Petrology and Geochemical Comparation of Pumice and Scoria Rocks of Slamet Volcano, Central Java

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Abstrak

Gunung Slamet adalah salah satu gunung api kuarter bertipe stratovolcano yang berlokasi di Jawa Tengah. Secara geologi Gunung Slamet dapat dibagi menjadi dua bagian yaitu Slamet tua di bagian barat dan Slamet Muda di bagian timur. Penulis melakukan perbandingan data dari batuan piroklastik di Gunung Slamet, yaitu pumis dari Slamet Tua, jatuhan skoria dan kerucut scoria dari bagian Slamet Muda. Pumis dan skoria memiliki perbedaan geokimia dan petrologi, pumis memiliki SiO_2 yang lebih tinggi dengan angka 60 - 64%, jatuhan skoria memiliki SiO_2 49.81 - 50.56%, dan kerucut skoria memiliki kandungan SiO_2 49.26%. Pengamatan petrografi menunjukan bahwa pumis memiliki struktur vesikuer dan mengandung fenokris berupa piroksen, plagioklas, dan biotit, jatuhan skoria dan kerucut skoria memiliki persamaan kandungan mineral berupa fenokris plagioklas, olivine, dan piroksen dengan hialopitik tekstur. Perbedaan yang kontras antara unsur utama dan petrografi dapat diinterpretasikan jika batuan piroklastik di Gunung Slamet berasal dari magma yang berbeda dan proses differensiasi magma yang terjadi di Gunung Slamet secara umum tidak hanya fraksinasi kristal tapi juga disebabkan oleh pencampuran magma.

Kata Kunci: *Slamet Volcano, Magma Mixing, Fractionation Crystal, Pumice, Scoria*

Abstract

Slamet Volcano is one of Indonesia Quaternary Stratovolcanoes in Central Java Province. Slamet volcano is divided into two parts, Old Slamet in the western part and Young Slamet. The author examined a comparation data of pyroclastic rock of Slamet Volcano, the pyroclastic rocks are pumice from Old Slamet, the scoria fall, and scoria cones are from Young Slamet. They have different geochemical and petrology features, pumice rock has higher SiO_2 from 60 to 64 wt.%, scoria fall has SiO_2 49.81 to 50.56 wt. %, and scoria cone has SiO_2 49.26 wt. %. Petrographic observation showed that pumice is vesicular and contains of phenocryst pyroxene, plagioclase and biotite, scoria fall, and scoria cones have similar petrographic characteristic they have phenocryst of plagioclase, olivine, and pyroxene with hyalopilitic texture. The contrast of major element combined with petrographic features suggest that pyroclastic rock in Slamet Volcano formed by different magma and the magma has differentiation process of Slamet magma is generally not only by fractional mineral but also caused by magma mixing.

Keywords: *Slamet Volcano, Magma Mixing, Fractionation Crystal, Pumice, Scoria*

1. Introduction

Petrogenetic study of igneous rock for understanding a genesis of volcanic rock in subduction zone is complicated of differentiation process such as fractional crystal, magma mixing and crustal assimilation and geochemical variation in source component such as mantle wedge, subducted sediment that control melt in a volcano [1]. Fractional crystallization is the dominant process of magmatic system that separated crystal from magma and remained a new magma composition when magma in equilibrium

phase, the remaining liquid can continue to crystallize as a rock with a composition quite different from that of the original liquid. Magma mixing is when two magmas, either the composition similar or may be the magma composition is completely different. Assimilation process is when magma interact with encountered route to the final crystallization site and the xenolith comes from the wall of the magma conduit or founder from the roof from magma chamber [2].

Magma mixing processes have been reported in many volcanoes in Island arc of Indonesia such as Krakatau [3], Papandayan [4], Ciremai, Tangkuban Perahu, Tampomas, Guntur, Galunggung [5], Sundoro volcano [6], Ijen volcano [7], Batur volcano [8] and Rinjani [9].

