Classification of Buton Rock Asphalt (Asbuton) Trap Rocks in Winning Village, Pasarwajo District, Buton Regency, Southeast Sulawesi Province

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January 8, 2025

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Abstract

This research is located in the IUP area of PT Wijaya Karya Bitumen, C Block Kabungka Mine, Winning Village, Pasarwajo District, Buton Regency, Southeast Sulawesi Province. The purpose of this study was to determine the classification of asbuton trap rocks based on chemical composition with XRF (X-ray fluorescence) and XRD (X-Ray Diffraction) analysis. The results of the XRF analysis showed that the asbuton trap rocks in the research area were dominated by CaO, MgO and SiO_2 elements. The CaO content varies between 24.56% to 44.46%. The SiO2 content in the samples varies, ranging from 7.81% to 12.54%. Three samples, namely TR1C-001, TR1C-002, TR1C-003 each contain MgO 0.57%, 0.85%, and 0.96%, while the other two samples, namely TR2C-001, TR2C-002 each contain MgO 14.40% and 17.51%, respectively. The results of XRD analysis showed three dominant minerals, namely Calcite ($CaCO_3$), Quartz (SiO_2) and Dolomite ($CaMg(CO_3)_2$). Based on the results of geochemical analysis (XRF and XRD) showed that the asbuton trap rock in the study area consists of 2 (two) types of carbonate rocks, namely Argillaceous Limestone and slightly calcitic dolomite.

1 Introduction

Asphalt is a black or dark brown adhesive material with bitumen as its main element. Asphalt can be classified into two types, namely natural asphalt and oil asphalt based on where it is obtained (Sukirman, 2003). Natural asphalt is asphalt that is formed naturally and can be directly utilized or through a processing process. According to (Siswosoebrotho et al., 2005)natural asphalt can be divided into 2 (two) types, namely lake asphalt found in Trinidad and rock asphalt found on Buton Island.

Buton Island is the only region in Indonesia that has natural asphalt resources in the form of rock asphalt and is known as Buton rock asphalt (asbuton) with estimated deposit reserves reaching 200 million tons with an asphalt content ranging from 10%-35% (Sukirman, 2003).

The formation of asbuton is controlled by three main things, namely source rock, trap rock, and cap rock. Source rock is sedimentary rock that contains enough organic material to form hydrocarbons. Trap rock is sedimentary rock that has good porosity and permeability to trap migrating hydrocarbons. Cap rock is sedimentary rock that has poor permeability, preventing oil and gas below the earth's surface from flowing to the surface (Hadiwisastra, 2009). If the trap rock is lifted to the surface, water washing, bacterial degradation or evaporation will occur which causes the formation of natural asphalt (Meyer et al., 2007).

Research on asbuton trap rocks is still very rarely carried out, so researchers consider it necessary to conduct research on the classification of asbuton trap rocks.

2 Regional Geology

Buton Island is composed of rock units from Mesozoic to Quaternary. The northern tip of Buton Island is found to have widespread Pre-Tertiary rock distribution and in the southern part of Buton Island around the Mukito river. While in the southern and central parts of Buton Island are dominated by reef limestone units (Hadiwisastra, 2009).

