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Geology and Geochemical Characteristics of Residual Soil From Tuff as Raw Material for Industry in Paccarammengan Area, Ujung Loe District, Bulukumba Regency, South Sulawesi Province

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ABSTRACTS

The research area is administratively included in the Paccarammangan Area, Ujung Loe District, Bulukumba Regency, South Sulawesi Province. The purpose of this study was to conduct a study of the geochemical characteristics of rocks and residual soil from tuff in order to obtain geology regarding the characteristics of rocks and residual soil information from tuff and its use as industrial raw materials. This study was conducted using geological surface mapping methods and laboratory analysis in the form of petrographic analysis and X-Ray Fluorescence (XRF) on 4 rock samples at stations 8, 15, 16, and 48. From the results of petrographic analysis, tuff in the Walanae Formation mostly comes from intermediate-ultrabasic magma series based on its mineral composition. From the results of geochemical analysis, tuff in the Walanae Formation has a positive and negative correlation to SiO_2 and the nature of its magma is intermediate-ultrabasic. Based on the naming of rocks, station 8 has a trachy basalt composition, stations 15, 16 have a basaltic andesite composition, and station 48 has a basanite composition. The use of the remaining tuff soil in the research area is suitable for use as bricks, roof tiles and fine pottery.

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INTRODUCTION

The geology of Indonesia, especially Sulawesi Island, is very complex. To find out the geological conditions of an area that is not entirely as described in theory, field work is needed that includes surface geological mapping by collecting lithology, geomorphology, and other geological structure data. Geologists have done a lot of geological mapping in Sulawesi. However, some studies are still general with a regional scale. There is a need for more detailed and local surface geological mapping to accurately determine the geological conditions of an area. Surface geological mapping is a work of reconstructing geological conditions. This mapping will produce geological information as a start in knowing the geological conditions of an area, both regarding the availability of mineral resources, energy and potential disasters in an area. This surface geological mapping is very necessary to determine the geological conditions of the research area.

This study was conducted in the Paccarammengan Area, Ujung Loe District, Bulukumba Regency, South Sulawesi and is included in the scale of 1: 250.000 in the Regional Geology of Ujung Pandang, Benteng, and Sinjai Sheets, according to Sukamto, R. and Supriatna, S. (1982). The research area consists of three formations, namely the Walanae Formation, the Selayar Member of the Walanae Formation, and the Lompobattang Volcanic Formation. Pyroclastic rocks composed of the consolidation of volcanic materials from the eruption took place. The destruction of the bedrock was ejected by volcanic activity to form pyroclastic deposits. The research area is indicated to contain quite extensive tuff deposits, making this area have the potential for residual soil mining resources from tuff that can be used as industrial raw materials. The variety of residual soil from tuff in the research area, the author conducted surface geological mapping and also conducted analysis to determine the nature of magma from the formation of tuff rocks and its genesis with petrographic and geochemical analysis along with the allocation of residual soil from tuff as industrial raw materials.

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

METHODS

Preparation

The preparation stage is carried out before field research, consisting of: Administrative management, including making research proposals to obtain legal research permits, Literature study, aims to find out the geological conditions of the research area from literature or scientific writings containing the results of previous research, and Preparation of field equipment, including procurement of base maps, preparation of field equipment and work plans.

Data Retrieval

Field data collection is recorded in a field book. The sequence of data retrieval is as follows: Determination of observation points on a 1:25,000 base map, Observation of outcrop conditions and their relationship to surrounding rocks, Taking documentation in the form of sketches and photos, Rock sampling for laboratory analysism Observations of the physical properties of rocks include: color, rock texture, rock structure and mineral composition, and Field checks need to be carried out to evaluate the results of detailed mapping research and to complete data that is considered lacking.

Data Processing

Data processing includes preparation of thin section samples and Geochemical testing of rocks and residual soil from tuff using the X-Ray Fluorescence (XRF) method.

Data Analysis

Petrology Analysis

Petrological analysis is carried out to determine the description of rocks and their names megascopically.

Petrography Analysis

Petrographic analysis is carried out to see in detail the microscopic appearance of rocks in thin sections measuring 0.03 mm for each rock, including: type, texture, rock structure, mineral size, composition and percentage of minerals that make up the rock, so that it can determine the naming of rocks petrographically.

