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PETROLOGICAL AND PETROGRAPHIC CHARACTERISTICS OF BUTON ROCK ASPHALT (ASBUTON) TRAP ROCK IN THE WINNING AREA OF BUTON REGENCY

KARAKTERISTIK PETROLOGI DAN PETROGRAFI BATUAN PERANGKAP ASPAL BATU BUTON (ASBUTON) DI DAERAH WINNING KABUPATEN BUTON

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Abstract

This study aims to identify the petrological and petrographical characteristics of carbonate rocks that act as natural asphalt (Asbuton) reservoir rocks in the Winning area, Buton Regency. The analysis was conducted through megascopic observation of rock outcrops and microscopic observation of thin sections using a polarizing microscope. The results show that the carbonate rock units in the study area are dominated by bioclastic limestone (biomicrite) and dolomitic limestone (biogenic dolomite). The bioclastic limestone consists of foraminiferal and shell fragments bound by micrite and sparry calcite cement, whereas the dolomitic limestone displays fine- to medium-crystalline textures with well-developed intercrystalline porosity formed through dolomitization. Partial to advanced dolomitization occurred due to the circulation of magnesium-rich fluids in a restricted marine environment during the post-depositional stage. The mineralogical transformation from calcite to dolomite enhanced both porosity and compactness, making these rocks potential reservoir rocks for natural asphalt accumulation. Overall, the petrological and petrographical characteristics indicate that the carbonate rocks in the Winning area underwent a complex diagenetic evolution and play a significant role in the formation and entrapment system of Buton Rock Asphalt (Asbuton).
Keywords: Petrology, Petrography, Trap Rock, Asbuton

Abstrak

Penelitian ini bertujuan untuk mengidentifikasi karakteristik petrologi dan petrografi batuan karbonat yang berperan sebagai batuan perangkap aspal alam (Asbuton) di daerah Winning, Kabupaten Buton. Analisis dilakukan melalui pengamatan megaskopis terhadap singkapan batuan dan pengamatan mikroskopis pada sayatan tipis menggunakan mikroskop polarisasi. Hasil penelitian menunjukkan bahwa satuan batuan karbonat di daerah penelitian didominasi oleh batugamping bioklastik (biomicrite) dan batugamping dolomitik (biogenic dolomite). Batugamping bioklastik tersusun oleh fragmen foraminifera dan cangkang mikrofosil yang terikat oleh mikrit dan semen karbonat (sparit), sedangkan batugamping dolomitik

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menunjukkan tekstur kristalin halus hingga sedang dengan porositas antar kristal (intercrystalline porosity) yang berkembang akibat proses dolomitisasi. Proses dolomitisasi parsial hingga lanjut terjadi akibat sirkulasi fluida kaya magnesium pada lingkungan pasca pengendapan tertutup (restricted marine environment). Perubahan mineralogi dari kalsit menjadi dolomit menyebabkan peningkatan porositas dan kekompakan batuan, menjadikannya berpotensi sebagai batuan perangkap (reservoir rock) bagi akumulasi aspal alam. Secara keseluruhan, karakter petrologi dan petrografi menunjukkan bahwa batuan karbonat di daerah Winning memiliki evolusi diagenetik yang kompleks dan berperan penting dalam sistem pembentukan serta perangkap Asbuton di Pulau Buton
Kata Kunci : Petrologi, Petrografi, Batuan Perangkap, Asbuton

1. INTRODUCTION

Buton Island is an area in Indonesia known for its potential natural resources in the form of natural asphalt called Asbuton (Buton Rock Asphalt). Asbuton's existence has long attracted attention because it is the only large-scale natural asphalt deposit in Indonesia and is one of the countries with large unconventional oil resources/tar sands/oil sands (Meyer & Attanasi, 2003) after Canada, Venezuela, the United States, and Russia (Ma et al., 2021). These deposits are composed of rocks containing solid bitumen and are formed as a result of complex natural processes, involving the migration of heavy hydrocarbons into porous sedimentary rocks (Hadiwisastra, 2009; Widarsono et al., 2023), then trapped and undergo oxidation and evaporation of light components (Meyer et al., 2007).

