MAGMA EVOLUTION IN THE FORMATION OF LAVA TUBE AT GOA LAWA PURBALINGGA

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Abstract. Goa Lawa Purbalingga is an eruption trace of Slamet Volcano. Currently used as a tourist destination. Geologically, it is an interesting phenomenon to study in more depth regarding the dynamics of magma evolution. The dynamics of the Plagioclase Mineral were measured using petrographic analysis and then confirmed using rock chemical analysis. Rock samples were taken in a structured manner from the bottom to the top, referring to the earlier of the eruption process to the later of the eruption process. In this way, the changes that occur in the magma from the beginning to the end of the eruption can determine the direction of its evolution. From this research, an understanding was obtained that morphologically the Goa Lawa area is included in the Slamet Volcano Lava Flow Ridge morphological unit. Which is composed of the Slamet volcana Lava rock group which consists of Scoria Basalt Lava. In Goa Lawa there are 5 layers of lava. In order from bottom to top, also meaning from Old to Young, there are Lava A, Lava B, Lava C, Lava D, and Lava E. The chemical composition of the lava ranges from SiO2 content values of 50.53 to 51.35, still included in Basalt. The position of the depth where the initial magma melted did not significant dynamics, at a depth of 150 km. The mineralogical and chemical characteristics of the lava have not changed significantly and are still in the basaltic range, so the character of the magma has not changed, it has low viscosity and effusive eruption.

Keywords: goa Lawa, lava tube, magma evolution

1. Introduction

Magma is molten natural substance which, on cooling, solidifies as a crystalline or glassy igneous rocks. [1]. Magma rises to shallow levels or even up into the earth surface, prior to an eruption it may become saturated in volatiles, as a result of decompression, or as a result of crystallization of anhydrous phases. If volatile contents are very low, or if volatiles are able to escape from the magma, an effusive eruption will occur, generating lava flows or domes [2].

The origin of magma is related to heat source within the earth. Part of earth crust subducts into mantel melts, due to high pressure and high temperature and water presence also [3]. The heat sources that can come from decay of radioactive elements, rock deformation, subduction of plates in the earth's crust, and partial burial of the earth's mantle material by some reason. Primary magma is formed when as the result of partial melting of the shell earth composed of Peridotite Magma. This primary magma is often also called primitive magma or parent magma which is always in composition basalt is rich in magnesium characterized by a high Mg/Mg + Fe ratio, Ca/Ca+Na+K and contains lots of it Ni, Cr, and other compatible elements. The results of the differentiation of the parent magma form derived magma, starting from low Mg basalt, basalt andesite, andesite, dacite, and rhyolite, its magma evolution.

This research was conducted at Goa Lawa Purbalingga. It is a trace of the eruption activity of Slamet Volcano, it is a lava tube. Currently used as a tourist destination. It is interesting to study how the dynamics of magma are the background for the formation of rocks that make up lava tubes.

This research is useful to determine the characteristics and dynamics of magma during the formation of lava tubes. In addition, to increase the educational content of Goa Lawa tourism and of course for disaster mitigation.

2. Methods

The research carried out includes the geological conditions of Goa Lawa, lava stratification, lava geochemical analysis, and magma evolution in the range of lava tube formation.

2.1. Geological study

Geological mapping methods are carried out to understand the geological conditions of the research area. Embodied in geological maps, and stratigraphic columns. From stratigraphic analysis, it is known that the position of Goa Lawa lava tube in the stratigraphic order of Slamet Volcano.

2.2. Lava stratification

Detailed mapping of Goa Lawa to find out the sequence of lava formation. The sequence of lava formation as a chronological basis for magma evolution analysis.