Geochemical Analysis

Geochemical analysis was conducted to determine the geochemical characteristics including magma evolution, magma type, geochemical rock naming, and the designation of residual soil from tuff using the augustinic method using the Geochemical Data Toolkit GCDkit ver 3.00 software.

Journal Preparation

The results of field research and data processing are then compiled in the form of a journal.

RESULTS AND DISCUSSION

Petrology

Tuff in the research area consists of Walanae Formation tuff in the research area. Sampling was carried out at several points in the Paccarammengan Area. For the Walanae Formation, 4 rock sample points were taken, namely in the fine tuff unit at stations 8, 15, 16, and 48. The naming of tuff rocks in the field is based on the classification of pyroclastic rocks according to Fisher (1966) by considering the characteristics of the rocks. The tuff at station 8 is fresh yellowish brown, and weathered is blackish gray. The texture has an angular-subangular grain shape, fine ash material size (<0.06 mm), non-layered structure. Based on its physical characteristics, the name of this rock is fine tuff (Fisher, 1966). Contains biotite minerals (Figure 1).

Figure 1. Fine tuff outcrop at station 8 exposed in Kupang area with photo direction N 286˚ E

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

The tuff at station 15 is fresh yellowish brown, and weathered is blackish gray. The texture has an angular-subangular grain shape, fine ash material size (<0.06 mm), layered structure with a rock layer thickness of 5-10 cm. Based on its physical characteristics, the name of this rock is fine tuff (Fisher, 1966). Contains quartz and biotite minerals (Figure 2).

Figure 2. Fine tuff outcrop at station 15 exposed in the Salo Bembe area with photo direction N 292˚ E

The tuff at station 16 is fresh brown, and weathered blackish brown. The texture has an angular-subangular grain shape, fine ash material size (<0.06 mm), layered structure with a rock layer thickness of 8-10 cm. Based on its physical characteristics, the name of this rock is fine tuff (Fisher, 1966). Contains quartz minerals (Figure 3).

Figure 3. Fine tuff outcrop at station 16 exposed in Tamapalalo Area with photo direction N 194˚ E

Figure 4. Fine tuff outcrop at station 48 exposed in Badoah Area with photo direction N 260˚ E

Tuff at station 48 is fresh brownish gray, and weathered gray. The texture is in the form of angular-subangular grains, the size of the ash material is fine (<0.06 mm), the structure is layered with a rock layer thickness of 2-10 cm. Based on its physical characteristics, the name of this rock is fine tuff (Fisher, 1966). Contains quartz and olivine minerals (Figure 4).

Petrography

Microscopic appearance of petrographic observation with section number ST.8 shows brownish yellow absorption color, blackish yellow interference color, subhedral-anhedral mineral shape. Mineral size ± 0.02 mm - 0.9 mm. Mineral composition consists of clinopyroxene (10%), biotite (10%), rock fragments (10%), and volcanic glass (70%). Based on the optical properties and mineral composition, the name of the rock at station 8 is vitric tuff (Pettijohn, 1975) (Figure 5).

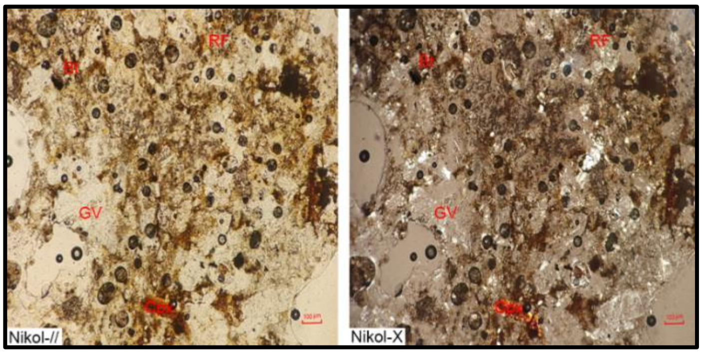

Figure 5. Petrographic appearance of vitric tuff in section ST 8, showing composition of biotite (Bt), clinopyroxene (Cpx), rock fragments (RF), and volcanic glass (GV).

Microscopic appearance of thin section petrographic observation with section number ST. 15 shows yellow-brown absorption color, blackish gray interference color, subhedral-anhedral mineral shape. Mineral size ± 0.02 mm - 0.8 mm. Mineral composition consists of quartz (5%), biotite (5%), rock fragments (30%) and volcanic glass (60%). Based on the optical properties and mineral composition, the name of the rock at station 15 is vitric tuff (Pettijohn, 1975) (Figure 6).