Pyroclastic rocks are the type of rocks that formed by fragmented magma of volcano explosive eruption. The different of pyroclastic rocks and igneous rocks are the igneous rock formed by lava cooling on the earth surface such as andesite and basalt or magma cooling beneath of earth surface such as granite. Pyroclastic rocks are formed by fragmented magma on the volcano conduit due to the gas pressure in the magma. The term "pyro-clast" derives from Greek and Latin roots meaning "fire-broken" rock. Explosive eruption can produce some pyroclastic material on general those material can be divided into three: Pyroclastic fall is the pyroclastic material that deposited by falling material after the material reaching umbrella cloud when explosive eruption. Pyroclastic flow is the pyroclastic material that deposited by flowing of pyroclastic material. The material can be fast-moving forward along the volcano flank. Pyroclastic surge is the pyroclastic material that deposited by turbulent flow during emplacement, usually it will come together with pyroclastic flow as the base of pyroclastic flow. [10]

Slamet Volcano is the Quaternary Volcano in Indonesia that located in Java Island. Its height is 3428 asl (above sea level) that makes it is the second of the highest volcano in Java Island after Semeru Volcano. Geologically Slamet Volcano is in Central Java, Indonesia (Figure1). The First eruption that recorded in history of Slamet Volcano was from 1772 to 2014. The eruption was characterized by ash plume, ash fall and lava on the summit with volcanic eruption index 2 [11]. Based on Geological map Purwokerto and Tegal Slamet Volcano is divided into two parts, Old Slamet in the western part and Young Slamet in the eastern part, (Figure 2). The rock compositions are basaltic andesite to andesitic for Old Slamet, basaltic to basaltic andesite for Young Slamet and dacite was formed in the transitional stage between Old and Young Slamet. they were formed in Pleistocene until Holocene [12].

Slamet Volcano situated on Neogene Sediment facies [13] about 160 km above subduction zone 310 northward of distance trench [14]. The Old Slamet is characterized by rough terrain and deep valleys indicating the older rock units and Young Slamet is characterized by smooth and sloping morphology. The eastern part of Slamet Volcano there are 35 Scoria cones which were studied by Sutawidaja and Sukhyar (2009), radiometry dating by using K-Ar method has been done for these Scoria cones and the age is 0.042±0.020 Ma. [15]

Previous researchs have been conducted by some researchers. The first publication of Slamet Volcano basalt was from Neumann van Padang in 1951 and next was Whitford in 1975 [16] and Vukadinovic and Nicholls (1989) [17], and Vukadinovic and Sutawidjaja (1995) [13] they presented about geochemistry of Slamet Volcano Lava. The newest publication of Slamet Volcano was done by Harijoko, et, al (2017) they presented about pumice fall in western part of Slamet Volcano [18].

The discussed of scoria fall and comparation of petrology and geochemical data of pyroclastic rock in Slamet Volcano is lack and no one discussed it. This paper will compare pyroclastic rocks data of Slamet volcano include pumice fall and scoria rocks of scoria fall and scoria cones of Slamet Volcano.

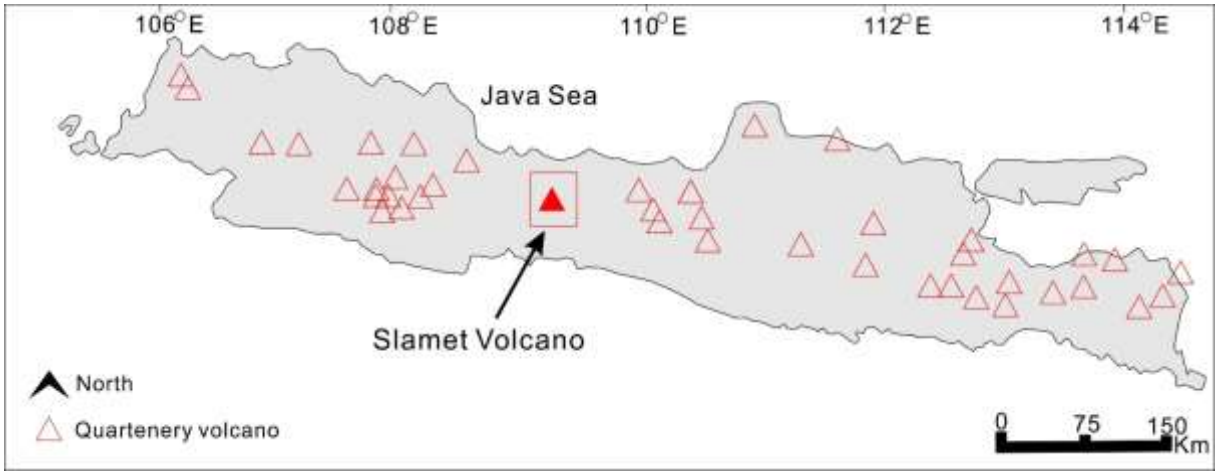

Figure 1. **The volcano distribution on Java Island and research location is marked by red box. (Modified from Harijoko, et., al., 2017 [19])**