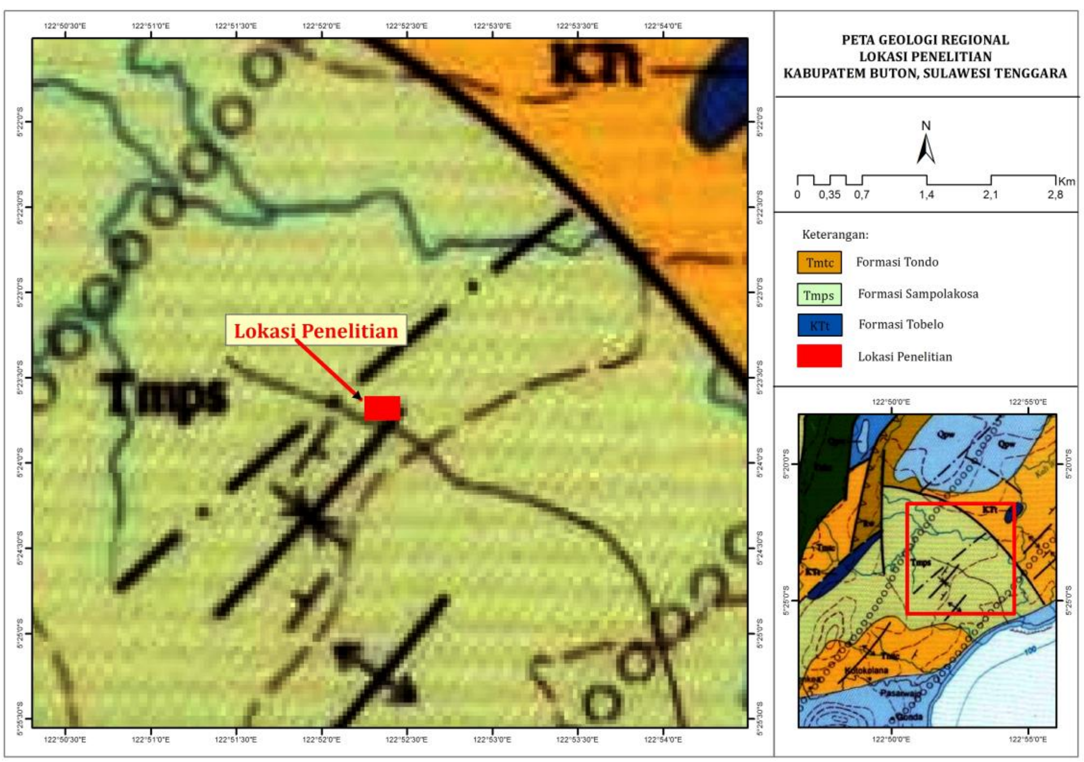

Figure 1: Regional geological map of the Buton sheet modified from **(Sikumbang et al., 1995)**

Based on the regional geological map of the Buton sheet, the sequence of rock formations on Buton Island from old to young is the Mukito Formation (PRm) estimated to be pre-Triassic, the Doole Formation (Rd) estimated to be Triassic to Jurassic, the Winto Formation (Rw) Upper Triassic, the Ogena Formation (Jo), the Rumu Formation (Jr) Late Jurassic, the Tobelo Formation (KTt) Cretaceous, Basalt (Ba), Diorite (Di) estimated to be Eocene, the Kapantoreh Ultrabasic Complex (Tukc), the Tondo Formation Limestone Member (Tmtl) Early Miocene, the Tondo Formation (Tmtc) Middle Miocene to Late Miocene, the Sampolakosa Formation (Tmps) Upper Miocene-Early Pliocene and the Wapulaka Formation (Qpw) (Sikumbang et al., 1995).

The research location is in the Sampolakosa Formation (Tmps) (Figure 1) which is located in harmony above the Tondo Formation (Tmtc). The Sampolakosa Formation (Tmps) is composed of marl, calcarenite, and pinnacle reefs and all of its lithologies are rich in foraminifera and locally molluscs and reef fragments are found. The thickness of the formation ranges from 30 meters to more than 1,000 meters (Davidson, 1991).

3 Research Methods

Administratively, the research location is in Winning Village, Pasarwajo District, Buton Regency, Southeast Sulawesi Province and is the Mining Business Permit (IUP) area of PT Wijaya Karya Bitumen, precisely in the C Block Kabungka Mine.

The procedure in the research is a systematically arranged stage that covers all research activities, from the stage to the completion of the research. The initial stage of the research includes the preparation stage before collecting field data which includes administration, data collection equipment and literature studies regarding the research location.