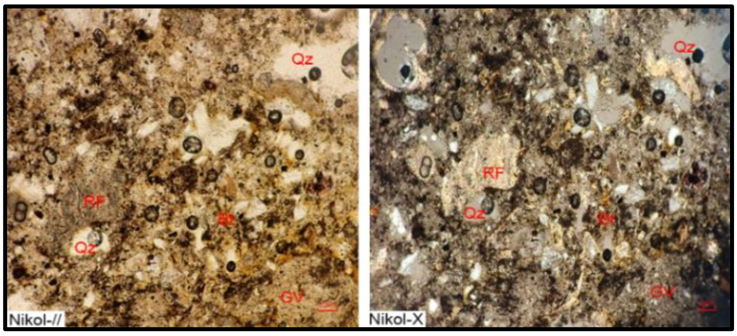

Figure 6. Petrographic appearance of vitric tuff in section ST 15, showing composition of quartz (Qz), biotite (Bt), rock fragment (RF), and volcanic glass (GV)

Microscopic appearance of petrographic observation with section number ST. 16 shows brownish yellow absorption color, blackish gray interference color, subhedral-anhedral mineral shape. Mineral size ± 0.02 mm - 0.9 mm. Mineral composition consists of quartz (5%), biotite (10%), opaque minerals (15%), iron oxide (10%), and volcanic glass (60%). Based on the optical properties and mineral composition, the name of the rock at station 16 is vitric crystal tuff (Pettijohn, 1975) (Figure 7).

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

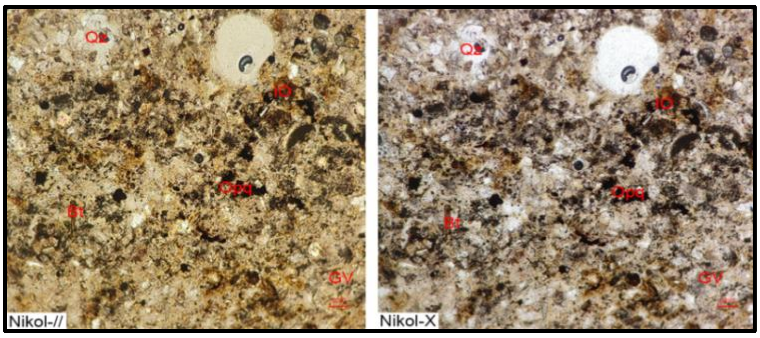

Figure 7. Petrographic appearance of vitric crystal tuff in section ST 16, showing composition of quartz (Qz), biotite (Bt), iron oxide (IO), opaque minerals (Opq), and volcanic glass (GV).

Microscopic appearance of petrographic observation of thin section with section number ST.48 shows brownish yellow absorption color, blackish gray interference color, subhedral-anhedral mineral shape. Mineral size ± 0.02 mm - 0.8 mm. Mineral composition consists of quartz (10%), olivine (10%), opaque minerals (5%), clinopyroxene (15%), and volcanic glass (60%). Based on the optical properties and mineral composition, the name of the rock at station 48 is vitric crystal tuff (Pettijohn, 1975) (Figure 8).

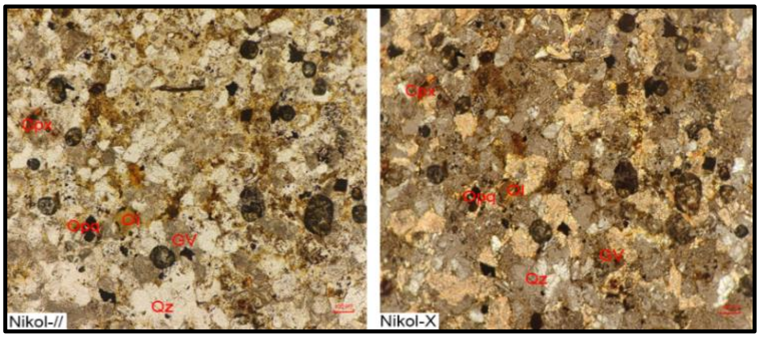

Figure 8. Petrographic appearance of vitric crystal tuff in section ST 48, showing composition of olivine (Ol), clinopyroxene (Cpx), quartz (Qz), opaque minerals (Opq), and volcanic glass (GV)