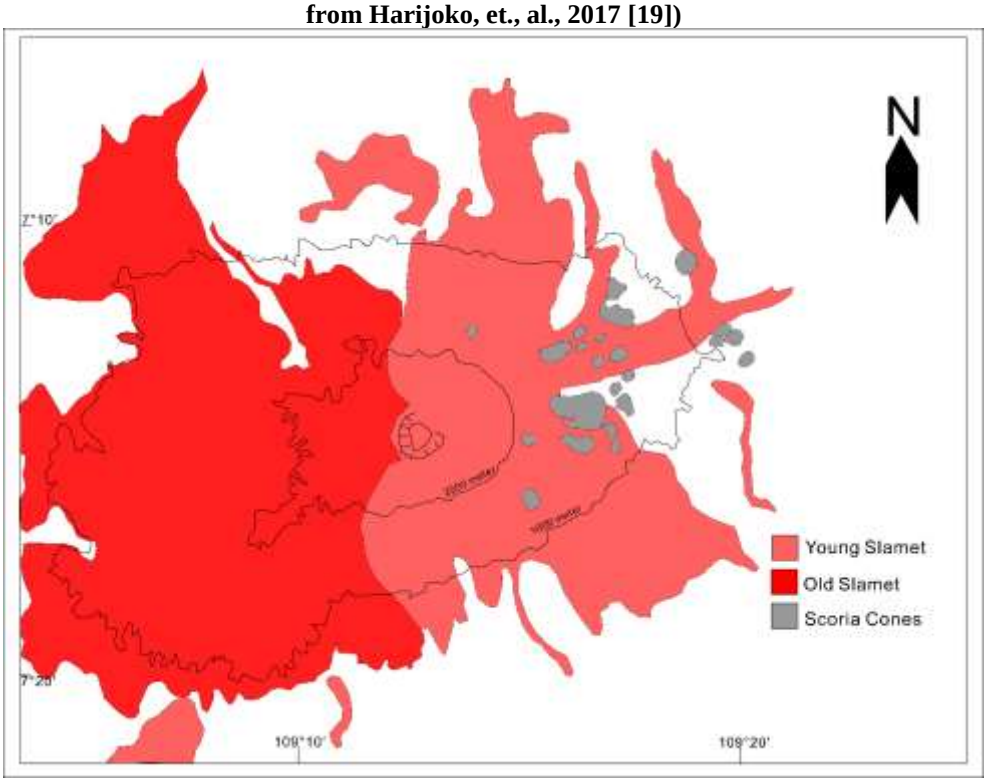

Figure 2. **The distribution of Slamet Volcano deposit. (Modified from Vukadinovic and Sutawidjaja, 1995 [13])**

2. Method

Thin section method is the general method that has been used widely for geology research, the method is to observe mineral composition of rock sample by cutting and polishing it to 30µm thickness and analyzed under an optical microscope. The whole rock chemistry is the method that obtained by crushing the rock sample and pressing into pellets to be analyzed in XRF tools, The geochemistry of rock samples was plotted into Total Alkali Silica (TAS) diagram from Le Maitre (2002) [20] and K_2O diagram from Peccerillo and Taylor (1976) [21]

The primary method and secondary method were used on our research, the primary method was from our field observation in July and September 2017. The scoria fall samples were picked up from eastern part of Slamet Volcano in Baturaden area and scoria cones samples were picked up in Purbalingga on the local mining (Figure 3). These two scoria samples are mentioned as Young Slamet rock sample, the 9 samples of scoria fall and 1 sample of scoria cone were analyzed by X-ray

fluorescence (XRF) at Laboratory Earth and Planetary Science, Kyushu University, Fukuoka, Japan to get major element. The 23 samples of these scoria sample were identified using optical microscop with thin section method to get mineral composition at Laboratory Earth and Planetary Science, Kyushu University, Fukuoka, Japan.

The second data is secondary data from Harijoko, et, al, (2017)[18] that has been published on International Symposium on Earth Hazard and Disaster Mitigation (ISEDM) 2017. The pumice sample were picked up on the western part of Slamet Volcano specifically at Keruh Village, Brebes distric. The rock samples are 10 samples of pumice rock (Figure 3). These samples were analysed X-ray fluorescence (XRF) at ALS Laboratorium, Canada to get major element and mineral composition was carried out at Gadjah Mada University.