2.3. Geochemical analysis

XRF analysis is used to determine the chemical content of rocks from each layer of lava

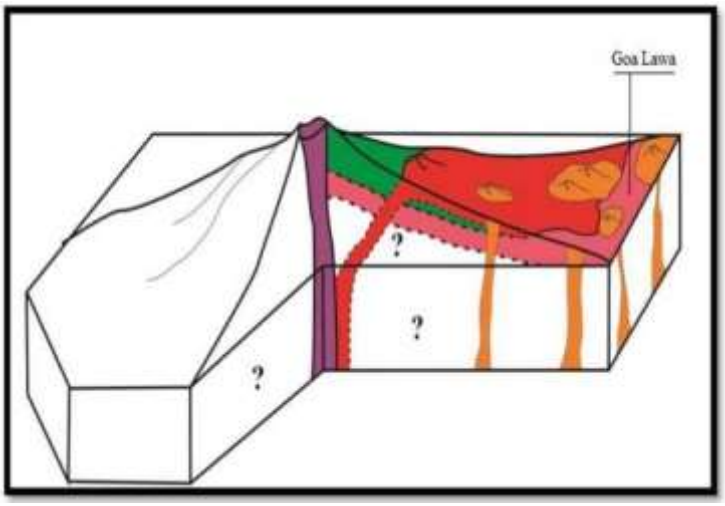
2.4. Magma evolution

Comparing the chemical composition of primary magma with the chemical composition of magma that forms lava at Goa Lawa to determine the evolution of magma. In the chronology of the formation of lava layers, the dynamics of magma evolution can be determined in the time span of lava tube formation.

3. Result and Discussion

3.1. Geology of Goa Lawa.

Goa Lawa is part of the Slamet Volcano system. It is composed of basalt scoria lava of the Lava Rock unit of Slamet Volcano. The geological conditions of this area are depicted in the following geological models and stratigraphic columns:



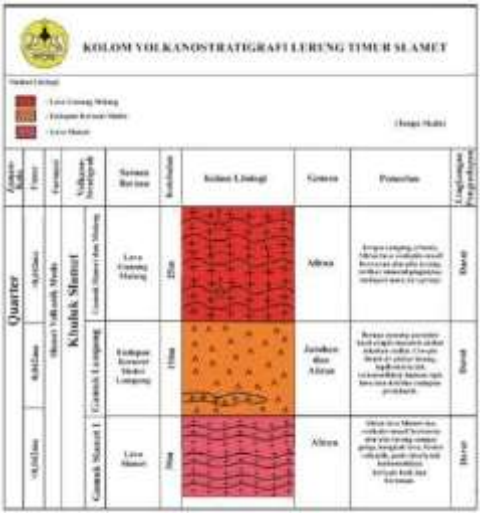


Figure 1. Geological Model and Stratigraphy of Goa Lawa

Lava at Goa Lawa is part of the lowest rock unit in the stratigraphic. There are 5 layers of lava; Lava A, Lava B, Lava C, Lava D and Lava E; sequential from bottom to top; from old to young. The lava layers sequence is chronological, as a basis for analysis of evolution in time. Figure 2.

