

Petrographic and major elements results as indicator of the geothermal potential in Java

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Abstract. Geothermal manifestations existed in West Java (Cilayu, Papandayan Mountain, Telagabodas, Karaha, Tampomas Mountain), Central Java (Slamet Mountain, Dieng) and East Java (Argopuro Mountain) show a difference in their mineral and geochemical compositions. The petrographic analysis of volcanic rocks from Garut (West Java) are basalt, andesite basaltic and andesite. However, based on SiO₂ vs K₂O value, those volcanic rocks have wide ranges of fractionated magma resulting basalt – basaltic andesite to dacitic in composition rather than those of Slamet Mountain, Dieng, and Argopuro Mountain areas which have a narrower range of fractionation magma resulting andesite basaltic and andesite in compositions. The volcanic rocks from Garut show tholeiitic affinity and calc-alkaline affinity. The geothermal potential of Java is assumed to be related to the magma fractionation level. Geothermal potential of West Java (Garut) is higher than that of Central Java (Slamet Mountain, Dieng) and East Java (Argopuro Mountain).

1. Introduction

Study of geothermal in Java Island has been conducted since the 1900s and the studies mainly focus on the hydrothermal alteration and their structure control [1]. Research Center for Geotechnology was involved in the study of geothermal at several locations in West Java (Papandayan Mountain, Cilayu, Ciarinem, Talagabodas, Karaha and Tampomas Mountain), Central Java (Guci, Baturaden, and Dieng), and East Java (Argopuro Mountain). The distribution of volcano related geothermal systems in West Java is more abundant and has bigger potential than those of the Central and the East Java. There are 45 locations of geothermal in West Java, which is the highest locality in Java and Indonesia in general [2]. The change of volcano-magmatic compositions along west to east of Java Island is of particular importance. In addition, the relation of modal mineral composition and major elements compositions of volcanic related geothermal environments in Java Island is not well studied yet. This paper aims to elucidate the potential of the geothermal based on their modal mineral composition and major elements geochemistry. Distribution of volcano related geothermal system is shown in Figure 1.

Regional structures in Java Island, among the West Java, Central Java, and East Java had a unique difference [3]. West Java is mainly dominated by north-south-east trend of the Sumatran fault while that of Central Java and East Java has the northeastern-southwestern [4-5]. The major structures that control the geothermal system in West Java are west-south-trending structures and the appearance of circular features [6]. The structure is also interpreted as that controls the formation of hydrothermal mineralization of the area.

The geothermal system in Java Island can be divided into the giant volcano geothermal (volcano-hosted) and fault geothermal (fault-hosted). A volcano-hosted geothermal system which includes the system including Segaran, Arjuno-Welirang, Lawu, Ungaran, Candi Duku, Dieng, Kaliang, Slamet,



Ciawi, Kampungsumur, Tampomas, Cipanas, Ciater, Darajat, Kamojang, Pangalengan, and Patuha contained in the Quaternary volcanic path [7]. While the system of geothermal which includes fault-hosted are: Pacitan, Maribaya, Pakenjeng, Cilayu, Cikundul, Cisolok, and Parang tritis located in the path of Tertiary volcanic [7].

2. Petrographic

The volcanic around the West Java geothermal manifestations particularly of Garut regency (Cilayu, Ciarinem, Papandayan Mountain, Telagabodas, Karaha, Tampomas Mountain), Central Java, Slamet Mountain (Guci and Baturaden) and Dieng, East Java (Argopuro Mountain) mainly consist of interlayered lava and breccia tuffs and occasionally there are fine tuffs (crystal glass (vitric) tuff) as inserts and lava breccias. The volcanic rocks which are near to the manifestation usually had undergone the hydrothermal alteration.

The results of the petrographic analysis indicate that the volcanic rocks existed in a number of locations as mentioned above are composed of basalt, basaltic andesite, andesite, and dacite. The change from basalt to basalt andesitic, andesite and dacite is indicated by their modal mineral composition.

The porphyry basalt consists of labradorite, pyroxene, and olivine as phenocryst, while volcanic glass is as the ground mass. In addition to porphyry basalt, the intergranular texture of trachy basalt consisting of pyroxene and K-feldspar and minor olivine is occasionally found.