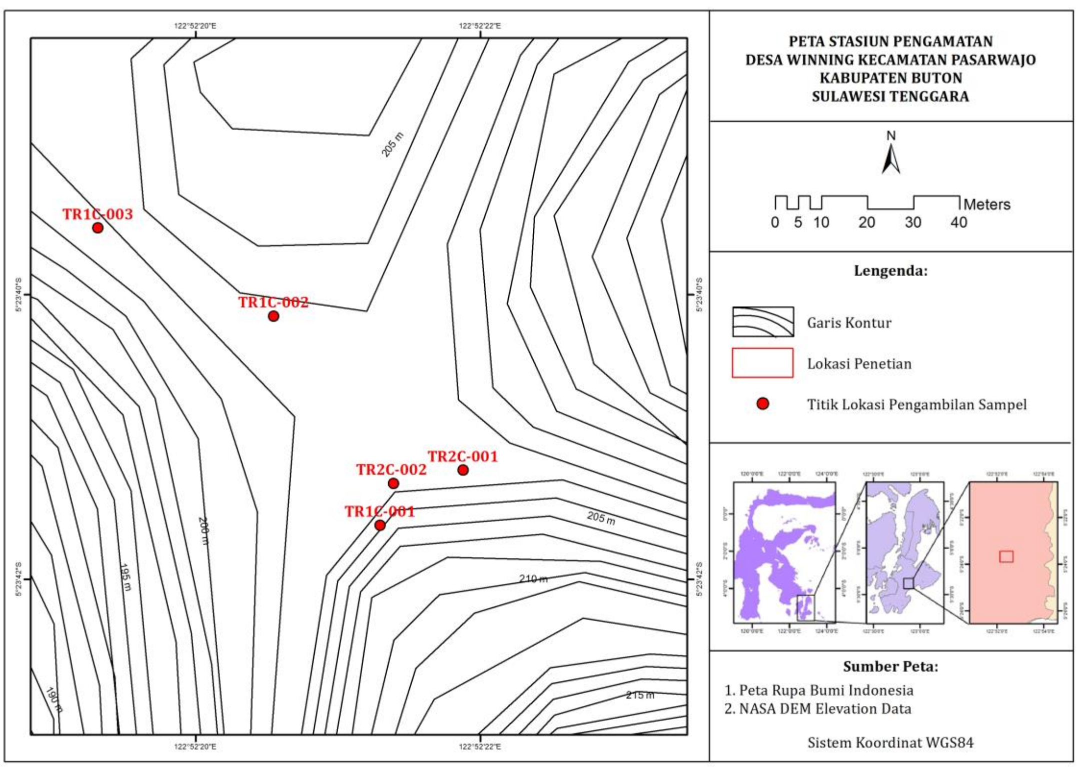

Figure 2: Observation Station Map

The second stage is to collect and take primary and secondary data. Primary data is data obtained directly from field data collection in the form of rock samples consisting of 5 (five) samples of asbuton trap rocks with labels TR1C-001, TR1C-002, TR1C-003, TR2C-001, and TR2C-002 (Figure 2); sample coordinate points; sample photos; and megascopic lithology descriptions. Secondary data used in this study is a regional geological map of the research area.

The third stage is the secondary data processing and analysis stage. Primary data processing is carried out using XRF (X-ray fluorescence) analysis to determine the major elements (Thomas & Haukka, 1978) and XRD (X-Ray Diffraction) analysis to determine the most dominant mineral content in rocks (Cai et al., 2024). XRF analysis was carried out at the PT Intertek Utama Services laboratory, East Jakarta. XRD analysis was carried out at the Mineral Analysis and Processing Laboratory, Faculty of Engineering, Hasanuddin University, Gowa Regency. Based on the results of XRF and XRD analysis, the classification of rock types can be determined based on the chemical composition of the rock.

4 Results and Discussion

4.1 Outcrop Analysis

Megascopically, the asbuton trap rock at the research location consists of two types of rocks. The first type of trap rock has a grayish white color, is silt-grained and has blackish spots throughout the rock body which indicates the presence of asphalt content that fills the pores of the rock (Figure 3). This rock is the main asbuton trap rock.

Figure 3: Outcrop of grayish white asbuton trap rock

The second type of asbuton trap rock has a dark gray color, is not granular, very compact and contains asphalt that fills the cracks in the rock (Figure 4). The asphalt contained in this trap rock does not mix with the trap rock because the trap rock is very compact so that very little asphalt can fill the pores of the rock and most of the asphalt only fills the cracks in the rock.

Figure 4: Dark grey asbuton trap rock outcrop

4.2 Geochemical Analysis

The chemical composition of trap rock is based on the composition of the major elements of trap rock. Major elements are obtained from the results of XRF analysis of trap rock samples. The composition of major elements from the results of XRF analysis of trap rock samples is shown in Table 1.

