doi: 10.37905/jgeosrev.v6i2.21524 ejurnal.ung.ac.id/index.php/jgeosrev

Vol. 6, No. 2, July 2024: 47-53

Jambura Geoscience Review

p-ISSN 2623-0682 | e-ISSN 2656-0380

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Clay Mineral Identification for the Utilization of the Brick Industry in Samarinda using X-Ray Diffraction (XRD) Analysis

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ARTICLE INFO

Article history:
Received: 11 August 2023
Accepted: 19 June 2024
Published: 29 July 2024

Keywords:
Brick; Clay Mineral; Quartz; X-Ray Diffraction; Sandstone

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ABSTRACT

The clay minerals occurrences can be utilized into various products, including bricks. Brick industry often used the materials taken from the local area. The objective of the research is to identify the lithology of the brick material as well as the mineral consist in the soil or material, including clay mineral. The analysis is carried out in field observation and X-Ray Diffraction (XRD) analysis. The analysis resulting the lithology of the research area is predominantly sandstone and the bricks material is taken from the clayey soil part of from the quartz sandstone lithology. The quartz sandstone predominantly composed by quartz (97%) and plagioclase as minor mineral (3%). The analysis of the clay soil sample in quartz sandstone layer which used as the main component of the brick showing that the minerals composition are mainly quartz (95%) and plagioclase as minor mineral (3%), while the clay mineral that detected is kaolinite (2%). The formation of the kaolinite is interpreted as the result of the weathering of plagioclase trough hydrolysis process. From those data, it is identified that the brick in the research area mainly composed by quartz and clay mineral as kaolinite is formed in just minor abundance.

How to cite: Raharjanti, NA. (2024). Clay Mineral Identification for the Utilization of the Brick Industry in Samarinda using X-Ray Diffraction (XRD) Analysis. *Jambura Geoscience Review, 6*(2), 47-53. https://doi.org/10.37905/jgeosrev.v6i2.21524

1. INTRODUCTION

Minerals are the main component in rocks formation. Generally, minerals are divided into two types namely ore minerals and industrial minerals. Industrial minerals are defined as mineral which can be utilized without prior processing (Evans, 1993). One of the examples of the industrial minerals in clay minerals. Clay minerals are describes as the members of phyllosilicate minerals, have plasticity characteristics, and harden upon drying and firing. Clay minerals also can be formed naturally or synthetic. The examples of the clay minerals are kaolin, smectite, chlorite, and pyrophyllite (Bergaya, 2008; Guggenheim, 1995). The minerals can be utilized in various industry including ceramics, cosmetics, polymer coatings, and bricks (Danish et al., 2022; Gonggo & Edyanti, 2013; Murray, 2007; T. Winarno, Kurniasih, Marin, & Kusuma, 2018). Clay bricks are one of the building materials which widely used in Indonesia, including Samarinda (Rahmi & Syarief, 2014).

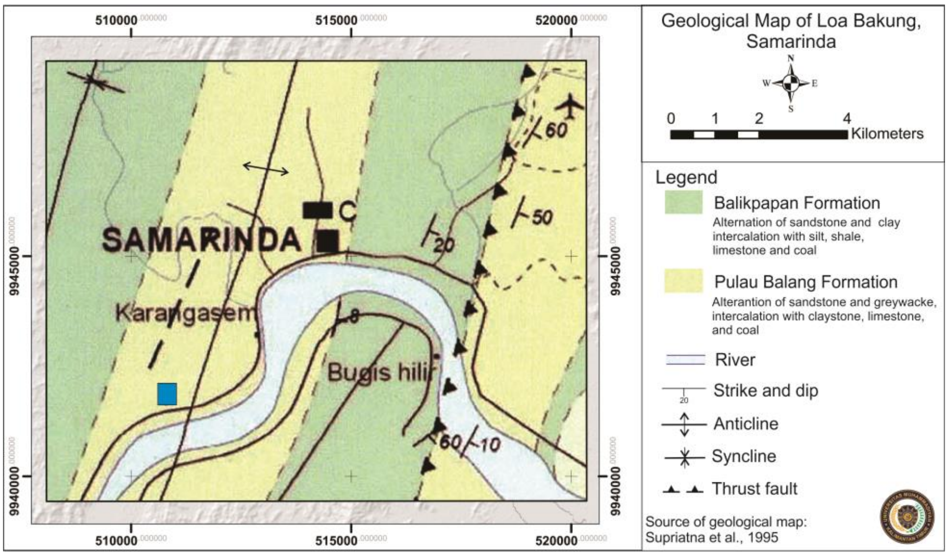

Figure 1. The geological map of the research area which is a part of Pulau Balang Formation (blue rectangle) which consists of alterantions of greywacke and sandstone, intercalations with limestone, claystone, and coal (modified from Supriatna, Sukardi, & Rustandi, 1995).