The Winning area in Buton Regency is a key location for Asbuton deposits with varied geological characteristics. Regionally, the study area is located in the Sampolakosa Formation, which is composed of thick-layered marl and calcarenite intercalations. (Davidson, 1991; Sikumbang et al., 1995). Previous research conducted by Saleh and Firdaus (2024) found two rock units that were the main traps for Asbuton based on the chemical composition of the rocks, namely limestone and dolomitic calcite.

Observations of lithological characteristics, both megascopically (petrology) and microscopically through thin sections (petrography), provide important information regarding the composition of the rock. Observations can identify both skeletal and non-skeletal fragments, carbonate mud (micrite) (Munnecke et al., 2023), and carbonate cement (sparite) (Folk & Schwab, 2025). These components are key indicators in determining limestone type based on rock composition, analysis of sedimentary texture, grain size uniformity (sorting), and the relationship between rock grains (packing).

This study aims to identify the petrological and petrographic characteristics of limestone units in the study area. Through macroscopic and microscopic observations of rock samples, this study is expected to determine the mineral composition, texture, and structure of the rocks that act as asphalt traps. Furthermore, this study also aims to determine the type of limestone based on petrographic observations using the Folk (1962) classification.

2. RESEARCH METHOD

The research location is geographically located at coordinates 122°52’20” East Longitude and 5°23’40” South Latitude, administratively located in Winning Village, Pasarwajo District, Buton Regency, Southeast Sulawesi Province. (Figure 1). Identification of the petrological and petrographic characteristics of Asbuton trap rocks is based on direct observations in the field to collect primary data in the form of rock samples that can represent

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each rock unit, then continued with petrographic laboratory analysis for rock observations under a polarizing microscope to identify the texture and main components of the rock and determine the type of limestone using Folk's (1962) limestone classification. Folk's (1962) classification is based on two main rock components: matrix and grains (allochem). There are four different grain types, as well as those without grains or reef-forming. The matrix material, either sparse calcite cement (greater than 10 µm) or microcrystalline cement (1-4 µm), is used as the primary classifier (Perras & Diederichs, 2011). According to Folk's classification, this system can also be applied to classify dolomite rocks, provided that the "ghosts" of the original allochems are still recognizable within the dolomite. If the dolomite was formed through replacement of a limestone, the rock name depends on whether the original carbonate grains are still identifiable or not. For instance, if the original structures such as oolites remain visible, the rock is termed oolitic dolomite; however, if these structures are no longer discernible, it is simply called medium crystalline dolomite. Furthermore, Folk suggested that very fine-grained primary dolomites should be referred to as dolomicrite (Boggs, 2009).