Elements (%)	Number of Sample				
	TR1C-001	TR1C-002	TR1C-003	TR2C-001	TR2C-002
Al_2O_3	2,27	2,44	3,49	3,24	1,02
CaO	44,46	42,09	39,96	24,56	31,42
Cr_2O_3	<0,01	<0,01	<0,01	0,06	0,01
Fe_2O_3	0,92	1,10	1,53	2,69	0,63
K_2O	0,35	0,38	0,51	0,43	0,14
MgO	0,57	0,85	0,96	14,40	17,51
MnO	0,03	0,02	0,02	0,05	0,03
Na_2O	0,13	0,14	0,20	0,33	0,15
P_2O_5	0,066	0,083	0,100	0,040	0,026
SiO_2	7,81	8,49	12,54	17,55	4,59
TiO_2	0,13	0,11	0,17	0,21	0,08
S	0,415	0,473	0,491	0,880	0,301
Total	NA	NA	NA	NA	99,9
LOI	40,75	41,02	37,20	33,44	43,98

Table 1: Major element composition of trap rock

Table 1 shows the results of chemical analysis of five (5) trap rock samples. The CaO content varies between 24.56% to 44.46% due to the calcite mineral content in the trap rock samples. The SiO_2 content in the samples varies, ranging from 7.81% to 12.54%. Table 1 also shows significant differences in MgO content. Three samples, namely TR1C-001, TR1C-002, TR1C-003, each contain 0.57%, 0.85%, and 0.96% MgO, while the other two samples, namely TR2C-001, TR2C-002, each contain 14.40% and 17.51% MgO. The MgO content is generally supplied by dolomite minerals ($CaMg(CO_3)_2$).

CaO shows a very strong negative correlation with SiO_2 as indicated by the correlation coefficient value (r) = -0.95314 (Figure 5). The negative correlation between CaO (derived from calcite mineral) and SiO2 (derived from quartz) (Figure 7) indicates that CaO and SiO_2 originate from two different unrelated mineral phases.

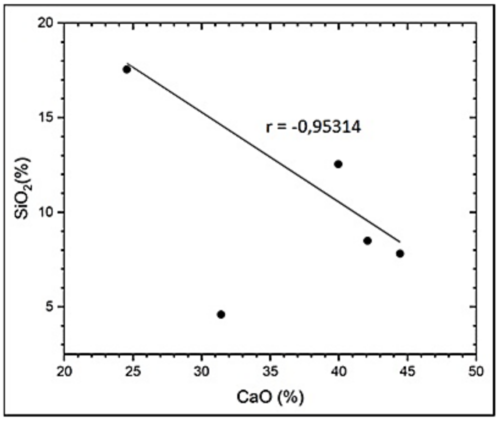

Figure 5: Correlation between CaO and SiO_2

The CaO content in the trap rock samples showed a very strong positive correlation with the LOI as indicated by the correlation coefficient value (r) = 0.9354 (Figure 6) because the LOI mostly comes from the carbonate mineral content.

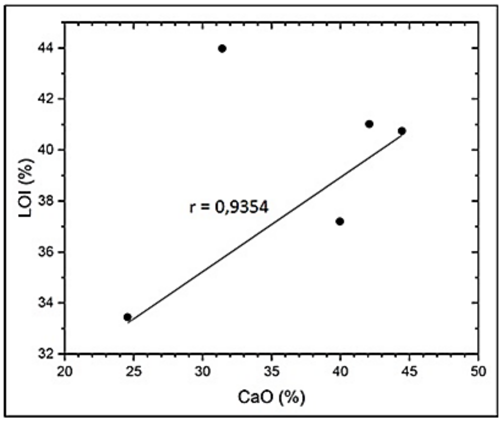

Figure 6: Correlation between CaO and LOI

4.3 Classification of Asbuton Trap Rocks

The classification of carbonate rocks based on the CaO/MgO ratio was first made by S.G. Vishnyakov (1933, in (Chilingar, 1960). Vishnyakov (1933) classified limestone and dolomite into six types, namely:

1. Limestone (ratio CaO/MgO = 50,1-~)
2. Slightly dolomitic limestone (ratio CaO/MgO = 9,1-50,1)

3. Dolomitic limestone (ratio CaO/MgO = 4,0-9,1)
4. Calcitic dolomite (ratio CaO/MgO = 2,2-4,0)
5. Slightly calcitic dolomite (ratio CaO/MgO = 1,5-2,2)
6. Dolomite (ratio CaO/MgO = 1,4-1,5)

Based on Vishnyakov's classification, the five trap rock samples obtained three types of rocks, namely limestone, slightly dolomitic limestone and slightly calcitic dolomite. The classification of the five trap rock samples can be seen in Table 2.