Pumice and scoria data are combined and compared to get the distribution and the different of mineral composition and geochemical variation. The data will be used to understanding the magma genesis of Slamet Volcano of Old Slamet and Young Slamet.

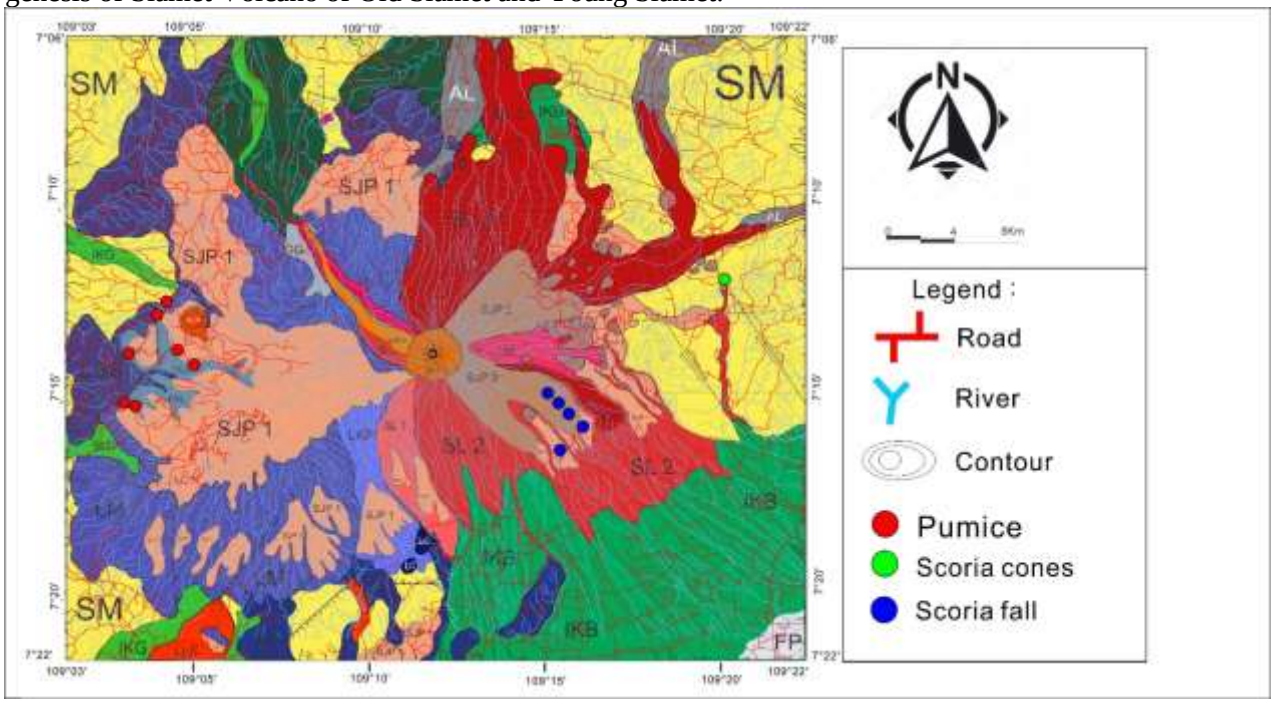

Figure 3. Geological map of Slamet Volcano (modified from Sutawidjaja, 1985 [22]) and the localities of sampling location in Slamet volclano.

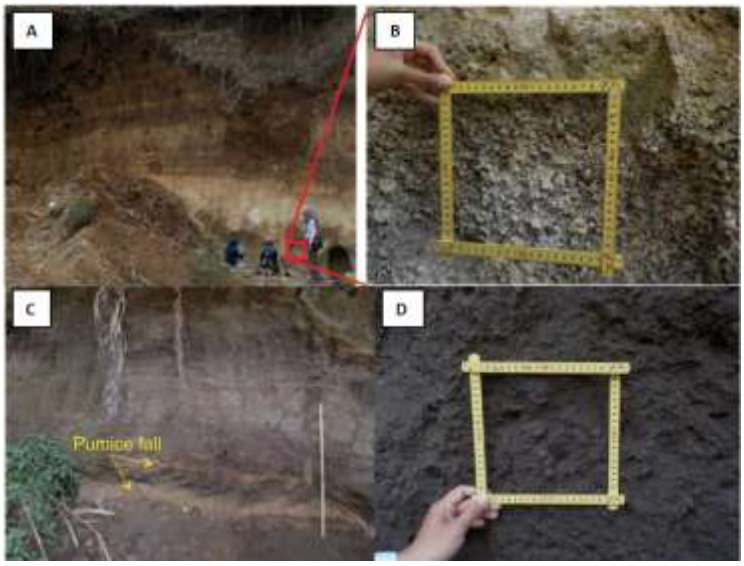

Figure 4. The outcrop of pumice deposit on western part of Slamet Volcano from Harijoko et., al. 2018.