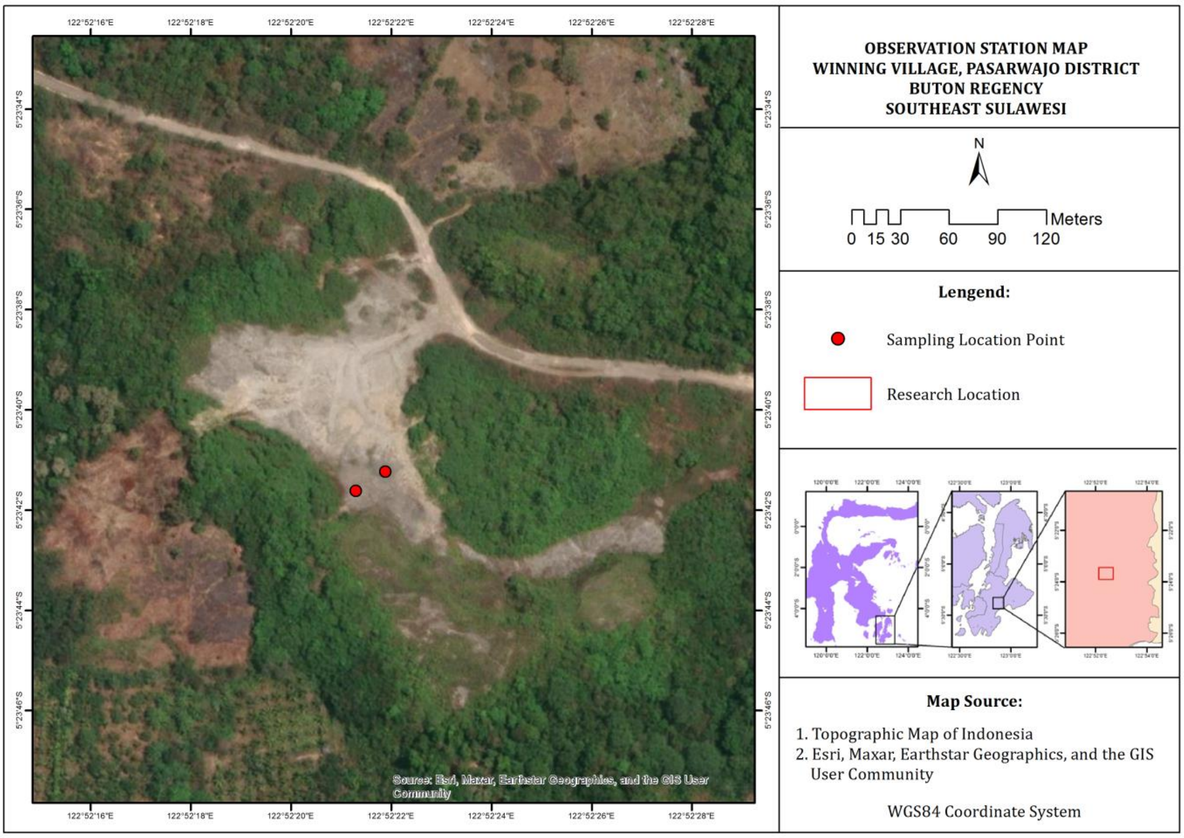

Figure 1. Research location map

3. RESULTS AND DISCUSSION

The rock samples used in this study consist of two types of limestone based on chemical content (CaO/MgO ratio), namely limestone and calcitic dolomite (Saleh & Firdaus, 2024).

1. Limestone

Based on the macroscopic appearance of the outcrop, the limestone shows a grayish-white color with a fine to medium texture and a rough and somewhat brittle surface. This rock

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has quite good compactness in its intact parts, but in some parts it appears weathered and fragmented due to physical weathering. On the surface there are visible cracks or fissures filled with thick black material, which is bitumen or natural asphalt (Asbuton) (Figure 2). This characteristic indicates that the limestone acts as a trap rock (reservoir rock) for natural asphalt materials. The layering structure is not clearly visible, the rock composition is dominated by the mineral calcite ($CaCO_3$) (Saleh & Firdaus, 2024) which is the main characteristic of limestone.

Figure 2. Outcrop of limestone rock units

Based on the petrographic appearance, it shows a relatively dense grain texture with a dominance of bioclastic fragments in the form of foraminifera and other microfossil shell fragments. The internal structure of the foraminifera is clearly visible, some displaying thin-layered walls and test chambers filled with sparry calcite or micrite (Figure 3).

The primary matrix is composed of dark gray-brown fine-grained carbonate mud (micrite) that acts as a binding agent between bioclastic fragments. Some cavities or pores between fragments are filled with carbonate cement (sparite), which exhibits high optical expansion below the XPL. There are also a few reddish-brown spots scattered within the matrix, indicating bitumen impregnation.

