



# Characterization of the Volcanic Rocks of Mount Sinabung, Simacem Village, Karo Regency, Conducted With XRD, SEM-EDX

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**Abstract.** The study of volcanic rocks characterization of Sinabung Volcano erupted on September 15, 2017. The volcanic rocks crystal system was performed with XRD, elemental analysis and microstructure with SEM-EDX. Volcanic rocks contain: Anorthite phase 87,11 (wt%), Triclinic crystal, lattice constant,  $a = 8.1742 \text{ \AA}$ ,  $b = 12.844 \text{ \AA}$ ,  $c = 14.204 \text{ \AA}$ ; Quartz phase 2.26%, Hexagonal crystals, lattice constants,  $a = 4.799 \text{ \AA}$ ,  $b = 4.799 \text{ \AA}$ ,  $c = 5.379 \text{ \AA}$ ; Cristobalite phase 7.72 (wt%), Tetragonal crystals, lattice constants  $a = 4.970 \text{ \AA}$ ,  $b = 6.990 \text{ \AA}$ ,  $c = 6.998 \text{ \AA}$ ; Alunite phase 2.91 (wt%), Hexagonal crystals, lattice constants,  $a = 6.990 \text{ \AA}$ ,  $b = 6.990 \text{ \AA}$ ,  $c = 17.282 \text{ \AA}$ .

**Keyword:** Volcanic rock, Crystal Structure, Phase, Microstructure

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## 1 Introduction

Mount Sinabung's activity aroused after its 400-year slumber. The activity was firstly noticed on August 27th, 2010. Hot clouds, lava, volcanic dust, sand and volcanic rocks were seen bursting out from the bowels of the mountain. Volcanic dust was bursting high and far, reaching tens of kilometers along with sand and volcanic rocks to residential areas. The adverse impacts inflicted to the residents were including the agricultural damage, water pollution, health problems and flight disruption [1]. The volcanic dust of Mount Sinabung contains some elements such as Nitrogen (N) 0.13%, Potassium ( $K_2O$ ) 0.55%, Carbon (C-Organic) 0.54%, Phosphor ( $P_2O_5$ ) 0.55%, Silica ( $SiO_2$ ) 59.92%, Sulfur (S) 0.18%, Iron (Fe) 16.11% [1]. Albert Daniel [2] in his research stated that volcanic dust contains silicon dioxide ( $SiO_2$ ) dominated by hexagonal structure. The volcanic dust of Mount Sinabung has the structure of a crystal which microscopically looks pointy and irregular in shape [1] [2]. This makes the volcanic dust of Mount Sinabung hazardous to people who reside at the surroundings, especially to their health, as the dust might cause bronchitis and eye irritation [3-7].

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In this matter, the researcher would like to study the characteristics of the volcanic rocks and volcanic dust, especially those which are harmful to human health. On the other hand, the researcher would also like to know the beneficiary use of volcanic dust, black and red volcanic rocks [8, 9]. The volcanic rocks were collected from Simacem Village in Karo Regency, which is located 2 kilometers from the volcano and crystal analysis system with XRD [10-14] and microstructure analysis with SEM-EDX [15-20].

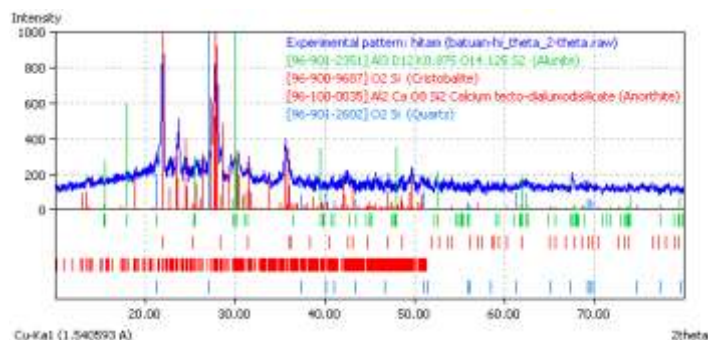
## 2 Materials and Methods

The sample used in this research were the volcanic rocks, collected from Simacem Village, Namantaner Sub-District, Karo Regency, North Sumatera, located 2 kilometers from the center of eruption. The rocks were broken into pieces, grinded in ball mill, and sifted to 100 mesh in size, and then dried. 50 g of volcanic rocks powder were used as the sample of crystal analysis system, phase analysis by XRD, and the other 50 g powder were used for elemental and microstructure analysis with SEM-EDX.