Geochemistry

Table 1. Summary of mineral constituents of rocks based on petrography

Station	Konstituent Minerals								Formation
	RF	Ol	Cpx	Bt	IO	Opq	Qz	GV	
8	10%	-	10%	10%	-	-	-	70%	Walanae
15	30%	-	-	5%	-	-	5%	60%	
16	-	-	-	10%	10%	15%	5%	60%	
48	-	10%	15%	-	-	5%	10%	60%	

From the results of petrographic analysis, the tuff in the Walanae Formation contains clinopyroxene, olivine, and biotite minerals so that this tuff mostly comes from intermediate-ultrabasic magma series. The texture of the lightly compacted-tuff fracture, volcanic ash that is extensively transformed into clay minerals that are sensitive to thermal conditions and geochemical environments. Geochemical analysis was carried out to determine the components in the rocks. Pyroclastic rocks are assumed to have the same chemical properties and composition as the magma as the origin of their formation. For this reason, chemical analysis is needed on rocks in the research area. This chemical

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

analysis was carried out in the laboratory of PT. Jasa Mutu Mineral Indonesia, Kendari. The results of chemical analysis on rock samples can be seen in Table 2 which has been completed.

Table 2. XRF Test Results

No.	Element	Formation Walanae			
		ST. 48	ST. 8	ST. 15	ST. 16
1	SiO_2	41.54	50.38	55.03	55.89
2	K_2O	2.56	2.86	2.75	2.75
3	$Al_2O_{.3}$	16.82	18.30	21.89	21.24
4	Fe_2O_3	4.11	7.38	7.81	6.92
5	CaO	13.46	5.31	2.63	2.75
6	TiO_2	0.84	0.97	1.07	0.82
7	MgO	1.54	1.90	1.71	1.8
8	Na_2O	2.01	2.65	0.23	0.19
9	MnO	0.08	0.07	0.11	0.16
10	P_2O_5	1.32	1.35	0.22	0.23

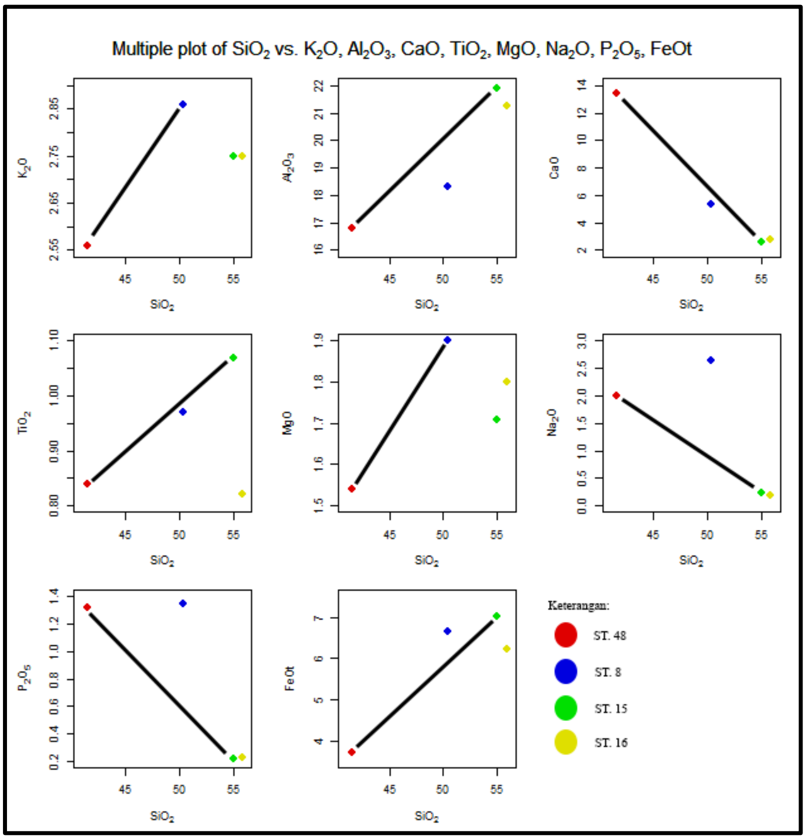

Figure 9. Plot the major element content against SiO_2 on a variation diagram (Harker, 1909 in Rollinson, 1993)