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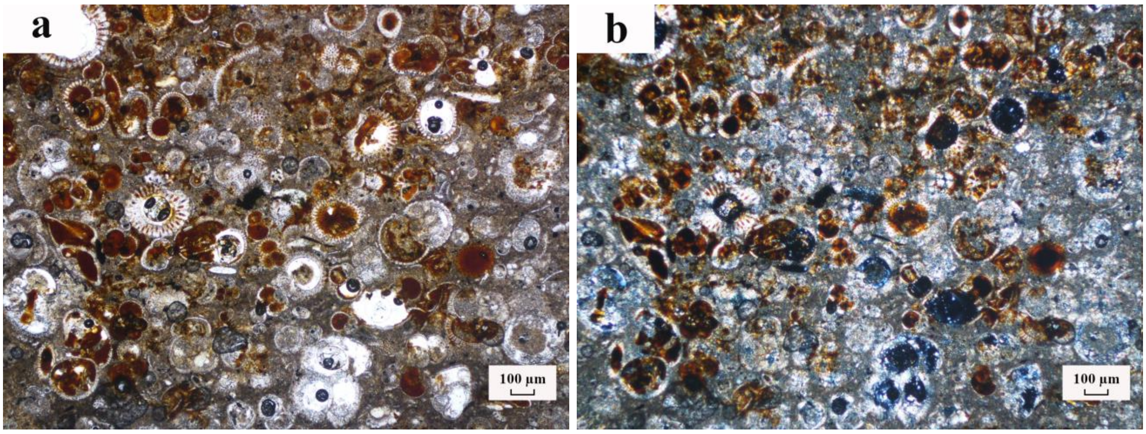

Figure 3. Photomicrographs of limestone thin sections showing microfossils allochem, micrite and spary (a) PPL; (b) XPL

Based on the type of grain (allochem), namely microfossils, and the presence of micrite that acts as a glue between the grains, this rock is classified as biomicrite. Folk (1962) further determined the rock naming based on the percentage of allochem, micite, and cement. The biomicrite sample shows a dominance of allochem (grain supported allochem). Spary calcite cement covers the grains but its presence is very limited and does not reach two-thirds of the grain. The allochem is glued together by micrite. Therefore, based on Folk's (1962) classification, the name of the sample rock is poorly washed biosparite.

2. Calsitic Dolomite

Based on the appearance of the rock outcrop, it displays a light gray to dark gray lithology with a fine to medium texture and a relatively sharp and dense fracture surface. The rock shows a massive structure without clear layers, but there are fractures and fracture planes filled with thick black material, suspected to be bitumen or natural asphalt. In some parts, variations in color from light gray to yellowish are visible, indicating changes in mineral composition due to the process of partial dolomitization. This rock is classified as calcitic dolomite, namely limestone in which some of the calcite mineral has been replaced by dolomite, thus showing harder and more compact properties than limestone. (Christie et al., 2001). The presence of bitumen in the fractures indicates that this rock serves as a reservoir in a natural asphalt system (Asbuton). In general, these outcrops reflect the results of advanced diagenetic processes in carbonate rocks that underwent partial dolomitization and were subsequently filled with solid hydrocarbon material (Figure 4).

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Figure 4. Outcrop of calcitic dolomite rock unit

Microscopic observation with cross-sectional imagery (XPL) reveals a fine to medium crystalline texture, dominated by dolomite minerals ranging in size from 0.02 to 0.1 mm. Dolomite crystals appear subhedral to euhedral in shape with a dense mosaic pattern (interlocking texture). Some crystals exhibit the rhombohedral cleavage typical of dolomite and have a low interference color (yellowish to pale gray).