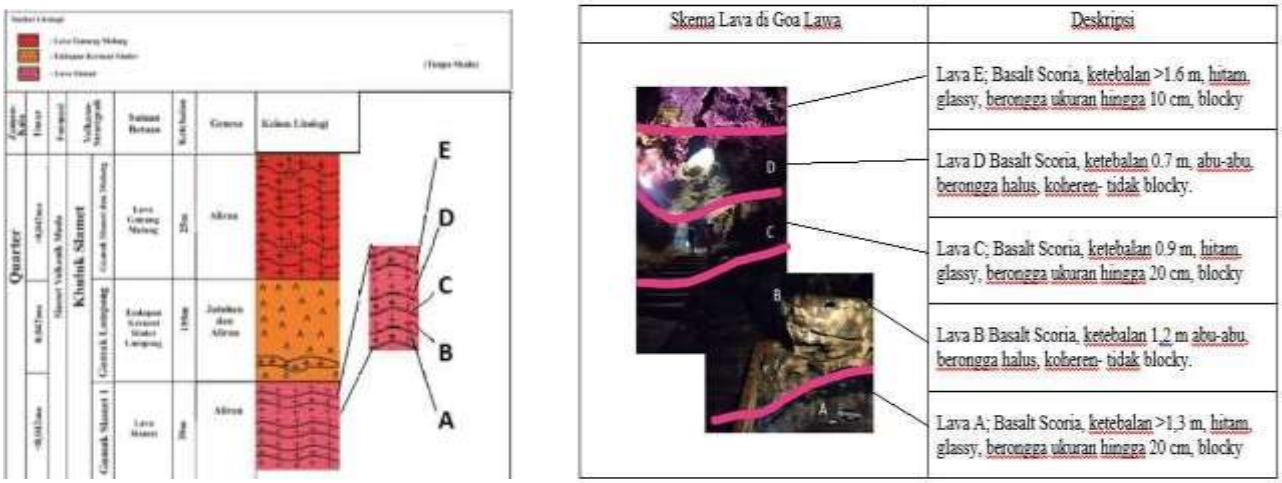


Figure 2. Lava sequence position on stratigraphy of Goa Lawa area.

3.2. Magma Evolution

Rock samples were taken from each layer of lava. The results of geological analysis of the Goa Lawa area obtained there are 5 lava layers from old to young as; Lava A, Lava B, Lava C, Lava D and Lava

E. Each layer was sampled as Sis 01(A), Sis 02 (B), Sis 03 (C), Sis 04 (D), and Sis 05 (E) samples. Rock samples were analyzed to determine the chemical composition of the constituents with the XRF method.

Magma evolution analysis is comparing primary magma chemical composition with existing magma. The data of primary magma refer to [4] [5]. Comparison of the chemical composition of Lava in Goa Lawa with the chemical composition of primary magma is in following table.

Table 1. Chemical Composition of Primary Magma [4] [5] and Goa Lawa Basalt Lava.

Oksida Mayor	Magma Primer (Bronto, 2002)	Sis 01 A	Sis 02 B	Sis 03 C	Sis 04 D	Sis 05 E
SiO_2	50.0 – 49.0	50.53	51.08	50.73	51.35	50.54
TiO_2	0.8 – 0.7	1.1	1.46	1.25	1.52	1.31
Al_2O_3	16.4 – 15.1	16.02	16.53	15.74	18.48	15.62
FeO	8.3 – 9.2	9.95	10.3	10.11	9.73	10.36
MgO	10.0 – 12.5	7.59	5.93	7.7	4.57	7.7
CaO	10.9 – 11.7	10.35	9.9	10.46	9.26	10.51
Na_2O	2.4 – 1.9	2.96	3.36	2.66	3.66	2.88
K_2O	0.4 – 0.	1.11	1.26	1	1.43	1.06
Total		99.61	99.82	99.65	100	99.89

According to type of rock classification [6], those are still at Basalt. That is not significantly changes. It's still at Basalt, Figure 3.

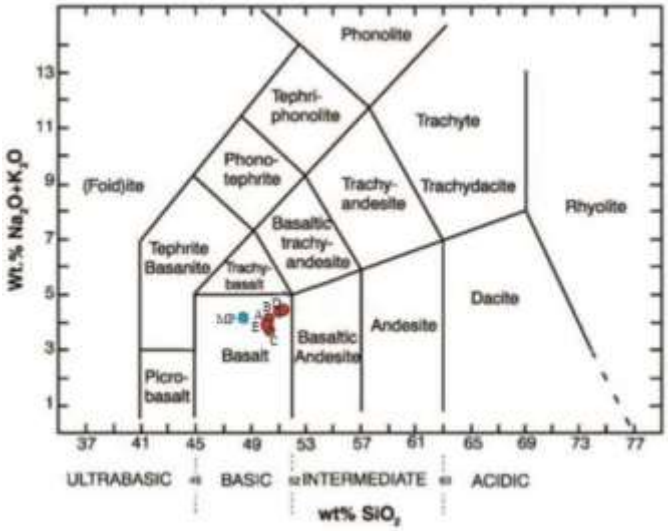


Figure 3. Rock Class, The Blue Dot is Parent Magma, the Red Dots are sample magma from Goa Lawa

Basalt Magma is Heavy, Fluid, and has low content of gas; makes difficult to up rise to the surface. Even when magma can reach the surface, it will only erupt effusively. [7] [10] [11]