In determining the evolution of magma, it can be seen in the diagram of variations in the content of major elements (oxides) to the SiO_2 compound (Harker, 1909 in Rollinson, 1993). This diagram will display a positive or negative correlation of the content of major element oxides to SiO_2. From the results of plotting major elements on the Harker diagram, it shows a negative correlation in the compounds MgO, P_2O_5, CaO to SiO_2 which is indicated by a decrease in the content of oxide compounds when SiO_2 compounds are added, while for the positive correlation in the compounds Al_2O_3, CaO, Na_2O,

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

FeO, and TiO_2 to SiO_2 which is indicated by an increase in the content of oxide compounds when SiO_2 compounds are added (Figure 9). A positive correlation indicates that the element has undergone enrichment and has not undergone a fractional crystallization process and is still in the magma solution, while a negative correlation indicates that the element or compound has undergone a fractional crystallization process which causes the compound or element to no longer be in solution and undergoes a crystallization process to form minerals.

Classification of magma types is seen from the amount of SiO_2 content in the constituent rocks. Based on this classification, the SiO_2 content in the constituent rocks of the research area ranges from 41.54 wt% - 55.89 wt% (Table 3), so the type of magma from this rock is intermediate-ultrabasic magma (Le Maitre et al., 1989 in Rollinson, 1993).

Table 3. Classification of magma based on SiO_2 content (%) or acidity level (Le Maitre et al., 1989 in Rollinson, 1993).

Rock Name	Silica Content
Acid rock	> 63%
Intermediate rock	52-63%
Alkaline rock	45-52%
Ultrabasic rock	< 45%

The diagram used to determine the naming of rocks is the Total Alkali Silica diagram by Le Bas et al in 1986 (Figure 10).

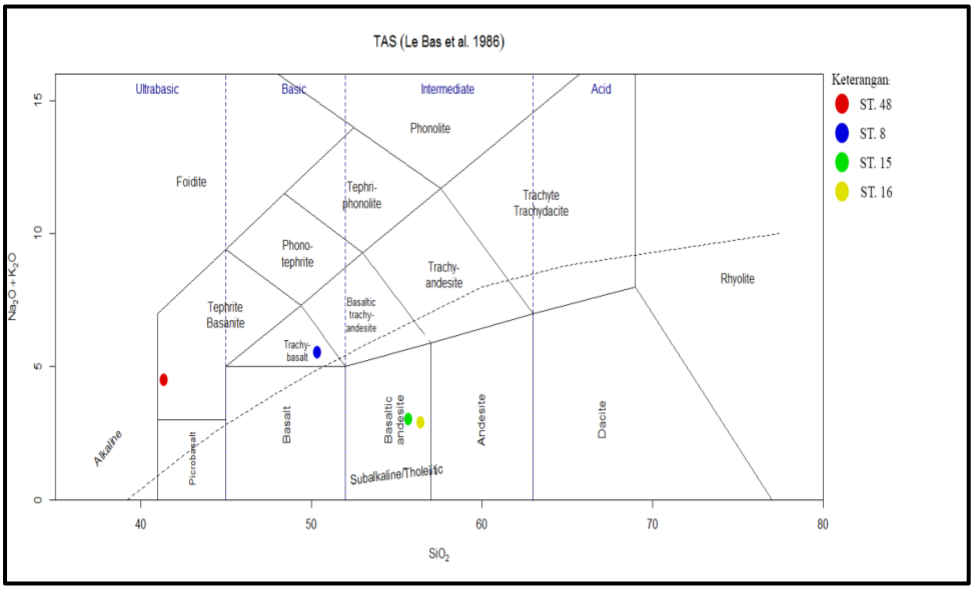

Figure 10. Total Alkali Silica (TAS; Le Bas et al, 1986) diagram for the classification of volcanic rocks

The results of the analysis using the Total Alkali Silica diagram (Le Bas et al, 1986) show that the Walanae Formation tuff at station 8 has a trachy basalt composition, stations 15 and 16 have a basaltic andesite composition, and station 48 has a basanite composition.