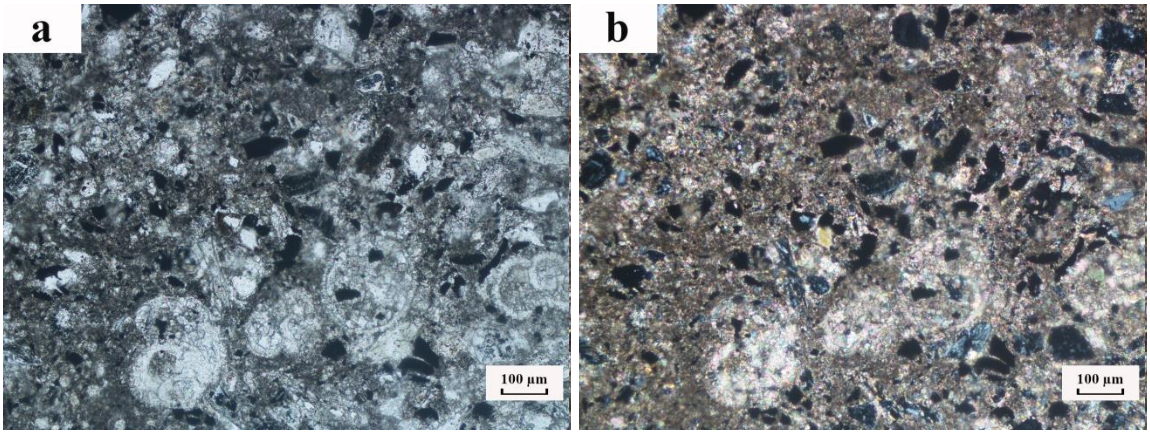

Figure 5. Photomicrographs of Calsitic Dolomite thin sections showing ghost original allochem (a) PPL; (b) XPL

Between the dolomite crystals there are non-uniform intercrystalline pores, some filled with dark material, possibly bitumen or organic residue, in accordance with the characteristics of asphalt limestone (Asbuton). Some areas show fine recrystallization zones and the presence of carbonate micrite residues in the intergranular part, indicating a partial dolomitization process of the original limestone.

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Partially replaced bioclastic fragments were found, indicating that this rock has undergone intensive recrystallization due to advanced diagenesis. The overall texture indicates non-fabric selective dolomitization, where the dolomite forms completely without changing the initial orientation of the sedimentary structure. Based on Folk's (1962) classification, this rock is called biogenic dolomite because "ghosts" of the original allochems are still identifiable in the dolomite (Boggs, 2009).

Based on petrographic observations, the carbonate rock units in the Winning area vary from biomicrite limestone to biogenic dolomite, indicating progressive dolomitization. This process was likely triggered by the circulation of magnesium-rich fluids during diagenesis, transforming calcite micrite into dolomite (Herlambang et al., 2022), it is found forming today principally in restricted regimes that differ from normal, open marine environments, usually in terms of one or more conditions of elevated salinity, temperature, and saturation state (Arvidson & Morse, 2014). The increasingly perfect development of dolomite is accompanied by a reduction in bioclastic fragments and increased dolomite crystallization, which has the potential to influence the porosity and permeability of the Asbuton trap rock.

4. CONCLUSION

Based on the results of petrological and petrographic observations of carbonate rock samples in the Winning area, Buton Regency, it is known that the constituent rock units are dominated by bioclastic limestone (biomicrite) and dolomitic limestone (biogenic dolomite) which show a close diagenetic relationship, where the bioclastic limestone undergoes a partial to advanced dolomitization process that produces a fine to medium crystalline texture with well-developed intercrystalline porosity. The dolomitization process is thought to occur due to the circulation of magnesium-rich fluids in a restricted marine environment, which replaces calcite minerals with dolomite and increases the compactness, porosity, and permeability of the rock. This condition makes the carbonate rock in the Winning area potentially a trap rock (reservoir rock) for the accumulation of natural asphalt (Asbuton). Overall, the petrological and petrographic characters indicate that the carbonate rock units in the Winning area have a complex diagenetic evolution and play an important role in the formation system and Asbuton traps, so that the results of this study can be a scientific basis for further development and exploration of the potential of Buton Stone Asphalt resources in the Buton Regency area.

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