Figure 5. The outcrop of scoria fall layer on eastern part of Slamet Volcano (left) and scoria cones (right).

3. Results and Discussion

Scoria deposits are located on the eastern part of the Slamet Volcano, primary deposit of scoria fall occurs as layered coarse and fine scoria, it is 20cm thick, black color scoria, well sorted, angular shape, maximum size is 5 cm it contains few lithic (Figure 5). Fine layer contains small charcoal. Scoria cones have several kinds of size from small size less than 100 m to 750-meter height. The scoria cone is layering, black colour, glassy, coarse grain, angular grain shape, well sorted, fresh rock (Figure 5).

Olivine, pyroxene and plagioclase phenocryst and glass volcanic groundmass, the scoria fall has bigger crystal size and scoria cones has small crystal size. The mineral textures were observed such as glomerocryst, sieve, and zoning (Figure 7). The whole rock chemistry of scoria samples classified as basalt plotted on TAS diagram. Scoria falls has silica content ranging from 49.81 to 50.56 wt. % and K_2O from 1.07 to 1.23 wt.% (Table 1).

Pumice fall that wisdespread on western part of Slamet Volcano is grouping into Old Slamet Volcano. The outcrop is layered with tickness up to 15 meter. Pumice layer consist of pyroclastic fall, pyroclastic flow and pyroclastic surge. Based on the field observation the pumice rock has various color of white, tan, grey, and reddish. Pumice layer is well sorting with the size range from 1 mm – 40 mm and rock fragment ranging from 1 mm – 20 mm. The variation of thickness of pumice deposit is observe from 5 cm – 110cm. Generally the pumice deposit is divided into three parts, the lower part, dominated by pyroclastic fall and pyroclastic flow, middle part is consist of pyroclastic fall interbeded with pyroclastic flow layer and then upper part dominated by pyroclastic fall fine size. On the top of these pumice deposit there are lahar deposite and fluvial deposit (Figure 4)