The results of geochemical analysis at stations 8, 15, 16, and 48 for oxide elements are as follows:

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

Table 4. XRF test results of oxide elements

Sample Name	Chemical Composition of Elements (%)													
	SiO_2	K_2O	Al_2O_3	Fe_2O_3	CaO	TiO_2	MgO	Na_2O	LOI	$CaCO_3$	MnO	P_2O_5	SO_3	Cr_2O_3
ST. 8	50.38	2.86	18.3	7.38	5.31	0.97	1.9	2.65	8.12	9.48	0.07	1.35	0.02	0.01
ST. 15	55.03	2.75	21.89	7.81	2.63	1.07	1.71	0.23	6.23	4.69	0.11	0.22	0.05	0.02
ST. 16	55.89	2.75	21.24	6.92	2.75	0.82	1.8	0.19	6.41	4.91	0.16	0.23	0.18	0.03
ST. 48	41.54	2.56	16.82	4.11	13.46	0.84	1.54	2.01	11.89	24.02	0.08	1.32	0.1	0.03

To determine the use of residual soil mining materials from tuff in the research area for industrial use, calculations were carried out using the Augustinic Method.

Table 5. The results of the calculation of the Augustinian method of sample ST. 8

Chemical Elements	% Cumulative	Molecular Weight g/mol	Grol
SiO_2	46.31	60.8	0.7616
K_2O	2.63	94.2	0.0279
Al_2O_3	16.82	101.96	0.1650
Fe_2O_3	6.78	159.69	0.0425
CaO	4.88	56.08	0.0870
TiO_2	0.89	79.87	0.0112
MgO	1.75	40.3	0.0433
Na_2O	2.44	61.98	0.0393
LOI	7.46	0	0
$CaCO_3$	8.71	100.08	0.0871
MnO	0.06	70.93	0.0009
P_2O_5	1.24	283.88	0.0044
SO_3	0.02	80.06	0.0002

R_2O = grol Na_2O + grol K_2O = 0.0683
RO = grol Fe_2O_3 + grol MgO + grol CaO = 0.1728
Ordinal value = Al_2O_3/SiO_2 = 0.2
Abscissa value = R_2O + RO = 0.2411 = 0.2

Table 6. The results of the calculation of the Augustinian method of sample ST. 15

Chemical Elements	% Cumulative	Molecular Weight g/mol	Grol
SiO_2	52.69	60.8	0.8666
K_2O	2.63	94.2	0.0280
Al_2O_3	20.96	101.96	0.2056
Fe_2O_3	7.48	159.69	0.0468
CaO	2.52	56.08	0.0449
TiO_2	1.02	79.87	0.0128
MgO	1.64	40.3	0.0406
Na_2O	0.22	61.98	0.0036
LOI	5.97	0	0
$CaCO_3$	4.49	100.08	0.0449
MnO	0.11	70.93	0.0015
P_2O_5	0.21	283.88	0.0007
SO_3	0.05	80.06	0.0006

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

R_2O = grol Na_2O + grol K_2O = 0.0316
RO = grol Fe_2O_3 + grol MgO + grol CaO = 0.1323
Ordinal value = Al_2O_3/SiO_2 = 0.2
Abscissa value = R_2O + RO = 0.1639 = 0.1

Table 7. The results of the calculation of the Augustinian method of sample ST. 16

Chemical Elements	% Cumulative	Molecular Weight g/mol	Grol
SiO_2	53.60	60.8	0.8815
K_2O	2.64	94.2	0.0280
Al_2O_3	20.37	101.96	0.1998
Fe_2O_3	6.64	159.69	0.0416
CaO	2.64	56.08	0.0470
TiO_2	0.79	79.87	0.0098
MgO	1.73	40.3	0.0428
Na_2O	0.18	61.98	0.0029
LOI	6.15	0	0
$CaCO_3$	4.71	100.08	0.0470
MnO	0.15	70.93	0.0022
P_2O_5	0.22	283.88	0.0008
SO_3	0.17	80.06	0.0022

R_2O = grol Na_2O + grol K_2O = 0.0309
RO = grol Fe_2O_3 + grol MgO + grol CaO = 0.1314
Ordinal value = Al_2O_3/SiO_2 = 0.2
Abscissa value = R_2O + RO= 0.1623 = 0.1

Table 8. The results of the calculation of the Augustinian method of sample ST. 48