The basalt and basaltic andesite are indicated by the existence of plagioclase of andesine to labradorite types, and occasionally olivine which is partially replaced by pyroxene. The change of basaltic andesite to andesite is indicated by the existence of relatively dominant andesine, and a small amount of labradorite or absent, whereas common mafic minerals are pyroxene and hornblende minerals were found in a small amount. Sometimes pyroxenes are replaced by hornblende. The feature of pyroxene is distinguished by its cleavage, but pleochroism has relatively moderate pleochroism (typical for hornblende).

The change from andesite to the dacite is indicated by the presence of oligoclase, K-feldspar, quartz, and occasionally a small amount of andesine, and mafic minerals such as hornblende and biotite. Sometimes the hornblende body is replaced by biotite. Hornblende, which is replaced by biotite, shows a partially angled cleavage, but the other side shows partial hemispheres and moderately strong pleochroism with the parallel extinction angle. Such phenomena can be found almost in all locations in Garut, Dieng and Argopuro Mountain (Figure 1).

A Plutonic rock was identified as diorite and was found in Cilayu River, southern part of Garut. The diorite was likely to have been formed during the Late Miocene due to the frontal subduction [2]. This subduction has produced a basalt tholeiitic at Ciarinem area.

3. Major Element

A number of volcanic rocks from the field around the geothermal manifestations were prepared for geochemical analyses at a commercial laboratory in Canada. The analyses include of major, trace, and rare earth elements analyses. The aims are to obtain the geochemical characteristics of volcanic-magmatic rocks. Some of analyzed data (Figure 1) [8].

The relation between K_2O and SiO_2 indicates that the volcanic rocks in West Java represented by the volcanic rocks from Cilayu, Ciarinem (Garut 1) (dark green colour) had undergone the crystal fractionation. They had evolved from a tholeiitic magma of basalt, andesite-basaltic, andesite. The volcanic rocks around Papandayan show series of calc-alkaline with wider compositions of andesite to dacite (Figure 1). The high K_2O content of Papandayan volcanic suggests the contamination with continental materials [9].

The volcanic rocks at Telagabodas and Karaha (Garut 2) indicate the character of tholeiitic, and transition between tholeiitic and calc-alkaline. The calc-alkaline rock consists of basalt, andesite basaltic, and andesite. In the north of Garut, Tampomas Mountain exhibits a series of calc-alkaline and a tholeiitic series [3]. They consist of breccias tuff and lava. Fragments of the breccias tuff are basalt, andesite-basaltic, andesite, hornblende andesite, and the lavas composition of the same rocks.

The major elements of volcanic rocks of Slamet Mountain (Guci and Baturaden) show a character of calc-alkaline with a relatively low to medium potassium in the central part of Java. Slamet Mountain has higher K₂O content compared to Sundoro and Ciremai Mountain, while their relatively similar distance from trench suggests that it has been contaminated by crustal material [10]. They consist of basalt and andesite basaltic (Figure 1). Plot of the major elements of andesite-basaltic, and andesite from Dieng (Central Java), and Argopuro (East Java) have the calc-alkaline and high-K calc-alkaline series. Some volcanic rocks from Argopuro indicated a shoshonitic series (Figure 1). All the evidence suggests the contamination of continental materials during the magma differentiation.