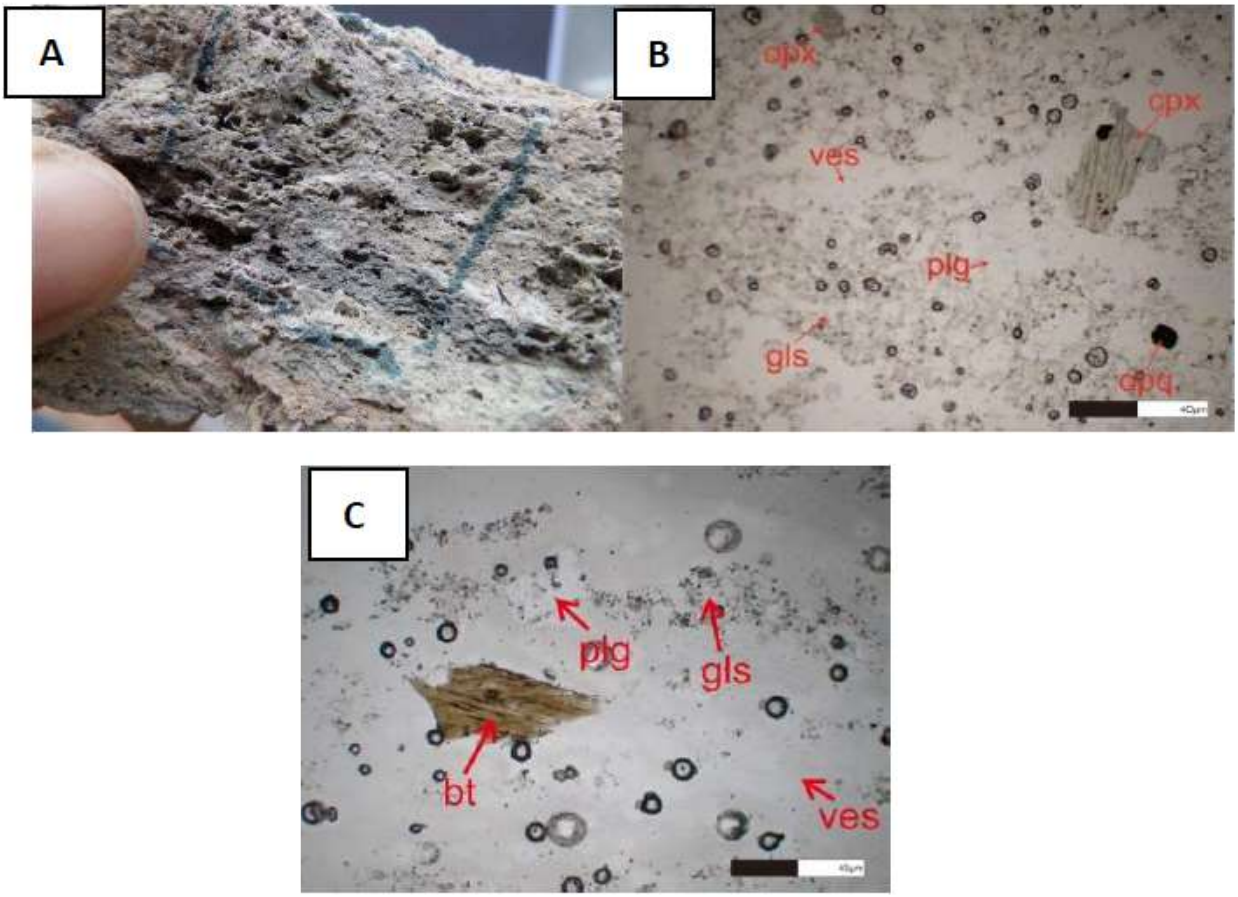

Figure 6. A. the pumice sample of pumice deposit, B-C. the thin section shows mineral composition of pumice. Plag: plagioclase, cpx: clinopyroxene, bt: biotite.

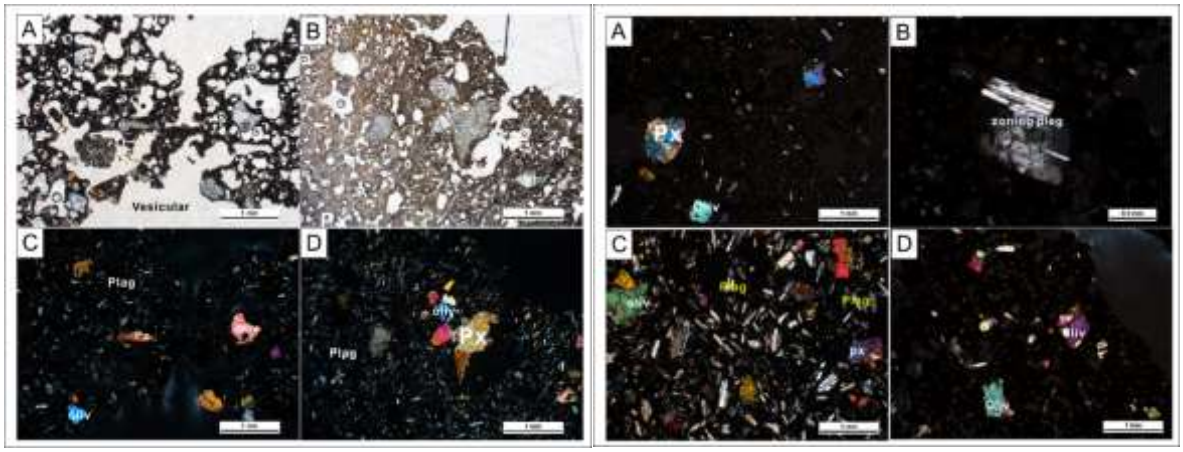

Figure 7. The thin section of scoria fall (left) shows crystal rich of plagioclase and pyroxene. The thin section of scoria cones (right) shows a vesicular structure and crystal composition. Plag: plagioclase, Px: pyroxene, Ol: olivine.

Table 1. The XRF data of pumice and scoria from Slamet Volcano.