Chemical Elements	% Cumulative	Molecular Weight g/mol	Grol
SiO_2	34.52	60.8	0.5678
K_2O	2.13	94.2	0.0226
Al_2O_3	13.98	101.96	0.1371
Fe_2O_3	3.42	159.69	0.0214
CaO	11.19	56.08	0.1995
TiO_2	0.70	79.87	0.0087
MgO	1.28	40.3	0.0318
Na_2O	1.67	61.98	0.0270
LOI	9.88	0	0
$CaCO_3$	19.96	100.08	0.1995
MnO	0.07	70.93	0.0009
P_2O_5	1.10	283.88	0.0039
SO_3	0.08	80.06	0.0010

R_2O = grol Na_2O + grol K_2O = 0.0495
RO = grol Fe_2O_3 + grol MgO + grol CaO = 0.2527
OrdinaL value = Al_2O_3/SiO_2 = 0.1
Abscissa value = R_2O + RO= 0.3022 = 0.3

Journal of Geology & Exploration
Vol. 4, No. 1, June 2025 : 23 – 33
E-ISSN 2963-2869

After that, it was plotted into an Augustinic diagram to determine the use of residual land from tuff in the research area as a suitable raw material for industry. The following are the plotting results on the Augustinic diagram:

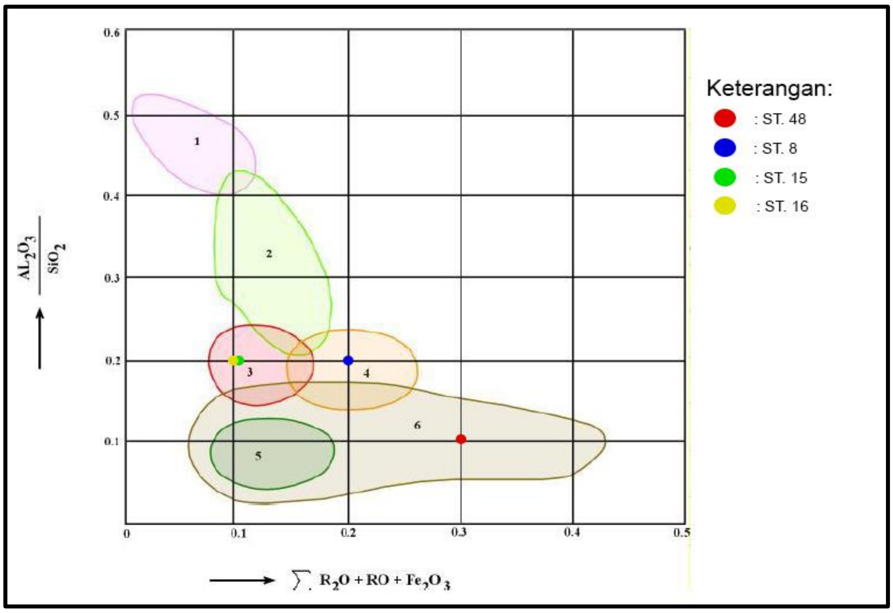

Figure 11. Results of the Augustinian diagram plot (Syahrulyati, 1989)

The plotting results in the augustinic diagram at station 8 are in area 4, which is suitable for raw materials for the roof tile industry with a residual soil thickness of 1 m and has the potential to be further developed based on physical aspects including easy to shape and environmentally friendly, while the chemical aspects meet the requirements based on major elements.

At stations 15 and 16, they are in area 3, which is suitable for raw materials for the fine pottery industry with a residual soil thickness of 2-3 m and have the potential to be developed based on physical aspects in the form of fire resistance and chemical aspects that have high SiO_2 values to increase the strength and durability of pottery so that they meet the requirements.

At station 48, it is in area 6, which is suitable for raw materials for the brick industry with a residual soil thickness of 1.5 m and has the potential to be further developed based on physical aspects in the form of high resistance and chemical aspects that have high MgO and K_2O values, increasing the durability of bricks so that they meet the requirements.

CONCLUSION

Petrographic analysis results, tuff in the Walanae Formation mostly comes from intermediate-ultrabasic magma series based on its mineral composition. With a lightly compacted-tuff fracture texture, volcanic ash that is extensively transformed into clay minerals that are sensitive to thermal conditions and geochemical environments while from the results of geochemical analysis, tuff in the Walanae Formation has a positive and negative correlation to SiO2 and the nature of its magma is intermediate-ultrabasic. Based on the naming of rocks, station 8 has a trachy basalt composition, stations 15 and 16 have a basaltic andesite composition, and station 48 has a basanite composition. The use of residual land from tuff in the research area is suitable for use as material for making bricks, roof tiles and fine pottery.

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