Nomor Sampel	CaO (%)	MgO (%)	CaO/MgO	Jenis Batuan
TR1C-001	44,46	0,57	78,00	*Limestone*
TR1C-002	42,09	0,85	49,52	*Slightly dolomitic limestone*
TR1C-003	39,96	0,96	41,63	*Slightly dolomitic limestone*
TR2C-001	24,56	14,40	1,71	*Slightly calcitic dolomite*
TR2C-002	31,42	17,51	1,79	*Slightly calcitic dolomite*

Table 2: Classification of trap rocks based on the CaO/MgO ratio

Sample TR1C-001 has a content of CaO=44.46% and MgO=0.57%, so, the ratio between CaO/MgO = 44.46%/0.57% = 78.00, so sample TR1C-001 is included in the limestone rock type.

Sample TR1C-002 has a content of CaO=42.09% and MgO=0.85%, so, the ratio between CaO/MgO = 42.09%/0.85% = 49.52, so sample TR1C-002 is included in the slightly dolomitic limestone rock type or limestone containing a little dolomite.

Sample TR1C-003 has a content of CaO = 39.96% and MgO = 0.96%, so, the ratio between CaO / MgO = 39.96% / 0.96% = 41.63, so sample TR1C-003 is a type of slightly dolomitic limestone or limestone containing a little dolomite. Sample TR2C-001 has a content of CaO = 24.56% and MgO = 14.40%, so, the ratio between CaO / MgO = 24.56% / 14.40% = 1.71, so sample TR2C-001 is a type of slightly calcitic dolomite or dolomite rock containing a little calcite.

Sample TR2C-002 has a content of CaO = 31.42% and MgO = 17.51%, so, the ratio between CaO / MgO = 31.42% / 17.51% = 1.79, so sample TR2C-001 is a slightly calcitic dolomite rock type or dolomite rock containing little calcite.

In general, the five samples can be grouped into two types of rocks, namely limestone and dolomite. Samples TR1C-001, TR1C-002, and TR1C-003 are included in the limestone rock type. While samples TR2C-001 and TR2C-002 are included in the dolomite rock type.

The results of the XRD analysis show that the carbonate mineral content in the limestone sample, namely CaCO3, is 76.6% to 79.7% (Figure 7).

So based on Pettijohn's classification, the limestone sample is included in the Argillaceous Limestone type (Figure 8).