In Samarinda, one of the utilization of the industrial minerals particularly clay mineral is bricks industry, which is produced in the level of home industry. Samarinda is an area composed by Miocene-Pliocene sedimentary rocks predominantly as parts of Balikapapan, Pulaubalang and Kampug Baru Formation (Supriatna, Sukardi, & Rustandi, 1995). The location of the bricks industry in Samarinda is included in in Pulau Balang Formation, consist of alternation of sandstone and greywacke, intercalations with claystone, limestone, and coal. The sandstone in this formation is identified as quartz sandstone, locally found as calcarous. While the greywacke identified as greenish grey colored and compact. The Limestone contains larger foraminifera which indicate a Middle Miocene age, and claystone has blackish grey color, locally intercalating with coal. (Chambers et al., 2004; Supriatna et al., 1995; A. Winarno, Hendra Amijaya, & Harijoko, 2019) (Figure 1).

The bricks in Samarinda is made from the clay which the source is from the surrounding lithology. It is located in the Batu Penggal area, Loa Bakung, Sungai Kunjang, Samarinda which according to regional geology map is included in Pulau Balang Formation (Supriatna et al., 1995) (Figure1). However, the characteristics of the lithology which formed clay minerals and the species of the clay minerals in the research area has not identified yet. In fact, the identification of the minerals may provide the information of the features of the minerals which can provide the information of how to utilized it effectively, because each minerals have their own features which lead to the recommendation of utilization (Bergaya, 2008; Kogel, 2009). Hence, the identification of the clay minerals in the research area are important to be done. The objectives of the research are to identify the clay minerals and its minerals associations in the lithology of the research area. Therefore, origin of clay minerals which utilized as bricks can be determined.

2. METHOD

The research was carried out in several steps, including field observation and laboratory analysis. Field observation was done to analyze geological features in the research area particularly the lithology which used as the material for the bricks. Samples of the soil contained clay and the rocks underneath the clay.

The laboratory analysis that was used is X-Ray Diffraction (XRD). The samples was grinded become powder and analyze using Rigaku Miniflex II for initial 3.0-70°2θ scanning angle. The Reference Intensity Ratio (RIR) is the method used for quantification to obtain mineral and phase estimation. Minerals/phases identification is carried out by using Jade9 software with ICDD database, hence the presentation of the minerals is obtained.

The XRD analysis was categorized into two types, namely bulk and clay analysis. The bulk analysis was done in fresh lithology underneath the clay profile to identify the mineral associations which composed the rocks in the research area. The clay sample was analyzed using clay analysis. Clay analysis also conducted to identify the specific clay mineral name in the samples which is utilized as clay bricks (Guggenheim, 1995; Moore & Reynolds, 1997; Rahmi & Syarief, 2014). Clay analysis that was conducted are bulk oriented clay sample and ethylene glycol.

The data from the field observation and XRD analysis then integrated and analyzed to determine the species of the minerals and interpret the source of the clay minerals which used as the bricks in the research area.

3. RESULTS AND DISCUSSION

3.1. Lithology

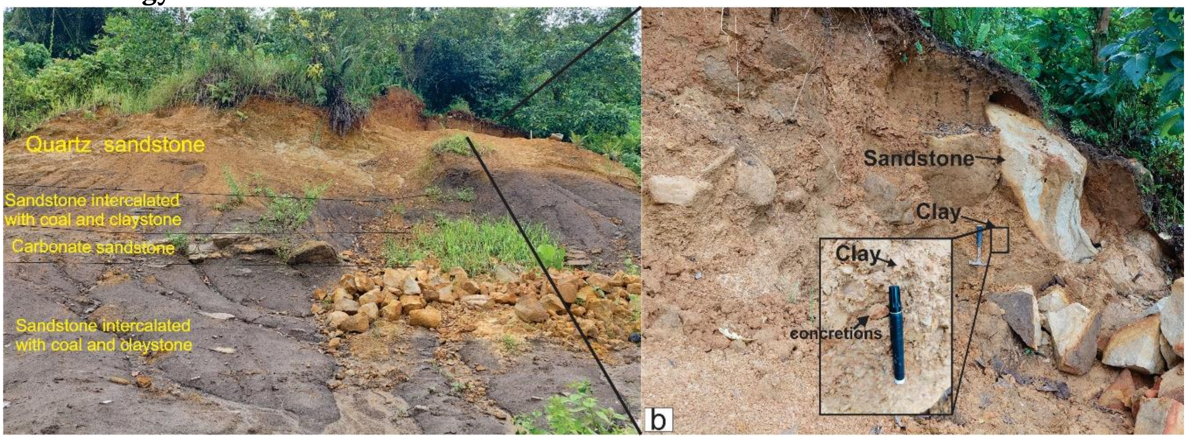

Figure 2. The outcrop in the research area containing the lithology that used as bricks (a) the lithological bedding in the research area (b) detailed quartz sandstone outcrop.

