyaningrum, S. E. (2019). Utilization of limestone as hydroxyapatite raw material. *UNESA Journal of Chemistry, 8*(2), 62-66.

Yang, Z., Zhang, W., Zhu, H., Chen, Y., Xu, L., Wang, P., & Lai, Y. (2023). Thaumasite form of sulfate attack in ettringite rich-ternary systems: Effects of limestone filler, etching solutions and exposure temperature. *Developments in the Built Environment*, *15*(October), 1–8.

Zahara, A., Bhernama, B. G., & Harahap, M. R. (2020). Literature review: Pengaruh suhu kalsinasi terhadap sintesis katalis heterogen CaO dari cangkang telur. *Amina, 2*(2), 84-91.