## 3 Result and Discussion

### 3.1 The Structure Analysis of Volcanic Rocks

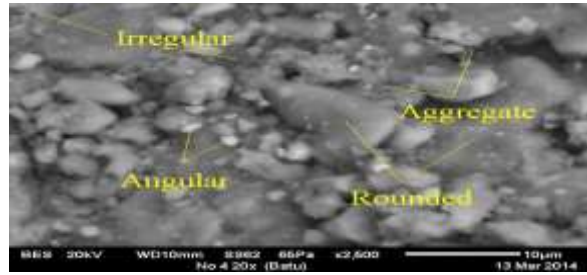
Following is the obtained diffraction pattern of volcanic rocks as seen in Figure 1:



**Figure 1.** The Diffraction Pattern of Volcanic Rocks from Mount Sinabung

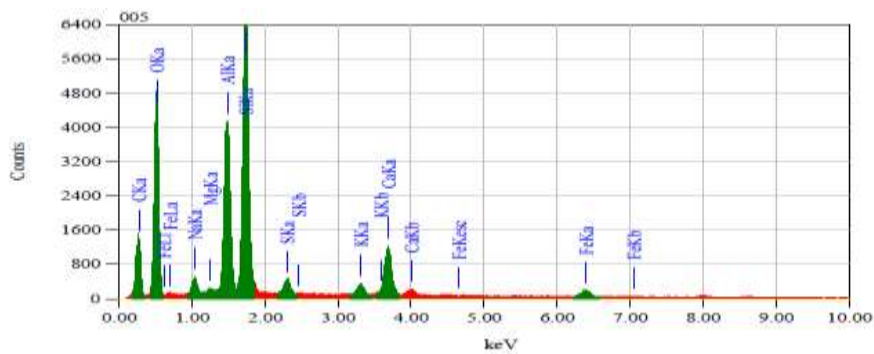
The figure above indicates that the edges of volcanic rocks contain the Anorthite phase,  $\text{Al}_2\text{CaO}_8\text{Si}_2$ ; Quartz,  $\text{SiO}_2$ ; Cristobalite,  $\text{SiO}_2$ ; Alunite,  $\text{Al}_3\text{H}_{12}\text{K}_{0.875}\text{O}_{14.125}\text{S}_2$ . The Anorthite compounds contain the Triclinic crystal system, with lattice constant  $a = 8.174(2)\text{\AA}$ ,  $b = 12.844(3)\text{\AA}$ ,  $c = 14.204(3)\text{\AA}$ ,  $\alpha = 93.4(2)^\circ$ ,  $\beta = 116.1(2)^\circ$ ,  $\gamma = 90.3(2)^\circ$ , The density of Anorthite reaches  $= 2.768 \text{ g.cm}^{-3}$ ; Quartz compounds contain the Hexagonal crystal system, with lattice constant of  $a = 4.799(1)\text{\AA}$ ,  $b = 4.799(1)\text{\AA}$ ,  $c = 5.397(1)\text{\AA}$ ,  $\alpha = \beta = 90^\circ$  and  $\gamma = 120^\circ$ , The density of Quartz is  $\rho = 4.262 \text{ g.cm}^{-3}$ ; Cristobalite compounds contain Tetragonal crystal system, with lattice constant  $a = 4.970(3)\text{\AA}$ ,  $b = 4.970(3)\text{\AA}$  and  $c = 6.998(8)\text{\AA}$ ,  $\alpha = \beta = \gamma = 90^\circ$  The density is  $\rho = 2.308 \text{ g.cm}^{-3}$ ; While Alunite compounds contain Hexagonal crystal system, with lattice constant  $a: 6.990(9)\text{\AA}$ ,  $b = 6.990(9)\text{\AA}$ , and  $c = 17.282(2)\text{\AA}$ ,  $\alpha = \beta = 90^\circ$  and  $\gamma = 120^\circ$ , with

density  $\rho = 2.843 \text{ g.cm}^{-3}$ . The volcanic rocks contain Anorthite phase of 87.11 (wt%), Quartz phase of 2.26 (wt%), Cristobalite phase of 7.72 (wt%) and Alunite phase of 2.91 (wt%). [8] [10]. This volcanic rocks microstructure analysis was conducted with SEM-EDX, as shown in Figure 2 below:



**Figure 2.** The Microstructure of Volcanic Rocks

The general topography of volcanic rocks is round with varied sizes, while some rocks are oval with some fine aggregate. The elemental spectrum analysis of the volcanic rocks from Mount Sinabung is presented in Figure 3:



**Figure 3.** The Elemental Spectrum Analysis of The Volcanic Rocks of Mount Sinabung

The elemental analysis of volcanic rocks can be done with the help of computer, as identified in this following table:

**Table 1.** The Elemental Analysis of Volcanic Rocks

ZAF Method Standardless Quantitative Analysis							
Fitting Coefficient : 0.2428							
Element	(keV)	Mass%	Error%	Atom%	Compound	Mass%	Cation
C	0.277	23.22	0.14	33.10			K
O	0.525	45.64	0.22	48.84			6.8946
Na	1.041	1.26	0.13	0.94			49.6220
Mg	1.253	0.30	0.10	0.21			1.4692
Al	1.486	8.44	0.09	5.36			0.3105
Si	1.739	14.32	0.10	8.73			10.5487
S	2.307	0.85	0.08	0.45			19.0862
K	3.312	0.78	0.12	0.34			1.3838
Ca	3.690	3.71	0.13	1.59			1.3878
Fe	6.398	1.48	0.30	0.45			6.9635
Total		100.00		100.00			2.3335

### 3.2 The Composition Analysis of The Volcanic Rocks of Mount Sinabung

The mass fraction of volcanic rocks was analyzed from the highest peak of elemental spectrum analysis with the help of computer program. The percentage data are presented in table 2:

**Table 2.** The Mass Fraction of the Volcanic Rocks of Mount Sinabung

No	Compounds	Phase	Reference	Mass Fraction
1.	Anorthite	$\text{Al}_2\text{CaO}_8\text{Si}_2$	ICDD- 96-100-0035	87.11
2.	Quartz	$\text{SiO}_2$	ICDD- 96-901-2602	2.26
3.	Cristobalite	$\text{SiO}_2$	ICDD- 96-900-9687	7.72
4.	Alunite	$\text{Al}_3\text{H}_{12}\text{K}_{0.875}\text{O}_{14.125}\text{S}_2$	ICDD- 96-901-2351	2.91

Referring to Table 2, it can be concluded that Anorthite compounds,  $\text{Al}_2\text{CaO}_8\text{Si}_2$  contain the mass fraction of 87.11%wt, Quartz compounds  $\text{SiO}_2$  contain mass fraction of 2.26 %wt, Cristobalite compounds,  $\text{SiO}_2$  contain 7.72 %wt and Alunite compounds,  $\text{Al}_3\text{H}_{12}\text{K}_{0.875}\text{O}_{14.125}\text{S}_2$  contain mass fraction of 2.91 %wt.

#### 4 Conclusion

Based on the analysis conducted on the volcanic rocks of Mount Sinabung, the conclusion is:

1. Volcanic rocks contain: Anorthite phase 87.11 (wt%), the Triclinic crystals, lattice constants  $a = 8.1742 \text{ \AA}$ ,  $b = 12.844 \text{ \AA}$ ,  $c = 14.204 \text{ \AA}$ ; Quartz phase 2.26%, Hexagonal crystals, lattice constants ,  $a = 4.799 \text{ \AA}$ ,  $b = 4.799 \text{ \AA}$ ,  $c = 5.379 \text{ \AA}$ ; Cristobalite phase 7.72 (wt%), Tetragonal crystals, lattice constants =  $4.970 \text{ \AA}$ ,  $b = 6.990 \text{ \AA}$ ,  $c = 6.998 \text{ \AA}$ ; Alunite phase 2.91 (wt%), Hexagonal crystals, lattice constant  $a = 6.990 \text{ \AA}$ ,  $b = 6.990 \text{ \AA}$ ,  $c = 17.282 \text{ \AA}$ .
2. The volcanic rocks from Mount Sinabung contain Anorthite phase (87.11%), and classified as Feldspar because its Triclinic crystal system can be used as the material of ceramics.
3. The microstructure of volcanic rocks has round shape with varied sizes. Some are oval with small part containing fine aggregate.

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