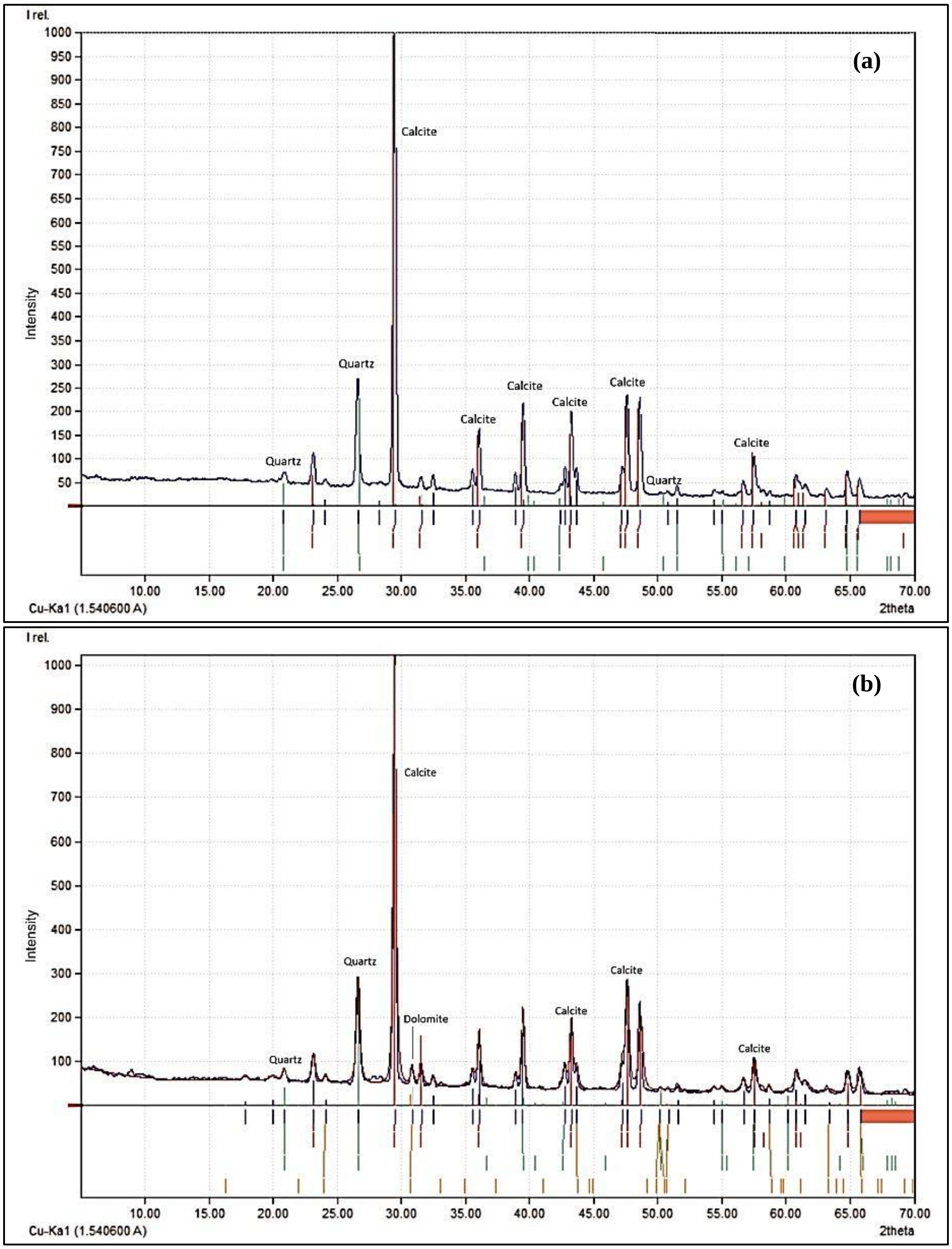

Figure 7: XRD analysis results of samples (a) TR1C-001: $CaCO3$ = 79.7, $SiO2$ = 20.3%; (b) TR1C-003: $CaCO3$ = 76.6%, $SiO2$ = 19.3%, $CaMg(CO3)2$ = 4.1%

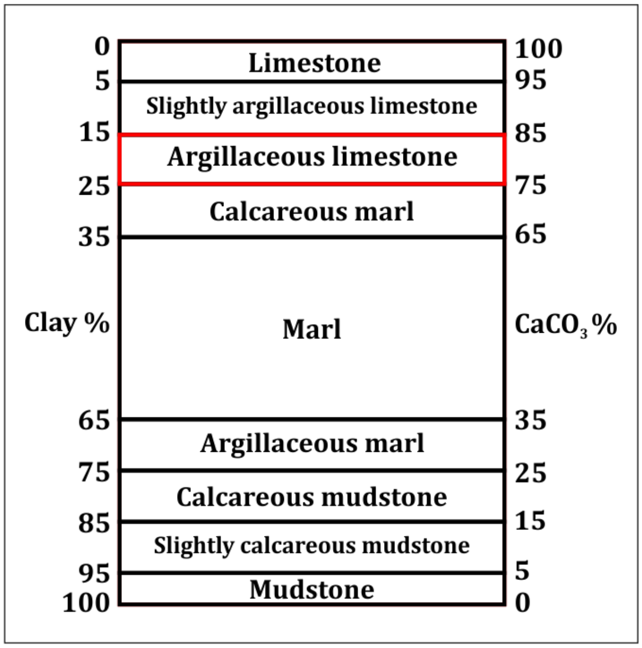

Figure 8: Classification of limestone samples based on the scheme of Pettijohn (1957) in **(Jamshidi & Sedaghatnia, 2023)** which is shown by the red box.

5 Conclusions

Based on the results of geochemical analysis (XRF and XRD), it shows that the asbuton trap rock in the research area consists of 2 (two) types of carbonate rock, namely Argillaceous Limestone with a $CaCO_3$ content of 76.6% to 79.7% and slightly calcitic dolomite.

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