Pumice (Harijoko, et.al., 2017)													
Kode Sampel	SiO_2	TiO_2	Al2O3	FeO*	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	LOI	Total	$Na_2O + K_2O$
SU1-A01	58.7	0.71	18.15	6.52	0.14	1.74	5.64	3.82	2.34	0.21	2.02	99.99	6.16
SU1-A02	61.2	0.71	17.5	6.78	0.14	1.78	5.47	4	2.38	0.2	1.69	101.85	6.38
SU1-A03	59.7	0.71	17.45	6.66	0.13	1.74	5.57	3.8	2.34	0.2	1.81	100.11	6.14
SS1-F01	63.9	0.59	16.4	5.57	0.12	1.36	4.21	4.06	2.99	0.14	2.3	101.64	7.05
SS2-F01	61.7	0.62	16.5	5.98	0.13	1.42	4.04	4	3	0.17	2.28	99.84	7
SS2-F03	60.5	0.76	17.5	6.79	0.14	1.95	5.7	3.96	2.38	0.2	1.46	101.34	6.34
SS2-F03	58.9	0.78	17.7	6.96	0.14	2.04	5.53	3.67	2.24	0.23	1.53	99.72	5.91
SS2-F04	59.8	0.67	16.8	6.01	0.13	1.66	4.7	3.65	2.54	0.18	2.06	98.2	6.19
SS3-F01	60	0.67	17.6	6.03	0.12	1.4	4.41	3.71	2.53	0.2	3.06	99.73	6.24
Scoria													
Kode Sampel	SiO_2	TiO_2	Al_2O3	FeO	Fe_2O3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	Total	$Na_2O + K_2O$
Scoria Fall 1	49.81	1.34	19.8	9.18	1.638	0.17	4.36	8.15	3.3	1.07	0.31	99.13	4.37
Scoria Fall 2	50.27	1.31	19.45	8.96	1.599	0.18	4.3	8.17	3.33	1.16	0.3	99.03	4.49
Scoria Fall 3	50.66	1.28	19.09	8.81	1.572	0.18	4.32	8.27	3.35	1.21	0.31	99.05	4.56
Scoria Fall 4	50.09	1.31	19.28	8.99	1.6035	0.18	4.31	8.17	3.27	1.21	0.28	98.69	4.48
Scoria Fall 5	50.26	1.32	19.62	9.03	1.611	0.17	4.28	8.17	3.31	1.15	0.3	99.22	4.46
Scoria Fall 6	50.35	1.31	19.38	8.97	1.6005	0.17	4.33	8.2	3.29	1.15	0.3	99.05	4.44
Scoria Fall 7	50.56	1.3	19.36	8.91	1.59	0.18	4.33	8.2	3.36	1.17	0.31	99.27	4.53
Scoria Fall 8	50.28	1.3	19.29	8.94	1.5945	0.18	4.31	8.19	3.31	1.21	0.3	98.90	4.52
Scoria Fall 9	50.55	1.3	19.24	8.89	1.587	0.18	4.29	8.21	3.31	1.23	0.29	99.08	4.54
Scoria Cones	49.26	1.34	16.7	8.94	1.596	0.18	6.91	10.04	2.63	0.97	0.28	98.85	3.6
wt.%													

The mineral composition of pumice fall shows phenocryst are plagioclas, pyroxene and biotite with glassy groundmass and vesicular structure (Figure 6). The whole rock chemistry of pumice rock samples are are classified as andesite todacite ($SiO_2$60 to 64 wt. %) in the sub-alkaline and High-K region (2.24 - 3 wt. %) (Table 1).

Based on the data of fieldwork, mineral composition, and whole rock chemistry we can see that the Old Slamet and Young Slamet has the different color of rock, mineral composition, and chemistry composition. The pyroclastic rock is evidence of explosive eruptions, it means Slamet Volcano has ever explosive eruptions on the past. Although that Slamet Volcano currently has small eruptions with strombolian eruptions type. The difference of mineral and geochemistry composition between Young Slamet and Old Slamet represent that magma chamber of Slamet Volcano. It means the Slamet Volcano magma changed from felsic magma in Old Slamet to mafic magma in Young Slamet. Normally crystal

fractionation in magma changes magma composition from mafic to felsic but in Slamet Volcano is vice versa.

This result can be interpreted that mafic magma in Young Slamet is not only result of crystal fractionation of magma differentiation, but it can also be interpreted that mafic magma is from different magma source. Magma mixing signature in Young Slamet was observed by whole rock chemistry and petrographic observation such as sieve texture, zoning, synneusis and glomerocryst are a result of disequilibrium processes in magma chamber. Glomerocryst are aggregate of two minerals or more that formed when the partially resorbed crystal gets spatially closer,[23]. Sieve texture was produced by reaction with hotter Ca-rich melt [24] or mixing of the magma with a higher-temperature that may lead to the resorption of phenocrysts that originally equilibrium [25].