Changes in the chemical composition of lava over time are magma dynamics. From the characteristics of Lava A with a SiO_2 content of 50.53 changed to 51.08 in Lava B, indicating a change from basaltic magma to intermediate magma. While the change from Lava B to Lava C; from SiO_2 value 51.08 to SiO2 50.73, is declining, towards basaltic magma. While the change from Lava C to Lava D, from SiO_2 value 50.73 to SiO_2 51.35, increased, changing towards intermediates. And finally, the change from Lava D to Lava E from SiO_2 51.35 to SiO_2 50.54, decreased towards basaltic magma. Thus, there is twice the phase increase and twice the phase decrease in SiO_2 concentration. Figure 4.

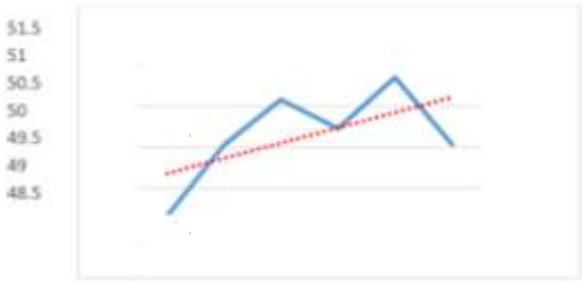


Figure 4. The Changes of lava chemical composition in time according to sample position.

However, this change when referring to the Classification [6] is still in the same class range, Basalt. So the dynamics that occur are not insignificant, and have no effect on the physical characteristics of rocks.

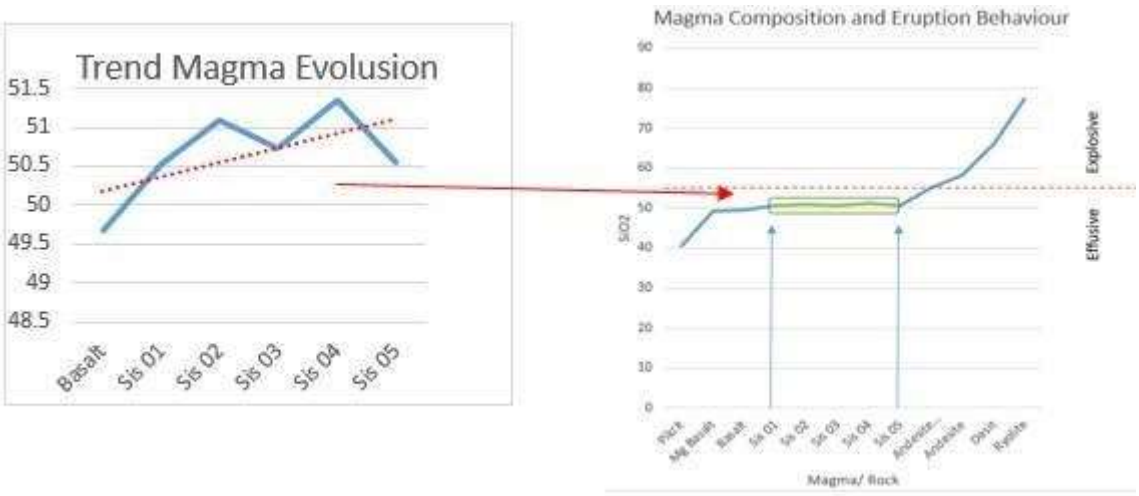


Figure 5. The dynamics that occur are not insignificant

Looking at where the initial magma formed, refers to the relationship of the percent weight ratio (wt%) K_2O vs SiO_2, as referred to [8], that the ratio of K_2O vs SiO_2 can be used to determine the position into the Benioff zone. The Benioff zone is a place within the subduction zone where oceanic crust with colliding continental crust begins to melt. The position of magma initial melt was at 15 KM beneth the surface.Fig.6