Batu Penggal area is composed by sedimentary rocks. The rocks are mainly composed with sandstone intercalated with carbonate sandstone and coal. The lithology has experienced structural geology, shown by the orientation of the strike/dip of the lithology layers, measured as N 28°E/ 23°. This dipping of the taken from the quartz sandstone lithology which located in the upper bedding of the stratigraphy (Figure 1a and 1b). bedding is corresponds to the direction of the regional geological structure in Samarinda, identified as Samarinda anticlinorium (Supriatna et al., 1995; Witts, Davies, Morley, & Anderson, 2016) (Figure 1a).

According to the XRD bulk analysis which conducted to the quartz sandstone which located right under the clay layer (Figure 3), the minerals mainly identified as quartz and plagioclase in minor form, accounted for 97% and 3% respectively (Table 1). It is indicated that according to classification of sedimentary rocks, the lithology is categorized as quartz arenite (Pettijohn, 1975). This quartz arenite is a part of a sequence of sedimentary rocks which mainly consist of interbedded shales, claystone, and sandstone. The analysis on sedimentary environment showing that the sedimentary rocks in the research area are included in the representing prograding shelf lobes in a prodelta environment. This sediment sequence is part of Pulau Balang Formation that formed in the Middle Miocene until Late Miocene (Marshall et al., 2015; Permana et al., 2022; Supriatna et al., 1995).

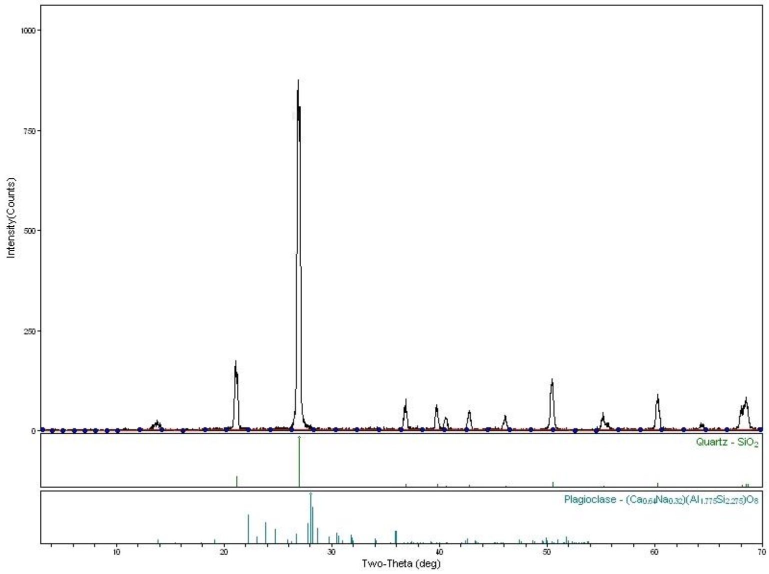

Figure 3. The result of the XRD analysis in the quartz sandstone showing the quartz and plagioclase.

Table 1. The mineral composition of the quartz sandstone samples identified using XRD

Id Sample	Minerals Composition	Chemical Formula	Minerals Composition Estimation (%)
STA 1-SMD_Batupasir	Quartz	SiO_2	97
	Plagioclase	$(Ca_{0.64}Na_{0.32})(Al_{1.775}Si_{2.275})O_8$	3
Total			100%

3.2. Clay Minerals

According to the bulk XRD analysis in the clay sample which used the material of brick, the minerals that detected are quartz and plagioclase formed as minor minerals. While the according to XRD clay analysis, clay mineral that detected is kaolinite by its d peak on 7.15A with 2 theta value 12.41 shown in the clay oriented analysis (Figure 4). Quantitative analysis on the sample shows that the estimated abundance of the quartz is 95%, plagioclase 3%, and kaolinite 2% (Tables 2). The composition of the minerals is obtained using The Reference Intensity Ratio (RIR) method. The analysis is carried out automatically by using using Jade9 software with ICDD database.

From the result of the clayey soil analysis which utilized as the material of the bricks in Samarinda still dominated with quartz. The clay in the research area is interpreted to be result of the weathering process of experienced in the quartz sandstone, hence the plagioclase mineral altered into kaolinite through hydrolysis process in acid condition (Manning, 2022). The plagioclase in the research area has chemical formula (Ca0.64Na0.32)(Al1.775Si2.275)O8, while the kaolinite has chemical formula Al2(Si2O5)(OH)4, therefore alteration reaction from plagioclase to the kaolinite is written in the equation (1) (Manning, 2022).