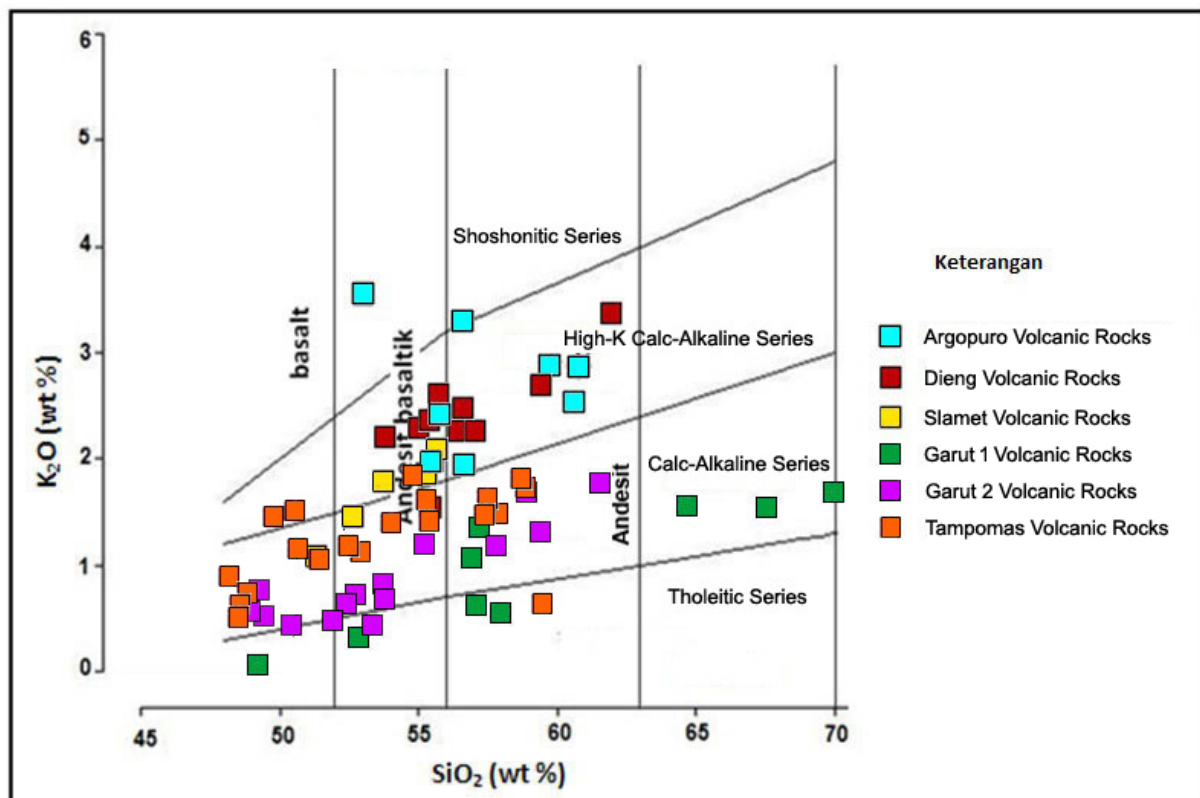


Figure 1. Plotting of SiO_2 versus K_2O to identify the rock affinity [Pecerillo dan Taylor, 1976].

The volcanic rocks from West Java which are represented by Garut 1 and Garut 2 show a relatively complete magma fractionation rather than those of the central and the east of Java. They have resulted in the formation of basalt tholeiitic near the trench side. While those from Cilayu, Ciarinem (Garut 1) and other calc-alkaline magma series suggest the results of back arc side volcanisms (Figure 1).

The series of tholeiitic in Garut is likely to form in the late Miocene due to the frontal subduction of the southward direction [1]. Based on diagram of SiO_2 versus K_2O [8] the volcanic rocks from West Java (Garut 1 and Garut 2) have a longer and more complete fractionation than those from the central and the east of Java, i.e. Slamet Mountain (Guci, Baturaden) and Dieng Central Java, and Argopuro Mountain (Probolinggo East Java). The Ungaran Mountain in Central Java that consists of basalt shoshonitic, andesite basaltic, and andesite the high K-calc alkaline suggest the characteristic of the later stage of magma evolution [11].

4. Conclusions

The petrographic results of volcanic rocks from Garut West Java, Slamet Mountain and Dieng of Central Java, and Argopuro Mountain (Probolinggo) of East Java show that magma has undergone crystal

fractionation. They had evolved from the basic to intermediate and finally to the acidic rocks. Garut has a wider range of SiO₂. Magma resulted in basalt to dacite in composition.

Based on the major elements of K₂O versus SiO₂ of volcanic rocks from Garut 1 and Garut 2, they have the character of tholeiitic up to the calc-alkaline magma series. The tholeiitic series did not exist around Slamet Mountain (Guci, Baturaden and Dieng), and Argopuro Mountain. The volcanic rocks of central to the east contained higher of Potassium content (High K-Calc-Alkaline).

The various modal mineral compositions and major elements content of the volcanic rocks along the Java Island may have correlated with the different number of existed geothermal potential.

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