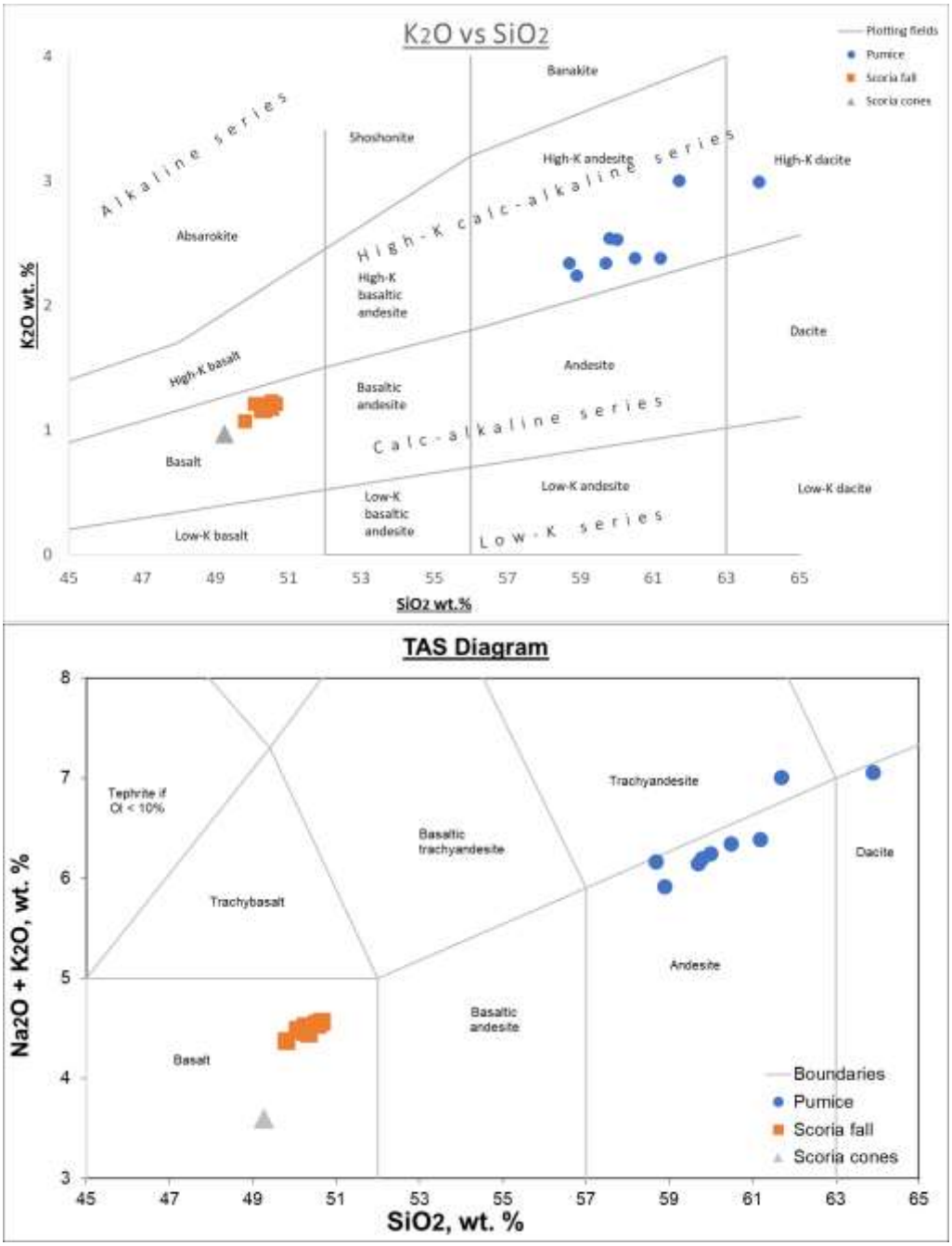

Figure 9. The TAS (total alkali silica) diagram and K_2O diagram of pumice and scoria of Slamet Volcano

4. Conclussion

Based on data and analysis of pyroclastic rock in Slamet Volcano, it can be concluded that Slamet Volcano has two types of pyroclastic rocks, pumice as product of Old Slamet that has has mineral composition pyroxene, biotite, plagioclase and glassy groundmass, the silica content of pumice is range from 60-64 wt.% and Scoria as the product of Young Slamet Volcano that has mineral compositions are plagioclase, pyroxene, and olivine the whole silica content is ranging from 49.81 to 50.56 wt. %. The magma of Slamet Volcano changed from felsic magma to mafic magma that interpreted the mamga source is different and the magma mixing observed from sieve texture.

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