Ca-Plagioclase to Kaolinite:

$$CaAl_2Si_2O_8 + 2H^+ + H_2O = Ca^{2+} + Al_2Si_2O_5(OH)_4 \quad (1)$$

Na-Plagioclase to Kaolinite:

$$2NaAl_2Si_2O_8 + 2H^+ + 9H_2O = 2Na^+ + Al_2Si_2O_5(OH)_4 + 4H_4SiO_4 \quad (2)$$

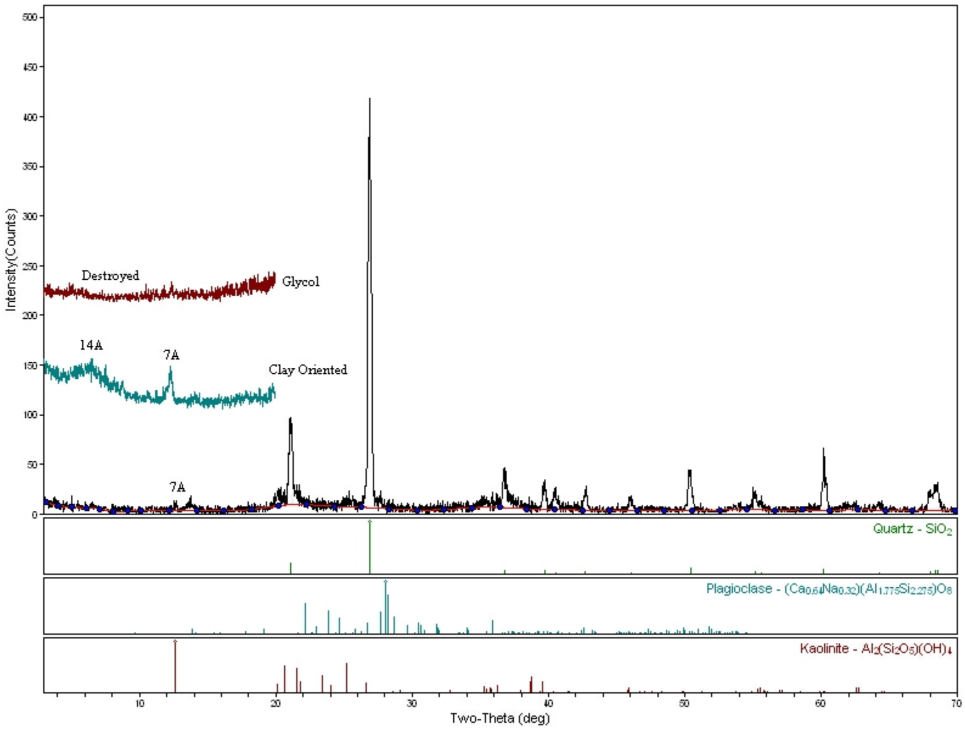

Figure 4. The result of the XRD analysis in the clay samples, showing that the clay mineral in the research area consists of kaolinite mineral.

Table 2. The mineral composition of the clay samples identified using XRD

Id Sample	Minerals Composition	Chemical Formula	Minerals Composition Estimation (%)
STA 1B-SMD_Clay	Quartz	SiO_2	**95**
	Plagioclase	$(Ca_{0.64}Na_{0.32})(Al_{1.775}Si_{2.275})O_8$	**3**
	Kaolinite	$Al_2(Si_2O_5)(OH)_4$	**2**
Total			**100%**

Comparison on the bricks composition in Bukaka, Bone, shows that the material used for bricks has a significant lower quartz concentration, indicated by SiO_2 content as the chemical formula of quartz, accounted for aroung 44%. This indicated that clay in the Bukaka, Bone is higher than in the research area (Nur, 2020). The abundance of clay in the materials affect their plasticity characteristics. The higher clay content the plasticity will be higher too. On the other hand, the high quartz content, will lower the plasticity of the materials (Gonggo & Edyanti, 2013). Hence, the utilization of the clay in Samarinda may not be suitable for the ceramic since the clay minerals which identified kaolinite is low and the plasticity is low too.

4. CONCLUSIONS

The materials in the research area which utilized as bricks material for the local people is taken from the quartz sandstone lithology. Mineralogy analysis resulting that composed by predominantly quartz, with minor minerals plagioclase and clay minerals identified kaolinite. The kaolinite is characterized using XRD clay analyisis identified in peak 7.15A and 2 theta 12.41. The kaolinite is derived from the plagioclase weathering process. The detailed analysis such as geochemistry and quality assessment of the material and the bricks in the research area is recommended to determine the quality of the products compare to the National Standard of Indonesia.

5. ACKNOWLEDGMENTS

We would like to thank LPPM Muhammadiyah University of East Kalimantan for supporting the funding of this research through internal research grants in SK number 085/KEP/SKT/A.2/C/2023.

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