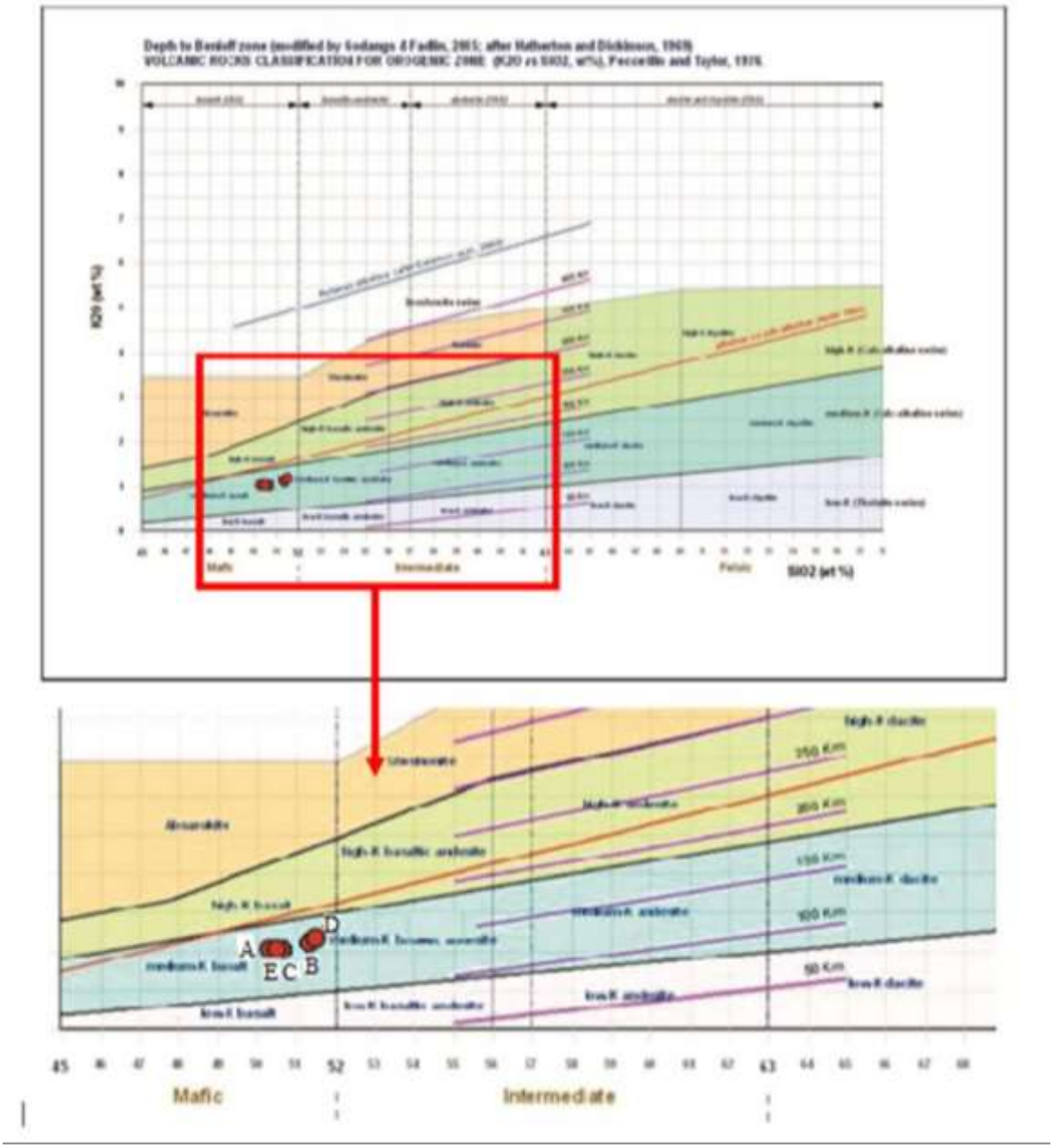


Figure 6. The position of Magma Initial melt according to K_2O vs SiO2 ratio, as

4. Conclusion

There are 5 layers of lava in Gua Lawa, in order from bottom to top; Lava A, Lava B, Lava C, Lava D, and Lava E. It is also the sequence of events. Geochemically is range between 50 -51 % of SiO_2; Basalt. The magma is not significantly change from parent magma. The changes trend tend to intermediate composition in slight and still at Basalt. The place were magma initially melt at 15 KM beneath the surface.

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